CALUMET'S CRITICAL WETLANDS IN ILLINOIS:

A Conservation Action Plan

AUDUBON GREAT LAKES · FOREST PRESERVES of Cook County · THE WETLANDS INITIATIVE · ILLINOIS DEPARTMENT OF NATURAL RESOURCES · COASTAL Management Program IL Dept of Natural Resources

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Executive Summary

Historically, the Calumet Region was a vast, interconnected wetland hydrologic complex along the southern shore of Lake Michigan, home to abundant wildlife and a vital migratory route for many birds. The region's legacy of industrialization and urbanization greatly reduced the amount and quality of wetlands and marshes in the area, though many fragmented wetlands and marshes remain. Multiple emerging and complex threats face these remaining and potentially restorable marshes of the Calumet Region, and, by extension, the water-loving birds that depend on them. These threats primarily include invasive species, altered hydrology, climate change, and pollution.

Conventional restoration efforts focus on individual sites. While this is a valuable and necessary measure, it is essential that we re-envision the region's marshes as a broad and interconnected ecosystem—the historic Calumet Region—in order to sustain the water and wildlife that connect each site in this hydrologic system. Landscape-level coordinated water management, cooperative weed management, and collaborative fundraising help build efficiencies, facilitate comparative advantages of partners, and accomplish large-scale restoration goals at our most important natural areas.

Broad and diverse partnerships, alongside years of dedicated effort, will be needed to return high-quality functioning wetland ecosystems to the region. The Calumet Wetland Working Group was formed to take on these challenges and has subsequently produced this action plan as a guiding document.

As is often the case, birds in the Calumet Region provide an identifiable barometer to healthy ecosystems and waterways. Not as easily identifiable given their secretive nature, breeding marsh birds have suffered a rapid decline across the Midwest in association with a loss of quality hemimarsh habitat. Through a science-based, conservation-action planning process, the Calumet Wetland Working Group has established a baseline of focal breeding marsh bird populations and has set the following ambitious goal to restore bird communities and the functional marsh habitat on which they depend.

By 2027, 190 acres of hemimarsh in the Calumet region of Illinois will support at least 70 breeding pairs of Pied-billed Grebe, 20 breeding pairs of Least Bittern, and 40 breeding pairs of Common Gallinule.

In order to achieve this goal, we will:

- Establish regular water, habitat, and bird monitoring by 2020;
- Adapt site management based on monitoring results by 2020;
- Coordinate invasive species control at a regional scale by 2022; and
- Implement restoration plans across 13 high-priority sites by 2025.

Introduction

The Calumet Region

The Calumet region was once home to a large coastal wetland complex teeming with unique ecosystems and wildlife. The region housed an extensive system of dune and swale habitat, formed by the gradual deposition of sand as water levels of ancient lakes slowly diminished and the rising shoreline was released from the heavy weight of retreating glaciers (Schoon 2016[1]). Thin, parallel ridges of dunes line the coast, with swales between each dune. These swales maintain a broad diversity of wetland types, which vary due to their proximity to the lakeshore, the water level of the lake, and the season. Freshwater dunes and swales are found only in the Great Lakes, making it an extraordinarily unique and ecologically rich wetland mosaic. Prior to the 1800s, the Lake Michigan shoreline—as well as nearly 45,000 acres of coastal wetlands—provided a habitat for numerous wildlife (including rare and threatened species), such as passerines, waterfowl, shorebirds, and, in particular, breeding marsh birds.

Industrialization in the Calumet since the mid-1800s has been transforming the wetland landscape throughout the region, filling wetlands, damming flows, straightening channels, and fragmenting those systems that remain. Marshes in particular were hardest hit due to their dependence on natural water dynamics. However, many wetlands in the Calumet remained regionally significant to Midwest marsh birds through the 1980s. But over the past 30 years, the ongoing assault on natural hydrology has come to a head: invasive species such as common reed (*Phragmites australis*), narrowleaf cattail (*Typha angustifolia),* and common carp *(Cyprinus carpio*) have degraded vegetative structure and biodiversity beyond a tipping point; they no longer provide even minimal marsh functionality. This regional decline in wetland quality is now strongly correlated with the rapidly declining populations of breeding marsh birds.

Breeding marsh birds depend on intact, healthy wetlands and therefore serve as an excellent indicator of wetland quality. In particular, the restoration of hemimarsh wetlands is a preferred strategy for increasing the number of breeding marsh birds. Hemimarshes are dynamic wetlands with a relatively equal distribution of emergent vegetation and open water. The vegetative composition of hemimarsh systems responds to a variety of dynamic factors, such as natural variation in water levels and the impact of herbivory. Through hemimarsh restoration, a broad spectrum of wetland habitat conditions develop within the system, ensuring a diversity of nesting and foraging sites for breeding marsh birds.

Wetland restoration, particularly hemimarsh restoration, needs to occur on the landscape level in the Calumet, as both wetland quality and function are so strongly influenced by hydrologic dynamics at a broader scale. Beyond breeding marsh bird habitat, there are several reasons why landscape-level wetland restoration is important to the Calumet region: a healthy, functioning wetland system also provides ecosystem services such as flood control and nutrient filtration, reducing flood risks and improving water quality for the southern shore of Lake Michigan.

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[1]Schoon, *Shifting Sands: The Restoration of the Calumet Area.*

Due to the wide interest in wetland restoration at a landscape level in the Calumet, the Calumet Wetland Working Group—a coalition of land managers, scientists, and conservationists—was formed in 2015. This group aims to investigate marsh bird breeding trends, assess current and potential wetlands, and formulate an action plan to restore and maintain wetlands in the Calumet region with a focus on hemimarsh habitat.

Conservation Action Planning

Having identified the critical need for quality marsh habitat, this planning effort quickly targeted the assessment of conservation and/or restoration opportunities to develop higher-quality wetlands, focusing on the potential to restore or enhance hemimarsh habitat in remaining wetlands. The underlying assumption is that restoring the conditions under which hemimarsh can develop would prove most beneficial to our wetland-dependent focal bird species, which in turn would benefit many other wetland-dependent species at each site. In other words, actions that improve habitat quality at the intersection of shallow emergent marsh and open water should also improve conditions across the entire habitat spectrum between these two endpoints.

In consultation with key partners and with our collective understanding of the current extent of wetlands in the Calumet area in Illinois, we identified 21 sites that offered promising potential for developing significant stands of hemimarsh (Figure 1). Each site was visited at least once to assess the current conditions and to help determine which actions could be taken to effect habitat improvement. Each visit was both preceded and followed by an extensive analysis of satellite imagery in order to determine landscape configuration and features relevant for conservation planning. This included a GIS analysis of the project area, open-surface water area, and invasive cover area. We accessed public records to ascertain ownership, ownership boundaries, and our ability to access each site. For sites owned by public agencies such as the Chicago Park District, the Forest Preserves of Cook County, or the Illinois Department of Natural Resources, we met with appropriate personnel to acquire their insight into each site's history, the challenges facing each site, the potential for conducting various restoration activities, and how they would like to see each site develop. We also assessed limiting factors on restoration potential, e.g., conflicts with public access or limits to hydrologic manipulation. We attempted to identify the key gaps in information that would be necessary to project restoration potential, such as information on:

- Hydrology
- Hydrologic management options
- Bathymetry and topography
- Identity and cover of invasive species
- The presence of common carp
- Invasive management options

To proceed with our analysis, we needed to understand the hydrologic conditions at each site in order to determine its potential to develop the 'natural' functions of a marsh system. Where the natural dynamics of marsh hydrology were no longer present, we needed to determine if the system could be modified to impose or develop these functions. In their absence, the potential to restore marsh functions becomes limited. An understanding of local bathymetry was also critical for projecting restoration potential, assuming hydrologic control could be implemented: water that is too deep will not support emergent marsh vegetation, and water that is too shallow will not support the vegetated open-water mosaic necessary for creating hemimarsh. An understanding of the local topography was necessary to assess hydrologic management options, i.e., the extent to which landscape position and elevation permitted drainage, inflows, and the potential for water control. The type and density of invasive species, both plant and animal, and the potential to manage or eradicate them, would directly influence the efficacy of marsh restoration efforts. A number of questions had to be answered, including:

- Can the invasive plant community be managed?
- Can the recurring input of new invasive propagules be controlled?
- Can common carp be eliminated and their access routes for reinvasion controlled?

Based on the profiles assembled for each of our 21 focal sites, we were able to categorize sites in regard to their overall restoration potential and hemimarsh restoration potential (Table 1). Our analysis suggests that nearly all of the sites could be improved with sufficient application of resources, although the will, mandate, or capacity to do so clearly varies among the different landowners—as does their ability to manage a site post-restoration. Since hydrology on most of these sites no longer follows natural rhythms, e.g., water levels are static due to weirs or they periodically dry out due to their isolation from natural inflows, we evaluated each to determine if controls could be imposed that would allow water levels to function naturally or be manipulated to mimic natural rhythms. Since all sites were infected with the invasive common carp (*Cyprinus carpio*) except for those that periodically dry out (4 sites), we also evaluated each for the potential to impose carp control, which is critical to the restoration of marsh functions. We also determined which sites had sufficient and appropriate bathymetry across the range of depths in which hemimarsh occurs. Although bathymetric data was not available for most sites, it could be inferred from aerial imagery across dry (low-water) and wet (high-water) years. At least some appropriate bathymetry was found at all sites except those with steep-sided, deep basins or those that were too shallow and densely vegetated. We also noted which sites have reported ecotoxicology issues, which must be considered in any future detailed restoration planning.

Collectively, we identified 823 acres of water surface distributed among the 21 sites. While all of the sites had some wetland restoration potential, only 14 of the 21 were identified as having significant higher-quality hemimarsh restoration potential. These 14 have been identified as conservation priority sites (Table 2). There were 552 acres of water surface found within the priority sites, with 300 acres potentially restorable as marsh habitat (55% of the priority site total) and 194 acres potentially restorable as hemimarsh habitat (36% of the priority site total).

Illinois Calumet Sites of the Conservation Action Plan

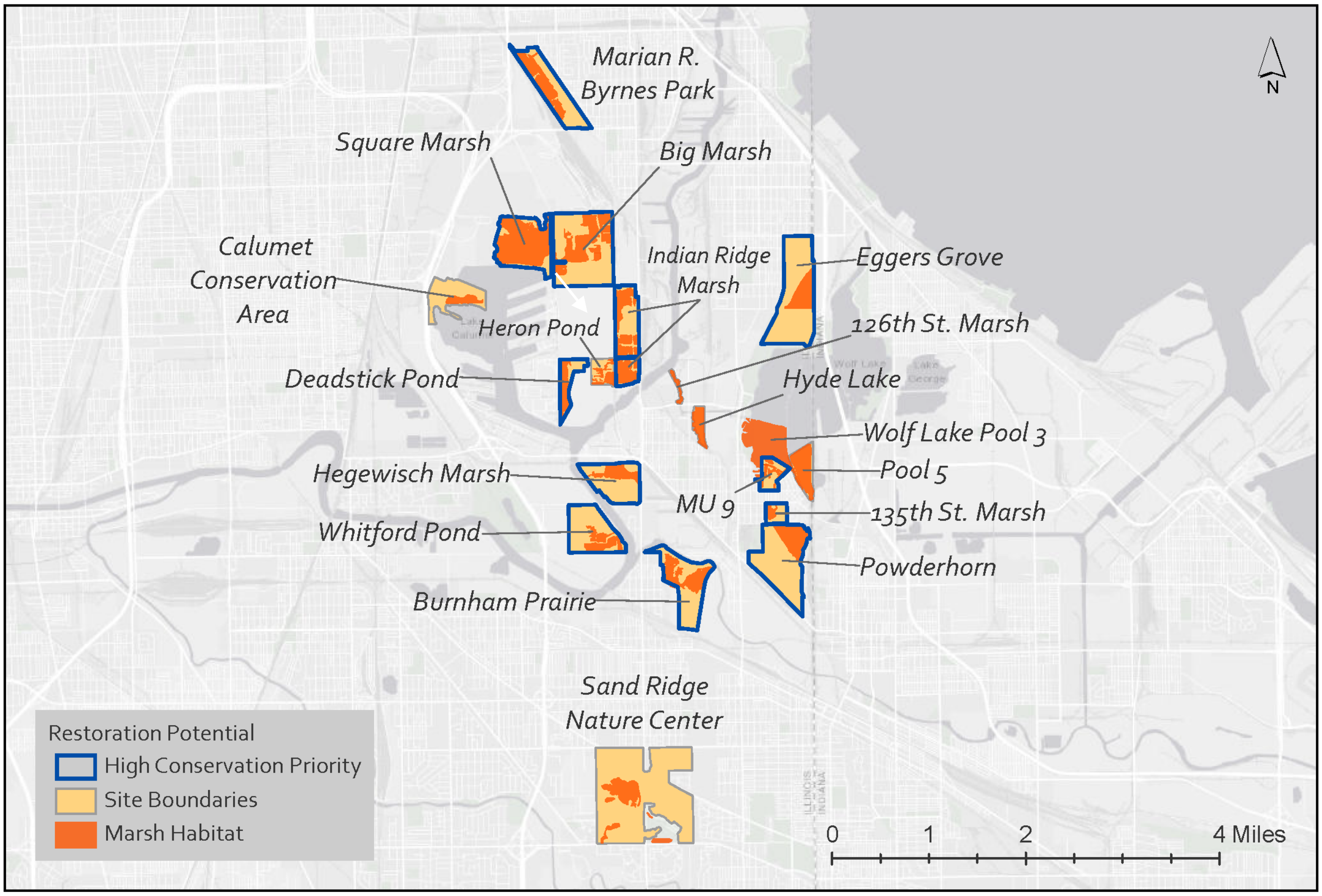


Figure 1. Map of the Calumet region showing the distribution of wetlands assessed in the Conservation Action Plan. Imagery courtesy of Google Earth.

Table 1
Status of each site in regard to the primary concerns affecting restoration potential. Other factors not listed were invasive species pressure (severeon most sites), the presence of common carp (confirmedon nearly all sites), and shoreline modification (severe on most sites) Under land ownership, CPD: Chicago Park District, FPCC: Forest Preserves of Cook County, MWRD: Metropolitan Water Reclamation District, PA: Port Authority, RR: Railroad, WPISP: William Powers Illinois State Park, and CC: City of Chicago, NA: not applicable.]

Marshes	Land Ownership	Water Control Potential	Carp Control Potential	Appropriate Bathymetry	Ecotoxicity Issues
126th Street Marsh	Private	partial	no	no	yes
135th St Marsh	FPDCC	no	no	yes	unknown
Big Marsh	CPD	yes	yes	yes	yes
Burnham Prairie	FPDCC	yes	yes	yes	yes
Calumet Conservation Area	PA	yes	no	no	unknown
Calumet 'Square Marsh'	PA	yes	yes	yes	yes
Dead Stick Pond	MWRD	yes	yes	yes	yes
Eggers Marsh	FPDCC	yes	yes	yes	unknown
Hegewisch Marsh	CPD	yes	yes	yes	yes
Heron Pond	CC, MWRD	yes	yes	no	yes
Hyde Lake Marsh	Private, CC	no	no	no	yes
Indian Ridge North	CPD	yes	yes	yes	yes
Indian Ridge South	CPD	yes	yes	yes	yes
Marian Byrnes	CPD	potentially	NA	yes	unknown
Powderhorn	FPDCC, RR	yes	yes	yes	unknown
Sand Ridge	FPDCC	no	NA	no	no
Whitford Marsh	CPD	yes	yes	yes	unknown
Whitford Pond	CPD	yes	yes	yes	unknown
Wolf Lake IL MU9	WPISP	no	no	yes	yes
Wolf Lake IL Pool 3	WPISP	no	no	yes	unknown
Wolf Lake IL Pool 5	WPISP	no	no	yes	Yes

Table 2
Summary of the wetland area calculated in each of the conservation priority sites and lower priority sites identified in the conservation action planning effort, with number of potential pool, open water, shallow marsh, and hemimarsh habitat acres for each site

Marshes	pool area acres	open water acres	potential total marsh acres	potential emergent marsh acres	potential hemimarsh acres
35th St. Marsh	7.2	2.2	5.0	2.5	2.5
Big Marsh	97.5	58.0	39.5	15.5	24.0
Burnham Prairie	34.8	9.0	25.8	14.6	11.2
Deadstick Pond	28.2	4.1	24.1	10.8	13.3
Eggers Marsh	25.3	0.0	25.3	13.7	11.6
Hegewisch Marsh	30.8	3.7	27.1	6.7	20.4
Indian Ridge Marsh North	56.5	45.3	11.2	3.8	7.4
Indian Ridge Marsh South	32.7	9.5	23.2	7.7	15.4
Marian R. Byrnes Park	5.3	0.0	5.3	3.8	1.5
Powderhorn Marsh	51.7	5.0	46.7	2.7	44.0
Square Marsh	144.0	112.6	31.4	6.4	25.0
Whitford Marsh	10.3	0.0	10.3	7.0	3.3
Whitford Pond	19.4	0.0	19.4	8.8	10.6
Wolf Lake MU9	8.6	3.4	5.2	1.6	3.6
Conservation Priority Sites	552.3	252.8	299.5	105.6	193.8
126th St. Marsh	5.6	2.9	2.7	2.7	0.0
Calumet Conservation Area	15.9	15.9	0.0	0.0	0.0
Heron Pond	12.8	9.7	3.1	3.1	0.0
Hyde Lake	23.9	0.0	23.9	23.9	0.0
Sand Ridge Nature Center	50.8	9.6	41.3	40.4	0.9
Wolf Lake Pool 3	114.7	114.7	0.0	0.0	0.0
Wolf Lake Pool 5	46.8	46.8	0.0	0.0	0.0
Lower Priority Sites	270.5	199.5	71.0	70.1	0.9
All Sites combined	822.8	452.3	370.5	175.7	194.7

Hemimarsh

An emphasis on restoring hemimarsh in the Calumet region is crucial given its potential to provide critical habitat for rare and threatened marsh-dependent bird species as well as public open space for the benefit of neighboring communities. With its legacy of industrial development, contamination, and dumping, an influx of invasive species, and poor hydrologic management over the last few decades, the Calumet wetlands have suffered severe loss and degradation of all wetland habitats. We are characterizing the potential to re-develop hemimarsh as *restoration*, as hemimarsh was historically one of the dominant habitats in the region—and arguably the one suffering the greatest collapse due to the collective impact of changing conditions within the Calumet.

Hemimarsh was once found extensively throughout the Calumet region, providing regionally significant breeding grounds for populations of several Illinois-based threatened and endangered bird species. For example, Indian Ridge Marsh was at one time home to the largest rookery of Black-crowned Night-Herons (*Nycticorax nycticorax*) in the Upper Midwest, a species on the Illinois endangered species list and nearly extirpated from the region. In the post-industrial wetland landscape at Calumet, poorly managed water control, in combination with highly aggressive exotic species such as common reed, has not only spelled doom for hemimarsh habitat but also for the rare and threatened species that depend on its unique ecology.

For each of the 21 sites surveyed, one of our primary goals was to quantify the potential to restore hemimarsh habitat given a reasonable restoration strategy and appropriate management. To assess hemimarsh potential, it is critical to understand the physical conditions required for its development, the hydrologic dynamics required to maintain it, and the complex ecological interactions taking place among organisms within functioning hemimarsh systems.

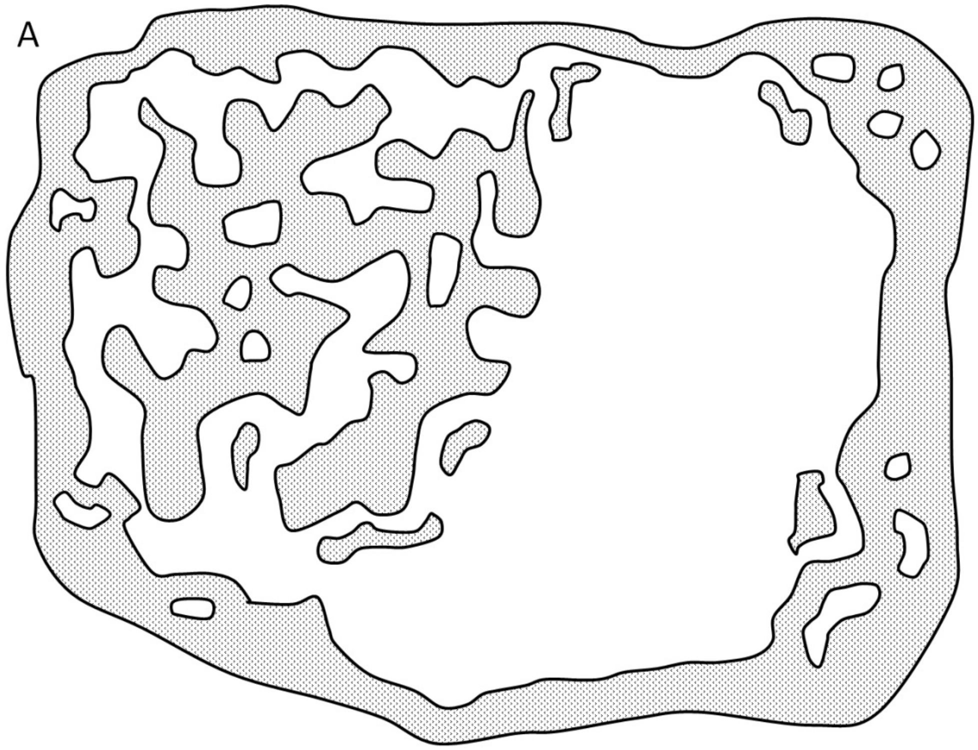


Figure 2A. Distribution of emergent marsh vegetation (stippled) in a water body that is approximately 1/3 emergent shallow marsh (around perimeter), 1/3 hemimarsh (left side), and 1/3 open water (right side).

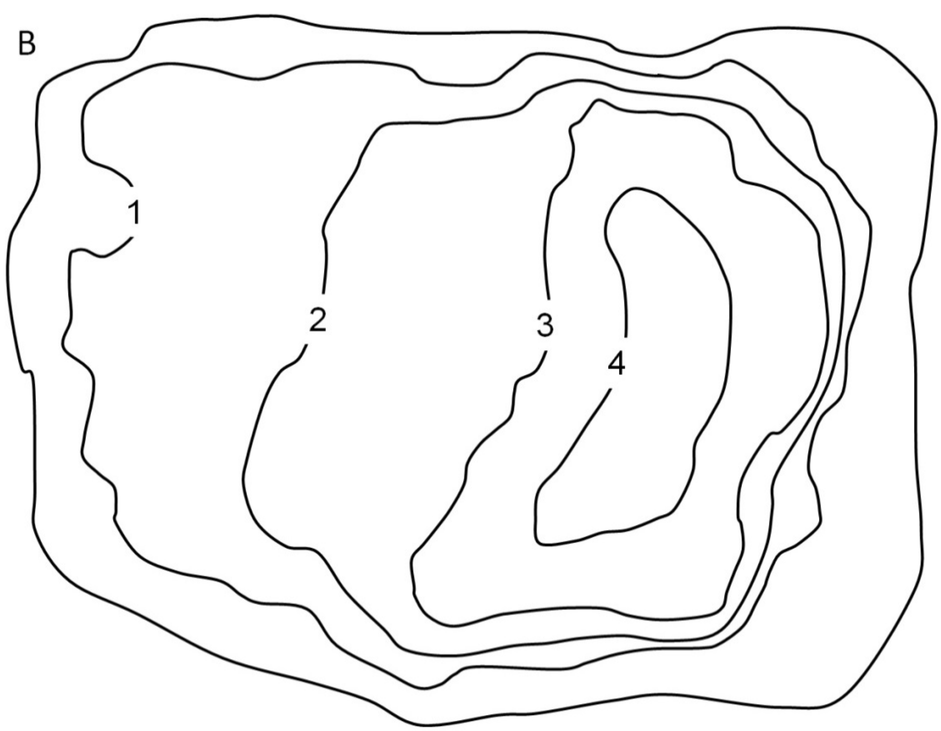


Figure 2B. Depth contours illustrating the distribution of depths in the same water body. [Note that in this example, hemimarsh occurs across a range of depths between 1 and 3 feet deep.]

Structure

Hemimarsh is a type of mid- to deep-water marsh characterized by a combination of emergent vegetation (EV) and open water (OW) in a ratio approximating 1:1. Deep-water marshes dominated by EV are not considered hemimarshes, nor are areas of OW with scattered stands of EV; i.e., neither has hemimarsh characteristics. The exact ratio of EV to OW is dynamic and fluctuating based on factors such as variation in water levels, bathymetry, plant establishment dynamics, herbivore activity, and invasive species impacts. The key condition that makes a marsh a functional hemimarsh is the level of interspersion between the EV and OW, i.e., both types occur in a mosaic characterized by a high edge-to-volume ratio (Figures 2A and 2B). It is this relatively complex, open structure that provides habitat for many marsh-dependent animal species. Just as the emergent portion of a hemimarsh is characterized by emergent marsh vegetation, the OW portion is characterized by submersed and/or floating-leaved vegetation.

Limits to Emergent Plant Distribution Across Depths

Emergent marsh plant species grow along a gradient, from moist soil along shorelines out to where depth limits their ability to establish or survive. A number of factors determine the range of depths in which each species establishes itself and grows, some of which are determined by a plant's characteristics (e.g., plant structure, height, and germination requirements) and some by characteristics of the system in which it grows. These include both intra- and inter-annual spatial and temporal variation in water levels, water clarity, pH, alkalinity, and interactions with other species, such as invasive or aggressive species, algal blooms, and/or common carp (*Cyprinus carpio*). Some factors are only limiting at a certain stage in a plant's life history, e.g., sufficient light penetration may be required to stimulate seed germination or growth to the surface, meaning that new plants can only be established in murky waters when water levels become low enough to transmit sufficient light. Consequently, the range of depths across which each species is distributed varies with the conditions under which it grows. In general, emergent plants grow in deeper water when it is clear and under little pressure from herbivores or competitors. Plants will grow in even deeper water if water levels are occasionally lower so that new plants may periodically reestablish. Although the distribution of each emergent species becomes limited at different depths, marsh species that occur in deeper water may, in general, also be found at shallower depths.

Hemimarsh Dynamics

The mosaic configuration of EV in hemimarsh does not spontaneously occur, but rather is the result of ongoing rounds of plant death and subsequent regeneration. The process can be driven by a combination of limiting water depths and differential senescence or physical damage, but it is greatly facilitated and accelerated by herbivory, primarily by muskrats (*Ondatra zibethicus*). Muskrats create openings within emergent communities by harvesting EV to build nests and feeding platforms. Both result in mounds of vegetation surrounded by a cleared area, with additional smaller clearings associated with feeding zones and access runs. In shallower water, emergent species will regrow the next season, but in deeper water, permanent clearings are created and maintained. As muskrat density increases, the number of openings increases until large swathes of marsh vegetation are cleared to create the classic hemimarsh architecture. Submersed or floating-leaved vegetation may then colonize the openings if the conditions are appropriate. Since the muskrat population will usually grow until limited by space or resources, including sufficient EV, the ratio of emergents to OW continues to decline until there is not enough to support the density of muskrats. Hemimarsh-dependent species generally abandon such a system once the hemimarsh architecture drifts too far from the 1:1 ratio without recovery.

This process most often occurs in a cycle that starts with a new flush of EV, followed by muskrat colonization, and eventually ends with the declining density of EV until the process starts over again with another new flush of EV. Consequently, fluctuating water levels are critical to maintaining a hemimarsh; i.e., periodic low water levels are needed to stimulate the germination and establishment of new plants when EV density is low. This is also why hemimarsh rarely develops in shallow water, as water levels are already low enough to maintain a high density of EV through ongoing germination and establishment. Depths that are too great to allow germination at low water levels or for emergents to survive at higher water levels remain as open water zones. Periodic high water or flooding events may also cause the death of emergents. The frequency of this cycle is dependent upon the density of muskrats and/or the frequency of both low- and high-water periods.

Non-native species (e.g., common reed or *Phragmites australis*) can short-circuit this process through competition with desirable species or disruptive behaviors (e.g., common carp). Carp can eliminate both emergent and submersed species through their feeding behavior, causing a downward spiral of habitat quality. They uproot plants while digging through and suspending sediments in the water column, directly killing them or preventing enough light penetration to maintain submersed plants and/or germinate and establish emergent plants in all but the shallowest depths.

Marsh Plant Species

The most common and dominant hemimarsh species are cattails, of which there are two found in the Midwest plus a hybrid between them: the native broadleaf cattail (*Typha latifolia*), non-native narrow-leaf cattail (*Typha angustifolia*), and the hybrid cattail (*Typha x glauca*). The hybrid is generally the tallest and survives in the deepest water, making it a structurally dominant component of deeper hemimarshes but an aggressively destructive species in shallower systems. Additionally, many bulrushes, sedges, and other species may be part of an emergent hemimarsh community (Table 3), while a diversity of submersed and floating-leaved species can be found in open water (Table 4). Some floating-leaved species develop emergent leaves as they mature, although they may not contribute significantly to the architecture of hemimarsh habitat. Many other marsh species may be part of the hemimarsh community, but generally only dominate in the denser shallow marsh habitat.

Table 3
List of relatively common emergent marsh species with the range of depths in which they occur [the deepest depth in each range varies with water clarity and disturbance history. In this analysis, shallow depths range from shore up to 1 foot deep, mid-depths range up to 2 feet deep, and deep ranges up to 3 feet deep.]

Species	Common Name	Depth Range
Acorus americanus	Sweet flag	shallow
Bolboschoenus fluviatilis	River bulrush	shallow to mid-depth
Carex atherodes	Slough sedge	shallow
Eleocharis palustris	Marsh spike rush	shallow
Juncus effusus	Soft rush	shallow
Ludwigia peploides	Creeping primrose	shallow to mid-depth
Polygonum amphibium	Water smartweed	shallow to deep
Pontedaria cordata	Pickeral weed	shallow to deep
Sagittaria latifolia	Duck potato	shallow to mid-depth
Schoenoplectus acutus	Hardstem bulrush	shallow to mid-depth
Schoenoplectus pungens	Three-square bulrush	shallow to mid-depth
Schoenoplectus tabernaemontani	Softstem bulrush	shallow to mid-depth
Scirpus atrovirens	Dark green bulrush	shallow
Scirpus cyperinus	Wool grass	shallow
Scirpus microcarpus	Barber pole sedge	shallow
Scirpus pendulus	Red bulrush	shallow
Sparganium eurycarpum	Giant bur-reed	shallow to mid-depth
Typha angustifolia[1]	Narrowleaf cattail	shallow to deep
Typha latifolia	Broadleaf cattail	shallow to mid-depth
Typha xglauca[1]	Hybrid cattail	shallow to deep
Zizania palustris	Northern wild rice	shallow to deep

[1]Non-native species

Table 4
List of relatively common submersed or floating-leaved open water species [the depth range of submersed species is limited by water clarity and disturbance history. The depth range of floating-leaved species varies with plant structure, but is generally deeper in clearer, calmer water.]

Species	Common name	Type
Brasenia schreberi	Water shield	floating-leaved
Ceratophyllum demersum	Coontail	submersed
Elodea canadensis	Common waterweed	submersed
Myriophyllum sibiricum	Northern watermilfoil	submersed
Myriophyllum spicatum[1]	Eurasian watermilfoil	submersed
Najas gracillima	Slender naiad	submersed
Najas minor[1]	Brittle naiad	submersed
Nelumbo luteo[2]	Lotus	floating-leaved
Nuphar lutea[2]	Spatterdock	floating-leaved
Nymphaea odorata	White water lily	floating-leaved
Potamogeton amplifolius	Large-leaved pondweed	submersed
Potamogeton crispus[1]	Curly leaf pondweed	submersed
Potamogeton foliosus	Leafy pondweed	submersed
Potamogeton illinoensis	Illinois pondweed	submersed
Potamogeton nodosus	Nodding longleaf	submersed
Stuckenia pectinata	Sago pondweed	submersed
Vallisneria americana	Water celery	submersed

[1]Non-native species
[2]Mature plants can be emergent

Hemimarsh species provide important habitat for many marsh-dependent bird species, but also for many fish, insect, amphibian, and reptile species. Hemimarsh provides ecosystem services not provided by EV or OW species alone; e.g., if deep marsh vegetation is too dense, it does not provide appropriate structure for building nests, or if the EV in an OW zone is too sparse, it may not provide sufficient cover.

Many birds nest in hemimarsh but utilize different parts of the habitat. Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*) nest in the upper emergent canopy; Least Bitterns (*Ixobrychus exilis*) more commonly nest in the mid-canopy. Pied-billed Grebes (*Podilymbus podiceps*) build floating nests in OW out of floating-leaved vegetation. Common Gallinules (*Gallinula galeata*) and American Coots (*Fulica Americana*) build nests that can float and are anchored to emergent plants near the water line, while Canada Geese (*Branta Canadensis*) build nests on top of muskrat houses or feeding platforms. All of these species utilize the hemimarsh to provide cover from predators and shelter from storms.

A complex food web is also characteristic of hemimarshes, providing for an anastomosis of energy-transfer pathways. A wide range of aquatic insects can be found in submersed vegetation, which in turn provide food for insectivorous fish, herps, birds and mammals. Small, insectivorous fish not only provide food for bigger fish, but also for a variety of other piscivores. Fish, amphibians, reptiles, birds, and mammals all provide food for each other at different life stages in the hemimarsh. All non-migratory species overwinter in the marsh, although none may be as iconic in this regard as the muskrat, whose overwintering lodges and the surrounding open zone ('eat-outs') may completely blanket the emergent community.

Hemimarsh Restoration: General Recommendations

The potential to restore the conditions under which hemimarsh may develop—and for managing hemimarsh going forward at any of the Calumet wetlands—will depend a great deal on the ability to manage water levels. Although water levels are not managed in natural systems, most of these wetlands no longer function naturally; they have been heavily altered hydrologically to the extent that natural wetland functions are no longer possible without intervention. Roads, rail lines, ditches, and development (e.g., residential, industrial, and commercial) have isolated these systems and cut them off from the larger landscape. Wetlands have been filled, drained, dammed, and channelized to the point where natural rhythms of flooding and drying no longer occur, or occur at, or for, unnatural periods of time. For these wetlands, establishing water level control will be critical for initiating the conditions under which a robust hemimarsh community may develop.

The reason it is important to initially draw water levels down and expose bottom sediments in these systems is not only for the practicalities of planting and germinating seed or establishing plants, but because most of these marshes have soft bottoms with flocculent sediments that are not conducive to establishing emergent vegetation. This is an even bigger problem for systems that have, or have had, a population of common carp. Carp are constantly re-suspending sediments in the course of feeding, a behavior that simultaneously uproots plants and reduces light penetration to near zero. Loose sediments will not easily support emergent plants, nor will low light levels stimulate germination. During a drawdown, exposed sediments can dry out and consolidate until they are firm enough to support emergent plants. This period of low water is also the ideal time in which to eliminate common carp through the application of a piscicide or through systems that can be drained shallow enough to freeze them out or suffocate them from lack of oxygen.

It is important to remember that hemimarsh is actually a type of mid-to-deep marsh that develops over time through the interaction of several ecological forcing functions, e.g., dynamic water levels, the impact of common carp, and the activity of muskrats. It is not possible to directly restore or establish hemimarsh; rather, the goal should be to restore the conditions under which a hemimarsh may develop. Specific recommendations on how to proceed with hemimarsh restoration will be dictated by the capacity to lower water levels at each site, i.e., the strategy will vary based on how significantly water levels can be lowered, where they can be lowered, when they can be lowered, and for how long they can be lowered. The initial drawdown will generally be the most critical in determining the course of restoration, in that the area of sediment exposed and allowed to consolidate across the appropriate range of depths will strongly influence where and which species will be able to develop. The ability to effect a significant drawdown is also a critical step in eliminating common carp. The relative success of these actions will in turn directly enhance the probability of attracting and sustaining a muskrat population. That said, we recommend the following in order to establish the conditions under which a resilient and diverse hemimarsh system may develop:

- Hydrology: where necessary and possible, utilize a water-level control structure to adjust water levels for restoration purposes and ongoing management;

- Invasive species: initiate a program to eliminate common reed, reed canary grass, purple loosestrife, hybrid cattail, and any other invasive plants;
- Enhance diversity: plant marsh species during a planned drawdown to establish a biologically diverse shallow and deep marsh, including emergent, floating-leaved, and submersed aquatic vegetation;
- Fish community: when possible and desirable (e.g., when potential conflicts with amphibian breeding is not a consideration), introduce a community of small fish adapted to overwintering in shallower systems;
- Long-term management: develop a strategy and implement steps to sustain and enhance the marsh, utilizing an adaptive approach to long-term management.

Hydrology

Assuming the ability to control water levels, we recommend lowering them in the fall, or early enough to avoid killing amphibians and reptiles after they have begun hibernation—lowering water levels before they have begun hibernation will allow them to find alternative hibernacula. With a fall drawdown, the bottom sediments can be seeded during late fall or early winter with native marsh species. A fall drawdown is also more beneficial for consolidating loose sediments and/or for killing common carp, if present. If possible, water levels should remain low at least through early summer, i.e., long enough for sediments to have dried and consolidated to the maximum extent and for native marsh species to germinate and establish. Water levels can be left low even longer to achieve additional goals, such as invasive management, after which they can gradually be raised at a pace to maintain new marsh vegetation. If water levels cannot be lowered in the fall, they should be lowered early in the spring once water temperatures have begun to rise and daytime air temperatures are in the 40s (ºF) so that hibernating herps are not adversely affected. Once the low-water-level target elevation has been achieved, stratified native seed or plugs can be planted as appropriate, after which water levels can gradually be allowed to rise, just as in a fall drawdown.

A water-level control structure will also give managers much greater flexibility in managing water levels during periods of normal operation (i.e., outside of a drawdown). Under normal operation, stop logs can be used to raise or lower water depths to mimic natural levels of variation associated with wet or dry years, or to assist in managing invasives around the shoreline, such as common reed. Another suggested initial step is simply installing a staff gauge and reading it periodically throughout the growing season. This would not only create a record of how water levels respond to precipitation and other weather phenomenon (extremely important for managing the system adaptively), but also allow water levels to be adjusted quickly and easily as needed through the addition or removal of stop logs. The goal should be to manage water levels dynamically around the average water level, letting them naturally fluctuate both seasonally and inter-annually in response to severe precipitation events, snowmelt, or drought.

The ability to draw down water levels strategically will be critical for stimulating new plant germination and growth when emergent plant densities in the deeper marsh begin to drop lower than desired (as they inevitably will), although this may only occur every 5 to 15 years. Strategic drawdowns to increase the density of emergent vegetation will occasionally be necessary: even where water clarity is good, most deep marsh emergents will not successfully germinate and establish in depths over a foot. Depending on how a control structure is configured, it may not be possible to completely empty a marsh if the invert at the outlet is higher than deepest pool; this means that some water will always remain in the marsh unless it simply dries out.

If water levels in relatively static pools cannot be managed, the options for establishing hemimarsh conditions are limited. For systems without water-level control or where variation in water levels is not possible, then establishing emergent vegetation in depths greater than 8–12 inches becomes less likely. If natural dynamics were sufficient, it is likely that appropriate marsh vegetation and architecture would already have established. It is possible that the lack of emergent vegetation in an otherwise functional marsh is simply due to the deleterious effects of common carp, although eliminating and diverting carp may still require a control structure despite an otherwise appropriate hydrology.

The Plant Community: Managing Invasive Species and Enhancing Diversity

We recommend addressing invasive species as soon as is practical. This process begins with identifying and mapping the invasive threats, then developing a comprehensive, strategic plan to control or eliminate them. The plan will need to specifically address any population of non-native common reed, reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), narrowleaf or hybrid cattail, or other noxious invasive species along the shore through the programmatic application of appropriate herbicides. Common reed is often the largest invasive threat to restoring Calumet shallow marsh communities, while reed canary grass and purple loosestrife generally suppress native species from the margins of the marsh and continuing through wetland habitat above the water line. This will require a multiyear effort to bring these species under control, with ongoing management required to maintain the integrity of the native community.

Once invasive management is underway, steps can then be taken to establish or enhance the diversity of the marsh community with native marsh vegetation, as outlined below. As discussed above, water levels will have to be strategically lowered in order to establish emergent and floating-leaved species away from shore, which will greatly assist in the establishment of shallow-water and submersed species as well. If water levels cannot be drawn down sufficiently to expose all of the bottom sediments, then plants can be started on whatever portion is exposed. Most emergents could be introduced through the planting of seed following a fall drawdown and/or plugs the following growing season before water levels re-establish. Plants can also be planted in the shallower pools that remain, although establishing emergents will be more difficult where sediments remain unconsolidated, even in very shallow water. Water levels should be raised gradually as plants grow and elongate to keep the upper portion of emergent plants above the surface.

Seeding can and should be supplemented with planting plugs of desired emergent species, e.g., hardstem bulrush (*Schoenoplectus acutus*), softstem bulrush (*S. tabernaemontani*), three-square bulrush (*S. pungens*), river bulrush (*Bolboschoenus fluviatilis*), pickerel weed (*Pontedaria cordata*), giant bur-reed (*Sparganium eurycarpum*), or other native species that is part of the local community. Species may be chosen to establish a functional marsh community from those listed in Tables 3 and 4, but other species might also be used, especially when working in areas of higher quality or those with distinct physical conditions, e.g., wetlands with calcareous sandy substrates. Broadleaf cattail (*Typha latifolia*) is often a dominant species in hemimarsh systems and should be considered in marshes where it doesn't threaten other species. Cattails will always remain contentious in that they are structurally the ideal wildlife to support deep marsh species, but do not play well with others—especially near shore and outside of the marsh. Cattails may become aggressive if they establish onshore in wet prairie, sedge or wet meadow communities. The probability of this occurring can be reduced by establishing a matrix of native species able to successfully compete with cattails for available real estate, such as lake sedge (*Carex lacustris*), tussock sedge (*Carex stricta*), or giant bur-reed. For this reason, we recommend establishing broadleaf cattail in the marsh while treating it as an invasive along the shoreline or on land. This is an easier decision to make in systems lacking a high-quality shallow marsh or wet meadow community, but one deserving careful consideration in higher-quality systems. Other marsh species more commonly found in shallower water could also be planted at this time, e.g., sweet flag (*Acorus americanus*), lake sedge, or duck potato (*Sagittaria latifolia*), all of which are capable of supporting shallow marsh wildlife, such as King Rail (*Rallus elegans*).

Once planted, water levels should be held low for enough time to let plants establish or seeds germinate. This period will likely last through early spring or mid-summer but could take as long as an entire growing season. During the drawdown, submersed species capable of providing habitat support for small fish, herps, and waterfowl should also be planted in both the hemimarsh and open water zones. Such species include wild celery (*Vallisneria americana*), sago pondweed (*Stuckenia pectinata*), nodding longleaf (*Potamogeton nodosus*), and white waterlily (*Nymphaea tuberosa*).

Fish Community

The primary action regarding the fish community is to assess whether common carp are present, and subsequently develop a plan to eliminate them if found. Since carp may co-exist with native species, the fish community should also be sampled prior to carp treatment so that native species may be salvaged if possible and practical. Carp exist in most of the Calumet wetlands except where occasional drying has transpired during periods of drought. If carp are discovered, they can be treated with an application of piscicide during the first drawdown, or they may be frozen out if water levels can be maintained sufficiently low over winter following a fall drawdown. Once carp extermination has occurred (if warranted), it should be possible to establish a native fish community if the landowner decides they want fish to become a component of the marsh ecosystem. Although water levels may remain relatively shallow in many of these systems, it is possible to establish a number of small fish species that are adapted to overwintering in shallow waters. It may also be possible to use a water-level control structure to raise water levels in the fall in order to improve overwintering survival with greater depth. Candidate fish species include central mudminnows (*Umbra limi*), starhead topminnows (*Fundulus dispar*), or brown bullheads (*Ameiurus nebulosus*). These fish are all non-game species; game fish would not be appropriate in most of these systems. However, there are potential tradeoffs to consider: while these fish species can play various beneficial roles in the aquatic environment (e.g., by eating mosquito larvae or serving as food for predators such as herons or turtles), their presence could make the marsh less attractive for breeding amphibians, especially salamanders. If the decision to introduce fish is made, then partners such as the Illinois Department of Natural Resources Fisheries biologists can be engaged to introduce appropriate species.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management, a responsibility of the landowner. Some of these sites already have staff dedicated to overseeing the area surrounding these wetland habitats, although generally little effort is dedicated to the marsh. To improve outcomes, these wetlands will have to be adaptively managed, although the level of effort need not be extraordinary and may be little more than the site already receives. Moving forward, actions that could be incorporated into a relatively modest strategy to improve long-term outcomes in the marsh include:

- Installation of a staff gauge and periodic monitoring of water levels,
- Maintaining the water level control structure if applicable,
- Enhancing diversity with the installation of submersed and floating-leaved species,
- Monitoring emergent cover at least once annually,
- Monitoring the plant community and especially the establishment of marsh invasives,
- Proactively managing invasive plant species.

A record of water levels, even if only taken once every 4–6 weeks, allows managers to better understand the marshes' hydrology and respond accordingly if it requires adjustment. It is important to recognize that even though natural systems do not require adjusting, most of these systems no longer function naturally and may benefit a great deal from lightly management to achieve positive outcomes. Where appropriate, this also means that water-level control structures (if present) must be maintained. Water-level monitoring can also be coupled with assessing emergent plant cover, a measure that need only be examined once or twice annually. Quantitative assessments of the marsh are not required for this purpose; a qualitative assessment of cover is generally sufficient to assess marsh condition. Although accurately estimating emergent cover from shore is difficult, it important to determine if it is thinning to the point where deep marsh is no longer functioning as hemimarsh, i.e., if the open water fraction of hemimarsh is expanding beyond 60% cover, a condition that could warrant a drawdown to stimulate the re-establishment of more emergent plants. This assessment may be executed by boat or wading, or by simply examining aerial imagery from a drone flight or publicly available satellite imagery (e.g., Google Earth).

It it clear that invasive species need to be managed in any system restored to provide natural functions. Yet history tells us that monitoring the restored plant community—an action necessary to know what, when, and where to manage invasives—is often overlooked or given insufficient attention. Even a once-annual effort should reveal developing invasive threats before they become insurmountable. Monitoring common reed and other marsh invasives is critical, especially in the period immediately following active restoration. Monitoring cattails along and above shorelines should also be prioritized, especially in regard to which species occur and where they grow. Hybrid and narrowleaf cattails should always be suppressed (unless growing in a wetland with no other options), especially in the shallow marsh and near shore meadows. However, broadleaf cattails, especially in deeper water, can be an significant component of the marsh community.

Finally, we must recognize that although the Calumet wetlands all share many features, each system has unique characteristics that will dictate differences in the approach taken to restore marsh wetland functions. All of them have been partially filled to some extent; some have been excavated or mined. Some evince a shallow transition zone from shore to the limits of emergent vegetation, while others drop precipitously at the shore's edge due to the patterns of fill, including to depths that preclude the establishment of any emergent vegetation. The extent, depth, and location of fill make some of these wetlands extremely poor candidates for restoration. Some of the systems are still connected to the broader hydrologic landscape (including to Lake Michigan), while others have been severed from the surrounding hydrology except through local precipitation and runoff. Many of the Calumet wetlands no longer support any native vegetation, while others may include remnants that should be protected and enhanced. Consequently, the plant communities to be established will vary from system to system, e.g., cattails will be a desirable matrix species providing high-quality wildlife habitat benefits in some of the more degraded wetlands, but may be viewed with suspicion in systems with a remnant marsh or wet meadow. Each landowner will have to develop an approach that works for their wetland while meeting the potentially conflicting demands of each landowner's mandate or mission, financial capacity, and ability to manage natural habitats. Our goal was to develop a conservation action plan for those Calumet wetlands with the greatest restoration potential, and our hope going forward is for the following analyses to provide both a rationale and strategic plan for the 14 wetlands with significant hemimarsh restoration potential.

Marsh Birds

Marsh birds serve as a primary indicator of wetland quality and their charismatic nature also promotes great public interest, which serves to raise the profile of this large collaboration. The 16 species profiled below represent a suite of species threatened by the loss and degradation of wetlands and, in particular, hemimarsh in Calumet. The first three species, Pied-billed Grebe, Least Bittern, and Common Gallinule, were selected as the primary focal species for this action plan and form the basis of this goal setting. They regularly occur in the region, are in the core of their breeding ranges, and respond to improved habitat conditions. Conservation planners use terms such as 'focal' or 'surrogate' when developing lists of representative management umbrellas and management-indicator species.

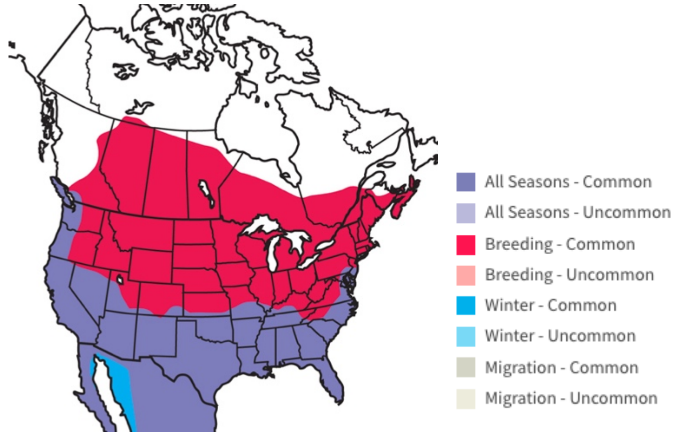
The umbrella concept assumes the presence of a particular species in a geographic area and indicates other species will also be present. Conservation of this focal species is believed to benefit a guild or suite of species (Zacharias & Roff, 2001). Similarly, 'management indicators' are any species or group of species selected to focus conservation for resource production, population recovery, or ecosystem diversity (Caro, 2010). Changes in populations of management indicator species are believed to reflect the effects of conservation activities and common environmental influences on other species within a guild (see USFWS, 2014a). Use of U.S. Fish and Wildife Service Joint Venture focal species was highlighted for the breeding period, where a reduced number of models simplified development of habitat objectives.

Table 5

Marshes	Potential Hemimarsh	Pied-billed Grebe pair potential	Least Bittern pair potential	Common Gallinule pair potential
135th St. Marsh	2.5	1	2	1
Big Marsh	24.0	14	3	5
Burnham Prairie	11.2	5	2	4
Calumet 'Square Marsh'	25.0	20	3	6
Dead Stick Pond	13.3	3	1	2
Eggers Marsh	11.6	4	2	3
Hegewisch Marsh	20.4	5	2	4
Indian Ridge North	7.4	8	1	4
Indian Ridge South	15.4	4	1	2
Marian Byrnes	1.5	0	1	1
Powderhorn	44.0	7	4	4
Whitford Marsh Wetlands	3.3	3	1	2
Whitford Pond	10.6	2	1	2
Wolf Lake IL MU9	3.6	1	1	1
Conservation Priority Sites	193.8	76	23	40
126th Street Marsh	0.0			
Calumet Conservation Area	0.0			
Heron Pond	0.0	1	1	1
Hyde Lake Marsh	0.0			
Sand Ridge	0.9			
Wolf Lake IL Pool 3	0.0			
Wolf Lake IL Pool 5	0.0	1	1	1
Lower-Priority Sites	0.9	3	4	3
All Sites combined	194.7	79	27	43

Pair Potential Among Calumet Wetlands for Primary Focal Species

PIED-BILLED GREBE (Podilymbus podiceps)



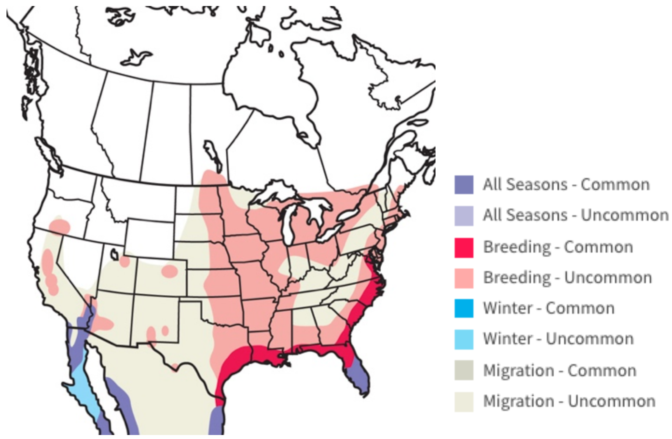
Habitat: All-purpose territory usually associated with dense stands of emergent vegetation or aquatic vegetation close to surface for nest construction and anchorage, and nearby open water, which may be intersecting channels, for foraging. Nest is a floating platform, most often placed among tall emergent vegetation, although may be among low vegetation or out in open, usually anchored to vegetation.

Historical Calumet population status: Historically a common, widespread breeding species in the Calumet region of Illinois and Indiana.

Current Calumet population status: Declining (absent in many wetlands), but still has a limited presence as a breeding species. Territorial birds were detected at 6 of 18 Illinois Calumet wetlands and 3 of 10 Indiana Calumet wetlands surveyed in 2016. Illinois observations in 2016 included at least 4 territories and up to 5 broods at Hegewisch Marsh. Declines are likely related to overall lack of hemimarsh habitat, rampant infestations of invasive exotics (most notably common reed and common carp), overall lack of vegetative diversity, and vexing hydrological problems.

Pied-billed Grebe Conservation Goals	
2016 Breeding Pair	10
2027 Breeding Pair Target	70

LEAST BITTERN (Ixobrychus exilis)



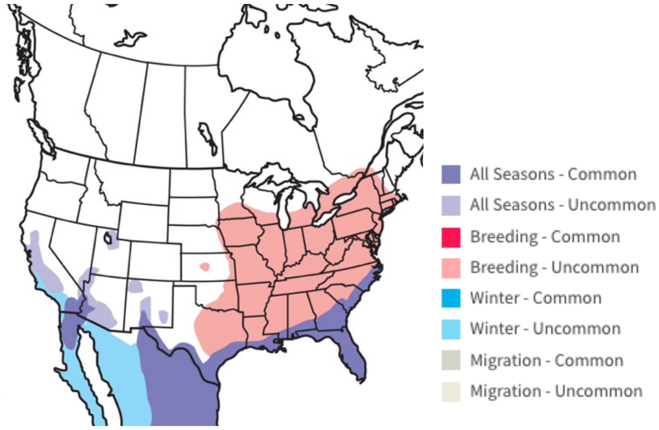
Habitat: Nests in freshwater and brackish marshes with dense, tall growths of aquatic or semiaquatic vegetation, typically cattail, sedge, and bulrush, occasionally reed, arrowhead, willow, or buttonbush. Most abundant in freshwater marshes during years when ratios of emergent vegetative cover to open water are equal (the hemimarsh condition). Several authors have noted a strong association with cattail in northern regions, but this strong association may occur only because cattail is the most common tall plant there, growing in dense stands above deep water.

Historical Calumet population status: Historically a widespread breeding species in the Calumet region of Illinois and Indiana.

Current Calumet population status: Declining, but still has a very limited presence as a breeding species. Territorial birds were detected at 3 of 18 Illinois Calumet wetlands and 1 of 10 Indiana Calumet wetlands surveyed in 2016. Like other marsh birds, recent declines are likely related to overall lack of hemimarsh habitat, rampant infestations of invasive exotics (most notably common reed and common carp), overall lack of vegetative diversity, and vexing hydrological problems.

Least Bittern Conservation Goals	
2016 Breeding Pair	**4**
2027 Breeding Pair Target	**20**

COMMON GALLINULE (*Gallinula galeata*)



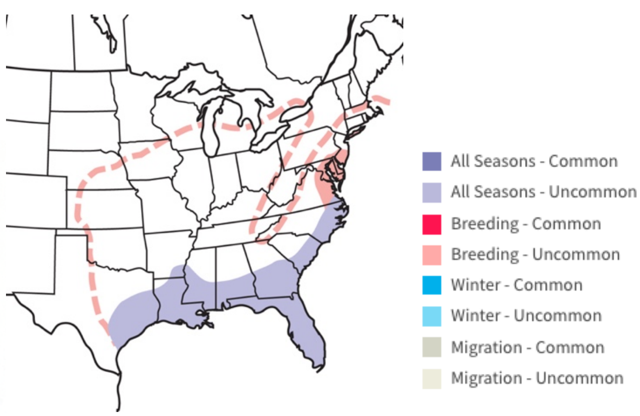
Habitat: Found in northern portions of U.S. range, breeds principally in permanently flooded, nontidal, deep marshes and slightly brackish or freshwater tidal marshes where robust emergent grasslike plants about 1–4 m tall are interspersed with pools and channels containing floating-leaved and submerged plants, or with mudflats. Outside the Deep South, commonly associated with cattail-dominated marshes.

Historical Calumet population status: Historically a common, widespread breeding species in the Calumet region of Illinois and Indiana.

Common Gallinule Conservation Goals	
2016 Breeding Pair	2
2027 Breeding Pair Target	40

Current Calumet population status: Steep, severe declines as a breeding species in the Illinois Calumet region occurred during the first two decades of the 21st century, and in the Indiana Calumet region after the late 1980s. Territorial birds were not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016, but one pair nested at Hegewisch Marsh, Chicago following the survey period. Like other marsh birds, declines are likely related to overall lack of existing hemimarsh habitat, infestations of invasive exotics, lack of vegetative diversity, and persistent hydrological problems.

KING RAIL (Rallus elegans)

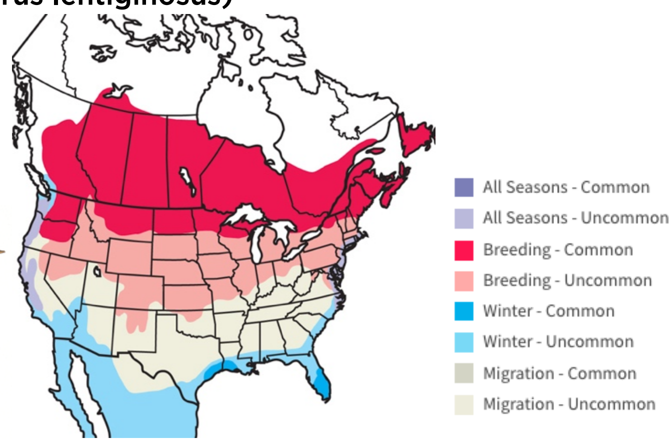


Habitat: The King Rail feeds largely on crustaceans and aquatic insects in a variety of water bodies, including shallow flooded emergent vegetation, temporary ponds, creeks, and along the edge of ditches, lakes, and mudflats. Habitat selection of particular wetland vegetation species may correspond with precipitation and flooding in a particular year or over several years. Nest may be placed in a clump of grass, among thick vegetation, or between several grass clumps or a sedge tussock; sides of clumps are often used in fashioning the canopy.

Historical Calumet population status: Formerly considered a common summer resident in the Chicago region, but has become a rare, local breeding species in the 21st century.

Current Calumet population status: King Rail populations have declined alarmingly in the past 50 years, with the species now listed as a threatened or endangered species in 12 eastern and midwestern states, as well as in Canada. These population declines likely stem at least in part from the direct loss of wetlands. Current Calumet area status unclear; they were not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016, nor among any other known 2016 Calumet area reports.

AMERICAN BITTERN (Botaurus lentiginosus)

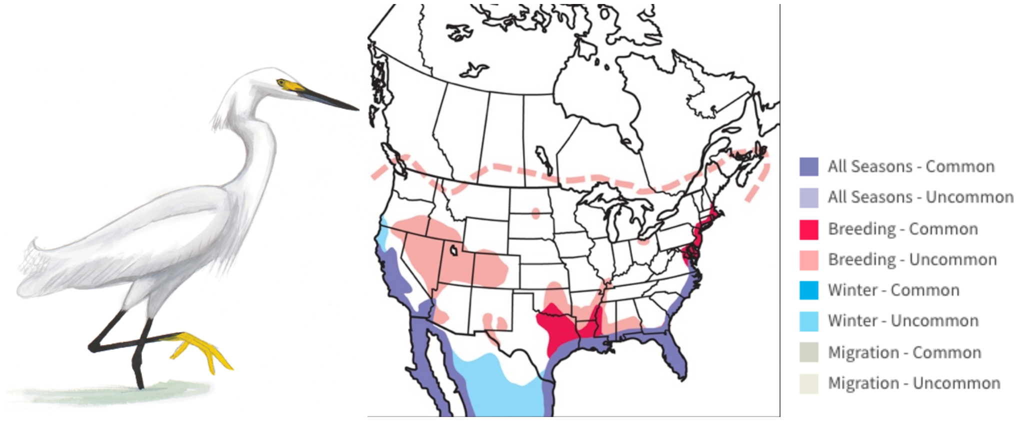


Habitat: Breeds almost exclusively in freshwater wetlands with tall, emergent vegetation. Dependence on inland, freshwater marshlands suggests that this species may be a relict over much of the U.S. Nest consists of a platform of reeds, sedges, cattail, or other available emergent vegetation. Nests often over water in standing cattails, bulrushes and sedges, less often on dry ground in grassland fields.

Historical Calumet population status: Formerly considered to be a common summer resident in the Chicago region, but in the 21st century is present only rarely and locally during the breeding season. Undergoing substantial declines over much of the U.S. owing largely to loss and degradation of wetland habitats.

Current Calumet population status: No recent confirmed breeding evidence in the Illinois Calumet region. A few scattered, sporadic summer records in Northwest Indiana in recent years. During the early 21st century in the Indiana Calumet region, the American Bittern has been considered a spring and fall transient that formerly nested.

SNOWY EGRET (*Egretta thula*)

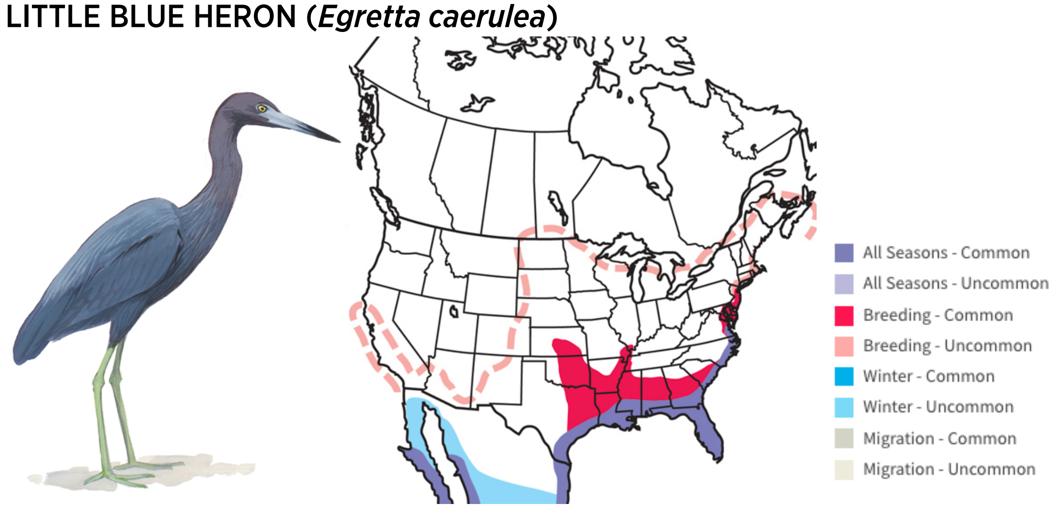


Habitat: Preferred foraging habitats/conditions range from small salt-marsh pools to large freshwater marshes, and from solitary to mixed-species aggregations. Typically nests colonially, often with other heron species.

Historical Calumet population status: Not known to breed in the Calumet region of Illinois and Indiana. Population has increased significantly after laws were enacted in the early 20th century to protect the species from exploitation by the millinery trade, but by the mid-20th century this species was still considered accidental in the Chicago region. In recent decades it has occurred sparingly as a spring and summer visitant (including post-breeding dispersals), occasionally remaining into the month of October.

Current Calumet population status: Still occurs sparingly as a spring and summer visitant (including post-breeding dispersals). Reported somewhat more during the early 21st century in Northwest Indiana (probably reflecting habitat improvements), but fewer records in the Illinois Calumet region (probably reflecting habitat degradation).

LITTLE BLUE HERON (*Egretta caerulea*)

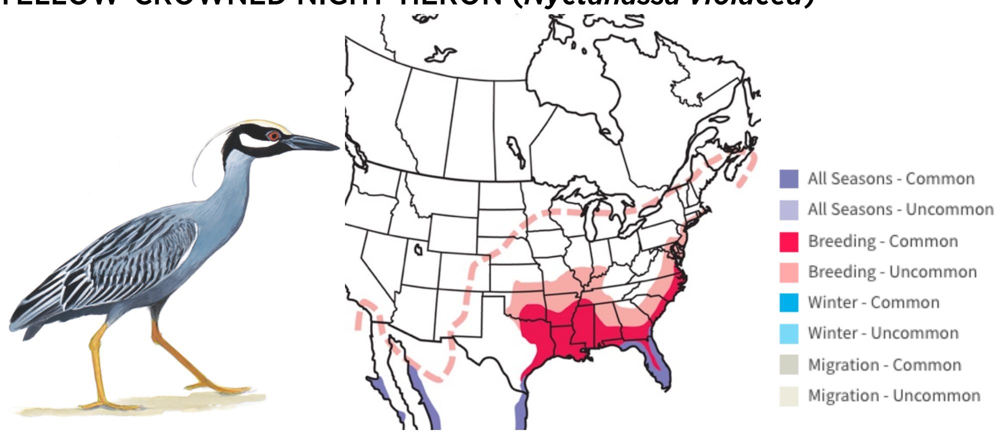


Habitat: Nests in mixed-species assemblages of colonial waterbirds using varied colony habitat and nesting substrate. Feeds in a variety of freshwater and marine-estuarine habitats, including marshes, swamps, streams and rivers, ponds, lakes, impoundments, lagoons, tidal flats and wetlands, canals, ditches, fish-rearing facilities, and flooded agricultural fields. Nests mostly in shrubs and small trees in standing water or upland sites on islands.

Historical Calumet population status: Historically has occurred primarily as a spring and summer visitant (including post-breeding dispersals), sometimes remaining into the month of September, but has been known to breed in the Illinois Calumet region in recent decades: first confirmed breeding record in northeastern Illinois at Indian Ridge Marsh North in 1999. One to two active nests observed at that location or Heron Pond through 2005 and again in 2009, with nest building noted in 2006–2008; no nests observed after 2009. Frequency of Calumet area occurrence apparently reflects regionwide population trends.

Current Calumet population status: Not detected in any of the 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016, but an adult was observed at Indian Ridge Marsh North, Chicago on 4–5 June 2016, and an immature bird was photographed at Big Marsh, Chicago on 6 August 2016. Paucity of recent Calumet records likely reflects regionwide population declines.

YELLOW-CROWNED NIGHT-HERON (*Nyctanassa violacea*)



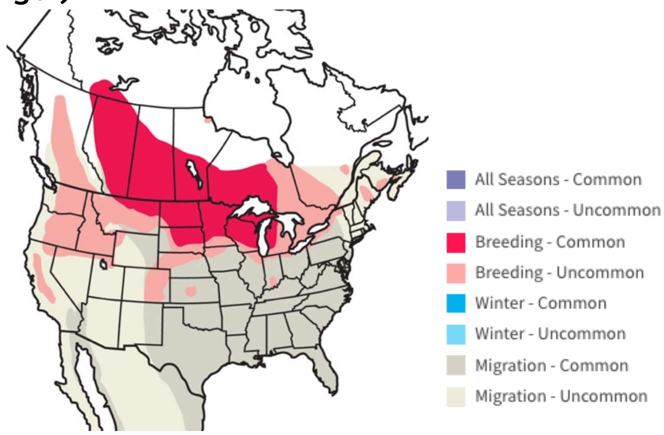
Habitat: This species most often inhabits forested wetlands, swamps, and bayous. Scattered pairs and small colonies are typical, particularly inland. Foraging areas are nearly always associated with high concentrations of crustaceans. Nest built 1–50 ft. (0.3–15.2 m) from ground or water in a variety of trees and shrubs.

Historical Calumet population status: During the mid-20th century, this species was still considered a casual visitor to the Chicago region, but frequency of occurrence has clearly increased since then. Nested regularly at Powderhorn Lake Forest Preserve, Illinois from 1989–1994. An attempted nesting in a Munster, Indiana woodlot occurred in May 1976; however, by 2 June the eggs were destroyed, and the nests abandoned.

Current Calumet population status: Current Calumet area status unclear: not detected in any of the 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016, but perhaps still occurs as an occasional breeding species in very small numbers in the Illinois Calumet region. By 2010, the

Yellow-crowned Night-Heron was considered a visitant to the Indiana Dunes area. Observational data suggests that Indiana's Yellow-crowned Night-Heron population is in decline.

BLACK TERN (Chlidonias niger)

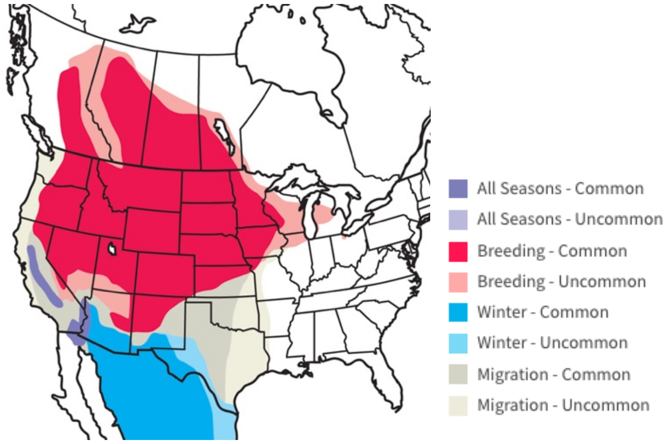


Habitat: During the breeding season, prefers marshes or marsh complexes of 20+ ha; smallest reported is 5.3 ha. Habitat suitability appears to be determined more by landscape structure at a larger scale (wetland complex) than local vegetation conditions within wetlands, and Black Terns selectively choose wetlands located in high-density wetland landscapes. Main clusters of nests are in areas of still water, usually with 25–75% of surface covered with emergent vegetation. Nests semicolonially amidst emergent vegetation in biologically rich fresh-water wetlands. Nests are flimsy, often floating, and are easily destroyed by wind or changing water levels. Nest is usually built on floating substrate of matted dead marsh vegetation, detached root masses of predominant vegetation, boards, or muskrat-built feeding platforms of fresh-cut vegetation; less often (but in majority at some sites) on nonfloating substrates such as muskrat lodges, small mud patches, rooted but flattened vegetation, or abandoned nests of other marsh birds.

Historical Calumet population status: Historically a widespread breeding species in the Calumet region of Illinois and Indiana, and formerly considered a common summer resident. In the Indiana Calumet region, the status of Black Tern has changed drastically over the decades. In former years, Black Terns commonly nested in marshes and sloughs of the lacustrine plains, but in 1997 Indiana's last-known nesting occurred at Horseshoe Lake in northern LaPorte County, where two eggs were seen on 6 June. Small numbers are still known to breed in northeastern Illinois, but the Black Tern is no longer among Indiana's nesting avifauna.

Current Calumet population status: Populations of this tern in North America and Europe have declined markedly, at least since the 1960s. Not detected in any of the 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016. No longer known to breed in the Illinois Calumet region, and no longer occurs as a breeding species anywhere in Indiana. Loss of wetlands on breeding grounds and migration routes is likely a major cause of these declines, but food supplies may have been reduced through agricultural control of insects and overfishing in the marine winter range.

YELLOW-HEADED BLACKBIRD (Xanthocephalus xanthocephalus)

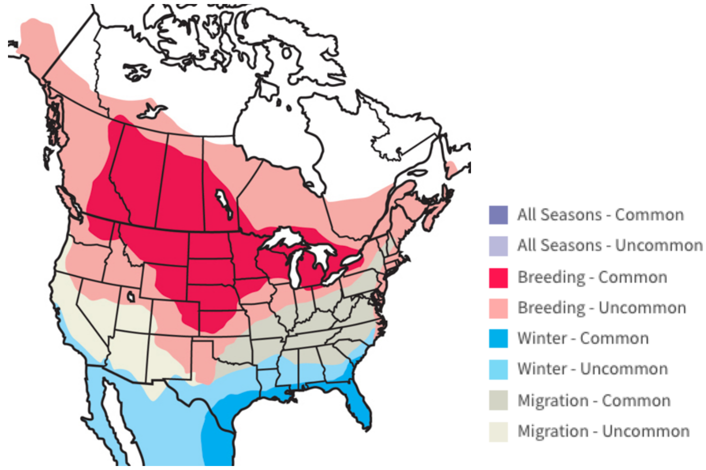


Habitat: Breeds in emergent vegetation of deep-water palustrine wetlands. Nests constructed over deeper water, primarily in cattails, bulrushes, or reeds. The average area within a territory covered by emergent vegetation ranges from 35–77%. Forages within wetlands and surrounding grasslands, croplands, or savanna. Nests located only over water, fixed to dead emergent vegetation from the previous year or to robust growing vegetation.

Historical Calumet population status: Considered a fairly common summer resident in the Chicago region during the mid-20th century, but by 1984 considered to be very local in the Chicago region. Formerly nested in marshes throughout the Illinois Calumet region; an example of late 20th-century breeding records includes 33+ pairs that raised 46 young in the Lake Calumet area in 1982. The last territorial male reported in the Illinois Calumet was at Eggers Grove Forest Preserve in 2013. Historically less widespread in the Indiana Calumet region.

Current Calumet population status: Not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016. No longer known to breed in the Illinois Calumet region; the decline of this species in the Illinois Calumet is likely related to overall lack of hemimarsh habitat, rampant infestations of invasive exotics (most notably common reed and common carp), and widely fluctuating water levels. After a long absence from Northwest Indiana, small numbers of Yellow-headed Blackbirds nested at Grant Street Marsh in Gary, Indiana in 2013, 2014, and 2015. One adult male also summered at Grant Street in 2016. The return of the Yellow-headed Blackbird to the breeding avifauna of Northwest Indiana undoubtedly reflects recent habitat improvements at Grant Street Marsh.

BLUE-WINGED TEAL (*Anas discors*)

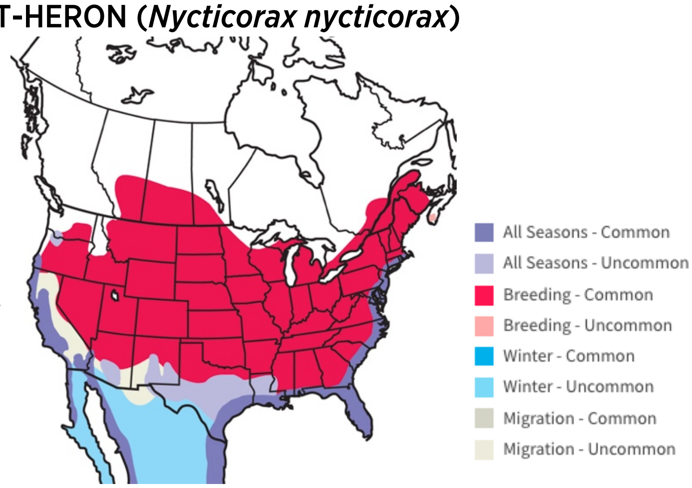


Habitat: During the breeding season, found in shallow ponds with abundant invertebrates, which predominate in diets of both sexes in the breeding season. Breeding numbers positively related to density and diversity of benthic invertebrates. Highest pair densities occur under hemimarsh (50% water and 50% cover) conditions. Prefers to nest in grass or herbaceous vegetation. Nests almost always in upland habitats with residual cover from prior year's growth. Nests located 30 cm above nearest water level, so typically not highly susceptible to flooding.

Historical Calumet population status: Historically considered to be a common migrant and fairly common summer resident in the Chicago region.

Current Calumet population status: Still occurs commonly as a migrant; likely decreasing as a breeding species, but data insufficient. Very scarce during the breeding season at most wetland sites, but remains widespread in well-maintained habitat areas at the DuPont Tract in East Chicago, Indiana, where several pairs summer annually. Breeding was confirmed in 2014, 2015, and 2016.

BLACK-CROWNED NIGHT-HERON (*Nycticorax nycticorax*)

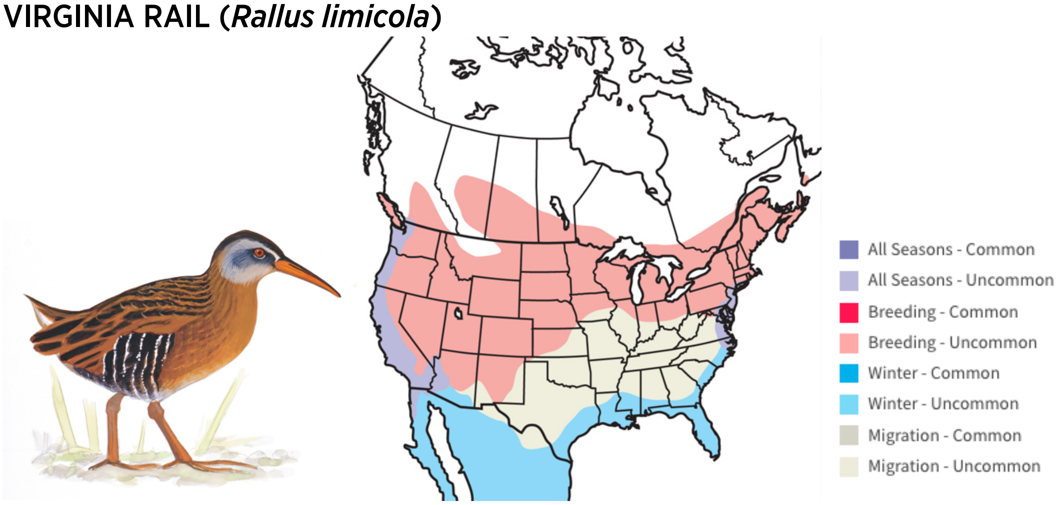


Habitat: Breeds in a wide variety of habitats near fresh, brackish, or salt water; in trees, shrubs, groves, forests, thickets, even city parks; and in marshes among *Phragmites* reeds, cattails, grass tussocks, and *Scirpus validus*. Most adaptable of all herons. Nests are located in small-to-large colonies, close together, usually adjacent to nests of other heron species. Site from ground to 160 ft. (48.8 m) in trees, shrubs, cattails, *Phragmites*.

Historical Calumet population status: Formerly considered a common summer resident in the Chicago region. Nested in large numbers (maximum count: 762 nests in 1988) in common reed (*Phragmites australis*) at Big Marsh in the Illinois Calumet region from 1984–1998; smaller numbers subsequently nested at Indian Ridge Marsh and Heron Pond in the Illinois Calumet region, with nesting behavior last noted 2011. Following the abandonment of the Kaiser Refractory colony in 1981, no nesting was detected anywhere in Indiana until 1993, when a new colony (101 nests) was discovered at the Mittal Steel (formerly LTV Steel) plant on the East Chicago lakefront. 255 nests (163 in trees, 92 on ground) were reported at that site in 2007, and 233 nests (70 in trees, 163 on ground) were reported in 2011.

Current Calumet population status: Still observed in small numbers as a visitant in the Illinois Calumet region, but no breeding behavior has been detected there since 2011. In the Illinois Calumet region the decline of reed-nesting populations is most likely linked to unsuitable water levels. Observational data suggest that this species has declined in Indiana. The Mittal Steel colony in East Chicago, Indiana has declined consistently since 2011, with only 64 nests observed there in 2016.

VIRGINIA RAIL (*Rallus limicola*)

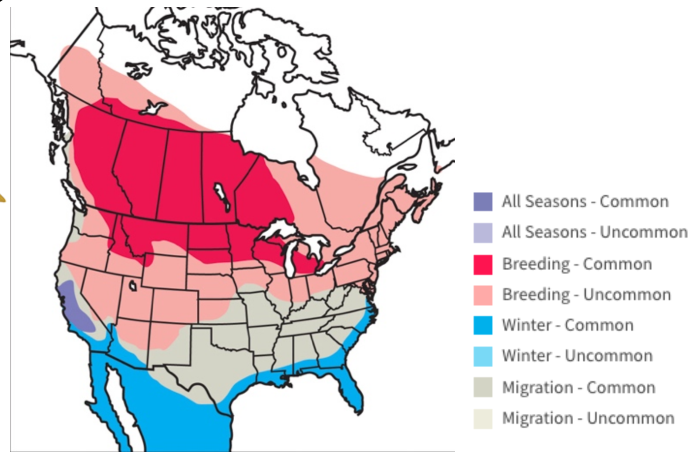


Habitat: Shallow water, emergent cover, and substrate with high invertebrate abundance are thought to be the most important features of Virginia Rail habitat. Needs standing water, moist soil, or mudflats for foraging; avoids dry stands of emergents. Most common in wetlands with 40–70% upright emergent vegetation interspersed with open water, mudflats, and/or matted vegetation. Nests in robust emergent vegetation (e.g., cattails, bulrush). Will nest within a wide variety of emergents, so the dominant plant species in a marsh is not considered a good indication of habitat suitability.

Historical Calumet population status: Historically a widespread breeding species in the Calumet region of Illinois and Indiana.

Current Calumet population status: Secretive and probably declining, but still has a limited presence as a breeding species. Territorial birds were detected at 3 of 18 Illinois Calumet wetlands and 3 of 10 Indiana Calumet wetlands surveyed in 2016, including a copulating pair of adults at Wolf Lake Pool 6.

SORA (Porzana carolina)

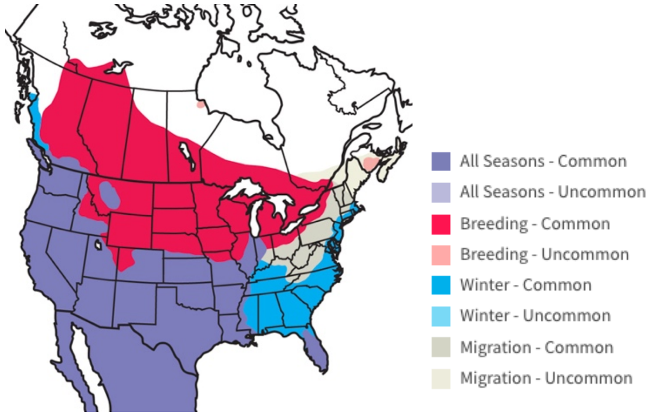


Habitat: Breeding range habitat is primarily freshwater wetlands with shallow and intermediate water depths dominated by robust or fine-leaved emergent vegetation, especially cattails, sedges, bur-reeds and bulrushes. Highest breeding densities are in relatively shallow, shoreward portions of wetlands where water level instability produces diverse mosaics of fine and robust emergent vegetation. This habitat preference may be related to increased prevalence of seeds of wetland plants, especially sedges, which are important foods during the breeding season. Nest site is usually in robust or fine-leaved emergent vegetation with shallow (18–22 cm) water.

Historical Calumet population status: Historically a widespread breeding species in the Calumet region of Illinois and Indiana.

Current Calumet population status: Still occurs as a breeding species, but status uncertain due to secretive nature. Breeding populations likely declining, but data insufficient. Territorial birds were detected at 2 of 18 Illinois Calumet wetlands and 2 of 10 Indiana Calumet wetlands surveyed in 2016. Illinois observations in 2016 included a brood of 4 downy young at Indian Ridge Marsh South (Nat Miller, personal communication). Indiana observations in 2016 included 10 territorial birds and 1 brood (1 downy young) at the DuPont Tract in East Chicago (Walter Marcisz, personal communication). Regarded as the most common rail in the Indiana Dunes area (Brock, 2010) and the most common rail in Indiana (Brock, 2006).

AMERICAN COOT (*Fulica americana*)

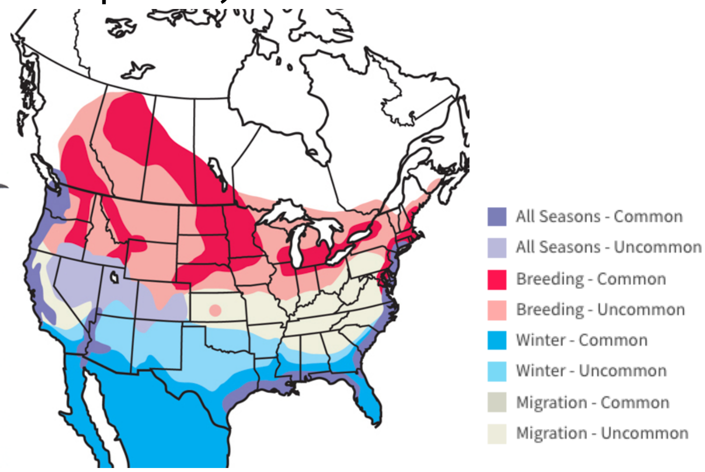


Habitat: Nests in emergent vegetation in various bodies of water including lakes, ponds, canals, sloughs, sewage ponds, slower-moving rivers, and swamps with some open water. Maximum breeding densities attained in semi-permanent wetlands that are well-flooded and maximize interspersion of open water and emergent vegetation. Cattails and bulrush are by far the most common forms of emergent macrophytes in coot breeding habitat throughout North America. Nests are built over water on floating platforms in dense stands of emergent vegetation.

Historical Calumet population status: Historically a widespread breeding species, abundant migrant, and occasional winter resident in the Calumet region of Illinois and Indiana. Notable late 20th-century Illinois Calumet breeding records include a remarkable 32 nests at Hegewisch Marsh in 1982.

Current Calumet population status: Still occurs as a common-to-abundant migrant and winters in smaller numbers on ice-free lakes and rivers but has declined precipitously as a breeding species. Territorial birds were detected at 2 of 18 Illinois Calumet wetlands and 1 of 10 Indiana Calumet wetlands surveyed in 2016. Two broods discovered at Hegewisch Marsh in 2016 were the first confirmed breeding evidence in the Illinois Calumet region since 2009. Recent declines are likely related to overall lack of hemimarsh habitat, rampant infestations of invasive exotics (most notably common reed and common carp), overall lack of vegetative diversity, and vexing hydrological problems.

MARSH WREN (Cistothorus palustris)



Habitat: Breeds in a diversity of marshland habitats throughout North America. Marsh Wrens use a diversity of vegetation to support their nests. Males build numerous nests, and a prospective mate typically inspects those nests while being escorted by the resident male. She often accepts one of his nests, lining it with soft materials before laying eggs. Alternatively, she can initiate a new nest, which is believed to be the more common practice in some locations.

Historical Calumet population status: Historically a widespread breeding species in the Calumet region of Illinois and Indiana. Many well-documented late 20th-century and early 21st-century breeding records. Notable late 20th-century Illinois Calumet breeding records include 24 nests at Van Vlissingen Prairie and 18 nests at Hegewisch Marsh in 1982.

Current Calumet population status: Still occurs as a widespread breeding species in the Calumet region of Illinois and Indiana. Territorial birds were detected at 12 of 18 Illinois Calumet wetlands and 4 of 10 Indiana Calumet wetlands surveyed in 2016. Found at most sites where cattails grow in abundance. This species appears to be far less dependent on hemimarsh conditions than most other marsh-nesting species, and more willing to accept closed emergent marshes as a viable nesting habitat.

Individual Marsh Site Descriptions

Conservation Priority Sites

135th St. Marsh

Summary

The 135th St. Marsh is part of a 28-acre parcel owned and managed by the Forest Preserves of Cook County (FPCC) on Chicago's South Side since 2014. A little over seven acres of the site can be characterized as marsh habitat, almost equally divided among shallow marsh, deep marsh, and open water habitats. The marsh is currently dominated by non-native invasive species, although native species can still be found, especially within and at the edge of the open water zone. Hydrologically, the site is cut off from the broader landscape by roads, rail lines, and residential development. The existing deep marsh habitat already has hemimarsh characteristics, although they are not well developed. This is most likely because it appears there are few muskrats onsite to initiate or maintain hemimarsh architecture. We strongly recommend that if resources permit, an aggressive program of invasives management be initiated to improve the quality of the 7.2-acre marsh system found on the site for the benefit of all wetland dependent-species currently onsite (or potentially colonizing in the future).

Site Description

The 135th St. Marsh is 7.2-acre body of shallow water located just north of Powderhorn Lake and Marsh. The marsh is part of a 28-acre parcel owned and managed by the Forest Preserves of Cook County (FPCC) that is bounded to the north by E. 134th Street, to the west by private land owned by a mobile home park, to the south by the Norfolk Southern Railroad, and to the west by private land along S. Ave. K (Figure 1). The 135th St. Marsh was formerly part of an extensive deep marsh system located at the south end of Wolf Lake. The wetland area was originally cut off from the rest of the marsh and lake after construction of an east-to-west causeway to the south that connected rail yards on either side of the marsh (Figure 2). Eventually, most of the marsh north of the rail lines was also filled in for residential use, leaving about a quarter of the former wetland intact, albeit degraded from the deposit of slag, construction debris, and extensive fly dumping in later years.

Figure 1. The Forest Preserves of Cook County's 7.2-acre 135th Street Marsh, with the marsh footprint outlined in yellow. The site is located just north of Powderhorn Marsh and Lake, and is separated from it by a spur of the Norfolk Southern Railroad and a dirt road running along the north side of the rail line. Digital imagery courtesy of Cook County, 2013.

Figure 2. 1939 aerial image (Illinois State Geological Survey, 1939) of the marsh system surrounding the southwest end of Wolf Lake (upper right quadrant of image), with the future 135th Street Marsh area outlined in yellow.

Hydrology

Hydrologically, the 135th Street Marsh was once part of the vast system of deep marshes surrounding Wolf Lake (Figure 2). The marsh has since been isolated and cut off hydrologically from the broader landscape, with inputs now coming from precipitation and local runoff. In 1953, the marsh was still connected to Wolf Lake through a channel running north from E. 134th St. (Figure 3). The portion of the channel running north from E. 133rd still remains, as does a large culvert connecting the channel to the south under E. 133rd Street, suggesting there may still be an underground connection between the channel and the 135th Street Marsh. However, that section of the channel north of E. 133rd Street appears to have been subsequently cut off from the lake by another expansion of the mobile home park, which effectively isolated the 135th Street Marsh from any connection with Wolf Lake. If the connection is in fact no longer active, the marsh is solely connected to Wolf Lake through groundwater, resulting in a much more dynamic response in water levels to inter-annual variation between wet and dry years. This also signifies there is no effective way to manage water levels in the marsh.

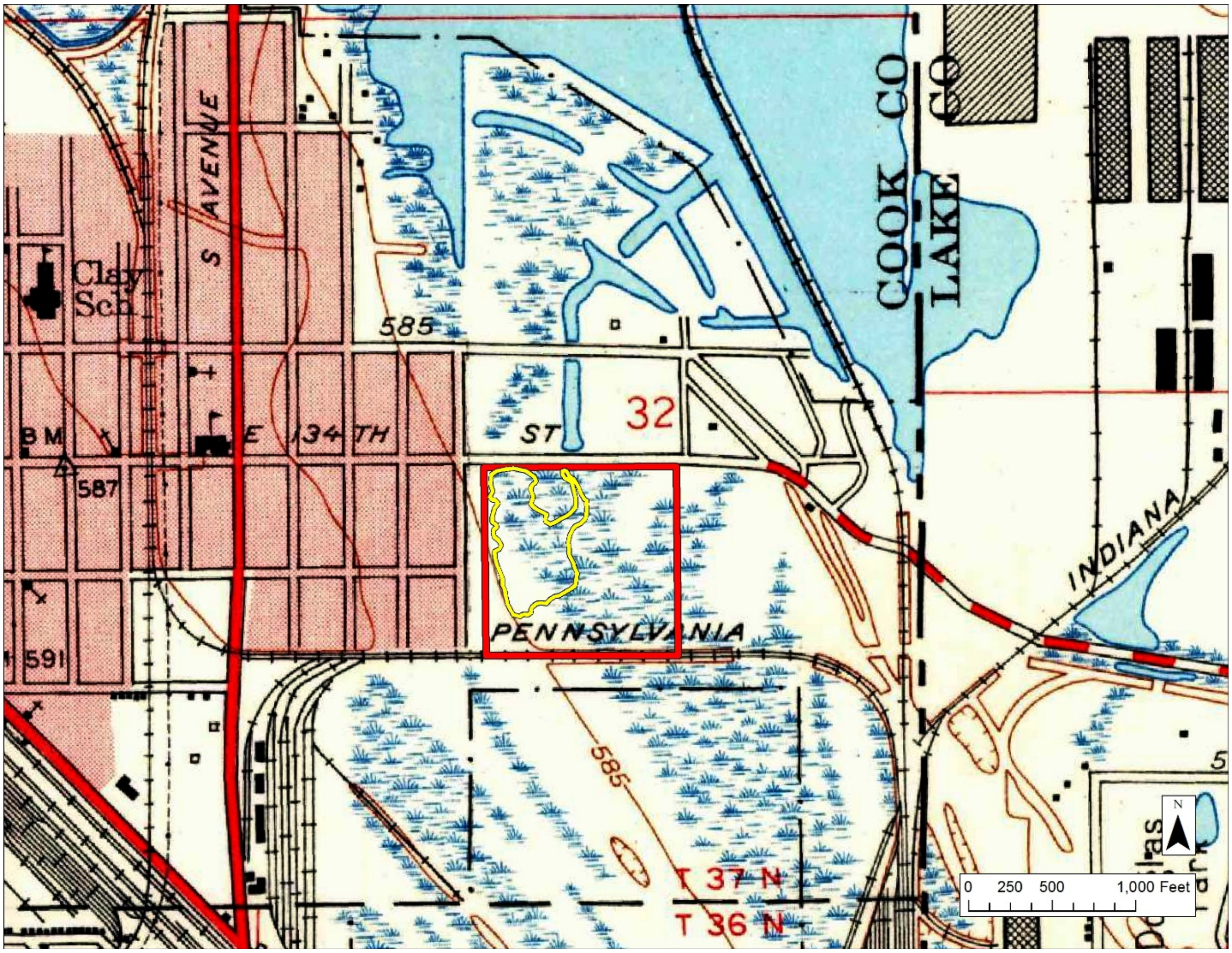


Figure 3. 1953 USGS map of the marsh system surrounding the southwest end of Wolf Lake, with the future 135th Street Marsh outlined in red. Note the channel draining the marsh to the north into Wolf Lake through E. 134th and E. 133rd Streets.

Bathymetry

We were unable to discover any information or data in regard to the bathymetry at the 135th Street Marsh, although the distribution of emergent vegetation and open water suggests that most of area is relatively shallow, with an area of open water indicating greater depths (Figure 4).

Current Habitat and Invasive Species

Much of the 135th Street Marsh wetlands are dominated by invasive common reed (*Phragmites australis*) and cattails (*Typha* species), with scattered patches of native species tucked in around the shoreline. The deeper open water is colonized with white waterlily (*Nymphaea* species) and at least one unidentified submersed species. The deeper portion of the marsh has some hemimarsh characteristics, although they are not well developed. A few muskrats have colonized the emergent marsh over the past 20 years, but neither in large numbers nor consistently from year to year (based on visual inspection of the presence of muskrat dens or feeding platforms). Based on the presence of marsh vegetation and what appears to be relatively clear water—i.e., free from a heavy suspended sediment load—it is likely that common carp are not in the system.

Figure 4. The current distribution of the 7.2-acre wetland habitat at 135th Street Marsh, with 2.5 acres of shallow marsh in yellow, 2.5 acres of hemimarsh in green, and 2.2 acres of open water in blue. Digital imagery courtesy of Cook County, 2013.

Hemimarsh Restoration Potential

There appears to be little potential at the 135th Street Marsh to create more deep marsh habitat exhibiting hemimarsh characteristics. This is primarily due to the lack of any plans at this time to actively implement any type of water level control at the marsh. Regardless, much of the marsh already functions as deep marsh habitat, albeit without strong hemimarsh characteristics. Absent water level control, the potential to expand the marsh footprint further will be limited by depth, although the emergent footprint does vary annually through normal expansion and contraction dynamics occurring in response to natural variation in water levels and animal activity. Most of the expansion occasionally taking place is likely due to clonal expansion in years with naturally lower water levels and/or muskrat pressure. This is not to say that a much higher-quality, diverse marsh could not be developed; the prospect of improving the existing marsh would be quite high if an aggressive program of invasives management were to be implemented. The positive results of an invasives management program could also be dramatically improved by including an effort to remove the trash, tires, and other debris left from years of fly dumping at the site.

If circumstances change and a future decision is made to implement water level control, the potential to increase the footprint of deep marsh habitat would be greatly improved, as would the ability to manage invasive species within the system.

Recommendations

If our goal is to further develop the deep marsh habitat footprint at the 135th Street Marsh, then there is little we can recommend to achieve that goal without implementing some sort of water level control. However, the quality of both the shallow and deep marsh habitat could be improved dramatically with the initiation of an intensive, long-term invasives management program in this area. Converting the existing invasives-dominated marsh into a higher-quality native system would provide a great deal of benefit to local wildlife, especially herps, rails, and other marsh-dependent species.

We also recommend introducing a native fish community to the marsh ecosystem. Although overwintering water depths will remain relatively shallow, a number of small fish species are adapted to overwintering in well-vegetated shallow waters. Candidates could include central mudminnows (*Umbra limi*), starhead topminnows (*Fundulus dispar*), or brown bullheads (*Ameiurus nebulosus*). These fish are not game species (as game species are not appropriate), but they do play various beneficial roles in aquatic environments (e.g., by eating mosquito larvae or serving as food for other species such as herons, grebes, or turtles). If the decision is made to introduce fish, then partners such as the Illinois Department of Natural Resources Fisheries biologists should be engaged to introduce appropriate species.

References

Illinois State Geological Survey. (1939). Unpublished material, Illinois historical aerial photographs: 1936 to 1941 v.4: Illinois State Geological Survey, Champaign, Illinois.

Big Marsh

Summary

Big Marsh is a 300-acre site with 97.5 acres of mixed shallow and deep water wetlands and a 40+-acre public bike park located in southeast Chicago, just east of north Lake Calumet. The site, now owned and managed by the Chicago Park District (CPD), was once part of the Lake Calumet shoreline and lake plain wetlands around the lake. In the past, the wetlands provided important hemimarsh habitat and functions, including extensive habitat for marsh birds, fish, and other marsh-dependent species. Over the past 30–40 years, the hemimarsh vegetation has disappeared, along with all other vegetation within the marsh pools. Water quality has also degraded to the extent that the marsh no longer provides habitat support for most obligate wetland species other than a large population of the invasive common carp (*Cyprinus carpio*). Restoration of the upland portion of the site began in 2015, followed by a major drawdown once a new water-level control structure was put online in 2016.

Our analysis of the marsh's history, its current condition, and its restoration potential indicates that the marsh could be enhanced and managed to develop up to 39.5 acres of high-quality marsh, including a potential 24.0 acres of rare hemimarsh habitat. However, effective restoration and management of the deep marsh habitat will not be possible until the ability to lower water levels is again incorporated as a management tool. The ability to lower water levels is critical for initially establishing emergent vegetation, and then later to regenerate emergent plants once densities inevitably decline over time. High-quality hemimarsh, i.e. deep marsh habitat ranging from 1–3 feet deep, could be developed by initiating a modest monitoring program, improving the water-level management strategy, enhancing native marsh species and functional group diversity, managing wetland invasive species, and adaptively managing the marsh henceforth. Should the ability to impose low water levels be re-incorporated into the system, Big Marsh could develop into one of the region's most significant marsh restorations demonstrating hemimarsh characteristics.

Site Description

Big Marsh is a 300-acre parcel of land owned by the Chicago Park District (CPD) that is being developed as a commercial outdoor bike park and a restored natural area. The site includes 97.5 acres of water that the park district wants to develop into higher-quality marsh wetlands and open water (Figure 1). The bike park is located at the south end of the site and covers approximately 40 acres of the site. Big Marsh is located northeast of Lake Calumet within the City of Chicago and is bounded by S. Stony Island Ave. to the west, a Norfolk Southern rail line to the north and east, and the Paxton Landfill sites to the south.

Big Marsh was once part of the vast marsh wetlands associated with the shores of Lake Calumet. Aerial imagery from 1939 shows that the Lake Calumet shoreline, along what would later become Big Marsh, was still largely intact, although the New York, Chicago, and Saint Louis Railroad had already been constructed. This was in part to service the Coke Plant built along the eastern border of the site between E. 110th and E. 116th Streets (Figure 2). The 1960 USGS Lake Calumet quad map indicates that the lake, shoreline, and marsh wetlands were still largely intact, but by 1965 a spur of the adjacent rail line (now the Norfolk Western) had cut across the north and west sides of the site to service the new Lake Calumet shipping and barge slips (Figure 3).

The configuration of Big Marsh uplands and wetlands was dictated by the pattern of fill deposited in the marsh. The marsh was a significant dumping ground for slag from the nearby steel industry, with 88 of the 100 acres south of E. 114th St. covered in slag up to 15 feet deep, leaving a remnant pool at the SE corner of E. 114th St. and S. Stony Island Ave. North of E. 114th St., slag was dumped along another 15 acres adjacent to the Norfolk Southern rail line. The slag zones have been characterized by isolated pockets of heavy metal toxicity and highly alkaline soil and water readings (18-month study with pH readings > 12.0, as high as 13.3 (Waska & Lenczewski, 2012)). Another 76 acres of the marsh was filled with a combination of slag, construction debris, and old vehicles in the NW quadrant of the site. Some of this area has also been impacted by heavy metals, along with pockets of organic toxicity. Sand was mined from the NE corner of the site, resulting in three deeper adjacent pools covering approximately 20 acres. Most of the remaining shallow marsh appears to consist of material eroded from the adjacent fill mixed with native sediments.

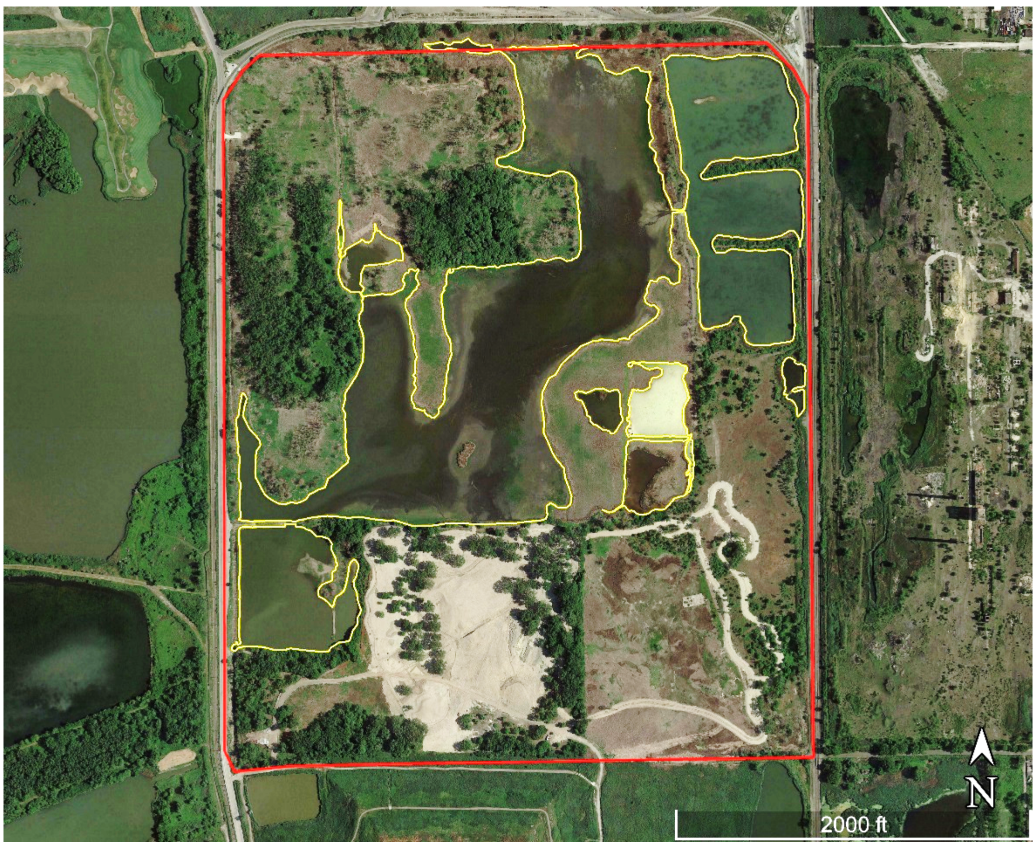
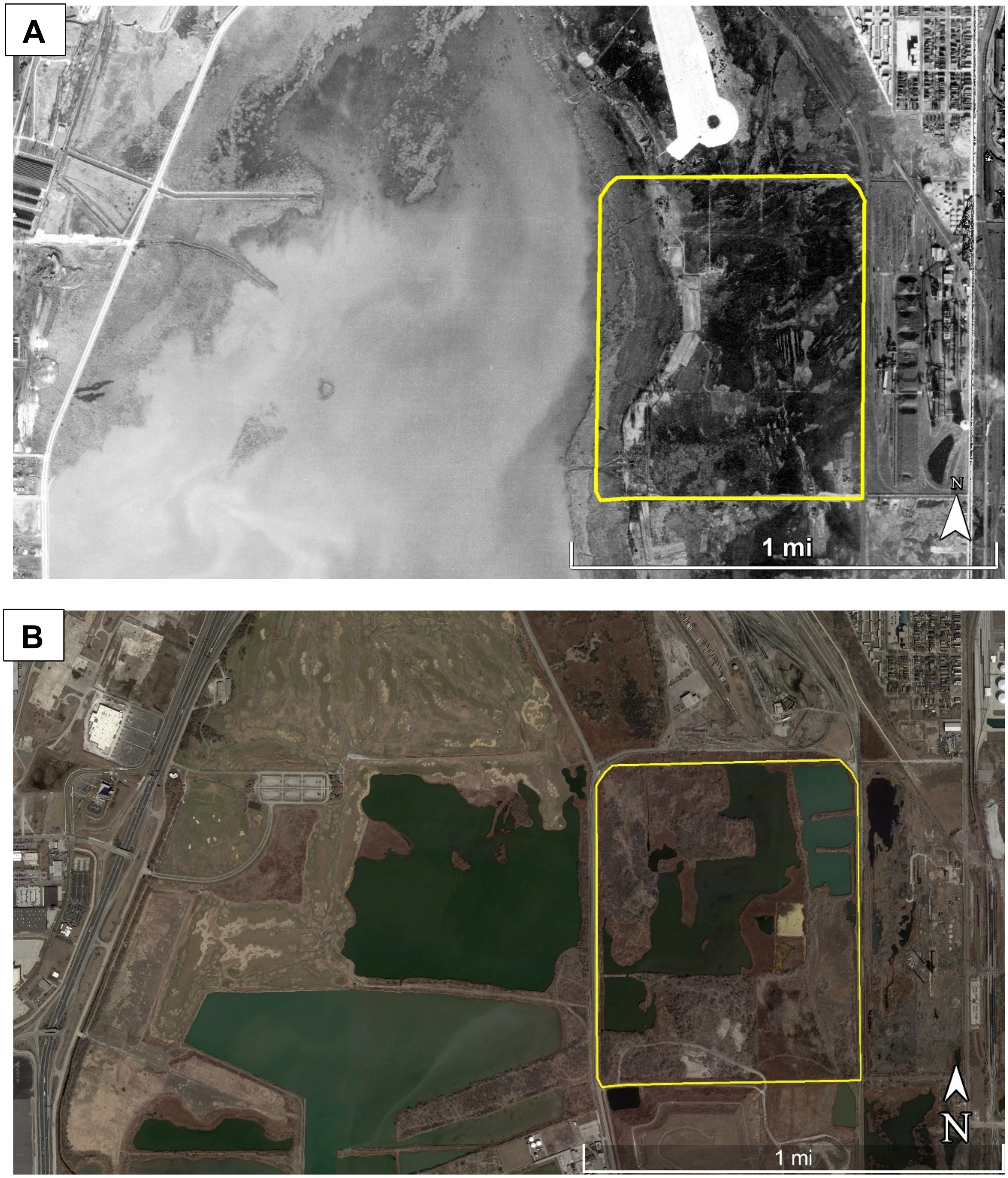
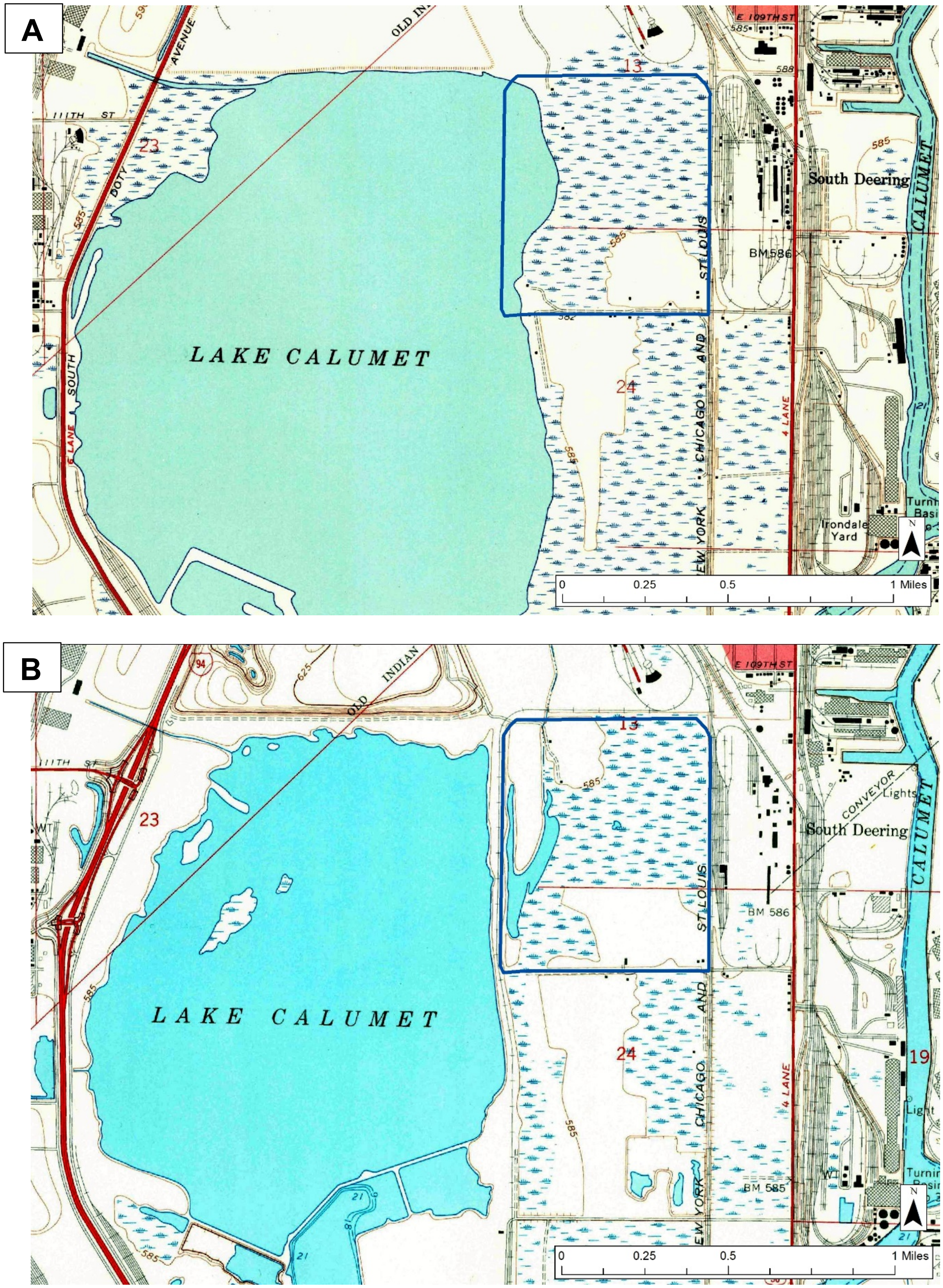


Figure 1. A 2016 satellite image of the 300-acre Big Marsh site owned by the Chicago Park District outlined in green. Pools comprising 96 acres of water are outlined in yellow. All areas not outlined in yellow were created by the deposition of slag or other material into the Calumet marshes. Imagery courtesy of Google Earth.



Figures 2A and 2B. (A) The north end of Lake Calumet showing the Big Marsh area circa 1939 (Illinois State Geological Survey, 1939) and (B) the same area in 2014 (imagery courtesy of Google Earth). The Big Marsh restoration site is outlined in yellow in each panel.



Figures 3A and 3B. USGS map of Lake Calumet in 1960 (A) showing marshland in the future Big Marsh area along the east shore of the lake (in blue). (B) USGS map of Lake Calumet in 1965 showing much of the lake has been filled, a rail line has been built across the north and west side of Big Marsh, and much of the Big Marsh area (in blue) has been lost to slag deposition.

Hydrology

In addition to precipitation and surface runoff, the Big Marsh system has two primary direct inputs of water: the first is water through Inlet A from the old Coke Plant to the east through a 36-inch culvert under the Norfolk Southern rail line (Figure 4; V3 Companies Ltd., 2006). Once entering the site, water flows north parallel to the rail line and into Pool 3 adjacent to the tracks. Pool 3 flows into the main marsh area (Pool 2) through an opening in the berm separating them. The other primary inlet brings water from the Norfolk Southern Railroad Marsh to the north through Inlet B. From there, water flows south through Indian Treaty Creek until draining into the main marsh (Pool 2). Water in Pool 2 flows through an opening in a berm separating Pool 1 from 2, then through a water level control structure (Structure C) into the outlet channel at the SE corner of Pool 1. Water then flows through a culvert under the new Big Marsh entry road (Structure E) before exiting the site through Culvert D under S. Stony Island Ave. and into Lake Calumet. Some additional water also enters the outlet channel from the Paxton Landfill sites to the south (Structure F) and empties into Lake Calumet through Culvert D. It is likely that additional groundwater enters the site from the north, east, and south.

The hydrology of Big Marsh is inextricably tied to that of Lake Calumet, which in turn is a function of water levels in Lake Michigan. Since water drains from Big Marsh into Lake Calumet, it can only do so if the surface water elevation of Lake Calumet is lower than in Big Marsh. There must be a sufficient difference in elevation between the two in order for water to drain efficiently, i.e., at a rate greater than the inputs to Big Marsh. As the surface elevation of Lake Calumet approaches the surface elevation of Big Marsh, water will begin to drain more slowly and eventually begin to back up water, raising the water levels in Big Marsh. For example, a water level of 581.5 feet above mean sea level (MSL) relative to the North American Vertical Datum of 1988 at the outlet in Big Marsh could only be maintained if the Lake Calumet water level was no higher than approximately 581.0 feet MSL, and less than that during periods of high precipitation or snowmelt.

Monthly average water levels in Lake Michigan have ranged over the past 100 years from a high of 582.89 feet MSL in October 1985 to a low of 576.56 feet MSL in January 2013 (Figure 5). These extreme highs and lows are rare and have historically only occurred over periods of a few months. Other than in 1985, the monthly average has only exceeded 582.0 feet MSL for a few months in two other years, 1952 and 1974. The long-term average over the past 50 years is 579.75 feet MSL. Over the past 12 months, the monthly average has ranged from 579.51 to 580.72 feet MSL at the Calumet Harbor (gauge 9087044).

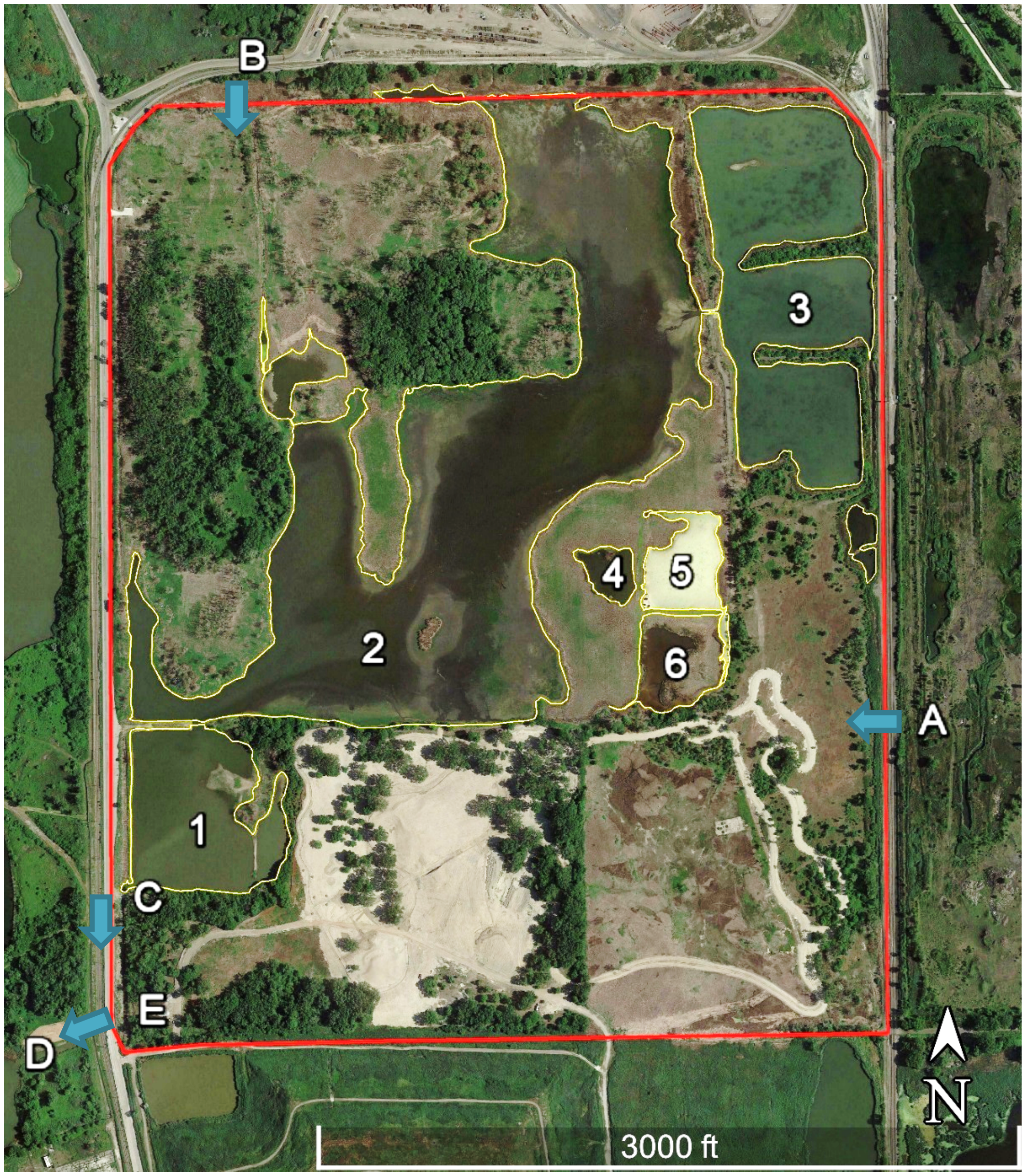


Figure 4. Hydrologic characteristics of Big Marsh, with major pools (1 through 6), inlets (A, B, and F), water control structures (C and D), and the dam created by the new entryway culverts (E). Imagery courtesy of Google Earth.

By 2016, the outlet channel at Big Marsh had been dredged and a water-level control structure installed that would allow water to drain from Pools 1 and 2 down to a level set by the stop logs (Structure C). The structure was designed to give Big Marsh managers maximum flexibility in managing water levels at the park. The invert of the structure was set at 579.0 feet MSL, while stop logs could be added to raise water levels in the marsh as high as 583.75 feet MSL (V3 Companies Ltd., 2015a). The channel bottom in the Lake Calumet outlet west of S. Stony Island Ave. was dredged to an elevation below 578.0 feet MSL to ensure maximum drainage capacity from Big Marsh given appropriate water surface elevations in Lake Calumet—i.e., the lake must be lower than the Big Marsh target elevation.

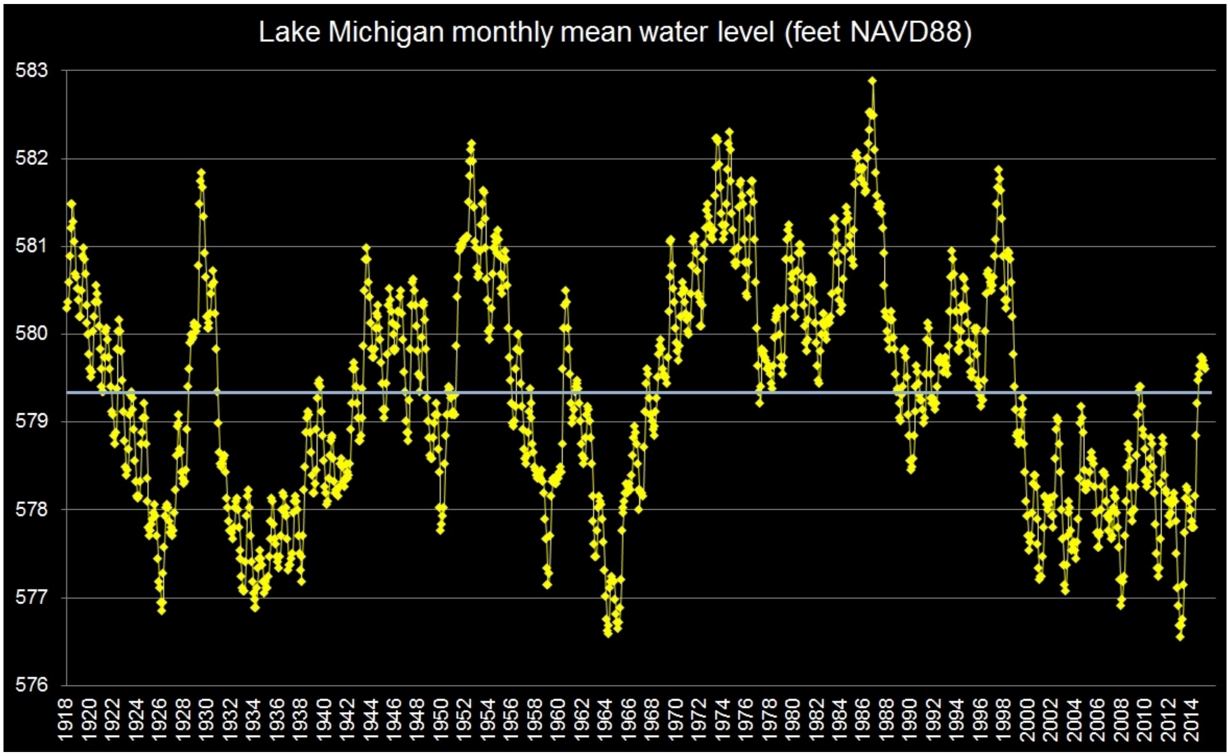


Figure 5. Monthly mean surface water elevations in feet above sea level NAVD88 (North American Vertical Datum of 1988) for Lake Michigan (and Huron) since 1918, with the overall mean elevation depicted with the horizontal solid blue line (NOAA-GLERL Great Lakes Dashboard, 2018). Great Lakes data are reported relative to the International Great Lakes Datum of 1985 (IGLD85), but were converted here to the NAVD88 datum for comparison with Big Marsh elevations, which is 0.54 feet higher than IGLD85 at Calumet Harbor (i.e., IGLD85 + 0.54ft = NAVD88).

Bathymetry and Topography

Field surveys of Big Marsh were conducted at the site from 2014–2015 to identify the extent, location, and configuration of the Big Marsh slag deposits and shoreline, along with the plant communities surviving the harsh physical and chemical landscape in each. A topographic survey with some bathymetry conducted by V3 Companies Ltd. (2015b) showed that most of the slag surface varied in elevation from 4–6 feet above the water line (approximately 582.5 feet MSL at time of survey). The NW quadrant outside of the marsh varied more in elevation, ranging from 2–8 feet above the water surface, with the lower elevations found east of the Indian Treaty Creek inflow from Railroad Marsh to the north.

Assuming a surface elevation of 582.5 feet MSL, the profile of the marsh edge along most of the shoreline is relatively steep, with banks characteristically dropping three feet or more from top of bank to the waterline over 3–10 feet of run. The marsh drops up to a foot or more in depth within 30 feet of shore, depending upon location within the wetland. Most of the main 60.6-acre marsh (Pool 2) is about 2 feet deep, with depressions up to 3 feet deep. Since the eastern portion of Pool 2 is separated from the western portion by a ridge with an elevation between 580.5 and 581.0 feet MSL, the eastern portion can only drain to that elevation. The NE section of this pool is about a foot deep. Due to the dredging of the connecting channel between Pools 1 and 2 and the outlet channel, the western portion of Pool 2 could potentially drain as low as 580.0 feet MSL. The deeper, 20.2-acre pools to the east are over 10 feet deep, while the 8.9-acre pool to the southwest ranges up to approximately 4 feet deep.

Current Habitat and Invasive Species

Restoration activities at Big Marsh have been underway since 2015, so that much of the current habitat is under development, but none of it has been completed. The restoration plan was developed by V3 Companies, Ltd. in 2015 and is being implemented in stages as funding becomes available. Nearly all of the extensive common reed (*Phragmites australis*) stands have been treated and burned at least once, and a large quantity of undesirable trees and shrubs have been removed. Many of the heavy metal and organic 'hot spots' have been capped, and tons of debris have also been removed.

The marsh habitat has undergone a significant transformation associated with the lowering of water levels in 2016 in order to treat common reed. The drawdown exposed sediments for the first time in many years, consolidating them by fully or partially drying them while water levels were low. There was no access to a staff gauge, but it appears from the comparison of V3's bathymetry data (V3 Companies Ltd., 2015b) with satellite imagery (Google Earth, 2016) that water levels were drained to approximately 580.5–581.0 feet MSL. An existing seedbank of cattails (*Typha latifolia*) and various bulrushes and sedges (e.g., *Schoenoplectus* and *Cyperus* species) germinated and established a dense cover of marsh vegetation over most of the exposed sediments (Figure 6). Those sediments remaining vegetation-free were at lower elevation, i.e., in deeper water, and as such were not exposed long enough to dry the sediments and/or germinate whatever seed bank remained. As water levels recovered later in 2016 and into 2017, the emergent vegetation was flooded to create the ideal conditions under which hemimarsh could develop. Those deeper, unvegetated areas mark the extent of the open water zone.

Unfortunately, the highly destructive and invasive common carp (*Cyprinus carpio*) was not eliminated through the application of a piscicide when the opportunity was presented by the 2016 low water levels. If the culvert situation under the new entranceway off S. Stony Island Ave. is not addressed, carp removal in the future will be both more difficult and costly (high water levels engender more places for carp to escape, more area and volume to treat, and more piscicide required to achieve a target concentration). If carp are not treated, experience dictates that they will eventually kill off emergent vegetation, prevent future reestablishment, and maintain low water quality.

Figure 6. Big Marsh aerial photo from 8/25/16 showing the newly vegetated marsh zone between the upper and lower yellow lines. A small island vegetated with untreated common reed and a peninsula where common reed was treated are both outlined in orange. All other areas between the yellow lines were entirely unvegetated open water prior to 2016.

Hemimarsh Restoration Potential

To develop hemimarsh habitat, it will be necessary to manage occasional drawdowns of water levels across the marsh. V3 Companies Ltd. (2015a) designed the water control structure with an invert at 579.0 feet MSL, a level that could maximize the germination and establishment of marsh vegetation over all exposed marsh surfaces and allow the development of hemimarsh characteristics throughout the marsh in all areas exceeding approximately 1 foot in depth (Figure 7). Periodic drawdowns would also greatly facilitate the ability to manage invasive species and conduct prescribed burns.

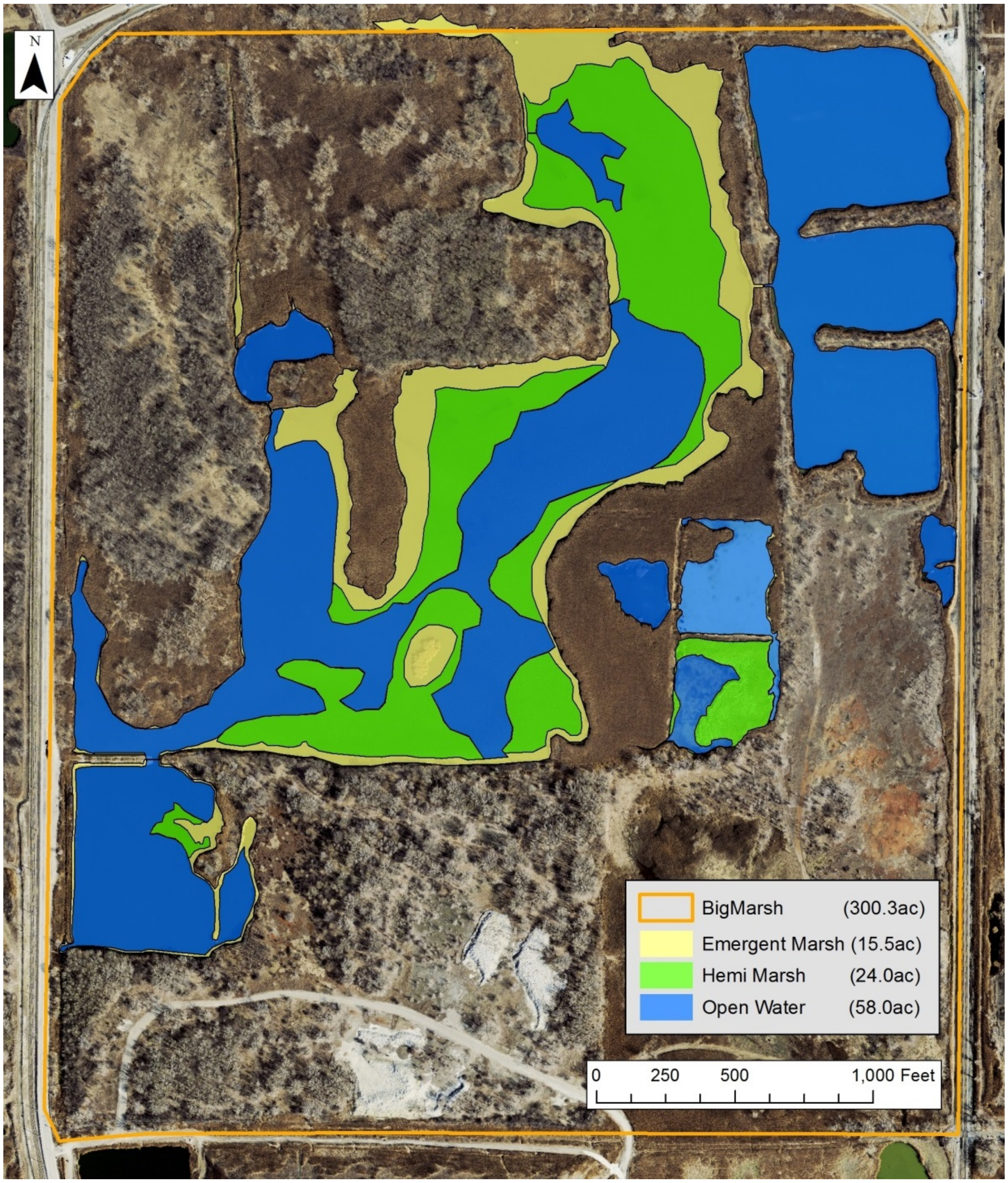


Figure 7. The distribution of habitat that could potentially be developed at Big Marsh. Marsh area varies with water level, which in this depiction is at an approximate water surface elevation of 582 feet MSL NAVD88. Digital imagery courtesy of Cook County, 2013.

With the ability to manage water levels already in place, the second condition necessary for developing hemimarsh or any other vegetated marsh community—eliminating common carp—can then be addressed. Although carp may be treated without drawing water levels down, it would require a significantly greater volume of the piscicide rotenone. Rotenone is a natural product imported from South America; its production is limited, however, as it requires the destruction of the trees that produce it. Given its limited supply but increased worldwide demand, rotenone's cost has risen dramatically. Different formulations are available, which result primarily from the addition of a chemical 'accelerant' that exacerbates its impact on fish. Treatment rates vary, but when carp are present in the system, it is recommended that higher rates be used. Assuming a treatment rate of approximately 1.25 gallons per acre-foot, lowering the marsh even 1 foot would reduce the water volume by 97.5 acre-feet, which translates into approximately 120 less gallons of rotenone. Cost aside, concentrating fish in a smaller volume of water is a more efficient way of controlling variables and reducing the possibility of error.

To develop hemimarsh habitat following hydrologic modifications (and potentially in concert with the rotenone application), it will be necessary to maximize the distribution of emergent vegetation across the range of depths in which it occurs. Water levels will need to be low in the spring and held low long enough to stimulate a round of emergent germination and establishment. This had already been done in 2016, but not as part of a strategic plan to eliminate carp or enhance species and functional group diversity. A future strategic drawdown can and should be supplemented with planting plugs of desired emergent species, e.g., broadleaf cattail (*Typha latifolia*), hardstem bulrush (*Schoenoplectus acutus*), softstem bulrush (*S. tabernaemontani*), three-square bulrush (*S. pungens*), river bulrush (*Bolboschoenus fluviatilis*), pickerel weed (*Pontedaria cordata*), or giant bur-reed (*Sparganium eurycarpum*). Other marsh species more commonly found in shallower water could also be planted at this time, e.g., sweet flag (*Acorus americanus*), lake sedge (*Carex lacustris*), or duck potato (*Sagittaria latifolia*). Water may be maintained at a low level for as long as an entire growing season, but low water conditions should last from early spring through mid-summer at minimum. During the drawdown, submersed species capable of providing habitat support for small fish, herps, and waterfowl should also be planted in both the hemimarsh and open water zones. Such species include wild celery (*Vallisneria americana*), sago pondweed (*Stuckenia pectinata*), nodding longleaf (*Potamogeton nodosus*), and white waterlily (*Nymphaea tuberosa*). It will also be critical to address the invasive community around the marsh perimeter in order to develop a shallow emergent marsh capable of supporting shallow marsh species, such as King Rail (*Rallus elegans*) and other wildlife.

Once a marsh community has been established, actively managing water levels at Big Marsh should be a relatively simple activity requiring only occasional monitoring coupled with a water level adjustment once every few years. An estimated 24.0 acres of hemimarsh could be developed and maintained at Big Marsh for many years to come. However, it may take one or more seasons before a muskrat population expands sufficiently for the marsh to develop the characteristic interspersion ratio of 1:1 between emergent vegetation and open water in the deeper marsh.

Recommendations

Our recommendation for restoring marsh functions at Big Marsh begins with the periodic drawdons detailed in the the water-level management plan developed for the CPD by The Wetlands Initiative (TWI) in 2015. Specific recommendations are addressed below, with additional detail provided in the introduction to these analyses.

- Hydrology: adopt the water level management plan prepared by TWI in 2015;
- Fish community:
    - Initiate a program to eliminate the invasive carp;
    - Introduce a community of small fish adapted to overwintering in shallower systems.
- Invasive species: initiate a program to eliminate common reed, reed canary grass, and other invasive plants,
- Enhance diversity: plant additional species during a planned drawdown to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community,

- Topography/bathymetry: re-contour steep shoreline areas to create a more extensive shallow marsh-to-upland transition zone,
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps that can be taken to sustain and enhance the marsh

Hydrology

The first step in water level management should be to decide an average elevation around which to manage marsh water levels, which in turn determines the distribution of marsh plant species. Based on a desire by CPD at that time to maintain lower water levels, a mean surface water elevation of 581.75 feet MSL was recommended in the 2015 TWI report, as well as letting water levels drift seasonally higher to mimic patterns of natural fluctuation. A restoration plan developed by V3 subsequent to the TWI recommendations suggested an even lower target elevation of 581.25 feet MSL. Based on new bathymetry information available after the 2016 drawdown, we are raising our recommended mean water level to 582.0 feet MSL. However, whichever water level is chosen between 581.25 and 582.25 feet MSL could result in a high- quality wetland, with more wet meadow and shallow marsh developing at a lower target elevation and more hemimarsh developing at a higher target elevation. The area projected to potentially develop as hemimarsh in this analysis is based on 582.0 feet MSL surface water elevation.

Fish Community

Based on many observations, common carp are present in the Big Marsh system, and possibly the dominant species. Thus, we strongly recommend their removal through the application of a piscicide to the entire system. This can only be done in partnership with Illinois Department of Natural Resources Fisheries biologists, as its application is strictly controlled by the state. Following use of a piscicide, we recommend introducing a native fish community to the marsh ecosystem. Although overwintering water levels will remain relatively shallow over most of the marsh, the deep-water Pool 3 is sufficiently deep (up to 10 feet) to overwinter a diverse community of fish species. Smaller species adapted to shallower water include candidates such as central mudminnows (*Umbra limi*), starhead topminnows (*Fundulus dispar*), or brown bullheads (*Ameiurus nebulosus*). These smaller species play various beneficial roles in the aquatic environment, e.g., by eating mosquito larvae or serving as food for other species such as herons or turtles. Other, larger candidate species include largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed sunfish (*Lepomis gibbosus*), spotted gar (*Lepisosteus oculatus*), and bowfin (*Amia calva*). If the decision to introduce fish is made, then partners such as the Illinois Department of Natural Resources Fisheries biologists should be engaged to introduce appropriate species.

The Plant Community: Managing Invasive Species and Enhancing Diversity

We recommend addressing invasive species as soon as is practical, and in particular the remaining populations of common reed through a joint land and aerial application effort. Common reed is the biggest invasive threat to restoring the shallow marsh community. This will be a continuation of ongoing efforts already underway at Big Marsh, with the acknowledgement that a multiyear effort will be required to bring common reed and other species under control. If this effort can be undertaken and maintained, steps can then be taken to introduce a biologically diverse community of native marsh vegetation as outlined in the Hemimarsh Restoration Potential section above. Water levels will have to be strategically lowered in order to establish emergent and floating-leaved species, which will also greatly assist in the establishment of shallow water and submersed species. Most emergents could be introduced through the planting of seed and plugs in one growing season, allowing water levels to naturally re-establish as plants grow and elongate to keep up with the rising water surface.

Bathymetry and Topography

The entire eastern shore of Lake Calumet was filled in the 1960s, creating the western border of the Big Marsh site. Ongoing deposits filled the remaining wetlands, leaving only those pools of water that remain today. These deposits not only filled in a significant portion of the marsh, but also eliminated any of the remaining marsh-to-upland transition zone. In order to develop higher-quality marsh habitat along the existing shoreline, the slope could be re-contoured by taking a cut-and-fill approach coupled with deposition in areas where exposing soil contaminants would be considered a problem. This is already being done along the north shore of Pool 2. Elsewhere, most of the shoreline rapidly drops off at a steep angle from the upland to a depth of 1–2 feet so that there is almost no upland-to-marsh transition zone. The upland along the shore itself is up to five feet above the water line, even when the marsh levels are relatively high. All fill along the southern half of Pool 2 and nearly all of Pools 1, 4, 5, and 6 have steep slag edges. Other areas appear to be composed of poor-quality soils comprised of old fill and construction debris. Where appropriate, soil with high clay content could be utilized to build a shelf that extends the shallow zone further from shore to create more area capable of supporting marsh vegetation. This would provide the added benefit of capping some of the slag alkaline exudate draining the pools.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management, a responsibility of the landowner, the Chicago Park District. CPD currently maintains staff dedicated to Big Marsh, engaged in actively managing the bike park, trail system, and natural area. Assuming the new entryway culverts are modified, an agenda of action-items to enhance long-term outcomes at the marsh (some of which have been discussed above) include:

- Installation of a staff gauge and periodic monitoring of water levels;
- Using and maintaining the water-level control structure;
- Enhancing diversity with the installation of submersed and floating-leaved species;
- Monitoring emergent cover at least once annually;
- Monitoring the plant community and especially the establishment of marsh invasives;
- Proactively managing invasive plant species.

A record of water levels, even if only a once-monthly record, allows managers to better understand the marsh's hydrology and respond accordingly if adjustment is warranted. It is important to recognize that even though natural systems do not need adjusting, this is no longer a natural system and will need to be at least lightly managed to achieve positive outcomes. This also means that the water-level control structure needs to be maintained; the site's infrastructure only serves a purpose if it is utilized. Stop logs can be manipulated to effectively increase or lower water levels as seasonally or interannually appropriate. Since the water-level control structure was installed but subsequently taken offline before the marsh could be planted with emergent, submersed, and floating-leaved plants, a second drawdown should be conducted as soon as is practical to increase the quantity and quality of the marsh and hemimarsh communities.

Water level monitoring can also be coupled with assessing emergent plant cover, a measure that need only be examined once or twice annually. Although accurately estimating emergent cover from shore is difficult, it is possible to determine if it is thinning to the point that the deeper marsh is no longer functioning as a hemimarsh—i.e., the open water fraction is expanding to 60% or more cover, a condition that could warrant a future drawdown to stimulate establishment of more emergent plants. Examination of publicly available satellite imagery (e.g., Google Earth) is an additional viable method of more accurately assessing cover as new data become available.

It seems obvious that invasive species need to be managed in any system restored to provide natural functions. Yet history tells us that monitoring the restored plant community, a necessary action for knowing what, when, and where to manage invasives, is often overlooked or given insufficient attention. Even a once-annual effort should reveal developing invasive problems, allowing managers to address them before they develop into large, intractable problems. Monitoring cattails should be a priority, especially regarding which species occur and where they grow. Hybrid and narrowleaf cattails should be suppressed, especially in the shallow marsh and near shore meadows. Broadleaf cattails, especially in deeper water, are an important component of the marsh community.

The goal of any management plan should be to maintain a restoration once the installation has been completed. At Big Marsh, one or more staff should be responsible for proactively assessing ground conditions as they change from month to month (and year to year) in order to address problems as they appear, when they are minor and manageable. The penalty for taking a more passive approach is for problems to become insurmountable in terms of cost, scope, or management. Appropriate management need not be a huge effort in terms of manpower or resources, but it must be a consistent effort in order to be successful.

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Burnham Prairie

Summary

Burnham Prairie Marsh is a 34.8-acre marsh and open water wetland located between S. Torrence and S. Burnham Avenues, just south of the Grand Calumet River in southeast Chicago. The site was once part of the local river floodplain and associated wetlands, but is now a shallow basin that is hydrologically isolated from the river by levees, roads, and rail lines. The marsh is owned and managed by the Forest Preserves of Cook County (FPCC), with the western portion in Burnham Prairie Park and the eastern portion in the Burnham Prairie Nature Preserve. The old oxbow and associated marsh wetlands were once characterized by a community of emergent vegetation providing hemimarsh habitat, but much of these hemimarsh characteristics were lost once relatively static water levels were imposed following construction of a levee separating the site from the Grand Calumet.

Our analysis of the marsh's history, its current condition, and its restoration potential indicates that marsh habitat could be expanded and restored if appropriately managed to become a higher-quality marsh, much of which could again develop hemimarsh characteristics. However, since the marsh hydrology no longer fluctuates as it once did, the ability to *actively* restore deep marsh habitat will only be possible if the ability to impose occasional low water levels is incorporated into the design. This would take place through the installation of a new outlet and water-level control structure. The ability to lower water levels is critical for initially establishing deep marsh emergent vegetation, and then later for regenerating aquatic plants once densities inevitably decline over time. Without the ability to lower water levels, the extent to which deep marsh can *passively* be restored becomes much more limited, both in terms of potential quality and area restored. Once restored, a high-quality hemimarsh occurring in up to 3 feet of water could be maintained by initiating a modest monitoring program, enhancing native marsh species and functional group diversity, managing wetland invasive species, initiating a water-level management strategy within the limits of flexibility within the system, and adaptively managing the marsh henceforth. If the ability to impose low water levels is incorporated into the system, Burnham Prairie Marsh could develop into a superior marsh system with a significant portion exhibiting hemimarsh characteristics capable of supporting a wide range of marsh-dependent species.

Site Description

Burnham Prairie Marsh (BPM) is a 34.8-acre marsh and open water wetland found within a complex mosaic of restored wetland, prairie and savanna habitat on land owned and managed by the Forest Preserves of Cook County (FPCC): Burnham Prairie Park and the Burnham Prairie Nature Preserve (Figure 1). The site is located in the village of Burnham, IL and is bordered to the north by the Grand Calumet River, to the east by an Amtrak CSX line, to the south by a Norfolk Southern rail line, and to the west by private land on the east side of S. Torrence Ave. The site underwent vegetational restoration sponsored by the U.S. Army Corps of Engineers (the Corps) from 2010–2015. Much of this effort consisted of woody and herbaceous invasive management in the prairie and wetlands to the south (as much of the original plant community remained intact), as well as extensive common reed (*Phragmites australis*) and cattail (*Typha* species) management coupled with native marsh plantings to the north.

BPM was once part of the Grand Calumet River floodplain wetlands and was formed in part by one of its old meanders, still visible in 1939 aerial imagery (Figure 2A). The marsh was cut off from the Grand Calumet with construction of a levee along the south bank of the current river channel and the Amtrak CSX line to the east (Figure 2B). Drier ground to the west was created when that portion of the floodplain was also filled for residential development. Approximately half of the floodplain wetlands north of the oxbow were lost when they were used as a location to dump slag and other debris. Alkaline leachate from the slag deposits can be seen in satellite images along much of the north shore of the wetland in Pools 3 and 4 in Figure 1. The south border of the marsh transitions gradually into a mosaic of wet meadow, wet-mesic shrub prairie, wet-mesic prairie, and a small remnant savanna.

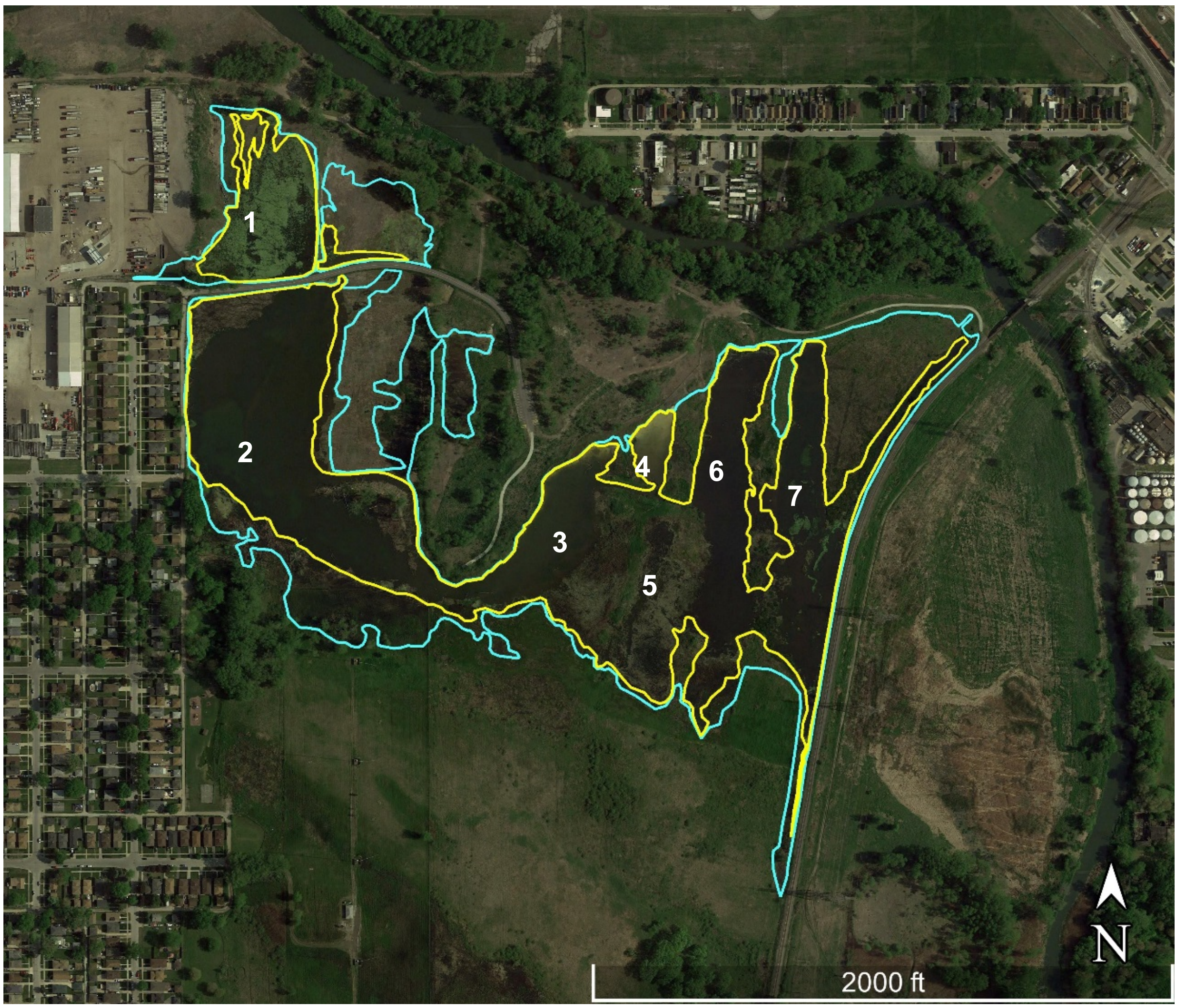
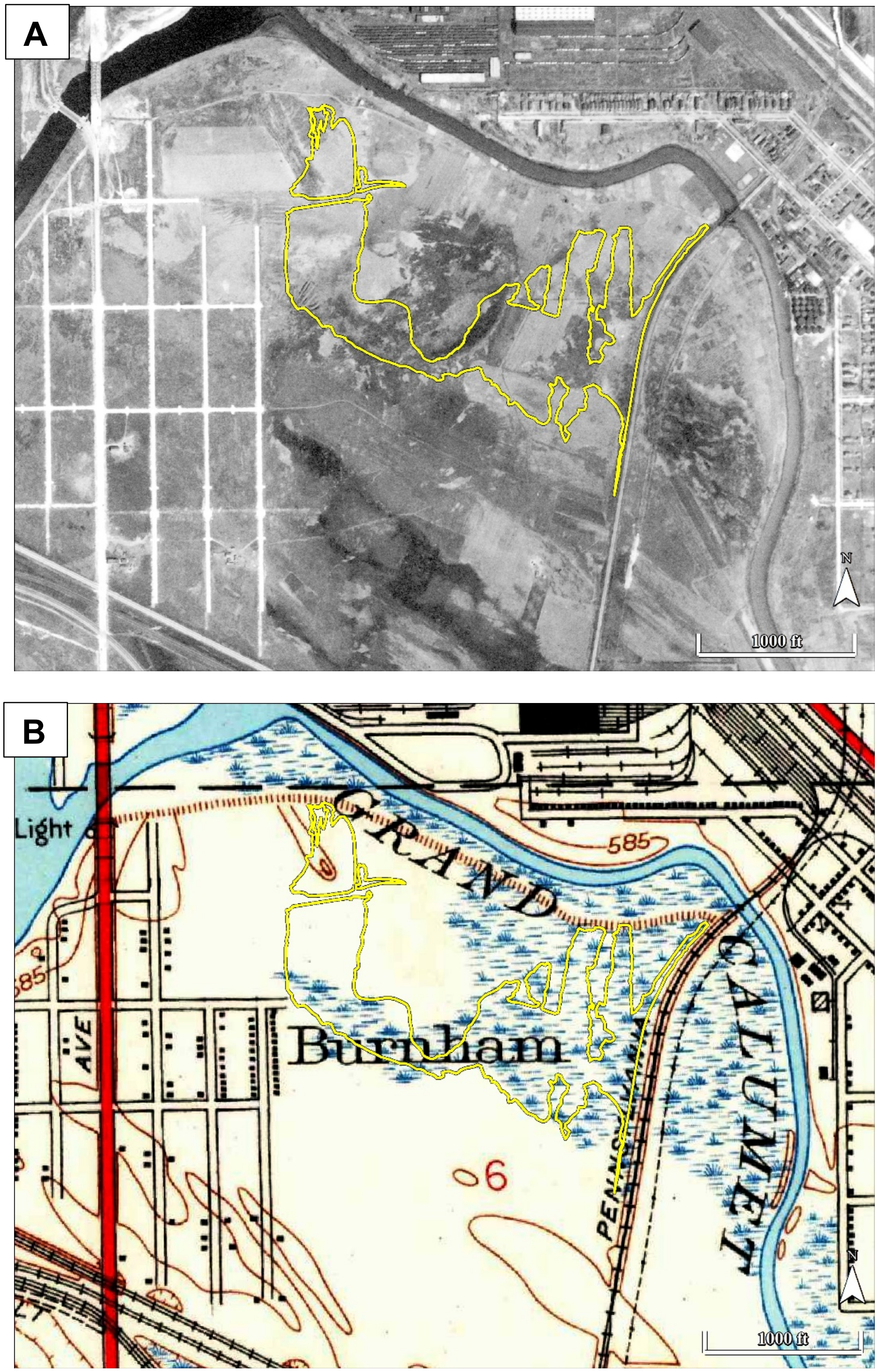


Figure 1. A 2016 satellite image of Burnham Prairie Marsh. The highest water level is set by the invert of the existing outlet (54.3 acres, outlined in blue). Typical summer water levels within the marsh are outlined here in yellow, showing seven major pools arbitrarily designated as differing in depth and vegetation patterns. Satellite imagery courtesy of Google Earth.



Figures 2A and 2B. Burnham Prairie Marsh and the Grand Calumet River during two periods of development, illustrating the history of fill and re-channelization: (A) 1939 aerial photograph (Illinois State Geological Survey, 1939), and (B) 1953 USGS map. [Note the levee in the 1953 map traversing the site and designated by the hashed line running through the word *Grand*.]

Hydrology

Hydrologically, the BPM basin is separated from the Grand Calumet River by the river levee running from the Amtrak CSX line west to S. Torrence Ave. (Figure 2B). With no input of water from the river, the marsh is primarily fed by surface water runoff, precipitation, and snowmelt. High water levels are controlled by an outlet structure constructed with a one-way duckbill check valve that was installed when the levee was modified during the recently completed Corps-sponsored restoration work (Figure 3). This was essentially installed as a safety valve to prevent the influx of polluted river floodwaters, and to prevent excessively high interior water levels from damaging the marsh and near-shore communities. One of the primary benefits of the check valve is that it is passive; i.e., it opens to allow drainage only when water levels inside are high enough to force the mouth open—although this won't happen if water levels outside are high enough to put pressure on the opening to keep it closed. This allows high water levels to drain by gravity as long as the Grand Calumet is lower than the check valve. By design, the water control outlet is slightly higher than the target mean water level to ensure that no water drains below the invert elevation. Consequently, there is no mechanism in place to actively drain the marsh below the maximum water level for management purposes. However, the marsh surface elevation may drop well below this level during prolonged periods without rain, coupled with water loss from excessive evapotranspiration or groundwater losses through porous soils.

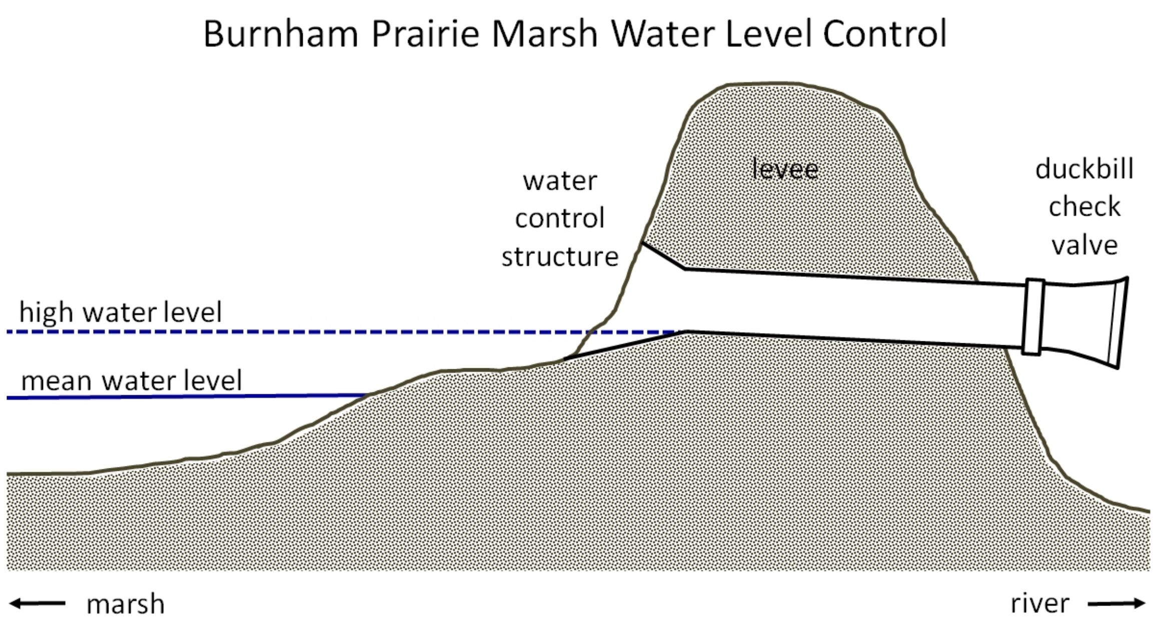


Figure 3. The existing Burnham Prairie Marsh water outlet structure with a duckbill check valve on the outlet, which sets the maximum high water level (provided the river water level is lower than the valve, thus allowing it to open).

Bathymetry and Topography

We were unable to locate adequate topography or bathymetry data, nor were any available from the FPCC. However, we were able to approximate depths by combining insights gained by comparing field survey notes and photographs with changing patterns of vegetative cover associated with different surface water elevations observed on aerial or satellite imagery (available through Google

Earth). Vegetation at different depths presents different signatures. Although this estimated bathymetry is inexact, it does allow us to project the extent of marsh depths that could support various marsh plant communities.

Current habitat and invasive species

The communities restored in work sponsored by the Corps have developed into a biologically diverse and functional prairie-wetland-savanna complex. Prior to restoration, much of the current shallow and shoreline marsh zone was a monoculture of the invasive, non-native common reed (*Phragmites australis* ssp. *australis*; Figure 4). A massive eradication effort was mostly successful by 2015, though some dense patches of invasive common reed remain within the relatively shallow portions of Pools 5, 6, and 7 (Figure 1). The native, non-invasive common reed (*Phragmites australis* ssp. *americanus*) can be found mixed in with the invasive common reed and some of the other native wetland communities as well. There are a few relatively small pockets of *Typha* species also scattered through the near-shore marsh. The marsh areas planted most heavily are in and around Pools 6 and 7 (Figures 1 and 5), while the western basins (Pools 1 and 2) received much less effort, as they were not part of Burnham Prairie when the project was initiated. There is some thinly scattered native emergent marsh vegetation in water < 1.0 feet deep in all pools, but little in depths > 1.0 feet deep.

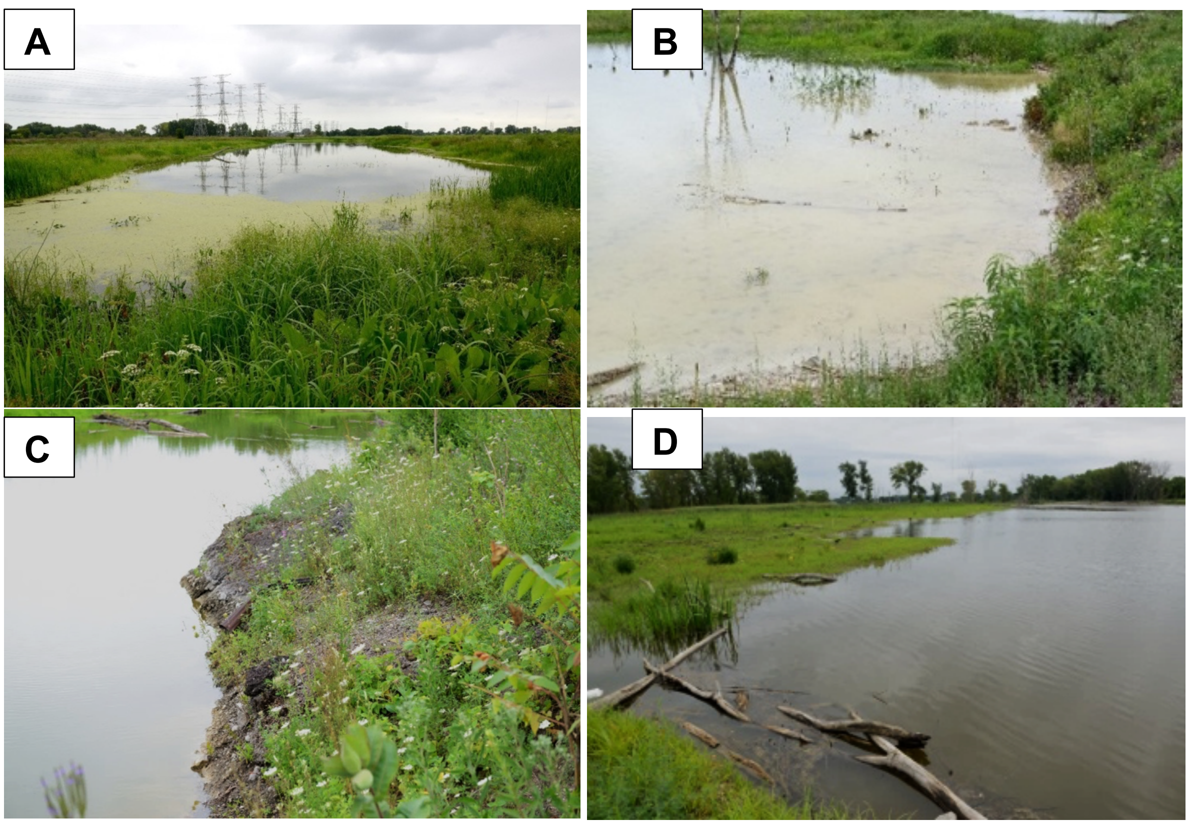
Hemimarsh Restoration Potential

The extent to which hemimarsh can actively be restored at BPM will depend on the extent to which water levels can be managed as part of the marsh restoration effort. Currently, the ability to lower water levels below the maximum level does not exist—i.e., a water-level control structure was not incorporated into the newly completed restoration design. This could be remedied with the installation of a dropbox outlet or similar structure within the levee. Depending on how low the invert was designed, an outlet channel might have to be excavated to get water to the structure for deeper drawdowns. The best location for such a channel, and the shortest run to sufficiently deep water, is at the north end of Pool 7 (Figure 1). Since the site is a recently completed, Corps-sponsored restoration and is still being managed under the Corps' guidelines, the FPCC would need the Corps to agree that a new water-level control structure installation is compatible with the long-term management goals for the site.

If a new outlet structure cannot be incorporated into the design, then the ability to restore or develop more hemimarsh becomes significantly limited. Water levels do vary at the site through the dynamic combination of evapotranspiration, precipitation, and runoff, with lower water levels occurring only under conditions of drought. However, this condition occurs only rarely and unpredictably, so that it is not possible to anticipate when to have plants or seed ready for installation. Furthermore, after many years with little or no emergent cover, bottom sediments are generally loose and unconsolidated. This condition will be exacerbated if common carp have been in the system (yet to be determined). Only under conditions of extreme drought will water levels become low enough to dry and consolidate sediments to support a developing emergent community. Consequently, the extent of marsh habitat at BPM can be enhanced with shallow water plantings (coupled with a commitment to monitor and respond to intermittent low water levels and additional plantings), but significantly developing additional hemimarsh habitat will require incorporating additional water level control.

A new water-level control structure would be designed to occasionally lower water levels sufficiently to initially stimulate and eventually regenerate emergent species growth when emergent cover drops below an acceptable 'hemimarsh density', i.e., a ratio of approximately 1:1 emergent plants to open water. It is not possible to predict how often this action would need to be taken, but it typically ranges from once every 5–15 years (or more), depending on the density and activity level of muskrats in the system, the activity of common carp (if present), and other stochastic factors. Once drained to achieve management goals, water levels need only remain low enough for a few months, after which they can naturally refill. This period may be longer, and water levels held lower therein, if sediments need to first dry and consolidate.

Figures 4A, 4B, and 4C. Changing marsh habitat at Burnham Prairie: (A) pre-restoration, 2010; (B) active restoration, 2013; (C) post-restoration, 2015. Satellite imagery courtesy of Google Earth.



Figures 5A, 5B, 5C, and 5D. The range of marsh habitat at Burnham Prairie Marsh in 2016: (A) diverse marsh around the shore of the easternmost pool; (B) alkaline leachate from slag in shallow pool 4; (C) steep slag shoreline colonized with non-natives in Pool 3; and (D) the much less diverse east shore of Pool 2. Photos by Gary Sullivan.

To develop hemimarsh habitat, it will be necessary to first maximize the distribution of emergent vegetation across the range of depths in which it occurs. Unlike many of the Calumet wetlands, the marsh and surrounding habitat at Burnham Prairie has a relatively diverse wetland community with many higher-quality remnant species. Consequently, species introductions will have to be carefully matched to the existing community under the supervision of FPCC biologists. To establish these species in the deeper marsh, water levels will need to be lowered in the fall and held low long enough to stimulate a round of emergent germination and establishment the following spring. This can—and should—be supplemented with the planting of plugs of desired emergent species. Other marsh species more commonly found in shallower water could also be planted at this time. Planting and establishment could last for as long as an entire growing season, but low water conditions should last from early spring through mid-summer potentially if growth is slow. During the drawdown, submersed species compatible with the existing community and capable of providing habitat support for small fish, herps, and waterfowl could also be planted in both the hemimarsh and open water zones, such as wild celery (*Vallisneria americana*) or white waterlily (*Nymphaea tuberosa*). It will also be critical to address the invasive community around the marsh perimeter in order to develop a shallow emergent marsh capable of supporting shallow marsh wildlife, e.g., Marsh Wrens (*Cistothorus palustris*), King Rail (*Rallus elegans*), and other species.

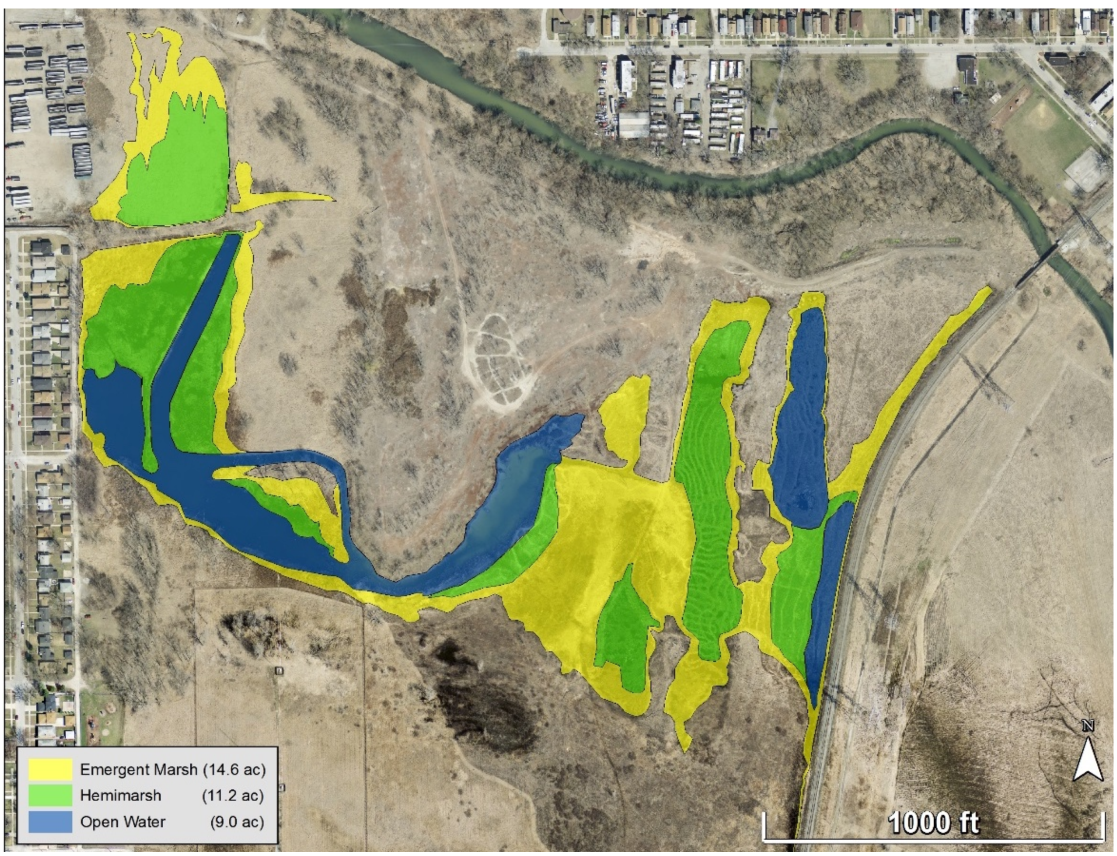


Figure 6. The projected distribution of marsh habitats that could be developed with appropriate water level management. This includes 14.6 acres of shallow emergent marsh, 11.2 acres of hemimarsh, and 9.0 acres of open water.

Once appropriate vegetation has been established, actively managing water levels at BPM should be a relatively simple activity requiring only occasional monitoring, potentially coupled with an occasional water level adjustment every few years. An estimated 11.2 acres of hemimarsh could be developed and maintained at BPM for many years to come (Figure 6). Assuming muskrats find the marsh, it may take a season or two for their population to expand sufficiently enough for the marsh to develop the characteristic interspersion ratio of 1:1 between emergent vegetation and open water in the deeper marsh.

Recommendations

Any recommendation on how to proceed with hemimarsh restoration at Burnham Prairie Marsh will be dictated by the initial decision regarding a new water control outlet structure. Absent this installation, the options become limited, as hemimarsh cannot develop or be sustained without occasional periods of low water to regenerate the plant community. This does happen naturally during periods of drought, but low water periods may not be low enough, or happen as often in highly managed sites (or those with unnatural hydrology). Moreover they are not predictable, so initially restoring or re-establishing deep marsh vegetation cannot be planned. If the goal is to restore or enhance deep water hemimarsh habitat, then our recommendation is to install some type of outlet that will allow water levels to be controlled. The critical issue here is that if you wish to restore hemimarsh, you must restore the conditions under which hemimarsh can develop—and the key condition within this context is periodic low water levels. Thus, given that there are two potential options to be implemented, we have recommendations for restoration with a new outlet incorporated into the design, as well as other recommendations to considered either way:

New outlet option.

- Hydrology:
  - Install a new outlet and water-level control structure, which may include excavation of a channel from the outlet to sufficiently deep water in order to achieve the desired range of water levels.
- Install emergent aquatic plants and enhance marsh diversity:
  - Plant additional species during a planned drawdown to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
  - Plant marsh and wet meadow species in the shallower marsh areas and surrounding wetlands to enhance the overall diversity of the site.
- Fish community:
  - Initiate a program to eliminate the invasive carp if present;
  - Introduce a community of small fish adapted to overwintering in shallower systems.

Options with or without a new outlet.

- Cap the slag shoreline: place a clay cap along the slag shoreline zone where alkaline leaching is impacting water and sediment chemistry and discoloring the water;
- Invasive species: initiate a program to eliminate non-native common reed, reed canary grass, and other invasive plants;
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps that can be taken to sustain and enhance the marsh.

Hydrology

We recommend installation of a new outlet in the levee at the north end of Pool 7. The outlet should include a dropbox-type water-level control structure that will allow the marsh to be drained up to 30 inches below the target mean water level. The installation would require a channel to be excavated into the marsh deep enough to drain water to the outlet, extending south far enough to reach an appropriate depth. The new outlet would also give managers much greater flexibility in managing water levels during periods of normal operation, i.e., outside of a drawdown. Under normal operation, stop logs could be used to raise or lower water depths to mimic natural levels of variation associated with wet or dry years, or to assist in managing invasives, such as common reed.

The Plant Community: Managing Invasive Species and Enhancing Diversity

Managing invasive species is already a priority at Burnham Prairie, which we are confident will continue whether or not a new outlet is installed. This ongoing effort should in particular address the remaining populations of non-native common reed, reed canary grass, and *Typha* species along the shore through the application of appropriate herbicides. Common reed is the biggest invasive threat to restoring the marsh community, while reed canary grass may suppress native species from the margins of the marsh up through all habitats found at BPM. This will be a multiyear effort to bring these species under control, with ongoing management required to maintain the integrity of the native community. If these efforts can be undertaken and largely completed, steps should also be taken to enhance the diversity of the marsh community with native marsh vegetation, as outlined in the Hemimarsh Restoration Potential section above. This would primarily take place in and around the more western pools at BPM that lack the levels of diversity already restored to the east. Water levels will have to be strategically lowered in order to establish emergent and floating leaved species away from shore, which will also greatly assist in the establishment of shallow water and submersed species. Most emergents could be introduced through the planting of seed and plugs in one growing season, allowing water levels to naturally re-establish as plants grow and elongate to keep up with the rising water surface.

Fish Community

It is possible that no common carp exist in the marsh, a hypothesis that could be tested by FPCC Fisheries biologists. This would potentially be due to a history of low water during winter or drying during periods of drought. If this is borne out, it is likely no actions need be taken to keep carp out of the system. If carp are discovered, however, they should be eliminated through the application of a piscicide during the first drawdown for management purposes. Following carp extermination (if warranted), FPCC Fisheries biologists could establish a native fish community if they decide they want fish to become a component of the marsh ecosystem. Although water levels will remain relatively shallow (maximum overwintering depths between 3–4 feet), a number of small fish species could be established that are adapted to overwintering in shallow waters. Candidates could include central mudminnows (*Umbra limi*), starheaded topminnows (*Fundulus dispar*), or brown bullheads (*Ameiurus nebulosus*). These fish would not be game species; game fish would not be appropriate. These fish species can play various beneficial roles in the aquatic environment, e.g., as consumers of mosquito larvae or serving as food for other species such as herons or turtles. Conversely, the presence of fish could make the marsh less attractive for breeding amphibians, especially salamanders.

Clay Capping

Slap deposited along the north shore of the old Grand Calumet meander, i.e., within Burnham Prairie but outside the nature preserve, is leaching highly alkaline materials in other, similar Calumet wetlands. The lack of native marsh vegetation in the leaching zone suggests that conditions associated with the slag edge are not benign, despite these areas having supported common reed in the past (Figure 4A), a species shown to be resilient in highly alkaline habitats elsewhere. Currently, most of the north shoreline rapidly drops off at a steep angle from the upland to a depth of 1–2 feet, so there is almost no upland-to-marsh transition zone. We recommend that soil with high clay content be deposited to cap the slag and used to build a shelf extending below the water surface a short distance away from the shoreline, effectively creating an area more capable of supporting marsh vegetation.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management. FPCC has existing dedicated staff who manage the Burnham Prairie system and actively engage in conducting invasive management. The general approach that we recommend for maintaining marsh vegetation and enhancing diversity is presented in detail in the introduction to these analyses. This includes strategies to manage the site adaptively both during and after the conclusion of active restoration activities. Moving forward, monitoring water levels and emergent vegetative cover will be critical for making informed decisions. Monitoring cattails should be a priority, especially regarding which species occur and where they grow. Hybrid and narrowleaf cattails should be suppressed, especially in the shallow marsh and near shore meadows. Conversely, broadleaf cattails, especially in deeper water, are an important component of the marsh community. The restoration and ongoing management of hemimarsh habitat within the marsh at Burnham Prairie should provide an invaluable extension of the impressive landscape mosaic that is the Burnham Prairie Nature Preserve.

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Deadstick Pond

Summary

The marsh at Deadstick Pond is a 28-acre marsh and shallow open water wetland located just east of south Lake Calumet and north of where the Calumet River flows south to the O'Brien Lock and Dam. The site was once part of the extensive lake plain wetlands surrounding Lake Calumet, but is now a relatively shallow basin hydrologically disconnected from the lake and river system. The marsh and adjacent property are owned and managed by the Metropolitan Water Reclamation District of Greater Chicago.

Our analysis of the marsh, its current condition, and its restoration potential indicates that the marsh could be enhanced and managed to develop up to 24.1 acres of high-quality marsh, including a potential 13.3 acres of rare hemimarsh habitat. High-quality hemimarsh, i.e., a deep marsh mosaic of open water and emergent vegetation ranging from 1–3 feet deep, could be developed by initiating an appropriate water-level management strategy, enhancing native marsh species and functional group diversity, managing wetland invasive species, and incorporating a modest monitoring and adaptive management program in the marsh henceforth. This will only be possible if the flexibility to impose occasional low-water levels is incorporated into the site's management. The ability to lower water levels will be critical to first establish emergent vegetation, and then later to regenerate emergent plants once densities inevitably decline over time. This site can—and should—develop into a highly functional example of the region's best marsh restorations, with the potential to support a wide range of marsh-dependent species and other wildlife.

Site Description

The marsh at Deadstick Pond is a 28.2-acre area of open water and marsh, wet meadow, and a wet-mesic woodland on the south side of Chicago, southeast of Lake Calumet. The site, now owned and managed by the Metropolitan Water Reclamation District of Greater Chicago (MWRD), is bounded by S. Stony Island Avenue to the west, E. 122nd St. to the north, S. Paxton Ave. and the concrete-surfaced sludge drying area to the east, and the Calumet River to the south (Figure 1). The site was once part of the wetland bordering Lake Calumet, but was hydrologically cut off from the lake system with the construction of S. Stony Island Ave. and E. 122nd St (Figure 2).

The configuration of the marsh was dictated by the pattern of fill deposited to create the roads and drying beds. Direct access to the site was not granted to us by MWRD for an extensive survey, but limited information on conditions was determined from bird surveys conducted on the property in 2015. More useful data on bathymetry was prepared by V3 Companies, Ltd. for the City of Chicago's Department of the Environment at Deadstick and Heron Ponds (V3, 2006a). Based on their report, the profile of the marsh along the shoreline is relatively steep, with banks rapidly dropping five feet or more to the water line, and the marsh dropping another two feet in depth within 50 feet of shore throughout most of the wetland. Most of the marsh floor appears to consist of material eroded from the adjacent fill mixed with native sediments.

Figure 1. 2012 Satellite image showing the marsh pool outlined in yellow at Deadstick Pond. Imagery courtesy of Google Earth.

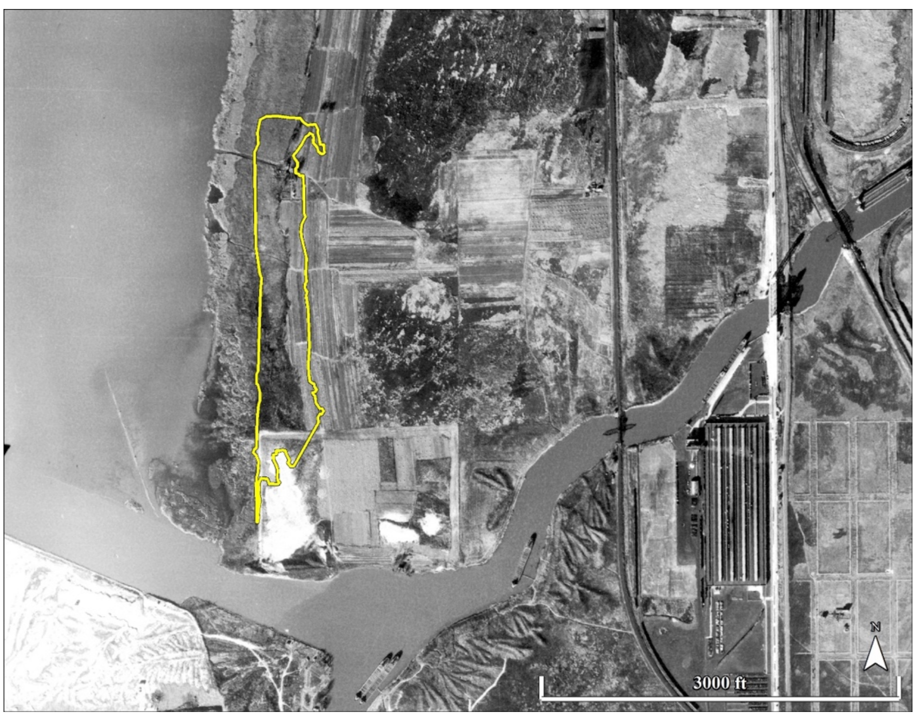

Figure 2. The location of Deadstick Pond, along the east shore of Lake Calumet and north of the Calumet River, in 1939 (Illinois State Geological Survey, 1939).

Hydrology

The marsh at Deadstick Pond is a perched wetland draining south through a narrow channel into the Calumet River. Water surface elevation varies at Deadstick with precipitation and drought patterns, but rests around 584 feet in elevation relative to mean sea level (MSL) as determined by the North American Vertical Datum of 1988 (NAVD88). Water elevation is determined by a dropbox, stop log, and weir structure at the outlet, which maintains the water level higher than the surface elevation of the Calumet River, into which it drains. The Calumet River is directly connected to Lake Michigan, whose water levels vary over a range of approximately 6 feet, but have not exceeded 583 feet MSL during the entire period of record (NOAA 2017; Figure 3). The current water level in the marsh is about 3.0 feet higher than in the Calumet River. Deadstick Pond is maintained by precipitation and local surface runoff, and also receives some input from the north through a culvert under E. 122nd St. (V3, 2006b).

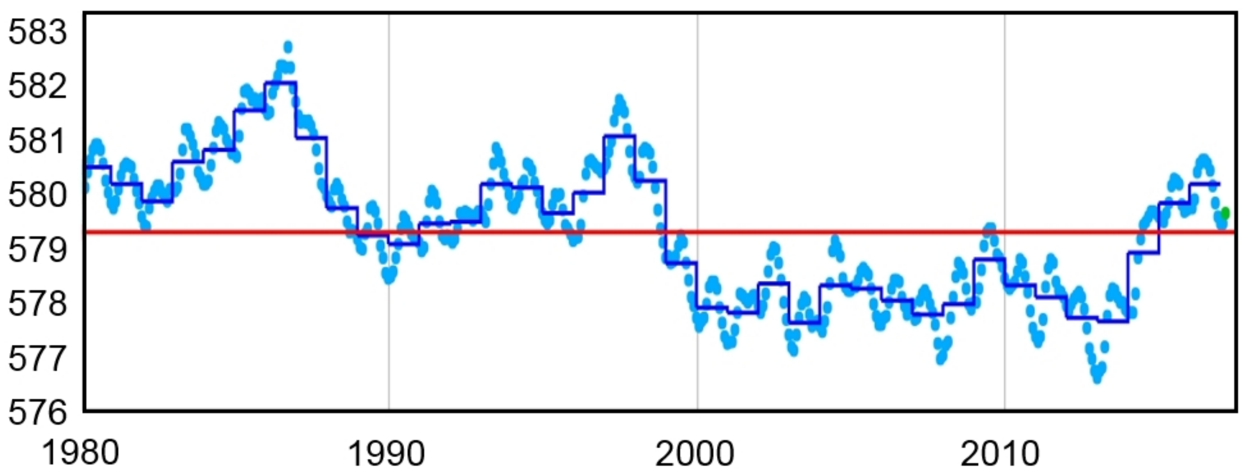

Figure 3. Mean monthly (dots), annual (blue line), and 100-year average (red line) surface water elevations of Lake Michigan in feet relative to mean sea level NAVD88 (North American Vertical Datum of 1988) from 1980 to the present (NOAA, 2017). The period includes the highest water surface elevations ever recorded (October 1986) and the lowest (January 2013).

Bathymetry and Topography

We were fortunate to access bathymetry and topography data prepared by V3 Companies, Ltd. (V3, 2006a), which presented a detailed, 1-foot contour map of the Deadstick Pond area. The map indicated that water elevation over most of the site was approximately 584.2 feet MSL (values ranged from 583.9–584.6). The depth of the marsh was not uniform, with the floor of the northern marsh area at approximately 582.25 feet MSL based on reported spot elevations (~1.75 feet deep). The northern end of the marsh was demarcated from the central and south ends by an 8.5-foot deep depression measuring approximately 200 feet across at the top. South of the depression, the marsh floor averaged approximately 581.5 feet MSL (~2.50 feet deep). The southernmost end of the marsh was characterized by a 350-foot wide depression with depths ranging from 585.15–585.96 (~3.33 feet deep). Outside the marsh, the surface of Stony Island Ave. and E. 122nd St. was at least at 588.0 feet MSL throughout its length. Spot elevations on the sludge drying area ranged from 586.1 to over 589.0

feet MSL, while spot elevations within the wet meadow area ranged from 585.5–588.7 MSL. Based on these data, it appears that outside of depressions in the marsh, depth ranged from approximately 1.75–2.50 feet deep. Water levels within the marsh appear to be relatively stable, suggesting that the wet meadow area was rarely, if ever, flooded.

Current Habitat and Invasive Species

The marsh at Deadstick Pond is mostly open water surrounded by a near monoculture of common reed (*Phragmites australis*) extending onto the adjacent degraded wet meadow. Cattails (*Typha* spp.) have been reported as part of the shallow marsh community over the past 20 years, but we have seen no evidence of them surviving. Considering the absence of emergent, submersed, or floating-leaved aquatic species, it is likely that common carp (*Cyprinus carpio*) are present in the system.

Hemimarsh Restoration Potential

Currently, the marsh is a relatively steep-sided, shallow basin devoid of vegetation except around the margins in shallow water. An emergent marsh community has been reported there in the past, but the conditions to support such a community currently appear to be non-existent; it has now declined to the point of insignificance. The regeneration potential of the marsh was lost once the outlet dropbox and weir structure was put in place to maintain stable water levels. The resulting static water levels have precluded emergent seed germination and re-establishment, and will continue to do so without occasional periods of low water.

The potential to restore hemimarsh at Deadstick Pond will be dictated by a key decision of MWRD: whether they will manage, or allow others to manage, water levels as part of the marsh restoration and long-term management effort. The existing water-level control structure, as configured, should be sufficient to allow occasional drawdowns for management purposes. A bigger question concerns the outlet channel leading to the water-level control structure: as surveyed, the channel is not deep enough to allow sufficient water to reach the outlet structure. Otherwise, the system is ideal, insofar as water could be drained by gravity to allow installation of marsh vegetation, and later allowed to slowly rise until it reaches management target levels. An initial drawdown would also greatly facilitate management of the common reed found all along the margins of the system.

To develop hemimarsh habitat, it will be necessary to first maximize the distribution of emergent vegetation across the range of depths in which it occurs. Initially, water levels could be lowered in the spring and held low long enough to stimulate a round of emergent germination and establishment. This can and should be supplemented with planting plugs of desired emergent plant species, e.g., broadleaf cattail (*Typha latifolia*), hardstem bulrush (*Schoenoplectus acutus*), softstem bulrush (*S. tabernaemontani*), three-square bulrush (*S. pungens*), river bulrush (*Bolboschoenus fluviatilis*), pickerel weed (*Pontedaria cordata*), or giant bur-reed (*Sparganium eurycarpum*). Other marsh species more commonly found in shallower water may also be planted at this time, e.g., sweet flag (*Acorus americanus*), lake sedge (*Carex lacustris*), or duck potato (*Sagittaria latifolia*). Water may be maintained at a low level for as long as an entire growing season, but low water conditions should last from early spring through mid-summer at minimum. During the drawdown, submersed species capable of providing habitat support for small fish, herps, and waterfowl should also be planted in both the hemimarsh and open water zones. This would include species such as wild celery (*Vallisneria americana*), sago pondweed (*Stuckenia pectinata*), nodding longleaf (*Potamogeton nodosus*), and white waterlily (*Nymphaea tuberosa*). It will also be critical to address the invasive community around the marsh perimeter in order to develop a shallow emergent marsh capable of supporting shallow marsh bird species, such as King Rail (*Rallus elegans*) and other wildlife. The most efficient method will likely be aerial application of herbicide followed by multiple years of backpack-based applications.

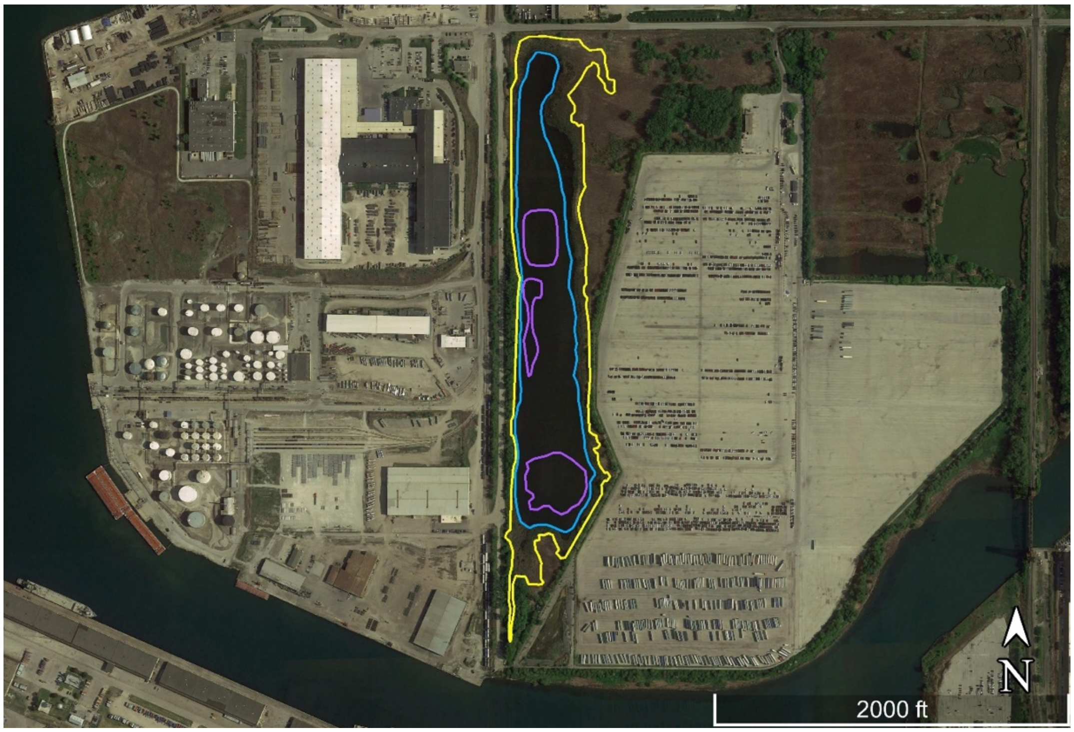

Figure 4. The distribution of habitat projected to develop at Deadstick Pond following initiation of a water-level management strategy that mimics natural marsh rhythms. The extent of the marsh pool is demarcated by the yellow outline (28.2 acres). Shallow emergent marsh habitat is projected to occur between the yellow and blue outlines (10.8 acres), the potential extent of hemimarsh habitat is projected to occur between the blue and purple outlines (13.3 acres), and the extent of open water is projected to occur within the purple outlines (4.1 acres).

Assuming the outlet channel can be dredged and appropriate vegetation established, actively managing water levels at Deadstick Pond should be a relatively simple activity requiring only occasional monitoring coupled with an occasional water level adjustment every few years. The conditions could be developed under which up to 13.3 acres of hemimarsh would be maintained at Deadstick Marsh for many years to come (Figure 4). It may take a season or two for the muskrat population to expand sufficiently for the marsh to develop the characteristic interspersion ratio of 1:1 between emergent vegetation and open water in the deeper marsh.

Recommendations

Because of its favorable landscape position and the presence of water level control, the most important recommendation is to develop a long-term management plan and begin managing the site. There are currently few knowledge gaps requiring addressing, and none that would preclude undertaking initial restoration actions immediately. Our first recommendation is to decide whether to develop and manage a resilient and diverse hemimarsh at Deadstick Pond. Should the decision to proceed be made, we further recommend the following actions be undertaken as soon as is practical:

- Hydrology: develop a water level management strategy;
- Hydrology: rehabilitate the outlet structure and channel;
    - Inspect the outlet and stop log structure, clean up and make repairs,
    - Dredge or excavate the outlet channel to an elevation that allows the marsh to be lowered to a surface water elevation of 581.5 feet MSL.
- Hydrology: monitor water levels and strategically adjust them for restoration purposes and ongoing management drawdowns;
- Invasive species: initiate an aerial and ground-based program to eliminate common reed and other invasive plants;
- Enhance diversity: plant marsh species during a planned drawdown to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
- Fish community: introduce a community of small fish adapted to overwintering in shallower systems;
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps that can be taken to sustain and enhance the marsh.

Additional information on specific recommendations to restore the plant community, manage invasives, and develop an adaptive management strategy is presented in greater detail in the introduction to these analyses.

Hydrology

The first step in water level management is to decide an average elevation around which to manage marsh water levels. Based on an analysis of habitat area at a range of surface water elevations, the area of marsh is maximized when water levels fluctuate around the current elevation of 584.0 feet MSL (Table 1). If water levels were managed at a foot higher, around 585.0 feet MSL, more area would occur across the potential hemimarsh depth range (+4.1 acres), but at the expense of shallow marsh area (-8.4 acres). Although this is potentially a tradeoff worth considering, it would decrease the overall flood storage capacity of the system and potentially back water up at inputs. Managing water levels at any depth lower than 584 feet MSL would result in less hemimarsh area and less marsh overall. Thus, we recommend managing water levels around the current water surface elevation of 584.0 feet MSL. We also strongly recommend the installation of a staff gauge at the outlet structure in order to monitor water levels and facilitate management decisions.

Table 6

Water surface area, marsh area, and surface area distribution at one-foot depth intervals for each water level elevation between 582 and 585 feet msl navd88. [total marsh area (from 0 to 3 feet depth) is maximized at a surface water elevation of 584 feet msl (row in bold and yellow).]

Surface Water Elevation (ft. MSL)	Water Surface Area (ac.)	Marsh Area (ac.)	0–1′ Shallow Marsh	1–2′ Hemi-marsh	2–3′ Hemi-marsh	3′ + Open Water
582	10.8	10.4	6.7	3.3	0.4	0.4
583	17.4	16.6	6.6	6.7	3.3	0.8

584	28.2	24.1	10.8	6.6	6.7	4.1
585	30.6	19.8	2.4	10.8	6.6	10.8

The outlet dropbox control structure appears to be functional, but will likely need to be serviced in order to be actively utilized in the lowering and raising of water levels for purposes of initial plant introduction and future management. More importantly, based on the topography reported by V3 Companies, Ltd. (V3, 2006a), sections of the outlet ditch and adjacent marsh are not deep enough to allow the marsh to sufficiently drain for management purposes. This will require the channel to be dredged or excavated to 581.0 feet MSL, or at least deep enough to drain the marsh to 581.5 feet MSL. This is low enough to expose and consolidate most bottom sediments and allow for planting in the remaining shallow water, as appropriate.

The Plant Community: Managing Invasive Species and Enhancing Diversity

We recommend addressing invasive species immediately once the decision to proceed with restoration is made. In particular, the remaining population of common reed and reed canary grass should be treated through a joint land and aerial application effort. Common reed is the most serious invasive threat to restoring the marsh community; reed canary grass is a threat to all native species outside the shoreline at Deadstick. This will require a multiyear effort to bring these species under control, with ongoing management required to maintain the integrity of the native community. Once these efforts are undertaken, steps should concurrently be initiated to introduce a biologically diverse community of native marsh vegetation, as outlined in the Hemimarsh Restoration Potential section above. Water levels will have to be strategically lowered in order to plant and establish emergent and floating-leaved species, which will also greatly assist in the planting and establishment of shallow water and submersed species. Most emergents could be introduced through the planting of seed and plugs in a single growing season, allowing normal water levels to naturally re-establish as plants grow and elongate to keep up with the rising water surface.

Fish Community

Based on casual observations, we were unable to determine whether common carp are present in the system, although it seems probable due to poor water quality. If carp are identified within the system, we would strongly recommend their removal. This can only be done in partnership with Illinois Department of Natural Resources Fisheries biologists by applying a piscicide to the entire system (piscicides are strictly controlled by the state). Following use of a piscicide, we would recommend introducing a native fish community to the marsh ecosystem. Although overwintering water levels will remain relatively shallow over most of the marsh, there is a hole sufficiently deep (maximum depth of nearly 8 feet) to overwinter a community of small fish species adapted to well-vegetated shallow waters. Candidates include central mudminnows (*Umbra limi*), starhead topminnows (*Fundulus dispar*), or brown bullheads (*Ameiurus nebulosus*). These fish are not game species, but can play various beneficial roles in the aquatic environment, e.g., by eating mosquito larvae or serving as food for other species, such as herons or turtles. If the decision to introduce fish is made, then partners such as the Illinois Department of Natural Resources Fisheries biologists should be engaged to introduce appropriate species.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management, a responsibility of the landowner, the Metropolitan Water Reclamation District of Greater Chicago. MWRD does not currently maintain staff dedicated to managing Deadstick Pond or engaged in conducting invasive management at the site. If MWRD decided to restore or enhance marsh functions at Deadstick either through its own staff or through working with partners, an agenda of action-items to improve long-term outcomes at the marsh (some of which have been discussed above) include:

- Installation of a staff gauge and periodic monitoring of water levels;
- Maintaining the water-level control structure in working condition;
- Enhancing diversity with the installation of submersed and floating-leaved species;
- Monitoring emergent cover at least once annually;
- Monitoring the plant community, especially the establishment of marsh invasives;
- Proactively managing invasive plant species.

A record of water levels, even if only a once-monthly record, allows managers to better understand the marsh's hydrology and respond accordingly if adjustment is warranted. It is important to recognize that even though natural systems do not need adjusting, this is no longer a natural system and will need to be at least lightly managed to achieve positive outcomes. This also means that the water-level control structure needs to be maintained; the ability to add or remove stop logs is critical in effectively managing water levels.

Water level monitoring can also be coupled with assessing emergent plant cover, a measure that may only need to be examined once or twice annually. Although accurately estimating emergent cover from shore is difficult, it is possible to determine if it is thinning to the point that the deeper marsh is no longer functioning as a hemimarsh—i.e., the open water fraction is expanding to 60% or more cover, a condition that could warrant a drawdown to stimulate establishment of more emergent plants. Examination of publicly available satellite imagery (e.g., Google Earth) is an additional viable method of more accurately assessing cover.

It seems obvious that invasive species need to be managed in any system restored to provide natural functions. Yet history tells us that monitoring the restored plant community, a necessary action for knowing what, when, and where to manage invasives, is often overlooked or given insufficient attention. Even a once-annual effort should reveal developing invasive problems, allowing managers to address them before they develop into large, intractable problems. Monitoring cattails should be a priority, especially regarding which species occur and where they grow. Hybrid and narrowleaf cattails should be suppressed, especially in the shallow marsh and near shore meadows. Broadleaf cattails, especially in deeper water, are an important component of the marsh community.

The goal of any management plan should be to maintain the restoration once the installation has been completed. At Deadstick Pond, at least one staff person should be responsible for proactively assessing ground conditions as they change from month to month (and year to year) in order to address problems as they appear, when they are still minor and manageable. The penalty for taking a more passive approach is for problems to become insurmountable in terms of cost, scope, or management. Appropriate management need not be a huge effort in terms of manpower or resources, but it must be a consistent effort in order to be successful.

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Eggers Marsh

Summary

Eggers Marsh is a complex marsh and open water wetland located along the Indiana border in SE Chicago just north of Wolf Lake. The wetland pool is now approximately 41.4 acres, varying in area within and among years depending on rainfall patterns and impediments to drainage (Figure 1). Eggers Marsh was once part of the extensive marsh system bordering Wolf Lake prior to European settlement, but is now limited to a shallow basin that is hydrologically isolated from the lake by fill, roads, and rail lines. The marsh is part of a nature preserve owned and managed by the Forest Preserves of Cook County. The marsh wetlands were once characterized by a community of emergent vegetation providing hemimarsh habitat, but much of these hemimarsh characteristics were lost once the marsh was cut off from Wolf Lake by the extensive deposition of slag across the south end of the marsh.

Our analysis of the marsh's history, its current condition, and its restoration potential indicates that habitat with hemimarsh characteristics could be restored and expanded if appropriately managed. This will soon be possible once a new water-control structure is installed and online. One of the more immediate goals of the structure will be to lower high-water levels to help maintain the adjacent dune habitat, but this can also be adapted for deeper drawdowns for marsh management purposes. The ability to lower water levels is critical for initially establishing deep marsh emergent vegetation, and then later for regenerating aquatic plants once densities inevitably decline over time. High-quality hemimarsh, i.e., deep marsh habitat occurring in up to 3 feet of water, could be maintained by initiating a modest monitoring program, enhancing native marsh species and functional group diversity, managing wetland invasive species, initiating a water level management strategy within the limits of flexibility within the system, and adaptively managing the marsh going forward. Once the ability to impose low water levels is incorporated into the system, Eggers Marsh can develop into a high-quality marsh with a significant portion exhibiting hemimarsh characteristics capable of supporting a wide range of marsh-dependent species.

Site Description

Eggers Marsh is currently a 41.4-acre complex of marsh and open water wetland that is found within a remnant dune and swale mosaic of wetlands and woodlands on land owned and managed by the Forest Preserves of Cook County (FPCC): the ~176-acre Eggers Grove Nature Preserve (Figure 1). The wetland pool varies in area depending on water level, ranging from approximately 25 acres or less during drier periods up to a high of 41 acres or more during wetter periods. The site is located on the southeast side of Chicago, IL and is bordered to the east by the Illinois-Indiana state line, to the north by East 112th St, to the west by private land along S. Avenues G and H, and to the south by the FPCC's Wolf Lake Overlook.

Eggers Grove is being managed as a high-quality natural area by the FPCC. Much of this effort consists of woody and herbaceous invasive management in the swales and woodland edges and around the margins of the open water. Marsh management over the past few years has focused primarily on an extensive campaign to remove common reed (*Phragmites australis*), but has also included removal of reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria),* and cattails (*Typha* species). Currently, the surface water elevation of the open water area (Eggers

Marsh) is higher than desired, resulting in water flooding the swales and woodland dune edges. To combat chronic high water, a new water control structure has been designed that will allow water levels to be lowered to a new, lower mean level, potentially allowing even lower drawdowns for marsh management purposes.

Eggers Marsh is all that remains of the deep marsh that once served as a transition zone between the Calumet dune/swale landscape and the open waters at the northwest end of Wolf Lake (Figure 2). Eventually, most of the Wolf Lake NW marsh and shallow lake was filled in for residential and industrial use, and by an extensive slag dump just south of the Eggers Grove. Eggers Marsh is a relatively small remnant of this once-extensive mosaic of marsh and shallow-lake habitat. The marsh is now an important part of the area's natural heritage and a focal point of interest for birders and naturalists alike.

Figure 1. The Eggers Grove Nature Preserve in 2016, outlined here in yellow. The current 41.4-acre high water extent of Eggers Grove Marsh is outlined in blue. Imagery courtesy of Google Earth.

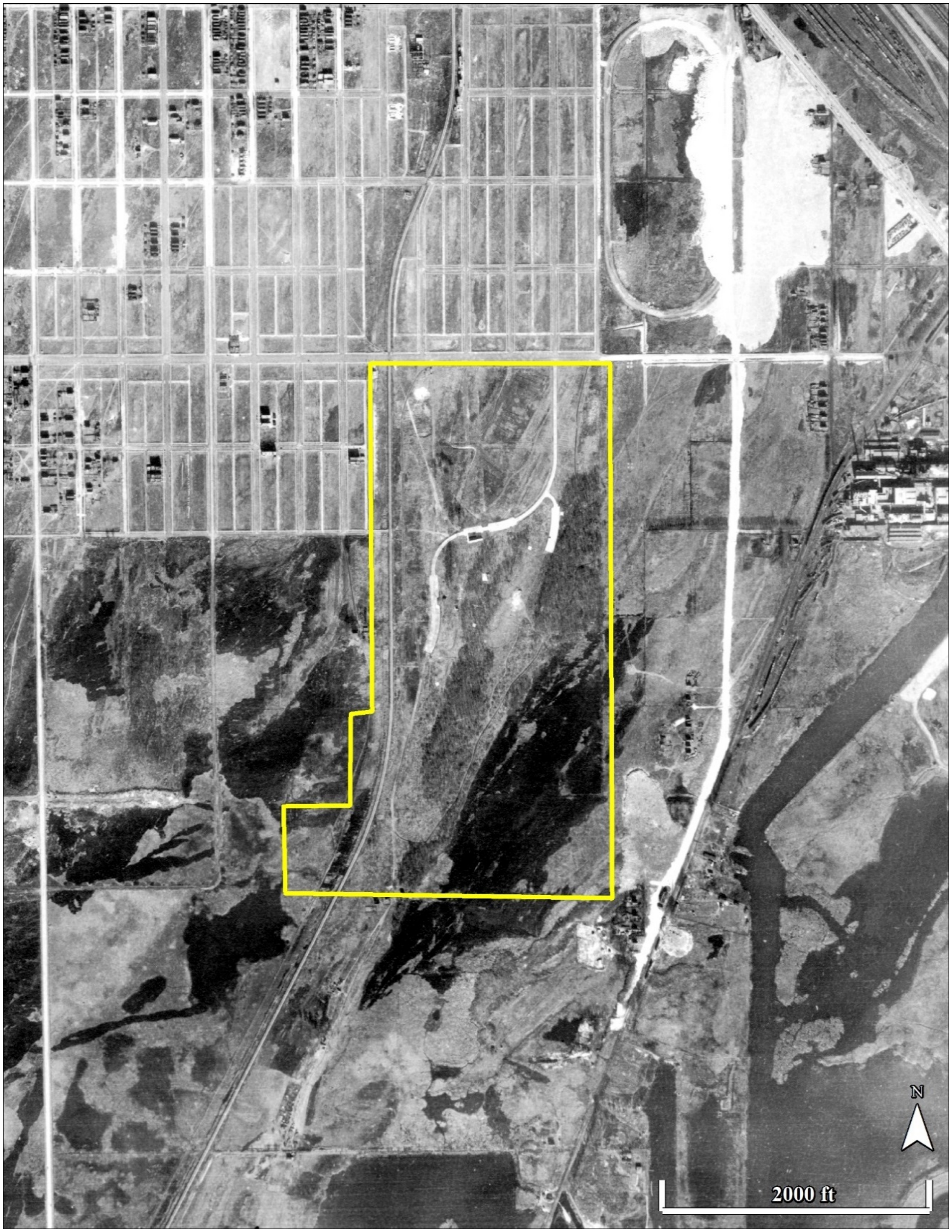


Figure 2. 1939 aerial of the future Eggers Grove Nature Preserve, outlined in yellow. The preserve lies just west of the Calumet River, which drains Wolf Lake (SE corner of image) into Lake Michigan (NE of image). The future Eggers Marsh (the dark, SE portion of the preserve) is all that now remains of the marsh wetland complex that formerly bordered the NW end of Wolf Lake (Illinois State Geological Survey, 1939).

Hydrology

Hydrologically, the Eggers Marsh basin is fed by precipitation and local runoff. The marsh drains through a shallow ditch, leaving the marsh at the north end until reaching the outlet culvert at the north end of the park (Figure 3), presumably draining into the municipal drainage system until eventually reaching Lake Michigan. As of our last survey of the site (summer 2016), the drainage way was choked with common reed and silt accumulation, effectively damming the outlet and maintaining elevated water levels within the marsh. Water levels are now approximately one foot higher than desired, flooding much of the marsh shoreline. Based on consultation with FPCC staff, the design of the new water-control structure has largely been completed and is scheduled for construction in 2018. A lower target-mean water level will reduce the marsh footprint by approximately 10.5 acres (Figure 4).

Figure 3. Photographs of Eggers Marsh from September 2015. Clockwise from upper left: (1) the outlet culvert at the north end of Eggers Grove; (2) the drainage ditch between Eggers Marsh and the outlet culvert; (3) the northwest marsh shoreline after common reed management; (4) the flooded SW shoreline, showing how water has moved into the dune tree line.

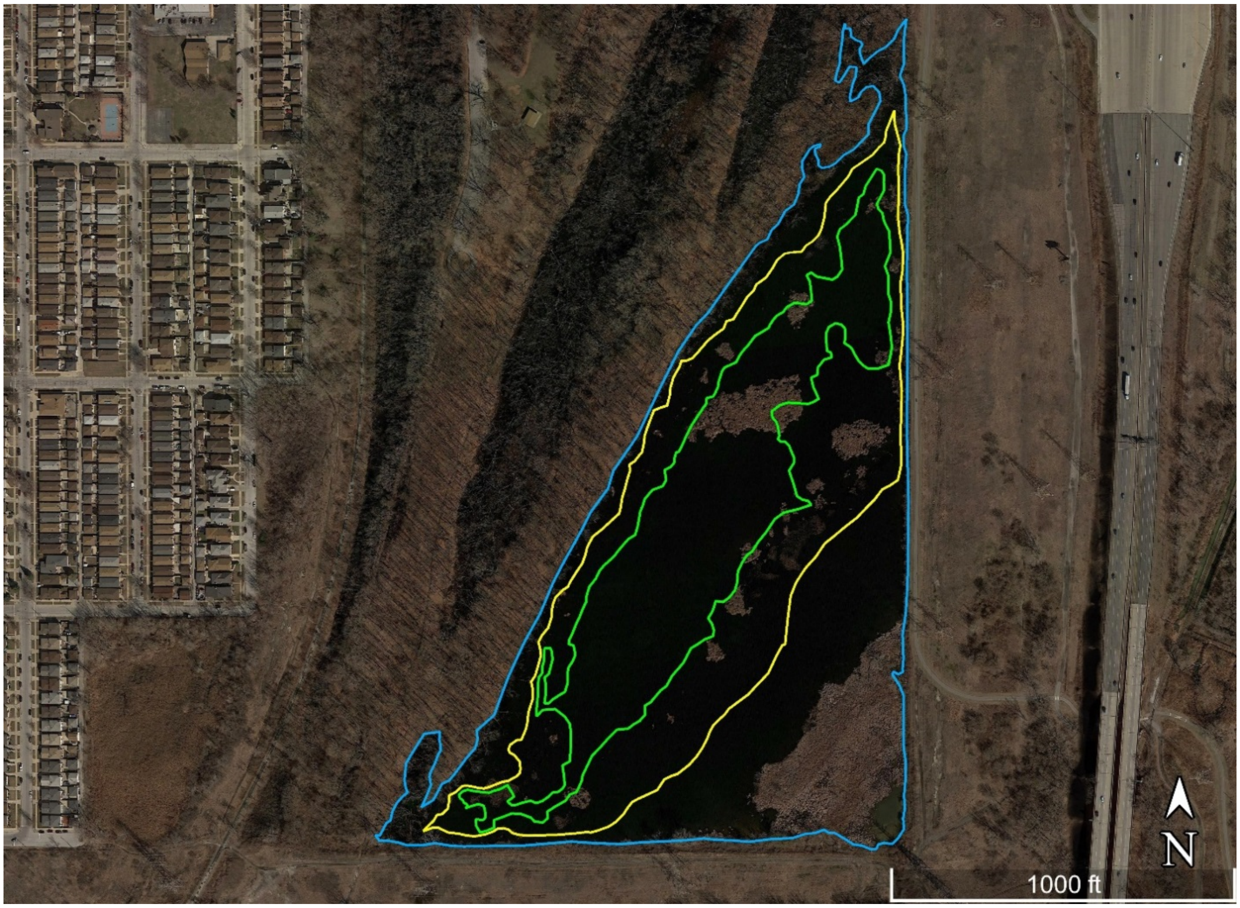


Figure 4. Eggers Marsh showing the current high-water level of approximately 41.4 acres outlined in blue, the future 25.3-acre mean target water level outlined in yellow (at approximately the current 1-foot depth contour), and the future 11.6-acre, 1-foot depth contour outlined in green (at approximately the current 2-foot depth contour). Imagery courtesy of Google Earth.

Bathymetry

We were unable to acquire detailed bathymetry data, although FPCC staff conducted a depth survey by measuring water depths at a number of points (Figure 5). By comparing the results of this survey with Google Earth aerial imagery from 1998 to 2016, we were able to approximate depth contours based on changing patterns of vegetative cover associated with different surface water elevations (Figure 4). Although the projected contours are not exact, they do allow us to estimate the extent of water depths that could support different marsh plant communities once the marsh is being managed at its target-mean surface water elevation.

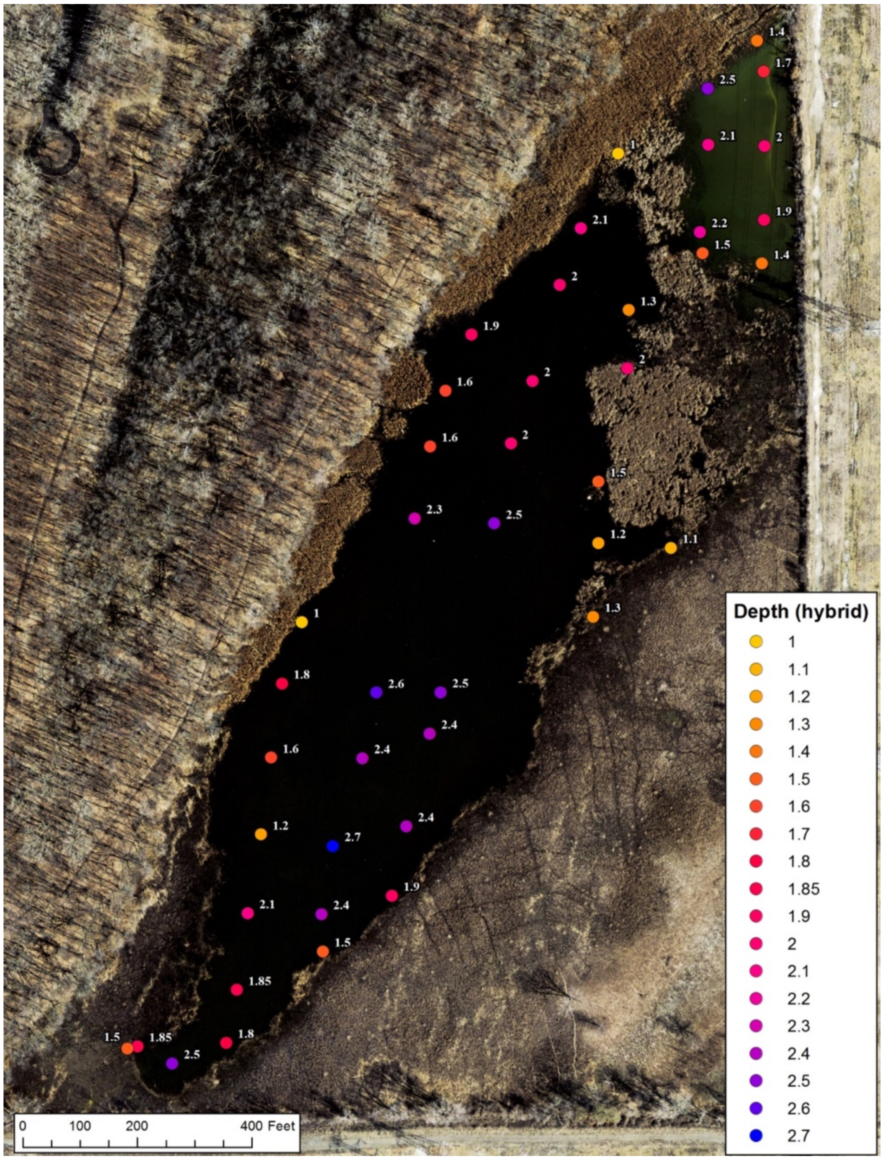


Figure 5. Results of a depth survey of the Eggers Marsh open water area by the FPCC, measuring distance from the water surface to the bottom with (1) a graduated rod; and (2) a depth finder. The points represent the composite (i.e., hybrid) results. Imagery courtesy of the FPCC.

Current Habitat and Invasive Species

The Eggers Marsh plant community has until recently been dominated by common reed, with a dense monoculture found around the perimeter of the marsh and most extensively along the broad shallow slope of the eastern shoreline. The marsh community is currently in a state of transition following a massive common reed eradication effort conducted in 2014. Prior to that, common reed was found in waters over a foot in depth (maximum depth varies with water level, with much of the population established under lower-water regimes). Much of the former common reed zone has now been planted with native marsh species, although establishment is hampered by the ongoing high-water levels. Other non-native species have also established themselves in this transition zone, including purple loosestrife and reed canary grass, each of which is subject to ongoing management efforts by the FPCC. A population of cattails remains at the north end of the site in shallow water, expanding and contracting from year to year based on changing depths and muskrat activity. Some submersed aquatic species are found in the open water zone, but have not yet been identified. The invasive common carp (*Cyprinus carpio*) does not appear to be present in the system, most likely due to occasional drying of the marsh during prolonged periods of drought.

Hemimarsh Restoration Potential

The potential to restore hemimarsh at Eggers Marsh will depend somewhat on the design of the new water control structure yet to be installed, and by the long-term water level management employed by the FPCC. The water level control structure will allow water levels to be dropped to achieve the desired mean target water elevation, approximately one foot lower than the current high-water level. This will help maintain the integrity of the dune woodland community and shallow marsh shoreline community. Lowering water levels further for most or all of a growing season will allow the FPCC to establish both an emergent and submersed aquatic plant community in water up to two feet in (final) depth, initiating the conditions under which a robust hemimarsh community may develop.

To develop hemimarsh habitat, it would be best to initially lower water levels, maximizing the area of bottom sediments exposed in order for them to dry and consolidate. If possible, water levels would be lowered in the fall (or at the latest, early spring), then held low long enough to stimulate a round of emergent germination and establishment. A fall drawdown would also facilitate seeding the marsh area. If water levels cannot be drawn down enough to expose a significant portion of the bottom sediments, then potted plants could be started on whatever portion is not exposed, i.e., in shallow water from 6–12 inches in depth. However, if sediments are loose and flocculent, it may be difficult to establish emergents, even in very shallow water.

A number of species may well germinate from an existing seed bank (including the invasive common reed, which will have to be treated). In addition to the native species that should be encouraged, additional species typically found in the region's hemimarsh communities could be introduced to enhance diversity. Such species include hardstem bulrush (*Schoenoplectus acutus*), softstem bulrush (*S. tabernaemontani*), three-square bulrush (*S. pungens*), river bulrush (*Bolboschoenus fluviatilis*), pickerel weed (*Pontedaria cordata*), or giant bur-reed (*Sparganium eurycarpum*). Broadleaf cattail (*Typha latifolia*) should also be considered being placed away from the shoreline: this provides some of the best marsh bird habitat structure, although it will require a commitment to maintaining it at a distance from the shoreline. Other marsh species more commonly found in shallower water that are consistent with the existing flora include sweet flag (*Acorus americanus*), lake sedge (*Carex lacustris*), or duck potato (*Sagittaria latifolia*). Low water could ideally be maintained for an entire growing season, but should stay low through at least mid-summer and be raised slowly enough to allow growing emergent shoots to stay above the surface.

While water levels are low, submersed species capable of providing habitat support for small fish, herps, and waterfowl could also be planted in both the hemimarsh and open water zones. These could include such species as wild celery (*Vallisneria americana*), sago pondweed (*Stuckenia pectinata*), nodding longleaf (*Potamogeton nodosus*), and white waterlily (*Nymphaea tuberosa*). At the same time, it will be critical to address the invasive community around the marsh perimeter in order to facilitate development of a shallow emergent marsh capable of supporting shallow marsh-dependent species, such as King Rail (*Rallus elegans*), Soras (*Porzana carolina*), and other wildlife.

Depending on the dynamics of muskrat activity and water level fluctuation, occasional drawdowns may need to be conducted on an intermittent basis to re-stimulate emergent establishment if the emergent plant cover falls below a suitable emergent-to-open water ratio. Once appropriate vegetation has been established, actively managing water levels at Eggers Marsh should be a relatively simple activity requiring only occasional monitoring (potentially coupled with occasional water level adjustments to mimic natural rhythms). An estimated 11.6 acres of hemimarsh could be developed and maintained at Eggers Marsh for many years to come (Figure 6). Assuming muskrats are active in the marsh, their population should expand sufficiently enough for the marsh to develop the characteristic interspersion ratio of 1:1 between emergent vegetation and open water in the deeper marsh zones.

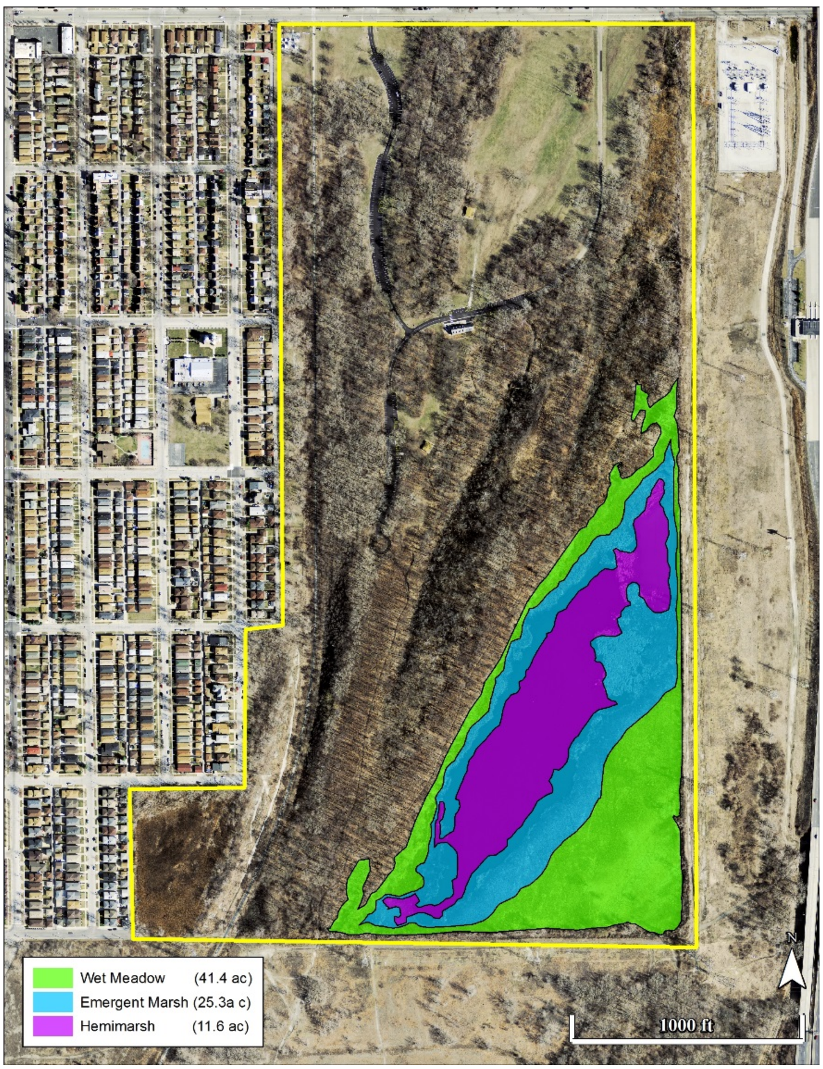


Figure 6. The projected distribution of marsh habitat that could be developed with appropriate water level management. The 16.1 acres in green is projected as wet meadow (currently open water and shallow marsh), the 13.7 acres in blue is projected as shallow marsh, and the 11.6 acres in purple is projected as hemimarsh habitat.

Recommendations

Our recommendations on how to proceed with hemimarsh restoration at Eggers Marsh will be dictated by the ability of the new outlet water control structure to lower water levels: i.e., the strategy will vary based on the extent to which water levels can be lowered. The initial drawdown will be the most critical in determining the course of restoration, in that the area of sediment exposed will determine where—and which—species will be able to develop. That said, only a few knowledge gaps require addressing at present, and none that would preclude taking further restoration actions once the new outlet structure is online. In order to develop a resilient and diverse hemimarsh, we recommend the following:

- Hydrology: utilize the new outlet control structure to adjust water levels for restoration purposes and ongoing management drawdowns;
- Invasive species: maintain the existing program to eliminate common reed, reed canary grass, purple loosestrife, and other invasive plants;
- Enhance diversity: plant additional species during a planned drawdown to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
- Fish community: if consistent with PFCC goals, introduce a community of small fish adapted to overwintering in shallower systems;
- Long-term management: utilizing an adaptive management approach, develop a strategy, and implement steps to sustain and enhance the marsh

Hydrology

Following installation of a new water-level control outlet structure, we recommend lowering water levels in the fall—provided it can be done early enough to avoid killing amphibians and reptiles after they have begun hibernation. With a fall drawdown, the bottom sediments can be seeded with native marsh species during late fall or early winter. A fall drawdown is also more beneficial for consolidating loose sediments and/or for killing common carp if they are in the system. Water levels should remain low at least through early summer, i.e., long enough for sediments to have dried and consolidated and for native marsh species to germinate and establish. Water levels can be left low even longer to achieve additional goals (e.g., invasive management), after which they can gradually be raised at a pace to maintain new marsh vegetation. If water levels cannot be lowered in the fall, they should be lowered early in the spring once water temperatures have begun to rise and daytime air temperatures are in the 40s (ºF) so that hibernating herps are not adversely affected. Once the low-water-level target elevation has been achieved, stratified native seed or plugs can be planted, after which water levels can gradually be allowed to rise, just as in a fall drawdown.

The new outlet structure will also give managers much greater flexibility in managing water levels during periods of normal operation (i.e., outside of a drawdown). Under normal operation, stop logs could be used to raise or lower water depths to mimic natural levels of variation associated with wet or dry years, or to assist in managing invasives around the shoreline, such as common reed. Another suggested initial step is simply installing a staff gauge and reading it periodically throughout the growing season. This would not only create a record of how water levels respond to precipitation and other weather phenomena (extremely important for managing the system adaptively), but also allow water levels to be adjusted quickly and easily as needed through the addition or removal of stop logs. The goal should be to manage water levels dynamically around the average water level, letting them naturally fluctuate both seasonally and inter-annually in response to severe precipitation events, snowmelt, or drought. The ability to then draw down water levels strategically will be critical to stimulate new plant germination and growth when emergent plant densities begin to drop lower than desired (as they inevitably will). Depending on how the new outlet structure is configured, it may not be possible to completely empty the marsh if the invert at the dropbox is higher than the deepest pool; this means that some water will always remain in the marsh unless it simply dries out.

The Plant Community: Managing Invasive Species and Enhancing Diversity

We recommend treatment of invasives as a top priority, regardless of whether a new outlet is installed. This treatment targets the remaining populations of non-native common reed, reed canary grass, and purple loosestrife along the shore through the ongoing application of appropriate herbicides. Common reed is the biggest invasive threat to restoring the marsh community; reed canary grass and purple loosestrife suppress native species from the margins of the marsh and continuing through all other wetland habitats. This ongoing effort must be maintained in order to bring these species under control. Concurrently with management actions, native marsh vegetation can be installed to develop the marsh community, as outlined in the 'Hemimarsh Restoration Potential' section above and in concert with the FPCC biologists managing this site. Water levels will have to be strategically lowered in order to establish emergent species away from shore, which will greatly assist in the establishment of shallow water, floating-leaved, and submersed species as well. Most emergents could be introduced through the planting of seed following a fall drawdown and/or plugs the following growing season before water levels re-establish. Water levels should be raised gradually as plants grow and elongate to keep the upper portion of the plants above the surface.

Fish Community

There appear to be no common carp in the marsh, potentially due to occasional drying during periods of drought. If this is borne out, no actions need be taken to keep carp out of the system. If carp are discovered, they should be eliminated through the application of a piscicide during the first drawdown for management purposes, or frozen out if water levels can be maintained sufficiently low throughout winter, following a fall drawdown. Since carp extermination usually means the loss of all fish unless they are first salvaged, the native fish community will have to be re-established. Although water levels will remain relatively shallow (maximum overwintering depths around three feet), it will be possible to establish a number of small fish species that are adapted to overwintering in shallow waters. To facilitate overwintering, it is possible to let water levels rise late in the fall by adding stop logs in order to achieve more depth. Candidates would be any previously found species, as well as central mudminnows (*Umbra limi*), star-headed top minnows (*Fundulus dispar*), or brown bullheads (*Ameiurus nebulosus*). These are not game fish; game fish would be inappropriate for this environment. However, there are also potential tradeoffs to consider: while these fish species play various beneficial roles in the aquatic environment (e.g., by eating mosquito larvae or serving as food for other species such as herons or turtles), their presence could make the marsh less attractive for breeding amphibians, especially salamanders.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management. FPCC has existing dedicated staff managing the Eggers Marsh system and actively engaging in conducting invasive management. The general approach we recommend for maintaining marsh vegetation and enhancing diversity is presented in detail in the introduction to these analyses. This includes strategies to manage the site adaptively both during and after the conclusion of active restoration activities. Moving forward, monitoring water levels and emergent vegetative cover will be critical for making informed decisions. Monitoring cattails should be a priority, especially in regard to which species occur and where they grow. Hybrid and narrowleaf cattails should be suppressed, especially in the shallow marsh and near shore meadows. Conversely, broadleaf cattails, especially in deeper water, are already an important component of the existing marsh community. The restoration and ongoing management of hemimarsh habitat within the marsh at Eggers should provide an invaluable extension of the impressive landscape mosaic at the Eggers Woods Preserve and a critical resource for the region's marsh-dependent species.

References

Illinois State Geological Survey. (1939). Unpublished material, Illinois historical aerial photographs: 1936 to 1941 v.4: Illinois State Geological Survey, Champaign, Illinois.

Hegewisch Marsh

Summary

Hegewisch Marsh is a 130-acre site located along the east side of the Calumet River just south of Lake Calumet. The site was once part of the extensive lake plain wetlands around Lake Calumet and is now owned by the Chicago Park District (CPD). It has a remnant marsh wetland holding up to 31 acres of water that has, at various times, functioned as a hemimarsh providing important habitat for marsh birds and other marsh-dependent species. The site has undergone various restoration activities since 2006, but there was little improvement to marsh function until the CPD began utilizing water level control in 2015 to maintain seasonal water levels.

Our analysis of the marsh's history, its current condition, and its restoration potential indicates that it could be enhanced and managed to develop up to 27 acres of high-quality marsh, including a potential 20 acres of rare hemimarsh habitat. High-quality hemimarsh, i.e. deep marsh habitat ranging from 1–3 feet deep, could be developed by initiating a modest monitoring program, improving the water-level management strategy, enhancing native marsh species and functional group diversity, managing wetland invasive species, and adaptively managing the marsh henceforth. Additional improvements to the potential quality of the marsh habitat could be made by re-contouring the marsh margins to create a more extensive marsh-to-upland transition zone. An introduction of small native fish could also enhance the marsh community and add to the site's diversity. This site can—and should—develop into one of the region's best marsh restorations, with the potential to develop significant hemimarsh characteristics.

Site Description

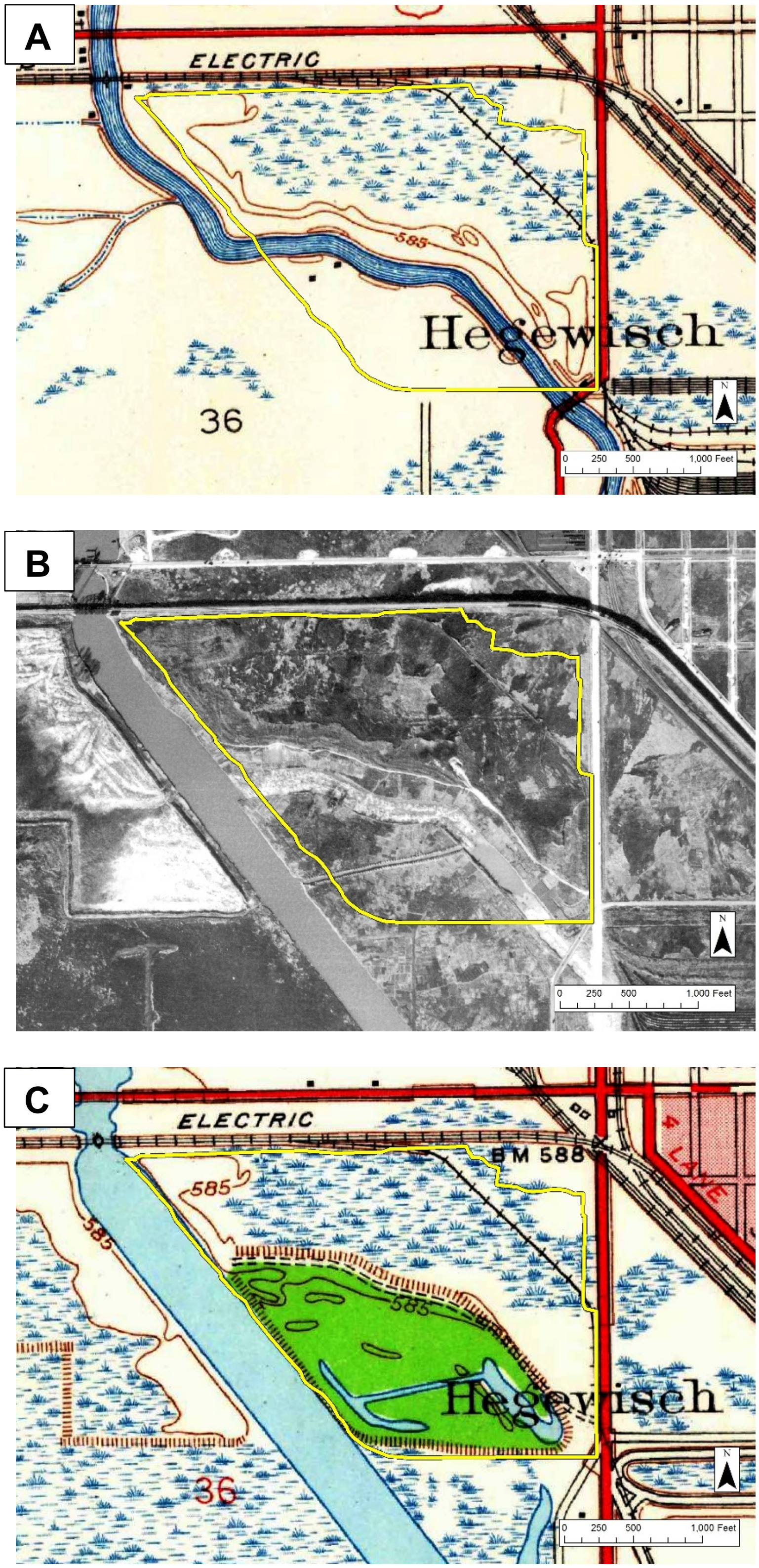
Hegewisch Marsh is a 130-acre area of mixed uplands and wetlands on the south side of Chicago located just southeast of Lake Calumet. The site, now owned and managed by the Chicago Park District (CPD), is bounded by the Calumet River to the west, the South Shore rail line to the north, S. Torrence Ave. to the east, and E. 134th St. to the south (Figure 1). An abandoned spur of the Chicago Lake Shore and South Bend Electric Railroad cuts across the northeast corner of the site (now mostly underwater). Most of the original marsh area has been filled with debris and other material. Those areas outside the marsh have been colonized and dominated primarily by trees: cottonwoods, black willows, and buckthorn. Approximately 31 acres of the old marsh remains, bounded by fill to the south and west, the South Shore line and fill to the north, and S. Torrence Ave. to the east. Due to the pattern of fill deposited, the profile of the marsh shoreline is relatively steep, dropping one or more feet in depth within a few feet of shore. Most of the floor of the remaining marsh appears to consist of material eroded from the adjacent fill mixed with original native sediments.

Hegewisch Marsh has been the subject of many studies over the past 20 years or more that were conducted as preliminary work in restoring natural habitat to the area (U.S. Army Corps of Engineers, 2012). Some of the work to restore natural functions to Hegewisch Marsh has already been conducted, including clearing invasive woody vegetation (e.g., buckthorn (*Rhamnus* species)), planting oak trees and prairie vegetation in openings, and digging shallow trenches to simulate ephemeral wetlands. A solar-powered pump and dropbox structure was also installed to assist in controlling hydrology, since the marsh floor is higher than the adjacent river and there are no other significant inputs. Significantly contaminated soils have since been capped and no longer pose a threat to human health. Cleanup activity included the removal of several tons of debris, including abandoned cars, tires, construction material, and miscellaneous refuse. A system of trails has now been established, and the marsh's quality in particular has improved quality since the CPD began actively managing the site in 2015. Additional restoration work sponsored by the U.S. Army Corps of Engineers (the Corps) is now being planned.

Figure 1. A spring 2008 satellite image of Hegewisch Marsh, with the South Shore rail line at the top, S. Torrence Ave. on the right, E. 134th St. on the bottom (leading to the O'Brien Lock and Dam), and the Calumet River on the left. Digital imagery courtesy of Cook County, 2008.

Hydrology

Over the past 100 years, the hydrology of Hegewisch Marsh has been significantly altered. It was once part of an extensive system of marsh wetlands surrounding Lake Calumet. The marsh, located just south of Lake Calumet, drained north through the Calumet River into Lake Michigan, near South Chicago. In 1938, the Calumet River bisected what is now the Hegewisch Marsh site into a northeast and southwest riparian zone (Figure 2A). Beginning in 1938, a portion of the Calumet River channel was filled in and moved to the south, redefining the western edge of the site by the new east bank of the river (Figure 2B). At various times since, clay fill and rubble were deposited (Figure 2C), reducing the marsh to its current 31-acre footprint and isolating it from the floodplain (Figure 3).



Figures 2A, 2B, and 2C. Hegewisch Marsh and the Calumet River during three periods of development, illustrating history of fill and re-channelization: (A) 1929 USGS map; (B) 1938 aerial photograph (Illinois State Geological Survey, 1938); and (C) 1952 USGS map.

Hydrology in the marsh basin is now driven by snowmelt, precipitation, and local runoff. Water levels in the marsh vary both among and within years, typically getting lower as summer progresses due to diminishing recharge from precipitation. Marsh depth is a function of water surface elevation, which is currently controlled by the stop log placement in the dropbox control structure at the outlet on the west side. The solar-powered pump at the same location may augment low water levels. The size of the marsh varies little with depth due to the steep basin sidewalls until water levels fall below 582 feet above mean sea level (MSL; all elevations are relative to the North American Vertical Datum of 1988 (NAVD88)).

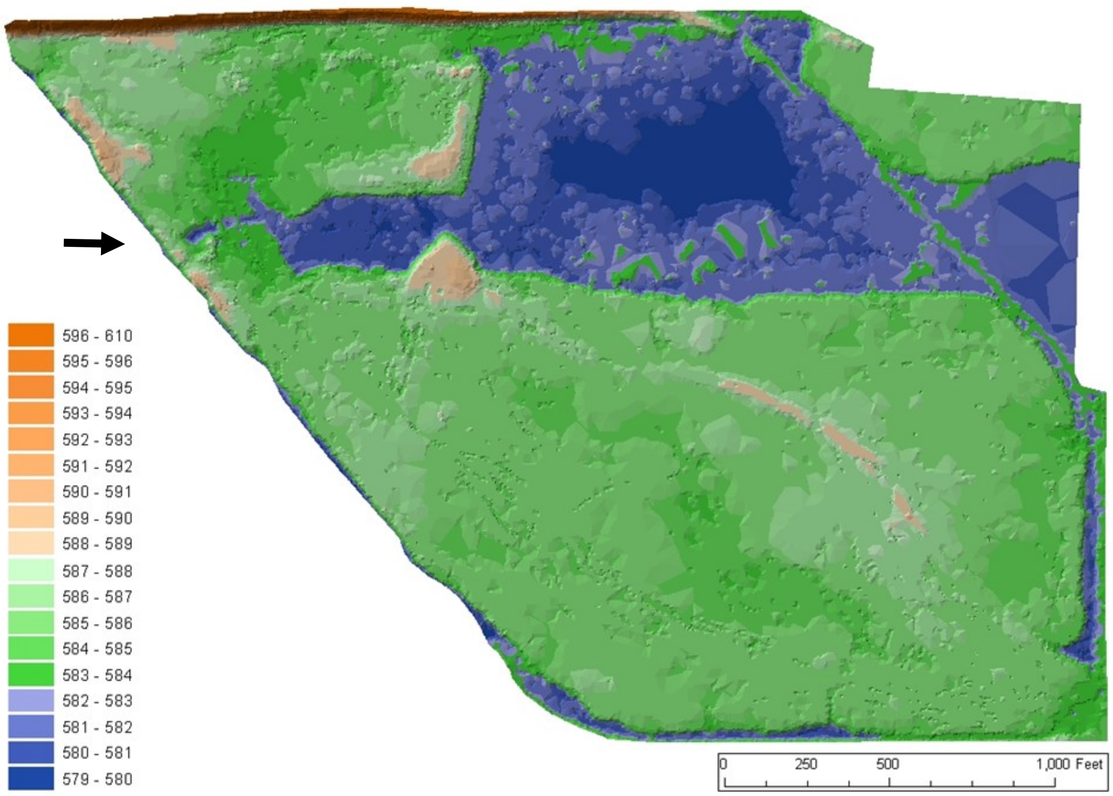


Figure 3. A three-dimensional surface generated from contour line data (data courtesy of U.S. Army Corps of Engineers) illustrating the current Hegewisch Marsh bathymetry and topography. The marsh and drainage swale elevations are depicted in shades of blue between 579 and 583 feet MSL NAVD88. The black arrow indicates location of the control structure determining water levels at the site.

Prior to CPD initiating water level management actions in 2014, the water control apparatus was not being utilized, either to prevent water from draining or to refill the marsh when it was drying out. With the marsh perched above the Calumet River (Figure 4), occasionally occurring extreme water losses were driven in part by percolation, while groundwater levels were low during the summer months. Perhaps more significantly, ground- and surface water was also being lost to the atmosphere through evapotranspiration associated with the extensive cottonwood (*Populus deltoides*) and black willow (*Salix nigra*) woodlands onsite. However, over the past few years, CPD has kept water levels higher with the placement of stop logs, and the pumping system has been put online to add water when levels drop too low. This has resulted in more predictably consistent water levels that support a higher-quality, perennial emergent marsh plant community. The new entryway constructed off S.

Torrence Ave. is now blocking an outlet channel that drained the site when water levels exceeded 584 feet MSL, so water levels are now controlled only at the west outlet along the Calumet River (Figure 3).

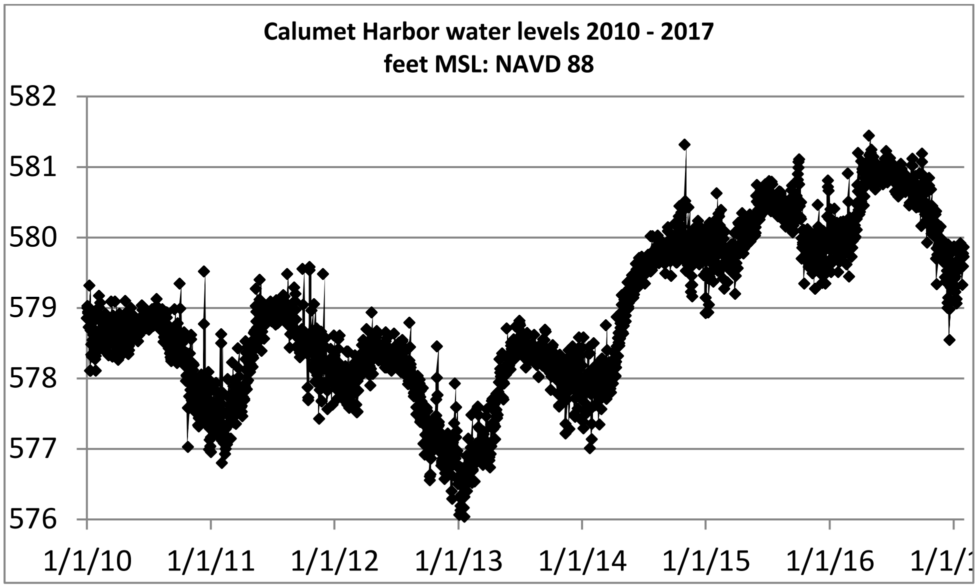


Figure 4. Mean daily surface water elevations of Lake Michigan and the Calumet River measured at the Calumet Harbor gauge (station 9087044) in feet MSL NAVD88 (converted from the International Great Lake Datum of 1985). (NOAA Tides and Currents, 2018).

Bathymetry and Topography

Over the past 60 years, Hegewisch Marsh has been used as a site to deposit fill and other refuse, raising ground surface elevations over most of the site to the extent that much of it no longer functioned as a marsh system. The fill deposition zones sit from 2–5 or more feet above the marsh floor, and drop down into the marsh at the edges on very steep slopes (Figure 3). Consequently, the marsh has been reduced from covering most of the 130-acre site to its current 31-acre footprint. This remaining portion of the marsh has a base elevation between 579 and 580 feet MSL, close to the current elevation of the Calumet River (mean of 579.6 ft. during January 2017), although this relationship can vary greatly among years (Figure 4). With the record high water level in Calumet Harbor at 583.3 feet MSL (in Oct. 1986), there has been no direct surface connection between the marsh and the Calumet River/Lake Michigan system since the old river channel was filled in 1939 (Figure 2).

Current Habitat and Invasive Species

Based on site visits both inside and outside of the growing season, it was possible to determine the general type of habitat currently found at Hegewisch Marsh (Figure 5). The marsh is now vegetated with a mix of annual and perennial species, including invasive species such as reed canary grass (*Phalaris arundinacea*) and common reed (*Phragmites australis*), which appear to have colonized over the past few years when the marsh was losing water and/or drying up. With the return of higher water levels under management by the CPD, the community is slowly evolving to one dominated by perennial emergent species, although non-native grasses still dominate the margins. Although conditions have improved, the marsh community is not yet stable, nor has it developed a significant submersed vegetation community. Cattails (*Typha* spp.), which declined significantly due to several years of low water stress coupled with muskrat activity, are slowly making a comeback. There are no common carp in the marsh, as it has a history of completely drying up during dry years (most recently 2012).

Most of the area outside the marsh is occupied by relatively open woodlands that are not easily classifiable into a natural community, i.e., they are mostly composed of early successional species that have established on degraded substrate. There are 38.4 acres of wet-mesic open woodlands dominated by cottonwoods and in some areas by black willow, 25.8 acres of mesic open woodlands dominated by cottonwood and silver maple, and 8.4 acres of wet woods, again dominated by cottonwoods. All of these areas have a significant reed canary grass presence. The woodlands are functionally analogous to wet-mesic savanna, mesic savanna, and northern flatwoods respectively, but they share few of the conservative species found in these natural communities. Given sufficient time, freedom from ongoing disturbance, and fairly intense invasive management, these areas could begin to develop more of the characteristics typical of Illinois natural communities.

Most of the area that is not marsh or woodlands may be loosely classified as wet or sedge meadow, or as either mesic or wet grasslands (based on landscape position relative to hydrology). The wet meadow zone is colonized by a relatively large number of wetland species, many of which are native. Conversely, the ‘grassland’ zones are relatively depauperate and dominated by either invasives (mesic grasslands) or switchgrass (*Panicum virgatum*; wet grasslands). The remaining areas include a 7.1-acre zone to the northeast recently turned over to the CPD by the Illinois Department of Transportation, a 0.5-acre shrub zone located on rubble along the north edge of the marsh, a 1.0-acre drainage swale to the south, and 1.0 acre of riparian shoreline along the Calumet River.

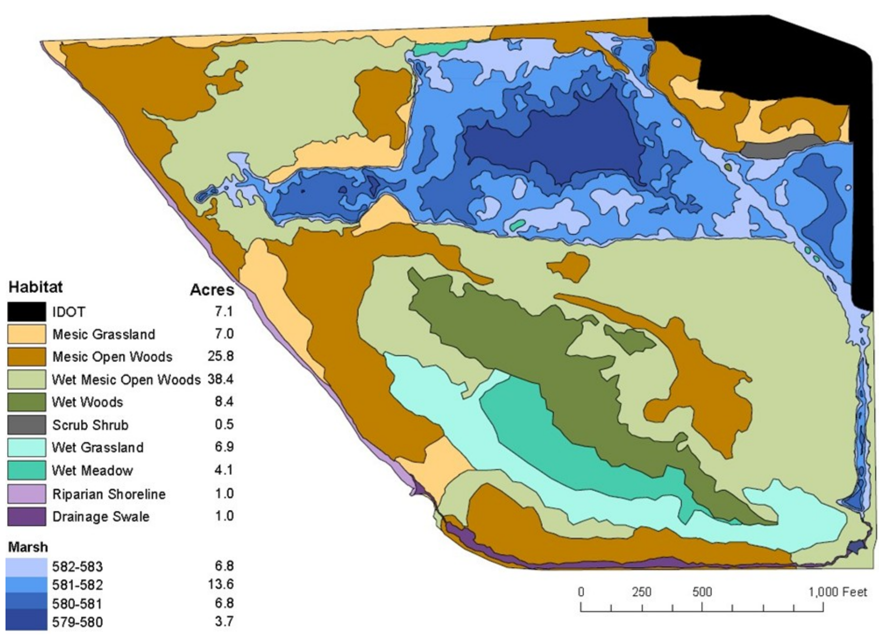


Figure 5. The distribution of habitat currently found at Hegewisch Marsh. Marsh area varies with water level, which, in this depiction, is ‘full’ at water surface elevation 583 feet MSL NAVD88. The marsh will not exceed 584 feet MSL due to a drainage swale at that elevation (east side).

Hemimarsh Restoration Potential

The CPD has already begun taking the most important step in restoring higher-quality marsh habitat at Hegewisch Marsh: utilizing the stop log control structure to set or lower water levels, as well as the solar-powered pumping system to maintain or raise water levels. The solar powered pump is controlled by a float-switch that can be set to maintain any given elevation within its range. However, if CPD wants to improve the quality of the existing marsh community, promote the conditions under which hemimarsh characteristics develop, and maintain those characteristics into the foreseeable future, a number of additional actions are to be considered.

Because of the timing in which water levels were allowed to rise as stop logs were inserted (i.e., prior to the growing season), the emergent community never fully established optimal density or diversity levels. Water levels should have remained low long enough for emergent species to germinate from seed or to be planted, then raised slowly only after the plants had begun to grow, (i.e., at a rate that would not overtop the establishing emergents). This would also include the installation or planting of submersed and floating-leaved species in addition to a greater diversity of emergent plants. It is now clearly better than what it was, but not nearly as good as it could be, and will not sustain itself in the absence of water level management. Managing water levels alone will not be sufficient to develop and maintain high-quality marsh conditions, however; an aggressive program of invasive plant management will also have to be implemented, in particular for common reed and reed canary grass.

Once appropriate vegetation has been established, maintaining water levels at or around an elevation that maximizes marsh vegetation should generally require little effort. However, this does include occasional monitoring coupled with water level adjustments as needed to reestablish emergent vegetation or to manage invasive species. With implementation of an appropriate adaptive management strategy, up to 20.4 acres of hemimarsh could be developed and maintained at Hegewisch Marsh into the foreseeable future (Figure 6).

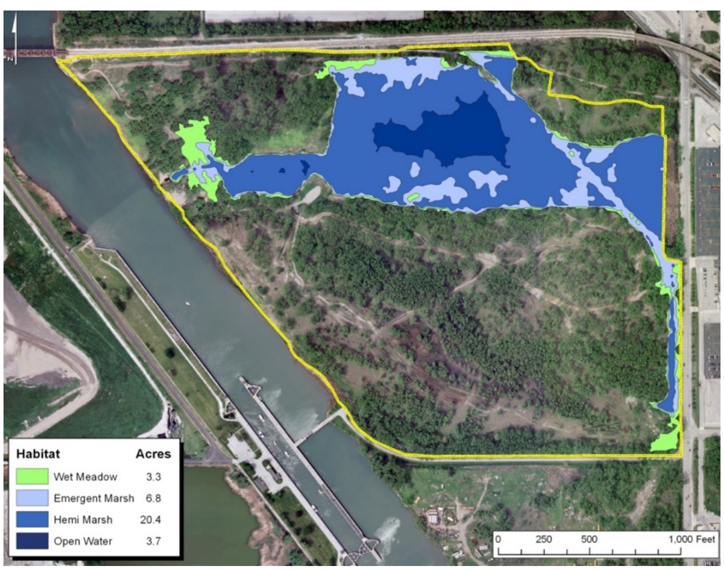


Figure 6. The projected distribution of marsh habitats based on a water level management strategy designed to maximize hemimarsh development. Digital imagery courtesy of Cook County, 2008.

Recommendations

Because of the restoration work completed at Hegewisch Marsh over the past few years and the foresight of CPD to restore functional water level control structures, many of the most important steps we might recommend have already been taken (or at least the necessary first steps in the process of restoring higher quality marsh functions). There are few knowledge gaps requiring addressing, and none that would preclude taking further restoration actions immediately. Specific steps that we recommend, should the decision to develop a more resilient and diverse hemimarsh be made, include:

- Hydrology: monitor water levels and utilize the dropbox control structure to adjust them for restoration purposes and ongoing management drawdowns;
- Topography/bathymetry: re-contour steep shoreline areas to create a more extensive shallow marsh-to-upland transition zone;
- Invasive species: initiate a program to eliminate common reed, reed canary grass, and other invasive plants;
- Enhance diversity: plant additional species during a planned drawdown to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
- Fish community: introduce a community of small fish adapted to overwintering in shallower systems;
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps that can be taken to sustain and enhance the marsh.

The recommended general approach for establishing marsh vegetation and enhancing diversity is presented in detail in the introduction to these analyses. The introduction also details an approach for developing a strategy to manage these sites adaptively both during and after the conclusion of active restoration activities. At Hegewisch Marsh, we strongly recommend addressing invasive species as soon as is practical, and, in particular, the remaining populations of common reed and reed canary grass through a joint land and aerial application effort. Common reed is the biggest invasive threat to restoring the marsh community, while reed canary grass suppresses native species from the shore up through all habitats found around the marsh. Devising and executing a long-term strategy to manage invasive species will be critical to the success of these restoration efforts.

Information on establishing a fish community in shallow systems is also detailed in the introduction to these analyses, should the CPD decide to incorporate fish to as a component of the marsh ecosystem. Fish can eat mosquito larvae and serve as food for other species, such as herons or turtles, but fish can make the marsh undesirable for many breeding amphibians, especially salamanders. Since there are currently no common carp in the marsh due to the lack of access and the marsh's history of drying, no actions need to be taken to keep carp out of the system (i.e., the water control structure appears to be sufficient). Specific recommendations addressing hydrologic and topographic restoration at Hegewisch Marsh are addressed below.

Hydrology

The first step in managing hydrology at Hegewisch Marsh is to decide an average elevation around which to manage marsh water levels. An elevation of 583.0 ft. results in the greatest surface area across which deep and shallow marsh could potentially develop (27.1 acres), resulting in the greatest potential area of hemimarsh (13.6 + 6.8 = 20.4 acres; Table 1). Choosing a mean water level of 583.0 feet MSL leaves another foot of freeboard to be utilized if desired, e.g., to assist in overwintering fish. Another recommended step is simply installing a staff gauge that can be read periodically throughout the growing season (the previous staff gauge was temporary). This would not only create a record of how water levels respond to precipitation and other weather phenomena (extremely important for managing the system adaptively), but would allow managers to respond quickly and easily if needed by adding or removing stop logs. The ability to manage water levels dynamically around an average water level is an important tool that facilitates both plant establishment and invasive management when such actions are warranted. If or when a complete drawdown is required, e.g., to re-stimulate the germination and establishment of emergent marsh vegetation, it will not be possible to completely empty the marsh as the system is now configured, as the invert at the dropbox is at approximately 581–582 feet MSL, which means that some water will always remain in the marsh unless the outlet is lowered (or it simply dries out).

Table 1
Water surface area, marsh area, and surface area distribution at one-foot depth intervals
[for each surface water level elevation between 580 and 584 feet msl navd88; total marsh area and potential hemimarsh area (1 to 3 feet in depth) are maximized at a surface water elevation of 583 feet msl (in yellow).]

Surface Water Elevation (ft. MSL)	Water Surface Area (ac.)	Total Marsh Area (ac.)	Marsh Zone			Open Water	
			0–1' deep	1–2' deep	2–3' deep	3–4' deep	4–5' deep
580	3.7	3.7	3.7				
581	10.5	10.5	6.8	3.7			
582	24.1	24.1	13.6	6.8	3.7		
583	30.8	27.1	6.7	13.6	6.8	3.7	
584	34.1	23.6	3.3	6.7	13.6	6.8	3.7

Bathymetry and Topography

Two of the last wetland areas at Hegewisch Marsh to be filled were the former north shore of the Calumet River (in 1939), and later the northeast corner of the marsh. These deposits not only filled in a significant portion of the marsh, but also eliminated any of the remaining marsh-to-upland transition zone. In order to develop higher-quality marsh habitat along the existing shoreline, the slope could be re-contoured by taking a cut-and-fill approach coupled with deposition in areas where exposing soil contaminants would be considered a problem. Currently, most of the shoreline rapidly drops off at a steep angle from the upland to a depth of 1–2 feet so that there is almost no upland-to-marsh transition zone. The upland along the shore itself is up to 30 inches above the water line even when the marsh levels are relatively high. There remain some contamination concerns from soils deposited along the shoreline, especially in the 'hot spot' areas that have now been capped. Other areas appear to be composed of poor-quality soils comprised of old fill and construction debris. Where appropriate, soil with high clay content could be utilized to build a shelf that extends the shallow zone further from shore, creating more area capable of supporting marsh vegetation. This would provide the added benefit of an additional cap over questionable materials in the existing fill abutting the pools.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management. CPD has dedicated staff to Hegewisch Marsh, who are actively engaged in managing the trails and conducting invasive management. Moving forward, the plan at minimum should be to maintain the gains that have been made, but ideally to further enhance the quality of the marsh, hemimarsh, and surrounding habitat. The impressive strides that have already been made at Hegewisch Marsh underscore the potential of this wetland to become one of the highest-quality hemimarsh systems in the region.

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Indian Ridge Marsh North

Summary

The north end of Indian Ridge Marsh is a 112-acre site located between the Calumet River and Lake Calumet. The site was once part of the extensive lake plain wetlands around Lake Calumet and is now owned by the Chicago Park District (CPD). It has a remnant marsh wetland holding up to 56.5 acres of water that has, at various times, functioned as a hemimarsh providing important habitat for marsh birds and other marsh-dependent species. The site has undergone various restoration activities since 2011, but none of this work was targeted at the marsh. Consequently, there has been little or no improvement to marsh function since the 1930s, the period during which it began to be used as a home for various types of fill.

Our analysis of the marsh's history, its current condition, and its restoration potential indicates that the marsh could be enhanced and managed to develop 11.2 acres of higher-quality marsh habitat, including a potential 7.4 acres of rare hemimarsh habitat. Higher-quality hemimarsh, which in this system would be shallow to mid-depth marsh habitat found in water up from 1.0 to 2.0 feet in depth, could be developed by properly managing the recently modified water-level control structure, i.e., initiating a relatively modest water-level monitoring program, improving the water-level management strategy, enhancing native marsh species and functional group diversity, managing wetland invasive species, and adaptively managing the marsh henceforth. Additional improvements to the quality of the marsh habitat could be made through re-contouring the marsh margins to create a more extensive marsh-to-upland transition zone. With proper marsh management and the development of hemimarsh characteristics, this site could become one of the Calumet's more significant migratory and breeding bird habitat resources.

Site Description

Indian Ridge Marsh North (IRN) is the 112-acre northern portion of the 151-acre Indian Ridge Marsh (IRM). The site includes approximately 56.5 acres of marsh wetlands and open water (Figure 1). IRN is located within the City of Chicago and is bounded by S. Torrence Ave. to the east, 116th Street to the north, the Norfolk Southern Railroad to the west, and E. 122nd St. to the south. The site has been owned and managed by the Chicago Park District (CPD) since early 2016; prior to 2016, the site was owned and managed by the City of Chicago.

Indian Ridge Marsh, both north and south of E. 122nd Street, was once part of the vast wetland system associated with Lake Calumet. By 1939, the process of filling most of the IRN wetland had already begun (Figure 1). By 2016, the remaining open water areas were those not receiving fill, while nearly all of the area outside the pools is upland (Figure 2).

Figure 1. 1939 aerial image of the east Lake Calumet wetlands, with the north end of Indian Ridge Marsh outlined in yellow (Illinois State Geological Survey, 1939). [Note the causeway at the south end of the site running west from S. Torrence Ave., which was later to become E. 122nd Street (dashed line in blue).]

Figure 2. 2016 aerial image of the former east Lake Calumet wetlands, with the north end of Indian Ridge Marsh outlined in yellow. Imagery courtesy of Google Earth.

Recognizing the potential to restore wetland functions at IRM, the U.S. Army Corps of Engineers (the Corps), working with the City of Chicago, began restoring wetland and upland habitat there in 2011. The primary goals of this initial effort were outlined in *Brownfield Redevelopment and Ecological Restoration at Indian Ridge Marsh, Chicago, Illinois* (Smalley et al. 2009), which, in essence, were to restore appropriate native plant habitat for the benefit of wildlife and the public. Details of the restoration plan can be found in the *Design Analysis Report* (Final 100% Design Submittal) *of the Indian Ridge Marsh Ecological Restoration Project* (Tetra Tech EM, Inc., 2009). That plan called for massive quantities of fill and debris to be removed, hydrology to be stabilized and controlled, invasive species to be treated, and native communities to be installed. The scope of this work at IRN was limited to the uplands and wetlands outside of the open water pools (Figure 3). In addition to the open water pools, a 21.5-acre area to the NW that was previously used for nesting by Black-crowned Night-Herons (*Nycticorax nycticorax*) was also excluded to protect the nesting zone.

Figure 3. The Corps' 112-acre Indian Ridge Marsh (north) restoration site outlined in yellow, and the 21.5-acre Black-crowned Night-Heron exclusion zone outlined in red. Imagery courtesy of Google Earth.

Nearly all of the watered areas at IRN can be characterized by steep-sided banks dropping to a near-shore depth of 1–3 feet. A narrow drainage channel runs parallel and adjacent to the entire western shore. Most of IRN is less than 2 feet deep, with scattered areas in each pool as deep as 3 feet, and one pool up to 8 feet in depth (Figure 4). The water level is controlled at 582.5 feet MSL by the dropbox culvert and outlet structure at SW corner of the site adjacent to E. 122nd Street. Part of the Corps' restoration strategy was to reintroduce native fish species following the eradication of *Cyprinus carpio* (common carp). It was initially belived that carp were successfully eradicated with the piscicide treatment of rotenone and prevented from reinvading by the configuration of the dropbox and outlet structure; however, a 2017 electroshocking survey by Illinois Department of Natural Resources Fisheries personnel revealed that adult carp in breeding condition remain, as well as a large population of *Carassius auratus* (common goldfish). A number of smaller native fish were also found in the pools, although several of the species stocked during the Corps-sponsored restoration effort were not detected. The open water pools of IRN are devoid of emergent vegetation (other than common reed) and of submersed aquatic vegetation (most likely a consequence of the previous common carp population).

The upland areas represent the legacy of fill (including slag, concrete, brick and other construction rubble) and assorted debris (tires, cars, garbage, etc.). Based on soil borings conducted by Civil and Environmental Consultants, Inc. (as reported in the 2009 Tetra Tech 100% Final Design Submittal to the Corps), soil from 580.0 feet MSL (the approximate water table) and below appears to be 5–8 feet of relatively undisturbed gravel or silty sand overlying at least 20–30 feet of lean clay (to bottom of borings).

Hydrology

Water enters IRN from at least four sources: from the west through a railroad ballast and three culverts under the rail line draining approximately 13 acres of the Cluster superfund site, through a culvert draining the Coke Plant site to the north under the west end of 116th Street, through a surface runoff from the east and S. Torrence Ave. overflows, and from minor groundwater inputs to the IRN east pools (Roadcap et al., 1999). Little is known what ecotoxicology issues result from water entering IRN from the Cluster site or the Coke Plant site, although high concentrations of ammonium have been measured at the site and are believed to originate at the Cluster site. In general, water flows through the IRN wetlands on the west side from north to south, with the bulk of the flow traveling through the deeper drainage way parallel to the Norfolk Southern Railroad to the west. The IRN eastern pools (Pools 2, 3, 6, and 9) primarily drain to the west through surface swales or groundwater connections. All water eventually leaves the site and drains into Indian Ridge Marsh South through the dropbox culvert at E. 122nd Street.

Bathymetry

A bathymetric study of IRM was sponsored by Tetra Tech in order to inform the restoration planning effort at the site. One-foot contour drawings prepared in 2010 from this study were published in the Corps' 2014 Draft Operation and Maintenance Manual. Based on these contours and personal observations, most of the pool area at IRN is less than 581 feet MSL, i.e., less than 1.5 feet in depth when the pool is in equilibrium with the invert of the drop-culvert control structure (582.5 feet MSL). The narrow drainage channel running along the west side and parallel to the Norfolk Southern Railroad ranges in depth from 1.5–3.5 feet deep (through pools 1, 4, and 7). Although most of IRN is less than 1.5 feet deep, parts of Pool 5 have been measured up to 8 feet in depth due to former sand mining. Most of the area within the Black-crowned Night-Heron exclusion zone at the north end of Pool 1 is much less than 1.5 feet deep.

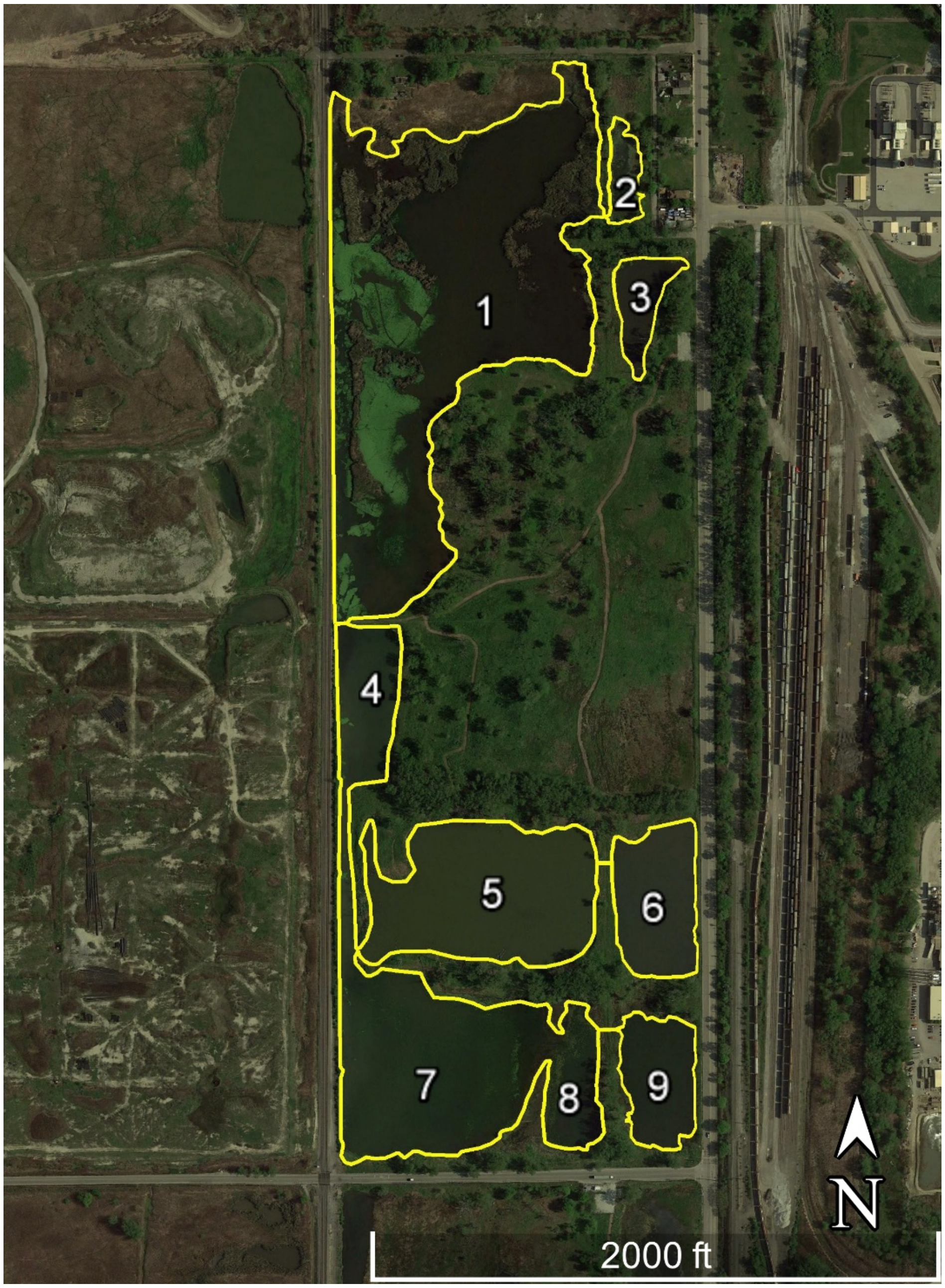

Figure 4. The 56.5 acres of pools at Indian Ridge Marsh north. Depths vary, with Pool 2 the shallowest at ~0.5 feet, and Pool 5 the deepest with depths of nearly 8.0 feet. Imagery courtesy of Google Earth.

Invasive Species

Following the 2011–2015 restoration efforts sponsored by the Corps, many of the invasive species at IRN were strongly suppressed—but not entirely eliminated. Due to the lengthy transition in ownership from the City of Chicago to the CPD (completed in 2016), many of these plant species had a chance to rebound following the end of active Corps-sponsored restoration. By far the most troublesome of these species at IRN throughout the wetlands is common reed (*Phragmites australis*), which is now scattered in the wet prairie, wet meadow, and marsh along the shorelines. Common reed and other non-natives in the Black-crowned Night-Heron exclusion zone are currently being eliminated as part of a restoration effort begun in 2016 by The Wetlands Initiative and Audubon Great Lakes in partnership with the CPD. Other wetland invasives in the marsh include *Phalaris arundinacea* (reed canary grass), *Lythrum salicaria* (purple loosestrife), and *Typha angustifolia* (narrowleaf cattail).

Hemimarsh Restoration Potential

None of the restoration work sponsored by the Corps addressed the 56.5 acres of surface water pools—i.e., no work was done beyond the shoreline. Beginning in 2016, restoration work has been conducted by The Wetlands Initiative and Audubon Great Lakes on the 21.5-acre Black-crowned Night-Heron exclusion zone at the north end of IRN, an area that has since been expanded to approximately 35.0 acres. This includes 25.4 acres of surface water (Pool 1), of which 7.4 acres will be potentially restored as mixed open water and emergent marsh under an improved water-level management strategy (Figure 4). It is likely that emergent vegetation would establish in this area since the water is relatively shallow, with the shallowest areas having been colonized by common reed for quite some time. Following successful treatment of common reed throughout the area, emergent and submersed species were planted in 2017 and 2018, as well as 5.2 acres of wet meadow and prairie species along the north end of the site. Local populations of common carp and goldfish have hampered the establishment of native marsh vegetation; ongoing invasive management by the aforementioned partners will be conducted through September of 2018.

Without water level management, it is unlikely that a significant quantity of shallow or hemimarsh would develop, primarily due to the combination of invasive species, poor water quality, and fixed water levels. The Corps previously recommended that IRN water levels remain static at 582.5 ft. MSL and controlled by the dropbox culvert at E. 122nd Street. With carp and goldfish activity and static water levels, there is low likelihood that enough light will penetrate to stimulate seed germination and establishment beyond the marsh edge. Summer algal blooms stimulated by high nitrogen levels also diminish light penetration. As long as common carp remain in the system, there is scant potential to establish native submersed and emergent vegetation away from shore. However, the recent modification to the outlet structure adjacent to E. 122nd St. will allow water levels to be lowered up to 12 inches, which will expose nearly half of the bottom sediments in Pools 1, 2, 4, 7, and 8. This will also significantly reduce the volume of water north of E. 122nd St., which in turn will facilitate a future carp eradication effort.

To develop hemimarsh habitat, it will be necessary to continue managing the common reed infestation along the shoreline and in shallower water. Secondly, the distribution of emergent vegetation should be maximized across the range of depths in which it can occur. Initially, water levels could be lowered in the spring and held low long enough to stimulate a round of emergent germination and establishment. This can—and should—be supplemented with planting plugs of desired emergent species, e.g., broadleaf cattail (*Typha latifolia*), hardstem bulrush (*Schoenoplectus acutus*), softstem bulrush (*S. tabernaemontani*), three-square bulrush (*S. pungens*), river bulrush (*Bolboschoenus fluviatilis*), pickerel weed (*Pontedaria cordata*), or giant bur-reed (*Sparganium eurycarpum*). Other marsh species more commonly found in shallower water could also be planted at this time, e.g., sweet flag (*Acorus americanus*), lake sedge (*Carex lacustris*), or duck potato (*Sagittaria latifolia*). This could be done for as long as an entire growing season, but should at least occur from early spring through mid-summer. During the drawdown, submersed species capable of providing habitat support for small fish, herps, and waterfowl should also be planted in both the hemimarsh and open water zones, such as wild celery (*Vallisneria americana*), sago pondweed (*Stuckenia pectinata*), nodding longleaf (*Potamogeton nodosus*), and white waterlily (*Nymphaea tuberosa*). It will also be critical to address the invasive community around the marsh perimeter in order to develop a shallow emergent marsh capable of supporting shallow marsh bird species, such as King Rail (*Rallus elegans*) and other wildlife.

Recommendations

There are a number of steps aimed at increasing the area restored as hemimarsh as well as the overall quality of the habitat, once restored. The first is to address significant existing knowledge gaps, primarily in regard to bathymetry. The existing bathymetric data is of low resolution and error-prone; the ability to plan additional marsh restoration will be difficult without better information on depth profiles, i.e., information indicating the extent of potential habitat across a specific range of depths. Another knowledge gap is ecotoxicology: a significant portion of the water entering IRN comes from the Cluster superfund site and S. Paxton landfills through culverts under the railroad tracks along the northwest end of the site. We do not know the extent to which this runoff contains toxic material or is a potential threat to human health or wildlife. High concentrations of ammonium have been reported, which can be directly toxic, and high levels of ammonium can also initiate cycles of low light and oxygen associated with nitrogen-fueled algal blooms. Workers on the site have also reported milky substances in the water and noxious fumes following rain events. Filling these knowledge gaps will be a crucial step in improving the overall quality and safety of the restoration, and for adaptively managing the site in the future.

In addition to addressing these gaps in our knowledge of IRN, a number of other important actions to be undertaken include:

- Hydrology: begin managing the dropbox outlet structure to adjust water levels for restoration purposes and ongoing management;
- Hydrology: connect the isolated eastern pools to the main pools;
- Invasive species: eliminate common reed and other invasive plants;
- Enhance diversity: establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
- Infrastructure removal and cleanup: removing non-functional infrastructure, e.g., power line poles and wires; remove debris and building foundations, stop the discharge of raw sewage into the marsh;
- Topography/bathymetry: modify the shoreline to create a marsh-to-upland transition zone;
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps that can be taken to sustain and enhance the marsh.

Specific recommendations are detailed below, with a general approach to managing invasive species, enhancing diversity, and adaptively managing the site covered in greater detail in the introduction to these analyses.

Hydrology

The dropbox outlet structure should be managed so that water levels can be strategically lowered, thus facilitating development of the marsh community. This would also allow water levels to be managed dynamically, fluctuating both seasonally and inter-annually in response to changing precipitation and temperature patterns. The ability to draw water levels down will be critical for stimulating new plant germination and growth when emergent plant densities begin to drop lower than desired. Directly connecting the isolated pools to the main pool is another important action for managing water levels across the site.

Another recommended initial step is simply installing a staff gauge and having it read periodically throughout the growing season. This would not only create a record of how water levels respond to precipitation and other weather phenomena (extremely important for managing the system adaptively), but also allow water levels to be adjusted quickly and easily as conditions within the marsh dictate.

Invasive species management

An important early step in the restoration process will be to eliminate marsh invasive species. The remaining monocultures of common reed in particular must be removed, in this case through a joint shore and aerial application effort. Although this action is already underway within the Black-crowned Night-Heron exclusion zone, marsh invasives found elsewhere throughout IRN will still need to be addressed. Due to an extensive seed bank and the difficulty of enacting a complete kill in one or even two applications of herbicide, this will, by necessity, be a multiyear effort followed up with spot checks for several years thereafter.

Enhance Diversity

Once these efforts have been undertaken and largely completed, native marsh vegetation should be introduced. Although IRN does not currently support a native marsh community, a diverse community of shallow water marsh, emergent and floating-leaved species, and submersed species should be introduced as long as water levels can be strategically lowered and managed to facilitate the initial introduction; such species will also greatly assist in the establishment of additional shallow water and submersed species. Most emergents could be introduced through the planting of seed and plugs in one growing season, allowing water levels to naturally re-establish as plants grow and elongate to keep up with the rising water surface.

Infrastructure Removal and Cleanup

A number of circumstances are found across IRN that should be addressed in order to work to be safely conducted at the site, for plants and wildlife to flourish, and for aesthetic reasons. Several active power lines on decomposing poles emerge from the pools, which create a hazard for those working around the pools (especially in the aerial application of herbicides). These poles, along with the tons of debris that have been dumped across the site, are not part of a natural landscape and should be removed. Another risk to the restoration and worker safety is the poor water quality due to the direct and ongoing discharge of raw sewage from one of the houses adjacent to the NE corner of the site. As aforementioned, these concerns also extend to the quality of water from the Cluster superfund site to the west, as well as from the Coke site to the north.

Bathymetry and Topography

Currently, most of the shoreline rapidly drops off at a steep angle from the upland to a depth of 1–2 feet so that there is no upland-to-marsh transition zone. Despite contamination concerns from buried fill along the shoreline, soil with high clay content could be introduced to build a shelf that extends the shoreline to create a shallow water zone capable of supporting marsh vegetation. An added benefit to this approach is that it would further serve to cap potential toxic materials in the upland fill abutting the pools.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management, a responsibility of the landowner, the Chicago Park District. A commitment to long-term management is critical to the success of any restoration, and this site is no exception. CPD already has dedicated IRN staff conducting invasive management; and moving forward, a number of specific actions could be incorporated to improve longitudinal outcomes as part of a long-term strategy of adaptively managing the site. Specific actions that apply to this and all restoration sites are reported at length in the introduction to these analyses.

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Indian Ridge Marsh South

Summary

The south end of Indian Ridge Marsh is a 39-acre site located between the Calumet River and Lake Calumet. The site was once part of the extensive lake plain wetlands around Lake Calumet and is now owned by the Chicago Park District (CPD). It has a remnant marsh wetland holding approximately 23.3 acres of water that has, at various times, functioned partly as a hemimarsh providing important habitat for marsh birds and other marsh-dependent species. The site has undergone extensive restoration activities since 2011, but little of this work has resulted in developing high-quality deep marsh, i.e., a wetland that could potentially develop into hemimarsh habitat.

Our analysis of the marsh's history, its current condition, and its restoration potential indicates that the marsh could be enhanced and managed to develop 23.2 acres of higher-quality marsh habitat, including a potential 15.4 acres of rare hemimarsh habitat. Higher-quality hemimarsh, which in this system would be shallow to mid-depth marsh habitat found in water from 1.0 to 2.0 feet in depth, could be developed by utilizing a water-level control structure (currently un-utilized), initiating a modest water-level monitoring program, implementing a water-level management strategy, enhancing native marsh species and functional group diversity, managing wetland invasive species, and adaptively managing the marsh henceforth. Additional improvements to the quality of the marsh habitat could be made through re-contouring the marsh margins to create a more extensive marsh-to-upland transition zone. With proper marsh management and the development of hemimarsh characteristics, this site could become an exemplar of the resources of the Calumet's migratory and breeding bird habitat.

Site Description

Indian Ridge Marsh, both north and south of E. 122nd Street, was once part of the vast wetland system associated with the margins of Lake Calumet (Figure 1). The southern portion of Indian Ridge Marsh (IRS) is a 39.3-acre site that currently holds approximately 23.3 acres of wetlands, including 20.8 acres of marsh wetlands and 2.6 acres of open water (Figure 2). The site is located within the City of Chicago and is bounded by Torrence Ave. to the east, E. 122nd Street to the north, the Norfolk Southern Railroad to the west, and land owned by the Metropolitan Water Reclamation District of Greater Chicago on the north shore of the Calumet River to the south. The site has been owned and managed by the Chicago Park District (CPD) since early 2016; prior to 2016, the site was owned and managed by the City of Chicago.

Recognizing the potential to restore wetland functions at IRS, the United States Army Corps of Engineers (the Corps), working with the City of Chicago, began restoring wetland and upland habitat there and at the portion of Indian Ridge Marsh north of E. 122nd Street (IRN) in 2011. The primary goals of this initial effort were outlined in *Brownfield Redevelopment and Ecological Restoration at Indian Ridge Marsh, Chicago, Illinois* (Smalley et al., 2009), which, in essence, were to restore appropriate native plant habitat for the benefit of wildlife and the public. Details of the restoration plan can be found in the *Design Analysis Report* (Final 100% Design Submittal) *of the Indian Ridge Marsh Ecological Restoration Project*, prepared by Tetra Tech EM, Inc. and submitted to the Corps in November 2009. That plan called for massive quantities of debris to be removed, hydrology to be stabilized and controlled, invasive species to be treated, and native communities to be installed.

Although most of the IRS wetland areas were restored by the end of the 2014 growing season, some of the common reed (*Phragmites australis*) removal and rehabilitation work was never completed. Consequently, much of the marsh zone has been recolonized by common reed prior to the site being transferred to the CPD.

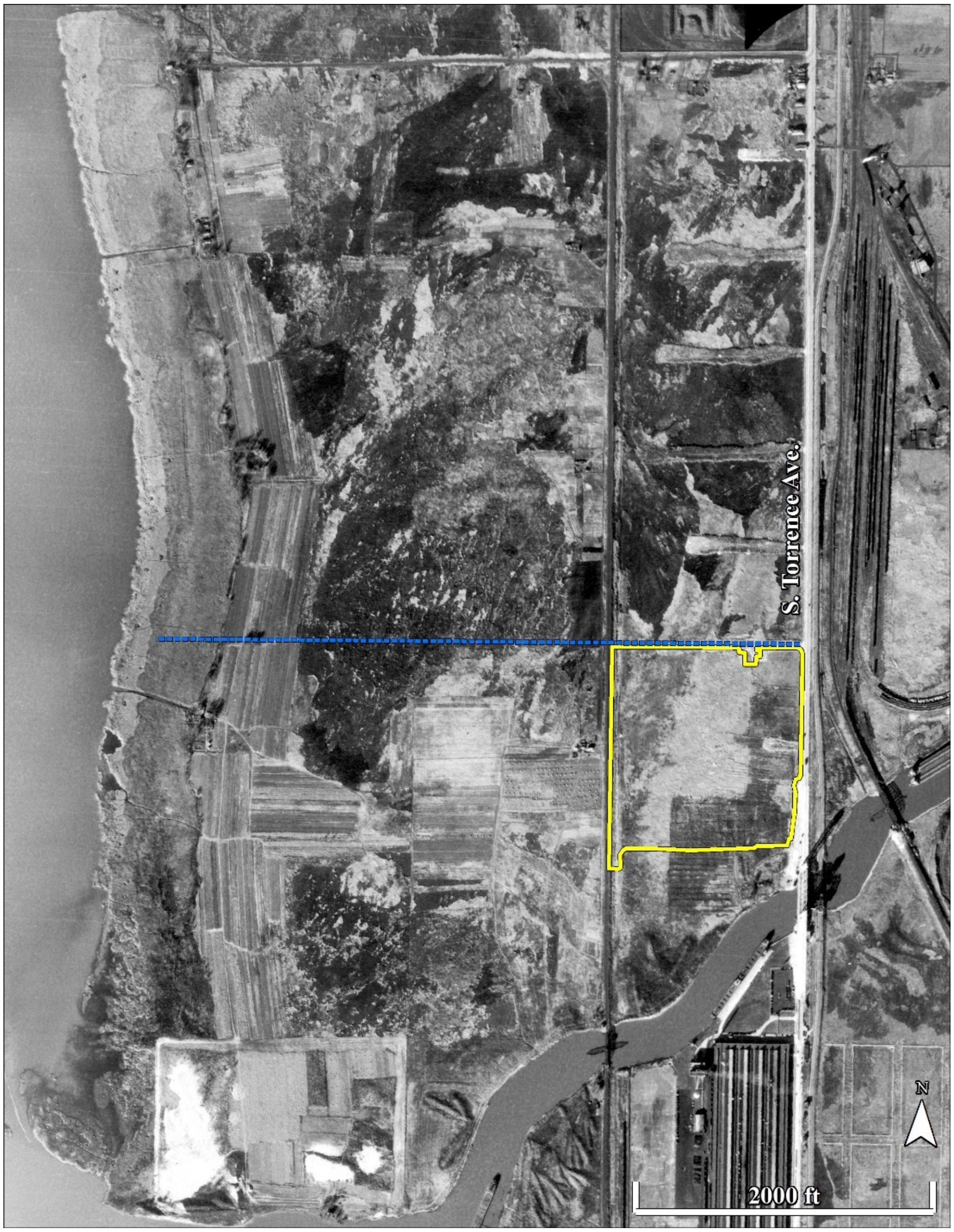

Figure 1. 1939 aerial image of the east Lake Calumet wetlands, with the south end of Indian Ridge Marsh outlined in yellow (Illinois State Geological Survey, 1939). [Note the causeway at the north end of the site running west from S. Torrence Ave., which was later to become E. 122nd Street (dashed line in blue).]

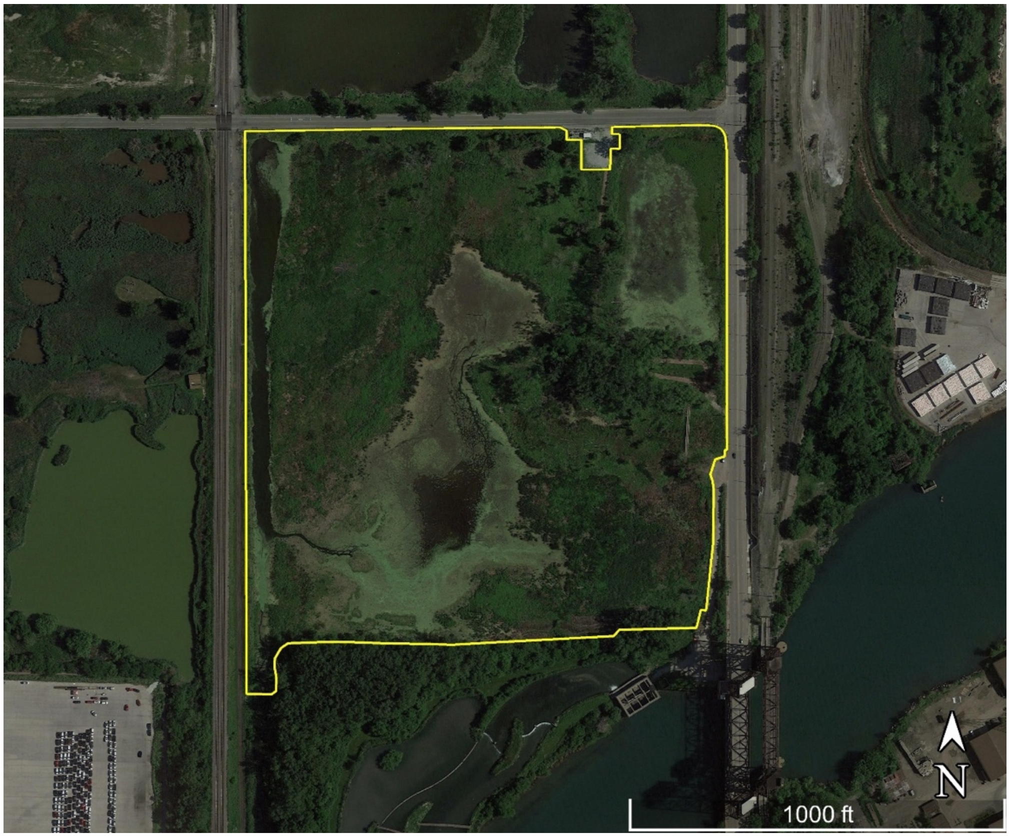

Figure 2. Aerial image of the 39.3-acre Indian Ridge South site outlined in yellow. Imagery courtesy of Google Earth, 2016.

Currently, the main 20.1-acre wetland pool at IRS can be characterized by depths of little more than a foot from a surface water elevation of ~581 feet MSL, with water draining south to the Calumet River by gravity through an outlet at the southwest corner of the site. A deeper channel up to 3 feet deep runs parallel to the Norfolk Southern rail line and carries water draining from IRN to the outlet. Most of the relatively steep IRS shoreline was constructed by the deposition of fill, dropping to depths of little more than a foot from a surface water elevation of ~581 feet MSL. Other parts of the shoreline not impacted by fill still have more natural, shallow-sloped contours. Water levels do not drop below ~581 feet MSL, as that is the approximate elevation of the invert at the outlet channel. There is a stop-log water level control structure at the outlet that was constructed under the Corps' sponsored restoration effort that could, if utilized, increase the pool elevation by 1.5 feet and the pool footprint by 9.4 acres. There is also a second, 3.2-acre pool in the NE corner of the site that appears to be perched above the main pool at a depth of approximately 1 foot with a surface water elevation of ~582 feet MSL. Water levels in either pool vary seasonally with periods of dry weather, precipitation, and snowmelt.

Hydrology

Water enters IRS from at least three sources: from the north through the outlet draining IRN under E. 122nd Street, from groundwater moving in from Heron Pond to the west under the Norfolk Southern rail line, and from local surface runoff and occasional drainage from Torrence Ave. overflows (Roadcap et al., 1999). The IRS eastern pool appears to drain to the main western pool solely through a groundwater connection. In general, most of the water flows through the IRS wetlands from north to south, with the bulk of the flow traveling through the deeper drainage way parallel to the Norfolk Southern rail line to the west. All water eventually drains from the site into the Calumet River through the outlet channel at the SW corner of the site. It is also possible for water to flow into the site from the Calumet River when Lake Michigan water levels exceed the outlet elevation of ~581 feet MSL (or higher if the stop logs are being used to maintain higher water levels within IRS), although Lake Michigan only rarely exceeds this elevation (Figure 3). When this does occur, IRS equilibrates with the Calumet River at the river surface elevation. It is currently unknown which ecotoxicology issues result from water entering IRS, although high concentrations of ammonia have been reported in water coming in from IRN.

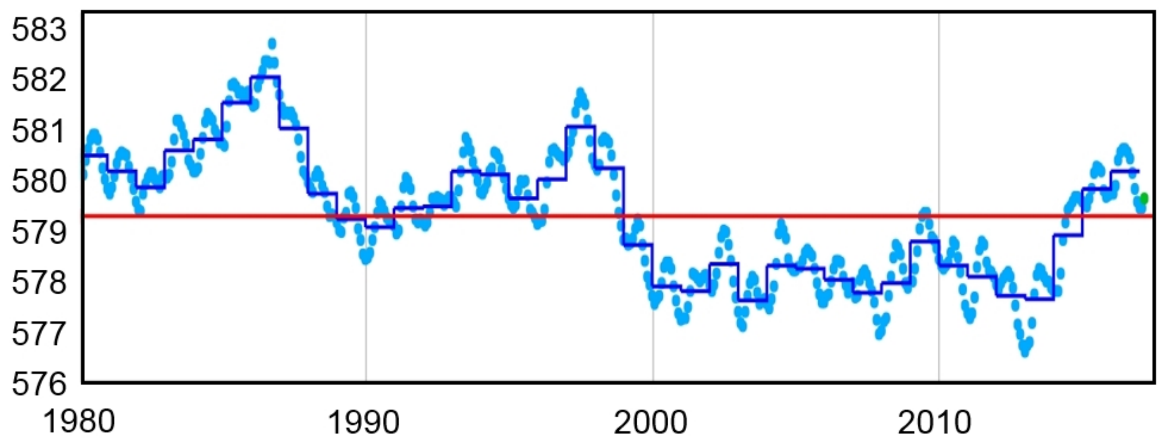

Figure 3. Mean monthly (dots), annual (blue line), and 100-year average (red line) surface water elevations of Lake Michigan in feet relative to mean sea level NAVD88 (North American Vertical Datum of 1988) from 1980 to the present (NOAA 2017). The period shown includes the highest water surface elevations ever recorded (October 1986) and the lowest (January 2013).

Bathymetry

Tetra Tech sponsored a bathymetric study of IRM in order to inform the Corps-sponsored restoration effort at the site. One-foot contour drawings prepared in 2010 from this study were published in the Corps' 2014 *Draft Operation and Maintenance Manual*. Based on these contours, most of the pool area at IRS falls between 580 and 581 feet MSL, i.e., less than 1 foot in depth throughout most of the site when the outlet is open, i.e., the stop logs are not in place. The deeper narrow drainage channel running parallel to the Norfolk Southern rail line ranges in depth from 3–5 feet deep. The smaller, isolated pool to the east appears to be perched above the main IRS pool at a depth of approximately 1 foot at a surface water elevation of ~582 feet MSL.

Current Habitat and Invasive Species

During the 2011–2014 restoration efforts sponsored by the Corps, a somewhat diverse community of native upland and wetland species were introduced to IRS. Many of these species have established, but a rapidly expanding community of invasive species that were strongly suppressed—but not entirely eliminated—during restoration activities now compromises the wetlands. Due to the lengthy transition in ownership from the City of Chicago to the CPD (completed in 2016), many of these invasives had a chance to rebound following a period of scant management during the 2015–2016 growing seasons. By far the most troublesome of these species is common reed (*Phragmites australis*), which is now scattered widely across all of IRS. Other wetland invasives include *Phalaris arundinacea* (reed canary grass), *Lythrum salicaria* (purple loosestrife), *Typha angustifolia* (narrowleaf cattail), and *Typha x glauca* (hybrid cattail), although these do not currently pose the same level of threat as common reed if they are addressed relatively soon.

The primary invasive animal species threatening the marsh is *Cyprinus carpio* (common carp). An extensive population of common carp persists unchecked within the IRS wetlands, as it cannot be controlled until a barrier is erected between the wetland and the Calumet River (they cannot be kept from reinvading through the outlet channel). Their ongoing presence, namely their incompatibility with the aquatic vegetative community, will remain an obstacle to marsh restoration efforts.

Restoration Potential

The potential to restore higher-quality marsh or to develop hemimarsh conditions at IRS will depend upon three interrelated factors: The first is the potential to control or eliminate common reed from the IRS wetlands. The Corps-sponsored restoration of marsh habitat revolved around implementing a massive aerial treatment of common reed and other invasives, followed by the planting of native marsh species in the shallower, near-shore areas. Although this effort was largely unsuccessful, many of the marsh native plants did establish but are now severely threatened by the rapidly rebounding population of common reed. The potential to save or develop new marsh vegetation in the near-shore areas and shallow marsh moving forward will be completely dependent upon the potential to control and eliminate common reed from these wetlands.

Secondly, the potential to establish the conditions under which a marsh, deep marsh, or hemimarsh community can develop will depend entirely on eliminating common carp from the IRS marsh system. The dense population of carp currently in the marsh is completely suppressing the establishment of submersed, floating-leaved, and emergent marsh species in depths more than a few inches away from shore. Unless the carp are eliminated, the potential to develop marsh vegetation will remain limited. Toward this end, the outlet structure has recently been modified with a screening system to keep common carp from entering the marsh via the Calumet River. Consequently, carp will not be able to re-enter the marsh from the river once a successful eradication effort has been implemented.

Lastly, the ability to develop a diverse, native marsh community will depend upon utilizing the existing water control structure at the outlet to IRS. Utilizing the structure simply means installing stop logs that will allow water levels to rise approximately 1.5 feet at the structure, i.e., to the limits of the structure as designed. This is the ideal time in which to implement a carp eradication effort, as the marsh must be closed off following the application of the piscicide Rotenone to prevent it from contaminating the Calumet River. The Rotenone will have broken down by the time the marsh is high enough to overtop the control structure. The resulting higher water levels will also expand the marsh footprint by nearly 10 acres as well as hamper the reestablishment of common reed from areas in which it has been eliminated. The carp screening barrier will have to be maintained once these measures have been implemented, as the improved marsh discharge will quickly attract fish from the Calumet River, signaling both a food source and a high-quality breeding habitat.

Assuming the aforementioned three factors can be addressed successfully, the installation of marsh vegetation could then be maximized across the range of depths in which it occurs (Figure 4). Water levels could then be lowered in the fall and held low for an entire growing season, or at least through the mid-summer, drying and consolidating sediments and stimulating a round of emergent seed germination and establishment. This can—and should—be supplemented with planting plugs of desired emergent species, e.g., broadleaf cattail (*Typha latifolia*), hardstem bulrush (*Schoenoplectus acutus*), softstem bulrush (*S. tabernaemontani*), three-square bulrush (*S. pungens*), river bulrush (*Bolboschoenus fluviatilis*), pickerel weed (*Pontedaria cordata*), or giant bur-reed (*Sparganium eurycarpum*). Other marsh species more commonly found in shallower water could also be planted at this time, e.g., sweet flag (*Acorus americanus*), lake sedge (*Carex lacustris*), or duck potato (*Sagittaria latifolia*). During the drawdown, submersed species capable of providing habitat support for small fish, herps, and waterfowl could also be planted in both the hemimarsh and open-water zones: e.g., wild celery (*Vallisneria americana*), sago pondweed (*Stuckenia pectinata*), nodding longleaf (*Potamogeton nodosus*), and white waterlily (*Nymphaea tuberosa*). It will also be critical to address the invasive community around the marsh perimeter in order to develop a shallow emergent marsh capable of supporting shallow marsh bird species, e.g., King Rail (*Rallus elegans*) and other wildlife.

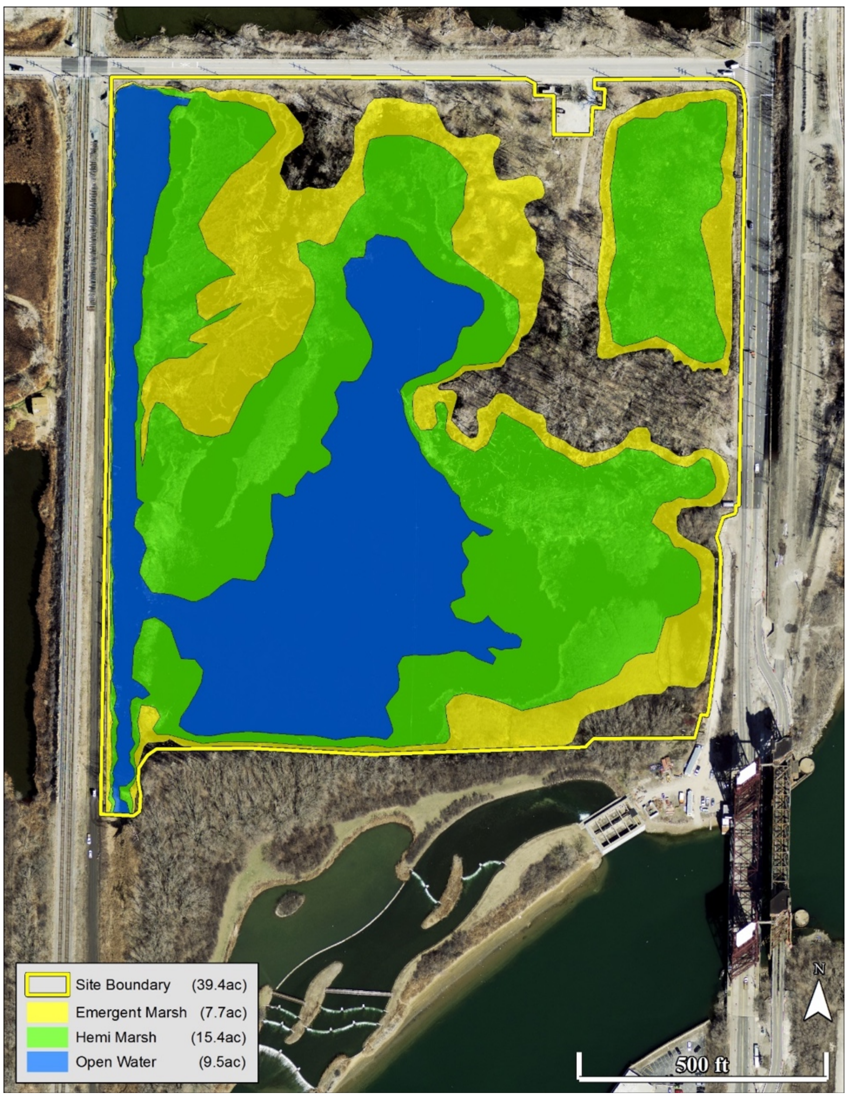

Figure 4. The 32.7 acres of marsh habitat that could potentially be developed at the southern end of Indian Ridge Marsh if the marsh is managed with a higher water level of 582.5 feet MSL. There could be 7.7 acres of shallow

emergent marsh habitat (in yellow), 15.4 acres of deep or hemimarsh habitat (in green), and 9.5 acres of open water habitat (in blue). Imagery courtesy of Google Earth.

Recommendations

There is significant potential to enhance the recently completed wetland restoration at IRS if common carp can be eliminated. Although much of the area at IRS was not fully restored, the CPD and partners have committed to a campaign of adaptive management commencing in 2017 that should begin paying dividends almost immediately outside the marsh. The following steps could also be undertaken this year to restore marsh habitat within the shallow and deeper pools across the site. This not only includes what might be done to establish marsh vegetation along the shorelines and in shallow water, but to create a deeper marsh community as well. This community would have a significant hemimarsh component once deeper water levels have been established as part of the carp management effort. Specific actions that could be undertaken include:

- Hydrology: utilize the dropbox outlet structure to raise water levels to 582.5 feet MSL and permit water level adjustments for restoration purposes and ongoing management drawdowns;
- Invasive species: eliminate common carp now that the outlet has been modified to screen carp from reinvading;
- Invasive species: eliminate common reed and other invasive plants;
- Enhance diversity: establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
- Topography/bathymetry: modify the shoreline to create a marsh-to-upland transition zone;
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps that can be taken to sustain and enhance the marsh.

Hydrology

The first step to be taken in enhancing the marsh and/or restoring hemimarsh conditions at IRS is to begin exercising water level control. This should include installation of a staff gauge that can be used to assess water levels and their impact on site conditions. The water control structure at IRS is currently un-utilized; consequently, water levels are too low to support development of hemimarsh conditions outside of a few small pockets of deep water. Another foot of water could be added to the site by simply implementing the stop logs already present. The additional depth would significantly increase the acreage of both marsh and hemimarsh that could be developed, assuming common carp can be eliminated. Furthermore, it would flood nearly 10 additional acres that are now being recolonized by common reed. Even if it is not feasible to eradicate carp immediately, it would still be useful to install the stop logs as soon as is practical to determine the upper pool limit. The 582.5-feet MSL water level should not present any concerns in regard to flooding at Torrence Ave. (at an elevation of approximately 584.0 feet MSL). If executing higher water levels at any point presents a conflict with common reed management, then water levels can be managed at a lower level until such efforts have been completed. Regardless of when stop logs are put in place, they can always be removed in order to implement the carp treatment at a later date.

Invasive Species

Since the presence of common carp is not consistent with the survival of any submersed species and most emergent species growing in soft sediments, controlling common carp will be a key factor in developing hemimarsh throughout IRS. This can only be done by IDNR Fisheries biologists, so a carp remediation plan will have to be developed in coordination with the appropriate IDNR personnel. Modifications to the stop log structure to prevent common carp from reinvading the site from the Calumet River will also have to be implemented prior to the carp treatment effort: the outlet structure as configured would not provide a sufficient barrier to adult common carp traveling up the outlet channel to enter the marsh, as they are capable of jumping over a 12- to 15-inch barrier if sufficiently motivated. This should not be a concern now, as a screening system has been installed to prevent larger carp from entering the system.

In order for any of these restoration efforts to succeed, invasive plant species will have to be managed or largely eliminated from IRS. However, since much of this area has already been planted with native species, decisions involving significant tradeoffs will have to be made regarding how to treat these areas. Pursuing a blanket broad-spectrum treatment effort, either by air or by land, is by far the most economical approach to controlling the invasives. But this approach will also result in killing all of the natives in the treatment areas, returning most of the plant establishment effort to the initial stages of restoration. Alternatively, more select, costly herbicides and/or hand- and backpack-application methods may be employed in an attempt to preserve more of those native species already established, but this will dramatically increase the manpower costs associated with this alternative. A careful survey of each treatment zone will have to be made in order to determine the best approach to take, which may differ among each area.

Enhance Diversity

As the hydrology is developed, a diverse native marsh community should be installed throughout those areas that are not yet colonized by natives, as well as in the upland and meadow areas that will develop into marsh as water levels rise. Following the successful treatment of common reed and common carp throughout the area, emergent and submersed species should be planted as soon as is practical. Specific recommendations on planting the marsh community are presented at length in the introduction to these analyses.

Bathymetry and Topography

Although most of the IRS shoreline is not as drastically steep as in some other Calumet-area wetlands, much of the shoreline does have steep sides that transition over a short distance into a foot or more of water. Despite contamination concerns from buried fill along the shoreline, soil with high clay content could be brought in to build a shelf that extends the shoreline out to create an upland-to-shallow water transition zone capable of supporting marsh vegetation. An added benefit of this approach is that it would further serve to cap potentially toxic materials in the upland fill abutting the pools.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management, which is the responsibility of its landowner, the Chicago Park District. A commitment to long-term management is critical to the success of this restoration, and without appropriate monitoring and management, the effort will be wasted. CPD has existing dedicated IRS staff; moving forward, a number of specific actions could be incorporated to improve outcomes as part of a long-term strategy of adaptively managing the site. Specific actions that apply to this and all restoration sites are presented at length in the introduction to these analyses.

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Marian R. Byrnes Park

Summary

The Marian Byrnes Natural Area is 129-acre nature preserve owned and managed by the Chicago Park District that includes a 49-acre wetland located just north of E. 103rd Street and east of S. Stony Island Avenue. The site was once part of the extensive lake plain surrounding Lake Calumet, but is now hydrologically isolated from the broader landscape by roads and rail lines. Most of the wetland area dries out annually during the summer months except for a few smaller, deeper pools that maintain some water except during prolonged periods of drought. Until recently, the wetland was nearly a monoculture of common reed (*Phragmites australis*), but ongoing efforts by the Chicago Park District are making significant inroads into eliminating this aggressive regional invasive.

The wetland system includes remnant marsh and open water habitat that fluctuates in size based on the dynamics of precipitation and evapotranspiration. Assuming common reed can be eliminated, 5.3 acres or more of the wetland could potentially be developed as marsh habitat, 1.5 acres of which could potentially develop into hemimarsh. The potential to establish a diverse marsh community and the prospects for managing it henceforth will be greatly enhanced if the existing drainage system on the site can be modified to control water levels. Since most of the wetland primarily occurs on very shallow soils or limestone bedrock, some of the species that could be developed include a number of rare, calcareous species. Deep marsh habitat with hemimarsh characteristics could be developed by implementing an appropriate water-level management strategy, enhancing native marsh species and functional group diversity, managing wetland invasive species, initiating a modest monitoring program, and adaptively managing the marsh hereafter.

Site Description

The Marian Byrnes Natural Area is a 129-acre nature preserve of mixed woodlands, prairie, and wetlands on the south side of Chicago, located just north of Lake Calumet. The site, now owned and managed by the Chicago Park District (CPD), is bounded by a retail plaza and office space on the south side of E. 95th Street to the north, private residences along S. Van Vlissingen Road to the east, E.103rd Street to the south, and a Norfolk Southern rail line to the west (Figure 1). Much of the 80-acre upland prairie and woodland area was created by dumping debris and rubble onto wetlands once surrounding Lake Calumet. The remaining 49-acre wetland is located outside the deposition zone on very shallow soil, some of which is exposed limestone bedrock. Approximately 6.1 acres is mostly marsh and open water with a few small islands, while the remaining wetland is a seasonally inundated wet meadow recently dominated by common reed (*Phragmites australis*). The wetlands are now being actively managed by the CPD and may eventually develop into a much higher-quality marsh and wet meadow system.

The Marian Byrnes wetlands were once part of the extensive system of marshes, wet meadows, and wet prairies surrounding Lake Calumet (Figure 2). However, they differed from most of these other wetlands in that they were formed on a limestone bedrock base found at or near the surface less than a kilometer from the old Lake Calumet shoreline. It is not clear whether the Marian Byrnes wetlands were originally found on shallow calcareous soils, or whether the soils were mined to expose the near-surface bedrock. The latter seems more likely, as the current wetland footprint appears to be completely un-vegetated in the 1939 aerial, which is consistent with soil removal over bedrock.

Regardless, today the wetland community mosaic is dominated by common reed interspersed with remnants or restored pockets of native plant species, including a variety of plants adapted to calcareous conditions. The common reed is now declining, as it is being treated by CPD, which has opened up larger areas to native colonization.

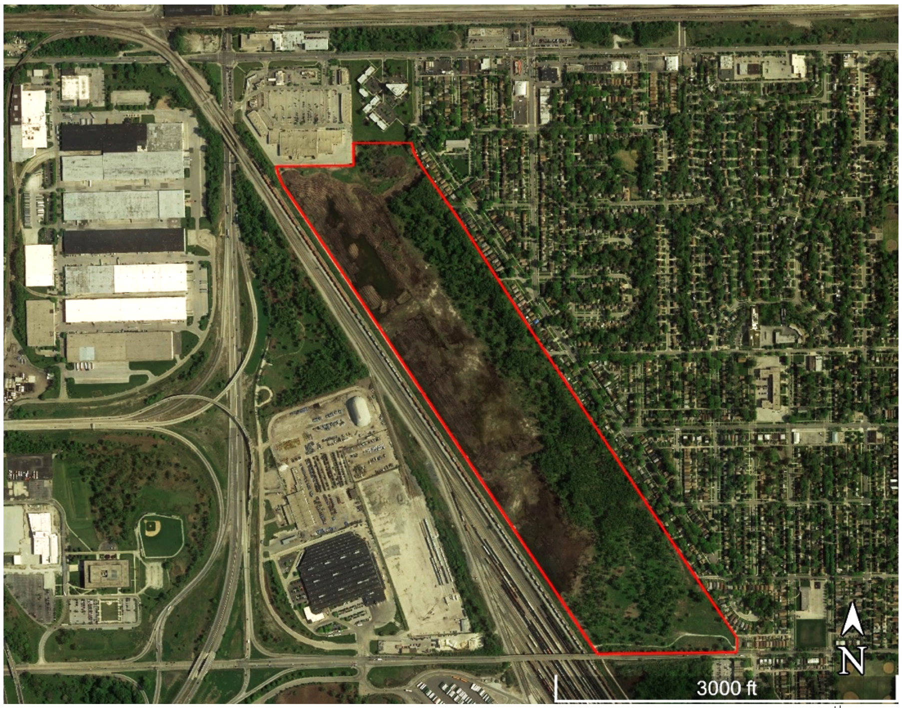


Figure 1. A 2016 satellite image of the Marian Byrnes Natural Area, outlined in red between E. 95th Street to the north, S. Stony Island to the west, and E. 103rd Street to the south. Imagery courtesy of Google Earth.

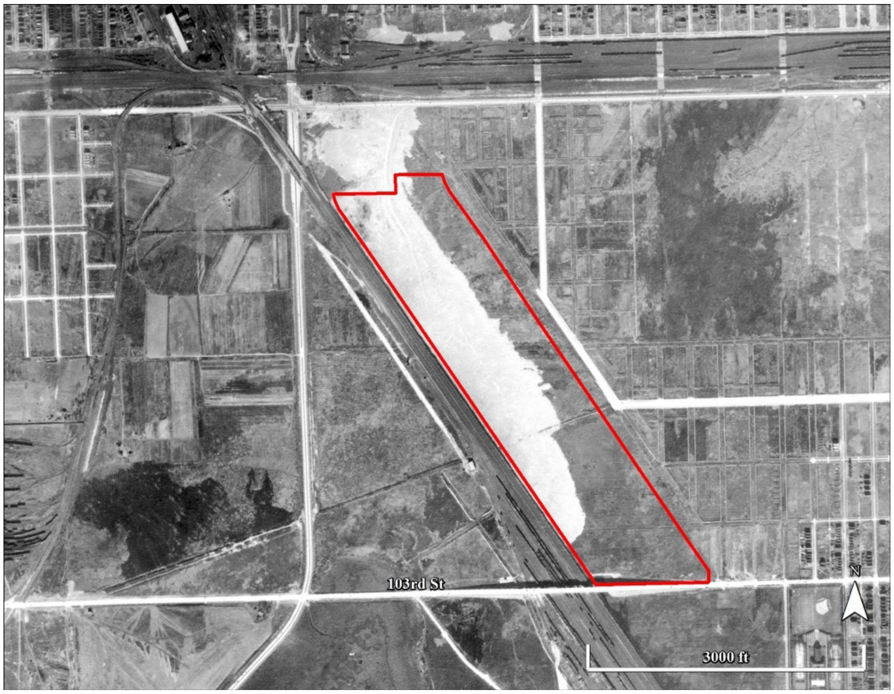


Figure 2. A 1939 aerial image of the Marian Byrnes Natural Area outlined in red. [Note that the north end of the Lake Calumet wetlands extends just north of E. 103rd Street, approximately 0.5 km from the Marian Byrnes wetlands (Illinois State Geological Survey, 1939).]

Hydrology

Hydrology in the Marian Byrnes wetlands is driven by local precipitation and runoff trapped in the drainage basin, with losses driven by evapotranspiration. Streams that once drained or fed the site have been cut off from the broader landscape by roads and rail lines. Recently, CPD personnel reported a drainage outlet in one of the wetlands, suggesting that at least some water drains away through the municipal stormwater system (or possibly into Norfolk Southern's Railroad Marsh to the south). Most of the wetland footprint holds water each spring, but by mid-to-late summer, that water is gone from all but the deepest pools (Figure 3). The footprint of remaining water and the size of the islands within the marsh can vary greatly from year to year depending on patterns of precipitation and temperature.

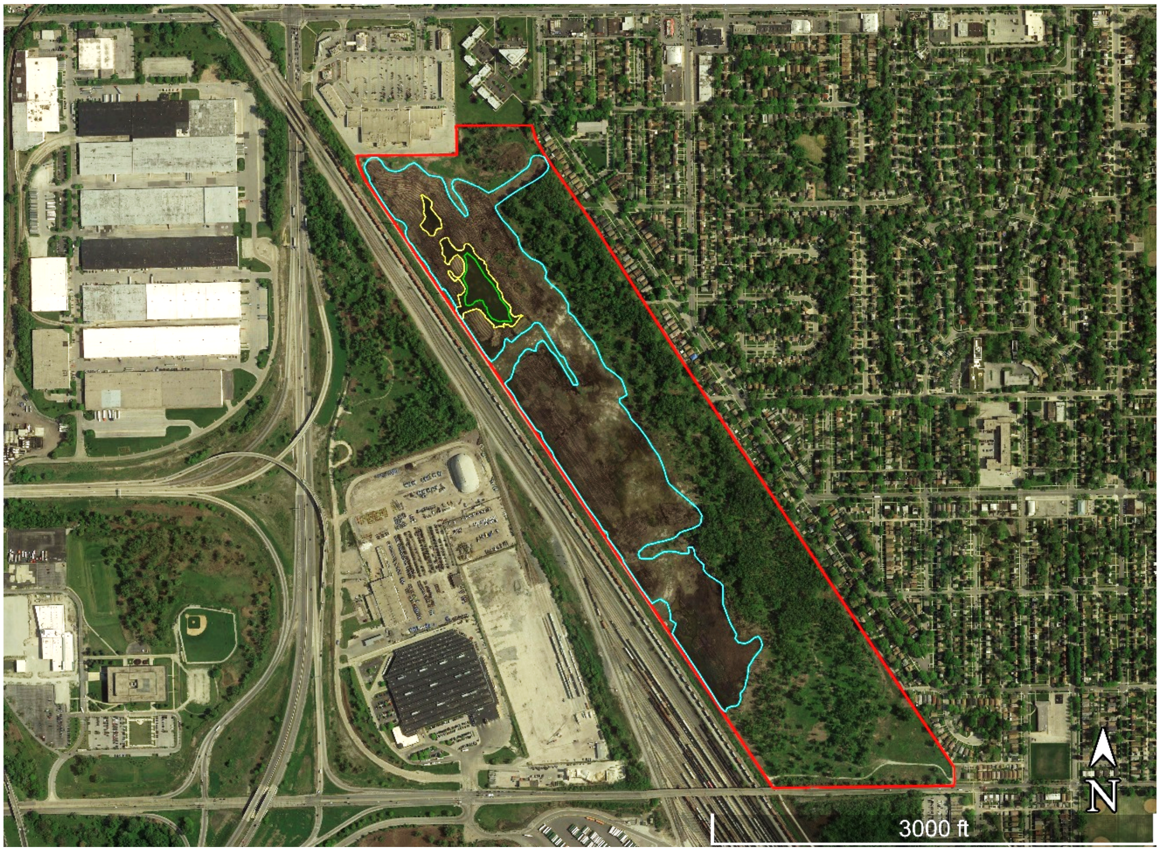


Figure 3. The distribution of habitat currently found at the Marian Byrnes Natural Area. The 49.0-acre wetland outlined in blue is primarily seasonal, with nearly all of it drying in the summer months except for the deeper areas within the 5.3 acres of marsh outlined in yellow. Five islands totaling 0.75 acres within the marsh are shaded in yellow, while the 1.5-acre deep marsh is outlined in green. Imagery courtesy of Google Earth.

Bathymetry and Topography

We know very little about the bathymetry or topography of the Marian Byrnes wetlands and surrounding habitat. Most of the wetland is both shallow and flat based on how quickly water is lost from most of the wetland in the summer months. Since the deepest pools maintain water year-round (except in the driest years), they appear to be deep enough to prevent common reed from colonizing, suggesting they are at least 1 foot deep at the edge of the common reed monoculture. The actual distribution of depths has not yet been determined.

Current Habitat and Invasive Species

Until recently, most of the 49.0-acre wetland was dominated by a monoculture of common reed. That is gradually changing, as common reed is being managed by the CPD and replaced by native wetland species. This will, by necessity, be an ongoing effort that will gradually require less energy once the native community establishes itself more strongly and the common reed seed bank is exhausted. Many of the native species found at the Marian Byrnes wetlands are calceophiles, i.e., plants adapted to alkaline conditions due to the influence of limestone on the chemistry of shallow soils or in the cracks of bare bedrock. The future development of emergent plants along the shore and within the marsh may be stunted by the low quantity of sediment available throughout the wetland and in the deeper pools. The invasive common carp (*Cyprinus carpio*) does not appear to be present in the system, most likely due to occasional drying of the marsh during prolonged periods of drought.

Hemimarsh Restoration Potential

The potential to restore hemimarsh at the Marian Byrnes wetlands will primarily depend on how successfully common reed is managed, and subsequently on the water-level management strategy adopted. Once common reed dominates a site as extensively (in terms of both land area and time) as it has at the Marian Byrnes Natural Area, it takes a significant, consistent effort to suppress resprouting shoots and new plants from the seedbank while simultaneously developing the native plant community. This is an effort that will likely require several years of diligent monitoring coupled with a timely, appropriate response. However, eliminating common reed can be done successfully within a 4–5 year period if the effort can be sustained, especially in the critical first few years of treatment.

Although the site initially appeared to be hydrologically free running, i.e., fluctuating naturally under the stochastic dynamics of precipitation and evapotranspiration, the reported presence of a drain biases the system toward more rapid water loss. This in turn can reduce the overall wetland footprint and the potential area to be developed as hemimarsh. Although fluctuating water levels can have a positive impact on vegetation dynamics, water levels influenced by an active drain will both vary less and be chronically lower. Assuming that the drain is active, the potential to restore and maintain deeper marsh habitat can be enhanced if the drain were modified to function as a water-level control structure. This would allow CPD to set a maximum water level if desired as well as drain the site for management purposes when necessary.

To develop hemimarsh habitat, it will be necessary to first maximize the area of bottom sediments that are exposed and dried in order to consolidate them. Even shallow sediments overlying bedrock would provide a better substrate for emergent plants if they were first dried. The extent of area that could potentially be exposed depends on whether the drain remains active and if it can be modified, all of which has yet to be determined. If the drain is no longer active and water-level control cannot be imposed, then emergent plant plugs or rhizomes should simply be planted across the range of depths in which they can establish. If sediments are loose and flocculent it will be more difficult to establish emergents, even in very shallow water. Submersed species can be planted from seed, tubers, or rhizomes, as appropriate.

If water-level control can be imposed, then water levels should be lowered in the fall and held low long enough to stimulate a round of emergent germination and establishment from seed the following spring. Seeding should be supplemented with the planting of plugs, tubers, or rhizomes of desired emergent species assuming sufficiently deep sediments are found, e.g., broadleaf cattail (*Typha latifolia*), hardstem bulrush (*Schoenoplectus acutus*), softstem bulrush (*S. tabernaemontani*), three-square bulrush (*S. pungens*), river bulrush (*Bolboschoenus fluviatilis*), pickerel weed (*Pontedaria cordata*), or giant bur-reed (*Sparganium eurycarpum*). Other marsh species more commonly found in shallower water may also be planted at this time, e.g., sweet flag (*Acorus americanus*), lake sedge (*Carex lacustris*), or duck potato (*Sagittaria latifolia*). During the drawdown, submersed species capable of providing habitat for herps and waterfowl could also be planted in the hemimarsh and open water zones, such as wild celery (*Vallisneria americana*), sago pondweed (*Stuckenia pectinata*), nodding longleaf (*Potamogeton nodosus*), and white waterlily (*Nymphaea tuberosa*).

Once appropriate vegetation has been established, there should be little need to actively manage water levels at the marsh. Natural fluctuations driven by precipitation and evapotranspiration patterns will likely be sufficient to stimulate vegetation establishment dynamics in the shallow marsh zones. Depending upon the activity of muskrats and other herbivores, occasional drawdowns may be needed to occasionally stimulate emergent re-establishment in the deeper marsh if emergent plant cover drops below desired densities. With a commitment to long-term management, an estimated 1.5 acres of hemimarsh could potentially be developed and maintained at the Marian Byrnes Natural Area, along with another 3.8 acres of shallow emergent marsh (Figure 3). Assuming muskrats become active in the marsh, their population should expand sufficiently for the marsh to develop the characteristic interspersion ratio of 1:1 between emergent vegetation and open water in the deeper marsh zones.

Recommendations

Because of the ongoing restoration work at the Marian Byrnes Natural Area over the past few years, the common reed management program is already well underway. Nevertheless, there are two significant knowledge gaps that must be addressed as soon as is practical: The first is the status of the drain and the potential to have it modified. Secondly, a survey of depths should be conducted in the open water areas at Van Vlissingen Road. Otherwise, we recommend the following additional steps to develop a more resilient and diverse marsh system:

- Topography/bathymetry: conduct a survey to determine the extent and range of depths occurring across the open water wetlands;
- Hydrology: monitor water levels and modify the drainage structure (if possible) to adjust them for restoration purposes and ongoing management drawdowns;
- Invasive species: continue the program to eliminate common reed, reed canary grass, and other invasive plants;
- Enhance diversity: plant additional species during a planned drawdown to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps that can be taken to sustain and enhance the marsh.

Bathymetry and Topography

As indicated above, we are recommending a depth survey to determine the extent of open water that might be converted to deep marsh habitat. The survey could be as simple as walking through the open water zone and taking depth measurements with a graduated stadia rod, then marking the location with GPS. This approach assumes that the maximum depth is relatively shallow, e.g., <4.0 feet deep. If greater depths are encountered, one or more teams could follow the same procedure by boat, canoe, or kayak. This is not to suggest that a more formal technical survey would be undesirable, just that it is not needed to map and determine the extent of the potential planting zones. Fewer readings will be necessary wherever the bottom is fairly uniform, though they should be taken more densely to capture holes or heterogeneous bathymetry.

Hydrology

The first step in water-level management is always to decide an average elevation around which to manage marsh water levels, assuming they can be managed at all. The first step is to determine the nature of the existing drainage structure, whether it is still active, and if it can be modified to control water levels. In this case, water-level control means establishing a high-water-level set point, e.g., with stop logs that can be raised or lowered to achieve a target elevation. The set point represents the maximum water level that can be achieved (assuming the structure is in working order), but evapotranspiration can always lower it. There will be no way to raise water levels once they have been lowered other than to let the basin recharge naturally.

As aforementioned, the capacity to lower water levels will be critical for establishing new marsh vegetation and for improving access to facilitating invasive management. If the drainage structure cannot be modified to adjust water levels, the system will function as originally assumed, i.e., as a naturally fluctuating basin subject to the dynamics of precipitation and evapotranspiration.

Establishing the Plant Community, Managing Invasives, and Long-Term Management

Recommendations for establishing a biologically diverse marsh plant community and the conditions under which hemimarsh could develop are presented in detail in the introduction to these analyses. Specific actions for each site may vary based on local circumstances and the ability to manage water levels, including the extent to which water can be lowered, when it can be lowered, and for how long. At the Marian Byrnes Natural Area, these limitations will revolve around whether CPD has the ability to lower water levels, the ability of the soils to support sufficient emergent vegetation, and the prospects for managing invasive plant species.

Of critical importance will be the ability to maintain the restoration once the installation has been completed. At any of these sites, at least one staff member should be periodically responsible for assessing changing ground conditions in order to proactively address problems as they appear; monitoring does not need to occur frequently, just often enough to catch problems before they become insurmountable in terms of either scope, cost, or management. Once major restoration work has been completed, checking water levels and invasive species establishment may be only be necessary a few times per year, assuming monitoring will be followed by management actions if and when warranted.

References

Illinois State Geological Survey. (1939). Unpublished material, Illinois historical aerial photographs: 1936 to 1941 v.4: Illinois State Geological Survey, Champaign, Illinois.

Powderhorn Marsh

Summary

Powderhorn Marsh is a 51.7-acre marsh and shallow open water wetland located near the south end of Wolf Lake in Illinois, along the Indiana border. The site was once part of the extensive lake plain wetlands surrounding Wolf Lake in the Calumet region, but is now an isolated and relatively shallow basin perched above and draining into Wolf Lake. Most of the marsh is located within the Powderhorn Lake Forest Preserve owned by the Forest Preserves of Cook County (FPCC); a portion is owned by the Norfolk Southern Railroad. It was once characterized by a community of emergent vegetation providing hemimarsh habitat, but the emergent plant species were lost once relatively static water levels were imposed by manipulating the outlet to Wolf Lake.

Our analysis of the marsh's history, its current condition, and its restoration potential indicates that the marsh could be restored and managed to become a high-quality deep marsh, with up to 44.0 acres that could potentially develop into rare hemimarsh habitat. However, since the marsh hydrology no longer fluctuates as it once did, the restoration of deep marsh habitat will only be possible if the ability to impose occasional low water levels is incorporated into the design. This could be executed through the installation of a water-level control structure and associated modifications to the drainage channel between the marsh and Wolf Lake. High-quality deep marsh habitat exhibiting hemimarsh characteristics could be developed and maintained by implementing a water-level management strategy, enhancing native marsh species and functional group diversity, managing invasive species, initiating a modest monitoring program, and adaptively managing the marsh henceforth. Considering the quality of the remnant plant community elsewhere at Powderhorn, the restoration should focus more strongly—or exclusively—on species already onsite or in similar preserves within the FPCC system. Should the ability to impose low water levels be incorporated into the system, Powderhorn Marsh could once again develop into one of the region's best marshes, with a significant hemimarsh component.

Site Description

Powderhorn Marsh is a 51.7-acre body of shallow water located just north of Powderhorn Lake, situated partially within the 192-acre Powderhorn Lake Forest Preserve of the Forest Preserves of Cook County (FPCC). Only 33.5 acres of the marsh are found within the forest preserves; 18.2 acres lie to the north and east (Figure 1). The marsh is bounded to the north and east by Norfolk Southern (NS) railroad lines, and to the south and west by the forest preserve. The marsh was formerly part of an extensive marsh system at the south end of Wolf Lake, but was cut off from the lake by the deposition of fill to build causeways for rail lines, roads, and other development (Figure 2). The shore along the rail line at the marsh edge drops steeply, marking the outer edge of material deposition. A small remnant of the extensive dune and swale system that once demarcated the south shore of Wolf Lake now borders the southwest edge of the marsh.

Powderhorn Marsh is all that remains of the deep marsh zone transitioning between the Calumet dune/swale landscape and the open waters of Wolf Lake. It was originally cut off from the rest of the marsh and lake after construction of an east-to-west causeway connecting rail yards on either side of the marsh (Figure 2). Eventually, most of the marsh north and east of the rail lines was also filled in for residential and industrial use. The 7.2-acre 135th St. Marsh is one of the small remnants that remains, and is found a short distance north of the NS line (Figure 1). Powderhorn Lake had been excavated from the dune and swale system just south of the marsh by 1958 (Figure 3); the marsh at that time was characterized by an extensive hemimarsh that has since evolved into an open water system, as water levels have remained too high to support the germination and regeneration of the emergent community. North of the marsh, Powderhorn Lake is the focal wetland of the preserve and is open to boating and public fishing. Access to the marsh, however, is limited.

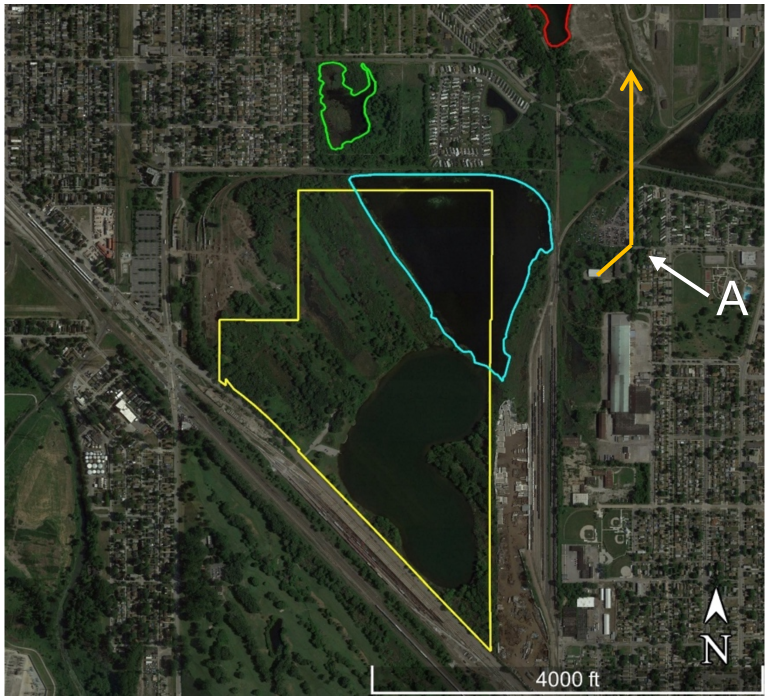
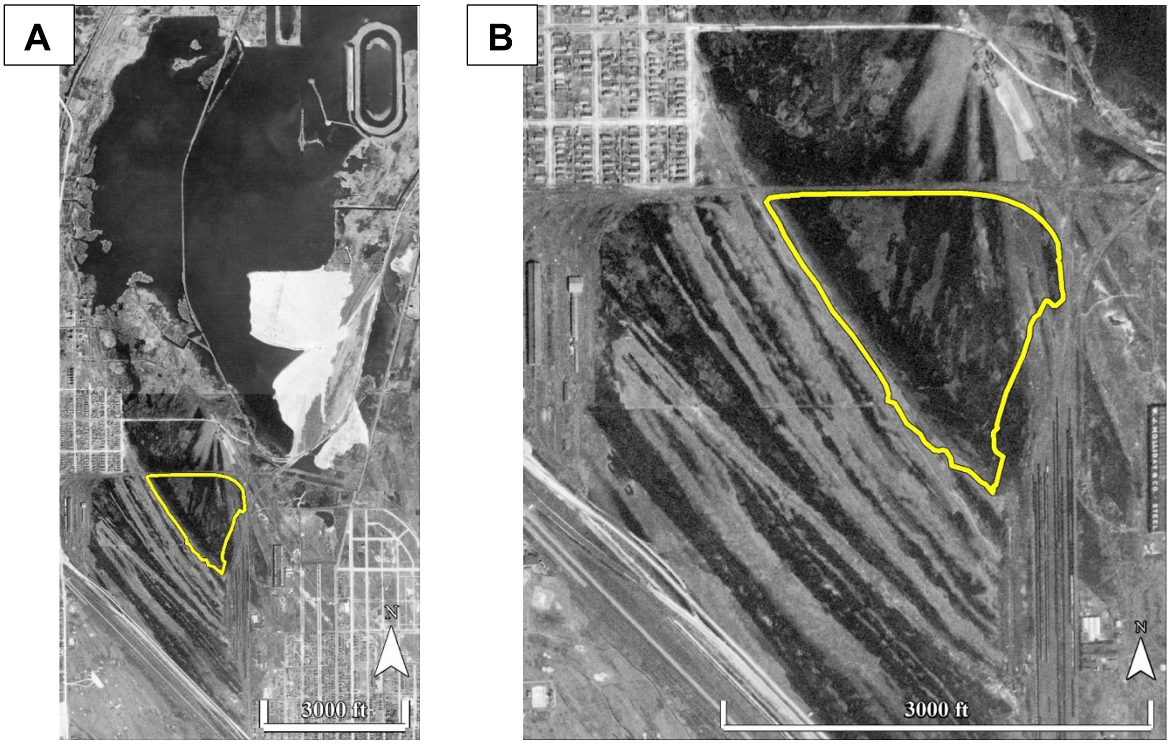


Figure 1. The 52-acre Powderhorn Marsh outlined in blue, the 192-acre Powderhorn Lake Forest Preserve outlined in yellow, the 135th St. Marsh outlined in green, and the southern tip of Wolf Lake outlined in red. The marsh outlet ditch is approximated by the orange arrow. Marsh and lake surface water elevation is controlled by the culvert invert at point A. Imagery courtesy of Google Earth.



Figures 2A and 2B. A) The southern portion of Wolf Lake in 1939 with the Powderhorn Marsh shown in yellow. B) A more detailed view of Powderhorn Marsh outlined in yellow in 1939. [Note the dune and swale system demarcating what was once the southwest shore of Wolf Lake. Imagery courtesy of the Illinois State Geological Survey, 1939].

Figure 3. A view of Powderhorn Lake looking northwest in 1958, shortly after it was excavated from the dune and swale remnant. Note that Powderhorn Marsh in the upper right (to the north) is dense with emergent vegetation in a mosaic of hemimarsh. Historical aerial photo unattributed.

Hydrology

Powderhorn Lake and Marsh are hydrologically connected through an open channel between them. Water enters the system from precipitation, local runoff, and possible groundwater inputs. Water drains northward into a ditch system that flows north adjacent to another spur of the NS rail line until emptying into Wolf Lake's Pool 5 (Figure 1). Water enters the ditch from the marsh after filtering through riprap under the rail line at the northeast end of the marsh. As long as the ditch is free of obstruction, water drains from the lake and marsh system until reaching the low-water elevational control point at the invert of a culvert at the intersection of a NS access road (point A in Figure 1; Figure 4).

Powderhorn water levels fall below the outlet control point elevation only when evapotranspiration exceeds inputs, and they rise above this point when either inputs exceed normal outlet flow or normal outlet flow is obstructed by vegetation and/or debris (as it was from 2015–early 2017). We also found a small volume of flow in a shallow drainage channel exiting the northwest corner of the marsh, which suggests there may be another outlet, perhaps into the city stormwater drainage system. This channel was also choked with debris until recently. Following the clearing of debris from these channels this summer, water levels dropped up to 18 inches over a period of just a few weeks.

Moving downstream in the outlet ditch from the water-level-controlling culvert, there is an 8.5-inch drop in elevation to the invert at the next culvert downstream at E. 134th Street. Moving downstream from E. 134th Street, there is an additional drop of 9 inches to the bottom of an outlet ditch that drains into Wolf Lake's Pool 5. When surveyed on July 14, 2017, the drainage channel had no flow, as the Powderhorn system had already drained as far as it could, i.e., to the controlling outlet elevation at point 'A' in Figure 1 (the specific elevation was not measured). There was no water (from Wolf Lake) in the channel downstream of E. 134th Street for over 400 lineal feet, and an additional drop of at least six inches (estimated). This difference between the minimum surface water elevation at Powderhorn and the elevation of Wolf Lake on July 14, 2017 (8.5 + 9.0 + 6.0 = 23.5 inches; Figure 4) indicates that the Powderhorn system is perched nearly two feet above Wolf Lake, and potentially greater considering that Wolf Lake water levels have been unusually high over the past two years due to one or more blockages in the outlet at Indian Creek.

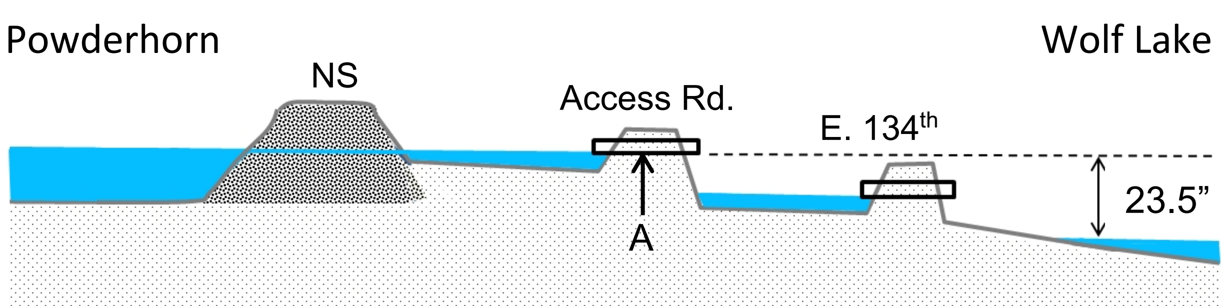


Figure 4. A cross-sectional view of Powderhorn water level and drainage to Wolf Lake. Water flows through riprap under the Norfolk Southern (NS) rail line to an outlet ditch, then through a culvert at the NS access road (A), then through another culvert under E. 134th St. and out to Wolf Lake. The low water level at Powderhorn is controlled by the invert of the culvert at the access road. The fall to Wolf Lake varies with lake surface elevation.

Bathymetry and Topography

We were unable to locate any information on the bathymetry of Powderhorn Marsh. To assess whether the marsh depths were appropriate for potentially developing a hemimarsh community, a limited bathymetry survey was conducted on August 20, 2016 by staff from the FPCC, Chicago Park District, Audubon Great Lakes, and the Wetlands Initiative. Staffs traversed the lake in kayaks, measuring depths with graduated rods and marking locations with GPS (Figure 5). Water levels were extremely high during this survey, i.e., 15–18 inches higher than when the system is at its base elevation (based on observations from a July 14, 2017 survey). At the August 2016 survey, we determined there was a very steep shore-to-marsh transition zone along all shorelines created from the deposition of fill (typically dropping 3 feet within 25 feet of shore). The shore of the marsh along the dune and swale system was much less steep, although depths still dropped off relatively quickly (typically dropping 2.5 feet within 250 feet of shore). None of the depths recorded exceed 48 inches, although most of the area surveyed was between 36–48 inches in depth.

Based on the results of the depth survey, we created a map of one-foot depth contours to determine the potential extent of depths that could support emergent vegetation as part of a hemimarsh community. Since debris in the outlet ditch was backing water up to approximately 1.25–1.50 feet higher than the ‘base condition,’ we made the simplifying assumption that depths would eventually drop that much once flow through the drainage ditch was restored (Figure 6). This is now the case as of mid-July 2017, when we estimate that the yellow line represents the potential one-foot contour, the green line the potential two-foot contour, and the blue line the potential three-foot contour. These estimates assume that sediments will be exposed as part of a temporary management effort, and that de-watering or drying will consolidate sediments to slightly increase depth upon refilling.

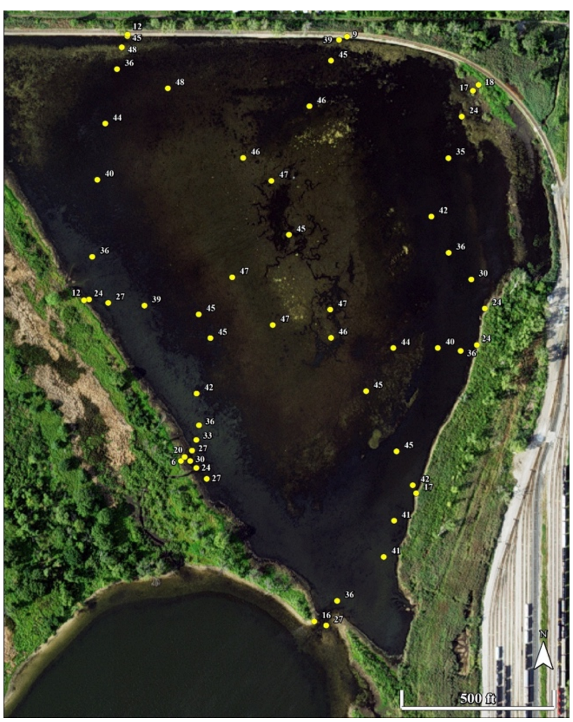


Figure 5. Results of a bathymetry survey of Powderhorn Marsh conducted in August 2016 during a period of high water levels. Depths were spot-checked from kayaks at various locations across the marsh and recorded with GPS. Imagery courtesy of the National Agricultural Imagery Program.

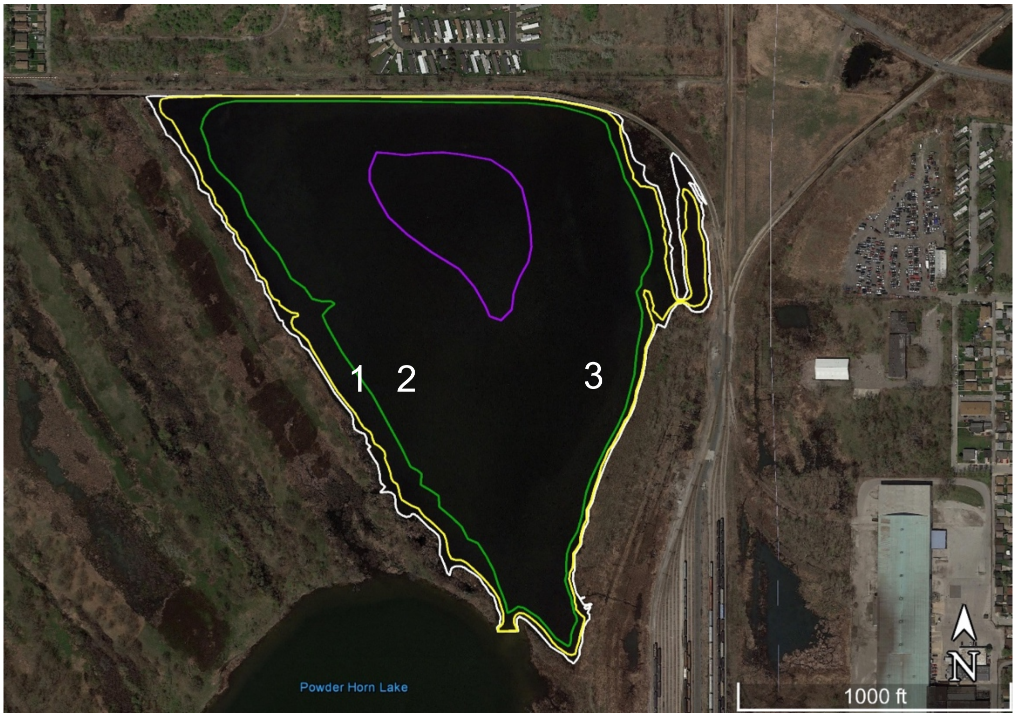


Figure 6. Conservative estimate of depth contours based on the results of the bathymetry survey conducted at Powderhorn Marsh in August 2016 as they would occur *after* blockages to the outlet channel are removed and water levels return to normal, or the base condition. The projected pool would be 51.7 acres (outlined in white), the one-foot depth contour would be 49.0 acres (in yellow), the two-foot depth contour would be 41.7 acres (in green), and the three-foot depth contour would be 5.0 acres (in purple). Imagery courtesy of Google Earth.

Current Habitat and Invasive Species

The entire marsh is colonized by a diversity of submersed aquatic vegetation, with a few emergent species scattered around the shallower water and approximately 1.4 acres colonized by woody wetland shrubs (willows, buttonbush (*Cephalanthus occidentalis*), and other species). The margins of the marsh can be characterized by a typical diversity of shallow marsh species, including various sedges (Carex and Cyperus spp.), native grasses, smartweeds, marsh milkweed (*Asclepias incarnata*), water plantain (*Alisma subcordatum*), and the aforementioned shrubs. Cattails (Typha species), reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), and purple loosestrife (*Lythrum salicaria*) can also be found. Common reed has made serious inroads into the native swales, although it has been under treatment by Forest Preserves staff. A higher-quality black oak dune and buttonbush swale community can be found further from the marsh to the west, a poor-quality shrubby remnant to the southeast, and nearly bare railroad ballast to the north and northeast.

Hemimarsh Restoration Potential

Currently, the marsh is a relatively steep-sided basin dominated by submersed aquatic species. Although there was once a robust emergent deep marsh community, the conditions to maintain such a community no longer exist, and it has now declined to the point of insignificance. The regeneration potential of the marsh has largely been lost due to continuous high water levels, and with periodic higher water levels occasionally making the situation worse (i.e., exacerbating the loss of remaining emergents). Relatively static high water levels preclude emergent seed germination and re-establishment, and will continue to do so without occasional periods of low water.

The potential to restore hemimarsh at Powderhorn will be dictated by a key decision by the FPCC, i.e., whether they decide to manage water levels as part of a marsh restoration effort. A significant hurdle complicates this decision: they do not own the land at the outlet, nor along the drainage way to Wolf Lake; the land is owned by the NS Railroad. Thus, if the FPCC decides they want to actively manage water levels in the marsh to promote development of hemimarsh habitat, they will need to work out an agreement with the railroad that allows them to install and manage a water-level control structure and maintain the outlet channel. Assuming an agreement with the railroad is made, the outlet would be modified by installing a stop log-controlling structure coupled with deepening the outlet channel and the culverts at the NS access road and E. 134th Street. Alternatively, a new outlet channel could be excavated elsewhere if warranted, although any potential outlet must still cross the NS Railroad. The channel should be deepened to allow the marsh to be drained for management purposes. The highest invert elevation (channel depth or culvert) would then determine the lowest depth to which the marsh could be drained, as long as it was higher than the surface water elevation of Wolf Lake.

The water control structure could be designed to occasionally lower water levels to sufficiently regenerate the emergent community when it inevitably drops below an acceptable density. It is not possible to predict how often this action would need to be taken, but it typically occurs once every 5–15 years (or more) depending upon the density and activity level of muskrats in the system, the activity of common carp (if present), or other stochastic factors. Once adequately drained, water levels must remain low long enough to facilitate consolidation of the bottom sediments and the installation of plants, after which the basin can naturally refill. Actively draining Powderhorn to Wolf Lake would also require that a means of preventing common carp from entering the marsh be incorporated into the design.

An additional significant modification to the system may be required to implement this strategy. This would be driven by the lowering of water in Powderhorn Lake during a marsh drawdown. Since the connection between the marsh and lake (i.e., the sill) is relatively shallow, the lake would stop draining after a loss in depth of approximately 9–12 inches, the depth of water over the sill separating the two bodies under 'normal' conditions (this depth was 27 inches when measured in August 2016). Since the drawdown would be initiated in fall or early spring and last through at least mid-summer, this could present a conflict with the fishing mission of the Forest Preserves. If a period of low water in Powderhorn lake is unacceptable, then the loss could be avoided if the sill between the two systems was raised. This could be accomplished with the installation of clay berm, potentially incorporating a simple stop log structure in the design to allow boat passage when and if desired under 'normal' conditions. It would then be kept closed during a drawdown to maintain a higher level within the lake. The costs and logistics of such an approach would have to be considered carefully, but this same approach is routinely used all over the world to independently manage levels in adjacent bodies of water.

If the decision is made to restore and manage deep marsh habitat at Powderhorn, then the potential to develop a high-quality hemimarsh is very high. Since most of the marsh is relatively steep at the edges and ranges between 1–3 feet deep, there is potential to develop up to 44.0 acres of deep marsh habitat potentially capable of developing hemimarsh characteristics (85% of the pool area). Specific steps to be taken are outlined in the introduction to these analyses. Considering the quality of the remnant plant community elsewhere at Powderhorn, the restoration could focus more strongly or exclusively on species already onsite or in similar preserves within the FPCC system. Once appropriate vegetation has been established, the effort to manage water levels at Powderhorn Marsh should not be extensive, although as in all restorations, the system should be monitored periodically to ensure that it is performing as desired. It may take one or more seasons for a muskrat population to colonize and expand sufficiently enough for the marsh to develop the characteristic 1:1 interspersion ratio between emergent vegetation and open water in the deeper marsh, but the payoff would be 40+ acres of hemimarsh developed and maintained at Powderhorn Marsh for many years to come.

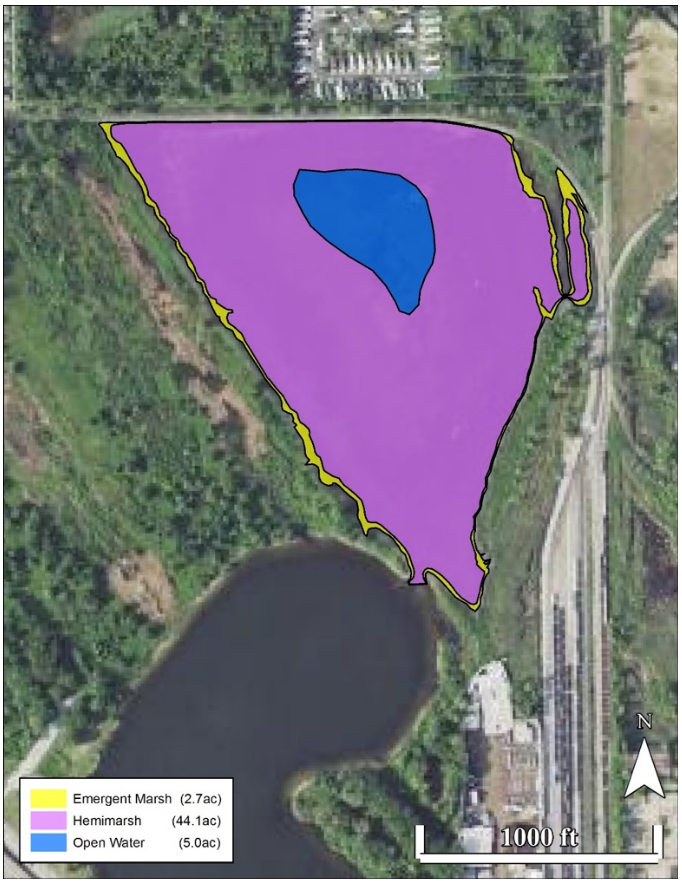


Figure 7. Projected distribution of habitat that could be developed if water level control could be implemented, coupled with a strategy to develop the conditions under which hemimarsh could develop. The projected habitat distribution is based on the depth contours illustrated in Figure 6. The includes 2.7 acres of shallow emergent marsh (in yellow), 44.1 acres of hemimarsh (in purple), and 5.0 acres of open water (in blue). Imagery courtesy of the National Agricultural Imagery Program.

Recommendations

Any recommendation on how to proceed with hemimarsh restoration at Powderhorn Marsh will be strongly influenced by the potential agreement negotiated between the FPCC and NS Railroad on water-level management. Absent an agreement between the two parties, the options become limited. However, if an acceptable agreement can be made, a gravity-driven, water-level management plan could subsequently be implemented. The ability to impose a drawdown will be critical, as hemimarsh cannot develop or be sustained without occasional periods of low water to regenerate the plant community. In a system where low water conditions no longer occur during dry years, establishing emergent species beyond the shoreline will not be possible. An exception is the clonal expansion of at least some species into deeper water, although this process is generally too slow to be effective in systems with muskrats or other herbivores. Regardless, to develop hemimarsh at Powderhorn, the goal will be to first restore the conditions under which a hemimarsh can develop, and the key condition within this context is occasional low water levels. Our recommendations for restoration include the following:

- Norfolk Southern: secure an agreement with the railroad to modify the outlet and drainage way (or build a new one if utilizing the existing outlet is not possible);
- Hydrology:
    - Install a water control structure at the outlet that will allow drainage down to an elevation approaching the water level of Wolf Lake;
    - If necessary, modify the connecting passage between the lake and marsh so that water levels in the marsh can be managed independently of the lake.
- Install emergents and enhance diversity:
    - Plant additional species during a planned drawdown to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
    - Plant marsh and wet meadow species in the shallower marsh areas and surrounding wetlands to enhance the overall diversity of the site.
- Fish community:
    - Initiate a program to eliminate the invasive common carp if present, and modify the water control structure to prevent carp from reinvading;
    - Enhance the fish community if desired with the installation of small fish (not already present) adapted to overwintering in shallower systems.
- Invasive species: initiate a program to eliminate common reed, reed canary grass, and other invasive plants;
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps that can be taken to sustain and enhance the marsh.

Norfolk Southern

Continue engaging Norfolk Southern in the discussion (now ongoing for the past four years) to be good neighbors. There may be an implied or overt obligation for them to maintain drainage from the site. The ability to control or lower water levels should be in their own self-interest, especially considering the situation they are currently facing with water lapping the bottom of their rails. Although their motivation may change now that lower water levels have once again been restored due to the reopening of the drainage way to Wolf Lake, improvements to the outlet channel should still benefit both parties.

Hydrology

We strongly recommend installation of a water-level control structure capable of lowering the marsh down as much as possible. The installation will need to be coupled with improvements to the ditch system draining Powderhorn to Wolf Lake. These improvements would also lend Powderhorn managers greater flexibility in managing water levels during periods of normal operation, i.e., outside of a drawdown. Stop logs could be used to raise or lower water depths to achieve any hydrologic management goals as long as water levels remain higher than that of Wolf Lake. If common carp can be eliminated from the system, then the water-level control structure could also incorporate a carp-control function in the design.

We recommend that the elevation of the connecting passage between the lake and marsh be raised with the construction of a clay berm that would hold back sufficient water in the lake during drawdown operations to maintain other priorities. The passage as currently configured will already do this, but not until it first drops 9– 12 inches to the invert elevation. The clay berm would in effect become a dam between the two to maintain higher lake water levels during a drawdown. This approach could also incorporate a stop log structure within the passage so that the two systems remain connected under normal operating conditions, thus facilitating the passage of fish and other wildlife.

Install Emergents and Enhance Diversity

Once marsh water levels are drawn down, we recommend introducing a biologically diverse community of native marsh emergent vegetation, as detailed in the introduction to these analyses. Once water levels have been strategically lowered and sediments have been consolidated, plants of emergent, floating-leaved, and submersed species consistent with FPCC management goals should be installed through planting plugs or the seed of target species. After plants are introduced, water levels can naturally re-establish as plants grow and elongate to keep up with the rising water surface. Stop logs may also be used to regulate the rate at which water levels rise, if the plant community is unable to grow at a sufficient rate. We also recommend installation of shallow marsh and wet meadow species in the surrounding wetlands to enhance the overall diversity of the site and to provide a native community buffer to the marsh.

Invasive Species and Enhancing Diversity

Regardless of the decision to restore a deep water hemimarsh, we recommend addressing invasive species as soon as is practical, and in particular the remaining populations of common reed, reed canary grass, and purple loosestrife. Common reed appears to the greatest invasive threat to restoring the marsh community, while reed canary grass and purple loosestrife impact native species throughout much of the wetlands bordering the marsh. We recognize that cattails are also a considered a threat in this and other systems, so their inclusion within the emergent marsh community may not be warranted or acceptable. This will be a multiyear effort to bring these species under control, with ongoing management required to maintain the integrity of the native community.

Long-Term Management

The final stage in any restoration effort is the transition from restoration to site management. FPCC has existing dedicated staff managing the Powderhorn system and actively engaging in conducting invasive management. The general approach we recommend for maintaining marsh vegetation and enhancing diversity is presented in detail in the introduction to these analyses. This includes strategies to manage the site adaptively both during and after the conclusion of active restoration activities. Although Powderhorn is already one of the most impressive examples of remnant dune and swale habitat in the region, the overall quality and diversity of the landscape will be enhanced if the marsh and hemimarsh habitat once embedded within the site can be restored and managed henceforth.

References

Illinois State Geological Survey. (1939). Unpublished material, Illinois historical aerial photographs: 1936 to 1941 v.4: Illinois State Geological Survey, Champaign, Illinois.

Square Marsh

Summary

The Lake Calumet Conservation Area's Square Marsh is a 144.0-acre open water area owned by the Illinois International Port District at the Port of Chicago, at the north end of Lake Calumet. Square Marsh is located adjacent to the Harborside International Golf Center, just west of S. Stony Island Ave. and north of the open waters of Lake Calumet. Square Marsh can be characterized as a turbid, open water body up to approximately 8 feet deep, with a few small islands and peninsulas. The shoreline is dominated by a combination of common reed *(Phragmites australis*) or mixed weedy trees, shrubs, forbs, and grasses. The shoreline is relatively steep, as it was created as the lake was filled with various materials pushed in from the edges until achieving its current configuration by 1980.

The hydrology of Square Marsh is primarily driven by local runoff, with water levels controlled by gravity at a dropbox structure emptying into Lake Calumet along the south shore of the site. Water levels are currently about two feet higher in the pool than in Lake Calumet, with depths estimated up to 10 feet deep. With the installation of an appropriate water-level control structure and management plan, approximately 31.4 acres of marsh could potentially be developed at Square Marsh, 25.0 acres of which could potentially develop as hemimarsh. We believe this to be a conservative estimate given the ability to manipulate water levels by gravity. The extent of shoreline and depth modification incorporated into the restoration plan could also increase the extent and distribution of shallow and deep marsh that could be developed, though the successful development of marsh vegetation will be entirely dependent upon the eradication of common carp.

The success of the restoration will ultimately depend on a well-conceived plan to adaptively manage the marsh once major restoration activities have been completed. If properly restored, Square Marsh could become the largest and one of the highest-quality examples of hemimarsh in the Calumet Region.

Site Description

The Calumet Conservation Area's Square Marsh (hereinafter Square Marsh) is a 144.0-acre open water area located at the north end of Lake Calumet (Figure 1). Square Marsh is located just west of S. Stony Island Ave., east and south of the Harborside International Golf Center, and north of a berm and dirt track separating it from the open waters of Lake Calumet. Square Marsh is owned by the Illinois International Port District at the Port of Chicago. The open water pool, once part of the open waters at the north end of Lake Calumet, became isolated from the rest of the lake by the ongoing deposition of various materials from 1900–1980 (Kay et al., 1997; Figure 2). Square Marsh can now be characterized as an open water body up to approximately 8 feet deep, with a few small islands and peninsulas. The shoreline along the golf course is highly managed, while other areas are dominated by a combination of common reed *(Phragmites australis*) or mixed weedy trees, shrubs, forbs, and grasses. The near-shore area is relatively steep, as it was created as the lake was filled by dredge spoils, slag, municipal waste, construction debris, and other materials pushed in from the edges. Currently, Square Marsh can only be viewed from shore along the Harborside International Golf Center; it is not open to the public.

Figure 1. A 2016 satellite image of Square Marsh at the north end of Lake Calumet (outlined in yellow). The 144-acre pool is owned by the Port Authority. Imagery courtesy of Google Earth.

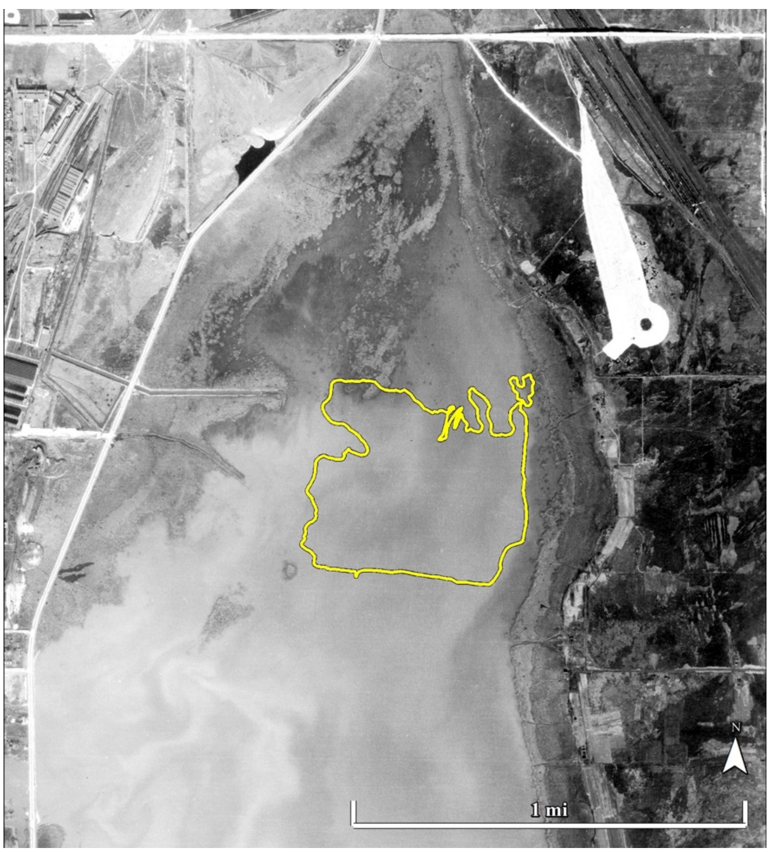


Figure 2. A 1939 aerial image of the north end of Lake Calumet. The future location of Square Marsh is outlined in yellow (Illinois State Geological Survey, 1939).

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Hydrology

Our knowledge of Square Marsh's hydrology is limited, as we were only able to make one site visit on October 15, 2015 (with the generous cooperation of the golf course management) to view the water-level control structure separating Square Marsh from Lake Calumet. Subsequently, we were denied permission by the Port Authority to conduct an appropriate survey to ascertain the distribution of depths, sediments, and additional relevant information. Inputs to the pool appear limited to local surface runoff, although we cannot rule out the presence of springs beneath the surface. The Lake Calumet water surface elevation on the date of our visit was approximately 580.0 feet above mean sea level (ft. MSL) relative to the North American Vertical Datum of 1988 (NOAA 2017a). Based on visual inspection, water levels in Square Marsh were estimated to be approximately 24 inches higher than in Lake Calumet, or 582.0 ft. MSL. We believed this to be a conservative estimate; the difference may have been greater (i.e., the water surface of Square Marsh may have been higher than 582.0 ft. MSL.) That elevation is 2.7 feet higher than the 100-year average for Lake Calumet (579.3 ft. MSL; Figure 3), and 3.1 feet higher than the average record over the past seven years (578.9 ft. MSL; Figure 4). Consequently, based on the long-term average for Lake Calumet, Square Marsh is perched over 2.5 feet above Lake Calumet, and over 3.0 feet higher than Lake Calumet based on its more recent history.

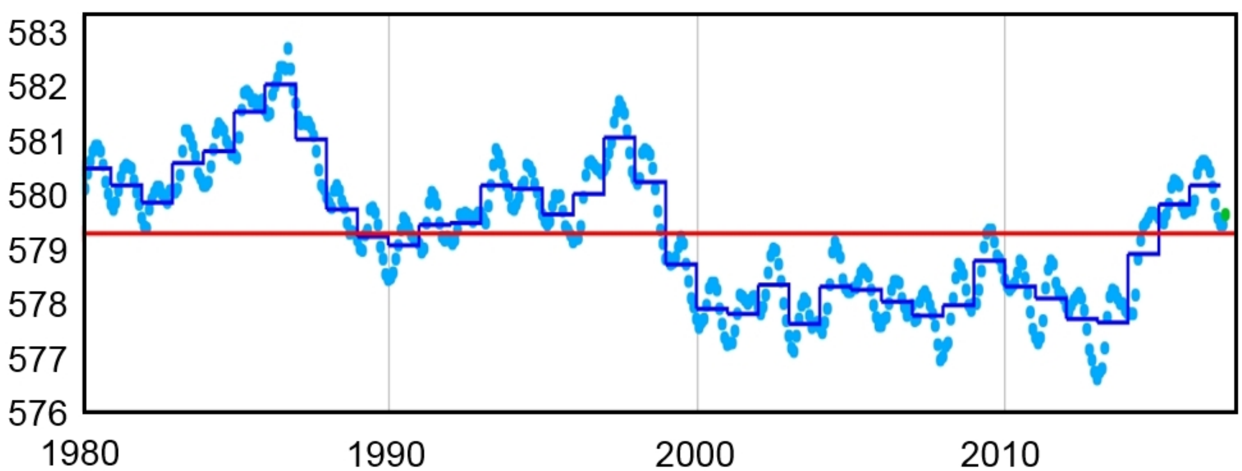

Figure 3. Mean monthly (dots), annual (blue line), and 100-year average (red line) surface water elevations of Lake Michigan in feet above mean sea level relative to the North American Vertical Datum of 1988 from 1980 to the present (NOAA 2017b). The period includes the highest water surface elevations ever recorded on Lake Michigan (October 1986) and the lowest (January 2013).

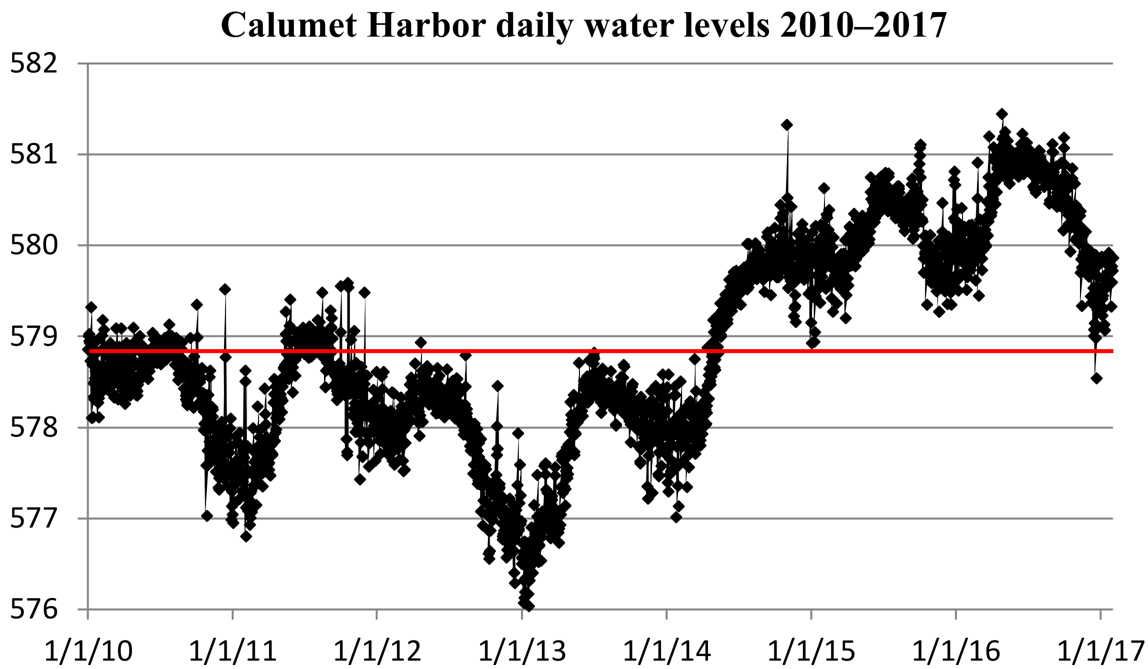

Figure 4. Mean daily surface water elevations of Lake Michigan measured at the Calumet Harbor gauge (Station 9087044) from January 2010 through January 2017 in ft. MSL relative to the North American Vertical Datum of 1988. The mean surface-water elevation over this period was 578.9 ft. MSL (line in red) (NOAA 2017a).

Bathymetry

We have little specific information on the bathymetry of Square Marsh, as we were unable to locate any records of depth, nor were we able to perform a depth survey. However, anecdotal information suggests that depths outside the berm along the south end of the marsh (i.e., in the Lake Calumet turning basin) have been measured around 6–8 feet deep, suggesting the bathymetry inside the berm on the southern portion of Square Marsh is similar, except depths would be at least two feet deeper due to the higher water level. Although Square Marsh was once part of the open waters at the north end of Lake Calumet (Figure 2), it is reasonable to assume that depths become somewhat shallower toward the north end of the open water body, especially along the northwest quadrant where emergent vegetation was evident in 1939 (Figure 2). Additional material was later placed in the north end of Square Marsh over a 20- to 25-acre zone to create a number of small islands, peninsulas, and relatively shallow water, all of which can be observed in satellite imagery during periods of higher water clarity (Figure 5).

Current Habitat and Invasive Species

There is little vegetation growing in Square Marsh other than the non-native common reed (*Phragmites australis*) and a few submersed species in the shallows around the margins and on the islands. This is partly due to the deep near-shore depths, but also due to the activity of common carp (*Cyprinus carpio*) in the shallow zones, which dig up rooted vegetation and suspend sediments as part of their feeding behavior. Uprooting directly kills aquatic plants, while the suspended sediments reduce water clarity to levels precluding the germination and establishment of new plants. Although not tested, water clarity may be further reduced due to planktonic algae responding to the higher nutrient loads typically associated with runoff from golf courses.

Figure 5. The 144-acre Square Marsh is outlined here in yellow on an October 2007 satellite image courtesy of Google Earth. The 6.4-acre projected footprint of the shallow emergent marsh is outlined in light purple; the 25.0-acre projected hemimarsh footprint in the shallow water zone is outlined in blue. The remaining area is projected to remain open water. Imagery courtesy of Google Earth.

Hemimarsh Restoration Potential

The potential to restore higher-quality marsh vegetation in Square Marsh is relatively strong if two key management actions are undertaken: The first concerns water levels, which appear to remain perched two or more feet above Lake Calumet under the current range of surface water elevations within Lake Michigan. A more sophisticated water-level control structure could be installed at the location of the current structure, which would allow water levels in Square Marsh to be lowered for management purposes. The second action is the elimination of common carp from the system. Once a new water-level control structure is installed, water levels could be lowered as much as possible as a prelude to eliminating common carp, and subsequently to initiate both invasive plant management and the establishment of native marsh vegetation (as detailed in the introduction to these analyses). Once carp have been eliminated and native marsh vegetation has been established, water levels can be raised enough to maintain a head between the marsh and Lake Calumet, as long as it is low enough to maintain both a shallow and deep marsh community. The range of water levels over which the marsh should be managed will ultimately depend on the bathymetry, which can only be estimated at this time.

One other element that should be incorporated into the water-level control structure will be modifications to divert common carp from reinvading the marsh in the future. Relatively clean water draining from the marsh into Lake Calumet will be strongly attractive to carp both as a source of food and as breeding habitat. If water-level management can be coupled with appropriate carp and invasive plant management, the potential for establishing and maintaining a relatively diverse marsh community to be enjoyed by humans and wildlife alike is quite high.

Recommendations

If a decision is made by the Port Authority or any other future owner to develop a diverse marsh habitat capable of acquiring hemimarsh characteristics, then a number of specific actions can be recommended. The first of these is to survey and map the bathymetry of Square Marsh to ascertain the acreage at each depth. The interaction of bathymetry and water level will determine the extent of marsh habitat that can potentially develop, and will become the basis of future water-level management decisions. At the same time, the water surface elevation in Square Marsh—or more specifically, the annual range of water surface elevations typically experienced in Square Marsh—should be measured, which will be used to determine the potential disparity in water levels between the marsh and Lake Calumet. Since water levels in Square Marsh cannot be lowered below that of Lake Calumet (by gravity), this will determine the minimum level to which water can be lowered in the marsh for management purposes. This level will vary, as water levels in Lake Calumet fluctuate naturally, so the optimal time to lower water levels extensively will coincide with low-water years in Lake Michigan. Additional recommendations include the following:

- Hydrology: monitor and record water levels throughout the year to better understand the hydrology and to inform the water-level management strategy;
- Hydrology: install and utilize a dropbox water-level control structure with greater capacity to lower water levels, i.e., so they can be adjusted lower for restoration and ongoing management;
- Invasive species: initiate a program to eliminate common reed, reed canary grass, and other invasive plants;
- Fish community:
    - Plan and execute a strategy to eliminate the invasive common carp;
    - Introduce a community of native fish associated with marsh and shallow open water ecosystems.
- Enhance diversity: plant marsh species during drawdowns to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
- Topography/bathymetry: if possible, re-contour steep shoreline areas to create a more extensive shallow marsh to upland transition zone;
- Long-term management: utilizing an adaptive management approach, develop a strategy and implement steps to sustain and enhance the marsh and near-shore plant communities.

We believe that the 31.4-acre estimate of marsh area that can be restored or developed at Square Marsh to be conservative given the potential to manipulate water levels by gravity at the site. The extent of shoreline and depth modification incorporated into the restoration plan can also influence and increase the potential extent and distribution of shallow and deep marsh able to be developed. The ultimate balance between the marsh and open water habitats will in turn determine the potential extent of hemimarsh that can develop at Square Marsh, which should be at least up to 22% of the total pool area. The successful development of marsh vegetation will be entirely dependent upon the eradication of common carp and prevention from reinvading the system. Since carp eradication will also result in the loss of the native fish community, native species adapted to these systems can and should also be reintroduced. As in all restorations, the success of the efforts will ultimately hinge on the development and implementation of a well-conceived plan to adaptively manage the marsh once major restoration activities have been completed. If properly restored, Square Marsh can become the largest and one of the highest-quality examples of hemimarsh in the Calumet Region.

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Whitford Marsh

Summary

The 19.7-acre interior wetland at the Whitford site is part of a 142-acre parcel owned by the Metropolitan Water Reclamation District of Greater Chicago, but managed by the Chicago Park District under a 39-year lease agreement signed in December 2012. The site is located just west of the O'Brien Lock and Dam and east of Interstate 94. The interior wetland is located entirely on a 46.8-acre site used as tailings ponds, over 50 years ago, on the east side of the Little Calumet River. A little over 10 acres of the wetland can be characterized as marsh habitat, with at least 7 acres of shallow emergent marsh and potentially up to 3.3 more acres capable of developing into hemimarsh. However, the site is shallow enough that little open water will likely develop unless muskrats colonize the marsh. The marsh zone is currently dominated by invasive herbaceous plant species, with few native species represented.

There are two major uncertainties concerning the site's restoration potential that will have to be investigated prior to moving forward: The first is in regard to the marsh sediments within the former tailings ponds; an ecotoxicology analysis should be conducted to determine if contaminants remain from what was deposited in these ponds. The existing plant community suggests that the sediments will support marsh vegetation, although this does not rule out potential toxic contamination. The second uncertainty is in regard to hydrology: i.e., whether there is sufficient water entering the site to support marsh development should the site be decoupled from Whitford Pond to the south. If these questions can be addressed satisfactorily, the prospects of developing 10 or more acres of mixed emergent marsh and hemimarsh habitat following the installation of a water control structure are quite good.

Site Description

The wetlands at the Whitford site are part of a 142-acre parcel owned by the Metropolitan Water Reclamation District of Greater Chicago, but managed by the Chicago Park District (CPD) under a 39-year lease agreement signed in December 2012. The site is located between two arms of a large meander of the Little Calumet River system, just to the southwest of the O'Brien Lock and Dam, east of Interstate 94, and north of a Waste Management CID landfill (Figure 1). There are three distinct wetland areas at the site: the 11.7-acre O'Brien Lock Marsh basin to the north, the 30.4-acre Whitford Pond basin to the south, and the 19.7-acre central interior wetland lying between the north and south basins that we are calling Whitford Marsh. The three wetland areas are distinct enough from each other that we are considering them separately. Based on history, landscape position, and configuration, Whitford Marsh and Whitford Pond both possess the potential to be developed into marshes with hemimarsh characteristics. However, the steep-sided O'Brien Lock Marsh, which is collecting and holding runoff from the landfill to the north of E. 134th Street, appears to have relatively poor restoration potential due to its depth and isolated position on the landscape. The following analysis specifically focuses on Whitford Marsh, a wetland located within a former 46.8-acre, four-celled system of tailings ponds (Figure 2). Whitford Pond will be addressed as a separate, independent site, as the characteristics of that site and the strategy utilized to develop its wetlands differ significantly from those at the Whitford Marsh wetlands.

Figure 1. The 142-acre Whitford Pond site outlined in red, with the three major wetlands systems outlined in yellow: the 11.7-acre O'Brien Lock Marsh basin to the north, the 19.7-acre Whitford Marsh wetlands in the middle, and the 30.4-acre Whitford Pond basin to the south. Imagery courtesy of Google Earth.

The entire Whitford area is a remnant of the once-extensive lake plain and riverine wetlands associated with Lake Calumet and the Little Calumet River (Figure 3A). The configuration and hydrology of the remaining wetlands within the area have been strongly altered by excavations and landfills, construction of a tailings pond, and construction of the Calumet portion of Chicago's deep tunnel system (Tunnel and Reservoir Plan: TARP). Natural movements of surface water have also been channeled or diverted by roads, rail lines, berms, and construction of the lock and dam. Construction of the Calumet deep tunnel system directly beneath the site in the early 2000s further isolated and filled more of the wetlands with limestone, including portions of Whitford Marsh. Whitford Marsh is found within what remains of the four-celled tailing ponds (Figures 2, 3B), with the two western cells characterized as shallower and partially wooded. These cells are separated from the deeper, open SE basin by the original berm dividing east and west basins. All of the basins were used to stockpile limestone from the deep tunnel excavation. The NE basin was completely filled, and, along with part of the SE basin, is now the site of a pumping station with two deep tunnel vent and access points (Figure 2). Whitford Marsh is now perched above that stretch of the Little Calumet River below the O'Brien Lock and Dam by the original berms containing the tailings. Whitford Marsh drains south into Whitford Pond through an opening in the berm, which in turn eventually drains east into the Little Calumet River.

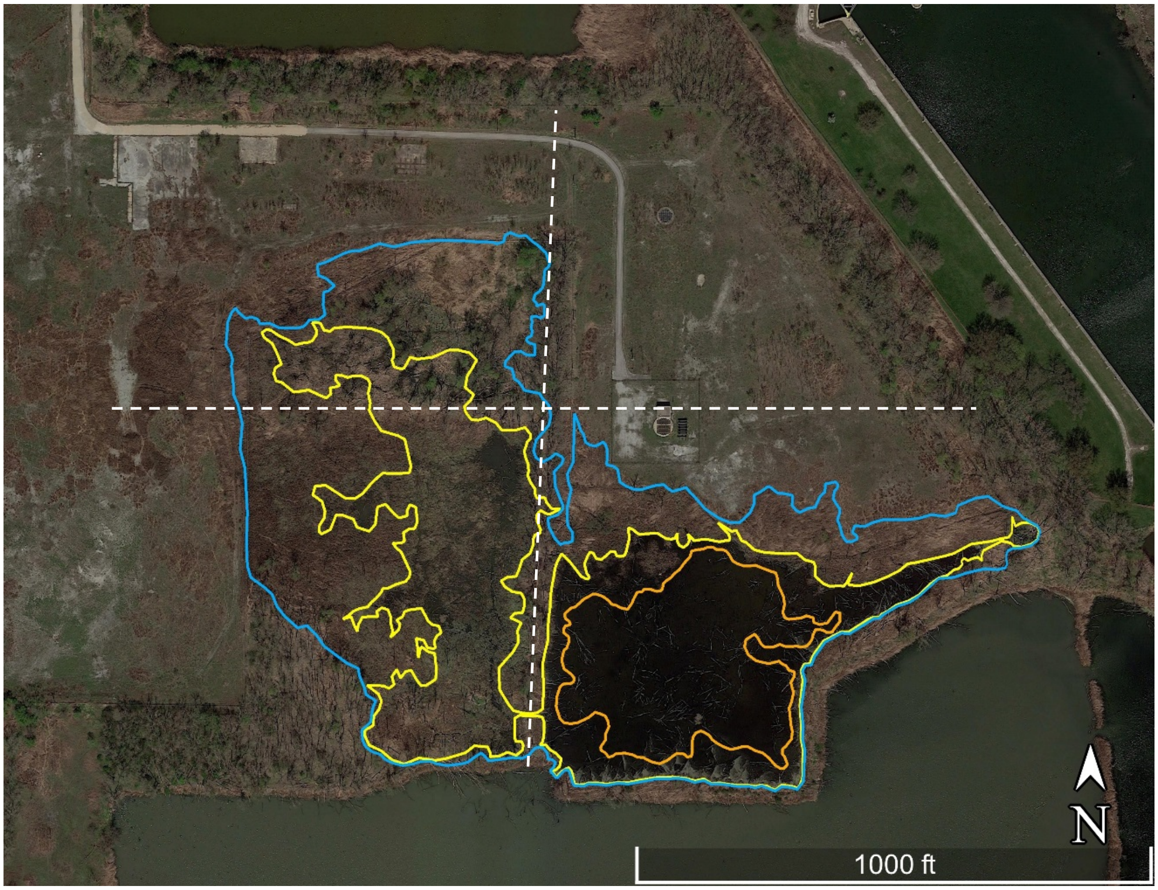
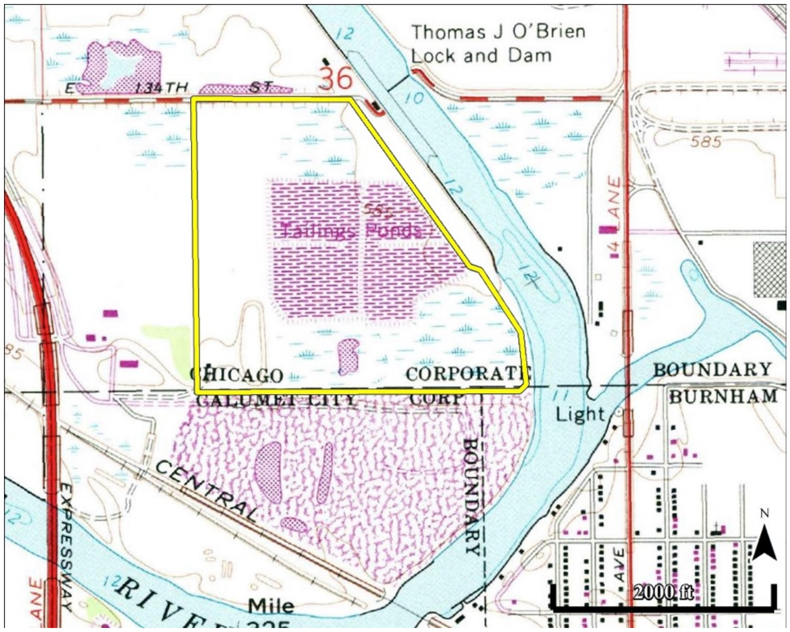


Figure 2. The 19.7-acre Whitford Marsh wetland outlined in blue, with the 10.3-acre marsh outlined in yellow, and a potential 3.3-acre hemimarsh outlined in orange. The dashed white lines are located on the interior berms dividing the tailing ponds into four cells (see Figure 3B). Whitford Pond is directly south of the marsh, while the O'Brien Lock pool is to the north. Note the Calumet deep tunnel pumping station built between the former NE and SE quadrants of the tailing ponds. Imagery courtesy of Google Earth.

B



Figures 3A and 3B. (A) A 1939 aerial image of the future Whitford Pond area outlined in yellow (Illinois State Geological Survey, 1939); and (B) the 1965 USGS map of the future Whitford Pond area outlined in blue. [Note the former extent of wetlands in the top image; the bottom image reveals that Whitford Marsh was formerly the site of a four-celled tailings pond for the containment of an unknown waste product.]

Hydrology

Hydrologically, Whitford Marsh was once part of the vast system of marsh wetlands surrounding Lake Calumet and the Little Calumet River (Figure 3A). Most of the area's wetlands have since been filled, and the future Whitford Marsh was created by the construction and later abandonment of the aforementioned tailings ponds. The areas directly north and south of the tailings ponds were excavated to create what are now functionally two large drainage basins, both of which are perched higher than the Little Calumet River. The hydrology of Whitford Marsh is driven by the configuration of the remaining berms separating the old tailings ponds into four cells (the north and west outer berms were removed during the deep tunnel construction work to accommodate the stockpiling and subsequent removal of limestone spoils). Most of the water now comes from precipitation and local surface runoff, eventually draining from the west pools through the central berm into the east pool, then south into Whitford Pond. During periods with little input, the marsh surface will be in equilibrium with Whitford Pond, and water may flow into the marsh from Whitford Pond under some circumstances. Water levels vary seasonally, with the highest levels generally found during periods of peak snowmelt in the spring. We have no information on where (or even if) Whitford Pond drains into the Little Calumet River, although water levels within the marsh occasionally appear to be higher than in pond to the south, suggesting some drainage is occurring.

Bathymetry and Topography

We have scant specific data on the bathymetry or topography at the Whitford site. What we do know is based on multiple surveys of the area assessing the hydrology and topography. The original berms defining the tailings ponds are mostly still intact, with the outer berms rising up to five feet above the water surface (except as noted above). We can infer that the SE marsh basin is relatively shallow from the large number of trees lying partially exposed above the waterline (i.e., < 24 inches deep) and the lack of emergent vegetation. The SW basin appears to be even shallower based on the distribution of common reed (*Phragmites australis*) in addition to the downed trees within the pool (i.e., < 16 inches deep). The NW basin appears to have little open water or downed trees and can largely be characterized as a monoculture of common reed with few trees, suggesting it primarily consists of wet soils with little standing water other than in the spring.

Current Habitat and Invasive Species

The Whitford Marsh wetlands are dominated by common reed where water levels are shallow enough to permit their establishment, with reed canary grass (*Phalaris arundinacea*) in the drier areas and wetlands under the tree canopy. The tree community occurring throughout the marsh area on the berms or on the wet soils is dominated by eastern cottonwood (*Populus deltoides*), with lesser numbers of black willow (*Salix nigra*), ash-leaved maple (*Acer negundo*), and a few other species interspersed. Native forbs and grasses are minor components of the flora. Although we did not see any common carp (*Cyprinus carpio*), the extremely poor water clarity due to suspended sediment suggests that the carp are instead present in Whitford Pond, which affords them access to the marsh for feeding and breeding in the spring. This would also account for the lack of vegetation in the SE marsh basin.

Hemimarsh Restoration Potential

The potential to restore higher-quality marsh habitat with native vegetation is quite strong if a few assumptions are borne out. There are two major uncertainties concerning restoration potential: The first is in regard to the marsh sediment within the former tailings ponds: we do not know what was actually deposited in the ponds, but we are assuming that the bottom sediments are appropriate for growing plants (i.e. they are not toxic to plants). This assumption is based on the observation that the basins once supported a large population of trees, as evidenced by the downed trees still present at the site. Although the trees are dead, they appear to have died from prolonged exposure to water levels higher than those during their growth. Higher water levels likely developed when Whitford Pond was excavated and filled, thereby inhibiting drainage from the former tailings ponds. However, soils or sediments that will support plant growth may still contain toxic materials, so they will have to be assessed prior to any subsequent restoration effort. That said, a report published by the U.S. Geological Survey suggests that fill deposits in that area of the Calumet are primarily composed of dredge spoils (Kay et al., 1997), although it is unlikely that dredge spoils were the reason tailings ponds were constructed.

The second uncertainty to be resolved before implementing a strategy to restore marsh habitat is whether there is sufficient water entering the site to sustain marsh development if the site were to be decoupled from Whitford Marsh. Decoupling could take place for two reasons: firstly to prevent common carp from accessing the marsh, and secondly to convert Whitford Pond into a deep marsh system capable of developing hemimarsh characteristics. The former would be necessary in order to develop emergent, submersed, or floating-leaved marsh vegetation, while the latter may prove desirable should the CPD decide to manage Whitford Pond as a marsh system, i.e., at a lower water level. If the two systems are hydrologically decoupled, then marsh development will depend entirely on sufficient inputs to sustain marsh vegetation.

Assuming this will be the case, it will then be necessary to construct a water-level control structure capable of draining water from the marsh for management purposes. Should sufficient water inputs occur, the marsh footprint could then be expanded and marsh depths increased. There are at least two locations where a water-level control structure could be easily and inexpensively installed to allow gravity-driven water level management: the first is at the extreme east end of the marsh, which could drain water through a drop log structure in the old tailings berm directly into the Little Calumet River. The second is at the current outlet from the marsh into Whitford Pond, assuming the pond is subsequently managed at a lower water level than it is currently. If the potential issues with sediment toxicology and hydrology do not present insurmountable hurdles, then there is no reason that 10.3 acres of marsh habitat cannot be developed, including 3.3 acres of deeper marsh capable of developing hemimarsh characteristics (Figure 2).

A strategy for managing invasive species, critical to the successful development of native marsh habitat, would need to be implemented as detailed in the introduction to these analyses. The introduction also discusses the strategy for introducing native marsh vegetation as well as an appropriate strategy for managing the site adaptively once the native communities have been introduced. Adaptive management includes appropriately managing water levels to first eliminate common carp, then to install native marsh vegetation, and, lastly, to periodically re-establish marsh vegetation as needed to maintain a desired density of emergent cover. The potential water levels within the marsh may be too shallow to sustain a fish community, although one or more species may be able to overwinter should sufficiently deep water levels develop. The site is likely too shallow for open water to develop unless muskrats colonize the marsh. Assuming this happens, it may take a season or more for them to find the site and expand their numbers sufficiently for the marsh to develop the characteristic interspersion ratio of 1:1 between emergent vegetation and open water in the deeper marsh areas.

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Whitford Pond

Summary

The 30.4-acre Whitford Pond is part of a 142-acre parcel owned by the Metropolitan Water Reclamation District of Greater Chicago, but managed by the Chicago Park District under a 39-year lease agreement signed in December 2012. The site is located just west of the O'Brien Lock and Dam and east of Interstate 94. The pond was built in an area that was once part of the wetland system surrounding Lake Calumet on the west side of the Little Calumet River, just south of the O'Brien Lock and Dam. None of the pond can currently be characterized as marsh habitat except for two small patches (< 1.0 acres) of common reed (*Phragmites australis*).

There are two major questions that will have to be addressed before a restoration plan can be developed and executed. The first is in regard to the suitability of marsh sediments within the pond, which may be contaminated with material in runoff from the adjacent tailings ponds and CID landfill. An ecotoxicology analysis should be conducted to determine what, if any, remediation should be done before ecological restoration can begin. The second uncertainty is in regard to hydrology: i.e., whether water levels in Whitford Pond can be lowered and managed following installation of a water control structure in the berm separating the pond from the Little Calumet River. If these potential issues can be addressed satisfactorily, including installation of an appropriate water control structure, then the prospects of developing approximately 19.4 acres of marsh habitat, which includes 10.6 acres of hemimarsh, are quite good.

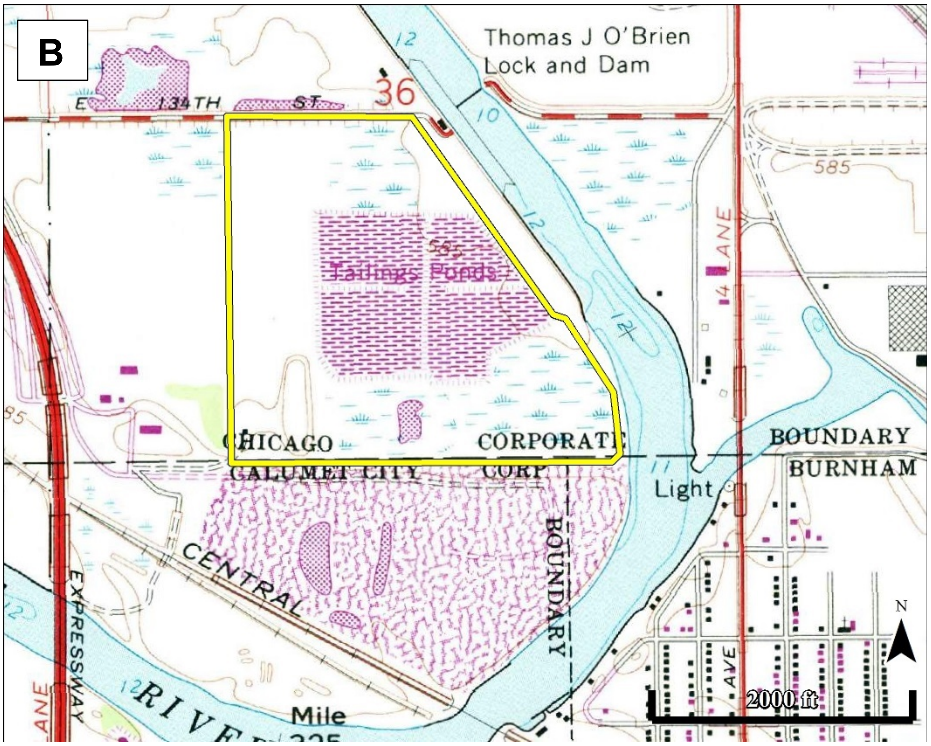
Site Description

The 30.4-acre Whitford Pond is part of a 142-acre parcel owned by the Metropolitan Water Reclamation District of Greater Chicago, but managed by the Chicago Park District (CPD) under a 39-year lease agreement signed in December 2012. The pond is located between two arms of a large meander of the Little Calumet River system, just to the southwest of the O'Brien Lock and Dam, east of Interstate 94, and north of a Waste Management CID landfill (Figure 1). There are three distinct wetland areas at the site: the 11.7-acre O'Brien Lock Marsh basin to the north, the 30.4-acre Whitford Pond basin to the south, and the 19.7-acre central interior wetland lying between the north and south basins that we are calling Whitford Marsh. The three wetland areas are distinct enough from each other that we are considering them separately. Based on history, landscape position, and configuration, Whitford Marsh and Whitford Pond both possess the potential to be developed into marshes with hemimarsh characteristics. However, the steep-sided O'Brien Lock Marsh, which is collecting and holding runoff from the landfill to the north of E. 134th Street, appears to have relatively poor restoration potential due to its depth and isolated position on the landscape. The following analysis specifically focuses on Whitford Pond (Figure 2); Whitford Marsh will be addressed as a separate, independent site, as the characteristics of that site and the strategy utilized to develop its wetlands differ significantly from those at Whitford Pond.

Figure 1. The 142-acre Whitford Pond site is outlined in red, with the three major wetlands systems outlined in yellow: the 11.7-acre O'Brien Lock Marsh basin to the north, the 19.7-acre Whitford Marsh wetlands in the middle, and the 30.4-acre Whitford Pond basin to the south. Imagery courtesy of Google Earth.

The entire Whitford area is a remnant of the once-extensive lake plain and riverine wetlands associated with Lake Calumet and the Little Calumet River (Figure 3A). Natural movements of surface water have been channeled or diverted by roads, rail lines, berms, and dredge spoil (Kay et al., 1997). The configuration and hydrology of Whitford Pond specifically has been altered by construction of a tailings pond system to the north (over 50 years ago) and construction of the CID Landfill by Waste Management to the south. The pond developed following construction of the tailing ponds and landfill, each of which filled in the wetlands, north and south of the future pond, respectively (Figure 3B). Drainage from the wetland was then cut off from the Little Calumet River when berms were constructed along the west shore of the river, running between the tailings ponds and the landfill, preventing the wetland from draining into the river. This caused water levels to rise, effectively creating an open water body that now captures runoff from the landfill and drainage from the Whitford Marsh wetlands.

Figure 2. The 30.4-acre Whitford Pond pond-wetland (outlined in yellow) is found on the south end of the 142-acre Whitford Pond site. The pond is located just north of the CID landfill on the west side of the Little Calumet River, and just south of the Whitford Marsh wetlands. Imagery courtesy of Google Earth.



Figures 3A and 3B. (A) A 1939 aerial image of the Whitford site outlined in yellow (Illinois State Geological Survey, 1939); and (B) the 1965 USGS map of the future Whitford site outlined in blue. [Note the former extent of wetlands in the top image; the bottom image shows that Whitford Pond was once part of the broader Calumet wetland system on the west side of the Little Calumet River.]

Hydrology

Hydrologically, Whitford Pond was once part of the vast system of marsh wetlands surrounding Lake Calumet and the Little Calumet River (Figure 3A). Most of the area's wetlands have since been filled, and the future Whitford Pond site was the wetland area situated between the aforementioned tailings ponds and CID landfill, following their construction. Once this area was bermed off from the river, precipitation and runoff filled the resulting basin to create Whitford Pond. The pond is deepest at the east end, as this was originally the lowest elevation, i.e., the elevation adjacent to the river. The pond is perched relative to the river, with the pond's water surface well above the river surface water level (we were unable to measure the elevational difference, but it appears to be five to eight feet above the river surface). The eastern end of the pond drains into the Little Calumet River, although we were unable to determine the exact location of the overflow as we were unable to gain access to the area. Runoff water enters the pond from the landfill to the south, Whitford Marsh to the north, and the Waste Management site to the west. During periods of high-water levels, water from the pond may back up into the Whitford Marsh wetland. During periods of drought, the water surface drops due to evaporative processes.

One question that remains unanswered is why the pond was created: the north and south berms were already in place to create the tailings ponds and the landfill, but the only apparent purpose of the eastern berms was to create a perched water body above the river. We were unable to find any record of why this was done, although the pond may simply have served as a detention basin to hold runoff from the landfill or the tailings ponds in order to prevent it from running directly into the river. Without further information, these conclusions are speculative.

Bathymetry and Topography

We have no specific data on the bathymetry at Whitford Pond. What we do know is based on multiple surveys of the area assessing the plant community, hydrology, and topography. The original berms holding water above the Little Calumet River at the east end of the pond rise up to five feet above the pond's surface, as do the berms separating the pond from Whitford Marsh and the landfill. A second, lower interior berm divides the far eastern portion of the pond from the main body (Figure 2), although the water surface remains contiguous due to at least three breaks in this berm. The smaller section of the pond adjacent to the river appears to be deeper based on color differences (i.e., it is often darker in multiple satellite images). The western end of the pond is bordered by higher ground, although all of the land in this area was once dredge spoil. Water depths along portions of the northwest shore appear to be relatively shallow based on the presence of many downed trees lying partially exposed above the water. Several areas along the south shore of the pond also appear to be quite shallow based on the extent to which common reed (*Phragmites australis*) has colonized from shore. These shallows are consistent with erosional deposition from the landfill to the south.

Current Habitat and Invasive Species

Although vegetation does not appear to be growing within the main body of Whitford Pond, the shoreline is dominated by common reed where water levels are shallow enough to permit its establishment, with reed canary grass (*Phalaris arundinacea*) and other weedy species found on the drier berm slopes. There are trees bordering parts of the pond shoreline, primarily eastern cottonwood (*Populus deltoides*) and black willow (*Salix nigra*), with a few other species interspersed. Native forbs and grasses are minor components of the flora. Although we did not see any common carp (*Cyprinus carpio*), they appear to flourish in Whitford Pond (an assessment based on water quality). This would also account for the lack of submersed or emergent vegetation throughout the pond.

Hemimarsh Restoration Potential

The potential to restore higher-quality marsh habitat capable of developing hemimarsh characteristics is quite strong if a few assumptions are borne out. There are two major uncertainties concerning restoration potential: The first is in regard to the marsh sediment within the pond; we do not know if Whitford Pond was actively used for the disposal of contaminants, or if contaminants from either the tailings ponds or the landfill passively collected in the pond as water draining from these areas passed through. It is likely that the sediments will support plant growth based on the presence of vegetation around the pond's margin; i.e., they do not appear to be toxic to plants. The lack of emergent, submersed, or floating-leaved vegetation throughout the basin is more likely due to the presence of common carp. However, soils or sediments that will support plant growth may still contain toxic materials, so they should be assessed prior to any subsequent restoration effort. A 1997 report published by the U.S. Geological Survey suggests that fill deposits in this part of the Calumet were primarily composed of dredge spoils (Kay et al., 1997), which should be appropriate to support marsh vegetation if the potential contaminants issue can be addressed.

The second uncertainty to be determined before implementing a strategy to restore marsh habitat is whether water levels can be lowered and managed with the installation of a water-level control structure. The key question in this regard is whether there is a logistical reason to maintain the current water levels; i.e., would there be an unforeseen consequence to lowering them? There is no obvious reason for maintaining them, but there is also a lack of clear reasoning as to why the berms were initially created (forming a deep pond perched above the Little Calumet River). This will have to be ascertained prior to developing a wetland restoration strategy. If water levels do not require maintenance at the present elevation, then a control structure capable of draining the entire pond for management actions should be installed. This would be followed by the implementation of a water-level management strategy designed to support marsh habitat capable of developing hemimarsh characteristics. A well-designed control structure should allow complete dewatering given the presumed bathymetry, which in turn will allow sediments to be dried and consolidated and all common carp to be eliminated from the system.

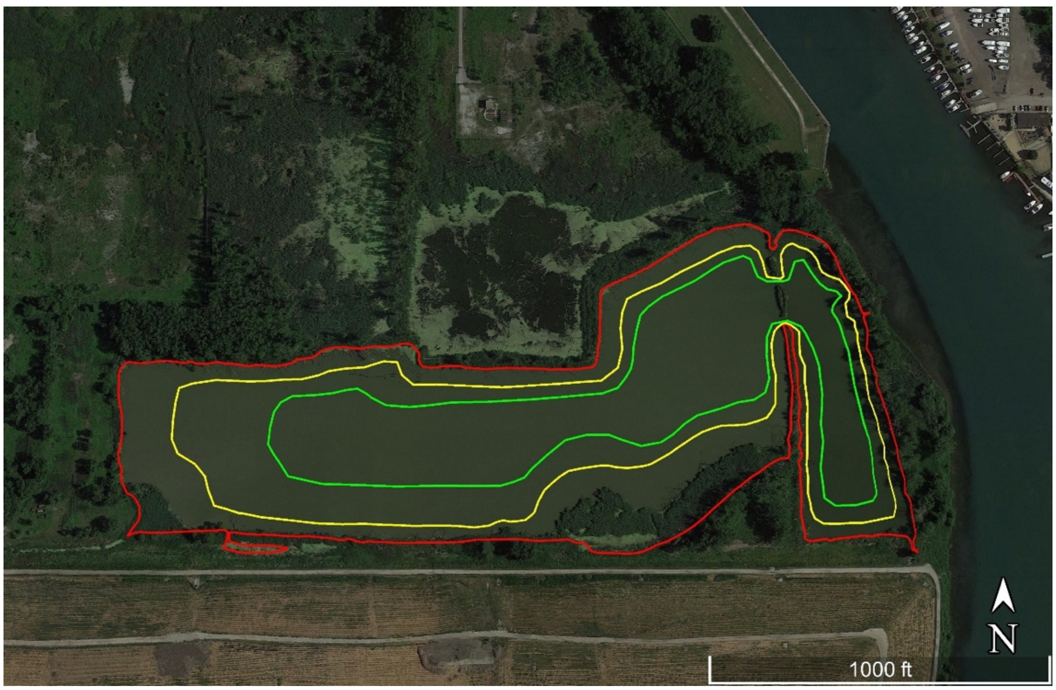


Figure 4. Projected habitats to be developed at Whitford Pond once water levels are lowered to establish marsh vegetation. The current 30.4-acre pond footprint is outlined in red. The projected new 19.4-acre marsh footprint is outlined in yellow, with 8.8 acres of emergent marsh (between the yellow and green lines), and 10.6 acres of hemimarsh outlined in green. Imagery courtesy of Google Earth.

If the potential issues with sediment contamination and hydrology do not present insurmountable hurdles, then there is no reason the restoration of marsh habitat capable of developing hemimarsh characteristics cannot proceed. Following installation of a water control structure, lowering and managing the pond approximately two feet below the current water surface elevation would result in a smaller water body with a range of depths capable of developing marsh vegetation. We are estimating the new marsh could support approximately 8.8 acres of emergent marsh and 10.6 acres of deep marsh capable of developing hemimarsh characteristics (Figure 4).

A strategy for managing invasive species, critical to the successful development of native marsh habitat, is detailed in the introduction to these analyses. The introduction also discusses the strategy for introducing native marsh vegetation as well as an appropriate strategy for managing the site adaptively once the native communities have been successfully introduced. Adaptive management includes appropriately managing water levels to first eliminate common carp, then to install native marsh vegetation, and, lastly, to periodically re-establish marsh vegetation as needed to maintain a desired density of emergent cover. Some areas of the eastern marsh may be deep enough to sustain fish capable of overwintering in relatively shallow water, should CPD decide to introduce a fish community. Assuming muskrats find the site, it may take a season or more for them to expand their numbers sufficiently for the marsh to develop the characteristic interspersion ratio of 1:1 between emergent vegetation and open water in the deeper marsh areas.

References

Illinois State Geological Survey. (1939). Unpublished material, Illinois historical aerial photographs: 1936 to 1941 v.4: Illinois State Geological Survey, Champaign, Illinois.

Kay, R. T., Greeman, T. K., DuWelius, R. F., King, R. B., & Nazimek, J. E. (1997). Characterization of fill deposits in the Calumet Region of northwestern Indiana and northeastern Illinois. U.S. Geological Survey water-resources investigation report 96-4126. Prepared in cooperation with the U.S. Environmental Protection Agency.

Wolf Lake: Management Unit Nine

Summary

Management Unit Nine (MU9) is a 32.0-acre parcel owned by the State of Illinois that surrounds an additional 11.3-acre parcel now in private ownership. The two parcels comprise 43.3 acres are located at the south end of Wolf Lake's Pool 3. The site extends north from E. 133rd Street between S. Ave. F and S. Ave. L. There are seven MU9 pools totaling 9.1 surface acres (6.3 acres on state-owned land) with two channels open to Wolf Lake, which adds an additional 2.3 acres that could potentially develop deep marsh characteristics. The open water pools are part of a peninsula that was created through the deposition of slag into Wolf Lake, an area that later served as a base of radar operations for the Nike Missile Site C-44 in the 1950s.

Today, the MU9 pools and channels are relatively long, narrow, and steep-sided shallow water bodies that have at least some portion of the bottom covered with loose slag or gravel over native sediments. Depths vary with Wolf Lake water levels, ranging from approximately 1– 2.5 feet deep. Water levels in the lake, pools, and channels are controlled by the Wolf Lake outlet weir at Indian Creek. Consequently, the surface water level will not fluctuate below the outlet invert elevation in a manner that would promote the occasional establishment and expansion of emergent vegetation in water over a foot deep. However, sediment could be added to selectively raise depths around the steep-sided margins and open water zones of the state-owned pool system to improve marsh functions. This would serve to create a more extensive marsh-to-shoreline transition zone supporting up to 5.2 acres of marsh habitat, including a 3.6-acre mosaic of depths that could provide hemimarsh function.

Site Description

The state-owned Management Unit Nine (MU9) is an irregularly-shaped, 32.0-acre parcel located at the south end of Wolf Lake's Pool 3 (Figure 1). The site also includes an additional 11.3-acre interior parcel recently purchased by a private party. The entire 43.3-acre site extends north from E. 133rd Street between S. Ave. F and S.Ave. L. There are seven pools on the site totaling 9.1 surface acres (6.3 acres on state-owned land), with two channels open to Wolf Lake, adding an additional 2.3 acres that could potentially develop deep marsh characteristics (Figure 2). There also are 31.9 acres of mixed uplands found outside the pools: 23.4 acres on state-owned land and 8.5 acres on the privately owned parcel. The wetland pools were all that remained of the south end of Wolf Lake after much of the site had been used by the steel industry to dump slag. The resulting landform was later used as a base of radar operations associated with the Nike Missile Site C-44, whose missiles were deployed at the north end of Wolf Lake. Site C-44 has long been abandoned as a relic of the Cold War.

The MU9 pools and channels are relatively long, narrow, and steep-sided (Figure 2), representing zones that were selectively not filled with slag, although most have at least some portion of the bottom covered with loose slag or gravel over native sediments. Depths vary, ranging from approximately 1–2.5 feet deep. Emergent or floating-leaved vegetation have colonized portions of the pools, while other areas remain bare. The upland areas outside the pools have been colonized by a mixture of forbs, trees, and shrubs that are able to survive on the shallow soils overlying the slag deposits. The remnants of building foundations can be also found on these areas, as well as piles of more recent dumping, e.g., concrete slabs and rubble.

Figure 1. A March 2012 satellite image the 43.3-acre area designated as Management Unit Nine (MU9) at the south end of Wolf Lake's Pool 3 (outlined in yellow). This includes an 11.3-acre interior parcel that is privately owned (outlined in red), while the remaining 32.0 acres are owned by the state of Illinois. Imagery courtesy of Google Earth.

Figure 2. MU9 with wetland pools outlined in blue and channels open to Wolf Lake outlined in purple. Pool 7 and a portion of Pool 6 are located on the interior parcel in private ownership. Imagery courtesy of Google Earth.

Hydrology

Hydrologically, the MU9 pools channels have either a direct connection (Pools 1 and 5, and Channels A and B) or groundwater connection (Pools 2, 3, 4, and 6) to Wolf Lake; thus, the water level within each area reflects water levels throughout Wolf Lake's Pool 3 (Figure 2). Since water levels in Wolf Lake are controlled by the outlet elevation at Indian Creek (assuming evapotranspiration has not lowered water levels below the Indian Creek weir), the MU9 pools and channels are directly influenced by the dynamics of Indian Creek drainage. Due to blockages in Indian Creek, Wolf Lake and MU9 water levels have been approximately 0.8 feet higher than the weir elevation throughout 2016, although levels have gradually lowered over the past two years. Water levels within the pools without a direct connection to Wolf Lake may also vary with local precipitation and runoff events.

Current Habitat and Invasive Species

Although bathymetry is not available to inform projections, the existing patterns of marsh vegetation suggest that portions of the pool area will support emergent and/or floating-leaved vegetation. Marsh vegetation around the margins of deeper water and scattered across the shallower pools is comprised of cattails, common reed, purple loosestrife, spadderdock, and an assortment of bulrushes, sedges, and smartweeds (Figure 3). Willows and other wetland shrubs have colonized much of the area at the edge of the water. Above the water line, the flora is dominated by woody species such as cottonwoods, willows, buckthorns, and a variety of shrubs, with an understory of herbaceous species that include aggressive invasives mixed with both common and somewhat conservative native species.

Figure 3. MU9 pool photos showing emergent vegetation in Pool 1 (A), open water in Pool 3 (B), slag substrate around Pool 4 (C), and floating-leaved vegetation in Pool 5 (D). Photographs by the author.

Hemimarsh Restoration Potential

Based on the current distribution of vegetation in MU9, water depths in all but Pools 1 and 6 preclude development of deep marsh habitat. The distribution of vegetation may also be influenced by the bottom substrate of pools or channels—i.e., the presence of slag within the substrate may also inhibit the development of emergent vegetation. This conclusion is supported in at least some of the areas by the lack of submersed vegetation. The relative lack of emergent vegetation is not too surprising, as the water surface does not drop below the Indian Creek weir elevation except during prolonged dry periods. Most marsh vegetation in depths greater than 1 foot cannot readily re-establish due to depth-limiting germination potential. The lack of an upland-to-wetland transition zone due to the steep slag shorelines also precludes a distinct shallow marsh from developing around much of the pool margins. Consequently, the potential to develop more extensive shallow or deep marsh habitat, including the development of hemimarsh, will be dependent on modifying the shorelines and creating shallower zones capable of supporting emergent vegetation through the deposition of additional substrate. This would create a more extensive upland-to-wetland transition zone as well as a mosaic of deeper and shallower marsh depths. Raising the bottom elevation in a portion of the deeper pools will create a shallow zone from which emergent vegetation can re-establish, while the deeper zones receiving little or no additional substrate would remain open water.

To develop hemimarsh habitat within this context, it will be necessary for the new sediment to be deposited in a pattern approximating the configuration of emergent vegetation in the resultant hemimarsh. The deeper zones will remain open water; cover in the emergent zones will change in time through the dynamic of herbivory and senescence, coupled with germination and establishment. The shallow and deep marsh zones and the open water zones could then be planted as detailed in the introduction to these analyses.

We saw no evidence of common carp (*Cyprinus carpio*) in any of the pools, despite Pools 1 and 5 and the channels being open to Wolf Lake, which does support a significant carp population. Even if carp occasionally make their way into the open pools, they may do little harm in areas where the bottom is composed of slag or gravel (it is not uncommon for marsh or aquatic vegetation to coexist with carp where their feeding behavior is ineffective in uprooting and suspending sediments). Since softer sediments will likely be introduced as part of the shoreline and depth modification work, a carp management strategy should be developed and implemented within the pools. Following the elimination of carp, simply closing off access to the open waters of Wolf Lake with berms would prevent their reinvasion. Carp cannot be managed in the channels.

Recommendations

In order to develop more extensive marsh habitat within the MU9 pools, we would start by recommending that sediment or suitable substrate be brought in to change the pools' bathymetry, i.e., the bottom contours. This material will most likely need to be dredged, dewatered, transported, deposited and contoured in place. There is little likelihood of enhancing the marsh vegetation or expanding the marsh footprint absent this first step. If the decision is made to bring in material to create an upland-to-marsh transition zone and pockets of shallower water throughout the pools, we recommend the following:

- Topography/bathymetry: re-contour up to 60% of the steep shorelines to create a more extensive shallow marsh-to-upland transition zone;
- Topography/bathymetry: create shallow water zones (i.e., water ≤ 12 inches deep) in up to 60% of the open water zones by depositing appropriate sediment material in a coarse mosaic for developing emergent vegetation;
- Topography/bathymetry: close off access from Pools 1 and 5 to the lake through the construction of berms for carp management;
- Woody management: clear trees and shrubs from all shorelines that have been amended by the addition of sediment;
- Invasive species: initiate a program to eliminate common reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), and other invasive plants;
- Invasive species: eliminate common carp from any pools in which they are found;
- Enhance diversity: plant emergent, floating-leaved, and submersed species throughout the pools at appropriate depths to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community;
- Long-term management: utilizing an adaptive approach to management, develop a strategy and implement steps that can be taken to sustain and enhance the marsh.

The extent of shoreline and depth modification will determine the potential distribution of shallow marsh, deep marsh, and open water communities that can be developed across the 8.6-acre pool and channel area found on state land. The ultimate balance between these different habitats will in turn determine the potential extent of hemimarsh that can be developed at MU9. This could be up to 42.2% of the total pool area, including 0.5 acres in the shallower portion of Channel B (for a total of 3.6 acres of the pool and channel area). Work during the initial growing season would primarily consist of invasive and/or non-native plant management, followed by native plant introductions and ongoing adaptive management.

We have included information in this analysis on those pools found within the 11.3-acre privately owned parcel since there has been some discussion of managing the entire 43.3-acre site to develop marsh vegetation. This would add an additional 2.8 acres to the marsh footprint of MU9 (part of Pool 6 and all of Pool 7).

Individual Marsh Site Descriptions

Lower Priority Sites

126th Street Marsh

Summary

The 126th Street Marsh is a 5.4-acre riparian wetland created in 2003 along the lower 0.4-mile reach of Indian Creek just before it empties into the Calumet River. The south end of the wetland begins at E. 126th Street and extends north to the river. The original channel was filled in to build a warehousing/manufacturing and shipping facility, currently occupied by PECO Pallet of Chicago. Indian Creek was deepened and re-channelized a short distance to the east of its original channel, incorporating a series of meanders and lowered banks to create a shallow marsh floodplain. The current wetland provides a modest amount of open water habitat coupled with a shallow marsh zone around the stream margins.

We are not currently recommending the restoration of additional marsh habitat at the 126th Street Marsh wetlands: the system is performing well as designed, and the benefits of altering the hydrology to develop a hemimarsh spread thinly along the stream channel are modest at best. Although improving the quality or quantity of hemimarsh habitat is an important goal, the potential benefits of pursuing this goal do not outweigh the potential costs in a wetland habitat that is currently functional.

Site Description

The 126th Street Marsh (Figure 1) is a 5.4-acre riparian wetland created in 2003 along the lower 0.4-mile reach of Indian Creek just before it empties into the Calumet River. The south end of the wetland begins at E. 126th Street and extends north to a rock dam at the edge of the Calumet River. Approximately three-fourths of the original channel and adjacent floodplain (Figure 2) were filled in to build a warehousing/manufacturing building and shipping facility, which is now home to PECO Pallet of Chicago. Indian Creek was deepened and re-channelized a short distance to the east of its original channel, incorporating a series of meanders and lowered banks to create a shallow marsh floodplain (Figure 3). The current wetland is working well as designed to provide a modest amount of open water habitat coupled with a shallow marsh zone around the stream margins.

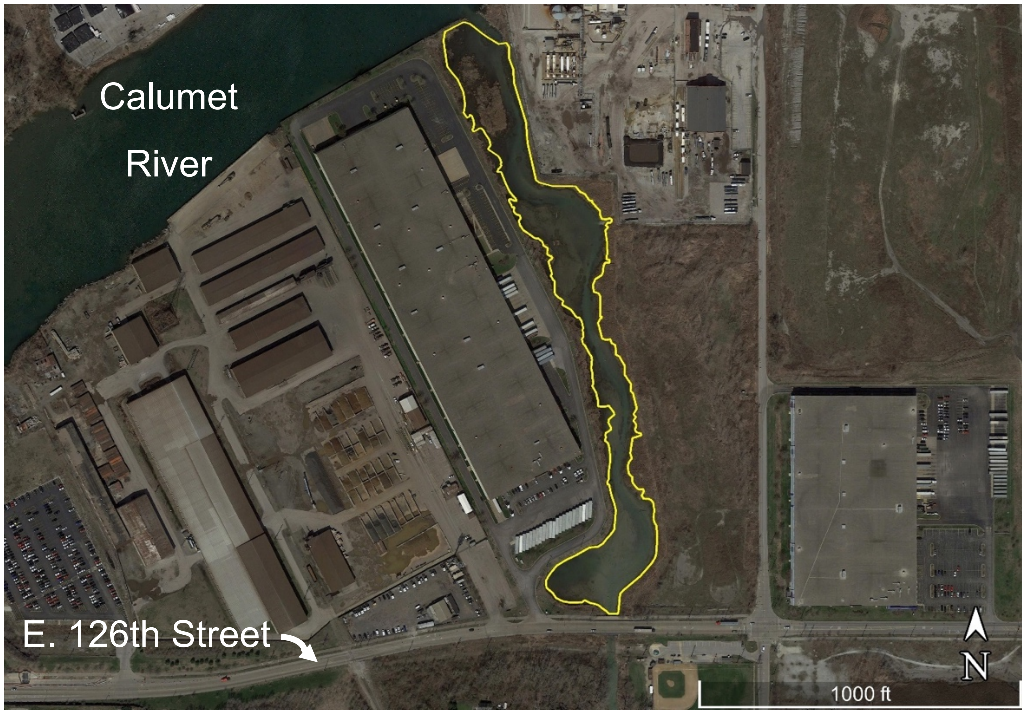


Figure 1. Satellite image of the E. 126th Street Marsh, a previously restored riparian wetland at the mouth of Indian Creek draining north into the Calumet River. Image courtesy of Google Earth.

Figure 2. A 2002 satellite image showing the flow path of Indian Creek (in yellow) prior to riparian restoration in 2003. The creek channel north of E. 126th Street was meandered to create a longer reach and an extended riparian wetland along its length. Image courtesy of Google Earth.

Hydrology

Hydrology of the 126th Street Marsh is a function of Indian Creek flow characteristics, which in turn are determined by the volume of water draining into its source at Wolf Lake. Whatever drains into Wolf Lake eventually makes its way to the 126th Street Marsh and the Calumet River. However, there is a rock dam at the mouth of the marsh that is designed to maintain an approximate surface water elevation of 580.5 feet above mean sea level (ft. MSL) relative to the North American Vertical Datum of 1988 (this elevation is approximate, in that the dam is leaky by design and may drain lower under conditions of low or no flow from Indian Creek). Water elevation at the 126th Street Marsh is relatively static and maintained around this elevation except when the surface elevation of the Calumet River rises above 580.5 ft. MSL, in which case the creek surface also rises and floods the lower floodplain elevations upstream (e.g., the marsh at Hyde Lake). Since the Calumet River is in effect an arm of Lake Michigan, this occurs whenever Lake Michigan water levels rise above 580.5 ft. MSL.

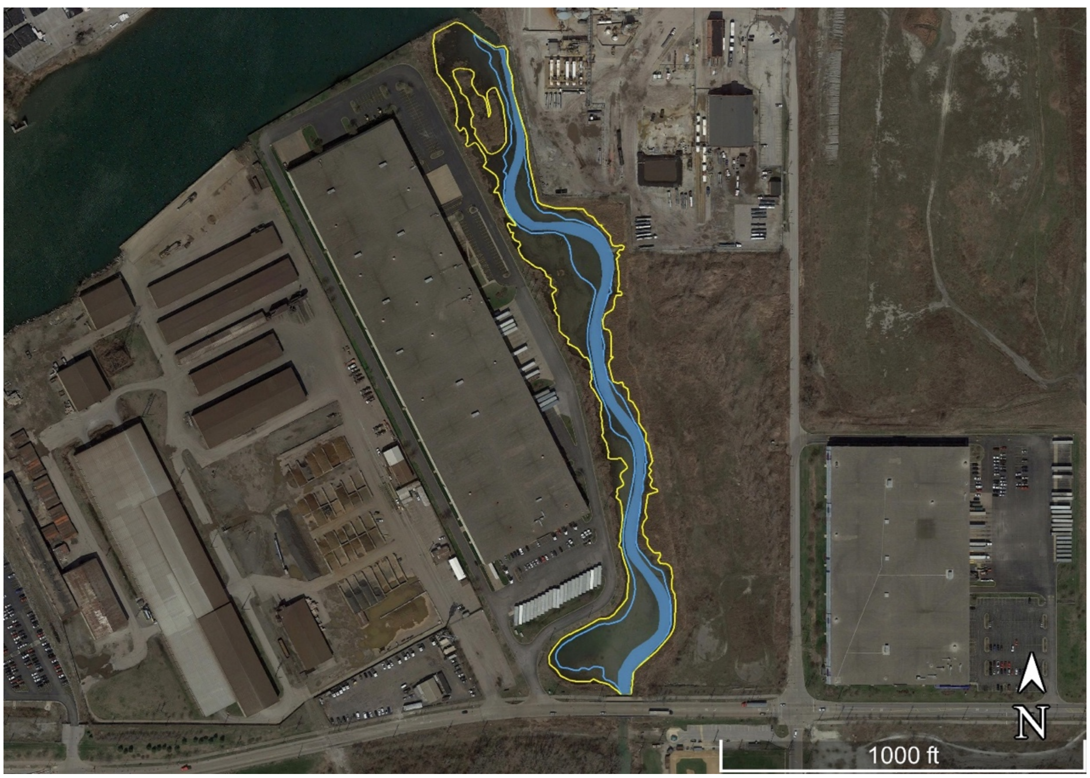


Figure 3. 2017 Satellite image of the 5.4-acre 126th Street Marsh outlined in yellow, with 2.7 acres of shallow emergent marsh located between shore and the 2.9 acres of open water outlined in blue. The 1.3-acre meandering channel is indicated by the solid blue zone within the open water habitat. Image courtesy of Google Earth.

Bathymetry and Topography

We do not have any specific data on the bathymetry of the 126th Street Marsh. However, based on visual inspection during several trips to the marsh, the meandering channel appears to be between 3–4 feet in depth. There is a deeper open water pool on the north side of E. 126th Street that ranges in depth from shore out to 2.5–3 feet in depth, and a smaller, deep open water pool 1,300 feet downstream of E. 126th Street (Figure 3). Other portions of the wetland are much shallower (< 1.0 feet deep).

Hemimarsh Restoration Potential

There currently is little hemimarsh restoration potential for the 126th Street Marsh wetlands without significant modification to the existing outlet at the Calumet River. This is primarily because water depths are too deep in the pools or channel to initiate or maintain an emergent deep marsh community, or too shallow elsewhere to support development of an open water community. With no naturally occurring low-water periods and no current water-level control potential, there is little ability to establish emergent vegetation in the relatively small open water zone. This situation could change marginally if the mouth at Indian Creek could be modified to lower creek water levels to that of the Calumet River, which in turn would reduce the wetland footprint upstream of the mouth. Adjusting this structure is unlikely, as it was initially designed to create a larger wetland footprint while allowing migratory fish passage, including migratory salmon moving upstream to Wolf Lake. If such a strategy were pursued, the ability to lower 126th Street Marsh water levels would remain modest as long as Lake Michigan water levels remain higher than average, as they have done over the past few years.

Recommendations

We do not currently recommend restoring additional marsh habitat at the 126th Street Marsh wetlands given that the system is functioning well as designed as well as the minimal impact of changing water levels to develop <1 acre of hemimarsh, which would be spread thinly along the length of stream channel. Although improving the quality or quantity of hemimarsh habitat is an important goal, the potential benefits of pursuing this goal do not outweigh the potential costs in a currently functional wetland habitat.

Calumet Conservation Area

Summary

The Lake Calumet Conservation Area west wetland is an irregularly shaped 15.9-acre pool located adjacent to the shoreline in the northwestern quadrant of Lake Calumet, just east of Interstate 94. Now owned by the Illinois International Port District at the Port of Chicago, the wetland was created in what was once the west-central portion of the open waters of Lake Calumet before it was filled for development. The wetland appears to be relatively deep, steep-sided, and unvegetated except for the fringe of invasive species around the margins.

We are not making any recommendations at present for restoring marsh habitat in the Lake Calumet Conservation Area west wetlands. However, this conclusion is based on assumptions regarding depth, but limited by the information we could gain within the scope of this analysis. This conclusion could be reevaluated should further investigation show that the depth profile is less than 3 feet deep. Should this prove to be the case, marsh development would require that a water-level control structure be designed to keep common carp out of the marsh, followed by a significant invasive eradication effort, native plantings, and a commitment to managing the site adaptively into the foreseeable future.

Site Description

The Lake Calumet Conservation Area west wetland (hereinafter the LCCA west wetland) is an irregularly shaped 15.9-acre pool located adjacent to the shoreline in the northwestern quadrant of Lake Calumet, just east of Interstate 94 opposite E. Kensington Ave. (Figure 1). It is owned by the Illinois International Port District at the Port of Chicago. The wetland was created in what was once the west-central portion of the open waters of Lake Calumet before it was filled to develop space for shipping, industry, and other uses (Figure 2). The near-shore area is relatively steep, as construction debris and other materials were deposited and pushed in from the edges. The wetland is unvegetated except for a fringe of common reed (*Phragmites australis*) and invasive trees around the margins (Figure 3). Currently, access to the wetland is restricted and closed to the public.

Figure 1. Satellite image of Lake Calumet with the 15.9-acre LCCA west wetland outlined in yellow (top), and with a closer view of the wetland (bottom). Images courtesy of Google Earth.

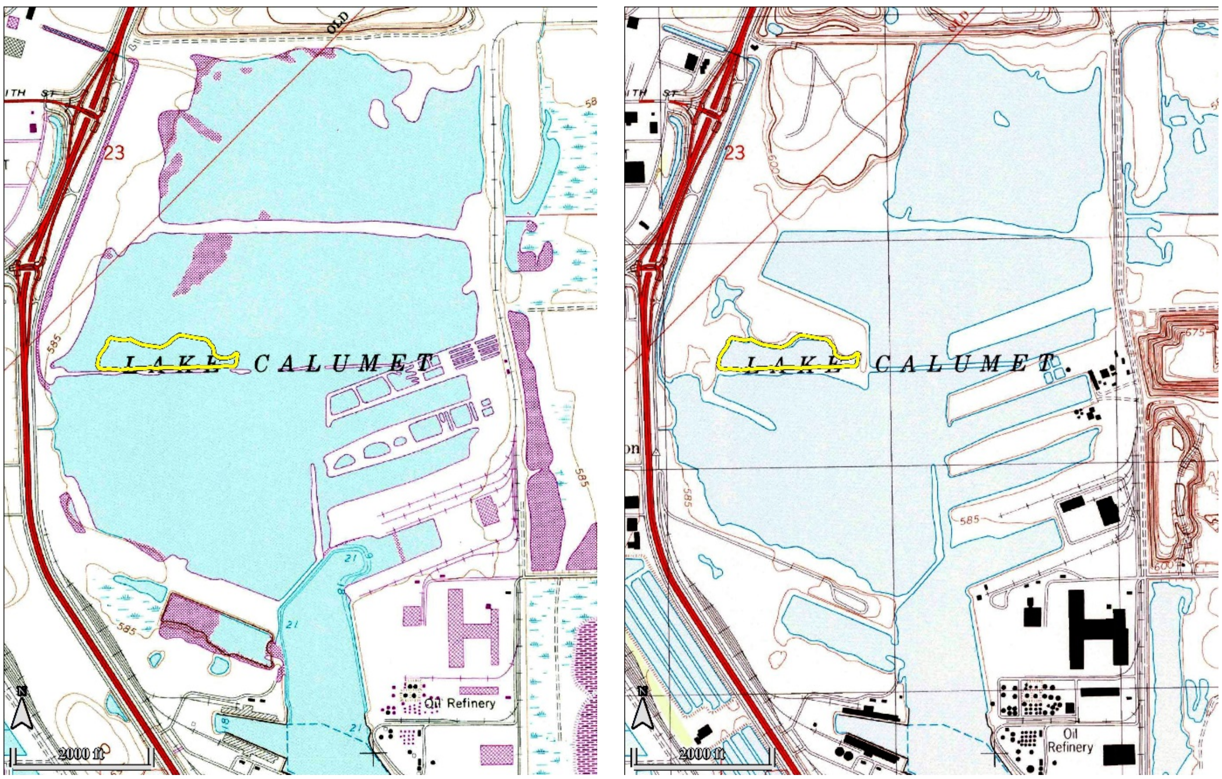


Figure 2. 1965 USGS map of Lake Calumet (left) after construction of the berm bisecting the lake at approximately E. 114th Street. Also depicted is the 1991 USGS map of the same area (right) following a massive deposition of fill between 1975 and 1980 (Kay et al., 1997). Location of the LCCA west wetland is outlined in both maps in yellow.

Figure 3. Photograph of the near-shore vegetation around the margins of the LCCA west wetland taken October 14, 2015. The flora is dominated by common reed and common buckthorn (*Rhamnus cathartica*). Photograph by the author.

Hydrology

Hydrology in the LCCA west wetland appears to be driven primarily by local surface runoff, although we could not rule out the presence of springs. Water drains from the open water pool through an outlet in the south shore berm into Lake Calumet. The outlet is located approximately 800 feet from the eastern edge of the wetland. When the site was surveyed on October 14, 2015, Lake Calumet was at a surface elevation of 580.0 feet above mean sea level (ft. MSL) relative to the North American Vertical Datum of 1988. Although we did not determine the surface water elevation in the wetland pool, it appeared to be approximately two feet higher than the Lake Calumet water surface (i.e., ~582 ft. MSL). Consequently, the pool will remain isolated from Lake Calumet unless the lake surface elevation exceeds 582 ft. MSL. This has only occurred once since the wetland was created, during the highest period on record (from the middle of 1985 through late 1986). Water levels within the wetland may fall below the invert at the outlet during periods of high evapotranspiration.

Bathymetry

We have no specific data on the bathymetry of the LCCA west wetland. The lack of vegetation away from the wetland margins indicates that the sides are steep and the water is too deep for emergent vegetation to establish. Nor is it possible to estimate depth through visual inspection, as the water is nearly opaque because of suspended sediments in the water column (most likely due to the presence of common carp (*Cyprinus carpio*)). It is possible, and even likely, that some of the material used to fill in Lake Calumet and create the isolated wetland is overlying the native sediments across the bottom so that the open water is now much shallower.

Hemimarsh Restoration Potential

There appears to be no current potential to restore or develop hemimarsh habitat at the LCCA west wetlands due to water depths, which present as too deep to support development of an emergent marsh community. However, this conclusion is based on assumptions made with the information we could gather within the scope of this analysis, but could be reevaluated should further investigation demonstrate that the depth is less than it appears. Should this prove to be the case, a water-level control structure designed to keep common carp out of the marsh would need to be installed (following a successful carp eradication effort). Such an approach, if warranted, would also require a significant invasive eradication effort, coupled with native plantings, and followed by a commitment to managing the site adaptively into the foreseeable future. Before such a restoration effort could be initiated, the site should be evaluated for the presence of contaminants that could pose a potential threat to human or wildlife health.

Recommendations

We are not offering any current recommendations for restoring marsh habitat at the LCCA west wetlands. However, this conclusion is based on assumptions that were made regarding depth, but were limited by the information we could gain within the scope of this analysis. Should further evaluation of the site reveal a more appropriate depth profile (i.e., the depth profile is less than 3feet deep), this conclusion could then be reevaluated. Marsh development would require that a water-level control structure be designed to keep common carp out of the marsh, followed by a significant invasive eradication effort, native plantings, and a commitment to managing the site adaptively into the foreseeable future.

References

Kay, R. T., Greeman, T. K., DuWelius, R. F., King, R. B., & Nazimek, J. E. (1997). Characterization of fill deposits in the Calumet Region of northwestern Indiana and northeastern Illinois. U.S. Geological Survey water-resources investigation report 96-4126. Prepared in cooperation with the U.S. Environmental Protection Agency.

Heron Pond

Summary

The Heron Pond wetlands consist of 9.7 acres of open water and 3.1 acres of shallow water, emergent wetlands on a 40.5-acre site located south of E. 122nd Street, west of S. Torrence Avenue, east of S. Paxton Avenue, and north of the Calumet River (Figure 1). Other than the open water ponds, the site can be characterized as a monoculture of the invasive common reed (*Phragmites australis*). Aerial imagery in 1939 indicates that the site was in agriculture at that time, after which the ponds were created by a series of excavations (Figure 2). Most of the site is owned by the City of Chicago, with the southernmost section owned by the Metropolitan Water Reclamation District of Greater Chicago and portions of the largest pool in private ownership. There are contaminant issues from former land use, including lead and polycyclic aromatic hydrocarbons from a shooting club, waste dumping associated with adjacent tailings ponds, and potential groundwater contamination from the Lake Calumet Cluster site.

The pools may be characterized as open water bodies devoid of vegetation, except for the margin of common reed surrounding each pool. Water quality is poor and strongly suggestive of a common carp (*Cyprinus carpio*) infestation. The larger pools are deep and steep-sided, making them poor candidates for significant marsh restoration and unsuitable for developing hemimarsh characteristics. However, the pools could still benefit from active restoration and management, assuming the contaminant and carp infestation issues could be overcome. With relatively few infrastructure improvements, the pools could be developed into deeper water bodies providing a range of benefits to waterfowl, fish, herps, and other wildlife.

Site Description

The wetlands at Heron Pond consist of 9.7 acres of open water and 3.1 acres of shallow water, emergent wetlands on a 40.5-acre site located just south of E. 122nd Street, west of a Norfolk Southern (NS) Railroad line running parallel to S. Torrence Avenue, east of S. Paxton Avenue, and north of the Calumet River (Figure 1). The ponds and emergent wetlands are surrounded by 27.7 acres of moist soil and upland completely dominated by the invasive common reed (*Phragmites australis*). The ponds appear to have been created by a series of excavations or a mining operation, as most of the land was previously in agriculture based on a 1939 aerial image of the site (Figure 2). Most of the site is now owned by the City of Chicago, with the southernmost section owned by the Metropolitan Water Reclamation District of Greater Chicago and portions of the largest pool in private ownership. The site has a history of ecotoxic issues associated with former land use, e.g., lead and polycyclic aromatic hydrocarbons from a shooting club, waste dumping associated with adjacent tailings ponds (Figure 3), and potential groundwater contamination from the adjacent Lake Calumet Cluster site.

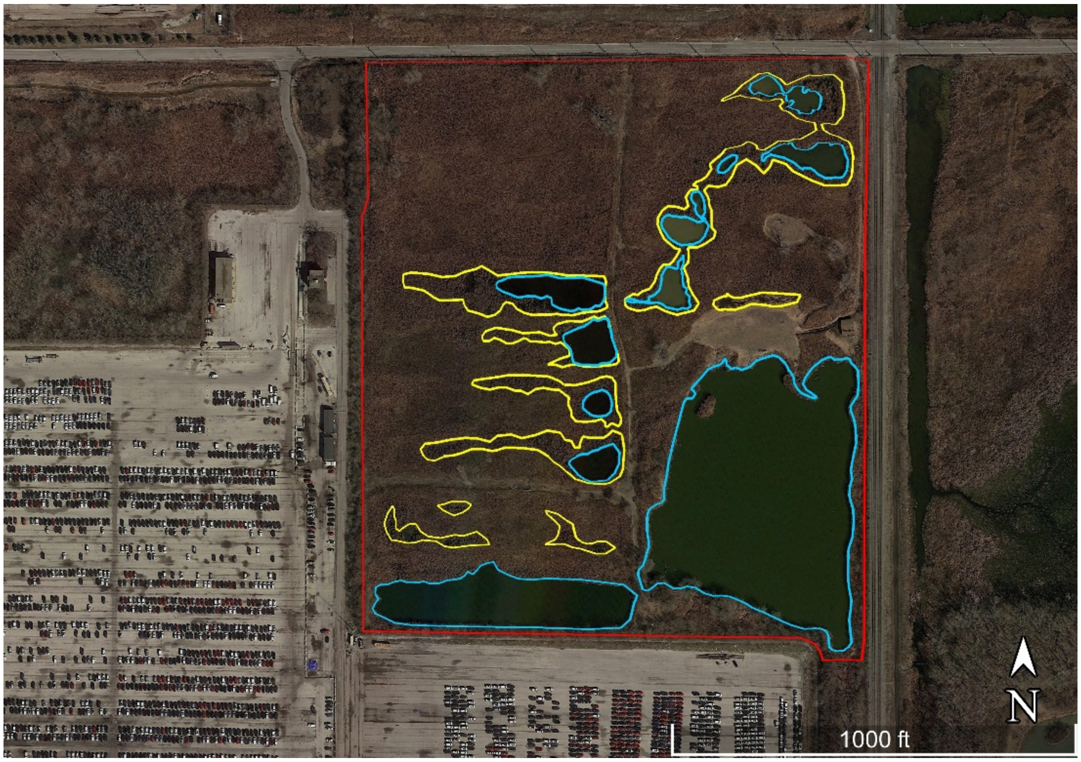


Figure 1. Satellite image of the 40.5-acre Heron Pond wetland site, outlined here in red. Also shown are open water ponds outlined in blue (9.7 acres) and associated emergent wetlands outlined in yellow (3.1 acres). Image courtesy of Google Earth.

Hydrology

Hydrology in the marsh basin appears to be driven by precipitation and local hard surface runoff, with potentially some inputs from the Cluster site to the north. There also appears to be some overflow from pools with a higher surface water elevation to lower elevation pools. The largest pool in the southeast corner of the site (6.4 acres) is also the pool with the lowest reported surface water elevation at 582.5 feet above mean sea level (feet MSL). Although not specified, we believe MSL was determined relative to the National Geodetic Vertical Datum of 1929 (0.34 feet higher than MSL determined relative to the North American Vertical Datum of 1988). The elevation of this pool is set by the invert of the water control structure at the southeast corner of both the pool and the entire site. Water drains from this pool southwards into an outlet ditch that empties into the Calumet River.

Figure 2. A 1939 aerial image of the Heron Pond site outlined here in red (Illinois State Geological Survey, 1939). The future Norfolk Southern rail line is indicated in orange and the future E. 122nd Street in yellow. Note that most of the site was agricultural at that time, with the farm buildings found adjacent to the railroad at approximately the midline of the site.

Bathymetry and Topography

All bathymetry and topographic data are based on the findings published by V3 Consultants for the City of Chicago's Department of the Environment in 2006 (V3 Companies, LTD 2006). Contour and spot elevation data are provided for the two largest pools in the site, with surface water elevational data reported for some, but not all of the smaller pools. Both of the larger pools drop steeply from shore, with depths up to 10 feet deep in the largest 6.4-acre pool and up to 12 feet deep in the second largest 1.8-acre pool. The data also indicate that surface water elevations vary among the various pools, ranging from 582.5 to 587.5 feet MSL. The highest reported pool elevation (587.5 feet MSL) is still lower than the lowest spot elevation reported outside the pools, with many spot elevations being seven feet or more higher than the measured pool elevations. These differences suggest that much of this area is upland despite being covered in a monoculture of common reed.

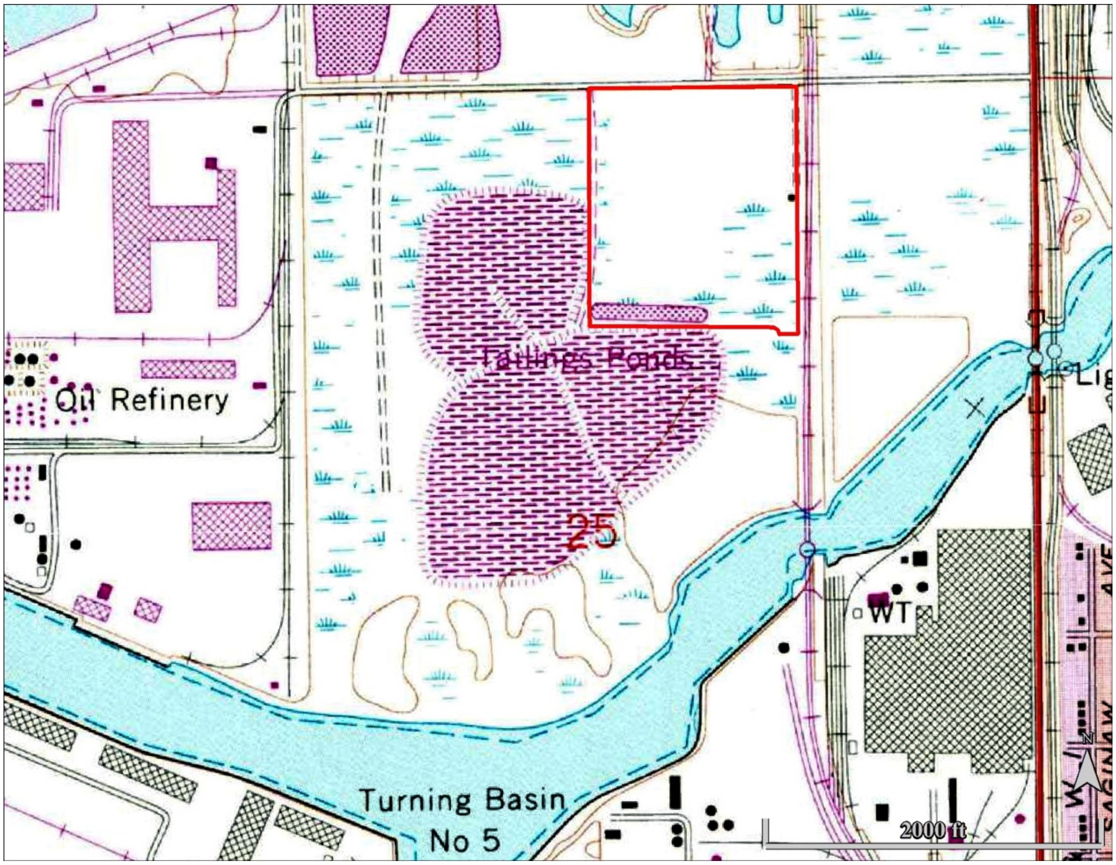


Figure 3. 1965 USGS map of the Heron Pond wetland (outlined in red). The site is located southwest of the intersection of E. 122nd Street and the Norfolk Southern Railroad, and northeast of a former set of tailings ponds (now an open concrete parking area).

Hemimarsh Restoration Potential

There is little potential to restore hemimarsh habitat within the two largest ponds at the Heron Pond site due to the steep-sided depth profiles that characterize these pools. Although the near-shore area could develop emergent vegetation across a narrow fringe at the pond margins, the extent of this zone would be insufficient for developing hemimarsh characteristics. This isn't to say that the pools couldn't benefit from active restoration and management; indeed, they could be greatly improved even if the potential to develop higher-quality deep marsh habitat is quite limited. For example, the pools could be developed into deeper water bodies that provide a range of benefits to waterfowl, fish, herps, and other wildlife. This would require the presence of a functional water-level control structure at the main outlet, with additional improvements to facilitate cascading flows among the smaller pools.

Although data on the depth profiles of the smaller pools was not reported, they appear to be similar in nature to the larger pools in that they can be characterized as open water bodies devoid of vegetation, surrounded by a fringe of common reed. The opacity of the water throughout this system suggests that the pools have been colonized by common carp (Cyprinus carpio), which would also have to be eliminated before any vegetative community could be restored. Lastly, the potential impact of contaminants on this site should be investigated and examined carefully before any decision to invest in developing higher-quality habitat at this site is made.

Recommendations

We do not have any current recommendations for restoring hemimarsh habitat at the Heron Pond wetlands, but would recommend an aggressive program of invasives management and pond habitat development if the water-level control structures can be improved and the contaminant issues resolved.

References

Illinois State Geological Survey. (1939). Unpublished material, Illinois historical aerial photographs: 1936 to 1941 v.4: Illinois State Geological Survey, Champaign, Illinois.

V3 Companies, Ltd. (2006). Calumet area hydrologic master plan, Task 104, bathymetric mapping.

Hyde Lake

Summary

The Hyde Lake wetlands are a 23.9-acre remnant of the once-extensive wetland system surrounding the former Hyde Lake. The wetland is located on private land just south of E. 126th St., and is bounded to the west by residences along S. Carondolet Ave. and to the east and south by rail lines of the Norfolk Southern system. The shallow wetland is completely dominated by common reed (*Phragmites australis*) except for the Indian Creek channel bisecting the north end of the site. Hydrology is controlled by water levels within Indian Creek, which rarely fall below 580.5 ft. MSL and only exceed that elevation when creek water levels are higher, primarily due to higher water levels within the Calumet River.

There is no potential to restore deep marsh, open water, or hemimarsh habitat at this site due to its relatively shallow depth profile. However, a higher-quality wet meadow wetland with a shallow marsh component could be restored following a significant invasive eradication effort and a commitment to long-term management at the site. Potential contamination issues should be further assessed and overcome before such an effort begins.

Site Description

What is known as Hyde Lake today (Figure 1) is actually a 23.9-acre remnant of the once-extensive shallow marsh system surrounding the shoreline of the original Hyde Lake (Figure 2). This remnant is privately owned and found just south of E. 126th St., east of S. Carondolet Ave., north of E. 130th St., and west of the Norfolk Southern Calumet River rail line. The north end of the Hyde Lake wetland is bisected by Indian Creek, which drains Wolf Lake westward into the Calumet River. The original Hyde Lake was filled in many years ago for industrial development north of E. 126th St., and with slag from the steel industry south of E. 126th St. Much of the remnant marsh has also been filled, and the site was subdivided for residential development (Figure 3). This development was never completed, leaving a highly disturbed shallow wetland choked with common reed (*Phragmites australis*). The Indian Creek drainage channel is somewhat deeper and colonized by submersed and floating-leaved marsh vegetation such as white waterlily (*Nymphaea odorata* ssp. *tuberosa*).

Figure 1. Satellite image of the Hyde Lake remnant wetland, bisected by Indian Creek draining Wolf Lake into the Calumet River. Image courtesy of Google Earth.

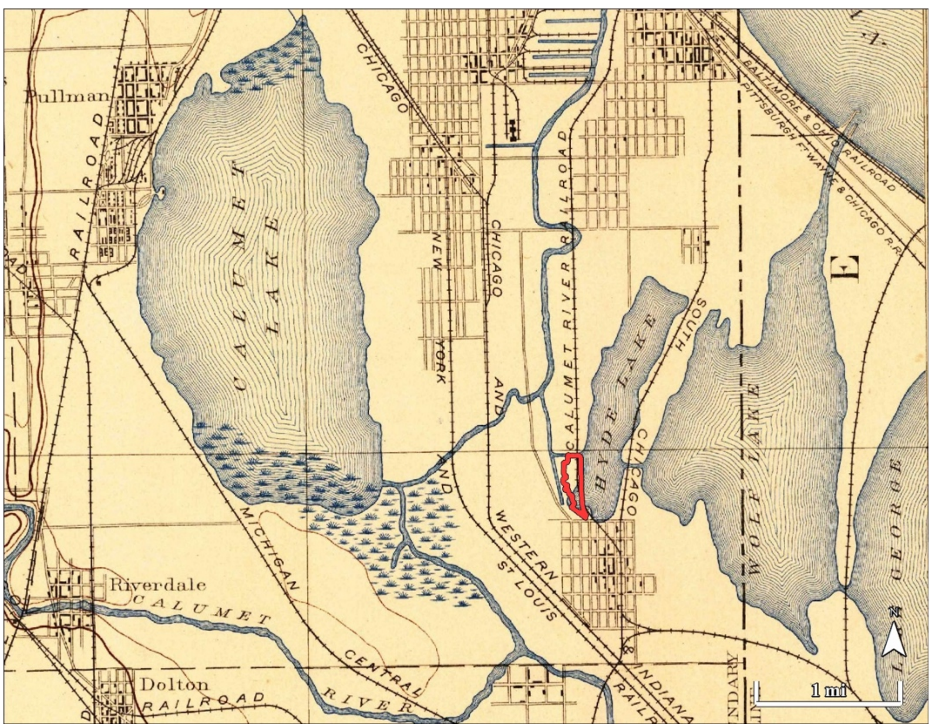


Figure 2. 1892 USGS map of the Calumet Region lakes showing the footprint of Hyde Lake situated between Wolf Lake and the Calumet River. [Note the location of Hyde Lake between the arms of what were then the Calumet River Railroad and the South Chicago & Southern Railroad.] What is left of Hyde Lake today is part of a remnant marsh along the southwest shore of Hyde Lake (outlined in red), just west of what is now the Norfolk Southern Calumet River Industrial Track.

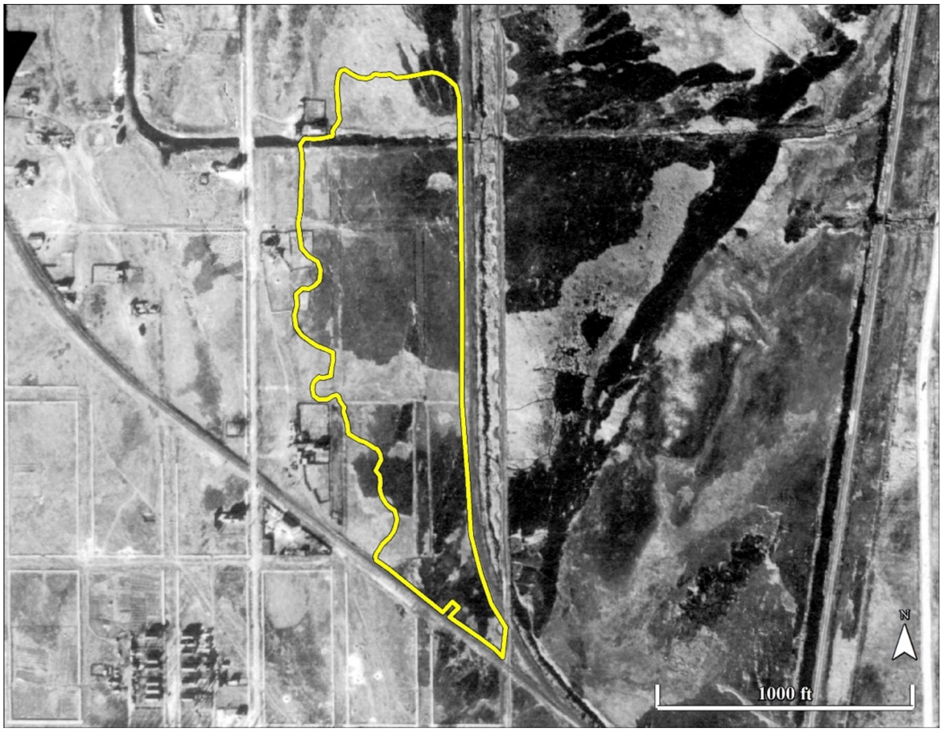


Figure 3. A 1939 aerial photograph showing the south end of Hyde Lake, with the adjacent Hyde Lake marsh to the west outlined in yellow (Illinois State Geological Survey, 1939). [Note that the marsh was already being filled in to lay out streets for future residential development.]

Hydrology

Hydrology of the Hyde Lake marsh is a function of water levels in Indian Creek, which are maintained at approximately 580.5 feet above mean sea level (ft. MSL) relative to the North American Vertical Datum of 1988 (NAVD88) by a crude rock dam at the Calumet River (Figure 4). If surface water levels in the Calumet River exceed 580.5 ft. MSL, then water begins to back up the creek channel to maintain the creek surface elevation in equilibrium with the river. As water levels rise in Indian Creek, they also rise within the Hyde Lake marsh.

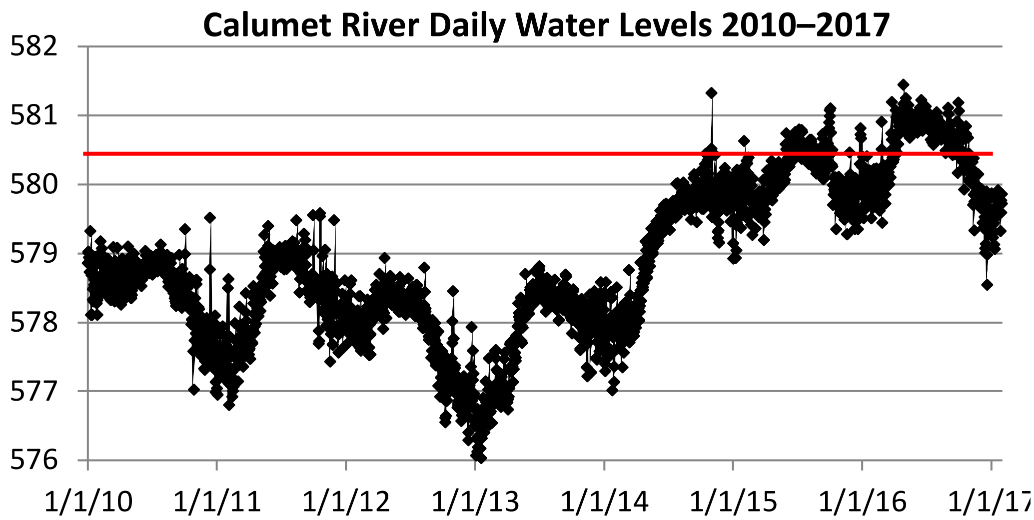


Figure 4. Mean daily surface water elevations of the Calumet River from 2010–2017 in feet above mean sea level (ft. MSL). The minimum Hyde Lake wetland water level is maintained by the outlet dam in Indian Creek at approximately 580.5 ft. MSL (line in red) until water levels in the Calumet River exceed this elevation. Calumet River water levels are measured at the Calumet Harbor gauge (station 9087044), reported here in ft. MSL relative to the North American Vertical Datum of 1988 (converted from the International Great Lake Datum of 1985). (NOAA Tides and Currents, 2018)

Bathymetry and Topography

We do not have any data on bathymetry or topography in the Hyde Lake marsh, although the remnants of old roads once built for residential development are visible in satellite imagery on portions of higher and/or drier ground. However, the marsh wetland is clearly shallow in that it supports a dense canopy of common reed that covers the entire site outside of Indian Creek, suggesting that maximum depths are less than a foot deep (other than when water levels in the Calumet River flood the marsh during periods of high water in Lake Michigan and the Calumet River). Considering that the wetland footprint south of Indian Creek was initially being developed for residential use, there is likely little open water under the common reed canopy.

Hemimarsh Restoration Potential

There is no current hemimarsh restoration potential for the Hyde Lake wetlands, primarily because water depths are too shallow to support development of an open water or deep marsh community. However, this isn't to say that a higher-quality wet meadow wetland with a small shallow marsh component couldn't be developed; this would require a significant common reed eradication effort coupled with native plantings, followed by a commitment to managing the site adaptively into the foreseeable future. Such a restoration effort will have to be considered carefully, as recently discovered contaminants pose a potentially threat to human health

Recommendations

We currently do not have any recommendations for restoring marsh habitat in the Hyde Lake wetlands. If the contamination issues currently being assessed are deemed tractable, then the potential to restore a wet meadow and shallow marsh wetland on the site can be re-evaluated at that time.

References

Illinois State Geological Survey. (1939). Unpublished material, Illinois historical aerial photographs: 1936 to 1941 v.4: Illinois State Geological Survey, Champaign, Illinois.

NOAA Tides and Currents. (2018). Retrieved from https://tidesandcurrents.noaa.gov/waterlevels.html?id=9087044

Sand Ridge Nature Center

Summary

The Sand Ridge wetlands are a part of a large remnant dune and swale system owned and managed by the Forest Preserves of Cook County just south of the City of Chicago. Of 50.8 acres of wetlands on the site, 41.3 acres can be characterized as marsh and 9.6 acres as open water. Most of the marsh is very shallow marsh habitat dominated by non-native invasive species. Hydrologically, the site is cut off from the broader landscape by roads and development. There is little potential to develop the existing wetlands into deep marsh habitat with hemimarsh characteristics, primarily because the bathymetry necessary for deep marsh development is not found, except for in one small marsh where natural hemimarsh characteristics have already developed. We do recommend that if resources permit, a program of invasive management be initiated to restore an extensive 36-acre shallow marsh system, both for the benefit of all wetland-dependent species and to protect the remaining wetlands from non-native invasion.

Site Description

The Sand Ridge wetlands are part of a dune and swale complex on land owned and managed by the Forest Preserves of Cook County (FPCC). This includes the Sand Ridge Nature Preserve, the Sand Ridge Nature Center, and the Green Lake Savanna. The Sand Ridge complex is located between South Holland and Calumet City, just east of I-94 between Pulaski Road and 159th Street. It is bisected north to south by S. Torrence Ave., with most of the marsh wetlands found west of S. Torrence (Figure 1).

With nearly 500 acres of protected habitat, the Sand Ridge complex is one of the largest and finest examples of remnant dune and swale habitat remaining in Illinois. In addition to a superior dune and swale habitat, the site features 41.3 acres of marsh and another 9.6 acres of open water habitat, primarily in the form of small lakes or ponds. The marsh habitat is found in two locations: the larger, 36.4-acre shallow marsh centrally located just west of S. Torrence Ave. and north of the Sand Ridge Nature Center (Figure 1), and within the smaller, 6.0-acre marsh and open water complex located at the southwest corner of the site.

Figure 1. The Forest Preserves of Cook County's 500-acre Sand Ridge area, including the Sand Ridge Nature Preserve and Nature Center, and the Green Lake Savanna. Major wetland habitats include 40.4 acres of shallow marsh (green), 0.9 acres of deep marsh (purple), and 9.6 acres of open water ponds (blue). The location of the Sand Ridge Nature Center is indicated by the yellow star. Imagery courtesy of the Cook County, 2013.

Hydrology

Hydrologically, the Sand Ridge wetlands were once part of the wetland mosaic of swales, marshes, and streams found across much of the area south of Lake Michigan. Over the past 200 years, most of the dune and swale habitat has been lost to residential, commercial, and industrial development. Sand Ridge, along with most of the other remaining fragments, is isolated and cut off hydrologically from the broader landscape, with inputs coming from precipitation and local runoff and most surface water in equilibrium with the water table. The large 41-acre marsh basin lying between S. Torrence and S. Paxton Avenues appears to be a dense shallow marsh with no inlet or outlet, and with less than one acre of open water. Four small ponds are found on the site, with only the 6.0-acre pool found on the southwest corner of the site characterized by a significant marsh component along the shoreline (Figure 1).

Bathymetry

We were unable to discover any information or data in regard to bathymetry in the Sand Ridge wetlands, although the distribution of emergent vegetation and open water suggests that the vast majority of area is very shallow, with the few smaller pockets of open water indicating greater depths.

Current Habitat and Invasive Species

Although much of the dune and swale habitat can be characterized by multiple high-quality, conservative plant species, the marshes appear to be dominated by invasive common reed (*Phragmites australis*) and cattails (*Typha* species). During our survey of Sand Ridge, the marsh vegetation was so thick that it precluded penetration beyond a few feet into the marsh. Based on inspection of high-resolution aerial imagery (Google Earth), the signature of the vegetation indicates it is primarily one of the two aforementioned species. Conversely, open water zones within west side pools were characterized by a diversity of submersed and floating-leaved species. This includes a small, 0.7-acre area with hemimarsh characteristics in the wetland on the southwest corner of the site.

Hemimarsh Restoration Potential

There appears to be little potential to develop a significant component of the Sand Ridge wetlands into deep marsh with hemimarsh characteristics; there does not appear to be enough wetland habitat with the range of depths necessary for developing a deep marsh. Moreover, there are few, if any, pockets in the larger north marsh that could potentially develop into hemimarsh (the one we identified is indicated in Figure 1). This is not to say that a high-quality, diverse shallow marsh could not be developed, but rather that the range of depths needed to support hemimarsh does not appear to be present. However, it does appear that a portion of the southwest wetland already has developed hemimarsh characteristics, which are maintained by naturally fluctuating water levels across an appropriate range of depths.

Recommendations

If our goal is to develop a significant component of hemimarsh habitat capable of supporting a range of marsh-dependent wildlife, then there is little we can recommend at Sand Ridge to achieve this goal. The site is already of high quality with the exception of the large shallow marsh west of S. Torrence Ave., and there is little that could be accomplished within that marsh to develop deep marsh characteristics. However, the quality of the shallow marsh habitat could be improved dramatically with the initiation of an intensive, long-term invasive management program in this area. Converting the existing invasive-dominated marsh into a high-quality native system would provide a great deal of benefits to local wildlife, especially herps, rails, and other shallow marsh-dependent species. The existing deep marsh and open water pools found elsewhere on the site would also benefit a great deal from invasive management.

Wolf Lake: Pool 3

Summary

Pool 3 is the most southwestern of Illinois' five Wolf Lake pools. It is approximately 115 acres in area and has a mean depth of approximately 3 feet. Located on Chicago's southeast side, it is the pool next to which the William Powers State Recreational Area visitor center is built. There is currently little emergent marsh vegetation and no hemimarsh habitat on the unit, and no potential to develop this habitat without significant modification to Pool 3's hydrology. Although the modifications to accomplish this goal are not logistically unreasonable, the legal, regulatory, and political hurdles are beyond the scope of these analyses. Consequently, we feel that the development of a conservation action plan at this site is premature, and we are unable to recommend a specific plan to move forward at present. However, we strongly suggest that the Illinois Department of Conservation consider the benefits of developing up to 50 acres of marsh and hemimarsh in Pool 3 and whether such benefits are in the public interest and worth pursuing further.

Site Description

Wolf Lake's Pool 3 is one of five pools comprising the Illinois side of Wolf Lake (Figure 1), which is located on the southeast side of Chicago and is owned and managed as part of Illinois' 580-acre William Powers State Recreation Area (hereafter William Powers). The 114.7-acre Pool 3 is the southwesternmost of the five pools and drains all of Wolf Lake into the Calumet River through Indian Creek. It is bordered by Pool 2 to the north, Pools 4 and 5 to the east, and the state park's Management Unit Nine (MU9) to the south (Figure 2). Like all of the Wolf Lake pools, much of Pool 3 has been filled with slag, dredge spoil from the Calumet River, and other material so that it is relatively shallow (average depth of 3.3 feet), with smaller holes over 14 feet deep (Stevenson et al., 2017). Pool 3 is also the pool on which the William Powers Visitor Center is located, immediately south of Indian Creek.

Figure 1. Satellite image of Wolf Lake showing Illinois' five separate pools and the Illinois- Indiana state border (in yellow). The pools are separated from each other by berms, but all are hydrologically connected by openings through the berms to allow drainage from Pool 3 through Indian Creek (in blue) to the Calumet River (upper left). Imagery courtesy of Google Earth.

Figure 2. Wolf Lake's Pool 3, outlined in yellow, with the outlet stream at Indian Creek designated by the blue line. Pool 3 is separated from Pool 2 to the north by a berm, and from Pools 4 and 5 to the east by a berm and rail line. Imagery courtesy of Google Earth.

Hydrology

Wolf Lake's Pool 5 hydrology is driven by the same dynamics as Wolf Lake as a whole: primarily from springs, precipitation, and local surface runoff. Wolf Lake has some inputs from small, local, and intermittent sources, such as the Forest Preserve of Cook County's Powderhorn Lake. The mean water surface elevation is approximately 583.0 feet above mean sea level (MSL) relative to the North American Vertical Datum of 1988 (NAVD88). The lake elevation is set by the weir invert at the Indian Creek outlet, although the water surface can rise temporarily when inputs exceed the drainage capacity or decrease when evapotranspiration exceeds inputs. Water blockages along Indian Creek due to human or animal activities have caused prolonged periods of high water, with water levels exceeding the invert elevation by up to a foot (water levels over the past six months have been between 6 and 8 inches higher than the invert, but have recently dropped due to management by local volunteers). High water levels have resulted in flooding along the shoreline of Wolf Lake, as well as the backing up of water draining from Powderhorn Lake.

Bathymetry and Topography

The bathymetry of Wolf Lake's Pool 3 is largely the result of the massive deposition of fill material, a large portion of which was slag up to 10 feet or more in depth. Other materials include dredge spoils from deepening of the Calumet River. The resulting bottom contours represent a mosaic of depths (Figure 3) that primarily range between 0 and 4 feet deep (Stevenson et al., 2017), with an average depth of approximately 3 feet (Dar Lin et al., 1996). Much of the bottom is divided by ridges that extend nearly to the surface. We were unable to determine the origin of these ridges, although it seems likely that they once functionally divided Pool 3 into several smaller units until they were eroded by wind and wave action. Regardless of their origin, they now divide Pool 3 into a few deep and several shallow sub-basins that are defined by the remnant ridges clearly visible in Figures 2 and 3.

Current Habitat and Invasive Species

Pool 3 is nearly all open water that has been colonized by submersed aquatic vegetation to the limits of light penetration. Species observed include wild celery (*Vallisneria americana*) and several pondweeds (*Potamogeton* species), plus the invasive species Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*). There is little floating-leaved or emergent vegetation. The margins of Pool 3 have been colonized by a variety of shrubs, trees, and both native and non-native herbaceous vegetation.

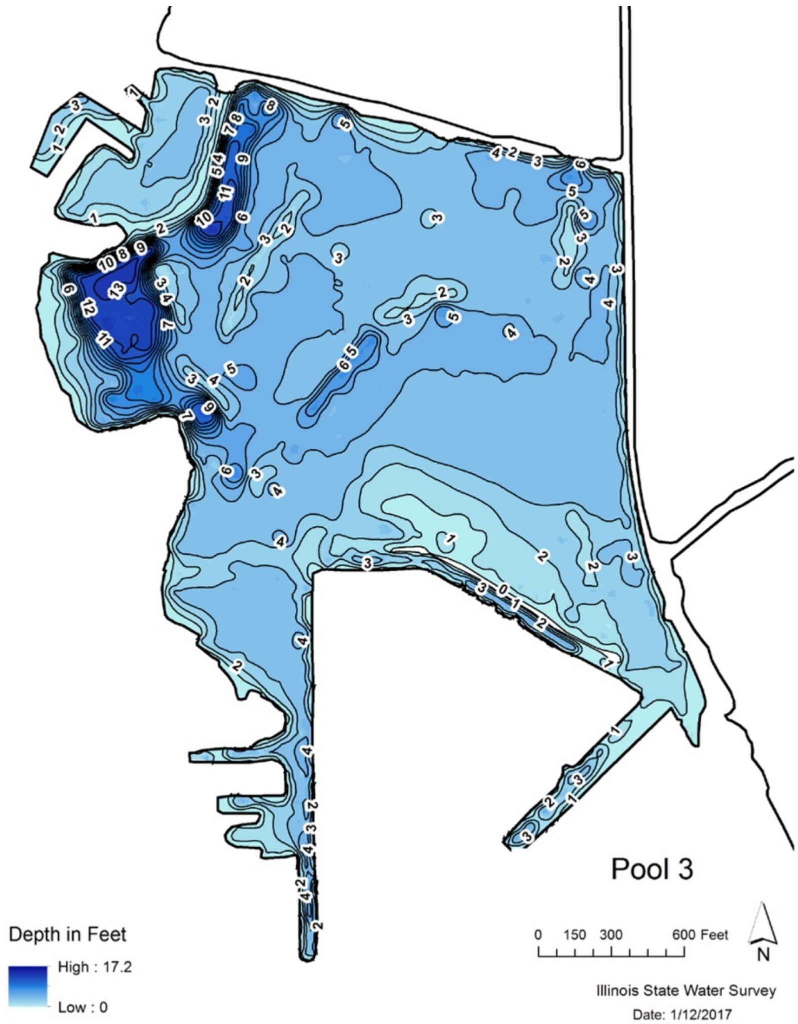


Figure 3. Bathymetric contours of Wolf Lake's Pool 3. The average depth is approximately 3.3 feet deep. Depth contours courtesy of the Illinois State Water Survey, Illinois Natural History Survey, and Prairie Research Institute (Stevenson et al., 2017).

Hemimarsh Restoration Potential

There is little potential to develop emergent marsh vegetation in Pool 3 without altering the unit's hydrology. Even where depths are shallow enough to support emergent vegetation, it does not occur due to fetch and wave energy, as well as the impact of either herbivores or common carp (*Cyprinus carpio*). Other areas capable of supporting emergent vegetation will have limited germination potential in deeper water. In order to develop emergent marsh vegetation in Pool 3, managers would need the capacity to temporarily lower water levels up to two feet or more and maintain them up to one foot lower than the current level for extended periods of time. The initial lowering of water levels would be executed in order to initiate the establishment of emergent marsh vegetation, much in the manner described in the section on developing marsh vegetation in the introduction to these analyses. Water levels could subsequently be raised to determine which water level was most suitable for maintaining a deep marsh community over the long term.

The aforementioned approach would require that Pool 3 be isolated from the other pools so that water levels could be manipulated without impacting them elsewhere in Wolf Lake. This would require the elimination of cross-pool connections along the berms dividing Pool 3 from the other pools. A water control structure would then be installed between Pools 2 and 3 so that Pool 3 could be lowered while maintaining water levels in Pool 2 (and hence any other portions of Wolf Lake). At the same time, a separate water-level control structure would be installed in the outlet at Indian Creek, allowing water levels in Pool 3 to be adjusted for management purposes. In addition, lower water levels could be maintained for longer periods at a depth that would facilitate the establishment of emergent vegetation in areas now at a depth of 3 feet or less. This might require that the upper reach of Indian Creek be dredged to allow gravity drainage. The second water-level control structure would replace the weir currently controlling water levels in Wolf Lake at the outlet. A 1–2-foot drop in surface water elevation would result in a decrease in the size of Pool 3 by up to 25 acres, but a potential 50-acre increase in emergent marsh habitat capable of developing hemimarsh characteristics.

The engineering to manage Pool 3 in the manner suggested above is not particularly difficult: the technology is ‘out of the box’ and utilized in large marsh systems all over the world. However, this approach would result in a number of tradeoffs that managers may or may not be willing to make: much of the open water in front of the state park visitor center would become vegetated, the lower water levels would change the fishing opportunities for park visitors, and fish passage from Indian Creek to the other pools would be restricted except for periods when the pools were allowed to reach equilibrium (i.e. when the stop logs between Pools 2 and 3 were removed for fish migratory passage). A long list of regulatory hurdles would also have to be overcome in pursuance of such a strategy.

Recommendations

Due to the complicated logistics of managing water levels and establishing marsh vegetation, the multiplicity of landowners divided between two states, the potentially conflicting or competing interests of the public and private sectors, the many different regulatory agencies with oversight responsibility, and myriad unforeseen issues that would undoubtedly arise, we are not making any recommendations for restoration at this time. However, we do recommend that William Powers consider the benefits of establishing up to 50 acres of marsh habitat capable of developing hemimarsh characteristics as an enhancement of the benefits already being provided to the public. The benefits to wildlife, and in particular to rare marsh-dependent species and migratory waterfowl, would be significant. A decision to proceed would involve tradeoffs that should be considered carefully in regard to the potential benefits of developing or restoring a significant marsh at Pool 3. The first step would be to initiate a feasibility study to determine if this could be legally, logistically, and politically accomplished.

References

Dar Lin, S., Raman, R. K., Bogner, W. C., Slowikowski, J. A., Roadcap, G. S., & Hullinger, D. L. (1996). Contract report 604: Diagnostic-feasibility Study of Wolf Lake, Cook County, Illinois, and Lake County, Indiana. Prepared for the City of Hammond, Indiana Illinois Environmental Protection Agency, and Indiana Department of Environmental Management, October 1996. Illinois State Water Survey, Chemistry and Hydrology Divisions, Champaign, Illinois.

Stevenson, K., Allan, K., & Slowikowski, J. A. (2017). Bathymetric survey of Wolf Lake. Illinois State Water Survey and Illinois Natural History Survey, Prairie Research Institute. University of Illinois at Urbana-Champaign.

Wolf Lake: Pool 5

Summary

Pool 5 is the southeasternmost of Illinois' five Wolf Lake pools, located on Chicago's southeast side along the Illinois-Indiana border. It is approximately 47 acres in area and has a mean depth of approximately 8 feet. There currently is little emergent marsh vegetation and no hemimarsh habitat on the unit, and no potential to develop this habitat without significant modification to Pool 5's hydrology. Modifications to accomplish this goal are not logistically or financially reasonable, especially considering there is little area to develop as marsh habitat should the effort be made. Consequently, we feel that a conservation action plan to establish hemimarsh at this site is not warranted, and we cannot recommend a plan to move forward.

Site Description

Wolf Lake's Pool 5 is one of five pools comprising the Illinois side of Wolf Lake (Figure 1). The Illinois side of Wolf Lake is located on the southeast side of Chicago and is owned and managed as part of Illinois' 580-acre William Powers State Recreation Area (hereafter William Powers). The 46.8-acre Pool 5 is the southeasternmost of Illinois' five pools; it is bordered by Pool 4 to the north and Pool 3 and the state park's Management Unit Nine (MU9) to the west (Figure 2). Like all of the Wolf Lake pools, much of Pool 5 has been filled with slag and other material so that it is relatively shallow (average depth of 8.0 feet), with holes over 18 feet deep (Dar Lin et al., 1996; Stevenson et al., 2017).

Hydrology

Wolf Lake's Pool 5 hydrology is driven by the same dynamics as Wolf Lake as a whole: primarily by springs or groundwater, precipitation and local surface runoff. There are some inputs from small, local, and intermittent sources, such as the Forest Preserve of Cook County's Powderhorn Lake. The mean water surface elevation is approximately 583.0 feet above mean sea level (MSL) relative to the North American Vertical Datum of 1988 (NAVD88). The lake elevation is set by the weir invert at the Indian Creek outlet, although the water surface can rise temporarily when inputs exceed the drainage capacity or decrease when evapotranspiration exceeds inputs. Water blockages along Indian Creek due to human or beaver activity has caused more prolonged periods of high water, with water levels exceeding the invert elevation by up to a foot (water levels over the past six months have been between 6 and 8 inches higher than the invert, but have recently dropped due to management by local volunteers). High water levels have resulted in flooding along the shoreline of Wolf Lake, as well as the backing up of water draining from Powderhorn Lake.

Figure 1. Satellite image of Wolf Lake showing Illinois' five separate pools and the Illinois-Indiana state border in yellow. The pools are separated from each other by berms, but all are hydrologically connected by openings through the berms to allow drainage from pool to pool and eventually to the Calumet River (upper left) via Indian Creek (in blue). Imagery courtesy of Google Earth.

Figure 2. Wolf Lake's Pool 5 is outlined in yellow in this 2010 satellite image. Pool 5 is separated from Pool 4 to the north and Pool 3 to the west by a berm. The eastern border of the Illinois portion of Pool 5 is the state line. Imagery courtesy of Google Earth.

Bathymetry and Topography

The bathymetry of Wolf Lake's Pool 5 is largely the result of the massive deposition of fill material, a large portion of which was slag up to 10 feet or more in depth. Some of the bathymetry is also the result of dredging. The resulting bottom contours represent a mosaic of depths (Figure 3) that primarily range between 0 and 16 feet deep (Stevenson et al., 2017), with an average depth of approximately 8 feet (Dar Lin et al., 1996). Approximately half of the pool is relatively shallow (up to 7 feet deep), but drops off precipitously to over 16 feet deep in the northeast half of the unit. The deep zone appears to be the result of past dredging operations. Consequently, Pool 5 can be characterized by a bimodal distribution of depths.

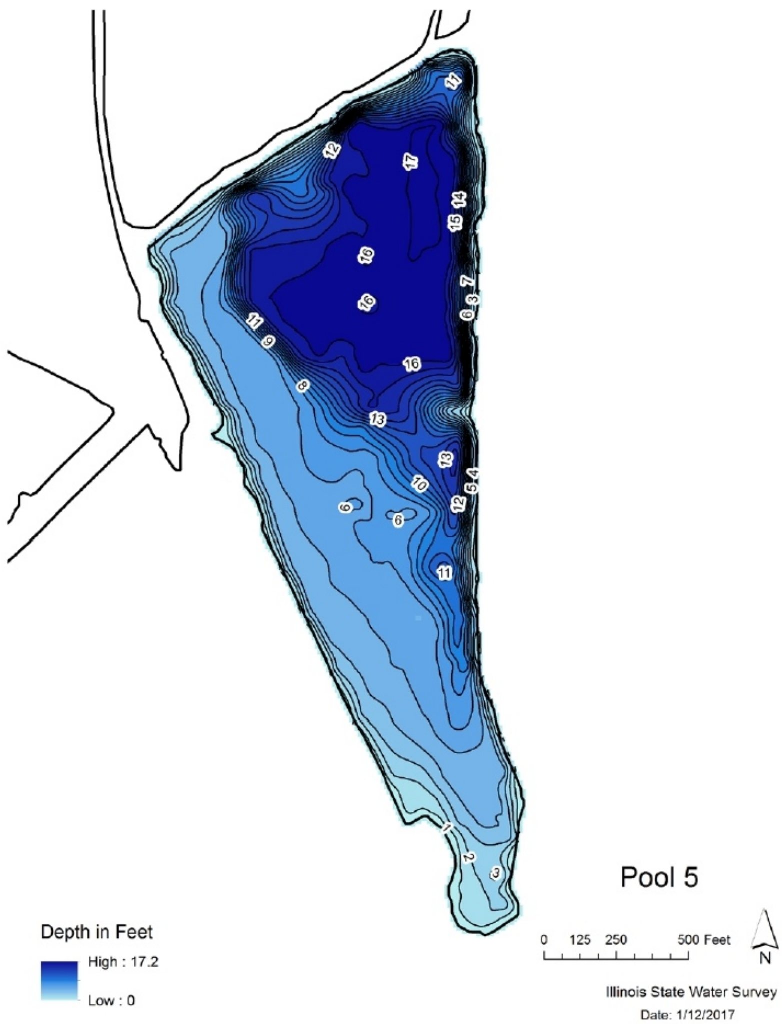


Figure 3. Bathymetric contours of Wolf Lake's Pool 5. The average depth is approximately 8.0 feet deep. Depth contours courtesy of the Illinois State Water Survey, Illinois Natural History Survey, and Prairie Research Institute (Stevenson et al., 2017).

Hemimarsh Restoration Potential

There is little potential to develop emergent marsh vegetation in Pool 5 without altering the unit's hydrology. Even where depths are shallow enough to support emergent vegetation, it does not occur due to fetch and wave energy, as well as the impact of either herbivores or common carp (*Cyprinus carpio*). Other areas capable of supporting emergent vegetation will have limited germination potential in deeper water. In order to develop emergent marsh vegetation in Pool 5, managers would need the capacity to temporarily lower water levels up to two feet or more and maintain them at a lower elevation than the current level for extended periods of time. This strategy is not possible without creative hydrologic engineering requiring the use of pumps. Given that the area potentially capable of supporting emergent marsh vegetation is relatively small (a maximum of up to 2.5 acres based on depth contours), it is a not realistic goal to pursue.

Recommendations

We have no recommendations that would result in the development of shallow or deep marsh vegetation in Wolf Lake's Pool 5. There are no steps to be taken short of a massive hydrologic engineering effort resulting in little habitat gain, should the Illinois Department of Natural Resources wish to pursue that course.

References

Dar Lin, S., Raman, R. K., Bogner, W. C., Slowikowski, J. A., Roadcap, G. S., & Hullinger, D.L. (1996). Contract report 604: Diagnostic-feasibility study of Wolf Lake, Cook County, Illinois, and Lake County, Indiana. Prepared for the City of Hammond, Indiana Illinois Environmental Protection Agency, and Indiana Department of Environmental Management, October 1996. Illinois State Water Survey, Chemistry and Hydrology Divisions, Champaign, Illinois.

Stevenson, K., Allan, K., & Slowikowski, J.A. (2017). Bathymetric survey of Wolf Lake. Illinois State Water Survey and Illinois Natural History Survey, Prairie Research Institute. University of Illinois at Urbana-Champaign.

Appendix A

Evaluating Calumet Wetland Bird Population Response to Wetland Characteristics

Author: Nicole Michel

Contributors: Caitlin Jensen, Chad Wilsey, Nathaniel Miller, and Michael Ward

Wetland-dependent birds are undergoing long-term population declines across North America. These declines are often attributed to wetland loss. Indeed, Illinois historically lost wetlands to a much greater degree than the United States as a whole: 90% loss during 1780–1980; across the U.S., 53% of wetlands were lost during the same time period (Dahl, 1990). Yet wetland bird abundance in northeastern Illinois declined over 26 years even at intact wetlands, indicating that other local or regional factors are also important drivers of wetland bird population declines (Ward et al., 2010). These regional population declines were linked to increased development and degradation of wetland habitat, specifically the loss of emergent vegetation used as nesting and cover habitat by many wetland birds. Wetland restoration could reverse population declines, but little is known about the extent of emergent vegetation cover needed to improve bird habitat.

Methods

We used a two-stage approach to investigate relationships between wetland bird abundance and emergent vegetation cover. We focused on four wetland-dependent bird species: Common Gallinule (*Gallinula galeata),* Least Bittern (*Ixobrychus exilis*), Pied-billed Grebe (*Podilymbus podiceps*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). We used a 26-year dataset (1980–2005) of annual full-wetland bird censuses at 196 wetlands across northeastern Illinois (Fig. 1), accompanied by emergent vegetation surveys derived from aerial imagery and surrounding land cover (percent agriculture, developed land, and grassland within 2km) derived from remotely sensed data in 1988 and 1998 (Ward et al., 2010). Emergent vegetation cover was estimated at the scale of the full wetland and grouped into five interspersion categories, with one representing a 'vegetation monoculture' (80–100% vegetation, 0–20% open water) and five representing 'open water' (0–20% vegetation, 80–100% open water). Of the 196 wetlands surveyed, we analyzed data from 87 wetlands that were surveyed for 5 or more continuous years, and at which emergent vegetation cover was estimated in both years. First, we identified trends in wetland-carrying capacity (the number of birds that a wetland can support) using a density-dependent population model that estimates annual estimates as well as linear change in carrying capacity over time (Solbu et al., 2015). We then related these trends to emergent vegetation cover and wetland size using general linear mixed models with log-transformed carrying capacity as the response, linear and squared terms for all predictors with the exception of year (linear only, due to the linear form of the carrying capacity models), and a random intercept for each wetland. We validated the predictive models by estimating the proportion of the predicted carrying-capacity estimates that fell within 95% confidence intervals of the carrying capacities calculated by the density-dependent population models. All analyses were conducted in R version 3.3.1 (R Core Team, 2016) using packages INLA (Rue et al., 2009) and nlme (Pinheiro et al., 2017).

Results

Common Gallinule carrying capacity declined 33.9% during 1988–1998 (P=0.0001), with declines observed at 32 of 87 wetlands (36.7%; Fig. 2A). Carrying capacity of Common Gallinules showed a slight but non-significant (P=0.42) curvilinear relationship with interspersion, with the highest estimated carrying capacity at class four (20–40% vegetation, 60–80% open water) and the lowest carrying capacity at class one (80–100% vegetation, 0–20% open water; Fig. 2B). Common Gallinule carrying capacity was not significantly related to wetland size (P=0.74; Fig. 2C), grassland land cover (P=0.21; Fig. 2D), agricultural land cover (P=0.75; Fig. 2E), or developed land cover (P=0.48; Fig. 2F). Together, a model including all six variables explained 8.2% of the variation in carrying capacity. This model effectively predicted Common Gallinule carrying capacity from wetland characteristics for 81 of 87 wetlands (93.1%).

Least Bittern carrying capacity declined non-significantly by 7.6% during 1988–1998 (P=0.25), with declines observed at 44 of 87 wetlands (50.6%; Fig. 3A). Carrying capacity of Least Bitterns showed a slight but non-significant (P=0.51) curvilinear relationship with interspersion, with the highest estimated carrying capacity at class five (0–20% vegetation, 80–100% open water) and the lowest carrying capacity at class two (60–80% vegetation, 20–40% open water; Fig. 3B). Least Bittern carrying capacity was not significantly related to wetland size (P=0.18; Fig. 3C), grassland land cover (P = 0.27; Fig. 3D), agricultural land cover (P=0.24; Fig. 3E), or developed land cover (P=0.54; Fig. 3F). Together, a model including all six variables explained 10.9% of the variation in carrying capacity. This model effectively predicted Least Bittern carrying capacity from wetland characteristics for 55 of 87 wetlands (63.2%).

Pied-billed Grebe carrying capacity declined non-significantly, by 17.7%, during 1988–1998 (P=0.09), with declines observed at 39 of 87 wetlands (44.8%; Fig. 4A). Carrying capacity of Pied-billed Grebes showed a slight but non-significant (P=0.45) curvilinear relationship with interspersion, with the highest estimated carrying capacity at class five (0–20% vegetation, 80–100% open water) and the lowest carrying capacity at class three (40–60% vegetation, 40–60% open water; Fig. 4B). Pied-billed Grebe carrying capacity was not significantly related to wetland size (P=0.48; Fig. 4C), grassland land cover (P=0.20; Fig. 4D), agricultural land cover (P=0.74; Fig. 4E), or developed land cover (=0.26; Fig. 4F). Together, a model including all six variables explained 11.0% of the variation in carrying capacity. This model effectively predicted Pied-billed Grebe carrying capacity from wetland characteristics for 75 of 87 wetlands (86.2%).

Yellow-headed Blackbird carrying capacity declined significantly by 62.6% during 1988-1998 (P = 0.001), with declines observed at 21 of 87 wetlands (24.1%; Fig. 5A). Carrying capacity of Yellow-headed Blackbirds showed a slight but non-significant (P=0.96) curvilinear relationship with interspersion, with the highest estimated carrying capacity at class five (0–20% vegetation, 80–100% open water) and the lowest carrying capacity at class two (60–80% vegetation, 20–40% open water; Fig. 5B). Yellow-headed Blackbird carrying capacity was not significantly related to wetland size (P=0.41; Fig. 5C), grassland land cover (P=0.63; Fig. 5D), agricultural land cover (P=0.73; Fig. 5E), or developed land cover (P=0.91; Fig. 5F). Together, a model including all six variables explained 12.7% of the variation in carrying capacity. This model effectively predicted Yellow-headed Blackbird carrying capacity from wetland characteristics for all 87 wetlands (100%).

Discussion

We found that carrying capacities of all four wetland bird species studied here are slightly (Least Bittern, Pied-billed Grebe) or significantly (Common Gallinule, Yellow-headed Blackbird) declining. Two species—Common Gallinule and Least Bittern—have slightly higher carrying capacities in wetlands with hemimarsh conditions (i.e., interspersed emergent vegetation and open water), but carrying capacities were not affected by wetland size or surrounding land cover for any species. These results were surprising, given the significant relationships between abundance of these species and interspersion reported in earlier studies (Ward et al., 2010). However, this is likely due to the difference in the measures of wetland bird abundance used in each analysis. Here, we modeled carrying capacity, which exhibits linear declines in response to long-term and likely large-scale population-level processes (Solbu et al., 2015). Ward et al. (2015) modeled raw counts, which vary substantially among years with movements of birds among lakes, likely swamping long-term population processes. Taken together, this suggests that wetland birds track emergent vegetation over the short term by moving to lakes with preferred hemimarsh conditions. However, other drivers not evaluated in these studies are likely responsible for the long-term population-level declines. There are many possible factors contributing to declines of wetland birds, including carp, predators, invasive plants (e.g., *Phragmites*), and predators. Further research may be able to identify causes of long-term declines and, consequently, contribute to conservation of wetland birds in the Great Lakes region.

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Figures

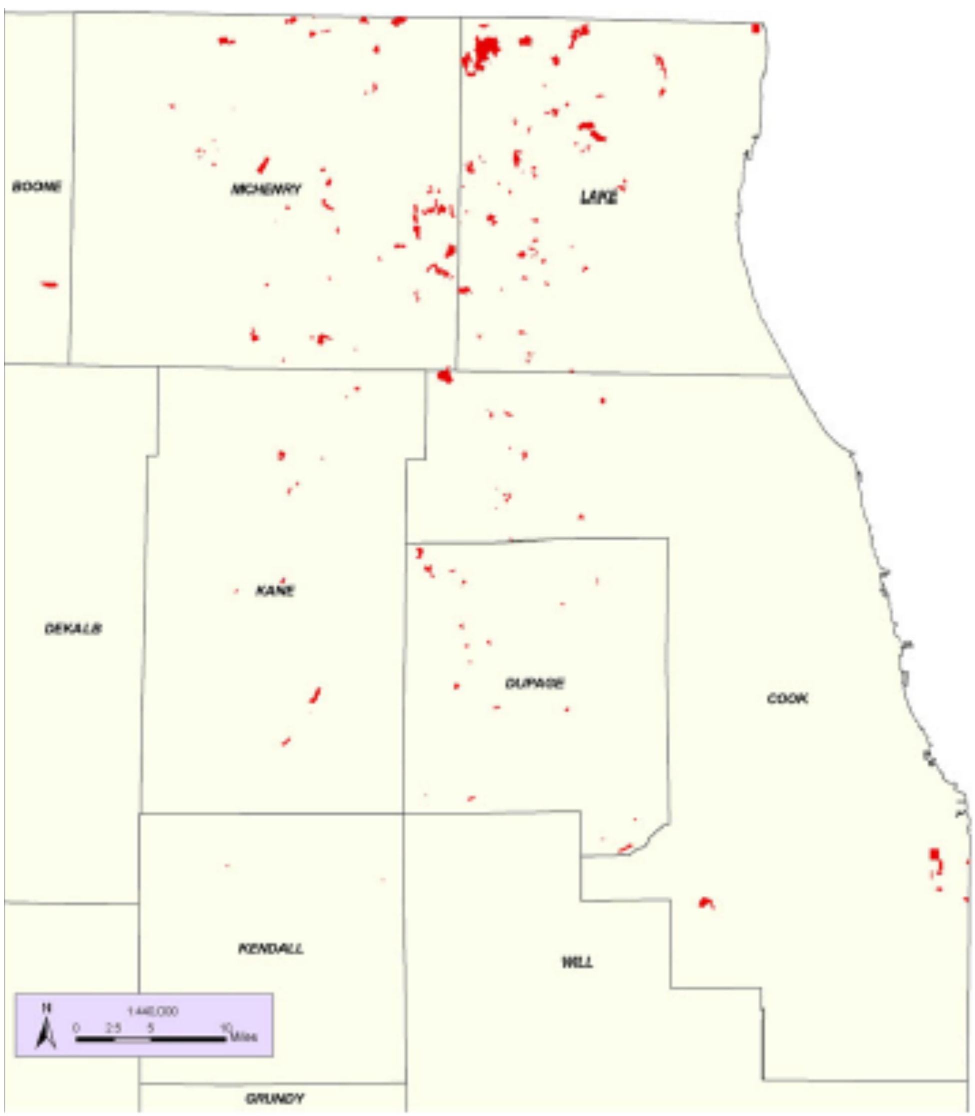

Figure 1. Map showing locations of the 196 wetlands surveyed during 1980–2005 in northeastern Illinois (Ward et al., 2010).

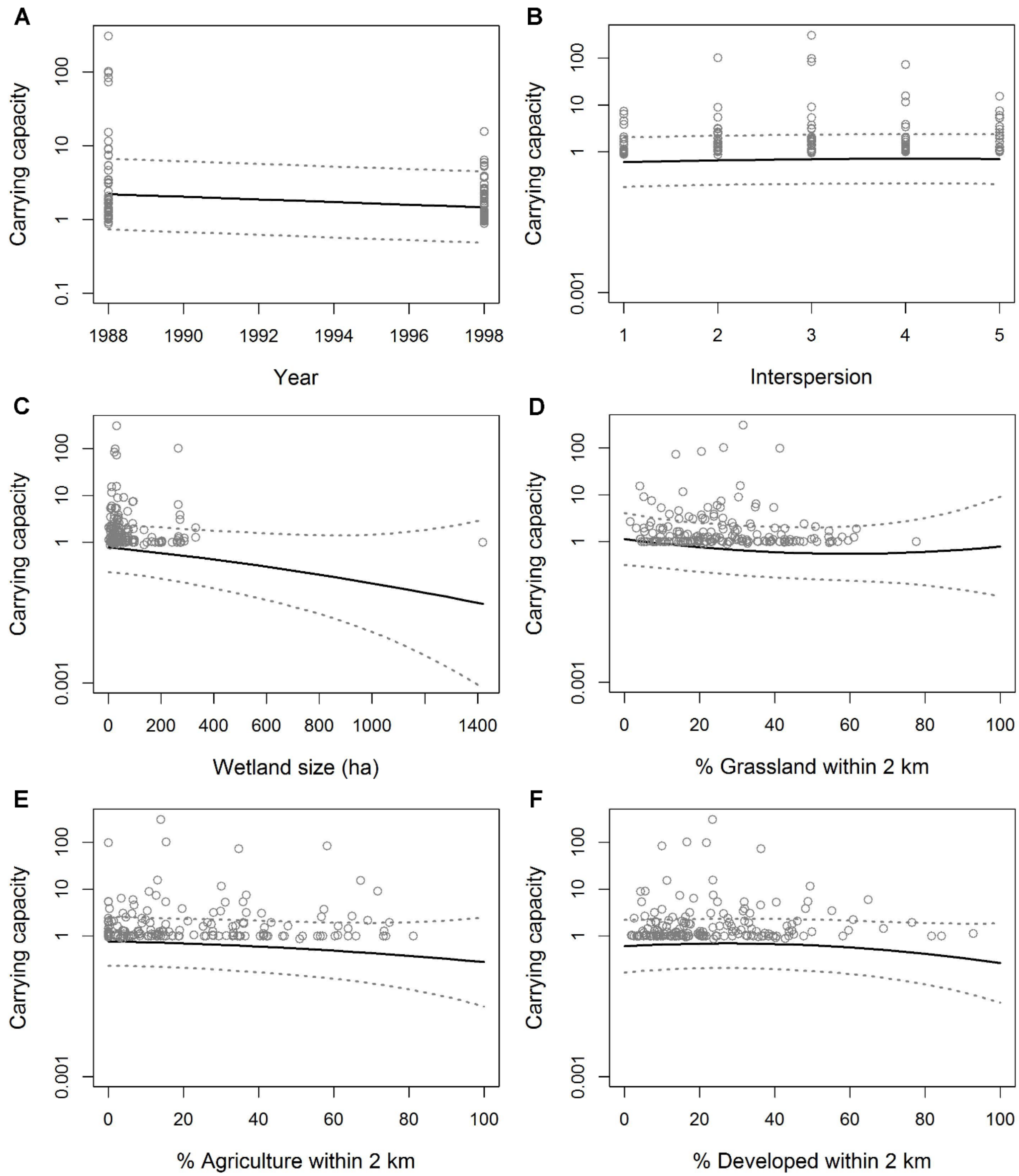

Figure 2. Relationships between carrying capacity of Common Gallinule in 87 wetlands in northeastern Illinois and (A) year, (B) interspersion, (C) wetland size, (D) percent grassland, (E) percent agricultural land, and (F) percent developed land within surrounding 2 km.

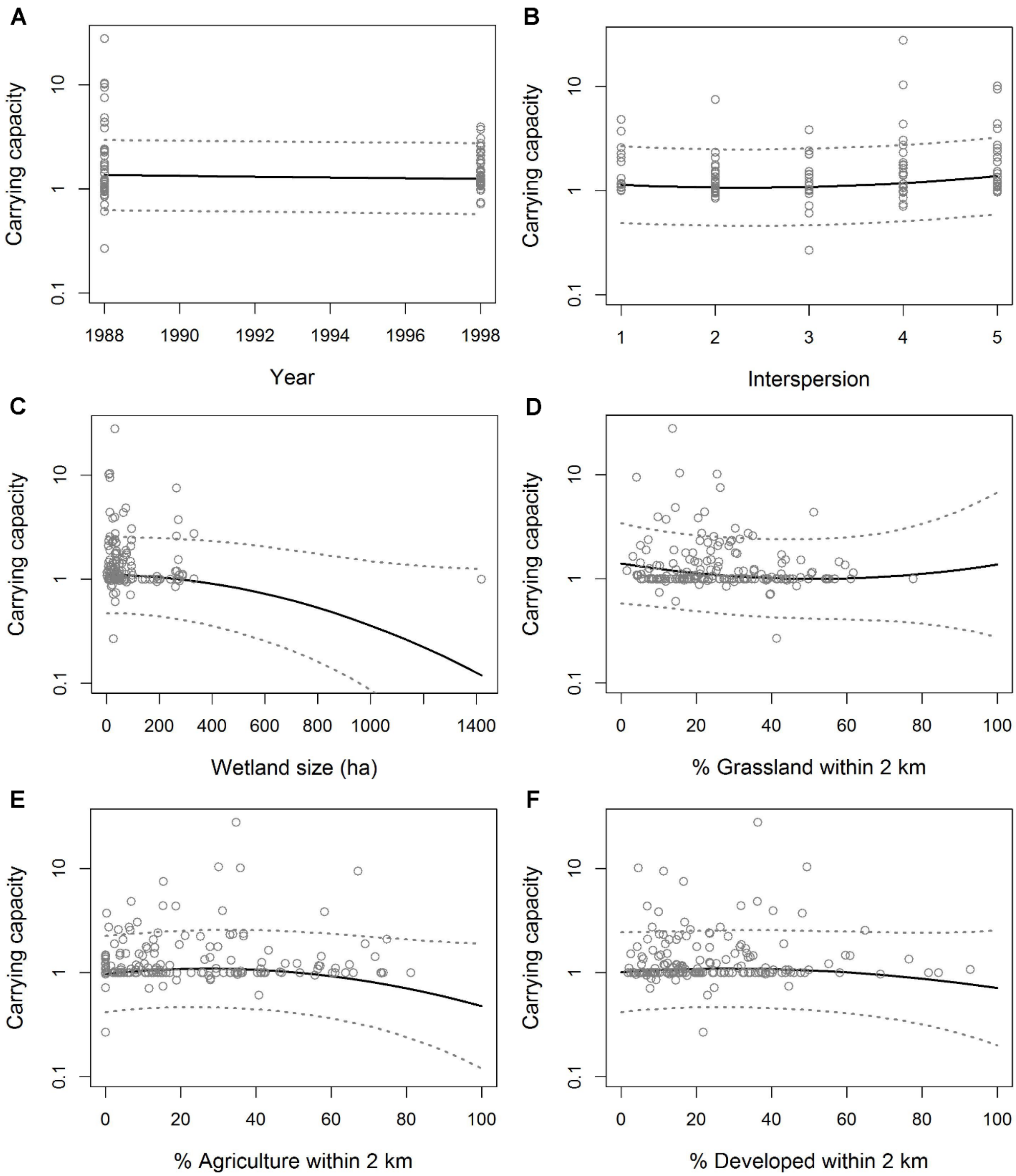

Figure 3. Relationships between carrying capacity of Least Bittern in 87 wetlands in northeastern Illinois and (A) year, (B) interspersion, (C) wetland size, (D) percent grassland, (E) percent agricultural land, and (F) percent developed land within surrounding 2 km.

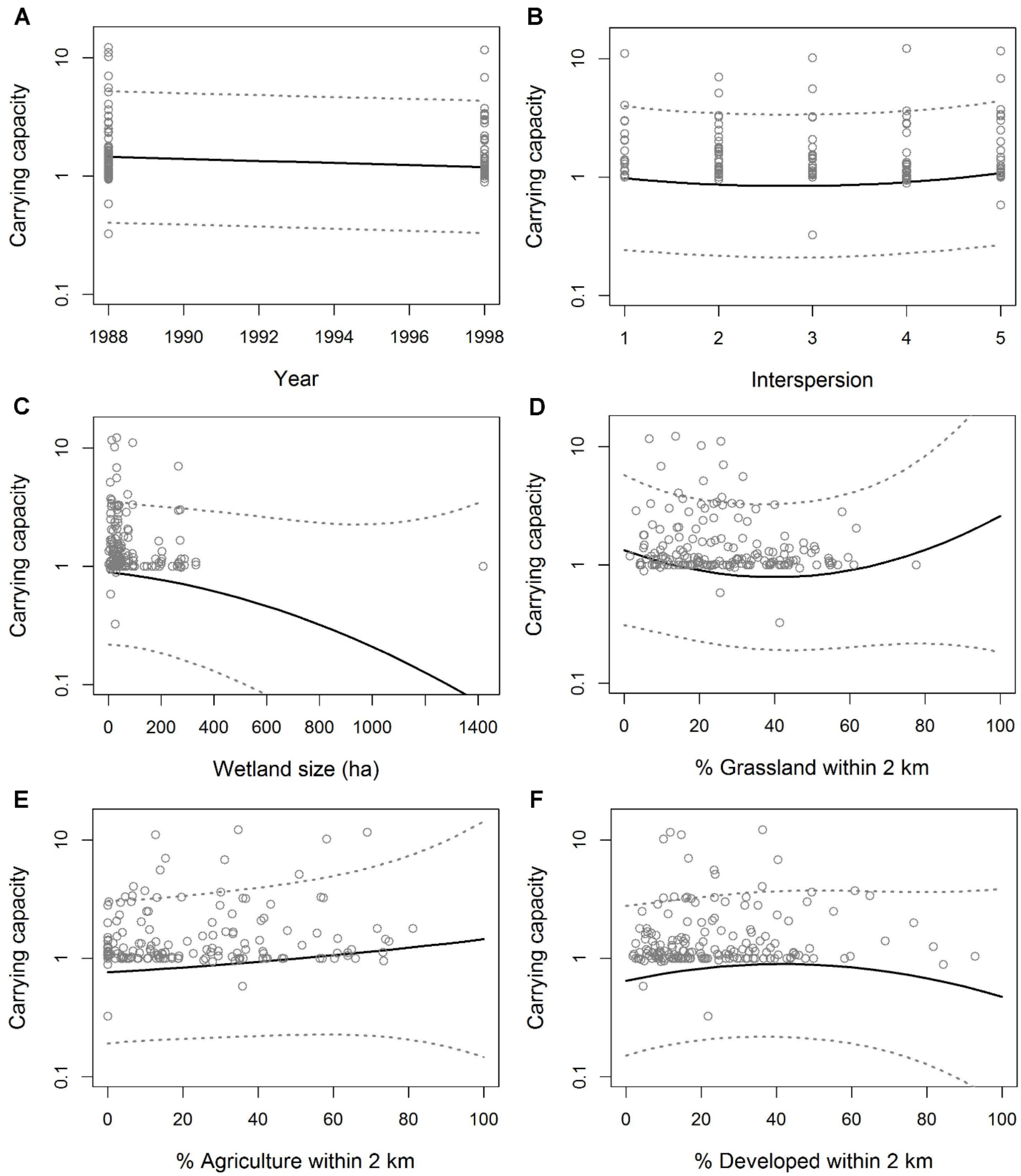

Figure 4. Relationships between carrying capacity of Pied-billed Grebe in 87 wetlands in northeastern Illinois and (A) year, (B) interspersion, (C) wetland size, (D) percent grassland, (E) percent agricultural land, and (F) percent developed land within surrounding 2 km.

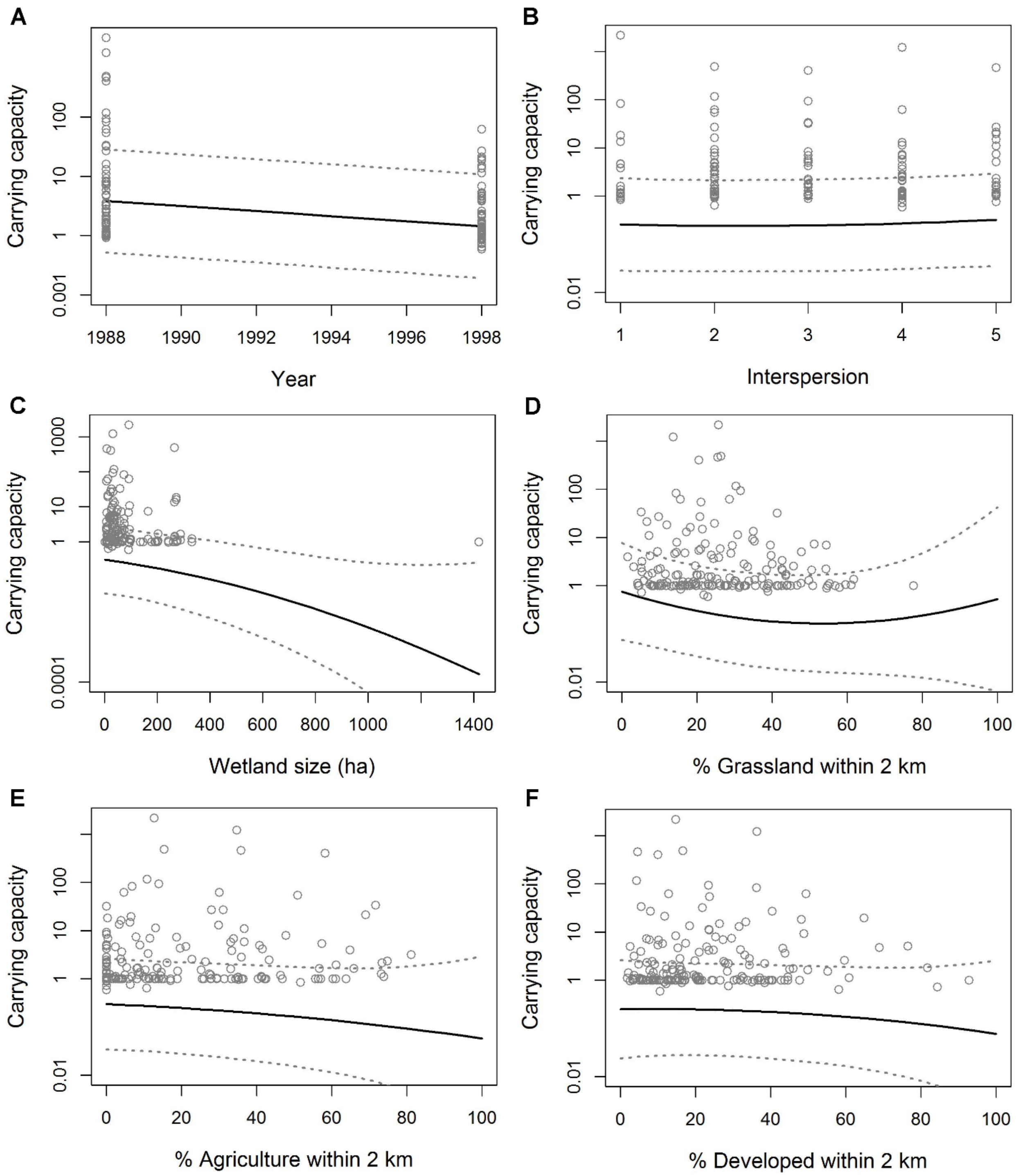

Figure 5. Relationships between carrying capacity of Yellow-headed Blackbird in 87 wetlands in northeastern Illinois and (A) year, (B) interspersion, (C) wetland size, (D) percent grassland, (E) percent agricultural land, and (F) percent developed land within surrounding 2 km.

Appendix B

Calumet Marsh Bird Monitoring 2015–2016

Calumet Marsh Bird Monitoring

2015-2016

Audubon GREAT LAKES

Audubon GREAT LAKES

Calumet Marsh Bird Monitoring 2015-2016

Prepared by Caleb Putnam, Walter Marcisz, and Nat Miller

Calumet marsh bird monitors: Roberta Asher, Peter Avis, Thomas Barnes, Erin Grey, Libby Keyes, Paul Labus, Linda Magyar, Walter Marcisz, Nat Miller, Jessica Rico, Axel Rutter, Caleb Putnam, Teri Radke, Dan Spencer, Byron Tsang. Scientific advisors: Courtney Conway, Nicole Michel, Mike Monfils, Charles O'Leary, Doug Stotz, Gary Sullivan, Mike Ward, and Chad Wilsey.

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The Calumet wetland working group consists of: The Forest Preserves of Cook County, The Chicago Park District, Illinois Department of Natural Resources, Audubon Great Lakes, The Wetlands Initiative, The Field Museum, The Nature Conservancy, Illinois Natural History Survey and the U.S. Fish and Wildlife Service.

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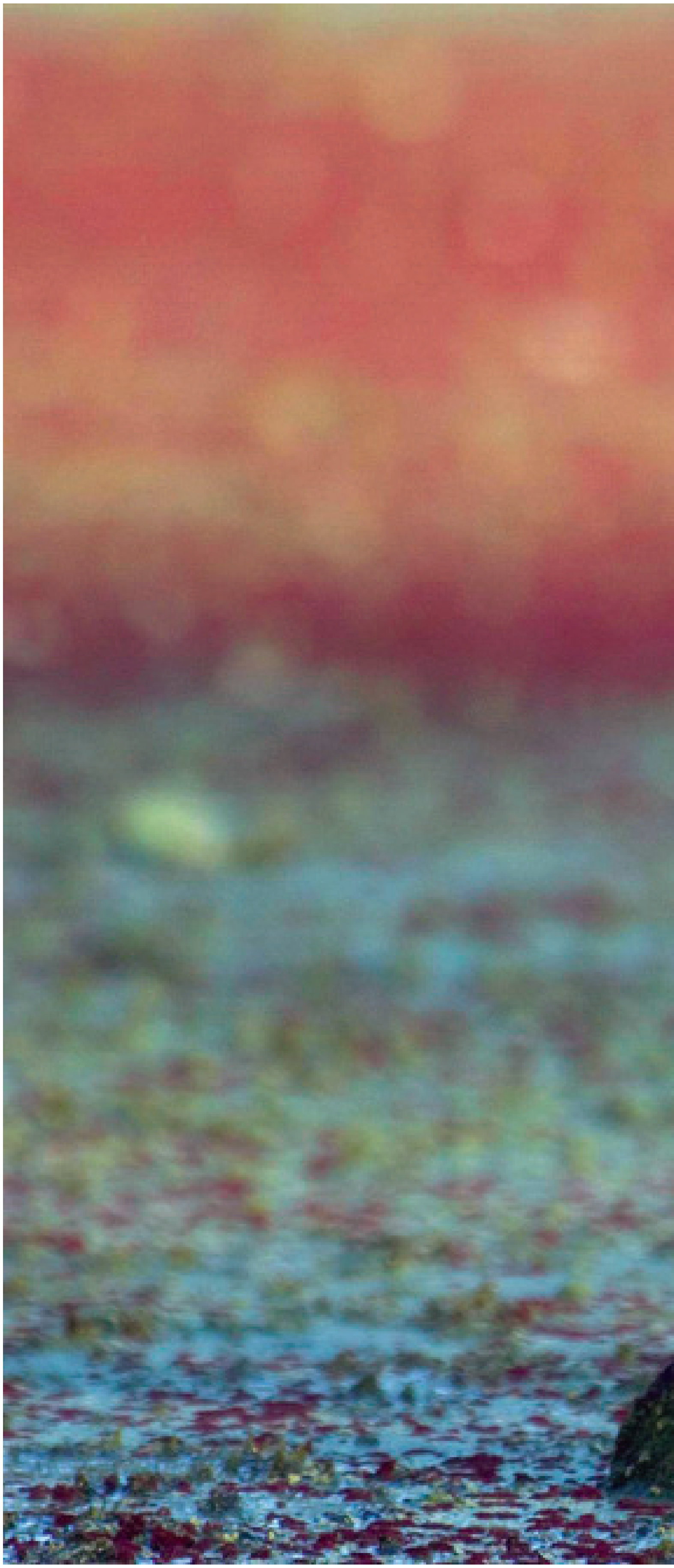
Cover: American Coot. Photo: Alan Murphy



Introduction

The Calumet wetland working group is an informal coalition of land managers, scientists, and conservationists working together to restore the valuable wetlands of the Millennium Reserve in northeast Illinois. A long history of industrialization and urbanization has highly altered hydrology in the region creating threats to the long-term sustainability of wetlands and, in particular, marshes, which depend on natural and dynamic water conditions. Invasive species such as common reed (*Phragmites australis*) and narrowleaf cattail (*Typha angustifolia)* further degrade marsh conditions as reflected by documented declines of the region's marsh-dependent birds (W. Marcisz 2016).

Marsh birds serve as a primary indicator of wetland quality and their charismatic nature also promotes great public interest which serves to raise the profile of this large collaboration. This report summarizes the result of monitoring established in 2015 and expanded in 2016 with the goal of documenting marsh bird breeding populations and distribution to serve as a baseline for goal-setting within the conservation action planning process of the Calumet wetland working group.

Methodology

During 2015, Audubon Great Lakes organized the monitoring of ten urban wetlands in northeastern Illinois. In 2016 with additional funding, an additional 16 sites were added (12 of which were in Northwest Indiana and four of which were in Illinois). Together these 26 sites represent the Calumet marsh complex, identified based on existing hemi-marsh or potential hemi-marsh conditions. Audubon relied on staff, partners and a network of experienced volunteers to conduct the surveys. The surveys were conducted using the widely-recognized "Standardized North American Marsh Bird Monitoring Protocol" (Conway, 2011), developed by the U.S. Fish and Wildlife Survey as a continent-wide, standardized protocol for measuring breeding marsh bird densities. In addition to using this protocol, surveyors also conducted territory mapping at each site with the goal of counting how many pairs of each focal species were present. Territory mapping provides an actual count of the numbers of each nesting species at each site, which will serve as a baseline against which future restoration efforts can be gauged on a site by site basis.

Yellow-crowned Night-Heron. Photo: Vaughn Cottman

Species

The four primary focal species for this study were selected due to their indication of quality hemi-marsh habitat. They regularly occur in the region, are in the core of their breeding ranges, and respond to improved habitat conditions (Table 1). Secondary focal species are less reliable indicators of hemi-marsh due to either being range peripheral or extirpated colonial nesting species (Table 2). Secondary focal species may or may not respond to future hemi-marsh restoration. Three of these species are colonial or semi-colonial nesters not suited for territory mapping and dependent on stochastic processes out of land managers' control (e.g. the presence of suitable rookery trees). American Bittern is a strong indicator of marsh habitat quality but breeds primarily north of the Calumet. Black Tern and Yellow-headed Blackbird are both breeding range peripheral and may be absent for reasons outside of land managers' control. Finally, we also collected data for several additional incidental focal species (Table 3), without producing territory maps. Some of these species breed primarily north of the Calumet and others are generalists not requiring hemi-marsh (Blue-winged Teal nests in upland meadows adjacent to marshes; Sora and Virginia Rail occur in both marsh and wet meadow/ditches; Marsh Wrens occur in *Phragmites* monocultures in addition to hemi-marshes). Black-crowned Night-Heron requires suitable nesting trees (or occasionally tall *Phragmites* or cattail stands) for its rookeries, but even then rookeries may not be occupied for stochastic reasons. However, since these species use hemi-marsh habitat during all or part of their life cycles, they are included. Figures 1-4 show the four primary focal species.

Table 1. Primary Focal Species.

Species	Good hemi-marsh indicator	Moderate hemi-marsh indicator	Poor hemi-marsh indicator
Pied-billed Grebe (*Podilymbus podiceps*)	✓		
Common Gallinule (*Gallinula chloropus*)	✓		
King Rail (*Rallus elegans*)	✓		
Least Bittern (*Ixobrychus exilis*)	✓		

Table 2. Secondary Focal Species.

Species	Breeding range peripheral	Extirpated colonial breeder	Good hemi-marsh indicator	Moderate hemi-marsh indicator	Poor hemi-marsh indicator
Snowy Egret (*Egretta thula*)	✓				✓
Yellow-crowned Night-Heron (*Nyctanassa violacea*)	✓				✓
Little Blue Heron (*Egretta caerulea*)	✓				✓
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	✓	✓		✓	
Black Tern (*Chlidonias niger*)	✓	✓			✓
American Bittern (*Botaurus lentiginosus*)	✓			✓	

Table 3. Incidental Focal Species.

Species	Breeding range peripheral	Wetland generalist	Good hemi-marsh indicator	Moderate hemi-marsh indicator	Poor hemi-marsh indicator
American Coot (*Fulica americana*)	✓		✓		
Blue-winged Teal (*Anas discors*)	✓				✓
Black-crowned Night-Heron (*Nycticorax nycticorax*)					✓
Marsh Wren (*Cistothorus palustris*)		✓			✓
Sora (*Porzana carolina*)		✓		✓	
Virginia Rail (*Rallus limicola*)		✓		✓	


Fig. 1. Pied-billed Grebe.
Photo: Nick Chill (used under Flickr Creative Commons).


Fig. 2. Common Gallinule.
Photo: Caleb Putnam.


Fig. 3. Least Bittern.
Photo: Caleb Putnam.


Fig. 4. King Rail.
Photo: Andy Jones.

Data Collection

Following the Standardized North American Marsh Bird Monitoring Protocol (Conway 2011), participants conducted three regular point counts at each assigned point three times each season (first during May 1-15, then again May 16-31, and finally June 1-15). The number of points varied from two to thirteen depending on the size of the site and the amount of marsh habitat therein. Points were distributed at a spacing of one point per 200m grid cell, at an accessible location within the marsh. Kayaks were used to survey seven of the sites, as no land-based access was available to most of the points. Each point was visited for 14 minutes in sequence starting 30 minutes prior to sunrise and finishing at the latest three hours post-sunrise. At each point, a pre-recorded playback including vocalizations of each of the four primary focal species was broadcast, with periods of silent listening before and after the recordings. All visual and audio responses were recorded on the datasheet. After each survey, the observer sketched the boundaries of each territory on a satellite imagery map based on their interpretation of territory locations. Photos of our monitors working in the Calumet are shown in Figures 4-6.

Fig. 4. A rainy day for training - NIRMI Stewardship liaisons Axel Dutton (center), Libby Keyes, and Linda Magyar (right) at Wolf Lake with Thomas Barnes and Nat Miller of Audubon Great Lakes (left). Photo: Peter Avis (NIRMI).

Fig. 5. NIRMI Stewardship Liaison Axel Dutton surveying birds at Kennedy to Cline West. Photo: Peter Avis (NIRMI).

Fig. 6. NIRMI Stewardship Liaison Libby Keyes conducting a bird survey at Kennedy to Cline West. Photo: Peter Avis (NIRMI).

Table 4. Sites included in Calumet wetlands bird surveys from 2015-2016. *Gibson Woods was not surveyed during 2016, due to access problems.

Site	# points	Kayak survey	Surveyed 2015	Surveyed 2016
Eggers Grove	6	✓	✓	✓
Burnham Prairie	11	✗	✓	✓
Hegewisch Marsh	8	✗	✓	✓
126th St. Marsh	3	✗	✓	✓
Heron Pond	5	✗	✓	✓
Park 564 (Big Marsh)	13	✓	✓	✓
136th St. marsh	3	✗	✓	✓
Powderhorn	7	✗	✓	✓
Park 565 (Indian Ridge North)	5	✓	✓	✓
Park 565 (Indian Ridge South)	4	✗	✓	✓
Park 562 (Van Vlissengen)	7	✗	✗	✓
Park 576 (Whitford Pond)	8	✗	✗	✓
Calumet Conservation Area 2	7	✗	✗	✓
Lake Calumet Conservation Area	11	✓	✗	✓
Hyde Lake	8	✗	✗	✓
Roxana Marsh	6	✓	✗	✓
Strawberry Island	10	✓	✗	✓
DuPont	5	✗	✗	✓
Ivanhoe	11	✗	✗	✓
Pine Station Nature Preserve	6	✗	✗	✓
Clark and Pine	11	✗	✗	✓
Tolleston Ridges & Gibson Woods*	6	✗	✗	✓
Kennedy To Cline East	6	✗	✗	✓
Kennedy To Cline West	10	✗	✗	✓
Wolf Lake Pool 6	7	✗	✗	✓
Wolf Lake Pool 5	7	✗	✗	✓
Wolf Lake Management Unit 9	2	✗	✗	✓
Sand Ridge Nature Center	2	✗	✗	✓

Conway density estimates

We report two Conway protocol density metrics. First, the raw number of detections of primary focal species divided by the number of survey points divided by the number of surveys per season. The raw number of detections only includes independent individual birds recorded during an active point count, and excludes birds recorded only between points and those thought to be duplicative observations. Second, we report the proportion of sites with at least one detection of each primary focal species (Table 6). These metrics will be sensitive to actual abundance changes in the future, but do not directly measure breeding birds, since all detections are included (both migrant individuals and breeding individuals).

Estimating territory numbers

Conway densities are useful for standardizing the dataset across North America and for broad abundance and trend estimates, but their strongest site-level value is with large wetlands where survey effort cannot cover the entire site. With relatively small sites in the Calumet, in addition to densities, we also pursue territory counts in order to obtain a more precise metric of abundance and trends for each species, and to closely measure breeding occupancy, rather than breeding/migrant density. To do so, each datasheet and territory map from each of the three survey periods were compared in order to determine the maximum well-documented number of breeding territories for each non-colonial species for the 2016 season. We created cutoff dates for each species and only use birds observed after these cutoffs in order to exclude migrants (Table 5). In cases where our surveys missed a species, but other data were discovered showing presence (eg. eBird or personal observations of outside individuals), such data were used to fill in information gaps. This yields a reliable minimum territory count for each site for each year. We acknowledge that some or all of these counts may be lower than the actual number of territories present, but because the sites are limited in extent and allow a complete survey of the available emergent habitat, we argue these counts are reasonable metric of actual occupancy. In combination with the two density metrics above, we have a very reliable indicator of the success of future marsh restoration. American Coots occasionally breed in the Calumet but are rare, however migrant flocks of up to 10-20 birds can linger in the region until at least June 1, so birds were not counted as territo-

Yellow-headed Blackbird. Photo: Gene Putney

rial until after June 1. Black-crowned Night-Herons forage in many of the Calumet marshes but do not currently breed. This is a result of arbitrary processes and the absence of proper nesting trees, not the condition of the hemi-marsh. Marsh Wrens begin arriving in the Calumet in late April, and are highly vocal throughout the survey period, suggesting the interpretation of territory numbers is straightforward. Additionally, this species nests in any tall emergent vegetation, including invasive common reed (*Phragmites australis)* monocultures, rendering it of low value to assessing the success of hemi-marsh restoration.

Table 5. Migration cutoff dates for selected focal species

Species	Date	Explanation
Pied-billed Grebe	May 10	C. Putnam/W. Marcisz, pers. obs.
Least Bittern	May 25	C. Putnam/W. Marcisz, pers. obs.
Common Gallinule	May 25	C. Putnam/W. Marcisz, pers. obs.
Virginia Rail	May 20	C. Putnam/W. Marcisz, pers. obs.
Sora	May 20	C. Putnam/W. Marcisz, pers. obs.
American Coot	June 1	C. Putnam/W. Marcisz, pers. obs.
Black-crowned Night-Heron	none	Early migrant. Use of habitat for foraging, not territories.
Marsh Wren	none	Counts do not vary significantly between survey periods.

Results

Conway densities for each primary focal species are given in Table 6. Pied-billed Grebes are the most prevalent primary focal species, with several sites showing consistently high detection rates. No King Rails were observed during 2015 or 2016. Least Bitterns were detected at three of the 28 sites in 2016 and none of the ten sites surveyed in 2015. Common Gallinule observations were few, and only at a few sites, with almost all observations likely being migrants rather than breeders.

Table 6. Conway density estimates for primary focal species in the Calumet wetlands by year. Density estimates consist of the raw number of independent individual detections per point per survey, and thus incorporate both migrants and breeders, unlike territory counts. Duplicate individuals and those recorded between point counts are excluded. PBGR=Pied-billed Grebe. COGA=Common Gallinule. KIRA=King Rail. LEBI=Least Bittern.

Site	PBGR 2015	PBGR 2016	KIRA 2015	KIRA 2016	COGA 2015	COGA 2016	LEBI 2015	LEBI 2016
Eggers Grove	0.278	0.167	0	0	0	0	0	0
Burnham Prairie	0.061	0.212	0	0	0	0	0	0
Hegewisch Marsh	0.292	0.875	0	0	0.125	0	0	0
126th St. Marsh	0	0	0	0	0	0	0	0
Heron Pond	0	0.133	0	0	0	0	0	0
Park 564 (Big Marsh)	0	0	0	0	0	0	0	0
136th St. marsh	0.111	0.500	0	0	0	0	0	0
Powderhorn	0	0.143	0	0	0	0	0	0.286
Park 565 (Indian Ridge North)	0	0	0	0	0.067	0	0	0
Park 565 (Indian Ridge South)	0	0	0	0	0	0	0	0
Park 562 (Van Vlissengen)	-	0	-	0	-	0	-	0
Park 576 (Whitford Pond)	-	0	-	0	-	0	-	0
Calumet Conservation Area 2	-	0	-	0	-	0	-	0
Lake Calumet Conservation Area	-	0	-	0	-	0	-	0
Hyde Lake	-	0	-	0	-	0	-	0
Roxana Marsh	-	0	-	0	-	0	-	0
Strawberry Island	-	0	-	0	-	0	-	0
DuPont	-	0.267	-	0	-	0	-	0
Ivanhoe	-	0.030	-	0	-	0	-	0
Pine Station Nature Preserve	-	0.167	-	0	-	0	-	0.083
Clark and Pine	-	0.303	-	0	-	0.030	-	0.060
Tolleston Ridges/Gibson Woods	-	0	-	0	-	0	-	0
Kennedy To Cline East	-	0	-	0	-	0.056	-	0
Kennedy To Cline West	-	0	-	0	-	0	-	0
Wolf Lake Pool 6	-	0	-	0	-	0	-	0
Wolf Lake Pool 5	-	0	-	0	-	0	-	0
Wolf Lake Management Unit 9	-	0	-	0	-	0	-	0
Sand Ridge Nature Center	-	0.833	-	0	-	0	-	0

The proportion of sites containing at least one individual of each primary focal species is offered in Table 7. Observed occupancy was relatively high both years for Pied-billed Grebe, low for both Common Gallinule and Least Bittern, and zero for King Rail.

Table 7. The proportion of Calumet wetland sites occupied by each primary focal species by year, using Conway density estimate data.

Species	2015 (n=10)	2016 (n=28)
Pied-billed Grebe	0.40	0.39
King Rail	0.00	0.00
Common Gallinule	0.20	0.07
Least Bittern	0.00	0.11

Least Bittern fledgling. Photo: Jim Guyton

Territory counts for each of the 28 sites surveyed during 2015 and 2016 are given in Tables 8 and 9. Black-crowned Night-Herons, which are colonial nesters and do not stake out territories, did not breed in the Calumet and were recorded as present (i.e. using the habitat for foraging) or not detected.

Table 8. Territory counts for 2015. PBGR=Pied-billed Grebe. COGA=Common Gallinule. KIRA=King Rail LEBI=Least Bittern. VIRA=Virginia Rail. SORA=Sora. BCNH=Black-crowned Night-Heron. AMCO=American Coot. MAWR=Marsh Wren. Asterisks represent totals populated or supplemented from data outside our Conway protocol dataset, including eBird, Bird Studies Canada protocol data, and personal communications with Walter Marcisz.

Site	PBGR	COGA	KIRA	LEBI	VIRA	SORA	BCNH	AMCO	MAWR
Eggers Grove	2	0	0	2	0	0	Present	1*	9*
Burnham Prairie	0	0	0	0	1	0	Not detected	0	8
Hegewisch Marsh	3	0	0	0	0	2	Not detected	1	9
126th St. Marsh	0	0	0	0	0	0	Present	0	0
Heron Pond	0	0	0	0	0	0	Present	0	0
Park 564 (Big Marsh)	0	0	0	0	0	0	Present	0	4
136th St. marsh	0	0	0	0	1	1	Not detected	0	1
Powderhorn	0	0	0	0	1	0	Not detected	0	12
Park 565 (Indian Ridge North)	0	0	0	0	0	0	Present	4	1
Park 565 (Indian Ridge South)	0	0	0	0	0	0	Present	0	0
Total	**5**	**0**	**0**	**2**	**3**	**3**	**n/a**	**6**	**44**
% sites occupied	40	0	0	10	30	20	60	30	70

Table 9. Territory counts for 2016. Codes as in Table 8. Codes and asterisks as in Table 8.

Site	PBGR	COGA	KIRA	LEBI	VIRA	SORA	BCNH	AMCO	MAWR
Eggers Grove	2	1*	0	0	0	0	Present	1*	7
Burnham Prairie	1	0	0	1	1	0	Present	0	16
Hegewisch Marsh	4	1*	0	0	0	1	Not detected	2	10
126th St. Marsh	0	0	0	0	0	0	Present	0	1
Heron Pond	1	0	0	0	0	0	Present	0	0
Park 564 (Big Marsh)	0	0	0	0	0	0	Not detected	0	10
136th St. marsh	1	0	0	2	1	0	Present	0	0
Powderhorn	0	0	0	1	0	0	Present	0	18
Park 565 (Indian Ridge North)	0	0	0	0	0	0	Present	0	2
Park 565 (Indian Ridge South)	0	0	0	0	1	1	Present	0	0
Park 562 (Van Vlissengen)	0	0	0	0	0	0	Present	0	8
Park 576 (Whitford Pond)	0	0	0	0	0	0	Present	0	0
Calumet Conservation Area 2	0	0	0	0	0	0	Not detected	0	2
Lake Calumet Conservation Area	0	0	0	0	0	0	Not detected	0	4
Hyde Lake	0	0	0	0	0	0	Not detected	0	3
Roxana Marsh	0	0	0	0	0	0	Present	0	0
Strawberry Island	0	0	0	0	0	0	Present	0	11
DuPont	3	0	0	1*	1	10	Present	2	13
Ivanhoe	0	0	0	0	1	0	Present	0	0
Pine Station Nature Preserve	2	0	0	0	0	0	Present	0	0
Clark and Pine	2	0	0	0	0	0	Present	0	3
Tolleston Ridges/Gibson Woods	0	0	0	0	0	0	Not detected	0	0
Kennedy To Cline East	0	0	0	0	0	0	Not detected	0	0
Kennedy To Cline West	0	0	0	0	0	0	Not detected	0	0
Wolf Lake Pool 6	0	0	0	0	1	3	Present	0	1
Wolf Lake Pool 5	0	0	0	0	0	0	Present	0	0
Wolf Lake Management Unit 9	0	0	0	0	0	0	Present	0	1
Sand Ridge Nature Center	1	0	0	0	0	0	Present	0	0
Total	**17**	**2**	**0**	**5**	**6**	**15**	**n/a**	**5**	**110**
% sites occupied	32	7	0	14	21	18	64	11	57

Snowy Egret. Photo: Robert Bailey

Incidental observations of secondary focal species

Little Blue Heron

A review of eBird data and other outside observations discovered the following significant observations within the Calumet region. An adult Little Blue Heron was observed at Indian Ridge Marsh north on June 4-5, 2016. A juvenile Little Blue Heron was photographed at Big Marsh on August 6, 2016.

Snowy Egret

An adult Snowy Egret was present at 126th St. Marsh from late May 2015 to early July 2015. Another was present at Wolf Lake Pool 5 in late April 2015. Another adult was alternating between Wolf Lake Pool 5 and Strawberry Island during April-June 2016. Walter Marcisz photographed a single Snowy Egret at Burnham Prairie on June 12, 2016. NIRMI volunteer Libby Keyes recorded a single Snowy Egret at Kennedy to Cline West on June 6, 2016 (not during her official survey).

Yellow-headed Blackbird

Two Yellow-headed Blackbirds lingered at Big Marsh until early May 2016 but did not attempt to breed.

American Bittern

One American Bittern was seen at Big Marsh on May 1, 2015 by Walter Marcisz and Caleb Putnam, and was clearly a migrant. Migrants were also observed at Hegewisch Marsh on May 3, 2016, at Burnham Prairie on April 18, 2016, and Sand Ridge Nature Center on May 3, 2016. Much more surprising was the presence of two individuals at DuPont on June 8, 2016, strongly suggestive of attempted breeding, and two individuals at Powderhorn on May 15, 2016, also somewhat suggestive of breeding (but possibly late migrants). Finally, American Bitterns summered at DuPont during 2013, 2014, and 2015 (P. Labus, pers. comm.) and were observed during summer at both Clark and Pine (three on June 16, 2016), and Pine Station Nature Preserve (two on June 16, 2016) during 2016. These represent evidence of attempted breeding, though no nests have yet been discovered.

Conclusions and Discussion

The marsh bird community of Calumet is in poor condition indicating a poor condition of the overall Calumet wetland system. The four primary focal species are all at or near historic lows and occupy a small proportion of Calumet's wetlands. Determining the habitat related bottleneck for each species and addressing it is the primary focus of this coalition's work. Relevant factors are: 1) a lack of water level management leading to either monocultures or open water lakes, 2) an over-prevalence of invasive plants, particularly common reed (*Phragmites australis*) and hybrid cattail (*Typha angustifolia x latifolia*), 3) lack of native vegetative diversity, 4) carp infestation leading to low food abundance, turbid waters, and decreased emergent cover, and 5) the presence of slag in the soil bed changing water chemistry and negatively influencing flora and fauna. Understanding the extent to which these factors limit avian use at each particular wetland will lead to effective site-specific strategies for improving and maintaining better habitats in the Calumet region.

There were no significant changes between 2015 and 2016 in site occupancy rates of primary focal species and key incidental focal species in the Calumet wetlands (Tables 5 and 6). This was expected because habitat rarely changes on the scale necessary to severely impact marsh bird populations within a one year timeframe. High occupancy for Pied-billed Grebes, Marsh Wrens, and foraging use by Black-crowned Night-Herons were evident both years. Low use was observed for Least Bittern, Sora, and Virginia Rail, and near zero use for Common Gallinules. King Rails, as expected, were not observed.

Secondary focal species continue not to breed in the Calumet wetlands (American Bittern is the important exception), but some are observed in small numbers annually. Occurrences of Little Blue Heron, Snowy Egret, and migrant Yellow-headed Blackbirds are somewhat indicative of quality hemi-marsh, but are largely dependent upon factors outside the control of land managers, especially random factors dictating northward vagrancy. American Bitterns, which primarily breed well north of the Calumet, were a pleasant surprise, and appear to be attempting to nest at more well-managed sites. This is a moderate indication of quality hemi-marsh, but may only be possible at sites with relatively large portions of habitat. We do not believe occupancy can be expected based solely on good habitat restoration work.

There are notable exceptions to the overall poor condition of the ecosystem. Several sites have received recent management actions to which secretive marsh birds have quickly responded. Hegewisch Marsh, for example, after a long period of no management action in the early 2000s, quickly became a cattail monoculture following a string of drought years. Water levels eventually returned to higher levels, and subsequent depletion of cattail by over-abundant muskrats and low cattail regrowth created an open water lake by 2010. In 2010 and 2011 active water level manipulation by Chicago Park District returned cattails as the dominant vegetation by lowering and raising the water level in response to changing cattail growth. At this site, active management of water levels, muskrat controls (ie. complete drawdown), and elimination of common reed, was what was needed to maintain a healthy proportion of emergent plants to open water and maximize secretive marsh bird occupancy.

Burnham Prairie tells a similar story, though with some notable differences. This site lacks a water control structure, and hence its water level is largely dependent upon rain. As of 2011 the site had become infested with common reed, so the first step was herbicide treatment. This was successful in removing this invasive from key areas of the marsh. However, subsequent high water levels since then have limited the regrowth of cattails and the main area of potential hemi-marsh is becoming increasingly open. Gaining the ability to manage the water levels, establishing native emergent plants, and continued treatment of common reed, has great potential to return this site to a more productive hemi-marsh and maximize avian occupancy.

Comparably, Eggers Grove also has no water level management structure, and so is also subject to rainwater inflow. Hemi-marsh still exists, but currently cattails are receding and water level control will need to be gained in order to moderate the downturn of emergent cattails. Any net loss of hemi-marsh is extremely difficult to reverse without this. Additional attention to any effects from beaver dams and potentially abundant muskrats also merit monitoring and quick response.

An additional threat to about half of the Calumet's wetlands is common carp (*Cyprinus carpio*). Carp deplete food resources directly and indirectly, prevent emergent plant growth and limit vegetative diversity by disturbing the benthos, and increasing water turbidity. The effects this has on the Calumet's secretive marsh birds is currently being investigated, but negative effects have been demonstrated on marsh birds in other regions, and we suspect carp management will be an important component of restoring the Calumet wetlands. This may require dikes or other structures to prevent re-entry of carp following control measures.

In 2017 we recommend several changes to the Calumet wetlands protocol. First, we recommend removing King Rail as a primary focal species, and adding both Sora and Virginia Rail as primary focal species. King Rail, although it is very rare at this latitude, is a very important species for the project, as any occupancy would be extremely noteworthy. It is state endangered in both Illinois and Indiana. But because it often responds to Virginia Rail "kek-hurrah" vocalizations (C. Putnam, pers. obs.), we recommend removing it from the recordings. Sora and Virginia Rail are both moderately good indicators of hemi-marsh quality, although they occur in other cover types, and belong as primary focal species. Finally, we recommend adding Swamp Sparrow as an incidental focal species, as it is a good indicator of hemi-marsh habitat.

The Calumet wetland system presents a phenomenal opportunity for effective restoration. The partners of the Calumet wetland working group working and its partners look forward to developing collaborative management recommendations and strategies for land managers and measuring the resulting avian response.

Recommended Citation

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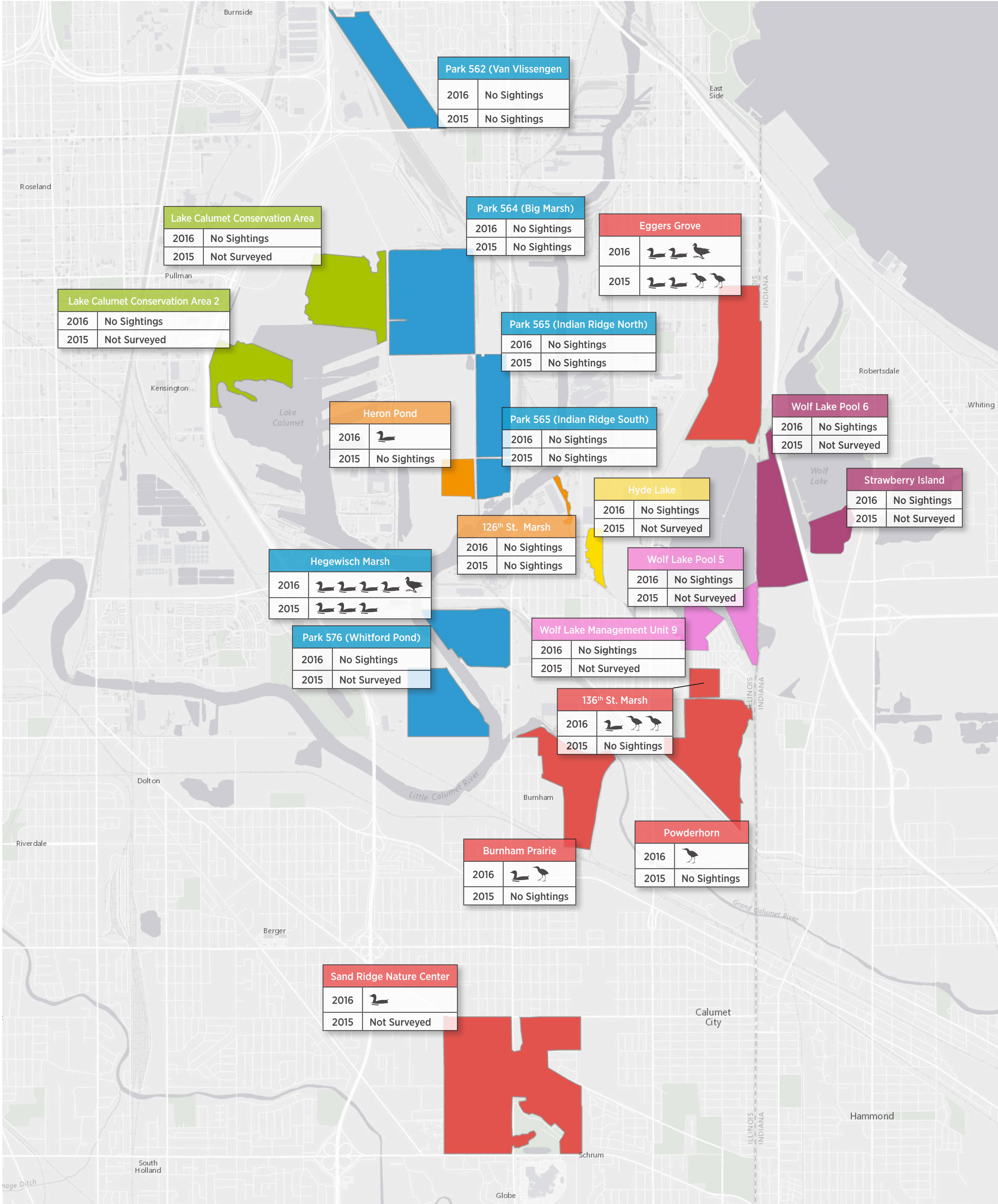
Marcisz, W. 2016. Species Profiles. Report to Audubon Chicago Region. April 18, 2016.


Burnside
Park 562 (Van Vlissengen
2016 No Sightings
2015 No Sightings
East Side
Roseland
Lake Calumet Conservation Area
2016 No Sightings
2015 Not Surveyed
Park 564 (Big Marsh)
2016 No Sightings
2015 No Sightings
Eggers Grove
2016
2015
Pullman
Lake Calumet Conservation Area 2
2016 No Sightings
2015 Not Surveyed
Park 565 (Indian Ridge North)
2016 No Sightings
2015 No Sightings
Robertsdale
Kensington
Lake Calumet
Heron Pond
2016
2015 No Sightings
Park 565 (Indian Ridge South)
2016 No Sightings
2015 No Sightings
Wolf Lake Pool 6
2016 No Sightings
2015 Not Surveyed
Whiting
Wolf Lake
Strawberry Island
2016 No Sightings
2015 Not Surveyed
Hyde Lake
2016 No Sightings
2015 Not Surveyed
126th St. Marsh
2016 No Sightings
2015 No Sightings
Hegewisch Marsh
2016
2015
Wolf Lake Pool 5
2016 No Sightings
2015 Not Surveyed
Park 576 (Whitford Pond)
2016 No Sightings
2015 Not Surveyed
Wolf Lake Management Unit 9
2016 No Sightings
2015 Not Surveyed
136th St. Marsh
2016
2015 No Sightings
ILLINOIS INDIANA
Dolton
Little Calumet River
Burnham
Riverdale
Burnham Prairie
2016
2015 No Sightings
Powderhorn
2016
2015 No Sightings
Grand Calumet River
Berger
Sand Ridge Nature Center
2016
2015 Not Surveyed
Calumet City
Hammond
Schrum
South Holland
Globe

Primary Focal Species Territory Counts in 2015 and 2016.

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Appendix C

Full Marsh Bird Profiles

Author: Walter Marcisz

PIED-BILLED GREBE (*Podilymbus podiceps*)
Pied-billed Grebe is a small, highly aquatic duck-like bird with mostly brownish plumage year-round, and a white, "chicken-like" bill with a black ring during the breeding season. Immature birds have boldly striped heads. Length: 30.5–38.1 cm (12–15 in). Like other members of the Grebe family, it has lobed (rather than webbed) feet, and habitually dives from the surface of the water in pursuit of food in habitats ranging from freshwater marshes and lakes to sluggish rivers.

Distribution: Breeds from the northern prairie provinces of Canada south locally through southern Canada, U.S.A., the West Indies, and Mexico; resident from Panama south through southern South America (except tropical forest regions). Extreme northern populations of the widespread North American subspecies (*Podilymbus podiceps podiceps*) vacate breeding areas for ice-free regions during the colder months.

Habitat: All-purpose territory usually associated with dense stands of emergent vegetation or aquatic vegetation close to surface for nest construction and anchorage, and nearby open water, which may be intersecting channels, for foraging. Seeks similar habitat during migration and wintering, as long as it is ice-free (Muller & Storer, 1999).

Behavior: Highly aquatic, but awkward on land because of posterior placement of feet. Swims and dives from the surface of the water in pursuit of food, propelled by lobed feet. Like other grebes, needs long running start and flapping wings, before becoming airborne from water (Muller & Storer, 1999). Able to gradually sink to any desired depth, with various amounts of head, neck and bill above water surface. Commonly heard "owhoop" courtship/territorial call is a series of "wut," "whut" or "kuk" notes followed by 4–20 "kaow" or "cow" notes. (Conway, 2009). Aggressively defends territory from intruding conspecifics and other water birds.

Food preferences: Collects most food underwater during foraging dives. Opportunistic as to kind and size of prey; takes what is most readily available, including fishes, crustaceans (especially crayfish [*Cambarus* spp.]), and aquatic insects and their larvae (Muller & Storer, 1999). Diet varies greatly, depending on availability at any particular place and time. Overall, includes decapod crustaceans, especially crayfish (*Cambarus*, *Potamobius*), aquatic insects (especially bugs [Hemiptera], beetles [Coleoptera], and nymphs of dragonflies [Odonata]), and fishes (especially carp and minnows [Cyprinidae], catfishes [Ictaluridae], sculpins [Cottidae], killifish [Cyprinodontidae], sticklebacks [Gasterosteidae], and sunfishes [*Lepomis*]). In some areas, also leeches (Hirudinea), gizzard shad 6–10 cm long (*Dorosoma*), or frogs and tadpoles (especially *Rana*) (Munro, 1941; Trautman, 1940; Wetmore, 1924;). In fishless wetlands in Manitoba, takes tiger salamander (*Ambystoma tigrinum*) and its neotenic form (axolotls; E. Osnas, unpubl.) (as cited in Muller & Storer, 1999).

Nesting habits: Nest is a floating platform, most often placed among tall emergent vegetation, although may be among low vegetation or out in open, usually anchored to vegetation. For platforms among emergent vegetation, two overriding factors affect nest-site selection: (1) Water depth >25 cm to allow for escape, feeding, and construction of floating platform; (2) emergent vegetation density ≥10 $cm^2$of stem basal area/m^2. No preference for any of 6 nesting cover types found on Rush Lake, Winnebago Co., WI, as long as these two requirements were met; center of nesting activity on lake shifted in response to changes in water levels and availability of emergent vegetation cover, both within and between nesting seasons (Krapu et al., 1970; Otto, 1983b). As with all other grebes, material used in platform construction and to cover eggs reflects availability. Crude circular platform of buoyant material (year-old bulrush stems, fresh waterlily stems) is placed among emergent vegetation, or decaying material is placed on top of lily leaf. Hardstem bulrush (*Scirpus acutus*), Eurasian watermilfoil (*Myriophyllum spicatum*), sago pondweed (*Potamogeton pectinatus*), roots, stonewort (*Chara* spp.), cattails, and small sticks are added. Prefers new-growth hardstem bulrush culms over previous years' growth. Uses flexible material to cover eggs: more construction materials, plus oak leaf (*Quercus* spp.), unidentified plants, and common bladderwort (*Utricularia vulgaris*) (Glover, 1953; Muller, 1995; Otto, 1983b). Female lays 3–10 (usually 4–8) whitish eggs. Semi-precocial chicks are carried on adult's back during first week after hatching, are autonomous swimmers after first week.

Continent-wide population status: Listed as Least Concern (population trend: stable) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically a widespread breeding species in the Calumet region of Illinois and Indiana (Brock, 2010; Ford, 1956; Mlodinow, 1984). Notable late 20th century Illinois Calumet breeding records include 5 broods at Hegewisch Marsh in 1990, 4 broods at Big Marsh in 1995, and 4 broods at Eggers Grove F.P. in 1998.

Current population status in Calumet region: Declining (absent in many wetlands), but still has a limited presence as a breeding species. Territorial birds were detected at 6 of 18 Illinois Calumet wetlands and 3 of 10 Indiana Calumet wetlands surveyed in 2016. Illinois observations in 2016 included at least 4 territories and up to 5 broods at Hegewisch Marsh. Brock (2010) states that breeding birds of this species are widespread throughout the lacustrine plains of Northwest Indiana. Nesting habitat requirements are likely somewhat less stringent than in other marsh species, but like other marsh birds, declines are likely related to overall lack of hemimarsh habitat, rampant infestations of invasive exotics (notably common reed and common carp), overall lack of vegetative diversity, and vexing hydrological problems.

LEAST BITTERN (Ixobrychus exilis)

Least Bittern is the smallest member of the heron family. Length: 28–36 cm (11–14 in). It is a secretive bird, usually well hidden in emergent marsh vegetation, and only occasionally detected during the breeding season by its soft cooing call, or when it takes a brief sally across a marsh. It is relatively short-legged for a heron, but, like other herons, its long neck and daggerlike bill are well adapted for catching prey. When seen, it is a striking bird with light brown sides to the head and neck, a white foreneck and belly, contrasting white scapular lines, and dark flight feathers with contrasting bright buffy wing coverts or shoulder patches. In adult males, the crown and back are black; in adult females the crown and back are dark brown. Like other bitterns, it is well-known for its cryptic coloration, perching in marsh vegetation with bill pointed straight up, effectively mimicking the structure and coloration of surrounding emergent vegetation.

Distribution: North American subspecies (*Ixobrychus exilis exilis*) breeds in the eastern USA east of the Great Plains (absent from the Appalachians) north to southeastern Canada, and south to Florida and Texas, with isolated breeding populations in Oregon, California, and Arizona. Arrives at breeding grounds later in spring than most marsh birds (about 1 month later than American Bittern) and migrates south earlier (about 2 months earlier than American Bittern). Winters in the Florida Panhandle, eastern and southern Mexico, Central America, and the West Indies (also resident at each of these locations). Other subspecies are resident in Peru, Colombia, Panama, and around the eastern coasts of South America south to Paraguay.

Habitat: Nests in freshwater and brackish marshes with dense, tall growths of aquatic or semiaquatic vegetation, typically cattail (*Typha*), sedge (*Carex*), and bulrush (*Scirpus*), occasionally reed (*Phragmites)*, arrowhead (*Sagittaria)*, willow (*Salix)*, buttonbush (*Cephalanthus*), and (*Rhizophora*). Weller and Spatcher (1965) noted that in Iowa, Least Bitterns were most abundant in freshwater marshes during years when ratios of emergent vegetative cover to open water were equal (the hemimarsh condition). Several authors have noted a strong association with cattail in northern regions, but Frederick et al. (1990) believed this strong association may occur only because cattail is the most common tall plant growing there in dense stands above deep water (Poole et al., 2009).

Behavior: Usually clambers through dense marsh vegetation. Often moves deliberately from stalk to stalk, grasping vegetation with toes. Seemingly flies weakly; flutters short distances when flushed (<25 m), legs dangling, and drops quickly back into vegetation. Assumes upright "Bittern stance" when alarmed by larger animals such as humans, raptors, and large herons; points head vertically, eyes forward, and compresses feathers. May move from side to side in bittern stance as camouflaging behavior in wind-blown marsh vegetation (Weller, 1961). Quite vocal, with a varied repertoire of calls. Males utter a dovelike cooing, frequently heard in spring (Poole et al., 2009).

Food preferences: Major food items include small fishes, including top minnows (*Fundulus*), mud-minnows (*Umbra*), sunfishes (Centrarchidae), and perches (*Perca*). Also snakes, frogs, tadpoles, salamanders, leeches, slugs, crayfish, insects (mainly *Odonata* and *Orthoptera*), small mammals (shrews and mice), and vegetable matter (Bent, 1926; Howell, 1932; Palmer, 1962; Warren, 1890; Weller, 1961). May also prey on the eggs and young of Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*; Roberts, 1936). Small repertoire of feeding behaviors (Kushlan, 1978). Among 28 recognized behaviors used by herons, Least Bitterns employ only 4: "standing in place," "walking slowly," "neck swaying" (to overcome glare, to increase camouflage, or to have muscles in movement when strike begins), and "wing-flicking," which involves quick, repeated extension and retraction of wings that may startle prey from hiding (Sutton, 1936). By clinging to emergent vegetation and constructing platforms, this tiny heron is able to forage over water as deep as that used by the largest North American herons (25–60 cm deep), although most foraging occurs at the water's surface (Poole et al., 2009).

Nesting habits: Nests typically built among dense, tall stands of emergent or woody vegetation (typically *Typha*, *Carex*, and *Scirpus*, occasionally *Phragmites*, *Sagittaria*, *Salix*, *Cephalanthus*, and *Rhizophora*; (Palmer, 1962; Weller, 1961). Nests usually 15–76 cm above water 8–96 cm in depth, and

<10 m from open water, channels, or openings made by muskrat (*Ondatra zibethicus*) (Aniskowicz, 1981; Kushlan, 1973; McVaugh, 1975; Nero, 1950). Nests (*n*=28) in a South Carolina marsh were 3–4 m from open water, 60 cm above water 30 cm in depth, and located in cattail about 2 m high, of which live and dead stems comprised equal proportions (Post, 1998), i.e., nests were high enough to avoid flooding during storms, but low enough in the vegetation column to be well screened from above. In Ontario, one nest built on top of an active nest of a Marsh Wren (*Cistothorus palustris*) (Peck & James, 1994; Poole et al., 2009). Female normally lays 4–5 very pale blue-green eggs, sometimes 3 or 6 (of 50 nests, 70% contained 5 eggs) (Harrison, 1975). At hatching, young are nidicolous and semi-altricial. Adults brood hatchlings at nest until young leave the nest (Poole et al., 2009).

Continent-wide population status: Listed as Least Concern (population trend: stable) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically a widespread breeding species in the Calumet region of Illinois and Indiana. Ford (1956) considered it a common summer resident in the Chicago region. Butler (1890) considered Least Bittern a locally common summer resident (in suitable habitat) in northern Indiana (Mumford & Keller, 1984).

Current population status in Calumet region: Declining, but still has a very limited presence as a breeding species. Territorial birds were detected at 3 of 18 Illinois Calumet wetlands and one of 10 Indiana Calumet wetlands surveyed in 2016. Illinois observations in 2016 included 2 territories at the 136th St. Marsh, and 1 territory each at Powderhorn Lake F.P. and Burnham Prairie (Walter Marcisz, personal communication). Indiana observations in 2016 included 1 territory at the DuPont Tract in East Chicago (Walter Marcisz, personal communication). Up to 2 territories were detected at Eggers Grove F.P., Chicago, in 2015 (Thomas Barnes, personal communication). Least Bitterns nested at Grant Street marsh in Lake County, Indiana in 2014. The high count came on 29 July, when 3 individuals were observed by Landon Neumann (Ayer, 2014). In addition to the above, a pair of adults and another adult at a separate location were seen at the DuPont Tract, East Chicago, Indiana on 5 July 2014, suggesting at least two territories there (Walter Marcisz, personal records). This creature of the cattail marshes has suffered in recent decades with reduction of wetlands. Despite increased observer effort, Indiana numbers are considerably lower than in the 1980s (Brock, 2006). Like other marsh birds, recent declines are likely related to overall lack of hemimarsh habitat, rampant infestations of invasive exotics (notably common reed and common carp), overall lack of vegetative diversity, and vexing hydrological problems.

KING RAIL (Rallus elegans)

King Rail is a large, rusty rail (about the size of a small duck) with a slender, slightly decurved bill that is slightly longer than head, a laterally compressed body, and long toes (Pickens & Meanley, 2015). Length: 38 cm (15 in). In adult, upper parts are olive brown, breast rufescent orange, flanks barred with black and white; tail short and often uplifted. Alternating dark brown and pale orange stripes on sides of neck give way to well-streaked back: black centers to scapulars with pale orange-buff edges. Juvenile is similar to adult, but back feathers blacker with grayer edges and paler; grayer sides of head and underparts, with little or no cinnamon. Like other rails, King Rail is difficult to observe, but it is noted for its striking appearance and loud vocalizations. The King Rail is associated with fresh and brackish marshes, as well as rice fields (Pickens & Meanley, 2015).

Distribution: North American subspecies *Rallus elegans elegans* breeds in eastern North America from southeast North Dakota east to New York and south to the Gulf of Mexico; resident along the Atlantic Coast north to Long Island, across the Florida peninsula, on the Gulf slope, in the lower Mississippi Valley, and across East Texas south through eastern Mexico to southern Veracruz. Cuban subspecies *R. e. ramsdeni* is resident in freshwater marshes of Cuba and the Isle of Pines (Pickens & Meanley, 2015).

Habitat: The King Rail feeds largely on crustaceans and aquatic insects in a variety of water bodies, including shallow flooded emergent vegetation, temporary ponds, creeks, and along the edge of ditches, lakes, and mudflats. It has a wide geographic distribution in the eastern U.S., with strongholds along the Gulf Coast of Texas and Louisiana, and possibly Florida. Northern populations are migratory, but the specific wintering locations of these populations remain unknown (Pickens & Meanley, 2015). From Pickens and King (2013, 2014a, 2014b), and others as noted, King Rail distribution is positively associated with open water-vegetation edge (i.e., interspersion) in interior marsh (Darrah & Krementz 2009) as well as coastal marsh. More specifically, Midwestern and Gulf Coast King Rail use habitat ranging from 4%–30% open water within wetlands (Bolenbaugh et al., 2012). Individuals with 20–29% open water within their home range had smaller home ranges and shorter maximum movements. Presumably, low water availability forces King Rail to move longer distances to find adequate foraging locations. Habitat selection of particular wetland vegetation species may correspond with precipitation and flooding in a particular year or over several years. For example, grasses (*Poaceae*) and sedges (*Cyperaceae*) may be habitat for King Rail in wet years, but not in dry years. Similarly, cattail (*Typha* spp.) marsh may be too deep in wet years, but may be ideal habitat during droughts (Pickens & Meanley, 2015). For fresh marsh, plant species habitat selection remains unclear. In Louisiana, King Rail are in marsh dominated by maiden cane (*Panicum hemitomon*) and *Sagittaria lancifolia*. Other plants used in fresh marsh include sawgrass (*Cladium jamaicense*), giant cutgrass (*Zizaniopsis miliacea*), and cattail. In coastal North Carolina and Virginia, habitat includes abundant *Spartina* spp., cattail, *Schoenoplectus* spp. (formerly *Scirpus* spp.), *Hibiscus moscheutos*, and *Juncus romeriansus* (Rogers et al., 2013). Beecher (1942) noted that King Rails on the east shore of Pistakee Lake, a half-mile south of the village of Fox Lake in Lake County, Illinois, were much more abundant in lake sedge (*Carex lacustris*) than in cattails.

Behavior: Mostly walks and runs, flying when flushed or provoked, when crossing a barrier, or when migrating. May also swim to cross creeks, ditches, or ponds. Flight begins with legs dangling, but as the bird levels off, flies in a straight line, usually close to the ground with legs extended straight back beyond the tail. Primary contact call is given by adults of both sexes year-round and at any time of day, but most often at dusk; seems to vary as *jupe-jupe-jupe*, *cheup-cheup-cheup*, *gelp-gelp-gelp*, or *chac-chac-chac*. Territorial, courtship, or mating call is usually given as a harsh and loud *kik-kik-kik* during day and occasionally at night; may vary from a series of *kiks* to *kuks* or *bups* (Pickens & Meanley, 2015).

Food preferences: Feeds mainly on crustaceans and aquatic insects. Active foragers near dawn and dusk. Usually forage in areas concealed by plant cover or in open areas where they blend with surroundings and are only a few steps from vegetation cover. Crustaceans are the most important food: crayfish (*Cambarus, Procambarus,* and other genera) in freshwater marshes, crayfish farms, and rice fields; red-jointed fiddler crabs in oligohaline and brackish marshes. Aquatic insects, fish, frogs, grasshoppers, crickets, and seeds of aquatic plants frequently taken. In a series of 118 stomachs from domestic rice fields at Stuttgart, AR, animal life comprised 95% by volume of foods taken in spring, 90% in summer, 74% in the fall, and 58% in winter. Crayfish formed 61% by volume of foods in spring, 22% in summer, 3% in fall, and 7% in winter. Fish comprised 26% of food in fall when many fish became impounded in shallow borrow pits of drained rice fields and were easy prey. Predaceous diving beetles (Dytiscidae) furnished 19% of the winter food. Rice seeds formed 16% of the annual diet (Pickens & Meanley, 2015).

Nesting habits: Nest site characteristics include shallow water in tidal and nontidal marshes; broad roadside ditches with cattails, grasses, and sedges (Arkansas and Louisiana); rice fields and rice field levees in Arkansas, Louisiana, and Texas; occasionally shrub swamps and upland fields near water. Nest may be placed in a clump of grass, among thick vegetation, or between several grass clumps or a sedge tussock; sides of clumps often used in fashioning the canopy. Base of most nests made of wet decaying vegetation and the platform or cup of dead dry grasses, sedges, or rushes. Completed nest is a round elevated platform with a saucer-shaped depression, usually with a round or cone-shaped canopy and a ramp (Pickens & Meanley, 2015). Of four nests found by Beecher (1942) on the east shore of Pistakee Lake, a half-mile south of the village of Fox Lake in Lake County, Illinois, all were in lake sedge (*Carex lacustris*). Females lay 6–15 pale buff eggs sparingly spotted with brown. Precocial young are covered with black down and leave nest soon after hatching, then follow parents after leaving the nest.

Continent-wide population status: Listed as Near Threatened (population trend: decreasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Ford (1956) considered this species to be a common summer resident in the Chicago region. This is no longer true: in the 21st century, it occurs only as a very rare and local breeding species. Observed in some years during the breeding season; recent Illinois Calumet breeding records include young juveniles (indicating local nesting) seen in 1994 at Big Marsh and 2003 in Deadstick Pond (Marcisz & Pollock, 2013). Eifrig (1918) described this species as more common than the Virginia Rail in Northwest Indiana, a situation certainly untrue at present (Brock, 2010). On 11 August 1984, an adult and three downy young were observed at George Lake, Lake County, Indiana (IAQ 63:116).

Current population status in Calumet region: King Rail populations have declined alarmingly in the past 50 years, with the species now listed as a threatened or endangered species in 12 eastern and midwestern states, as well as in Canada. These population declines likely stem from direct loss of wetlands, but evidence in the Gulf Coast suggests that King Rails are sensitive to broad-scale changes in hydrological regimes such as the impoundment or stabilization of water levels, which influences wetland vegetation (Pickens & Meanley, 2015). Current Calumet area status unclear: not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016, and no other known 2016 Calumet area reports. In 2014, King Rails bred for the first time in over a decade in Lake County, Indiana at Grant Street Marsh, Gary. The high count came on 12 July, when 3 individuals, including a chick, were observed by Michael Topp (Ayer, 2014). Along with other wetland species, habitat destruction has reduced King Rail numbers in Indiana (Brock, 2006).

COMMON GALLINULE (Gallinula galeata)
Formerly treated as conspecific with *Gallinula chloropus*, the Common Moorhen of Eurasia, the Common Gallinule is now separated on the basis of differences in vocalizations, bill and shield morphology, and mitochondrial DNA. See the *52nd Supplement to the AOU Checklist of North American Birds* (7^{th} edition) for details (Bannor & Kiviat, 2002). Only Common Gallinule (*Gallinula galeata*) is discussed herein. A member of the rail family, the Common Gallinule is about the size of a small duck, and it is intermediate ecologically and behaviorally between American Coot (*Fulica americana*) and the Rails. Length: 32–35 cm (12.5-14 in). A short-tailed bird, its legs are greenish with large feet and very long (unwebbed) toes. The short bill and frontal shield are bright scarlet with a yellow tip in breeding adults, duller in nonbreeding adults and juveniles. Breeding adults are mostly slate gray with a blackish head, brownish upperparts, and contrasting white flank stripes and lateral undertail coverts. Nonbreeding adults and juveniles are similar, but overall duller in color. Flies weakly, with legs trailing behind. Closely associated with marshes, ponds, canals, ditches, and rice fields where pools with submerged or floating-leaved vegetation are interspersed with emergent or shoreline vegetation, this species forages for plant materials and macroinvertebrates on the water surface, among submerged plants, and in shoreline and upland vegetation (Bannor & Kiviat, 2002).

Distribution: Wide-ranging, scattered, and locally changeable distribution, as sometimes ephemeral breeding locations are quickly exploited or abandoned (Bannor & Kiviat 2002). North American subspecies (*Gallinula galeata cachinnans*) breeds in the eastern USA east of the Great Plains (absent from the Appalachians) with isolated resident populations in California, Nevada, Utah, Arizona, New Mexico, the Galapagos Islands, and Bermuda. Northern populations vacate breeding areas for ice-free regions during the colder months. Also resident in Florida, and the Gulf coast through Texas, Mexico (including Baja California), and Central America south through western Panama. Other subspecies are resident in Hawaii (endemic), Barbados (endemic), eastern Panama south to northwest Peru and then throughout the Andes from Peru through Argentina, also the West Indies, Trinidad, the Guyanas, and from Brazil south of the Amazonas to northern Argentina and Uruguay.

Habitat: In northern portions of U.S. range, breeds principally in permanently flooded, nontidal, deep marshes and slightly brackish or freshwater tidal marshes, where robust emergent grasslike plants about 1–4 m tall are interspersed with pools and channels that have floating-leaved and submerged plants, or with mudflats (Bannor & Kiviat, 2002). Outside the deep south, commonly associated with cattail (*Typha* spp.)-dominated marshes (Beardslee & Mitchell 1965; Braislin, 1906; O'Meara et al., 1982). Other locally prominent species include bulrushes (*Scirpus* spp.), wild rice (*Zizania aquatica*), maidencane (*Panicum hemitomon*), rush (Juncus), bur-reed (*Sparganium*), pickerel weed (*Pontederia cordata*), arrow arum (*Peltandra virginica*), bulltongue (*Sagittaria lancifolia*), waterlilies (*Nuphar*, *Nymphaea*), American lotus (*Nelumbo lutea*), coontail (*Ceratophyllum demersum*), pondweed (Potamogeton), wild celery (*Vallisneria americana*), hydrilla (*Hydrilla verticillata*), willows (*Salix* spp.), and buttonbush (*Cephalanthus occidentalis*) (Bell, 1976; Bent, 1926; Bent & Copeland 1927; Brackney, 1979; Bull, 1964; Fosdick, 1995; Fredrickson, 1971; O'Meara et al., 1982; Sibley, 1988). Density of submerged and floating-leaved vegetation is important (Brackney, 1979; Chabot, 1996). Duckweeds (*Lemnaceae*) often dense (e.g., Abbott 1907; Braislin 1906). Breeding densities peaked in marshes with about half (or somewhat more) open water and half emergent vegetation, and were correlated with the amount of edge in southwestern Lake Erie marshes (Brackney, 1979). In Ohio, nesting densities highest on semipermanently flooded wetlands with narrow-leaved persistent emergent vegetation, an abundance of submerged aquatic plants, and a 1:1 ratio of cover to open water (Brackney & Bookhout, 1982). Muskrat activity may positively affect gallinule nesting by maintaining a favorable ratio of emergent vegetation to open water (Beecher, 1942; Weller & Fredrickson, 1974).

Behavior: Characteristically swims or walk on aquatic vegetation or on soft or firm soil. Climbing in vegetation, diving, and flying are less common forms of locomotion (Bannor & Kiviat 2002). Large feet and long toes allow moorhens to walk on floating plants and soft soils (e.g., Bent, 1926). Swims well despite lack of lobes or webs on toes (Bannor & Kiviat 2002). Seldom seen flying, most often takes cover in vegetation when startled or pursued. When flushed on breeding grounds, flight short, with legs hanging, appearing "feeble and labored," ending with abrupt drop into vegetation (Brewster, 1891, p. 4). May half fly, half run across water (Bent, 1926). Commonly heard vocalizations include the "keep" contact call, and the "wipe out" or "cackle" call (*ka-ka-ka-ka-ka-kree-kree-kree-kree*) heard during the breeding season (Conway, 2009).

Food preferences: Plant food predominates overall, but animal food increases in spring and summer. Prefers small, hard items. Sedge (*Cyperaceae*) seeds and snails are most important (Haag et al., 1987; Mulholland & Percival 1982; O'Meara et al., 1982; Patuxent Wildlife Research Center, unpubl.; Wetmore, 1916). Commonly eats seeds of aquatic and terrestrial grasses (Poaceae), smartweeds (*Polygonum* spp.) and pondweeds; duckweeds; flowers, seeds, and vegetative material of waterlily (Nymphaeaceae); and seeds and vegetative material of various other aquatic plants. Most frequent animals eaten are snails, beetles (Coleoptera), true bugs (Hemiptera), ants and wasps (Hymenoptera), true flies (Diptera), spiders (Araneida), crustaceans (Crustacea), dragonflies and damselflies (Odonata), leeches, and moss animals (Bryozoa) (Bell, 1976; Forbush, 1925; Greij, 1994; E. Greij pers.

comm.; Haag et al., 1987; Mulholland & Percival 1982; O'Meara et al., 1982; Patuxent Wildlife Research Center, unpubl.; Saunders, 1926; Simpson, 1939; Wetmore, 1916; as cited in Bannor & Kiviat, 2002).

Nesting habits: Most nests are in robust emergent aquatic vegetation. Use of a variety of robust emergent plants for nest support suggests preference for plant sturdiness and moderate water depth rather than plant species per se. Data from 183 North American Nest Record Cards that allowed identification at least to family revealed the following plants supporting nests: cattail (97 nests, or 53%), bur-reed (23 nests), "marsh mallow" (probably Hibiscus; 17), bulrush (8), common reed (6), purple loosestrife (6), woody plants (buttonbush, willow, gray dogwood [*Cornus racemosa*]; 5), arrowhead (4), pickerelweed (4), other grasses (maidencane, torpedo grass [*Panicum repens*], "cutgrass" [probably *Zizaniopsis miliacea*]; 3), smartweed (2), soft rush (*Juncus effusus*; 2), sedge (Carex; 2), spatterdock (Nuphar; 1), dollarwort (Hydrocotyle; 1), iris (Iris; 1), and water hyacinth (1) (Bannor & Kiviat, 2002). Females usually lay 5–11 (but sometimes more or fewer) whitish or buff eggs irregularly blotched and spotted with brownish color. Precocial young are covered with black down, then follow parents after leaving the nest. Frequently produces 2 broods per season. Juveniles that have reached independence remain on their natal territory to help rear successive broods (Gibbons 1986, 1987).

Continent-wide population status: Listed as Least Concern (population trend: stable) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically a widespread breeding species in the Calumet region of Illinois and Indiana. Ford (1956) considered it a common summer resident in the Chicago region, and Mlodinow (1984) stated that the Lake Calumet area is particularly favored by this species. Notable late 20th-century Illinois Calumet breeding records include 12 nests at Hegewisch Marsh in 1982 (EnCap, 1982), 15 nests at Big Marsh in 1986 (Elston, 1986), 79+ individuals (including 17 broods with 45+ young) in the Lake Calumet area in 1979 (Mlodinow, 1984), and 76 individuals (including 14 broods with 49 young) in the Lake Calumet area in 1994 (Marcisz & Pollock, 2013). A remarkable 90 individuals at Roxana Pond, East Chicago on 4 September 1980 remains the highest-documented count for the state of Indiana (Brock 2006, 2010).

Current population status in Calumet region: Steep, severe declines as a breeding species in the Illinois Calumet region occurred during the first two decades of the 21st century and in the Indiana Calumet region after the late 1980s (Brock 2006; Marcisz &Pollock 2013). Territorial birds were not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016, but an adult was seen by several observers at Eggers Grove F.P., Chicago, during late May and June of 2016, strongly suggesting a territory at that location (Josh Engel, personal communication). A bigger surprise was a pair first detected at Hegewisch Marsh, Chicago after the 2016 study period had already been completed. The pair went on to nest successfully, with 3 adults and a brood of 8 young observed at that location in August 2016 (Walter Marcisz, personal communication). This observation constitutes the first known breeding record in the Illinois Calumet region since 2012, when Samuel Burckhardt located a pair of adult Common Gallinules with a brood of 5 downy young at Indian Ridge Marsh South on 8 August 2012 (Marcisz & Pollock, 2013). Three adults summered at Grant Street Marsh in Gary (Lake County), Indiana in 2016, and a brood of 4 young was observed there by Matt Kalwasinski in July 2016 (IN-BIRD-L). Common Gallinules also nested successfully at this Indiana location in 2015 (IN-BIRD-L) and 2014 (Ayer, 2014). In the Indiana Calumet area, "Numbers have declined in recent years, perhaps due in part to the disappearance of habitat at Roxana Pond, as this site provided extraordinary counts in the 1980s. A falling water table converted this former shallow pond into a field choked with cattails and phragmites. In the site's heyday, unprecedented Moorhen (Common Gallinule) counts were logged there" (Brock, 2006). In the Illinois Calumet region, "Over a dozen broods and scores of birds were common observations until 1995. Hemimarsh conditions have been diminished throughout the Calumet since then, as have the number of gallinule nests. In the years between 1996 and 2002, between one and seven broods were observed annually. After that, one to two broods (or none) was the rule, with the exception of 2009, when muskrats briefly created the hemimarsh conditions needed by these birds at Hegewisch Marsh" (Marcisz & Pollock 2013). Like other marsh birds, declines are likely related to overall lack of existing hemimarsh habitat, infestations of invasive exotics, lack of vegetative diversity, and persistent hydrological problems.

AMERICAN BITTERN (Botaurus lentiginosus)

American Bittern is a short-legged, medium-sized heron (averages slightly larger than the Night-Herons) well known for its cryptic plumage and secretive habits. Length: 60–85 cm (23.5–33.5 in). Upperparts brown, underparts boldly streaked brown and white. A conspicuous black malar line frames the white throat on both sides, and blackish flight feathers contrast sharply with brown wing coverts when in flight. Legs and daggerlike bill are greenish yellow. Breeds in freshwater wetlands dominated by tall emergents. Assumes upright "Bittern stance" with head pointed vertically for camouflage; striped neck blends in with surrounding emergent vegetation. Distinctive deep, pounding, gulping call.

Distribution: Breeds from British Columbia and the Canadian prairie provinces east through Ontario, southern Quebec, Newfoundland and the maritime provinces; south through western California, the Great Basin, and the northern Great Plains states south to northern Kansas, and very locally across the northern tier of states east to Chesapeake Bay. Breeding discontinuous south of Pennsylvania, Ohio, Indiana, Illinois, Missouri, Kansas, Colorado, Utah, Nevada, and California. *Breeding Bird Survey* sighting frequencies (an index of population size) indicate this species has been more abundant in Canada than in the U.S., declining sharply below the northern border states (Lowther et al., 2009). Winters in the southern U.S. in wetlands along the southern Atlantic coast, Florida, the Gulf Coast, and southern California; south through southern Texas, Mexico, northern Middle America, Cuba, and Bermuda.

Habitat: Breeds almost exclusively in freshwater wetlands with tall, emergent vegetation. Dependence on inland, freshwater marshlands suggests that this species may be a relict over much of the U.S. (Payne & Risley, 1976). In Maine, breeds in wetlands dominated by emergent and aquatic-bed vegetation with diverse vegetation and a high degree of cover-water interspersion (Gibbs et al., 1991). Inhabits wetlands of all sizes (0.1–1,000 ha), but more abundant on larger than smaller wetlands, and prefers impoundments and beaver-created wetlands to wetlands of glacial origin. In Quebec, the birds prefer lakes with patches of floating-leaved plants, emergent growth along shorelines, and abundant amphibian populations (DesGranges & Houde, 1989). In Iowa, found only on wetlands >10 ha, suggesting species may be largely dependent on a wetland's area (Brown & Dinsmore, 1986). At a large Wisconsin marsh, found only in shallow water and dry cattail habitats, seemingly avoiding deep-water cattail and river bulrush (*Scirpus fluviatilis*) habitats (Manci & Rusch, 1988). Interspersion, i.e., land-water edge density, and other factors (marsh area, cover-to-water ratios, and marsh area within 5 km) were related to the abundance of marsh birds on 16 emergent wetlands in New York during 2005. Interspersion, as measured by edge density, was the best predictor of abundance for American Bittern (Rehm & Baldassarre, 2007). Vegetation and water interspersed in a spatially complex pattern likely increases breeding diversity and density of marsh birds like bitterns (Lowther et al., 2009).

Behavior: Frequents vegetation fringes and shorelines within freshwater wetlands dominated by tall, emergent vegetation. Relies on stealth more than pursuit to forage, waiting motionless for long periods to capture passing prey. Most active during crepuscular hours (Lowther et al., 2009). Flight is hurried, ungraceful, and stiff. Beats wings rapidly (3.3 beats per second) (Palmer, 1962). Male displays white shoulder plumes during courtship. Largely asocial, as far as known. Minimal pair bonds between sexes, and foraging entirely solitary. May migrate in small groups. Little information on interactions with members of other species. Assumes bittern stance when alarmed by larger animals such as humans or larger herons; points bill skyward, stretches body vertically, compresses body feathers, and sways with breeze Call most often heard during the breeding season is low, resonant, and composed of 3 syllables, rendered as *pump-er-lunk* and *dunk-a-doo*, preceded by a series of clicking and gulping sounds. Vernacular names, including "stake-driver," "thunder-pumper," and "mire-drum" allude to the American Bittern's resounding call. When flushed from a marsh, American Bitterns often emit a hoarse *kok-kok-kok* or nasal *haink*. (Lowther et al., 2009).

Food preferences: Major food items include insects, amphibians, small fish and mammals, crayfish. Most active in dim light, but may forage throughout day and night (Lowther et al., 2009). Based on 160 specimens (133 with food remains) collected throughout North America, stomach contents composed of insects (23% of items), frogs and salamanders (21%), fish (21%), crayfish (19%), small mammals (10%), snakes (5%), and small quantities of crabs, spiders, and unidentified invertebrates (Cottam & Uhler, 1945).

Nesting habits: Nest consists of a platform of reeds, sedges, cattail, or other available emergent vegetation. Most nests placed among dense emergent vegetation over water 5–20 cm in depth (Bent 1926; Middleton 1949; Mousley 1939; Provost 1947). When nesting in uplands, nests over dry ground among dense, tall (> 30 cm) herbaceous cover in grasslands (Duebbert & Lokemoen, 1977). Nests often over water in standing cattails, bulrushes and sedges; less often on dry ground in grassland fields (Peck & James, 1994). In western NY State, nests (n=5) typically placed in tall (mean height=115 cm ± 9.3 SE) emergent vegetation (*Typha* and *Sparganium* spp.) in standing water (mean depth=46.4 cm ± 3.1 SE; % emergent veg cover 80.8% ± 2.5 SE; mean distance to land 123 m ± 29 SE; Lor &Malecki, 2006)). In northwest Minnesota (Agassiz Natl. Wildlife Refuge), nest located in a dense stand of giant reed grass (*Phragmites australis*) and sandbar willow (*Salix exigua*); water depth at the nest site 35 cm, height of tallest vegetation within 1 m of nest: 2.25 m (Azure et al., 2000a). Females usually lay 2–5 (occasionally up to 7) pale buffy-brown to olive-buff eggs. At hatching, young are nidicolous and semi-altricial (Lowther et al., 2009).

Continent-wide population status: Listed as Least Concern (population trend: decreasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Ford (1956) considered this species common summer resident in the Chicago region. This is no longer true: in the 21st century, it occurs only very rarely and locally during the breeding season. Undergoing substantial declines over much of the U.S. owing largely to loss and degradation of wetland habitats (Lowther et al., 2009). Population declines reported midcontinent by late 1970s, Atlantic coastal region by 1980, and entire continent by 1986 (Tate, 1986).

Current population status in Calumet region: No recent confirmed breeding evidence in the Illinois Calumet region, but the presence of two individuals at Powderhorn Lake F.P on 15 May 2016 was somewhat suggestive of breeding (Walter Marcisz, personal communication). Somewhat stronger evidence of attempted breeding has been obtained in the Indiana Calumet region in recent years, including two individuals observed at the DuPont Tract in East Chicago on 8 June 2016 (Walter Marcisz, personal communication). American Bitterns have also summered at DuPont during previous years (Paul Labus, personal communication). During the early 21st century in the Indiana Calumet region, the American Bittern has been considered "a spring and fall transient that formerly nested" (Brock 1997, 2010). In Indiana, "There is little doubt that the depletion of wetlands has negatively impacted this cattail loving bird" (Brock 2006).

SNOWY EGRET (Egretta thula)
Snowy Egret is an elegant, snowy-white, medium-sized heron with a sharp black bill, a long neck, and long black legs with yellow toes ("golden slippers"). Length: 56–66 cm (22–26 in). During the breeding season, adults feature shaggy plumes on the nape and lower neck, and showy recurved plumes on the lower back. Occurs in a wide variety of wetland habitats and typically nests colonially, often with other heron species. Frequently employs an active, animated foraging style while pursuing a wide variety of prey species.

Distribution: Overall range limits have changed over time in response to the effects of hunting, habitat loss, and other environmental factors (Parsons & Master, 2000). Numbers plummeted in response to extreme predation pressure on breeding adults exerted by the millinery trade between 1880 and 1910 (Ogden, 1978). Plundering for plumes peaked in 1903 and continued until 1910, when outraged citizens forced the passage of laws that reduced the slaughter. Hunting continued longer in Central and South America because of continued European demand (Hancock & Kushlan, 1984). Currently known to breed along the Atlantic coast from Maine to Florida, along the Gulf Coast through coastal Texas, north through Louisiana and western Mississippi to central Arkansas (Arkansas River) (James & Neal, 1986) , and the Mississippi lowlands of southeastern Missouri (Robbins & Easterla, 1992), western Tennessee (Ford, 1998), and southweatern Illinois (St. Clair & Madison Counties) (Bohlen, 1989), with isolated breeding populations in Oregon, California, Idaho, Wyoming, Nevada, Utah, Montana, South Dakota, Colorado, Arizona, New Mexico, and Oklahoma. Northern populations winter throughout Mexico and Central America, but first disperse north throughout the continental USA (as far north as southern Canada) following the breeding season (post-breeding dispersal). Resident in the Florida peninsula, the Gulf Coast, the Bahamas, the West Indies, southwestern Mexico, and most of South America (absent from the Andes, southern Chile, and southern Argentina).

Habitat: Preferred foraging habitats/conditions range from small salt-marsh pools to large freshwater marshes and from solitary to mixed-species aggregations (Parsons & Master, 2000). In Midwest, preferred habitats include marshes in Ohio (shores of Lake Erie; Peterjohn & Rice, 1991), swamps and flooded fields in Mississippi lowlands of Missouri (Robbins & Easterla, 1992), stands of trees around reservoirs in South Dakota (Peterson, 1995), and river bottomlands in Illinois (Bohlen, 1989).

Behavior: The breeding behavior of this species is typical of most herons and egrets, and is embellished with the use of graceful nuptial plumes during displays. It employs active, sometimes frantic foraging behaviors to capture small fish and crustaceans (Parsons & Master, 2000). Broadest behavioral repertoire (21 of 34 described behaviors) of all North American herons (Kushlan, 1978a; Willard, 1977). Some of these behaviors include walking slowly, walking quickly, running, hopping, wing-flicking, openwing-feeding, foot-stirring, foot-raking, foot probing, foot paddling, and foot-dragging. Many behaviors make use of distinctively colored feet (Kushlan, 1978a).

Food preferences: Wide range of prey items including earthworms, annelid worms, aquatic and terrestrial insects, crabs, shrimp, prawns, crayfish, other crustaceans, snails, freshwater and marine fish, frogs/toads, and snakes/lizards (Kushlan 1978a, 1978b).

Nesting habits: Typically nests colonially, often with other heron species. Not known to nest in the Calumet region of Illinois and Indiana. Generally prefers isolated estuarine sites, including barrier and dredge spoil islands in East; estuarine, freshwater swamps, river bottomlands, and mangroves in southern U.S. and tropics; and inland lakes and rivers in western U.S. Preferred nesting vegetation included *Opuntia* cactus in Texas (Burger, 1979), privet (*Ligustrum vulgare*) in coastal New York (Burger & Gochfeld, 1993), and a variety of other species from southern New Jersey to Boston Harbor, including common reed (*Phragmites communis*); woody vines like blackberry (*Rubus allegheniensis*), greenbriar (*Smilax* spp.), and grape (*Vitis* spp.); shrubs like southern arrowwood (*Viburnum dentatum*), bayberry (*Myrica pensylvanica*), wax myrtle (*Myrica cerifera*), groundsel tree (*Baccharis halimifolia*), marsh elder (*Iva frutescens*), blueberries (*Vaccinium* spp.); and trees such as eastern red cedar (*Juniperus virginiana*), black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), American holly (*Ilex opaca*), gray birch (*Betula populifolia*), sweet gum (*Liquidambar styraciflua*), and black gum (*Nyssa sylvatica*; KCP, TLM)." (Parsons & Master, 2000). Females usually lay 3–5 pale greenish-blue eggs. Young are semialtricial and are attended in the nest by adults.

Continent-wide population status: Listed as Least Concern (population trend: increasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Not known to breed in the Calumet region of Illinois and Indiana, but pair in courtship dance was reported by Terry Schilling at Big Marsh, Illinois on 31 May 1987 (Kleen, 1988; Marcisz & Pollock, 2013). In recent decades has occurred sparingly as a spring and summer visitant (including post-breeding dispersals), occasionally remaining into the month of October. Population has increased significantly after laws were enacted early in the 20th century to protect the species from exploitation by the millinery trade, but Ford (1956) still considered it accidental in the Chicago region. Numerous Illinois Calumet records during the last few decades of the 20th century, but far fewer records in the Indiana Calumet region. Brock (1997) stated that Snowy

Egret is by far the rarest of the herons recorded in the Indiana Dunes area. During the early 21st century, reported somewhat more in Northwest Indiana (probably reflecting habitat improvements), but fewer records in the Illinois Calumet region (probably reflecting habitat degradation).

Current population status in Calumet region: Still occurs sparingly as a spring and summer visitant (including post-breeding dispersals). One individual was at Burnham Prairie, IL on 12 June 2016 (Walter Marcisz, personal communication), and an adult was seen by many observers at Wolf Lake, IN during April–June 2016 (eBird). NIRMI volunteer Libby Keyes recorded a single Snowy Egret at Kennedy to Cline West on 6 June 2016. One individual was occasionally reported at the 126th Street Marsh, Illinois from late May–early July 2015 (eBird). Small numbers were widely reported in the Illinois Calumet region from late May to late August 2014 (including 3–4 individuals in August), but only 1 individual was reported in all of 2013 (Burnham Prairie, June 2013) (Walter Marcisz, personal records). Not detected in the Illinois Calumet region from 2010–2012 (Marcisz & Pollock, 2013). Two individuals at Wolf Lake, Lake County, Indiana were present throughout June/July 2014 and were reported by many observers (Ayer 2014). Recent high counts from the Little Calumet River floodplain near Chase Street, Gary, Indiana include 4 on 25 May 2004, 3 on 1 May 2001, and 4 on 1 July 1996 (Brock, 2010).

LITTLE BLUE HERON (Egretta caerulea)
Little Blue Heron is a medium-sized heron with a sharp, bicolored bill, long neck, and long greenish legs. Length: 56–74 cm (22–29 in). Adult has a black-tipped bluish bill (bright blue during breeding season) and uniform slate-blue body plumage with purplish tones to the head and neck. Adults also

have long lanceolate plumes on the nape and back during the breeding season. Juvenile has a black-tipped grayish bill and slate blue tips to the outer primary wing feathers, otherwise entirely white body plumage. Molting immature birds transitioning to adult plumage are white with scattered patches of slate blue. Forages for prey and breeds in a variety of freshwater and marine-estuarine habitats. Foraging style considerably less animated than in Snowy Egret.

Distribution: In North America, breed along the Atlantic coast from Maine to Florida, central Georgia, central Alabama, northwestern Tennessee, southwestern and north-central Kentucky, southwestern Indiana, southwestern Illinois, southeastern Missouri, northern Arkansas, south-central and southeastern Kansas, central Oklahoma, and East Texas. Northern populations winter in Baja California, northwestern coastal Mexico, and Central America, but first disperse north following the breeding season (post-breeding dispersal) throughout most of the continental USA, minus the Great Basin and the Rocky Mountains, as far north as southern Canada. Resident in the Florida peninsula, the Gulf Coast, the Bahamas, the West Indies, coastal western Mexico, and in South America from Colombia, Venezuela, and the Guianas west of the Andes to central Peru and east of the Andes to eastern Peru, central Brazil, and Uruguay.

Habitat: Nests in mixed-species assemblages of colonial waterbirds using varied colony habitat and nesting substrate. Feeds in a variety of freshwater and marine-estuarine habitats, including marshes, swamps, streams and rivers, ponds, lakes, impoundments, lagoons, tidal flats and wetlands, canals, ditches, fish-rearing facilities, and flooded agricultural fields. Migration and wintering habitat generally similar to breeding habitat (Rodgers & Smith, 2012).

Behavior: Generally forages in shallow water, where it employs a slow, stalking-type foraging style. Compared to other day-herons that run or use their wings while foraging, Little Blue Heron tends to hunt in a very methodical manner, using a serial, slow, walk-peer-walk sequence. Flight generally direct and unhurried, neck coiled below and head against mantle, legs held horizontal. It possesses a similar repertoire of courtship behaviors compared to other herons and often nests in mixed colonies with other waterbirds (Rodgers & Smith, 2012).

Food preferences: Little Blue Heron is opportunistic and will switch prey types as water depth and prey density change at a site (Gawlik, 2002; Smith, 1997). It feeds solitarily or in groups with conspecifics and other species of colonial waterbirds. Its feeding habits are typical of Day-Herons, and it consumes mostly fish, crustaceans, frogs, and grasshoppers (Rodgers & Smith 2012). Parsons (1994) reported that almost half of all boluses in a Delaware colony contained frog remains.

Nesting habits: Breeds colonially in mixed-species assemblages using varied habitat and nesting substrate. Nests mostly in shrubs and small trees in standing water or upland sites on islands. Wetlands used for nesting include both freshwater (cypress [*Taxodium*] and bottomland hardwood swamps) and marine-estuarine (mangrove- [*Avicennia, Rhizophora, Laguncularia*] dominated) habitats. Colony sites are located in riparian habitats, swamps, ponds, lakes, human-made impoundments, and on natural and human-made (dredged-material) islands (Rodgers & Smith 2012). Generally breeds in mosaic wetland habitats, which are reflected in nesting substrates. Notable exceptions include habitats and substrates dominated by poison ivy (*Rhus toxicodendron*) (Burger 1978a, 1978b), cattail (*Typha* spp.) (Hoppe & Kennamer, 1986), upland pine (*Pinus*) forest (Hanebrink, 1968; Peterson, 1965), reed grass (*Phragmites australis*) (Parsons, 2003), and nonnative vegetation (Rodgers, 1980b), but has nested in reeds (*Phragmites australis*) in the Illinois Calumet region (Marcisz

& Pollock, 2013). Varied use of natural and human-made habitats and substrates suggests that neither plant species nor the site are as important, per se, as is the availability of stable plant species (reduced nest collapse), predator avoidance (nest trees flooded or on islands), and access to nearby foraging habitat and resources. May nest side-by-side with other heron species or mostly with conspecifics (Rodgers & Smith, 2012). Females usually lay 3–5 pale greenish-blue eggs. Young are semialtricial and are attended in the nest by adults.

Continent-wide population status: Listed as Least Concern (population trend: decreasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically has occurred primarily as a spring and summer visitant (including post-breeding dispersals), sometimes remaining into the month of September, but has been known to breed in the Illinois Calumet region in recent decades: "Breeding suspected in 1996 and 1998. First confirmed breeding record in northeastern Illinois at Indian Ridge Marsh North in 1999. One to two active nests observed at that location or Heron Pond through 2005 and again in 2009, with nest building noted 2006 through 2008. No nests observed after 2009" (Marcisz & Pollock, 2013). Frequency of Calumet-area occurrence apparently reflects regionwide population trends. Ford (1956) considered it a fairly common summer and fall visitor in the Chicago region, but Mlodinow (1984) stated that it was "formerly seen much more frequently" in the Chicago area. Per Brock's Birds of the Indiana Dunes (2010): "Although a majority of the records occur in late summer, there are many recent spring sightings. These reports have come from Cowles Bog and the Wolf Lake. This species was far more common in the 1950s. The Little Blue Heron is primarily a spring and later summer visitant to the region's wetlands and marshes. There are periodic incursions in which unusually large numbers appear." Somewhat surprisingly, numbers spiked during the first decade of the 21st century, with confirmed breeding pairs and exceptionally high individual counts recorded in the Illinois Calumet region, including tallies of 14 at Burnham Prairie and 27 at Indian Ridge Marsh North in August 2004 (Walter Marcisz, personal records). Frequency of Calumet area occurrence dropped precipitously during the second decade of the 21st century, with the species sometimes completely undetected in a given year.

Current population status in Calumet region: Not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016, but an adult was observed at Indian Ridge Marsh North, IL on 4–5 June 2016 (Walter Marcisz, personal communication), and an immature bird was photographed at Big Marsh, IL on 6 August 2016 (eBird). One individual was reported in late April/early May 2014 at 126th Street Marsh, Illinois, but species went completely undetected in the Illinois Calumet region in 2013. Up to 3 individuals reported at 126th Street Marsh, Illinois in May 2012 (Walter Marcisz, personal records). Paucity of recent Calumet records likely reflects regionwide population declines.

YELLOW-CROWNED NIGHT-HERON (Nyctanassa violacea)
Yellow-crowned Night-Heron is a medium-sized heron, similar in size and structure to Black-crowned Night-Heron, but proportionately slimmer and with noticeably longer legs. Length: 55–70 cm (21.5–27.5 in). Adult has a glossy black head with white cheek patch and creamy-white crown, with an entirely uniform bluish gray neck and body. Dark gray bill is proportionately heavier than in Black-crowned Night-Heron. Iris orange-red. Legs of adults are yellow-green for most of the year, turning bright reddish-pink at height of the breeding season. Plumage of juveniles and 1st-winter birds brown above with tiny triangular buffy-white spots on back, scapulars, and upper wing coverts; underparts whitish striped with brown; heavy dark gray bill; legs are yellow-green; iris orange-yellow. A crustacean specialist across entire range. In inland areas, feeds almost exclusively on crayfish (*Cambarus* spp.).

Distribution: Six subspecies of this heron have been described, including five tropical subspecies, two of which are island endemics. North American subspecies (Nyctanassa violacea violacea) resident in se. United States from East Texas east to Georgia and south through eastern Mexico to eastern Costa Rica, with breeders north to southeastern Kansas east to, exclusive of Appalachia, southern New York; winters to Grenadines and Panama (Watts, 2011). Five other subspecies occur as residents in the West Indies, coastal Mexico and Central America (including endemic Isla Socorro race), and coastal northern and eastern South America (including endemic Galapagos Islands race).

Habitat: This species most often inhabits forested wetlands, swamps, and bayous of the deep south, where poor lighting seems to be the most reliable characteristic of its breeding sites. Nests in colonies, although less often than most waders. Scattered pairs and small colonies are typical, particularly inland. Foraging areas are nearly always associated with high concentrations of crustaceans. Migration foraging habitat is same as that of breeding season but more diverse and over a wider area, particularly during postbreeding dispersal. Winter range foraging habitat same as breeding but more coastal (Watts, 2011).

Behavior: Not as social and colonial as Black-crowned Night-Heron. Scattered pairs and small colonies are typical. Walks slowly and deliberately when stalking, with body bent over and head partially or fully retracted. When not foraging, walks erect, similar to Day-Herons. May run in shallow water when chasing prey. Flight similar to Black-crowned Night-Heron, but bulge of neck extends farther, body is longer, and legs extend beyond tail. Flapping is slow and deliberate. (Watts, 2011). *Scaup* Call is similar to *Quock* call of Black-crowned Night-Heron, but is higher pitched. *Scaup* call may be given throughout year whenever birds are disturbed (Bagley & Grau, 1979).

Food preferences: Across its range, the Yellow-crowned Night-Heron specializes in taking crustaceans, especially crabs, which it hunts using slow stalking movements. Specific crustaceans taken vary geographically according to availability and ability to capture and consume (Watts, 2011). In inland areas, feeds almost exclusively on crayfish (*Cambarus* spp.) (Drennen et al., 1982; Holt, 1933; Price, 1946; Wischusen, 1979;).

Nesting habits: More secretive in nesting habits than other herons except bitterns; less gregarious than Black-crowned Night-Heron (Harrison, 1975). Selection of nest sites is restricted to areas near water (Laubhan & Reid 1991; Watts, 1989). Nest built 1–50 ft. (0.3–15.2 m) from ground or water in a variety of trees and shrubs (Harrison, 1975). Microsite selection varies geographically according to substrate availability. Nest height varies according to available substrate (Watts, 2011). Females lay 2–6 pale bluish-green eggs. Young are semialtricial and are attended in the nest by adults.

Continent-wide population status: Listed as Least Concern (population trend: stable) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: The North American subspecies (*Nyctanassa violacea violacea*) experienced a dramatic northward range expansion between 1925 and 1960, with 11 new state breeding records established over this period. Northern populations increased throughout the 1960s, 1970s, and 1980s, many becoming more stable. Since the expansion peaked during the 1950s, however, the northern fringe of the range has retreated southward. Much of the area colonized during the range expansion had been previously occupied during the mid- to late 1800s. Causes of fluctuations in range boundaries are not clear (Watts, 2011). Ford (1956) still considered this species to be a casual visitor to the Chicago region, but frequency of occurrence has clearly increased since then. Notable late 20th century Illinois Calumet breeding records include 1 nesting pair in cottonwoods near Hegewisch Marsh in 1978, 1979, 1981, and 1991; and 1 nesting pair in black willows at Powderhorn Lake F.P. in 1986, 1989, 1990, and 1991 (increased to 2 nesting pairs in 1992 & 1993, 3 pairs in 1994). All three 1994 nests were eventually abandoned (cause unknown) and nesting has not been reported at Powderhorn since (Walter Marcisz, personal records; Marcisz & Pollock, 2013). This species has been reported with some regularity during late summer at Heron Pond, Chicago, Illinois from 2006 to at least 2013, including a count of 6 individuals (4 adults and 2 immature birds) in August 2006. Nesting definitely occurred at this location in 2009, when a fledged juvenile with much down was located. Nesting also likely occurred at this location in 2012, when an adult together and 2 very fresh juveniles were located (Marcisz & Pollock 2013; Walter Marcisz, personal records). Brock (2010) stated that the Yellow-crowned Night-Heron is a visitant to the Indiana Dunes area. An attempted nesting in a Munster woodlot occurred in May 1976; however, by 2 June, the eggs were destroyed and the nests abandoned (Brock, 2010).

Current population status in Calumet region: Current Calumet area status unclear: not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016, but perhaps still occurs as an occasional breeding species in very small numbers in the Illinois Calumet region. Brock (2010) stated that the Yellow-crowned Night-Heron is a visitant to the Indiana Dunes area. Observational data suggests that Indiana's Yellow-crowned Night-Heron population is in decline (Brock, 2006).

BLACK TERN (Chlidonias niger)

Black Tern is a small tern that nests in freshwater habitats and eats insects as well as fish. Length: 23–26 cm (9–10 in). Breeding adults are overall black with silvery-gray wings, a notched gray tail, and white undertail coverts. Nonbreeding adults and juveniles are similar, but have white heads and underparts with blackish markings on the crown, cheek, and sides of breast. Flight is light and buoyant, sometimes likened to flight style of the Common Nighthawk (Bent, 1921).

Distribution: American subspecies (*Chlidonias niger surinamensis*) breeds across central and southern Canada and northern half of United States; winters in southwest coastal Mexico (occasionally north to southwest coastal United States) and western coast of Central America south to northern and northwest coastal South America. Old World subspecies (*C. n. niger*) breeds from Spain and Norway east to western Mongolia; winters in the Nile Valley and southwest coastal Africa.

Habitat: During the breeding season prefers marshes or marsh complexes of 20+ ha (Brown & Dinsmore, 1986); smallest reported is 5.3 ha (Provost, 1947). Habitat suitability appears to be determined more by landscape structure at a larger scale (wetland complex) than local vegetation conditions within wetlands (Naugle et al., 2000b), and black terns selectively choose wetlands located in high-density wetland landscapes (Naugle et al., 1999a, Niemuth & Solberg 2003). Species more likely to select wetlands within landscapes where less than 50% of upland habitat was tilled, suggesting a negative correlation with agricultural activities (Naugle et al., 2000b) and less likely to occur in wetlands surrounded by woody vegetation (Naugle et al., 1999b). Nest-site characteristics reduce effects of wind and waves, major causes of nest loss. Main clusters of nests are in areas of still water, usually with 25–75% of surface covered with emergent vegetation (Bergman et al., 1970; Chapman Mosher, 1986; Goodwin, 1960; Weller & Spatcher, 1965, as cited in Heath, 2004).

Behavior: Agile flyer. Forages low over land or water with relatively slow wingbeats (Bent, 1921). Stronger downbeat than recovery gives lighter, more erratic appearance to flight than in *Sterna* terns (Heath et al., 2009). May hover briefly before sudden drop or swoop to surface, then dips bill into water or picks insects off vegetation. Sometimes hunts from perch over water (Welham & Ydenberg, 1993). Plunge dives are weak and rarely seen (Bent, 1921; Cuthbert, 1954; Chapman Mosher, 1986; Goodwin, 1960; Murphy, 1938). May catch insects in air, especially at insect swarms over land (Cuthbert, 1954; Goodwin, 1960). Aggressively defends nesting territory. Contact call is a short *kip* or *kik* (Heath et al., 2009).

Food preferences: On breeding grounds feeds mainly on insects and freshwater fish; proportions vary with availability. Rest of year feeds mainly on small marine fish; also insects (Heath et al., 2009). Relative frequency of insects versus fish eaten varies widely (e.g., 30% vs. 93% fish in 2 Great Lakes samples) (Clapp et al., 1983).

Nesting habits: Nests semicolonially amid emergent vegetation in biologically rich fresh-water wetlands. Nests are flimsy, often floating, and are easily destroyed by wind or changing water levels. Reproductive success varies greatly. Adaptations to marsh nesting include frequent renesting, low site tenacity, and eggshell morphology suited to damp conditions (Heath et al., 2009). Nest is usually built on floating substrate of matted dead marsh vegetation, detached root masses of predominant vegetation, boards, or muskrat-built feeding platforms of fresh-cut vegetation; less often (but in majority at some sites) on nonfloating substrates such as muskrat lodges, small mud patches, rooted but flattened vegetation, or abandoned nests of other marsh birds (Bailey, 1977; Bergman et al., 1970; Cuthbert, 1954; Dunn, 1979; Einsweiler, 1988; Firstencel, 1987; Gould, 1974; Weller & Spatcher, 1965, as cited in Hickey, 1997). Of 5 nests found on the east shore of Pistakee Lake, a half-mile south of the village of Fox Lake in Lake County, Illinois, 3 were specifically in cattail (*Typha* spp.), 1 was in *Scirpus*, and 1 was in lake sedge (*Carex lacustris*) (Beecher, 1942). Females usually lay 3 (but sometimes 2–5) deep olive or buff eggs, heavily spotted, blotched, overlaid, or wreathed with black or dark brown.

Semi-precocial young are covered with warm buff down mottled with black. Young are attended by adults and remain in the nest for about 2 weeks.

Worldwide population status: Listed as Least Concern (population trend: decreasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically a widespread breeding species in the Calumet region of Illinois and Indiana. Ford (1956) considered it a common summer resident in the Chicago region. In the Indiana Calumet region, the status of Black Tern has changed drastically over the decades. In former years Black Terns commonly nested in marshes and sloughs of the lacustrine plains. As an example, Gregory Jancich reported several hundred breeding birds at George Lake during the early 1950s (Brock, 2010). Status in the Illinois Calumet region has also changed drastically: last documented nesting in the Illinois Calumet region occurred in 1986, as follows: “Six adults summered at LCal (Big Marsh); birds seen on nest on 22 June; two adults with a juvenile on 4 July; four juveniles on 11 July and eight on 12 July; at least two successful nests likely” (James Landing, personal communication). In 1997, Indiana’s last-known nesting occurred at Horseshoe Lake in northern LaPorte County, where two eggs were seen on 6 June (Jackson, 1998). The Black Tern is no longer among Indiana's nesting avifauna (Brock, 2010).

Current population status in Calumet region: Not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016. No longer known to breed in the Illinois Calumet region, but very small numbers still breed in Lake and McHenry Counties, Illinois. No longer occurs as a breeding species anywhere in the state of Indiana (Brock, 2006; 2010). Populations of this tern in North America and Europe have declined markedly, at least since the 1960s. In North America, *Breeding Bird Survey (*BBS) data show an average annual decline of 3.1% over the period 1966–1996, with the steepest declines evident prior to 1980. Declines were largest in the prairie provinces of Canada. Loss of wetlands on breeding grounds and migration routes is likely a major cause of these declines, but food supplies may have been reduced through agricultural control of insects and overfishing in the marine winter range (Heath et al., 2009).

YELLOW-HEADED BLACKBIRD (Xanthocephalus xanthocephalus)

Yellow-headed Blackbird is a sexually dimorphic, robin-sized songbird well known for its striking plumage and unmusical “rusty gate” song. Length: 21.5–26.5 cm (8.5–10.5 in), with males averaging larger than females. Bill and legs are black in adults of both sexes. Adult male has a golden-yellow head and breast with contrasting black face mask, and an otherwise black body with contrasting white primary wing coverts. Adult female and first-year male are dark brown with a dull yellow throat, breast, and eyebrow stripe. Juvenile has a yellowish-buff head and breast, a pale whitish belly, and dark brown upper parts with two contrasting white wingbars. Although most numerous in prairie wetlands, Yellow-headed Blackbird is a conspicuous breeding bird in deep-water, emergent wetlands throughout nonforested regions of western North America. Highly social, these large-bodied blackbirds are polygynous, nesting on grouped territories. Postbreeding birds eat mostly grains, often forming large flocks that forage in uplands and roost in wetlands. Flocks migrate to the southern United States and Mexico for the winter (Twedt & Crawford, 1995).

Distribution: Breeds from central British Columbia (east of coastal range), northern Alberta (including Athabaska Delta and Peace River District), central Saskatchewan, southern Manitoba, and extreme southwestern Ontario south through Minnesota and Wisconsin to extreme Northwest Indiana and northern Illinois (Bohlen, 1989), southern Iowa, extreme northwestern Missouri (Robbins & Easterla, 1992), central and western Kansas (Thompson & Ely, 1992), western Oklahoma (Shakford & Tyler, 1987), northwest Texas, northern New Mexico, and Arizona, west to Southern California, and in Oregon and Washington largely east of the Cascade Mountains. Winters primarily from western and southern Arizona, southern New Mexico, and west and extreme south Texas south through Mexico to northern Veracruz on the Atlantic slope, Oaxaca and Guerrero in the interior and adjacent slope, and Nayarit on the Pacific slope (Howell & Webb,a 1995).

Habitat: Breeds in emergent vegetation of deep-water palustrine wetlands. Nests constructed over deeper water, primarily in cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), or reeds (*Phragmites* spp.), often in the same wetlands as nesting Red-winged Blackbirds that are relegated to emergent vegetation over shallower water (Orians & Willson, 1964). The average area within a territory covered by emergent vegetation ranges from 35–77% (Willson, 1966). Forages within wetlands and surrounding grasslands, croplands, or savanna. During migration, forages in open agricultural areas: harvested grain fields, plowed fields, meadows, and pastures. Uses emergent vegetation in wetlands for night roosts, loafs during day in wetland vegetation, shrubby vegetation, and small woodlots. On wintering range, forages primarily in highly disturbed sites such as harvested or plowed agricultural fields, but also on ranchlands and in farm yards (Twedt & Crawford, 1995).

Behavior: Males establish territories that are defended against other males. Breeding is characterized as being in grouped territories when most of the food resources are obtained within the territory, or loosely colonial when most food resources are obtained outside the territory (Twedt & Crawford, 1995). Yellow-headed Blackbirds are polygynous, with males normally taking on multiple mates. On 3 lakes in Washington, with 8–10 male territories on each, the mean number of females per territory varied from 1.7–4.2 (range 0–8) (Orians, 1980). Territorial males sing from a display perch (usually a stem of tall emergent vegetation) throughout the day. Song is extremely harsh and unmusical: a few hard, clacking notes on different pitches followed by a wavering raucous wail (Sibley, 2014), represented phonetically as *kuk— koh-koh-koh— waaaaaaaa*. Other common Yellow-headed Blackbird vocalizations include the *Check* (*Tsheck*) call, a loud, single note without defined harmonics frequently heard during the breeding season, during feeding and in flight; and the soft *Chuck* (*Clerrk*) more often given during autumn, when it probably functions as a flocking note (Twedt & Crawford, 1995). Red-winged Blackbirds are displaced from established territories by arriving Yellow-headed Blackbird males; Yellow-headed Blackbirds are dominant over Red-winged Blackbirds in establishing territories and in disputes off the breeding territory (Orians & Willson, 1964). Yellow-headed Blackbirds are also strongly aggressive toward Marsh Wrens (*Cistothorus palustris*) (Picman, 1988). In fall and winter, flocks forage in agricultural fields (Twedt & Crawford, 1995).

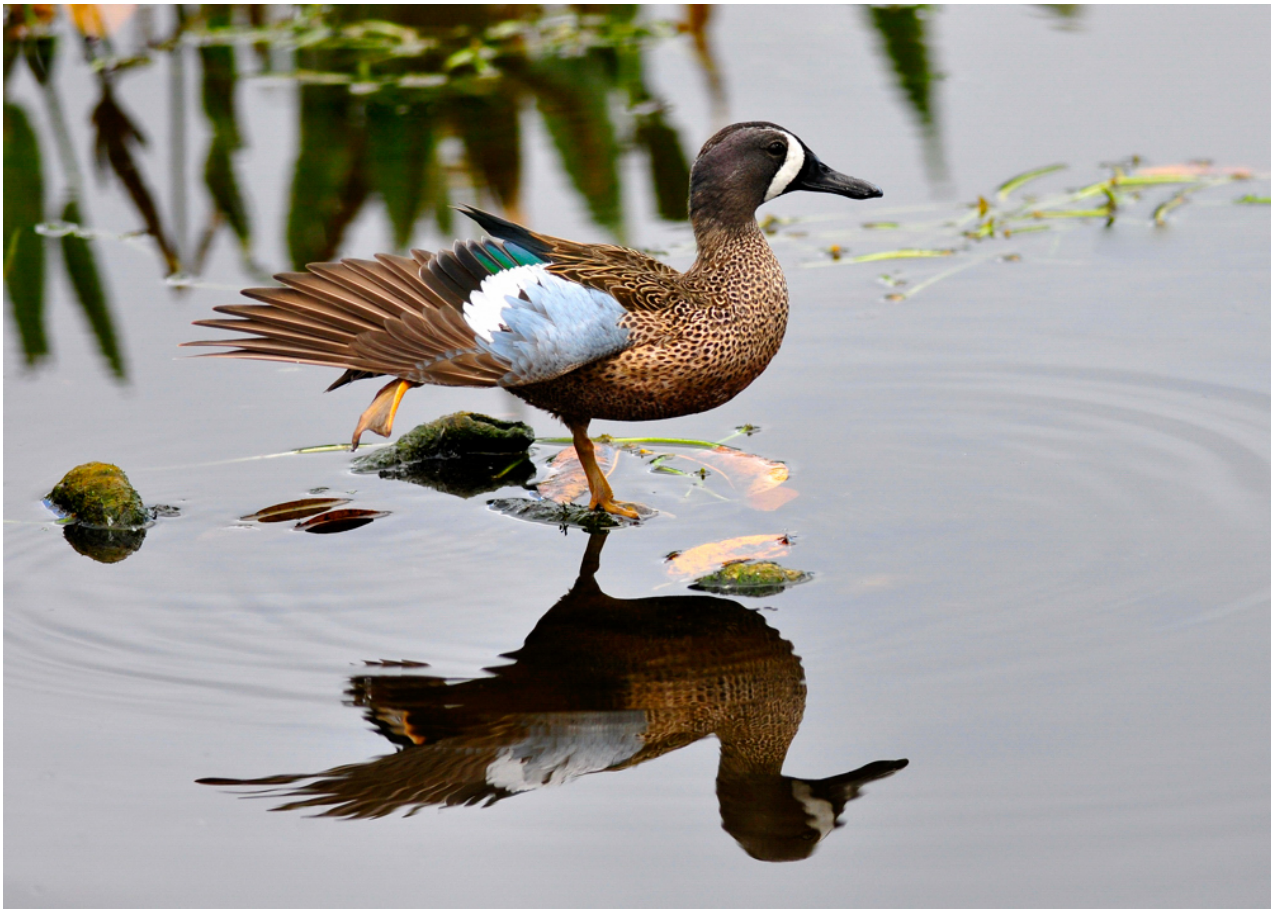
Food preferences: During breeding season, specializes in “aquatic” prey; feeds aquatic insects to nestlings (Twedt & Crawford, 1995). Where aquatic insects are abundant, forages almost exclusively within territorial boundaries. Forages mostly at water surface during periods of odonate (dragonfly, damselfly) emergence (Orians, 1980). Where aquatic insects are less abundant, territory size is reduced, and forages primarily in upland habitats adjacent to wetlands. Upland areas tend to be managed agricultural fields, e.g., alfalfa, with abundant invertebrate populations. Consumes primarily cultivated grains and weed seeds during the postbreeding season. Foraging sites include small grain (wheat, oat, barley, etc.), milo (millet, milo, sorghum), sunflower, and corn fields. Flocks also forage in plowed, bare, or fallow fields (Twedt & Crawford, 1995).

Nesting habits: Males establish territories in deeper-water areas of freshwater marshes with robust emergent vegetation, generally cattails or bulrushes. Nests located only over water, fixed to dead emergent vegetation from the previous year or fixed to robust growing vegetation. Most nests attached to cattails, bulrushes, and reeds but also built in willows (*Salix* spp.), tamarix (*Tamarix* *gallica*), and rarely in wild rice (*Zizania aquatica*). Nest is a compact and rigid open cup, constructed of woven and plaited strips, generally of the same vegetation as the supporting emergent vegetation to which it is firmly attached (Twedt & Crawford, 1995). Female lays 3–5 (usually 4) pale bluish-white eggs profusely dotted and blotched over entire egg with browns and grays. Altricial young are attended in nest by female or both parents.

Continent-wide population status: Listed as Least Concern (population trend: increasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Ford (1956) considered this species to be a fairly common (formerly 'common') summer resident, in the Chicago region. Mlodinow (1984) considered it very local in the Chicago region. Formerly nested in marshes throughout the Illinois Calumet region: an example of late 20th century breeding records includes 33+ pairs that raised 46 young in the Lake Calumet area in 1982 (Mlodinow, 1984). The last territorial male reported in the Illinois Calumet was at Eggers Grove F.P. in 2013 (Douglas Stotz, personal communication). Historically less widespread in the Indiana Calumet region. Per Brock (2010): "In former years the Yellow-headed Blackbird may have been a more widespread nester in marshes of the lacustrine plains. Bognar (1951) reported nesting at Lake George in 1936 and 1940. From 1980 through 1984, a large colony nested at Gleason Park, Gary, Indiana; however, this no longer exists."

Current population status in Calumet region: Not detected in any of 18 Illinois Calumet wetlands or 10 Indiana Calumet wetlands surveyed in 2016. No longer known to breed in the Illinois Calumet region, but limited numbers still breed in Lake, McHenry, and northwest Cook Counties, Illinois. The decline of this species in the Illinois Calumet region is likely related to overall lack of hemimarsh habitat, rampant infestations of invasive exotics (notably common reed and common carp), and widely fluctuating water levels. After a long absence from Northwest Indiana, small numbers of Yellow-headed Blackbirds nested at Grant Street Marsh in Gary, Indiana in 2013, 2014, and 2015. One adult male also summered at Grant Street in 2016, but it is not clear whether successful nesting occurred (IN-BIRD-L). The return of the Yellow-headed Blackbird to the breeding avifauna of Northwest Indiana undoubtedly reflects recent habitat improvements at Grant Street Marsh.



BLUE-WINGED TEAL (Anas discors)
Blue-winged Teal is a small, sexually dimorphic dabbling duck with a dark gray bill, conspicuous powder-blue shoulder patches, and iridescent green secondary patches (speculum). Length: 37–41 cm (14.5–16 in). Breeding male has orange legs, a slate gray head with a conspicuous white crescent in front of the eye bordering the base of the bill, and buffy brown underparts finely spotted with black. Adult female has dull, yellowish legs and overall mottled brown body plumage (plumages of juveniles and nonbreeding males are similar to adult female). During the breeding season, found in shallow ponds with abundant invertebrates and nearby uplands for nesting. Prefers freshwater marshes over saltwater in migration and wintering areas.

Distribution: Breeds from southeastern Alaska, south through central and southern Canada, across the northern USA south throughout the Great Plains states to Texas. Highest breeding densities occur in mixed-grass prairie and parklands of north-central U.S. and prairie provinces of Canada (northwest Iowa and the Dakotas, southern Manitoba, Saskatchewan, and Alberta), where species is often the most abundant breeding duck (Rohwer et al., 2002). Winters in southern USA, Mexico, the West Indies, Central America, and northern South America.

Habitat: During the breeding season, found in shallow ponds with abundant invertebrates, which predominate in diets of both sexes in the breeding season (Swanson et al., 1974). Breeding numbers positively related to density and diversity of benthic invertebrates (Murkin et al., 1982, Murkin & Kadlec, 1986). Highest pair densities occur under hemimarsh (50% water and 50% cover) conditions, but this relationship apparently results from the spatial needs of ducks, and not from significant differences in invertebrate resources available at different levels of interspersion (Kaminski & Prince 1981; Murkin et al.,1982). Early in spring, pairs mostly use temporary and seasonal wetlands, but later shift to semi-permanent wetlands (Swanson et al., 1974).

Behavior: Swims on the water surface propelled by webbed feet, feeds by dabbling with bill only or entire head submerged. Walks well on land and is a swift flier. Springs into the air from surface of water when taking flight. Adult males produce a series of quiet peeping notes during courtship; adult females quack.

Food preferences: Wide array of aquatic invertebrates, seeds, vegetative parts of aquatic plants, duckweeds, algae, and, on occasion, grains from agricultural crops (Bellrose, 1980; Botero & Rusch, 1994). Animal matter dominates diet of laying females (Swanson et al., 1974; Swanson & Meyer, 1977). Principal foods of breeding males and females in North Dakota include aquatic insects (65%, >70% of which were immature Chironomidae), snails (16%), crustaceans (9%), fingernail claims (Pelecypoda, 7%) and seeds (3%) (Swanson & Meyer, 1977). Primary foods of breeding females: snails (36%), aquatic insects (36%), crustaceans (16%), annelids (Annelida, 2%), and plant material, including seeds (9%) (Swanson et al., 1974). Intake of seeds increases significantly following the breeding season. Seeds most common item consumed by postbreeding males in Manitoba, accounting for 32% of their diet. Other items consumed: aquatic insects (25%, principally Chironomidae larvae), snails (20%), miscellaneous animals (12%), and vegetative items other than seeds (11%) (DuBowy, 1985a). Common foods of fall migrants in Texas Panhandle: millet seeds (*Echinochloa crusgalli*, 75%) and corn (*Zea mays*, 23%); animal foods uncommon (1%) (Sell, 1979). Cultivated rice (92%) and aquatic insects (8%) primary foods of individuals in Costa Rica (Botero & Rusch, 1994). During much of the year, foraging is opportunistic, with diet reflecting relative abundance of available food items (Rohwer et al., 2002).

Nesting habits: Prefers to nest in grass or herbaceous vegetation; rarely uses brushy nesting cover (Duebbert et al., 1986; Livezey, 1981). Nests almost always in upland habitats with residual cover from prior years' growth. Nests located 30 cm above nearest water level, so typically not highly susceptible to flooding (Glover, 1956). Water levels appear to be primary determinant of breeding areas, but pairs were 4 times more abundant on habitat blocks with grassland cover than on similar-sized blocks of cropland with approximately equal wetland abundance (Fischer, 1998). This suggests that upland nesting cover plays a role in selection of breeding habitat. Nest sites have shorter and less dense nesting cover than those of Mallard and Gadwall (*Anas strepera*; Livezey, 1981). Females do not select particular plant species, but do seek high-density stands of short to moderate grasses (Glover, 1956); generally nest within 150 m of water, which is closer than other dabbling ducks breeding in the Prairie Pothole Region (Duebbert & Lokemoen, 1976; Livezey, 1981). Female lays 5–15 creamy-white eggs in nest of dried grasses lined with down feathers. Young are precocial and nidifugous, covered with brown and light yellow down that dries in a few hours (Nelson, 1993). Entire brood leaves nest together within 24 hours of hatching, never returns to nest again (Rohwer et al., 2002).

Continent-wide population status: Listed as Least Concern (population trend: decreasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Ford (1956) considered Blue-winged Teal to be a common migrant and fairly common summer resident in the Chicago region.

Current population status in Calumet region: Still occurs commonly as a migrant—likely decreasing as a breeding species, but data insufficient. Very scarce during the breeding season at most wetland sites, but remains widespread in well-maintained habitat areas at the DuPont Tract in East Chicago, Indiana, where several pairs summer annually and breeding was confirmed in 2014, 2015, and 2016 (Walter Marcisz, personal records).

BLACK-CROWNED NIGHT-HERON (Nycticorax nycticorax)

Black-crowned Night-Heron is a stocky, short-legged, relatively short-necked, medium-sized heron with a wide distribution worldwide. Length: 58–66 cm (23–26 in). Adults have a black crown and upper back, otherwise uniform medium-gray upperparts; and white to pale gray underparts. Bill black, iris red. Adults display with 2 very long white lanceolate crown plumes during the breeding season. Legs of adults are yellow-green for most of the year, turning bright reddish-pink at height of the breeding season. Plumage of juveniles and 1st-winter birds brown above with large oval whitish spots on back, scapulars, and upper wing coverts; underparts whitish, heavily striped with brown; upper mandible mostly black but lower mandible yellowish with blackish tip; legs are yellow-green; iris yellowish or orange. The most widespread heron in the world, various subspecies of Black-crowned Night-Heron breed on every continent except Antarctica and Australia, where the genus is represented by the Nankeen (or Rufous) Night-Heron (*Nycticorax caledonicus*). Although widespread in North America, its nocturnal and crepuscular feeding habits render it less noticeable than many diurnal herons. This heron is an opportunistic forager that feeds on a wide variety of terrestrial organisms, but its diet consists primarily of fish and other freshwater and marine organisms (Hothem et al., 2010).

Distribution: Widespread North American subspecies (*Nycticorax nycticorax hoactli*) breeds across North America from Washington State in the west through Quebec and New Brunswick in the east, north through the Prairie Provinces of Canada, south through coastal Mexico, locally in Central America, the Caribbean, and Hawaii (Hancock & Kushlan 1984; Palmer, 1962; Peterson, 1980; Peterson, 1990). After a post-breeding dispersal, most herons in northern part of range migrate south, although a few winter as far north as Oregon and northern New England (Bent, 1926; Ohlendorf et al., 1978; Palmer, 1962). Northern populations winter throughout Mexico and Central America, but also resident along the U.S. Atlantic coast, the Florida peninsula, the Gulf Coast, the Mississippi and Ohio River Valleys, Texas, western California, western Baja California, eastern and southwestern Mexico, western coastal Mexico, Panama, and South America south to northern Chile and Argentina (absent from the Andes). Southern subspecies *N. n. obscurus* is resident in southern Chile and Argentina, and endemic *N. n. falklandicus* is resident in the Falkland Islands. Widespread Eurasian subspecies (*N. n. nycticorax*) breeds throughout much of temperate Europe and Asia but vacates northern parts of range during the colder months, winters/resident in most of sub-Saharan Africa and Madagascar, the Indian subcontinent, and Southeast Asia.

Habitat: According to Palmer (1962), breeding habitat is “so varied as to be difficult to describe—fresh, brackish, and salt-water situations appear equally suitable.” Nesting numbers increase with availability of foraging habitat (Kushlan, 1978), which includes swamps, streams, rivers, margins of pools, ponds, lakes, lagoons, tidal mudflats, salt marsh, freshwater marshes, manmade ditches, canals, ponds, reservoirs, and wet agricultural fields. Essentials seem to be good cover, and freshwater, saltwater, or brackish foraging area (Hancock & Kushlan, 1984).

Behavior: Very social and a colonial nester with largely nocturnal and crepuscular foraging habits. Slow and deliberate when foraging. Head and neck usually lowered when walking, rarely runs (Maxwell & Putnam, 1968). Also dives (alights on water) feet-first, or plunges (dives headfirst from the air) when feeding; can also swim or float on the surface of the water (Kushlan, 1978), resting or swimming actively (Wetmore, 1920a; White, 1947). Flight is more labored than that of day herons, and wings beat slightly faster. Most common call is a guttural *qua, quak, quark, or squawk* (Gross, 1923) or *woc, quock, guark, quawk*; this appears to be an alarm call (Hothem et al., 2010).

Food preferences: Opportunistic forager, taking a wide variety of foods including leeches, earthworms, aquatic and terrestrial insects, prawns and crayfish, clams, mussels, squid, freshwater and marine fish, amphibians, lizards, snakes, turtles, small mammals, birds, eggs, carrion, plant materials, and garbage/refuse from landfills (Bent 1926; Kushlan, 1978; Palmer, 1962; Parsons, 1990). Feeds mainly from evening to early morning, but feeds during day in times of high food demand such as during breeding season (Fasola, 1984; Williams, 1979). Generally considered to be solitary foragers that defend feeding territories (Hothem et al., 2010).

Nesting habits: Breeds in a wide variety of habitats near fresh, brackish, or salt water; in trees, shrubs, groves, forests, thickets, even city parks; and in marshes in *Phragmites* reeds, cattails, grass tussocks, and *Scirpus validus*. Most adaptable of all herons. Nests are located in small to large colonies; close together, usually adjacent to nests of other heron species. Site from ground to 160 ft. (48.8 m) in trees, shrubs, cattails, *Phragmites*. (Harrison, 1975; Harrison, 1978). Most colony sites are on islands, in swamps, or over water, suggesting that site selection is related to predator avoidance (Hothem et al., 2010). An enormous variety of substrate is used for nesting. Where available, Black-crowned Night-Herons prefer to nest in live rather than dead trees (Bjorklund & Holm, 1997; Cuthbert et al., 2002). However, this species has been observed nesting on the ground among rocks on islands in Hamilton Harbour, Ontario (Quinn et al., 1996). Females lay 3–5 (occasionally 6) pale greenish-blue eggs. Young are semialtricial and are attended to in the nest by adults.

Worldwide population status: Listed as Least Concern (population trend: decreasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Ford (1956) considered this species a common summer resident in the Chicago region. Nested in large numbers (maximum count: 762 nests in 1988) in common reed (*Phragmites australis*) at Big Marsh in the Illinois Calumet region from 1984 through 1998, but were forced out of that location by prolonged high water levels in 1999 (Elston, 1988; Levengood et al., 2005). Somewhat smaller numbers continued to nest in common reed (*Phragmites australis*) and eastern cottonwood (*Populus deltoides*) at Indian Ridge Marsh and Heron Pond in the Illinois Calumet region, with nesting behavior last noted at Indian Ridge Marsh in 2011 (Levengood et al., 2005; Marcisz & Pollock, 2013). In Indiana, George Pyle detected a nesting colony in a wooded swamp immediately north of the Kaiser Refractory plant in Gary in June 1976. One hundred birds were present in the rookery on 13 May 1978. A survey of the site on 25 April 1979 revealed 110 nests from the previous season, but for unknown reasons, the rookery was entirely abandoned in 1981 (Brock, 2010). Following the abandonment of the Kaiser Refractory colony, no nesting was detected anywhere in Indiana until 1993, when a new colony (101 nests) was discovered at the Mittal Steel (formerly LTV Steel) plant on the East Chicago lakefront (Brock, 2006). J.S. Castrale reported 255 nests (163 in trees, 92 on ground) at that site in 2007, and 233 nests (70 in trees, 163 on ground) in 2011 (Amy Kearns, Indiana DNR, personal communication).

Current population status in Calumet region: The decline of the colonial-nesting Black-crowned Night-Heron as a breeding species in the state of Illinois has been documented by a number of authors (Marcisz et al., 2005). Results of the Illinois Colonial Waterbird Survey indicated there were an estimated 1,900 nesting pairs in 1987 (Kleen, 1987), compared with 400+ in 1999 (Kleen, 1999). Habitat loss/degradation and other factors such as exposure to environmental contaminants and competition for nest sites at established colonies may have contributed to this decline (Marcisz et al., 2005), but in the Illinois Calumet region the decline of reed-nesting populations is most likely linked to unsuitable water levels (Marcisz & Pollock, 2013). Still observed in small numbers as a visitant in the Illinois Calumet region, but no breeding behavior has been detected there since 2011 (Marcisz & Pollock, 2013). Began nesting in trees in Lincoln Park, Chicago (13 nests) in 2007 (Bailey, 2008). This colony has continued to grow, with 271 nests observed in 2015 (Sharon Dewar, Lincoln Park Zoo, personal communication) and 600+ individuals (adults & young) present as of July 2016 (Matt Igleski, Lincoln Park Zoo Research Facilitator, personal communication). This is likely the largest remaining colony in Illinois, with only scattered small numbers nesting elsewhere in the state. Observational data suggest that this species has declined in Indiana (Brock, 2006). The Mittal Steel colony in East Chicago, Indiana has declined consistently since 2011, with only 64 nests observed there in 2016 (Amy Kearns, Indiana DNR, personal communication).

VIRGINIA RAIL (Rallus limicola)

Virginia Rail is a relatively small, laterally compressed rail, with body approximately the size of European Starling (*Sturnus vulgaris*). Length: 22–27 cm (8.5-10.5 in). Adult has a reddish breast, gray cheeks, and a long, slightly decurved bill. Wings chestnut-colored. Legs and bill reddish, flanks banded black and white. In many ways similar to King Rail in appearance, but King Rail is much larger, with less red on bill and less gray on cheeks (Conway, 1995). Juvenile similar to adult but duller blackish-brown above. Juvenile underparts, including sides of head but excepting middle of breast and abdomen, marked with brownish gray or blackish, this color almost solid on sides of breast (Oberholser, 1974). Virginia Rail is a secretive freshwater marsh bird that is more often heard than seen. A habitat generalist, this species probes mudflats and shallow water with its long, slightly decurved bill searching for invertebrates, small fish, and the occasional seed (Conway 1995).

Distribution: Breeds locally in North America from southern British Columbia, southeastern Alberta, central Saskatchewan, central Manitoba, southwestern Ontario, northeastern Minnesota, southeastern Ontario, southern Quebec, New Brunswick, Prince Edward Island, and Nova Scotia south to northern. Baja California (at least formerly), southern Arizona, central New Mexico, Kansas, northern Iowa, northern Illinois, northern Indiana, northern Ohio, southern Pennsylvania, eastern Virginia, and coastal N. Carolina; very locally in northern and southeastern Texas, Oklahoma, central Louisiana, and northern Alabama, and casually in other southeastern states (Bent 1926; Billard, 1948; Godfrey, 1986; Lowther, 1961; Ridgway & Friedmann, 1941; Robbins, 1949,). Resident in central Mexico (Puebla, Tlaxcala, and México and from central Chiapas to central Guatemala; probably also central Veracruz, and Oaxaca) (American Ornithology Union, 1983; Binford, 1972; Dickerman, 1966; Goldman, 1908; Ridgway & Friedmann, 1941, Howell and Webb, 1995). Resident in South America from southwestern Colombia to Ecuador and western Peru and in southern Chile and southern Argentina (Bent, 1926). Northern populations winter predominantly along the East, West, and Gulf coasts and the Florida peninsula from southwestern British Columbia south through southern Baja California and central Mexico south to Jalisco and Veracruz (Conway, 1995).

Habitat: Shallow water, emergent cover, and substrate with high invertebrate abundance are thought to be the most important features of Virginia Rail habitat (Andrews, 1973; Baird, 1974; Berger, 1951; Fredrickson & Reid, 1986; Gibbs et al., 1991; Glahn, 1974, Griese et al., 1980; Rundle & Fredrickson, 1981, Sayre & Rundle, 1984; Tacha, 1975). Needs standing water, moist-soil, or mudflats for foraging; avoids dry stands of emergents (Fredrickson & Reid, 1986; Gibbs et al., 1991; Johnson, 1984; Manci & Rusch, 1988). A moderate cover:water ratio within wetlands is important; Virginia Rails are often absent from wetlands lacking adequate shallow-water pools or mudflats. An equal mixture of emergent vegetation and flooded openings increases macroinvertebrate production (Kaminski, 1979; Nelson & Kadlec, 1984; Voigts, 1976) and Virginia Rails may use interspersion as a proximate cue in selecting habitats rich in macroinvertebrates (Kaminski & Prince, 1981; Reid, 1985). Most common in wetlands with 40–70% upright emergent vegetation interspersed with open water, mudflats, and/or matted vegetation (Fredrickson & Reid 1986; Krapu & Green, 1978). Mlodinow (1984) stated that this species is "found in bulrush, cattail, and sedge marshes, with cattail marshes favored."

Behavior: Walks and runs on ground. Long toes allow birds to walk on floating marsh vegetation, and laterally compressed bodies allow them to walk through dense understory marsh vegetation. Occasionally climb up stems of emergent plants and shrubs while foraging, occasionally using claw at tip of wing (Forbush, 1925; Nice, 1962; Walkinshaw 1937,). Tail normally fanned and erect while walking, exposing banded black-and-white undertail-coverts. Seldom flies except during migration. Flight involves rapid wingbeats on short, rounded wings. Often drops to ground, abruptly and ungracefully, after short flight (Conway, 1995). Can dive and swim, using wings for propulsion underwater; probably does so only to foil potential predators (Forbush, 1925). Frequently heard calls include the "grunt" call given by pairs for mate communication, and the "tick-it" call (*gik-gik-gik-gik-gidik-gidik-gidi-gidik*) used for mate attraction (Conway, 2009).

Food preferences: Animal foods predominate (85–97% of diet in summer) (Horak, 1970; Martin et al., 1951). During the breeding season diet includes small aquatic invertebrates, mainly beetles, snails, spiders, true bugs, and diptera larvae; during the winter includes invertebrates, a variety of aquatic plants, and seeds of emergent plants (Conway, 1995). Seeds of marsh plants (wild rice, bulrush, spikerush, sedge, buttonbush, cyperus, pondweed, cowlily, smartweed, cordgrass, marestail, bur-reed) are consumed more commonly in fall (32%) and winter (21%) than in spring (12%) and summer (3%) (Martin et al., 1951).

Nesting habits: Nests in robust emergent vegetation (e.g., cattails, bulrush). Will nest within a wide variety of emergents (reviewed by Walkinshaw, 1937 and Horak, 1964), so the dominant plant species in a marsh is not considered a good indication of habitat suitability. Nests are well concealed; built touching, slightly submerged below, or a short distance (< 15 cm) above water surface (Conway, 1995). Females lay 6–13 pale buff or whitish eggs, sparingly and irregularly spotted with brown.

Precocial young are covered with black down and leave nest soon after hatching, follow parents after leaving the nest.

Continent-wide population status: Listed as Least Concern (population trend: increasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically a widespread breeding species in the Calumet region of Illinois and Indiana (Brock 2010; Ford, 1956, Mlodinow 1984). Many well-documented late 20th century and early 21st century breeding records.

Current population status in Calumet region: Secretive and probably declining, but still has a limited presence as a breeding species. Territorial birds were detected at three of eighteen Illinois Calumet wetlands and three of ten Indiana Calumet wetlands surveyed in 2016, including a copulating pair of adults at Wolf Lake Pool 6 (Roberta Asher, personal communication).

SORA (Porzana carolina)

Sora is plump, relatively small rail with a short "chicken-like" bill, yellowish-green legs, and long toes. Length: 20–25 cm (8–10 in). Adult has a yellow bill (brighter in male); a brown crown, nape and upperparts with back and scapulars streaked with black and white; a black face mask, throat, and upper breast; gray sides of head and neck; a gray breast; bold white and blackish-gray bars on the sides and flanks; and clean white undertail coverts. Juvenile is similar, but has dusky or dusky-yellowish upper mandible; lacks black on throat and upper breast; lacks or only has pale suggestion of black face mask; and has gray tones of head, neck and breast replaced with warm buff. This widely distributed North American rail breeds and winters primarily in freshwater marshes dominated by emergent vegetation. It is more often heard than seen, and gives one of the most distinctive calls of any marsh bird. Feeds primarily on seeds of wetland plants and on invertebrates (Melvin & Gibbs, 2012).

Distribution: Breeds from Nova Scotia northwest to southern Yukon and Northwest Territories, south to California, Arizona, and New Mexico and northeast to Pennsylvania and New England. Wintering grounds include the northern portions of South America, including Ecuador, Columbia, and Venezuela, north through Central America and Mexico to Southern California in the west, and coastal regions of the Southeast. From southern Kansas south to northern and eastern Texas and east through the inland areas of the southeastern United States, Soras are typically only observed during migration in the spring and fall (Cornell Lab of Ornithology, 2003).

Habitat: Breeding range habitat primarily freshwater wetlands with shallow and intermediate water depths, dominated by robust or fine-leaved emergent vegetation, especially cattails (*Typha* spp.), sedges (*Carex* spp., *Cyperus* spp.), bur-reeds (*Sparganium* spp.) and bulrushes (*Scirpus* spp.) (Crowley, 1994; Dinsmore, 1985, 1986; Gibbs & Melvin, 1990; Gibbs et al., 1991; Walkinshaw, 1940). Highest breeding densities are in relatively shallow, shoreward portions of wetlands where water level instability produces diverse mosaics of fine and robust emergent vegetation. This habitat preference may be related to increased prevalence of seeds of wetland plants, especially sedges, which are important foods during the breeding season. It appears that vegetation and water interspersed in spatially complex patterns increases breeding density of marsh birds, including Soras (Melvin & Gibbs 2012). In central Minnesota, nesting densities increase with increasing abundance of cattail (Pospichal & Marshall, 1954). In eastern Alberta, where cattail is rare, *Carex* sedges form the predominant nesting habitat, and breeding densities are no greater where cattail does occur (Lowther, 1977). In British Columbia, Soras nest in wetter habitats and more often in cattails than Virginia Rails do (Campbell et al., 1990). Soras breeding in Massachusetts are present in wetlands with larger areas of cattail and greater interspersion of vegetation and water compared to wetlands where they are absent or where Virginia Rails are present (Crowley, 1994).

Behavior: Soras move primarily by walking or running through and over wetland vegetation and debris (Melvin & Gibbs, 2012). Reluctant to fly and difficult to flush, but flies more readily than Virginia or Yellow Rails (Walkinshaw, 1940). Readily swims and dives (Ripley, 1977). Sometimes submerges with only bill and eyes protruding (Pospichal & Marshall, 1954). Greatest array of vocalizations given during spring migration and breeding season (Melvin & Gibbs, 2012). The distinctive *whinny* call is used for territorial defense and mate communication, the *per-weep* call may be used for mate attraction, and the *keep* call is used as an alarm call (Conway, 2009).

Food preferences: Feeds mainly on seeds of wetland plants and aquatic invertebrates (Melvin & Gibbs, 2012). Soras consume more plant material, primarily seeds, and less animal material throughout the year than do Virginia Rails (Martin et al., 1951; Horak 1970). Food items that constituted the largest percent by volume in stomach contents (gizzards and proventriculi) of 19 Soras collected during summer in Iowa were seeds of *Carex* (21.5%), *Setaria* (20.0%), and *Polygonum* (18.0%) (Horak, 1970). Duckweed (*Lemna*) constituted 7.9%. Invertebrate foods that comprised the largest percent by volume were adult insects (Odonata, 8.7%; Gryllidae, 1.7%) and snails (Gastropoda, 2.5%). Soras consumed more plant material, primarily seeds, and less animal material than did Virginia Rails inhabiting the same wetlands. Grit constituted over 23% of the volume of stomach contents. Rice comprised 74.6% of the volume of stomach contents of 56 Soras collected in Arkansas rice fields during Sep and Oct (Meanley, 1960). The remaining volume was comprised of seeds of various rice field weeds (19.4%) and aquatic insects (6.1%).

Nesting habits: Nest site usually in robust or fine-leaved emergent vegetation with shallow (18–22 cm) water. Dominant plants at nest sites include cattail, sedges, and, less commonly, bulrushes, burreeds, or grasses (Billard, 1948; Glahn, 1974; Kaufmann, 1989; Pospichal & Marshall, 1954; Tanner & Hendrickson, 1956; Walkinshaw, 1940). Preferred nest sites seem to be in cattails or sedges, especially near borders between vegetation types or patches of open water (Glahn, 1974; Pospichal & Marshall, 1954; Walkinshaw, 1940;), or in mixtures of robust and fine emergents, e.g., cattail with understory of sedge (*Carex* spp.) (Kaufmann, 1989). Of 54 nests found on the east shore of Pistakee Lake, a half-mile south of the village of Fox Lake in Lake County, Illinois, the vast majority (40 nests) were specifically in blue joint grass (*Calamagrostis canadensis*), but the tussock habitat in which the nests were found was strongly believed to be a reflection that the stands of *Calamagrostis* had been preceded in succession by the genuinely tussock-forming *Carex stricta* (Beecher, 1942). Females usually lay 6–13 (but sometimes more or fewer) rich buff eggs irregularly spotted with shades of brown. Precocial young are covered with black down and leave nest within 1–2 days of hatching, but may return for brooding at night.

Continent-wide population status: Listed as Least Concern (population trend: increasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically a widespread breeding species in the Calumet region of Illinois and Indiana (Brock, 1997; Ford, 1956; Mlodinow, 1984).

Current population status in Calumet region: Still occurs as a breeding species, but status uncertain due to secretive nature. Breeding populations likely declining, but data insufficient. Territorial birds were detected at 2 of 18 Illinois Calumet wetlands and 2 of 10 Indiana Calumet wetlands surveyed in 2016. Illinois observations in 2016 included a brood of 4 downy young at Indian Ridge Marsh South (Nat Miller, personal communication). Indiana observations in 2016 included 10 territorial birds and 1 brood (1 downy young) at the DuPont Tract in East Chicago (Walter Marcisz, personal communication). Regarded as the most common rail in the Indiana Dunes area (Brock, 2010) and the most common rail in Indiana (Brock, 2006).

AMERICAN COOT (Fulica americana)
As one of the continent's most familiar wetland birds, the plump, dark-gray, chicken-like American Coot, with its black head and neck and distinctive white bill and frontal shield, is easily the most aquatic, most abundant, and widely distributed species of rail in North America. It may be found at one season or another in almost any of a broad variety of wetlands, including freshwater lakes, ponds, marshes, roadside ditches, and industrial waste impoundments, as well as in coastal marine habitats. It breeds almost exclusively in freshwater marshes, with the largest breeding concentrations in the Prairie Pothole Region of the southern Canadian Prairie Provinces and north-central United States. An awkward and often clumsy flier, it requires long running takeoffs across the water's surface to become airborne. It is, however, an accomplished swimmer and diver, maneuvering underwater with the aid of lobately webbed toes. Although the coot will consume grains, grasses, and agricultural crops on land, it generally forages in or under water, where it is almost exclusively an herbivore. This is a raucous and quarrelsome bird whose presence is often announced by its loud cackling, grunting, and croaking calls from deep within tall stands of emergent aquatic vegetation, particularly cattails, reeds, and bulrush (Brisbin et al., 2002).

Distribution: Widespread North American subspecies (*Fulica americana americana*) breeding range is centered in Prairie Pothole Region of southern Canadian Prairie Provinces and north-central U.S.; breeds throughout the Florida peninsula and most of western and south-central U.S., south to the Greater Antilles and Costa Rica, in varying degrees, in shallow freshwater lakes, ponds, and marshes with emergent vegetation, (Alisauskas & Arnold, 1994; American Ornithology Union, 1998). Birds from temperate North America east of the Rocky Mountains migrate to the southern U.S, and southern British Columbia. It is often a year-round resident where water remains open in winter. South American subspecies (*F. a. columbiana*) is resident of Andes of central Colombia (formerly also Ecuador) (Ridgely & Greenfield, 2001).

Habitat: Two features generally characterize all bodies of water where American Coots breed: (1) heavy stands of emergent aquatic vegetation along at least some portion of the shoreline and (2) at least some depth of standing water within those stands of vegetation, at least throughout the period of nesting and rearing of young (Brisbin et al., 2002). Within these restrictions, almost any form or size of water body may be used, including lakes, ponds, canals, sloughs, sewage ponds, slower-moving rivers, and swamps with some open water (Alisauskas & Arnold, 1994; Bent, 1926; Fitzner et al., 1980; Harrison, 1978; Kiel, 1955; Sugden, 1979; Sutherland & Maher, 1987). Maximum breeding densities are attained in those portions of semipermanent wetlands that are well-flooded and maximize interspersion of open water and emergent vegetation (Alisauskas & Arnold, 1994; Bett, 1983). Cattails (*Typha* spp.) and bulrush, notably tule/hardstem bulrush (*Scirpus acutus*) by far most common forms of emergent macrophytes in coot breeding habitat throughout breeding range in North America, with other common vegetation types including reeds (mostly *Phragmites* spp.), sedges (*Carex* spp.), willows (*Salix* spp.), and grasses (Brisbin et al., 2002). Herbicide treatments of cattail-dominated wetlands in North Dakota actually increased breeding-season densities of coots by creating a more open mosaic of live emergent vegetation, open water, and floating mats of dead vegetation; this increased carrying capacity persisted for 2 years post-treatment (Linz et al., 1997).

Behavior: Adept at walking and running rapidly either on land, or across water by ‘splattering’ (also termed ‘spattering’), in which water’s surface is beat noisily by flailing wings and feet—often resulting in becoming airborne. On land, head is nodded in step with foot movements; active walking/running often undertaken in a hunched-back posture. Lobed webbing of feet, which is folded as foot is lifted, does not impede active walking or running on dry land, and also allows bird to support its weight on soft or mucky substrate (Brisbin et al., 2002). Flight is strong and direct, much more vigorous and swift than flight of moorhens (Bent, 1926). As with walking, coot’s head nods in step with foot movements while swimming. Accentuated head and body movements while swimming may be associated with swimming as a form of display along territorial boundaries (Ryan & Dinsmore, 1979). Although lobed webbing of toes not as effective at propulsion as full interdigital webbing, American Coot is still a strong swimmer. Dabbles from water’s surface, or dives for food, depending on depth of food underwater (Brisbin et al., 2002). Although none of the vocalizations of American Coot can properly be considered “song,” this is a highly vocal species whose grunting, croaking, and squawking notes (Bent, 1926) represent a complex and frequently used series of calls. Use of dense stands of emergent aquatic vegetation as both breeding habitat and as night roosts on wintering grounds has undoubtedly increased importance of vocal communications as a component of species’ complex social behavior (Brisbin et al., 2002).

Food preferences: Feeds mainly on aquatic vascular plants and algae; some grasses, other terrestrial vegetation, and grains; aquatic invertebrates (mollusks, crustaceans, insects and their larvae) and vertebrates (fish, tadpoles, even some carrion) (Brisbin et al., 2002). Throughout North America, feeds predominantly on plant material, principally pondweeds (*Potamogeton*, *Najas*, *Ruppia* spp.), sedges (*Eleocharis*, *Scirpus*, *Cyperus*, *Carex* spp.), algae (*Chara*, *Nitella* spp., filamentous forms), and wild and domestic grasses, including wild rice (*Zizania aquatica*), oats (*Avena sativa*), and rice (*Oryza sativa*)

(Jones, 1940). Although animal matter generally less common in diet, may become an important component during breeding season, particularly for growing young (Desrochers & Ankney, 1986; Driver, 1988; Jones, 1940). Most comprehensive survey of coot food habits from across North America and for all seasons (Jones, 1940) was based on 792 stomach-content analyses (777 adults, 15 juveniles); study showed overall volumetric percentages of 89.4% plant and 10.6% animal foods. Summarized by month, this same study showed a continent-wide range of plant food volumetric occurrence from 99.9% (Jan) to 55.9% (Jun) and a range in animal foods from 0.08%–44.1% in the same months; gravel ranged from 44.4% (Nov) to 12.3% (Jul–Aug).

Nesting habits: Invariably nests are built over water on floating platforms and almost always associated with dense stands of living or dead emergent vegetation such as reeds, cattails, bulrushes, sedges, grasses, and other species. Occasionally nest may be built on edge of stand of vegetation, where it is clearly visible. More commonly, however, it is concealed within stand, but always close to open water (<1.2 m) (Gullion, 1954). Combined nest records from egg-set cards of the WFVZ and CNRP (*n*=754; from throughout North America, but with >40% coming from California and Utah) indicate cattail the most frequent dominant plant at site of coot nests (51.3%), followed by bulrush (32.0%), grasses (10.2%), and reeds (mostly *Phragmites*; 7.0%). Females usually lay 6–9 (but sometimes more or fewer) buff eggs evenly speckled with tiny dark brown dots. Precocial young are mostly covered with blackish down, but have a red bill and red-orange down on head and neck. Young are usually brooded by female and fed by male for first 3–4 days after hatching; later, young follow adults.

Continent-wide population status: Listed as Least Concern (population trend: decreasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically a widespread breeding species, abundant migrant, and occasional winter resident in the Calumet region of Illinois and Indiana (Brock, 2010; Ford, 1956; Mlodinow, 1984). Notable late 20th century Illinois Calumet breeding records include a remarkable 32 nests at Hegewisch Marsh in 1982 (EnCap, 1982), 6 nests at Big Marsh in 1986 (Elston, 1986), and 6 broods at Eggers Grove F.P. in 1990 (Walter Marcisz, personal records). In the Indiana Calumet Region, American Coots have nested at Gleason Park, Gary, and Roxana Pond, East Chicago. Downy chicks were observed at the latter site in 1985, 1986, and 1990 (Brock, 2010).

Current population status in Calumet region: Still occurs as a common-to-abundant migrant and winters in smaller numbers on ice-free lakes and rivers, but has declined precipitously as a breeding species. Territorial birds were detected at 2 of 18 Illinois Calumet wetlands and 1 of 10 Indiana Calumet wetlands surveyed in 2016. Two broods discovered at Hegewisch Marsh in 2016 were the first confirmed breeding evidence in the Illinois Calumet region since 2008 (Walter Marcisz, personal communication). Like other marsh birds, recent declines are likely related to overall lack of hemimarsh habitat, rampant infestations of invasive exotics (notably common reed and common carp), overall lack of vegetative diversity, and vexing hydrological problems.

MARSH WREN (Cistothorus palustris)
Marsh Wren is a very small but very vocal and aggressive songbird with a polygynous mating system and a habit of building multiple globular dummy nests in emergent vegetation on its territory. Length: 10.5–14 cm (4–5.5 in). Thin, sharp, slightly decurved bill; short, frequently upturned tail. Dark brown or blackish crown contrasting sharply with bright white eyebrow. Cheeks brownish; throat and breast whitish. Black back striped with white; rufous-brown wings; rufous-brown tail barred with black. Diffuse warm brown wash on sides of breast and belly.

Distribution: Two evolutionary groups, eastern and western, in North America (Kroodsma & Verner, 1987; Kroodsma, 1989), with at least 5 recognized subspecies in the eastern group, and at least 7 recognized subspecies in the western group (Kroodsma & Verner, 2014). Breeds from central British Columbia and northwestern Alberta south to northern Minnesota, southern Quebec, New Brunswick and Nova Scotia; south along the coast to the Mid-Atlantic states; then west through Ohio, Illinois, Nebraska and Colorado to Washington, Oregon, and California. Eastern and western breeding populations are separated by a wide swath of the western Great Plains, where the species is largely absent as a breeder. Resident in the far western portion of breeding range, and in the Mid-Atlantic States. Winters on the east coast of USA, the Florida peninsula, the Gulf Coast, southwestern USA, and northern and central Mexico, including Baja California.

Habitat: Breeds in a diversity of marshland habitats throughout North America. At Delta Marsh, Manitoba (Leonard & Picman, 1987c), nesting success was lower in relatively dry and homogeneous cattail (*Typha* spp.) marsh than in a denser, mixed stand of cattails, phragmites (*Phragmites australis*), and bulrush (*S. acutus*) in deeper water. In the Finger Lakes region of New York State, the species prefers cattail-sedge associations, and *Typha angustifolia* over *T. latifolia* (Welter, 1935). Among cattail-dominated wetlands in Ontario, Marsh Wren abundance increased as water depth increased, as wetland size increased, and as amount of wetland in surrounding landscape increased (Tozer et al., 2010). Breeding densities in the Colorado River valley are highest in the densest stands of cattail and bulrush (Rosenberg et al., 1991). Resident Florida birds occur in salt or brackish marshes, especially in tidal creeks dominated by cordgrass and/or black rush (*Juncus roemerianus*), and occasionally in sawgrass (*Cladium jamaicense*) (Stevenson & Anderson, 1994). Bent (1948) describes a variety of other nesting associations, such as phragmites marshes in coastal Connecticut. Of 48 nests located on the east shore of Pistakee Lake, a half-mile south of the village of Fox Lake in Lake County, Illinois, Beecher (1942) found that Marsh Wrens nested much more abundantly in lake sedge (*Carex lacustris*) than in cattails (17 nests in *Carex lacustris*, 15 nests in mixed *Carex*, 8 nests in *Calamagrostis*, 7 nests in *Typha*). Migration and winter habitat resembles breeding habitat, though often found in a wider variety of habitats (Kroodsma & Verner, 2014).

Behavior: Marsh Wrens cling to cattails or other emergent vegetation, climbing "nimbly up and down the reeds like a feathered gymnast… swinging jauntily from a swaying top" (Bent, 1948). Flights are usually short, with rapid wing-beats. Male uses a flutter flight that launches him above the territory before he flutters back down. More often heard than seen, the Marsh Wren's reedy, gurgling sounds abound in North American cattail and bulrush marshes. Songs are more liquid in the East; more harsh, grating, and variable in the West. The Marsh Wren's abundant singing and complex vocal behaviors are undoubtedly an evolutionary consequence of its polygynous mating system. About 50% of the males in some populations mate simultaneously with 2 or more females. In their zeal, the males also build multiple nests, typically at least a half dozen dummy nests for every breeding nest used by a female. Perhaps another consequence of intense competition for resources in these marsh environments is this species' habit of destroying eggs, not only of other species but also of other Marsh Wrens (Kroodsma & Verner, 2014).

Food preferences: Feeds mainly on invertebrates, especially insects and spiders; aquatic insects in freshwater marshes. Probably opportunistic, taking whatever invertebrates are available and accessible in diverse marsh habitats (Kroodsma &Verner, 2014). Major insect groups include bees, ants, and wasps (Hymenoptera); beetles (Coleoptera); leafhoppers (Homoptera); flies (Diptera); moths (Lepidoptera); and bugs (Hemiptera). Spiders (Araneida) occur in most stomachs (Beal 1907; Kale 1964; Welter 1935).

Nesting habits: Marsh Wrens use a diversity of vegetation to support their nests (Bent, 1948). Males build numerous nests, and a prospective mate typically inspects those nests while being escorted by the resident male. She often accepts one of his nests, lining it with soft materials before laying eggs (Tintle, 1982; Verner 1964, 1965a). Alternatively, she can initiate a new nest, which is believed to be the more common practice in some locations. Cattail, sedge, or grass typically forms outer shell of nest. In upstate New York (Welter, 1935), supporting plants are typically lashed together with *Carex* sedges and *Calamagrostis* grasses. First a cup is formed, on which the walls are woven, usually with water-soaked strips of cattail leaves or stems of grasses or sedges. These strands are formed into a domed structure, as supporting stems are woven into nest (Kroodsma & Verner, 2014). Female lays 3–10 (usually 4–6) dull brown or cinnamon eggs, evenly sprinkled with dark brown dots and spots, sometimes capped or obscuring ground color. Altricial young are attended in nest by female or both parents. Young leave nest at 13–15 days, males may feed them for another 7 days or so.

Continent-wide population status: Listed as Least Concern (population trend: increasing) in the IUCN Red List of Threatened Species (BirdLife International, 2015).

Historical population status in Calumet region: Historically a widespread breeding species in the Calumet region of Illinois and Indiana (Brock 2010; Ford 1956; Mlodinow 1984). Many well-documented late 20th century and early 21st century breeding records. Notable late 20th century Illinois Calumet breeding records include 24 nests at Van Vlissingen Prairie and 18 nests at Hegewisch Marsh in 1982 (EnCap, 1982).

Current population status in Calumet region: Still occurs as a widespread breeding species in the Calumet region of Illinois and Indiana. Territorial birds were detected at 12 of 18 Illinois Calumet wetlands and 4 of 10 Indiana Calumet wetlands surveyed in 2016, with notable Illinois records including 18 territorial males at Powderhorn Lake F.P. & 16 territorial males at Burnham Prairie; and notable Indiana records including 13 territorial males at DuPont Tract & 11 territorial males at Strawberry Island (Walter Marcisz & Caleb Putnam, personal communication). In the Indiana Calumet region, Brock (2010) states: “This wren is found at most sites where cattails grow in abundance. Good locations are fairly common on the Lacustrine Plain.” This species appears to be far less dependent on hemimarsh conditions than most other marsh-nesting species, and more willing to accept closed emergent marshes as viable nesting habitat.

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