Evaluating Nutrient Function Across Diverse Wetland Restoration, Construction, and Enhancement Projects: The H2Ohio Wetland Monitoring Program, Ohio, USA

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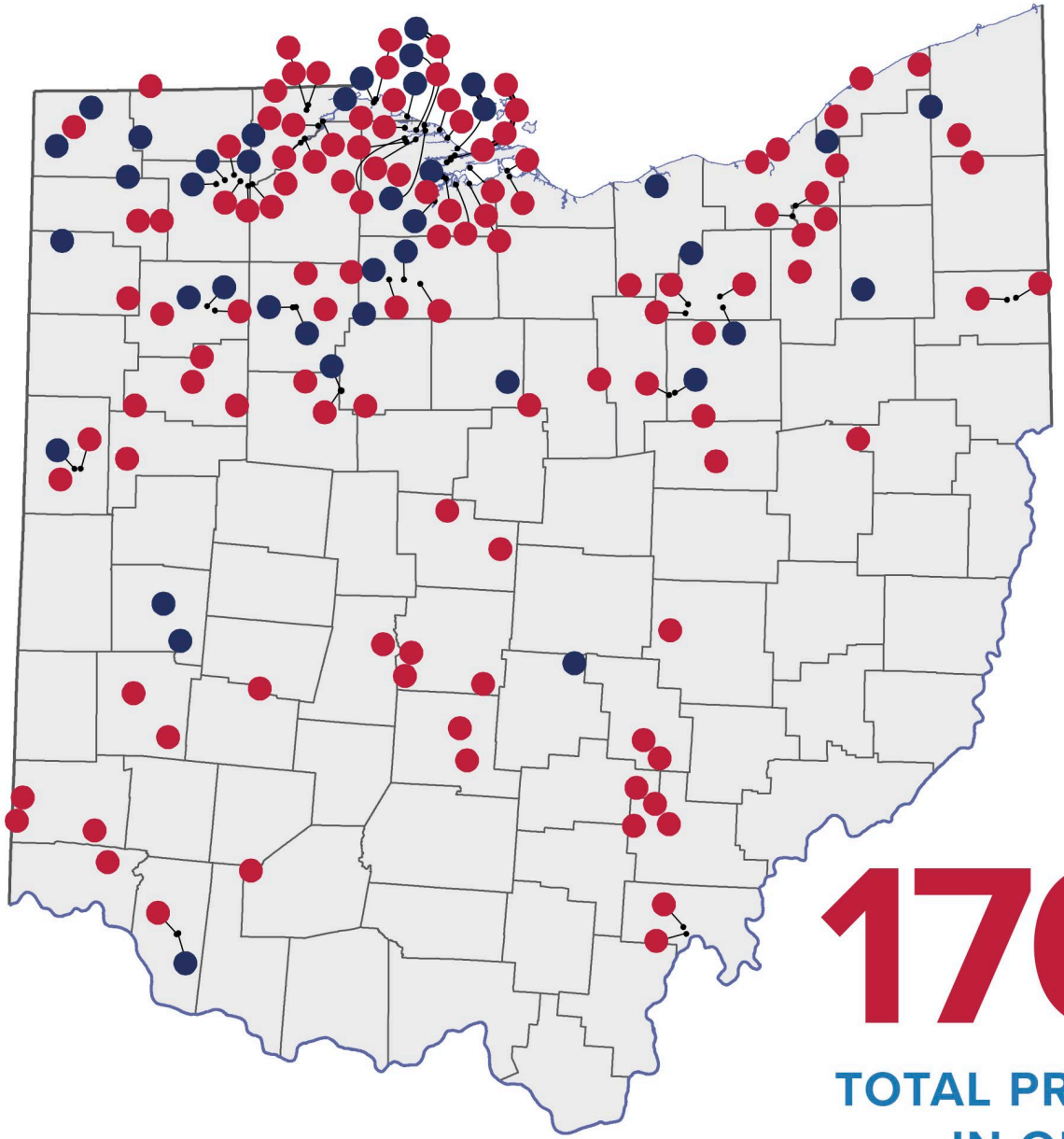
National Conference on Ecosystem Restoration ~ 2024

H2OHIO WETLAND PROJECTS



Restoration Complete

Restoration in Progress

170+

TOTAL PROJECTS IN OHIO

www.h2ohio.gov/natural-resources

H2Ohio

OHIO DEPARTMENT OF NATURAL RESOURCES

Wetland Restoration Projects

Administered by the Ohio Department of Natural Resources

“The Kidneys of the Landscape” for Nutrient Removal

BUT…

- Pollutant removal varies
- At times, some wetlands can be a nutrient source, rather than a sink
- Inherent differences between nitrogen and phosphorus

Critical Questions

H2Ohio

Ohio Department of NATURAL RESOURCES

- Is wetland restoration a cost-effective method for mitigating nutrient loads?
- How do we effectively manage wetland restoration in the future?

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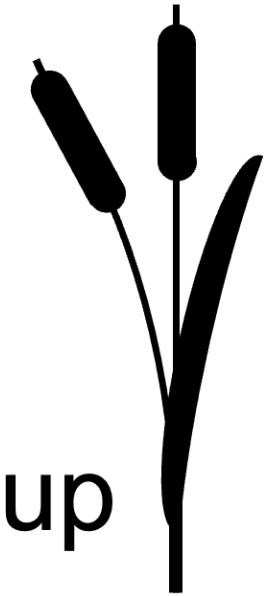
Wetlands & Water Quality Research Group



Principal Scientists and Core Staff

interdisciplinary ~ inter-institutional

Chris Winslo

íssa
donça

Kevin McClu

Johnson

Kennedy Doro

Tom Bridgeman

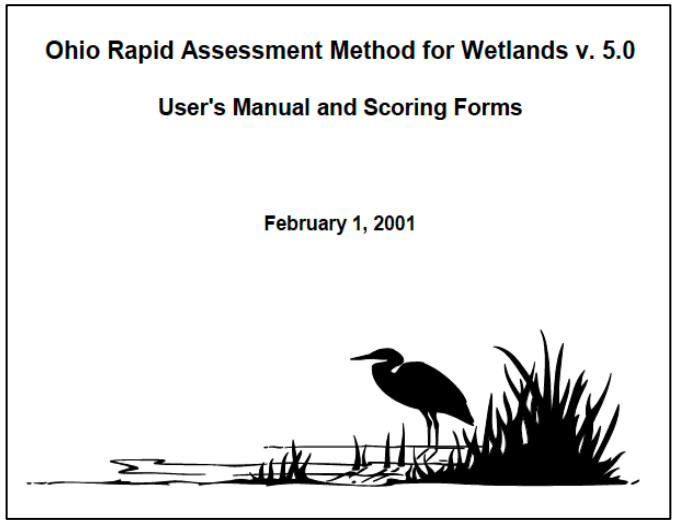
Ricky Becker

Stephen
Jacquemin

Silvia Newell

Wetland Monitoring & Assessment

- Regulatory Compliance
- Contractual Performance
- Ecosystem Health & Integrity



Directly Observed & Measured:

- Plant Biodiversity
- Substrate characteristics
- Ecosystem size

Assumed:

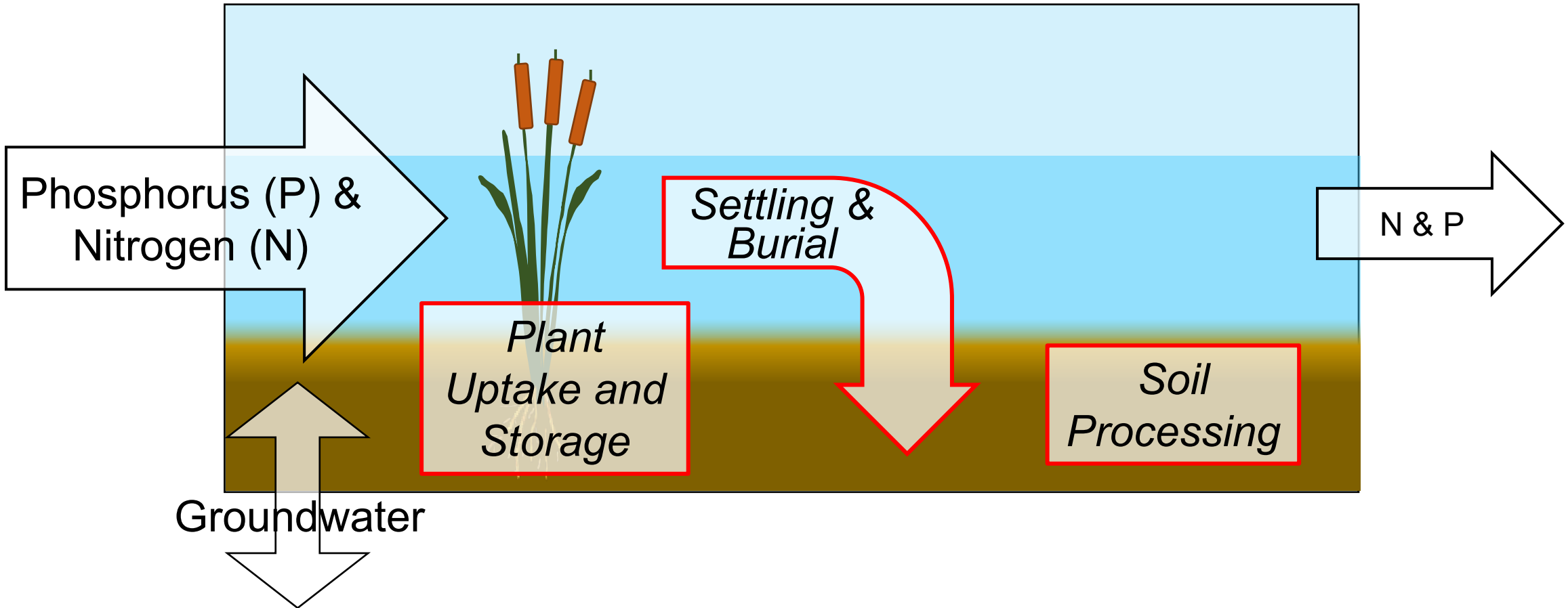
- **“Invisible” Functions**
- **Stability**

The H2Ohio Wetland Monitoring Program **Goal: Assessment & Action**

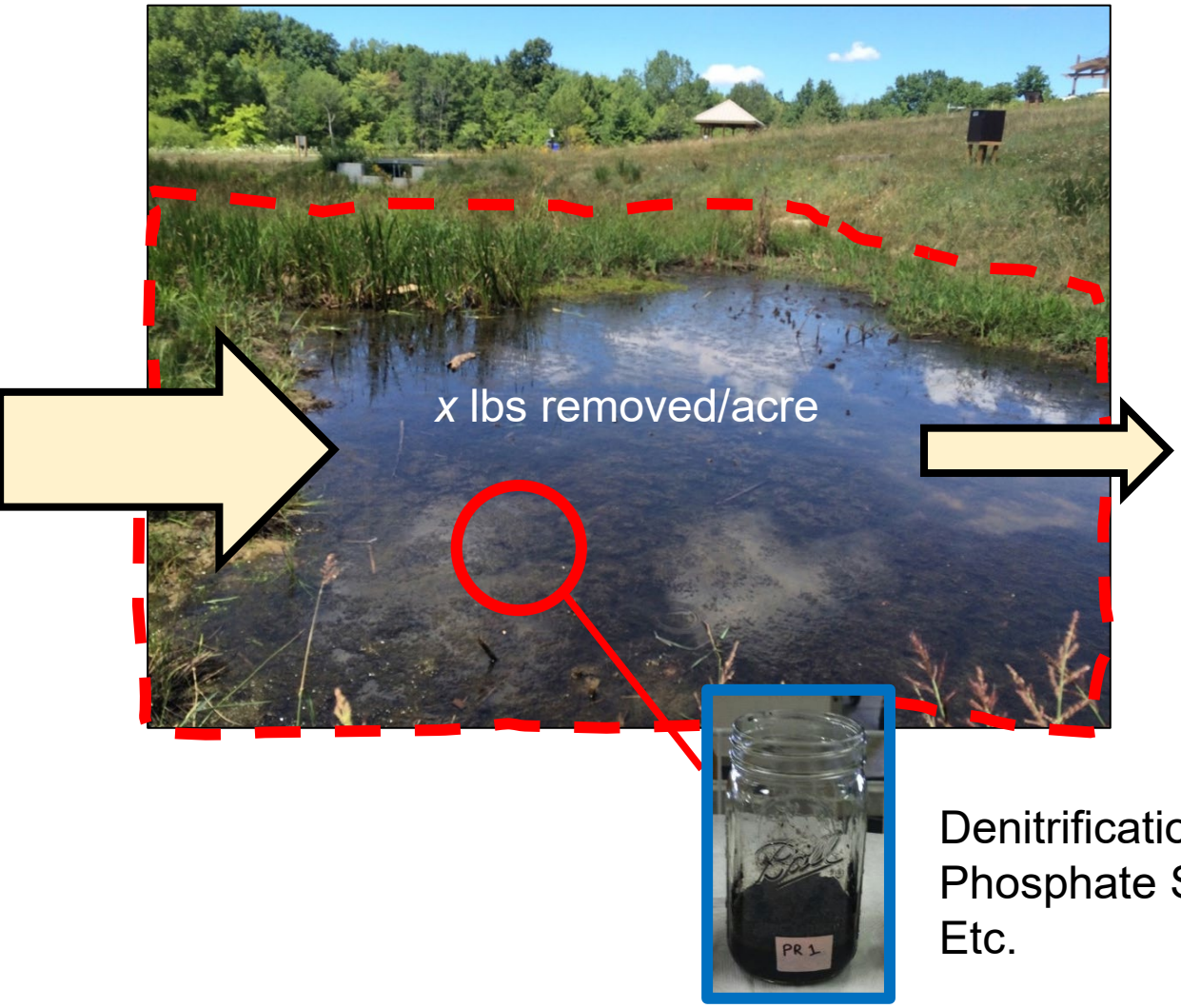
- to assess the nutrient removal function, either directly or by evidence-based proxy, of H2Ohio Wetland Projects
- Inform ODNR wetland restoration program decisions

How do wetlands remove nutrients?

- Plant uptake and storage
- Settling and burial of particulates
- Soil storage and processing of dissolved nutrients



How can we assess wetland nutrient removal?

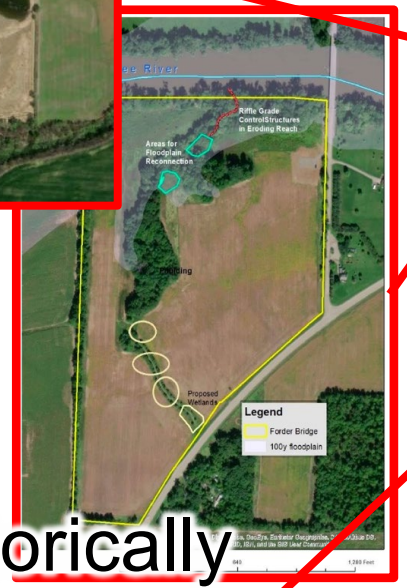


- *Assume* constant aerial removal rate and estimate by acreage
- Use soil-scale measures of potential and capacity
- **Directly quantify load reduction by measuring nutrient inputs and outputs**

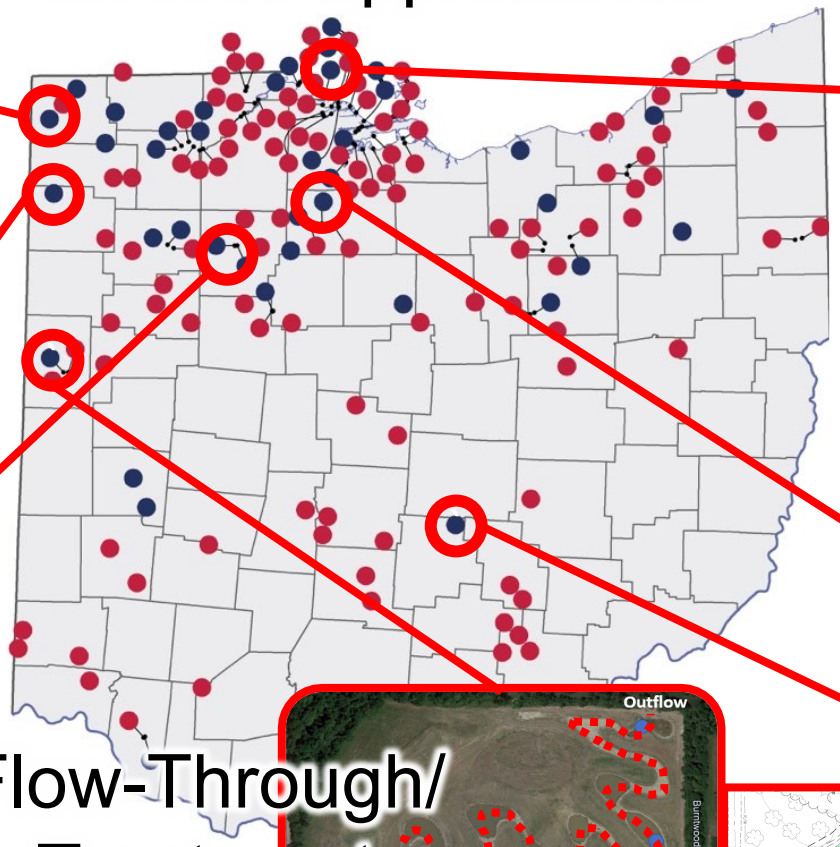
Denitrification Enzyme Assays
Phosphate Sorption Indices
Etc.

Developing a monitoring program for REAL (not cartoon) wetlands

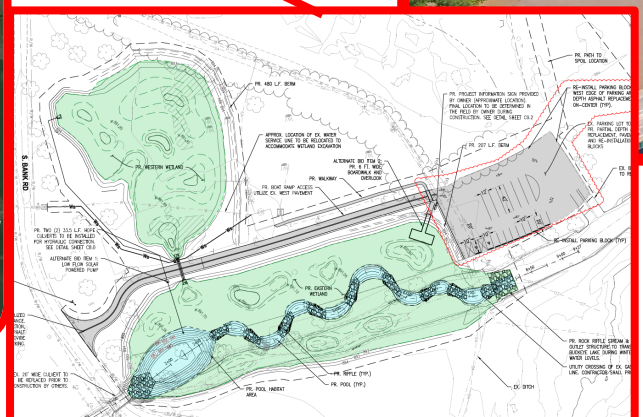
H2Ohio Wetland Projects:
170 (and counting!)
diverse approaches

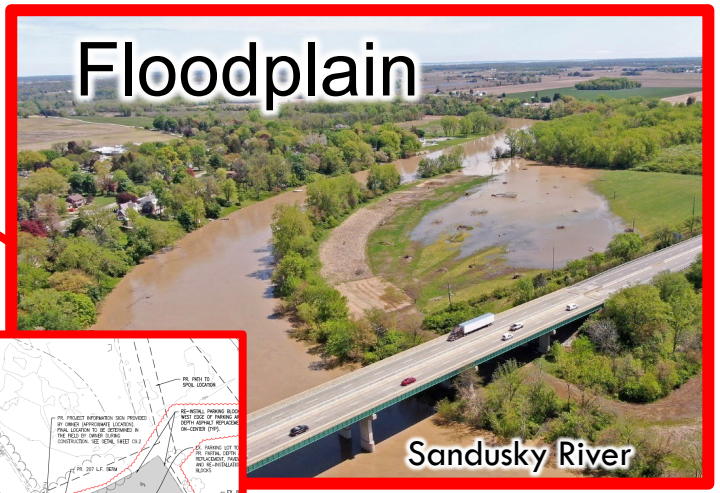


Historically Drained Agricultural Land

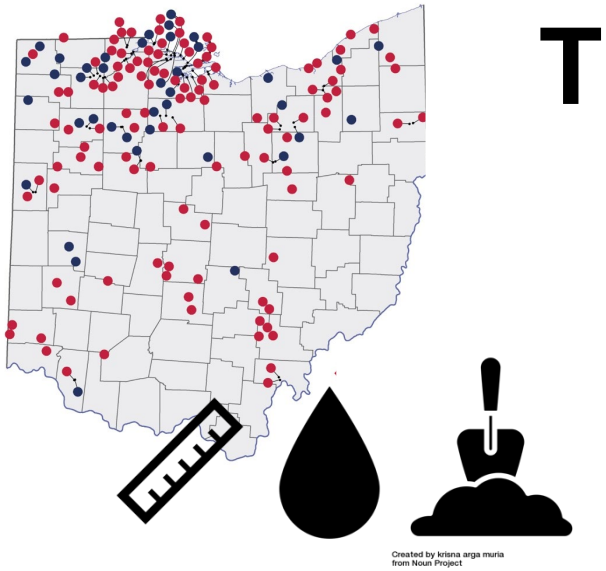


Flow-Through/ Treatment Trains



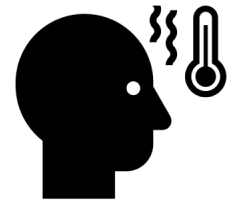


Tiered Approach



Baseline Data

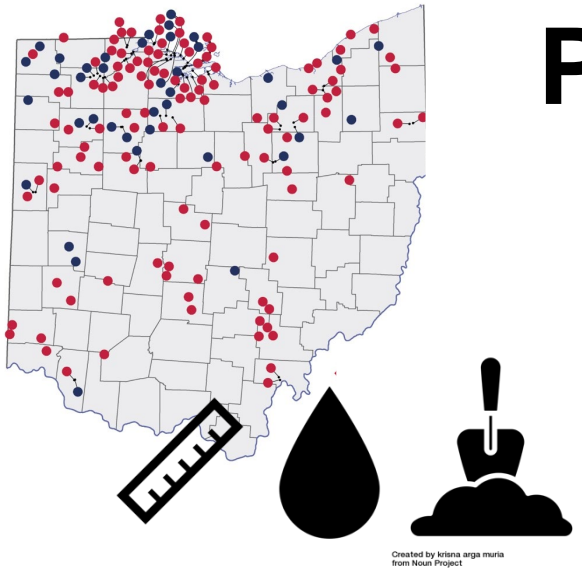
- All Monitored Projects (~40):
  - Baseline monitoring
  - We are learning how to **“Take a Wetland’s Vital Signs”:** indicators & red flags



- Intensively Monitored Focal Projects (8):
  - Representative of restoration approaches
  - Best nutrient budgets possible
  - Mechanistic understanding

Specialty Data & Modeling

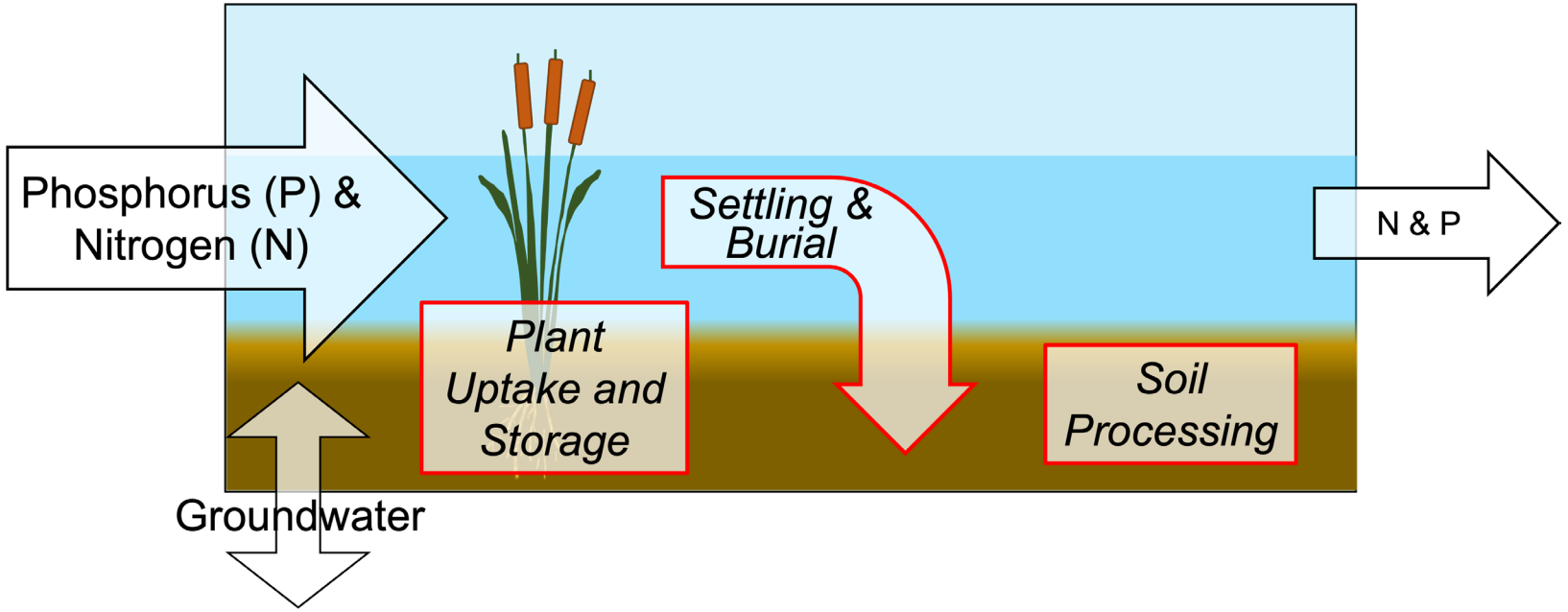
Project-Specific Monitoring



Baseline Data

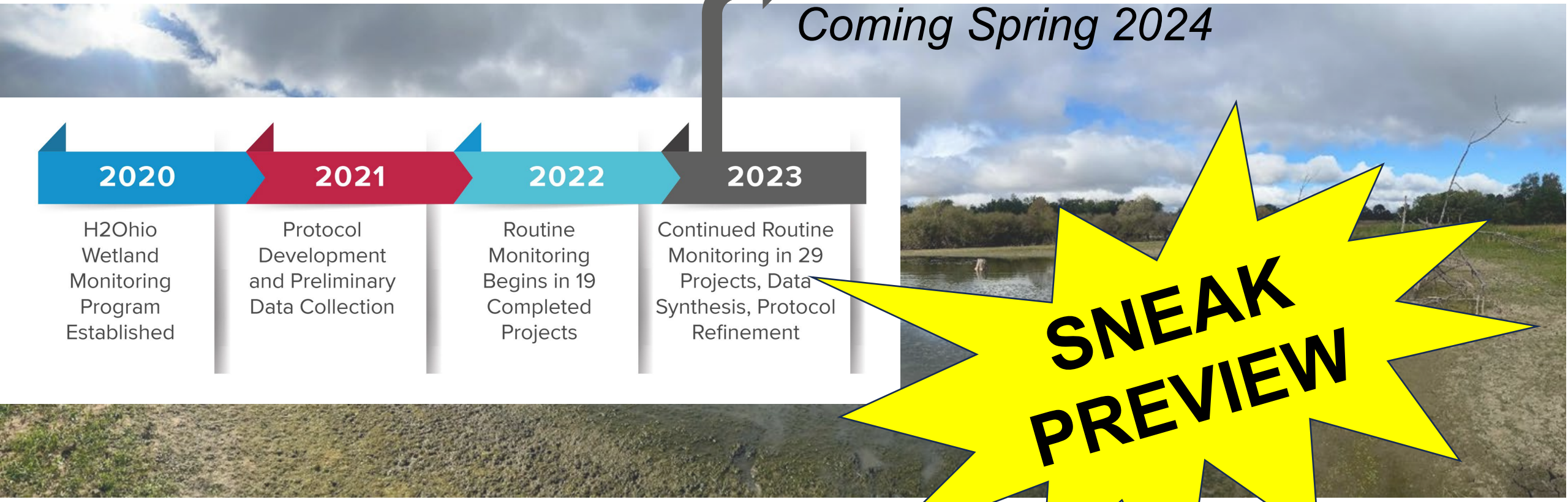
- Use standardized protocols to monitor diverse projects under a unified framework
- Project-specific monitoring plans

Specialty Data & Modeling



H2Ohio Wetland Monitoring Program Timeline

2023 Annual Report
Coming Spring 2024



Estimated load of phosphorus removed by 8 projects with sufficient data

Project	Type
Magee Marsh Turtle Creek Bay Wetland Reconnection	Coastal
Redhorse Bend Preserve Wetland Restoration	Floodplain
Oakwoods Nature Preserve Wetland Restoration Project East & West	Former Agricultural
Forder Bridge Floodplain Reconnection	Former Agricultural
St. Joseph's River Restoration Project	Former Agricultural
Tipp City Off-Channel Wetland	Floodplain
Burntwood-Langenkamp Wetland Conservation Area	Flow-through
Brooks Park Wetland Creation & Water Quality Initiative	Flow-through

Estimated load of phosphorus removed by 8 projects with sufficient data

Early Results:

- Most projects, most of the time retain both N and P on annual time scales
  - 0-10 lbs/acre
- Transient P release happens
- Uncertainties:
  - Drainage area
  - Tile drain inputs
  - Storm event loads

Project	Type	2023 Phosphorus Load Reduction Estimates	
		lbs P	lbs P/acre
Magee Marsh Turtle Creek Bay Wetland Reconnection	Coastal	0	0
Redhorse Bend Preserve Wetland Restoration	Floodplain	13	0.65
Oakwoods Nature Preserve Wetland Restoration Project East & West	Former Agricultural	82	1.6
Forder Bridge Floodplain Reconnection	Former Agricultural	4-45	0.8-9
St. Joseph's River Restoration Project	Former Agricultural	20-50	0.6-1.5
Tipp City Off-Channel Wetland	Floodplain	108	10.8
Burntwood-Langenkamp Wetland Conservation Area	Flow-through	33	1.2
Brooks Park Wetland Creation & Water Quality Initiative	Flow-through	-2 ± 5	-0.4 ± 1

Compared estimates with initial ODNR predictions

Early Results:

- Early projections overestimated input P loads and annual P removal amounts
- Informing ODNR predictive modeling

Project	Type	Load Reduction (Lbs P)		
		ODNR **Prediction**		WMP **Estimate** - *2023*
Magee Marsh Turtle Creek Bay Wetland Reconnection	Coastal	536-976	>	0
Redhorse Bend Preserve Wetland Restoration	Floodplain	1813-6880	>	13
Oakwoods Nature Preserve Wetland Restoration Project East	Former Agricultural			
Ford Rec	ral			
St. J Rest	ral			
Tipp Wetl	in			
Burn Wetl	ugh			
Broc Creation & Water Quality Initiative	Flow-through			

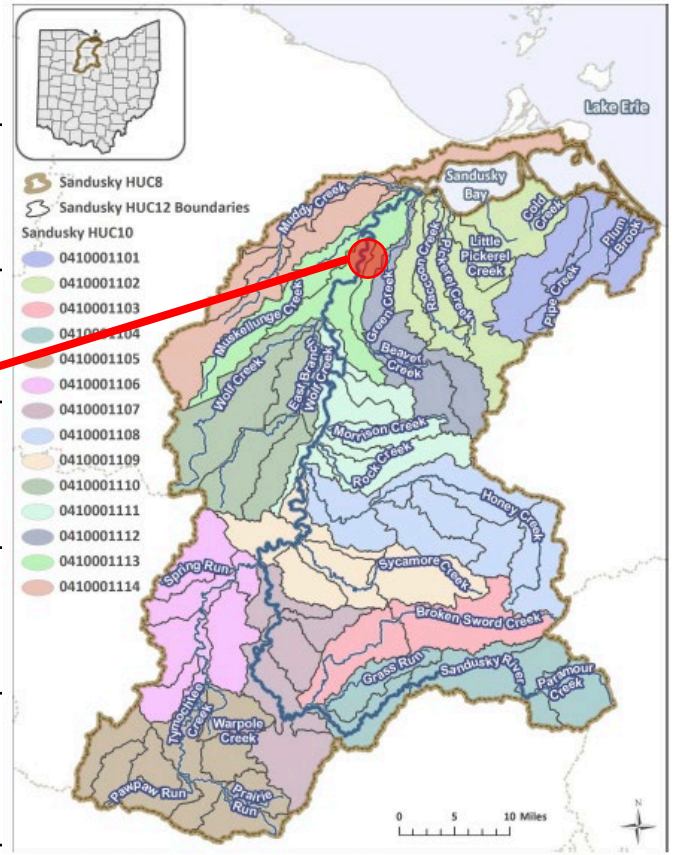


Figure 2. 10-digit hydrologic units in the Sandusky basin.

Looking ahead…

- Coordinated research & monitoring
  - Greenhouse gas flux
  - Carbon storage
  - Bird usage
  - …
- Outreach & engagement
  - Participatory/community/citizen science
- Long-term monitoring

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THANK YOU

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Funding Sources

Ohio Department of NATURAL RESOURCES

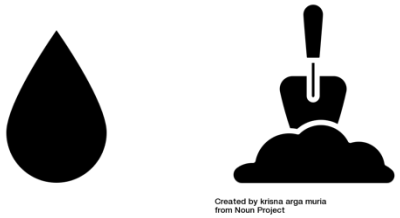
Ohio Water Development Authority

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

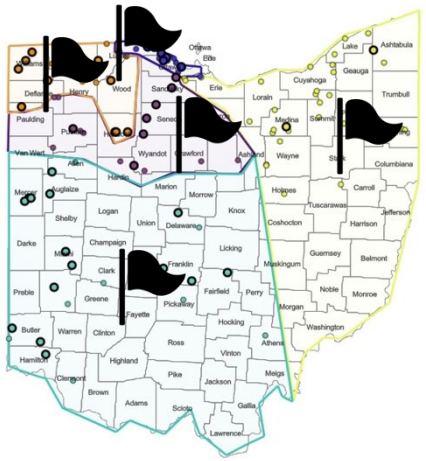
Great Lakes RESTORATION

OhioHigherEd
Department of Higher Education

The H2Ohio Wetland Monitoring Program



Soil & Water Sampling

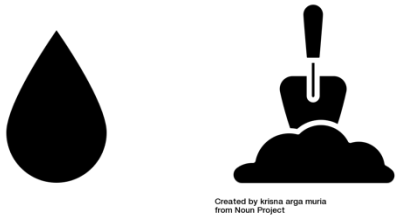


Base Data

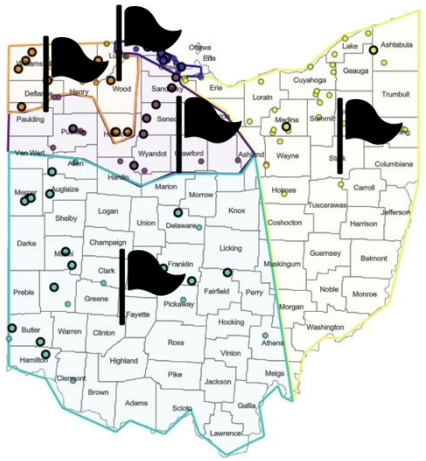
5 Base Crews

Indicator	Parameters
<u>Surface water nutrient concentrations:</u> Sampled in major inflows, outflows, and inundated wetland areas during ambient conditions and hydrologic events	Total Nitrogen (N) Total Phosphorus (P) Nitrate-N (NO_3^-N) &Ammonium-N (NH_4^+-N) Dissolved Reactive P (DRP) Dissolved Oxygen Turbidity Electrical Conductivity
<u>Soil characteristics and nutrient status:</u> Stratified by hydrobiogeomorphic zones, as indicated by elevation, inundation condition, wetland design plans, and/or vegetation communities	Moisture content, pH, Conductance Total carbon, Total inorganic carbon, Total organic carbon Total N & P Water-extractable SRP, NO_3^-N, and NH_4^+-N Mehlich III extractable P, Fe, and Al
<u>Water level</u>: Paired with topography to estimate depth and spatial extent of inundation, flows	

The H2Ohio Wetland Monitoring Program



Soil & Water Sampling



Hydrodynamic Modeling

Soil Geophysics

Plant Nutrient Uptake

Sensor Systems

Plant and Flood Mapping

Soil P Release, N Processing

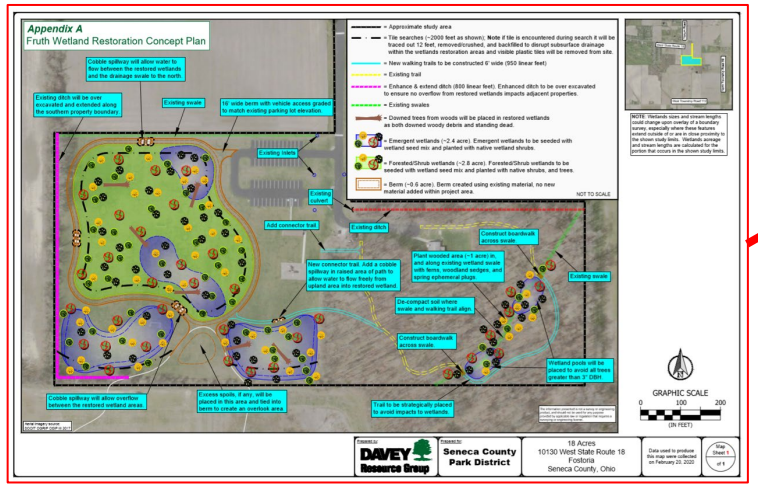
Base Data

5 Base Crews

Diagnostic Data

6 Specialty Crews

Hydrology matters: Residence Time & **Connectivity**



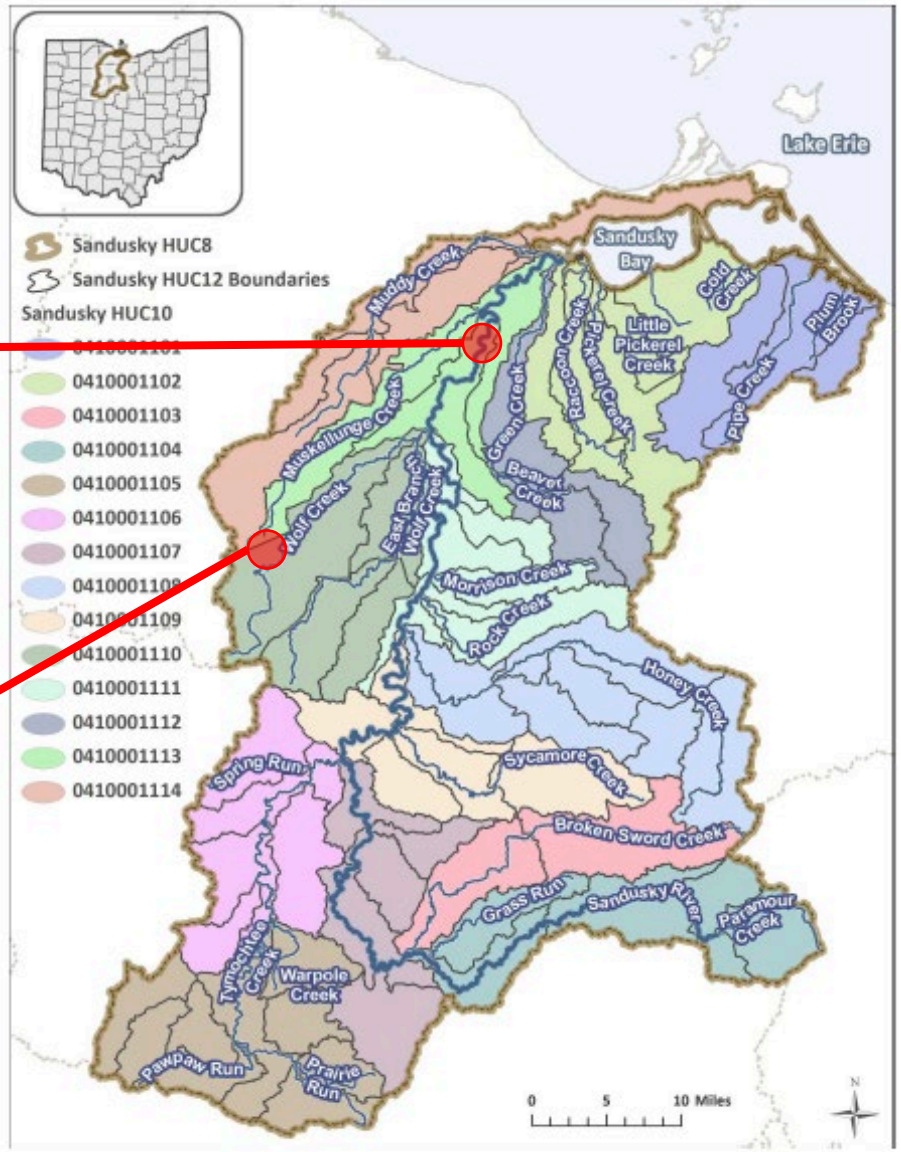
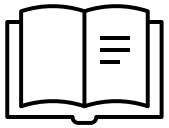


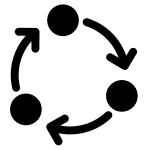
Figure 2. 10-digit hydrologic units in the Sandusky basin.

Guiding Principles

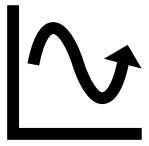


Responsible, Open, and Sound Science

A Community of Researchers, Professionals, and Partners



Learning by Doing in an Adaptive Framework



Building a Foundation for Long Term Monitoring

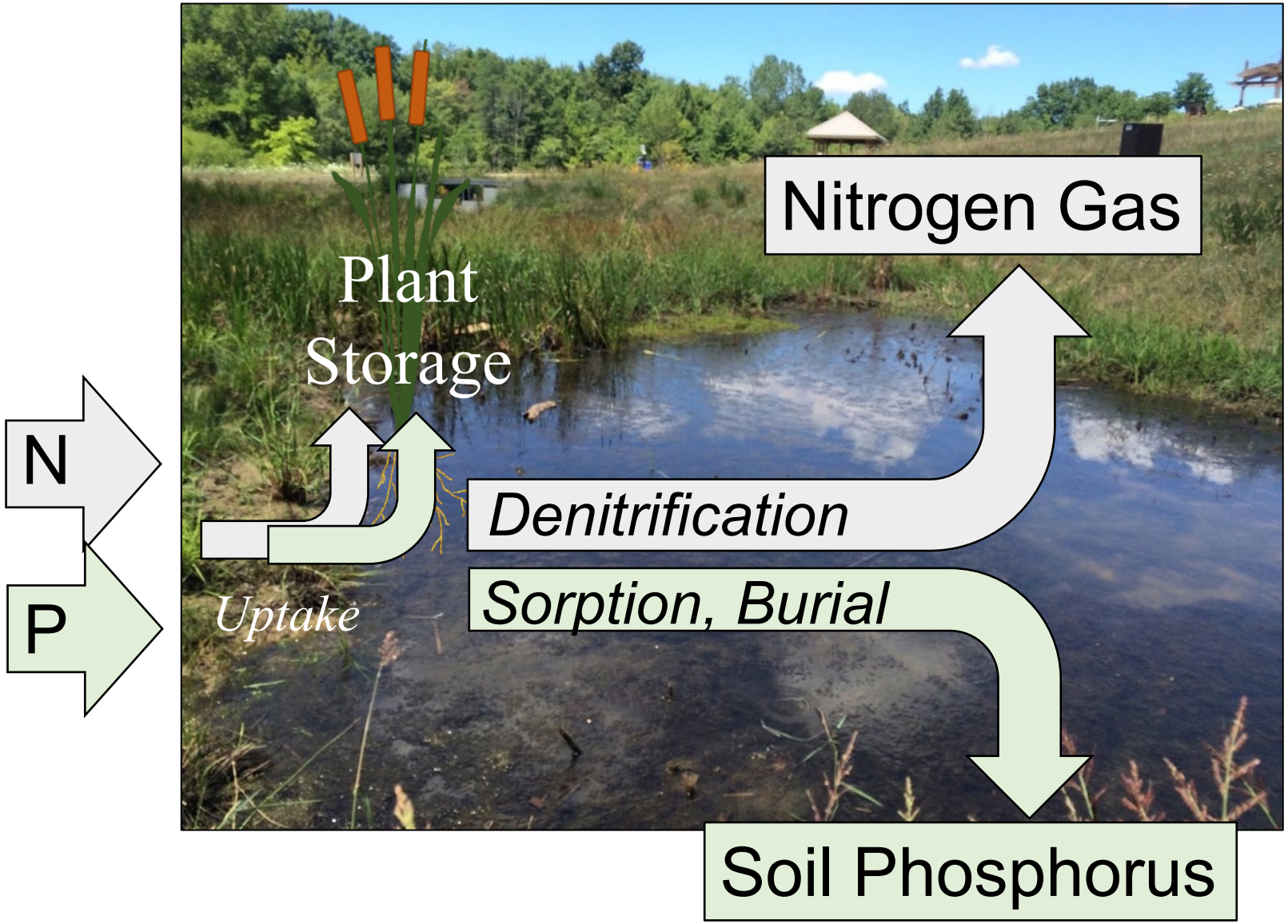
Focus on Function

Early Results:

- Most projects, most of the time retain both N and P on annual time scales
- Transient P release happens
- Early projections may have overestimated annual P removal amounts

Project	Restored Wetland Acres	Load Reduction Prediction		Load Reduction Estimate- *2023*	
		Lbs P	Lbs P/acre	Lbs	Lbs P/acre
Redhorse Bend Preserve Wetland Restoration	20	1813-6880	73-275	204	10.2
Tipp City Off-Channel Wetland	10	148-377	15-38	53.9	5.39
Forder Bridge Floodplain Reconnection	5	7-51	1.4-10	13-17	2.6-3.4
St. Joseph's River Restoration Project	33	6-39	0.2-1.2	14-107	0.4-3.2
Oakwoods Nature Preserve Wetland Restoration Project East & West	50	394-1599	7.9-32	82	1.64
Burntwood-Langenkamp Wetland Conservation Area	27	125-496	4.6-18	32	1.2
Brooks Park Wetland Creation & Water Quality Initiative	5	70-278	14-56	-2 ± 5	-0.4 ± 1
Magee Marsh Turtle Creek Bay Wetland Reconnection	173	536-976	3.1-5.6	0	0
	Average lbs/acre:		34.7		3

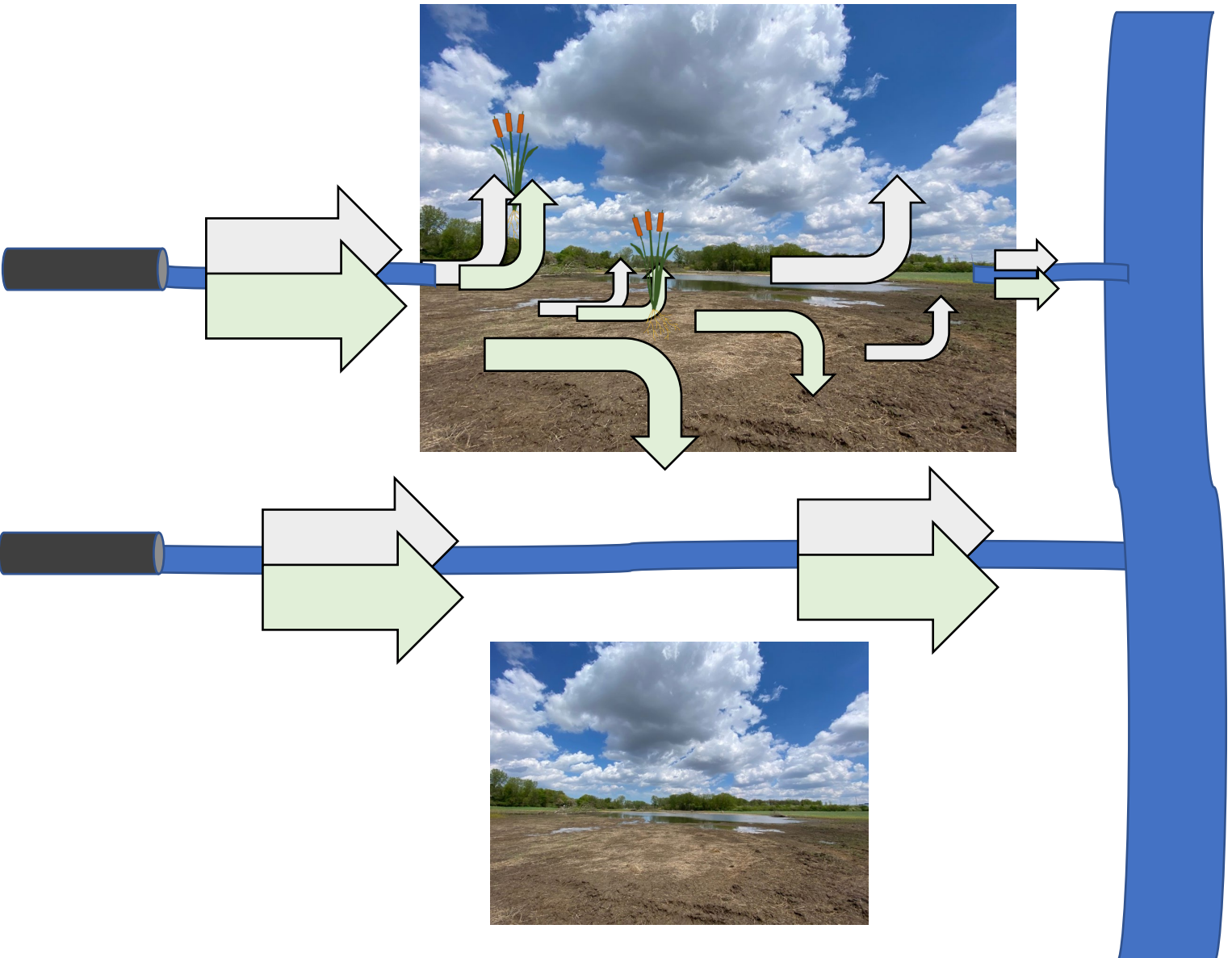
Nutrient Biogeochemisty 101



How do wetlands remove N & P?

- Plant uptake & storage removes both N & P
- Microbial denitrification removes N
- Physical settling, burial, and geochemical sorption removes P

How do wetlands remove nutrients?



- Processing rates vary in space and time
- Whole-ecosystem nutrient removal depends on wetland connectivity

H2Ohio

Ohio Department of Agriculture

Department of Agriculture

Best Management Practices

Ohio Environmental Protection Agency

Environmental Protection Agency

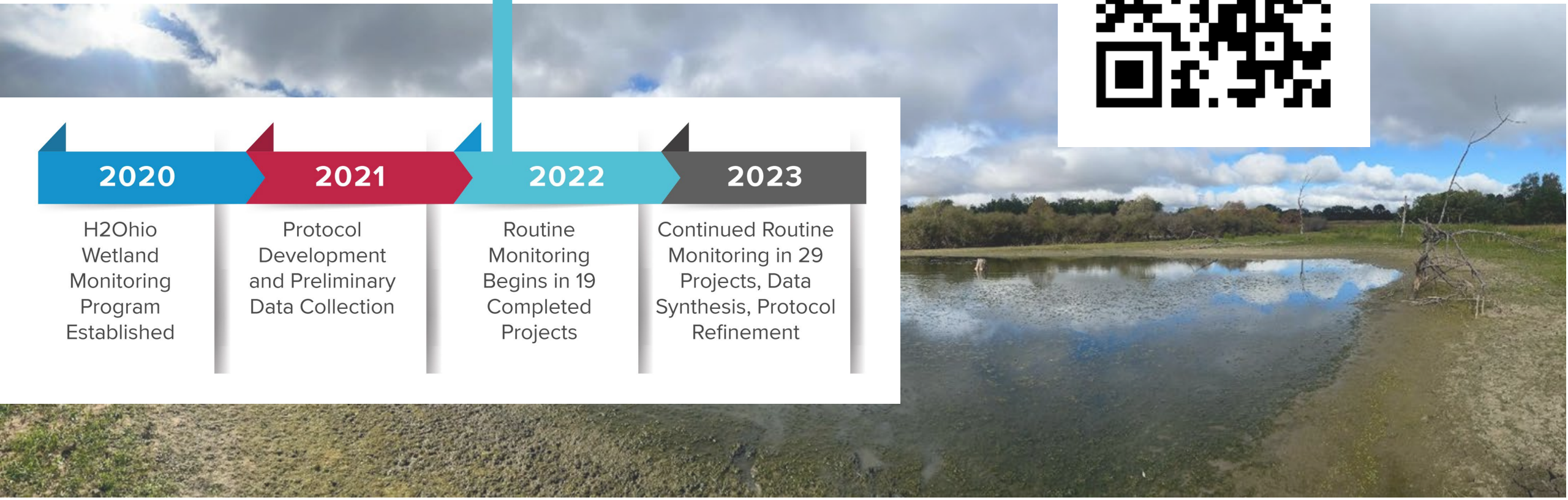
"Hard" Infrastructure: Septic System Upgrades & Lead Mitigation

Ohio Department of Natural Resources

Department of Natural Resources

Natural Infrastructure

Our 2022 Annual Report!
https://osf.io/cuwbp



2023 in review

H2Ohio Wetland Monitoring Program

Ohio Department of NATURAL RESOURCES

LEARN LAKE ERIE & AQUATIC RESEARCH NETWORK

200+
SAMPLING VISITS
to
46
WETLAND PROJECTS

=

1700+
WATER SAMPLES COLLECTED

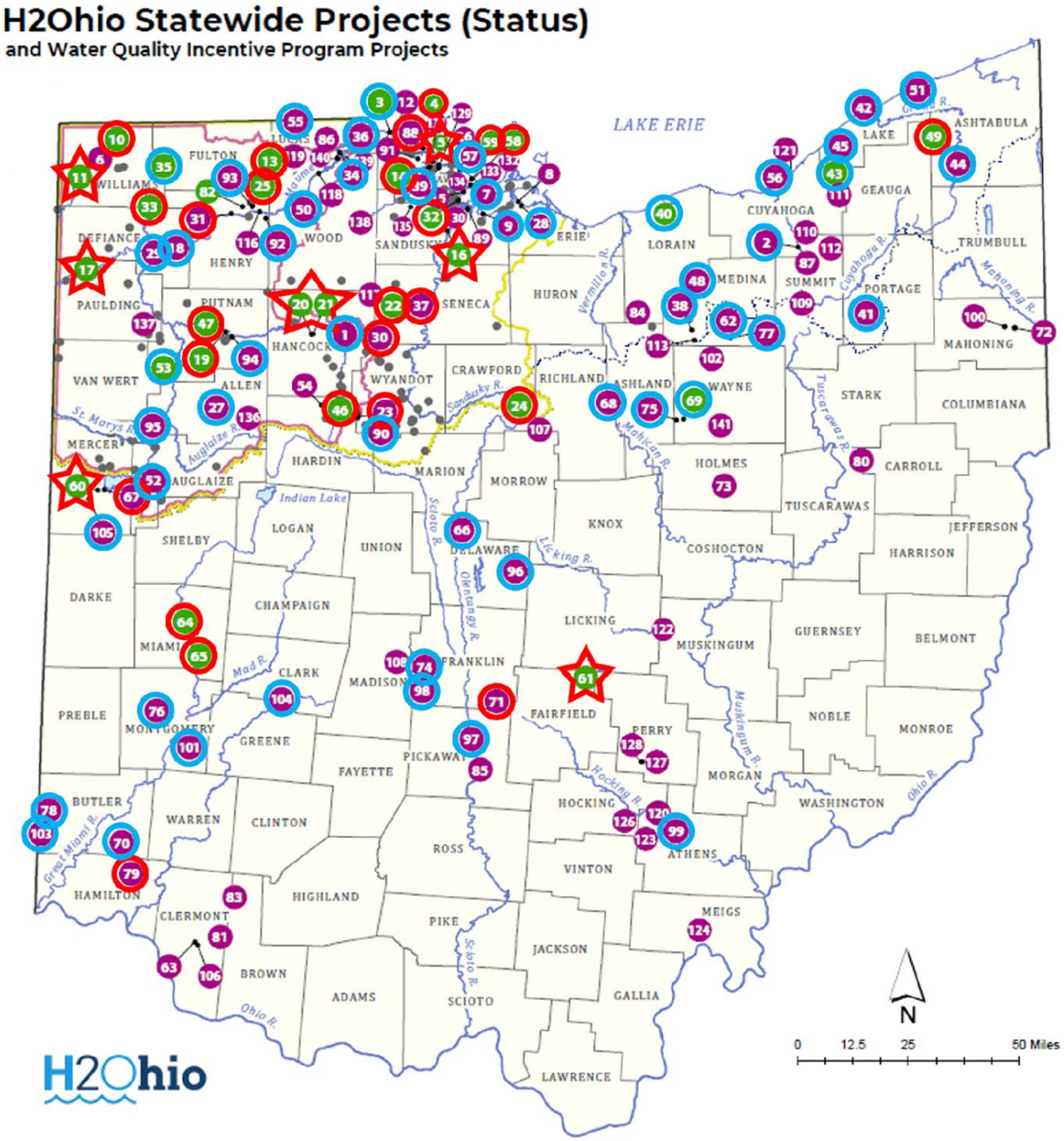
600+
SOIL SAMPLES COLLECTED

350+
BIOMASS SAMPLES COLLECTED

NUMBER OF WETLANDS WITH QUANTIFIED SOIL PROCESS RATES

NUMBER OF GROUNDWATER WELLS INSTALLED IN 3 FOCAL WETLANDS

NUMBERS OF WETLANDS WITH INSTALLED WATER LEVEL GAUGES AND SENSORS



In 2023, we monitored

33 H2Ohio Projects.

Of these, intensively monitored

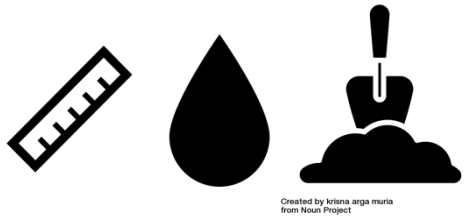
8 Focal Projects.

Focal - Intensive

Routine

Future

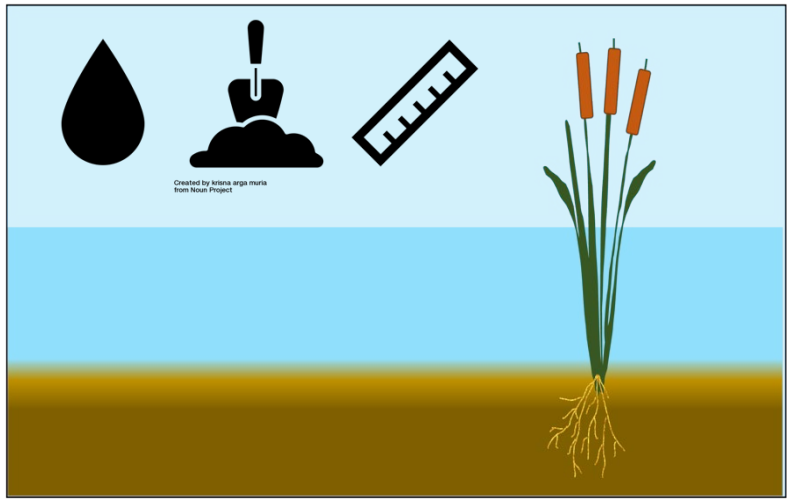
Base Data



Specialty Data

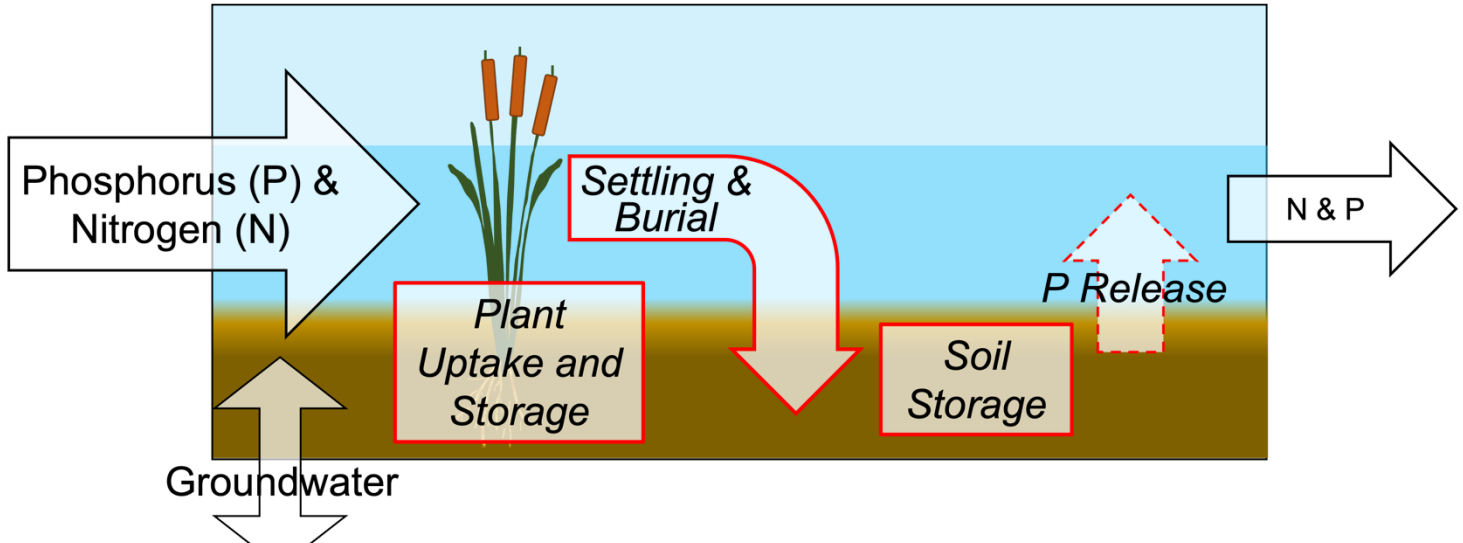
Nutrient Snapshots

"red flags" & "vital signs"



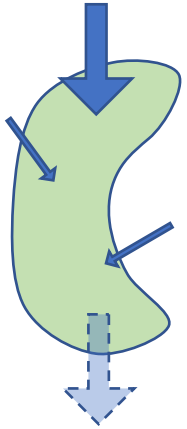
Load Reduction

- Measuring actual amount of P & N removed for cost/benefit analysis
- Understanding to inform management



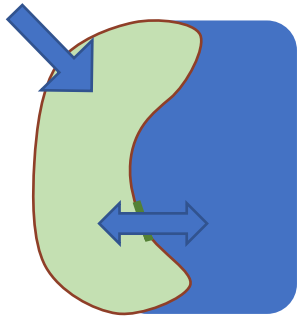
Challenge: *Many wetlands lack easily monitorable inflows and outflow for nutrient budgeting.*

Flow-through Wetlands:



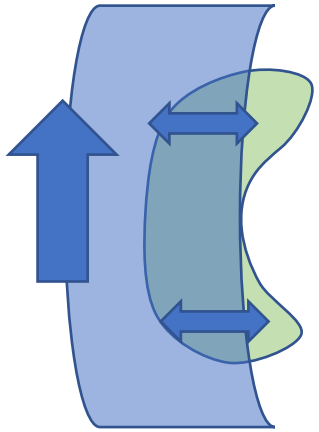
Constrained, unidirectional inflows and outflows

Coastal Wetlands:



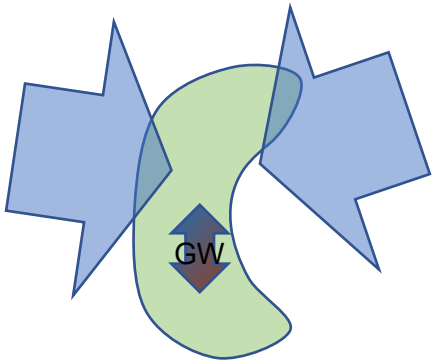
Constrained, unidirectional and bidirectional connections, influenced by water levels, seiches, and wetland management

Floodplain Wetlands:



Lateral, intermittent connection to river, stream, or ditch, influenced by intermittent flooding and river discharge

"Isolated" Wetlands:



Distributed, unconstrained inputs from surface runoff, likely connection to groundwater