# Documenting Change in Lake Erie Coastal Wetland Ecosystems

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## Abstract

*Geographic Information Systems (GIS) are a useful tool in assessing change in wetland ecosystems. A GIS was used to document historical changes in wetland vegetation in relation to water level conditions for two Lake Erie coastal wetlands ecosystems: Long Point and Turkey Point, Ontario. Maps of vegetation communities for years representing low, medium, and high water levels and declining and rising conditions were digitized into a GIS. A spatio-temporal analysis of the data documented changes in the composition and configuration of the wetland vegetation. During drier periods, the amount of tall, dense dry emergent and meadow vegetation increased significantly. During wetter periods, open water and wetter emergent communities expanded as drier vegetation communities were flooded and interspersed by the lake water. The historical response of the wetlands to climate and water level changes provides insight into the potential impacts of future climate change and water level declines.*

## Introduction

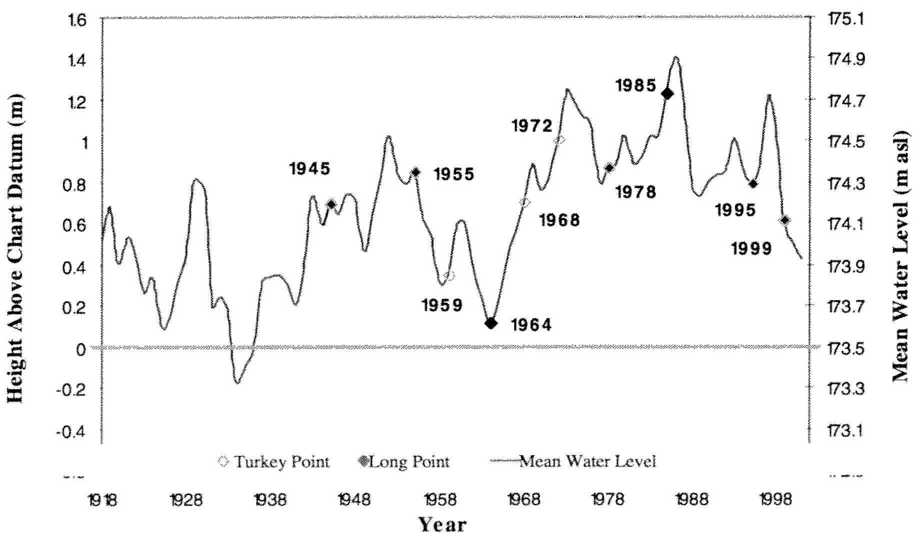
Located along the land-water interface, Great Lakes coastal wetlands are highly influenced by lake processes including waves, seiches, and seasonal and long-term water level fluctuations (GLIN, 1998a). Water level fluctuations are driven by natural climate variability. Variations in the climatic conditions of the Great Lakes affect the magnitude, frequency, duration, and timing of water level fluctuations, which in turn have a tremendous influence on the natural vegetation within wetland systems (ILERB, 1981). Temperature and precipitation, combined with other climatic variables including solar radiation, wind, cloud cover, and evapotranspiration are important regulators of water level fluctuations (Mortsch, 1998). Short-term water level fluctuations promote and enhance wetland productivity and diversity, but long-term water level changes resulting from enhanced global warming due to human activities may have serious and long-term consequences on the integrity and health of wetland systems.

To understand how a wetland can respond to projected climate change and associated water level change, it is important to quantify how the wetland has responded to historical changes in climate since water level changes are used as a surrogate for climatic change. Geographic information systems (GIS) have been identified as a useful tool for studying long-term changes in wetland systems (Johnson, 1990). An historical trend analysis provides a key to how wetland vegetation responds over time to fluctuating water levels. This analysis can be used to infer how the wetland may respond to alterations in water levels due to projected climate change. Therefore, a GIS was utilized to document the historical effects of water level fluctuations on wetland vegetation communities at the Long Point and Turkey Point coastal wetland systems located along the shore of Lake Erie, Ontario.

## Methodology

Aerial photographs for years of low, medium, and high water levels, and rising and declining water level conditions were interpreted for wetland vegetation communities and land-use classes and transcribed onto mylar maps (Figure 1). The mylar maps were developed as part of the Great Lakes 2000 Wetland Vulnerability to Climate Change project initiated by the Adaptation and Impacts Research Group (AIRG), Environment Canada. The project built upon and contributed to a study initiated by the Canadian Wildlife Service for the International Joint Commission Water Level Reference (IJCWLR) that included a database of wetland vegetation for a number of Lake Erie and Lake Ontario wetlands called *"Wetland Trends through Time"*.

***Figure 1.*** *Lake Erie mean annual water levels from 1918 to 2001 (IGLD 1985) and availability of wetland community data. [Chart datum for Lake Erie is 173.5 metres above sea level (m asl), the International Great Lakes Datum (IGLD) of 1985.]*




The mylar wetland classification maps were digitized or scan vectorized into a GIS and registered to real-world coordinates. The registered coverages for each wetland were clipped to a common study area boundary and simplified into 10 wetland communities. These communities were (from wettest to driest): lake, open water, floating emergent, emergent, tall wet emergent, tall dense dry emergent, short wet meadow, meadow, treed, and upland (non-lake, non-wetland). The simplified wetland coverages were converted into grids with a 12-metre cell resolution and overlaid together to produce a single combined grid. The areas of the wetland communities were analyzed to determine the direction and magnitude of change occurring within the wetlands over time. Inter-community changes within the wetland were quantified and characterized to identify the types of changes occurring over time and in relation to water level conditions. The locations of the changes within the wetlands were also noted.

## Results

Major changes during each period are described for each wetland, followed by a summary of the key findings associated with the response of the wetlands to declining and rising water level conditions. The historical wetland data for Long Point and Turkey Point are provided in Figures 2 and 3 respectively.

### *Long Point*

#### *1945-1955: Rising*

Between 1945 and 1955, as lake levels rose 0.16 metres (m) from 174.19 m asl to 174.35 m asl, there were noticeable changes to wetter and more water tolerant vegetation communities. The areas of floating emergent, emergent, and tall wet emergent vegetation increased as drier emergent and meadow communities were flooded and interspersed by the lake waters. These increases were particularly evident within the Inner Bay and along the northern portion of the outer peninsula. There were changes along the water-depth gradient as areas of meadow tended to tall dense dry emergent vegetation throughout Long Point, and upland tended to meadow and treed vegetation in the southern portion of the outer peninsula.

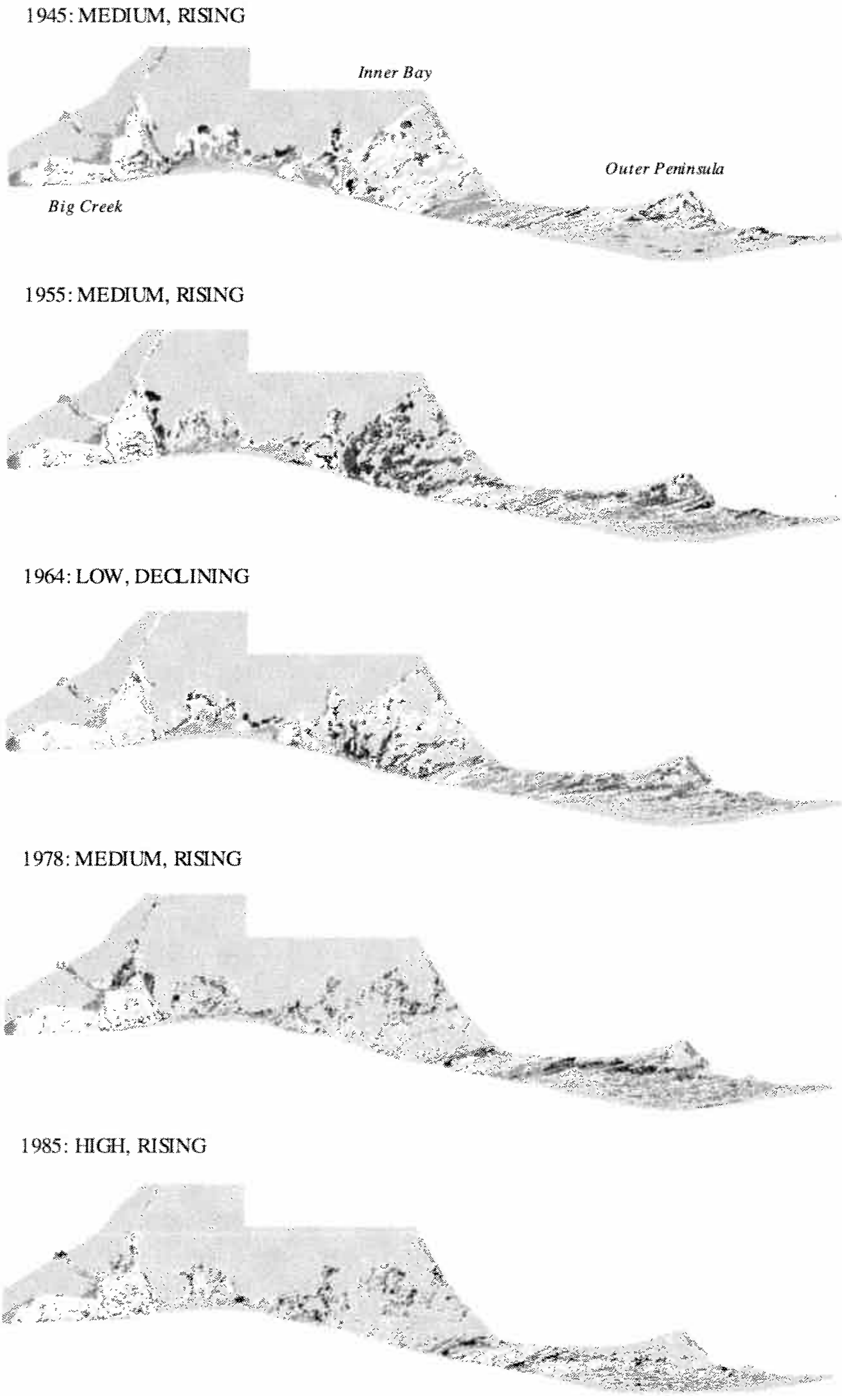
#### *1955-1964: Declining*

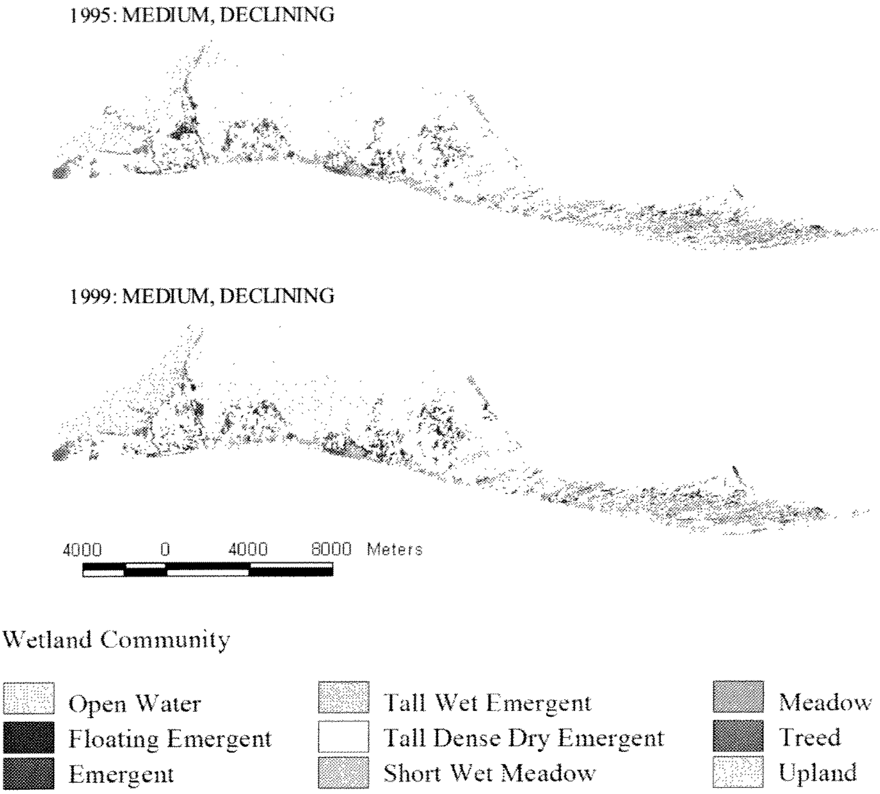
From 1955 to 1964, water levels declined by 0.74 m to 173.61 m asl, one of the lowest periods during the 84 years of water level data on record. As a result, vegetation tended to drier wetland communities. Areas of floating emergent, emergent, tall wet emergent, and short wet meadow decreased as tall dense dry emergent and meadow vegetation expanded with the drier moisture conditions. There were notable increases in the amount of tall dense dry emergent vegetation in the Inner Bay and outer peninsula, and emergent vegetation in swale areas of the outer peninsula. There were also increases in upland area along the peninsula.

#### *1964-1978: Rising*

There were significant changes in the wetland from 1964 to 1978, as water levels rose by 0.76 m to 174.37 m asl. Drier wetland vegetation communities throughout Long Point were flooded and interspersed by the high lake waters. There were notable losses in the amount of emergent, tall dense dry emergent, meadow vegetation and upland communities. Vegetated areas in the Inner Bay and northern portion of the outer peninsula developed into open water with small patches of floating emergent and tall wet emergent vegetation. There were increases in floating emergent and tall wet emergent vegetation in the Big Creek area, which is separated from the lake by the causeway and not directly influenced by lake processes.

***Figure 2.*** *Wetland vegetation community data for Long Point, 1945-1999.*






### *1978-1985: Rising*

Water levels continued to rise another 0.36 m between 1978 and 1985 to 173.74 m asl, the highest period on record. There were further increases to the area of open water in the Inner Bay and outer peninsula, but smaller fragmented patches of floating emergent and tall wet emergent vegetation still persisted. There were notable losses in meadow and emergent vegetation in the Inner Bay and peninsula. Shoreline areas along the peninsula were flooded and areas of short wet meadow developed in the southern portion of the outer peninsula.

### *1985-1995: Declining*

From 1985 to 1995, water levels rose another 0.17 m before declining 0.61 m to 1995 levels. The wetland tended towards drier wetland communities. Open water significantly declined in extent, while tall dense dry emergent and meadow vegetation expanded in all areas of the wetland, especially in the Inner Bay.

### *1995-1999: Declining*

Between 1995 and 1999, water levels continued to decline 0.18 m to 174.11 m asl. Further changes to tall dense dry emergent and meadow vegetation were evident. Open water continued to decline in extent. There were also decreases in the area of short wet meadow. Some patches of floating emergent vegetation did develop in the Inner Bay and meadow. Some patches of floating emergent vegetation did develop in the Inner Bay and outer peninsula, most likely developing during the short and rapid rise in water levels between 1995 and 1997.

## Summary

The historical trends at Long Point are summarized in Table 1 according to the wetland's response to declining and rising water level conditions.

***Table 1.*** *Key findings for Long Point.*

| RESPONSE OF WETLAND | |
|---|---|
| **TO DECLINING WATER L EVELS** | **TO RISING WATER LEVE LS** |
| • Vegetation tends to drier communities | • Vegetation tends to wetter communities |
| • Increase in tall dense dry emergent vegetation as they expand forming solid and continuous patches of veget ation | • Increase in open water, floating emergent, and emergent vegetation as these communities expand with rising water levels |
| • Decrease in floating emergent, tall wet emergent, short wet meadow as moisture conditions decline | • Decrease in tall dense dry emer gent and meadow vegetation as communities become flooded and interspersed by high lake waters |
| • Lake recedes exposing shoreline areas | • Lake water floods upland areas along shore |

### *Turkey Point*

#### *1945-1955: Rising*

The wetland vegetation tended to wetter communities as water levels rose 0.16 m from 174.19 m asl in 1945 to 174.35 m asl in 1955. Areas of open water, floating emergent, emergent and tall wet emergent vegetation developed in the centre of the marsh. Treed vegetation also increased significantly in the upland areas of the mainland, possibly due to land use changes. Short wet meadow and meadow experienced the greatest net loss in area, contracting to the periphery of the marsh.

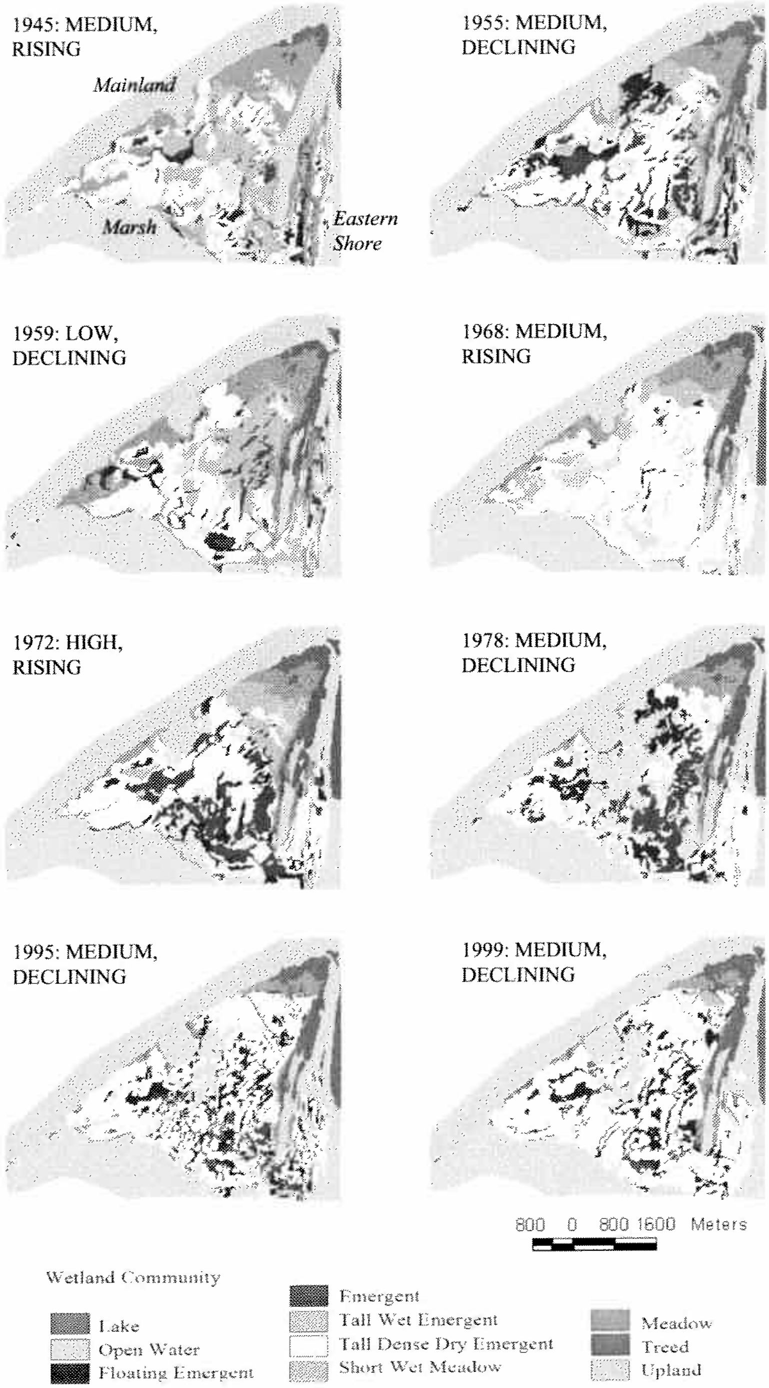
#### *1955-1959: Declining*

Between 1955 and 1959, water levels steadily declined by 0.50 m to 173.85 m asl. The loss in moist conditions led to an expansion of short wet meadow into the centre of the marsh and along the eastern shore of the wetland. Meadow also expanded inwards around the periphery of the marsh. There were notable losses in floating emergent and emergent vegetation, and the patches of vegetation within the wetland appeared less fragmented than in the previous wetter period.

#### *1959-1968: Rising*

From 1959 to 1968, water levels briefly rose then declined to the record lows in 1964 before substantially rising to 174.20 m asl in 1968. Water levels in 1968 were 0.35 m higher than those in 1959, but the vegetation in the wetland remained predominantly dry. There were dramatic increases in the amount of tall dense dry emergent vegetation in the wetland as this community thrived during the low water levels of 1964. The wetland was slow to respond to the rise in water levels, but there were small patches of wetter emergent vegetation in deeper areas of the marsh. Short wet meadow and meadow retreated back into the northern section of the marsh.

***Figure 3.*** *Wetland vegetation community data for Turkey Point, 1945-1999.*



### *1968-1972: Rising*

Between 1968 and 1972, water levels continued to rise another 0.30 m to 174.50 m asl and as a result, wetter wetland communities expanded. Tall dense dry emergent decreased in extent as floating emergent and emergent vegetation formed in the southern portion of the marsh and along the eastern shore and short wet meadow expanded south into the centre of the marsh.

### *1972-1978: Declining*

Water levels continued to rise until 1973, and remained relatively high until 1976 before declining to 174.37 m asl in 1978. Water levels declined marginally by 0.13 m between 1972 and 1978, therefore the wetland was still dominated by the wetter communities. A large area of open water developed in the centre of the marsh; patches of floating emergent and emergent vegetation were also dominant. Vegetation in the marsh was highly fragmented and interspersed by the open water. An area of tall dense dry emergent vegetation persisted along the eastern shore of the wetland. Short wet meadow completely disappeared from the wetland by 1978; this may have been due to the high lake levels during the previous period or due to other factors.

### *1978-1995: Declining*

Between 1978 and 1995, water levels were highly variable. Water levels rose by 0.53 m to 174.90 m asl in 1986, the highest period on record, before declining 0.61 m to 174.29 m asl in 1995. The wetland is still fragmented, but the amount of open water in the marsh has decreased as tall dense dry emergent vegetation has expanded. Floating emergent and emergent vegetation is limited to deeper areas of the wetland. Meadow has continued to decrease in extent, and has been restricted to the northern section of the marsh.

### *1995-1999: Declining*

Water levels periodically rose after 1995, before declining to 1999 levels. The wetland was less fragmented, as tall dense dry emergent vegetation continued to expand in the wetland. There were notable decreases in the amount of floating emergent, emergent and tall wet emergent vegetation, however small patches of floating emergent vegetation remained in deeper channels of the marsh. Meadow continued to contract despite the drier conditions, but short wet meadow re-established itself in the wetland after being absent since 1978.

## Summary

The Turkey Point wetland has dramatically changed over time. The results indicate that there is a delayed response in the wetland vegetation to water level fluctuations, particularly evident in 1968 when tall dense dry emergent vegetation dominated the wetland, although water levels had risen significantly leading up to 1968. The analysis also documented the gradual decline in meadow and short wet meadow over time. Trends evident in relation to water level fluctuations are summarized in Table 2.

***Table 2.** Key findings for Turkey Point.*

| RESPONSE OF WETLAND | |
|---|---|
| **TO DECLINING WATER LEVELS** | **TO RISING WATER LEVELS** |
| • Vegetation tends to drier communities | • Vegetation tends to wetter communities |
| • Increase in tall dense dry emergent vegetation as they expand forming solid and continuous patches of vegetation | • Decrease in tall dense dry emergent vegetation as the community becomes interspersed and fragmented by open water |
| • Decrease in open water and floating emergent | • Increase in floating emergent as the community expands with rising water levels |
| • Decrease in tall wet emergent and short wet meadow during extreme low period around 1964 | • Significant increase in open water from 1972 to 1978 during the extreme high water level periods |

## Discussion and Conclusions

The Long Point and Turkey Point wetlands have experienced substantial change from 1945 to 1999, and much of this change can be related to historical weather patterns affecting water level fluctuations in Lake Erie. The historical response of the wetlands provides a key to how the wetlands may respond to future climate change and associated water level fluctuations. Climate change scenarios are projecting Lake Erie water levels to decline significantly under enhanced global warming, which will affect the composition and configuration of the wetland vegetation within the Long Point and Turkey Point coastal wetlands (Mortsch *et al.,* 2000; GLIN, 1998b; Lee *et al.,* 1996; Staple, 1993).

With projected lake level declines, the spatio-temporal trend analysis suggests that for Long Point there may be an expansion of tall dense dry and meadow vegetation, especially within the Inner Bay and Big Creek Marshes, and shifts to meadow, treed, and upland in the outer peninsula. Open water and deeper emergent vegetation communities may decrease in extent as the drier communities expand forming solid and continuous patches of vegetation. As a result, there will be less fragmentation and interspersion within the wetland, and the complexity of the wetland will decline. Similar trends will also occur at Turkey Point. Tall dense dry emergent vegetation may dominate the marsh, while areas of open water and floating emergent vegetation diminish.

The suggested patterns of response of the wetlands to enhanced global warming and projected lake level declines may have serious implications for the integrity of these coastal wetland systems. The loss of submergent and floating emergent vegetation may reduce the utility of the wetlands for many wildlife species and the expansion of dense dry vegetation and non-wetland plants may decrease the overall quality and productivity of the wetland. The implications of these changes may be detrimental to the natural diversity and integrity of coastal wetland systems in the Great Lakes.

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