Wetlands of the Eastern and Southern Shores of Lake Ontario: Project Completion Report

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Wetlands of the Eastern and Southern Shores of Lake Ontario: Project Completion Report

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Background

The U.S. Army Corps of Engineers has an interest in coastal wetlands of Lake Ontario largely due to its role in maintaining navigation across the Great Lakes system. Lake Ontario is the lowest of the Great Lakes and connects the Great Lakes to the Atlantic Ocean through the St. Lawrence River. Discharge to the St. Lawrence River is controlled by the Moses-Saunders Power Dam between Massena, New York and Cornwall, Ontario. Since 1959, water levels and outflows have been controlled for hydropower and navigation purposes (Busch et al. 1990). Regulation of water levels has reduced interannual variation in lake levels that normally occurred, especially the lows (Figure B-1). This moderation of lake level dynamics has significantly impacted the vegetation of coastal wetlands by creating more stable water levels that favor the expansion of cattails (Typha spp.) (Farrell et al. 2010, Wilcox et al. 2008).

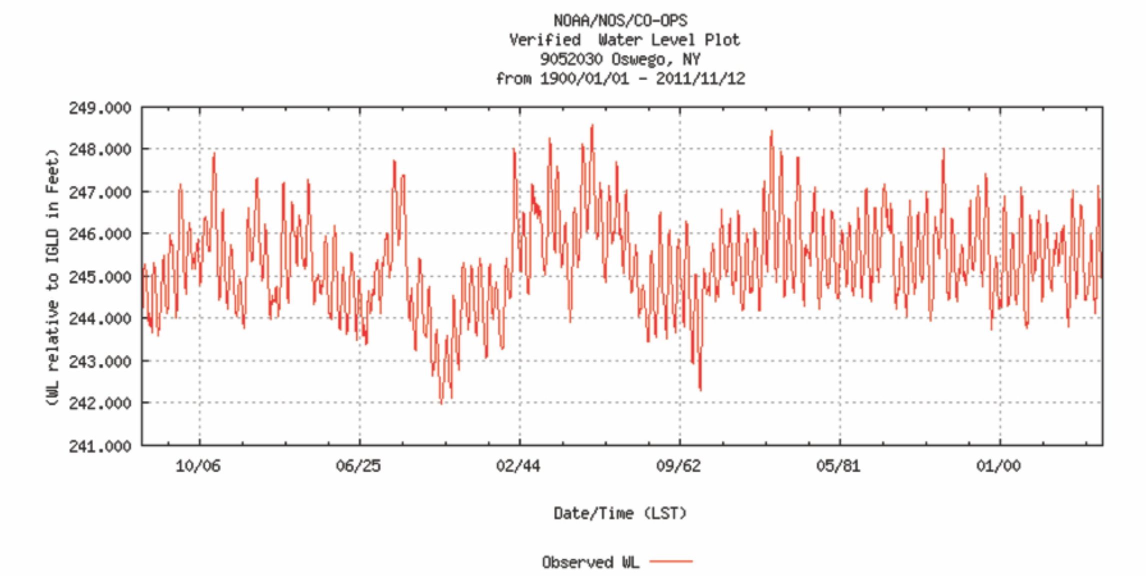

Figure B-1. Historic monthly water-level fluctuations of Lake Ontario (Oswego station) from 1900 to 2011. Prior to water level regulation in the 1960s, greater interannual fluctuations occurred with noticeably lower lows and the lowest occurring at 30- to 40-year intervals. Water-level regulation from the 1960s to the present reduced interannual variations and prevented extreme low water conditions from occurring.

Prior to such lake flow regulation, water levels rose and fell in accordance with water conditions across the Great Lakes system on a 30- to 40-year cycle between highest and lowest levels. These water level fluctuations created a more dynamic coastal environment that caused significant shifts in coastal vegetation patterns from more aquatic beds and marshes in wet years to more wet meadows following dry years. While water levels still fluctuate seasonally and annually, the differences between high water years and low water years have been suppressed by water-level regulation.

Recent concern over the effect of such regulation on shoreline properties and wetlands led to the International Joint Commission (IJC) conducting a study of various options to alter management of water levels. The IJC concluded a five-year study in 2006 and in 2007, they issued a proposed order that would adopt an "adaptive management approach" to regulation of the Lake Ontario and St. Lawrence River System that would regulate flows to "protect the resiliency of wetlands and biodiversity on Lake Ontario and on the St. Lawrence River" (International Joint Commission 2007). If adopted, this could restore more natural dynamics to the vegetation of Lake Ontario's coastal wetlands. In a letter to the Canadian and U.S. governments dated September 4, 2008, the IJC recommended establishing a multi-agency work group to resolve any outstanding issues and gain support from both governments for future regulation of water levels (http://www.ijc.org/en/activities/losl/index.php). No plan has been enacted as deliberations are still in progress (Wilcox 2011).

Lake Ontario's coastal wetlands have been inventoried by various surveys but data are at least 20 years old. For example, Geis and Kee (1977) mapped coastal wetlands in Jefferson County, New York. This survey was quite detailed in its classification of types within individual wetland complexes. The U.S. Fish and Wildlife Service's National Wetlands Inventory Project (NWI) included coastal wetlands in their work in New York but did not specifically classify coastal wetlands as a distinct type, nor did the Service produce any summary statistics of their work. Acreages for U.S. coastal wetlands along the U.S. shoreline of the Great Lakes were measured from NWI maps by Herdendorf et al. (1981) with the results presented in a series of technical reports on the fish and wildlife resources of Great Lakes coastal wetlands. More recently, Moffett et al. (2006) expanded the list and area of coastal wetlands by using federal, state, and provincial maps to produce acreage summaries of individual coastal wetlands for the entire Lake Ontario shoreline (U.S. and Canada). In this work they also classified a subgroup of coastal wetlands for some lakes as drowned-river-mouth based on descriptions by Keough et al. (1999), but did not do so for Lake Ontario's wetlands. Moffett et al. (2006) tabulated 168 coastal wetlands for Lake Ontario (Table B-1) compared to 167 from Herdendorf et al. (1981). Lake Ontario's coastal wetlands represent about five percent of the Great Lakes coastal wetlands.

Table B-1. Coastal wetland area for Lake Ontario according to Moffett et al. (2006). Area was originally reported in hectares and was converted to acres for this table.

Size Class	Number of Wetlands (%)	Area in Acres (% of Lake's Coastal Wetlands)
Small (<100 acres)	138 (82)	2,866 (20)
Medium (100-1000 acres)	28 (17)	8,755 (62)
Large (>1000 acres)	2 (1)	2,602 (18)
Total for Lake Ontario	168	14,223

References

Busch, W-D.N., R.G. Osborn, and G.T. Auble. 1990. The effects of water levels on two Lake Ontario wetlands. In: J. Kusler and R. Smardon. Wetlands of the Great Lakes: Protection and Restoration Policies; State of the Science. Proceedings of an International Symposium, May 16-18, 1990, Niagara Falls, NY. Association of State Wetland Managers, Inc., Berne, NY. pp. 92-96.

Farrell, J.M., B.A. Murry, D.J. Leopold, A. Halpern, M.B. Rippke, K.S. Godwin, and S.D. Hafner. 2010. Water-level regulation and coastal wetland vegetation in the Upper St. Lawrence River: inferences from historical aerial imagery, seed banks, and Typha dynamics. Hydrobiologia 647: 127-144.

Geis, J.W. and J.L. Kee. 1977. Coastal Wetlands Along Lake Ontario and St. Lawrence River in Jefferson County, New York. State University of New York, College of Environmental Science and Forestry, Institute of Environmental Program Affairs, Syracuse, NY.

Herdendorf, C.E., S.M. Hartley, and M.D. Barnes. 1981. Fish and Wildlife Resources of the Great Lakes Coastal Wetlands within the United States. Volumes 1-6: Overview, Lake Ontario, Lake Erie, Lake Huron, Lake Michigan, and Lake Superior. U.S. Fish and Wildlife Service, Division of Ecological Services, Twin Cities, MN. FWS/OBS-81/02-v1-6.

Keough, J.R., T.A. Thompson, G.R. Guntenspergen, and D.A. Wilcox. 1999. Hydrogeomorphic factors and ecosystem responses in coastal wetlands of the Great Lakes. Wetlands 19: 821-834.

Moffett, M.F., R.L. Dufour and T.P. Simon. An inventory and classification of coastal wetlands of the Laurentian Great Lakes. Chapter 2. In: T.P. Simon and P.M. Stewart (eds.). Coastal Wetlands of the Laurentian Great Lakes: Health, Habitat, and Indicators. AuthorHouse, Bloomington, IN. pp. 17-99.

Wilcox, D.A. 2011. Cattails as far as the eye can see. Society of Wetland Scientists Research Brief No. 2011-0002.

Wilcox, D.A., K.P. Kowalski, H.L. Hoare, M.L. Carson, and H.N. Morgan. 2008. Cattail invasion of sedge/grass meadows in Lake Ontario: photointerpretation analysis of sixteen wetlands over five decades. Journal of Great Lakes Research 34: 301-323.

Purpose of Study

The present study was initiated to establish baseline conditions for major coastal wetland types from Braddock Bay in the west to Cape Vincent. These conditions would serve as one benchmark for monitoring the effect of any future changes in water level regulation on coastal wetlands. By classifying wetlands into various types, the study results could also aid in random selection of wetlands for detail vegetation assessment and monitoring in the future. The study involved a combination of field investigations, interpretation of aerial imagery, and various data analyses through geographic information technology and laboratory analysis of soil samples. The results of this study are presented in three chapters: 1) inventory, 2) vegetation, and 3) soils.

Chapter 1. Inventory of Lake Ontario Wetlands

Ralph W. Tiner and Todd Nuerminger

Introduction

Historically coastal wetland vegetation patterns shifted over time in response to interannual and decadal changes in water levels. For Lake Ontario, water levels appear to change substantially during a 30- to 40-year cycle (Figure 1-1). During this cycle, there were annual cycles of high and low water levels with interannual variations producing higher high and lower lows over the course of the cycle. Coastal vegetation responded to these fluctuations creating a dynamic change in coastal wetland vegetation over the long-term cycle. During high water periods, aquatic bed and marsh vegetation dominated these marshes, while at low water periods wet meadows predominated. Given water-level regulation since the late 1950s, the extremes in Lake Ontario water levels have been dampened and fluctuations occur in a narrower range. These conditions promoted expansion of cattails into what once were wet meadows creating a loss of biodiversity (Wilcox et al. 2008, Farrell et al. 2010). Current plans to achieve more natural flows will likely increase the potential for lower low water levels that may favor establishment of more diverse wet meadows over monotypic cattail marshes.

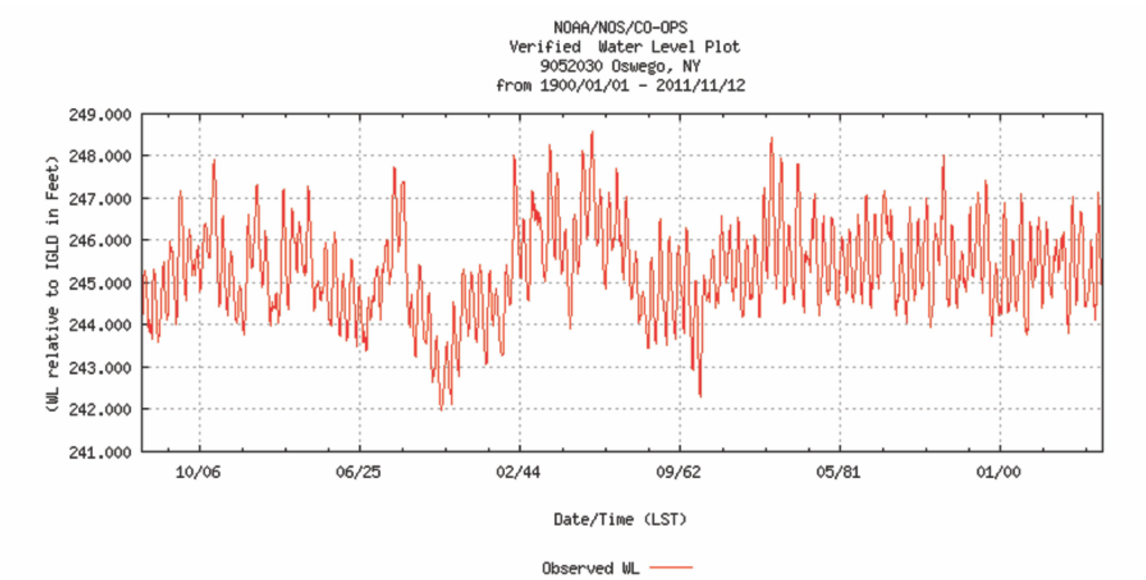

Figure B-1. Historic monthly water-level fluctuations of Lake Ontario (Oswego station) from 1900 to 2011. Prior to water level regulation in the 1960s, greater interannual fluctuations occurred with noticeably lower lows and the lowest occurring at 30- to 40-year intervals. Water-level regulation from the 1960s to the present reduced interannual variations and prevented extreme low water conditions from occurring.

Study Objective

The objective of the wetland inventory was to identify and map the location of coastal wetlands that would likely change over time due to modifications in regulated water-level regimes. The study was initially conceived as a multi-year study intended to track vegetation changes over a series of years. Such analysis if encompassing high and low water years would be able to detect in corresponding changes in vegetation patterns. However, funding was only available for one year, so this study created a baseline that can be used for comparison in the future should additional funding become available.

Methods

The study area consists of coastal wetlands in selected areas along the Lake Ontario shoreline just west of Rochester to Cape Vincent. The areas covered represent shorelines where coastal wetlands are most common. The study area consists of four areas where aerial imagery was acquired by the Corps: 1) Braddock Bay to Round Pond, 2) Irondequoit Bay, 3) Sodus Bay to Little Sodus Bay and the Pond, and 4) Mexico Bay to Cape Vincent. Acreage data for all wetlands in the coastal embayments (current and former lagoons) and along coastal rivers were included in the following summary. Since the data are geospatial, other summaries can be easily extracted from the database using standard geographic information system (GIS) analyses. All of these wetlands occur entirely within a zone extending six miles inland from the shoreline and most lie within a two-mile distance. Although coastal wetlands do not include wetlands not directly connected or formerly connected to the lake (e.g., inland wetlands), former coastal wetlands and wetlands along tributary rivers were also included in the geospatial database since they are also affected by lake levels to varying degrees.

Wetland Classification

For purposes of this inventory, wetlands were divided into several types: 1) aquatic bed, 2) marsh, 3) wet meadow, 4) shrub swamp, 5) mixed types, and 6) wooded swamp (Table 1-1). Dominant species would be identified depending on the uniqueness of their spectral signature which depends on the quality of the aerial imagery and the vegetative growth at the time of image acquisition. Wooded swamps were not targeted for mapping because imagery was acquired during a leaf-on condition making detection of forested wetlands from upland forests difficult in most cases and impossible in others. Also they are not types that are likely to change with a change in water regulation since they typically occur at elevations above the targeted wetland types. Nonetheless, some wooded swamps contiguous with coastal wetlands and that lie in what appear to be former coastal lagoons were delineated based on subtle image signatures and in consultation with collateral data such as U.S. Fish and Wildlife Service National Wetlands Inventory data and U.S. Geological Survey topographic data. These sources represent existing geospatial information on wetland location, type, and distribution for the study area. Lakes, ponds, and rivers were delineated where they are distinctly separate from Lake Ontario. The shoreline of Lake Ontario was not delineated.

Table 1-1. Definitions of general wetland types classified during this inventory. Note that various combinations of these types (mixed types) are possible given the intermixing of types associated with the fluctuating lake levels.

Common Type	General Definition
Aquatic Bed	Wetland dominated by floating, floating-leaved, or submerged plants growing in permanent or near permanent water.
Marsh	Wetland dominated by self-supporting herbaceous plants (such as cattails, pickerelweed, and arrowheads and perhaps intermixed with aquatic bed species like duckweeds) that grow in areas that are flooded throughout the growing season in most years.
Wet Meadow	Wetland dominated by self-support herbaceous plants (often grasses, sedges, and various flowering herbs) that typically grow in areas subject to periodic flooding and/or prolonged waterlogging where surface water is usually absent for a significant period of the growing season.
Shrub Swamp	Wetland dominated by woody plants that are less than 20 feet (6.6 meters) in height; hydrology is variable as some may be flooded throughout the growing season in most years while others are inundated for shorter periods.
Wooded Swamp	Wetland dominated by woody plants (trees) that are 20 feet (6.6 meters) or taller; like Shrub Swamp, it may be flooded for variable periods during the year.

In addition to the general classification of wetlands noted above, wetlands were also classified according to the Cowardin et al. system (1979) which is the national standard for wetland classification (Federal Geographic Data Committee 1996). In accordance with this classification, coastal wetlands fall into three ecological systems: 1) Lacustrine, wetlands in the shallow water zone of lakes, typically aquatic beds; 2) Riverine, wetlands in the shallow water zone of rivers and streams; and 3) Palustrine, wetlands dominated by persistent vegetation, including marshes and swamps. Some typical wetland types and their mapping codes are presented in Table 1-2. Since the coastal wetlands of interest were vegetated types, they were further classified by the dominant life form as aquatic bed (floating, rooted vascular, or submergent species), emergent wetland (graminoids and other herbaceous flowering plants), scrub-shrub wetland (dominated by woody plants less than 20 feet or 6.6 meters tall), and forested wetland (dominated by trees 20 feet/6.6 meters or taller). Mixtures of these cover types were classified based on spatial dominance. While the inventory did not delineate the entire shoreline of Lake Ontario or its major embayments which constitute deepwater habitats, some waterbodies (unconsolidated bottom, UB) were mapped, i.e, rivers emptying into the Lake (R1UBH) and numerous lakes (L1UBH) and ponds (PUBH) connected to Lake Ontario through permanent or seasonal inlets and perhaps some that were formerly connected but are now separated by strips of upland.

Table 1-2. Typical wetland types mapped according to the U.S. Fish and Wildlife Service's wetland classification system (Cowardin et al. 1979). Note that there are no subsystems in the Palustrine System. The space (_) indicates that various subclasses may be defined. Mixed types (e.g., EM/AB, SS/EM) may also be classified.

System	Code	Name (System, subsystem, class, and water regime)
Lacustrine	L2AB_H	Lacustrine (L), littoral (2), aquatic bed (AB), permanently flooded (H)
Riverine	R1AB_H	Riverine (R), lower perennial (1), aquatic bed (AB), permanently flooded (H)
Palustrine	PAB_H	Palustrine (P), aquatic bed (AB), permanently flooded (H)
	PEM_F	Palustrine (P), emergent (EM), semipermanently flooded (F)
	PEM_E	Palustrine (P), emergent (EM), seasonally flooded/saturated (E)
	PSS_F	Palustrine (P), scrub-shrub (SS), semipermanently flooded (F)
	PSS_E	Palustrine (P), scrub-shrub (SS), seasonally flooded/saturated (E)
	PSS_C	Palustrine (P), scrub-shrub (SS), seasonally flooded (C)
	PFO_E	Palustrine (P), forested (FO), seasonally flooded/saturated (E)
	PFO_C	Palustrine (P), forested (FO), seasonally flooded (C)

Field Data Collection

Field investigations were initiated to collect information on wetland plant communities to aid in wetland classification and interpretation through image analysis. The data would also be used to describe the general composition of Lake Ontario coastal wetlands. The objective was to access and record dominant species for many of the wetlands as possible from land or water given considerations of restricted access on private property. Two student teams spent two months in the field for this part of the project. Their work involved accessing wetlands by foot from roads and from the water's edge by canoe. Detailed field observations were collected at over 140 stations where plants were evaluated in pairs of 1-m^2 plots (see Chapter 2). Point observations of dominant species were made at another 283 locations across the study area. These data were used to designate certain dominance types.

Source Imagery

Aerial imagery for this study was provided by the Corps of Engineers, Buffalo District. Digital ortho-rectified imagery at a scale of 1: 12,000 (color infrared and natural color) was acquired from May 30 through June 1, 2011 by Northrop Grumman Corporation (Northrop Grumman Corporation 2011; Figure 1-2). The imagery covered four areas: 1) Braddock Bay to Round Pond, 2) Irondequoit Bay, 3) Sodus Bay and Little Sodus Bay/The Pond, and 4) Mexico Bay to St. Lawrence River (Figure 1-3). The dates of acquisition coincided with annual high-water levels (Figure 1-4) which was similar to many high-water periods during the past decade (Figure 1-5).

Collateral Imagery

Since early growing season and high-water conditions are not best for detection of all types of vegetation, the early season imagery was supplemented by viewing available online imagery via Google Earth and Bing maps. Google Earth provided access to a series of recent aerial imagery from the 1990s to the present to help interpret subtle signatures of marshes underwater due to high water conditions in early summer 2011. Bing maps had exceptionally high-quality leaf-off imagery that helped with detection of shrub swamps.

Figure 1-2. Example of color infrared aerial imagery provided for this project showing Salmon River deltaic wetlands.

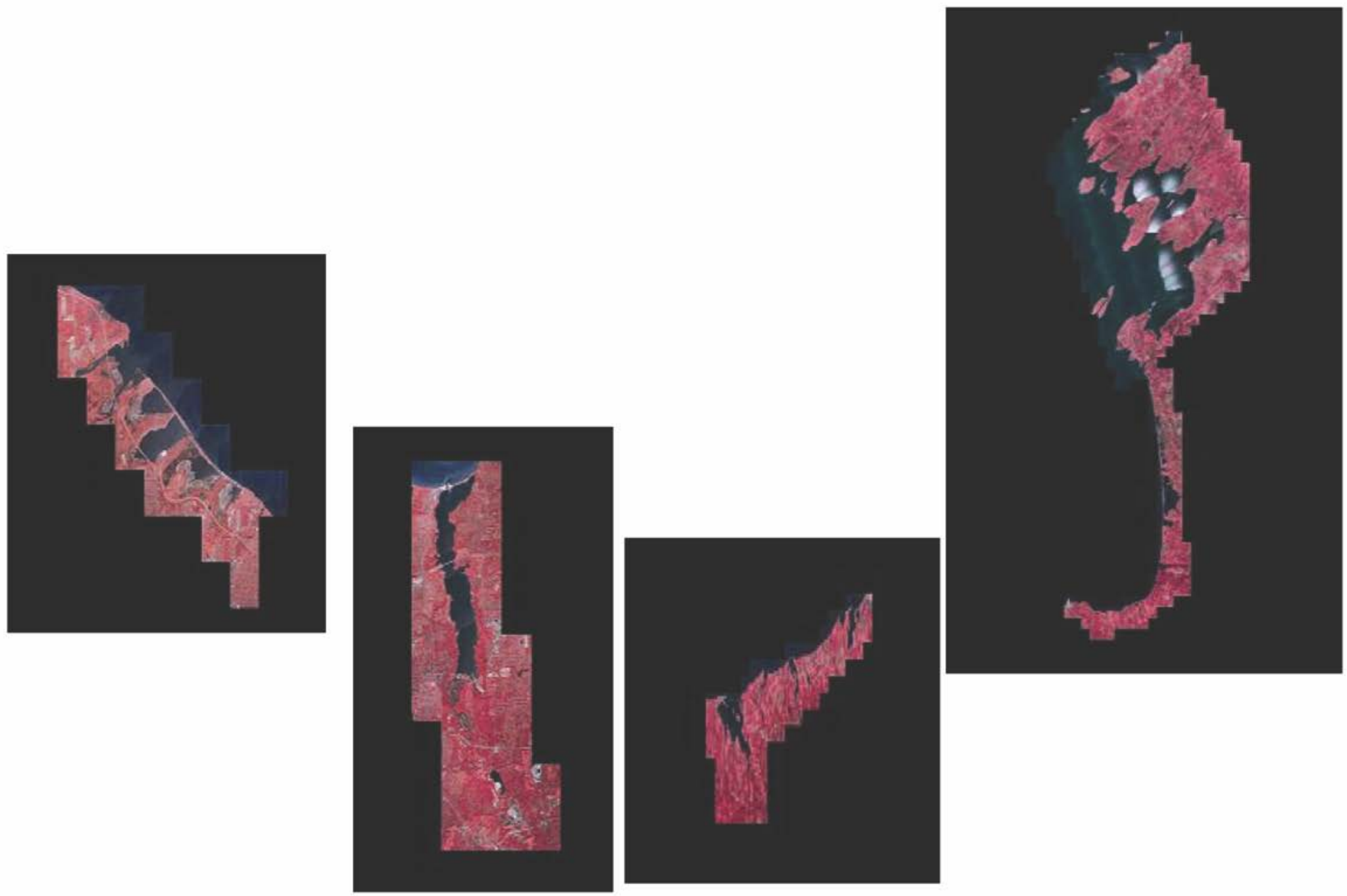

Figure 1-3. Four areas where imagery was acquired for this project. From left (west) to right (east): 1) Braddock Bay to Round Pond, 2) Irondequoit Bay, 3) Sodus Bay to Little Sodus Bay, and 4) eastern shore of Lake Ontario from Mexico Bay to the St. Lawrence River.

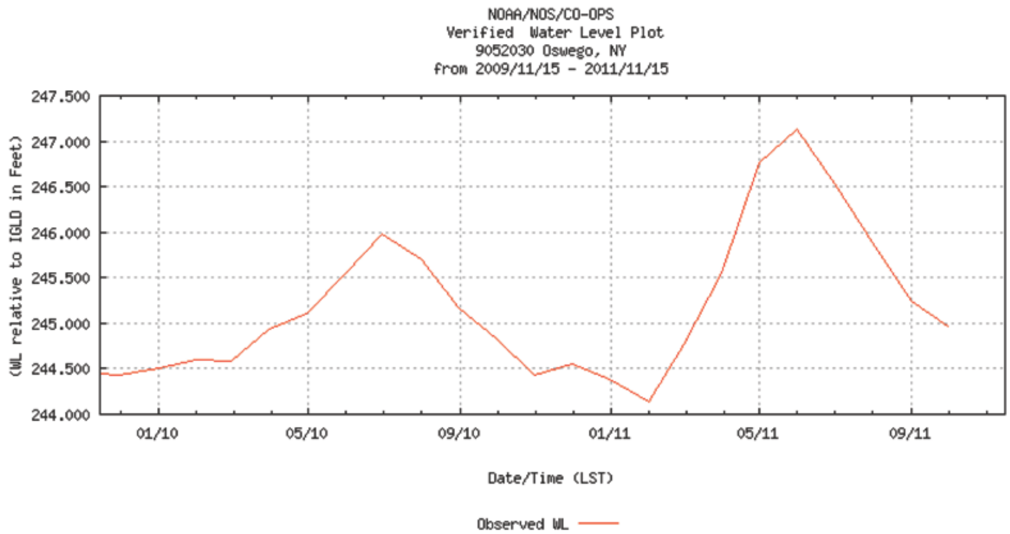

Figure 1-4. Lake levels at the Oswego station over the past two years from November 2009 to November 2011. (Source: NOAA). Note extreme high water in May and June 2011.

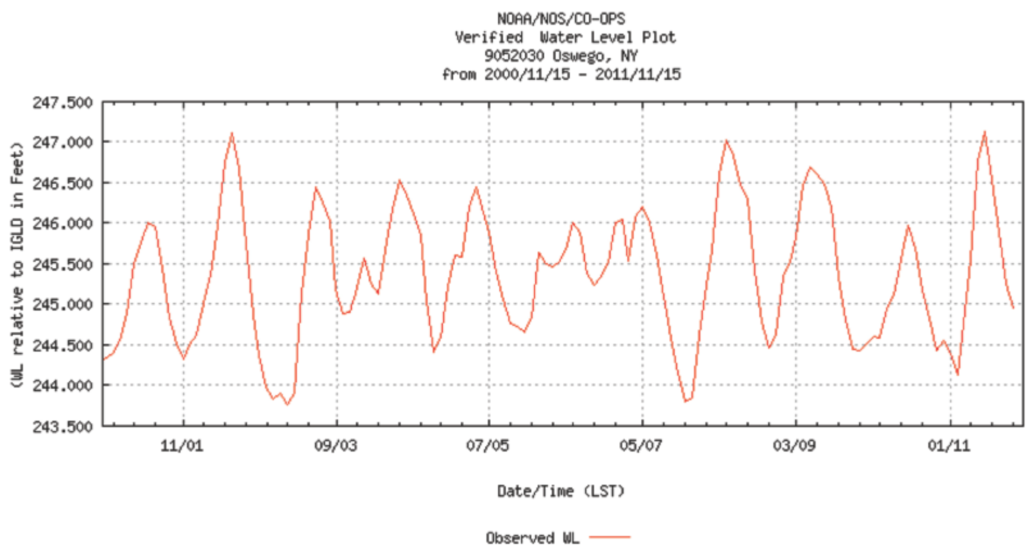

Figure 1-5. Lake levels at the Oswego station over the past decade. Lake levels in mid-2011 represent the highest levels during this decade. (Source: NOAA)

Wetlands Interpretation of Digital Imagery

Interpretation was done monoscopically on-screen using ArcGIS 10. Wetlands were delineated on-screen following recognizable spectral signatures using color and texture as clues (Figure 1-6) and classified according to Cowardin et al. (1979) and to a more generalized classification (Table 1-1). The target mapping unit was 0.5 acres. Interpretations were verified by consulting results of field investigations and by follow-up field investigations in October.

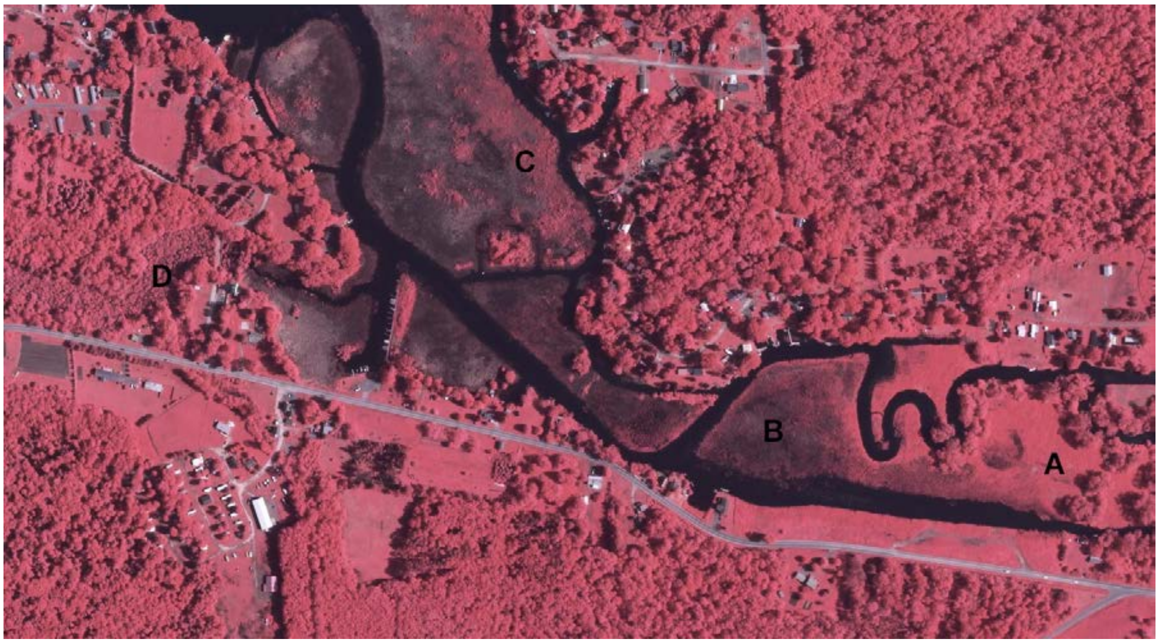

Figure 1-6. Example of color infrared imagery showing different wetland types along Little Sandy Creek, one of many tributaries of North Pond. A – reed canary grass meadow (with scattered trees in surrounding wetland), B – cattail marsh, C – mixed shrub swamp/marsh, and D – shrub swamp.

Products

The results of the wetland inventory are ArcGIS 10 geospatial data showing Lake Ontario coastal wetlands classified according to Cowardin et al. (1979) and the general types referenced in the Methods above. Where possible, dominance type was indicated for individual wetlands. Dominance type was generally limited to a few species whose spectral signature was unique enough for detection or where field data indicated sizable stands of the species. Study data for each geographic region (Braddock Bay, Irondequoit Bay, Sodus Bay area, and the Eastern Shore of Lake Ontario) are summarized in a set of tables and text in this and other sections of this report. The database contains attributes for common wetland type, NWI type, dominance type, count (# of polygons or units), acreage, region (one of the four geographic areas covered by the study), and county.

Results

Wetland Acreage Summaries

The wetlands inventoried by this project were aquatic beds, emergent types (marsh and wet meadow), mixed emergent-shrub swamps, and shrub swamps. While the target mapping unit was 0.5 acres, many wetland areas were identified that were much smaller than this size. Within the study area, approximately 11,420 acres of vegetated wetlands were inventoried. Tables 1-3 and 1-4 summarize the acreage by general wetland type and Cowardin et al. type, respectively for the entire project area and each of the four study areas. Specific types have been aggregated into a smaller set of types for these tables; for complete classifications as found in the geospatial database see Appendix A arranged by each study area (including by county). The difference of 1.6 acres between the two tables is due to rounding off. While coastal wetlands connected to Lake Ontario dominate these statistics, the acreage totals also include other wetlands whose hydrology is significantly affected by the lake. These wetlands include former coastal wetlands now separated by dryland (barred wetlands) and wetlands along the lower reaches of tributaries to Lake Ontario, coastal embayments or coastal lagoons.

Cattail marshes were the predominant wetland type, accounting for nearly 4,800 acres. This total represented about three-quarters of the study area's marshes, and possibly more as cattails may be well-represented in the "other marsh" type which did not possess the typical cattail photo-signature. Overall, marshes made up 82 percent of the emergent wetlands, occupying over 6,300 acres of the 7,687 acres of marshes and wet meadows. There was nearly 1,200 acres of emergent wetland where marsh and wet meadow were intermixed showing the effects of fluctuating water levels that characterize Lake Ontario.

Table 1-3. Acreage of general vegetated wetland types mapped for this project area. Note: The data includes coastal wetlands and other lake-influenced wetlands (former coastal wetlands and wetlands along coastal rivers in close proximity to coastal embayments). BB = Braddock Bay to Round Pond, IB = Irondequoit Bay, SB = Sodus Bay to Little Sodus Bay, and ES = Eastern Shore of Lake Ontario (Mexico Bay to St. Lawrence River).

	Subject Area				
Habitat Type	BB	IB	SB	ES	Total
Aquatic Bed	91.3	5.2	418.9	615.4	1,130.8
Aquatic Bed/Other Types	--	--	8.3	17.8	26.1
River/Aquatic Bed	--	--	95.6	136.5	232.1
Total Aquatic Bed-dominated	91.3	5.2	522.8	769.7	1,389.0
Cattail Marsh	1,117.3	201.7	1,643.8	1,819.0	4,781.8
Cattail Marsh/Wet Meadow	--	--	14.6	--	14.6
Common Reed Marsh	0.8	4.4	0.1	4.5	9.8
Other Marsh	29.1	9.2	52.2	133.5	224.0
Other Marsh/Wet Meadow	39.6	24.1	121.5	645.6	830.8
Other Marsh/Other Types	13.1	--	64.4	400.8	478.3
Total Marsh-dominated	1,199.9	239.4	1,896.6	3,003.4	6,339.3
Shrub Swamp	79.6	4.1	153.1	374.4	611.2
Shrub Swamp/Marsh	34.4	--	65.1	156.3	255.8
Shrub Swamp/Wet Meadow	14.8	1.7	191.6	220.0	428.1
Shrub Swamp/Other Types	22.5	0.4	41.6	174.3	238.8
Total Shrub Swamp-dominated	151.3	6.2	451.4	925.0	1,533.9
Reed Canary Grass Meadow	2.8	6.5	28.3	241.8	279.4
Wet Meadow	6.5	9.1	29.8	275.1	320.5
Wet Meadow/Marsh	--	9.5	35.4	306.6	351.5
Wet Meadow/Other Types	9.1	5.2	106.0	276.4	396.7
Total Wet Meadow-dominated	18.4	30.3	199.5	1,099.9	1,348.1
Wooded Swamp	15.1	1.0	135.4	236.1	387.6
Wooded Swamp/Marsh	--	--	--	3.3	3.3
Wooded Swamp/Wet Meadow	--	--	11.0	11.1	22.1
Wooded Swamp/Shrub Swamp	14.1	--	65.6	316.7	396.4
Total Wooded Swamp-dominated	29.2	1.0	212.0	567.2	809.4
Total Vegetated Wetlands	1,490.1	282.1	3,282.3	6,365.2	11,419.7

Table 1-4. Acreage of vegetated wetland types mapped for this project by system and class following Cowardin et al. (1979). BB = Braddock Bay to Round Pond, IB = Irondequoit Bay, SB = Sodus Bay to Little Sodus Bay, and ES = Eastern Shore of Lake Ontario (Mexico Bay to St. Lawrence River).

		Subject Area				
System	Class	BB	IB	SB	ES	Total
Palustrine	Aquatic Bed	44.6	2.9	87.6	89.1	224.2
	Emergent	1,218.2	270.6	2,091.5	4,080.6	7,660.9
	Scrub-Shrub	151.2	5.4	456.1	955.2	1,567.9
	Forested	29.2	1.0	211.9	559.8	801.9
	Total	1,443.2	279.9	2,847.1	5,684.7	10,254.9
Lacustrine	Aquatic Bed	46.7	2.1	324.9	535.8	909.5
	Total	46.7	2.1	324.9	535.8	909.5
Riverine	Aquatic Bed	--	0.2	109.0	144.7	253.9
	Total	--	0.2	109.0	144.7	253.9
All Mapped Vegetated Wetlands		1,489.9	282.2	3,281.0	6,365.2	11,418.3

Limitations of the Inventory

Due to the early season imagery acquired for this project (May 29 - June 1), the imagery was best for detecting persistent emergent vegetation and coastal wetlands dominated by woody plants (shrub swamps). At this time of the year, most aquatic bed species have just begun growing and have not emerged from the water nor reached their peak coverage, so these types may not be as well represented as they would be with late season imagery. We did use recent imagery in combination with direct field observations to locate the likely locations of such beds, yet the exact limits of the beds could not be mapped. Subtle signatures were used to help identify the extent of these beds.

While the early season imagery did help identify cattail marshes and reed canary grass meadows from other emergent wetlands, detection of other species may require imagery from later in the growing season. Stands that may be dominated by other species such as bluejoint and sedges were classified to species or genera based on the results of ground surveys, but the limits of these stands were approximated despite the lack of a reliable photo-signature. Consequently, numerous coastal wetlands could only be classified by general type and Cowardin et al. type rather than by dominant species due to the lack of a diagnostic signature and the frequent high diversity of plant communities related to hydrologic regimes.

The dynamic fluctuations of lake levels result in a seemingly unique combination of species that produces highly diverse plant communities where typical marsh species are intermixed with characteristic wet meadow species. The occurrence of these mixed stands and lack of extensive areas dominated by a single species makes it virtually impossible to identify many emergent wetlands to the genus or species level. Exceptions to this situation were large nearly pure stands of cattails and reed canary grass that produce what may be considered a unique signature. However, even with these wetlands, especially the cattail marshes, different signatures may reflect differences in the degree of flooding or more advanced growth of individuals in certain zones of the marsh. Shrub wetlands were also identified to general type and Cowardin et al. type and not to dominance type with some exceptions (e.g., some alder [Alnus incana ssp. rugosa] swamps and others dominated by buttonbush [Cephalanthus occidentalis] or dogwoods [Cornus spp.] based on field observations). Forested wetlands were beyond the scope of this survey, and while some were mapped, they were not mapped to the same degree as other types.

Recommendations for Future Inventories

The early growing season imagery did not allow the best discrimination of most individual herbaceous species largely because new growth was just beginning to emerge at this time (see Figure 1-7 – compare with mid-growing season condition Figure 1-8). Although detection of cattails (Typha spp.) and perhaps reed canary grass (Phalaris arundinacea; Figure 1-9) were readily identified for the most part, above normal high water conditions at this time plus the young growth of other species made separation of some marshes from wet meadows difficult and detection of other dominant species impossible. Although bluejoint (Calamagrostis canadensis) meadows were observed during field surveys (Figure 1-10) they did not provide reliable photo-signatures for detection elsewhere.

Imagery acquired during the peak or latter part of the growing season may be better for discrimination of individual species, especially for those that are late bloomers. Based on our observations, August or possibly September imagery might be best for future studies. A pilot study targeting a few areas with dense stands of different individual species would be extremely beneficial for choosing the best time to capture imagery for maximum species discrimination. It might be worth capturing images in both color infrared and true color to see if one yields better results than the other. We still believe that the nature of many coastal wetlands (i.e., diverse plant communities representing mixtures of marsh and wet meadow species) makes them particularly challenging features to classify beyond life form or general wetland type.

Figure 1-7. Early spring condition of vegetation in a cattail marsh (mid to late May 2011). Vegetative cover is dominated by last year's dead stems.

Figure 1-8. Cattails are in full form by late June.

Figure 1-9. Reed canary grass meadow in late May 2011.

Figure 1-10. Bluejoint meadow along the Salmon River near Pulaski in May 2011.

The focus of this inventory was on coastal marshes, wet meadows, and shrub swamps, while some portions of forested wetlands were also included. Future work should include mapping the full extent of forested wetlands associated with coastal wetlands. This may be done by utilizing other sources of imagery to help fill-in the gaps as it would be worthwhile to have the full limits of the coastal wetland complex inventoried. Leaf-off imagery acquired in early spring would be best for identifying forested wetlands. The existing NWI data for this area did not match up very well with the imagery used for our work as their data were compiled at a scale of 1:24,000 using U.S. Geological Survey topographic maps as the base maps.

References

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Washington, DC. FWS-OBS-79-31. http://library.fws.gov/FWS-OBS/79_31.pdf

Farrell, J.M., B.A. Murry, D.J. Leopold, A. Halpern, M.B. Rippke, K.S. Godwin, and S.D. Hafner. 2010. Water-level regulation and coastal wetland vegetation in the upper St. Lawrence River: inferences from historical imagery, seed banks, and Typha dynamics. Hydrobiologia 647: 127-144.

Federal Geographic Data Committee. 1996. Classification of Wetlands and Deepwater Habitats in the United States. FGDC-STD-004. http://www.fgdc.gov/standards/projects/FGDC-standards-projects/wetlands

International Joint Commission. 2007. Proposed New Order. In the matter of the applications of Government of Canada and the Government of the United States of America for an Order of Approval for the construction of certain structures for the development of power in the International Rapids Section of the St. Lawrence River. http://www.ijc.org/LOSLdocuments/pdf/LOSL_draft_order_e.pdf

Northrop Grumman Corporation. 2011. Minimum Technical Standards Report Control Survey & Specific Purpose Survey for Digital Orthophotos: 2011 Digital Orthophotos Lake Ontario South and East Shoreline New York State. Huntsville, AL. Prepared for the Corps of Engineers, Buffalo District. 9 pp. plus appendices.

Wilcox, D.A., K.P. Kowalski, H.L. Hoare, M.L. Carson, and H.N. Morgan. 2008. Cattail invasion of sedge/grass meadows in Lake Ontario: photointerpretation analysis of sixteen wetlands over five decades. Journal of Great Lakes Research 34: 301-323.

Chapter 2. Vegetation

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Introduction

Coastal wetland vegetation patterns along the Great Lakes exhibit frequent shifts due to interannual changes in water levels. During high-water periods, marshes and aquatic beds predominate the lake shores, while low-water periods promote expansion of wet meadows and shrub swamps (Figure 2-1). Few studies have been conducted to describe vegetation of Lake Ontario's coastal wetlands along the U.S. shoreline (e.g., Geis and Kee 1977, Wilcox et al. 2005), while more attention has been directed to the vegetation along the Canadian shoreline (e.g., Chow-Fraser et al. 1998, Chow-Fraser 2005, Quinlan and Mulamoottil 1987, Wei and Chow-Frazer 2005). These studies provide a foundation for understanding the diversity of plant species associated with these wetlands.

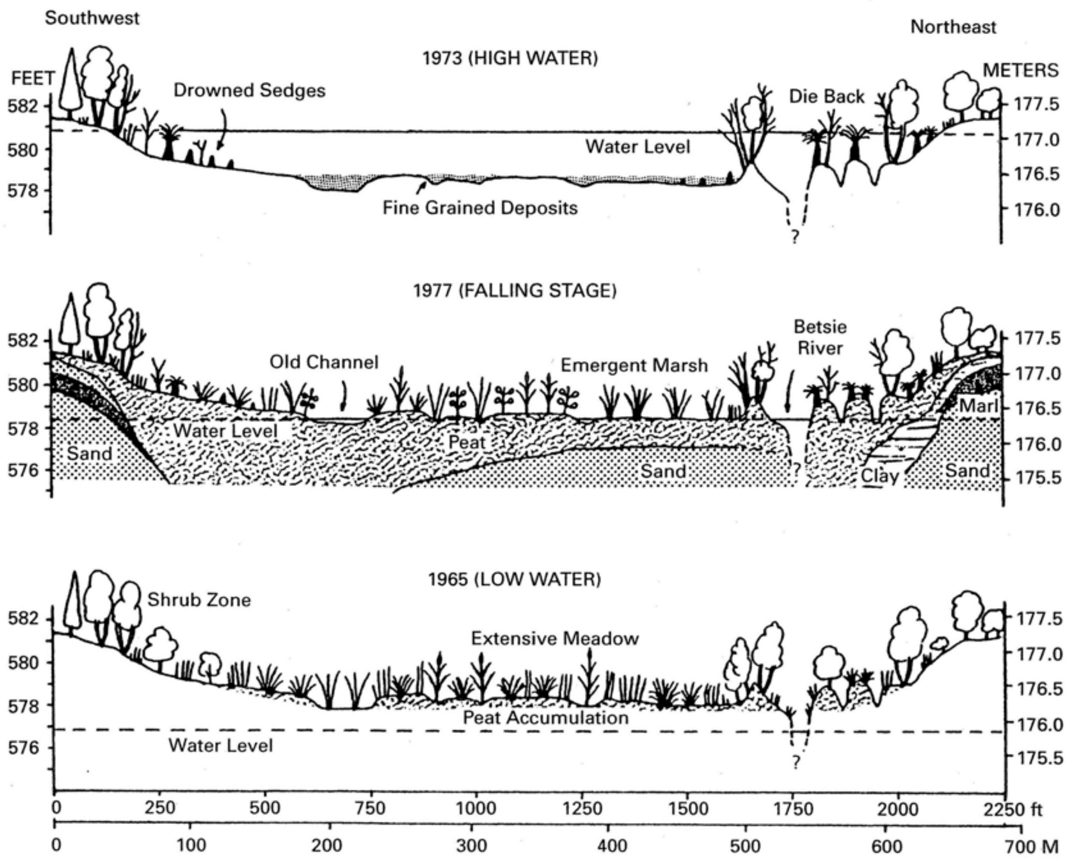

Figure 2-1. Changes in coastal wetland vegetation along the Great Lakes in response to changes in lake levels. (Source: Herdendorf et al. 1986).

While plant community composition was not the focus of the study, vegetation sampling was performed to produce more qualitative and quantitative information on Lake Ontario's coastal wetlands. Consistent with the mapping effort, the emphasis of this work was on herb-dominated wetlands – marshes and wet meadows, although sampling was also performed in mixed communities including those with aquatic bed species.

Methods

A field data form was created prior to field work (Appendix B). The form included space to record site location, date of field inspection, hydrology observations, soil properties (observed in the field), and plant community data. For the latter, a list of wetland plants likely to be observed was created from the results of prior studies of Lake Ontario coastal wetlands. This was intended to expedite the tabulation of species cover.

Field surveys were conducted from mid-June to mid-August 2011. During this time, two 2- or 3-person teams visited coastal wetlands from Braddock Bay on the west to Cape Vincent on the east. Access to wetlands was either on foot where road access was possible or by canoe where suitable water access was possible.

During the field surveys, numerous sites were chosen for plot sampling. The sites were intended to be representative of a variety of plant communities associated with Lake Ontario's coastal wetlands. A total of 142 stations were selected for sampling. Site locations were identified using a hand-held global positioning device (Rino 120 two-way radio/GPS). After the location was entered on a field data sheet, site characteristics (hydrology, soils, and vegetation) were then examined and recorded on the form.

Hydrologic observations. The water depth was recorded for aquatic beds, marshes, and any mixed marsh-meadow communities that were inundated. For non-inundated sites (e.g., wet meadows), the depth to free water in a soil auger hole and depth of saturation were recorded. Other signs of hydrology were noted such as water-stained leaves, iron deposits, water-carried debris, and oxidized rhizospheres for sites that were not inundated during the time of observation.

Soil sampling. Soil samples were collected for on-site evaluation and laboratory analysis. They were extracted by aid of a Dutch auger. The depth of organic matter was estimated by pushing an auger into the soil and soil texture and colors were described by feel and use of the Munsell soil color charts, respectively. Chapter 3 of this report provides a summary of soil characteristics associated with Lake Ontario coastal wetlands.

Vegetation sampling. Study sites were located along the water where accessed by canoe or near the upland when accessed by foot. No transects were run across the wetlands from upland to the water's edge due to high water conditions, difficulty of walking, and time considerations. At each marsh or wet meadow site, a pair of 1-m^2 plots was sampled. For each plot, a list of observed species was compiled and then the areal cover of each was estimated by one person of a two- or three-person team and discussed with other team members to arrive at a consensus value. The data from the field data sheet were entered into the database. Most plants were readily identified in the field using field guides, while other plants were collected in the field for verification with voucher specimens at the University of Massachusetts Herbarium.

Results

Over 125 species of plants were observed growing in the wetlands examined (Appendix B). Among the most frequently observed species were duckweed (Lemna minor), European frog-bit (Hydrocharis morsus-ranae), white water lily (Nymphaea odorata), narrow-leaved cattail (Typha angustifolia), hybrid cattail (Typha x glauca), broad-leaved cattail (T. latifolia), big bur-reed (Sparganium eurycarpum), reed canary grass (Phalaris arundinacea), bluejoint (Calamagrostis canadensis), lake sedge (Carex lacustris), buttonbush (Cephalanthus occidentalis), speckled alder (Alnus incana ssp. rugosa), and swamp loosestrife or water-willow (Decodon verticillatus). Invasive species of note were European frog-bit, hybrid cattail, water chestnut (Trapa natans), purple loosestrife (Lythrum salicaria), and multiflora rose (Rosa multiflora).

The vegetation survey represents an assessment of plant composition along the water's edge or upland edge. The associations typically represent a patch of plants growing under the same environmental conditions, except for any differences in microtopographic relief. Examples of plant associations recorded in 1 m^2 plots are summarized in Table 2-1. These groupings of plants may not cover extensive areas but show the diversity in plant community structure.

Table 2-1. Examples of plant associations found in Lake Ontario wetlands during the summer of 2011.

Dominant Species	Associated Vegetation
Lemna minor	Typha angustifolia, Chelone glabra, Alnus incana
Lemna trisulca	Typha latifolia, Solanum dulcamara
Ceratophyllum demersum/L. minor	Hydrocharis morus-ranea, Pontederia cordata
Hydrocharis morus-ranae	L. minor, Lythrum salicaria, C. demersum
Nymphaea odorata/T. angustifolia	Phalaris arundinacea, L. minor, Ceratophyllum demersum, Schoenoplectus fluviatilis
Nuphar lutea	Pontederia cordata, Typha x glauca
Lemna minor/T. x glauca	--
Typha angustifolia	L. minor, Hydrocharis morus-ranae
Typha latifolia	Impatiens capensis
L. minor/T. latifolia/Alnus incana	Peltandra virginica, Chelone glabra
Sparganium eurycarpum	L. minor, H. morus-ranae
Sparganium androcladum	Polygonum amphibium, H. morus-ranae, Phalaris arundinacea, Chelone glabra
Sagittaria latifolia	S. eurycarpum, Sagittaria cuneata, H. morus-ranae
Pontederia cordata	Schoenoplectus tabernaemontani, S. eurycarpum, S. latifolia, L. minor
Peltandra virginica	Carex lacustris, L. minor, L. salicaria, Scirpus atrovirens, Sparganium eurycarpum
Phragmites australis	L. minor, Solanum dulcamara
Phalaris arundinacea	Pilea pumila, Lycopus virginicus, I. capensis, Eupatorium maculatum, Calystegia sepium
Calamagrostis canadensis	Impatiens capensis, Polygonum hydropiper, Polygonum sagittatum

Lysimachia ciliata/C. lacustris	L. salicaria, Solidago canadensis, J. effusus, Juncus acuminatus, Glyceria striata, C. canadensis, Carex tribuloides
Juncus effusus	P. cordata
Decodon verticillatus/L. minor	H. morus-ranea, Typha x glauca, Cicuta bulbifera, C. demersum, Boehmeria cylindrica
Cornus amomum	L. minor, Typha latifolia
Alnus incana ssp. rugosa	C. canadensis, D. verticillatus, P. virginica, Rosa palustris, Thelypteris palustris
Myrica gale	P. virginica, Comarum palustre, T. angustifolia, Vaccinium macrocarpon, H. morus-ranae, Carex lasiocarpa
Viburnum recognitum	Lysimachia nummularia, Lobelia cardenalis, L. minor, I. capensis, Geum lacinatum, Eupatorium maculatum, Carex lurida, Aster (Symphyotrichum) sp. Asclepias incarnata, Apios americana

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Hydrologic Observations

While water levels vary considerably seasonally and from year to year, water levels for the summer of 2011 were quite high throughout the field study. Water levels were consistently higher in the aquatic beds and marshes than in the wet meadows and alder-dominated shrub swamps. Buttonbush swamps were often intermixed with marshes and were therefore flooded during the period of observation. Water levels in marshes were up to more than three feet deep in the cattail marshes (June in the western most marshes) and likely declined with falling lake levels throughout the summer. For example, less than one foot of water was recorded in some cattail marshes and aquatic beds in the eastern part of the study area by mid- to late-July. Some cattail marshes may actually occur as floating mats but this was not assessed. In mid-June, a reed canary meadow in the Port Bay system was flooded with 1.5 feet of water and although not revisited, it is expected that by the end of the summer, surface water would be absent from this wetland. Similarly, a bluejoint meadow was covered by nearly 20 inches of water in June (Wolcott Creek), while another bluejoint meadow sampled in mid-July (Deer Creek) had a water table recorded at 6 inches with saturation to the surface. By the end of July, water tables in wet meadows likely declined further as a wet meadow dominated by lake sedge (Westcott Beach State Park) had a water table below two feet with saturation observed at 20 inches.

While making hydrologic observation at one time during the year does not provide much useful information, it does provide a hydrologic comparison between different communities visited at the same time in the same general location. It would have been interesting to make observations of wetland hydrology during two time periods over the course of the study – during high and low water periods, but time did not allow for such assessment.

References

Chow-Fraser, P. 2005. Ecosystem response to changes in water level of Lake Ontario marshes: lessons from the restoration of Cootes Paradise Marsh. Hydrobiologia 539: 189-204.

Chow-Fraser, P., V. Lougheed, V. LeTheic, B. Crosbie, L. Simser, and J. Lord. 1998. Long-term response of the biotic community to fluctuating water levels and changes in water quality in Cootes Paradise Marsh, a degraded coastal wetland of Lake Ontario. Wetlands Ecology and Management 6: 19-42.

Geis, J.W. and J.L. Kee. 1977. Coastal Wetlands Along Lake Ontario and St. Lawrence River in Jefferson County, New York. State University of New York, College of Environmental Science and Forestry, Institute of Environmental Program Affairs, Syracuse, NY.

Herdendorf, C.E, C.N. Raphael, and E. Jaworski. 1986. The Ecology of Lake St. Clair Wetlands: A Community Profile. U.S. Fish and Wildlife Service, Washington, DC. Biological Report 85 (7.7).

Quinlan, C. and G. Mulamoottil. 1987. The effects of water-level fluctuations on three Lake Ontario shoreline marshes. Canadian Water Resources Journal 12: 64-77.

Wei, P., and P. Chow-Frazer. 2005. Untangling the confounding effects of urbanization and high water level on the cover of emergent vegetation in Cootes Paradise Marsh, a degraded coastal wetland of Lake Ontario. Hydrobiologia 544: 1-9.

Wilcox, D.A., J.W. Ingram, K.P. Kowalski, J.E. Meeker, M.L. Carlson, Y. Xie, G.P. Grabas, K.L. Holmes, and N.J. Patterson. 2005. Evaluation of Water Level Regulation Influences on Lake Ontario and Upper St. Lawrence River Coastal Wetland Plant Communities: Final Project Report. International Joint Commission, Ottawa, Canada and Washington, DC.

Chapter 3. Soils

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Introduction

Inland coastal wetlands are formed in protected shallow lake margins, in lagoons behind barrier beaches, and river-mouths. These areas are subject to short-term changes in water level brought about by wind, wave, and lunar tidal movements. Additionally long-term fluctuations which are brought about by changes in the climate patterns within the watershed (i.e., precipitation, evapotranspiration, temperature) come in 10- to 30-year cycles (Quinlan and Mulamoottil 1987). Water level fluctuations have significant impacts on the vegetation and wildlife of the coastal wetlands due to changes in nutrient cycling and hydrologic functions. On Lake Ontario, however, extreme lake levels are now prevented by the dams at Cornwall, Ontario, and Massena, New York which maintain a stable high-water level for shipping along the St. Lawrence Seaway and for power generation.

The lack of natural fluctuations in water levels and continued nutrient loading from surface and subsurface runoff may be responsible for decreasing species diversity as well as possible nutrient accumulation due to imbalances in the C:N:P ratio (Hill et al., 2006). The amount of soil organic matter and particle size are determining factors in the soil's ability to retain nutrients and/or contaminants and govern whether they are a source or a sink. This study, therefore, incorporated an examination of the physical properties, nutrient status, and contaminant concentration of the soils within the various coastal wetland communities surveyed.

Methods and Materials

Soil Sample Collection

Soil samples were collected with a 1½"- diameter Dutch auger where mineral soil was present and retrievable; primarily from wet meadows, marshes and mixed marsh/aquatic bed areas. Samples were generally taken from the 0-6 and 6-12 inch intervals, placed in plastic sample bags and labeled with site name, station number, and soil depth. For mineral soils, soil color was determined in the field using Munsell color charts, and soil textures determined in the field by "feel." The presence of oxidized rhizospheres and other redoximorphic features as well as the horizon depths were noted on the field forms. Collected samples were stored for delivery to the laboratory on a weekly basis.

Physical Analysis

Upon receipt at the laboratory, a subsample was taken from each sample bag and stored in the refrigerator at 4^{o}C until transport to the contract laboratory for mercury analysis. The remainder of all samples were air-dried and sieved to pass a 2-mm sieve. Any particles not passing the 2-mm sieve were weighed and recorded as coarse fragments. Organic matter (OM) content was determined gravimetrically by loss on ignition (LOI) as described in Methods of Soil Analysis, Part 3, Chemical Methods (Nelson and Sommers 1996) and summarized as follows. Air-dried samples were placed into crucibles, weighed, and dried to a constant weight at 105°C. These samples were then placed in a model F1730 muffle oven (Thermolyne Corp., Dubuque, IA), ashed overnight at 500°C, and reweighed after cooling. Soil pH was measured in a soil slurry (1:2 - soil:water) on an Accumet model 805MP pH meter (Fisher Scientific, Suwanee, GA).

Particle size analysis (PSA) was done by the method of Gee and Bauder (1986) and summarized as follows. Samples having greater than 10% OM as determined by LOI were pretreated with hydrogen peroxide to remove organic matter prior to running the PSA procedure. Samples were dispersed with sodium hexametaphosphate and mechanical shaking, following which the samples were wet sieved to pass a 53-µm sieve. The fraction retained on this sieve was dried and then sieved through the standard net of sieves (1, 0.5, 0.25, .010 and .053-mm) with the fraction remaining on each sieved weighed. The particles passing through the 53-µm sieve were collected in a sedimentation cylinder to obtain percent silt (53-µm to 2-µm) and clay (<2-µm) by the pipet method.

Chemical Analysis

Both micro (Cu, Zn, B, Mn, Fe, Al, Na, Ni) and macro nutrients (P, Ca, Mg, K, S) as well as several heavy metals (Cd, Cr, Pb) were extracted from5-cc of air-dried, sieved soil with 15 ml of Modified Morgan Solution (McIntosh, 1969) by shaking at 180 oscillations per minute on an Eberbach reciprocating shaker (EberbachLabtools, Ann Arbor, MI). Soil solutions were then filtered through Whatman No. 1 filter paper and the filtrate was analyzed on a SpectroCiros ICP (SPECTRO Analytical Instruments Inc., Mahwah, NJ).

Soil and peat samples were sent to a MA Certified Laboratory for analysis of mercury content by a modification of Standard Method SM7471A (American Public Health Association, 1989), which is a manual determination of mercury content by cold vapor. The certified laboratory employed a FIMS 100 automated mercury analysis system (Perkin Elmer, Waltham, MA). In this system digestates are placed on the autosampler and reagents are added automatically. Calibration curves are generated by the FIMS 100 software from standards prepared daily and checked against spiked samples. The minimum detection limit for all mercury analyses was 0.005 mg/Kg (5 ppb). Samples (1-2 g) were digested in 10 ml of 1:1 an Aqua regia/water solution in a 95°C water bath for 2 minutes and cooled; following which potassium permanganate (15 ml) and distilled water (50 ml) were added to eliminate possible interference from sulfide. Potassium persulfate solution (8 ml) was added and the samples were returned to the water bath for an additional 30 minutes, covered. Digests were cooled again, 6 ml of hydroxylamine hydrochloride solution was added and the samples were brought to final volume with distilled water (50 ml).

Results

Soil Texture and NRCS Mapped Soil Series

Web Soil Survey was consulted to determine the mapped soils series within the various coastal wetland areas surveyed. Differences in map units exist from county to county presumably based on the age of the mapping. In Monroe, Wayne, and Cayuga Counties the soil areas adjacent to open water tend to be mapped as “fresh water marsh”, while in Oswego and Jefferson counties these areas are mapped as either Humaquepts and Saprists (Oswego Co.) or Saprists and Aquents (Jefferson Co.) but with no series given (Figure 3-1). Saprists are mucks - wet Histosols (soils where more than half of the upper 80 cm is organic) in which the organic materials are well-decomposed. Aquents are wet Entisols, widely distributed soils formed in recent sediments. These soils support hydrophytic vegetation – plants that tolerate permanent or periodic prolonged wetness.

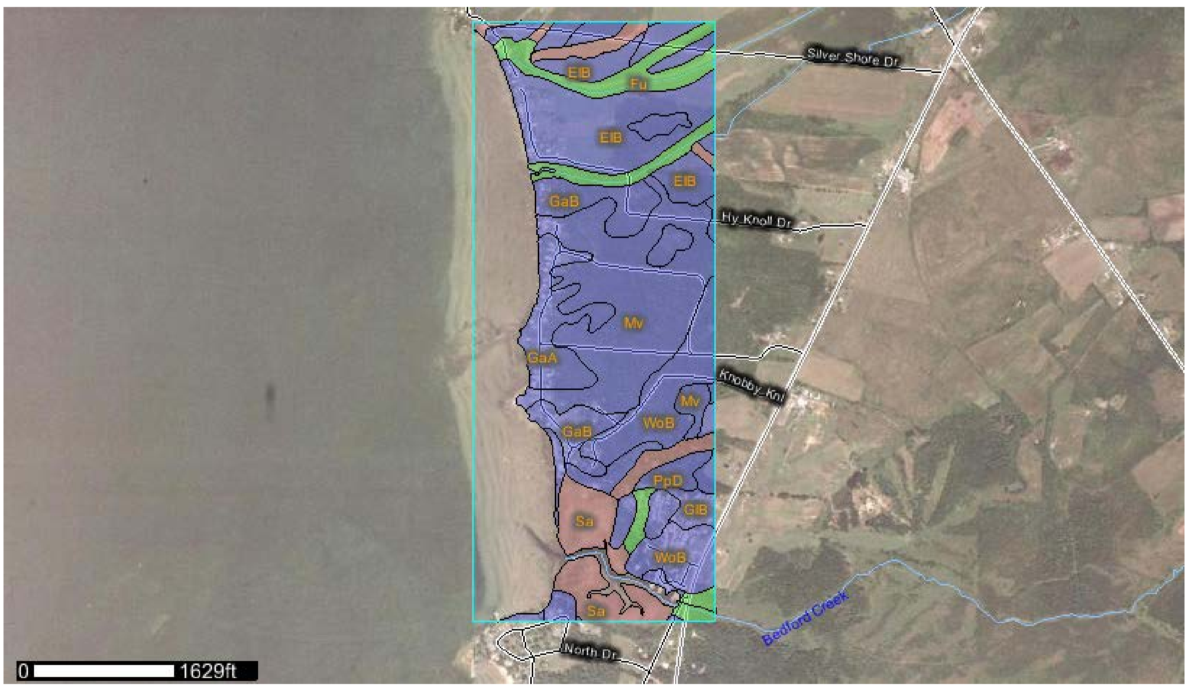

Figure 3-1. Soil map for a portion of Jefferson County NY showing ratings for hydric soils. Map units of interest are pink: Sa -Saprists and Aquents, ponded, all hydric; Sc- Scarboro mucky loamy fine sand, all hydric, and green: Fu - Fluvaquents-Udifluvents complex, frequently flooded, partially hydric. (Source: Web Soil Survey).

In Monroe County, map units adjacent to the wetland areas not mapped as fresh water wetlands tended to be mapped as “A+F3” which represents “Arkport, Dunkirk, and Colonie soils eroded” or Wayland silt loam. Field samples from sites around Irondequoit and Sodus bays agreed with these mapped soil series (descriptions found in Appendix C). Of the three A+F3 soils the Dunkirk is a silt loam, while the Arkport and Colonie soils are fine to very fine sands with loamy lenses. Samples from the Wolcott Creek area were silt loams as typified by the Williamson series. It should be noted that mapped soil units include areas of soils from soil series other that what is mapped. These inclusions for this area of New York mostly include the other soils mapped in the association. Many of the areas where the field determined dominant species was cattail (Typha spp.) were mapped as fresh water marsh, indicating that the area was determined not to be "soil". This was supported by field observations that many of these areas were floating peat beds. In Oswego and Jefferson Counties the surface soils from the wet meadows and marshes tended to be sand and loamy sand, with finer materials at depths. This may be indicative of the movement of coarse materials (sand) from the lake bottom onto the adjacent areas due to the prevailing onshore winds along the eastern shore of the lake.

Chemical Analysis

Nutrient, heavy metal, and organic matter content varied widely between the samples analyzed. Tables 3-1a through 3-1d list the maximum, minimum, and mean values for the elemental and physical analyses by geographic area. Area 1 is from Braddock Bay to Round Pond, area 2 is Irondequoit Bay, area 3 is Sodus Bay to Little Sodus Bay, and area 4 is the Eastern Shore of the lake. Standard deviations are large reflecting the variation in sites. Soluble elements would generally have been less available in the marshes and aquatic beds, but may have accumulated in the mineral soils. Additionally the concentration of some elements was greater at the surface, while with others the concentration increased with depth. Both of these factors add to the degree of variability within the sample set.

Table 3-1a. Descriptive statistics for soil physical properties and elemental analysis area 1, Braddock Bay to Round Pond. N=15.

Variable	Minimum	Maximum	Mean	Std. Dev.
	------------------------- ppm ------------------------			
Macronutrients				
P	0.8	13.1	3.7	3.2
K	9.5	149.3	55.6	39.5
Ca	716.7	16344	3516	4392
Mg	48.8	356.8	183.3	98.6
S	18.6	270.5	77.0	80.4
Micronutrients				
Zn	0.003	25.1	3.9	8.4
B	0.033	10.7	1.46	2.8
Mn	1.81	48.7	15.1	12.1
Cu	0.003	0.51	0.07	0.15
Fe	2.45	72.9	19.0	23.2
Al	5.9	155.2	26.2	36.7
Ni	0.007	0.25	0.071	0.07
Na	33.4	384.9	179.4	122
Heavy Metals				
Pb	0.12	67.10	5.75	17.06
Cr	0.015	0.272	0.053	0.062
Cd	0.009	0.999	0.141	0.271
Hg	0.024	0.210	0.066	0.067
Other Soil Properties				
Organic Matter Content	1.8%	10.6%	5.21%	3.03%
pH	5.48	7.69	6.41	0.6

Table 3-1b. Descriptive statistics for soil physical properties and elemental analysis area 2, Irondequoit Bay. N=10.

Variable	Minimum	Maximum	Mean	Std. Dev.
	-------------------------- ppm ------------------------			
Macronutrients				
P	4.60	9.84	7.19	1.76
K	13.9	102.5	63.7	29.2
Ca	4624	15955	9916	3930
Mg	103.2	292.1	174.4	61.7
S	102.7	591.7	213.9	146.2
Micronutrients				
Zn	4.79	33.33	13.83	9.01
B	0.411	1.449	0.733	0.321
Mn	16.67	106.0	50.38	29.4
Cu	0.240	1.407	0.530	0.34
Fe	4.623	30.22	13.06	9.47
Al	5.78	15.39	9.14	2.98
Ni	0.092	0.672	0.188	0.174
Na	102.7	591.7	213.9	146.2
Heavy Metals				
Pb	0.366	9.96	2.08	2.85
Cr	0.050	0.160	0.081	0.032
Cd	0.126	0.324	0.183	0.058
Hg	0.026	0.042	0.031	0.004
Other Soil Properties				
Organic Matter Content	2.5%	5.7%	3.72%	1.2%
pH	7.05	7.56	7.31	0.18

Table 3-1c. Descriptive statistics for soil physical properties and elemental analysis area 3, Sodus Bay to Little Sodus Bay. N=31.

Variable	Minimum	Maximum	Mean	Std. Dev.
	-------------------------- ppm ------------------------			
Macronutrients				
P	0.5	7.28	2.70	1.89
K	9.66	96.9	47.3	22.5
Ca	497	3189	1592	623
Mg	30.50	369.8	197.7	102.1
S	13.25	102.86	35.23	18.35
Micronutrients				
Zn	0.003	20.18	2.085	3.716
B	0.036	0.849	0.282	0.213
Mn	3.00	54.9	15.18	10.93
Cu	0.003	0.381	0.082	0.127
Fe	2.18	146.52	39.23	41.69
Al	9.40	204.3	42.54	46.73
Ni	0.028	0.163	0.068	0.032
Na	23.85	165.32	47.72	29.81

Table 3-1c. continued

Variable	Minimum	Maximum	Mean	Std. Dev.
	------------------------- ppm ------------------------			
Heavy Metals				
Pb	0.003	11.09	1.16	2.18
Cr	0.012	0.076	0.035	0.016
Cd	0.015	0.123	0.067	0.026
Hg	0.025	0.100	0.046	0.021
Other Soil Properties				
Organic Matter Content	1.5%	21.0%	7.5%	4.7%
pH	4.31	8.80	5.92	0.77

Table 3-1d. Descriptive statistics for soil physical properties and elemental analysis area 4, the Eastern Shore. N=50.

Variable	Minimum	Maximum	Mean	Std. Dev.
	------------------------- ppm ------------------------			
Macronutrients				
P	0.77	5.32	2.18	1.02
K	8.55	129.7	44.98	30.20
Ca	156	23935	2838	5995
Mg	9.125	222.8	91.12	58.93
S	7.23	421	66.9	97.4
Micronutrients				
Zn	0.003	13.00	2.672	2.981
B	0.066	1.023	0.411	0.226
Mn	0.99	294	33.2	43.0
Cu	0.018	1.119	0.326	0.239
Fe	0.78	173	50.2	42.8
Al	7.29	205	48.9	44.2
Ni	0.005	0.747	0.115	0.123
Na	19.7	664	82.0	135
Heavy Metals				
Pb	0.003	5.898	1.153	1.312
Cr	0.008	0.136	0.038	0.020
Cd	0.006	0.237	0.074	0.054
Hg	ND	0.320	0.058	0.056
Other Soil Properties				
Organic Matter Content	1.39%	26.2%	6.88%	4.88%
pH	4.77	7.56	5.74	0.77

ND = non detectable

Worthy of note from Tables 3-1a-d is that area 2 (Irondequoit Bay) has the largest minimum value for phosphorous, calcium and sulfur, 4.6, 156, and 7.2 mg/L, respectively. Area 3 (Sodus Bay to Little Sodus Bay) has the lowest maximum value for calcium (3,189 mg/L) while area 4 (the Eastern Shore) has the largest maximum calcium value (16,344 mg/L). Irondequoit Bay also had the highest minimum values for manganese, iron and sodium 16.7, 4.6, and 102.7 mg/L respectively. Area 1 (Braddock Bay to Round Pond) had the highest minimum values for lead, chromium and both the highest minimum and highest maximum values for cadmium. The Eastern Shore had the highest maximum mercury concentration of any sample as well as the only sample where lead was not detectable. In general the lack of correlations between soil/wetland physical properties and either macro or micro nutrient concentration in areas 1 and 2 are presumable due to the wide variation of sample concentrations and the small number of samples for the area, 15 and 10, respectively. The exception to the previous statement is magnesium concentration.

Table 3-2. Pearson Correlation Coefficients for soil physical properties with wetland physical properties.

	Depth of Standing Water	Wetland Type	Organic Matter Content
Area 1, Braddock Bay to Round Pond – N=15			
% Sand	NS	NS	NS
% Silt	NS	NS	NS
% Clay	-0.519*	NS	NS
Soil pH	NS	NS	NS
Area 2, Irondequoit Bay – N=10			
% Sand	NS	-0.871***	NS
% Silt	NS	0.869***	NS
% Clay	NS	0.795**	0.665*
Soil pH	NS	NS	NS
Area 3, Sodus Bay to Little Sodus Bay – N=31			
% Sand	0.584***	0.613***	NS
% Silt	-0.587***	-0.660****	NS
% Clay	ns	NS	NS
Soil pH	NS	NS	NS
Area 4, Eastern Shore – N=50			
% Sand	NS	0.397**	-0.542****
% Silt	NS	-0.395**	0.478***
% Clay	NS	-0.278*	0.618****
Soil pH	-0.608****	-0.435***	NS

* ** *** **** P = 0.05, 0.01, 0.001, <0.0001, respectively. NS = Non significant.

Table 3-3. Pearson Correlation Coefficients for soil macro nutrients with soil and wetland physical properties.

	P	K	Ca	Mg	S
Area 1, Braddock Bay to Round Pond – N=15					
% sand	NS	NS	NS	NS	NS
% silt	NS	NS	NS	NS	NS
% clay	NS	NS	NS	0.756**	NS
Standing water	NS	NS	-0.548*	-0.661**	NS
Wetland type	NS	NS	NS	NS	NS
Organic Matter Content	NS	NS	NS	NS	NS
Soil pH	NS	NS	0.778***	NS	0.612*
Area 2, Irondequoit Bay – N=10					
% sand	NS	NS	NS	-0.901***	NS
% silt	NS	NS	NS	0.896***	NS
% clay	NS	NS	NS	0.843**	NS
Standing water	NS	NS	-0.895***	NS	-0.870**
Wetland type	NS	NS	NS	0.736*	NS
Organic Matter Content	NS	NS	NS	0.731*	NS
Soil pH	NS	NS	NS	NS	NS
Area 3, Sodus Bay to Little Sodus Bay – N=31					
% sand	0.476**	NS	NS	-0.425*	NS
% silt	-0.490**	NS	NS	0.452*	NS
% clay	NS	NS	NS	NS	NS
Standing water	NS	NS	NS	NS	0.442*
Wetland type	NS	NS	NS	NS	0.368*
Organic Matter Content	NS	NS	NS	-0.414*	NS
Soil pH	NS	NS	NS	NS	NS
Area 4, Eastern Shore – N =50					
% sand	NS	-0.396**	NS	-0.526****	NS
% silt	NS	0.413**	NS	0.500***	NS
% clay	NS	NS	NS	0.461***	NS
Standing water	-0.314*	-0.429**	-0.431**	NS	-0.345*
Wetland type	-0.500***	-0.363**	-0.373**	-0.404**	-0.332*
Organic Matter Content	0.417**	0.292*	0.346*	0.602****	0.387**
Soil pH	NS	0.529****	0.723****	0.430**	0.658****

* ** *** ****P = 0.05, 0.01, 0.001, <0.0001, respectively. NS = Non significant.

Table 3-4. Pearson Correlation Coefficients for micro soil nutrients with soil and wetland physical properties.

	Cu	Zn	B	Mn	Fe	Al	Na	Ni
Area 1, Braddock Bay to Round Pond – N=15								
% sand	NS	NS	NS	NS	NS	NS	0.610*	NS
% silt	NS	NS	NS	NS	0.557*	NS	-0.719**	0.551*
% clay	NS	NS	NS	NS	NS	NS	NS	NS
Standing H_20	NS	NS	NS	-0.658**	NS	NS	NS	NS
Wetland type	NS	NS	NS	NS	NS	NS	NS	NS
OM Content	NS	NS	NS	NS	NS	NS	NS	NS
Soil pH	NS	-0.522*	NS	NS	-0.732**	NS	NS	NS
Area 2, Irondequoit Bay – N=10								
	Cu	Zn	B	Mn	Fe	Al	Na	Ni
% sand	NS	NS	NS	NS	NS	NS	-0.696*	NS
% silt	NS	NS	NS	NS	NS	NS	0.702*	NS
% clay	NS	NS	NS	NS	NS	NS	NS	NS
Standing H_20	NS	NS	NS	-0.855**	NS	-0.678*	NS	-0.870**
Wetland type	NS	NS	NS	NS	NS	NS	0.675*	NS
OM Content	NS	NS	NS	NS	NS	NS	NS	NS
Soil pH	NS	NS	NS	NS	-0.663*	NS	NS	NS
Area 3, Sodus Bay to Little Sodus Bay – N=31								
	Cu	Zn	B	Mn	Fe	Al	Na	Ni
% sand	NS	0.507**	0.434*	NS	0.364*	NS	NS	NS
% silt	NS	-0.513**	-0.459**	NS	-0.396*	NS	0.384*	NS
% clay	-0.371**	NS	NS	NS	NS	NS	-0.373*	NS
Standing H_20	0.402**	0.372*	NS	NS	NS	NS	NS	NS
Wetland type	NS	NS	0.360*	NS	NS	NS	NS	0.435*
OM Content	NS	NS	NS	NS	NS	NS	NS	NS
Soil pH	NS	NS	NS	NS	NS	NS	NS	NS
Area 4, Eastern Shore – N =50								
	Cu	Zn	B	Mn	Fe	Al	Na	Ni
% sand	-0.403**	NS	-0.406**	NS	NS	0.433**	NS	-0.637****
% silt	0.457***	NS	0.427**	NS	NS	-0.467***	NS	0.656****
% clay	NS	NS	NS	NS	NS	NS	NS	0.364**
Standing H_20	NS	0.310*	NS	NS	0.338*	0.414**	NS	NS
Wetland type	NS	0.305*	-0.416**	NS	NS	NS	NS	NS
OM Content	NS	NS	0.482***	NS	NS	NS	NS	NS
Soil pH	NS	-0.410**	NS	NS	-0.596****	-0.416**	NS	NS

* ** *** **** P = 0.05, 0.01, 0.001, <0.0001, respectively. NS = Non significant.

There were no significant correlations between soil or wetland physical parameters and heavy metal concentrations for areas 1, 2, and 4 except as noted below. Chromium and lead were negatively correlated to pH in area 4 and mercury is positively correlated to wetland type in area 2. In area 3, however, significant correlations were noted for all of the heavy metals and at least one of the soil/wetland properties (Table 3-5) with the exception of percent clay which was not correlated to any of the heavy metals.

Table 3-5. Pearson Correlation Coefficients for heavy metals with soil and wetland physical properties for area 3, Sodus Bay to Little Sodus Bay.

	Hg	Pb	Cd	Cr
% sand	NS	NS	0.589***	0.391*
% silt	NS	-0.398*	-0.603***	-0.423*
% clay	NS	NS	NS	NS
Standing water	NS	0.384*	0.371*	NS
Wetland type	NS	NS	0.468**	0.446*
Organic Matter Content	0.461**	NS	NS	NS
Soil pH	NS	NS	NS	-0.360*

* ** *** P = 0.05, 0.01, 0.001, respectively. NS = Non significant.

Summary

The values obtained from the soil analyses undertaken vary greatly based on the type of wetland the samples were taken from, and the location along the lake shore (southern shore, areas 1, 2, 3 vs. eastern shore, area 4). This variability does not allow general conclusions to be drawn, even within geographic area, but suggests many correlations and possibilities for future work. This study does, however, provide enough detailed information so that future studies can focus on specific wetland ecosystems, allowing replication of plots based on existing soil data. These data will also serve as a baseline (or point in time) to measure future changes against.

References

American Public Health Association, American Water Works Association and Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater 17th Edition. L.S. Clesceri, A.E. Greenberg, and R.R. Trussel (eds.), American Public Health Association, Washington, DC.

Gee, G.W. and J.W. Bauder. 1986. Particle size analysis. In: A. Klute (ed.), Methods of Soil Analysis.Part 1.Physical and Mineralogical Methods. 2nd Edition, 9(1): 383-411, Amer. Soc. of Agron., Madison, WI.

Hill, B.H., C.M. Elonen, T.M. Jicha, A.M. Cotter, A.S. Trebitz, and N.P. Danz. 2006. Sediment microbial activity as an indicator of nutrient limitation in Great Lakes coastal wetlands. Freshwater Biology 51: 1670-1683.

Nelson, D.W. and L.E. Sommers. 1996. Total Carbon, Organic Carbon, and Organic Matter. In: D.L. Sparks (ed.) and J.M. Bartels (managing ed.). Methods of Soil Analysis, Part 3, Chemical Methods. SSSA Book Series: #5. SSSA and American Society of Agronomy, Madison, WI. pp. 961-1010.

Quinlan, C. and G. Mulamoottil. 1987. The effects of water level fluctuations on three Lake Ontario shoreline marshes. Canadian Water Resource Journal 12:64-77.

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APPENDICES

APPENDIX A. Detailed acreage summaries for wetlands and other features mapped during this inventory by region and county.

Data were tabulated by region and by county. For each area, there are two tables – the first related to habitats by common name and the second by NWI types (see Appendix B for legend to NWI codes). The regional tables are provided first followed by county tables. *Be advised that the data for the counties represent only the portion of the county that was in the study area.*

Common Habitat Type for Braddock Bay Region	# of polygons	Acreage
Aquatic bed	51	91.3044
Cattail marsh	51	1117.2639
Common reed marsh	3	0.7775
Lake	6	1367.0031
Mixed marsh/shrub swamp	1	13.1433
Mixed marsh/wet meadow	8	39.5695
Mixed shrub swamp/marsh	3	34.3578
Mixed shrub swamp/wet meadow	11	14.7833
Mixed shrub/wooded swamp	10	22.4953
Mixed wet meadow/shrub swamp	5	9.1182
Mixed wooded/shrub swamp	7	14.0900
Other marsh	7	29.1111
Other wet meadow	11	6.4577
Reed canary grass meadow	4	2.7536
River	5	17.5304
Shrub swamp	69	79.5563
Wooded swamp	14	15.1445

NWI Types for Braddock Bay Region	**# of polygons**	**Acreage**
L1UBH	4	1292.5837
L2AB4H	18	45.2326
L2AB4Hh	1	1.4963
L2UBH	1	41.2561
L2UBHh	1	33.1633
PAB4H	30	44.0282
PAB4Hx	2	0.5473
PEM1/SS1E	4	8.0110
PEM1/SS1F	1	13.1433
PEM1E	19	11.0960
PEM1F	66	1185.9444
PFO1/SS1A	1	0.6584
PFO1/SS1E	6	13.4316
PFO1A	4	5.7209
PFO1E	10	9.4236
PSS1/EM1C	1	0.3807
PSS1/EM1E	10	14.4027
PSS1/EM1F	3	34.3578
PSS1/FO1A	1	0.7615
PSS1/FO1E	9	21.7338
PSS1E	66	67.3356
PSS1F	3	12.2208
R2UBH	3	13.3681
R2UBHx	2	4.1623

Common Habitat Type for Irondequoit Bay Region	# of polygons	Acreage
Aquatic bed	7	5.1881
Cattail marsh	64	201.6907
Common reed marsh	8	4.3807
Lake	1	1663.2348
Mixed marsh/wet meadow	14	24.1267
Mixed shrub swamp/wet meadow	4	1.7470
Mixed shrub/wooded swamp	1	0.4237
Mixed wet meadow/marsh	5	9.5101
Mixed wet meadow/shrub swamp	6	5.1748
Other marsh	9	9.2017
Other wet meadow	8	9.0941
Pond	4	1.1141
Reed canary grass meadow	13	6.5333
River	1	44.4398
Shrub swamp	18	4.0885
Wooded swamp	6	0.9837
upland	2	2.6782
upland island	2	0.9831

NWI Type for Irondequoit Bay Region	# of polygons	Acreage
No code = upland within wetland or water	4	3.6613
L1UBH	1	1663.2348
L2AB3H	2	2.0701
PAB3H	1	1.1152
PAB4H	2	1.0908
PAB4Hh	1	0.6899
PEM1/SS1E	7	6.0528
PEM1E	36	29.9488
PEM1F	82	229.0741
PEM1Fh	3	5.5144
PFO1C	2	0.2865
PFO1E	4	0.6973
PSS1/EM1E	3	0.8690
PSS1/FO1E	1	0.4237
PSS1E	18	4.0885
PUBH	3	0.7283
PUBHh	1	0.3858
R2AB3H	1	0.2220
R2UBH	1	44.4398

Common Habitat Type for Sodus Bay Region	# of polygons	Acreage
Aquatic bed	54	418.9320
Aquatic bed/wooded swamp	1	3.0096
Cattail marsh	176	1643.7772
Common reed marsh	1	0.1396
Lake	7	4685.3378
Mixed aquatic bed/marsh	1	5.3695
Mixed cattail marsh/wet meadow	1	14.5547
Mixed marsh/aquatic bed	2	21.3854
Mixed marsh/shrub swamp	9	42.9861
Mixed marsh/wet meadow	37	121.5451
Mixed shrub swamp/aquatic bed	1	1.5602
Mixed shrub swamp/marsh	18	65.1078
Mixed shrub swamp/wet meadow	30	191.6161
Mixed shrub/wooded swamp	11	40.0867
Mixed wet meadow/marsh	9	35.3798
Mixed wet meadow/shrub swamp	27	100.4032
Mixed wet meadow/wooded swamp	1	5.5746
Mixed wooded swamp/wet meadow	2	10.9887
Mixed wooded/shrub swamp	16	65.5873
Other marsh	29	52.1814
Other wet meadow	25	29.8354
Pond	3	2.3178
Reed canary grass meadow	37	28.3376
River	14	151.1509
River/aquatic bed	18	95.6055
Shrub swamp	232	153.0990
Wooded swamp	28	135.3562
upland	6	12.1506
upland island	5	181.1330

NWI Types for Sodus Bay Region	# of polygons	Acreage
No code = upland within wetland or water	11	193.2837
L1UBH	6	4642.3121
L2AB3H	4	67.6350
L2AB3Hx	1	3.5172
L2AB4H	17	238.8021
L2AB4Hh	1	14.9135
L2UBH	1	43.0258
PAB3/EM1H	1	5.3695
PAB3H	4	16.3112
PAB4/FO5H	1	3.0096
PAB4H	23	58.2196
PAB4Hb	1	1.4671
PAB4Hh	1	3.2086
PEM1/AB4F	2	21.3854
PEM1/FO1E	1	5.5746
PEM1/SS1A	1	0.1446
PEM1/SS1E	24	94.6200
PEM1/SS1F	10	44.0047
PEM1C	1	0.0991
PEM1E	73	99.2473
PEM1F	238	1821.5089
PEM1Fx	3	4.8955
PFO1/EM1E	2	10.9887
PFO1/SS1E	16	65.5873
PFO1A	2	2.2165
PFO1C	1	0.1105
PFO1E	25	133.0292
PSS1/AB4F	1	1.5602
PSS1/EM1E	31	196.2361
PSS1/EM1F	17	63.6868
PSS1/EM1Fb	1	1.4211
PSS1/FO1E	11	40.0867
PSS1E	210	137.1129
PSS1F	22	15.9861
PUBF	1	0.1317
PUBH	1	0.5777
PUBHh	1	1.6083
R2AB3H	11	58.9036
R2AB4H	8	50.0943
R2UBH	15	152.6162

Common Habitat Type for Eastern Shore Region	# of polygons	Acreage
Aquatic bed	113	615.3543
Aquatic bed/marsh	1	0.4565
Cattail marsh	461	1818.9593
Common reed marsh	13	4.4793
Farmed wetland	2	1.1023
Lake	37	2794.3655
Mixed aquatic bed/marsh	1	4.3271
Mixed aquatic bed/shrub swamp	1	12.9939
Mixed marsh/aquatic bed	4	272.0279
Mixed marsh/shrub swamp	20	113.9078
Mixed marsh/wet meadow	81	645.6273
Mixed marsh/wooded swamp	1	14.8575
Mixed shrub swamp/marsh	14	156.3132
Mixed shrub swamp/wet meadow	59	220.0108
Mixed shrub/wooded swamp	24	174.3200
Mixed wet meadow/marsh	37	306.5638
Mixed wet meadow/shrub swamp	51	272.1559
Mixed wet meadow/wooded swamp	5	4.2757
Mixed wooded swamp/marsh	1	3.3404
Mixed wooded swamp/wet meadow	11	11.1425
Mixed wooded/shrub swamp	37	316.6967
Other marsh	98	133.5329
Other wet meadow	179	275.0505
Pond	5	7.7778
Reed canary grass meadow	116	241.8102
River	39	596.3279
River/aquatic bed	35	136.5006
Shrub swamp	296	374.3744
Wooded swamp	127	236.1066
upland	11	22.4402
upland island	14	13.4470

NWI Types for Eastern Shore Region	# of polygons	Acreage
No code = upland within wetland or water	25	35.8871
PEM1E	1	0.1176
PEM1F	9	156.0249
PSS1F	1	0.3323
L1UBH	6	2651.4673
L1UBHx	15	14.4715
L2AB3H	11	99.8100
L2AB4/UBH	1	6.0342
L2AB4H	29	429.2722
L2AB4Hx	1	0.7090
L2UBH	4	120.0725
L2UBHx	12	8.3542
PAB3H	23	18.9623
PAB3Hh	1	0.1612
PAB4/EM1H	1	0.4565
PAB4/EMHh	1	4.3271
PAB4/SS1Hb	1	12.9939
PAB4H	35	44.4344
PAB4Hh	5	7.7872
PEM1/AB3F	1	7.6633
PEM1/AB4H	3	264.3646
PEM1/FO1A	1	1.3476
PEM1/FO1C	4	2.4451
PEM1/FO1E	1	1.1074
PEM1/FO5Fb	1	14.8575
PEM1/SS1A	1	1.3273
PEM1/SS1C	3	7.9268
PEM1/SS1E	43	244.6640
PEM1/SS1Eh	1	0.7755
PEM1/SS1F	19	111.7641
PEM1A	5	5.3732
PEM1C	52	42.7529
PEM1E	289	780.6260
PEM1Eh	3	1.4206
PEM1F	617	2431.0051
PEM1Fh	7	3.7002
PEM2F	1	1.3015
PFO1/4E	1	4.4041
PFO1/EM1A	6	7.7513
PFO1/EM1C	5	3.3913
PFO1/SS1A	3	3.0935

PFO1/SS1C	2	1.0988
PFO1/SS1E	31	308.4962
PFO1A	17	20.5183
PFO1C	15	5.1835
PFO1E	93	205.8219
PSS1/EM1A	1	1.2414
PSS1/EM1C	4	1.7256
PSS1/EM1E	56	234.6285
PSS1/EM1F	15	160.7893
PSS1/FO1A	1	0.7457
PSS1/FO1C	1	5.5160
PSS1/FO1E	22	171.4348
PSS1C	6	1.9096
PSS1E	237	315.5408
PSS1Eb	1	1.8706
PSS1Eh	2	2.5872
PSS1F	51	55.8140
PSS3/EM1F	1	0.7752
PSS3E	1	0.3176
PUBH	4	5.3036
PUBHh	1	2.4742
R2AB3H	28	69.2760
R2AB4H	10	70.0804
R2AB4Hx	4	5.3278
R2UBH	30	553.3765
R2UBHx	8	10.5004
R3UBH	1	32.4511
Pf	2	1.1023

Common Habitat Type for Cayuga County	# of polygons	Acreage
Aquatic bed	8	101.9919
Cattail marsh	23	388.8755
Common reed marsh	1	0.1396
Lake	3	792.9385
Mixed marsh/shrub swamp	2	4.1560
Mixed marsh/wet meadow	6	37.6900
Mixed shrub swamp/marsh	10	14.6139
Mixed shrub swamp/wet meadow	1	8.3122
Mixed wet meadow/marsh	1	6.6203
Mixed wet meadow/shrub swamp	4	1.8949
Mixed wooded/shrub swamp	2	0.8082
Other marsh	7	5.8524
Other wet meadow	7	8.0379
Pond	1	0.1317
Reed canary grass meadow	1	0.4654
River/aquatic bed	3	7.1992
Shrub swamp	90	34.9026
Wooded swamp	1	0.5136
upland island	1	0.2806

NWI Types for Cayuga County	# of polygons	Acreage
No code = upland within wetland or water	1	0.2806
L1UBH	2	749.9127
L2AB4H	2	77.5155
L2UBH	1	43.0258
PAB4H	3	8.1516
PAB4Hb	1	1.4671
PEM1/SS1A	1	0.1446
PEM1/SS1E	2	1.4408
PEM1/SS1F	2	4.1560
PEM1C	1	0.0991
PEM1E	8	15.0245
PEM1F	37	432.5575
PFO1/SS1E	2	0.8082
PFO1E	1	0.5136
PSS1/EM1E	2	8.6217
PSS1/EM1F	9	13.1928
PSS1/EM1Fb	1	1.4211
PSS1E	81	25.6227
PSS1F	9	9.2799
PUBF	1	0.1317
R2AB3H	2	11.1353
R2AB4H	3	10.9216

Common Habitat Type for Jefferson County	# of polygons	Acreage
Aquatic bed	80	487.7632
Aquatic bed/marsh	1	0.4565
Cattail marsh	324	1463.6724
Common reed marsh	7	1.3177
Farmed wetland	2	1.1023
Lake	22	279.2099
Mixed marsh/aquatic bed	3	264.3646
Mixed marsh/shrub swamp	13	87.7983
Mixed marsh/wet meadow	65	546.1390
Mixed shrub swamp/marsh	7	131.2024
Mixed shrub swamp/wet meadow	28	76.1143
Mixed shrub/wooded swamp	13	62.3448
Mixed wet meadow/marsh	20	100.3187
Mixed wet meadow/shrub swamp	30	100.5211
Mixed wet meadow/wooded swamp	1	1.1074
Mixed wooded/shrub swamp	12	23.3887
Other marsh	57	96.5705
Other wet meadow	100	159.0942
Pond	2	4.0064
Reed canary grass meadow	76	198.3213
River	17	258.6976
River/aquatic bed	17	64.4522
Shrub swamp	163	131.7473
Wooded swamp	81	42.7120
upland	1	6.5812
upland island	10	6.7402

NWI Types for Jefferson County	**# of polygons**	**Acreage**
No code = upland within wetland or water	11	13.3214
PEM1E	1	0.1176
PEM1F	9	156.0249
PSS1F	1	0.3323
L1UBH	4	148.5952
L1UBHx	2	2.1880
L2AB3H	9	79.3988
L2AB4H	18	349.9544
L2UBH	4	120.0725
L2UBHx	12	8.3542
PAB3H	13	2.6434
PAB3Hh	1	0.1612
PAB4/EM1H	1	0.4565
PAB4H	27	39.6344
PAB4Hh	5	7.7872
PEM1/AB4H	3	264.3646
PEM1/FO1E	1	1.1074
PEM1/SS1C	1	1.6273
PEM1/SS1E	27	98.0007
PEM1/SS1Eh	1	0.7755
PEM1/SS1F	12	85.6545
PEM1C	13	9.4304
PEM1E	193	451.8260
PEM1Eh	3	1.4206
PEM1F	425	1941.8463
PEM1Fh	5	1.0731
PFO1/SS1C	1	0.4114
PFO1/SS1E	11	22.9773
PFO1A	2	1.0057
PFO1C	7	2.9811
PFO1E	71	38.5464
PSS1/EM1C	1	1.1101
PSS1/EM1E	29	76.0204
PSS1/EM1F	7	132.9616
PSS1/FO1A	1	0.7457
PSS1/FO1E	11	60.9675
PSS1C	5	1.8577
PSS1E	138	106.4958
PSS1Eh	1	1.1900
PSS1F	20	25.8626
PUBH	1	1.5322

PUBHh	1	2.4742
R2AB3H	15	18.5609
R2AB4H	5	48.7472
R2AB4Hx	4	5.3278
R2UBH	16	254.4115
R2UBHx	1	4.2861
Pf	2	1.1023

Common Habitat Type for Monroe County	# of polygons	Acreage
Aquatic bed	58	96.4925
Cattail marsh	115	1318.9545
Common reed marsh	11	5.1582
Lake	7	3030.2379
Mixed marsh/shrub swamp	1	13.1433
Mixed marsh/wet meadow	22	63.6962
Mixed shrub swamp/marsh	3	34.3578
Mixed shrub swamp/wet meadow	15	16.5303
Mixed shrub/wooded swamp	11	22.9190
Mixed wet meadow/marsh	5	9.5101
Mixed wet meadow/shrub swamp	11	14.2931
Mixed wooded/shrub swamp	7	14.0900
Other marsh	16	38.3127
Other wet meadow	19	15.5518
Pond	4	1.1141
Reed canary grass meadow	17	9.2869
River	6	61.9702
Shrub swamp	87	83.6448
Wooded swamp	20	16.1283
upland	2	2.6782
upland island	2	0.9831

NWI Type for Monroe County	# of polygons	Acreage
No code = upland within wetland or water	4	3.6613
L1UBH	5	2955.8185
L2AB3H	2	2.0701
L2AB4H	18	45.2326
L2AB4Hh	1	1.4963
L2UBH	1	41.2561
L2UBHh	1	33.1633
PAB3H	1	1.1152
PAB4H	32	45.1190
PAB4Hh	1	0.6899
PAB4Hx	2	0.5473
PEM1/SS1E	11	14.0639
PEM1/SS1F	1	13.1433
PEM1E	55	41.0448
PEM1F	148	1415.0185
PEM1Fh	3	5.5144
PFO1/SS1A	1	0.6584
PFO1/SS1E	6	13.4316
PFO1A	4	5.7209
PFO1C	2	0.2865
PFO1E	14	10.1209
PSS1/EM1C	1	0.3807
PSS1/EM1E	13	15.2716
PSS1/EM1F	3	34.3578
PSS1/FO1A	1	0.7615
PSS1/FO1E	10	22.1575
PSS1E	84	71.4241
PSS1F	3	12.2208
PUBH	3	0.7283
PUBHh	1	0.3858
R2AB3H	1	0.2220
R2UBH	4	57.8079
R2UBHx	2	4.1623

Common Habitat Type for Oswego County	# of polygons	Acreage
Aquatic bed	33	127.5911
Cattail marsh	137	355.2869
Common reed marsh	6	3.1616
Lake	15	2515.1557
Mixed aquatic bed/marsh	1	4.3271
Mixed aquatic bed/shrub swamp	1	12.9939
Mixed marsh/aquatic bed	1	7.6633
Mixed marsh/shrub swamp	7	26.1096
Mixed marsh/wet meadow	16	99.4883
Mixed marsh/wooded swamp	1	14.8575
Mixed shrub swamp/marsh	7	25.1108
Mixed shrub swamp/wet meadow	31	143.8965
Mixed shrub/wooded swamp	11	111.9752
Mixed wet meadow/marsh	17	206.2451
Mixed wet meadow/shrub swamp	21	171.6348
Mixed wet meadow/wooded swamp	4	3.1682
Mixed wooded swamp/marsh	1	3.3404
Mixed wooded swamp/wet meadow	11	11.1425
Mixed wooded/shrub swamp	25	293.3080
Other marsh	41	36.9624
Other wet meadow	79	115.9563
Pond	3	3.7714
Reed canary grass meadow	40	43.4889
River	22	337.6303
River/aquatic bed	18	72.0483
Shrub swamp	133	242.6271
Wooded swamp	46	193.3946
upland	10	15.8590
upland island	4	6.7068

NWI Type for Oswego County	# of polygons	Acreage
No code = upland within wetland or water	14	22.5657
L1UBH	2	2502.8722
L1UBHx	13	12.2835
L2AB3H	2	20.4112
L2AB4/UBH	1	6.0342
L2AB4H	11	79.3178
L2AB4Hx	1	0.7090
PAB3H	10	16.3190
PAB4/EMHh	1	4.3271
PAB4/SS1Hb	1	12.9939
PAB4H	8	4.8000
PEM1/AB3F	1	7.6633
PEM1/FO1A	1	1.3476
PEM1/FO1C	4	2.4451
PEM1/FO5Fb	1	14.8575
PEM1/SS1A	1	1.3273
PEM1/SS1C	2	6.2995
PEM1/SS1E	16	146.6633
PEM1/SS1F	7	26.1096
PEM1A	5	5.3732
PEM1C	39	33.3225
PEM1E	96	328.8000
PEM1F	192	489.1588
PEM1Fh	2	2.6271
PEM2F	1	1.3015
PFO1/4E	1	4.4041
PFO1/EM1A	6	7.7513
PFO1/EM1C	5	3.3913
PFO1/SS1A	3	3.0935
PFO1/SS1C	1	0.6874
PFO1/SS1E	20	285.5188
PFO1A	15	19.5126
PFO1C	8	2.2024
PFO1E	22	167.2755
PSS1/EM1A	1	1.2414
PSS1/EM1C	3	0.6155
PSS1/EM1E	27	158.6081
PSS1/EM1F	8	27.8277
PSS1/FO1C	1	5.5160
PSS1/FO1E	11	110.4674
PSS1C	1	0.0518

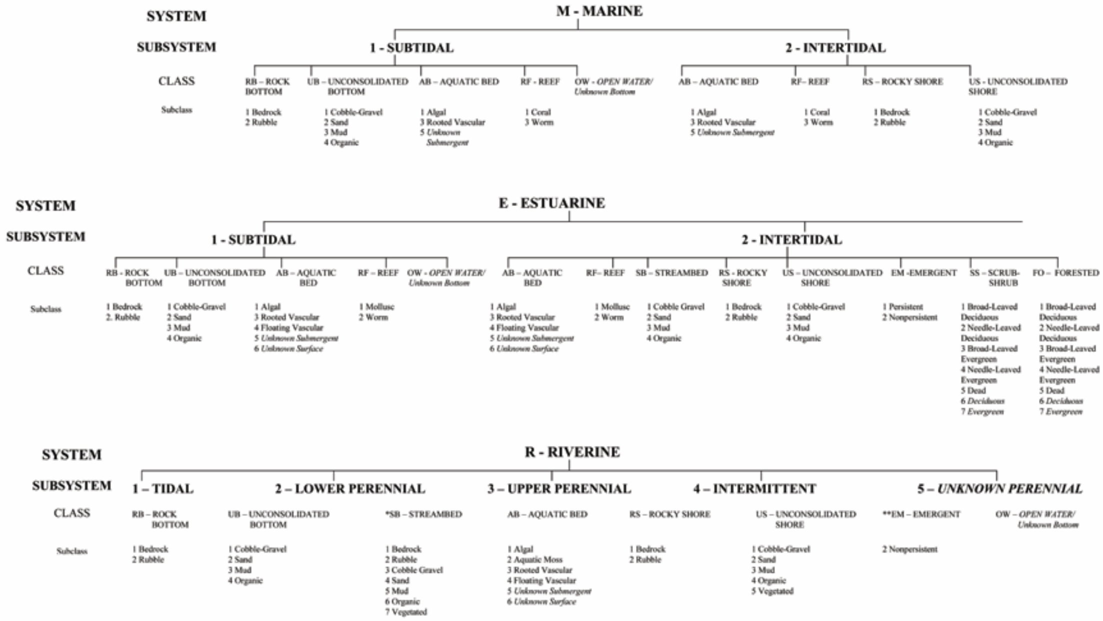
PSS1E	99	209.0450
PSS1Eb	1	1.8706
PSS1Eh	1	1.3971
PSS1F	31	29.9514
PSS3/EM1F	1	0.7752
PSS3E	1	0.3176
PUBH	3	3.7714
R2AB3H	13	50.7152
R2AB4H	5	21.3332
R2UBH	14	298.9650
R2UBHx	7	6.2142
R3UBH	1	32.4511

Common Habitat Type for Wayne County	# of polygons	Acreage
Aquatic bed	46	316.9401
Aquatic bed/wooded swamp	1	3.0096
Cattail marsh	153	1254.9017
Lake	4	3892.3994
Mixed aquatic bed/marsh	1	5.3695
Mixed cattail marsh/wet meadow	1	14.5547
Mixed marsh/aquatic bed	2	21.3854
Mixed marsh/shrub swamp	7	38.8300
Mixed marsh/wet meadow	31	83.8550
Mixed shrub swamp/aquatic bed	1	1.5602
Mixed shrub swamp/marsh	8	50.4939
Mixed shrub swamp/wet meadow	29	183.3039
Mixed shrub/wooded swamp	11	40.0867
Mixed wet meadow/marsh	8	28.7596
Mixed wet meadow/shrub swamp	23	98.5084
Mixed wet meadow/wooded swamp	1	5.5746
Mixed wooded swamp/wet meadow	2	10.9887
Mixed wooded/shrub swamp	14	64.7790
Other marsh	22	46.3290
Other wet meadow	18	21.7975
Pond	2	2.1860
Reed canary grass meadow	36	27.8722
River	14	151.1509
River/aquatic bed	15	88.4063
Shrub swamp	142	118.1964
Wooded swamp	27	134.8426
upland	6	12.1506
upland island	4	180.8524

NWI Type for Wayne County	# of polygons	Acreage
No code = upland within wetland or water	10	193.0030
L1UBH	4	3892.3994
L2AB3H	4	67.6350
L2AB3Hx	1	3.5172
L2AB4H	15	161.2865
L2AB4Hh	1	14.9135
PAB3/EM1H	1	5.3695
PAB3H	4	16.3112
PAB4/FO5H	1	3.0096
PAB4H	20	50.0680
PAB4Hh	1	3.2086
PEM1/AB4F	2	21.3854
PEM1/FO1E	1	5.5746
PEM1/SS1E	22	93.1792
PEM1/SS1F	8	39.8487
PEM1E	65	84.2228
PEM1F	201	1388.9514
PEM1Fx	3	4.8955
PFO1/EM1E	2	10.9887
PFO1/SS1E	14	64.7790
PFO1A	2	2.2165
PFO1C	1	0.1105
PFO1E	24	132.5157
PSS1/AB4F	1	1.5602
PSS1/EM1E	29	187.6144
PSS1/EM1F	8	50.4939
PSS1/FO1E	11	40.0867
PSS1E	129	111.4902
PSS1F	13	6.7062
PUBH	1	0.5777
PUBHh	1	1.6083
R2AB3H	9	47.7683
R2AB4H	5	39.1727
R2UBH	15	152.6162

APPENDIX B. Legend for NWI Types. Alpha-numeric codes – System, Subsystem (except for Palustrine), Class, Subclass, Water Regimes, and Modifiers from Cowardin et al. 1979.

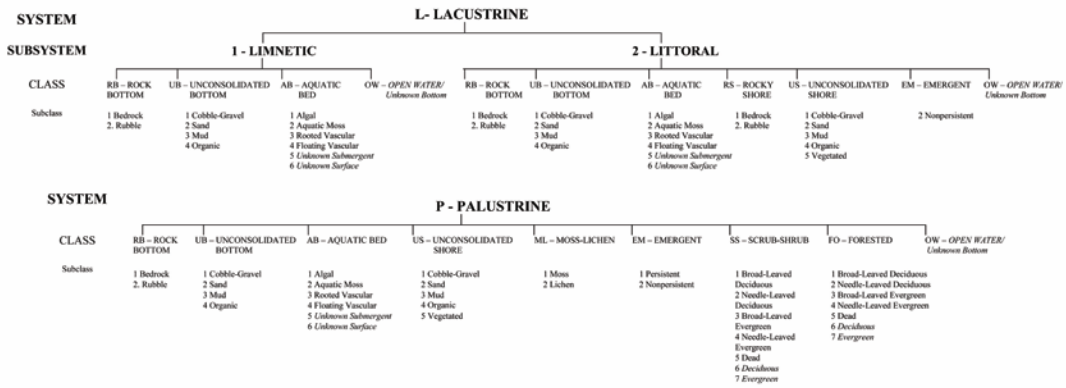
WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



* STREAMBED is limited to TIDAL and INTERMITTENT SUBSYSTEMS, and comprises the only CLASS in the INTERMITTENT SUBSYSTEM.
** EMERGENT is limited to TIDAL and LOWER PERENNIAL SUBSYSTEMS.

Classification of Wetlands and Deepwater Habitats of the United States
Cowardin ET AL. 1979 as modified for National Wetland Inventory Mapping Convention

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



MODIFIERS

In order to more adequately describe the wetland and deepwater habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME				WATER CHEMISTRY			SOIL	SPECIAL MODIFIERS	
Non-Tidal		**Tidal**		**Coastal Halinity**	**Inland Salinity**	**pH Modifiers for all Fresh Water**			
A Temporarily Flooded	H Permanently Flooded	K *Artificially Flooded*	*S Temporary-Tidal	1 Hyperhaline	7 Hypersaline		g Organic	b *Beaver*	h *Diked/Impounded*
B Saturated	J Intermittently Flooded	L Subtidal	*R Seasonal-Tidal	2 Euthaline	8 Eusaline	a Acid	n Mineral	d *Partially Drained/Ditched*	r Artificial Substrate
C Seasonally Flooded	K Artificially Flooded	M Irregularly Exposed	*T Semipermanent-Tidal	3 Mixohaline *(Brackish)*	9 Mixosaline	t Circumneutral		f Farmed	s *Spoil*
D *Seasonally Flooded/ Well Drained*	W Intermittently Flooded/Temporary	N Regularly Exposed	*V Permanent-Tidal	4 Polyhaline	0 Fresh	i Alkaline			x Excavated
E *Seasonally Flooded/ Saturated*	Y Saturated/Semipermanent/ Seasonal	P Irregularly Flooded	U *Unknown*	5 Mesohaline					
F Semipermanently Flooded	Z Intermittently Exposed/Permanent			6 Oligohaline					
G Intermittently Exposed	U *Unknown*			0 Fresh					
		*These water regimes are only used in tidally influenced, freshwater systems.							

NOTE: Italicized terms were added for mapping by the National Wetlands Inventory program.

APPENDIX C. List of plants recorded in plot sampling.

(Other aquatic species were observed but were not located in any plots including Potamogeton natans, P. pusillus, P. zosteriformis, and Trapa natans.)

Acer rubrum
Acer saccharinum
Allaria petiolata
Alnus incana ssp. rugosa
Andropogon glomeratus
Anemone canadensis
Apios americana
Apocynum cannabinum
Artemisia vulgaris
Asclepias incarnata
Asclepias syriaca
Aster sp. (Symphyotrichum sp.)
Barbarea vulgaris
Bidens sp.
Boehmeria cylindrica
Brasenia schreberi
Brassica sp.
Calamagrostis canadensis
Calystegia sepium
Cardamine pensylvanica
Carex comosa
Carex crinita
Carex lacustris
Carex lasiocarpa
Carex lurida
Carex pseudocyperus
Carex stipata
Carex stricta
Carex tribuloides
Carex utriculata
Carex vulpinoidea
Carya glabra
Cephalanthus occidentalis
Ceratophyllum demersum
Chamaedaphne calyculata
Chelone glabra
Cicuta bulbifera
Cicuta maculata
Cirsium sp.
Cladophora glomerata
Clematis virginiana
Comarum palustre
Cornus amomum
Cornus stolonifera
Cuscuta gronovii
Cynanchum louiseae
Decodon verticillatus
Eleocharis palustris
Eleocharis parvula
Eleocharis sp.
Equisetum arvense
Equisetum hymale
Eupatorium maculatum
Eupatorium perfoliatum
Euthamia graminifolia
Fragaria virginiana
Frangula alnus
Fraxinus pensylvanica
Galium palustre
Geum laciniatum
Glyceria striata
Hedeoma pulegioides
Holcus lanatus
Hydrocharis morsus-ranae
Ilex verticillata
Impatiens capensis
Ipomea sp.
Iris pseudacris
Iris versicolor
Juncus acuminatus
Juncus articulatus
Juncus canadensis

Juncus dudleyi
Juncus effusus
Justicia americana
Lemna minor
Lemna trisulca
Lobelia cardinalis
Lonicera sp.
Lonicera morrowii
Lycopus americanus
Lycopus virginicus
Lysimachia ciliata
Lysimachia nummularia
Lysimachia terrestris
Lythrum salicaria
Lysimachia thyrsiflora
Matteuccia struthiopteris
Mentha arvense
Monarda didyma
Myosotis scorpioides
Myrica gale
Nuphar lutea
Nymphaea odorata
Nymphaea odorata ssp. tuberosa
Onoclea sensibilis
Osmunda regalis
Panicum dichotomiflorum
Parthenocissus quinquefolia
Peltandra virginica
Phalaris arundinacea
Phleum pratense
Phragmites australis
Pilea pumila
Poa sp.
Poa pratensis
Polygonum amersum
Polygonum amphibium
Polygonum arifolium
Polygonum hydropiper
Polygonum pensylvanicum
Polygonum sagittatum
Pontederia cordata
Potamogeton richardsonii
Potentilla recta
Pteridium aquilinum
Rhexia virginica
Rosa multiflora
Rosa palustris
Rubus allegheniensis
Rubus sp.
Rumex verticillatus
Sagittaria cuneata
Sagittaria latifolia
Salix eriocephala
Salix sericea
Sambucus canadensis
Saururus cernuus
Schoenoplectus fluviatilis
Schoenoplectus tabernaemontani
Scirpus atrocinctus
Scirpus atrovirens
Scirpus cyperinus
Scrophularia lanceolata
Scutellaria sp.
Sium suave
Solanum dulcamara
Solidago canadensis
Solidago rugosa
Solidago sp.
Sparganium androcladum
Sparganium eurycarpum
Sphagnum sp.
Spiraea alba var. latifolia

Spiraea tomentosa
Stellaria pubera
Symphyotrichum novae-angliae
Teucrium canadense
Thelypteris palustris
Toxicodendron radicans
Triadanum virginicum
Typha angustifolia
Typha latifolia
Typha x glauca
Urtica dioica
Utricularia macrorhiza
Vaccinium corymbosum
Vaccinium macrocarpon
Verbena hastata
Viburnum recognitum
Vicia cracca
Vitis riparia
Wolffia columbiana
Zizania aquatica

APPENDIX D. Field Form.

LAKE ONTARIO COASTAL WETLANDS FIELD FORM

Marsh Name: ______________________ Location (town): ______________________

Date: ____________ Team #: _____ Team Members: ________________________

Coastal Wetland Type: Aquatic Bed Marsh Wet Meadow Mixed
Other (specify):___________________

Site ID: _________ GPS Location: N _______________ W _______________
Waypoint #: _________

Depth (in)	Horizon	Texture	Matrix Color	Redox Features	Other

Soil Sample Collected for Lab Work (circle): Yes No Water sample Collected: Y N

Depth of Surface Water (in) :_____ Depth to Water Table (in):_____

Depth to Saturation (in) :_____ Water pH: _____ Soil pH: _____

Other signs of hydrology for non-flooded sites (circle):

water-stained leaves aquatic invertebrates surface soil cracks oxidized rhizospheres

iron deposits presence of reduced iron water-carried debris algae water marks

hydrogen sulfide odor Other: ______________________________

Photos:			Notes:
Subject	Orientation	Number	
Plot A			
Plot B			
Habitat			

Shrub Height classes: 1: <0.5m 2: 0.5-2m 3: 2-5m 4: 5-15m 5: 15-30m 6: >30

Species	Height Class	Cover (%) Plot A	Cover (%) Plot B	Species	Height Class	Cover (%) Plot A	Cover (%) Plot B	Species	Height Class	Cover (%) Plot A	Cover (%) Plot B	Species	Height Class	Cover (%) Plot A	Cover (%) Plot B
Bare Ground/Substrate				Eupatorium perfoliatum (EMH)*				Polygonum amphibium (EMH)				Ulmus americana (TRE)			
Acer rubrum (TRE)				Fragaria virginiana (EMH)				Pontederia cordata (EMH)				Urtica dioica (EMH)			
Acer saccharinum (TRE)				Fraxinus americana (TRE)				Populus deltoides (TRE)				Utricularia macrorhiza (SM)			
Acorus calamus (EMH)				Fraxinus nigra (TRE)				Potamogeton amplifolius (SM)*				Vaccinium macrocarpon (WV)			
Agrostis perennans (GRAM)				Fraxinus pensylvanica (TRE)				Potamogeton crispus (SM)				Vallisneria americana (SM)			
Alisma plantago-aquatica (EMH)*				Galium obtusum (EMH)				Potamogeton flexilis (SM)				Viburnum cassinoides (SHB)			
Alisma trivale (EMH)				Galium tinctorium (EMH)				Potamogeton foliosus (FFA)				Viburnum recognitum (SHB)			
Alnus incana ssp. rugosa (SHB)				Geum laciniatum (EMH)				Potamogeton friesii (SM)				Vicia cracca (HV)			
Amphicarpaea bracteata (HV)				Heteranthera dubia (SM)				Potamogeton gramineus (SM)				Zizania aquatica (GRAM)			
Andromeda glaucophyllum (SHB)				Hydrocharis morsus-ranae (SM)*				Potamogeton natans (SM)							
Anemone canadensis (EMH)				Ilex verticillata (SHB)				Potamogeton pusillus (SM)							
Argentina anserina (EMH)*				Impatiens capensis (EMH)				Potamogeton richardsonii (SM)							
Asclepias incarnata (EMH)				Iris versicolor (EMH)				Potamogeton robbinsii (SM)*							
Bidens beckii (SM)*				Isoetes sp. (EMH)*				Potamogeton zosteriformis (SM)							
Bidens cernua (EMH)				Juncus alpinus (GRAM)*				Ranunculus longirostris (SM)							
Bidens frondosa (EMH)				Juncus canadensis (GRAM)				Ranunculus reptans (SM)							
Boehmeria cylindrica (EMH)				Juncus effusus (GRAM)				Ranunculus sceleratus (EMH)							
Brasenia schreberi (FLA)*				Juncus nodosus (GRAM)*				Ranunculus trichophyllus (SM)							
Calamagrostis canadensis				Juncus pelocarpus (GRAM)*				Riccia fluvitans (FFA)							
Caltha palustris (EMH)				Lathyrus palustris (HV)				Sagittaria cuneata (EMH)							
Campanula aparinoides (EMH)				Lemna minor (FFA)				Sagittaria latifolia (EMH)							
Cardamine pensylvanica (EMH)				Lemna trisulca (FFA)				Sagittaria rigida (EMH)							
Carex aquatilis (GRAM)				Lobelia cardinalis (EMH)*				Salix fragilis (TRE)							
Carex aurea (GRAM)*				Lobelia dortmanna (EMH)*				Salix nigra (TRE)							
Carex flava (GRAM)*				Lobelia kalmii (EMH)*				Salix spp. (SHB)							
Carex granularis (GRAM)*				Lobelia siphlitica (EMH)*				Salix spp. (SHB)							
Carex lacustris (GRAM)				Lycopus americanus (EMH)				Salix spp. (SHB)							
Carex stricta (GRAM)				Lycopus uniflorus (EMH)*				Sarracenia purpurea (EMH)							
Carex virescens (GRAM)				Lycopus virginicus (EMH)*				Schoenoplectus acutus (GRAM)							
Carex viridula (GRAM)*				Lysimachia ciliata (EMH)				Schoenoplectus pungens (GRAM)							
Cephalanthus occidentalis (SHB)				Lysimachia nummularia (EMH)				Schoenoplectus tabernaemontani							
Ceratophyllum demersum				Lysimachia thyrsiflora (EMH)				Scutellaria epilobiifolia (EMH)							
Chamaedaphne calyculata (SHB)				Lythrum salicaria (EMH)				Scutellaria galericulata (EMH)							
Chara vulgaris (SM)				Mentha arvense (EMH)*				Sium suave (EMH)							
Chelone glabra (EMH)				Myrica gale (SHB)				Solidago canadensis (EMH)							
Cicuta bulbifera (EMH)				Myriophyllum heterophyllum (SM)				Sparganium androcladum (EMH)							
Circaea lutetiana ssp. canadensis				Myriophyllum sibiricum (SM)				Sparganium emersum (EMH)							
Cladophora glomerata (FFA, SM)				Myriophyllum spicatum (SM)*				Sparganium eurycarpum (EMH)							
Cornus amomum (SHB)				Myriophyllum verticillatum (SM)				Sphagnum spp. (MOSS)							
Cornus racemosa (SHB)				Najas flexilis (SM)				Spiraea alba var. alba (SHB)							
Cornus stolonifera (SHB)				Nuphar lutea (FLA)				Spiraea alba var. latifolia (SHB)							
Cyperus strigosus (GRAM)				Nuphar lutea pumila (FLA)				Spirodela polyrhiza (FFA)							
Decodon verticillatus (EMH or SHB)				Nuphar lutea variegata (FLA)				Stuckenia pectinata (SM)							
Eleocharis acicularis (GRAM)				Nymphaea odorata (FLA)				Symphyotrichum novae-angliae							
Eleocharis palustris (GRAM)				Nymphaea odorata ssp. tuberosa				Thelypteris palustris (FRN)							
Elodea canadensis (FFA, SM)				Onoclea sensibilis (FRN)				Trapa natans (FLA)*							
Equisetum arvense (EMH)*				Osmunda regalis (FRN)				Triadanum virginicum (EMH)							
Equisetum fluviatile (EMH)				Peltandra virginica (EMH)				Typha angustifolia (EMH)							
Equisetum variegatum (EMH)*				Phalaris arundinacea (GRAM)				Typha latifolia (EMH)							
Eriocaulon aquaticum (EMH)*				Phragmites australis (GRAM)				Typha x glauca (EMH)							

Cattail Density (if Applicable)	**Density**	
Species	**A**	**B**
Typha xglauca		
Typha angustifolia (EMH)		
Typha latifolia (EMH)		

APPENDIX E. Soil Series Descriptions. (Source: U.S.D.A. Natural Resources Conservation Service)

ARKPORT SERIES

The Arkport series consist of very deep, well drained soils formed in glacio-fluvial deposits having a high content of fine and very fine sand. These soils have thin horizontal bands of loamy material in the subsoil. Saturated hydraulic conductivity is high throughout the mineral soil. Slope ranges from 0 to 60 percent. The mean annual temperature is 48 degrees F. and the mean precipitation is about 38 inches.

TAXONOMIC CLASS: Coarse-loamy, mixed, active, mesic Lamellic Hapludalfs

TYPICAL PEDON: Arkport very fine sandy loam on a 5 percent slope in a cultivated field. (Colors are for moist soil unless otherwise noted).

Ap-- 0 to 9 inches; brown (7.5YR 4/2) very fine sandy loam; weak fine granular structure; very friable; few medium and common fine roots; 1 percent very fine pebbles; moderately acid; abrupt smooth boundary. (7 to 12 inches thick.)

BE1-- 9 to 15 inches; brown (7.5YR 5/4) very fine sandy loam; weak fine granular structure; friable; common medium roots; many fine pores; moderately acid; gradual wavy boundary.

BE2-- 15 to 28 inches; brown (7.5YR 5/4) loamy very fine sand in intricate pattern with brown (7.5YR 5/2) clean very fine sand and few reddish brown (5YR 4/3) very fine sandy loam lamellae 1/16 inch thick and 3 to 6 inches long; massive; very friable; common fine and few medium roots; strongly acid; abrupt wavy boundary. (Combined thickness of the BE horizons is 0 to 23 inches thick.)

E and **Bt1**-- 28 to 45 inches; light reddish brown (5YR 6/3) very fine sand E material; massive; very friable; reddish brown (5YR 5/4) very fine sandy loam Bt material as lamellae 1/16 to 4 inches thick that total 6 inches in thickness; massive; firm; few medium roots; strongly acid; abrupt wavy boundary.

E and **Bt2**-- 45 to 58 inches; light reddish brown (5YR 6/3) loamy fine sand intricately patterned with reddish brown (5YR 4/4) wavy, branching, crudely horizontal lamellae 1/16 to 1/2 inch thick that total 1 1/2 inches in thickness; massive; very friable; lamellae are firm and slightly plastic; few roots; strongly acid; abrupt wavy boundary.

E and **Bt3**-- 58 to 92 inches; pinkish gray (5YR 6/2) loamy fine sand patterned with dark reddish brown (5YR 3/4) fine sandy loam, thin, wavy, horizontal, branching lamellae that total 1 inch in thickness and by reddish brown (5YR 4/4) very fine sandy loam 1/2 inch thick lamellae that total 4 inches in thickness; massive; very friable and friable; few roots in upper part; moderately acid; clear wavy boundary. (Combined thickness of the E and Bt horizons is 15 to 70 inches.)

C-- 92 to 106 inches; pinkish gray (5YR 6/2) fine sand; single grain; loose; slightly acid.

TYPE LOCATION: Orleans County, New York; 1/4 mile south of intersection of Highway 31 and Rich's Road; 2 miles east of Albion; 60 feet north and 90 feet west of southwest corner of small cemetery west of Keitall Road. USGS Albion, NY topographic quadrangle; Latitude 43 degrees, 14 minutes, 18 seconds N. and Longitude 78 degrees, 21 minutes, 46 seconds W., NAD 1927.

GEOGRAPHIC SETTING: The Arkport soils are nearly level to steep soils on the tops and sides of glacial deltas and glacio-fluvial sand plains, and on dunes and beach ridges. Slope ranges from 0 to 60 percent. The soil formed in water-sorted deposits having a high content of fine and very fine sand. The climate is humid and cool temperate. Mean annual precipitation ranges from 28 to 40 inches. Mean annual temperature ranges from 46 to 50 degrees F. The frost-free period ranges from 140 to 200 days. Elevation ranges from 300 to 900 feet above sea level.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. The potential for surface runoff is low to high. Saturated hydraulic conductivity is high throughout the mineral soil.

USE AND VEGETATION: Most of the acreage is cultivated. The dominant crops are corn, hay, and small grains but vegetable crops and deciduous fruits are prominent in many places. Some areas remain in woodlots of sugar maple, red oak, and American beech.

DUNKIRK SERIES

The Dunkirk series consists of very deep, well drained, silty soils on lake plains and along lower valley sides formed in glacio-lacustrine sediments. Saturated hydraulic conductivity is moderately high or high in the mineral surface and sub-surface layers and moderately low to high in the subsoil and substratum. Slope ranges from 0 to 60 percent. Mean annual temperature is 49 degrees F., and mean annual precipitation is 38 inches.

TAXONOMIC CLASS: Fine-silty, mixed, active, mesic Glossic Hapludalfs

TYPICAL PEDON: Dunkirk silt loam on a 6 percent slope in a cultivated field. (Colors are for moist soil unless otherwise stated.)

Ap-- 0 to 6 inches; dark grayish brown (10YR 4/2) silt loam; weak medium and fine granular structure; friable; many fine roots; strongly acid; abrupt smooth boundary. (6 to 10 inches thick.)

EB-- 6 to 11 inches; yellowish brown (10YR 5/4) silt loam; weak fine subangular blocky structure; very friable; many fine roots; common medium pores; strongly acid; gradual wavy boundary. (0 to 12 inches thick.)

E/B-- 11 to 14 inches; brown (10YR 5/3) silt loam; weak fine subangular blocky structure; friable; common fine roots; common medium pores with faint patchy clay films on surfaces along pores; 30 percent brown (7.5YR 4/4) ped interiors; strongly acid; clear wavy boundary. (0 to 6 inches thick.)

B/E-- 14 to 17 inches; brown (7.5YR 4/4) silt loam; moderate medium subangular blocky structure; firm; common fine roots; common fine and medium pores; grayish brown (10YR 5/2) ped faces 1 to 2 millimeters thick which constitutes less than 15 percent by volume; common clay films on surfaces along pores; moderately acid; gradual wavy boundary. (2 to 6 inches thick.)

Bt1-- 17 to 20 inches; brown (7.5YR 4/4) silt loam; moderate medium subangular blocky structure; firm; common fine roots; common medium pores; distinct clay films on surfaces along pores; common distinct patchy clay films on all faces of peds; moderately acid; gradual wavy boundary.

Bt2-- 20 to 36 inches; brown (10YR 4/3) silt loam; moderate coarse subangular blocky structure; firm; few fine roots; common medium and large pores; common distinct clay films on surfaces along pores; many distinct clay films on all faces of peds; slightly acid; gradual wavy boundary. (Combined thickness of the Bt horizon is 10 to 34 inches.)

C1-- 36 to 42 inches; brown (10YR 4/3) silt loam with thin layers of very fine sandy loam; massive within inherited varves; friable; few fine roots; neutral; clear wavy boundary.

C2-- 42 to 72 inches; dark grayish brown (10YR 4/2) layers (varves) of silt and very fine sand; friable; moderately alkaline; strongly effervescent.

TYPE LOCATION: Genesee County, New York; Town of Alexander, 0.35 miles north of U.S. Route 20, east of Brookville Road, and 1-1/8 miles northeast of the Village of Alexander. USGS Batavia South, NY topographic quadrangle; Latitude 42 degrees, 54 minutes, 16 seconds N. and Longitude 78 degrees, 14 minutes, 09 seconds W., NAD 1927.

GEOGRAPHIC SETTING: Dunkirk soils developed in glacio-lacustrine deposits dominated by silt, very fine sand, and clay. These soils are on lake plains and along lower valley sides in major valleys. Slope ranges from 0 to 60 percent, with the more sloping areas being prominently dissected. Surface shape is convex. Mean annual air temperature ranges from 45 to 52 degrees F., mean annual precipitation ranges from 26 to 44 inches, and the growing season is from 130 to 180 days.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. The potential for surface runoff is medium or very high. Saturated hydraulic conductivity is moderately high or high in the mineral surface and sub-surface layers and moderately low to high in the subsoil and substratum.

USE AND VEGETATION: Most areas have been cleared, and are used for growing corn, small grain, hay, and pasture. Vegetable crops and orchards are also important. Native vegetation is sugar maple, beech, oaks, hickories, black cherry, white ash, and white pine.

COLONIE SERIES

The Colonie series consists of very deep, well drained to excessively drained soils formed in glaciolacustrine, glaciofluvial, or eolian deposits dominated by fine sand and very fine sand. They are on nearly level to steeply dissected slopes on Wisconsinan age lake plains, dunes, outwash plains, beach ridges, and deltas. Saturated hydraulic conductivity is high through very high in the mineral soil. The mean annual temperature is about 49 degrees F, and the mean annual precipitation is about 37 inches.

TAXONOMIC CLASS: Mixed, mesicLamellicUdipsamments

TYPICAL PEDON: Colonie loamy fine sand, 5 percent slope, in a cultivated field. (Colors are for moist soil unless otherwise noted.)

Ap-- 0 to 8 inches; dark grayish brown (10YR 4/2) loamy fine sand, light brownish gray (10YR 6/2) dry; weak fine and very fine granular structure; very friable; many fine roots; slightly acid (limed); abrupt smooth boundary. (6 to 12 inches thick.)

E1-- 8 to 16 inches; yellowish brown (10YR 5/4) loamy fine sand; very weak very fine granular structure; very friable; many fine roots; moderately acid; gradual wavy boundary.

E2-- 16 to 28 inches; yellowish brown (10YR 5/4) fine sand; single grain; loose; few fine roots; strongly acid; abrupt wavy boundary. (The combined thickness of the E horizon is 0 to 33 inches.)

E and Bt1-- 28 to 44 inches; brown (10YR 5/3) fine sand; single grain; loose; very few fine roots; contains 3 wavy lamellae that range from 1/4 to 1/2 inch thick that are brown (7.5YR 4/4) fine sand, massive, friable, clay bridging sand grains; strongly acid; abrupt wavy boundary.

E and Bt2-- 44 to 63 inches; brown (7.5YR 5/2) fine sand; single grain; loose; contains 2 wavy 1/4 to 1/2 inch thick lamellae and 5 very thin branching lamellae 1/32 inch thick that are brown (7.5YR 4/4) sand and brown (7.5YR 5/3) fine sand, massive, friable, clay bridging sand grains; moderately acid; gradual wavy boundary. (Combined thickness of the E and Bt horizons is 8 to 65 inches.)

C-- 63 to 80 inches; brown (7.5YR 5/2) fine sand; single grain; loose; few medium prominent strong brown (7.5YR 5/6) areas of iron accumulation; moderately acid.

TYPE LOCATION: Orleans County, New York; Town of Gaines; 500 feet north of the junction of U.S. Highway 104 and Eagle Harbor Road; 275 feet east of the center of Eagle Harbor Road. USGS Ashwood, NY topographic quadrangle; Latitude 43 degrees, 16 minutes, 40 seconds N. and Longitude 78 degrees, 15 minutes, 5 seconds W., NAD 1927.

GEOGRAPHIC SETTING: The Colonie soils are on slight rises, summits, shoulders, back slopes and foot slopes of Wisconsin age lake plains, dunes, outwash plains, deltas, and beach ridges. Slopes are mostly nearly level to rolling, but some are moderately steep or steep and the gradient ranges from 0 to 60 percent. Colonie soils formed in glaciolacustrine or glaciofluvial (outwash) materials and associated eolian deposits dominated by fine and very fine sand. Elevations range from 95 to 860 feet msl. The climate is humid and cool temperate. The mean annual precipitation ranges from 26 to 40 inches, and the mean annual temperature ranges from 4

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained to excessively drained. The potential for surface runoff ranges from negligible to medium. Saturated hydraulic conductivity is high through very high in the mineral soil.

USE AND VEGETATION: Some areas are in woodlots of sugar maple, red oak, and other hardwoods. About 1/4 to 1/2 of the acreage is cultivated. Large areas are idle and are covered with poverty grass, quack grass, annual weeds, and shrubs such as sumac. Locally, the soil is used intensively for growing vegetables and deciduous fruits, and less intensively in other places for growing corn and hay.

WAYLAND SERIES

The Wayland series consists of very deep, poorly drained and very poorly drained, nearly level soils formed in recent alluvium. These soils are in low areas or slackwater areas on flood plains. Saturated hydraulic conductivity is moderately high or high in the mineral soil. Slope ranges from 0 through 3 percent. Mean annual temperature is 49 degrees F. and mean annual precipitation is 36 inches.

TAXONOMIC CLASS: Fine-silty, mixed, active, nonacid, mesic Fluvaquentic Endoaquepts

TYPICAL PEDON: Wayland silt loam, on a 1 percent slope in a pasture of native grasses. (Colors are for moist soil.)

A-- 0 to 6 inches; very dark grayish brown (10YR 3/2) silt loam; light brownish gray (10YR 6/2) dry; strong medium and coarse granular structure; friable; common fine prominent yellowish brown (10YR 5/8) masses of iron accumulation within old root channels; neutral; clear smooth boundary (4 to 9 inches thick.)

Bg1-- 6 to 12 inches; dark grayish brown (10YR 4/2) silt loam; weak fine and medium subangular blocky structure; friable; slightly sticky; many fine roots in upper part; common medium distinct dark yellowish brown (10YR 4/4) masses of iron accumulation in the matrix; slightly acid; clear smooth boundary.

Bg2-- 12 to 18 inches; grayish brown (10YR 5/2) silt loam; weak fine and medium subangular blocky structure; friable; slightly sticky; many fine roots in upper part; common medium distinct yellowish brown (10YR 5/6) and dark yellowish brown (10YR 4/4) masses of iron accumulation in the matrix; slightly acid; clear wavy boundary. (Combined thickness of the Bg horizon ranges from 12 to 24 inches thick.)

C1-- 18 to 46 inches; gray (5Y 5/1) silt loam; massive; friable; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation in the matrix; neutral; abrupt wavy boundary.

C2-- 46 to 72 inches; gray (5Y 6/1) silty clay loam; massive; firm in place, slightly plastic; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation in the matrix; slightly effervescent; slightly alkaline.

TYPE LOCATION: Chautauqua County, New York; in the town of Kiantone; 1/4 mile south of the intersection of U.S. Highway 62 and New York State Route 60, 1/4 mile east of U.S. Highway 62. USGS Jamestown, NY topographic quadrangle; Latitude 42 degrees, 03 minutes, 06 seconds N. and Longitude 79 degrees, 11 minutes, 38 seconds W., NAD 1927.

GEOGRAPHIC SETTING: Wayland soils are on nearly level or depressed parts of flood plains of streams receiving runoff from uplands that contain some calcareous drift. They are mainly in or bordering areas of Wisconsin glaciation. Slope ranges from 0 through 3 percent. The climate is humid temperate. Mean annual precipitation ranges from 30 through 45 inches; mean annual temperature ranges from 47 through 50 degrees F., and mean frost-free period ranges from 110 through 160 days. The elevation ranges from 150 through 1700 feet above sea level.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Poorly and very poorly drained. The potential for surface runoff is negligible to very high. Saturated hydraulic conductivity is moderately high or high in the mineral soil. An apparent water table is at the surface or to a depth of 0.5 feet below the surface with occasional ponding.

USE AND VEGETATION: Native vegetation is red maple, alder, willow, and other trees tolerant of wet sites. Some areas have been cleared and drained, and are used for growing pasture.

WILLIAMSON SERIES

The Williamson series consists of deep, moderately well drained soils on lake plains and uplands. They are nearly level to sloping soils formed in silty or very fine sandy lacustrine or eolian deposits. Permeability is moderate above the fragipan and slow or very slow in the fragipan. Slope ranges from 0 to 15 percent. Mean annual air temperature ranges from 45 to 50 degrees F., mean annual precipitation from 28 to 40 inches and mean growing seasons from 140 to 180 days.

TAXONOMIC CLASS: Coarse-silty, mixed, active, mesic Typic Fragiudepts

TYPICAL PEDON: Williamson silt loam - orchard (Colors are for moist broken soil.)

Ap-- 0 to 8 inches; dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; friable; many fine roots; very strongly acid; abrupt smooth boundary. (5 to 10 inches thick)

Bw-- 8 to 15 inches; yellowish brown (10YR 5/4) silt loam; weak fine granular structure; very friable; many fine roots; many fine pores; few fine prominent yellowish brown (10YR 5/8) masses of iron accumulation in the matrix; strongly acid; clear wavy boundary. (6 to 15 inches thick)

E -- 15 to 20 inches; coarsely intermingled light yellowish brown (10YR 6/4) and pale brown (10YR 6/3) very fine sandy loam; massive; friable; common fine roots; common medium pores; common fine distinct dark yellowish brown (10YR 4/4) and few medium distinct yellowish brown (10YR 5/6) masses of iron accumulation in the matrix; strongly acid; abrupt irregular boundary. (2 to 8 inches thick)

Bx1 -- 20 to 34 inches; brown (7.5YR 5/4) silt loam; strong very coarse prismatic structure; prisms are separated by 1/2 to 1/16 inch of light yellowish brown (10YR 6/4) very fine sandy loam with yellowish brown (10YR 5/6) masses of iron accumulation; very thick plates (4 to 8 inches) within prisms are separated by very thin bands of light brown (7.5YR 6/4) very fine sandy loam; very firm, brittle; many 2 to 4mm vertical holes with thin clay linings on surfaces along pores; few roots along faces of prisms; strongly acid; gradual wavy boundary.

Bx2 -- 34 to 48 inches; layers of brown (7.5YR 4/4) silt loam; 1 to 4 inches thick are separated by 1/8 to 1/2 inch lamellae of light brown (7.5YR 6/3) very fine sandy loam; massive; firm, brittle; few roots; many 1mm and common 2 to 4mm vertical holes with clay linings on surfaces along pores; common medium distinct yellowish brown (10YR 5/6) masses of iron accumulation in the matrix; strongly acid; gradual wavy boundary. (Combined thickness of Bx horizons is 8 to 38 inches.)

C -- 48 to 72 inches; layers of brown (7.5YR 4/4) firm silt loam and pinkish gray (7.5YR 6/2) friable very fine sandy loam; massive within layers; common distinct yellowish brown (10YR 5/6) masses of iron accumulation in the matrix in the lighter parts; strongly acid.

TYPE LOCATION: Wayne County, New York; town of Huron, 1.0 mile east of the village of Alton, 100 feet north of Highway 104, 200 feet west of a steep slope. USGS Rose, NY topographic quadrangle; Latitude 43 degrees, 12 minutes, 51 seconds N. and Longitude 76 degrees, 57 minutes, 33 seconds W., NAD 1927.

GEOGRAPHIC SETTING: Williamson soils are on lake plains and uplands mantled by wind or water-deposited silt and very fine sand. Slope ranges from 0 to 15 percent. Mean annual air temperature ranges from 45 to 50 degrees F., mean annual precipitation from 28 to 40 inches and mean growing seasons from 140 to 180 days.

DRAINAGE AND PERMEABILITY: Moderately well drained. The potential for surface runoff is medium to high. Permeability is moderate above the fragipan and slow or very slow in the fragipan.

USE AND VEGETATION: Most areas have been cleared. Dominant crops are corn, small grains, hay and vegetables with some pasture and fruit trees. Woodlots are of sugar maple with red oak, beech, hop hornbeam, black ash and other northern hardwoods.