Western Lake Erie Restoration Assessment (WLERA): further understanding the potential and benefits of coastal wetland restoration.

Justin A. Saarinen and others….

Bay Area Scientific Information Symposium 6

USFSP- September 29, 2015

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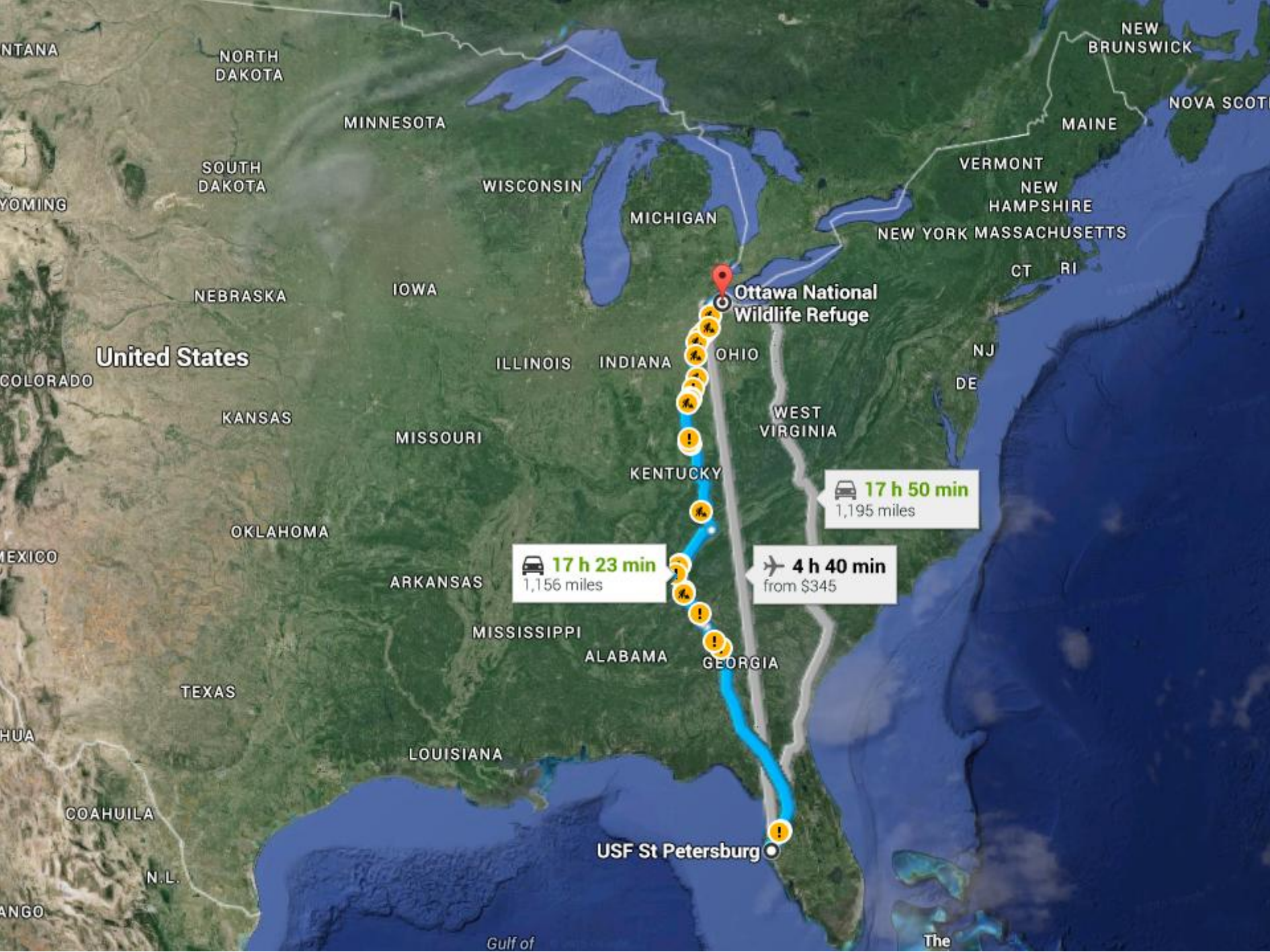
NTANA
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KANSAS
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4 h 40 min
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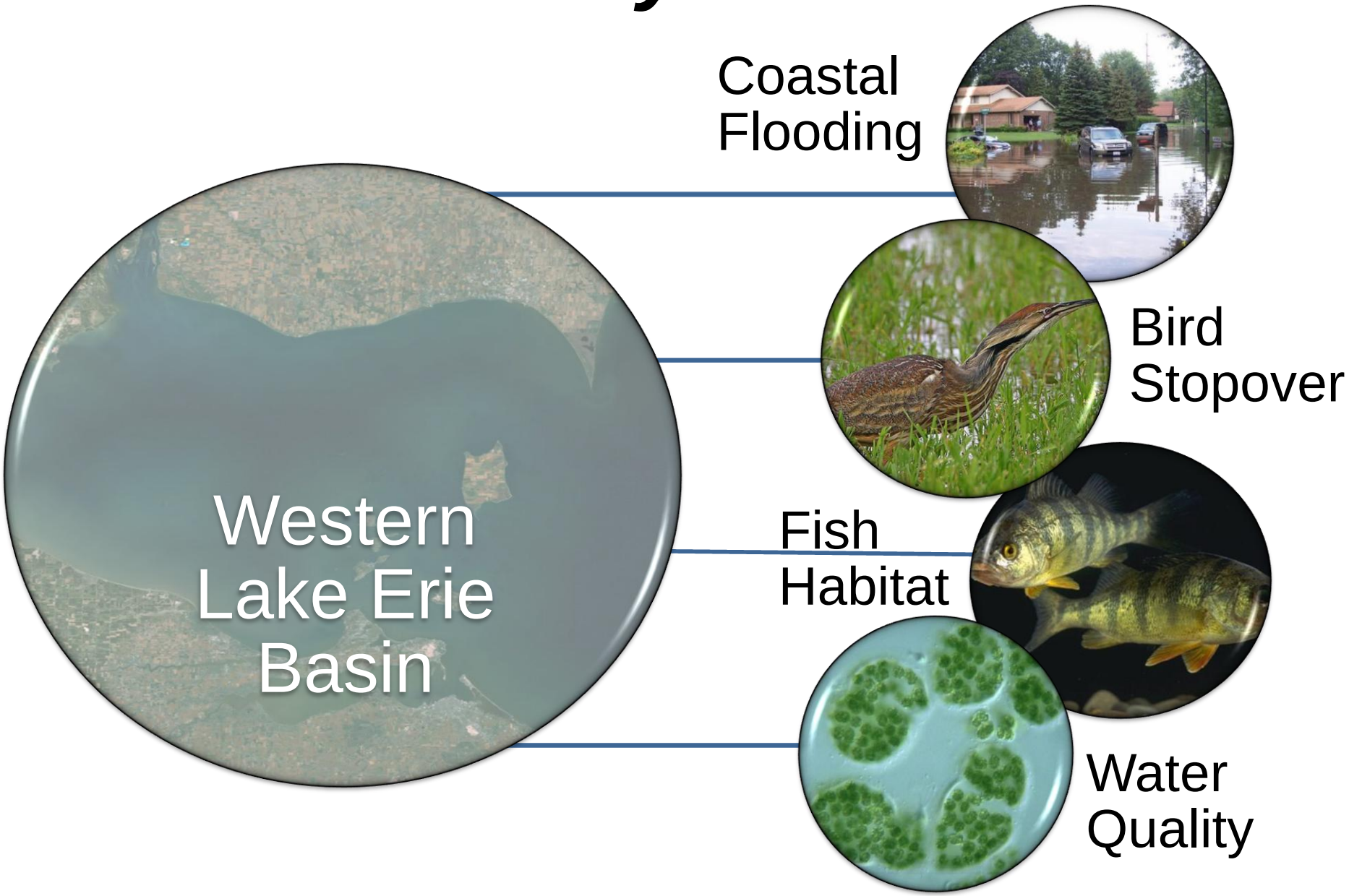
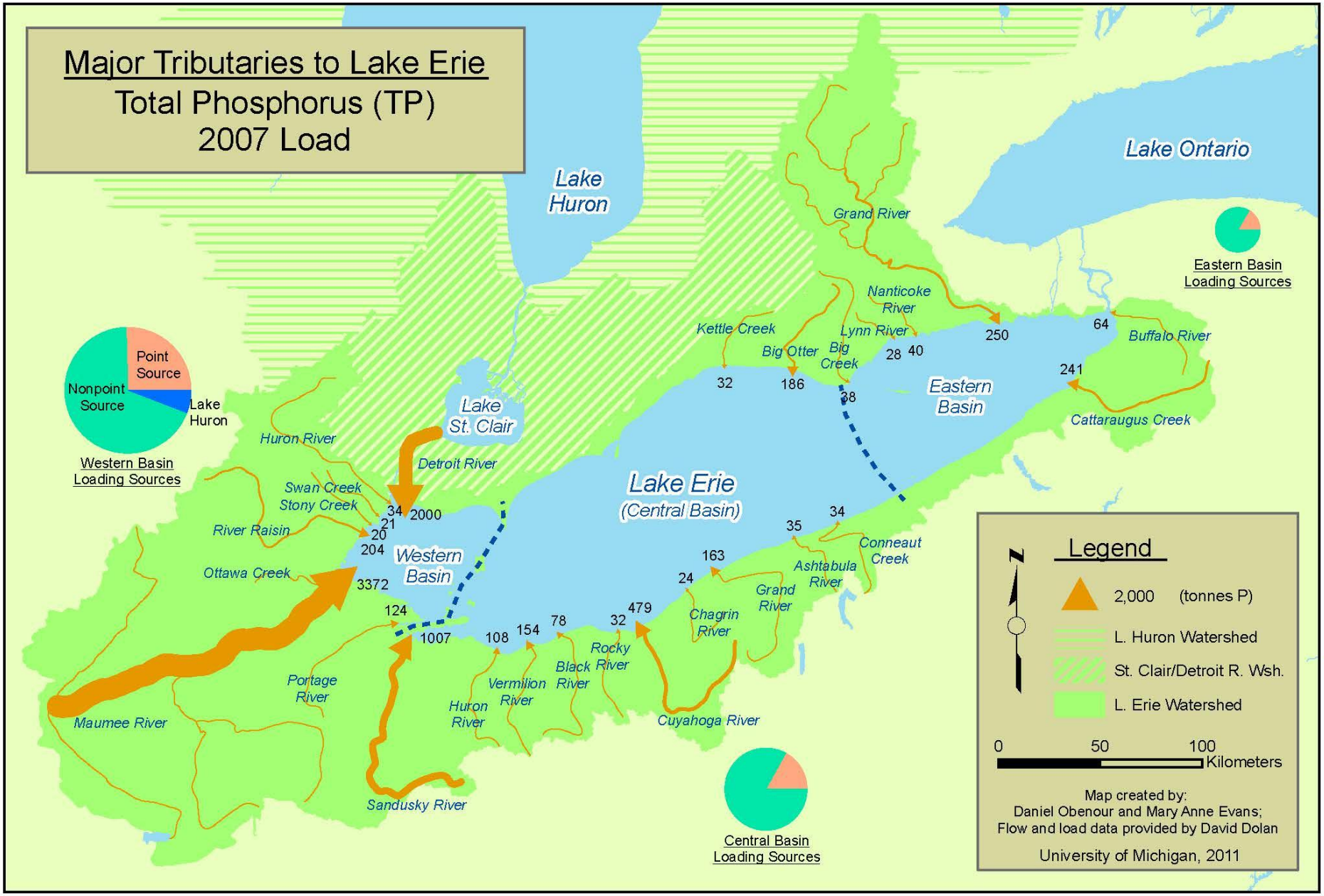
WLEB ***Eco-Hydro*** Problems




Major Tributaries to Lake Erie
Total Phosphorus (TP)
2007 Load
Lake Huron
Lake Ontario
Lake St. Clair
Lake Erie
(Central Basin)
Western Basin
Eastern Basin
Point Source
Nonpoint Source
Lake Huron
Western Basin Loading Sources
Eastern Basin Loading Sources
Central Basin Loading Sources
Huron River
Detroit River
Swan Creek
Stony Creek
River Raisin
Ottawa Creek
Maumee River
Portage River
Sandusky River
Huron River
Vermilion River
Black River
Rocky River
Cuyahoga River
Chagrin River
Grand River
Ashtabula River
Conneaut Creek
Cattaraugus Creek
Buffalo River
Kettle Creek
Big Otter
Big Creek
Lynn River
Nanticoke River
Grand River
34
21
2000
20
204
3372
124
1007
108
154
78
32
479
24
163
35
34
32
186
38
28
40
250
64
241
Legend
2,000 (tonnes P)
L. Huron Watershed
St. Clair/Detroit R. Wsh.
L. Erie Watershed
N
0
50
100
Kilometers
Map created by:
Daniel Obenour and Mary Anne Evans;
Flow and load data provided by David Dolan
University of Michigan, 2011

Importance of wetlands to the Great Lakes and all coastal nearshore areas.

"The small boat was rowed around the [Western Basin] islands…The lake water is so clear that fish [five dozen black bass] can be seen from **twelve to fifteen feet** below the surface." – G.T. Hopkins, 1862 [1]

Prior to 1862, western Lake Erie [US and Canada] was supported by **400,000 hectares** of coastal wetland. By 1990, **five-percent remains**, most of it diked and altered. – Herdendorf, 1987, 1992 [2,3]

$36 million in federal investment for restoring habitat, improving water quality and the overall restoration of ecologically degraded areas in western Lake Erie. - Great Lakes Restoration, 2014 [4]

1. Burns, Noel M. Erie: the lake that survived. New Jersey: Rowman & Allanheld, 1985.
2. Herdendorf, Charles E. The ecology of the coastal marshes of western Lake Erie: a community profile. Ohio, 1987.
3. Herdendorf, Charles E. "Lake Erie coastal wetlands: an overview." Journal of Great Lakes Research 18.4 (1992): 533-551.
4. http://greatlakesrestoration.us/, accessed January 10, 2014

FY15-19 Great Lakes Restoration Initiative Action Plan Summary*

Focus Areas	Objectives	Commitments
Toxic	Remediate, restore and	• Implement management actions necessary to remove Beneficial Use
Invasive Species	Prevent new introductions of invasive species	• Block pathways through which aquatic invasive species can be introduced to the Great Lakes ecosystem • Conduct early detection monitoring activities • Work with Great Lakes states to conduct rapid response actions or exercises
	Control established invasive species	• Implement control projects for GLRI-targeted invasive species
	Develop invasive species control technologies and refine management techniques	• Develop/enhance technologies and methods to prevent the introduction and to control the spread of invasive species • Develop/enhance invasive species specific collaboratives to support rapid responses and communicate the latest control and management techniques
	from urban watersheds	adopted a watershed strategy

- Implement management actions necessary to remove Beneficial Use Impairments and delist Areas of Concern
- Implement agricultural practices or other nutrient reduction practices in GLRI targeted watersheds.
- Remove or bypass barriers on Great Lakes tributaries to facilitate fish passage
- Protect, restore and enhance Great Lakes coastal wetlands
- Protect, restore and enhance GLRI-targeted habitats in the Great Lakes basin
- Develop and incorporate climate resiliency criteria in project selection processes
- Evaluate the effectiveness of GLRI-funded projects
- Assess the overall health of the Great Lakes ecosystem and identify the most significant remaining problems
- Identify watersheds, habitats, and species to be targeted by the GLRI
- Report on GLRI progress and Great Lakes ecosystem health

The Great Lakes Restoration Initi is Accelerating Great Lakes Prote

2010: GLRI Action Plan I	2014: GLRI Action Plan
Cleaning up Great Lakes Areas of Concern	
Preventing and Controlling Invasive Species	
Reducing Runoff that Contributes to Algal Blooms	
Restoring Habitat to Protect Native Species	
	Science-Based Adaptive Ma

.RI-funded projects

processes

sed adaptive
anagement approach for
RI

- Assess the overall health of the Great Lakes ecosystem and identify the most significant remaining problems
- Identify watersheds, habitats, and species to be targeted by the GLRI

September 2014

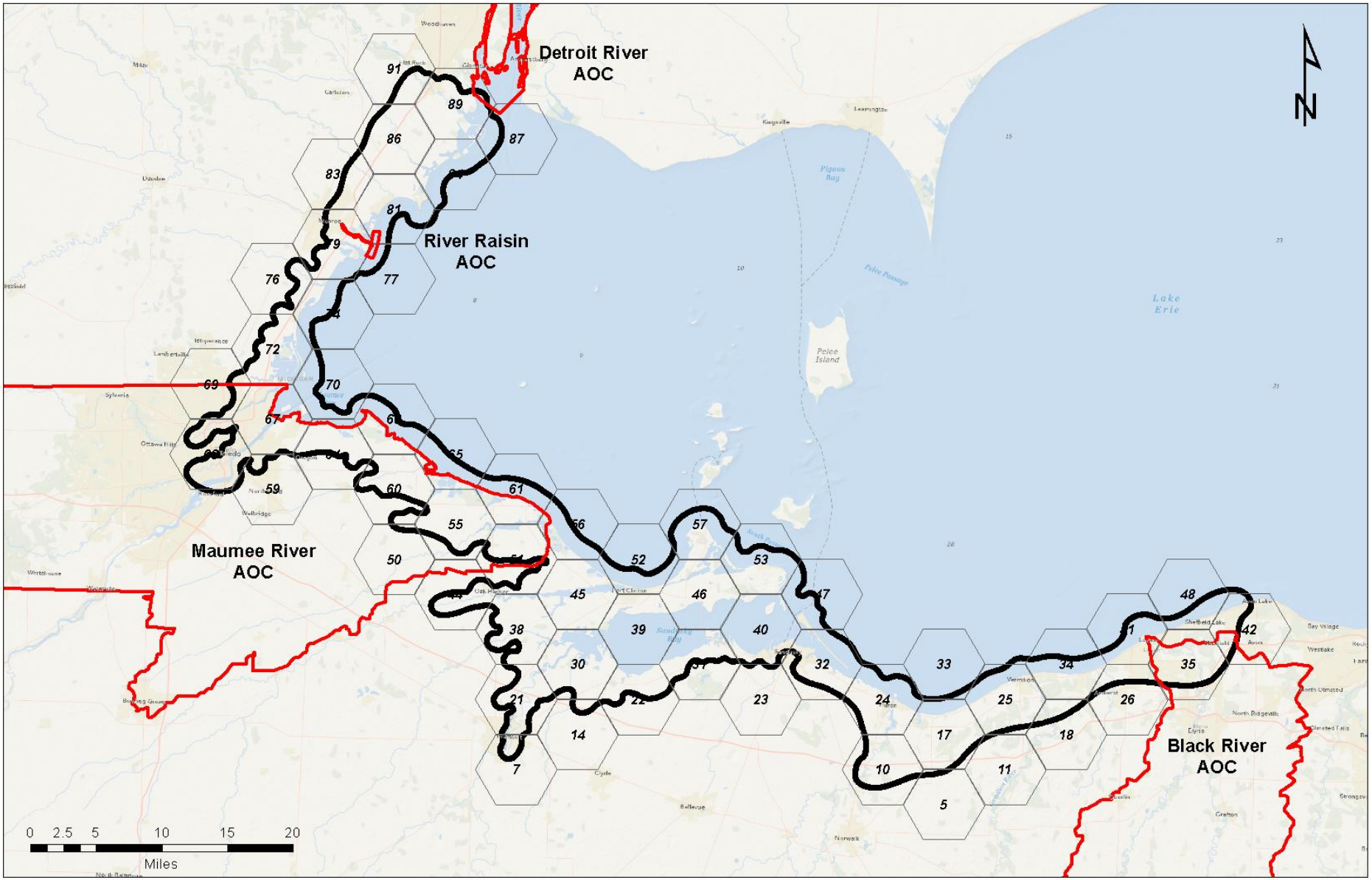
How much potential coastal wetland area can be restored along western Lake Erie and where is it?

Outcome is a methodology to

1. Identify
2. Prioritize
3. Track

Coastal Wetland Restoration

Study Area


Detroit River AOC
River Raisin AOC
Maumee River AOC
Black River AOC
Lake Erie
Pelee Island
Pelee Passage
Pigeon Bay
Sandusky Bay
Port Clinton
Kingsville
Leamington
Toledo
Sylvania
Ottawa Hills
Lambertville
Ida
Bowling Green
Fremont
Vermilion
Lorain
Elyria
Avon
Avon Lake
Sheffield Lake
Westlake
Bay Village
North Ridgeville
Olmsted Falls
North Olmsted
Berlin
Grafton
Strongsville
Bellevue
Norwalk
Clyde
Gibraltar
Grosse Ile
Gibraltar
Woodhaven
Carleton
Milan
Dundee
Ottawa
Wauseon
Whitehouse
Waterville
Delta
Oak Harbor
Wellington
Sandusky
0 2.5 5 10 15 20
Miles
N

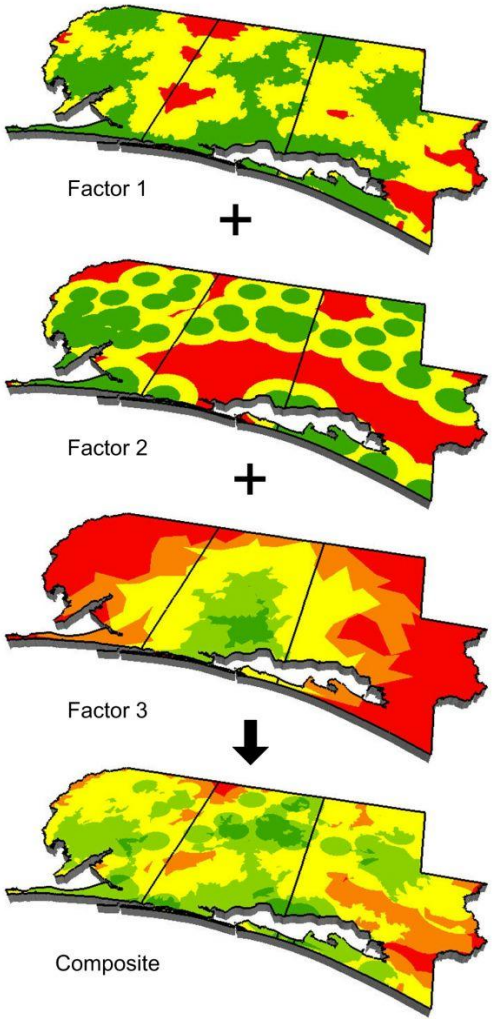
Narrative Definition of "Restorable"

Restorable wetlands are areas characterized by hydric soils and, under historical/natural Lake Erie-driven hydroperiods, would support hydrophytic vegetation.

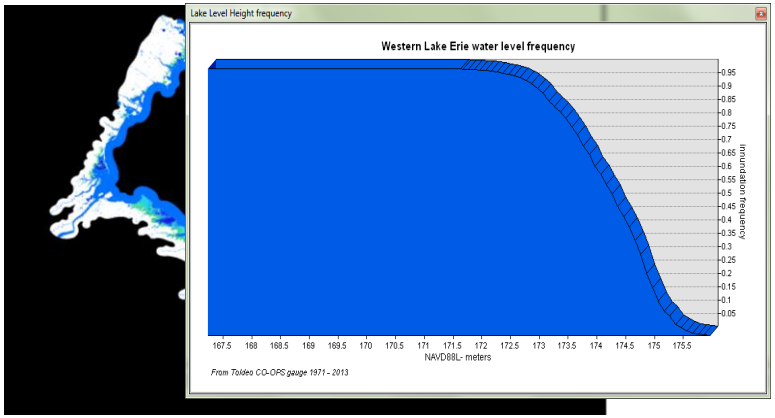
These areas are not currently affected by Lake Erie-driven hydroperiods, primarily due to human modification to the local environment.

The assessment focuses on restoring connectivity and drainage patterns to increase wetland acreage for improved ecosystem function and services.

Geodesign. Data Driven Restorability



Parameter	Description	Source	Scale	Values	Significance to WLERA
P1- Hydroperiod	The frequency and duration of flooding.	State of Ohio and Michigan; NOAA CO-OPS	1-m	0 - 100	Areas that flood more frequently and longer are more likely to be restored.
P2- Wetland Soils	Previously mapped wetlands and wetland soils	USF&W NWI; NRCS SSURGO; NOAA C-CAP	10-m	0,1	Areas that have been previously mapped as wetlands or with soils that support wetlands are more likely to be restored.
P3- Flowlines	The network of surface water drainage to Lake Erie	USGS NHD	10-m	0,1	Proximity to existing drainage features connecting the lake and coastal areas are more likely to be restored.
P4- CARL	Proximity to conserved lands	USF&W CARL	10-m	0,1,2,3,4	Areas within the boundaries of in proximity to existing conservation lands are more likely to be restored.
P5- Impervious Surfaces	Percentage of impervious surfaces within an area	USGS NLCD	30-m	0 - 100	Impervious surfaces represent urbanized and land uses and are less likely to be restored.
P6- Landuse	Developed land areas that do not have impervious surfaces	NOAA C-CAP	30-m	0 - 100	Areas such as crops, parks and golf courses do not have impervious surfaces and are less likely to be restored.
P0- Water	Open water areas	USGS NLCD	10-m	0 - 100	Analysis mask. Areas that are open water such as Lake Erie will not be restored.



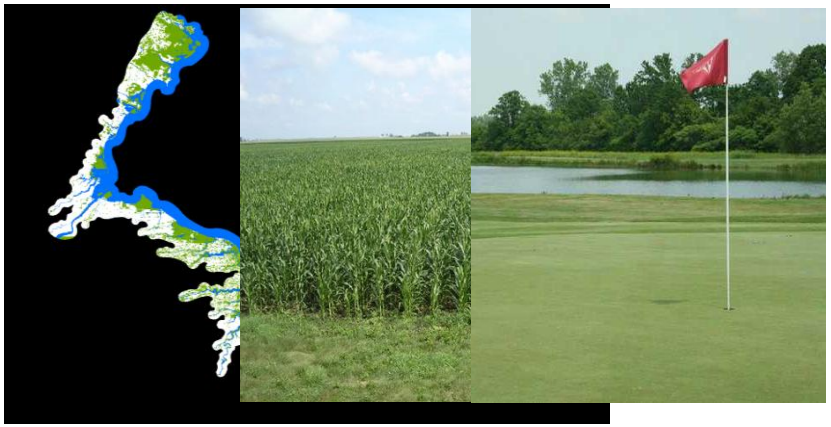
P1 Hydroperiod

P4 CARL Boundaries

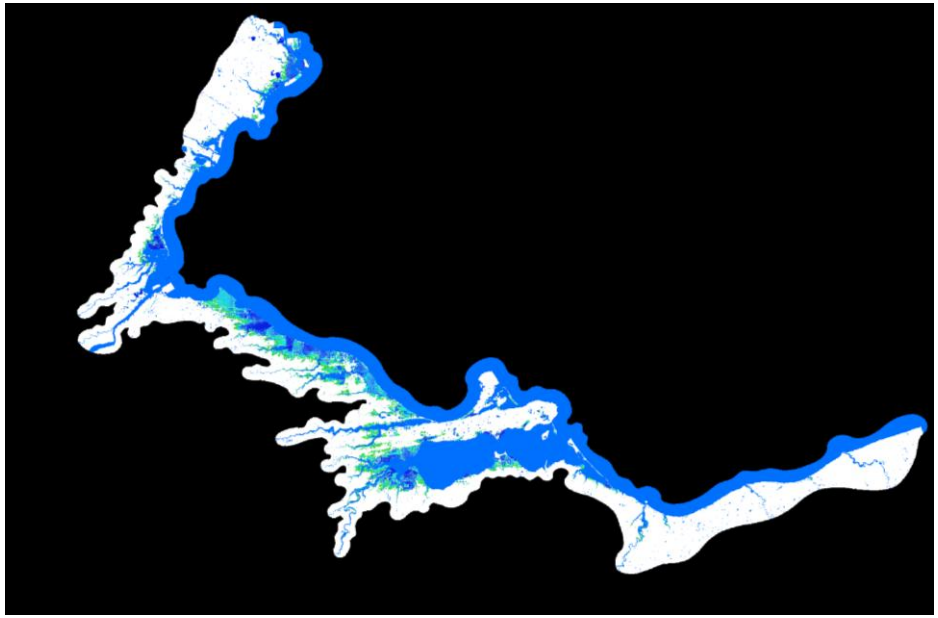
P2 Wetland Soils

P5 Impervious Surfaces

P3 Flowlines



P6 Landuse



P1 Hydroperiod

Purpose: Developed as the first parameter to the restorability model. Hydroperiod is the amount of time a coastal landscape area is inundated with surface water from western Lake Erie. Areas more frequently inundated are better for restoration.

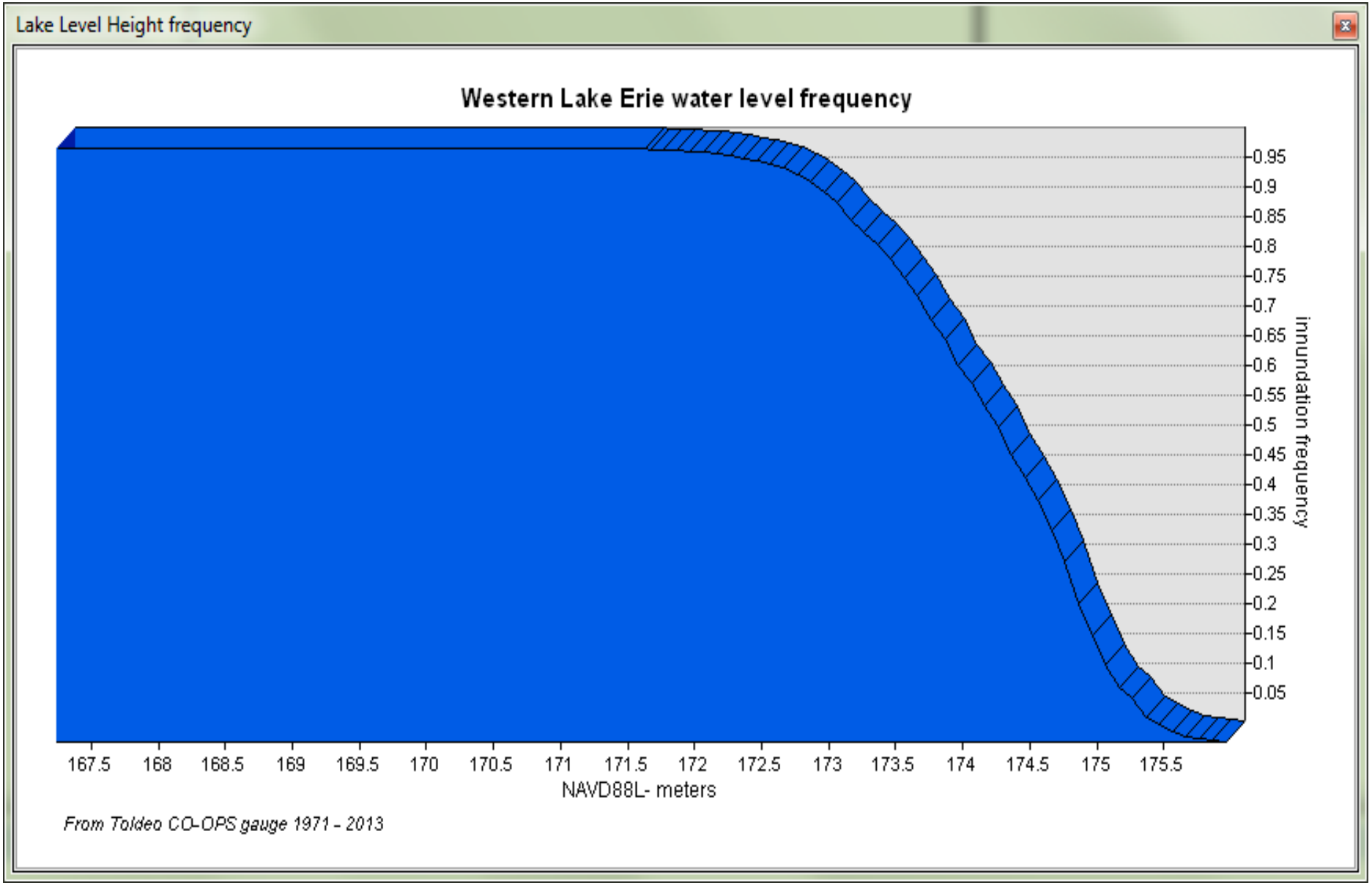
Attributes: Numerical values between 0.0 and 100.0. These represent percentages, as the percentage of time landscape areas are inundated.

Properties: Raster layer (Geo TIFF), 1-meter resolution, 142,610 x 98,740 cells, 21.09 Gb, cylindrical projection (UTM 17 North).

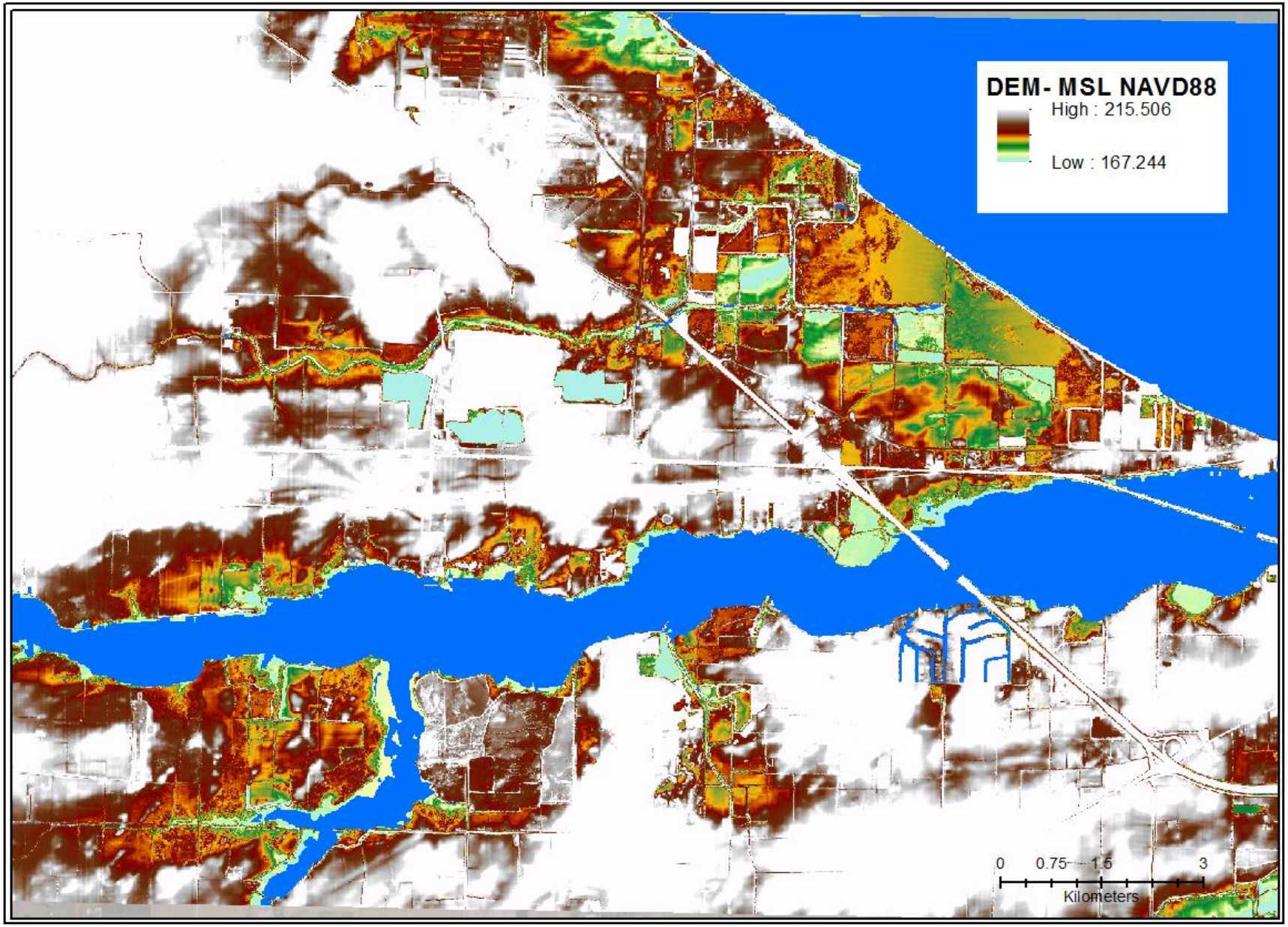
Derived: Reclassification from a statistical relationship between 30-year time series of lake level heights and bare earth lidar digital elevation model. Lake level heights were obtained from NOAA CO-OPS. Lidar was obtained from the State of Ohio and SEMCOG.

Limitations: Does not included flowline network for inundation. Uncertainty associated with lake level and terrain measurements. See hydroperiod error assessment.

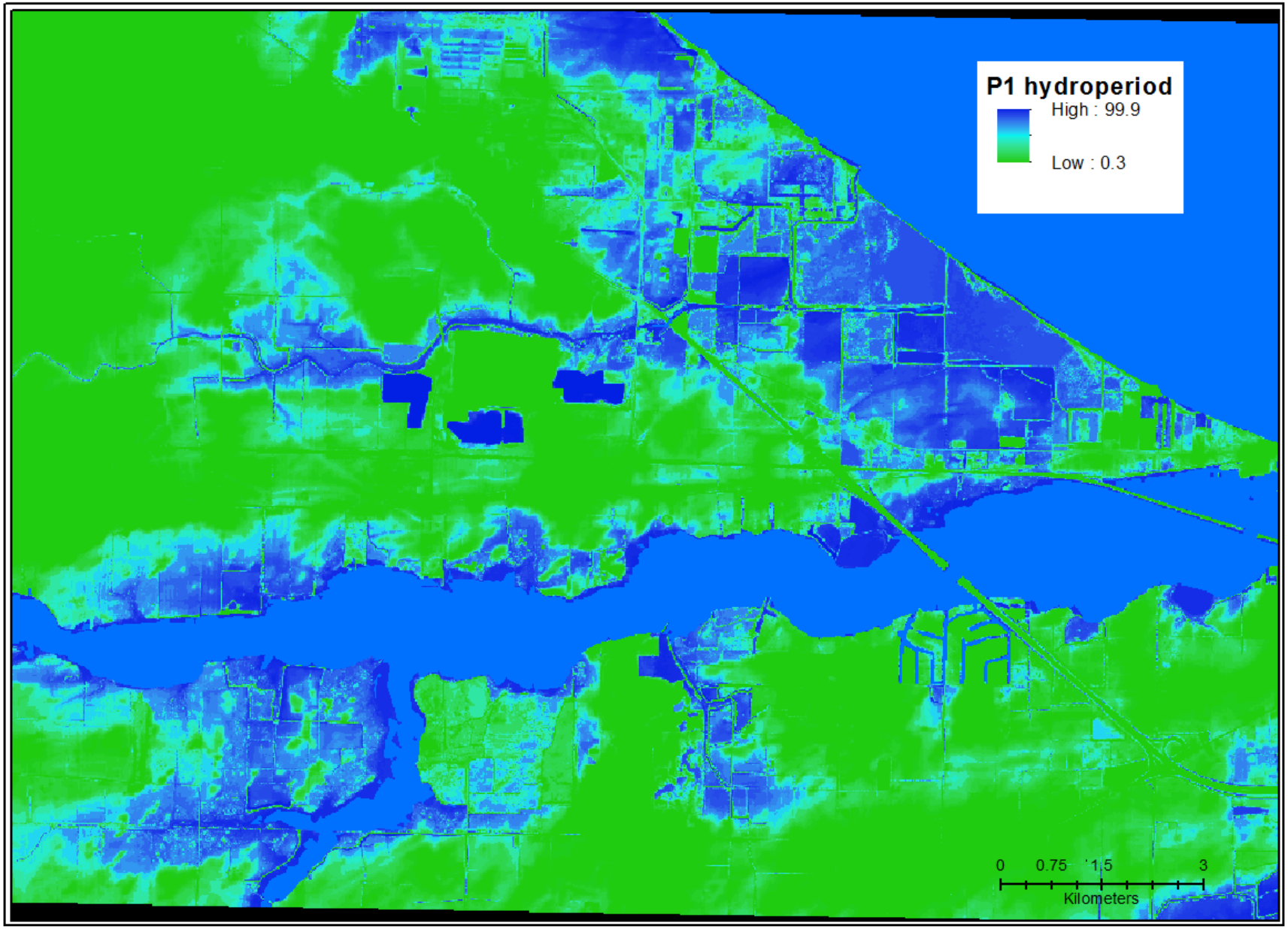
Statistically derived lake level hydroperiod



Terrain



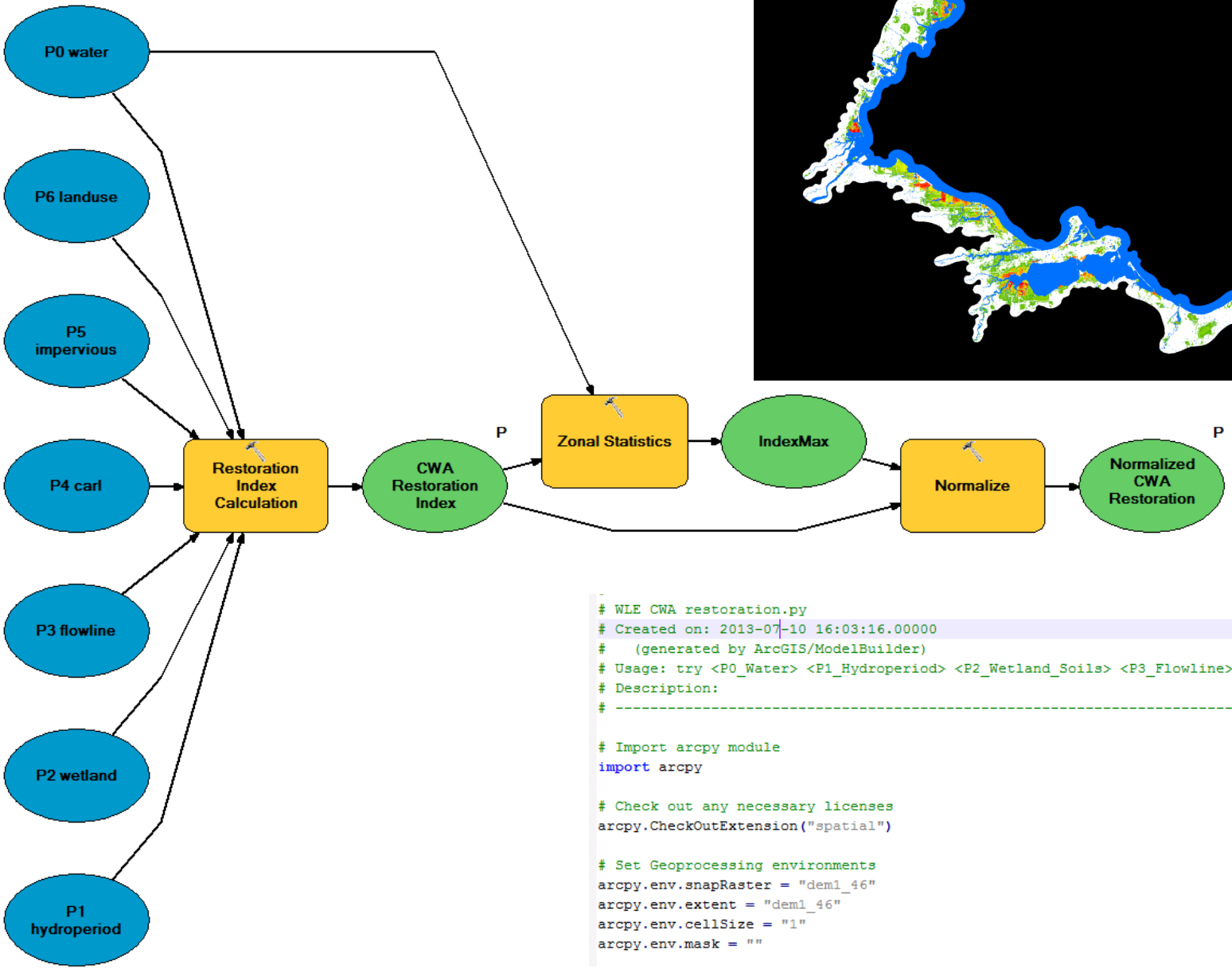
P1. Lake level hydroperiod

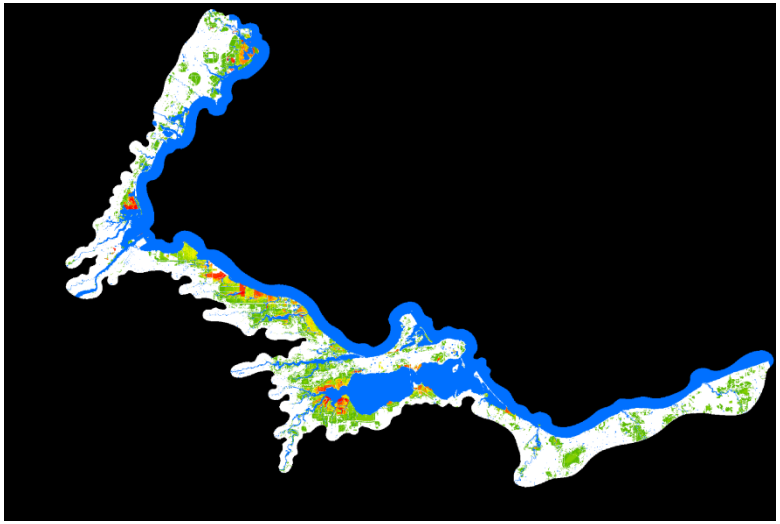


WLERA spatial model index formula.

$$f(x) = \sum_{n=1}^{\infty} \text{P0 water} \left(\frac{\text{P1 hydroperiod} + W2(\text{P2 wetland soils}) + W3(\text{P3 flowline}) + W4(\text{P4 CARL})}{\text{P5 impervious} + W6(\text{P6 landuse})} \right)$$

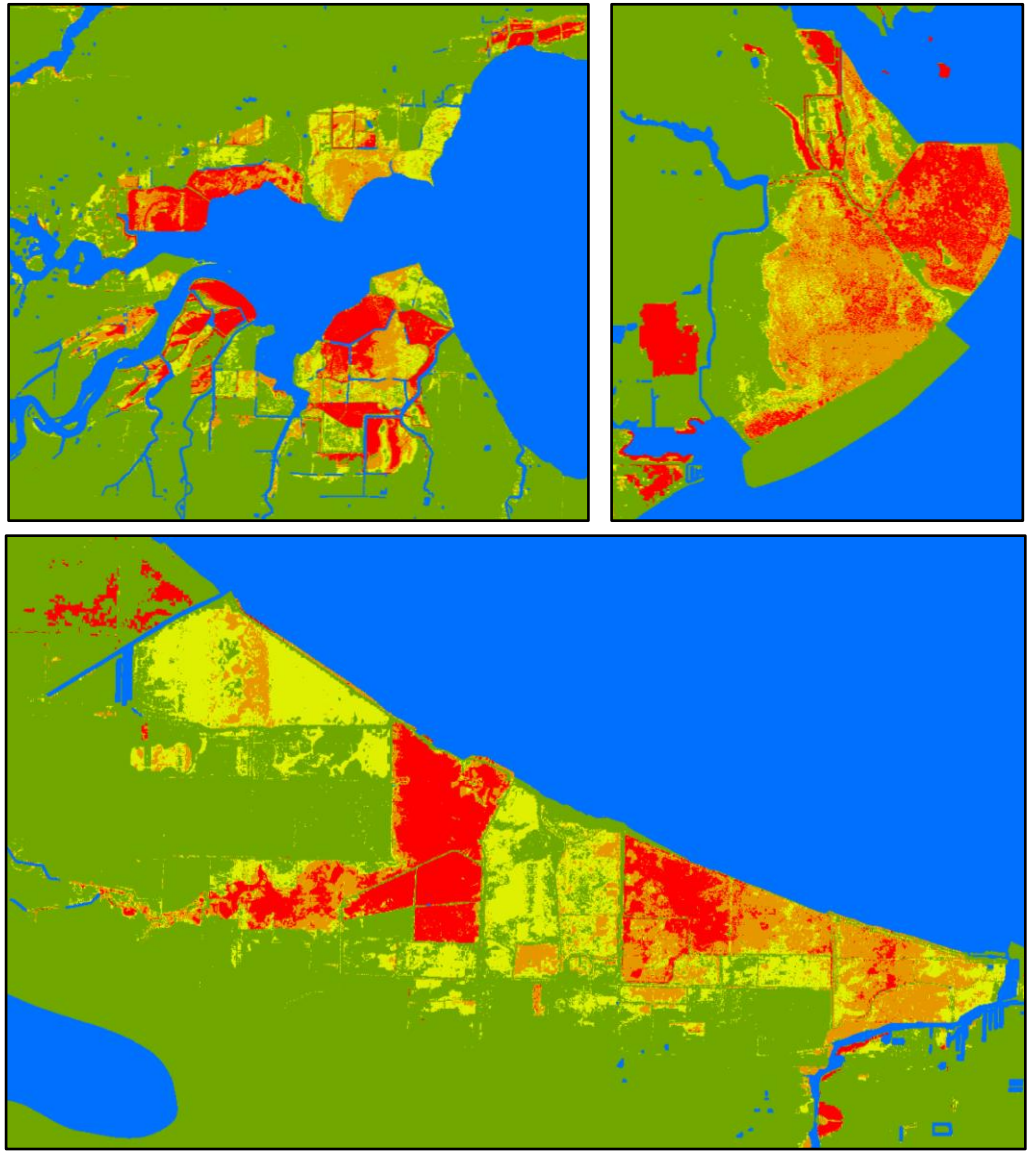
Design and implement





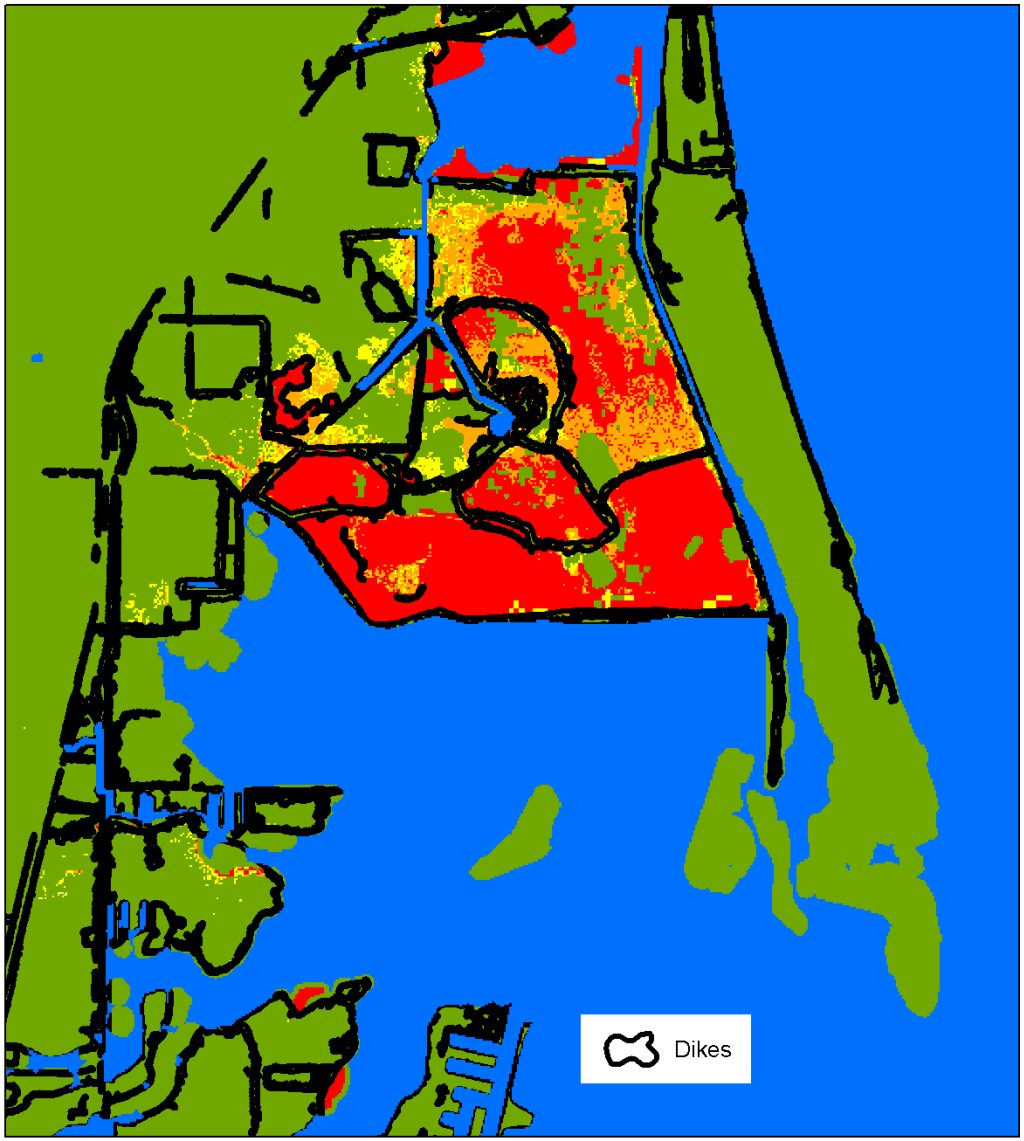
```
# WLE CWA restoration.py
# Created on: 2013-07-10 16:03:16.00000
#   (generated by ArcGIS/ModelBuilder)
# Usage: try <P0_Water> <P1_Hydroperiod> <P2_Wetland_Soils> <P3_Flowline> <P4_CARL> <P5_Ir
# Description:
# ---------------------------------------------------------------------------

# Import arcpy module
import arcpy

# Check out any necessary licenses
arcpy.CheckOutExtension("spatial")

# Set Geoprocessing environments
arcpy.env.snapRaster = "dem1_46"
arcpy.env.extent = "dem1_46"
arcpy.env.cellSize = "1"
arcpy.env.mask = ""
```

WLERA results- restorable areas



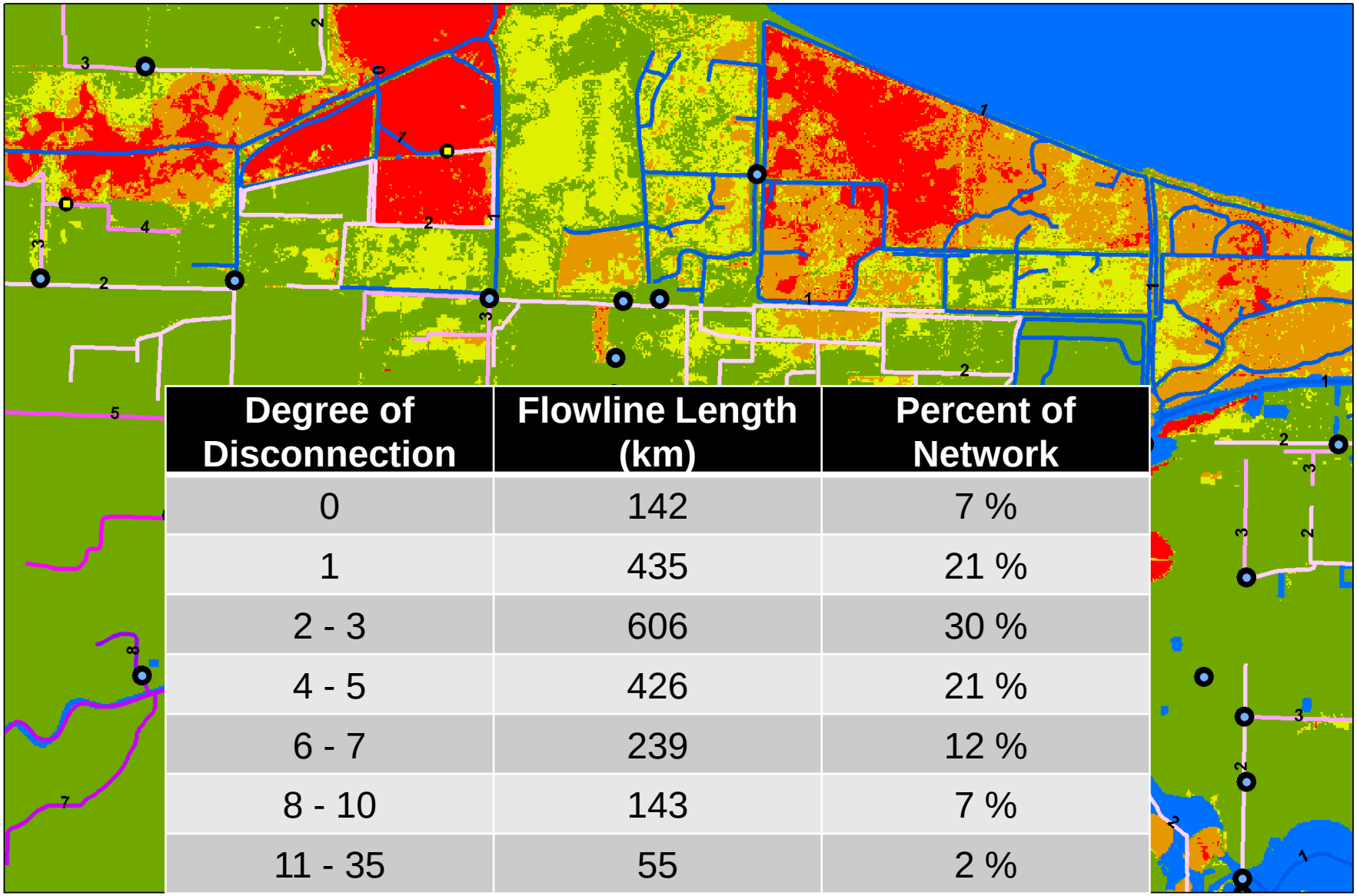
WLERA Range	Hectares	Percent of Study Area
Highly Restorable (100-81)	2,189	1.12%
Medium Restorable (80-61)	2,514	1.29%
Low Restorable (60-41)	2,860	1.46%
Not Restorable (41-0)	119,226	61%
WLERA Study Area (US)	195,621	100%

WLERA results- diked areas



WLERA Range	Diked Hectares	Percent of Range
Highly Restorable (100-81)	1,499	68.50%
Medium Restorable (80-61)	1,786	71.05%
Low Restorable (60-41)	2,405	84.08%
Not Restorable (41-0)	N/A	N/A

WLERA results- disconnection

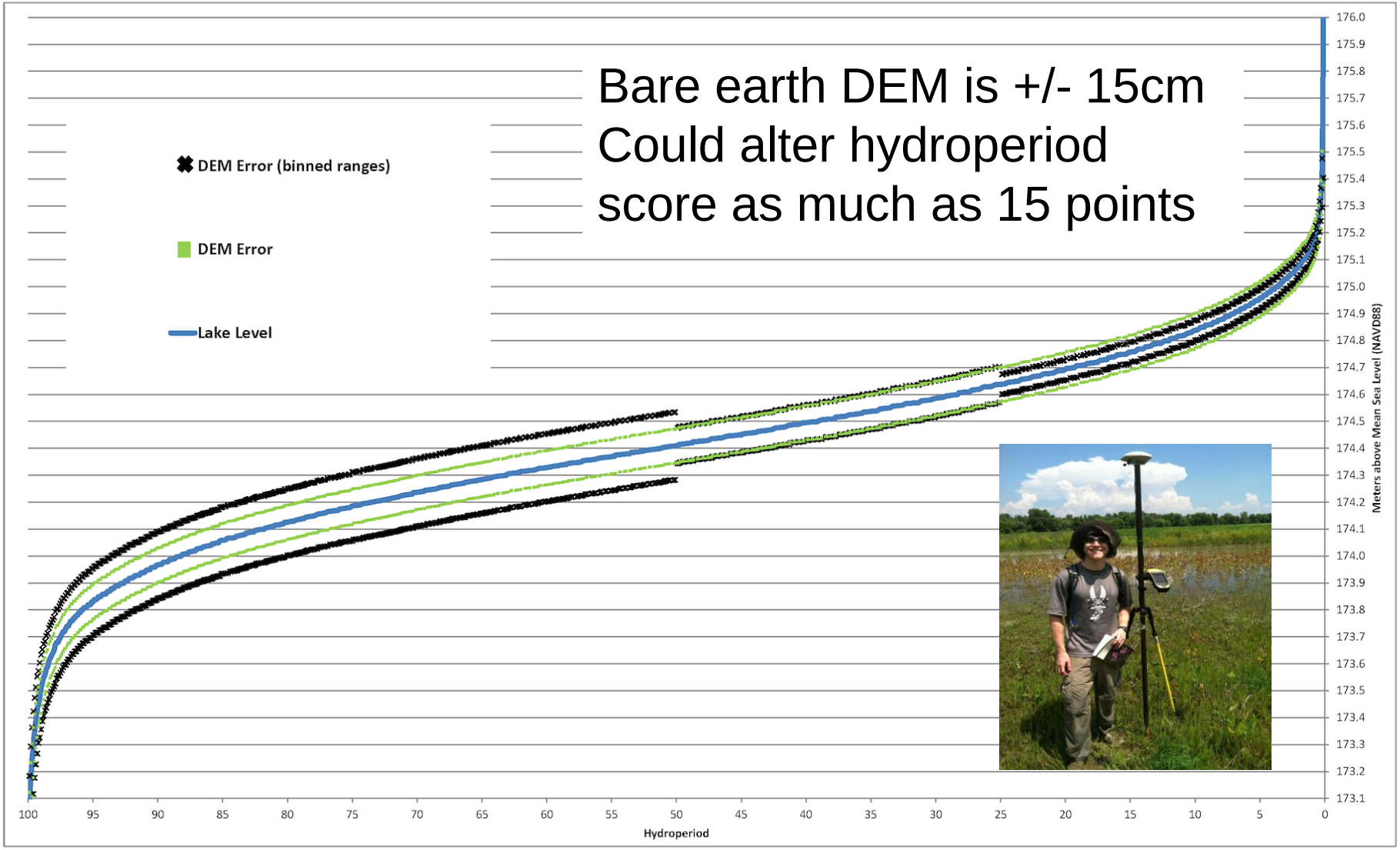


Degree of Disconnection	Flowline Length (km)	Percent of Network
0	142	7 %
1	435	21 %
2 - 3	606	30 %
4 - 5	426	21 %
6 - 7	239	12 %
8 - 10	143	7 %
11 - 35	55	2 %

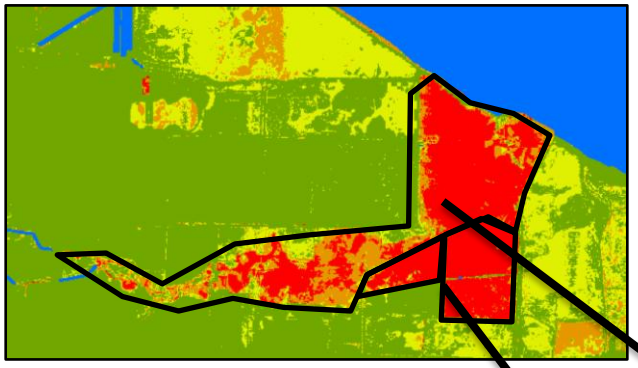
WLERA results- application summarizing areas by disaggregated model results

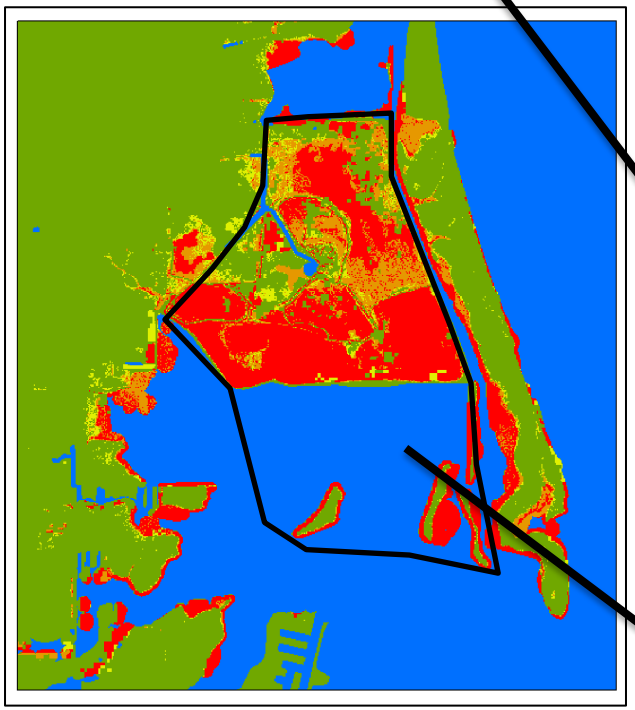
Parcel ID	I	1	2	3	4	5	6	D	H
42405	92	#	#	#	#	#	#	#	#
42432	80	#	#	#	#	#	#	#	#
42407	79	#	#	#	#	#	#	#	#
42428	0	#	#	#	#	#	#	#	#
42427	64	#	#	#	#	#	#	#	#
42418	70	#	#	#	#	#	#	#	#
42416	46	#	#	#	#	#	#	#	#
42410	24	#	#	#	#	#	#	#	#

Hydroperiod error assessment- Lake surface height frequency curve



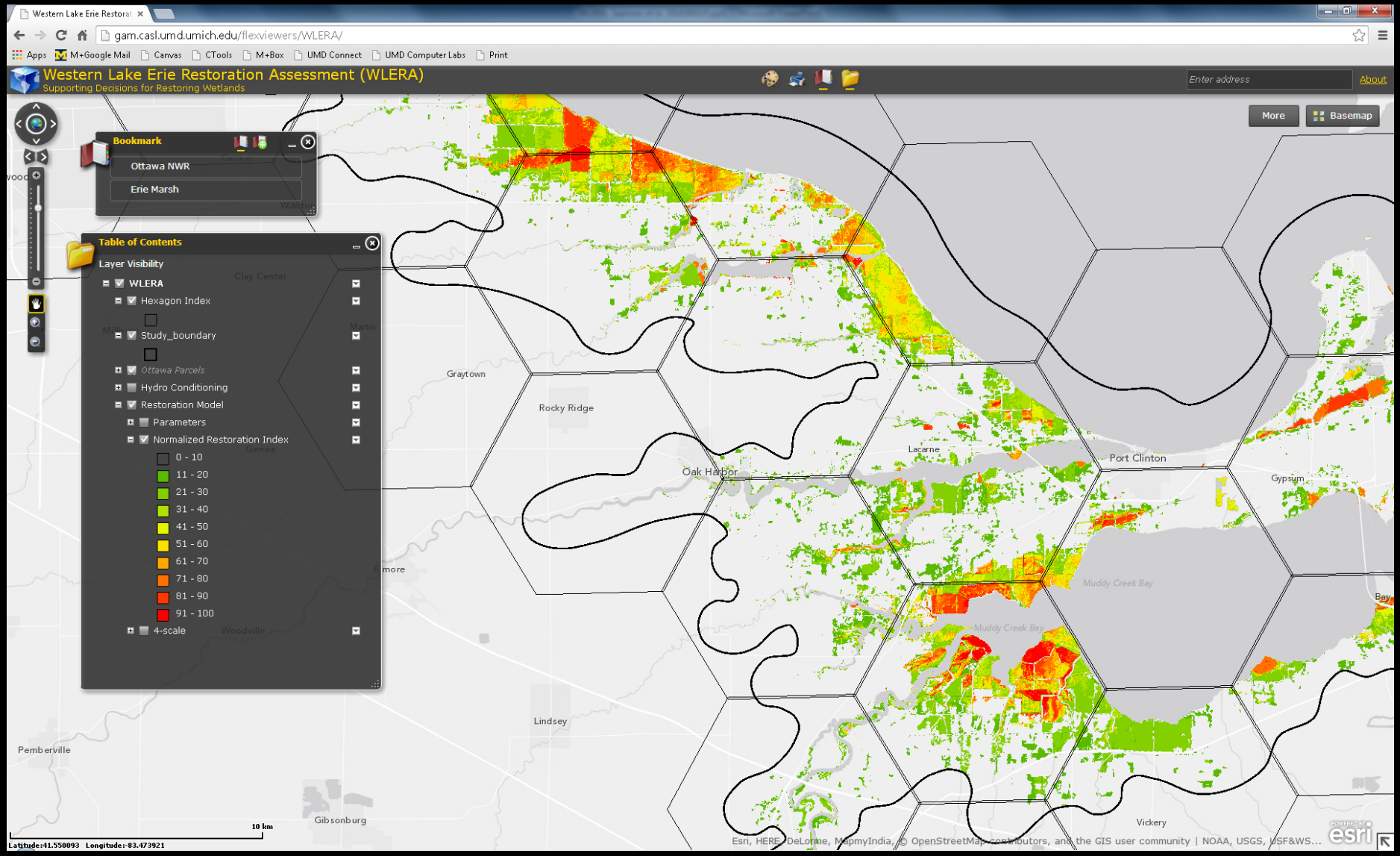
Validation and our confidence





Restoration Area	Area (ha)	Avg Score	Max Score
Toussaint Dike	45	37 ±23	76
Cedar Point Refuge 1	635	38 ±12	93
Cedar Point 2	65	36 ±14	80
Crane Creek	344	52 ±36	98
Crane Lake Pool 2A	29	80 ±27	97
Crane Lake Pool 2B	41	91 ±17	99
Point Aux Peaux	40	24 ±8	75
Blaussey Tract	105	40 ±26	99
Howards Farms	396	74 ±27	100
Erie Marsh	458	66 ±35	98

Deploy through GIS web services



How much potential coastal wetland area can be restored along western Lake Erie and where is it? (Check ☺)

NEXT→
How much ecological and economic benefit can be recovered by restoring these wetlands? What are the benefits and costs? How do we set obtainable ecosystem-based restoration goals?

WATER CENTER
UNIVERSITY OF MICHIGAN

Fred A. and Barbara M.
Erb Family Foundation

WATER QUALITY BENEFIT ASSESSMENT OF LAKE ERIE COASTAL WETLANDS

The U-M Water Center engages researchers, practitioners, policymakers, and non-profit groups with the goal of supporting, integrating, and improving current and future restoration and protection efforts.

The grants program is an important part of the Water Center's efforts to enhance restoration and protection activities by engaging exceptional multi-sector teams in advancing evaluation and assessment of restoration projects.

Investigators

Justin Saarinen, University of Michigan-Dearborn, jsaarine@umich.edu
Kurt Kowalski, USGS-Great Lakes Science Center

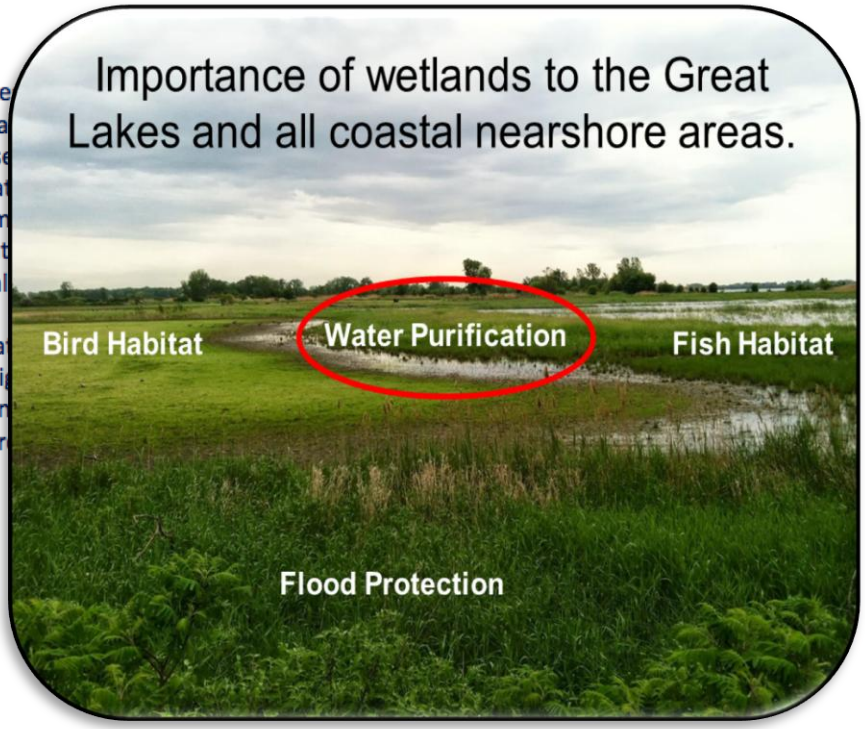
Partners

Rachael Franks-Taylor, The Nature Conservancy in Michigan
James Cole, The Nature Conservancy in Ohio

Project Summary

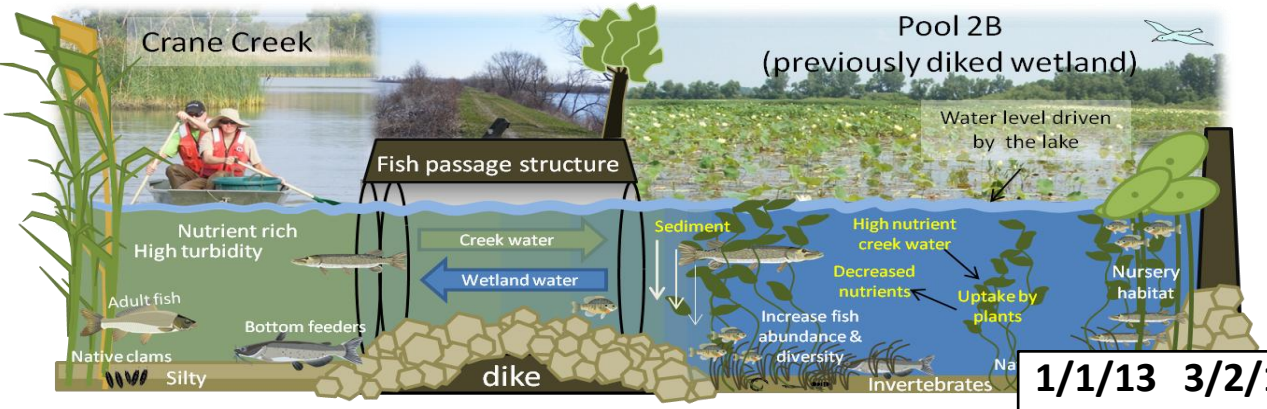
Fundamental questions about how humans affect Great Lake
have been well-studied and are summarized in the accumula
More recently, cumulative stress on the Great Lakes was asse
correlate with locations of landscape features , e.g. urbanizat
hardening, and ecosystem services directly beneficial to hum
Following ecosystem-based management strategies, restorat
be directed toward multiple stressors to maximize ecological

Currently, the National Oceanic and Atmospheric Administra
Survey, The Nature Conservancy, and the University of Michi
D) are assessing western Lake Erie's coastal and diked wetlar
could potentially be connected to the lake between the Detr

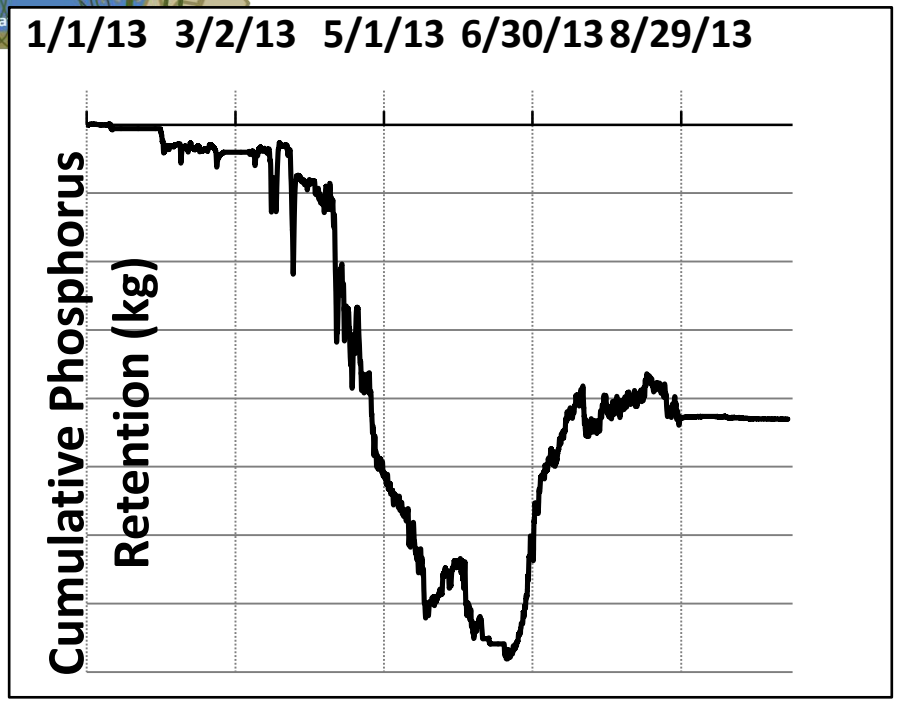


USGS- Great Lakes Science Center

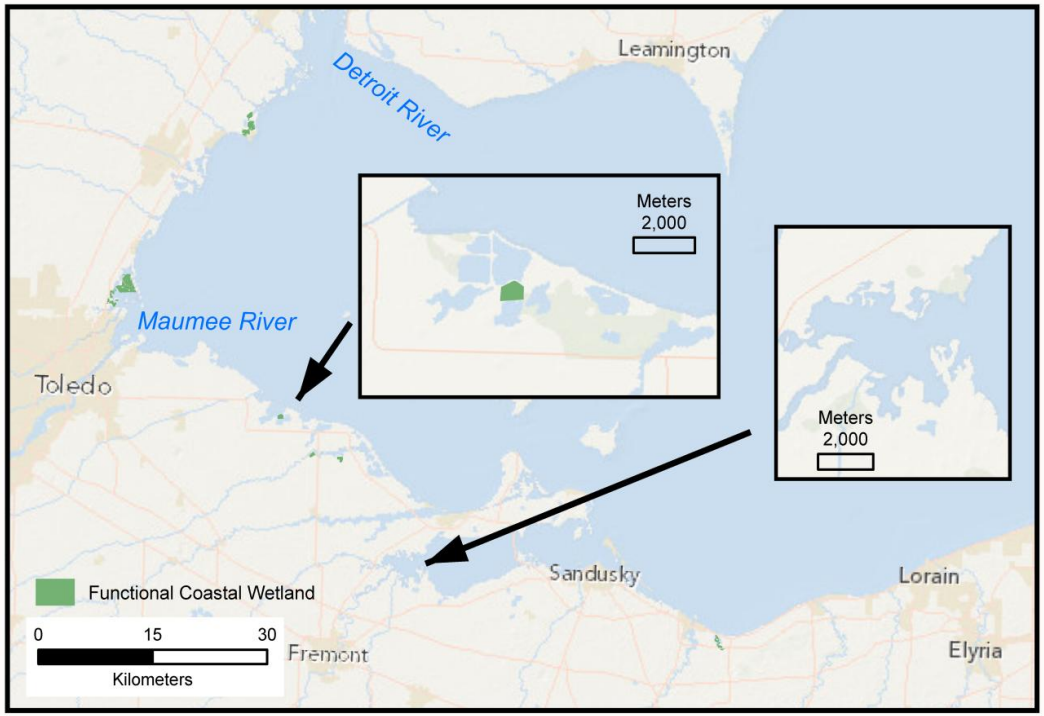
Question: Does restoring hydrology to a coastal wetland reduce nutrient concentrations (and benefit other services)?



Results: 43 kg of suspended total phosphorus (TP) was retained by this 40 ha wetland.



Alternative Restoration Futures



***Existing Landscape*:**

855 hectares of functional coastal wetlands.

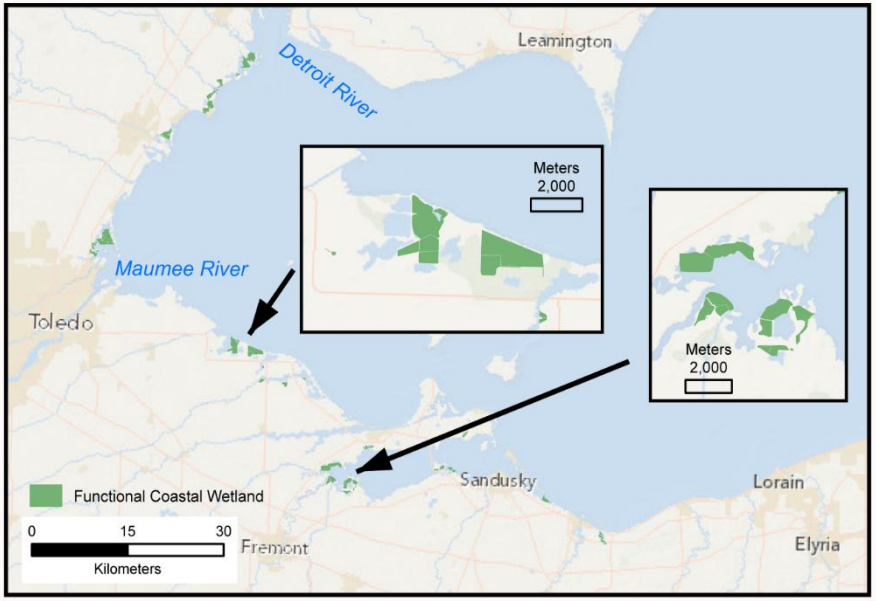
Restoration:

$36 Million spent over 3 years in WLE

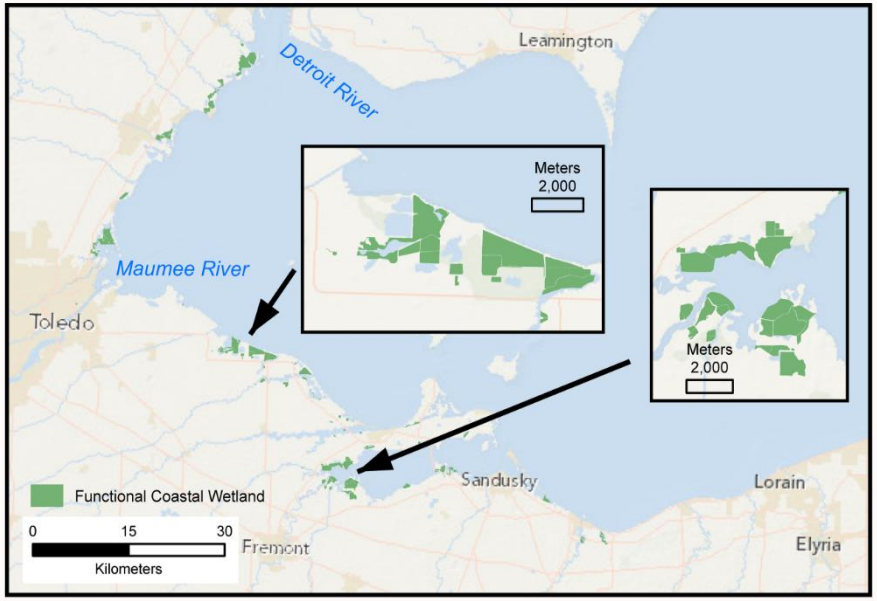
$11,000 / hectare for restoration

Restoration funding scenarios:

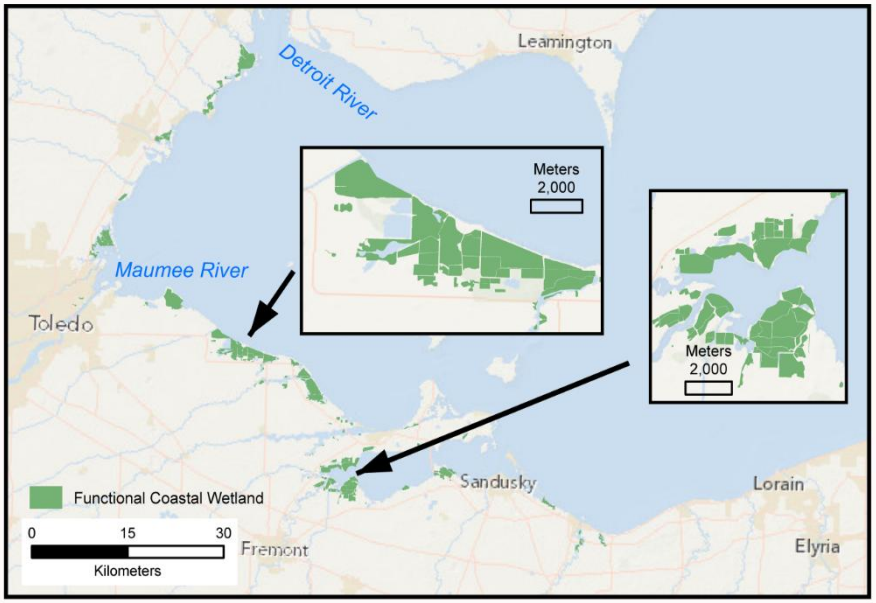
1) Reduced
2) Doubled
3) No Change
4) 2.5 times



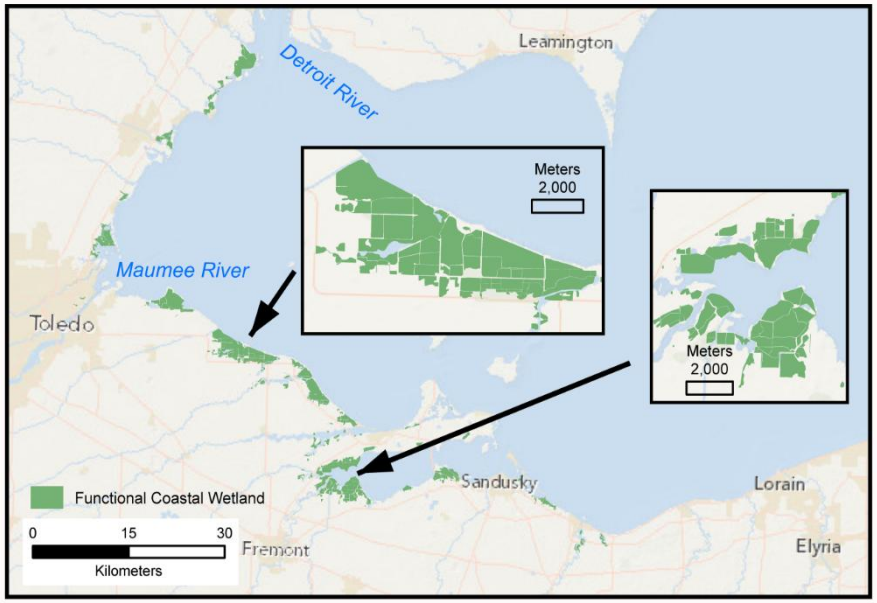
Reduced funding: 2,486 ha



No change funding: 4,118 ha



Doubled funding: 7,380 ha



2.5 x funding: 10,643 ha

Percent retention of total 2007 WLE TP load per restoration scenario

Percent retention (% / year) *

Funding scenarios

Western Lake Erie Basin	Low Example	Mid Example	High Example
Existing	0.01%	0.10%	3.11%
Reduced	0.04%	0.30%	9.10%
No Change	0.06%	0.50%	15.0%
Doubled	0.11%	0.90%	26.0%
2.5 X	0.16%	1.29%	38.7%

***Low Example*:** Measured mass retention of 43 kg / year at Crane Creek Pool 2B, 40 ha from Jan 1 – Aug 30, 2013. Kowalski unpublished data.

***Mid Example*:** Simulated retention of 0.79 g/m^2 per year at Old Woman Creek NERR, 60 ha for March 1 – Nov 30 1988. Mitsch and Breeder 1991.

***High Example*:** Measured mass retention of 3 g/m^2 per year at Old Woman Creek NERR, 60 ha for Mar 1 – Sept 1, 1988. Mitsch and Breeder 1993.

Outcomes and Opportunity

1. Estimated total amount of nutrient retention for WLE coastal wetlands.

2. Found a significant data gap of nutrient mass retention.

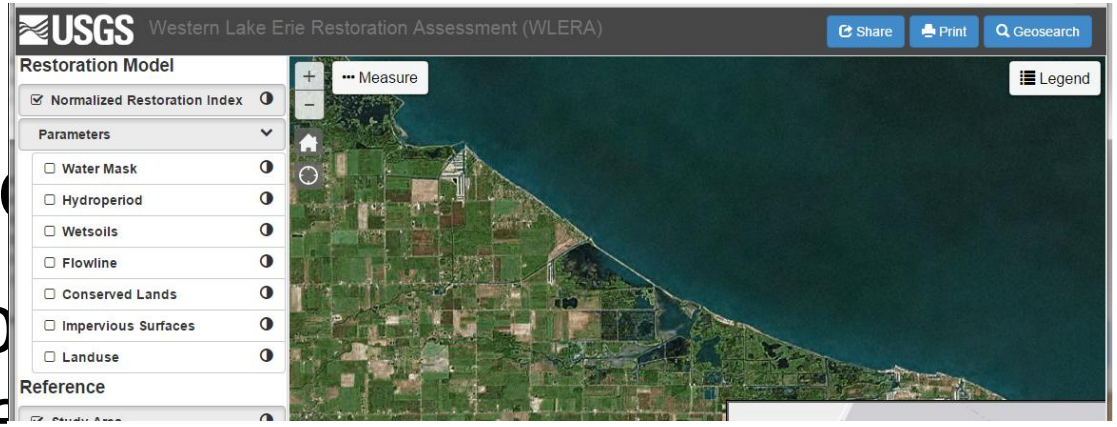
3. Identified a need in process modeling of coastal dynamics.

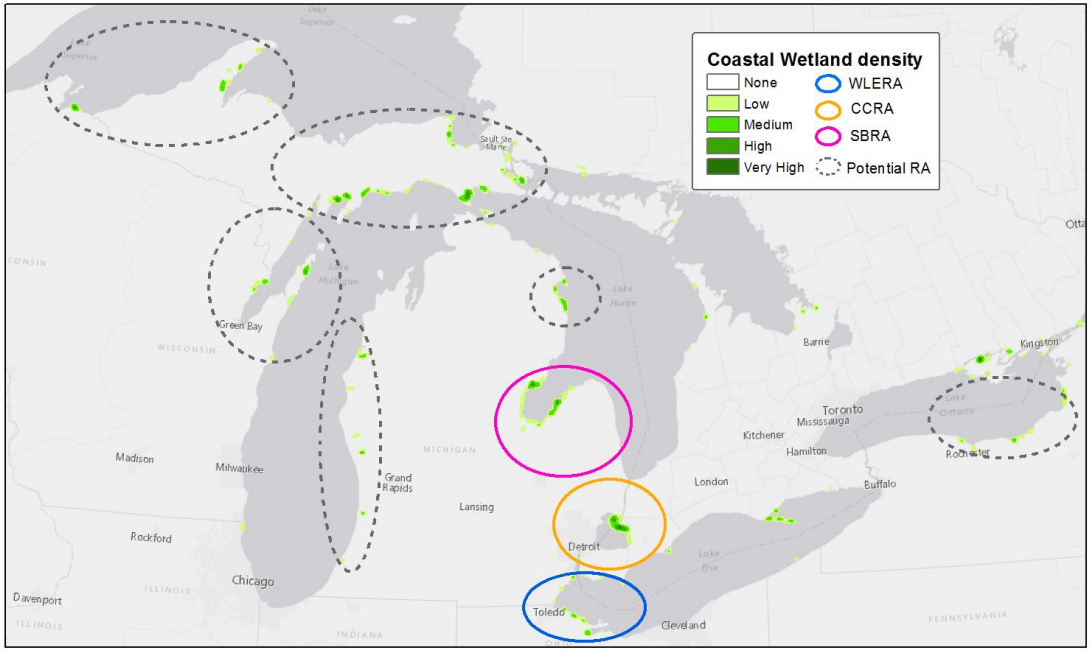
4. Scenarios and alternative futures studies for planning are effective.

Vision we are f

- User-friendly, po
  decisions, conse
  management.

- Increase our geo





- Precise spatially explicit ecosystem services models

Thank you!

Questions, Comments?

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