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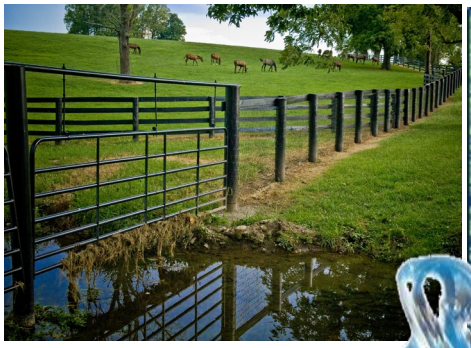
SAFE AND SUSTAINABLE WATER RESOURCES RESEARCH PROGRAM

Research Area 6:
Nutrient Reduction Strategies and Assessment

BOSC SSWR Subcommittee Meeting on Nutrients and HABs
December 1-2, 2021

Office of Research and Development

BOSC Meeting SSWR Nutrients and HABs

December 1-2, 2021

Background and Research Overview and Highlights

Yongping Yuan, Ph.D.

Center for Environmental Measurement and Modeling (CEMM)

Background

- Nutrient pollution is a widespread water quality problem with consequences for human and environmental health, environmental condition, and the economy.
- ORD research supports the development of new information and tools for OW, states, tribes, and local decision-makers to establish and achieve water quality goals.
- Science can inform recommendations to protect different types of waters and different designated uses (e.g., aquatic life, recreation, and drinking water source protection).

ORD's Nutrients and HABs Research

Research Area 4: Assessment and Management of HABs

Research Area 5: Science to Support Nutrient-Related Water Quality Goals

Research Area 6: Nutrient Reduction Strategies and Assessment

Nutrient Reduction Strategies and Assessment

Products from this work will help our customers plan, implement, and track the effectiveness of nutrient reduction strategies at multiple spatial and temporal scales, including watersheds draining to receiving waters potentially affected by HABs or other nutrient-related water quality issues.

Tools and approaches for implementing and tracking nutrient reductions. - *Jana Compton*

Effectiveness of restoration and conservation practices and systems. - *Yongping Yuan*

Best practices for integrated nutrient management programs. - *Chris Nietch*

Tools and Approaches for Implementing and Tracking Nutrient Reductions

Overview:

Research to develop and test approaches to design and implement nutrient management, and to track progress toward meeting a nutrient reduction goal.

Research Products:

- Integrated Multi-Media Modeling System (IMS) for nutrient management and policy options.
- Watershed-scale wetland treatment for nutrient management.
- Toolbox for nutrient pollution source tracking.
- Comparing landscape nutrient inputs to U.S. water chemistry over time.

Evaluating the Effectiveness of Restoration and Conservation Practices

Overview:

This research advances our understanding on the effectiveness of conservation and best management practices for nutrient reduction.

Research Products:

- Effectiveness of enhanced efficiency fertilizers (EEFs) for reducing nutrient pollution.
- Effectiveness of nutrient management on nitrate-nitrogen loss from subsurface drainage.
- Evaluation of river floodplain restoration approaches and the effects on water quality.
- Management options for water quality improvement of Lake Erie.

Best Practices for Integrated Nutrient Management Programs

Overview:

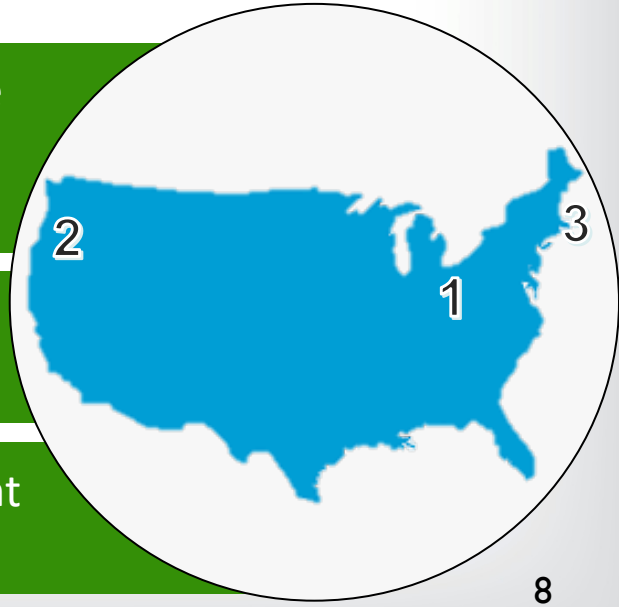
- Requires partnerships with land grant universities, soil and water conservation districts, business, NGOs, and other local, federal and state agencies.
- Research is solutions driven and through its partnerships strives for innovation in and better understanding toward reducing nutrients for large systems and by integrating nutrient management science, engineering, economics, and stakeholder engagement.
- Communication, economics, and/or behavioral science as critical components.

Research Products:

Ohio: Economic and water quality feasibility analysis to compare costs for non-traditional participants in market mechanisms like water quality trading (1).

Oregon: Integrated approaches in community nonpoint source nutrient management (2).

Cape Cod Nutrient Solution-Driven Research: Reducing non-point sources of nutrients via non-traditional approaches (3).



Evaluating the Effectiveness of Restoration and Conservation Practices

Yongping Yuan, Ph.D.
Center for Environmental Measurement and Modeling

Assessing the Effectiveness of Enhanced Efficiency Fertilizers (EEFs) for Reducing Nutrient Pollution

Issue: EEFs could reduce nutrient losses to air, land, and water.

Approach: Joint EPA-USDA Partnership and Competition on Next Gen Fertilizers to Advance Agricultural Sustainability in the United States.

Result: Two Challenges launched.

1. Existing EEFs: Stage 1 - EEFs selected; currently in Stage 2 - Greenhouse trials.
2. Next Gen Fertilizers: Winners awarded.

Impact: Acceleration of the development and use of EEFs and new product technologies for corn production that maintain or increase crop yields and reduce environmental impact.

POC: Christopher Clark
Internal partners: OW/OWOW, OAR/OAP, OCSPP/OPP, Ag advisor
External collaborators: USDA, The Fertilizer Institute, The International Fertilizer Development Center, The Nature Conservancy, National Corn Growers Association.

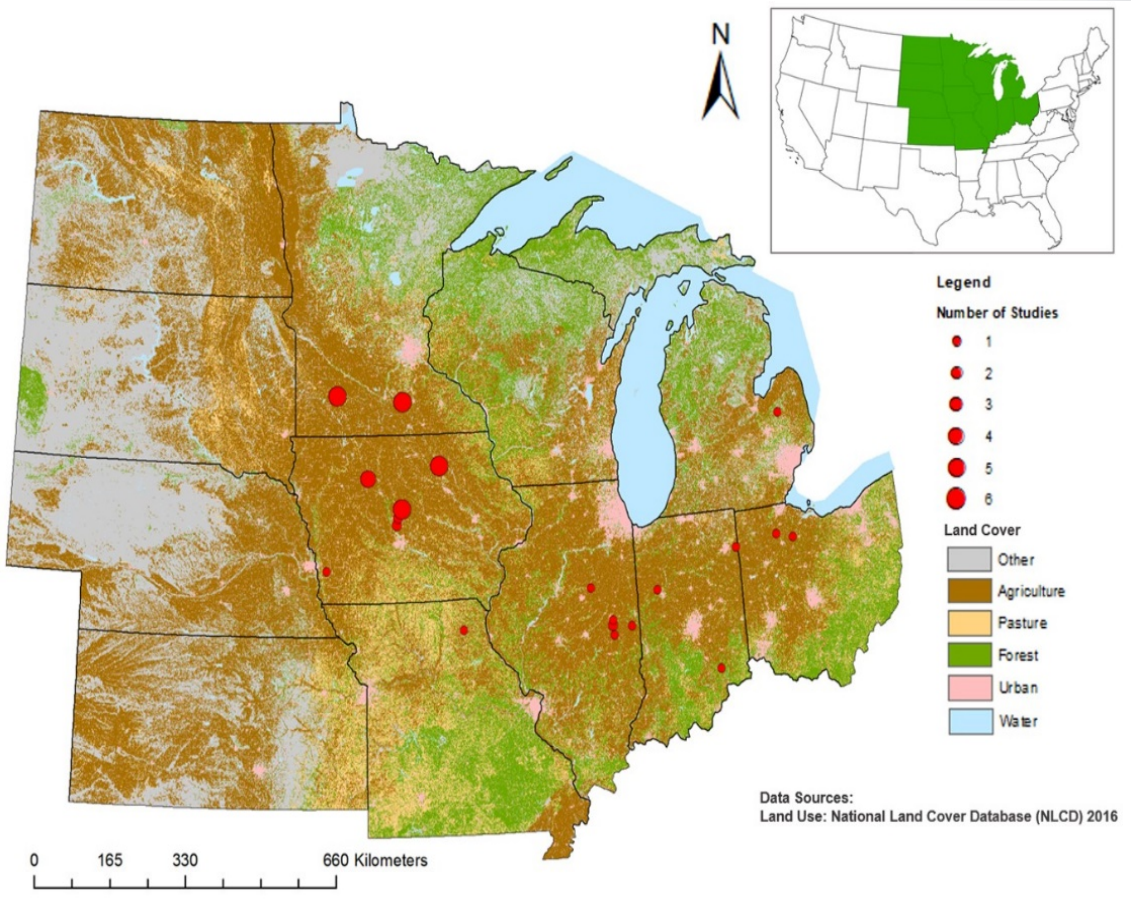
Effectiveness of Nutrient Management on Nitrate-Nitrogen Loss from Subsurface Drainage

Issue: Nutrient management (NRCS Code 590).

Approach: Managing rate, source, placement, and timing of plant nutrients and soil amendments while reducing environmental impacts (NRCS, 2019).

4Rs of nutrient stewardship — apply the right nutrient source with the right rate at the right time in the right place.

Literature review to synthesize available information on nutrient management and water quality.

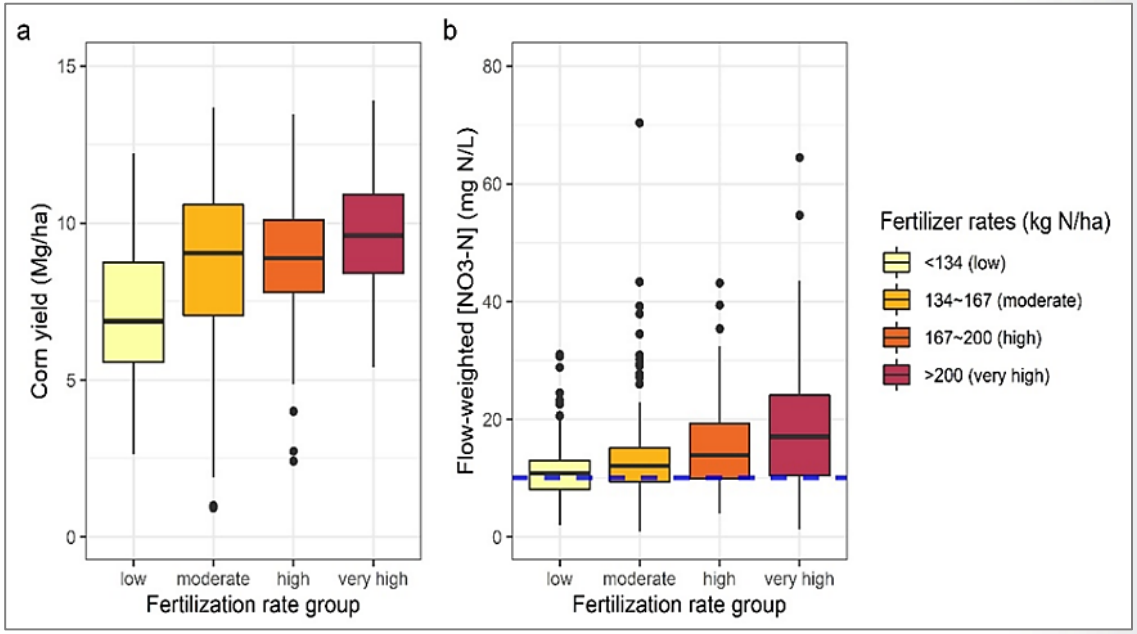


Effectiveness of Nutrient Management on Nitrate-Nitrogen Loss from Subsurface Drainage

Result: Fertilizer rate was found to be the most important factor controlling flow-weighted nitrate-N concentrations.

Impact: Results help us to make better decisions in recommending fertilization rate, specifically, fertilizer N recommendation rates need to consider both environmental and economic effects.

Agency Research Driver(s): Clean Water Act (Nonpoint).



Fertilization: rates, sources (organic vs inorganic), application methods (surface, injected and incorporated), timing (fall vs spring), single vs split (two or more fertilization events)

POC: Yongping Yuan

Evaluation of River Floodplain Restoration Approaches and the Effects on Water Quality

Issue: Large river floodplain infrastructure is being modified for flood protection, but there is concern about the consequences and benefits of these infrastructure changes to water quality.

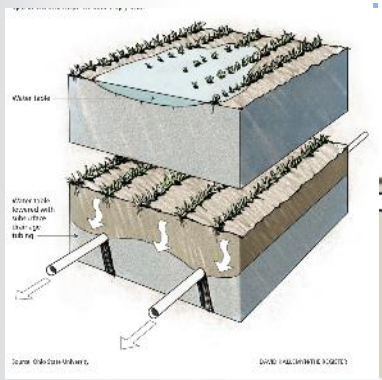
Approach: This work evaluates the hydrology and nutrient pollution effects of current practices at several sites to better support future installations and strategies.

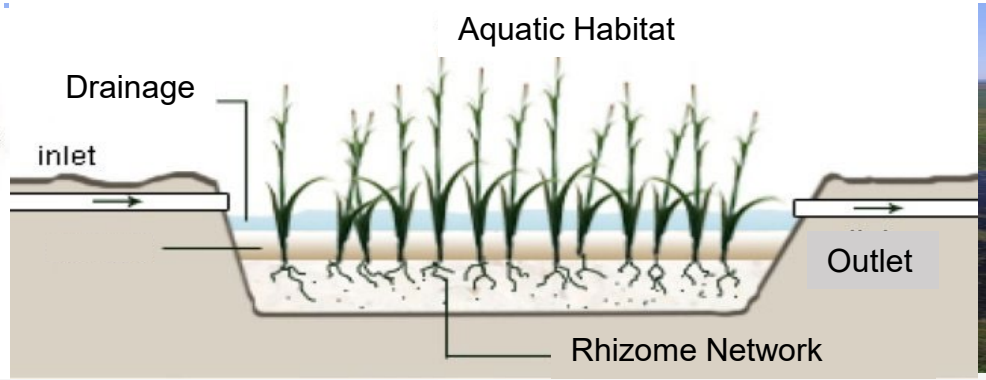
Agency Research Driver(s): Water quality and restoration.
POC: Ken Forshay (CESER/GCRD)
Internal partners: R7 (Chris Taylor, Doug Jones) ORD (Tamara Newcomer-Johnson, Doug Beak)
External collaborators: Iowa State University (William Crumpton); City of Yakima: Michael Price County of Yakima (Joel Freudenthal)

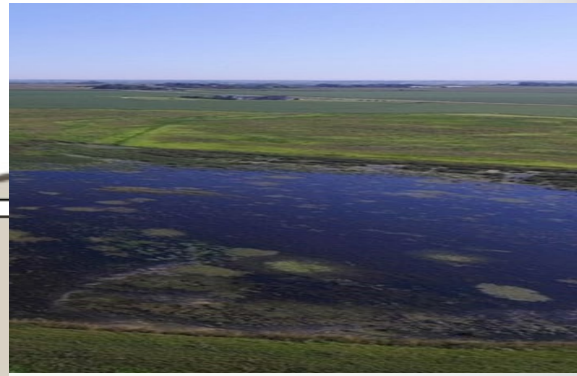
Evaluation of River Floodplain Restoration Approaches and the Effects on Water Quality

Result: Collaborative research efforts, with partners in the Upper Midwest Iowa, Pennsylvania, Oklahoma, and Washington state support the efficacy of several restoration and floodplain modification practices.

Impact: The effect of this work improves water quality and develops science-based support for river floodplain restoration practices.





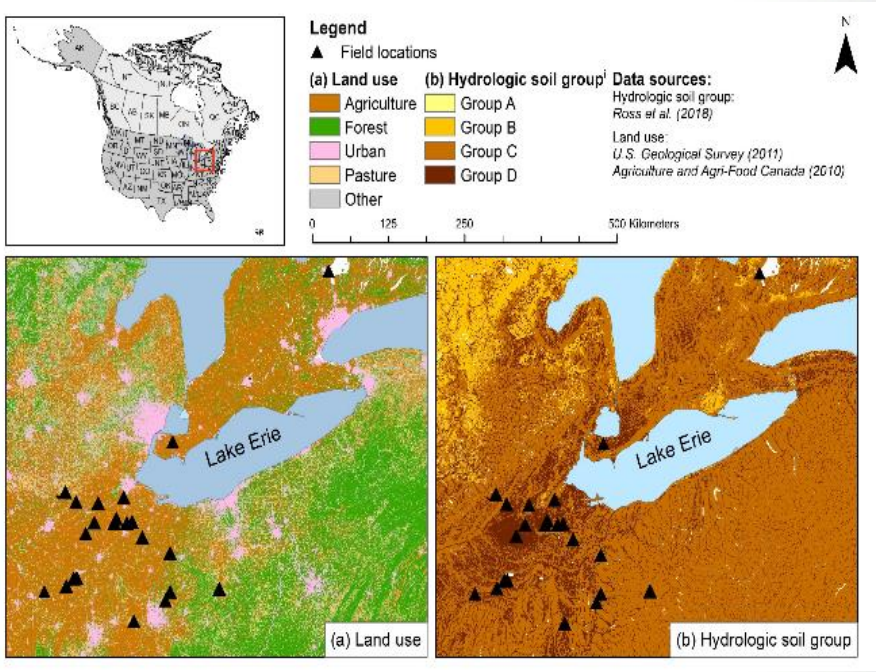


Management Options for Water Quality Improvement of Lake Erie

Issue: Excess dissolved reactive phosphorus (DRP) loading is the major driver of harmful algal blooms in Lake Erie, and agricultural non-point source are a major source of DRP to the lake.

Approach: DRP load reductions are proposed to be accomplished with widespread adoption of agricultural conservation practices (ACPs). Thus, identifying the most effective ACPs is critical.

Synthesize information from studies of ACP effectiveness on DRP losses across various site-specific conditions in agricultural landscapes in the Lake Erie basin to gain better insights on how to reduce DRP loading to the lake.

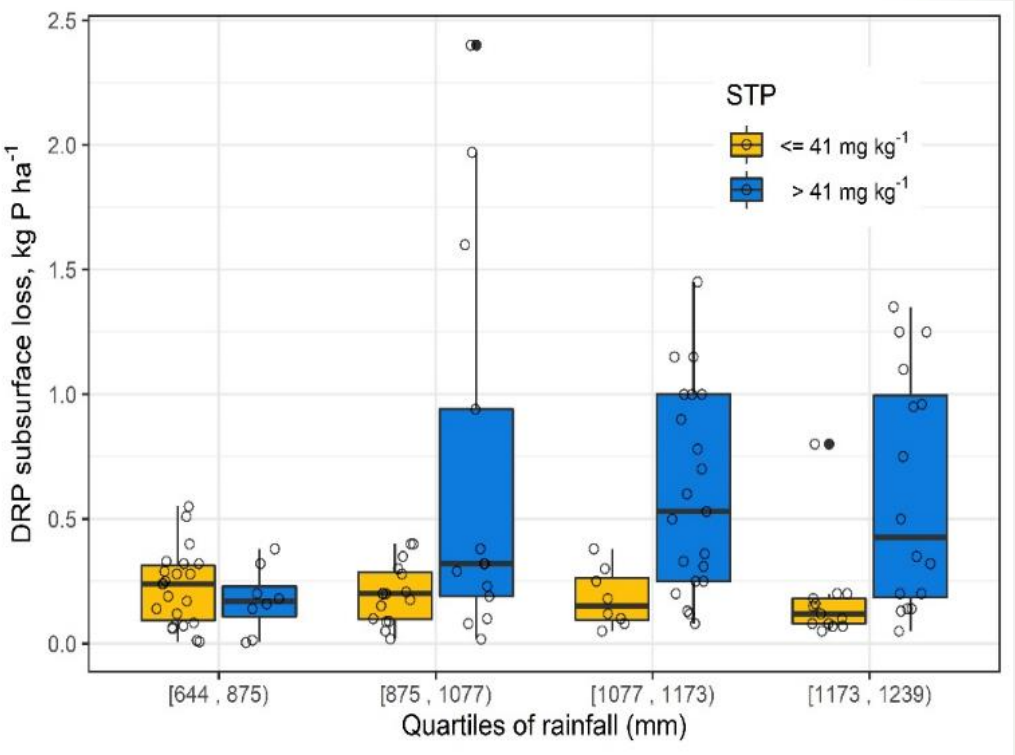


POC: Yongping Yuan
Internal partners: Katie Flahive, OW; Region 5, Ohio EPA

Management Options for Water Quality Improvement of Lake Erie

Result: Cropping systems involving soybean and cover crops, had no impact on DRP surface losses. No-till and conservation tillage enhanced DRP losses compared to conventional tillage, particularly for soils with high SOM and/or high clay content.

In fields with lower soil test P (<=41 mg kg-^{1}), rainfall had almost no impact on DRP subsurface losses; higher rainfall substantially enhanced DRP subsurface losses from fields with higher STP.



Impact: Better understanding of the effectiveness of practices to limit DRP losses can guide implementation to achieve better results.

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Tools and Approaches for Implementing and Tracking Nutrient Reductions

Jana Compton, Ph.D.

Center for Public Health and Environmental Assessment

Comparing Landscape Nutrient Inputs to U.S. Water Chemistry Over Time

National Rivers and Streams Assessment, National Nutrient Inventory

Issue: Tracking effects of nutrient management on nutrient inputs and concentrations across the US.

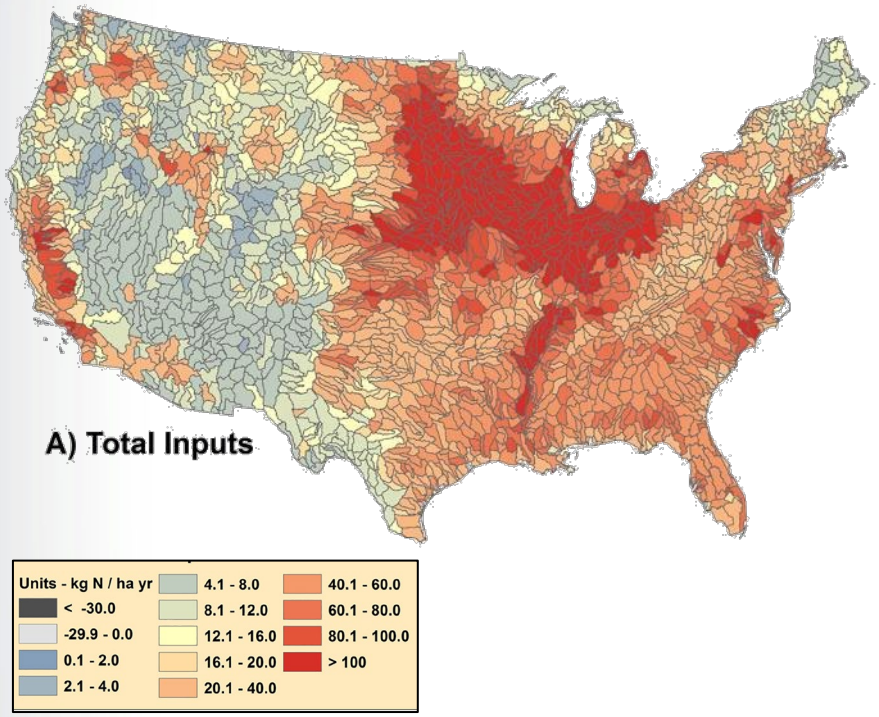
Approach: Compare nutrient inputs to the landscape, aquatic ecosystem N and P concentrations, and drinking water.

Impact: Regional patterns of the importance of non-point source relative to other nutrient sources, and relationship to water quality.

POC: Jana Compton
Internal partners: OWOW NARS team, OST, OGWDW

Combining EPA's National Nutrient Inventory with National Rivers and Stream Assessment Surveys

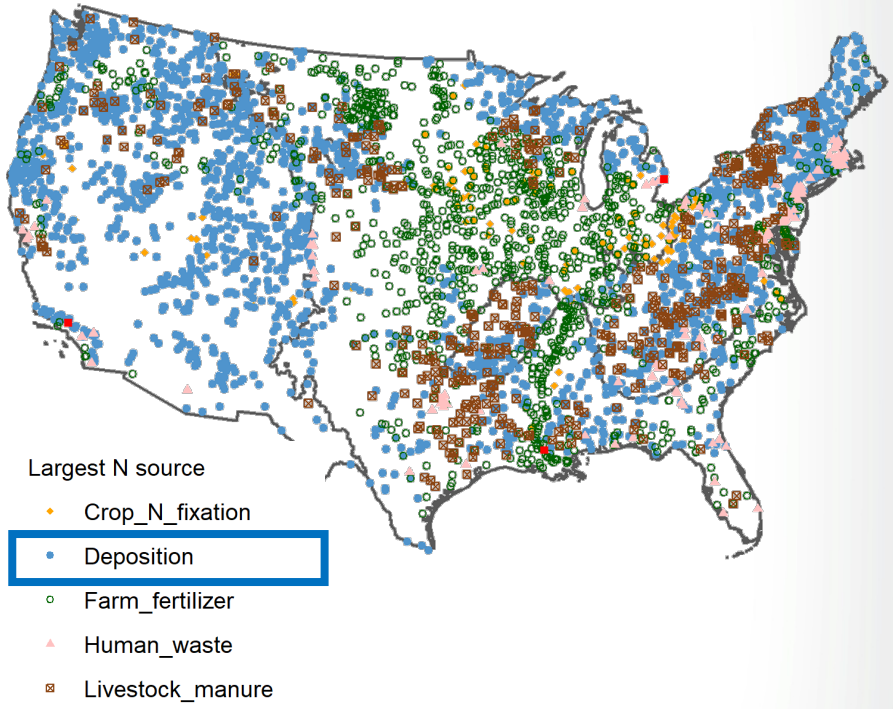
Nitrogen Inputs - 2012



- N and P inputs for 2002, 2007 and 2012
- Inputs are highest in agricultural areas.

Sabo, Clark, Rea, Compton et al. 2019 JGR Biogeosciences

NRSA surveys 00-04, 08-09, 13-14

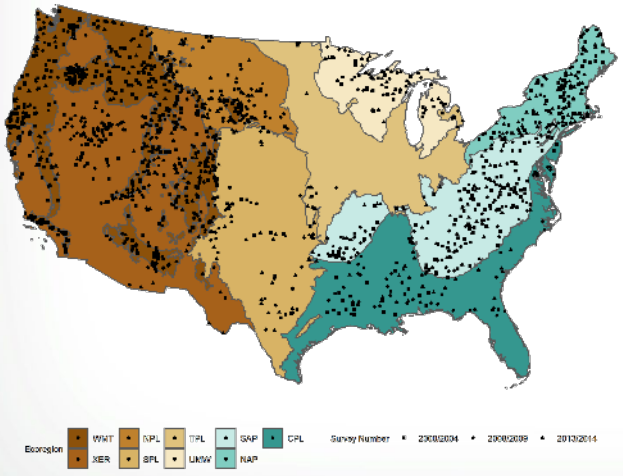


- Largest Anthropogenic N Source varies
- Fertilizer is dominant in farmland

Jiajia Lin et al. 2021, ES&T

Changes in N Deposition and Stream N

- Deposition declines in Appalachians, Coastal Plain and Upper Midwest.
- For stream NO_3, significant reductions in Apps.
- For TN, significant reductions in northern Apps and Plains (climate effects "browning").

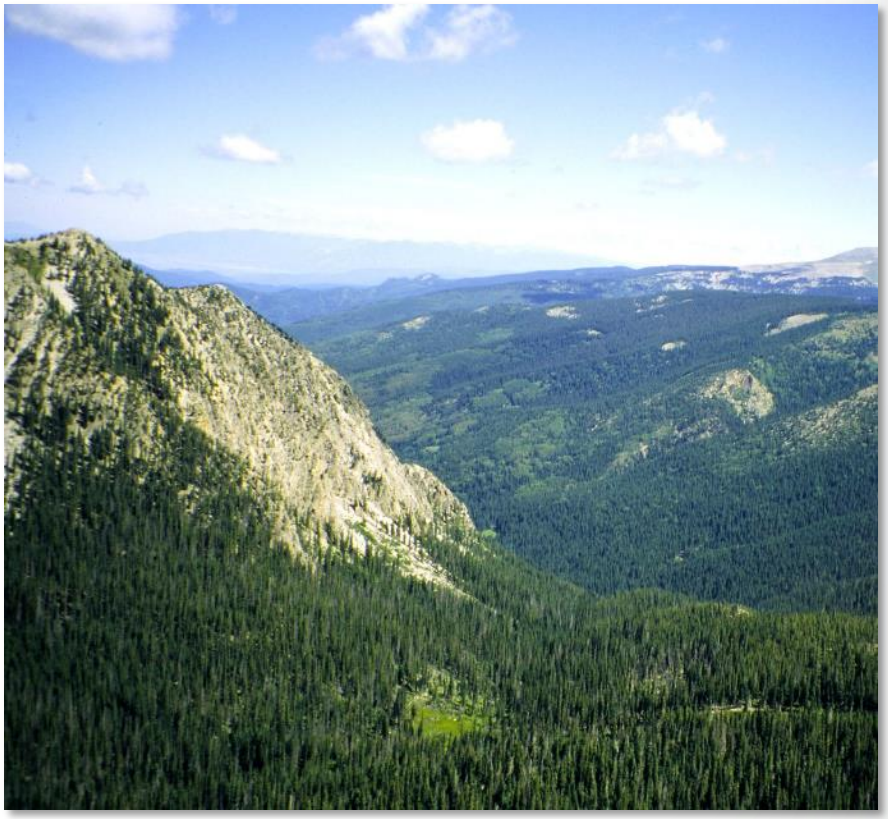


Jiajia Lin et al. In preparation

Overall Results and Impact

National Rivers and Streams Assessment, National Nutrient Inventory

- N deposition decreased from 2002-2012 by ~2 kg N ha^{-1} where deposition was the largest N source.
- Stream nitrate also declined significantly in the Northern and Southern Appalachians and the Upper Midwest.
- May be an important benefit of the Clean Air Act policies.



Jiajia Lin et al. In preparation

Toolbox for Nutrient Pollution Source Tracking: Stable Isotope and Sensor Approaches

Stable isotope indicators for nutrient pollution

Issue: What drives nitrate changes within groundwater wells?

Approach: Apply stable isotopic tracers and indicators to help pinpoint specific reasons for nitrate changes.

Result: In the South Willamette Valley Groundwater Management Area, stable isotopes provide information about sources and processing of N.

Impact: Added value to state monitoring program, allows state to better understand changes in well nitrate and develop action plans.

Weitzman et al. 2020 Env R Lett

POC: J. Renee Brooks ORD/CPHEA/PESD
External collaborators: State of Oregon. SWCDs, Farmers, Crop Advisers

Toolbox for Nutrient Pollution Source Tracking: Isotopes and Sensor Approaches

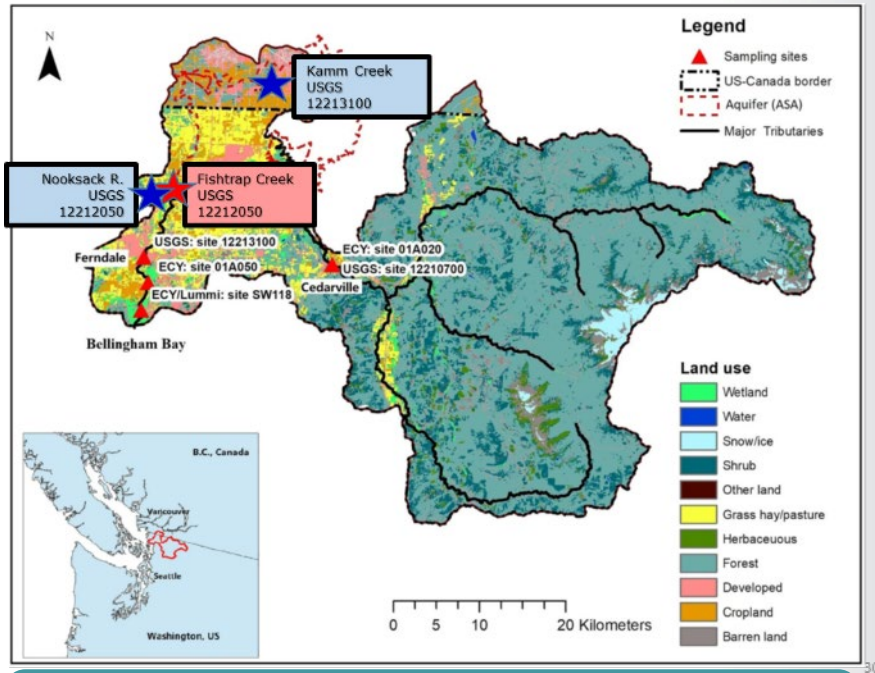
Using low-cost sensors to track nutrient reduction efforts

Issue: Can real-time nitrate monitoring provide more accurate and cost-effective results?

Approach: Sensor arrays in conjunction with community conservation programs.

Results: Lower-cost OTT ecoN compared favorably with the higher-cost SUNA and against grab samples.

Impact: Provides data to community on nitrate loading to N-limited Puget Sound. Allows comparison with manure-derived coliform.



POC: Jana Compton ORD/CPHEA/PESD
External collaborators: State of Washington, Whatcom Conservation District, USGS, Western Washington University

Best Practices for Integrated Nutrient Management Programs

Whole system integrated nutrient management science, engineering, economics, and stakeholder engagement

Christopher Nietch, Ph.D.
Center for Environmental Measurement and Modeling (CEMM)

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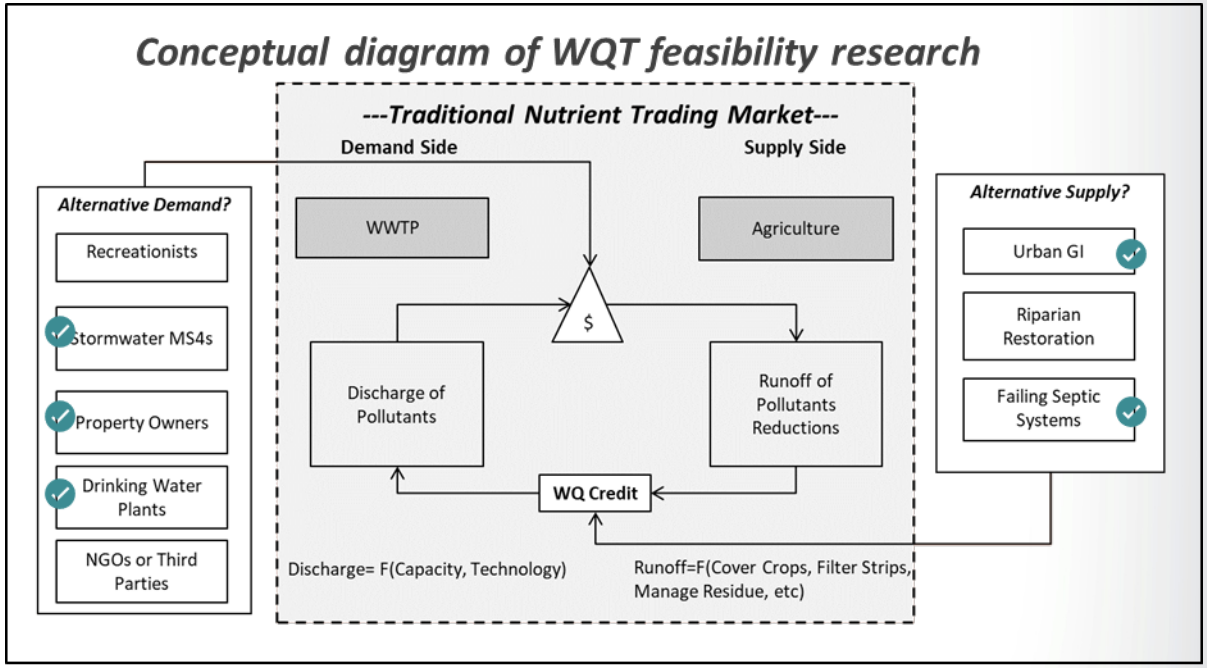
Project 1:
Using Water Quality Trading (WQT) Feasibility as an Integrative Theme for Studying Nutrient Management Alternatives in Ohio

Using Water Quality Trading (WQT) Feasibility as an Integrative Theme for Studying Nutrient Management Alternatives in Ohio

Issue: Agencies and communities want cost-effective approaches and WQT is a popular consideration that uses economic incentives to change behavior through market forces, but it has had limited success.

Approach: Through partnership, research methods that help agencies set goals for nutrient reduction, allow for considerations of market-based programs for paying for nutrient reductions, and track progress toward meeting goals.



Impact: Support Ohio's "New Vision" TMDL Process, Region 5, and OWOW with focus on inland systems. Characterize best approaches for cost-effectively protecting watersheds.

Partnership: The East Fork Watershed Cooperative (EFWCoop)

Federal Partners:

State Partners:

Local Partners:

The EFWCoop relies on the partnership to

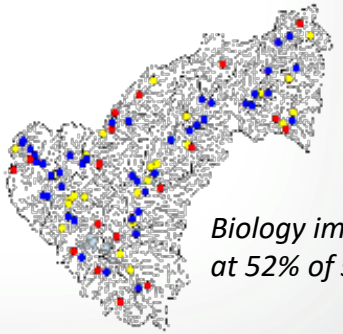
- document historical changes in water quality and coincident shifts in biotic communities,
- engage a broader stakeholder community to promote adoption of agBMPs,
- test and refine applicability of monitoring and modeling approaches, and
- help acquire funds to pay for nutrient reduction.

Design and Support of Strategic Monitoring and Integrative Modeling

Critical Sites:

- Continuously monitored
- Low order streams draining dominant land use/soil combinations
- Account for septics, point sources, and critical uses (e.g., beaches and DWTP intakes), and
- Intermediate-scale (HUC12) to validate modeled reductions and track effectiveness.

East Fork of the Little Miami River Watershed



Biology impaired at 52% of sites

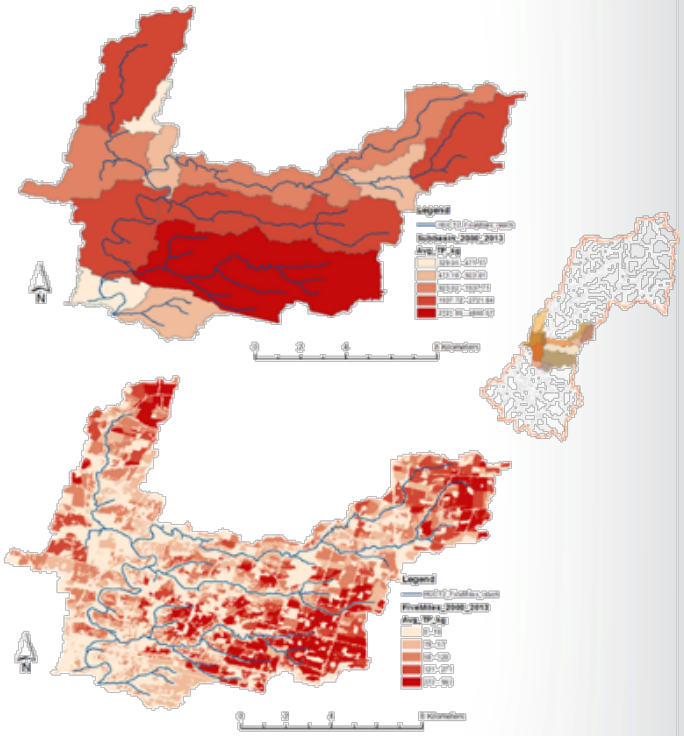
Design and Support of Strategic Monitoring and Integrative Modeling

- One model approach – Soil and Water Assessment Tool (SWAT) - Paired with Calibration and Uncertainty Program (CUP).
- High spatial resolution for market-based scenarios analysis and prioritizing implementation.
- Used to set nutrient reduction requirements and TMDL load allocations at unmonitored sites.

P Runoff Maps for one of the EFWs NWQI Priority HUC12s

a) Intermediate spatial resolution – catchment scale

b) High spatial resolution– about field scale

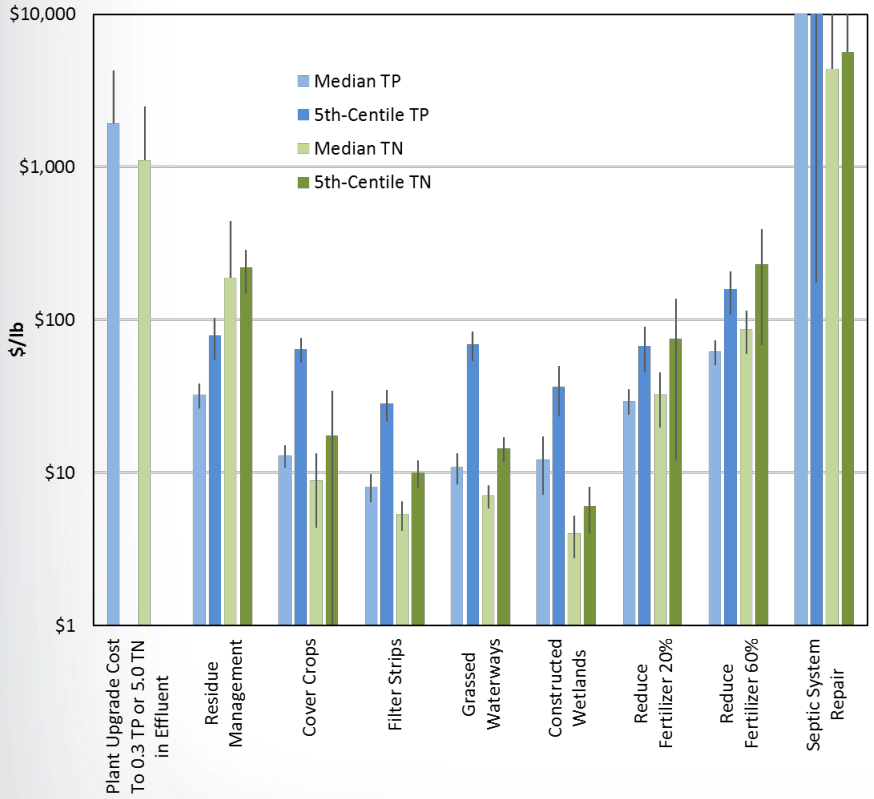


e.g., for TP TMDL - expressed as annual loads (kg/yr)

- ***TMDL = BL+(WLA + LA) + MOS + AFG***
- ***26,982 = 19,286 + (6,773) + 770 + 154***

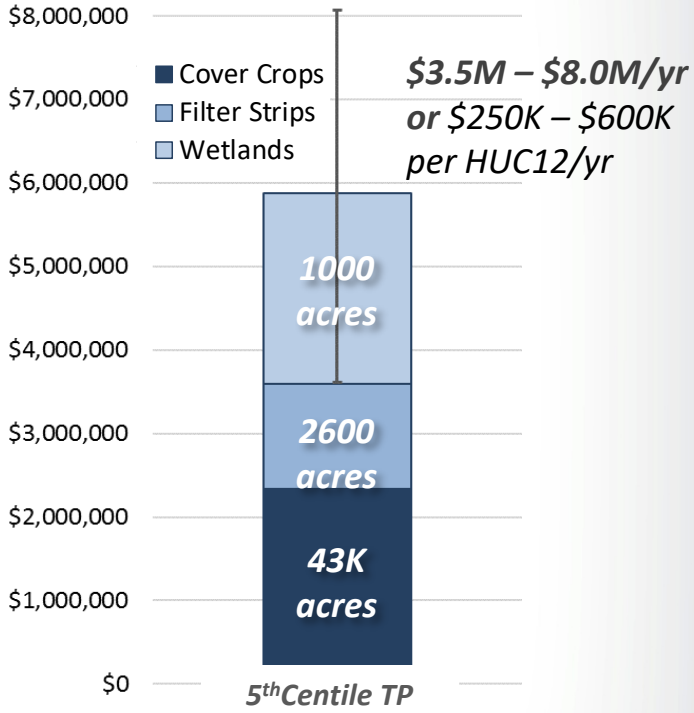
Estimate Cost Effectiveness of Management Alternatives at Watershed Scale

Watershed-wide modeled unit costs of nutrient reduction: septic repair >> WWTP upgrade >> reduce fertilizers > agBMPs



Unit costs help prioritize implementation strategies and inform market potential

Establish watershed planning implementation targets



- *Mean cost is 20% of row crop revenue.*
- *State currently spends about $250K per HUC12 in Maumee Watershed for Lake Erie.*
- *Lack of buyers to make WQT feasibility.*
- *Begin exploring pay-for-performance approach.*

Develop Wetland Implementation Plan Through Partnership - Ongoing

An EFWCoop supported proposal from Clermont County SWCD to Ohio DNR and US FWS.

Three components:

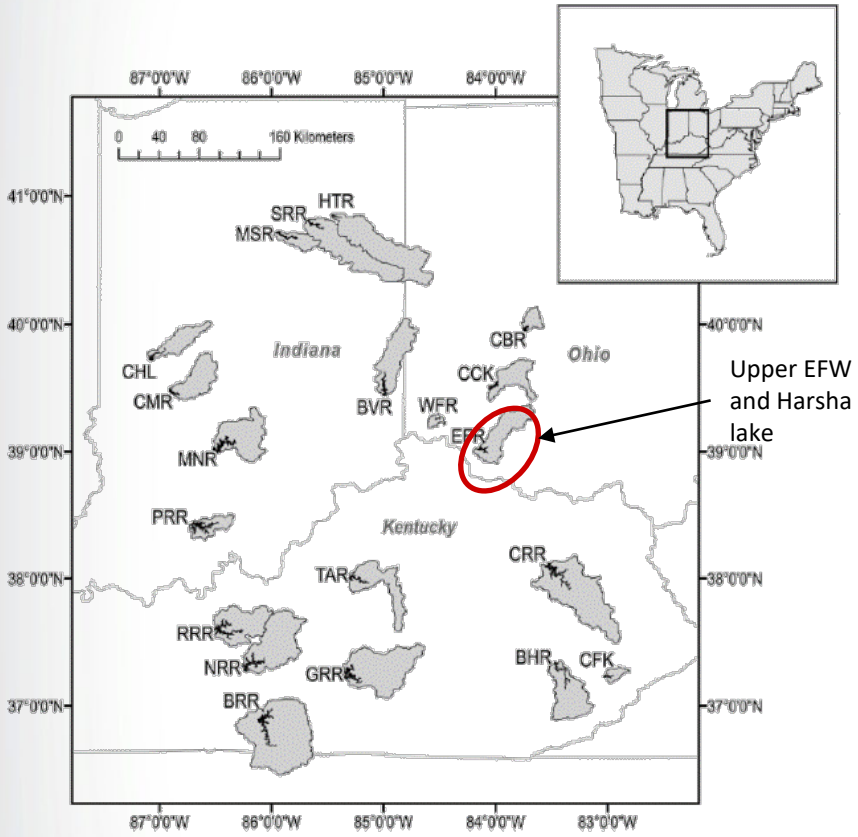
1. Off-Channel wetland treatment system optimized for nutrient removal.
2. Identification of priority wetland areas at watershed-scale using ACPF Tool.
3. Acquisition and construction of second or third wetland system.

Inland wetland projects in State program

Off-Channel wetland construction plan

Innovative headwater wetland system on private farm

Share Lessons Learned and Help Implement in Other Systems



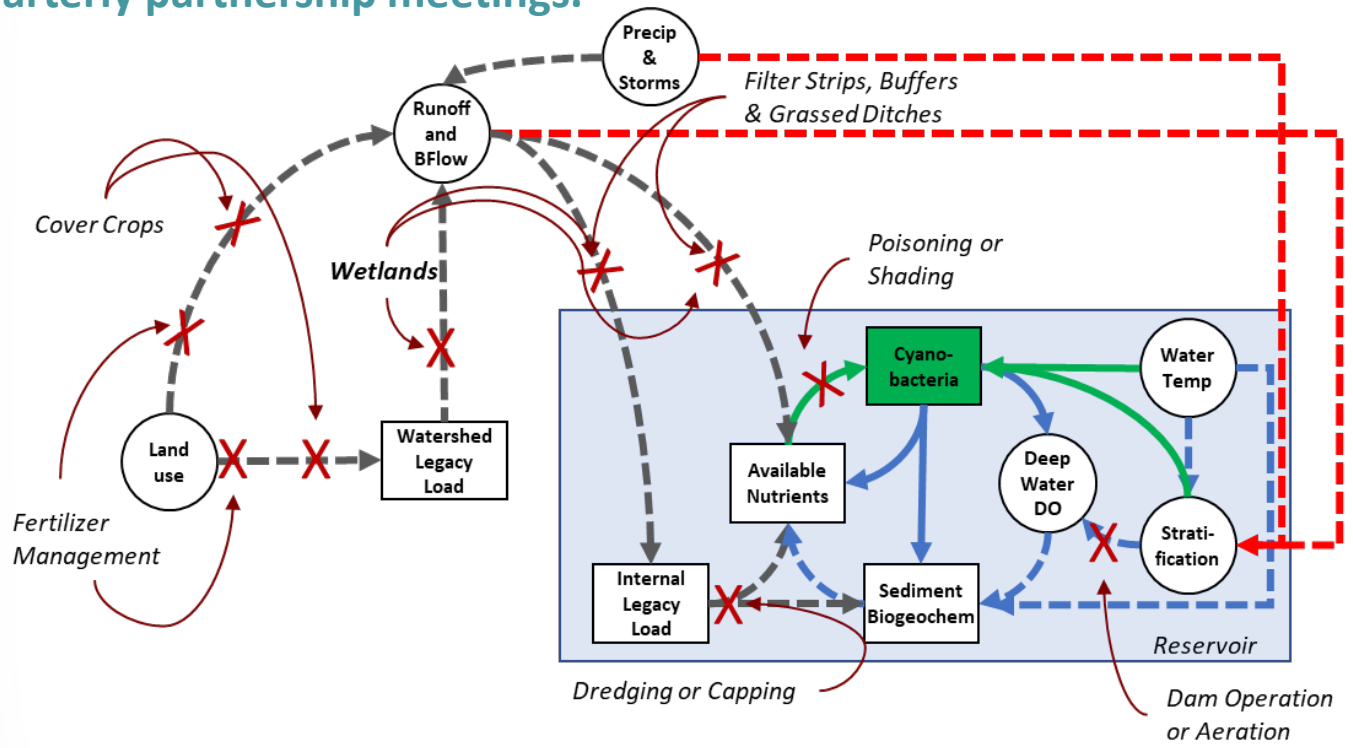
Densities of harmful cyanobacteria have been increasing in USACE reservoirs throughout the region

Communicate findings and extend partnerships:

Regional Watershed Network - OKI; Central State University; Miami Conservancy District; Caesar Creek Collaborative; Ohio Corn & Wheat; Ohio Soybean; Ohio Farm Bureau Federation; Greene, Warren, Clinton, Shelby County SWCDs; OSU Extension; Little Miami Conservancy District ; Ohio Lake Erie Commission.

Routinely Communicate Linkages Between Important Mechanisms and Management Measures

Conceptual model driving factors for HABs and role of management alternatives discussed at quarterly partnership meetings.



- Precip=precipitation; Bflow = base flow

watershed effects
- ve cyano effects
+ ve cyano effects
feedbacks

Indirect +ve cyano effects (via deep water warming & longer hypoxia)

Ongoing Work: TMDL development, monitoring and modeling for planning and implementation, publications in preparation or submitted related to implementing wetlands at watershed scale, evaluating economic incentives for SWP, modeling techniques for BMP effects across urban/rural interface, continue quarterly outreach effort.

Future Directions: Research pay for performance approach. Use ACPF tool to inform agBMP modeling scenarios. Monitor effectiveness of wetland implementation.

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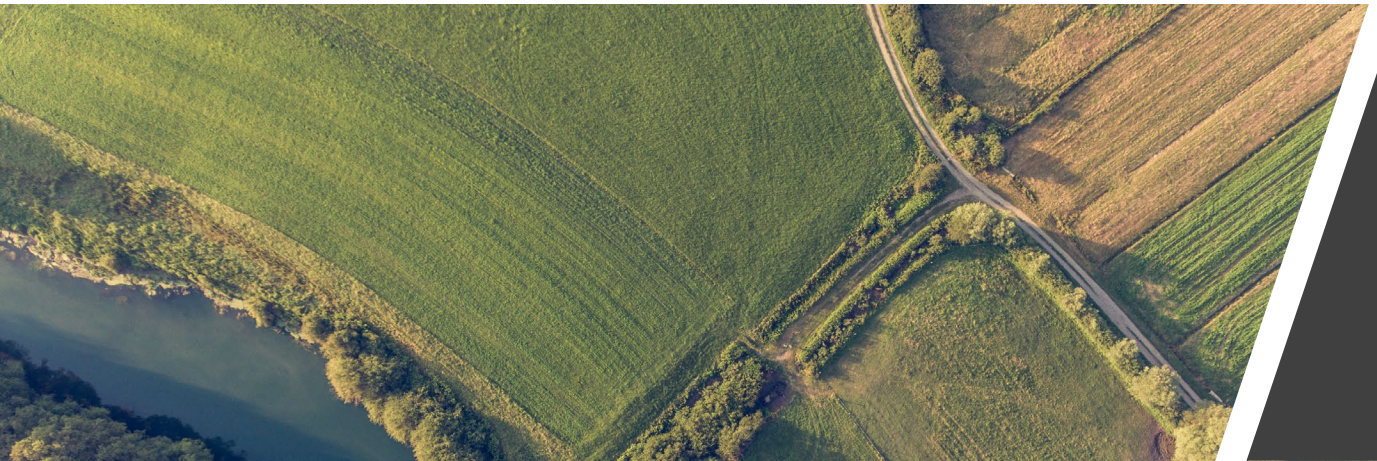
Project 2:
Partnership for Improved Nutrient Efficiency (PINE)



Partnership for Improved Nutrient Efficiency (PINE)

Issue: Drinking water quality in rural areas is impacted by non-point source nitrogen leaching.

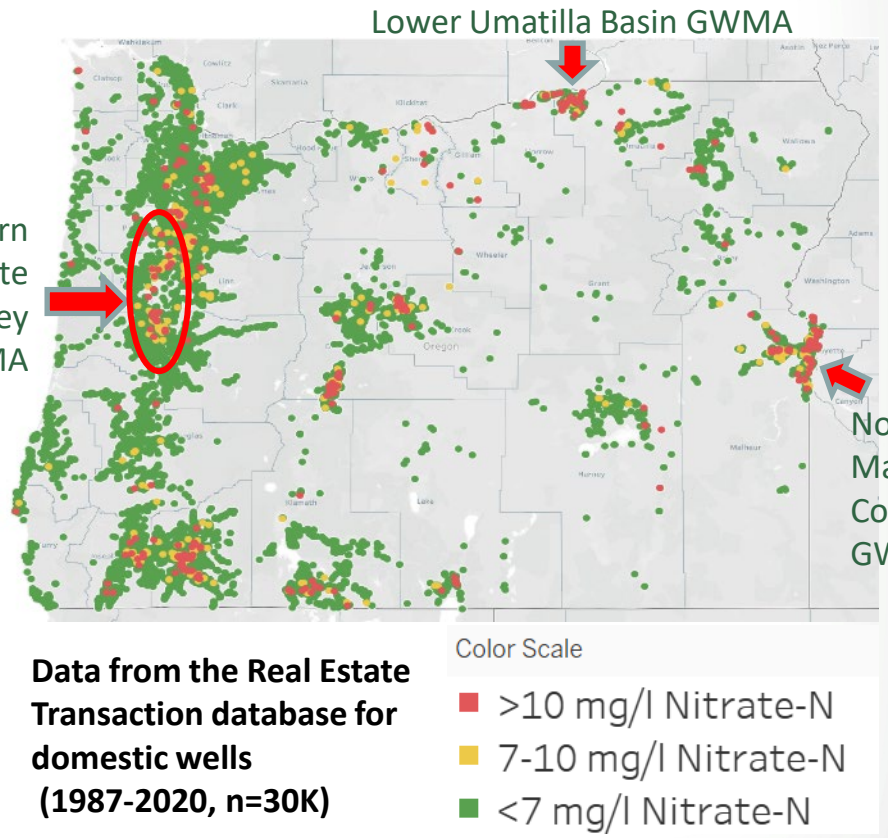
Approach: Community-driven research with farmers, crop advisers, state agencies and other stakeholders. Connect with EJ issues for renters, Latinx communities.

Impact: Build science-based efforts to support nutrient management, particularly for rural areas where non-point sources are the dominant nutrient inputs.

Partners: EPA Region 10, State of Oregon

POC: Jana Compton

Nitrate in Oregon's Groundwater Management Areas



Data from the Real Estate Transaction database for domestic wells (1987-2020, n=30K)

Partnerships

Objective: Provide information for stakeholders to quantify the water quality benefits of practices that they are conducting or funding.

Project Partners:

Messages for Community

- Nitrate leaching losses are concentrated in time, mainly during the fall and winter.
  - Challenge for nutrient management.
- Many crops have some N leaching.
  - ~20% of N inputs are leached as nitrate on average.
  - Poorly performing crops and bare ground can have very high leaching – cover crops could help?
- Thank you to farmers and crop advisers for working with us for entire 4-year project.

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Project 3:
Nutrients Solutions Driven Research Pilot on Cape Cod, MA

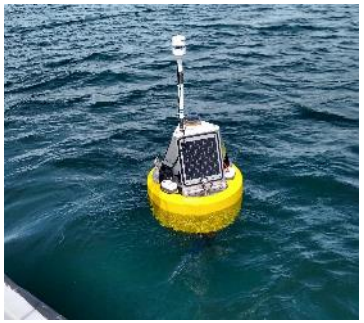
Nutrients Solutions Driven Research Pilot on Cape Cod, MA

Issue: Inform watershed-based solutions for non-point source nutrient loading using non-traditional interventions – achieve TMDL goals.

Approach: Actively engage stakeholders/partners throughout the research cycle.

- Co-design research with partners.
- Assist partners' goal to solve their nutrient problem.
- Combine social and environmental research
- Transferrable solutions.

POC: Tim Gleason



Partners and Stakeholders

Key Partners and Stakeholders

- EPA Region 1, MADEP, MADER, CCC, Town of Barnstable
- USGS, MASSTC, TNC, BCWC

Barnstable Clean Water Coalition (BCWC)

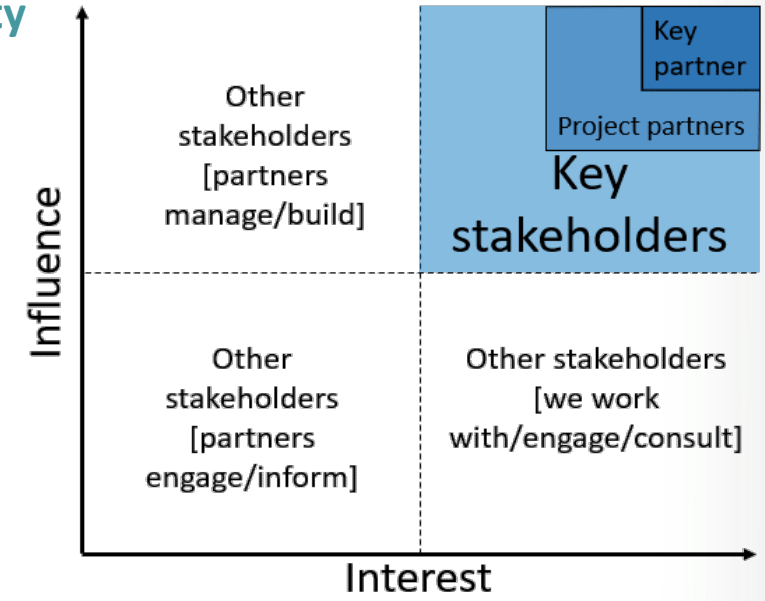
- Watershed-based solutions
- Non-traditional approaches
- Cost-effective and science-based solutions
- National model
- Aligned with ORD goals of Solutions Driven Research

Engagement Methods

Key partner - local on the ground in the community
Engaging directly/intensively

Conducted stakeholder workshops
Problem Formulation, Cranberry Bog, Septic System workshop

Developed a range of communications materials
Communications plan, Communications report, Bulletins, Science Matters, Twitter threads, Web page, Videos



Present to a variety of audiences

- BCWC annual meeting, Town official Barnstable, MADEP, Cape Cod Commission, One Cape Summit, NEWEA, Living Observatory, Homeowners, OW, ORD, Region 1, NEHA
- Field trips/site visits
- Monthly partner calls – with range of partners

Engagement Benefits

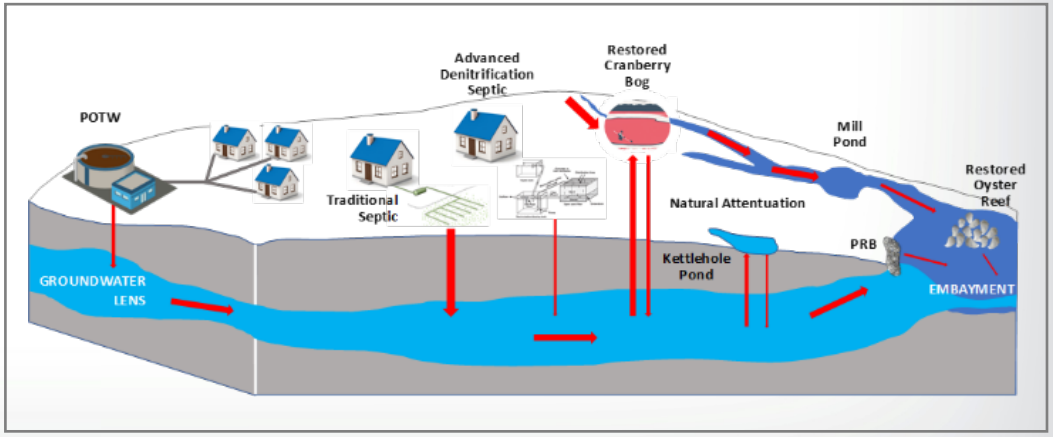
- Helped frame research questions to target specific research needs.
- Helped us to anticipate some of the research roadblocks.
- Developed better sense of the audience for our work and what their communication priorities are in terms of material and mode.
- We have brought together different organizations and individuals who are engaged with this type of research in a variety of ways to further conversations around data needs and management solutions.

Inform Watershed-based Solutions Using Non-Traditional Interventions

Advanced Septic System Designs to Reduce Nitrate with Approaches to Reduce Legacy Nitrate

- Social Environmental Systems (SES) approach
- Baseline monitoring
  - Groundwater, surface water, benthic condition
- Pilot Interventions using integrated social environmental research approach
  - Source control - Innovative Septic Systems
  - Groundwater
    - Permeable Reactive Barriers
    - Cranberry bog restoration
  - Sediment
    - Dredging
  - Water column – Oysters
  - HABs (freshwater)

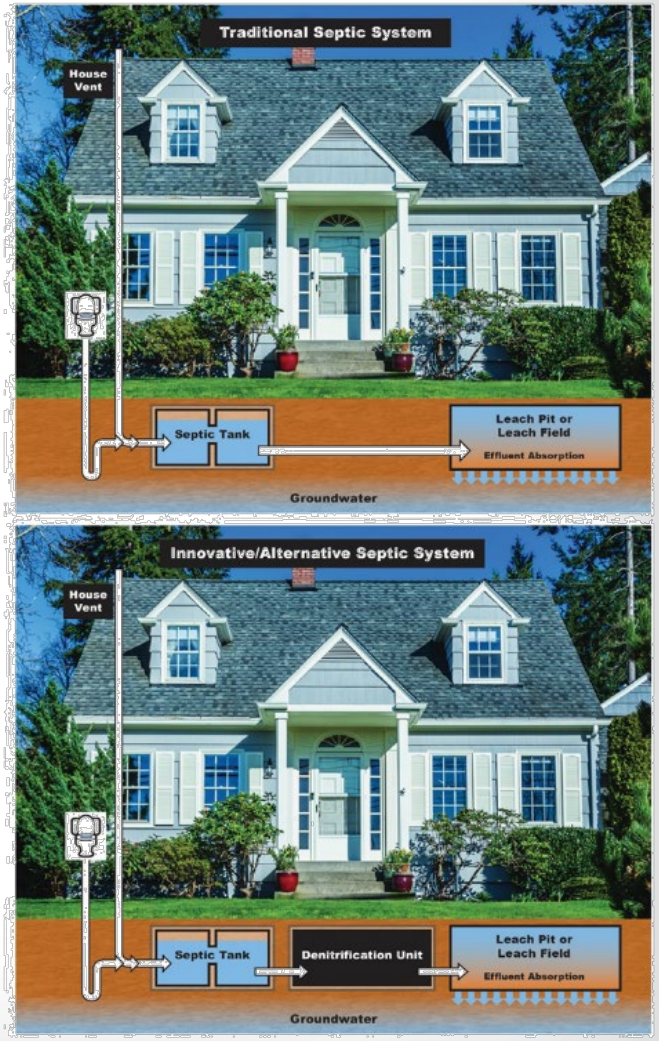
POC: Tim Gleason



Key Points

Engagement, Relationships, Partnership, Trust

- Co-development of research and problem solving.
- Integrate social science into research efforts.
- Evaluate novel interventions at the source, groundwater, sediments, and waterbody.
- Transferable solutions.
- Translation occurs throughout the project.
- We serve as the honest/objective broker.



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Questions?

Charge Question 2

While EPA, states, and tribes have made great efforts toward reducing nutrient pollution nationwide, it is still a challenge to identify best practices for implementing interventions and tracking their effectiveness to meet nutrient reduction goals in a comprehensive manner.

To address this issue, SSWR Research Area 6 focuses on:

1. applying tools, technologies, and best practices for nutrient management
2. monitoring and tracking the effectiveness of nutrient reduction strategies
3. working closely with stakeholders to apply management practices and monitoring within their nutrient reduction programs.

What suggestion(s)/ recommendation(s) does the Subcommittee have on ORD's implementation of this research area, particularly related to evaluating the effectiveness of nonpoint source nutrient reductions at local to large regional scales?