WETLANDS OF PENNSYLVANIA'S LAKE ERIE WATERSHED

STATUS, CHARACTERIZATION, LANDSCAPE-LEVEL FUNCTIONAL ASSESSMENT, AND POTENTIAL RESTORATION SITES

U.S. FISH AND WILDLIFE SERVICE   MAY 2014

Cover: Hardwood flat in the Lake Erie watershed. (Kevin Hess photo)
Classifications: 1) Palustrine Forested Wetland Seasonally Saturated, Partly Drained;
2) Terrene Flat Outflow, Headwater

U.S. Fish and Wildlife Service

Wetlands of Pennsylvania's Lake Erie Watershed: Status, Characterization, Landscape-level Functional Assessment, and Potential Restoration Sites

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TABLE OF CONTENTS

Least Bittern (Brian Berchtold)

INTRODUCTION

The Pennsylvania's Coastal Zone Management Program (PACZM) has cooperated with the U.S. Fish and Wildlife Service (FWS) to inventory wetlands in the state's coastal zone since the 1980s. The results of these projects were a set of maps, geospatial data, and reports (Tiner and Anderson 1986; Smith and Tiner 1992; Tiner and DeAlessio 2002). In 2012, PACZM contacted the National Wetlands Inventory Program (NWI) of the FWS's Northeast Region regarding their interest in updating and upgrading NWI data for the Lake Erie watershed in western Pennsylvania. Although NWI data for the Lake Erie coastal zone had been updated with 1989 imagery, the existing NWI data for the rest of the watershed was mostly from 1977. The latter data were extremely conservative in mapping wetlands given the quality of the imagery (spring and early summer 1:80,000 black and white photography). More current data were needed to help manage wetlands across the entire watershed. In July of 2012, the agencies officially entered into a cooperative agreement to produce more current wetlands data for the Lake Erie watershed.

During the past two decades, the Northeast Region of the U.S. Fish and Wildlife Service developed techniques for using NWI data to better characterize wetlands and predict wetland functions at the watershed scale or landscape level. The techniques involve adding hydrogeomorphic-type descriptors to standard NWI data to create what is now called a "NWI+ database" (Tiner 2010, 2011a). This expanded database has more attributes assigned to mapped wetlands to describe wetlands beyond what was possible through conventional NWI classification. These techniques were used in the early 2002 to report on the status and trends of wetlands in Pennsylvania's coastal zones (Tiner and DeAlessio 2002).

The Lake Erie watershed wetlands inventory involved updating existing NWI data for the watershed, expanding wetland classification by adding hydrogeomorphic properties to the create an NWI+ geospatial database, and using the results of the NWI+ data to predict wetland functions at the landscape scale. In addition, because multiple data sources were being analyzed, the project also included an inventory of potential wetland restoration sites. This report briefly describes the methodology employed and presents the results of the expanded inventory, the watershed-wide prediction of wetland functions, and the inventory of potential wetland restoration sites. In addition, a general overview of historic wetlands losses are presented based on an analysis of available soil survey data and recent land use/land cover data. The report is divided into three basic sections addressing: 1) current status, characterization of wetlands, and predicted wetland functions, 2) potential wetland restoration opportunities, and 3) historic perspective on wetland losses. The geospatial data produced for this project can be viewed through an online mapper (see Results). Although waterbodies were also classified by this project, the emphasis of this report will be on wetlands with only some reference to waterbody classification.

Study Area

The Lake Erie watershed of Pennsylvania encompasses about 515 square miles of land and water in Erie and Crawford Counties including Presque Isle Bay and many streams and ponds between New York and Ohio (Figure 1). This area is located in a region that was covered in ice during the last glaciation over 10,000 years ago and contains much glacial till and lake deposits from historically high levels of Lake Erie (Shepps et al. 1959). The watershed includes all Pennsylvania lands that drain into Lake Erie. Presque Isle, a lacustrine barrier spit extending from the city of Erie into Lake Erie, and its embayments are arguably the most prominent features in the watershed. Many watercourses provide drainage for the watershed. Generally moving from west to east they include Turkey Creek, Raccoon Creek, Crooked Creek, Elk Creek (with tributaries including Halls Run, Brandy Run, Lamson Run, Falk Run, and Little Elk Creek and its East and West Branches), Trout Run, Walnut Creek, Mill Creek, Fourmile Creek, Sixmile Creek, Sevenmile Creek, Elliots Run, Eightmile Creek, Scott Run, Twelvemile Creek, Sixteenmile Creek, and Twentymile Creek). The watershed also includes areas draining into Lake Erie via the Ashtabula River (e.g., East Branch and Ashtabula Creek). Lakes are conspicuously absent from this watershed's drainage area, with one exception – a shallow lake in Conneaut on State Game Lands Number 101. For more information on the water resources of the watershed, visit U.S. Geological Survey's website: http://water.usgs.gov/lookup/getwatershed?04120101/www/cgi-bin/lookup/getwatershed.

Figure 1. Lake Erie watershed of Pennsylvania. Project work area outlined in red.

WETLAND STATUS, CHARACTERIZATION, AND FUNCTIONAL ASSESSMENT

The main part of the wetlands mapping project involved producing an updated and enhanced wetlands inventory to provide current information on the status of the watershed's wetlands and to use that data to predict wetland functions for the entire Lake Erie watershed. This section of the report describes the methods used and limitations of the inventory and presents the results in narrative form along with a discussion of the limitations of the landscape-level functional assessment. An online mapping tool is used to display "maps" showing the results of the survey and watershed-wide wetland functional assessment.

METHODS

Updating the Wetland Inventory

For updating purposes, recent digital imagery was examined to inventory wetlands and deepwater habitats using ESRI's ArcMap 10.0. Wetlands and deepwater habitats were classified according to the official FWS classification system (Cowardin et al. 1979).[1] A geospatial wetland-deepwater habitat data layer was created through the following process. Several sources of aerial imagery were used for the interpretation: 2009 true-color leaf-off, 2005/6 true color leaf-off and the 2011 color infrared (CIR) leaf-off imagery, resulting in an effective date of 2011 for this inventory. The CIR photography was provided by PACZM for this project; it was georeferenced by matching it to rectified imagery for use in a geospatial environment. Imagery was viewed at a working scale of 1:10,000 while in many cases, image analysts zoomed to larger scales to check signatures and refine boundaries. During this process, the FWS's original wetland geospatial data (1980s wetlands) were reviewed using GIS techniques. Areas mapped as a wetland in the previous inventory that remained unaltered were included in this update unless interpreters felt that such areas were incorrectly identified due to topography or other factors. In many cases, the orientation and configuration of virtually all of these wetlands were adjusted to match the recent imagery. (*Note: Prior inventory data were transferred from aerial imagery to hardcopy topographic base maps via conventional cartographic techniques, i.e., zoom transfer scope.*) Collateral data sources used to help identify wetlands are listed in Table 1. The watershed boundary is largely that of U.S. Geological Survey hydrologic unit – 04120101 (Chautauqua-Conneaut) plus Presque Isle and a portion of Pennsylvania draining into Lake Erie via tributaries to the Ashtabula River.

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[1] This classification was adopted by the Federal Geographic Data Committee as the national standard for classifying wetlands when creating federally supported geospatial data (Federal Geographic Data Committee 1996).

Table 1. Data sources used in the inventory.

Primary Imagery Sources

1:30,000 Color-infrared Leaf-off (2011):
Provided by Pennsylvania Coastal Zone Management Program (PACZM)
Raster Data: 1 meter True Color Leaf-off (2009):
ftp://pamap.pasda.psu.edu/nga-usgs_imagery/200904_erie_pa/TIF/
Raster Data: 1 foot True Color Leaf-off (2005-2006):
http://www.dcnr.state.pa.us/topogeo/pamap/imagery/

Ancillary Data

Raster Data: True Color NAIP (2010): http://datagateway.nrcs.usda.gov/
Raster Data: 1-meter LiDAR derived Digital Elevation Model (DEM):
http://data1.commons.psu.edu/arcgis/services/pasda/PAMAP_Hillshade
(ArcGIS Server)
Raster Data: NRCS Digital Raster Graphics (DRG): http://datagateway.nrcs.usda.gov/
Vector Data: SSURGO Hydric Soil Data: http://datagateway.nrcs.usda.gov/
Vector Data: National Hydrography Dataset (NHD): http://datagateway.nrcs.usda.gov/
Vector Data: 1977/83/89 National Wetlands Inventory Data:
http://www.fws.gov/wetlands/Data/State-Downloads.html

Adding Other Areas that May Support Wetlands

While the mapping methods relied on interpretation of aerial imagery, the inventory used existing soil survey data. These surveys identified hydric soil mapping units that in their unaltered condition should support wetlands. Many of the hydric soil mapping units had photo-signatures that were interpretable as wetlands and were therefore classified as wetlands. There were, however, many other hydric soil units or portions of such units that did not. Some of the latter areas were developed (e.g., residential areas, impervious surfaces, or farmland) while others remained in "natural vegetation." The latter sites may include at least some wetland and were therefore designated as "P-wet areas" – areas with potential to support wetlands based on soil mapping.

Creating the NWI+ Database

Since a major objective of the wetlands inventory was to predict wetland functions for the watershed, hydrogeomorphic-type characteristics needed to be added to the wetlands database. These properties include landscape position, landform, water flow path, and waterbody type ("LLWW descriptors" representing the first letter of each feature). This information when combined with the basic wetland features from the Cowardin et al. classification (system, class, subclass, water regime, and special modifiers) greatly expands the functionality of the wetlands database, creating what is now called a "NWI+ database." By reviewing the literature and working with wetland specialists across the Northeast Region and beyond, a set of correlations linking the attributes in the NWI+ database to numerous wetland functions have been established (Tiner 2003, 2011b). An overview of this process and applications can be found in "NWIPlus: Geospatial Data for Watershed-level Functional Assessment" (Tiner 2010).

The updated wetlands inventory based on 2011 imagery served as the foundation for this characterization and functional assessment. To expand the wetland classification, the mapped wetlands were re-examined using digital geospatial data for streams (National Hydrography Data, NHD), topography (Digital Raster Graphics, DRGs), elevation (Digital Elevation Models, DEMs), and digital imagery from the summer of 2010 (Table 1). Adding hydrogeomorphic-type descriptors to existing wetland inventory data created an "NWI+ database" that could be further expanded to include other geospatial data such as wetlands of significance for a variety of functions and potential wetland restoration sites.

Expanded Wetland Classification

The LLWW classification contains four major elements to describe wetlands beyond the Cowardin et al. (1979) classification: 1) landscape position, 2) landform, 3) water flow path, and 4) waterbody type (Tiner 2011a). These hydrogeomorphic-type descriptors focus on abiotic properties that are vital to predicting wetland functions.

Five landscape positions describe the location of a wetland relative to a waterbody if present: 1) *marine* (along the ocean), 2) *estuarine* (along tidal brackish waters), 3) *lotic* (along rivers and streams and subject to overflow), 4) *lentic* (in basins of lakes and reservoirs), and 5) *terrene* (sources of streams or isolated – completely surrounded by upland, or not affected by the aforementioned waters). The first two landscape positions are not relevant for the Lake Erie watershed.

Landform describes the physical shape of the wetland. Several types are recognized: *basin* (depressional wetland), *flat* (wetland on a nearly level plain), *floodplain* (overflow land along rivers subject to periodic inundation), *fringe* (wetland in water, within the banks of a river, or on an estuarine intertidal plain), *island* (wetland completely surrounded by water), and *slope* (wetland on a hillside). A new landform – *peatland* – will be added in the near future to address formations of organic soils (bogs and fens) created by two processes: terrestrialization (in-filling of lakes and other waterbodies) and paludification (the blanketing of neighboring lands by peat moss followed by a succession of vascular plants).

Water flow path defines the direction of flow of water associated with the wetlands (Table 2). If the wetland is a source of a stream or a seep, it is an *outflow* wetland. River and streamside wetlands are *throughflow* wetlands with water running through them (both into and out of) during high water periods. Wetlands that only receive water from channelized flow without any outflow are considered *inflow* wetlands. Some wetlands have no channelized inflow or outflow (i.e., lack an inlet or an outlet); water rises and falls in response to changes in precipitation, snow melt, local runoff, evapotranspiration, and groundwater recharge. Water movement in these seemingly isolated wetlands is described as *vertical flow*. Wetlands along lakes and reservoirs have water levels that rise and fall with lake levels and are classified as *bidirectional-nontidal*; lakeshore wetlands associated with streams are described as *throughflow*. A new modifier has been added to bidirectional-nontidal to describe the hydrologic relationship between landlocked wetlands on Presque Island and Lake Erie levels via groundwater movement through sandy soils: *groundwater lake-influenced* (i.e., *Bidirectional, groundwater lake-influenced*).

The characteristics of all mapped wetlands and waterbodies were expanded by adding the above attributes plus waterbody type and some other descriptors (e.g., headwater) (Figure 2; see Table 3 for outline of steps). This NWI+ database would be used to describe wetlands in more detail than provided by Cowardin et al. (1979) and to predict eleven functions for the wetlands of the Lake Erie watershed.

Classifications: 1) Lacustrine Aquatic Bed/Emergent Wetland Semipermanently Flooded (foreground) and Palustrine Emergent Wetland Seasonally Flooded (background); 2) Lentic Fringe Wetland Bidirectional Flow (foreground), Lentic BasinWetland Bidirectional Flow at Presque Isle State Park (Kevin Hess)

Table 2. Brief definitions of water flow paths used in this study.

Water Flow Path (map code)	Definition
Bidirectional-outflow (BO)	Water levels rise and fall with water in an outflow lake
Bidirectional-throughflow (TB)	Water levels rise and fall with water in a throughflow lake
Bidirectional-groundwater lake-influenced (BIgl)	Water levels change in response to lake level effects on groundwater
Inflow (IN)	Water flows into an area with no surface flow outlet (a closed system); collected water is lost through evaporation, transpiration and possibly groundwater recharge
Outflow-artificial (OA)	Water flows out of the system through a ditch or manmade channel; no direct surface water inflow
Outflow-intermittent (OI)	Water flows out of the system periodically usually during the wet season or during and shortly after heavy rains; no direct surface water inflow; typically associated with intermittent streams and groundwater discharge; may be the source of a stream
Outflow-perennial (OU)	Water flows out of the system year-round; no direct surface water inflow; typically associated with perennial streams, rivers and groundwater discharge; often the source of a stream
Throughflow-artificial (TA)	Water enters from a water source above and flows out of the system via a ditch or manmade channel or canal
Throughflow-intermittent (TI)	Water enters from a water source above and flows out of the system via an intermittent stream; flow usually occurs during the wet season or during and shortly after heavy rains
Throughflow-perennial (TH)	Water flows through the system more or less year-round via a perennial stream; wetlands subject to seasonal overflow
Vertical Flow (VR)	Water levels affected by precipitation, local runoff and groundwater; no apparent surface water inlet or outlet

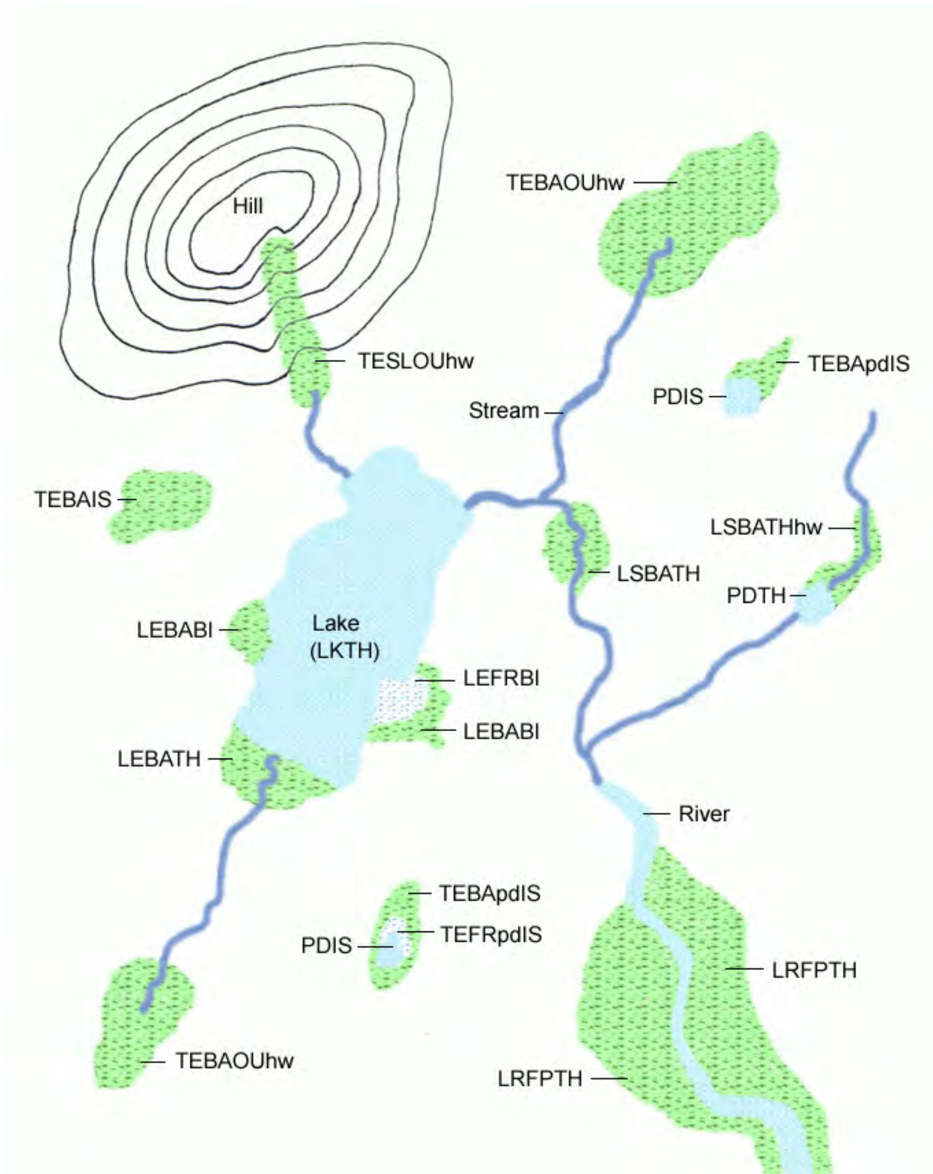


Figure 2. Nontidal wetlands classified by abiotic features: landscape position – TE (terrene), LE (lentic), LR (lotic river), LS (lotic stream); landform – BA (basin), FP (floodplain), FR (fringe), SL (slope) [FL – flat not shown]; water flow path – IS (vertical flow), TH (throughflow), OU (outflow), BI (bidirectional-nontidal); waterbody type – PD (pond), LK (lake); other modifiers: hw (headwater), pd (pond-associated wetland). To interpret code: TEBAIS = terrene basin vertical flow and LSBATH = lotic stream basin throughflow.

Table 3. Expanding wetland classification involves both automated and manual routines.

Step 1. Automation

a. Parse the Cowardin field.

b. Run Cowardin to LLWW tool that only populates known values, mostly marine and estuarine types.

Step 2. Manual Interpretation with some Automation

a. Intersect wetlands with the National Hydrography Data (NHD) layer using the FCODE 46003 for intermittent and 46006 for perennial throughflow. This will give a foundation to build from and greatly increases speed of visual interpretation.

b. Intersect the wetlands with the NHD layer using all linears, and then select all adjacent polygons to these selected wetlands until no new selections are made. The remaining polygons are seeded with the vertical flow path. Further inspection will require some polygons to be changed to outflows based of the more accurate DRG layer.

Step 3. Manual Review

a. Visual inspection using the Digital Raster Graphic (DRG) and already populated polygons to finish populating the water flow path.

b. Visual inspection of all lake basins is done to determine the proper flow for lentic wetlands.

c. Once everything has a correct flow using established relationships based on said flow, landscape and then landform are determined. Regional exceptions to these relationships are then applied as necessary.

d. Other modifiers such as tidal restriction and estuary discharge are done visually.

e. Outflows are generally considered headwater, and visual interpretation along with the NHD layer (which is used to display NHD headwaters) is used to determine other headwaters.

f. Error checking and consistency steps including later review during analyses.

Data Analysis and Compilation

ArcInfo 10.0 was used to analyze the data and produce wetland statistics (acreage summaries) for the study area. Tables were prepared to summarize the results of the inventory. After running the analyses, the data were used to produce a set of data layers that could be viewed via an online mapper (http://www.aswm.org/wetland-science/wetlands-one-stop-mapping/5043-nwi-web-mapper; Table 4). Statistics (acreage summaries) were mostly generated from Microsoft's Access program. Excel spreadsheets were also used to compile the summary statistics. *Special Note: When summarizing data, percentages given usually refer to percent of wetland acreage, while for convenience, the narrative will refer to them as "percent of wetlands."*

The NWI+ database was used to generate acreage summaries of wetlands and deepwater habitats grouped by the Cowardin et al. types and LLWW types (landscape position, landform, and water flow path) and to predict functions for the watershed's wetlands. To do the latter, relationships between properties in the NWI+ database and a variety of wetland functions had to be established. From previous studies, a table listing each of 10 functions and the relevant wetland properties was used to identify wetlands with potential to perform each function at high or moderate levels (Appendix A). The 10 functions were: 1) surface water detention (for nontidal wetlands only), 2) streamflow maintenance, 3) nutrient transformation, 4) sediment and other particulate retention, 5) carbon sequestration, 6) bank and shoreline stabilization, 7) provision of fish and aquatic invertebrate habitat, 8) provision of waterfowl and waterbird habitat, 9) provision of habitat for other wildlife, and 10) provision of habitat for unique, uncommon, or highly diverse wetland plant communities. The foundation for the functional assessment was an earlier report relating specific wetland types to functional performance (Tiner 2003, slightly revised based on more recent applications, e.g., Tiner 2011b).

Field Work

Since extensive field work had been conducted during the late 1980s survey, the 2010 inventory did not require a considerable investment in field investigation. A few days of field work was done in the fall of 2013 to check preliminary interpretations by image analysts.

Geospatial Data and Online Map Production

The NWI+ database was uploaded to an online mapping tool – NWI+ Web Mapper – using ESRI's ArcGIS online mapping service (Appendix B). Data layers included classifications of wetlands by NWI types (Cowardin et al. 1979), landscape position, landform, water flow path, and by their predicted potential to provide various functions, "P-wet areas" (other areas that may support wetlands based on soil mapping), and two types of potential wetland restoration sites. Using the online mapper allows users to zoom into specific areas of interest and thereby see more detail than could be provided by producing maps for a report. Moreover, the tool permits the user to display the data on aerial imagery or topographic or planimetric maps and to produce custom maps for use in reports or for other purposes. The geospatial data produced for this project allows for other geographic analyses (e.g., smaller watersheds, counties, towns, and other areas of special interest). Geospatial data will be available from PACZM.

Classifications: 1) Palustrine Forested/Emergent Wetland Seasonally Flooded; 2) Lotic Stream Basin Throughflow Wetland, Beaver-influenced (Kevin Hess)

Classifications: 1) Palustrine Unconsolidated Bottom Permanently Flooded, Beaver-created; 2) Lotic Stream Pond Throughflow, Beaver-influenced (Kevin Hess)

GENERAL SCOPE AND LIMITATIONS OF THE INVENTORY

Since the wetland data were derived from 2011 imagery, changes in some wetlands have occurred since then that are not reflected in the database. These changes may be due to: 1) permitted alterations by Federal, state, and local governments, 2) unauthorized activities impacting wetlands, 3) new pond construction, 4) natural processes (including erosion and accretion), and 5) differences in interpretation based on the quality of the source imagery. For example, Presque Isle State Park has recently initiated an aggressive *Phragmites* control campaign and many areas that were mapped as *Phragmites* (PEM5_) may be converting to other emergent species. In any event, the 2011 database should reasonably reflect current conditions because wetlands are subject to regulation by Federal and state agencies, and in some cases, by local governments.

It is important to recognize the limitations of any wetland mapping effort derived mainly through photointerpretation techniques (see Tiner 1990 and 1999 for details). Wetland data derived from these techniques do not show all wetlands. Some wetlands are simply too small to map given the imagery used, while others avoid detection due to evergreen tree cover, dry surface conditions, or other factors. The minimum target mapping unit was a one-half acre wetland, but many wetlands (especially ponds) smaller than this were mapped. Mapped wetlands may contain small areas that are different from the mapped type – inclusions – due to scale and map complexity issues. For example, a 10-acre forested wetland may include a 0.5-acre stand of emergent wetland and a 0.5-acre upland island that may not be pulled out of the larger wetland forest unit. Beach areas along the shores of Lake Erie were mapped as Lacustrine Unconsolidated Shores and may include portions of dunes (upland) due to scale limitations. Drier-end wetlands such as seasonally saturated and temporarily flooded palustrine wetlands are often difficult to separate from nonwetlands through photointerpretation. This area of Pennsylvania contained numerous seasonally saturated flatwoods on glaciolacustrine plains and on terraces in the rolling hills. To minimize their omission from the inventory, the “P-wet areas” data layer was created by using hydric soil data to identify locations where such wetlands may exist. P-wet areas were intended to represent undeveloped hydric soil areas not mapped as wetlands, but some P-wet areas may include small portions of developed areas due to scale and land use changes since the survey. Other areas that may support wetlands can be interpreted from USDA soils data – look for special feature symbols (i.e., the crow foot) that indicate wet spots detected during soil surveys, or from U.S. Geological Survey topographic maps via the “swamp” symbol. Finally, despite our best attempts at quality control, some errors of interpretation and classification are likely to occur due to the sheer number of polygons in the wetland database.

RESULTS

Geospatial Data and Online Mapper

Geospatial data for the Lake Erie watershed wetlands and deepwater habitats are available online via the NWI+ Web Mapper at http://www.aswm.org/wetland-science/wetlands-one-stop-mapping/5043-nwi-web-mapper (see Appendix A for an introduction to this tool). As mentioned earlier, custom maps for specific areas can be made using the online mapping tool with data displayed on a variety of basemaps (including aerial imagery). To view the location of wetlands (different types), P-wet areas, and wetlands of significance for various functions, readers must access the NWI+ Web Mapper. This ESRI-supported online mapping tool allows users to zoom in for more detail, to display results on a variety of basemaps, and to print maps for areas of interest.

Classifications: 1) Palustrine Emergent/Scrub-Shrub Wetland, Seasonally Flooded; 2) Lentic Basin Bidirectional, Groundwater-lake influenced (Kevin Hess).

Table 4. List of data layers included on the Wetlands One-Stop Web Mapper that were prepared for the Lake Erie watershed of Pennsylvania. Note that the legend for each thematic layer must be opened by clicking on the "Show Legend Tool" on the toolbar at the top of the mapper and then on the mark on the left of the applicable data layer on the list of legends.

"NWI+ Footprints" – shows project areas where some types of NWI+ data are available

"Wetland Codes" – shows dots on the wetlands and deepwataer that when clicked on opens a table that displays their classification by NWI type and by LLWW type

"NWI Types" – shows mapped wetlands and deepwater habitats by Cowardin et al. types

"NWI+ Landscape" – shows mapped wetlands classified by landscape position (color-coded types – view legend as described above)

"NWI+ Landform" – shows mapped wetlands classified by landform (color-coded types – view legend as described above)

"NWI+ WaterFlowPath" - shows mapped wetlands classified by water flow path (color-coded types – view legend as described above)

"______ Function" shows wetlands predicted to perform specific functions at significant levels (e.g., high or moderate): "BSS" (bank and shoreline stabilization, "CAR" (carbon sequestration, "CSS" (coastal storm surge detention), "FAIH" (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI codes only), and WBIRD (waterfowl and waterbird habitat).

"NWI+ P-WetAreas" – shows location of undeveloped hydric soils (not mapped as wetlands) that may support wetland in places

"NWI+ P-WetAreas Codes" – shows dots that when clicked on opens a table that displays the soil type for the area based on USDA soil surveys

"NWI+ Restoration Type1" – shows location and type of former wetlands that may be suitable for restoration

"NWI+ Restoration Type 2" – shows location and type of existing wetlands that are impaired in some way that could be restored to improve their current condition and/or function

"NWI+ P_RestType1 Soil Codes" – shows dots that when clicked on opens a table showing the soil type for Type 1 restoration sites

Status and Characterization of Wetlands

Wetlands Classified by NWI Type

A total of 29,904 acres of wetlands were mapped in the watershed (Table 5). This figure represents 9% of the Lake Erie watershed. Palustrine wetlands are the predominant type comprising 95% of the watershed's wetlands (Figure 3). Lacustrine wetlands - nearly all of which were associated with Lake Erie and Presque Isle - accounted for virtually all of the remainder (except for 106 acres of riverine wetlands).

Forested wetlands were most abundant accounting for 75% of the area's wetlands and 79% of the palustrine types (Figure 4). Scrub-shrub wetlands and emergent types (marshes and wet meadows) were next in abundance in nearly equal amounts. Ponds and the shallow lacustrine waters made up the bulk of the remaining types. Lacustrine wetlands occurred along the Lake Erie shoreline, mostly around Presque Isle. Shallow littoral unconsolidated bottoms were the most abundant lacustrine wetland type occupying the fringes of Presque Isle Bay, Misery Bay, and Thompson Bay (Figure 5). Only 106 acres of the riverine wetlands were inventoried.

From a hydrologic standpoint, 42% of the watershed's wetlands (12,576.8 acres) were classified as seasonally saturated (Figure 6). They are flatwoods that may have some standing water after snow melt and after heavy rains and a water table near the surface in spring that draws down considerably during summer. About 27% of the wetlands (8,275.9 acres) were seasonally flooded with water present on the surface for extended periods and most of these areas have high water tables extending into summer. Temporarily flooded wetlands accounted for 20% of the wetlands (5,819.2 acres); they were mostly found on floodplains. Permanently flooded wetlands (mainly ponds) comprised 10% of the wetlands (2,865.4 acres), while semipermanently flooded wetlands (343.4 acres) made up most of the remaining types. Five acres of wetlands were classified as artificially flooded and 18.4 acres of farmed wetlands were not assigned a water regime. The latter are likely to be seasonally saturated.

Humans and beaver have had an impact on the watershed's wetlands. Four percent were partly drained by ditching (1,248.9 acres), while 4.8% were impounded (1,431.5 acres) and 2.2% excavated (656.1 acres). Only 18.4 acres of farmed wetlands were identified while many acres of former wetland (hydric soil areas) are in active agricultural use. Beaver activity was detected in only 236.8 acres of watershed's wetlands. The effect of other human activities on wetlands, such as well construction, was not evaluated.

Table 5. Acreage of wetlands in Pennsylvania's Lake Erie watershed classified according to Cowardin et al. (1979). **Note: Presque Isle State Park is now actively managing this species within its borders.*

System	Class		Acreage
Palustrine	Aquatic Bed		148.8
	Emergent		
		Phragmites-dominated*	126.2
		Other Emergent	1,902.8 (*4.3 w/Phragmites)*
		(Subtotal Emergent)	(2,029.0)
	Forested		
		Evergreen	259.4
		Deciduous	19,983.8
		Mixed Forested	1,445.8
		Mixed/Scrub-Shrub	768.6
		Mixed/Emergent	39.3 (*8.2 w/Phragmites*)
		Dead	2.9
		(Subtotal Forested)	(22,499.8)
	Scrub-Shrub		1,256.8
	Scrub-Shrub/Emergent		545.7 (*2.8 w/Phragmites*)
	Scrub-Shrub/Forested		265.9
	Scrub-Shrub/Aquatic Bed		1.6
		(Subtotal Scrub-Shrub)	(2,070.0)
	Farmed		18.4
	(Vegetated Total)		*(26,766.0)*
	Unconsolidated Bottom		1,611.6
	Unconsolidated Shore		13.6
	(Nonvegetated Total)		*(1,625.2)*
Total Palustrine			***28,391.2***
Lacustrine	Aquatic Bed		115.5
	(Vegetated Total)		*(115.5)*
	Unconsolidated Bottom		1,063.4
	Unconsolidated Shore		228.4
	(Nonvegetated Total)		*(1,291.8)*
Total Lacustrine			***1,407.3***
Riverine	Unconsolidated Shore		86.6
	Rocky Shore		19.1
Total Riverine			***105.7***
TOTAL MAPPED			**29,904.2**

Figure 3. Wetlands classified by ecological system.

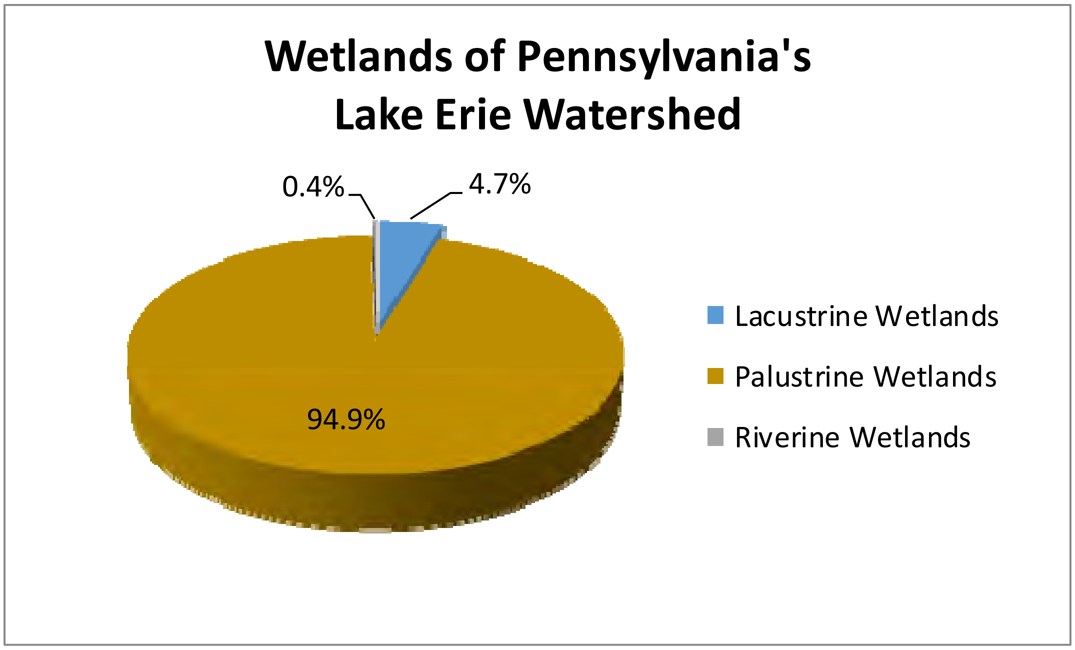


Figure 4. Distribution of palustrine wetlands by wetland class. "Nonvegetated" type includes mostly ponds (unconsolidated bottoms), but also unconsolidated shores and farmed wetlands.

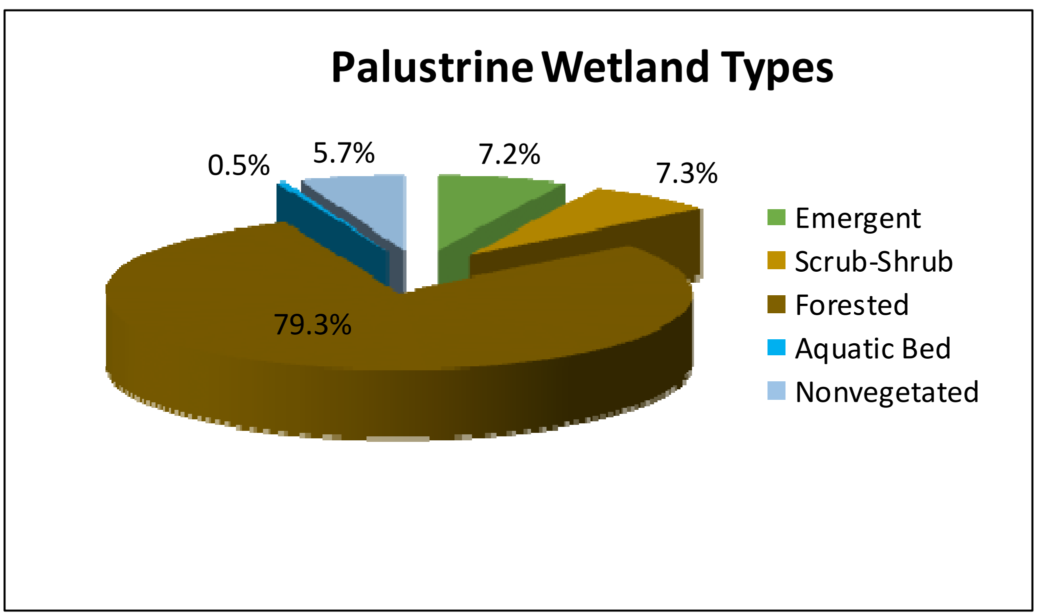


Figure 5. Distribution of lacustrine wetlands by wetland class.

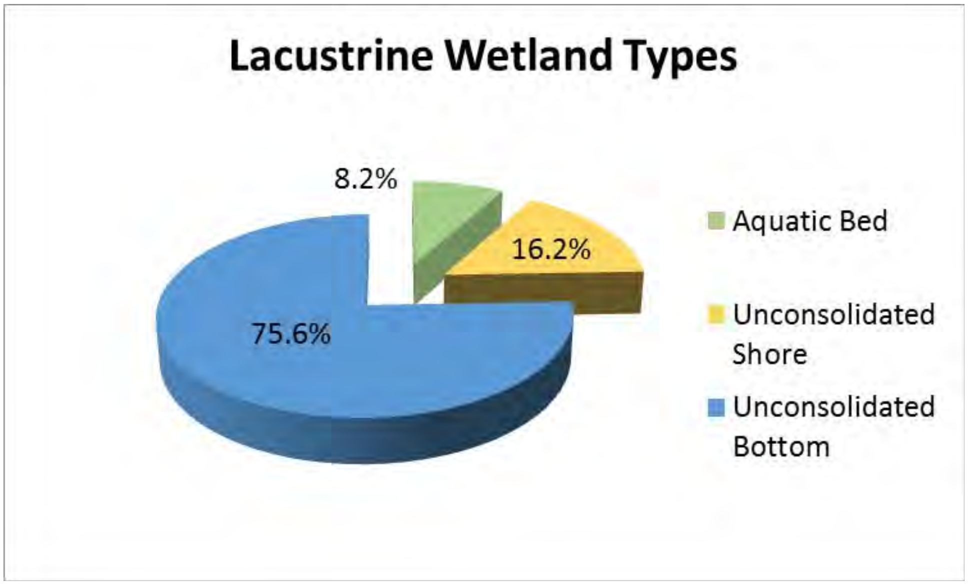
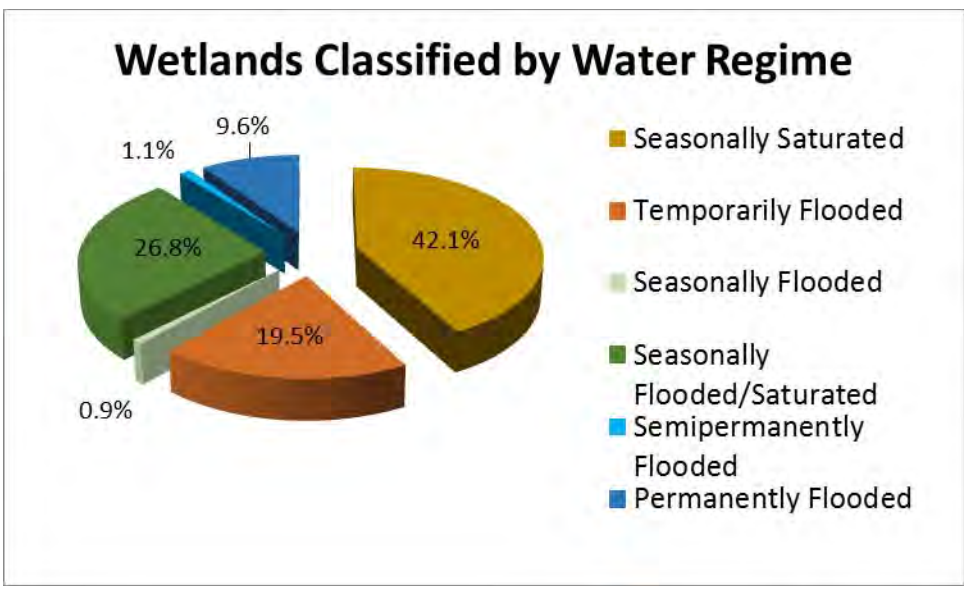


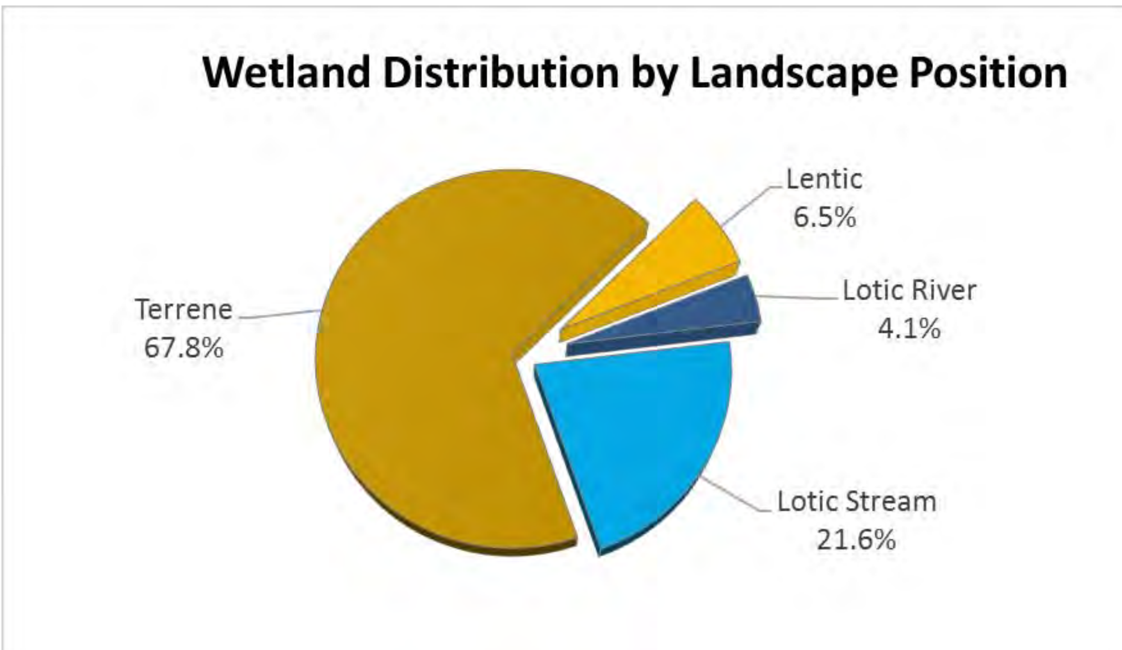
Figure 6. Extent of wetlands classified by water regime.



Wetlands Classified by LLWW Type

Slightly more than two-thirds of the watershed's wetlands were located in the terrene landscape position – the sources of streams and others lacking an apparent surface water inlet or outlet based on the imagery used and interpretation scale) (Figure 7; Table 6). Roughly one-quarter of the watershed's wetlands were associated with rivers and streams (lotic wetlands and in-stream ponds), while the remainder (nearly 7%) occurred along or were significantly influenced by Lake Erie (lentic wetlands).

Figure 7. Distribution of wetlands by landscape position according to Tiner (2011a).
Note: Ponds were assigned to a landscape position during the analysis phase of this project.



From the landform perspective, 57% of the watershed's wetlands were formed on broad flats (Figure 8). Basins and ponds accounted for 33% of the area's wetlands, while floodplain and fringe types accounted for about 4% each.

Forty-two percent of watershed's wetlands are outflow types that serve as sources of streams, while throughflow wetlands comprised 30% of the watershed's wetlands (Figure 9). The bulk of the remaining wetlands were characterized by vertical flow. Only 6% of the wetlands had bidirectional-nontidal flow; they were associated with Lake Erie with most on Presque Isle.

Table 6. Wetlands of Pennsylvania's Lake Erie watershed classified by LLWW descriptors according to Tiner (2011a). *(Note: Difference in sums is due to round-off procedures.)*

Landscape Position	Landform	Acreage	Water Flow Path	Acreage
Lentic	Basin	431.0	Bidirectional-outflow	1.1
	Flat	249.7	Bidirectional-throughflow	1,867.9
	Fringe	1,248.1	Outflow-perennial	64.5
	Island	3.3	Throughflow-perennial	5.7
	Pond	7.2	*Total*	*1,939.2*
	Total	*1,939.3*		
Lotic River	Floodplain	1,195.5	Throughflow-perennial	1,221.3
	Fringe	3.0		
	Pond	5.8		
	Total	*1,221.3*		
Lotic Stream	Basin	1,534.5	Throughflow-perennial	6,084.9
	Flat	4,339.3	Throughflow-intermittent	386.3
	Fringe	53.6	*Total*	*6,471.2*
	Slope	105.0		
	Pond	438.8		
	Total	*6,471.2*		
Terrene	Basin	6,207.7	Vertical Flow	6,575.8
	Flat	12,586.1	Outflow-artificial	785.3
	Fringe	32.2	Outflow-intermittent	3,588.9
	Slope	124.8	Outflow-perennial	8,059.3
	Pond	1,321.7	Throughflow-artificial	63.2
	Total	*20,272.5*	Bidirectional-throughflow	6.7
			Throughflow-perennial	1,184.9
			Throughflow-artificial	8.3
			Total	*20,272.4*

Figure 8. Distribution of wetlands by landform. "Other" includes slope and island landforms.

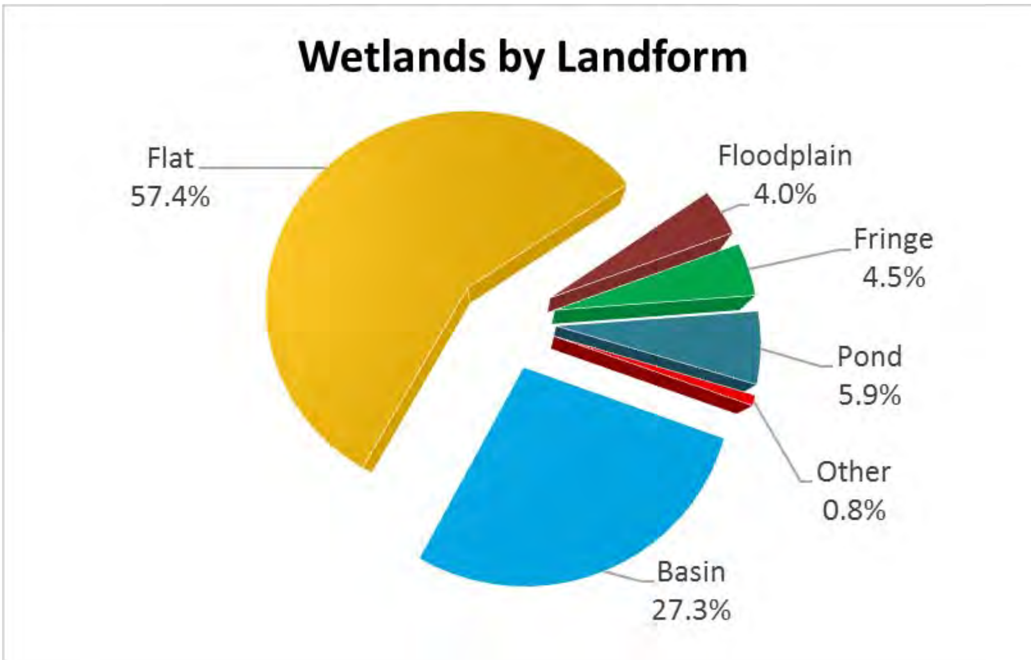
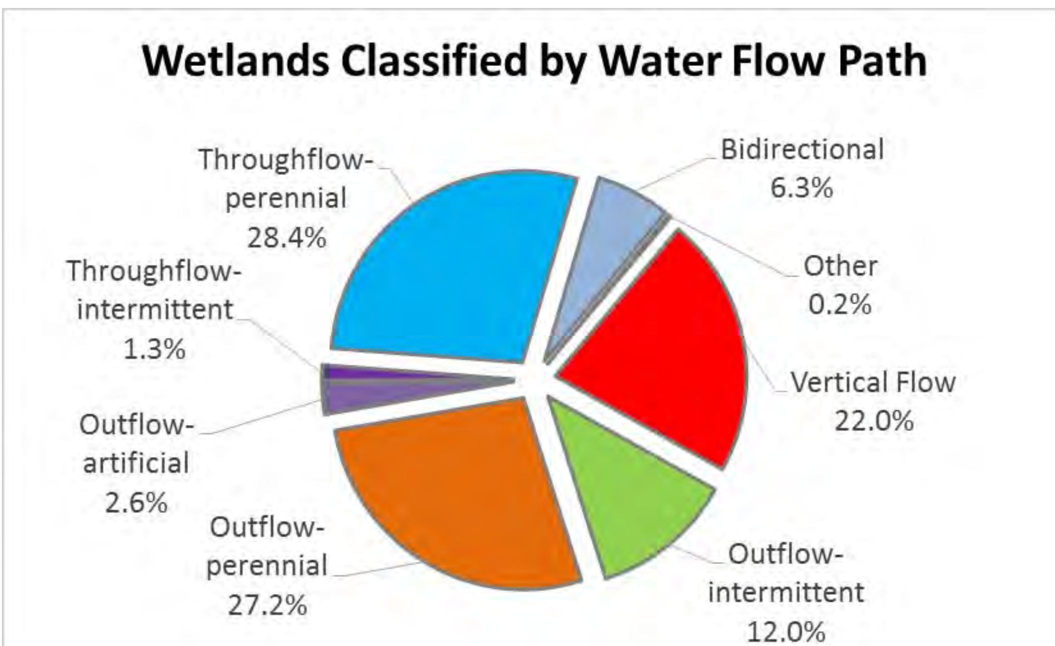


Figure 9. Distribution of wetlands by water flow path.



Status and Characterization of Waterbodies

Deepwater Habitats

Excluding Lake Erie, deepwater habitat in Pennsylvania's Lake Erie watershed were limited to rivers and the bays associated with Presque Isle. A total of 889 acres of riverine deepwater habitat was mapped. Lower perennial rivers accounted for 724 acres, while upper perennial rivers (faster flowing with little floodplain development) comprised 165 acres. Deepwater lacustrine habitat associated with by Presque Isle and Misery Bays occupied 2,782 acres, while the shallow water zone (considered wetland according to Cowardin et al. 1979) amounted to 624 acres. (*Note that the river total does not include most streams as they were too narrow to map.*)

Pond Types

A wide variety of ponds occurred in the watershed and the majority were created or altered (60% impounded and 31% excavated), with only 7 percent natural and 2 percent beaver-influenced (Table 7; Figure 10). Additional characteristics of natural ponds are given in Table 8, while Tables 9 and 10 present further classification of dammed/impounded and excavated ponds, respectively.

Table 7. Ponds of Pennsylvania's Lake Erie watershed classified according to Tiner (2011). *(Note: Difference in sums is due to computer round-off procedures.)*

Pond Type	**Acreage**	**Water Flow Path**	**Acreage**
Natural	120.5	Vertical Flow	1,052.7
Dammed/Impounded	1,057.1	Bidirectional/throughflow	7.2
Excavated	553.8	Outflow-artificial	32.2
Beaver	43.0	Outflow-intermittent	98.7
Total	*1,773.5*	Outflow-perennial	129.8
		Throughflow-artificial	8.3
		Throughflow-intermittent	70.2
		Throughflow-perennial	374.2
		Total	*1,773.3*

Figure 10. Distribution of different pond types in the Lake Erie watershed. These numbers include aquatic beds within the ponds, but do not include persistent vegetated wetlands associated with these waters.

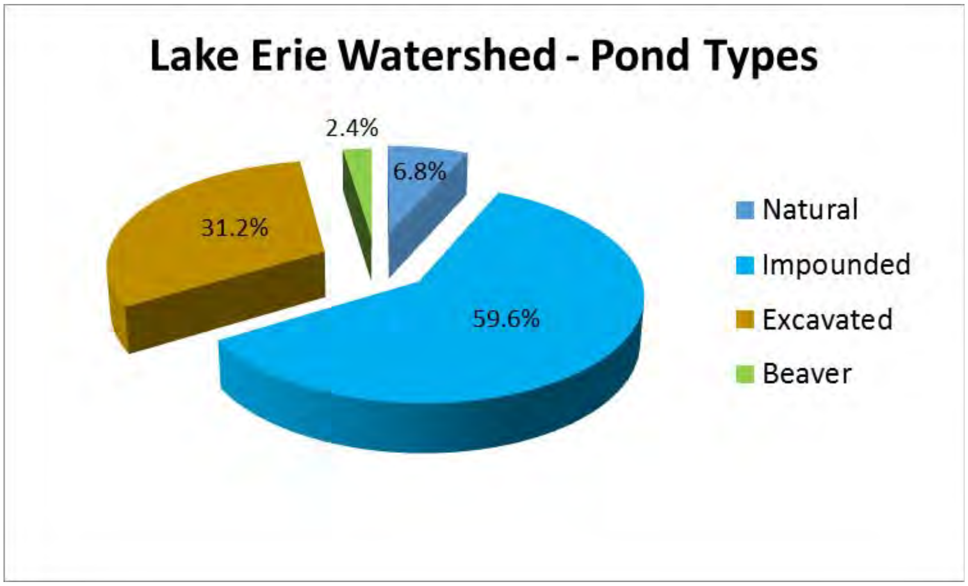


Table 8. Extent and characteristics of natural and beaver-created ponds.

Pond Type (code)	Acreage	Water Flow Path	Acreage
Woodland-wetland (PD1b)	107.9	Vertical Flow	18.9
Woodland-dryland (PD1c)	7.4	Outflow-artificial	2.2
Prairie-dryland (PD1e)	1.0	Outflow-intermitttent	7.4
Floodplain (PDq)	4.3	Outflow-perennial	27.1
Total	*120.6*	Bidirectional/throughflow	7.2
		Throughflow-perennial	51.8
		Throughflow-intermittent	6.0
		Total	*120.6*
Beaver	43.0	Vertical Flow	0.2
		Throughflow-perennial	42.8
		Total	*43.0*

Table 9. Extent and characteristics of dammed/impounded ponds.

Pond Type (code)	Acreage
Agriculture (PD2a)	180.4
Cropland (PD2a1)	348.0
Livestock (PD2a2)	70.4
Commercial (PD2c)	40.6
Industrial (PD2d)	16.2
Residential (PD2e)	342.6
Sewage Treatment (PD2f)	0.7
Golf (PD2g)	40.0
Other Recreational (PD2i)	8.5
Other (PD2o)	9.8
Total	*1,057.2*

Water Flow Path	Acreage
Vertical Flow	588.4
Outflow-artificial	27.0
Outflow-intermittent	46.7
Outflow-perennial	83.5
Throughflow-artificial	2.0
Throughflow-intermittent	64.5
Throughflow-perennial	245.1
Total	*1,057.2*

Table 10. Extent and characteristics of excavated ponds. *(Note: Difference in sums is due to round-off procedures.)*

Pond Type (code)	Acreage
Agriculture (PD3a)	44.9
Cropland (PD3a1)	146.6
Livestock (PD3a2)	26.5
Commercial (PD3c)	42.1
Industrial (PD3d)	7.1
Residential (PD3e)	121.7
Sewage Treatment (PD3f)	4.3
Golf (PD3g)	18.3
Wildlife Management (PD3h)	4.7
Other Recreational (PD3i)	3.4
Mining (PD3j)	37.0
Sand/gravel (PD3j1)	62.4
Other (PD3o)	33.7
Total	*552.7*

Water Flow Path	Acreage
Vertical Flow	445.2
Outflow-artificial	3.0
Outflow-intermittent	44.6
Outflow-perennial	19.3
Throughflow-artificial	6.3
Throughflow-perennial	34.5
Total	*552.9*

Inventory of Other Areas that May Support Wetlands

Undeveloped portions of hydric soil map units that did not display a reliable wetland photo-signature were classified as "P-wet areas" – areas that could potentially support wetland in places due to the soil type mapped by the USDA Natural Resources Conservation Service. Since these areas are part of map units that reportedly contain more than 80 percent hydric soil there is a high probability that they support wetlands to some extent, although they could represent upland inclusions as well. A total of 39,779 acres of these areas were identified (Table 11). The overwhelming majority of these soil map units may contain seasonally saturated forested wetlands. Interestingly, this total represents about 10,000 more acres than the acreage identified as wetland by the current survey; this figure, of course, may include upland inclusions and effectively drained areas that have been recolonized by trees and shrubs following abandonment by agriculture. The combination of mapped wetlands and these undeveloped hydric soil map units covers about 21% of the watershed's land area.

Table 11. The extent of other areas that may support wetlands based on USDA soil mapping. Map units marked with an asterisk (*) represent drier-end hydric soils; most are likely to occur on nearly level terrain, while those on floodplains may be temporarily flooded. Some of the acreage likely contains inclusions of nonhydric soils and possibly effectively drained hydric soils.

Soil Map Unit	Acres	Soil Map Unit	Acres
Adrian muck	24.9	Frenchtown silt loam	1,643.8*
Alden mucky silt loam	528.6	Getzville silt loam	815.5*
Alden silt loam	200.9	Halsey silt loam	117.9
Aquolls-Eutradepts complex	3,345.5*	Holly silt loam	1,150.7*
Canadice silt loam	691.0*	Holly silty clay loam	160.7
Canadaigua mucky silt loam	279.0	Lamson silt loam	1,266.6*
Canadaigua silt loam	110.4*	Mill silt loam	24,848.2*
Carlisle muck	27.1	Sebring silt loam	356.7*
Conneaut silt loam	1,081.8*	Stanhope silt loam	1,343.5*
Fredon silt loam	1,438.7*	Wick silt loam	347.6

Preliminary Landscape-level Functional Assessment

Wetlands are recognized as vital natural resources for the multitude of functions they provide (Table 12). It was not surprising that 89% or more of the watershed's wetlands were predicted to perform a number of functions at significant levels (Table 13; Figures 11 and 12). These functions include surface water detention (important for flood protection), nutrient transformation (important for productivity), carbon sequestration (important for mitigating climate change), and provision of habitat for "other wildlife" (not waterfowl, waterbirds, fish, or aquatic invertebrates). Other functions performed by most wetlands included bank and shoreline stabilization (important for reducing erosion, sedimentation of waterbodies, maintaining water quality, and protecting private property), maintenance of stream flow (vital for aquatic life), and sediment and other particulate retention (important for water quality renovation). Less than half of the area's wetlands (46%) were rated as significant for fish and aquatic invertebrates, yet only 6% represented aquatic habitat. Most of the "significant" acreage was streamside forested and shrub wetlands that provide shade and help moderate water temperatures. This role is important for maintaining desirable aquatic habitat. Sixteen percent of the watershed's wetlands were identified as potentially significant habitat for waterfowl and waterbirds and this was largely attributed to the occurrence of wooded wetlands along the many streams in this geographic area. Only 3%of the watershed's wetlands rated as potentially significant for providing uncommon wetland plant communities since the entire complex of vegetated wetlands on Presque Isle (excluding *Phragmites*-dominated types) were considered unique for the watershed and the state given the presence of this unique lacustrine barrier spit formation. It is also recognized that this area supports more than 70 state-species of concern (Bloss 1989).

Table 12. General relationships between wetlands in the Lake Erie watershed and ten functions. Predicted level of performance is also given for each function.
(See Appendix A for more detailed correlation.)

Function	**Wetlands Predicted to Perform This Function**
Surface Water Detention	
High	Wetlands along rivers, streams, and lakes and subject to flooding for more than 2 weeks; throughflow ponds; stormwater treatment ponds
Moderate	Wetlands in same locations subject to brief flooding; other ponds (except some types, e.g., isolated impoundments)
Streamflow Maintenance	
High	Headwater wetlands (except partly drained, impounded, and excavated types)
Moderate	Altered headwater wetlands; seasonally flooded wetlands along rivers and streams
Nutrient Transformation	
High	Seasonally flooded or wetter vegetated wetlands
Moderate	Temporarily flooded or seasonally saturated wetlands; ponds with mixtures of open water and vegetation
Carbon Sequestration	
High	Seasonally flooded or wetter vegetated wetlands; wetlands on organic soil (bogs); aquatic beds
Moderate	Temporarily flooded or seasonally saturated wetlands; ponds (excluding some types, e.g., isolated impoundments)
Sediment/Particulate Retention	
High	Vegetated wetlands (excluding seasonally saturated types); throughflow ponds and associated vegetated wetlands; stormwater treatment ponds

Moderate	Nonvegetated wetlands (excluding seasonally saturated types); other ponds (with some exceptions, e.g., isolated impoundments)

Bank and Shoreline Stabilization

High	Vegetated wetlands along river, and streams (excluding island wetlands)

Moderate	Vegetated wetlands along ponds

Fish/Aquatic Invertebrate Habitat

High	Aquatic beds; semipermanently flooded wetlands along lakes, rivers, streams, and ponds; shallow water zone of lakes; mixed open water/vegetated wetlands; ponds associated with semipermanently or permanently flooded vegetated wetlands

Moderate	Seasonally flooded marshes along rivers, lakes, and streams; semipermanently flooded *Phragmites* marshes adjacent to open water; seasonally flooded-tidal forested and shrub wetlands mixed with emergent species; certain types of ponds (typically $\geq$ 1acre)

Waterfowl and Waterbird Habitat

High	Semipermanently flooded vegetated wetlands; aquatic beds; lacustrine flats and shallow water; seasonally flooded marshes; waterfowl impoundments

Moderate	*Phragmites* marshes contiguous to open water; estuarine shrub wetlands mixed with emergents; aquatic beds and ponds (>1 acre; excluding some types); seasonally flooded marshes (>1 acre) along intermittent streams and in depressions

Wood Duck	Seasonally flooded or wetter forested and shrub swamps (not shrub bogs) along rivers and streams

Other Wildlife Habitat

High	Vegetated wetlands >20 acres; wetlands 10-20 acres in size with 2 or more vegetated classes (except *Phragmites*); natural ponds

Moderate	Other vegetated wetlands

Unique, Uncommon or Highly
Diverse Wetland Plant Communities

Significant	Wetlands on Presque Isle; lotic river fringe wetlands; lotic stream fringe wetlands (excluding those dominated by dead woody plants); lotic stream basin wetlands *(Note: This function is intended to identify wetlands that may be different from the majority of the watershed's wetlands and focuses on vegetation, landscape position, and special modifiers applied in the classification process. It excludes any ditched, excavated, or impounded wetland and those with Phragmites as dominant or co-dominant.)*

Table 13. Wetlands of potential significance for various functions for Pennsylvania's Lake Erie watershed.

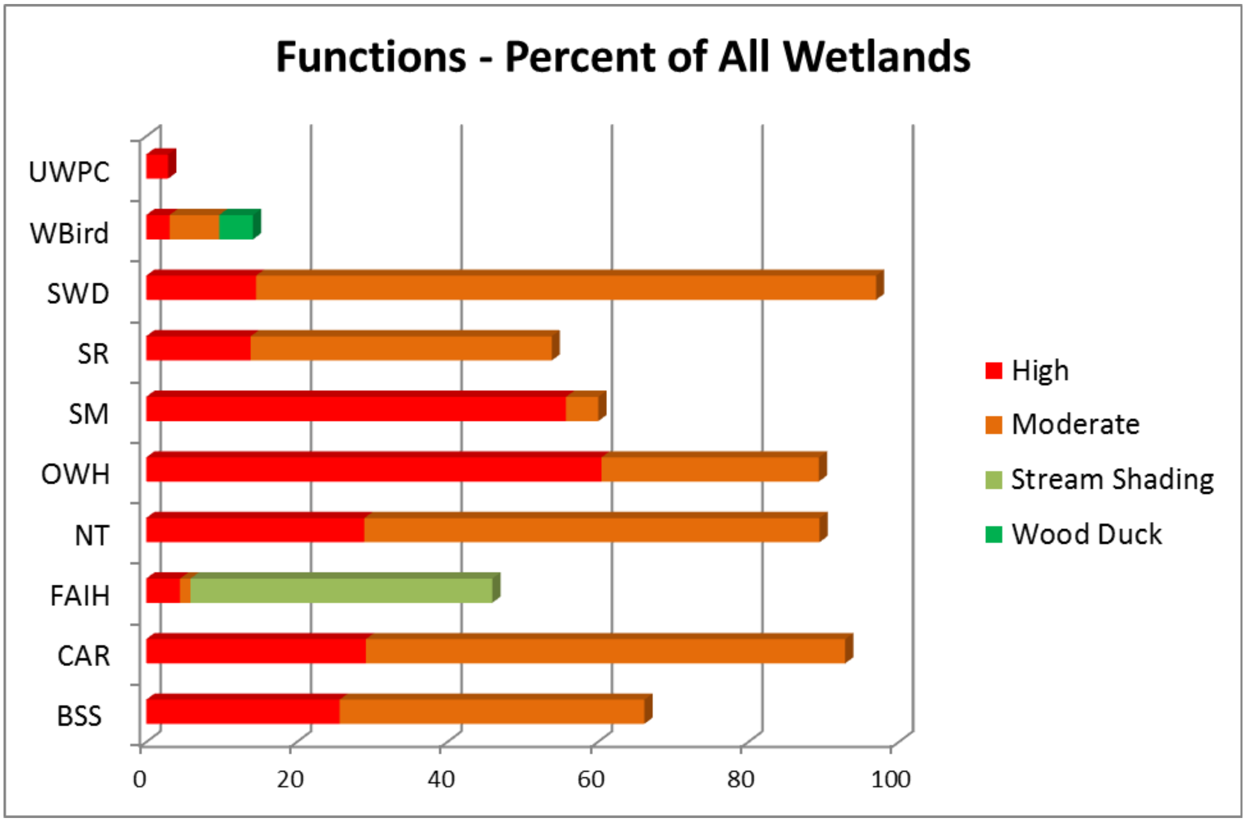
Function	Significance	Acreage	% of All Wetlands
Surface Water Detention	High	4,375.1	14.6
	Moderate	24,638.9	82.4
	Total	**29,014.0**	**97.0**
Streamflow Maintenance	High	16,701.3	55.8
	Moderate	1,287.3	4.3
	Total	**17,988.6**	**60.1**
Nutrient Transformation	High	8,674.6	29.0
	Moderate	18,094.3	60.5
	Total	**26,768.9**	**89.5**
Sediment and Other Particulate Retention	High	4,166.3	13.9
	Moderate	11,959.4	40.0
	Total	**16,125.7**	**53.9**
Carbon Sequestration	High	8,726.8	29.2
	Moderate	19,059.6	63.7
	Total	**27,786.4**	**92.9**
Bank and Shoreline Stabilization	High	7,682.8	25.7
	Moderate	12,124.8	40.5
	Total	**19,807.6**	**66.2**
Fish and Aquatic Invertebrate Habitat	High	1,344.8	4.5
	Moderate	421.3	1.4
	(Subtotal)	(1,766.2)	(5.9)
	Shading	11,984.7	40.1
	Total	**13,750.8**	**46.0**

Table 13 (cont'd).

Function	Significance	Acreage	% of All Wetlands
Waterfowl and Waterbird Habitat	High	922.4	3.1
	Moderate	1,960.1	6.6
	Wood Duck	1,340.7	4.5
	Total	**4,223.2**	**14.2**
Other Wildlife Habitat	High	18,083.1	60.5
	Moderate	8,636.1	28.9
	Total	**26,719.2**	**89.4**
Unique, Uncommon or Highly Diverse Plant Communities*			
Presque Isle Wetlands		786.2	2.6
Wetlands Elsewhere		87.1	0.3
Lotic River Fringe		(3.0)	
Lotic Stream Fringe		(46.7)	
Lotic Stream Basin		(37.4)	
	Total	**873.3**	**2.9**

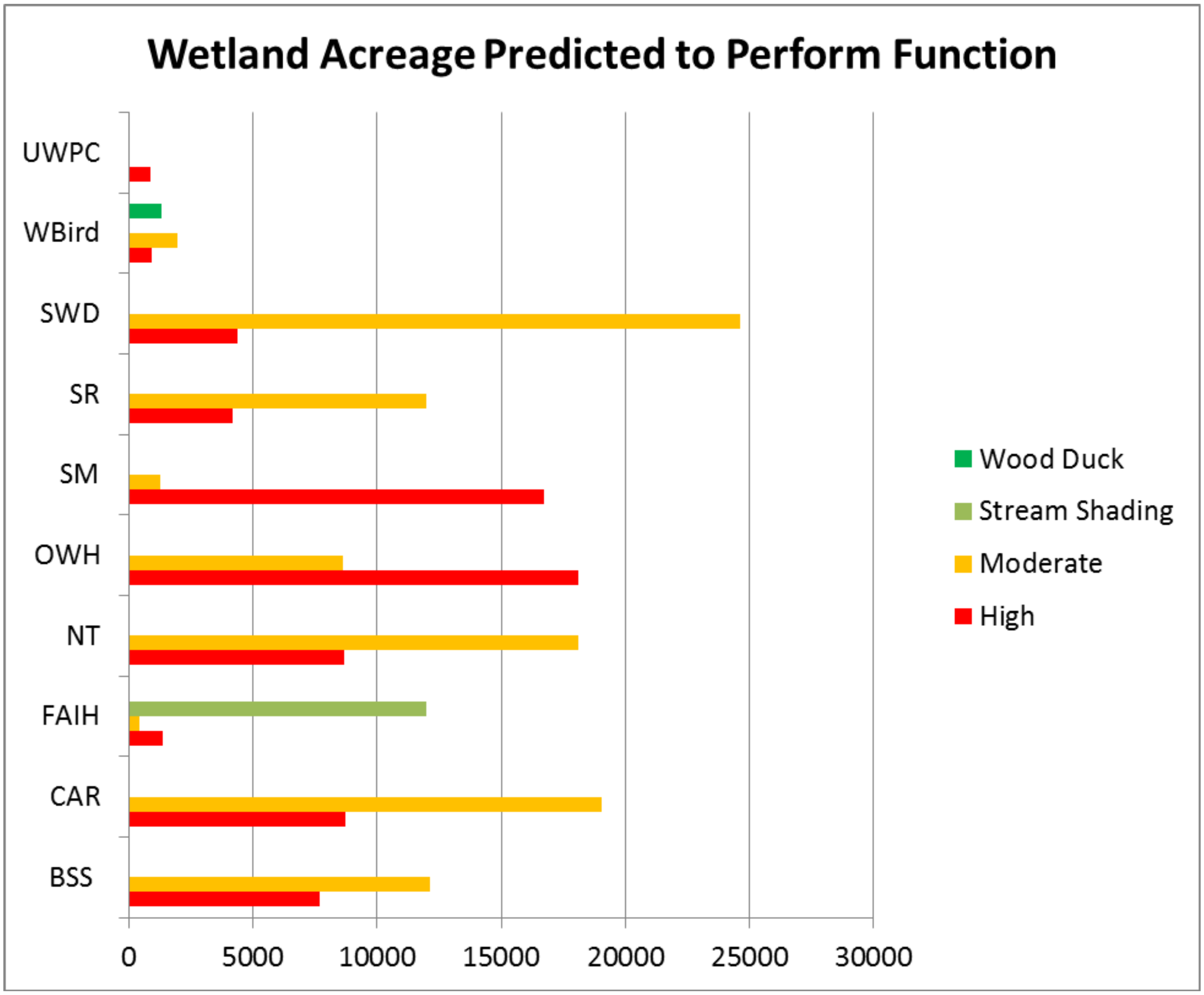
**This listing is very conservative as the inventory was not intended to fully address this function.*

Figure 11. Percent of the Lake Erie watershed's wetlands predicted to perform various functions at significant levels. *Note: Findings for "Uncommon Plant Communities" are very conservative.*



Coding: **UWPC** – Provision of Habitat for Unique, Uncommon or Highly Diverse Plant Communities; **WBird** – Provision of Habitat for Waterfowl and Waterbirds; **SWD** – Surface Water Detention; **SR** – Sediment and Other Particulate Retention; **SM** – Streamflow Maintenance; **OWH** – Provision of Habitat for Other Wildlife; **NT** – Nutrient Transformation; **FAIH** – Provision of Habitat for Fish and Aquatic Invertebrates; **CAR** – Carbon Sequestration; **BSS** – Bank and Shoreline Stabilization.

Figure 12. Acreage of wetlands predicted to perform various functions at significant levels. *Note: Findings for "UWPC" are very conservative.*



Coding: **UWPC** – Provision of Habitat for Unique, Uncommon or Highly Diverse Plant Communities; **WBird** – Provision of Habitat for Waterfowl and Waterbirds; **SWD** – Surface Water Detention; **SR** – Sediment and Other Particulate Retention; **SM** – Streamflow Maintenance; **OWH** – Provision of Habitat for Other Wildlife; **NT** – Nutrient Transformation; **FAIH** – Provision of Habitat for Fish and Aquatic Invertebrates; **CAR** – Carbon Sequestration; **BSS** – Bank and Shoreline Stabilization.

LIMITATIONS OF THE LANDSCAPE-LEVEL FUNCTIONAL ASSESSMENT

Functional assessment of wetlands can involve many parameters. Typically such assessments have been done in the field on a case-by-case basis, considering observed features relative to those required to perform certain functions or by actual measurement of performance. The preliminary assessments based on remote-sensing information do not seek to replace the need for field evaluations since they represent the ultimate assessment of the functions for individual wetlands. Yet, for a watershed analysis, basin-wide field-derived assessments are not practical, cost-effective, or even possible given access considerations. For watershed planning, a more generalized assessment (level 1 assessment) is worthwhile for targeting wetlands that may provide certain functions, especially for those functions dependent on landscape position, landform, hydrologic processes, and vegetative life form (Brooks et al. 2004). Later these results can be field-verified when it comes to actually evaluating particular wetlands for acquisition purposes (e.g., for conserving biodiversity or for preserving flood storage capacity) or for project impact assessment. Current aerial photography may also be examined to aid in further evaluations (e.g., condition of wetland/stream buffers or adjacent land use) that can supplement the preliminary assessment. Zooming into a particular wetland may reveal more information than was considered for this landscape-level assessment.

The landscape-level functional assessment approach -"Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF) - applies general knowledge about wetlands and their functions to develop a watershed overview that highlights possible wetlands of significance in terms of performance of various functions. To accomplish this objective, the relationships between wetlands and various functions are simplified into a set of practical criteria or observable characteristics based on the classification features in the expanded wetland database (i.e., NWI+ database).

W-PAWF does not account for the opportunity that a wetland has to provide a function resulting from a certain land-use practice upstream or the presence of certain structures or land-uses downstream. For example, two wetlands of equal size and like vegetation may be in the appropriate landscape position to retain sediments. One, however, may be downstream of a land-clearing operation that has generated considerable suspended sediments in the water column, while the other is downstream from an undisturbed forest. The former should be actively performing sediment trapping in a major way, whereas the latter may not. Yet if land-clearing takes place in the latter area, the second wetland will likely trap additional sediments as well as the first wetland. The entire analysis typically tends to ignore opportunity since such opportunity may have occurred in the past or may occur in the future but the important point is that the wetland is there to perform this service at higher levels when necessary.

W-PAWF also does not consider the condition of the adjacent upland (e.g., level of disturbance or stress) or the actual water quality of the associated waterbody that are important metrics for assessing the health of individual wetlands. Collection and analysis of these data may be done as a follow-up investigation, where desired, for so-called “condition assessments.”

It is important to re-emphasize that the preliminary assessment does not obviate the need for more detailed assessments of the various functions and assessment of wetland condition and opportunities to provide more benefits given the state of the contributing watershed and adjacent land use activities. This preliminary assessment should be viewed as a starting point for more rigorous assessments, since it attempts to cull out wetlands that may likely provide significant functions based on generally accepted principles and the source information used for this analysis. This assessment is most useful for regional or watershed planning purposes, for a cursory screening of sites for acquisition, and to aid in developing landscape-level wetland conservation and protection strategies. The approach can also be used to evaluate cumulative impacts of various alterations and changes in wetlands on key functions as was done for the Nanticoke River watershed on the Delmarva Peninsula (Tiner 2005b) or to consider the national and regional-scale impacts of policy changes on certain wetland types (e.g., "geographically isolated" wetlands or headwater wetlands, or determining significant nexus to waters of the United States). For site-specific evaluations, additional work will be required, especially field verification and collection of site-specific data for potential functions (e.g., following the hydrogeomorphic assessment approach as described by Brinson 1993 or other onsite evaluation procedures, e.g., rapid field assessment such as procedures being developed by the state, PADEP 2014). This is particularly true for assessments of fish and wildlife habitats. Other sources of data may exist to help refine some of the findings of this report (e.g., state natural heritage data). Additional modeling could be done, for example, to identify habitats of likely significance to individual species of animals based on their specific life history requirements (see U.S. Fish and Wildlife Service 2003 for Gulf of Maine habitat analysis).

Also note that the criteria used for the relationships were based on current applications of the Service's wetland classification (Cowardin et al. 1979) and on professional judgment of many experienced wetland scientists in the eastern region. Through this analysis, numerous wetlands are predicted to perform a given function at a significant level presumably important to a watershed's ability to provide that function. "Significance" is a relative term and is used in this analysis to identify wetlands that are likely to perform a given function at a high or moderate level. Wetlands not highlighted may perform the function at a low level or may not perform the function at all. It is also emphasized that the assessment is limited to wetlands (i.e., areas classified as wetlands according to the Cowardin et al. classification system). Deepwater habitats and streams were not included in the assessment, although their inherent value to wetlands and many wetland-dependent organisms is apparent and widely recognized.

Source Data Limitations

Source data are a primary limiting factor for landscape-level functional assessment. Updated wetlands inventory data (expanded to include hydrogeomorphic properties, e.g., landscape position, landform, water flow path, and waterbody type) and existing stream data (e.g., NHD and DRGs) were used as the foundation for this assessment. All wetland and stream mapping have limitations due to scale, photo quality, date of the survey, and the difficulty of photointerpreting certain wetland types (especially evergreen forested wetlands and drier-end wetlands; see Tiner 1990, 1999 for details) and narrow or intermittent streams especially those flowing through dense evergreen forests and beneath built-up lands. Consequently many small streams were not identifiable on the imagery used for the inventory. This would affect their LLWW classification. Also, joining different geospatial data sources is challenging and often times inexact since they were interpreted from different imagery and aligned to different products (i.e., aerial imagery or maps).

Since wetland classification drives a wetland's designation as high, moderate, or not significant for a given function (see Appendix A), any misclassification could affect the results. For example, wetlands identified as having vertical flow (internal water movement) may be connected to other wetlands and waters by a small stream or a ditch that was not visible on the image at the scale examined for this inventory. Where this is the case, the wetland is actually an outflow wetland and should be significant for streamflow maintenance with possible differences in other functions as well. When examining a wetland with its water flow path designated as "vertical flow," the user is encouraged to view the wetland on imagery (provided via the NWI+ web mapper) and zoom in to see if there is a small stream present.[2] If a stream is observed, then reclassify the wetland and use the correlation table (Appendix A) to determine the appropriate levels of functions for this wetland. Of course, the best assessment of the possible hydrologic connectivity of this wetland to others is by field examination – look for small streams, ditches, or drainageways for possible links.

Another situation where misclassification may be an issue is where wetlands along major rivers occurred above a distinct topographic break (visible on a USGS topographic map). These wetlands were classified as terrene wetlands (e.g., outflow where a stream was present). Some of these wetlands may occur on the river's active floodplain depending on the height of the topographic break relative to the river flood stage elevation. The terrene outflow wetland would have been designated as moderate for surface water detention, whereas if classified as a lotic river floodplain wetland (or lotic stream basin), the wetland would be rated as high for that function. A similar issue may arise along streams where wetlands were classified with a seasonally or temporarily flooded water regime. Streamside wetlands with these water regimes were routinely classified as lotic stream wetlands. If, however, they are not subject to annual overbank flooding because they are located on a terrace, they should be classified as terrene wetlands. They would be groundwater types and not overflow wetlands. This classification difference could influence a number of functions.

Recognizing source data limitations, it is equally important to understand that this type of functional assessment is a preliminary one based on wetland characteristics interpreted through remote sensing and using the best professional judgment of various specialists to develop relationships between wetland characteristics in the database and wetland functions. As mentioned earlier, this type of functional analysis is designed to produce landscape- or watershed-level assessments covering large geographic areas. The wetland classification employed, although expanded from the traditional NWI, does not account for all elements of variability in wetlands such as chemical variation in surface waters that are strongly influenced by underlying geology, especially in relatively undisturbed watersheds (Azzolina et al. 2007).

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[2] This imagery is different than that used for this survey and may therefore show a stream; also zooming in allows viewing at a larger scale than used for the inventory which also facilitates identification of small streams and other features.

Based on their biotic or abiotic characteristics wetlands in the Lake Erie watershed were rated as having high or moderate potential for supporting each of ten wetland functions: surface water detention (nontidal wetlands), streamflow maintenance (headwater wetlands), sediment and other particulate retention, nutrient transformation, carbon sequestration, bank and shoreline stabilization (wetlands along waterbodies), and provision of habitat for: a) fish and aquatic invertebrates, b) waterfowl and waterbirds, c) other wildlife, and d) unique, uncommon, and highly diverse wetland plant communities. Wetlands not assigned a rating are assumed to have little or no potential for providing such function at a significant level, with one exception for unique, uncommon, and highly diverse wetland plant communities which is by design a very conservative assessment. The ratings are based on a review of the literature and best professional judgment of numerous wetland scientists from public agencies, private non-government organizations, and academia. Also, no attempt is made to produce a more qualitative ranking for each function (e.g., comparison to a "reference" type representing a wetland of the type in the "best" condition, or considering the degree to which it actually performs a function given opportunity and adjacent land uses) or for each wetland based on multiple functions. To do that would require more input from others and more data, well beyond the scope of this type of broad-scale evaluation. For detailed reviews of wetland functions, see Mitsch and Gosselink (2007) and for a broad overview, see Tiner (2005).

Limitations of Predictions for Certain Functions

Predicting Waterfowl and Waterbird Habitat

For wood duck, wooded wetlands in urban areas were also identified by the selection process. The width of the wetlands and the intensity of development in the surrounding area may have an effect on the actual function, but this was not evaluated. Consult state waterfowl biologists for more information. Some streamside wetlands along what may be intermittent streams may have been designated as significant for wood duck.

Predicting Provision of Habitat for Other Wildlife

Size and diversity of vegetative life-forms were used in highlighting wetlands important for this function, yet natural ponds of any size were rated as high since they may be important for amphibians. This was an attempt to highlight potential vernal pools. Given limitations of scale in mapping streamside wetlands, the NWI data represented what may be a larger linear wetland as a series of smaller wetlands. Consequently, some streamside wetlands may be identified as having moderate significance for this function when they may actually be a single large wetland based on a field survey. Such wetlands should then be rated as high for this function. Similarly some wetlands identified as moderate for this function are separated from adjacent wetlands by minor roads and do not meet the size requirement for a high rating. If considered part of the neighboring wetland, the combined wetland might be large enough to be assigned a high rating.

Predicting Provision of Habitat for Unique, Uncommon, or Highly Diverse Wetland Plant Communities

This function is intended to identify wetlands that may be different from the majority of the watershed's or the state's wetlands and focuses on vegetation, landscape position, salinity, and special modifiers applied in the classification process. Prediction for the function is a conservative assessment based on the Cowardin et al. (1979) and the LLWW classifications (Tiner 2011a). It may include some plant communities that are common but uncommon in that they occur in a particular landscape, such as a marsh along a river versus one in a depression. Wetlands that were ditched, excavated, or impounded and those with *Phragmites* as dominant or co-dominant vegetation were not considered significant for this function due to alteration or the presence of invasive species. A more comprehensive listing could be developed by combining the results of this analysis with data on critical habitats from the state or other sources but that was beyond the scope of this project.

Deer in wetlands at Presque Isle State Park (Brian Berchtold)

INVENTORY OF POTENTIAL WETLAND RESTORATION SITES

Given the extensive analysis of soil data in updating the basic wetland inventory and that the new survey identified certain impacts to existing wetlands, the project also used these data to generate a preliminary inventory of potential wetland restoration sites. The purpose of this section of the report is to explain the methodology and summarize the findings of this analysis.

Types of Wetland Restoration Sites

"Wetland restoration" is a widely used term that covers both re-establishment and rehabilitation of wetlands. Re-establishment involves the process of reviving a former wetland to produce a gain in wetland area (acreage) as well as function. Re-establishment is called Type 1 restoration in this paper. Rehabilitation involves rejuvenating an impaired wetland (e.g., a partly drained or impounded wetland) bringing it back to a more natural condition. Rehabilitation results in an increase in wetland functions that ideally creates conditions more like those of natural wetlands. It does not result in an increase of wetland acreage overall. Rehabilitation is called Type 2 restoration in this paper. Two other situations are sometimes confused with wetland restoration: wetland creation (or establishment) and wetland enhancement. Creating a wetland from dryland by excavating a depression or impounding a stream is not considered restoration. Neither is altering a natural wetland to change its functions, e.g., diking a wet meadow to convert it to a marsh for the benefit of waterfowl. This type of activity is considered wetland enhancement and increases one or more wetland functions at the expense of others.

Former wetlands that have potential for re-establishment (Type 1 sites) are mostly effectively drained lands that are often used today for agriculture (e.g., cropland or pasture), while others are now open waterbodies or filled land that is relatively undeveloped (i.e., idle land lacking structures). For the former sites, restoring hydrology through plugging ditches or breaking tile drains is the main technique used to bring these lands back to a functioning wetland, yet dikes and water-control structures have been used in some situations. The first of the latter sites are former wetlands that are now dammed or diked. Restoring them back to wetlands would involve dam or dike removal or breaching the dike in one or more places. Filled former wetlands would require removal of fill, re-grading, and possible re-creation of drainage patterns.

Existing wetlands that have been altered by ditching, excavation, impoundment, or by road or railroad crossings, are candidates for rehabilitation (Type 2 sites). Some of these activities may have promoted colonization by invasive species such as common reed (*Phragmites australis*). A variety of restorative measures may be applied depending on the nature of the alteration, e.g., ditch-plugging, adding fill to restore elevations, dike breaching, or increasing a more natural water flow pattern. Where invasive species are to be controlled, application of herbicides and other treatments (e.g., periodic mowing) may be required.

METHODS

Data Sources

Analysis of several sources of geospatial information through geographic information system (GIS) technology was performed to build a watershed-wide database of potential wetland restoration sites. Four primary sources were used for this analysis:

- Existing soils data (U.S.D.A. Natural Resources Conservation Service; http://datagateway.nrcs.usda.gov/
- the updated and enhanced wetlands inventory (described in the preceding section of this report),
- World Imagery (ESRI), and
- 2011 four-band infrared digital aerial imagery (acquired by PACZM).

Geographic information system technology (GIS) was used to combine digital imagery with geospatial data bases on soils and wetlands. ESRI's ArcGIS 10.0 was the GIS platform used for this project.

Identification of Type 1 Sites (Former Wetlands)

The U.S.D.A. soil data provide the foundation for identifying Type 1 sites (former wetlands). Soil map units dominated by hydric soils are viewed as historic or contemporary wetlands (depending on current conditions), recognizing data limitations (see "General Scope and Limitations of the Inventory"). Hydric soil map units that were not mapped as a wetland or P-wet areas (undeveloped, "naturally" vegetated hydric soils not mapped as a 2011 wetland) during the current update and that upon examination of the 2011 aerial imagery were cropland, pasture, barren land, or other idle land were viewed as having some potential for restoration. Most of these areas were expected to be effectively drained former wetlands. All "dryland" Type 1 sites were delineated and entered into the expanded database (NWI+ database). A geospatial data layer was created from a hydric soil data layer by viewing that layer and the 2011 wetlands data on the 2011 digital imagery and delineating those areas that were in a land use that may be suitable for wetland restoration. Hydric soil areas that were not mapped as wetlands by the current survey and on the 2011 imagery appeared as an open land use (agricultural or barren land) were classified as potential Type 1 wetland restoration sites.

The "deepwater habitat" Type 1 sites were identified by analyzing the soil characteristics of all deepwater habitats. If the soil survey mapped the area as "water" it was not considered a former wetland for this analysis. If however, the deepwater habitat or a portion of that habitat occurred within a hydric soil map unit, it was classified as a Type 1 site. These polygons were delineated, classified as Type 1 sites, and entered into the NWI+ database.

Identification of Type 2 Sites (Existing Impaired Wetlands)

Since Type 2 sites are existing wetlands with some type of impairment, most were identified by consulting the mapped wetland type in the enhanced wetland database and searching for "special modifiers:" partly drained/ditched ("d" modifier), diked/impounded ("h" modifier), excavated ("x" modifier), and farmed ("f" modifier). While all such wetlands are affected, some of these wetlands may be created by these actions (e.g., excavated depression or impounded stream). To sort out possible created wetlands from altered natural wetlands, soil survey data was consulted to identify the likely presence of hydric soil. Our approach was conservative: if more than 50 percent of the subject wetland fell within a hydric soil map unit, it was considered a natural wetland and classified as a potential wetland restoration site. The other sites may have been created wetland and were not included as Type 2 sites. Wetlands dominated by common reed were also listed as Type 2 restoration sites.

Target Mapping Unit

The target minimum mapping unit for identifying a potential restoration site was set at 0.5 acre. During the interpretation some sites smaller than this were mapped where the feature was obvious and readily delineated.

Database Construction

The wetland restoration database was created in ESRI's ArcMap 10.0. Two restoration layers were created: one for Type 1 sites and the other for Type 2 sites. The distribution and characteristics of these areas are displayed via an ESRI-based online mapping tool – NWI+ Web Mapper – posted on the Association of State Wetland Managers webpage "Wetlands One-Stop" (http://aswm.org/wetland-science/wetlands-one-stop-mapping).

GENERAL SCOPE AND LIMITATIONS OF THE INVENTORY

The quality of the data sources used for any inventory is a major limitation of any mapping effort. The data sources used for this inventory of potential wetland restoration sites are no exception: soil survey data and wetland inventory data interpreted from aerial imagery. Also, it is not a simple matter to separate effectively drained hydric soils from partly drained soils through image analysis since the images capture conditions at a single moment in time.

Type 1 Sites

Hydric soil map units are generalized areas derived from a combination of aerial photointerpretation and on-the-ground soil mapping. All soil map units may contain soils of a different type ("inclusions;" USDA 2008). Consequently hydric soil mapping units may contain nonhydric soil areas as inclusions. Table 14 lists the hydric soil mapping units used to help identify former wetlands for the Lake Erie watershed. The list contains five soils classified as Aeric subgroups (e.g., Aeric Endoaquepts) and these soils tend to be drier in the upper part of the soil profile. Type 1 sites or portions of these sites located on these soil map units may include areas that do not have potential for restoration since those portions were never wetland. This must be determined through field inspection. In using the NWI+ web mapper, the soil for all Type 1 sites can be identified by using the "codes" function, clicking on the applicable dot, and viewing the dropdown table with the soil information.

Some sites identified as Type 1 sites may be "missed" wetlands that were not mapped by the 2011 inventory because they were in active agricultural use. They may actually be farmed wetlands or grazed or mowed wet meadows. Field examination and perhaps hydrologic monitoring would be necessary for a positive determination.

Although not identified as Type 1 sites, some areas classified as "P-wet areas" (areas lacking a photointerpretable wetland signature but occurring on an undeveloped hydric soil) represent abandoned farmland and while they are being recolonized by shrubs and/or trees, restoration of full-capacity wetland hydrology may be worthwhile.

Some Type 1 sites may have structures built since 2011. In other cases, a portion of a Type 1 site may have a structure while the majority of the site should not. This may be largely attributed to scale issues related to mapping.

Table 14. Hydric soil mapping units used to identify potential wetland restoration sites. (Source: USDA)

Soil Map Unit (Taxonomic Classification)	Drainage Class*
Alden mucky silt loam (Mollic Endoaquepts)	VPD
Alden silt loam (Mollic Endoaquepts)	VPD
Aquolls-Eutrudepts complex, frequently flooded	Variable
Canadice silt loam (Typic Endoaqualfs)	PD
Canandaigua mucky silt loam (Mollic Endoaquepts)	PD
Canandaigua silt loam, loamy substratum (Mollic Endoaquepts)	PD
Carlisle muck (Typic Haplosaprists)	VPD
Conneault silt loam (Aeric Epiaquepts)	PD, SPD
Fredon silt loam (Aeric Endoaquepts)	PD, SPD
Frenchtown silt loam (Typic Fragiaqualfs)	PD
Getzville silt loam (Aeric Endoaquepts)	PD, VPD
Halsey silt loam (Typic Humaquepts)	VPD
Holly silt loam (Fluvaquentic Endoaquepts)	PD, VPD
Holly silty clay loam (Fluvaquentic Endoaquepts)	PD, VPD
Lamson silt loam (Aeric Endoaquepts)	PD, VPD
Mill silt loam (Aeric Epiaquepts)	PD
Sebring silt loam (Typic Endoaqualfs)	PD
Stanhope silt loam (Fluvaquentic Endoaquepts)	PD
Wick silt loam (Fluvaquentic Endoaquepts)	VPD

*Coding: VPD – very poorly drained, PD – poorly drained, SPD – somewhat poorly drained

The list of deepwater habitat sites referenced as Type 1 sites is likely to be a conservative listing for the following reason. Other impounded deepwater habitats were designated as "water" by the soil survey. These impoundments were created prior to the recent soil survey. Although not recorded as potential restoration sites in this report, such areas likely include former wetlands and therefore may also qualify as restoration sites. If you are interested in these sites, simply look for impounded wetlands in the NWI+ database and then review historic imagery or topographic maps to determine their earlier condition.

Type 2 Sites

The limitations of interpreting aerial imagery for mapping wetlands are well known (see Tiner 1999, 1990). Classification errors (omissions and commission errors) can also produce inaccurate results. While a serious attempt was made to limit these errors, it is possible that some such errors remain due in part to the number of polygons mapped, the quality of the available imagery, and the general scope of the project. Also, given differences in methods and minimum map unit sizes between the soil survey and the wetlands inventory, all the mapped wetlands do not necessarily fall within a hydric soil map unit.

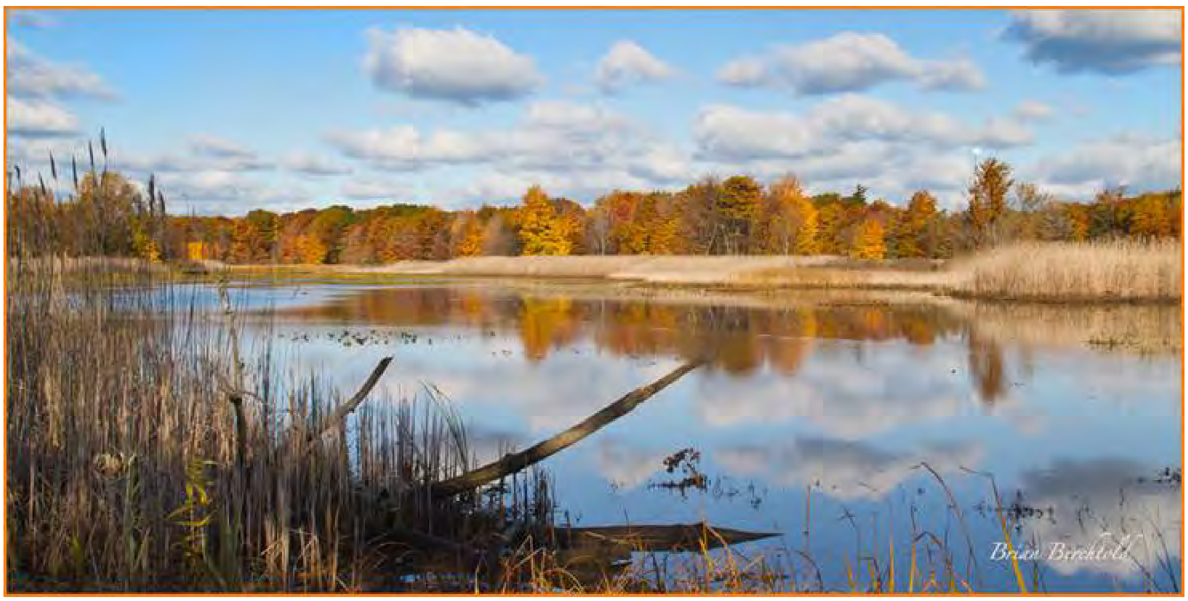
As mentioned earlier, to separate possible created wetlands from natural wetlands for identifying potential Type 2 restoration sites, soil survey data were consulted and examined for mapped wetlands on hydric soil map units. We established a 50 percent threshold for identifying altered wetlands on hydric soil map units as potential restoration sites. Affected wetlands that did not meet this requirement were considered to be more likely created wetlands (e.g., created by impoundment) and were not designated as potential restoration sites. While the limitations of both the soil survey and the updated wetlands inventory at identifying hydric soils and wetlands are realized, sites with a greater correspondence between hydric soils and mapped wetlands should have a higher probability of being a naturally formed wetland. The results of this analysis are, therefore, conservative, but should represent the bulk of the watershed's wetlands with restoration potential. Similar areas contiguous to these sites that did not occur within a hydric soil map unit may also have potential for restoration, but would require field inspection for validation. Other wetlands identified as partly drained, impounded, farmed, or excavated (i.e., those not occurring within a hydric soil map unit) could also be evaluated in the field for restoration potential in a particular locale.

Invasive species are a significant ecological problem and controlling these species is often an important restoration objective for wetlands and uplands alike. These non-native species become so abundant that they displace native species. In some places, common reed (*Phragmites australis*) has replaced native species and established a thick surface mat of slowly decomposing plant remains. While these wetlands still perform many wetland functions, their fish and wildlife value has been, in most cases, diminished or at least significantly changed for native marsh fauna. Identifying invasive species is often impossible to do on aerial imagery, with some exceptions. Common reed is one exception; large stands of this species can be interpreted. Purple loosestrife (*Lythrum salicaria*) is another exception, but requires imagery captured during the peak blooming period for identification. Other invasives such as multiflora rose (*Rosa multiflora*), glossy or European buckthorn (*Frangula alnus*), common buckthorn (*Rhamnus cathartica*), and honeysuckles (*Lonicera* spp.) are among the many invasives that likely require identification through field surveys. The imagery used for this survey did allow for identification of large stands of common reed as sites for possible restoration.

Wetlands fragmented by roads or railroads may represent other opportunities for restoration. Such areas were not mapped as Type 2 sites since there was no way to determine the hydrologic connectivity between adjacent wetlands and the degree of impairment. If the vegetation is significantly different on one side of the road from that on the other side, the hydrology may be adversely affected. A dramatic example of this situation would be a forested wetland on one side and an emergent wetland on the other of the road. This change could be the result of altered hydrology.

INTERPRETATION OF FINDINGS

The preliminary nature of this inventory is emphasized. The designated sites or portions of these sites may have potential for restoration. Whether or not they are practical sites depends on many factors including the current use of the sites, the interest of the landowner, actual site conditions, work required for restoration, project budgets, and agency/organization priorities. It is obvious that some sites will be easier to restore while others would be more difficult and costly. Nonetheless, the inventory provides a large population of sites for restoration specialists to consider. They can prioritize sites based on their objectives. Wetlands designated as *Phragmites*-dominated at Presque Isle State Park are now actively managed to control this invasive species.



Presque Isle wetlands in fall (Brian Berchtold). Note *Phragmites* stands along the shoreline. The State Park is actively using various control measures to reduce this species.

RESULTS

Distribution of Restoration Sites

The location and type of potential wetland restoration sites can be displayed via the Wetlands One-Stop Web Mapper on the Association of State Wetland Managers' website - "Wetlands One-Stop Mapping" (http://aswm.org/wetland-science/wetlands-one-stop-mapping). This website is a cooperative effort between the Association, Virginia Tech's Conservation Management Institute, and the U.S. Fish and Wildlife Service to display NWI+ data, associated reports, and state and other agency/organization wetland mapping data and information. The web mapper contains a number of data layers, four of which pertain to the restoration inventory:

- *NWI+ Restoration Type1* – this layer identifies former wetlands (now nonwetlands) that are in a land use where wetland restoration may be possible. Type 1 restoration sites should be former wetlands that were converted to either "developable land" by drainage and/or filling or deepwater habitats by impoundment (diking) or excavation (dredging).

- *NWI+ Rest Type 1 Soil Codes* – places dots on map to access information on soil properties for Type 1 sites.

- *NWI+ Restoration Type 2* – this layer shows existing wetlands that have been impaired to a degree that affects their ability to function like an undisturbed natural wetland. The color-coded types shown on the mapper focus on one type of impact; recognize that some wetlands have multiple impacts.

- *Wetland Codes* – places dots on the map to access information on wetland classifications that contain information on wetland impairments; in wetland code – look for the following special modifiers: d (partly drained/ditched), f (farmed), h (diked/impounded), and x (excavated).

All restoration layers can be viewed simultaneously since there should be no overlap between Type 1 and Type 2 sites. Simply click on the box for each layer and the layers will become active. Click on the "Legend" icon on the mapper's toolbar to view the applicable legends (may need to scroll down the list of legends to find the ones for the Restoration Type1 and Type2 layers).

Type 1 Potential Restoration Sites (Former Wetlands)

A total of 19,282 acres of possible former wetland were identified as dryland sites that may be suitable for restoration, while only 2 acres of former wetland are now underwater and may have potential for restoration (Table 15). The dryland sites typically represent effectively drained former wetlands, although some may represent farmed wetlands that were not mapped as "farmed wetland" because they did not show any indication of sufficient wetness on the

2011 imagery. Filled sites were extremely limited as nearly all these sites were developed; only 26 acres of barren land were identified as potential restoration sites. The limited extent of former wetlands that are now deepwater habitats reflects the fact that deepwater habitats are generally lacking in this watershed. As mentioned in the previous section, many other impoundments were likely created from wetlands yet mapped as "water" on the soil survey. Although not highlighted in this inventory, they too represent potential sites for re-establishment of wetlands.

Table 15. Acreage summary of potential Type 1 restoration sites for the Lake Erie watershed. Anderson et al. (1976) code is given for dryland sites, while general map code is given for deepwater sites.

Current Condition of Site (codes)	**Acreage**
Agriculture, Unspecified (200)	119.2
Cropland (211)	16,860.3
Pasture (212)	2,243.5
Orchards, Nurseries, etc. (220)	31.0
Subtotal Agriculture	***19,254.0***
Barren Land (799 with possible restoration potential)	26.0
Subtotal (now dryland)	***19,280.0***
Impounded Lake (L1UBHx)	2.4
Subtotal (now deepwater habitat)	***2.4***
Total Type 1 Sites	**19,282.4**

Type 2 Potential Restoration Sites (Existing Impaired Wetlands)

A total of 1,343 acres or 4.5% of the watershed's wetlands were designated as having potential for restoration (Table 16). These wetlands have been altered from that of a natural wetland of that type by one or more human actions (e.g., ditching, diking, excavation, or farming). Consequently, their natural functions may have been diminished to some degree. These wetlands fall into five categories: partly drained wetlands, impounded wetlands, excavated wetlands, farmed wetlands, and wetlands dominated by the invasive species - common reed. Most of the Type 2 restoration sites were affected by either ditches (partly drained; 42%) or dikes (impounded; 38%). Excavated wetlands and common reed marshes accounted for remainder, except for 142 acres of wetlands dominated or co-dominated by common reed (*Phragmites australis*) and 13 acres of farmed wetlands that were identified as Type 2 sites.

Table 16. Acreage summary of Type 2 restoration sites for Lake Erie watershed. These sites are impacted wetlands or portions of impacted wetlands that were located on hydric soil map units.

Current Wetland Condition	**Acreage**
Partly drained	560.1
Emergent Wetland	*11.2*
Forested Wetland	*535.4*
Scrub-Shrub Wetland	*13.5*
Impounded	507.8
Aquatic Bed	*36.3*
Emergent Wetland	*128.2**
Forested Wetland	*71.3*
Scrub-Shrub Wetland	*26.4*
Unconsolidated Bottom	*244.0*
Unconsolidated Shore	*1.7*
Excavated	123.9
Aquatic Bed	*4.7*
Emergent Wetland	*14.4*
Forested Wetland	*4.4*
Scrub-Shrub Wetland	*7.4*
Unconsolidated Bottom	*91.0*
Unconsolidated Shore	*2.0*
Phragmites-dominated Wetland	126.2* (2.8 acres = impounded)
Wetlands with *Phragmites* as co-dominant	15.3
Farmed	12.5
Total for All Sites	**1,343.0***

*2.8 acres of *Phragmites*-dominated wetland was also designated as impounded, so this amount was subtracted from the total to avoid double-counting.

HISTORIC PERSPECTIVE ON WETLANDS

Because the update and enhancement of the wetland inventory for the Lake Erie watershed involved detailed examination of soil mapping and aerial imagery and the area was relatively small in size, a cursory assessment of how wetlands may have changed since European settlement was easily accomplished. If we assume that all of the so-called "hydric soil map units" represented wetlands, the acreage of those units not identified as wetland or deepwater habitat can be interpreted as the area of historic wetland that has either: 1) been lost to development or 2) contains present-day wetlands that were not detected during our survey, recognizing limitations of soil mapping (e.g., units are not purely one soil type and may contain as "inclusions" other soils, some of which may be nonhydric, whereas others may represent effectively drained hydric soils that are now colonized by woody plants). The latter group was treated as "P-wet areas" – areas that may still support wetlands based on soil mapping, while the former group represents "developed hydric soils." Developed hydric soils totaled 24,483 acres (see Table 17 for the nature of such development). According to this assessment, agricultural activities were responsible for 79% of the historic losses, while residential development (13%) and transportation/utilities (4%) accounted for the bulk of the remaining losses.

Table 17. Historic losses of wetlands to various land uses based on contemporary conditions. Results were derived by identifying the current land use of developed portions of hydric soil map units.

Current Land Use	**Acreage**
Residential Development	3,188.4
Commercial Development	166.2
Industrial Development	121.9
Transportation, Communications & Utilities	1,231.5
Roads	*698.4*
Railroads	*275.5*
Powerlines	*233.5*
Other	*24.1*
Other Urban or Built-up Land	25.1
Recreational Land	343.0
Golf Courses	*247.5*
Parks	*35.6*
Other	*59.9*
Agriculture	19,348.0
Cropland	*16,860.3*
Pasture	*2,243.5*
Farm Buildings	*93.7*
Other	*150.5*
Tree Plantation	7.6
Altered or Barren Land	51.5

For the Lake Erie watershed, nearly 25,000 acres of hydric soil map units were identified as developed. If this figure is simply combined with the 2011 wetland acreage (29,904) and the 2011 acreage of P-wet areas (39,779), the total of "pre-settlement" wetland acreage is estimated to be 94,166 acres. This acreage suggests that as much as 29% of the watershed may have been wetlands prior to European settlement. If possible inclusions (estimated at 10% of unit) are deducted from the P-wet areas and the developed hydric soil map units, the estimated historic wetland acreage would be revised to 87,740 acres or 27% of the watershed. Consequently, it is possible that 25% of the "original" wetlands in the watershed have been lost due to agricultural practices. This figure would be higher if the area of drained hydric soil that now supports forest or woody thickets could be determined. The bulk of the watershed's historic wetland occurs in the southwestern portion of the watershed. This area has flat to gently undulating terrain characterized by Hiram clay to silty clay till (ground moraine) and is noted for the occurrence of poorly drained areas (Shepps et al. 1959).

Limitations of This Historic Assessment

The estimate of pre-settlement wetlands does not include any wetland that may have existed in the city of Erie because the soils there are typically mapped as some type of urban land. Also, the sand spit at Presque Isle is a growing feature so a portion of the present-day wetlands are newly formed and did not exist in colonial times. In addition to the inclusion of upland soils in the hydric soil mapping unit, there are hydric soil inclusions in some nonhydric (upland) soil mapping units that were not accounted for. Considering these issues and others mentioned above, this assessment, therefore, serves only as a general reference for gaining historic perspective rather than an actual accounting of pre-settlement wetland acreage.

SUMMARY

The Lake Erie watershed contained 29,904 acres of wetlands, accounting for roughly 9% of the watershed's land area (including Presque Isle). Most (75%) of the wetlands are wooded swamps (palustrine forested wetlands), with shrub swamps (palustrine scrub-shrub wetlands), marshes and wet meadows (palustrine emergent wetlands), and ponds (palustrine unconsolidated bottoms) representing the remainder. Nearly 40,000 acres of undeveloped hydric soil ("P-wet areas") were identified as other areas that may support wetlands in places due to prior soil survey mapping. These areas did not exhibit a recognizable "wetland-signature" on the aerial imagery and likely include drier-end wetlands (seasonally saturated types) as well as substantial areas on nonwetland due to limitations of soil mapping.

Slightly more than two-thirds of the watershed's wetlands were classified as terrrene wetlands – sources of streams and others that may be considered "geographically isolated" (completely surrounded by upland with no detectable inlet or outlet based on the mapping scale of this inventory). Lotic wetlands along the watershed's creeks accounted for 26% of the area's wetlands. From the water flow path perspective, 42% were outflow types while throughflow and isolated types comprised most of the remaining wetland acreage (30% and 22%, respectively).

Since wetlands are recognized as vital natural resources for the multitude of functions they perform, it was not surprising that more than 80 percent of the state's wetlands were predicted to perform a number of functions at significant levels. These functions included surface water detention (important for flood protection), carbon sequestration (important for mitigating climate change), nutrient transformation (important for productivity), and provision of habitat for "other wildlife" (e.g., more terrestrial species).

Besides the updated and enhanced wetlands inventory and the landscape-level functional assessment, the project also included an inventory of potential wetland restoration sites by comparing soil survey data with 2011 wetlands inventory data. The analysis identified two basic types of restoration sites: former wetlands lacking structures (buildings and other structures; Type 1 sites = re-establishment) and impacted wetlands whose functions may be reduced to some degree (Type 2 sites = rehabilitation). Restoring the former sites would result in a gain in both wetland acreage and function while rehabilitating the latter may produce wetlands with functions at levels more typical of undisturbed wetlands.

A total of 19,282 acres of Type 1 sites were identified and 1,343 acres of Type 2 sites were mapped. Most of the Type 1 sites were hydric soils that are now used as cropland and believed to be effectively drained. The Type 2 wetlands represent nearly 5% of the watershed's wetlands. Eighty percent of these sites were either partly drained due to ditching or impounded by dikes or dams. The location of these restoration sites can be viewed using the NWI+ web mapper which is accessed online at: http://aswm.org/wetland-science/wetlands-one-stop-mapping. The preliminary nature of this inventory is emphasized. The designated sites may have potential for restoration. Whether or not they are practical sites depends on many factors

including the actual site characteristics, current use of the sites, landowner interest, work required for restoration, project budgets, and agency/organization priorities.
Historically, wetlands may have covered as much as 94,000 acres or 29% of the watershed prior to European settlement. Comparing this figure with the acreage of mapped wetlands and P-wet areas suggest that 25% of the historic wetlands and the functions they provided may have been lost, while functions of some of the remaining wetlands and P-wet areas have likely been adversely affected by drainage, impoundment, and other disturbances from land use activities.

Presque Isle marshes in summer (Brian Berchtold)

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APPENDICES

APPENDIX A: Correlation table showing wetlands of significance for each of eleven functions

Note: For a key to the codes that appear on the following list, see "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors: Version 2.0." (Tiner 2011) http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1324)

CORRELATION BETWEEN FUNCTIONS AND WETLAND TYPES

Function (code)	Level of Function	Wetland Types
Surface Water Detention (SWD)	High	LEBA (excluding LE5 and LE6 wetlands and wetlands with "K" water regime unless in a reservoir or dammed lake), LEFR (excluding LE5 and LE6 wetlands and wetlands with "K" water regime unless in a reservoir or dammed lake), LEFL (only in reservoir or dammed lake: LE2FL and LE3FL; not in impoundments), LEIL (not "A", "B" or "K" water regime), LSBA, LRFPba, LSFR (not "A" water regime), LRFR (not "A" water regime), LRIL (not "A" water regime), PDTH, TEFRpdTH, TEBApdTH, TEBATH, TEBATI, PD2c1, PD2d1, PD2e1, PD3c1, PD3d1, PD3e1
	(Note: The high level should not include any wetlands with "A" or "B" water regimes with one exception for LEFL in reservoirs or dammed lakes. Retained floating mat bogs such as LEFR because their area will store surface water when lake levels rise. Does not include areas now classified as LK that were mapped as PUB_ by NWI following NWI mapping conventions. Also should not include any LE wetland associated with an artificial freshwater impoundment completely surrounded by estuarine wetland or water, or any isolated impounded ponds and associated wetlands.)	
	Moderate	LRFPfl, LRFR (other than above), LSFL, LE1FL, LEIL (other than above, excluding LE5 and LE6 wetlands), LSFR (other than above), TEBA (other than above; excluding isolated impounded), PD (other except PD2f , PD3f, and isolated impounded ponds), TE__pd (other, excluding slope wetlands TESLpd__), TEFP__, TEFL__
	(Note: This function should not include any tidal wetlands – E2___, R1US, R1EM, and P___N, R, S, T and V - as they are covered under the Coastal Storm Surge function.)	

Coastal Storm Surge Detention (CSS)	High	ESBA, ESFR, ESIL, LR5FR, LR5FP, LR5IL, LS5BA, LS5FL, LS5FR, MAFR, MAIL, LE__BT (should exclude diked wetlands and tidal ponds that are impounded and associated tidal wetlands in these categories since the dike prevents storm flowage except during extremes such as hurricanes)
	Moderate	Other tidal wetlands not include above (which includes diked tidal wetlands) and any TE wetland (except SL - slope) or LS1 wetland contiguous with an estuarine wetland (usually marked by “ed” – these are bordering nontidal wetlands subject to infrequent or occasional tidal flooding during storms), TE wetland (except SL – slope) contiguous with marine waters or wetlands (should be marked with “md” or “ow”), TE__tr, TE__td, LS1_td, LS1_tr
	(*Note: Taking a conservative approach by focusing on lowland wetlands along the estuary and not including similar wetlands in the tidal freshwater reach.*)	
Streamflow Maintenance (SM)		
	High	"hw" wetlands (unaltered - excluding "d", "h", and "x" types)
	Moderate	altered "hw" wetlands (excluding "h" types), LR1FPba (excluding “h” or “d” types), LS__BA (excluding "h" and not LS5), TEBAOUds (excluding “h” or “d” types)
	(Note: While acreage of headwater wetlands may increase due to building ponds in headwater seeps (point features not polygons) and blocking drainageways, these wetlands do not increase streamflow and are not included in this function. However, when headwater vegetated wetlands are excavated to create ponds, the streamflow maintenance function is lowered from high (natural headwater wetland) to moderate as the wetland still provides for flow at high water periods and some flow at other times as well.)	

Nutrient Transformation (NT)	High	P__(AB, EM, SS, FO and mixes)C, P__(AB, EM, SS, FO and mixes)E, P__(AB, EM, SS, FO and mixes including __/UB and UB/__, etc.)F, P__(AB, EM, SS, FO and mixes)R, P__(AB, EM, SS, FO and mixes)T, P__(AB, EM, SS, FO and mixes)N, P__(AB, EM, SS, FO and mixes)H, P__(AB, EM, SS, FO and mixes)L or V, E2AB, E2EM (and mixes), E2SS (and mixes), E2FO (and mixes), E2RF, M2AB, P__(AB, EM, SS, FO and mixes)Bt (fen) , L2_(AB, EM and mixes)C, L2_(AB, EM, and mixes)E, L2_(AB, EM, and mixes)F, L2_(AB, EM, and mixes)H, L2_(AB,EM, and mixes)N, L2_(AB,EM, and mixes)R, L2_(AB,EM, and mixes)T, L2_(AB, EM, and mixes)V
	(Note: In relevant regions, try to separate fens from bogs as the former are nutrient-rich sites while the latter are nutrient-poor sites: use circumneutral modifier "t" to identify fens EM1_t, SS__t, FO__t from bogs PSS__Ba, PFO__Ba, for example GA coast – Include PFO3B, PSS3B and mixes of the two since they are permanently saturated; but not mixes with other types of "B" wetlands (FO1, FO4, EM, etc.).. Exclude PFO5 and PSS5 from high.)	
	Moderate	P__(AB, EM, SS, FO and mixes)B (not "t" fen), P__(AB, EM, SS, FO)A, P__(AB, EM, SS, FO and mixes)S, L2EM_A, PUS/__(mixed with vegetation classes excluding FO5 and SS5), PUB/__(mixed with vegetation classes)H, L2EM_S, PFO5/other vegetated, PSS5/other vegetated
	(Note: Commercial cranberry bogs – PSSf – are not rated as significant for this function, nor are other farmed wetlands - Pf.)	

Carbon Sequestration (CAR)	High	P__ (AB,EM, SS, FO, and mixes)E, P__ (AB,EM, SS, FO, and mixes)F, P__ (AB,EM, SS, FO, and mixes)C, P__ (AB,EM, SS, FO, and mixes)T, P__ (AB,EM, SS, FO, and mixes)R, P___Ba (and mixes), P____g (=wetlands on organic soils), E2EM (and mixes), E2SS (and mixes), E2FO (and mixes), R1EM, R_EMC, R_EME, R_EMF, L2EM_F, L2EM_E, L2EM_C, L2AB_F, L2AB_H, P__B (permanently saturated types; bogs noted with "a"), L2AB_G, L2AB_V, R_AB_F, R_AB_G, R_AB_V, R_AB_H, PAB_V, PAB_G, PAB_H
	(Note: Bogs and other permanently saturated wetlands and wetlands with organic soils should be rated as high for this function. Exclude AB1, PFO5 and PSS5 from 'High'. GA coast – Include PFO3B, PSS3B and mixes of the two since they are permanently saturated; but not mixes with other types (FO1, FO4, EM, etc.).)	
	Moderate	P__ (AB,EM, SS, FO, and mixes)A, P__ (AB,EM, SS, FO, and mixes)B (seasonally saturated types; permanently saturated types should be rated as High), P__ (AB,EM, SS, FO, and mixes)S, E2AB, R_EMA, L2EM_A, E2US (including mixes dominated by nonvegetated class; focus on mudflats and organic flats for purely nonvegetated types and exclude sand flats/beaches and other substrates; not E2US_P), R1US (and mixes dominated by nonvegetated class; focus on mudflats and organic flats for purely nonvegetated types and exclude sand flats/beaches and other substrates), PUB (and mixes; and not PD2 b,c,d,e1,and f or PD3 b,c,d,e1, f and j1; also exclude isolated impounded ponds), PUS/vegetated, and L2US/vegetated, L2UB/vegetated, PFO5 (excluding isolated and impounded), PSS5 (excluding isolated and impounded)
	(Note: Mixes for vegetated wetlands are those where vegetation is the dominant class, while mixes for nonvegetated wetlands are those where the substrate is the dominant class. Commercial cranberry bogs – PSSf – and other farmed wetlands P__f are not included; also "mixes" should include nonvegetated wetlands where vegetated types predominate and vegetated wetlands where nonvegetated types predominate. If mapping includes any H, G or V wetlands that are vegetated by vascular plants other than aquatic bed species – not dead trees, they too should be rated as high for this function. Also exclude M2AB1__ and E2AB1__ as these types are typically associated with rocky shores as mapped.)	

Sediment and Other Particulate Retention (SR)	High	ES__(vegetated and mixes), LEBA, LEFR (vegetated and mixes, not “fm”-floating mat), LEIL(veg and mixes, not “fm”), M2AB3__, LSBA, LRBA, LSFP, LRFP, LRFR (veg, not “fm”), LSFR(veg, not “fm”), LRIL (veg, not “fm”), PDTH, TE__pdTH (including __pq), PDBT, TE__pdBT, TEBATH, TEBATI, TEIFbaTH, TEIFbaTI, TEFRpdTH, PD2c1, PD2d1, PD2e1, PD3c1, PD3d1, PD3e1
	Moderate	E2__(US, SB, RF, excluding RS), LEFR (nonveg), LEFL (veg), LSFL (not P___B_), LRIL (nonveg), LRFR (nonveg), LSFR (nonveg), M2US, M2RF, Other TEBA (not P__B_), PD1, PD2 and PD3 (not c, d, e, f, g, j types), PD4, TEFLpd (not P__B_), TEFP__ (not P_B_), TEFL__ (P__A, not P__B_), TE__pdOU, TE__pdIN, Other TEFRpd__
	(Note: No “B” wetlands should be identified as significant for this function; only flooded types: A, C, E, F, H, R, S, T, R, N, M, and L should be rated. This will exclude bogs.)	
Bank and Shoreline Stabilization (BSS)	High	E2__(AB, EM, SS, FO and mixes; not IL), E2RS (not ESIL), E2US_P (not ESIL), M2RS(not MAIL), M2AB1N (not IL), LR_(AB, EM, SS, FO and mixes; not LRIL and not “fm”), LS_(AB, EM, SS, FO and mixes and not “fm” ”), LE__(AB, EM, SS, FO and mixes; not LEIL and not “fm” ”), R_RS, L2RS
	Moderate	E2US_N or M (not IL), M2US (not IL), TE__pd (AB, EM, SS, FO and mixes), TE__OUhw (AB, EM, SS, FO and mixes), E2RF (when occur along a shoreline), M2RF (when occur along a shoreline)
	(Note: Exclude IL wetlands from this function since they are not shoreline features.)	

Fish and Aquatic
Invertebrate Habitat (FAIH)

High

E2EM (including mixes with other types where EM1 or EM2 predominates; excluding E2EM5P__ and mixes where EM5 predominates and mixed communities dominated by E2FO or E2SS), E2US_M, E2US_N, E2RF, E2AB, E2RS/AB, L2_F, L2_H or G, L2AB, L2UB/__(AB, EM, SS, FO), LE__ (vegetated; AB, EM, SS, FO) and NWI water regime = H (permanently flooded), M2AB, M2RS/AB, M2US_M, M2US_N, M2RF; P__F and adjacent to PD (PD1, PD2 a3,b,and h, PD3b and h, and PD4 only), LK, RV (all except LR4), or ST (all except LS4) waters; P__F and __FRsl or __BAsl (slough), PAB (not excavated or impounded), PUB/__(AB, EM, SS, FO), P__(EM, SS, FO)H, PEM__(N,R,T, or L, except EM5), PSS_T, PFO_T, PD (PD1, PD2 a3,b,and h, PD3b and h , and PD4 only) associated with P__(AB, EM, SS, FO)F, R1EM, R1AB, R1US(except S), R2AB, R2EM, PD (PD1, PD2a3, 2b, 2h, PD3b, and 3h, and PD4) associated with P__(AB, EM, SS, FO)H

(Note: M1AB3L = submerged eelgrass – important habitat but is not wetland so it is not included above; reports will note this. L2__K wetlands were not rated due to unknown management.)

Moderate

LE__ and PEM1E (and mixes and contiguous with waterbody), LR__ and PEM1E (and mixes and contiguous with waterbody), LS__ and PEM1E (and mixes and contiguous with waterbody), PEM5F and adjacent to LK, RV (except LR4), or ST(except LS4) waters, E2EM5N (and mixes), PEM5N (and mixes), E2EM5/1P, E2EM5P__ and adjacent to the estuary (and mixes, but not "interior" E2EM5P_), E2FO/EM__ (not EM5), E2SS/EM__ (not EM5), LR5__ and PFO/EM_R or T (not EM5), LS5__ and PFO/EM_R or T (not EM5), LS5__ and PSS/EM_R or T (not EM5), PD (≥ 1 acre in size and PD1, PD2 a, b, h, PD3 a3, b, h, or PD4), TEFRpd (along these ponds), PAB (impounded or excavated and ≥1 acre and not associated with PD2 c,d,e,f,and g or PD3 c,d,e,f, and g), LR_FPba

(Note: Ponds one acre or greater and certain types were selected as moderate. Residential ponds 5 acres or greater were also identified as moderate for CT assessment; larger size was used to exclude ponds in dense urban/suburban areas.)

	Stream Shading (Shade)	LS (not LS4 or not LS__pd) <u>and</u> PFO, LS (not LS4 or not LS_pd) <u>and</u> PSS (not PSS_Ba or not PSSf); excluding FO5 and SS5

(Note: Shrub bogs should be excluded from all the above, e.g., PSS3Ba and commercial bogs = PSSf)

Waterfowl and Waterbird Habitat (WBIRD)	High	E2EM1 or E2EM2 (includes mixes where they predominate), E2EM5N, E2US__ M, N, P, and T water regimes (not S water regime), E2RF, E2AB, E2RS, L2_F (vegetated, AB, EM, SS, FO and mixes with nonvegetated), L2AB (and mixes with nonvegetated), L2US_(F,E, C, R, or T), L2UB_F, L2_H (vegetated, AB, EM, SS, FO and mixes with nonvegetated), M2AB, M2RS (excluding jetties and groins – M2RSPr), M2US, M2RF, P__F <u>and</u> adjacent to PD (PD1, PD2a3, 2h, PD3h, and PD4 only), LK, RV(not LR4) or ST (not LS4) waters or along a slough ("sl" modifier); PAB (not excavated or impounded, except those associated with wildlife impoundment – "wi"), P__T, P__H (vegetated, EM, SS, FO including mixes with UB), PEM1Eh, PEM1Eb; PUS_F, PUS_E, LS__ <u>and</u> PEM1E (including mixes; not LS4), LR__ and PEM1E (including mixes; not LR4), TE__ hw and PEM1E (including mixes); LE__ and PEM1E (including mixes); PEM_N (and mixes), PEM__R, (includes mixes, but excludes Phragmites-dominated EM5), P__/EM_N, and P__/EM_R (not EM5), PD2h, PD3h, PD4, PD1 <u>associated with</u> P__(AB, EM, SS, FO)F, PD associated with P___T, PD1 <u>associated with</u> P__(AB, EM, SS, FO)H, PUB__b, R1EM, R_EMF, R1US (except S water regime), TE_pd and PEM1E (including mixes)

Moderate	E2EM5P (and mixes) and contiguous with open water (not "interior" marshes), E2SS1/EM1P6, E2SS1/EM1Ph, E2EM5/1P, PEM5__E,F, R, or T and adjacent to PD, LK, RV(not LR4), or ST(not LS4), other L2UB (not listed as high), Other PD (≥ 1 acre in size and PD1, PD2 a, h, PD3 a, h, or PD4), Other P__F (vegetated wetlands), PAB (impounded or excavated and >1 acre), LS4 and PEM1E (≥ 1 acre in size), TEBA and PEM1E (≥ 1 acre in size)
Wood Duck	LS(1,2, or 5)BA and P__ (FO or SS and mixes; not PSS3Ba or PSSf – commercial cranberry bog), LS(1,2, or 5)FR and P__ (FO or SS and mixes; not PSS3Ba or PSSf), LR(1,2, or 5)FPba and P__(FO or SS and mixes; not PSS3Ba or PSSf), LRFPba and PUB/FO; PFO_R, T, or L (and mixes) and contiguous with open water, PSS_R, T, or L (and mixes) and contiguous with open water

(Note: All waterfowl impoundments and associated wetlands that should be marked with "wi" should be rated as high for this function. Ponds used for aquaculture (2b, 3b) are excluded since management will likely deter use of these ponds; associated wetlands should also be excluded as should wastewater treatment, industrial, and commercial ponds and lakes and associated wetlands. Shrub bogs, e.g., PSS3Ba, commercial bogs = PSSf , and farmed wetlands: P__f should be excluded in Northeast, but check use of farmed wetlands in Prairie Pothole and elsewhere. Comment: PEM1C wetlands along waterbodies may also be important for this function in some regions, but in the Northeast these may be wet meadows rather than marshes; these wetlands are recognized as important for "Other Wildlife.")

Other Wildlife Habitat (OWH)	High	Any vegetated wetland complex ≥ 20 acres, wetlands 10-20 acres with 2 or more vegetated classes (excluding EM5), certain ponds (PD1a, b, c, d, e, f, h, i, j, k, l, m, n, o, p, q1, q2, q3, q4) , freshwater wetlands (P___ or L2____) on undeveloped portions of barrier islands or beaches, small permanently flooded or semipermanently flooded wetlands (including PUBH and PUBF) within a forested wetland or upland forest (can use specific PD types to identify these), other forested or scrub-shrub wetlands within 100m of these permanently flooded or semipermanently flooded wetlands
	Moderate	Other vegetated wetlands
	(Note: Vegetated wetlands should focus on EM, SS, and FO; exclude AB from the size determination of a vegetated wetland complex, but include AB mixes with EM, SS, and FO (e.g., AB/FO, EM/AB) except FO5 and SS5.)	
Unique, Uncommon, or Highly Diverse Wetland Plant Communities (UWPC)	Regionally significant	E2EM1N, E2EM1P6, R1EM, R1US (only where vegetated in summer), PEM1N, PEM1R, PEM2N, PEM2R, PSS_R, PSS_T, PFO4__g and PSS4__g (Atlantic white cedar; including mixtures), P___t (fens – EM, SS, FO), E2AB__ (eelgrass and SAV beds-not algae), LS__FR (excluding PFO5 and SS5), LR__FR excluding PFO5), *PD1m (woodland vernal pool), E2EM1N6, PEM1T
	(Note: Exclude any altered wetland – x, h, td, and tr – plus any "d" wetland that is channelized or extensively ditched; also exclude any EM5 wetland or wetland mixed with EM5 unless it is native Phragmites. R1US wetlands only where mapped on leaf-off imagery and no summer image was available; otherwise should be mapped as R1EM2 where vegetated in summer with emergents.)	

APPENDIX B. Introduction to the NWI+ Web Mapper

Introduction to the NWI+ Web Mapper

The NWI+ Web Mapper is an online mapping tool based on ESRI's ArcGIS online mapping platform that allows users to view special project data prepared by the U.S. Fish and Wildlife Service (FWS) but not available through the FWS's "Wetlands Mapper." The data were prepared for special projects and are not a standard NWI product. In addition to viewing NWI types for these areas, a number of other data layers are available. These layers may show wetlands classified by hydrogeomorphic properties (landscape position, landform, and water flow path = LLWW descriptors), areas that may support wetlands based on soil mapping (hydric soils lacking a recognizable wetland photo-signature = P-wet areas), wetlands that have been predicted to be important for providing numerous functions, and potential wetland restoration sites. These layers are briefly described below. Once you have opened the mapper, you'll see icons on the tool bar above the map plus a list of five topics: "Intro to the Mapper" (a must-read description of mapper contents and operation), "Wetlands One-Stop" (takes you to the page where other sources of wetland information can be accessed), "NWI" (takes you to the FWS's official NWI website), "Northeast NWI" (takes you to the home page of the Northeast Region's NWI Program), and "CMI" (takes you to the home page of Virginia Tech's Conservation Management Institute). For additional information on this tool and related topics, visit the Association of State Wetland Managers' "Wetlands One-Stop" website at http://aswm.org/wetland-science/wetlands-one-stop-mapping. (*Note: The mapper will likely be upgraded periodically so the actual procedures may vary slightly but using the guidance below should prepare users for future versions.*)

NWI+ Data Layers

Several data layers may be available for each project area: NWI Types, LLWW Types (NWI+ Landscape, NWI+ Landform, and NWI+ WaterFlowPath), eleven Functions, Restoration Types (NWI+ Restoration Type1, NWI+ Restoration Type2), NWI+ P-WetAreas, and layers for accessing more information (e.g., Wetland Codes). These layers are described below. For questions, contact Ralph Tiner, Regional Wetland Coordinator, U.S. Fish and Wildlife Service (FWS) at: ralph_tiner@fws.gov.

NWI Types (*NWI-Common Types*) – this layer displays wetlands and deepwater habitats mapped by the U.S. Fish and Wildlife Service's National Wetlands Inventory Program and classified by the FWS's official wetland classification system (Cowardin et al.1979). (*Note: Any differences between NWI+ data and NWI online data can be viewed by adding NWI data from the official NWI website as a separate layer.*) For display purposes wetlands have been separated into a number of groups typically by ecological system (Marine, Estuarine, Palustrine, Lacustrine, and Riverine) and/or vegetation type (aquatic bed, marsh, shrub swamp, forest, etc.; some of these terms are common names and not the official Cowardin designation). To view the legend for these types click on "Legend" icon on the tool bar at the top of the mapper, then locate the legend for the layer of interest. For specific NWI nomenclature, simply click on the "Wetland Codes" box and a series of dots (points) will appear on the wetlands. Click on a dot and a search box will appear showing the applicable NWI and LLWW codes for that area and the acreage of the polygon. The Cowardin et al. document can be accessed through the FWS Conservation Library Wetland Publications page (http://library.fws.gov/FWS-OBS/79_31.pdf).

LLWW Types – these layers (“NWI+ Landscape”, “NWI+ Landform”, and “NWI+ WaterFlowPath”) display NWI wetlands and deepwater habitats by hydrogeomorphic-types according to Tiner (2003, 2011, or more recent versions): landscape position, landform, and water flow path (see “LLWW” page for a description of these types and to access the classification document – dichotomous keys and mapping codes, go to: http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1324). For this classification, ponds have been separated from other wetlands for more detailed classification. Like was done for NWI Types, to view the LLWW code for a wetland and waterbody check the box “Wetland Codes” and dots will appear on the wetlands. Click on a dot and a search box will appear displaying the NWI code, LLWW Code, and acreage of the polygon (see the dichotomous keys/mapping codes document for a key to coding and the actual project report for additional information on the application of the classification for the specific project area). Some of the more frequently used codes are: for wetland landscape position = ES – Estuarine, MA – Marine, LS – Lotic Stream, LR – Lotic River, LE – Lentic, and TE – Terrene; for landform = BA – Basin, FL - Flat, FP - Floodplain, FR - Fringe, IS – Island, and SL – Slope; for water flow path = TH – Throughflow, OU – Outflow, VR - Vertical Flow (formerly IS – Isolated), IN – Inflow, and BI – Bidirectional-nontidal, and BT – Bidirectional-tidal. To view the legend, use the “Legend” tool.

_______ *Function* – these layers display wetlands identified as potentially significant for each of eleven functions: surface water detention (SWD), streamflow maintenance (SM), coastal storm surge detention (CSS), nutrient transformation (NT), sediment and other particulate retention (SR), carbon sequestration (CAR), bank and shoreline stabilization (BSS), provision of fish and aquatic invertebrate habitat (FAIH), provision of waterfowl and waterbird habitat (WBIRD), provision of other wildlife habitat (OWH), and provision of habitat for unique, uncommon, or highly diverse plant communities (UWPC). Descriptions of these functions and the wetlands that provide those functions are found in a 2003 correlation report and tables that update the relationships; a link to these documents can be found on the LLWW page. To view the functions for a particular wetland of interest just check the applicable function box. You can only view one function at a time. If interested in the NWI or LLWW classification for the wetlands simply check the "Wetland Codes” box. As with the other layers, if you want to see the legend, use the “Legend” tool.

NWI+ Restoration Type1 – this layer identifies former wetlands (now nonwetlands) that are in a land use where wetland restoration may be possible. Type 1 restoration sites should be former wetlands that were converted to either “developable land” by drainage and/or filling or deepwater habitats by impoundment (diking) or excavation (dredging). Most of the former sites should be agricultural land that involved wetland drainage or barren land that may represent drained wetlands or filled wetlands. The latter sites are deepwater habitats created from wetlands by impoundment (e.g., L1UBHh in NWI code) or by dredging (e.g., E1UBLx in NWI code). All of the designated sites were mostly likely wetlands based on soil mapping; these sites should not include deepwater habitats created by flooding dryland in river valleys. The referenced sites should have potential for restoration. Whether or not they are viable sites depends on site-specific characteristics, landowner interest, agency funding/priorities, and other factors. For the name of the soil type mapped at a particular site, click the “NWI+ Rest Type 1 Soil Codes.” If the site is agricultural land or barren land, restoration will typically require action to bring back the hydrology and may involve removal of fill. For an inundated sites (now deepwater habitats), full or partial removal of the dike or dam would be needed to restore more natural hydrologic regimes, while excavated sites would require restoration of wetland elevations by bringing in suitable fill material.

NWI+ Restoration Type2 – this layer shows existing wetlands that have been impaired to a degree that affects their ability to function like an undisturbed natural wetland. Click on the "Wetland Codes" box for access to NWI and LLWW codes as described above. In the coastal zone, most of these type 2 restoration sites are either partly drained wetlands (with "d" modifier in the NWI code) or tidally restricted wetlands. The former are extensively ditched (e.g., E2EM1Pd in NWI code) while the latter are separated by other tidal wetlands by roads and/or railroads (look for "td" – tidally restricted/road, "tr" – tidally restricted/railroad, or "to" – tidally restricted/other in the LLWW code). For inland wetlands, type 2 restoration sites include partly drained wetlands ("d" modifier), impounded wetlands ("h" modifier; often ponds – PUBHh – built on hydric soils), excavated wetlands ("x" modifier, typically ponds – PUBHx – dug out from a wetland), and farmed wetlands (NWI code = Pf or PSSf). Sites designated have impairments that may be restorable through various means such as plugging drainage ditches, destroying tile drains, removing tide gates, installing self-regulating tide gates, increasing culvert sizes, breaching impoundments, for example.

NWI+ P-WetAreas – this layer identifies "areas that may support wetlands based on soil mapping." These are areas that did not exhibit a recognizable wetland photo-signature on the aerial imagery used for NWI mapping, but were mapped as hydric soils by USDA soil surveys. They are portions of hydric soil map units from the USDA Natural Resources Conservation Service (NRCS) soil survey geographic database (SSURGO database) that were not farmland, roads, residential houses and lawns, or commercial, industrial or "other" development on the imagery used for NWI mapping (see applicable report). Since they were designated as hydric soil map units, they have a high probability of containing at least some wetland despite not possessing a readily identifiable wetland signature on the aerial imagery used by the NWI. It is a well-known fact that NWI methods cannot detect all wetlands (especially drier-end wetlands – seasonally saturated types) due to limitations of remote sensing techniques and the difficulty of identifying some types even in the field. Many of these hydric soil areas are adjacent to mapped wetlands and may therefore represent the drier portion or upper limit of the wetland while other areas may be upland inclusions within a hydric soil mapping unit. When you click on "NWI+ P-WetArea Codes" box a series of dots (or points) will appear on the polygons, click on these dots to see the hydric soil type ("MUSYM" – the soil map unit symbol used by NRCS, and "muname" – soil map unit name - predominant soil series). Inclusion of these data makes the NWI+ database more complete in terms of locating areas of photointerpretable wetlands and other areas with a high probability for wetland occurrence based on soil mapping.