Appendix 9.14: Upper Duck Creek North

Written by Erin Giese and Dr. James Horn

<table>
<tr><td>Location (centroid)</td><td>Lat. 44.569848°, Lon. -88.053762°[1] (NAD 1983, UTM Zone 16N)</td></tr>
<tr><td>Total Area (ha)</td><td>85.31 ha</td></tr>
<tr><td>Area Public Land (ha)</td><td>65.77 ha, land owned by the Wisconsin Department of Natural Resources</td></tr>
<tr><td>Area of Habitat Types Present (ha) and Percent of Each Habitat Type</td><td>Dominant Habitat Types: These habitat types were documented during a July 2015 habitat mapping effort led by the University of Wisconsin-Green Bay Cofrin Center for Biodiversity (CCB) across the Lower Green Bay and Fox River Area of Concern (LGB&FR AOC)[2]. Habitat types within Upper Duck Creek North are displayed as a static map at the bottom of this document. Note that the extent of submergent marsh was refined by the CCB's 2017 submerged aquatic vegetation field surveys. There is a total of 84.31 ha of natural habitat in Upper Duck Creek North.

<table>
<tr><th>Habitat Type</th><th>Area (ha)</th><th>Percent</th></tr>
<tr><td>Emergent Marsh (Inland)</td><td>2.05</td><td>2.43</td></tr>
<tr><td>Emergent Marsh (Riparian)</td><td>26.34</td><td>31.24</td></tr>
<tr><td>Emergent Marsh (Roadside)</td><td>1.18</td><td>1.39</td></tr>
<tr><td>Hardwood Swamp</td><td>14.46</td><td>17.15</td></tr>
<tr><td>Open Water Inland</td><td>0.08</td><td>0.10</td></tr>
<tr><td>Other Forest</td><td>26.65</td><td>31.61</td></tr>
<tr><td>Shrub Carr</td><td>8.60</td><td>10.20</td></tr>
<tr><td>Submergent Marsh</td><td>3.04</td><td>3.61</td></tr>
<tr><td>Surrogate Grassland (Old Field)</td><td>1.91</td><td>2.26</td></tr>
</table>

Disclaimer! Because this priority area is located within the Great Lakes coastal zone, the amount of habitat types can vary drastically across years and even within years (or months) due to changing Great Lakes water levels, precipitation, and seiche. Within this priority area specifically, the amounts of emergent and submergent marsh are known to fluctuate significantly from year to year and within years. The habitat types listed above and mapped below are based on a field effort conducted in July 2015. Plants recorded in the "Natural Habitat Communities and Significant Plants" section were primarily documented in July 2015 and late summer/fall 2016 and 2017. Great Lakes water levels were much higher in 2016 and 2017 than in July 2015.</td></tr>
<tr><td>General Description</td><td>Upper Duck Creek North is located just west of the mouth of Duck Creek and Interstate 41 and is a part of the Duck Creek Delta wetland complex. While the priority area has been significantly modified over the years from development, road construction, and agricultural/storm water runoff, it still features a hydrologic habitat gradient that grades from submergent/emergent marsh into southern sedge meadow, shrub carr, and hardwood swamp[2]. While the emergent marsh is heavily dominated by the invasive, hybrid cattail (*Typha* × *glauca*), parts of the shrub carr and especially southern sedge meadow have good quality plants[5], though restoration would significantly improve their overall ecological quality. Duck Creek flows northeast from roughly 22 km (13.8 mi) inland and empties into the bay of Green Bay, though it has been known to reverse course and flow upstream (i.e., southwest) as far as 6.4 km (4 mi) during high water levels and seiche in the bay[9]. It primarily consists of Tedrow loamy fine sand soils and</td></tr>
</table>

[1] File "AOC_PriorityAreas.v09_20171212.shp"
[2] LGB&FR AOC 2015 habitat field mapping effort

	Keowns silt loam[3]. While many parts of the Duck Creek Delta are heavily studied in the lower bay, the Upper Duck Creek North priority area is not well studied, at least not in recent years, with a few exceptions. By the fall of 2012, the Oneida Tribe removed two dams and modified an existing dam upstream in Pamperin Park, which improved fish habitat for species such as northern pike (*Esox lucius*)[35]. The UW-Green Bay's CCB led a LGB&FR AOC bird survey in 2015, habitat mapping effort in 2015, plant biodiversity hotspot mapping and inventory in 2016, and submerged aquatic vegetation mapping in 2017. All surveys included visits to the Upper Duck Creek North priority area. The WDNR has also conducted an aerial spraying of herbicide to manage common reed (*Phragmites australis*) along the west shore. They sprayed this priority area's emergent marsh in 2012.
Special Features	• Offers a landscape of submergent and emergent marsh that grades into southern sedge meadow, shrub carr, and hardwood swamp; this landscape describes the historical mosaic originally found in lower Green Bay[2,4,5]. • Features a small patch of southern sedge meadow, which is a rare habitat in the LGB&FR AOC and across the state, that is largely dominated by blue-joint grass (*Calamagrostis canadensis*), common tussock sedge (*Carex stricta*), and common lake sedge (*Carex lacustris*). • Important habitat for muskrats[6] and wetland birds (e.g., Swamp Sparrow [*Melospiza georgiana*], Marsh Wren [*Cistothorus palustris*]) in the emergent marsh.
Natural Habitat Communities and Significant Plants (ordered in terms of ecological importance and size/amount)	Despite many anthropogenic modifications, the Duck Creek Estuary North priority area still maintains a natural coastal gradient from submergent marsh, to emergent marsh, southern sedge meadow, shrub carr, and finally to hardwood swamp. Roughly one-third of this priority area consists of **emergent marsh (riparian)**, which is mostly dominated by hybrid cattail (*Typha* × *glauca*) toward the centers of the marsh and common reed (*Phragmites australis*; hereafter referred to as *Phragmites*) along the periphery. Most of the native plants are found along the edges of the marsh with little cover[5]. Natives include[5]: • Canada blue-joint grass (*Calamagrostis canadensis*) • Common tussock sedge (*Carex stricta*) • Common great angelica (*Angelica atropurpurea*) • Water smartweed (*Persicaria amphibia*) • Prairie cord grass (*Spartina pectinata*) • Spotted joe-pye weed (*Eutrochium maculatum*) Like emergent marsh (riparian), **other forest** constitutes roughly one-third of this priority area's habitats and is found in the northern half/northwestern corner[2]. Trembling aspen (*Populus tremuloides*), wild grape (*Vitis riparia*), cottonwood (*Populus deltoides*), and white poplar (*Populus alba*) occur here[2]. Approximately 17% of this priority area is made up of **hardwood swamp**, which is found in the far southwestern corner and northeastern edge[5]. Canopy dominants include green ash (*Fraxinus pennsylvanica*), swamp white oak (*Quercus bicolor*), box elder (*Acer negundo*), and cottonwood[5]. The understory is invaded by common buckthorn (*Rhamnus cathartica*) and glossy buckthorn (*Frangula alnus*) but also has native wild grape[5]. The herbaceous layer consists of small-spike false nettle (*Boehmeria cylindrica*), reed canary grass (*Phalaris arundinacea*), and others[5].

[3] Soil Survey Geographic (SSURGO) by the United States Department of Agriculture's Natural Resources Conservation Service. Published Dec 2010. Available: http://uwgb.maps.arcgis.com/home/item.html?id=204d94c9b1374de9a21574c9efa31164; accessed 15 Dec 2017

[4] Bertrand et al. 1976: The Green Bay Watershed Past/Present/Future

[5] LGB&FR AOC plant biodiversity hotspots field effort

[6] Muskrat lodges can easily be seen in the emergent marsh when looking at aerial imagery

	A linear stretch of **shrub carr** constitutes close to 10% of natural habitat in this priority area and is dominated by meadow willow (*Salix petiolaris*), sandbar willow (*Salix interior*), diamond willow (*Salix eriocephala*), and glossy buckthorn[2,5]. Just over 3.5% of the natural habitats in this priority area is **submergent marsh**, which occurs throughout the stream inlet that runs straight north from the main stem of Duck Creek[2,37]. Dominants include fragrant water-lily, (*Nymphaea odorata*), coontail (*Ceratophyllum demersum*), sago pondweed (*Stuckenia pectinata*), perennial duckweed (*Lemna turionifera*)[37]. Invasives Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) occur here as well though they are not the dominants[37]. Along the southern edge of this priority area, submergent marsh dominants include coontail, great duckweed (*Spirodela polyrrhiza*), water stargrass (*Heteranthera dubia*), flat-stem pondweed (*Potamogeton zosteriformis*), and small duckweed (*Lemna minor*)[37]. There is a small patch of **surrogate grassland (old field)** that is 1.91 ha in size in the northeastern corner of the priority area[2]. There is a nice mix of native plants, including native eudicot species, such as Canadian goldenrod (*Solidago canadensis*), bee balm (*Monarda fistulosa*), Culver's-root (*Veronicastrum virginicum*), and common milkweed (*Asclepias syriaca*).[2] Between the hardwood swamp in the southwestern corner and the emergent marsh (riparian) in the center is **emergent marsh (inland)** and makes up <2.5% this priority area. There is also a small patch of relatively good and appreciably native-rich, **southern sedge meadow** that is largely dominated by blue-joint grass (*Calamagrostis canadensis*), common tussock sedge (*Carex stricta*), common lake sedge (*Carex lacustris*). Other natives found moderately often include broad-leaved woolly sedge (*Carex pellita*) and marsh bluegrass (*Poa palustris*). Unusual species include swamp betony (*Pedicularis lanceolata*), common water dropwort (*Oxypolis rigidior*), northern meadow spike-moss (*Selaginella eclipes*), and nodding lady's tresses (*Spiranthes cernua*). Moderately common, though not dominant, invasive species include reed canary grass, redtop (*Agrostis gigantea*), and Canada thistle (*Cirsium arvense*). This sedge meadow was not digitized or mapped during the 2015 LGB&FR AOC field effort because it is very small, which is why it is not shown in the habitat map below. Its general location is identified with a star symbol.

Significant Animals	**Birds**:
	• Over 200 bird species have been recorded along parts of the west shore, however, there are records of just over 60 species reported within the Duck Creek area west of Interstate 41, including[7]
	  ○ Two state endangered species (Common Tern [*Sterna hirundo*], Forster's Tern [*Sterna forsteri*])
	  ○ One state threatened species: Great Egret (*Ardea alba*)
	  ○ Five state special concern species: American White Pelican (*Pelecanus erythrorhynchos*), Black-crowned Night-Heron (*Nycticorax nycticorax*), Canvasback (*Aythya valisineria*), Common Goldeneye (*Bucephala clangula*), and Redhead (*Aythya americana*)
	  ○ Six Wisconsin Wildlife Action Plan Species of Greatest Concern (e.g., Trumpeter Swan [*Cygnus buccinator*], Great Egret, Redhead)
	  ○ Five state special concern species (e.g., American White Pelican, Common Goldeneye)

[7] LGB&FR AOC Biota Database: file "AOCBiota_DB_ShareableVersion_20171213.accdb"

	• Despite the emergent marsh's lack of native plant diversity, it provides nesting habitat for many marsh-breeding birds[8]:
	  ○ Red-winged Blackbird (*Agelaius phoeniceus*)
	  ○ Swamp Sparrow (*Melospiza georgiana*)
	  ○ Marsh Wren (*Cistothorus palustris*)
	  ○ Common Yellowthroat (*Geothlypis trichas*)
	• Cliff Swallows (*Petrochelidon pyrrhonota*) and Barn Swallows (*Hirundo rustica*) nest under the Interstate 41 bridge along the eastern edge of this priority area's border[8].
	
	Fish:
	• Although >80 fish species have been recorded in the pelagic zone of the lower bay, only some may use areas near the Duck Creek Delta. Species that use the bay include[7]:
	  ○ One federally endangered species: chinook salmon (*Oncorhynchus tshawytscha*)
	  ○ Three state special concern species, including: American eel (*Anguilla rostrata*), banded killifish (*Fundulus diaphanus*), and lake sturgeon (*Acipenser fulvescens*)
	  ○ One International Union for Conservation of Nature-listed species as "vulnerable" (bloater [*Coregonus hoyi*]) and one as "endangered" (American eel)
	  ○ Two globally list species (G3 = vulnerable): redside dace (*Clinostomus elongatus*) and lake sturgeon (*Acipenser fulvescens*)
	  ○ Northern pike (*Esox lucius*)
	
	Mammals:
	• Although ~50 mammal species are known to or are expected to occur along the west shore (as noted in Roznik 1979)[9], only a few likely use the emergent and submergent marshes of Upper Duck Creek North, including muskrat (*Ondatra zibethicus*), North American river otter (*Lontra canadensis*), and American mink (*Neovison vison*)[10,11].
	  ○ In fact, when looking at Google Earth's 2017 aerial imagery, dozens of muskrat lodges are visible along the southern edge of this priority area in the emergent marsh.
	• Common terrestrial mammals, such as eastern gray squirrel (*Sciurus carolinensis*), eastern chipmunk (*Tamias striatus*), and eastern cottontail (*Sylvilagus floridanus*), likely use the hardwood swamp and other forest habitats[7].
	
	Anurans:
	• Spring peeper (*Pseudacris crucifer*) and American toad (*Bufo americanus*) have been recorded calling within the emergent marsh of neighboring priority area, Duck Creek Estuary North, based on 2012 and 2017 surveys[12]. Other anurans may use this marsh, too, such as eastern gray treefrog (*Hyla versicolor*).

Habitat Quality	Overall, the ecological quality of Upper Duck Creek North's habitats is mediocre though parts of this priority area are in fairly good condition. For example, there is a nice mix of native plants in the submergent marsh and southern sedge meadow, in which invasive plants are not the dominants. There is great potential for this priority area to be improved and restored, particularly the southern sedge meadow, which could be expanded. On the other hand, the emergent marsh (riparian) is heavily invaded by the hybrid cattail and *Phragmites* and thus is currently in poor ecological condition.

[8] WI Breeding Bird Atlas II Project – data available here: http://ebird.org/ebird/atlaswi/explore
[9] Green Bay West Shores Master Plan Concept Element 1979 by Roznik et al.
[10] Wisconsin Department of Natural Resources Technical Report PUB-LF-073
[11] Wisconsin Department of Natural Resources 2015 muskrat house survey
[12] Great Lakes Coastal Wetland Monitoring Program anuran surveys, 2012 and 2017; per Erin Giese

Significant Invasive Species Issues	**Invasive Plant Species**: Each of these species outcompetes and crowds out native plants[2,5,37]:
	• Eurasian water-milfoil (*Myriophyllum spicatum*)
	  ○ Found within the submergent marsh mixed in with native submergent species
	• Curly-leaf pondweed (*Potamogeton crispus*)
	  ○ Found within the submergent marsh mixed in with native submergent species
	• Common reed (*Phragmites australis*)
	  ○ *Phragmites* is found in the emergent marsh; some management has occurred in open areas of the emergent marsh in 2012 by the WDNR
	• Hybrid cattail (*Typha* × *glauca*)
	  ○ Largely dominates the emergent marsh
	• Glossy buckthorn (*Frangula alnus*)
	  ○ Commonly found throughout most of the hardwood swamp
	• Common buckthorn (*Rhamnus cathartica*)
	  ○ Found in the hardwood swamp
	• Reed canary grass (*Phalaris arundinacea*)
	  ○ Found in the small patch of southern sedge meadow, though it is not a dominant, and in the hardwood swamp
	• Honeysuckle (*Lonicera* × *bella*)
	  ○ Found in the hardwood swamp along the southern border of this priority area
	• European fireweed (*Epilobium hirsutum*)
	  ○ Found in the edges of the emergent marsh vegetation and in ditches along West Deerfield Avenue near Deerfield Docks boat landing
	
	Invasive Animal Species:
	• *Birds*[7]
	  ○ European Starling (*Sturnus vulgaris*)
	  ▪ Poses some threat to native species, particularly cavity nesters (e.g., Tree Swallow), by outcompeting them and occupying potential nest sites; not currently being managed
	  ○ It is extremely possible that House Sparrows (*Passer domesticus*) occur along the road/interstate, potentially outcompeting Cliff and Barn Swallows for nests since House Sparrows are known to use old swallow nests; not currently being managed
	
	• *Fish*[7]
	  ○ Alewife (*Alosa pseudoharengus*)[13]
	  ▪ Poses a threat to native fish species by consuming zooplankton and disturbing the natural food web; not currently being managed
	  ○ Common carp (*Cyprinus carpio*)[14]
	  ▪ Destroy vegetation by uprooting plants and increasing cloudiness of water; not currently being managed
	  ○ Rainbow smelt (*Osmerus mordax*)[15]

[13] Fuller, P., E. Maynard, D. Raikow, J. Larson, A. Fusaro, and M. Neilson. 2016. *Alosa pseudoharengus*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=490 Revision Date: 9/25/2015. Accessed 17 Oct 2016

[14] Nico, L., E. Maynard, P.J. Schofield, M. Cannister, J. Larson, A. Fusaro, and M. Neilson. 2016. *Cyprinus carpio*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=4 Revision Date: 7/15/2015. Accessed 17 Oct 2016

[15] Fuller, P., E. Maynard, J. Larson, A. Fusaro, T.H. Makled, and M. Neilson. 2016. *Osmerus mordax*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=796 Revision Date: 9/29/2015. Accessed on 17 Oct 2016

	▪ Negatively affect uncommon to rare native fish species; not currently being managed ○ Round goby (*Neogobius melanostomus*)[16] ▪ Prey on small native fish and eggs (e.g., darters) and outcompete similarly sized native fish; not currently being managed ○ White perch (*Morone americana*)[17] ▪ Prey on native fish eggs, such as walleye; not currently being managed • *Freshwater mussels* ○ Zebra mussel (*Dreissena polymorpha*)[18] - it is unknown whether zebra mussels occur at this priority area ▪ Poses threat to native freshwater mussels; not currently being managed.
Management and Restoration Recommendations	• Control the spread of *Phragmites* and invasive cattail and maintain extensive, high quality native plants in the emergent marsh (riparian). • Expand existing southern sedge meadow remnants, control invasive plants, restore hydrology if needed, and promote the spread of native plants. • Control introduced plant species (e.g., Eurasian watermilfoil) and improve the good quality submerged aquatic vegetation with native plants at Duck Creek. • Control woody invasive plants (e.g., glossy buckthorn) in the hardwood swamp. • Place woody debris for fish habitat. • Promote best management practices and innovative nutrient management measures in the Fox River watershed.
Reference Links and Documents	**Web Links**: • Dam removal on Duck Creek with Oneida Tribe, Wisconsin Department of Natural Resources, Brown County, U.S. Fish and Wildlife Service, and Oneida Golf and Country Club: https://greatlakesinform.org/projects-and-progress/498 • History of the Village of Howard as it pertains to the Duck Creek area: http://www.villageofhoward.com/245/History • Nonpoint Source Control Plan for the Duck, Apple, and Ashwaubenon Creeks Priority Watershed Project: http://dnr.wi.gov/topic/nonpoint/documents/9kep/Duck_Apple_Ashwaubenon_Creeks-Plan.pdf **Reference Documents**: • Bosley, T.R. 1978. Loss of wetlands on the west shore of Green Bay. Wisconsin Academy of Sciences, Arts, and Letters 66:235-245. • Chow-Fraser P. 2006. Development of the wetland Water Quality Index for assessing the quality of Great Lakes coastal wetlands. In: Simon TP, Stewart PM (eds) Coastal wetlands of the Laurentian Great Lakes: health, habitat and indicators. Indiana Biological Survey, Bloomington, IN, pp 137-166. • Dorney, J.R. 1975 The vegetation pattern around Green Bay in the 1840s as related to geology, soils, and land use by Indians with a detailed look at the Townships of Scott, Green Bay, and Suamico. Book available through the UW-Green Bay Cofrin Library Archives and Area Research Center.

[16] Fuller, P., A. Benson, E. Maynard, M. Neilson, J. Larson, and A. Fusaro. 2016. *Neogobius melanostomus*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=713 Revision Date: 1/7/2016. Accessed on 17 Oct 2016

[17] Fuller, P., E. Maynard, D. Raikow, J. Larson, A. Fusaro, and M. Neilson. 2016. *Morone americana*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=777 Revision Date: 1/15/2016. Accessed on 17 Oct 2016

[18] Wisconsin Department of Natural Resources Technical Report PUBL ER-818 2010

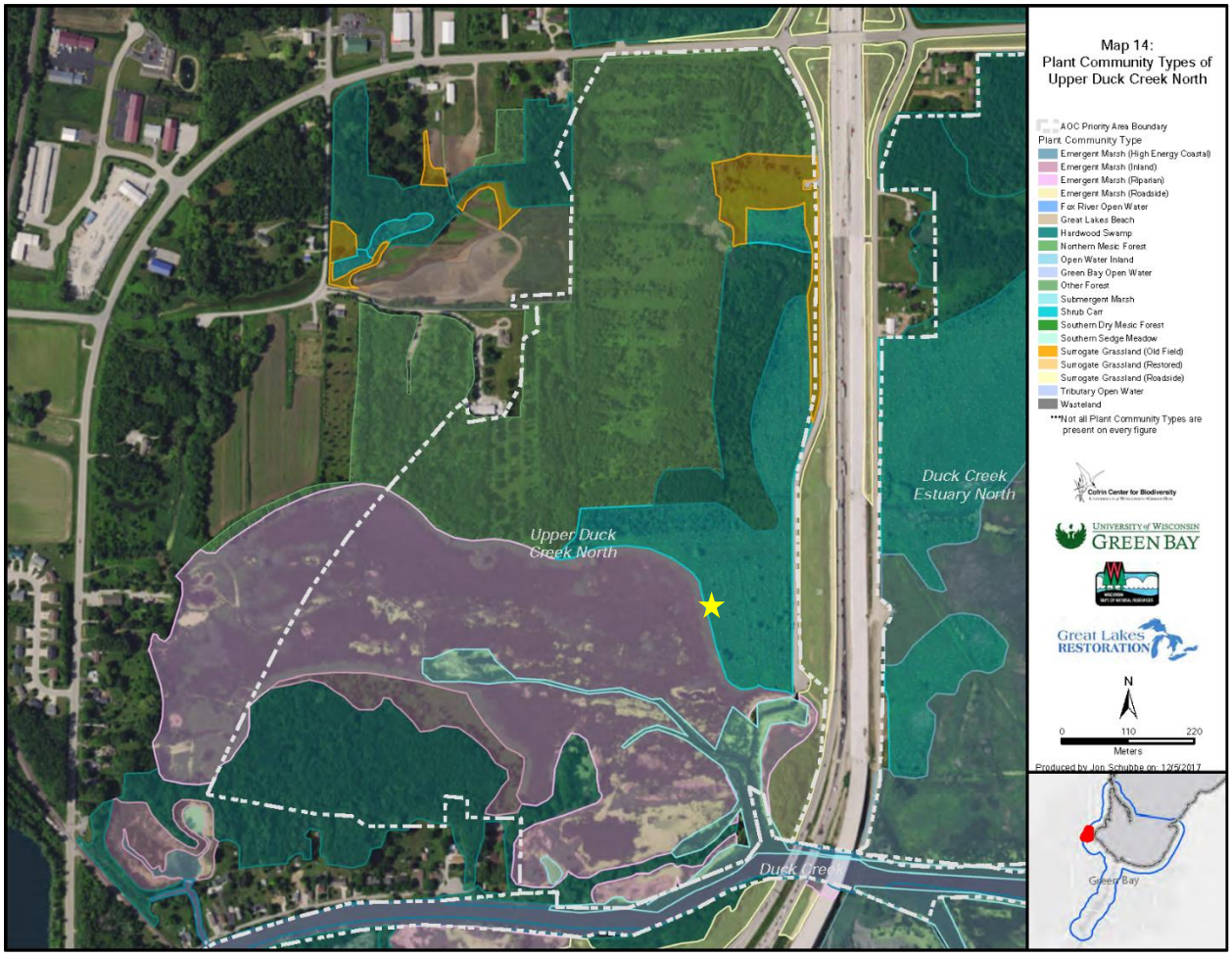
	• Frieswyk, C.B., C.A. Johnston, and J.B. Zedler. 2007. Identifying and characterizing dominant plants as an indicator of community condition. Journal of Great Lakes Research. 33(3):125-135. ○ Available: http://glei.nrri.umn.edu/default/documents/frieswyk_jglr_2007.pdf • Wisconsin Department of Natural Resources. 2013. Regional and property analysis: Green Bay Planning Group. Technical Report PUB-LF-073. • Wisconsin Department of Natural Resources. 2014. Green Bay Planning Group Master Plan. Technical Report PUB-LF-075.
Site History (e.g., original vegetation, past conservation projects)	In the early 1630s, Frenchman Jean Nicolet first arrived in lower Green Bay when it was primarily inhabited by Native American tribes[19]. Lower Green Bay consisted of large beds of wild rice (*Zizania* sp.) and wild celery (*Vallisneria americana*), extensive emergent marsh (*Schoenoplectus* sp., cattail [*Typha latifolia*]), sedge meadows (*Calamagrostis canadensis*), shrub carr (e.g., *Cornus* spp., *Salix* spp.), swamps, and wet conifer forest (black spruce [*Picea mariana*], balsam fir [*Abies balsamea*])[20,21,22,23,24]. Between the late 1600s and 1800s, European fur trade, duck hunting, fishing, logging, shipping, and agriculture were important early industries in lower Green Bay[25,26,27]. In the early 1800s, there were a few small settlements and farms of Europeans and Native Americans in the lower Bay[26]. In fact, there were a few Native American campsites near the mouth of Duck Creek with villages further upstream[28]. Historical vegetation of the Duck Creek Delta was described as consisting of a grassy marsh and meadow with swamp forest of tamarack and black ash[28,29]. Early European settlers founded the Town of Howard in 1835 and settled along Duck Creek. Residents worked in the timber, farming, quarry, and mail carrier businesses[30]. Most of the present day Upper Duck Creek North priority area was used for farming, which is visible in the 1938 air photo and perhaps maintained as farmland into the 1960s and 1970s, as shown in the Brown County Online GIS Portal. In the late 1960s and early 1970s, vegetation associated with Atkinson's Marsh, which is a part of the Duck Creek Delta complex, consisted of bulrush (*Scirpus* spp.), spike-rush (*Eleocharis* spp.), cattail, sedges (*Carex* spp.), grasses (*Calamagrostis* spp.), and organic mats of vegetation[31]. Panfish, carp, bullhead, yellow perch, and northern pike

[19] Jean Nicolet: French Explorer. By The Editors of Encyclopaedia Britannica. Available: https://www.britannica.com/biography/Jean-Nicolet (accessed on 24 Oct 2016)
[20] Arthur C. Neville's Map of Historic Sites on Green Bay, Wisconsin 1669-1689. Available: http://s3.amazonaws.com/labaye/data/Bay%20Settle ment%20Map%20WI%20Historical%20Bulletin%201926.pdf (accessed on 24 Oct 2016)
[21] Survey of the N.W. Lakes: East Shore of Green Bay 1843. Available: http://s3.amazonaws.com/labaye/data/1843%20East%20Shore%20of %20Green%20Bay.jpg (accessed on 24 Oct 2016)
[22] 1845 Chart of Green Bay. Available http://s3.amazonaws.com/labaye/data/1845%20Chart%20of%20Green%20Bay.pdf (accessed on 24 Oct 2016)
[23] 1820s Fox River Military Road Map to Ft. Crawford. Available: http://s3.amazonaws.com/labaye/data/1820s%20Fox%20River%20Military%20 Road%20Map%20to%20Ft.%20Crawford.pdf (accessed on 24 Oct 2016)
[24] Personal communication with Thomas Erdman
[25] City of Green Bay's History Webpage: http://www.ci.green-bay.wi.us/history/1800s.html (accessed on 20 Oct 2016)
[26] Excerpt from "Recollections of Green Bay in 1816-17" by James W. Biddle. Available: http://s3.amazonaws.com/labaye/data/Recollections %20of%20Green%20Bay%20in%201816-1817.pdf (accessed on 24 Oct 2016)
[27] The Early Outposts of Wisconsin: Green Bay for Two-Hundred Years, 1639-1839. Available: http://labaye.org/item/70/2810 (accessed on 25 Oct 2016)
[28] The vegetation pattern around Green Bay in the 1840s as related to geology, soils, and land use by Indians with a detailed look at the Townships of Scott, Green Bay, and Suamico by John Dorney, 1975
[29] Wisconsin Public Land Survey System (1834) from file "PLSS_SurveyData.shp"
[30] History of the Village of Howard: http://www.villageofhoward.com/245/History (accessed on 16 Dec 2017)
[31] Howlett, Jr. 1974: The rooted vegetation of west Green Bay with reference to environmental change

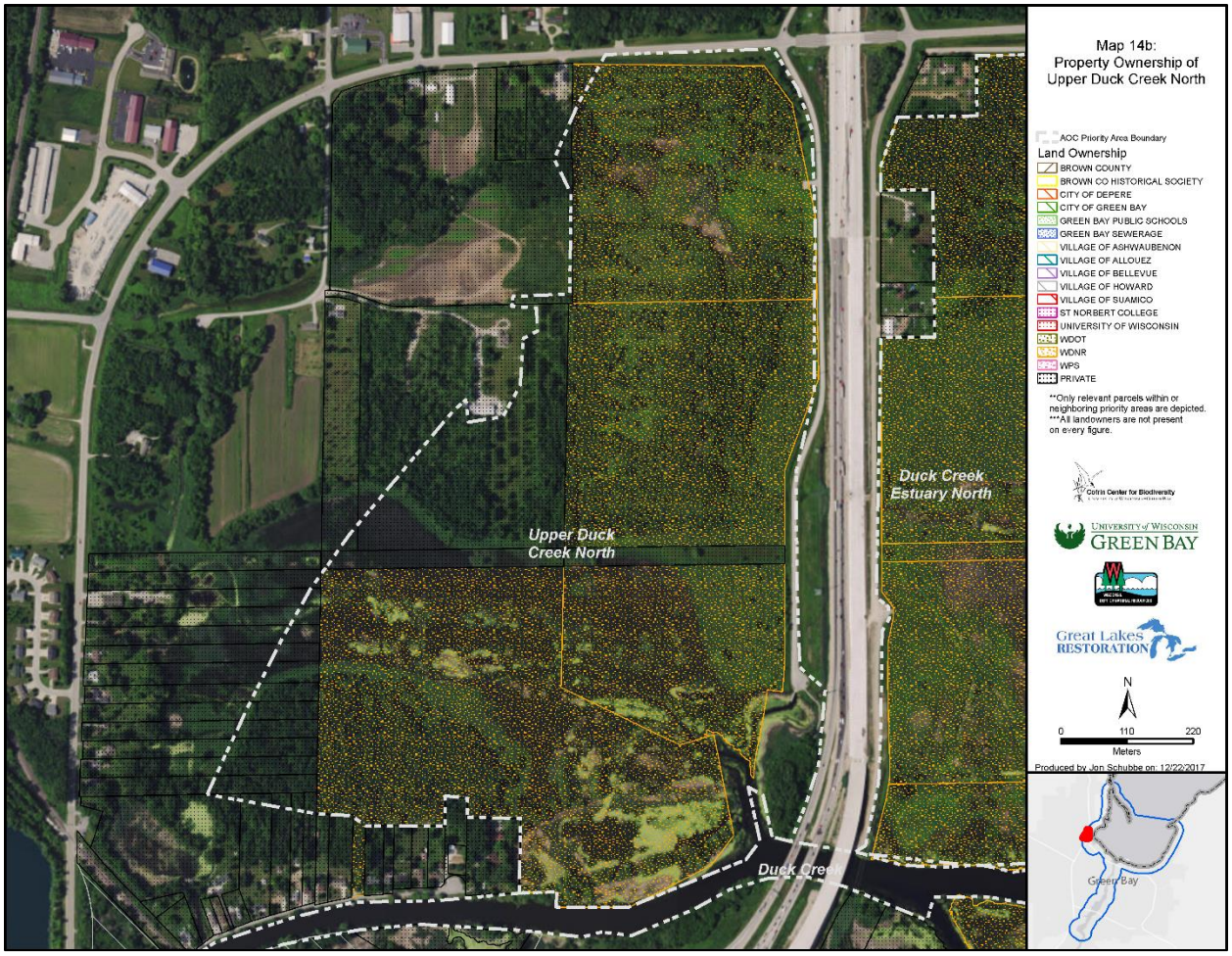
	were found in large numbers in Duck Creek in the 1970s, especially yellow perch[9,32]. In fact, there used to be a carp fishing crew based out of the Duck Creek area[31]. Unfortunately, between 1834 and 1975, 3.64 km^2 (2.26 mi^2) out of 4.07 km^2 (2.53 mi^2) of marsh were lost between the Fox River and Duck Creek due to the construction of Highways 41 and 141, a landfill, and dredge spoil deposition[33]. Between Duck Creek and the Little Suamico River, 1.92 km^2 (1.19 mi^2) out of 2.56 km^2 (1.59 mi^2) of wetland were also lost[33]. Unlike many parts of the Duck Creek Delta, the Upper Duck Creek North priority area is not well studied, at least not in recent years, with a few exceptions: • In 2012, the WDNR applied herbicide primarily targeting *Phragmites* throughout the emergent high energy marsh in Upper Duck Creek North[34]. • The Oneida Tribe recently led a dam removal project in collaboration with the WDNR, Brown County, FWS, and the Oneida Golf and Country Club[35]. By the fall of 2012, they had removed two dams and modified another one in order to improve fish passage for northern pike and other fish species[35]. • A group of high school students and teachers have conducted water quality monitoring (e.g., stream flow, pH, dissolved oxygen) for many years further upstream in Duck Creek for the Lower Fox River Watershed Monitoring Program[36]. • The UW-Green Bay's Cofrin Center for Biodiversity led a LGB&FR AOC bird survey effort in 2015, habitat mapping effort in 2015, plant biodiversity hotspot mapping and inventory in 2016, and submerged aquatic vegetation mapping in 2017[37]. All of these field efforts included surveys at Upper Duck Creek North.

[32] Fish and Wildlife Resources of the Great Lakes Coastal Wetlands within the United States, Volume 5: Lake Michigan, Part 3, October 1981
[33] Bosley 1978: Loss of wetlands on the west shore of Green Bay
[34] WDNR Phragmites treatment shapefile: "Aerial.shp"
[35] Dam removal project led by the Oneida Tribe: https://greatlakesinform.org/projects-and-progress/498
[36] Lower Fox River Watershed Monitoring Program: https://www.uwgb.edu/watershed/monitoring/overview.asp
[37] LGB&FR AOC Submerged Aquatic Vegetation Surveys 2017 – led by Dr. Amy Wolf and Dr. James Horn

Map of Upper Duck Creek North's plant communities, which are delineated based on the UW-Green Bay 2015 habitat mapping effort and 2017 submerged aquatic vegetation surveys. Map made by UW-Green Bay's Jon Schubbe. A small patch of southern sedge meadow was found by Dr. James Horn during the LGB&FR AOC 2016 plant biodiversity hotspot mapping and its general location is indicated by the yellow star below.



Land ownership boundaries at Upper Duck Creek North. Map made by UW-Green Bay's Jon Schubbe.



Photograph of the Upper Duck Creek North priority area in the background, to the west of Interstate 41. The mouth of Duck Creek and Duck Creek Estuary North are shown in the foreground. Photograph taken by Erin Giese on 2 December 2016 facing northwest.