# Ecologically Engineered Wetlands as Solutions for Nutrient Pollution in Lakes, Wetlands, and Coastlines


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More than 750 aquatic ecosystems worldwide currently suffer from degraded conditions due to urban and agricultural inflows that cause water quality degradation—often referred to as hypoxic or harmful algal blooms due to nitrogen and phosphorus

# Recent estimates of global wetland losses

1. Prigent et al. (2012) found a 6 percent decrease in land-surface water on the world from 1993 to 2007 alone, presumably mostly due to wetland drainage and increased water withdrawals.
2. TEEB (The Economics of Ecosystems & Biodiversity) study (Russi et al. 2013): world lost half of its wetlands in the twentieth century alone, reduced from 25 million $km^2$ to current 12.8 million $km^2$
3. Davidson (2014), in an analysis of 63 reports and other publications, determined that the world lost 53.5 percent of its wetlands "long-term" (i.e., multi-century) with higher loss rates in inland vs. coastal wetlands.

Source: Mitsch and Gosselink, 2015

Wetlands provide valuable “ecosystem services”:

- Water purification
- Flood regulation/storm protection
- Biodiversity islands and corridors
- Climate regulation (Carbon sequestration)
- Locations for human relaxation and nature observation/education

Source: Millennium Ecosystem Assessment 2005

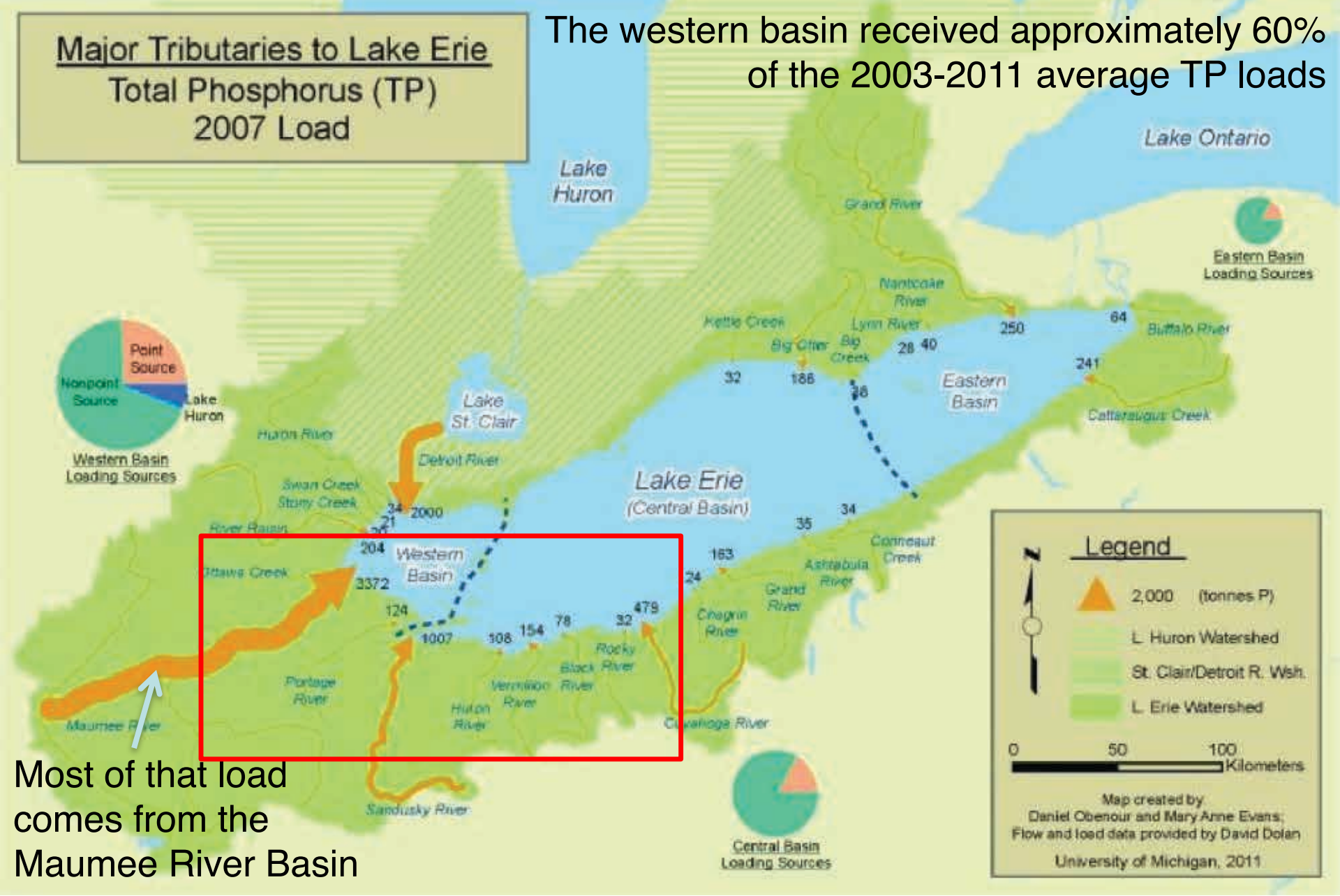
There are many opportunities to "ecologically engineer" a reversal the global loss of wetlands and at the same time mitigate, in a sustainable way, some of the most alarming pollution problems on our landscapes related to phosphorus, nitrogen, and carbon.

# Case Study 1
# Solving Lake Erie Eutrophication in the Laurentian Great Lakes

# Lake Erie Algal Blooms


"Nutrient impairment continues to plague Lake Erie, impacting an $11.5 billion tourism industry"
*Ohio Lake Erie Phosphorus Task Force (Nov 2013)*

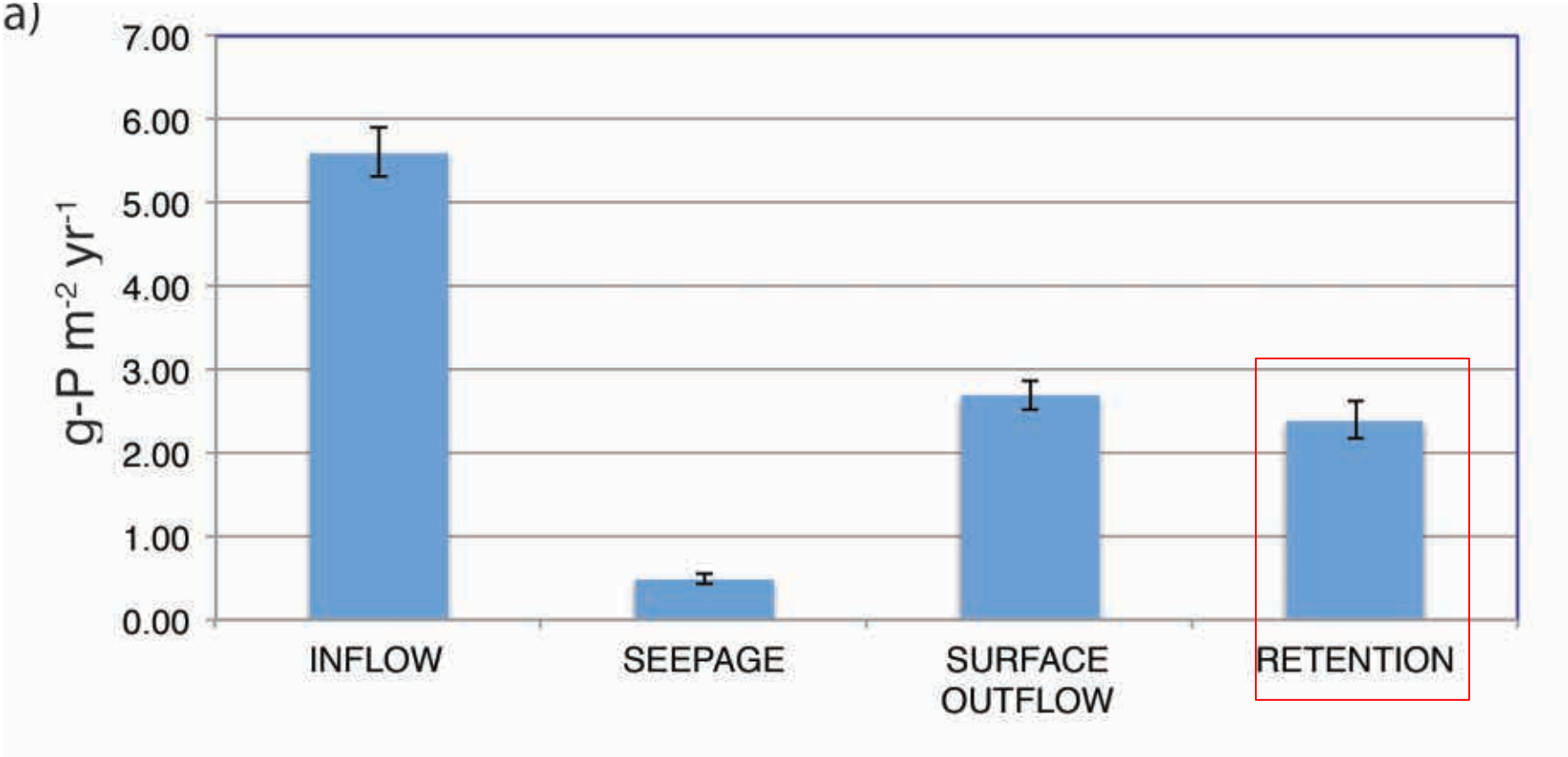
Satellite Image from Sept 3, 2011 of Western Lake Erie (Michalak et al. 2013) PNAS




Source: Scavia et al (2012) J. Great Lakes Res

# Olentangy River Wetland Research Park,  Columbus Ohio

# Annual Phosphorus Budgets, Olentangy River Wetland experimental wetlands, 1994 - 2010

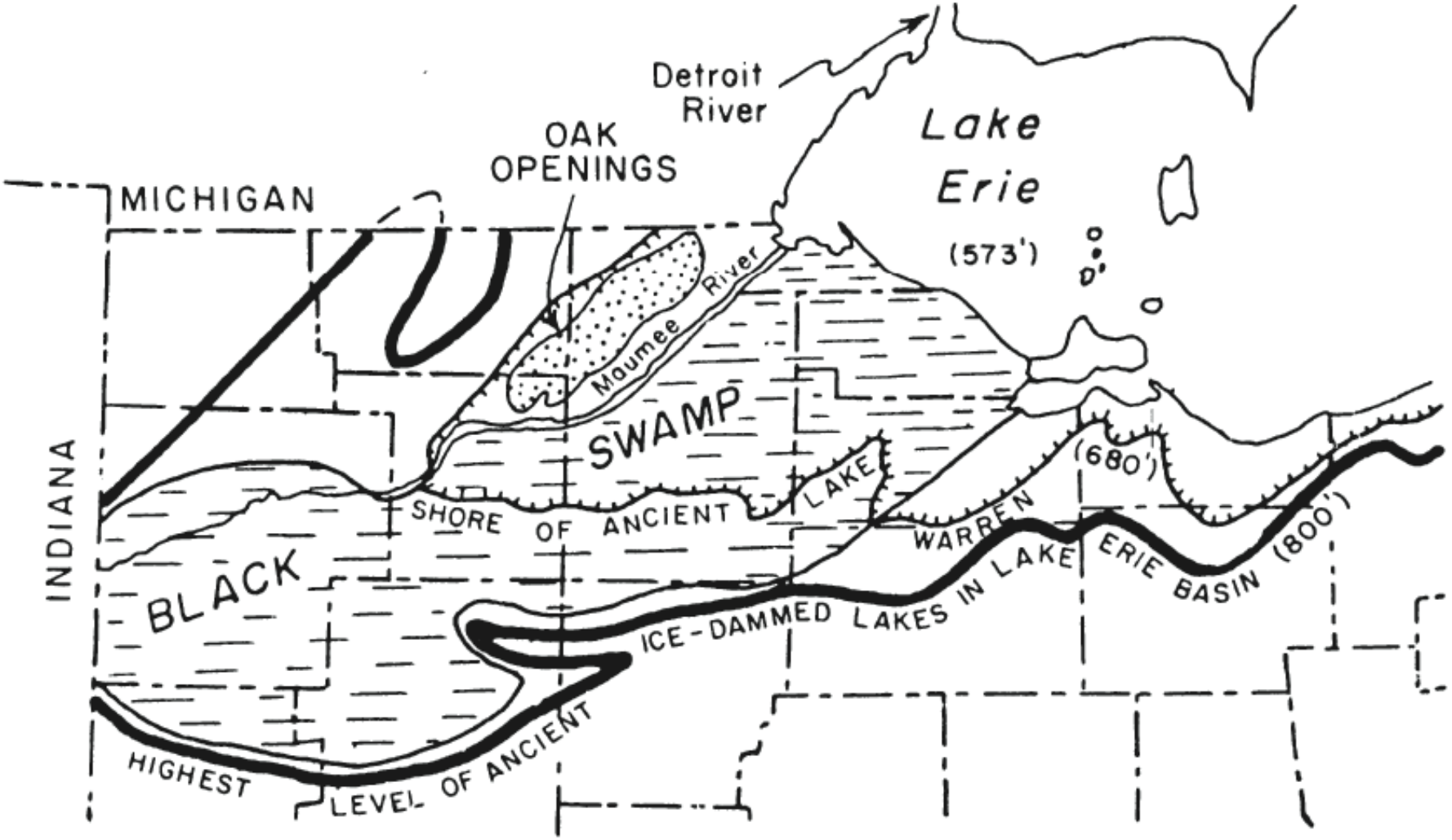



Mitsch et al. 2014

# Restoring the Black Swamp to Save Lake Erie

**By William J. Mitsch**
**Sept. 4, 2014  Water Environment Federation**

The harmful algal blooms in western Lake Erie for the past few years and the toxic algae that caused Toledo Ohio to shut down the municipal water supply in August 2014 are symptomatic that there is something very wrong with the way we are managing our landscapes. Nutrients, especially phosphorus are pouring into this shallowest (18 m average) portion of the shallowest Great Lake, mostly as runoff from agricultural fields, are causing seasonal bursts in algal production with their accompanying problems of slimy aesthetics, dissolved oxygen depletion in bottom waters, fish kills, and toxicity.




The original **Black Swamp** was combination of marshland and forested swamps that extended about 160 km long and 40 km wide in a northeasterly direction from Indiana toward Lake Erie and covered an estimated 400,000 ha. It has been completely drained.


# Wetlands in Lake Erie Watershed in Ohio, 1780s


# Wetlands in Lake Erie Watershed in Ohio today

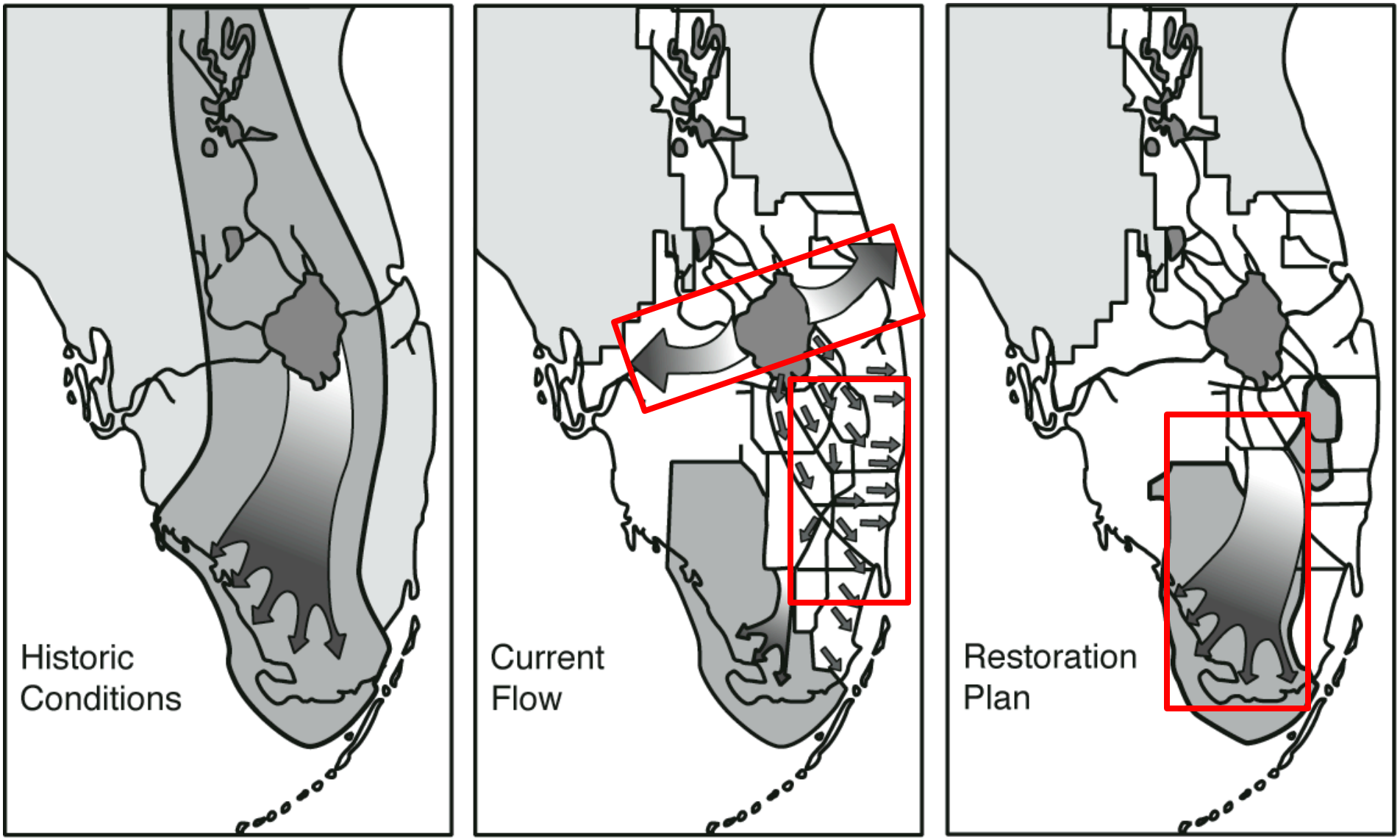

# Learning to Love the Great Black Swamp

**Midwestern settlers worked for generations to tame the wicked swamplands west of Lake Erie. Can they be convinced to give some back?**

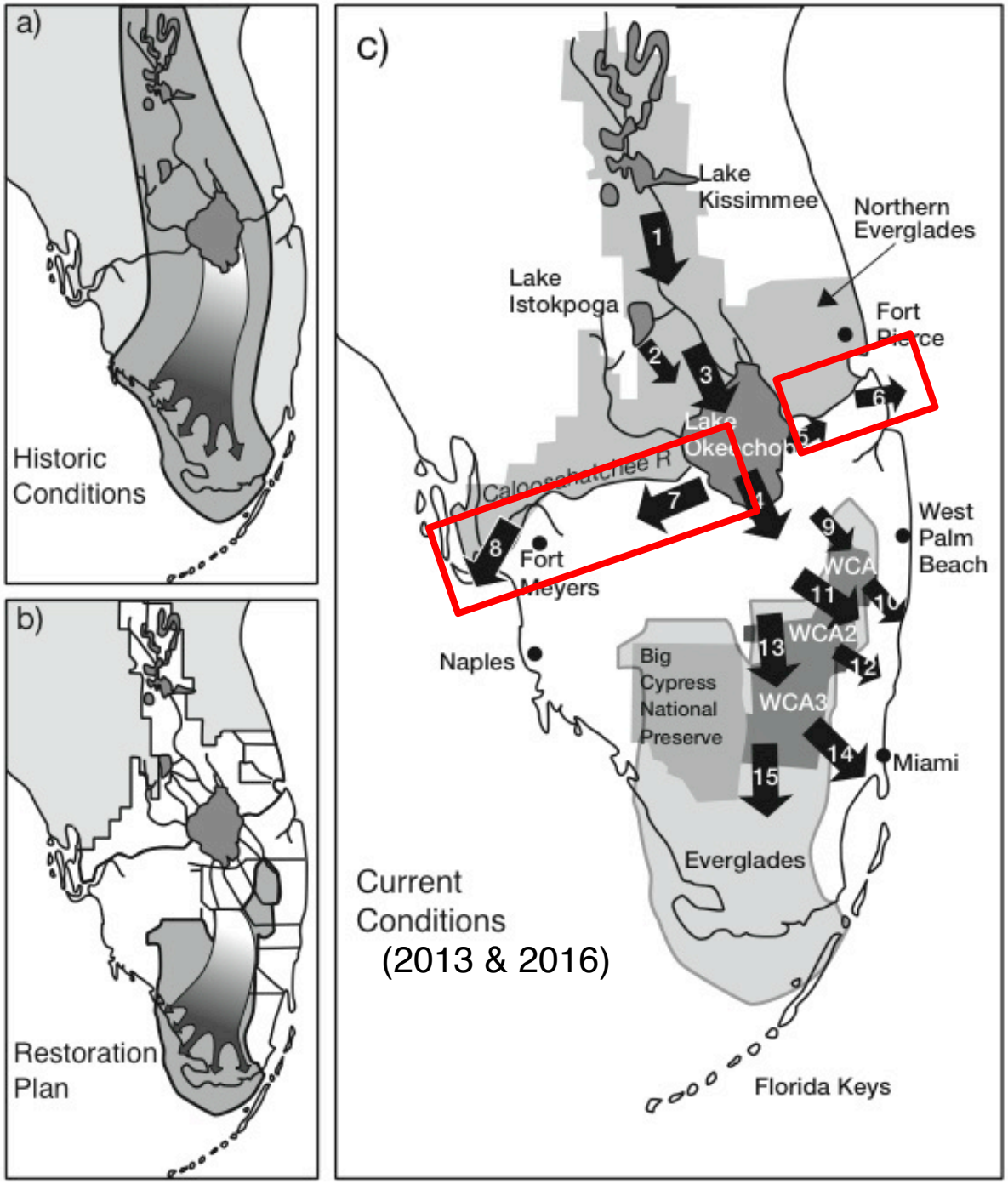
https://undark.org/

# Case Study 2
# Protecting the Florida Everglades and Coastal Florida from Excessive Nutrients

# Restoring the Florida Everglades




Source: Mitsch and Gosselink, 2015


a)
Historic Conditions
b)
Restoration Plan
c)
Lake Kissimmee
Northern Everglades
Lake Istokpoga
Fort Pierce
Lake Okeechobee
Caloosahatchee R
Fort Meyers
West Palm Beach
WCA
WCA2
WCA3
Naples
Big Cypress National Preserve
Miami
Everglades
Florida Keys
Current Conditions
(2013 & 2016)

# Recent Coastal Water Pollution Episode

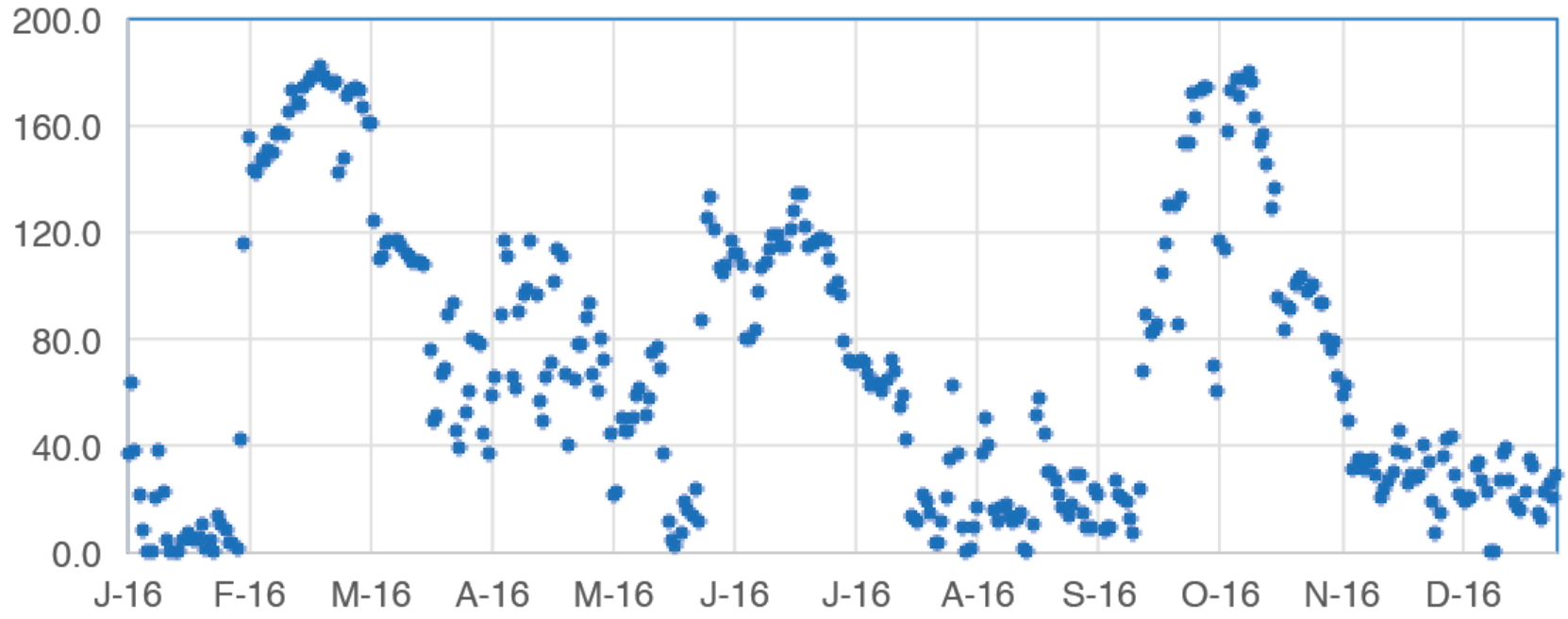
Gulf of Mexico

January 31, 2016 and through much of 2016


- An unseasonable amount of precipitation (>30 cm) fell on south Florida in the "dry season" in January 2016 due to extensive frontal storms caused by El Nino.
- Hundreds of million $m^3$ of polluted Lake Okeechobee (Lake O) water was sent down the Caloosahatchee River to the Gulf of Mexico and the St. Lucie Canal to the Atlantic Ocean beginning January 31 2016, severely polluting both estuaries. The flow continued more or less for the rest of 2016.
- The pumping of water to these outlets was deemed necessary because of high and unsafe Lake Okeechobee water levels, which were, in turn, due to the high rainfall events in January and back-pumping of even more water from flooded farmlands south of Lake O by the state of Florida.

# Discharge from Lake O to Caloosahatchee, 2016

m3/sec



Freshwater discharges from Lake Okeechobee to the sea in 2016

| | **x $10^9$ $m^3$** |
|---|---|
| Discharge to Caloosahatachee and Gulf of Mexico | 2.2 |
| Discharge to St. Lucie and Atlantic Ocean | 0.9 |
| TOTAL Discharge to the Sea in 2016 | 3.1 |
| Equivalent depth of Lake O discharged to sea | 1.6 m |

Lake O average depth < 3 m

*LOCAL*

# US Corps of Engineers was Unprepared for Wet January, says Local Wetlands Expert

By Silmedia Feb 03, 2016

*Photo provided.*

*By David Silverberg, special to the Naples Herald*

The US Army Corps of Engineers failed to prepare for a wet January that raised the level of Lake Okeechobee – leading to the pollution of nearby Gulf waters, according to a leading, Naples-based wetlands expert.

"They were asked to be prepared and they were not," William Mitsch, director of Florida Gulf Coast University's Everglades Wetland Research Park in Naples, told an audience visiting the Research Park in observance of World Wetland Day yesterday.

"I think it's a tragedy, what is going on now," said Mitsch in response to an audience question. Because this is an El Niño year, the dry season, which usually runs from November to April has been unusually wet, particularly in January.

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Editorial

# Restoring the greater Florida Everglades, once and for all

A B S T R A C T

The dilemma and ultimate solutions to recent ecological and economic disasters of polluted farm runoff being discharged in the Florida estuaries, described by some as much more severe than anything that happened to Florida's coastline during the 2010 BP oil spill on the Gulf of Mexico, is presented. Two particularly notable episodes have occurred in the last few years. In 2013, 746 million $m^3$/yr of water from Lake Okeechobee was discharged to the Gulf of Mexico and Atlantic Ocean estuaries, much of it in the summer wet season, with significant ecological disruption on both coasts. In February 2016, an unusually high amount of precipitation in the dry season (>30 cm in January 2015) led to 326 million $m^3$ of polluted Lake Okeechobee water being discharged to the sea over a 2-week period in early February. The obvious solution to this estuarine pollution is to allow water from the lake to flow to south as it historically did before water management was imposed on the lake and watershed. But that would cause polluted water to flow to the oligotrophic and much treasured Florida Everglades. We estimate that the water quality issue could be solved by creating an additional 40,000 Ha of stormwater treatment wetlands. Those would complement the 23,000 Ha of stormwater treatment wetlands that have already been created. Creating a deepwater reservoir to store the excess water is not a sustainable option.



There is currently major concern being expressed throughout Florida USA about the recent pulses of an excessive amount of polluted farm water from the 1890-$km^2$ shallow and eutrophic Lake Okeechobee (also known as "Lake O") into the Caloosahatchee River to the west and into the St. Lucie River to the east by the U.S. Army levels, which were, in turn, due to excessively high rainfall events in late January and back-pumping of even more water from flooded farmlands south of Lake O by the state of Florida.

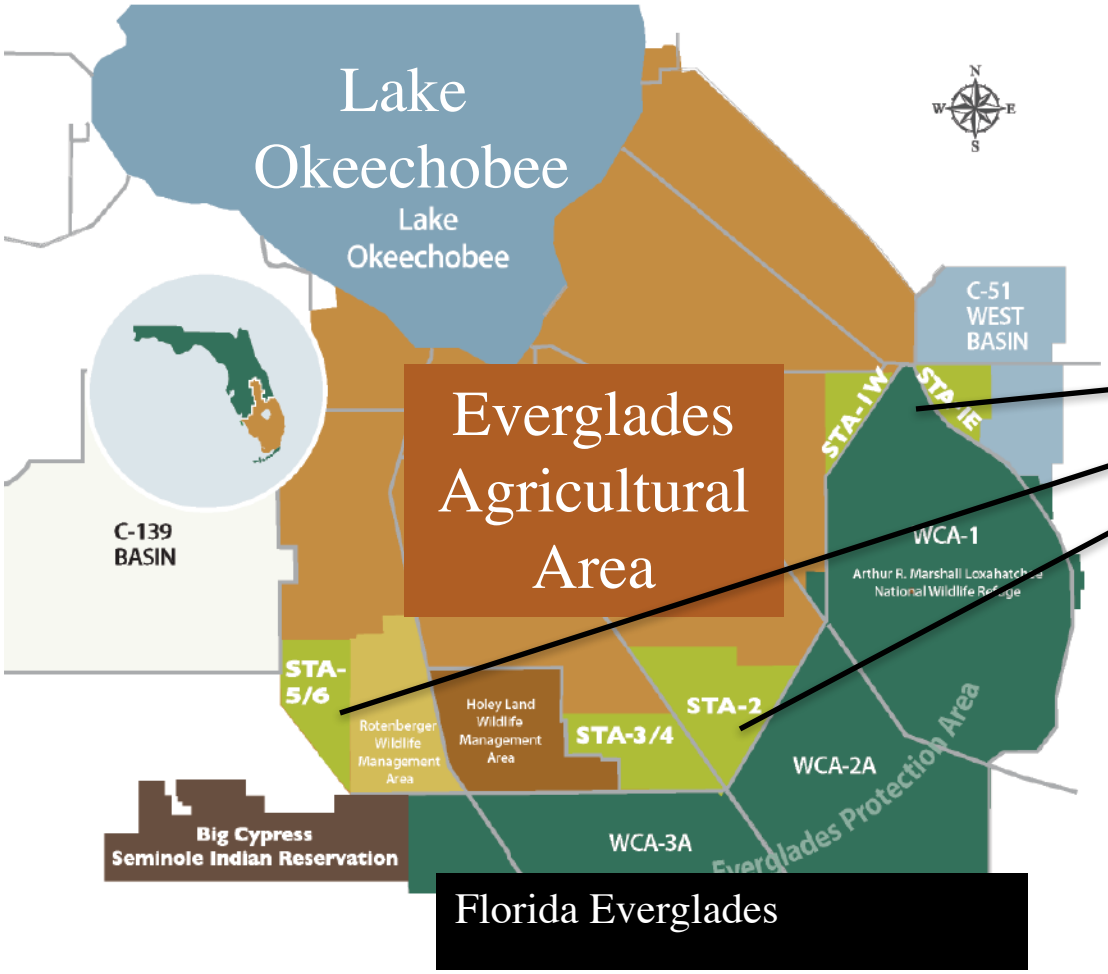
There are several concerns because of this management practice as the Florida Everglades is being restored. First, the agencies in

# Florida governor declares state of emergency over 'guacamole-thick' algae

Published June 30, 2016 FoxNews.com


LOOK GEORGE, YOU CAN SEE THE CORRUPT & IMMORAL ENVIRONMENTAL POLICIES FROM HERE!
FLORIDA
Andy
Marlette
WS Journal

# Treatment Wetlands in the Everglades aka Stormwater Treatment Area (STA's)



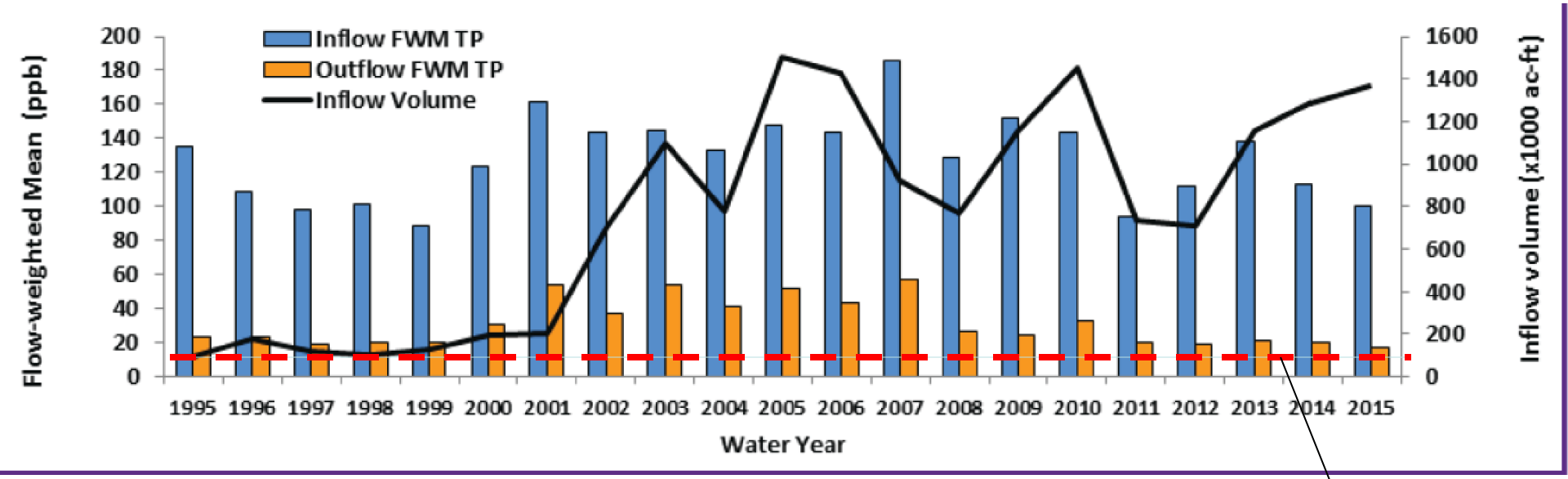

Stormwater Treatment Areas (light green)

**23,000 ha of these wetlands have been created.**

Source: SFWMD

# Stormwater Treatment Areas (STAs) upstream of Everglades

# Annual flow and inflow and outflow phosphorus concentrations in treatment wetlands (STAs) in northern Everglades designed to reduce phosphorus from agricultural runoff




In 2015
Inflow P: 99 ppb
Outflow P: 17 ppb

Source: SFWMD 2016 report

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journal homepage: www.elsevier.com/locate/ecoleng

# Protecting the Florida Everglades wetlands with wetlands: Can stormwater phosphorus be reduced to oligotrophic conditions?

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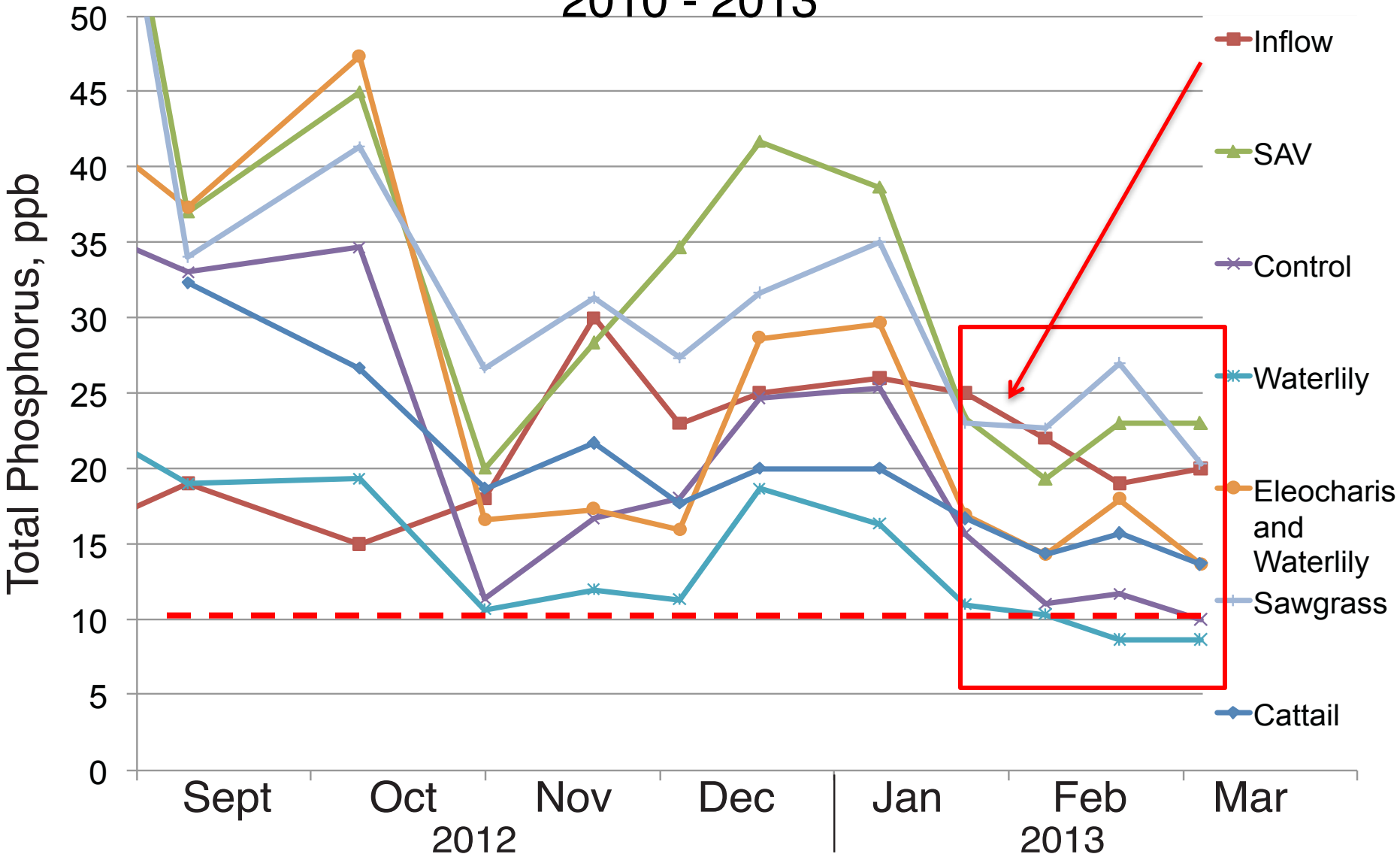
*Nymphaea odorata*
*Typha domingensis*
*Najas guadalupensis*

ABSTRACT

The Florida Everglades is being threatened by high-nutrient stormwater coming from agricultural runoff. The main nutrient problem is phosphorus, which causes the highly oligotrophic sawgrass (*Cladium jamaicense*) communities in the northern Everglades to become eutrophic *Typha latifolia*/*T. domingensis* communities. Current government directives require that the total phosphorus concentration of storm water drainage into the Everglades be limited to approximately 10 ppb (μg-P/L). Over 23,000 ha treatment wetlands, referred to locally as stormwater treatment areas (STAs), have been created from farmland to treat the stormwater. They are generally effective in removing 60–80% of the total phosphorus; however, the 10 ppb goal has rarely been achieved. A three-year experiment, involving mesocosms planted with Everglades-native wetland plants was conducted in the Florida Everglades from March 2010 to March 2013. Eighteen flow-through mesocosms (6 m × 1 m × 1 m with 40-cm water depth) received about 2.6 cm/day inflow. The eighteen mesocosms were randomly assigned with six different plant communities with three replicates of each treatment, consisting of sawgrass (*C. jamaicense*); waterlily (*Nymphaea odorata*); cattail (*Typha domingensis*); submerged aquatic vegetation (SAV) including *Najas guadalupensis*, and *Chara* sp. and a *Nymphaea–Eleocharis* sp. mixed community; and soil without vegetation as a control. Total phosphorus (TP) in the inflow water was 25 ± 1 μg-P/L ($n$ = 55) over the 3 years. Through 2012 the average outflow of all of the treatments was 34 ± 1 μg-P/L, a 51%


Stormwater Treatment Area (STA) mesocosm experiment
2010 - 2013

# Stormwater Treatment Area (STA) mesocosm experiment 2010 - 2013

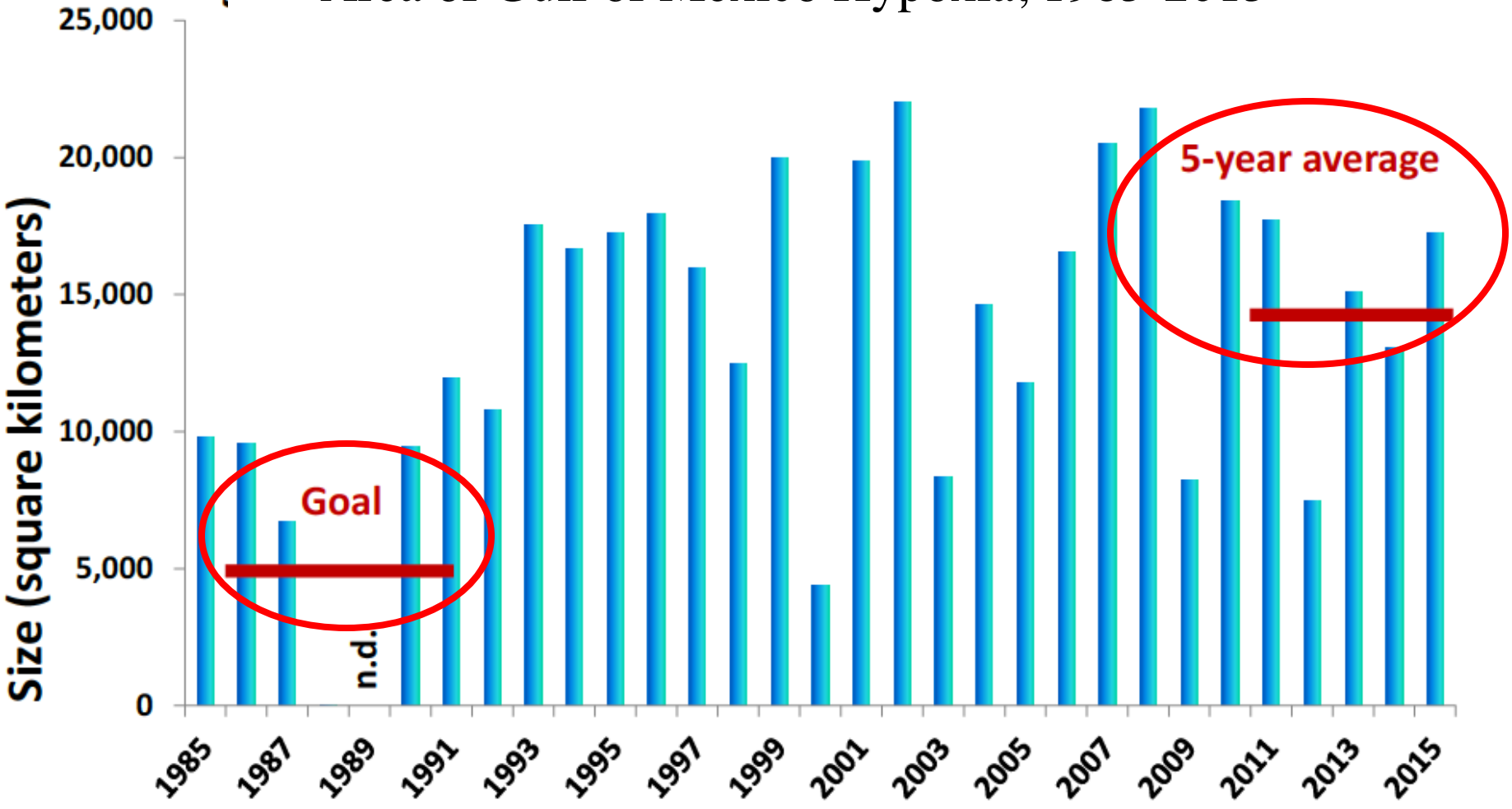


# Case Study 3

# Creating and Restoring Wetlands in Agricultural Midwest for Reducing Nitrogen Pollution of Coastal Ecosystems


# Mississippi-Ohio-Missouri (MOM) Basin Restoration

# Area of Gulf of Mexico Hypoxia, 1985-2015

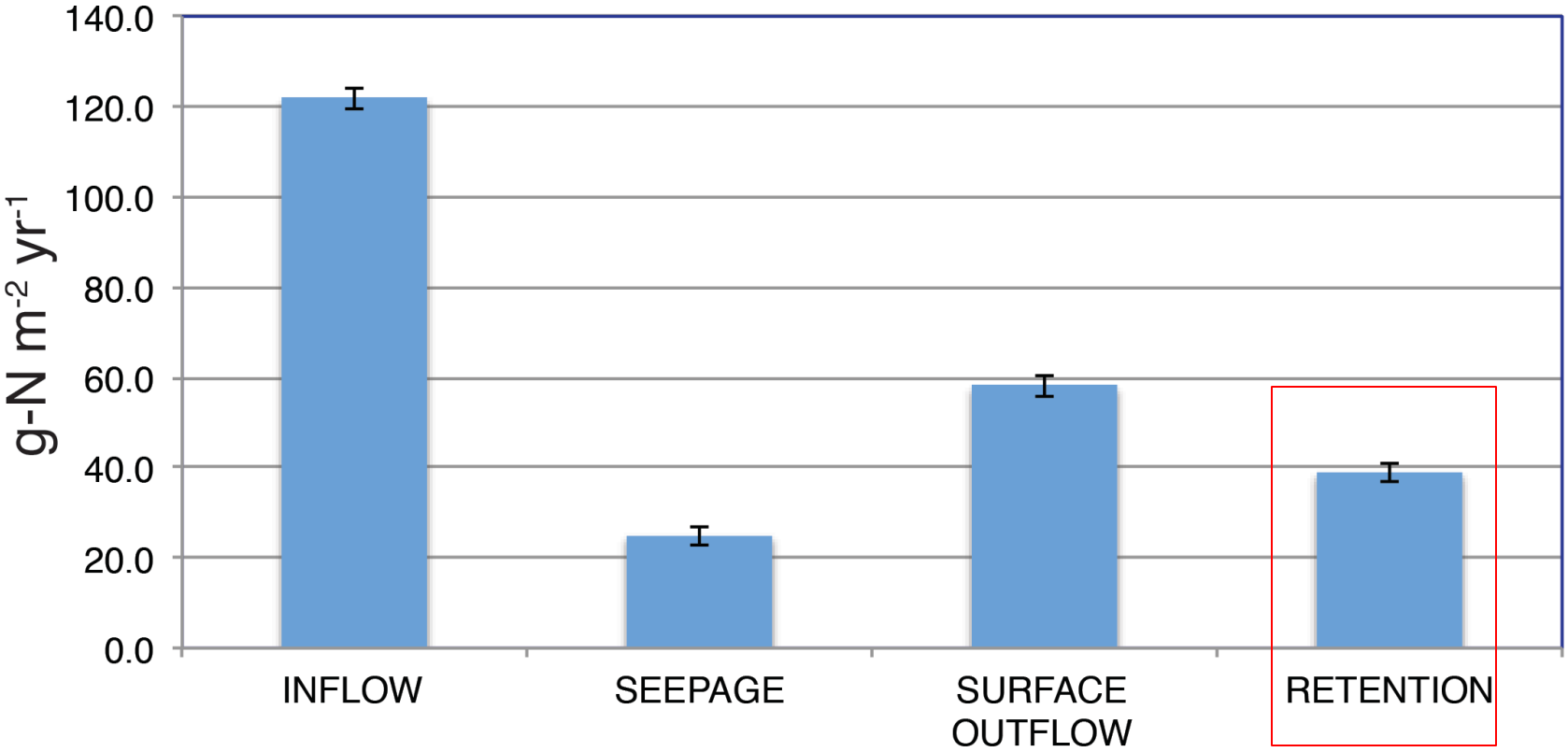



Data source: Nancy N. Rabalais, LUMCON, and R. Eugene Turner, LSU

Funding sources: NOAA Center for Sponsored Coastal Ocean Research and U.S. EPA Gulf of Mexico Program

# Olentangy River Wetland Research Park,  Columbus Ohio

# Annual Nitrogen Budgets, Olentangy River Wetland experimental wetlands, 1999 - 2010

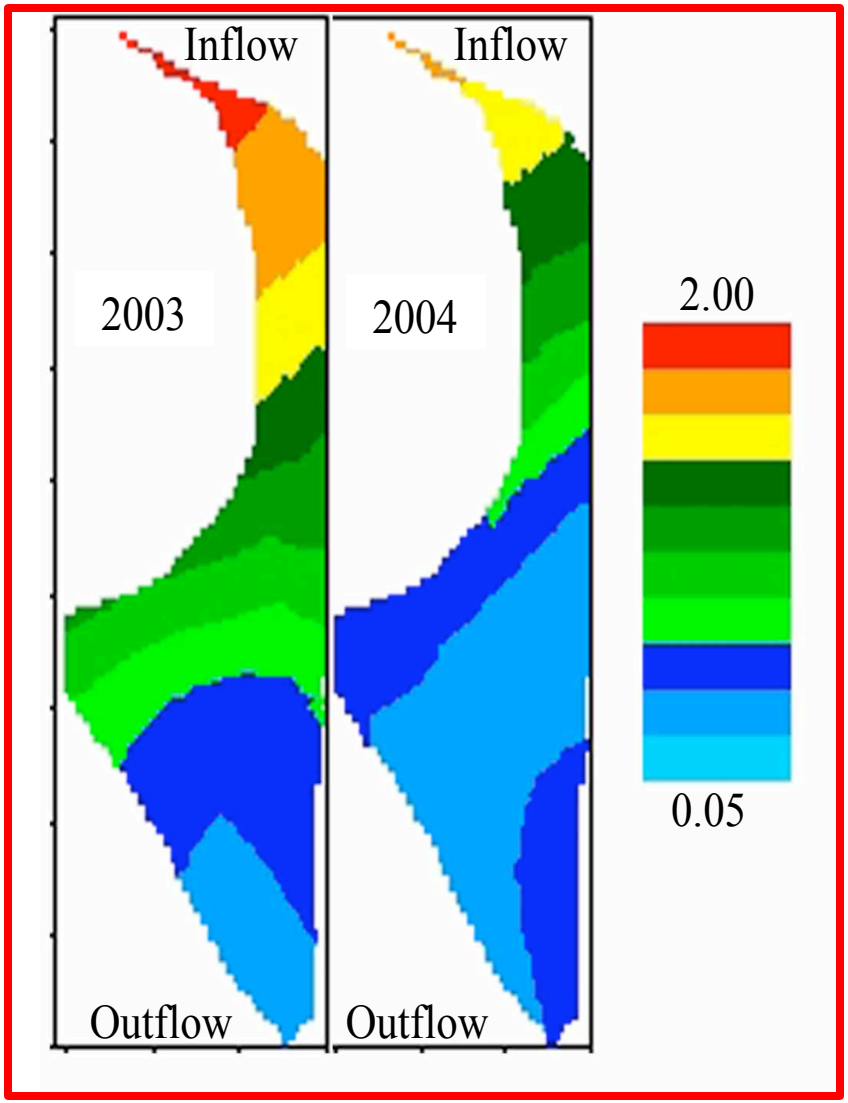


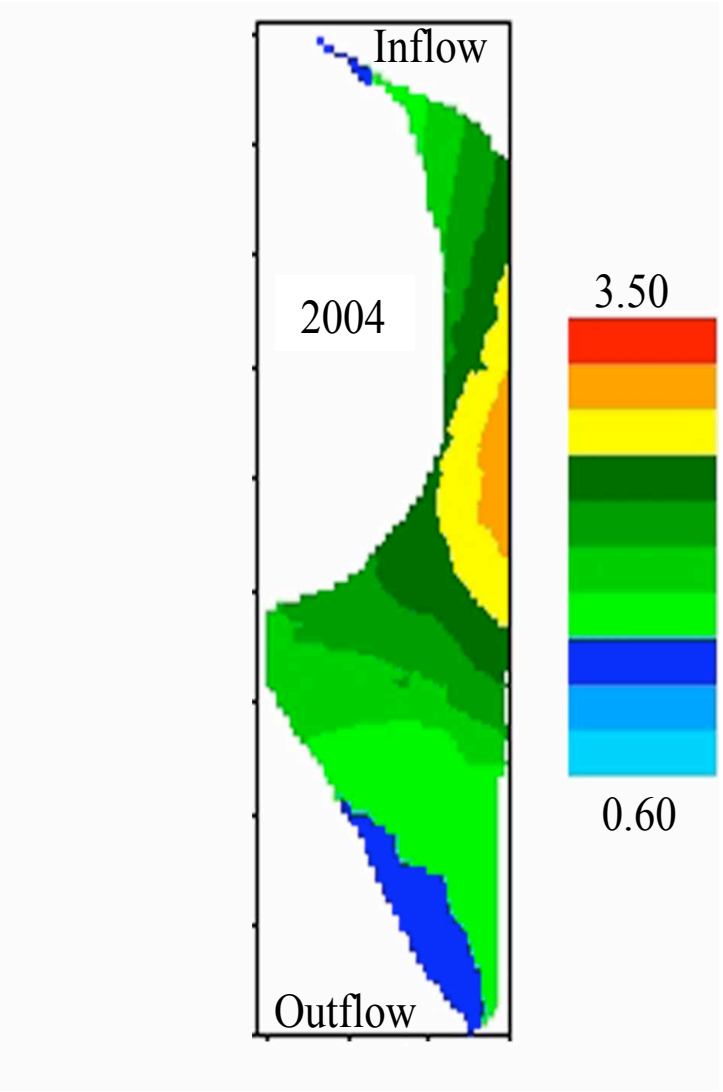

Mitsch et al. 2014

# Olentangy River Wetland Research Park,  Columbus Ohio

# Created Oxbow

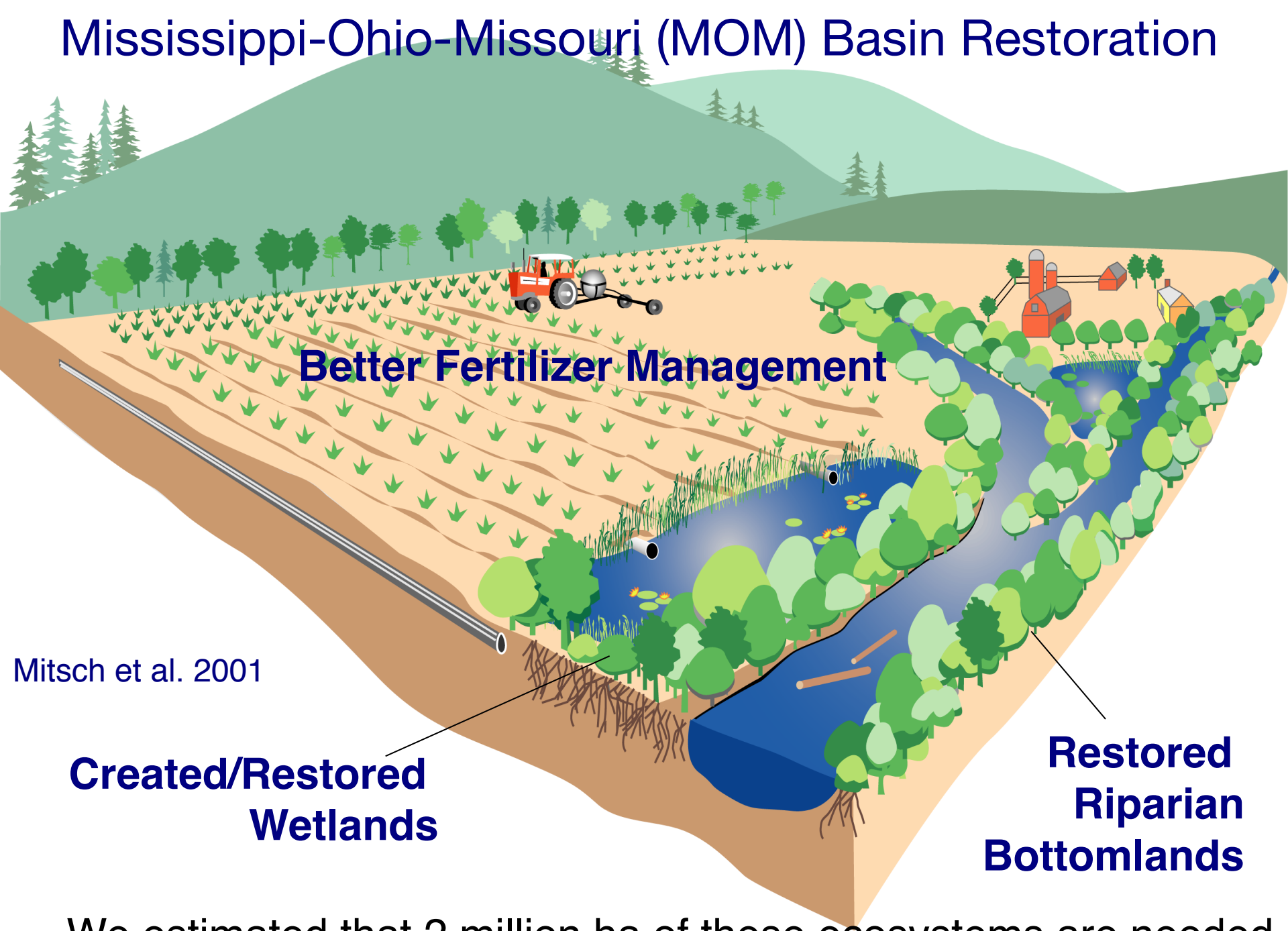
River water flow




Source: Fink and Mitsch, 2007

# Mississippi-Ohio-Missouri (MOM) Basin Restoration




We estimated that 2 million ha of these ecosystems are needed

# Conclusions

- Wetlands can be designed to remove significant amounts of nitrogen and phosphorus from agricultural and stormwater runoff. Concentrations on the order of 30 ppb of total phosphorus and 1 ppm total N are reasonable expectations but lower concentrations can be achieved.

- In the Florida Everglades, the pollution of the estuaries by Lake Okeechobee water has to stop and the original north to south flow of the greater Everglades must be achieved.

- To accomplish this, the state needs to install at least 40,000 ha of treatment wetlands south of the lake, perhaps even more, to save the estuaries while protecting the downstream Florida Everglades National Park.

# Conclusions

- Wetland restoration and creation are not easy. They require attention to **Mother Nature** (self-design) and **Father Time** (these projects just take time to reach their potential).

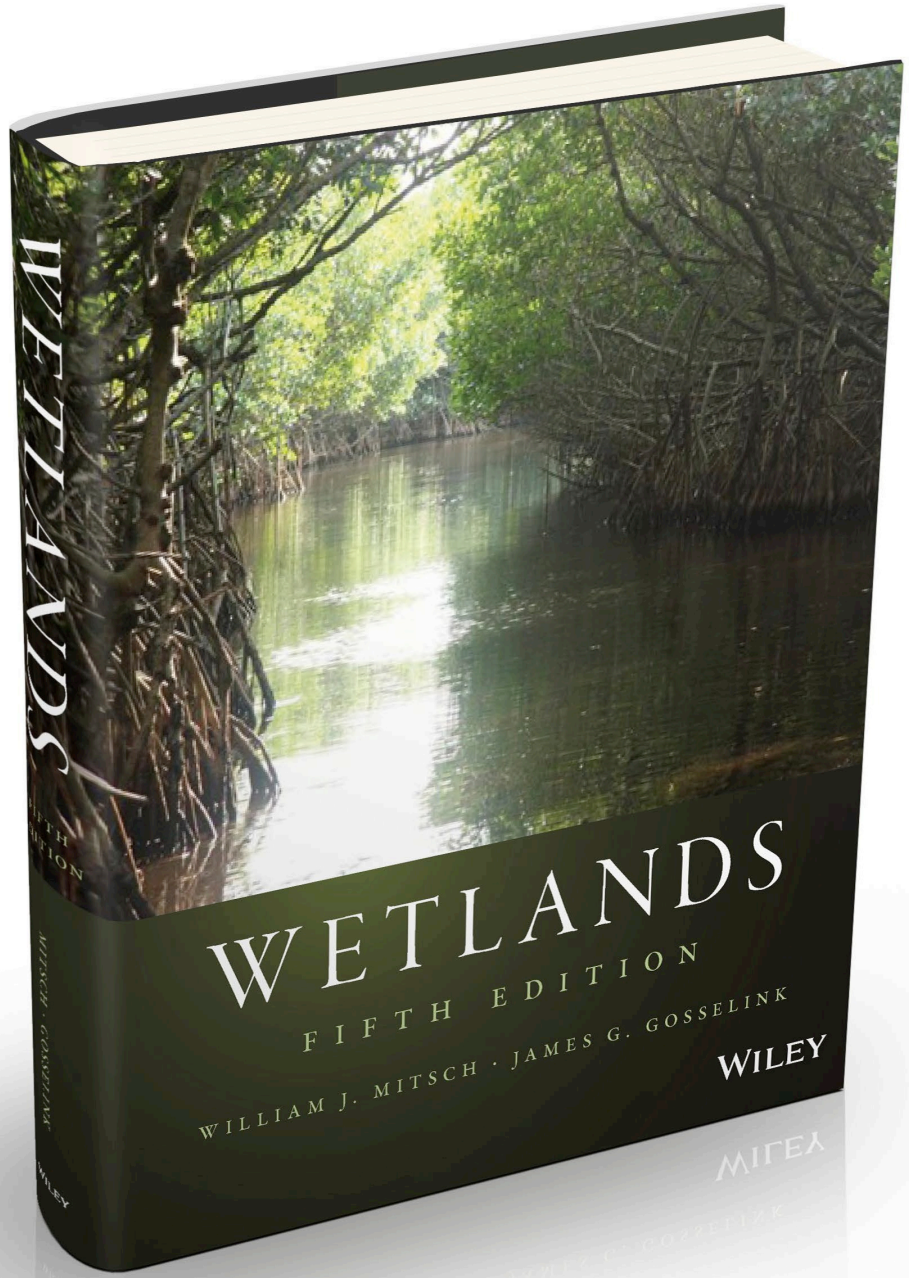
# Our inspiration

GEORGE BARLEY

WATER PRIZE

PRESENTED BY
EVERGLADES FOUNDATION

Awarded in 2020




Available on line at John Wiley and Amazon.com

Mitsch, W.J. and J.G. Gosselink. 2015. *Wetlands, 5th ed.* John Wiley & Sons, Inc., Hoboken, NJ. 744 pp.


**Thank you!**

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http://fgcu.edu/swamp

Everglades
Wetland
Research
Park