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# The Effects of Water Levels on Two Lake Ontario Wetlands

**Wolf-Dieter N. Busch**
U.S. Fish and Wildlife Service
Buffalo, New York

**Ronald G. Osborn and Gregor T. Auble**
U.S. Fish and Wildlife Service
Fort Collins, Colorado

## INTRODUCTION

Lake Ontario's water levels have been regulated since 1959, after the completion of the St. Lawrence River navigation and hydropower development project. The plan used to guide the regulation (1958-D) has been in effect since 1963 (Bryce, 1982). The purpose of the regulation was to prevent extreme high-water levels which increased erosion on the south shore of Lake Ontario, while protecting the interests of commercial navigation and hydropower production in the St. Lawrence River (T. Brown, personal communication, member of the Board of Control). Major user groups have sought further reductions in the range of lake level fluctuations. However, the biological resources, especially the lake influenced wetlands, benefit from the waterlevel fluctuations. Great Lakes wetlands are the most important habitat for wildlife of the region (Tilton and Schwegler, 1978). We provide information here on the responses of wetland plant communities in two wetlands to changes in lake levels over time.

## STUDY AREAS

The total area of wetlands associated with Lake Ontario is estimated to be 32,422 ha (LERSB, 1981), with the U.S. area estimated at 7,449 ha (USFWS, 1988). Sage Creek and Campbell Marshes are located along the southeastern shoreline of Lake Ontario (Figure 1). Sage Creek Marsh is located in the Town of Mexico, Oswego County, New York. It is a 12.15 ha (30 acre) flood pond system that has developed where Sage Creek enters Mexico Bay. Land use in the area includes seasonal and permanent residences, a wildlife sanctuary, farms, and forest (USFWS, 1981).

Campbell Marsh is in the Town of Hounsfield, Jefferson County, New York. It is a 28.35 ha (70 acre) streamside wetland that has developed where Bed-

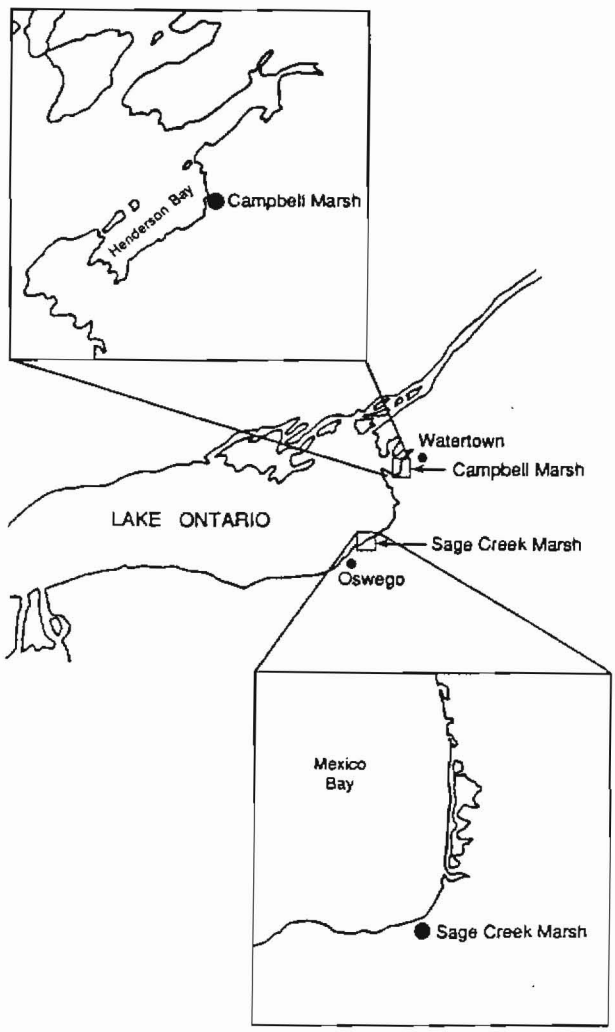


**Figure 1.** Locations of Campbell and Sage Creek Marshes

ford Creek empties into Henderson Bay. Land use includes permanent and seasonal residences, a golf course, abandoned farms, and park land (USFWS, 1981).

## METHODS

Data were obtained from low-level aerial photographs taken from 1938 to 1989 (Tables 1 and 2). The 1938 and 1955 photography at Campbell Marsh and the 1958 photography at Sage Creek Marsh were black and white; the rest of the photography was color. Scale of photography ranged from 1:4800 to 1:12000. Photointerpretation and habitat maps were based on the Cowardin wetland classification (Cowardin et al., 1979). Extensive ground truthing, including establishing elevation contours at one foot intervals, was conducted in conjunction with the 1978 photography (USFWS, 1981). Descriptions of photo interpretation, map preparations, and digitization for computer analysis are provided in Busch and Lewis (1984). Base maps for materials since 1980 were added to those taken from Lewis (1981) and entered into an Arc/Info Geographic Information System (GIS) for analysis.

Wetland habitats were re-classified into broad cover types using a GIS. Cover types consisted of open water, aquatic bed, non-persistent emergent, persistent emergent, scrub-shrub, forested, upland, and various human constructed facilities. Aggregation was required to achieve consistent classes for comparisons over all time periods and handle inconsistencies attributed to the time of year wetlands were photographed, quality of photography, differences in photo interpretation, and limited ground controls for registering maps across time periods.

At Sage Creek, the aquatic bed cover type is dominated by Elodea canadensis, Myriophyllum spp. with the aggregate emergent cover type dominated by Sparganium eurycarpum, Pontederia cordata, and Peltandra virginica (USFWS, 1981). At Campbell Marsh, Typha glauca dominates the aggregate emergent cover type while Ceratophyllum demersum and Myriophyllum spp. dominate the aquatic bed cover type (USFWS, 1981). Additional information on cover types, species composition, and relationship to the Cowardin wetland classification is detailed in USFWS (1981).

Final composite maps were created to identify changes between time periods at each wetland and the spatial extent for each cover type transition was computed with the GIS. A water-level index was calculated from lake levels to combine water level in the year of photography with conditions from the recent past (Busch and Lewis, 1984). This approach recognizes that the plant communities not only represent current conditions but also those of the recent past, at a decreasing level of influence. A weighted, 5-year moving average was calculated as:

$$\text{Index} = \frac{.5L(t)+.25L(t-1)+.125L(t-2)+.0625L(t-3)+.03125L(t-4)}{.96875}$$

Where L(t)=Average lake elevation (feet) in year t.

## RESULTS AND DISCUSSION

Wetland plant communities were related to water levels at both sites. At Sage Creek, the aquatic bed community (dominated by Elodea canadensis, Myriophyllum spp.) increased strongly at higher water levels (Figure 2, Table 1). The emergent plant communities together (dominated by Sparganium eurycarpum, Pontederia cordata, Peltandra virginica) had a corresponding decline with increased water levels. A similar general response of aquatic bed and emergent communities to water level occurred at Campbell Marsh (Figure 3, Table 2) despite differences in the species composition of the plant communities. Typha glauca dominated the emergent community while Ceratophyllum demersum and Myriophyllum spp. dominated the aquatic bed community at Campbell Marsh.

Even though both wetland complexes are lake influenced and are in the same general location with respect to wind influences on water levels, the dominant plant communities at the site are very different. The dominant Sage Creek wetland plant community was made up of non-persistent emergents while the dominant plant community at Campbell Marsh was persistent emergents (Tables 1 and 2). The differences may be related to the intermittent presence of a sand bar at the lake entrance to Sage Creek. This sand bar is the product of off-shore currents. When it is in place, water backs up in the wetland due to the water inflow from Sage Creek producing a wetter combination of aquatic bed, nonpersistent, and persistent emergent communities at Sage Creek than at Campbell Marsh.

The seasonal timing of photography in 1988 and 1989 produced some anomalies in the relation between water level and community composition. The 1988 photography at Sage Creek was taken on October 31, after some heavy frost and snow. This photography resulted in more open water, less total emergents, and a higher ratio of persistent to nonpersistent emergents than might be expected based on the pattern observed in other years (Table 1). Die-back probably resulted in underestimating the area of emergent and perhaps aquatic bed communities by classifying them as open water. Similarly, the abnormal ratio of persistent to nonpersistent emergents

Table 1. Sage Creek Marsh areas and water level index.

| | DATE (month/day/year) | | | | |
|---|---|---|---|---|---|
| | 6/29/38 | 9/6/55 | 9/2/65 | 9/13/78 | 10/31/88 |
| WATER LEVEL INDEX (feet) | 243.68 | 245.92 | 243.69 | 245.22 | 244.90 |
| COVER TYPES ($m^2$) | | | | | |
| Open water | 21,839 | 23,099 | 31,813 | 19,848 | 45,130 |
| Aquatic bed | 4,740 | 50,919 | 7,661 | 29,388 | 19,300 |
| Nonpersistent emergents | 87,571 | 50,849 | 97,097 | 72,192 | 42,760 |
| Persistant emergents | 15,162 | 4,180 | 4,114 | 6,789 | 24,665 |
| Scrub-shrub | 147 | 2,253 | 3,086 | 1,589 | 4,379 |
| Forest | 0 | 0 | 333 | 0 | 657 |
| Upland | 94,026 | 92,186 | 79,381 | 93,679 | 86,594 |

Table 2. Campbell Creek Marsh areas end water level index. Nonpersistent and persistant emergents were not distinguished in 1989 and ere combined in the persistent class.

| | DATE (month/day/year) | | | |
|---|---|---|---|---|
| | 8/12/58 | 7/1/66 | 7/5/78 | 4/20/89 |
| WATER LEVEL INDEX (feet) | 244.29 | 244.17 | 245.22 | 244.81 |
| COVER TYPES ($m^2$) | | | | |
| Open water | 36,962 | 37,885 | 43,118 | 73,663 |
| Aquatic bed | 8,547 | 3,523 | 10,141 | 19,103 |
| Nonpersistent emergents | 8,146 | 9,450 | 13,466 | |
| Persistent emergents | 132,917 | 131,257 | 104,349 | 88,089 |
| Scrub-shrub | 2,931 | 6,579 | 5,214 | 4,700 |
| Forest | 2,084 | 5,345 | 9,575 | 9,078 |
| Upland | 312,151 | 309,164 | 317,823 | 309,230 |
| Facilities | 196 | 732 | 250 | 71 |

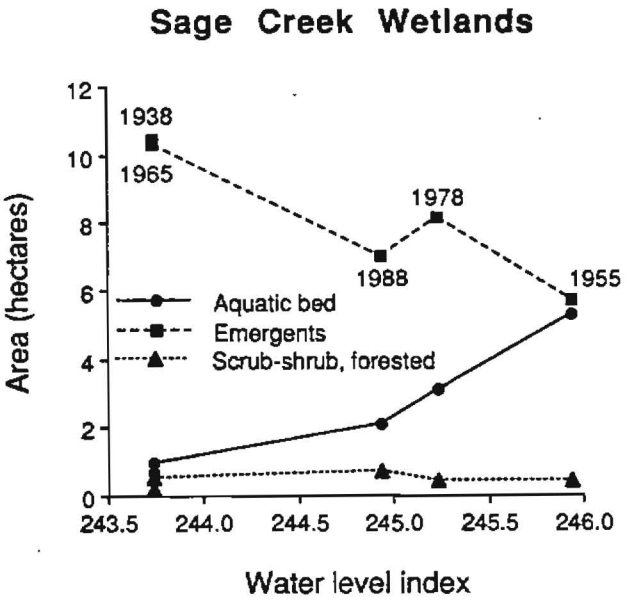


**Figure 2.** Areas of Selected Cover Types at Sage Creek Marsh in Relation to the Water Level Index
The emergents class includes both persistent and nonpersistent emergents.

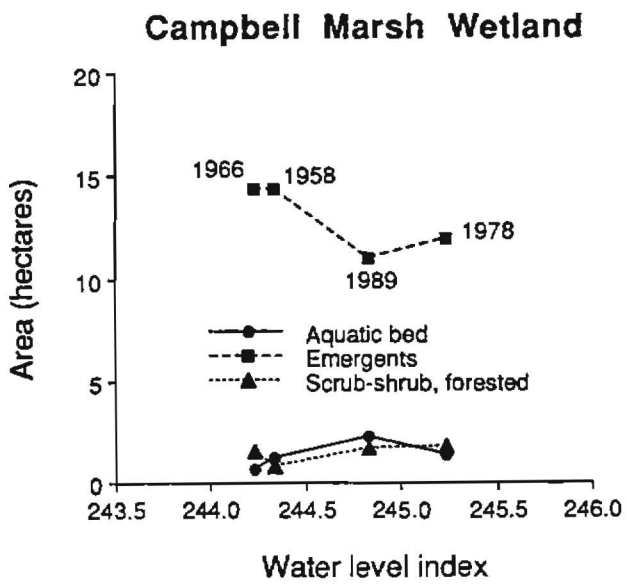


**Figure 3.** Areas of Selected Cover Types at Campbell Marsh in Relation to the Water Level Index
The emergents class includes both persistent and nonpersistent emergents.

was likely due to the die-back of nonpersistent emergents in mixed areas of persistent and nonpersistent species, resulting in an overestimate of the persistent class. The 1989 photography at Campbell Marsh was taken on April 20, too early in the growing season for adequate growth of emergents. Thus, emergents at Campbell Marsh were likely underestimated, with open water and perhaps aquatic bed communities being overestimated in 1989 (Table 2).

Even with the difficulties in estimating the areas of specific plant cover types, it is clear that water levels impacted the abundance of plant communities. Emergents were more abundant at lower levels while aquatic bed plant communities increased in size with higher water levels. Since both cover types are important to fish and wildlife resources, fluctuations in the annual water levels would prevent one cover type from achieving permanent dominance.

Although all the photointerpretation was based on the wetland classification system of Cowardin et al., (1979), subtle differences across time periods complicate and limit the interpretation of apparent differences in area. We are not particularly confident that distinctions between scrub-shrub, forest, upland and facilities were made consistently across time periods. Also, problems occur when deciding how to aggregate mixed classes (e.g., persistent/nonpersistent emergents) that were recognized in some time periods but not in others. The (GIS) tools employed in this analysis are powerful techniques for detecting and understanding the dynamic nature of wetland communities. However, change can only be effectively analyzed in terms of classification units that are common across intervals and precisely registered to one another. Thus, differences in the photography or detail of photo interpretation across time intervals must be aggregated into classes that are consistently defined. In this study, the persistent emergent cover type communities dominated by Typha glauca and identified as semi-permanently flooded were aggregated with those dominated by Calamagrostis canadensis and Carex stricta and identified as intermittently flooded because not all photointerpretation distinguished these water regimes.

## RECOMMENDATIONS

Our analysis is based on a correspondence of community composition with average hydrologic conditions at several widely separated points in time. As Van der Valk's (1981) qualitative model of wetland succession illustrates, transitions of freshwater marsh vegetation are often dependent on specific sequences of hydrologic conditions. Associating various vegetation transitions with specific hydrologic events or sequences requires that vegetation and hydrology be

recorded on a time scale appropriate to the process of vegetation change. In this case, shorter intervals between photography and likely more sampling times would be required to examine individual transitions more effectively.

The understanding of large ecosystems will often be based on a limited number of local studies carried out by a number of different agencies. A common practice is to "pool" such data, thereby attempting to address ecosystem concerns. As demonstrated in this paper, clear specifications are needed for standardization of data collection, interpretation, and processing. This increases in importance when using GIS tools, on detailed field measurements, for system-wide application.

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