Modelling Great Lakes Coastal Wetland Vegetation Communities Response to Climate Change

Andrea Hebb, Linda Mortsch

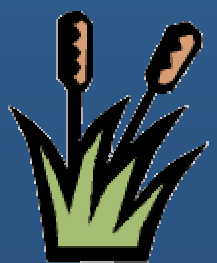
Adaptation and Impacts Research Group, Meteorological Service of Canada, Environment Canada

Joel Ingram

Canadian Wildlife Service, Environment Canada - Ontario Region

Peter Deadman

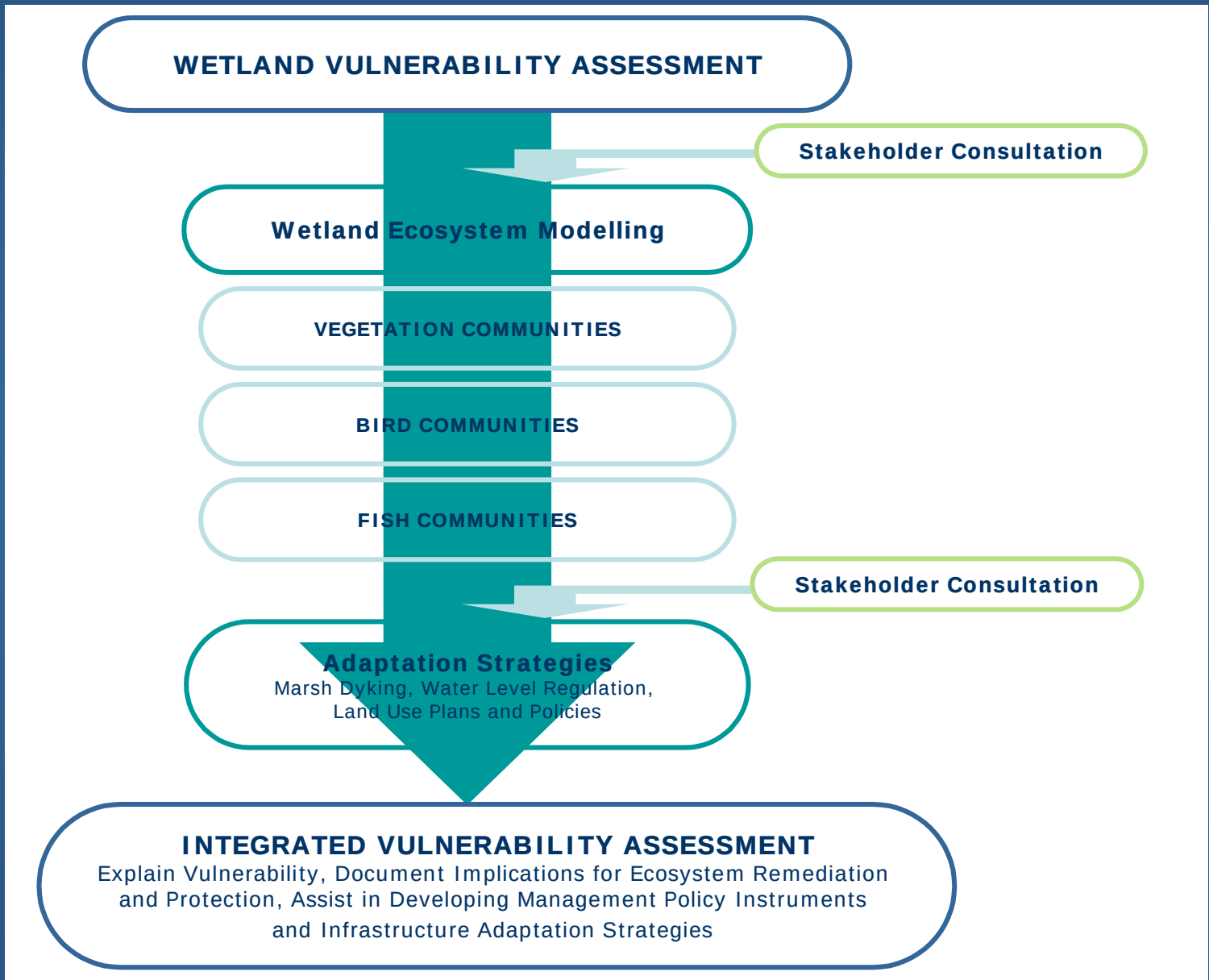
Department of Geography, University of Waterloo



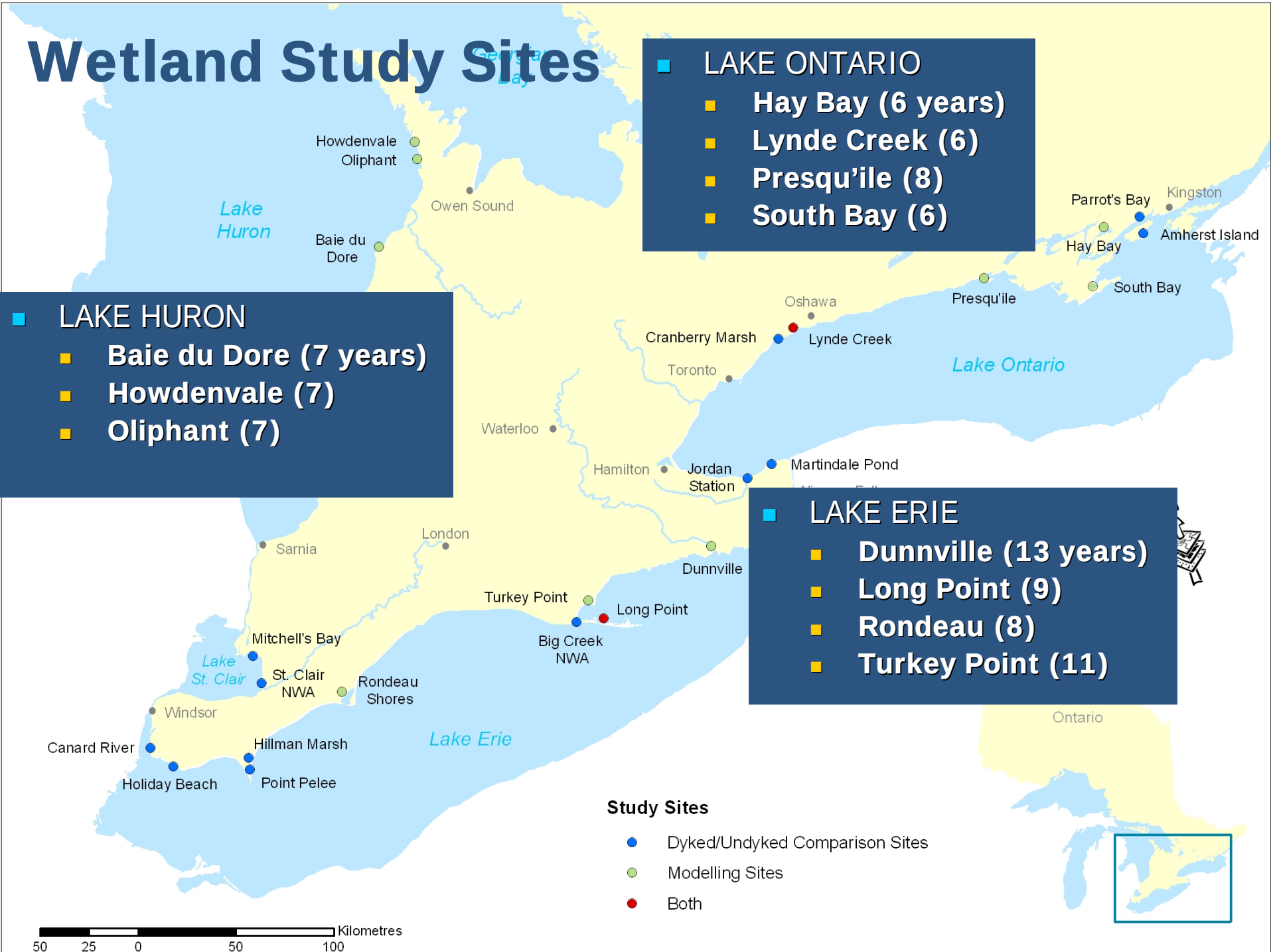
Huron-Erie Corridor/Lake St. Clair Research Needs Workshop 3.02
Windsor, Ontario

April 13, 2005

Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Response to Adaptation Strategies - Working Flow Diagram (Simplified)

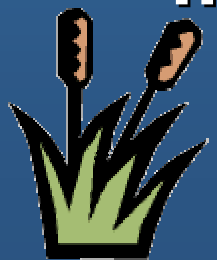


Wetland Study Sites

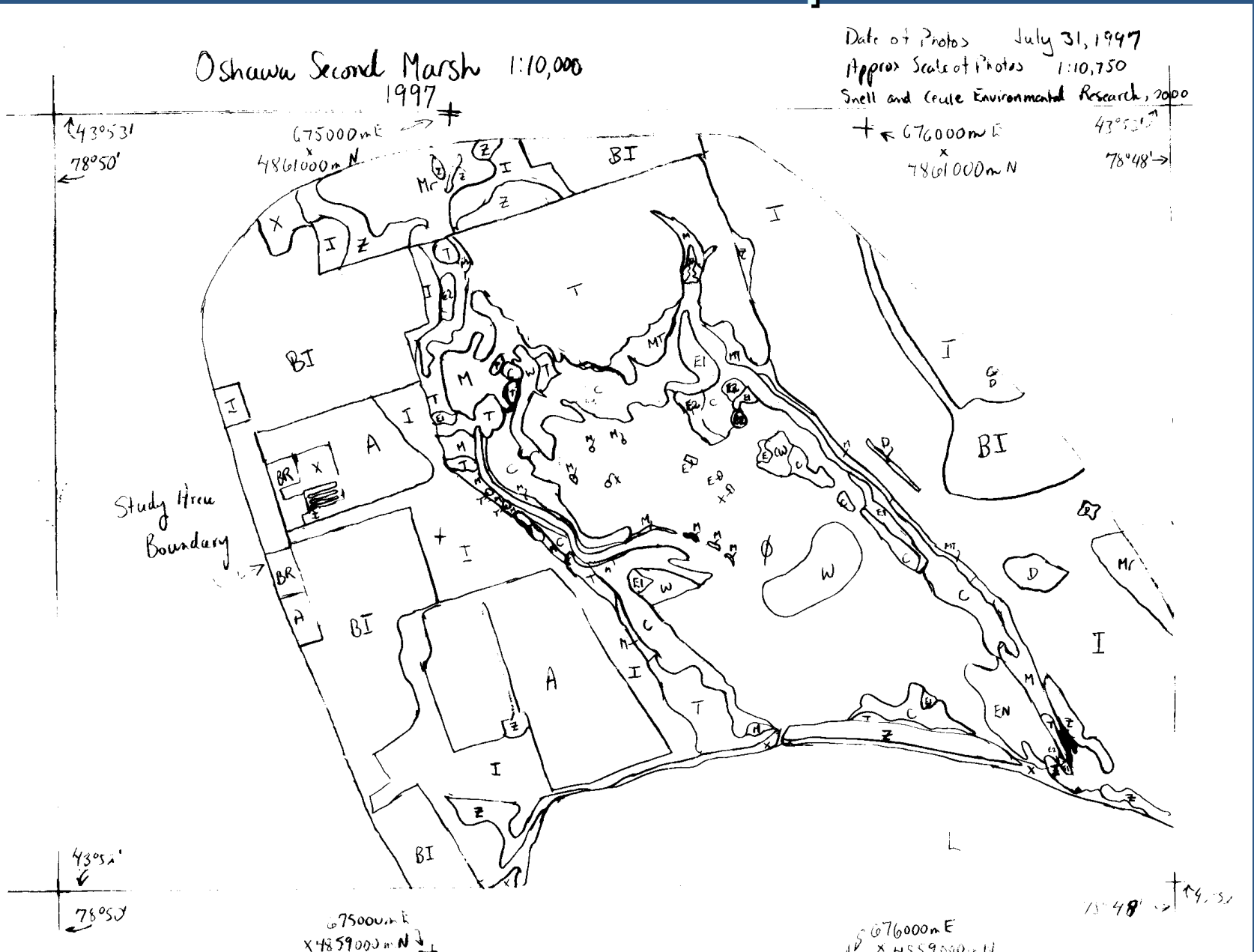


Methodology

- Collect and digitize wetland classification maps into a Geographic Information System (GIS)
- Simplify the wetland classification scheme
- Quantify and characterize spatial and temporal changes in wetland vegetation over time and in relation to water level conditions
- **Simulate wetland vegetation response to historic and projected future water levels**

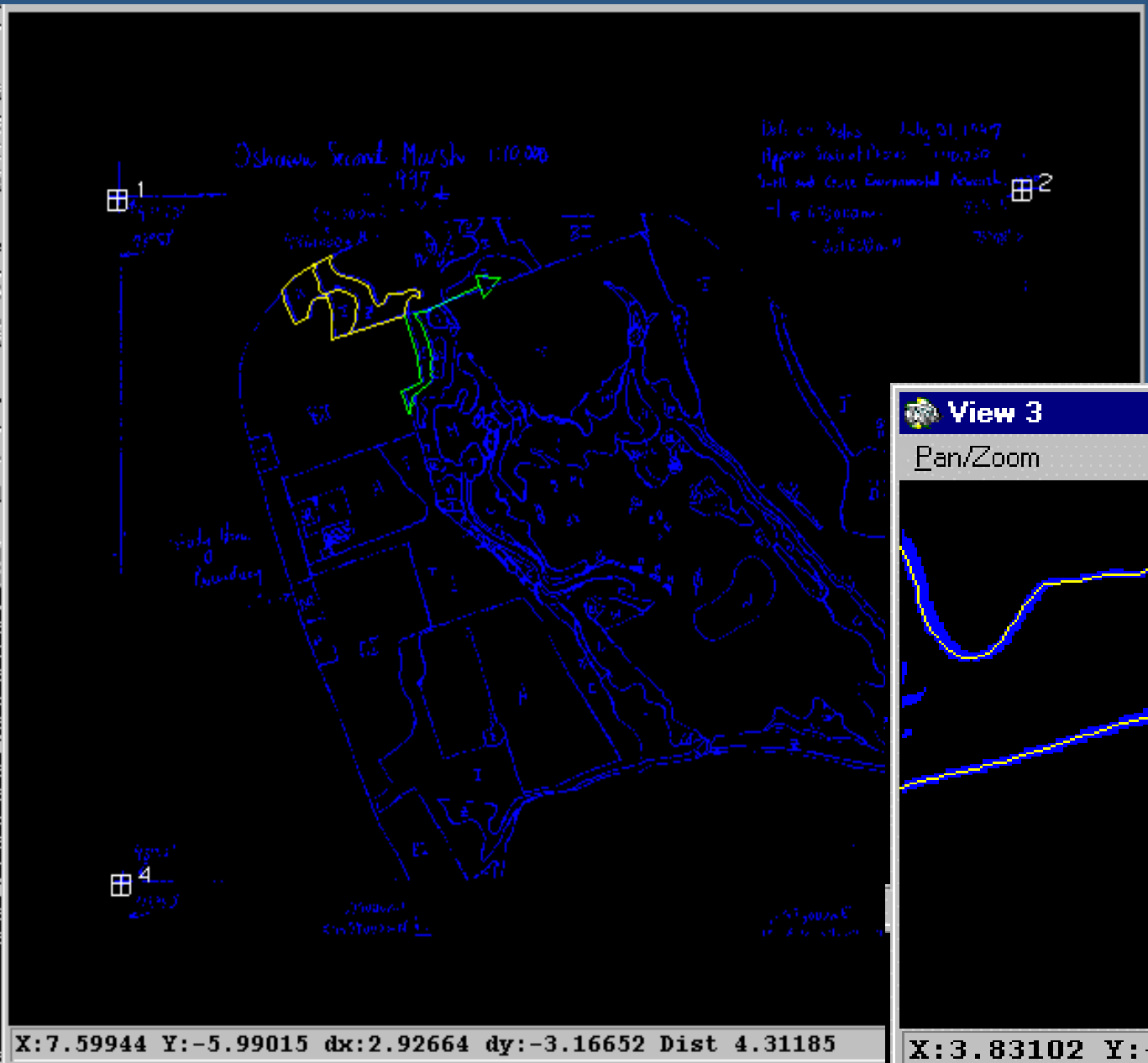


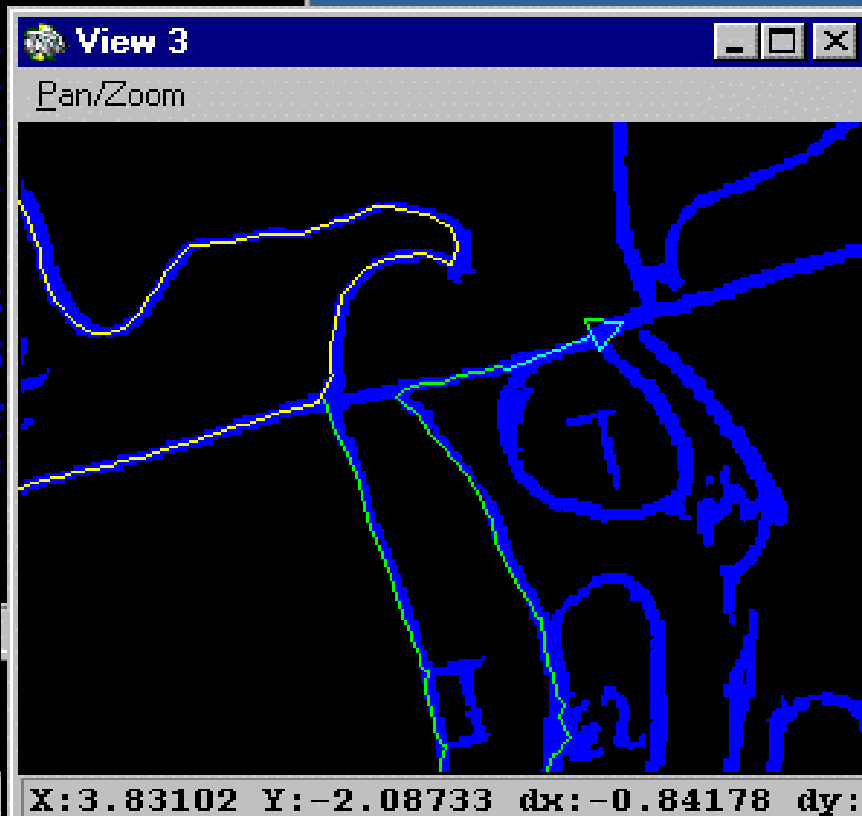
Scanned Map



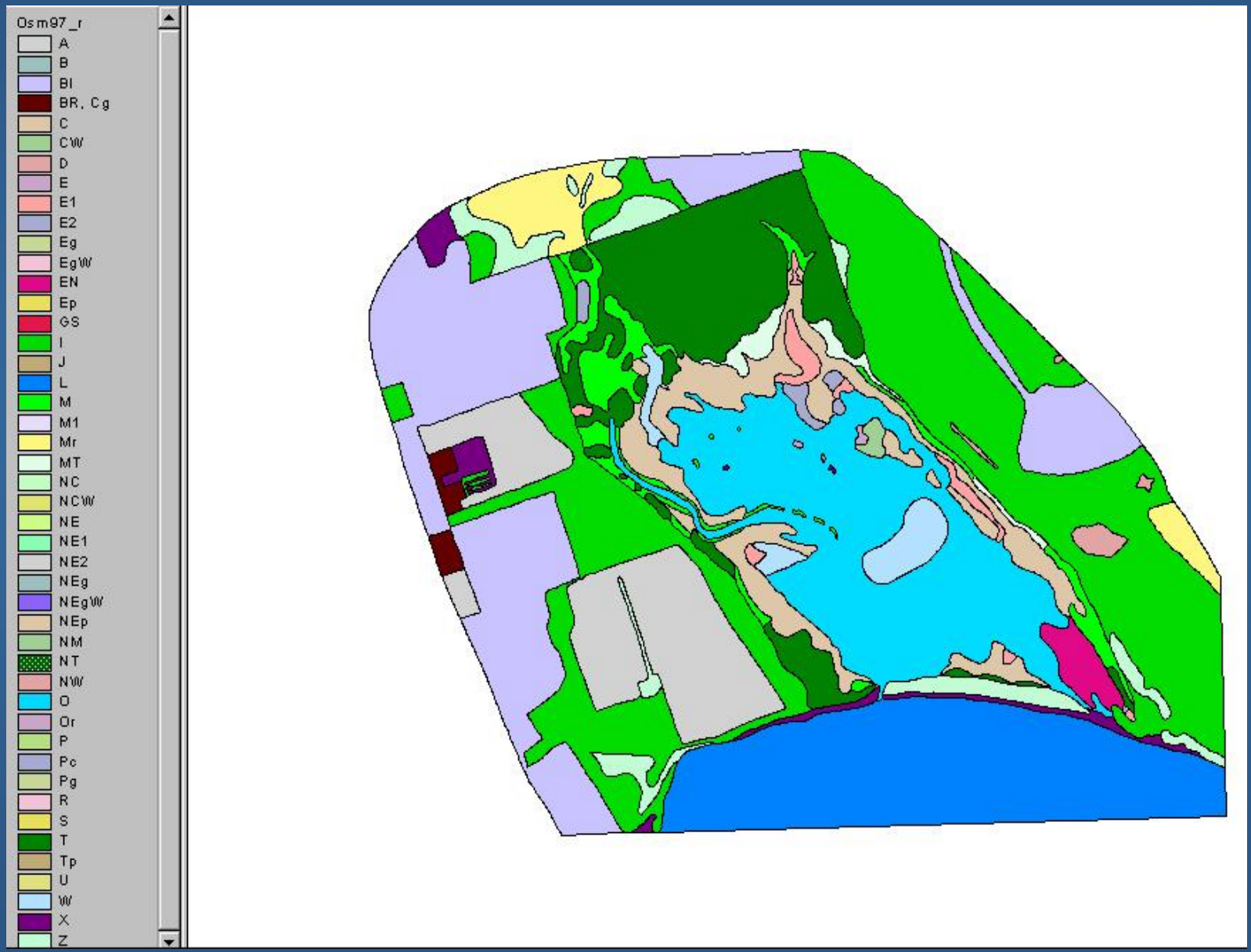
Oshawa Second Marsh 1:10,000
1997
Date of Photos July 31, 1997
Approx Scale of Photos 1:10,750
Snell and Ceule Environmental Research, 2000
43°53'
78°50'
675000mE
4861000mN
676000mE
4861000mN
78°48'
Study Area Boundary
BI
A
I
T
M
W
EN

Scan Vectorizing



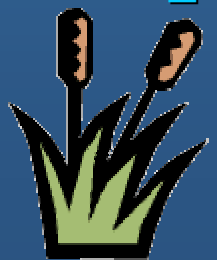


Final Product



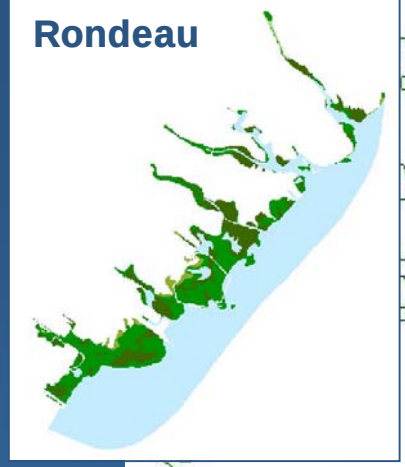
Vegetation Modelling

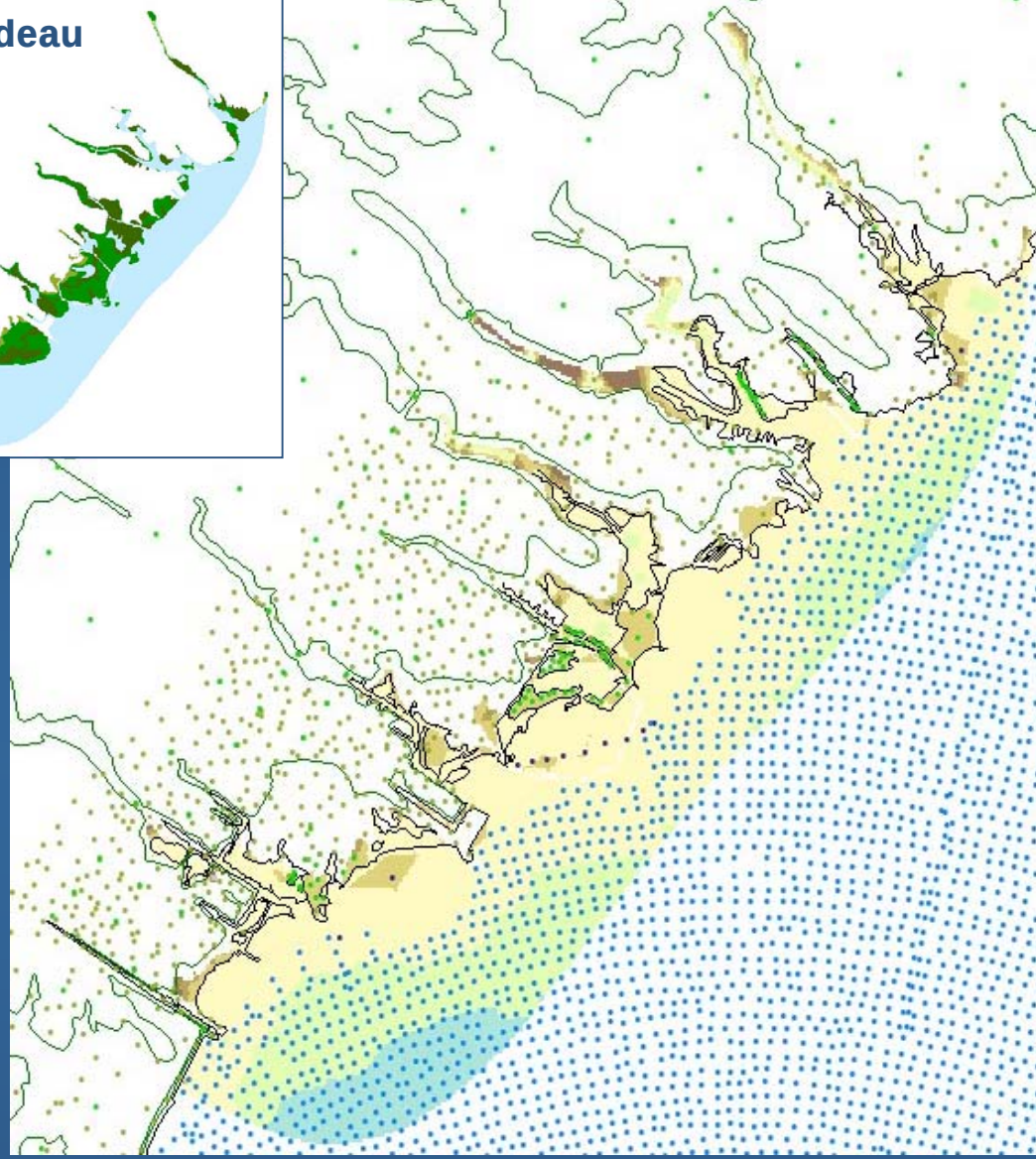
- Construct topographic models models for each wetland site
- Construct a rule-based vegetation community response model
  - Consider water depth and duration of hydrologic condition
  - Validate with historical wetland data
- Apply climate change scenarios to model future vegetation response
- Apply vegetation output as input for bird and fish modelling



Topographic Models

- Compiled using:
  - Bathymetry Data
  - Digital Terrain Modelling (DTM) Points
  - Ontario Base Map (OBM) Spot & Contours
  - Ocean Surveys Inc (OSI) data
  - Flood Damage Reduction Program
- Generated a TIN then a LATTICE (linear option)

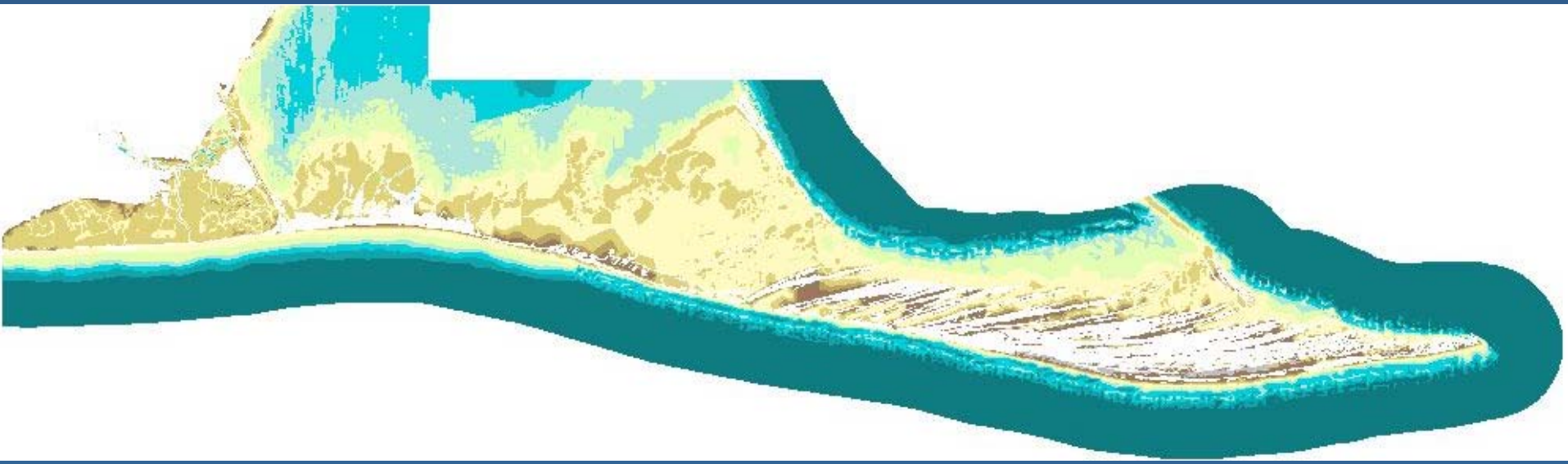




Elevation (m IGLD85)

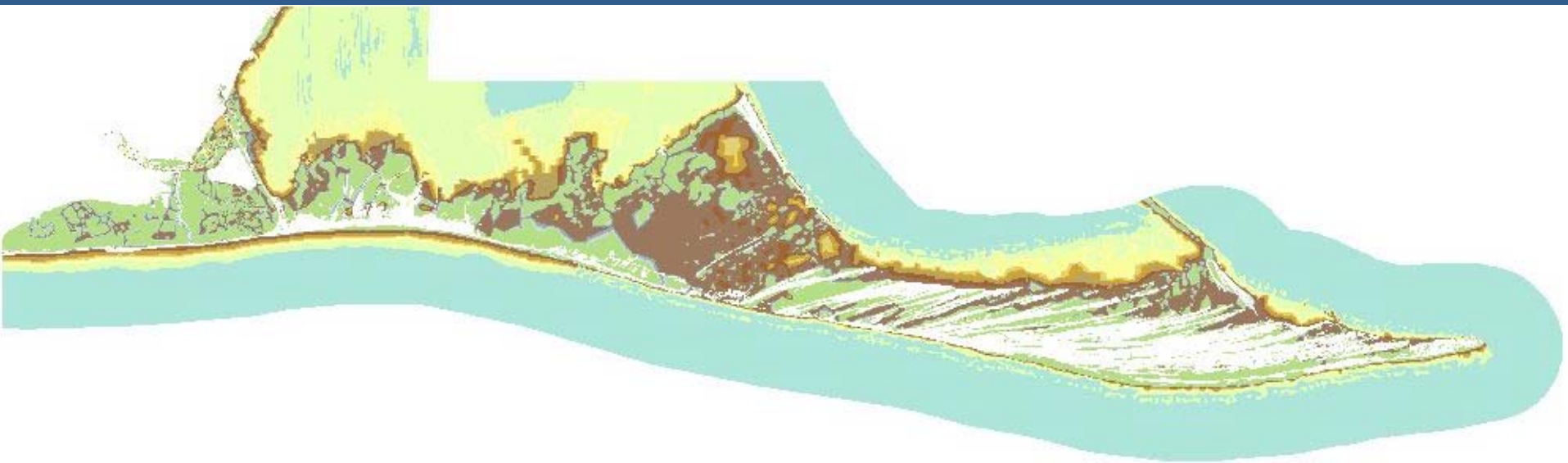
172-172.5	172.5-173	173-173.5	173.5-174	174-174.5	174.5-175	175-175.5	175.5-176

Input Grids – Long Point



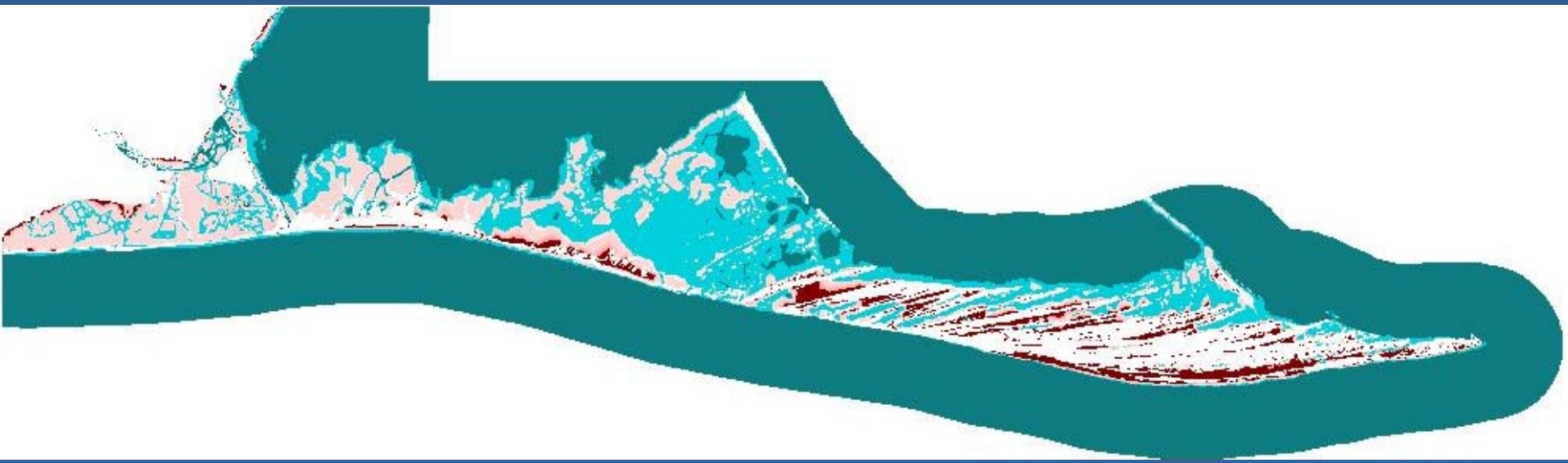
- Elevation (m IGLD85)

Input Grids – Long Point, 1964 (Low)

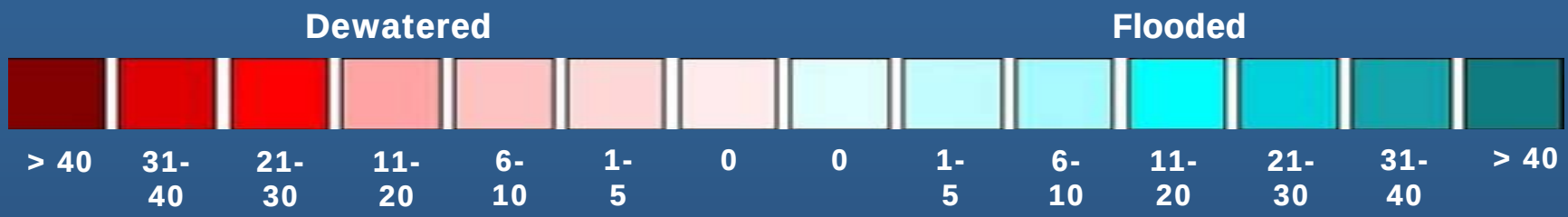


- Water Depth (m)

Input Grids – Long Point, 1964 (Low)



- Duration of Hydrologic Condition (years)



Vegetation Rules

Current Year Matrix

W = Water
EF = Emergent/Floating Mixed
E = Emergent
M = Meadow Marsh
T = Treed/Shrub

Height Above/Below Lake Level (cm)		MATRIX 1 (Current Year) Flooded >40	31-40	21-30	11-20	6-10	1-5	See Matrix 2 (Dewatered) 0	MATRIX 1 (Current Year) Dewatered 0	1-5	6-10	11-20	21-30	31-40	>40	See Matrix 2 (Flooded)
Above	> 101								M	T	T	T	T	T		
	91-100								M	M	T	T	T	T		
	81-90								M	M	T	T	T	T		
	71-80								M	M	M	M	T	T		
	61-70								M	M	M	M	T	T		
	51-60								M	M	M	M	T	T		
	41-50								M	M	M	M	T	T		
	31-40								M	M	M	M	T	T		
	21-30								E	E	E	M	M	T		
	11-20								E	E	E	M	M	T		
	0-10								E	E	E	M	M	T		
Below	1-10	W	E	E	E	E	E									
	11-20	W	EF	E	E	E	E									
	21-30	W	EF	E	E	E	E									
	31-40	W	EF	E	E	E	E									
	41-50	W	EF	E	E	E	E									
	51-60	W	W	E	E	E	E									
	61-70	W	W	E	E	E	E									
	71-80	W	W	E	E	E	E									
	81-90	W	W	EF	EF	EF	EF									
	91-100	W	W	EF	EF	EF	EF									
	101-110	W	W	EF	EF	EF	EF									
	111-120	W	W	EF	EF	EF	EF									
	121-130	W	W	EF	EF	EF	EF									
	131-140	W	W	EF	EF	EF	EF									
	141-150	W	W	EF	EF	EF	EF									
	151-160	W	W	EF	EF	EF	EF									
	161-170	W	W	EF	EF	EF	EF									
	171-180	W	W	EF	EF	EF	EF									
	181-190	W	W	EF	EF	EF	EF									
	191-200	W	W	EF	EF	EF	EF									
	≥ 201	W	W	W	W	W	W									

Duration of Hydrologic Condition (years)

Vegetation Rules

Height Above/Below Lake Level (cm)		Flooded							Dewatered						
		>40	31-40	21-30	11-20	6-10	1-5	0	0	1-5	6-10	11-20	21-30	31-40	>40
Above	> 101								M	M	T	T	T	T	T
	91-100								M	M	M	T	T	T	T
	81-90								M	M	M	T	T	T	T
	71-80								M	M	M	M	M	T	T
	61-70								M	M	M	M	M	T	T
	51-60								M	M	M	M	M	T	T
	41-50								M	M	M	M	M	T	T
	31-40								M	M	M	M	M	T	T
	21-30								E	E	E	E	M	M	T
	11-20								E	E	E	E	M	M	T
	0-10								E	E	E	E	M	M	T
Below	1-10	Ex	E	E	E	E	E	E							
	11-20	Ex	E	E	E	E	E	E							
	21-30	Ex	E	E	E	E	E	E							
	31-40	Ex	E	E	E	E	E	E							
	41-50	Ex	E	E	E	E	E	E							
	51-60	Ex	Ex	E	E	E	E	E							
	61-70	Ex	Ex	E	E	E	E	E							
	71-80	Ex	Ex	E	E	E	E	E							
	81-90	Ex	Ex	E	E	E	E	EF							
	91-100	Ex	Ex	E	E	E	E	EF							
	101-110	Ex	Ex	E	E	E	E	EF							
	111-120	Ex	Ex	E	E	E	E	EF							
	121-130	Ex	Ex	E	E	E	E	EF							
	131-140	Ex	Ex	E	E	E	E	EF							
	141-150	Ex	Ex	E	E	E	E	EF							
	151-160	Ex	Ex	E	E	E	E	EF							
	161-170	Ex	Ex	E	E	E	E	EF							
	171-180	Ex	Ex	E	E	E	E	EF							
	181-190	Ex	Ex	E	E	E	E	EF							
	191-200	Ex	Ex	E	E	E	E	EF							
	≥ 201	Ex	Ex	Ex	Ex	Ex	Ex	Ex							

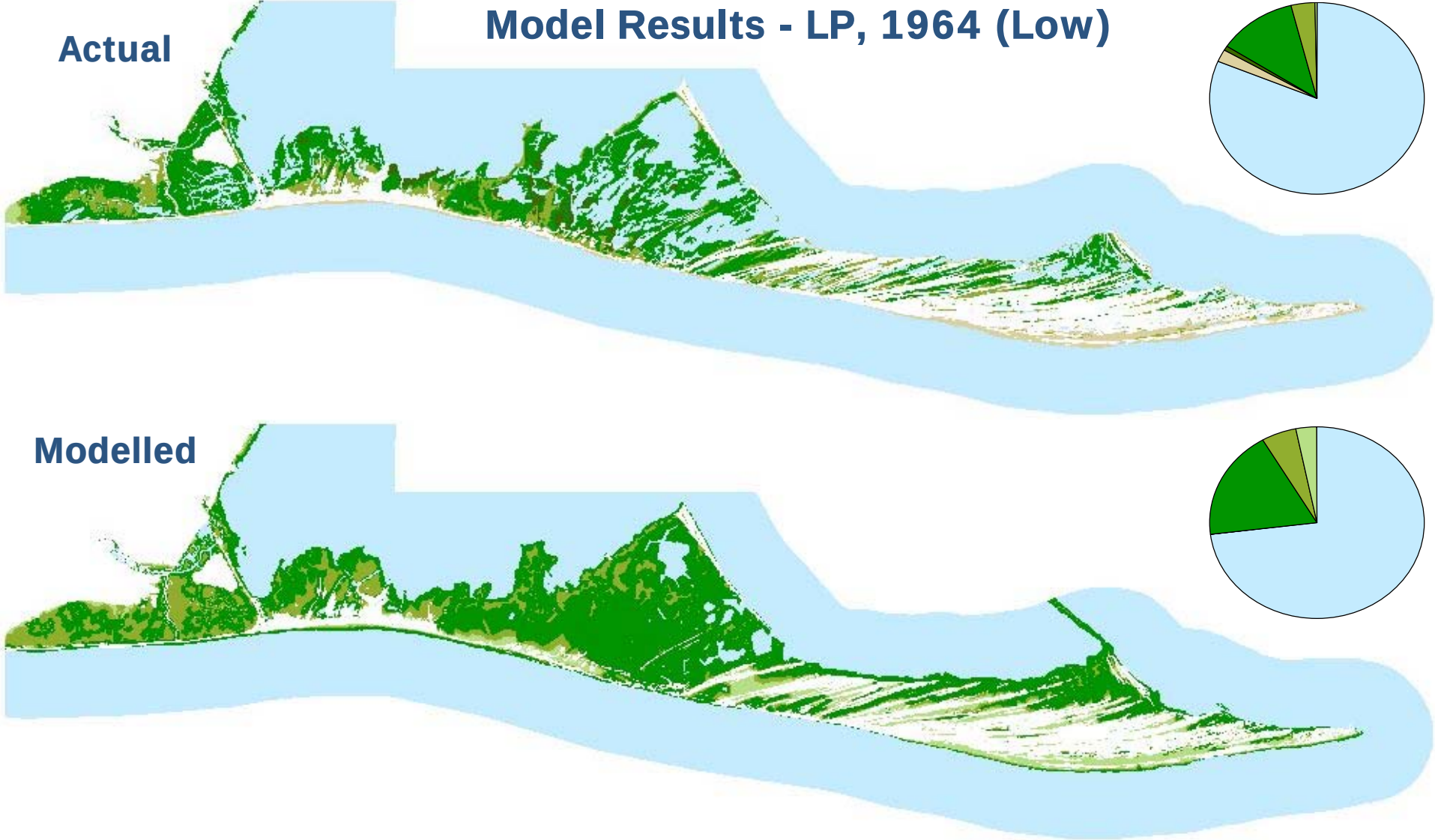
MATRIX 2 (Previous Year)

Duration of Hydrologic Condition (years)

Previous Year Matrix

Ex = Exposed Substrate
EF = Emergent/Floating Mixed
E = Emergent
M = Meadow Marsh
T = Treed/Shrub

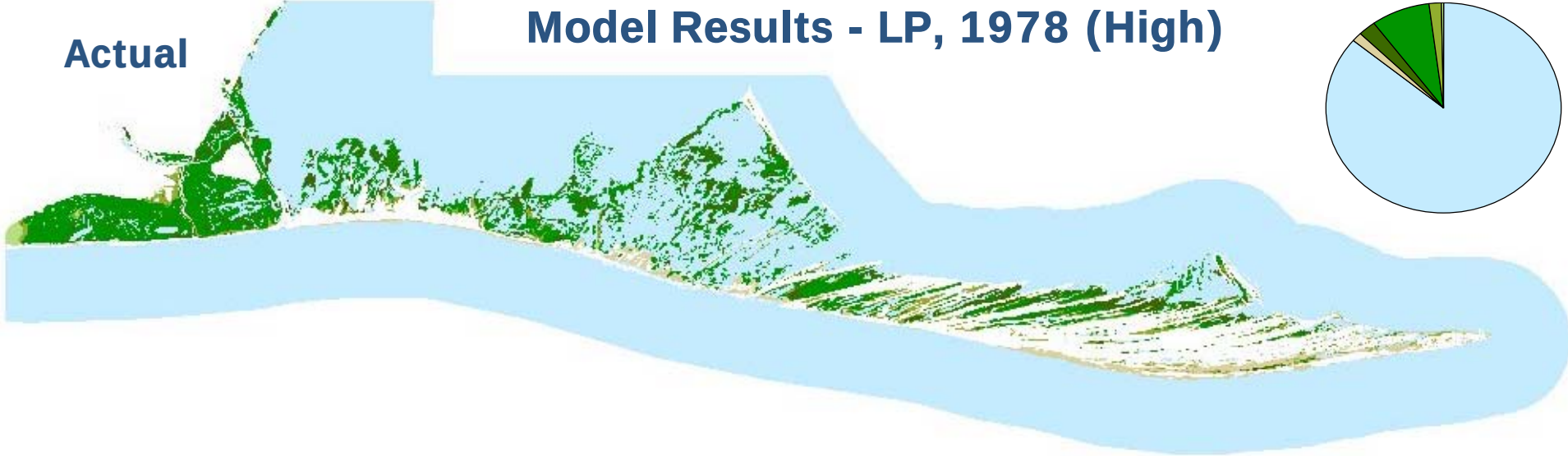
Model Results - LP, 1964 (Low)



- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Model Results
  - Spatial accuracy: 81.0%
  - Good success with water, emergent
  - Moderate success with meadow, treed
  - No floating; emergent, treed overestimated; water underestimated

Model Results - LP, 1978 (High)

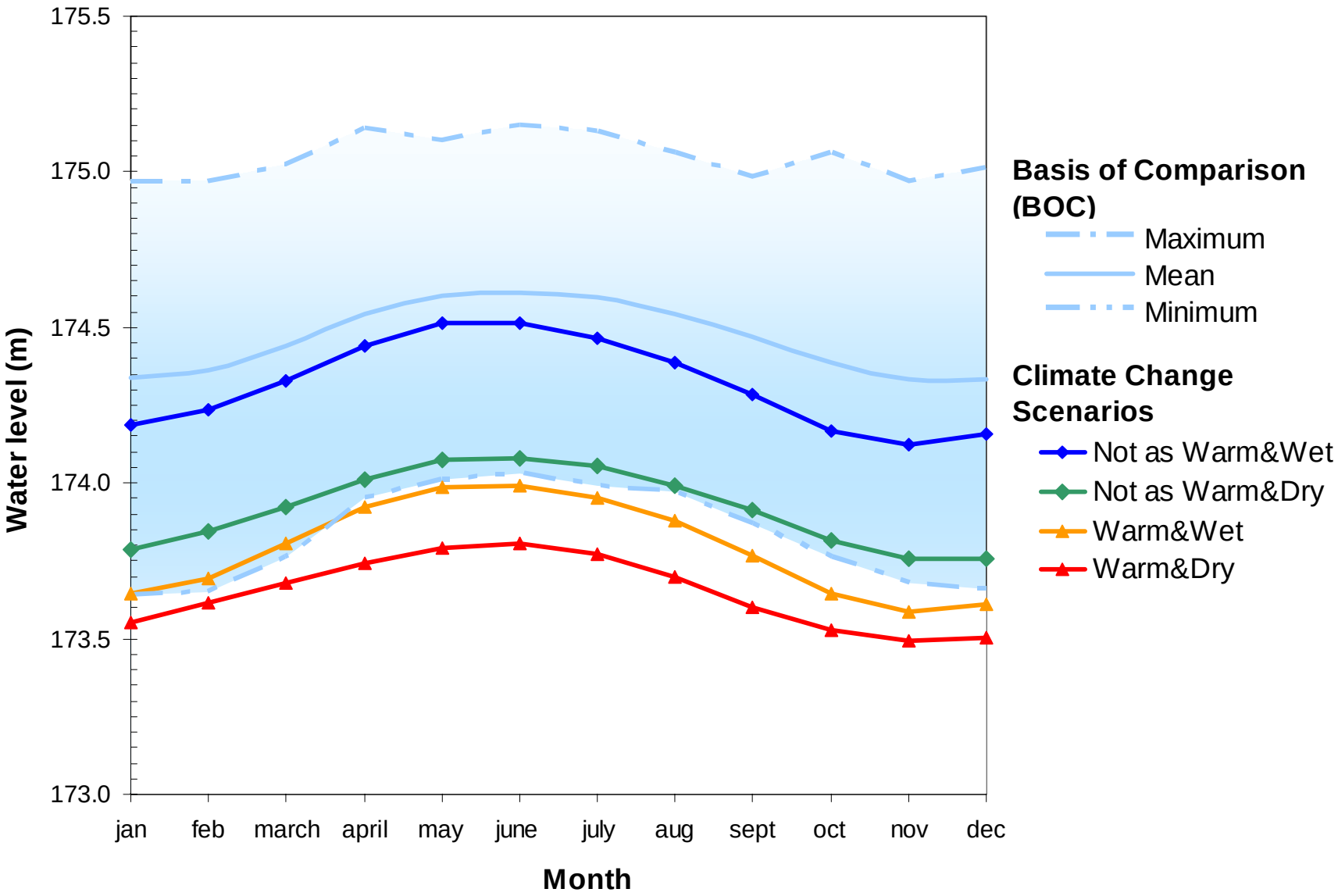
Actual



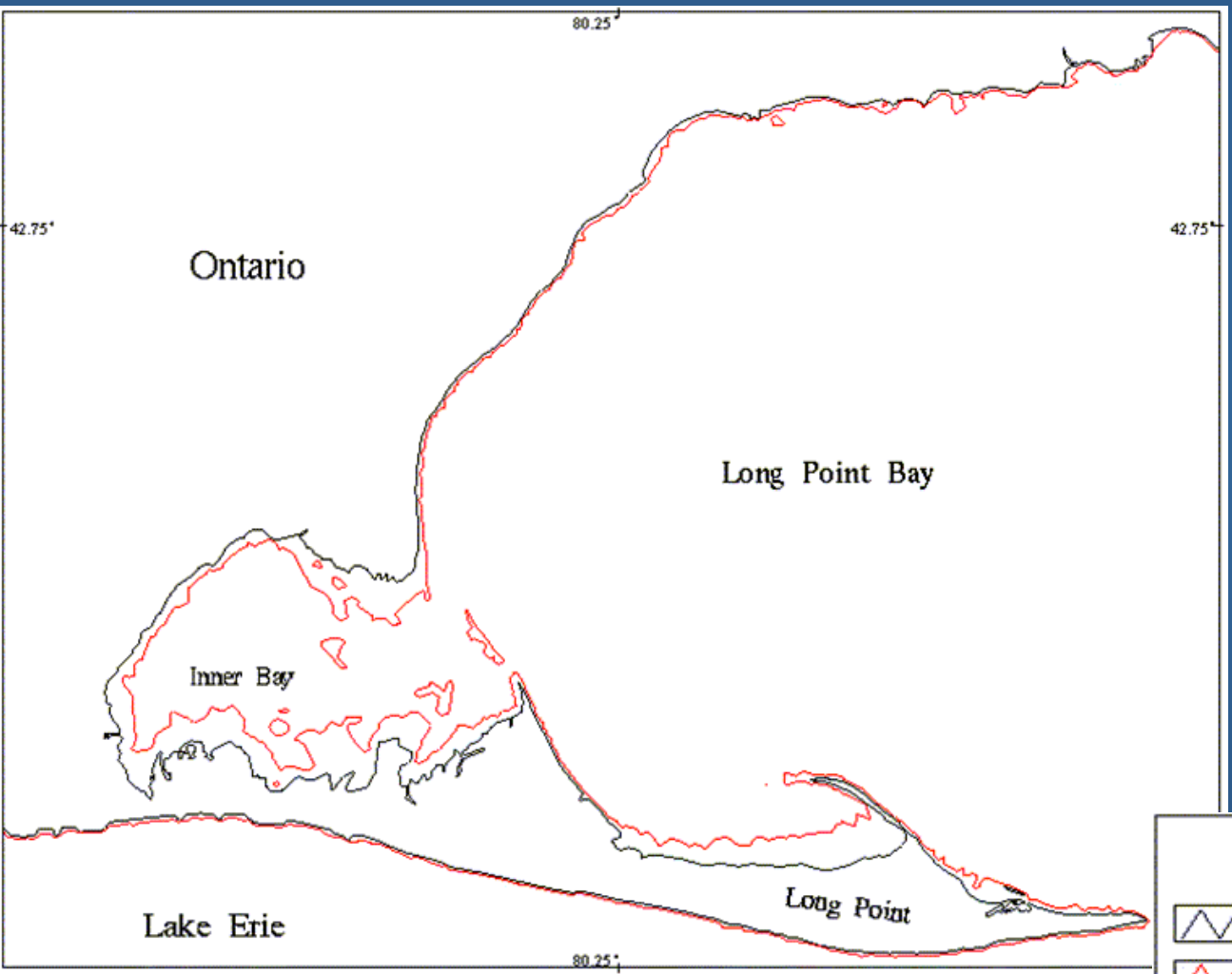
Modelled

- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Model Results
  - Spatial accuracy: 87.5%
  - Good success with water, emergent
  - Moderate success with treed/shrub
  - No floating or exposed; emergent, treed overestimated; meadow underestimated

Lake Erie Water Level Scenarios



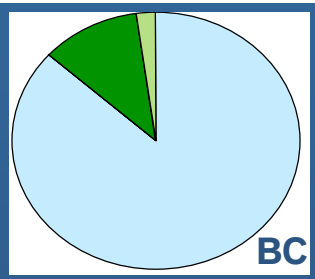
Lake Erie (Long Point) "What-if" Scenario



- **1.48 m** (IGLD85) water level decline
- Surface area of Inner Bay reduced by **32 %**
- Shoreline moves from **0.2 km to greater than 2 km**

Source: Lee et al, 1994

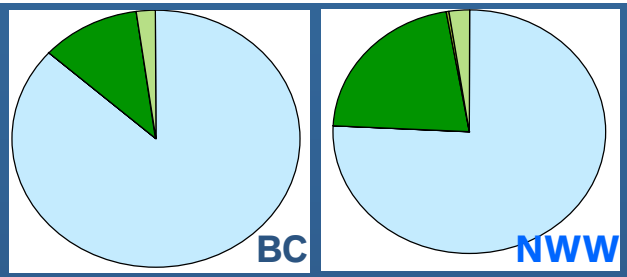
Projected Climate Change - LP, 1978 (High)



- Wetland Communities

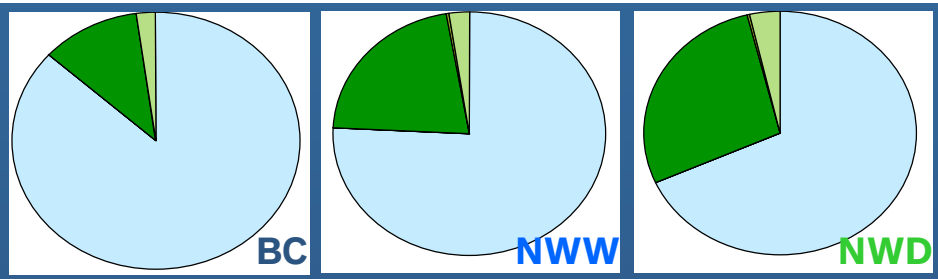
Water	Emergent
Exposed Substrate	Meadow Marsh
Floating Emergent	Treed/Shrub

Projected Climate Change - LP, 1978 (High)



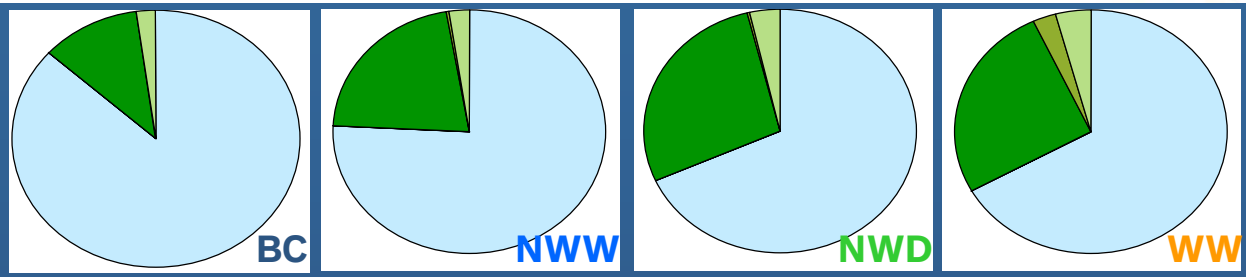
- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Projected Change (-0.15 m)
  - Increase in Emergent
  - Decrease in Water

Projected Climate Change - LP, 1978 (High)



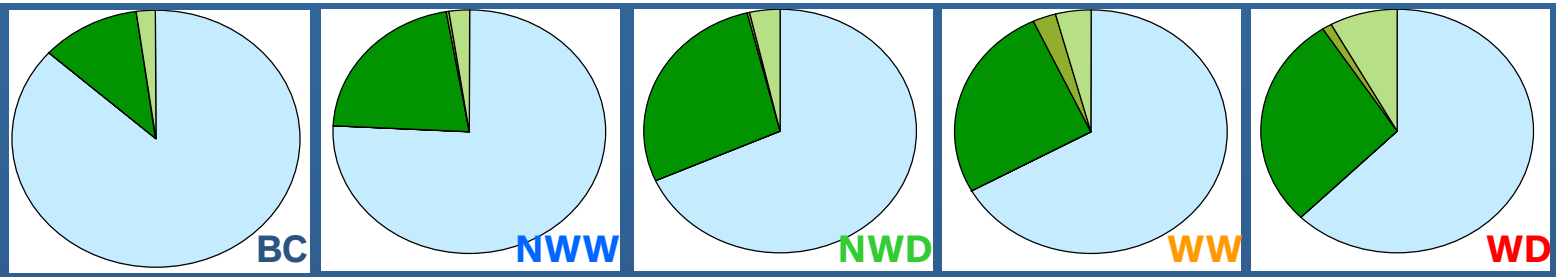
- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Projected Change (-0.55 m)
  - Increase Emergent, Treed
  - Decrease in Water
  - Lakeward Migration

Projected Climate Change - LP, 1978 (High)



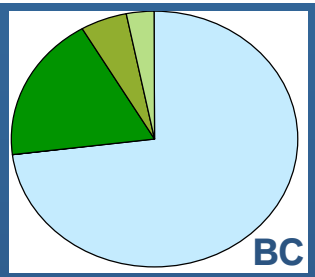
- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Projected Change (-0.67 m)
  - Increase in Emergent, Meadow
  - Decrease in Water

Projected Climate Change - LP, 1978 (High)



- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Projected Change (-0.81 m)
  - Increase Emergent, Treed Vegetation
  - Decrease in Water
  - Lakeward Migration

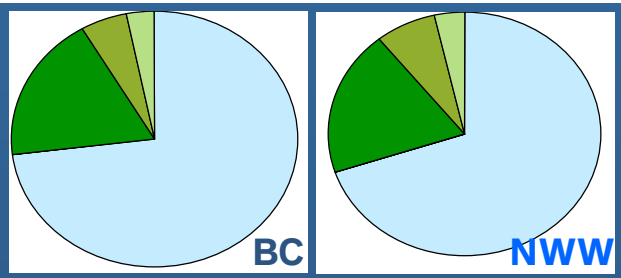
Projected Climate Change - LP, 1964 (Low)



- Wetland Communities

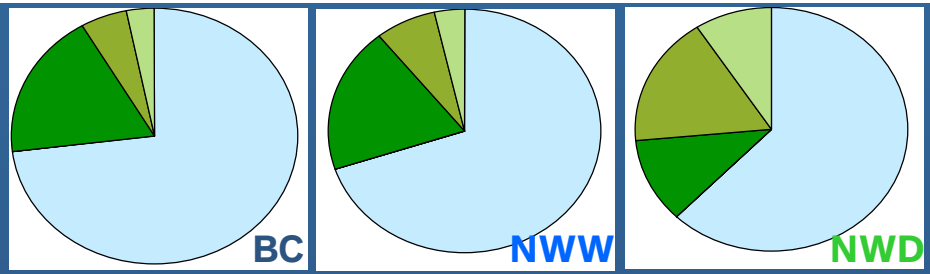
Water	Emergent
Exposed Substrate	Meadow Marsh
Floating Emergent	Treed/Shrub

Projected Climate Change - LP, 1964 (Low)



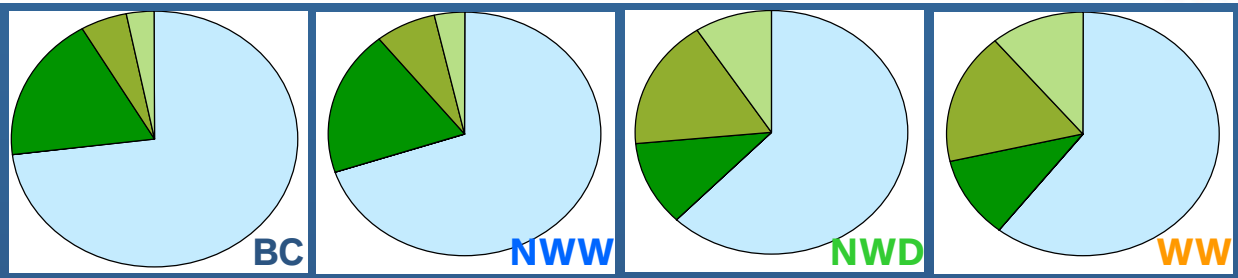
- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Projected Change (-0.15 m)
  - Increase Meadow, Treed Vegetation
  - Decrease in Water

Projected Climate Change - LP, 1964 (Low)



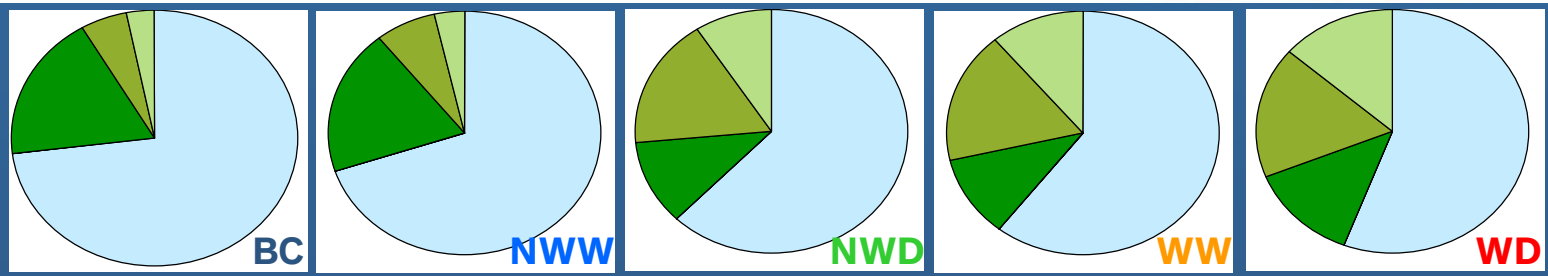
- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Projected Change (-0.55 m)
  - Increase in Meadow, Treed
  - Decrease in Water, Emergent
  - Lakeward migration

Projected Climate Change - LP, 1964 (Low)



- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Projected Change (-0.67 m)
  - Small Increase in Meadow, Treed
  - Decrease in Water, Emergent

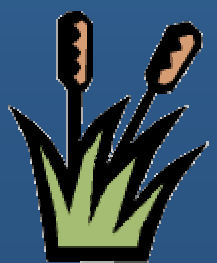
Projected Climate Change - LP, 1964 (Low)



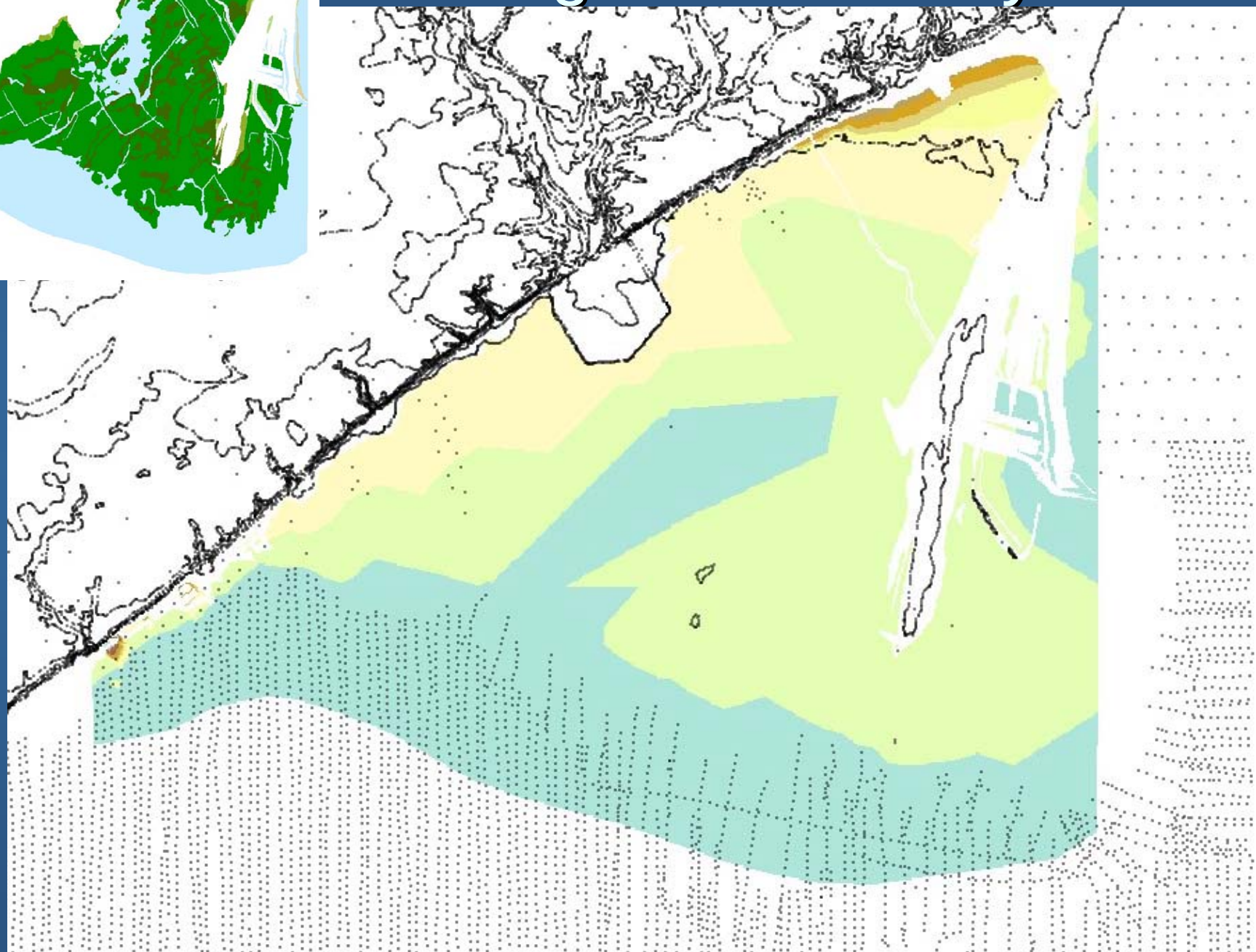
- Wetland Communities
  - Water
  - Exposed Substrate
  - Floating Emergent
  - Emergent
  - Meadow Marsh
  - Treed/Shrub
- Projected Change (-0.81 m)
  - Increases in Treed
  - Decrease in Water, Emergent, Meadow
  - Lakeward Migration

Modelling Problems and Considerations

- **Accurate elevation data is key!** Insufficient nearshore data
  - Model accuracy varies depending on available elevation data
  - Topographic model used to derive input grids
- Other considerations
  - No additional variables included in model (i.e., existing vegetation, soil/substrate)
  - No rules for fen and alvar communities for Lake Huron



Missing Data - Turkey Point



Great Lakes Coastal Wetland Communities: Vulnerabilities to Climate Change and Response to Adaptation Strategies

Climate Change Action Fund - Coastal Zone Project

Introduction
Wetland Sites
Vegetation Communities
Bird Communities
Fish Communities
Adaptation Strategies
Stakeholder Information
Project Partners
Data/Maps

Introduction

The Canadian Wildlife Service and the Adaptation and Impacts Research Group of Environment Canada have secured funding for a two-year project on Great Lakes Coastal Wetland Communities.

In partnership with Fisheries and Oceans Canada and the University of Waterloo, the project examines the vulnerability of coastal wetland plant, bird and fish communities to climate variability and change, and explores adaptation strategies to maintain ecosystem function and values.

Project Proposal

From l-r: Turkey Point Marsh, Big Creek NWA, Long Point Inner Bay, Long Point Provincial Park, Big Creek NWA, Turkey Point Hunt Club (AIRG)

For more information please contact:

Andrea Hebb
Adaptation and Impacts Research Group
Meteorological Service of Canada, Environment Canada
c/o Faculty of Environmental Studies, University of Waterloo
Waterloo, Ontario N2L 3G1

Phone: 519.888.4567 ext 6865
Email: ajhebb@fes.uwaterloo.ca

Last updated: Nov-04

Vegetation Communities

To help develop the wetland plant community vulnerabilities and vegetation response model, supplemental information was required regarding traits that make aquatic plants vulnerable to hydrologic variability. There are over 450 species of plants that regularly occur in Great Lakes wetlands.

Giant Burreed (Glen Barrett), Buttonbush (CWS), Cattail (CWS)

Literature review and expert opinion were used to determine the vulnerability of selected wetland plant species to hydrologic change. Plants were selected based on the most common species occurring in Lake Ontario coastal wetlands during extensive field surveys in the summer of 2003. Plants designated as Species at Risk in Canada were also considered. Several plant growth requirements and life history traits were determined to be important in evaluating how a plant would react to changes in hydrology. A "vulnerability" score was calculated for each species based on the unique combination of scores from this series of factors. The detailed literature review and vulnerability assessment methodology are found below.

Some interesting trends emerged (Figures 1 to 5). Species that are least vulnerable include many invasive species such as *Lythrum salicaria* (purple loosestrife), *Phragmites australis* (common reed), and *Hydrocharis morsus-ranae* (European frogsbit). Highly vulnerable species include the turbidity-sensitive *Zizania palustris* (wild rice) and *Potamogeton hillii* (Hill's pondweed), a species of Special Concern in Canada.

Frog's Bit (CWS)

- DRAFT: Review of factors influencing hydrological vulnerability of selected Great Lakes coastal wetland plants (pdf)
- DRAFT: Criteria and scoring for assessing hydrological vulnerability of selected Great Lakes plants (pdf)
- DRAFT: Hydrological vulnerability of selected Great Lakes coastal wetland plants (pdf)

White Water Lily (CWS), Northern Blue Flag Iris (Brian Branfiren), Pickerel Weed Stand, St. Clair NWA (CWS)

- http://www.fes.uwaterloo.ca/research/airg/wetlands