Coastal wetland integrity in the upper St. Lawrence River: status and considerations for restoration and enhancement

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INTRODUCTION

Coastal wetlands provide critical services to the St. Lawrence River ecosystem and the communities that depend upon it. These extensive wetlands are instrumental in the pelagic-littoral coupling in the river food web and downstream transport organic matter and essential nutrients while providing critical habitat to a multitude of both migratory and more sessile aquatic organisms. Throughout the Great Lakes, coastal wetlands are known to directly influence reproduction of most fish species (Jude and Pappas 1992) imparting a direct linkage to the economics of sport fisheries as well as biodiversity as a whole. Despite the known value of coastal wetlands, the Great Lakes have lost over 50% of their original wetland area, Lake Erie alone has lost >90% and Lake Ontario has loss over 50%, primarily to land conversion (Whillans 1996). In the upper St. Lawrence River the area of wetland area lost is not known but is likely considerable. Of additional concern, however, are losses of ecological integrity in the remaining wetlands as a response to anthropogenic change.

In order to begin to address this concern, an understanding of wetland successional forces and potential impacts of human activities (e.g. land use, water level regulation, and invasive species) must be developed. The intent here is to consider wetland integrity of the upper St. Lawrence River wetlands in the context of the existing knowledge base. Significant advances have been made in our understanding of wetland
processes of Lake Ontario and the St. Lawrence River due to the recent IJC water levels study (IJC). This information and other studies of St. Lawrence and Lake Ontario wetland systems will be reviewed to address the question of status of extant coastal wetlands in the upper St. Lawrence River.

UNDERSTANDING COASTAL WETLAND SUCCESSION

Wetland succession can be affected by both autogenic (internally-driven) and allogenic (externally-driven) processes. Paleoeccological studies based on peat and sediment cores provide information on past biota and depositional environments and allow inferences about the basic forces driving wetland successional processes. Changes in sediment properties (e.g. total organic carbon [TOC], total organic nitrogen [TON], bulk density, isotopic composition) coupled with analysis of biotic indicators such as pollen and macrofossils can provide a detailed picture of changes in the physical / hydrological environment and plant community of a wetland over millennia. A recent wetland paleoecological study was completed from a Goose Bay 10-meter sediment core representing a period of 10,500 years. Using pollen and macrofossil analysis as well as sediment δ¹³C, δ¹⁵N, and C:N ratios, past vegetation communities were reconstructed (Rippke et al. 2010). Evidence of the Nipissing Flood between 5200-4500 YBP was provided by a +8‰ shift in ¹³C, a concomitant persistent anomaly in organic matter, and depressed C:N ratios. Climate cycles, 3300 years in duration, were inferred from >50% shifts in grass (Poaceae) pollen abundance. An 80% increase in invasive cattail pollen occurred abruptly around 1894 AD following European settlement and land clearing (Rippke et al. 2010). This study and others in the Great Lakes basin reveal that changes in water depth due to climate cycles and the opposing forces of isostatic uplift and vertical sediment accretion regulate long-term succession of Great Lakes/St. Lawrence wetlands (McCarty and McAndrews 1988, Dalrymple and Carey 1990, Duthie et al. 1996, Booth et al. 2002).

Disturbances in the upland matrix surrounding wetlands may strongly influence succession by increasing erosion and sedimentation rates, reducing wetland microtopography (Werner and Zedler 2002), and favoring plants that tolerate burial (Jurik et al. 1994, Keddy 2000, Kercher and Zedler 2004). Like other paleoecological studies in the Great Lakes region (Singer et al. 1996, Warwick 1980), Rippke et al. (2010) show that disturbances associated
with European settlement and land use caused particularly rapid and substantial changes in the rate and trajectory of St. Lawrence River wetland succession in recent centuries.

**EVIDENCE FOR RECENT PERTURBATIONS AND WETLAND CHANGE**

Climate affects Great Lakes wetland vegetation dynamics on the scale of decades by controlling regional water level dynamics (Chow Frazer et al. 1998, Wilcox and Xie 2008). Cyclical periods of high water exclude trees and shrubs from St. Lawrence and Great Lakes marshes, and periods of low water allow recruitment of a diverse assemblage of wet-meadow and mud-flat species from the seed bank (Keddy and Reznicek 1986) while eliminating or reducing drought-intolerant *Typha* species, which may be pushed to lower portions of the elevation gradient (Wilcox et al. 2008). Without periodic low water periods, increased growth of *Typha* species in the meadow marsh zone is common, and may lead to reduced plant diversity (Wilcox et al. 2008, Vaccaro et al. 2009, Farrer and Goldberg 2009).

Several recent studies have documented vegetation community change over the preceding five or six decades in upper St. Lawrence River wetlands using historical aerial imagery interpretation (Wilcox et al. 2008, Cooper et al. 2008, Farrell et al. 2010). A common feature of each interpretation is the reduction of meadow marsh type habitats dominated by a native sedge community. Wilcox et al. (2008) go further by showing evidence of an upslope migration of meadow marsh, and suggest that these changes are effects of system-wide water level regulation. Concurrently, it appears that the hybrid cattail (*T. x glauca*), a cross between native *T. latifolia* and *T. angustifolia* (invasive) has expanded into former meadow marsh areas. Water depth increases and a lack of substantial low-water periods observed in recent decades have likely facilitated growth and expansion of hybrid cattail (Farrell et al. 2010).

**CURRENT STATUS OF VEGETATION COMMUNITIES AND LINKAGE TO INDICATOR FAUNAL HABITAT**
Among wetland geomorphic types that include drowned river mouth wetlands, open and protected embayments and along tributaries, high densities of invasive cattails predominate, and cattails continue to spread at the expense of other types of wetland vegetation. Stem densities can exceed 30 stems per m² and the thick litter layer produced in dense stands changes rates of nutrient cycling (Farrer and Goldberg 2009), inhibits germination and growth of native species (Vaccaro et al. 2009), and may fundamentally change the response of wetland vegetation to further water level fluctuations (Frieswyk and Zedler 2006, 2007). Studies of the competitive effects and water depth tolerance of hybrid cattail suggest that it will likely continue to outcompete other vegetation types along the wetland elevation gradient. Today expansive cattail monocultures are common across most wetland geomorphic types in Lake Ontario and the upper River.

In addition to the widespread dominance of freshwater coastal marshes by hybrid cattail, other invasive species are having transformational effects on wetlands. Populations of common reed (Phragmites australis), purple loosestrife (Lythrum salicaria), and flowering rush (Butomus umbellatus) all exist within these coastal wetlands and have potential to expand and further outcompete native species. Significant expansion of reed canary grass (Phalaris arundineacea) has already occurred in many wetlands in headwater areas influenced by beaver, and European frogbit (Hydrocharis morsus ranae), a floating leaved invasive, dominates in most drowned river mouth wetland habitats and extends into the Typha mats.

Despite the rapid and extensive changes produced by invasion of T. x glauca and the negative effects from other invasives, some high quality native habitat does still exist in upper St. Lawrence wetlands. Remaining meadow marsh communities are severely restricted but occur in a narrow band upslope of the dense Typha zone. Remnant meadow marsh areas also occur in locations with a stronger influence of local hydrology, including headwater streams, beaver flowages and groundwater dominated areas. Further downslope of the Typha zone near the open water edge there sometimes is greater plant diversity with a variety of forbs, the grass Calamagrostis canadensis and a littoral zone consisting of floating leaved plants (e.g Nuphar and Nymphaea) and submersed plants including Utricularia vulgaris, Ceratophyllum demersum and Myriophyllum species. Interestingly many tributaries and drowned river mouths have shown a recent resurgence.
in southern wild rice (\textit{Zizania aquatica}). This deep-emergent grass has cultural significance to native peoples and is valued as an excellent food source for wildlife (Steeves 1952). \textit{Z. aquatica} inhabits slow-flowing waters up to approximately 1 m in depth (Bean 1909), existing as a narrow bladed submersgent or floating-leaved plant early in the growing season and then emerging to set seed from a tall slender panicle in late summer (Steeves 1952).

A variety of animals species are linked with wetlands in this region, recent studies on vertebrate species include marsh birds (Rehm 2004), herpetofauna (Jensen 2004) mammals (Toner and Farrell 2010), and fish (Murry et al. 2007, McKenna et al. 2008). Two of the indicators reviewed here include a fish and mammal that have critical influences on the ecology of the St. Lawrence River, muskrat and northern pike.

Historically, St. Lawrence River northern pike were known to make large early spring potadromous spawning runs to reach seasonally flooded wetland habitats areas for spawning. Research has documented an unusual deepwater spawning trend (up to ~6 m) for northern pike in the St. Lawrence River system that may be linked to declines in recruitment (Farrell 2001). Spawning distribution of northern pike is controlled by habitat presence, access to suitable substrates (due to springtime water levels), and thermal regimes (Farrell et al. 2006). Farrell (2001) demonstrated a spatial and temporal transition of northern pike spawning from shallow flooded habitats to deeper offshore habitats at Rose Bay in the St. Lawrence River. Local northern pike year class failures occurred, with high levels of deepwater egg deposition.

Changes in the vegetation structure of historical spawning sites (tributaries and flooded shorelines), to habitats dominated by species such as \textit{Typha}, that are not preferred for spawning, as well as the effects of system-wide water regulation may have contributed to lack of northern pike population recruitment and recent declines.

\textit{Typha} marsh is known as a critical habitat linked to the life history of muskrat (\textit{Ondatra zibethicus}) and \textit{Typha} is a favored species for forage and mound construction. Muskrats are known as ecosystem engineers for their strong effect on wetlands through influencing vegetation structure, microtopography, and decomposition of litter. Recent research however, points to water level regulation as a major factor regulating the abundance of muskrat in upper St. Lawrence River coastal wetlands (Toner et al. 2010).
Low fall and winter water levels prevent access to the floodplain for overwintering water levels and a model analysis indicated the muskrat house density has been significantly suppressed relative to that predicted with unregulated levels.

POTENTIAL FOR RESTORATION AND ENHANCEMENT – ANTICIPATED WETLAND ECOLOGICAL BENEFITS OF A NEW REGULATION PLAN

The 1993 Lake Ontario Lake Levels Reference Study began to bring into question the role of water level regulation effects on environmental considerations. Under the current regulation Plan 1958D, no formal consideration of the environment exists in water level policy. The influence of regulation on wetlands was a primary emphasis in the most recent St. Lawrence River- Lake Ontario Water Levels Study and IJC regulators are attempting to craft a new regulation plan that could balance the many interests (e.g. hydropower, navigation, riparian interests, municipal water supplies, recreation, and other public interests) with consideration for environmental integrity (IJC 2005).

The study led to development of an Environmental Ecosystem Response Model (LimnoTech Inc.) to assist the IJC decision making process. The IERM contained 32 environmental indicators developed by an integrative group of researchers, the Environmental Technical Working Group. Many of the indicators revolved around those developed for wetlands in the upper River and Lake Ontario. Research toward development of a meadow-marsh indicator (Wilcox and Xie 2007) provided a sensitive indicator of long-term decadal scale effects of regulation plans changes on the movement of plant communities associated with wetland zonation. Regulation has prevented significant low water levels during the growing season that historically occurred every 30-35 years and has forced wet-meadow (sedge dominated) habitats further upslope into drier conditions. A restoration of hydrologic conditions to more closely approximate natural conditions of flow magnitude, duration and periodicity would be expected to create a greater diversity of wetland vegetation types and provide greater access and habitat features for important wetland fauna. These periodic lows would allow for seed bank responses by native species that have been suppressed (Carex spp.) and would select against invasive Typha x glauca (Farrell et al. 2010). More research is needed to
demonstrate how these changes in regulation would influence the spread of invasive species, most notably common reed (*Phragmites australis*) which is known to outcompete *Typha x glauca* and has expanded in the drought conditions of the upper Great Lakes.

Further downstream in the lower River of Quebec Canada a 2D hydrodynamic model has been developed (sensu Morin et al. 2003) and integrated with continued ecological models useful in policy development and environmental projections (e.g. climate change, water levels policy). This approach that focuses on the physics of the system as a basic building block may provide a useful model that could be applied to the entire system and coupled with ongoing monitoring and research as an adaptive management tool.

REFERENCES


