

CFAES

OHIO SEA GRANT COLLEGE PROGRAM

# State of Lake Erie: Nutrients and Harmful Algal Blooms

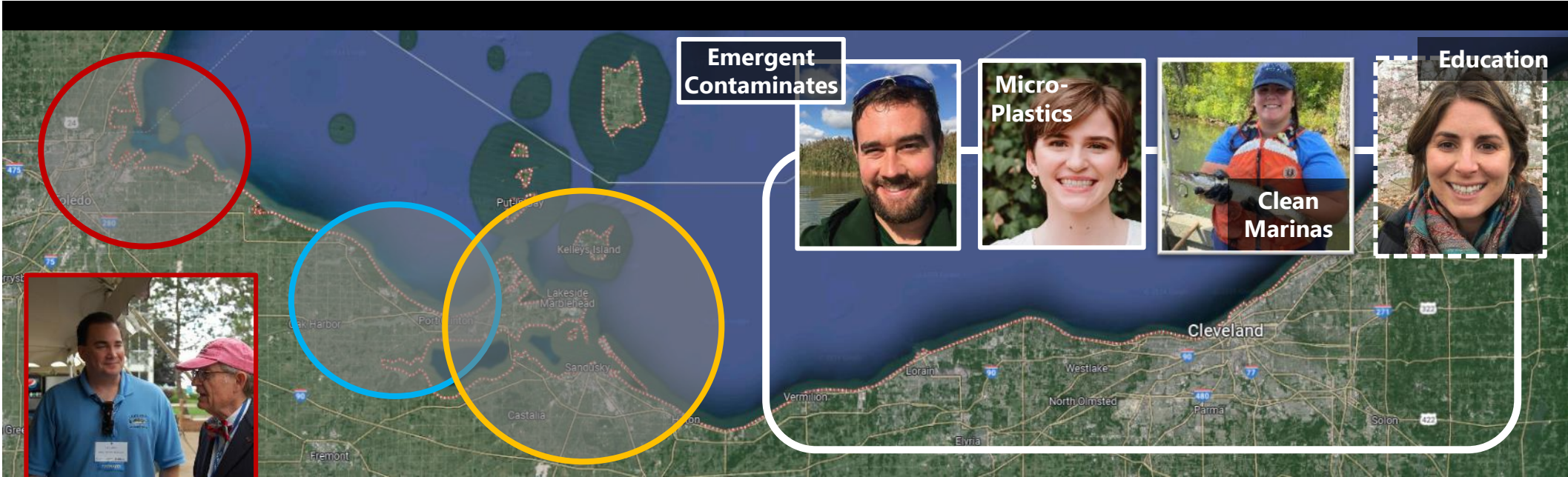
Dr. Chris Winslow, Director

Ohio Sea Grant and Ohio State University's Stone Lab

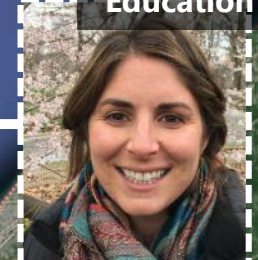
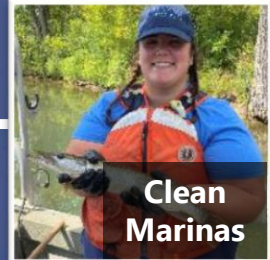
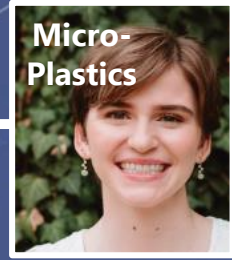


Presented at NOWRA 2025 Mega-Conference, October 19-22, 2025.

Oct 20<sup>th</sup>, 2025



Emergent Contaminates



Micro-Plastics

Clean Marinas

Education



BR&E



HABs



Fisheries and AIS



Clean Marinas



Coastal Resilience.



Aquaculture



[ohioseagrant.osu.edu/about/people#extension](https://ohioseagrant.osu.edu/about/people#extension)

# Microcystis near Marblehead



Photo: Richard Kraus, United States Geological Survey



Sara  
Guiher

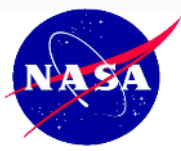
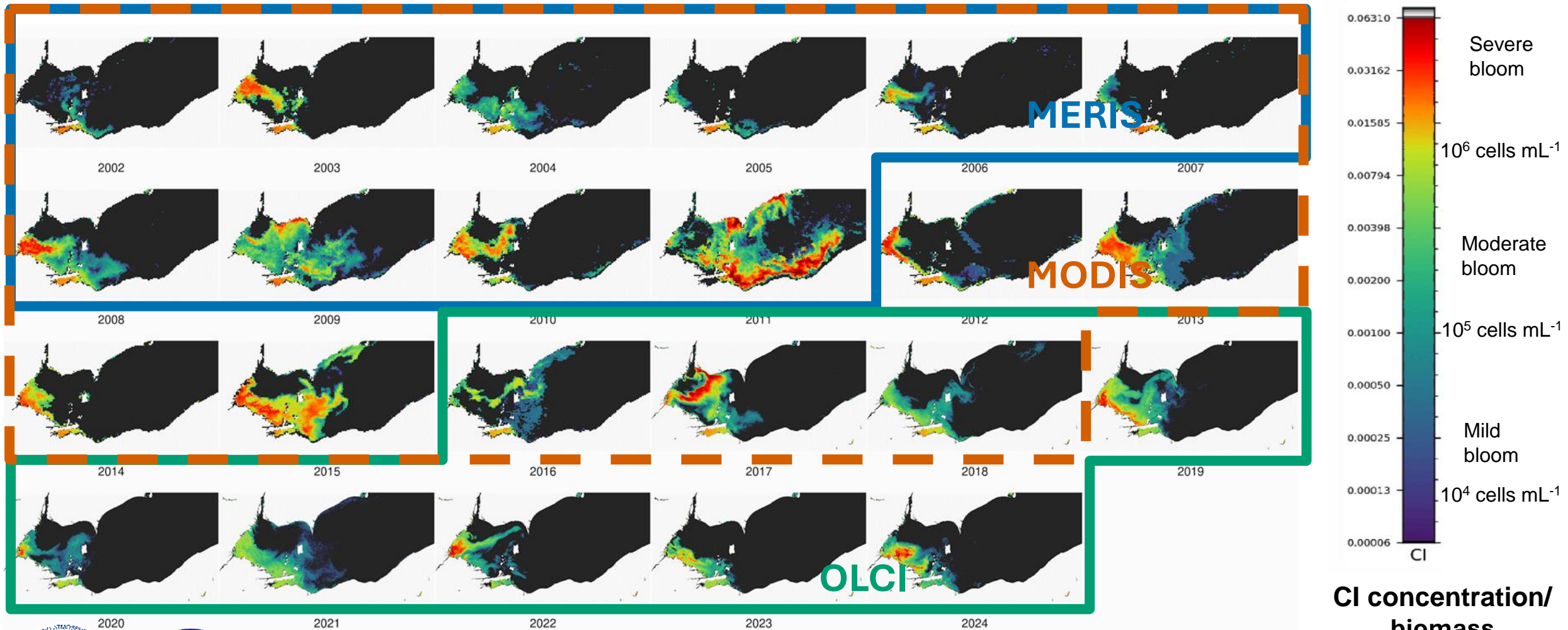


September 11<sup>th</sup>, 2011

CFAES

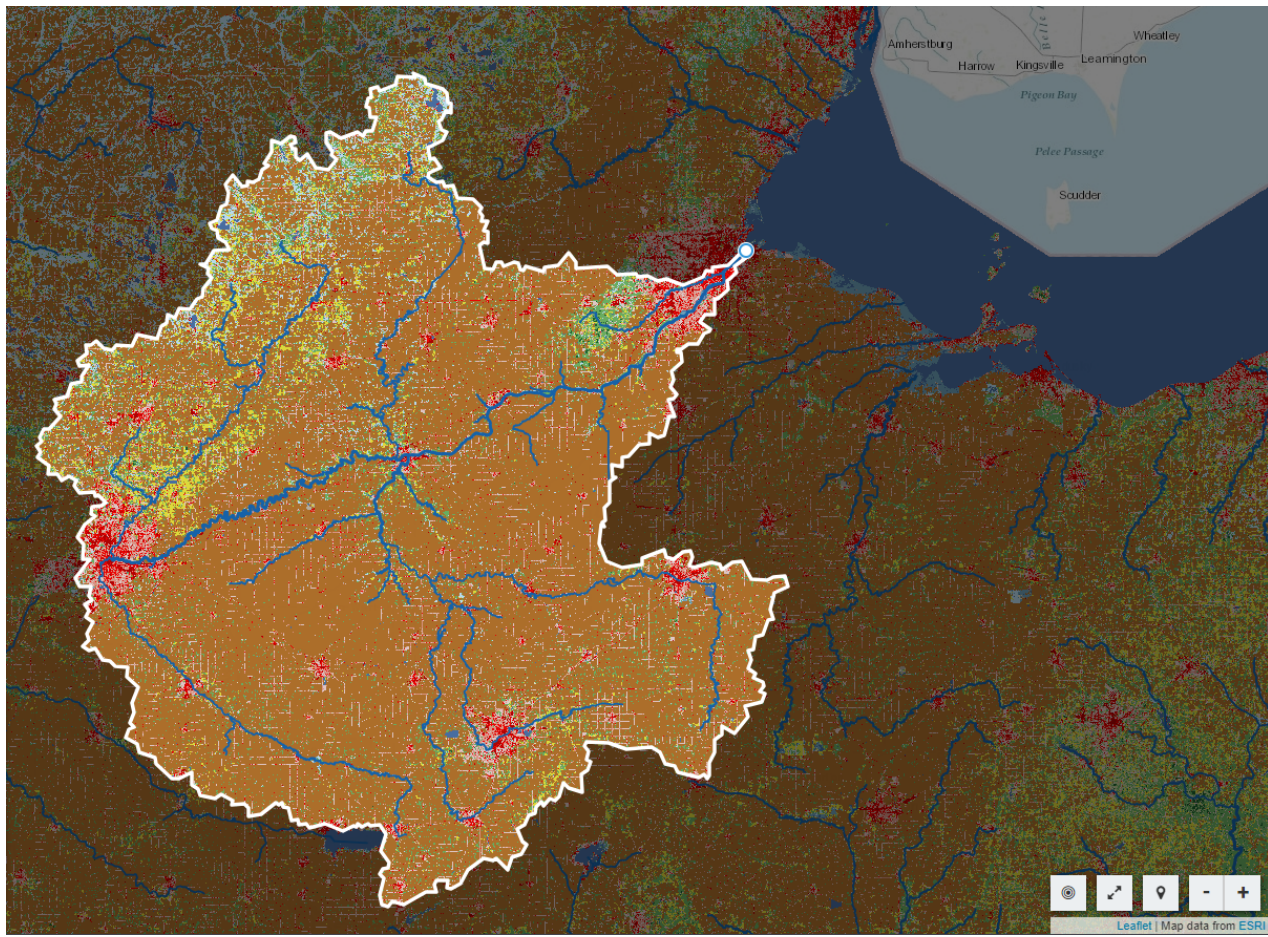


# Historical Bloom Peak: Spanning Satellite Missions



CI concentration/  
biomass

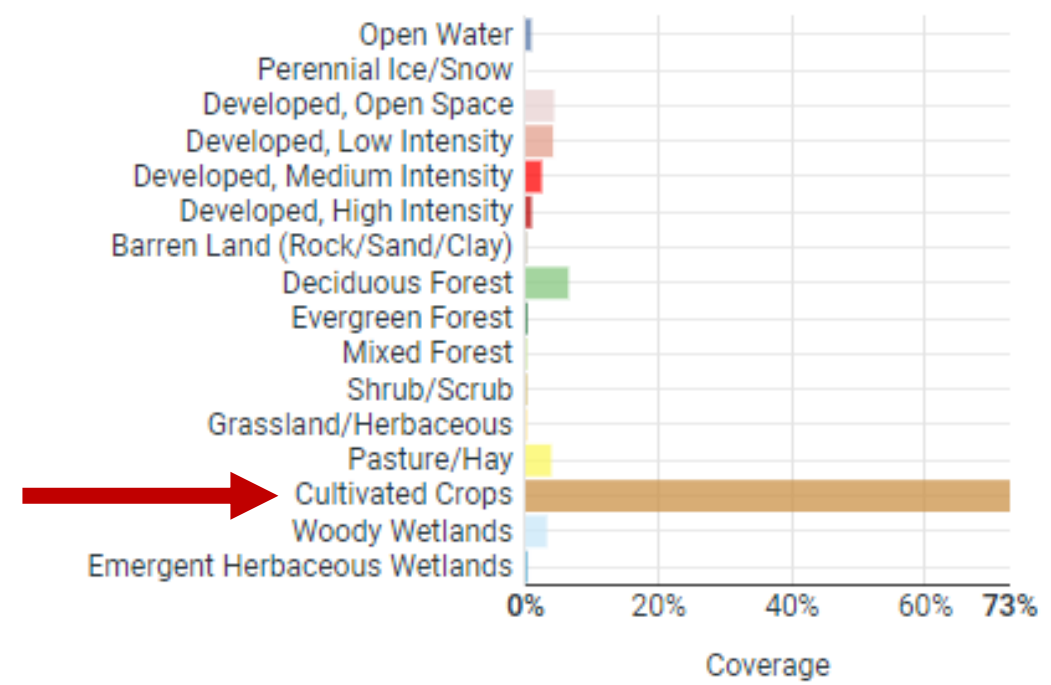
# — Maumee River Land Use / Cover



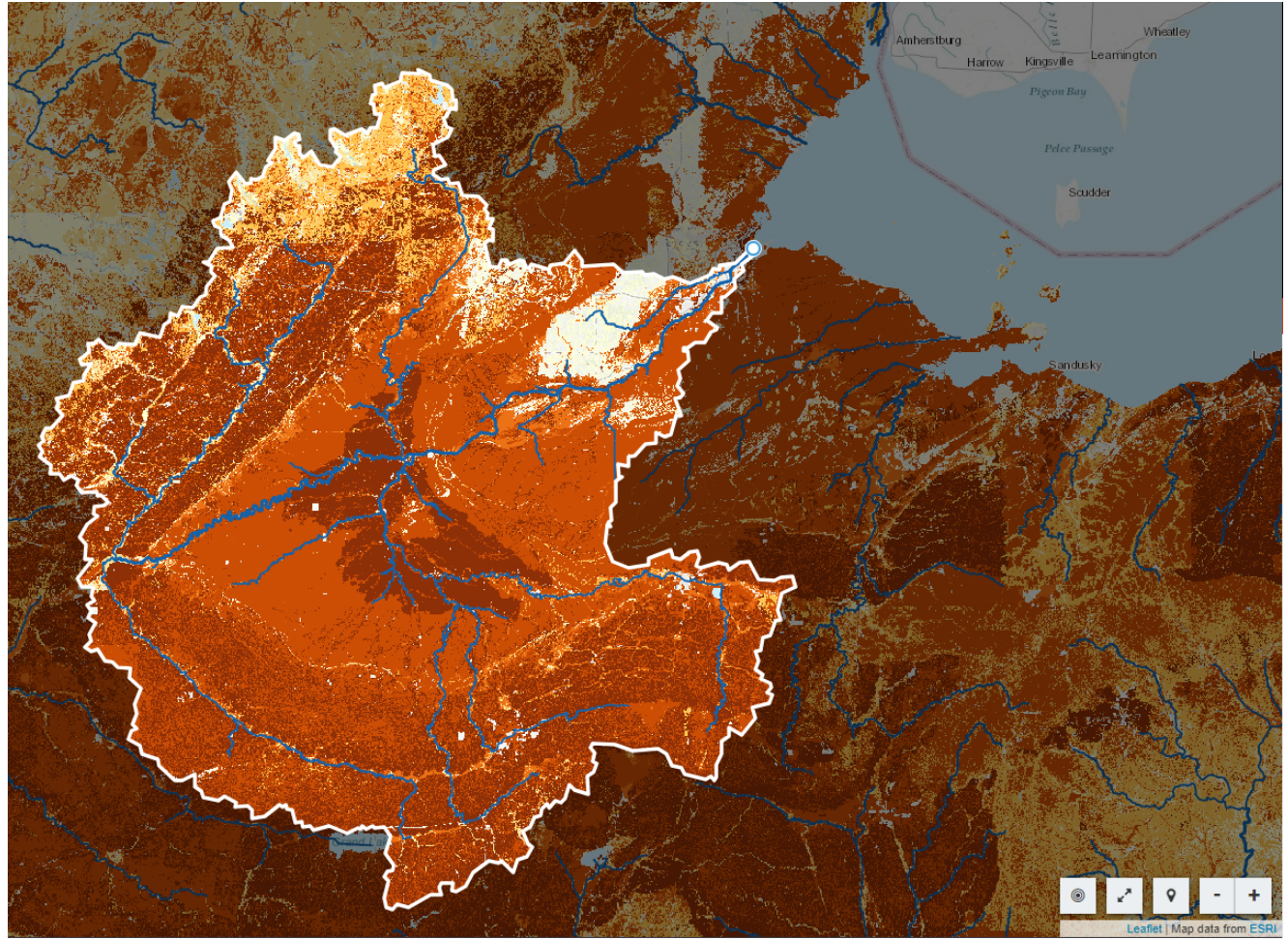
## Land Use/Cover 2019 (NLCD19)

Related Layer: Land Use/Cover 2019 (NLCD19)  Turn off

Source: National Land Cover Database (NLCD 2019) ⓘ

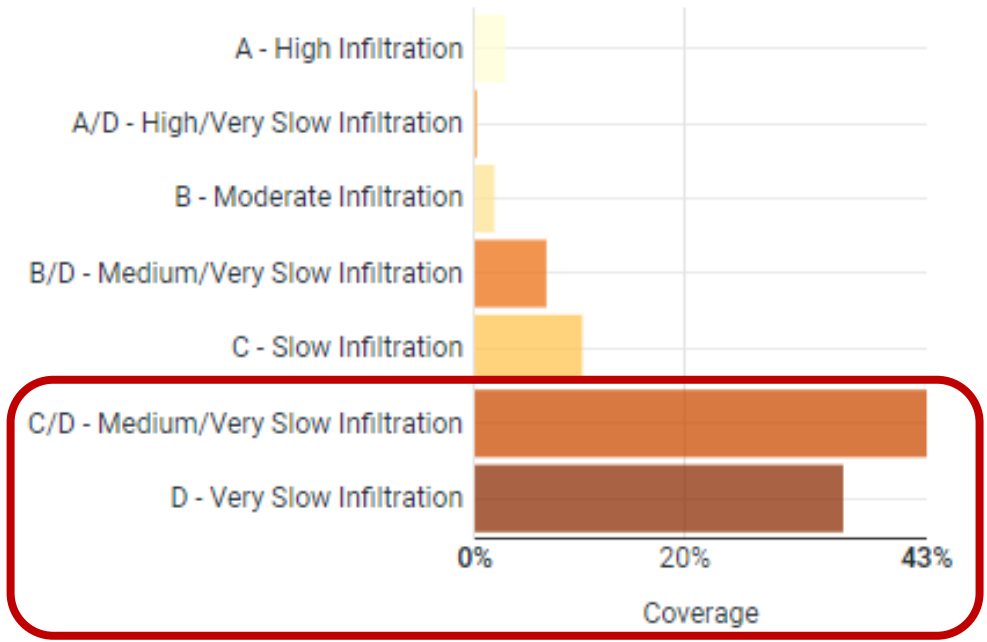


# Maumee River and Tile Drainage



## Hydrologic soil group distribution

Related Layer: Hydrologic Soil Groups From gSSURGO [Turn off](#)  
Source: USDA (gSSURGO 2016) [i](#)



# — Nutrient Sources Today

- Since mid 70's, >75% reduction in P from WWTPs; now <9%
- CSO Long Term Control Plans in place (<1% of P)
- Septic systems contribute ~4% P
- Scott's Miracle-Gro removed P from products (since 2013)
- "Internal loading" of Phosphorus ~3-7% of total load (13' and 14')



# — Deeper Dive into HABs

Total P



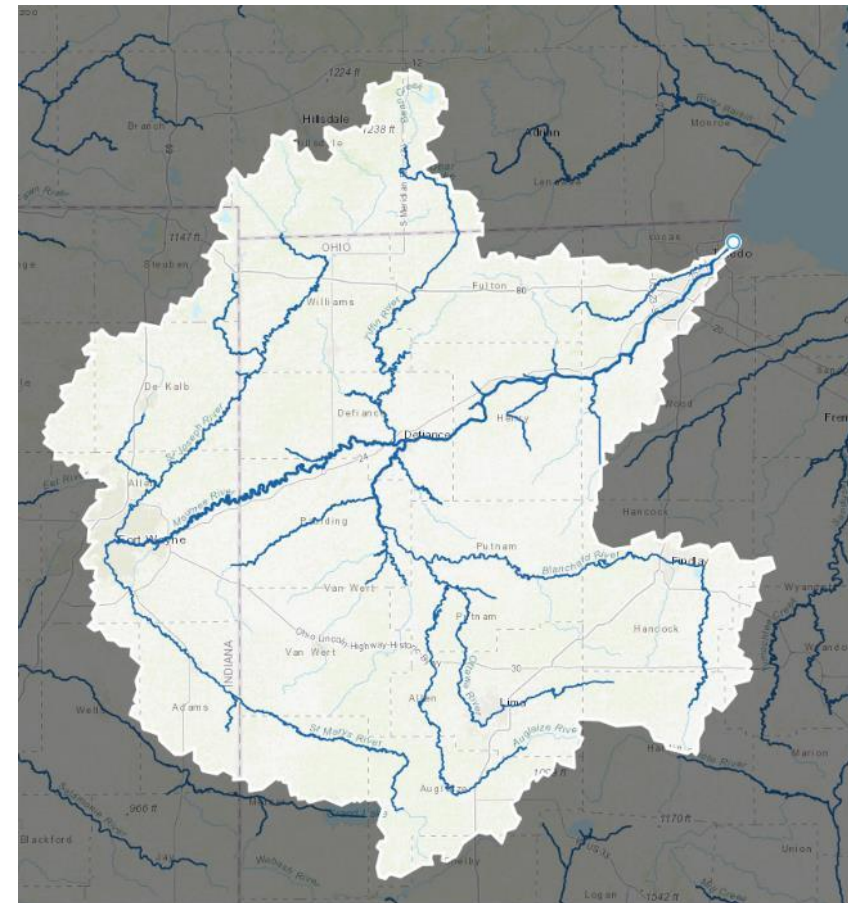
=



Dissolved P

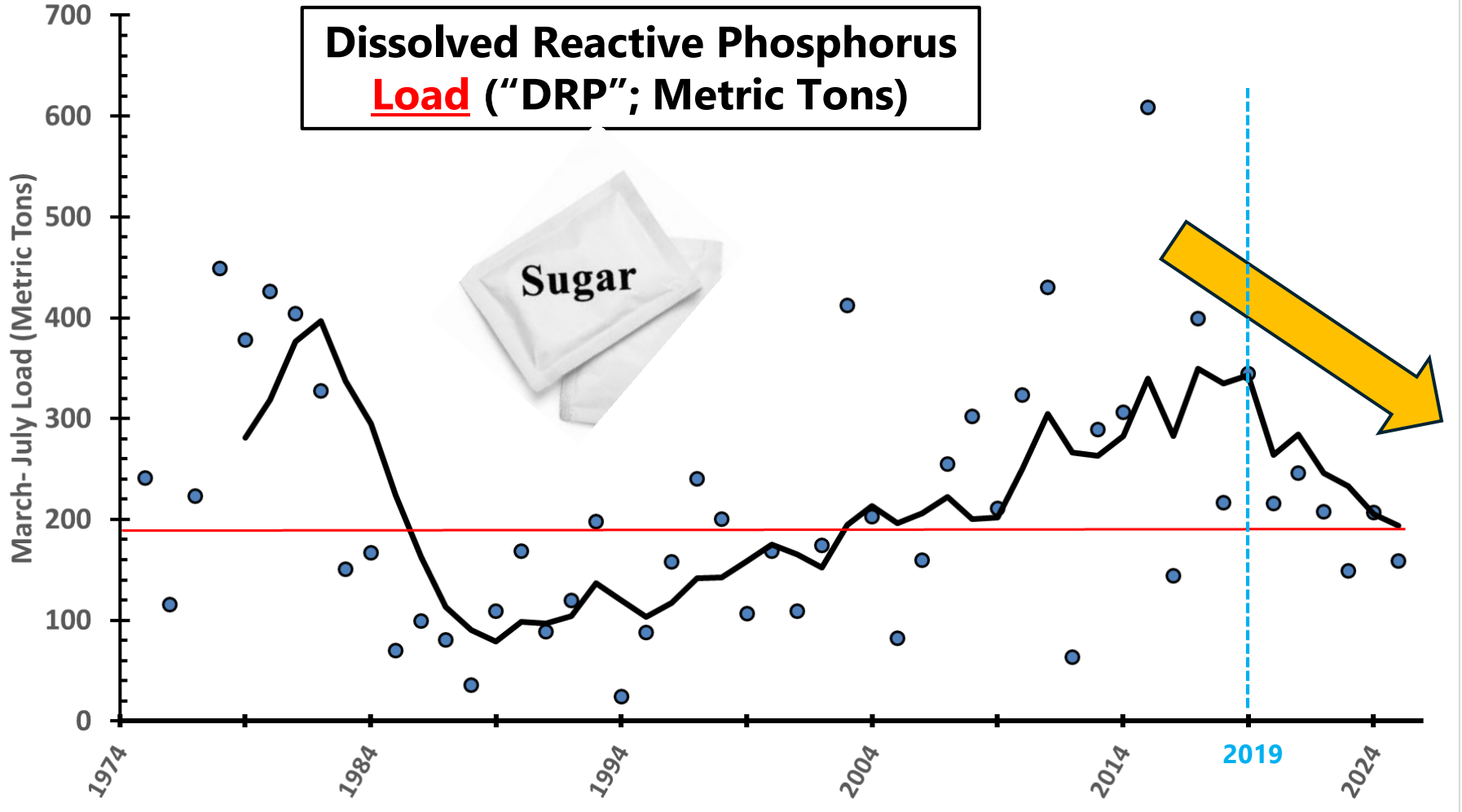
Particulate P

+



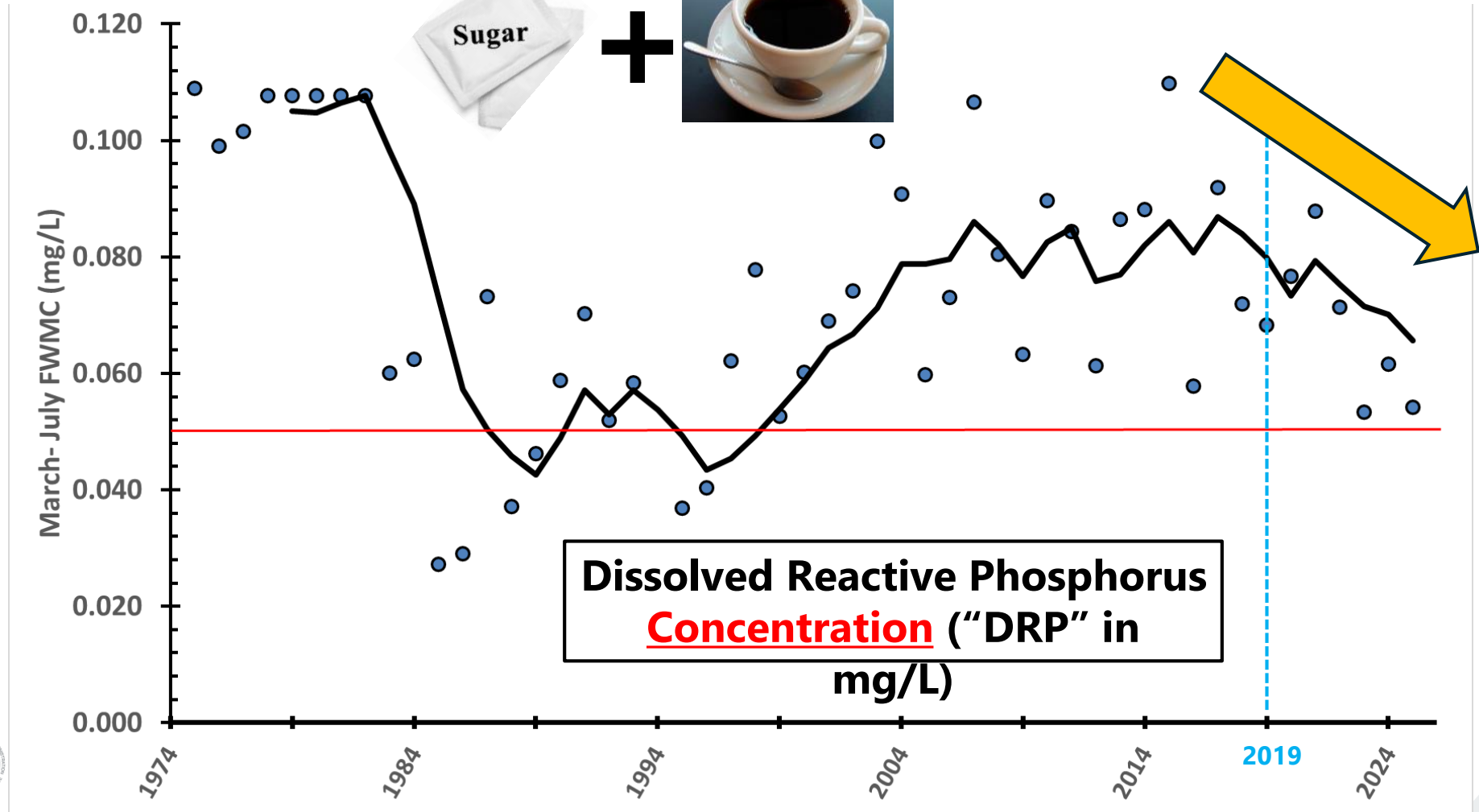
# Nutrient History in Lake Erie

Maumee River Data at Waterville



# Nutrient History in Lake Erie

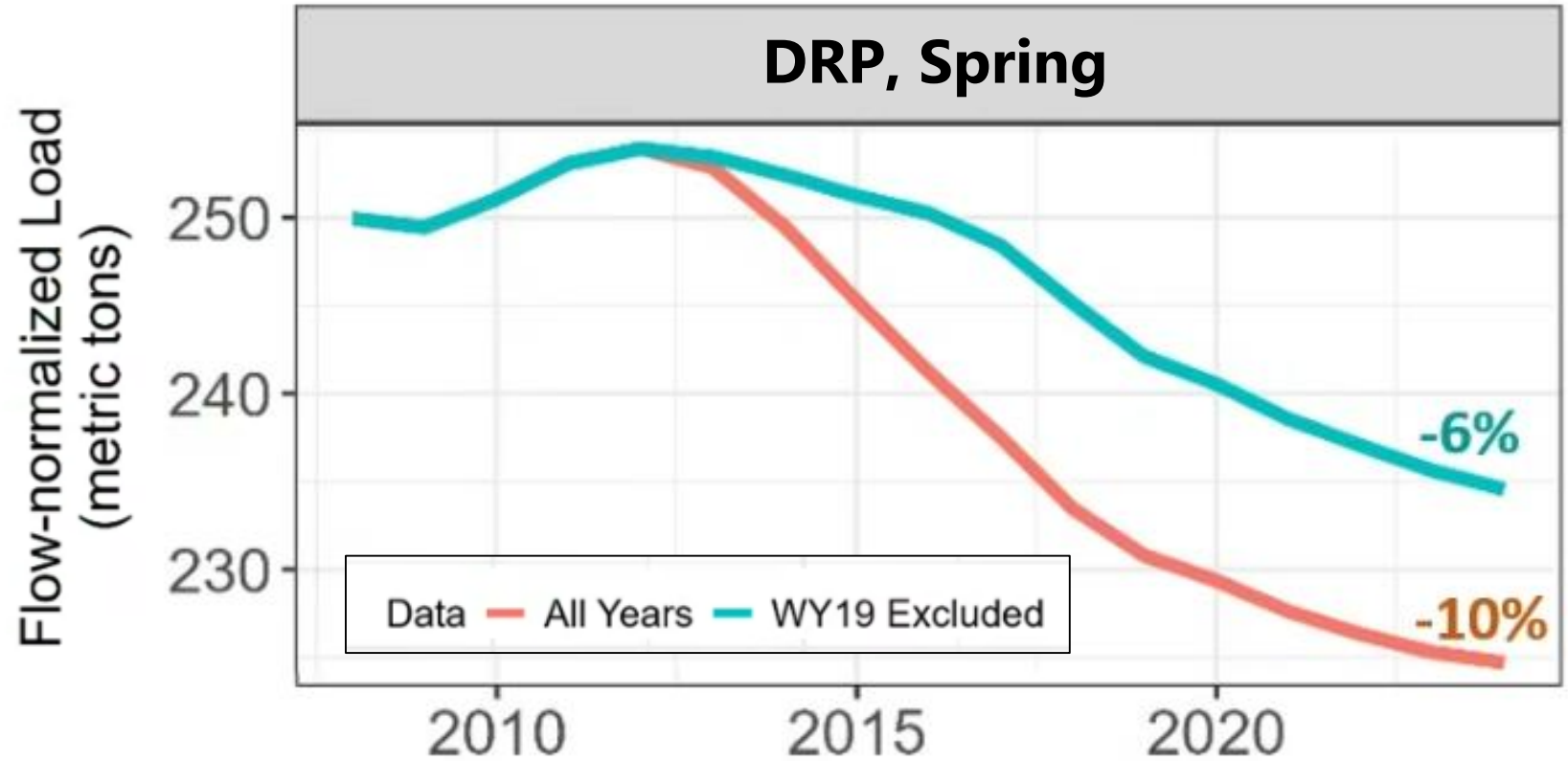
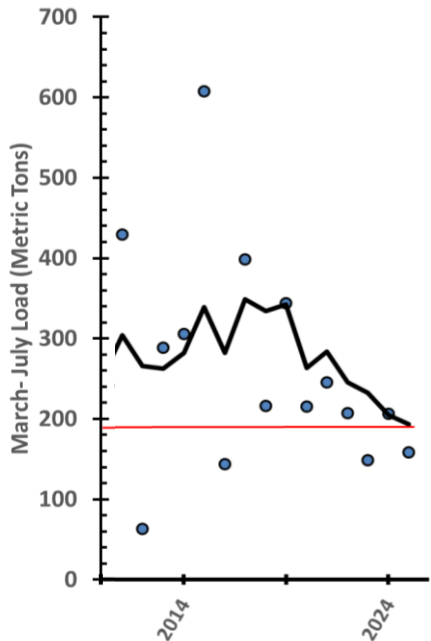
Maumee River Data at Waterville





# Are We Seeing a H2Ohio Difference?

*Flow normalized* to adjusts for “Wet” and “Dry” years



- Why exclude WY19 ( — )?
- H2Ohio's role?

# OHIO DEPARTMENT OF AGRICULTURE

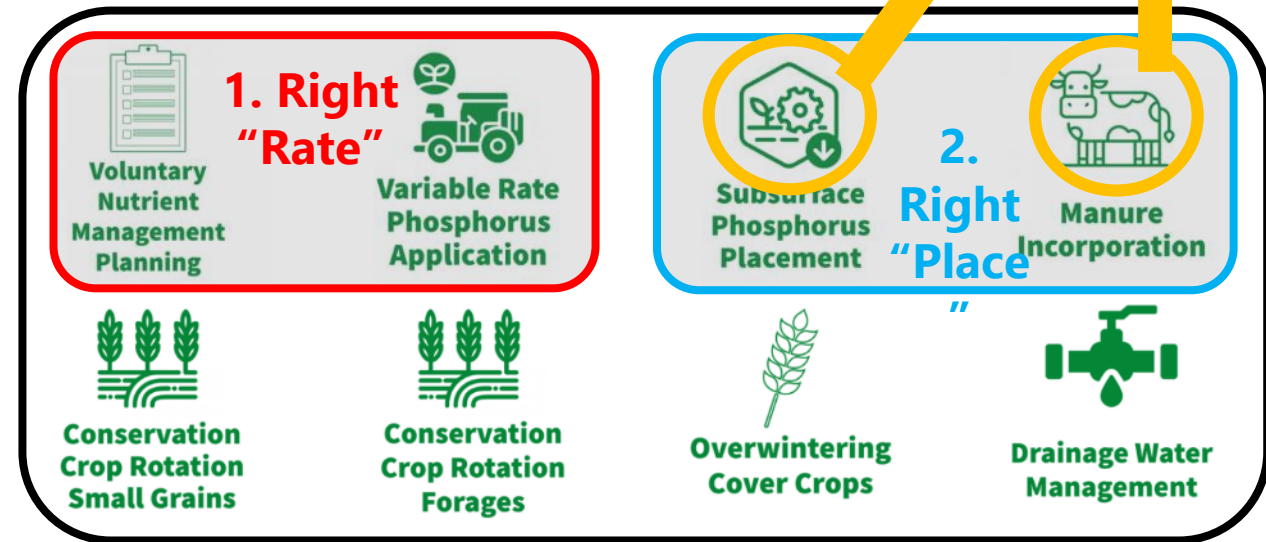
## REDUCING AGRICULTURAL PHOSPHORUS RUNOFF

ODA is committed to helping farmers reduce phosphorus runoff from commercial fertilizer and manure to prevent harmful algal blooms.

<https://h2.ohio.gov/agriculture/>

CFAES

3. Right "Source"



1. Right **Rate**  
2. Right **Place**

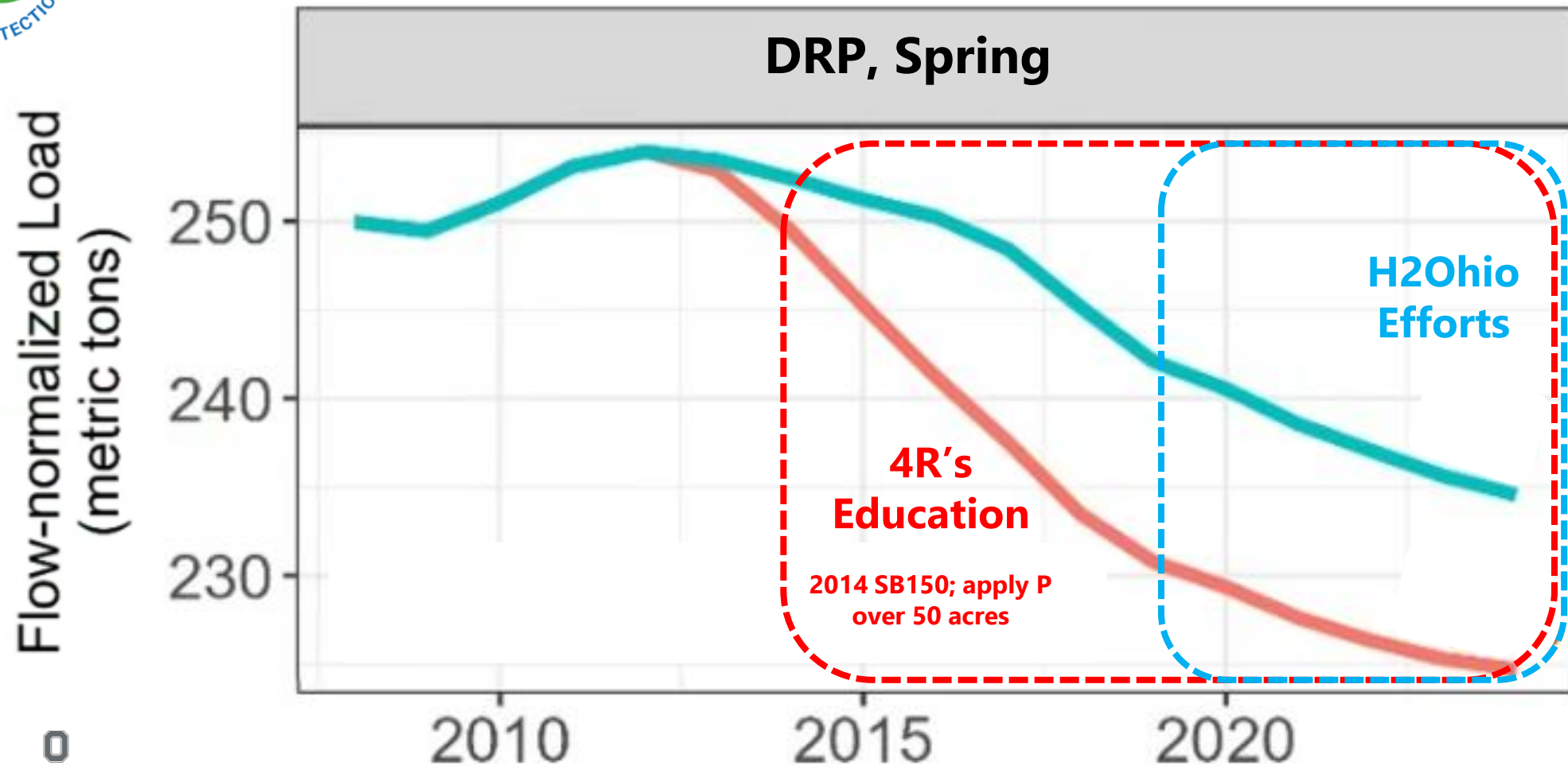
3. Right **Source\***  
4. Right **Time\***

Not before rain or on frozen ground



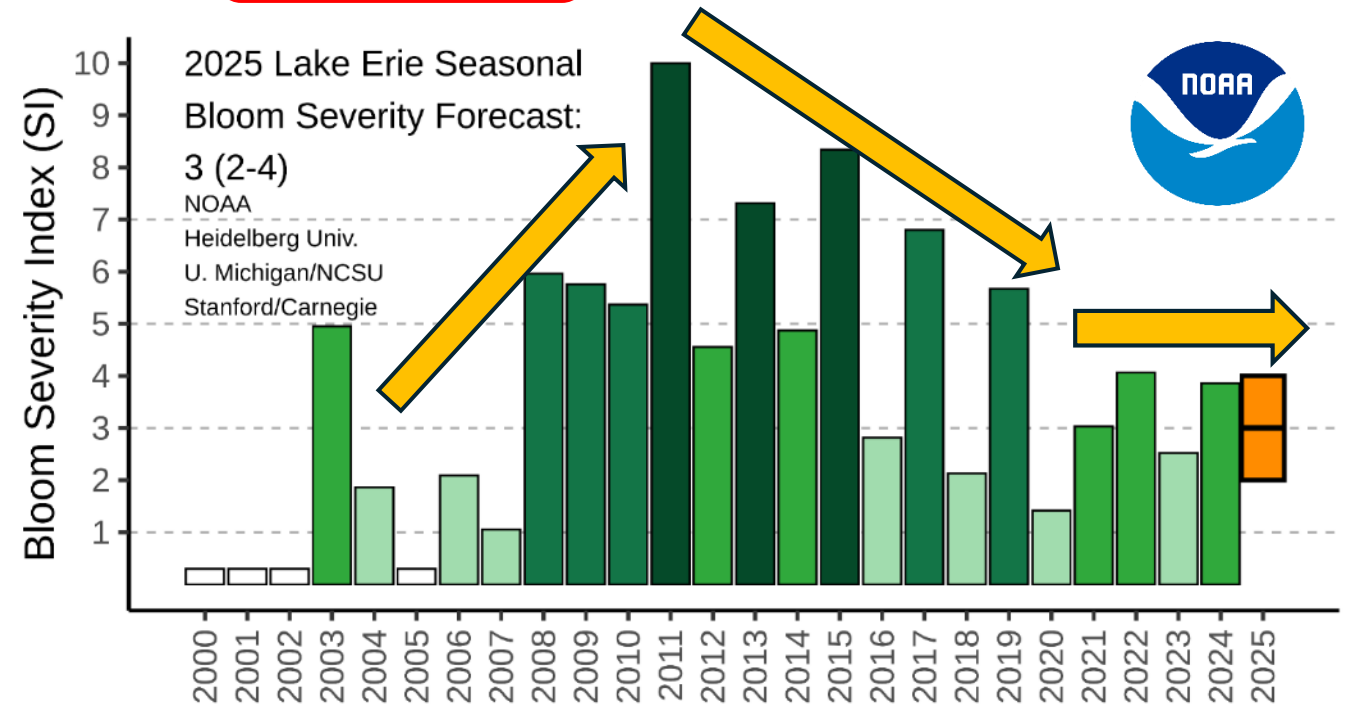
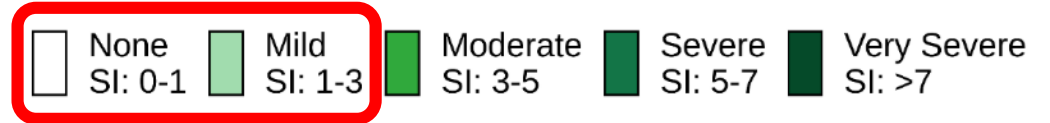
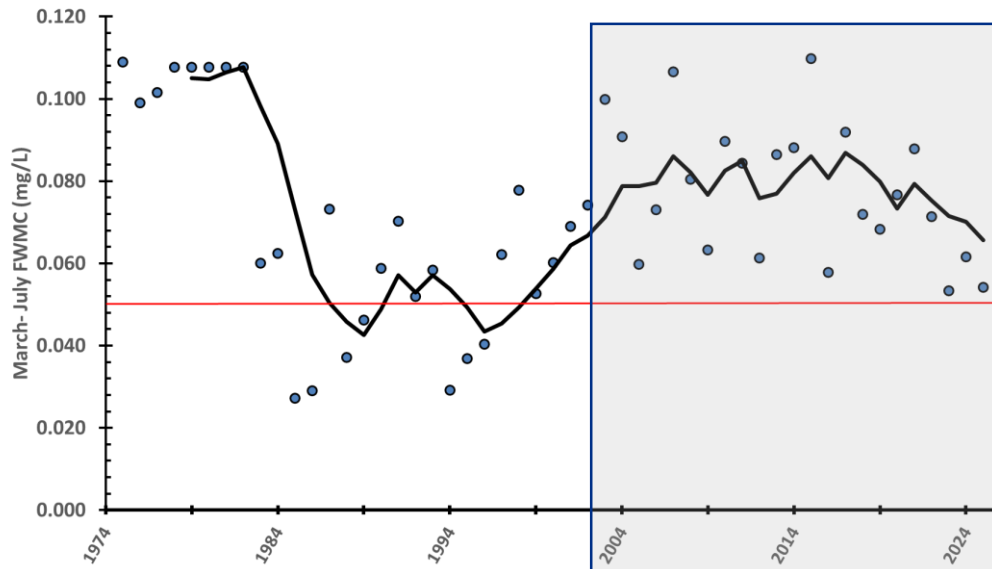


# Are We Seeing a Difference?



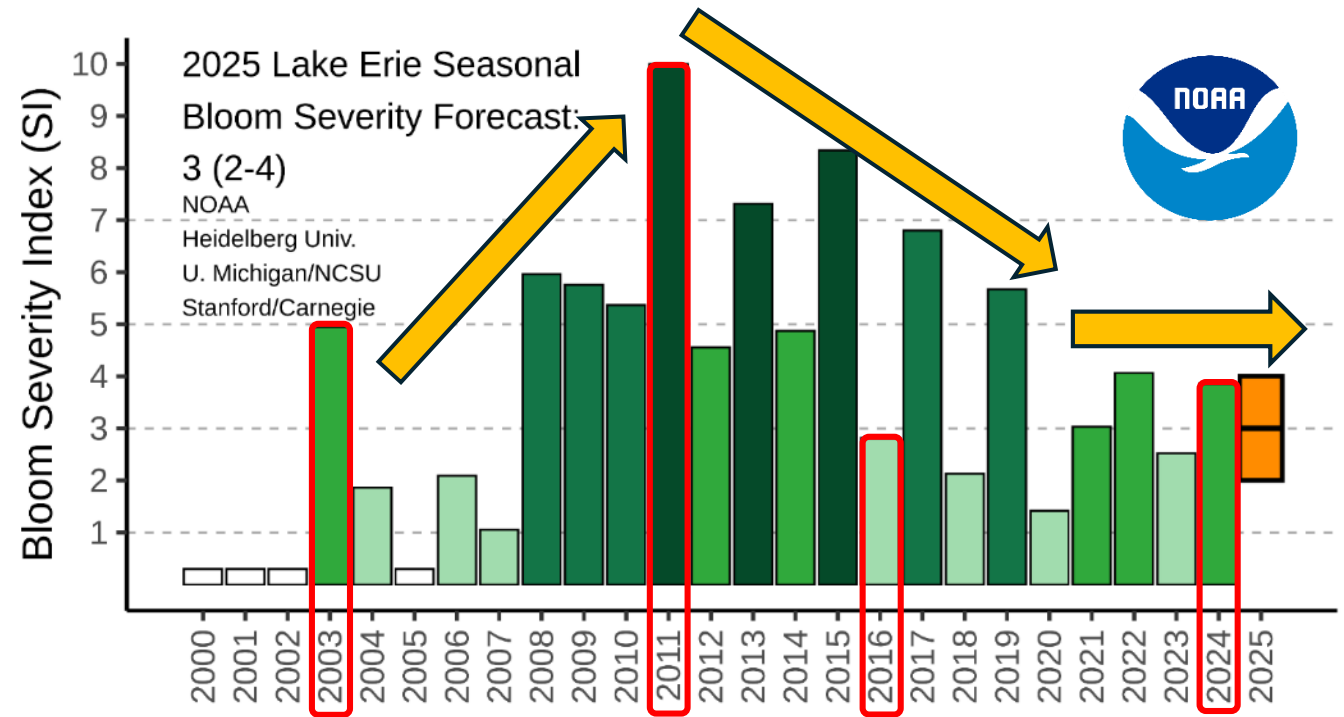
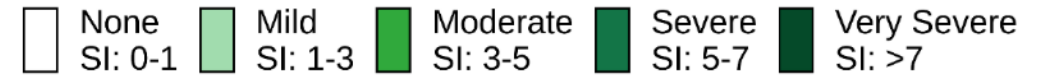
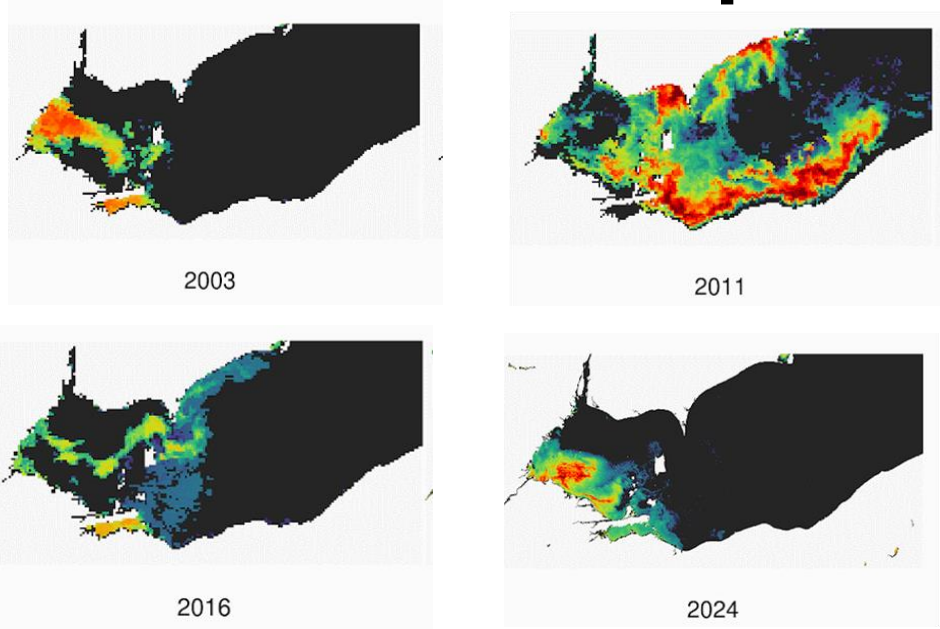
# How Do These Nutrients Manifest: "HAB Severity Index" in Lake Erie

**Dissolved Reactive Phosphorus Concentration** (DRP in mg/L)



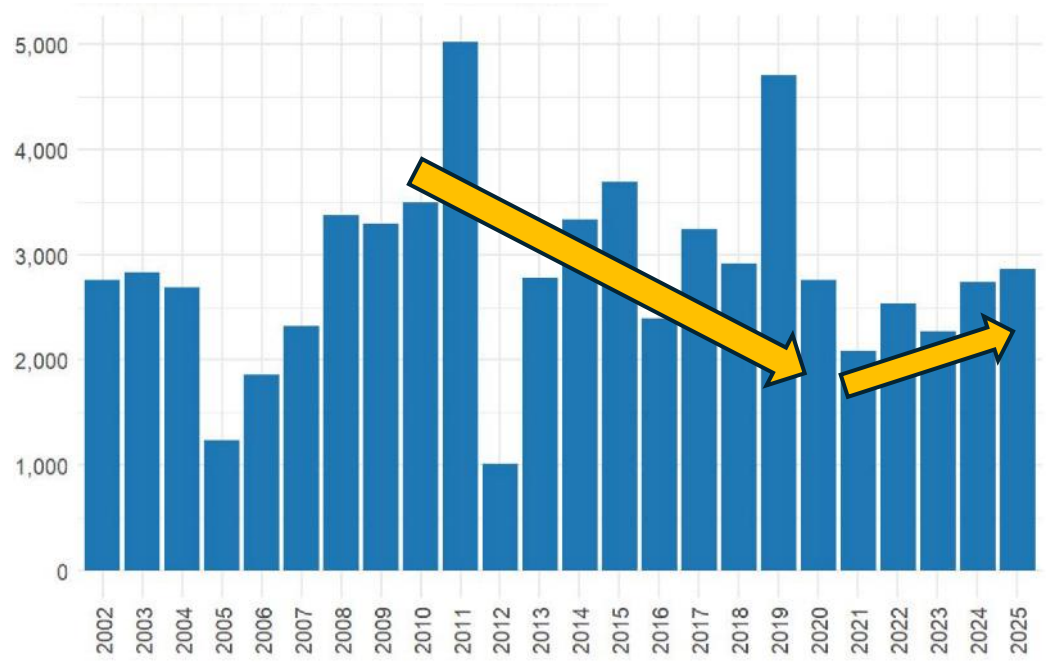
# "HAB Severity" in Lake Erie Via Satellites

## HAB "Heat Maps"

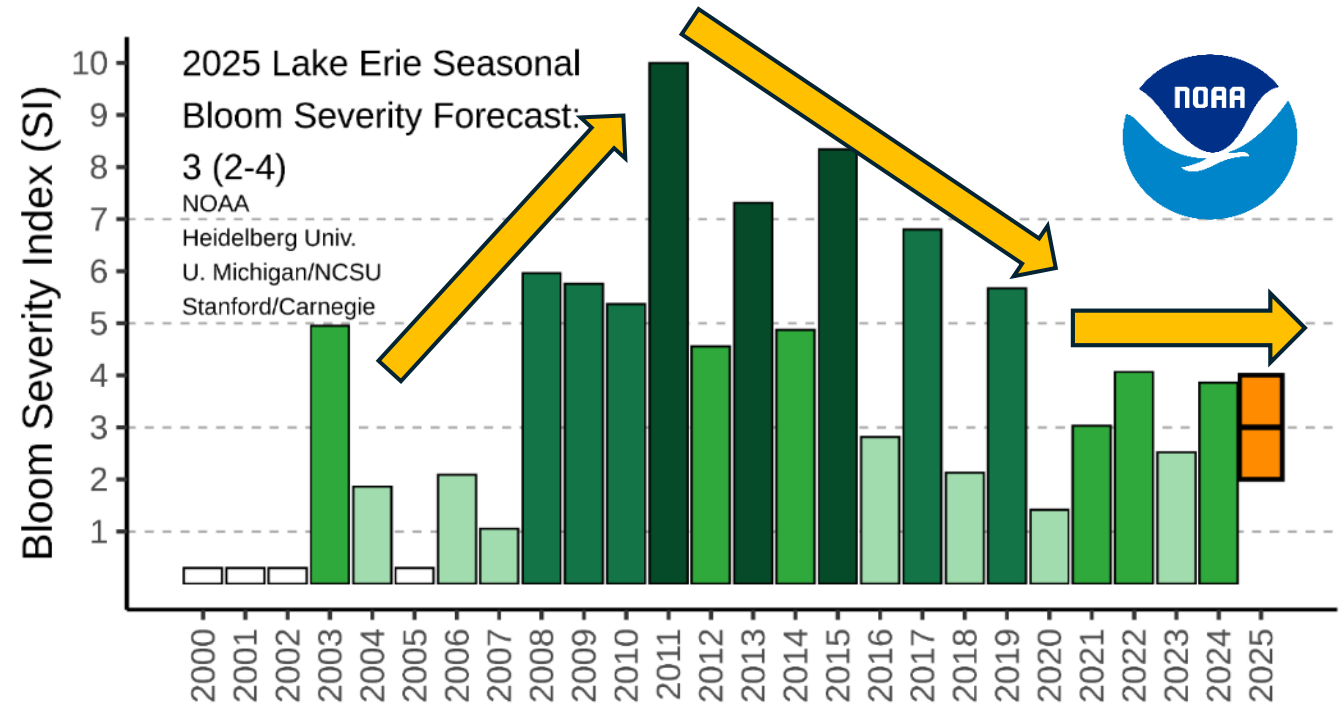


# “HAB Severity” Relative to Flow

Cumulative Discharge (Billion liters)



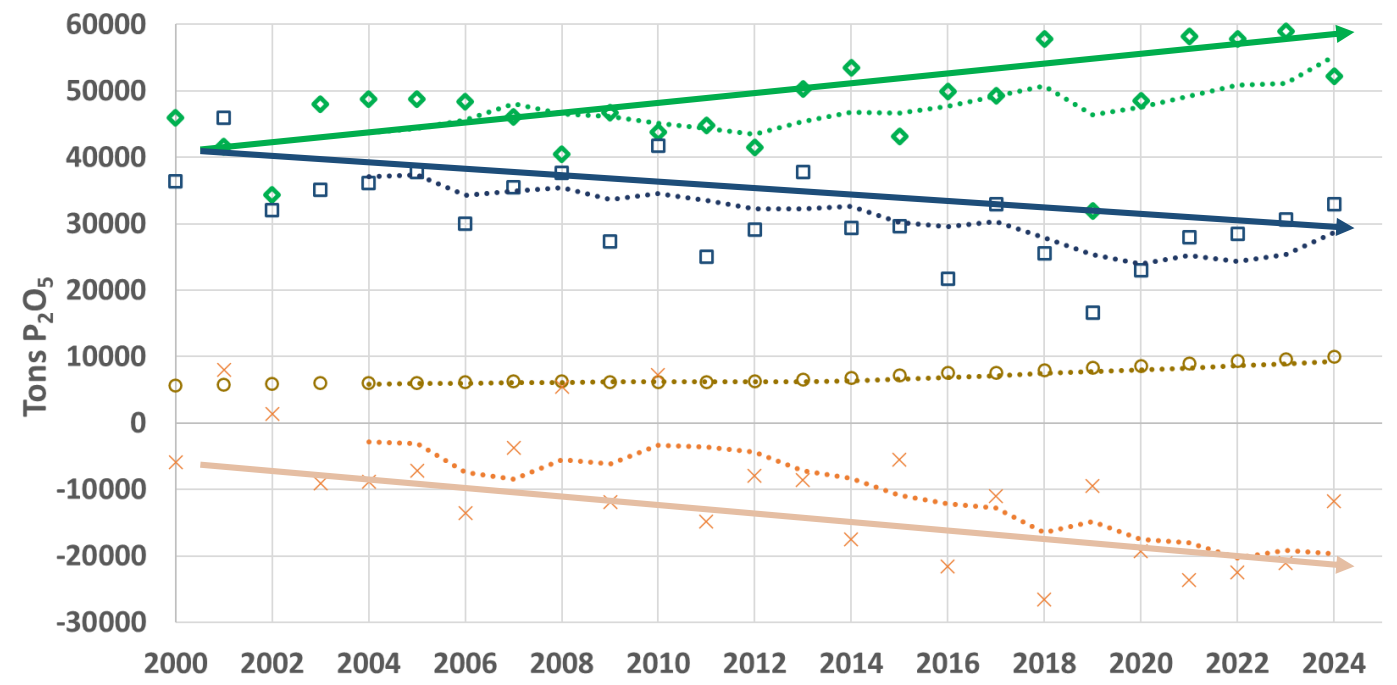
None SI: 0-1
  Mild SI: 1-3
  Moderate SI: 3-5
  Severe SI: 5-7
  Very Severe SI: >7



# Good News!



### Crop Reporting District 10



Sources:  
 1) <https://nugis.tfi.org/>  
 2) ODA Fertilizer Tonnage Data  
 3) NASS Ag Stats

◆ Crop Removal  
 □ Fertilizer P<sub>2</sub>O<sub>5</sub>  
 ○ Manure Recovered P<sub>2</sub>O<sub>5</sub>  
 × Net (Manure+Fertilizer minus Crop Removal)

**“Manure Recovered” is 70% of the manure excreted from the animal**

# Success to Date: H2Ohio ODA Data

## Right "Rate"

- VNMP = Voluntary Nutrient Management Plans
- VRT = Variable Rate

## Technology

## Right "Place"

- Sub. Comm. = Subsurface Commercial Fertilizer
- Incorp. Manure = Manure Incorporation



COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

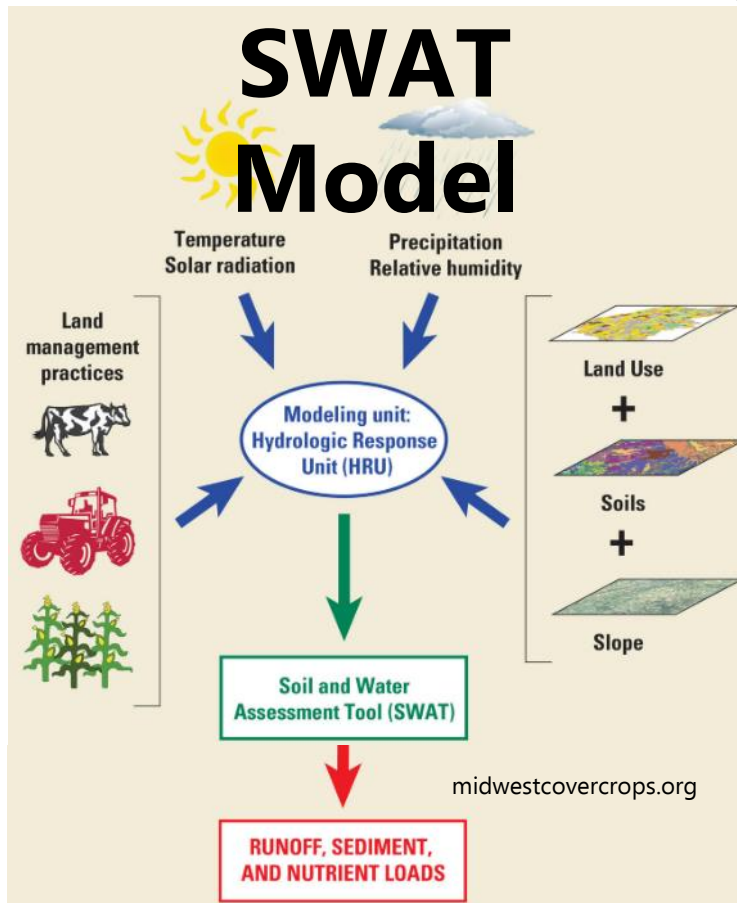
2024 Crop Year	What	Acres	% of 3.2M	Support	% of Support
	VNMP	1,755,400	55%	\$21,339,432	32%
VRT	958,869	30%	\$12,364,177	19%	
Sub. Comm.	451,315	14%	\$9,189,942	14%	
Incorp. Manure	43,966	1%	\$2,257,400	3%	
Cover Crops	566,734	18%	\$20,769,686	32%	

2023 Crop Year	What	Acres	% of 3.2M	Support	% of Support
	VNMP	1,386,675	43%	\$7,227,110	30%
VRT	381,568	12%	\$2,430,284	10%	
Sub. Comm.	157,720	5%	\$4,566,002	19%	
Incorp. Manure	51,414	2%	\$2,621,153	11%	
Cover Crops	228,797	7%	\$7,454,633	31%	

2022 Crop Year	What	Acres	% of 3.2M	Support	% of Support
	VNMP	856,402	27%	\$1,711,179	9%
VRT	163,715	5%	\$1,307,392	7%	
Sub. Comm.	119,919	4%	\$3,594,786	18%	
Incorp. Manure	43,949	1%	\$2,315,291	12%	
Cover Crops	371,558	12%	\$10,928,295	55%	

2021 Crop Year	What	Acres	% of 3.2M	Support	% of Support
	VNMP	842,889	26%	\$1,680,865	10%
VRT	212,350	7%	\$1,704,367	10%	
Sub. Comm.	150,832	5%	\$4,524,952	26%	
Incorp. Manure	38,075	1%	\$1,952,703	11%	
Cover Crops	281,244	9%	\$7,681,416	44%	

# Management Considerations: Research, Monitoring, and Models

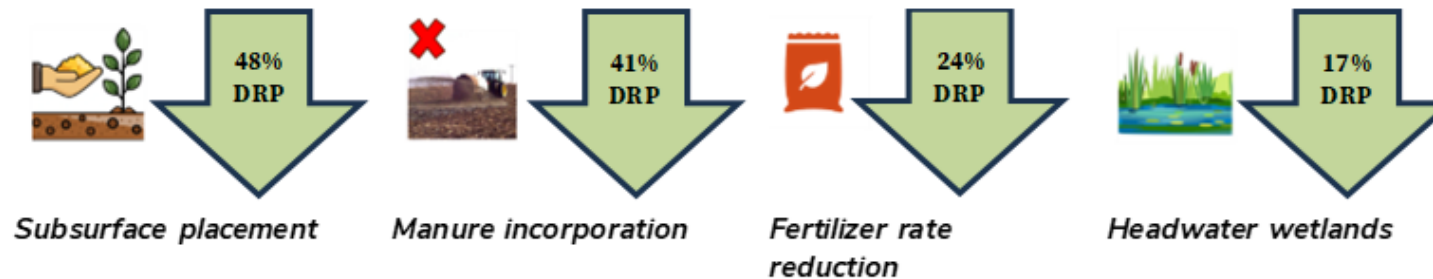


Conservation Practice	"Base"	Bundle One	Bundle Two	Bundle Three
<i>Tri-state Recommended Application Rates</i>	50%	87%	100%	100%
<i>Subsurface Nutrient Application</i>	10%	16%	19%	36%
<i>Manure Incorporation</i>	12%	14%	15%	20%
<i>Cover Crops</i>	10%	17%	19%	39%
<i>Drainage Water Management</i>	1%	2%	3%	4%



# — Key Findings (Dr. Murumkar et al.)

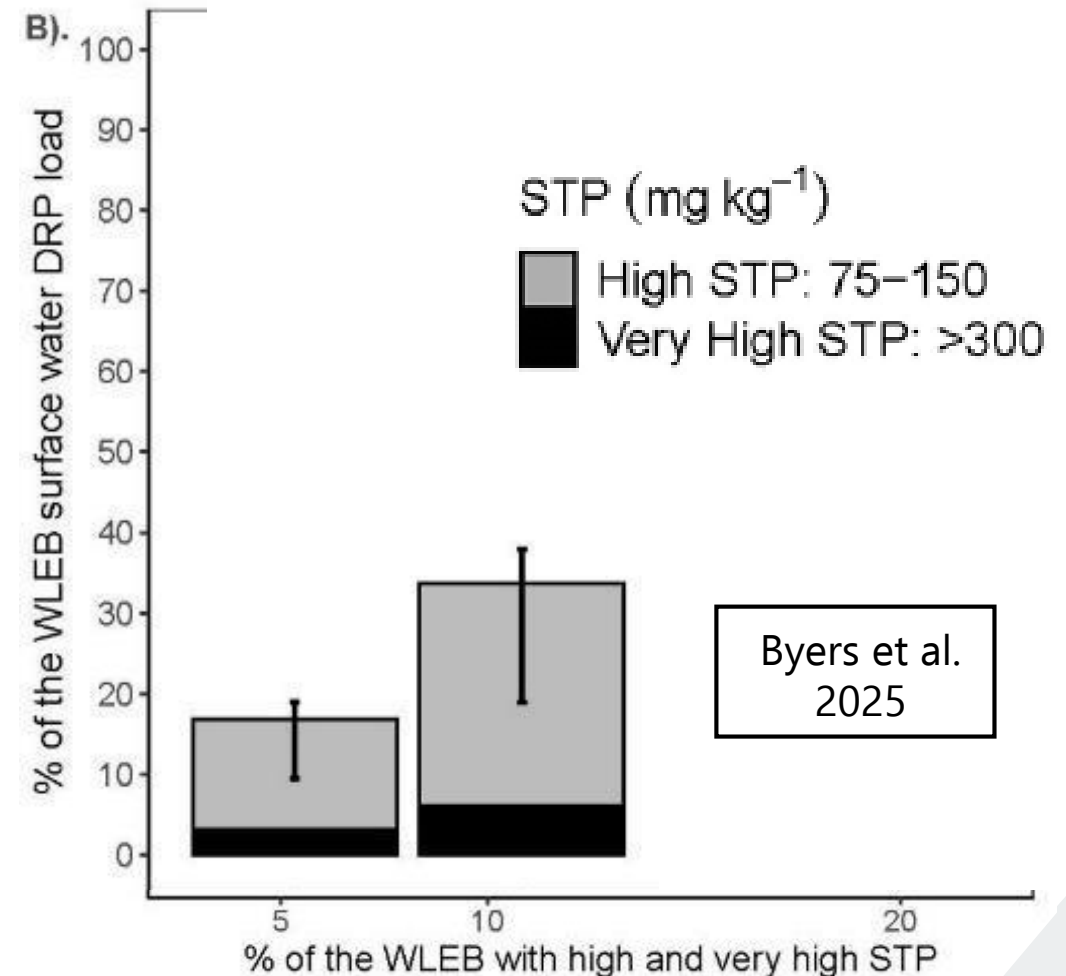
- At the field scale:



- At watershed scale: ~**Doubling** implementation from **pre-2018-2019** levels is predicted to reduce **DRP by 20%** (and TP by 10%)

# — Switching Gears: “New P” and “Old P” contribute to P Loss

- Between 17 and 34% of P loss estimated to come from “Old P”
- Conservation practices are required across a broad spectrum of STP; but targeting makes sense



# "Old P" Tools?



Oakwood's Nature Preserve  
Wetland Restoration



"Standpipe"



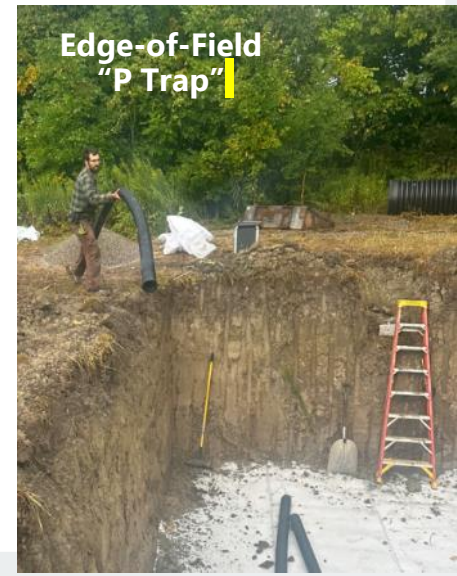
"Modified Blind Inlet" to  
replace "Standpipe"



"Modified Blind  
Inlet" to replace  
"Standpipe"



Edge-of-Field  
"P Trap"



Edge-of-Field  
"P Trap"

16,276

Acres of wetland and  
associated habitat  
restoration

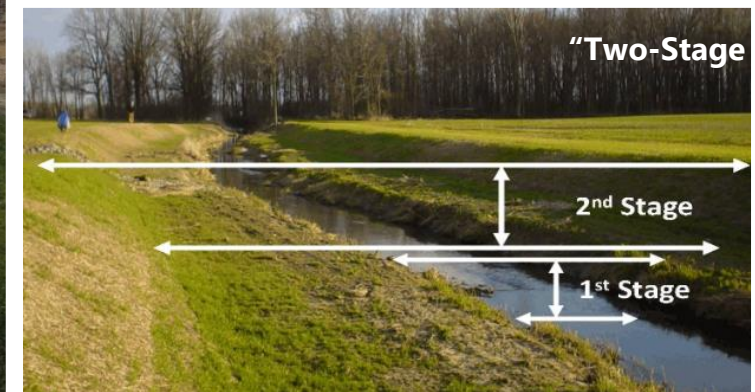


82

Conservation  
partners

# Switching Gears Again: Water Management Considerations

- Wetlands (Next slide)
- Retention basins
- Two-stage ditches
- Cascading waterways



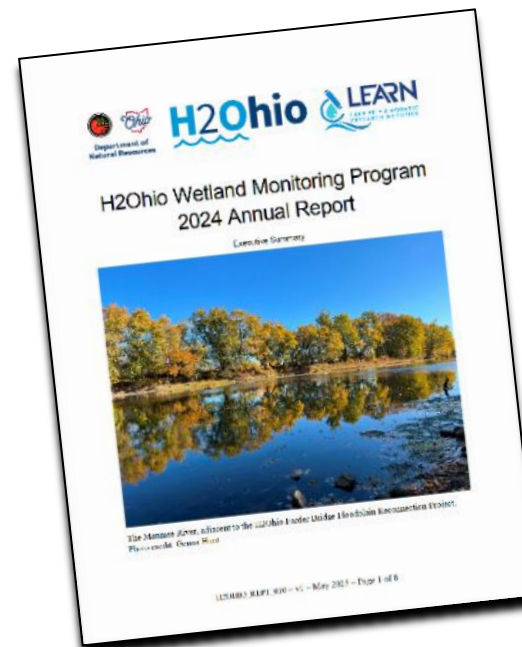
# The H2Ohio Wetland Monitoring Program

CFAES

## Goal: Assessment and Action

- Assess nutrient removal, either directly or by evidence-based proxy, of H2Ohio Wetland Projects
- Inform wetland restoration decisions

- H2Ohio wetlands remove
- 0.2–29 pounds of phosphorus per acre
  - Up to 863 pounds of nitrogen per acre



Lake Erie and Aquatic Research Network, Wetlands and Water Quality Group. 2025. *H2Ohio Wetland Monitoring Program: 2024 Annual Progress Report*. Ohio Department of Natural Resources, Office of Coastal Management.

<https://doi.org/10.5281/zenodo.15556397>

Sea Grant  
OHIO

  
THE OHIO STATE  
UNIVERSITY  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



# PILOT WATERSHED PROJECT

Meeting Lake Erie water quality goals while sustaining agricultural production



- Heavily **invest in practices, monitoring, outreach** in HUC 12 sub-watershed (5800 acres)
- Demonstrate ability of practices: Can we **move the needle**?
- **Only one year....**
  - 38% decrease DRP in Shallow Run
  - 47% increase in Potato Run (control)





CFAES



CFAES

KNOWLEDGE EXCHANGE



**Ohio Department of Natural Resources**

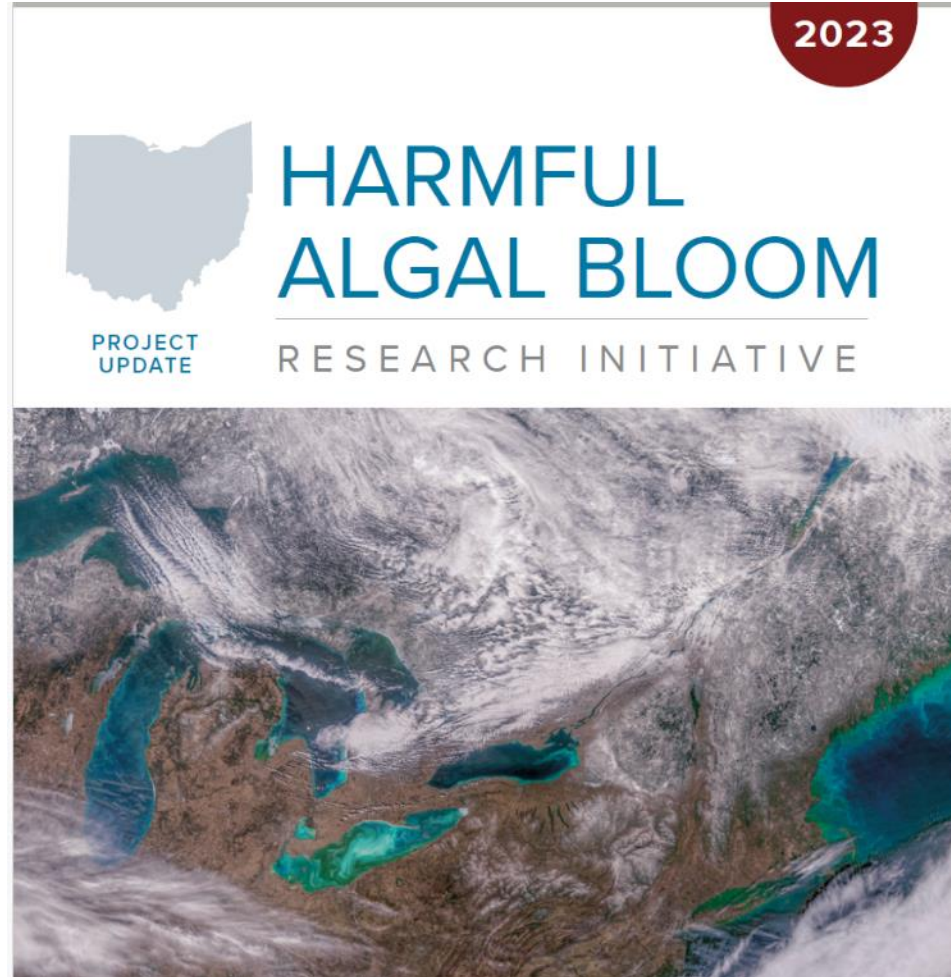
Mindy Bankey, Assistant Director  
 Scudder Mackey, Chief,  
 Office of Coastal Management  
 Scott Hale, Executive Administrator, Fish  
 Management and Research, Division of Wildlife  
 Eric Saas, H2Ohio Program Manager  
 Rich Zweifel, Inland Fisheries Program  
 Administrator, Division of Wildlife  
 Janice Kerns, Reserve Manager,  
 Old Woman Creek National Estuarine  
 Research Reserve

**Ohio Environmental Protection Agency**

Tiffani Kavalec, Chief, Division of Surface Water  
 Amy Klei, Chief, Division of  
 Drinking and Ground Waters  
 Paul Gledhill, Environmental  
 Specialist, Division of Surface Water  
 Ruth Briland, State HAB Specialist –  
 Emerging Contaminants Section,  
 Division of Drinking and Ground Water

**Ohio Lake Erie Commission**

Joy Mulinex, Executive Director  
 Lynn Garrity, Program Administrator  
 Sandra Kosek-Sills, Environmental Specialist



**Agency Advisory Board**

**Ohio Department of Agriculture**

Kirk Hines, Chief, Division of  
 Soil and Water Conservation  
 Terry Mescher, H2Ohio WLEB Program Coordinator,  
 Division of Soil and Water Conservation  
 Greg Nageotte, Grants and Watershed  
 Administrator, Division of Soil and  
 Water Conservation

**Ohio Department of Health**

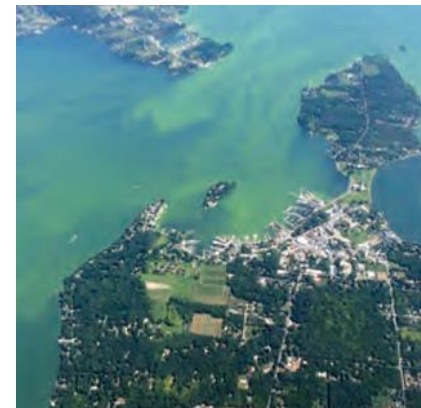
W. Gene Phillips, Chief, Bureau of Environmental  
 Health and Radiation Protection  
 Mary Shaffer, Assistant Chief, Bureau of  
 Environmental Health and Radiation Protection  
 Allison Buck-Priddy, Health Planning Administrator  
 Bryce Kerr, Environmental Specialist  
 Mridula Gupta, Environmental Scientist

117 projects intended to help state agencies prevent and manage future algal issues.



# Research Initiative Focus .....

- Understand bloom behavior
- Guide production of safe drinking
- Assess algal toxin risk to human health
- Address nutrient runoff



# — Priorities Coming Out of Ohio

- **Ohio DNR:** identifying, constructing, and managing wetland for nutrients
- **Ohio Dept. of Agriculture:**
  - Effectiveness of manure management and application methods
  - Cost-benefit analysis of subsurface placement
  - Agricultural climate change adaptation
  - Drainage retention / detention practice
  - Factors driving varying levels of farmer participation
- **Lake Erie Commission:** Effectiveness of Ohio's DAP, paired watershed, and "top eight" H2Ohio BMPs
- **Ohio EPA and Dept. Health:** Source water protection, H2O treatment, and health risk



2023

 <p><b>HAR ALG</b></p> <p>YEAR 2 PROJECT UPDATE</p> <p>RESEA</p>	 <p><b>HAR ALG</b></p> <p>YEAR 3 PROJECT UPDATE</p> <p>RESEA</p>	 <p><b>HAR ALG</b></p> <p>YEAR 4 PROJECT UPDATE</p> <p>RESEA</p>	 <p><b>HAR ALG</b></p> <p>PROJECT UPDATE</p> <p>RESEA</p>	 <p><b>HARMFUL ALGAL BLOOM</b></p> <p>PROJECT UPDATE</p> <p>RESEARCH INITIATIVE</p>
				



# Questions?



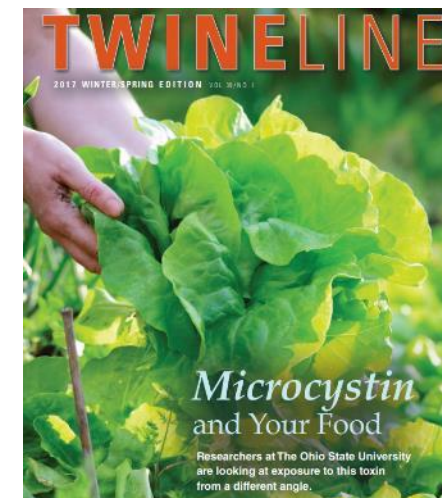
[Winslow.33@osu.edu](mailto:Winslow.33@osu.edu)



# Real Impact

- Expanded quality and frequency of collaborations (researchers and agencies)
- Early warning systems and researchers working directly with plant operators
- Changes in fish sampling protocol; time and location
- Modified permitting of water treatment residuals



Results from fish caught in 2015 show that out of 73 analyzed fish, six had detectable levels of microcystin in edible tissues—which don't include the liver and other organs—and those levels were still well below consumption limits.



FOCUS AREA	CHALLENGE	CRITICAL NEEDS OR KNOWLEDGE GAPS IDENTIFIED BY AGENCIES*
 <p data-bbox="188 505 573 615">Track Blooms From the Source</p>	<p data-bbox="606 311 1161 648">Algal blooms are not necessarily “harmful” unless they contain certain algae species and have the right mix of conditions to make toxins such as microcystin. With standard detection methods, public health officials may have to wait for hours or even days to confirm whether blooms are toxic and how they are growing and moving in the water body.</p>	<ul data-bbox="1225 268 1788 691" style="list-style-type: none"> <li>• Rapid determination of whether blooms are toxic and where toxins are moving (even apart from the main algae mass)</li> <li>• Prediction capability for the location and severity of blooms, even months ahead of time</li> <li>• The ability to track nutrients and stormwater upstream and correlate them with particular sources, storm events and algal bloom characteristics</li> <li>• Assessment of bloom and toxin locations within the vertical water column</li> </ul>
 <p data-bbox="206 958 558 1068">Produce Safe Drinking Water</p>	<p data-bbox="606 791 1161 1090">When pollutants end up in the water source for a city, water treatment officials need to know what they’re dealing with and how best to clear them out of the water. But toxins from harmful algal blooms present a relatively new challenge globally, and the detection and treatment protocols are not mature.</p>	<ul data-bbox="1225 801 1788 1033" style="list-style-type: none"> <li>• Laboratory testing of water treatment methods that give treatment facilities effective and cost-efficient options for clearing out algal toxins using their current infrastructure</li> <li>• Development of new, innovative techniques for producing safe drinking water</li> </ul>



## Projects in this Focus Area

**Evaluation of a Low-Cost In Situ Water Quality Monitoring Network to Assess Physical and Biological Changes in Ohio's Recreational and Drinking Water Sources**  
Darren Bade, Kent State University

**Investigation of Temporal Trends of Saxitoxin-Producing Cyanobacteria in Northern Ohio Lakes**  
Justin Chaffin, The Ohio State University

**Evaluating the Impact of Rivers on Phosphorus Delivery to Western Lake Erie**  
James Hood, The Ohio State University

**Quantifying the Role of Sediment in P Exports From Drainage Networks: Sources, Recency, and DRP Interactions**  
James Hood, The Ohio State University

**Exploring and Understanding Fate and Transport of Cyanotoxin in Porous And Fractured Media: Integrating Numerical Modeling, Laboratory Experiments and Field Studies**  
Ganming Liu, Bowling Green State University

**Evaluating the Interactive Effects of Dissolved Organic Matter and Nutrients on Cyanobacteria and Their Toxins**  
Craig Williamson, Miami University

**Synergies of Multisource Remote Sensing and In Situ Water Quality Data to Enhance Satellite-Based Monitoring of HABs in Ohio's Inland Lakes and Waters**  
Kaiguang Zhao, The Ohio State University

## Projects in this Focus Area

**Developing Fast Responding Solutions for Removing Cyanobacteria, Cyanotoxins and Nutrients With Coagulation/Flocculation/Sedimentation By Characterizing Site-Specific Bloom-Related Environmental Factors**

Soryong Chae, University of Cincinnati

**Evaluating Combined Approach of PAK-27 and Phoslock® to Mitigate Harmful Algal Blooms and Reduce PO<sub>4</sub> in Surface Water**

Teresa Cutright, The University of Akron

**Removing Cyanotoxins in Drinking Water Plants: Best Strategy When Saxitoxin and Anatoxin-a Present Alone or With Microcystin**

Teresa Cutright, The University of Akron

**Management of Harmful Algal Blooms By Clay-Biopolymer Composite Through Flocculation of Cyanobacterial Cells and Adsorption of Phosphorus**

Dionysios Dionysiou, University of Cincinnati

**Development of Corncob-based Materials and Filters for Removal of Cyanotoxins From Water**



Dragan Isailovic, The University of Toledo

**Discovery of Novel Cyanotoxins in HAB Samples From Lake Erie and Maumee River and Investigation of Their Toxicity**

Dragan Isailovic, The University of Toledo

**Optimization and Field Validation of a Full-Scale Dissolved Air Flotation System for Small Scale Water Treatment Plants Impacted by Harmful Algal Blooms**

Youngwoo Seo, The University of Toledo

FOCUS AREA	CHALLENGE	CRITICAL NEEDS OR KNOWLEDGE GAPS IDENTIFIED BY AGENCIES*
 <p>Protect Public Health</p>	<p>Algal toxins such as microcystin are known to have risks for humans and animals under certain circumstances. But the laboratory studies needed to make public health guidelines have not yet been updated and tailored for the more severe, persistent algal blooms we're seeing in Lake Erie and other freshwater sources around the world.</p>	<ul style="list-style-type: none"> <li>• New laboratory methods to detect the presence of algal toxins and their byproducts in living tissue such as blood</li> <li>• Laboratory studies on the effects of algal toxins at the cellular level and beyond</li> <li>• Testing of fish from affected water bodies to aid officials in advising anglers</li> </ul>
 <p>Engage Stakeholders</p>	<p>Effective crisis prevention and management involves many different types of people who need to be connected — ahead of time. The Toledo water quality crisis provided a galvanizing event that revealed the need for closer ties among scientists, agencies, municipalities and landowners.</p>	<ul style="list-style-type: none"> <li>• Establishment of connections between various land management practices upstream and nutrient flows downstream</li> </ul>



## Projects in this Focus Area

### How Much Is Too Much? Assessing the Microcystin Inhalation Risk to Shoreline Populations

April Ames, The University of Toledo

### Health Effects of Aerosolized Cyanotoxins in At-Risk Pre-Existing Disease States

Steven Haller, The University of Toledo

### Deep Phenotyping of Human Organ Biobank Specimens for Cyanotoxin Exposure in At-Risk Populations

Steven Haller and David Kennedy,  
The University of Toledo

### Microcystin Degrading Bacteria as a Novel Therapy for Microcystin Exposure and Hepatotoxicity

Steven Haller and David Kennedy,  
The University of Toledo

### Health Effects of Dermal Contact to Harmful Algal Bloom Cyanotoxins in At-Risk Pre-Existing Disease States

David Kennedy, The University of Toledo

### Needle BioFET Sensors for Detection of Microcystins in Fish Tissue

Wu Lu, The Ohio State University

### Toward the Improvement of Methods to Quantify Total Microcystins and Microcystin Congeners In Fish

Stuart Ludsin, The Ohio State University

### The Role of Foreshore Sands in Human Exposure to Microcystin

W. Von Sigler, The University of Toledo

## Projects in this Focus Area

### Effect of Soil Properties on Leaching Potential and Crop Uptake of Microcystin in Land Applied Drinking Water Treatment Residuals

Nicholas Basta, The Ohio State University

### Optimizing Manure Application Timing and Soil Health Testing to Improve Water Quality Outcomes and Farmer Profitability

Leonardo Deiss, The Ohio State University

### Tracing Flow and Transport Pathways in Geographically Isolated Wetlands Using Rainwater and Ambient Temperature (RwAT)

Kennedy Doro, The University of Toledo

### Development and Implementation of Low-Cost, On-Site, Real-Time Ionic Sensors for Assessing Water Quality From Land to Lake

Laura Johnson, Heidelberg University

### What's the Real Nutrient Load Reduction Achieved Using Controlled Drainage Structures?

Steve Lyon, The Ohio State University

### Using Stable Isotope Methods to Differentiate Among Agricultural Inorganic Phosphate Sources Seek Patterns of Addition Within the Grand Lake St. Marys Watershed

Melanie Marshall, Wright State University

### Evaluating Field- and Watershed-Scale Water Quality Benefits of H2Ohio Conservation Practices in the Maumee River Watershed

Asmita Murumkar, Jay Martin, The Ohio State University, and Kevin Czajkowski, The University of Toledo

### Quantifying Nutrient Reduction in a Constructed Wetland Complex Treating Storm Flows from East Fork Little Miami River

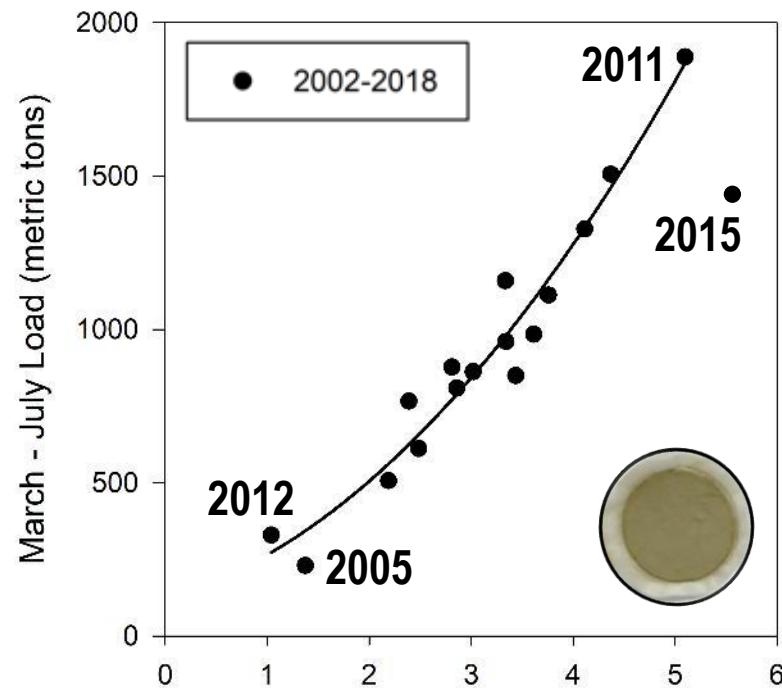
Ryan Winston, The Ohio State University

### Evaluation of a Modified Two-Stage Ditch Design Approach for Sediment and Nutrient Removal

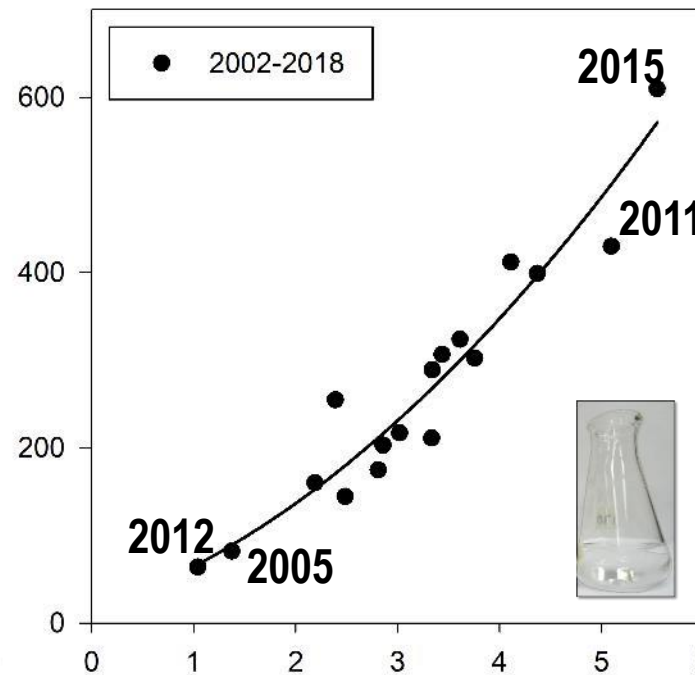
Jon Witter and Dan Mecklenberg, The Ohio State University

# Were 2024 *loads* what we expect based on 2002-2018?

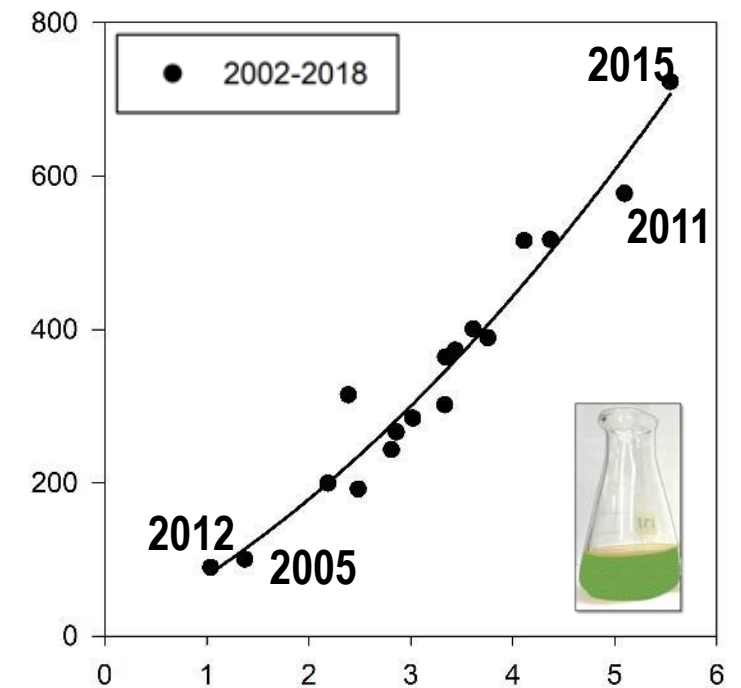
Total Particulate P



Dissolved Reactive P

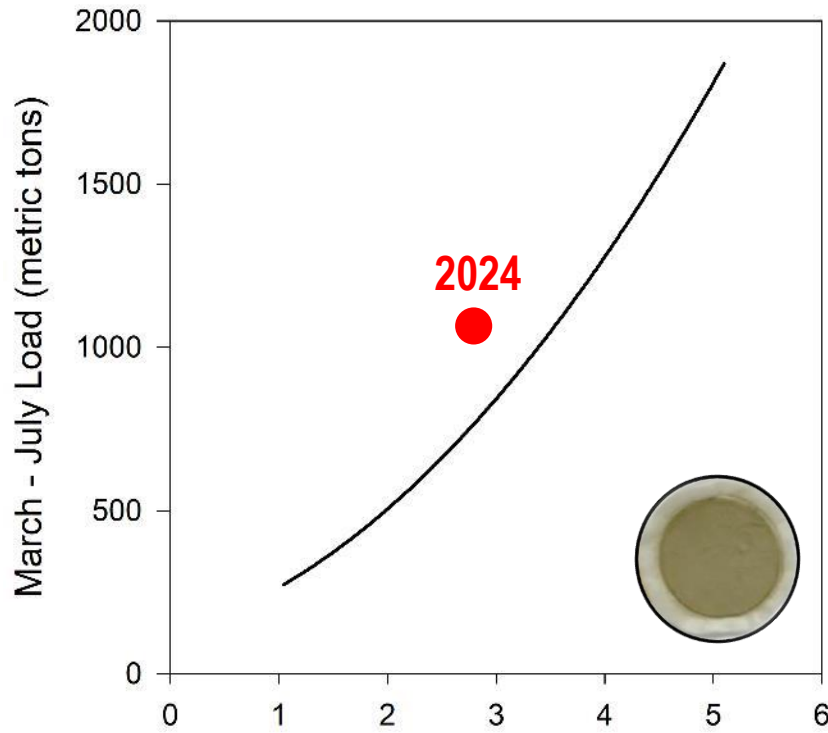


Total Bioavailable P

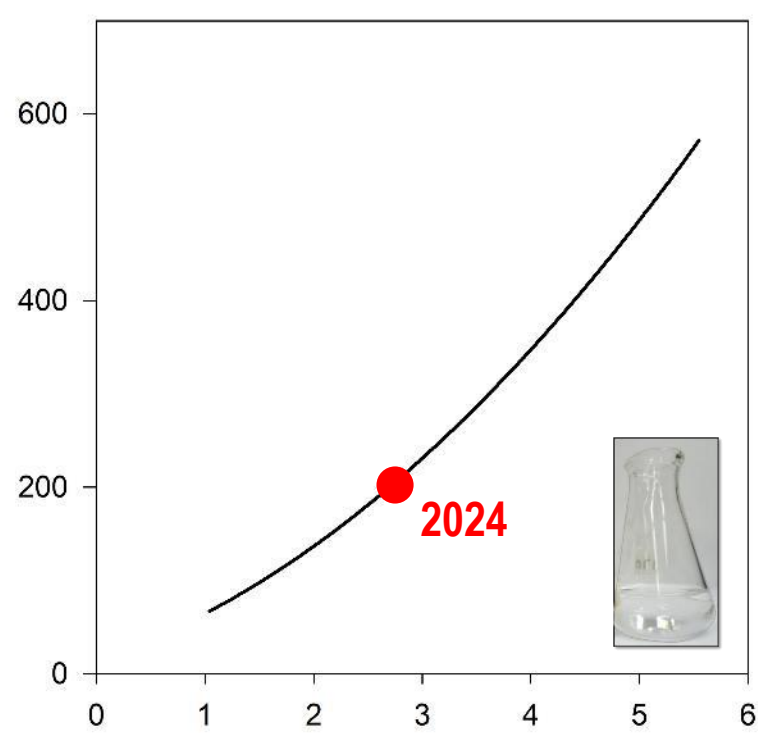


Streamflow discharge (km<sup>3</sup>)

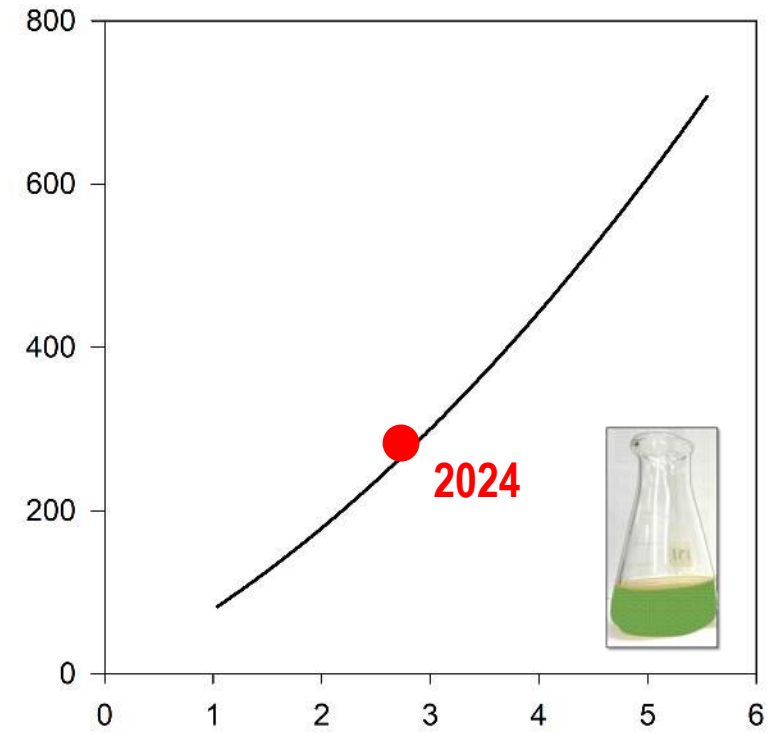
Total Particulate P



Dissolved Reactive P



Total Bioavailable P



Streamflow discharge (km<sup>3</sup>)