Welcome!

Please Keep Your Video Off

OCP

OSTARA

Sustainable Phosphorus Alliance

Welcome!

Founding/Current Members and Strategic Partners

OCP

OSTARA

NACWA

RENEWABLE NUTRIENTS

GreenEdge® GreenTechnologies, LLC

THE Water Research FOUNDATION

Biochar Now

THE SUSTAINABILITY CONSORTIUM™

FEECO INTERNATIONAL

CAB Consultants Associated With Brookside

Strategic Partners

AgSTAR

Water Environment Federation the water quality people

nebra North East Biosolids & Residuals Association

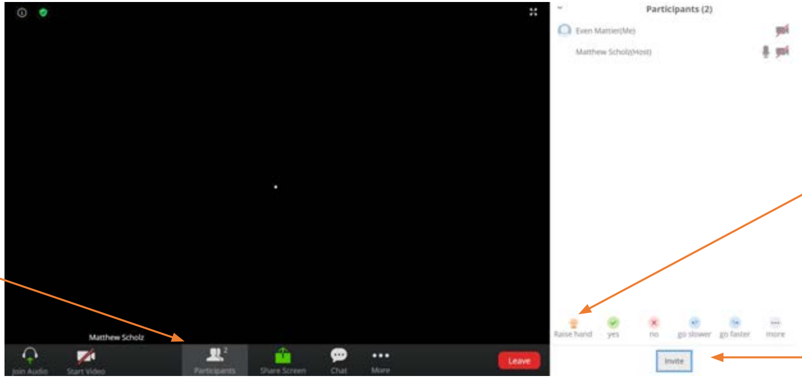
Agenda (all times ET)

12:00-12:20	Welcome from the Alliance (Drs. Jim Elser and Matt Scholz)
12:20-12:50	Dr. Don Boesch, Professor and President Emeritus, University of Maryland Climate Change and Coastal Eutrophication
12:50-1:10	Mr. Kerry McNamara, CEO, OCP North America Perspective on Phosphorus Sustainability
1:10-1:40	Dr. Jon Winsten, Agricultural and Environmental Economist, Winrock International Pay-for-Performance Program for Nutrient Pollution Mitigation
1:40-2:10	Drs. Carl Bolster and Barret Wessel, USDA-ARS Phosphorus Transport Modeling Group Report
2:10-2:30	Breakout rooms
2:30-2:50	Closing discussion & Raffle!

Meeting Controls

- To avoid chaos, we’ve muted you and prevented you from sharing screens. Please turn off your video (or we can turn it off for you!) to conserve bandwidth.
- Please use the hand-raise feature to ask a question at the end of each presentation. We will unmute you for your question. We will have ~5 minutes for Q&A after each.
- If you are cut off from Zoom, please try to relaunch from your registration email.
- Note: Meeting is being recorded

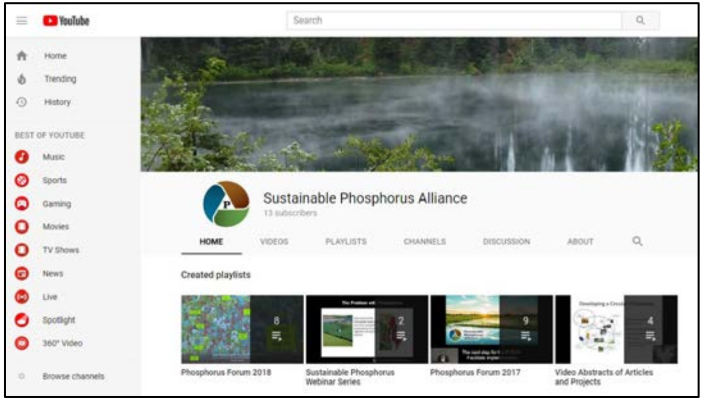
Please click Participants to open side pane to the right and to access hand raise icon



Hand-raise icon is here. Click a second time to lower your hand.

New invitees will not be admitted.

Community Resources



More than 31 hours of coverage including:

- Sustainable Phosphorus Webinar Series
- Phosphorus Science Now!
- Phosphorus Forum event coverage

Membership details for organizations available here!

News Items

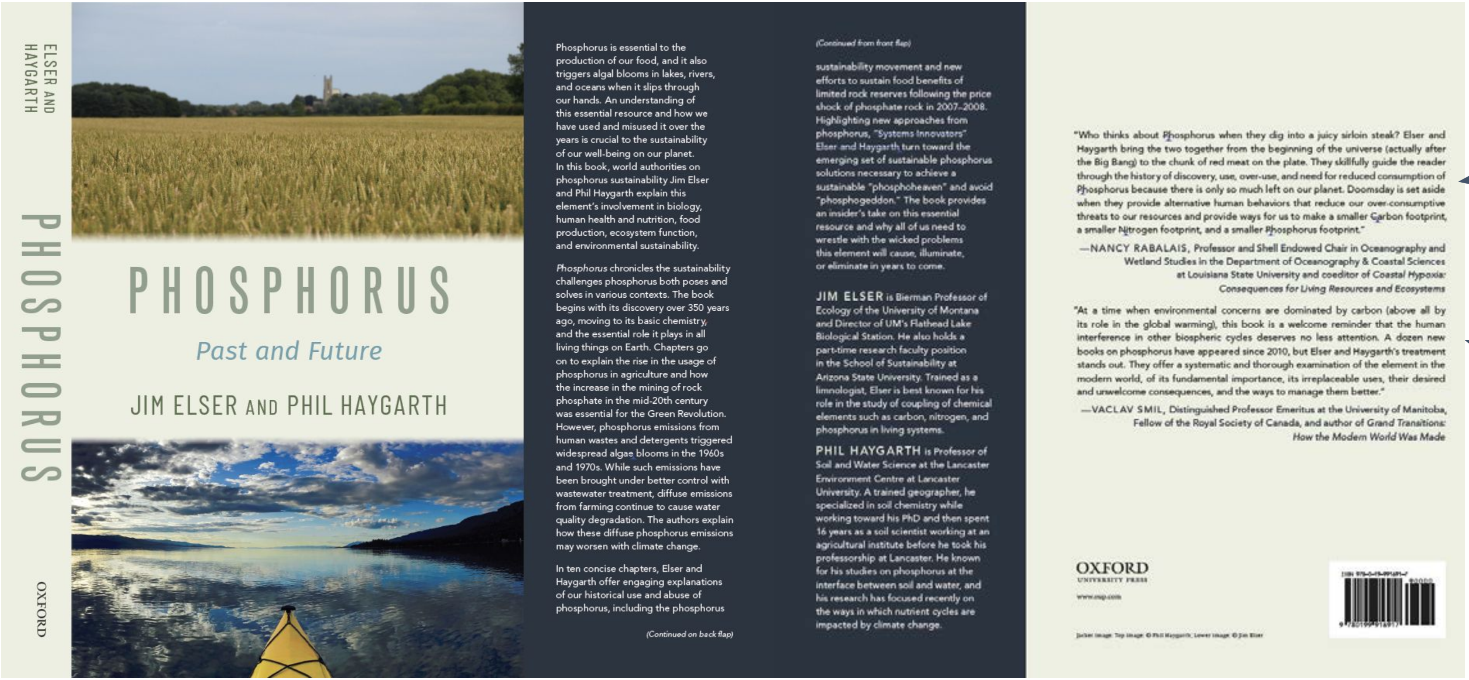
Jim's Book! *Phosphorus: Past and Future*

Our Symposium at the virtual 2020 ASA-CSSA-SSSA International Meeting, Nov 9-13:
Crop response, watershed loads, and global flows – oh my! Following the yellow-brick future of phosphorus modelling
Featuring: Drs. Josh McGrath, Chad Penn, Rebecca Muenich, Carl Bolster, Rem Confessor, David Vaccari, and Céline Vaneeckhaute

Our Symposium at the virtual AAAS 2021 Annual Meeting, Feb 8 at noon ET
Phosphorus and Climate Change: A Vicious Circle
Featuring: Drs. Jim Elser, Matt Scholz, Laura Johnson, John Downing, and Mr. Ahren Britton

ESPP SCOPE Newsletters on phosphorus and climate change
One to come soon and one online now at
https://phosphorusplatform.eu/scope-in-print/scopenewsletter/1984-july-2020-scope-135#

Welcome and news from Phosphorus-land!



blurb from Dr Nancy Rabalais

blurb from Dr Vaclav Smil

Now available for pre-order!

STEPS

Science and Technologies for Phosphorus Sustainability

NC STATE UNIVERSITY · Arizona State University · University of Florida · RTI International · Illinois · Marquette University · JSNN Joint School of Nanoscience and Nanoengineering · Appalachian State University

NC State University

Agriculture and Plant Science, Engineering, Informatics, Science Education, PSI, WSUN, Extension Program

Appalachian State University

Team Science, Nanoinformatics, Primarily Undergraduate Institution in a Rural Location

RTI International

Water Technologies, Adsorbents, Technoeconomics, Roadmapping

University of Illinois at Urbana-Champaign

Social Science, INFEWS-ER online educational experience and resource

COMPLEMENTARY INSTITUTIONAL STRENGTHS

University of Florida

Agriculture and Engineering, Sensors, Extension Program, Connection to Everglades

Joint School for Nanoscience and Nanoengineering (UNC Greensboro, NC A&T)

Organophosphates, Collaborative School Bridges an HBCU and MSI

Arizona State University

Urban Ecosystems, Sustainability and Environmental Science, P-RCN, SPA, NEWT, CAP-LTER

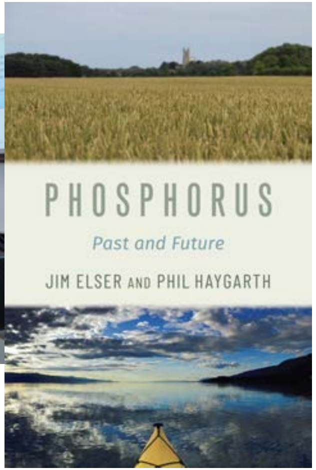
Marquette University

Water Quality, Policy, and Equipment; Phosphates

STEPS IS BUILT ON SOLID FOUNDATIONS AND INVESTMENTS

Phosphorus Sustainability RCN

Phosphorus Forum



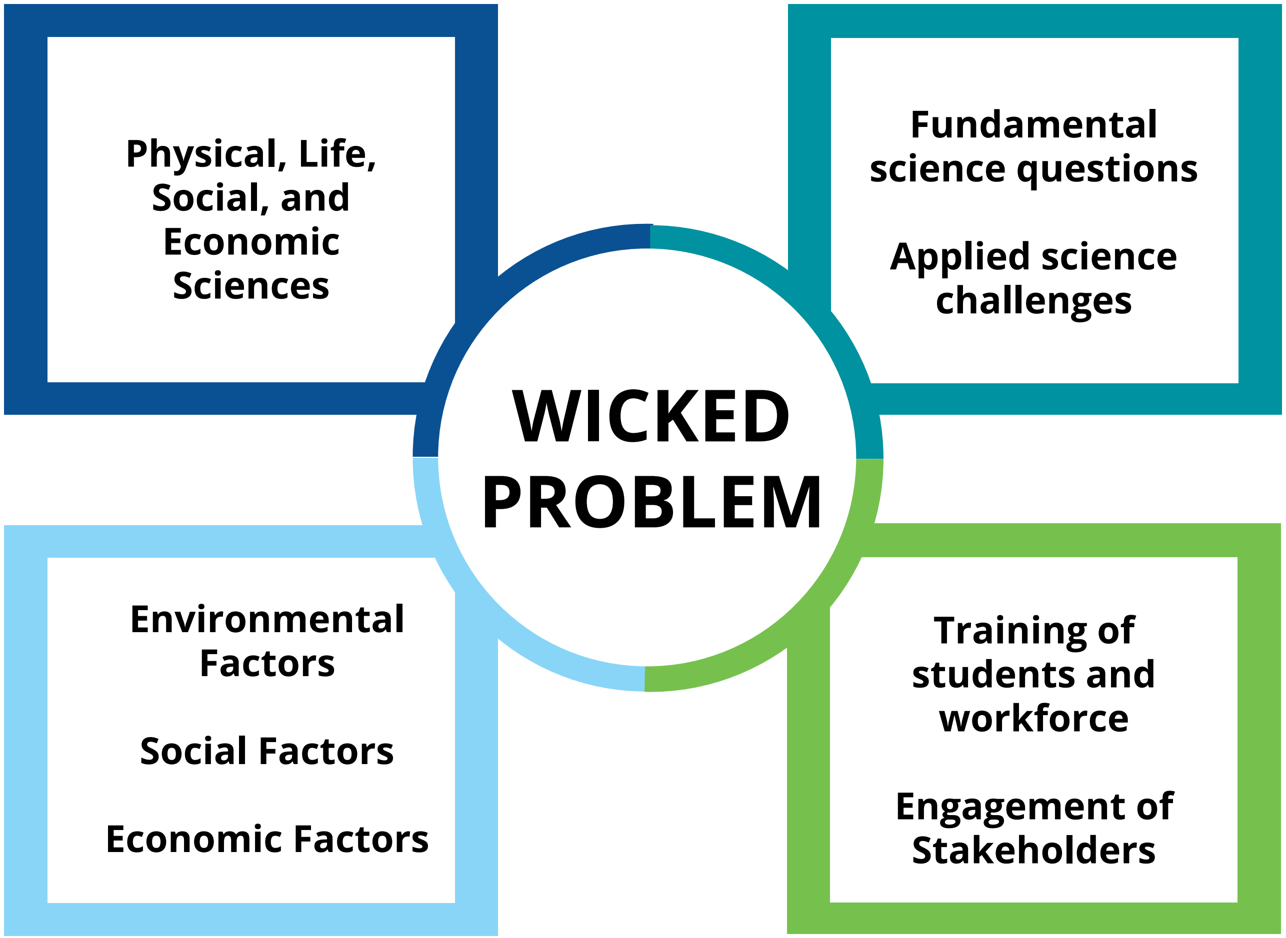
Phosphorus Sustainability Research Coordination Network (PRCN), 2013-2018

- 51 (26 US) core members and >174 individuals from at least 11 countries in stakeholder group
- 10 graduate students, and six postdocs involved
- PRCN outputs: 50 peer-reviewed research articles, 12 book chapters, 10 white papers, >113 presentations, and >19 subsequently funded research proposals

Sustainable Phosphorus Alliance

Sustainable Phosphorus Alliance (2016 to present)

- Membership organization addressing the complex problem of phosphorus sustainability
- Several events and activities including the annual Phosphorus Forum
- 11 members/partner organizations
- P Transport Modeling Working Group (14 researchers) and Biosolids and Manure Task Force (11 stakeholder groups)


Physical, Life, Social, and Economic Sciences
Fundamental science questions
Applied science challenges
WICKED PROBLEM
Environmental Factors
Social Factors
Economic Factors
Training of students and workforce
Engagement of Stakeholders

THE STEPS VISION

25-IN-25

Facilitate a **25% reduction** in human dependence on mined phosphates and a **25% reduction** in losses of point and non-point sources of phosphorus to soils and water resources within **25 years**, leading to enhanced resilience of food systems and reduced environmental damage.

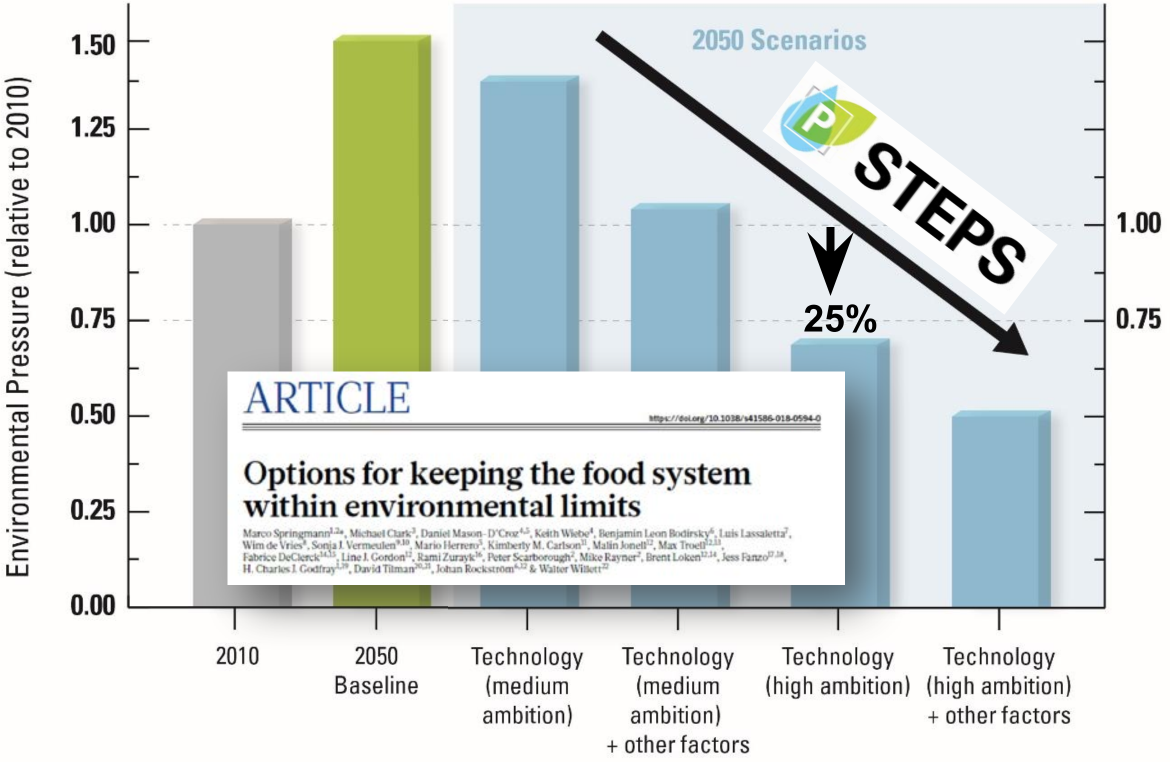
MODELS INFORM WHERE TO START

BUSINESS AS USUAL:

- An increase of 50% in environmental pressure due to phosphorus

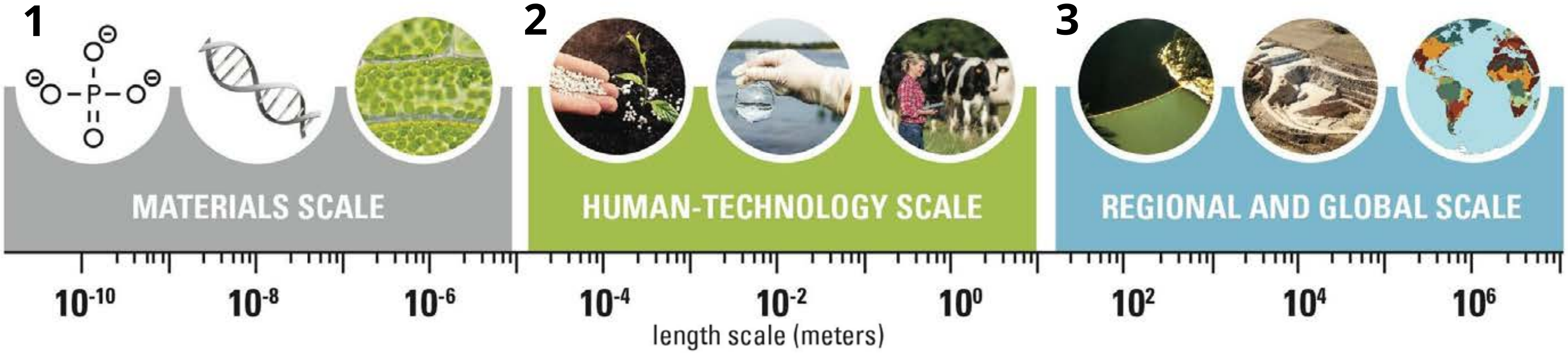
FACTORS TO EFFECT CHANGE:

1. Dietary changes toward healthier, more plant-based diets (e.g., flexitarian)
2. Reductions in food loss and waste
3. **Improvements in technologies and management, e.g. for agriculture and water treatment, were the most influential single factor**



Replotted using data from Springmann et al., Nature, 562, 519 (2018).
"Phosphorus footprint" estimates from Metson, Bennett, and Elser, Environ. Res. Lett., 7, 044043 (2012).

RESEARCH AGENDA - THEMES



Discovers and develops **high-ambition materials** that are essential to realizing the 25-in-25 vision using, e.g. **discovery-driven approaches**

Implements materials and technologies in surface waters and the **plant-soil-microbial system** using **lab, greenhouse, and field-scale techniques**

Provides **systems-level modeling and prioritization** across the economic, social, physical, and life sciences that guides research directions

FOUR SPECIFIC FOCI GUIDE STEPS RESEARCH TOWARD 25-IN-25

SOIL-BOUND-PHOSPHORUS
Materials, crops, and processes to make soil-bound phosphorus bioavailable to crops

Soybean plants at Tidewater Research Station, NC

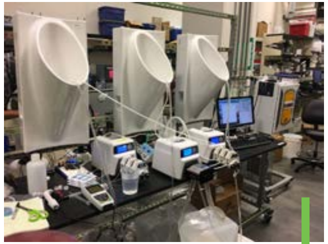
SURFACE WATER
Crops and materials to trap dilute phosphorus to prevent eutrophication

Algal bloom in FL Everglades

ANIMAL MANURE
Phosphorus capture from animal manure for reuse as fertilizers

Swine-waste lagoon at Tidewater Research Station, NC

HUMAN URINE
Materials and processes to capture phosphorus from concentrated solutions

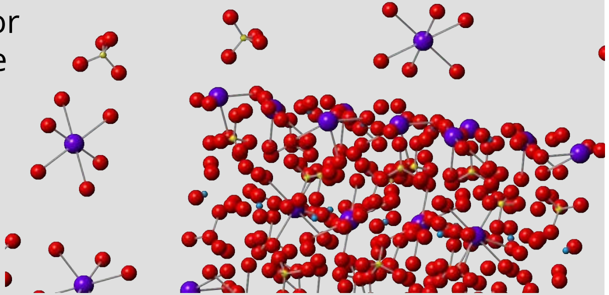


Waterless urinal experiments at ASU

ENVISIONING OUTCOMES

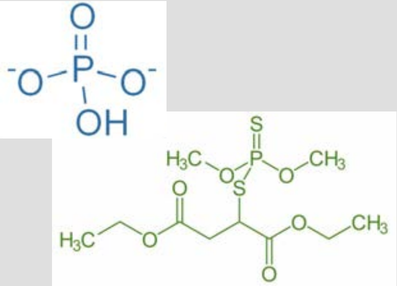
IMPACTFUL CONVERGENT RESEARCH BREAKTHROUGHS

Accelerated discovery of matrix-specific removal technologies for specific surface waters and wastewaters

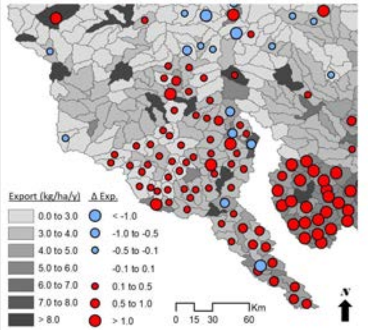


Inexpensive and environmentally benign **materials that recover phosphorus** from dilute surface waters and create phosphorus products with economic value

New **transformation pathways** between organic and inorganic phosphate, e.g. tuned by (electro)chemistry or structure for easier capture and re-use or uptake by plants



Effective **human intervention portfolios** that are resilient to socio-economic, policy, and environmental change



ENVISIONING OUTCOMES

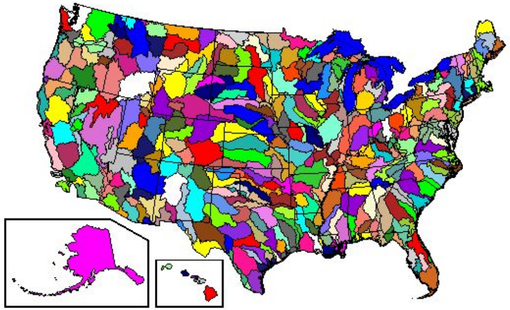
IMPACTFUL CONVERGENT RESEARCH BREAKTHROUGHS

Additives, e.g. enzymes and desorbers, that **address phosphorus fixation in soils** to make soil-bound phosphorus bio-available to plant roots

New **sensors to enable real-time tracking of phosphorus** in soil and water

Next-generation, **plant-responsive fertilizers** that function across all soil types

Innovations in spatiotemporal modeling to generate a **first-of-its-kind national map of phosphorus sinks and sources**



ENVISIONING OUTCOMES

STEPS GRADUATES AMPLIFY THE IMPACT TO SOCIETY

As a lasting legacy, **STEPS graduates** continue working in phosphorus sustainability, as researchers, practitioners, and educators, sustaining progress toward the 25-in-25 vision

STEPS graduates **contribute innovations to other societal grand challenges** that require convergence research, including clean water, sustainable cities, and climate action

STEPS

Science and Technologies for Phosphorus Sustainability

NC STATE UNIVERSITY · ASU Arizona State University · UF University of Florida · RTI International · ILLINOIS · Marquette University · JSNN Joint School of Nanoscience and Nanoengineering · Appalachian State University

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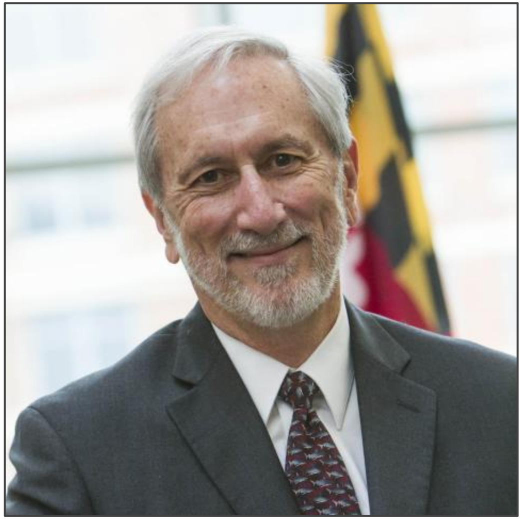
Keynote Speaker



Dr. Don Boesch
Emeritus Professor and President
University of Maryland Center for Environmental Science

Don has worked for many years to diagnose and reverse nutrient over-enrichment of coastal waters in many areas of the US and other parts of the world. He continues to write and advise on these issues as an emeritus professor and in September also became the first Senior Scholar at the Gulf Research Program of the National Academies of Sciences, Engineering and Medicine.

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Sustainable Phosphorus Alliance

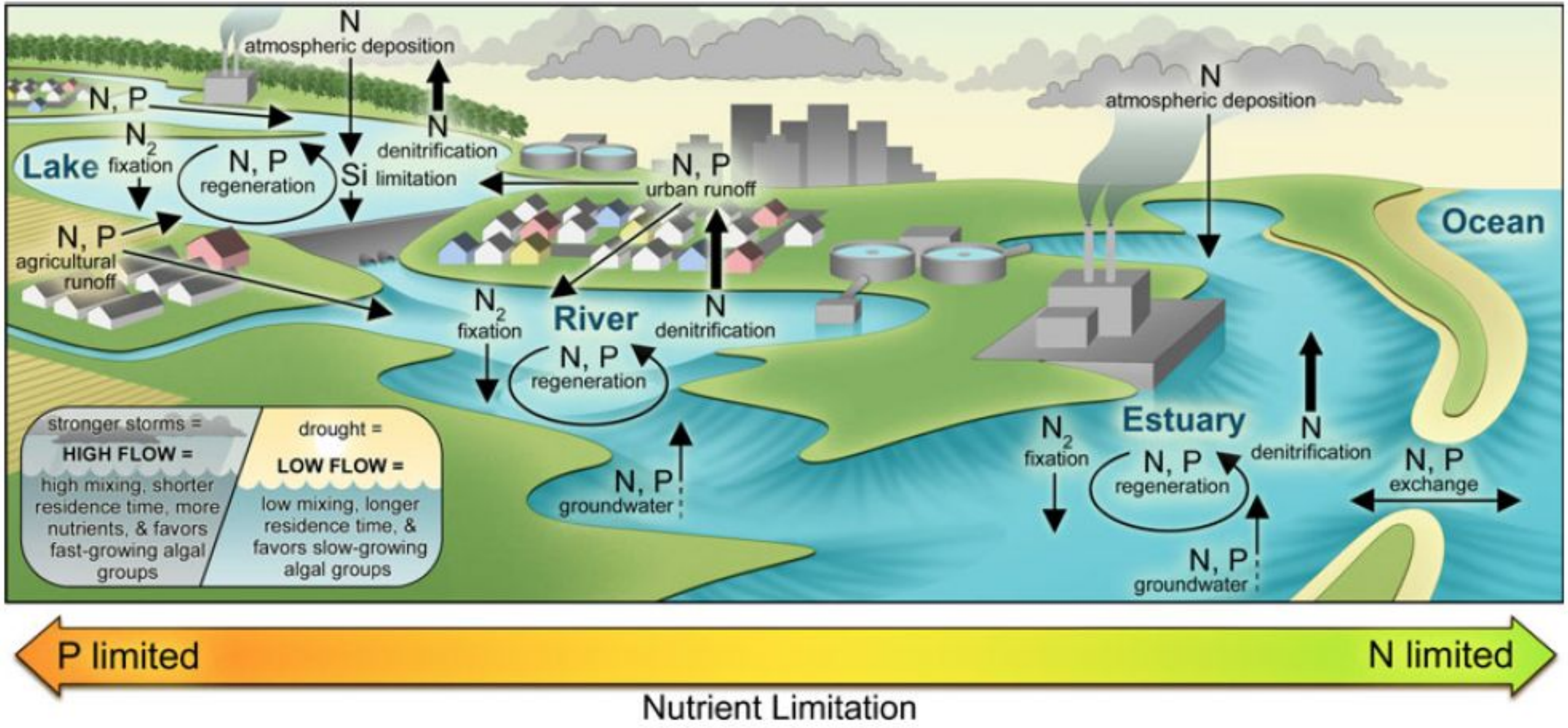
Reducing Both N and P Loads to Abate Coastal Eutrophication

Donald F. Boesch

Phosphorus Forum 2020

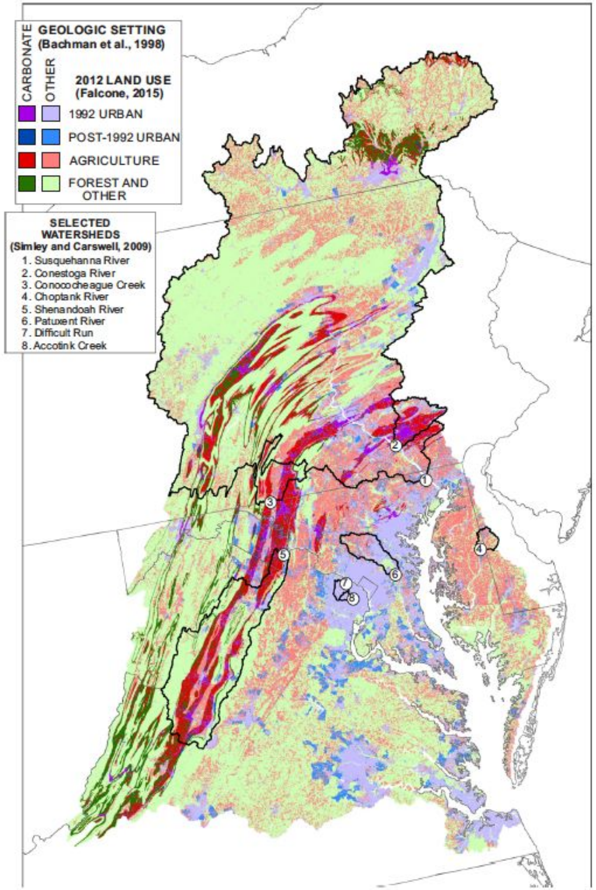
October 1, 2020

Simplified View of Nutrient Cycling & Limitation

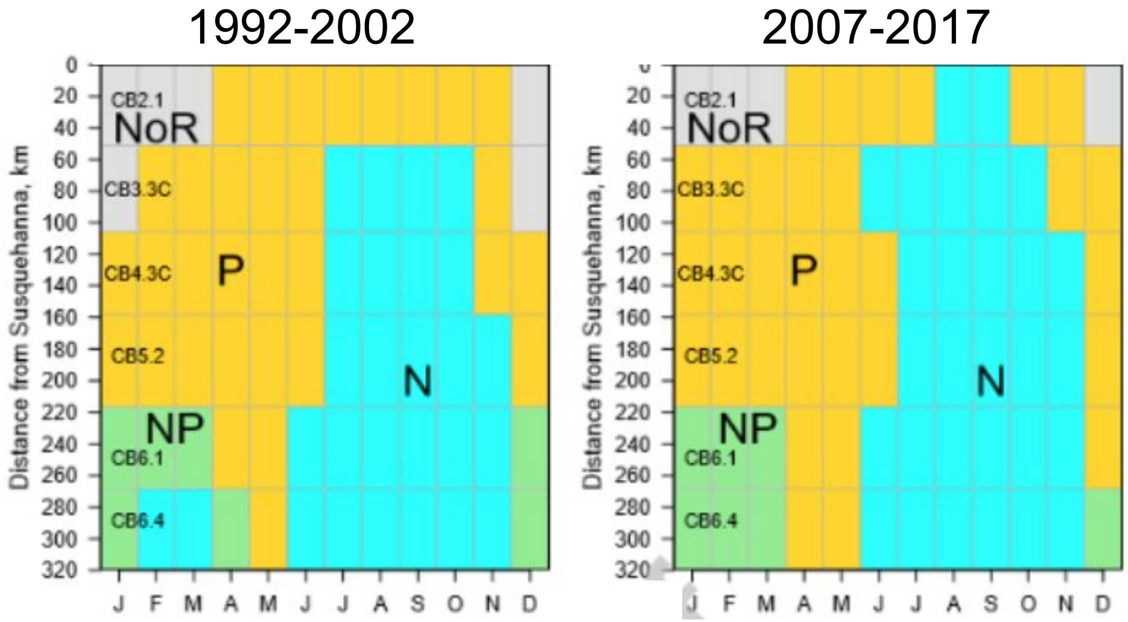


Paerl et al. 2014 *Estuaries and Coasts*

Chesapeake Bay: The Two Nutrient Challenge

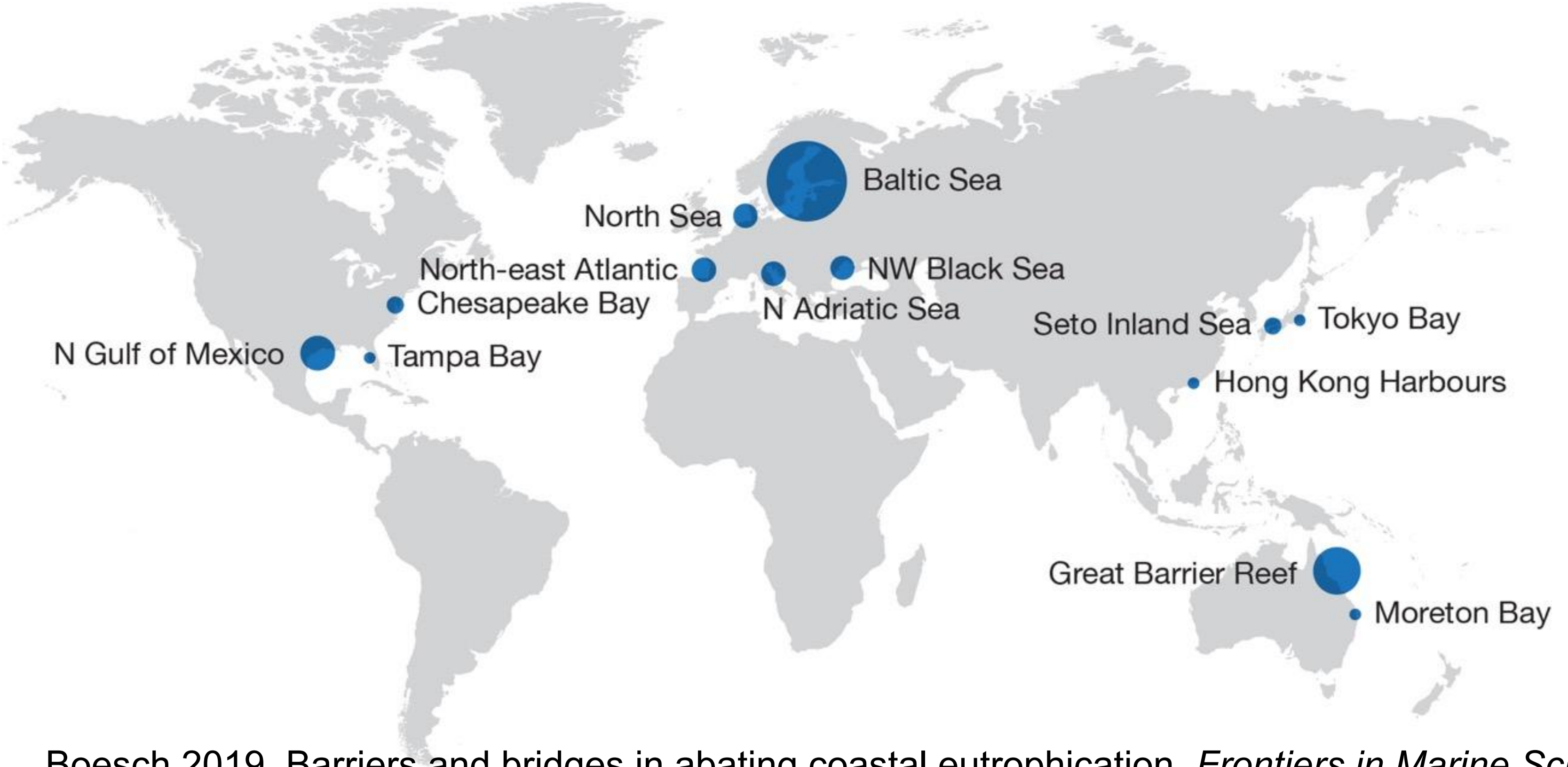


N and P Nutrient Limitation



Zhang et al. 2020. *Water Research*

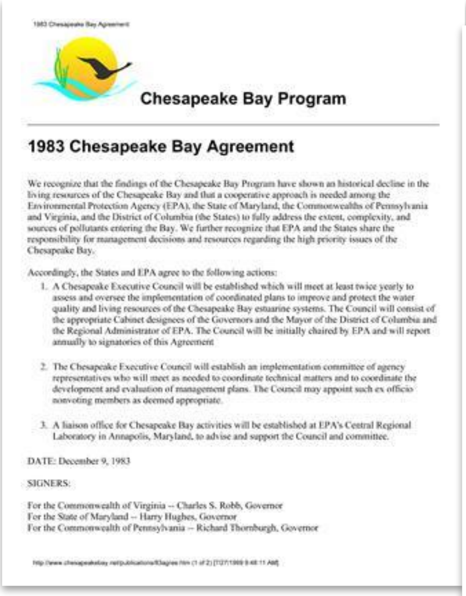
Coastal Eutrophication Abatement Campaigns



Boesch 2019. Barriers and bridges in abating coastal eutrophication. *Frontiers in Marine Science*

Chesapeake Bay: N & P Reduction Commitments

1983



1983 Chesapeake Bay Agreement

Chesapeake Bay Program

1983 Chesapeake Bay Agreement

We recognize that the findings of the Chesapeake Bay Program have shown an historical decline in the living resources of the Chesapeake Bay and that a cooperative approach is needed among the Environmental Protection Agency (EPA), the State of Maryland, the Commonwealths of Pennsylvania and Virginia, and the District of Columbia (the States) to fully address the extent, complexity, and sources of pollutants entering the Bay. We further recognize that EPA and the States share the responsibility for management decisions and resources regarding the high priority issues of the Chesapeake Bay.

Accordingly, the States and EPA agree to the following actions:

1. A Chesapeake Executive Council will be established which will meet at least twice yearly to assess and oversee the implementation of coordinated plans to improve and protect the water quality and living resources of the Chesapeake Bay estuarine systems. The Council will consist of the appropriate Cabinet designees of the Governors and the Mayor of the District of Columbia and the Regional Administrator of EPA. The Council will be initially chaired by EPA and will report annually to signatories of this Agreement.

2. The Chesapeake Executive Council will establish an implementation committee of agency representatives who will meet as needed to coordinate technical matters and to coordinate the development and evaluation of management plans. The Council may appoint such ex officio nonvoting members as deemed appropriate.

3. A liaison office for Chesapeake Bay activities will be established at EPA's Central Regional Laboratory in Annapolis, Maryland, to advise and support the Council and committee.

DATE: December 9, 1983

SIGNERS:

For the Commonwealth of Virginia -- Charles S. Robb, Governor
For the State of Maryland -- Harry Hughes, Governor
For the Commonwealth of Pennsylvania -- Richard Thornburgh, Governor

1987

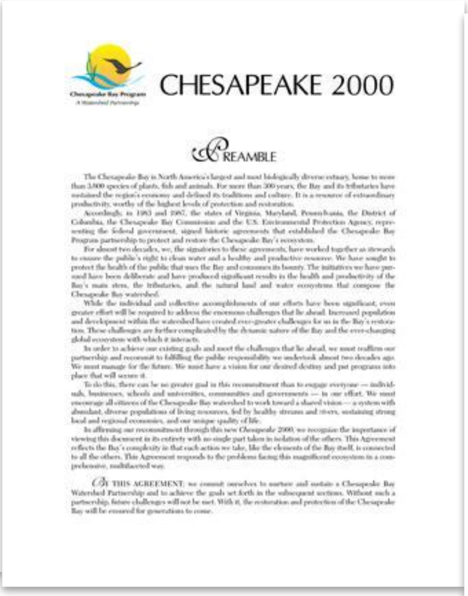
1987 CHESAPEAKE BAY AGREEMENT

THE CHESAPEAKE BAY IS A NATIONAL TREASURE

GOALS AND PRIORITY COMMITMENTS

-40% in N & P loads by 2000

2000



CHESAPEAKE 2000

Chesapeake Bay Program

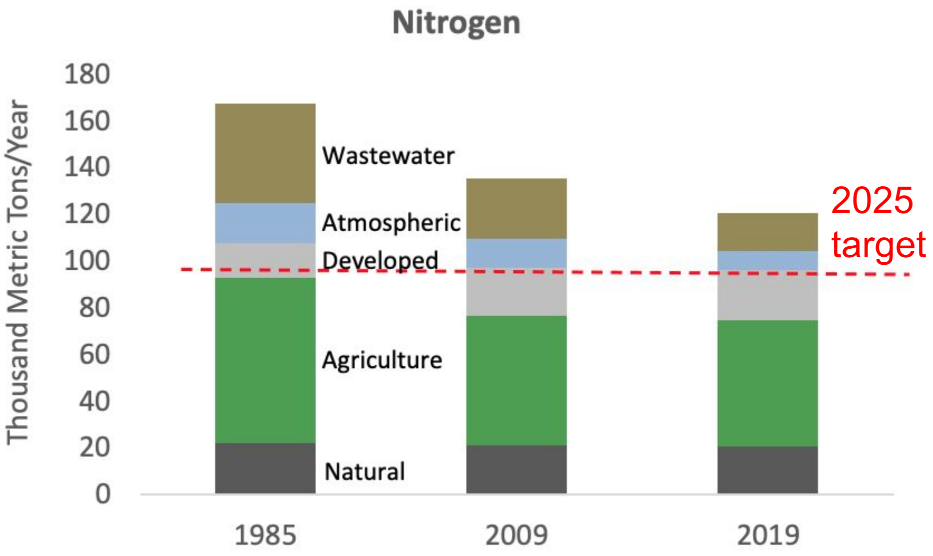
PREAMBLE

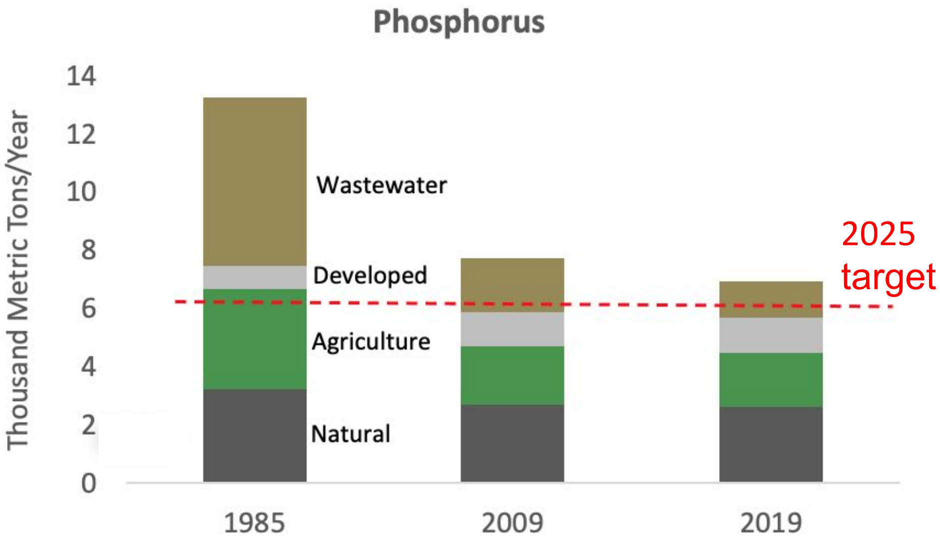
Voluntary reductions determined by science by 2010

2014

Mandatory Total Maximum Daily Load by 2025

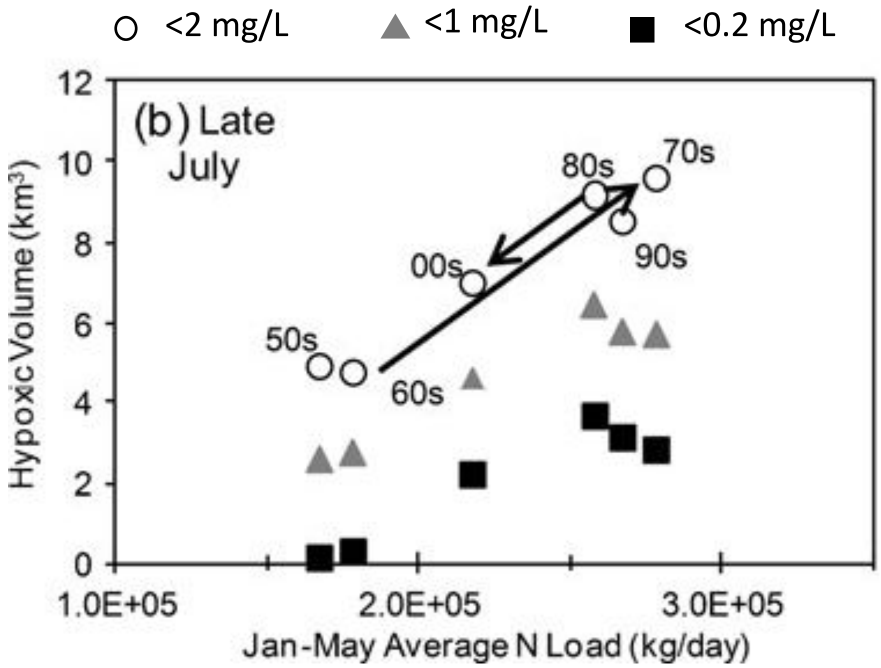
Chesapeake Bay: Declining Nutrient Loads
per Management Model



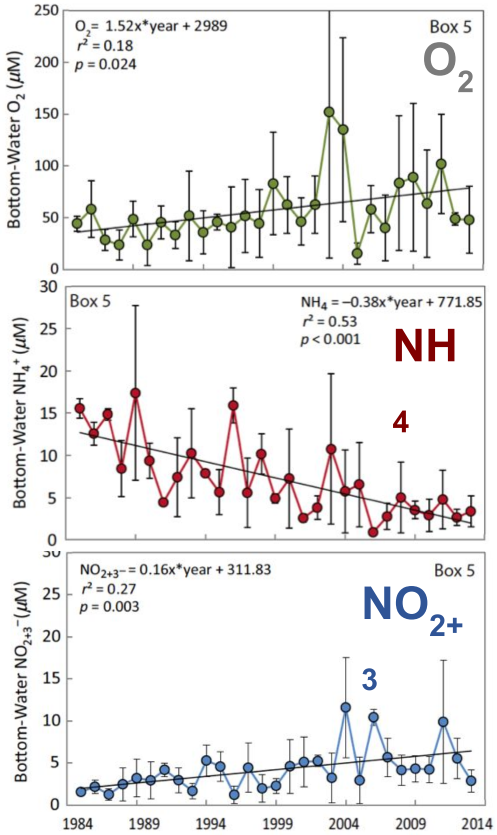


https://www.chesapeakeprogress.com/clean-water/watershed-implementation-plans

Chesapeake Bay: Hypoxia & N Cycling



Murphy et al. 2011 *Estuaries & Coasts* 34:1293

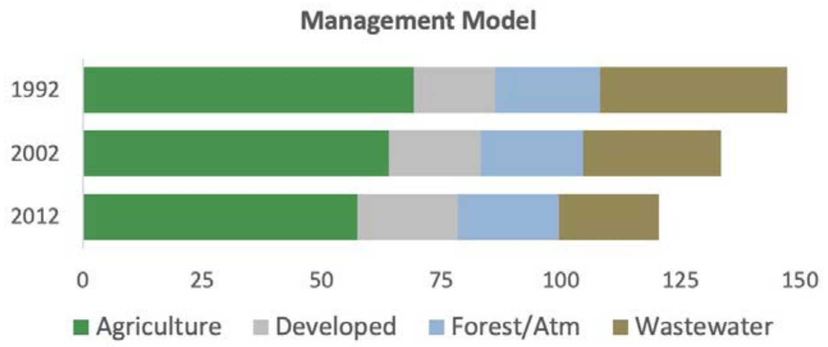


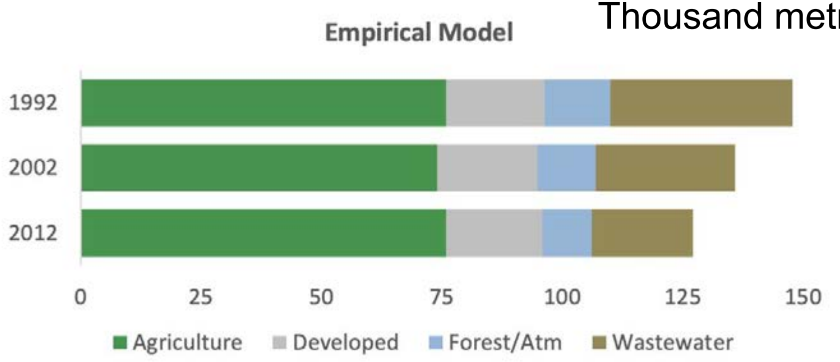
Testa et al. 2018 *L&O*

Chesapeake: Empirically-derived Estimates Differ

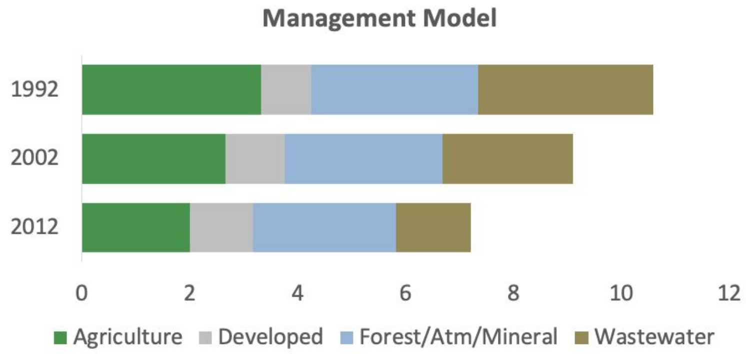
SPARROW Model Based on Stream Monitoring (Ator et al. 2020. *JEQ*)

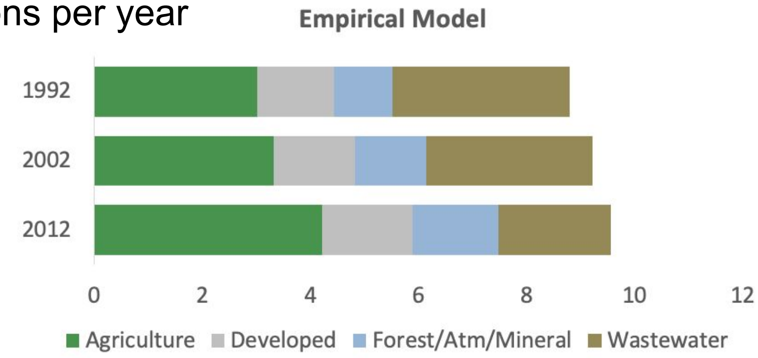
Nitrogen





Phosphorus





Thousand metric tons per year

Chesapeake Bay: Reconciling Model Differences

Nutrient Load Changes 1992-2012

	Nitrogen		Phosphorus	
Model	Mgmt.	Empirical	Mgmt.	Empirical
Agriculture	-17%	0%	-40%	+40%
Developed	+24%	-3%	+26%	+16%

Possible Explanations

- Lag times — just be patient!
- Model process differences.
- Assumptions of effects of actions.
    - Agricultural BMPs less effective
    - More urban nutrient retention

Legal Challenges to Chesapeake TMDL Implementation

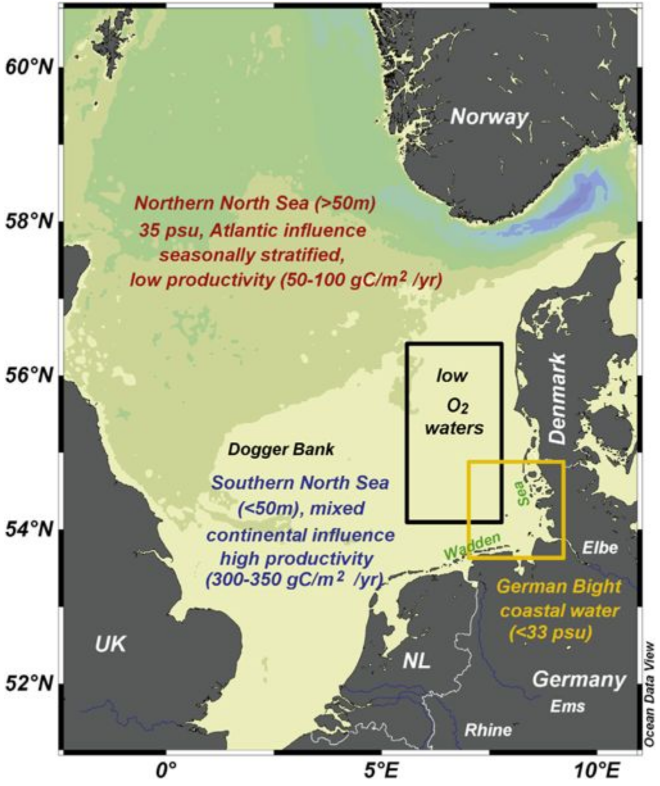
American Farm Bureau Federation®

- TMDL not lawful under Clean Water Act (detailed allocations, reasonable assurances, upstream states, implementation)
- Procedural violations: public access to critical information
- Arbitrary & capricious: overextended model and flawed data

EPA

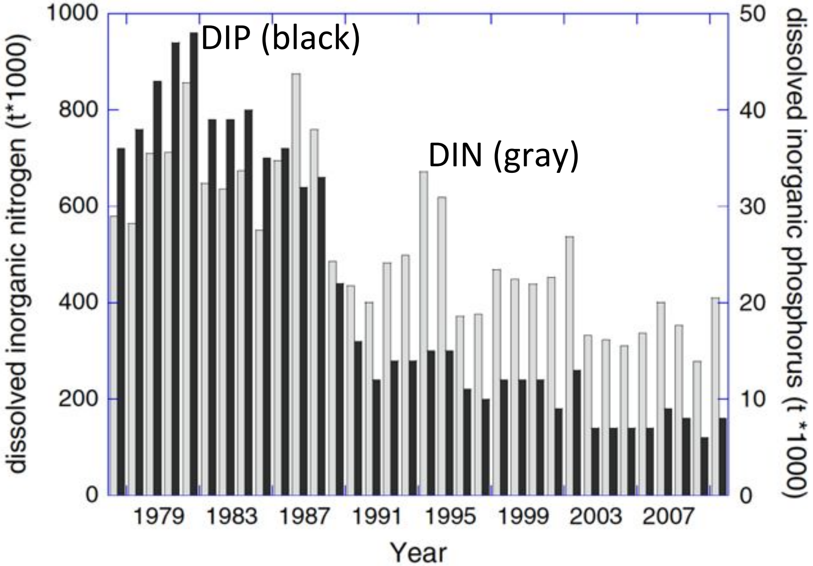
MD, VA, DC and Chesapeake Bay Foundation sued EPA in September 2020 for approving PA & NY implementation plans without reasonable assurance in meeting TMDL

Southern North Sea



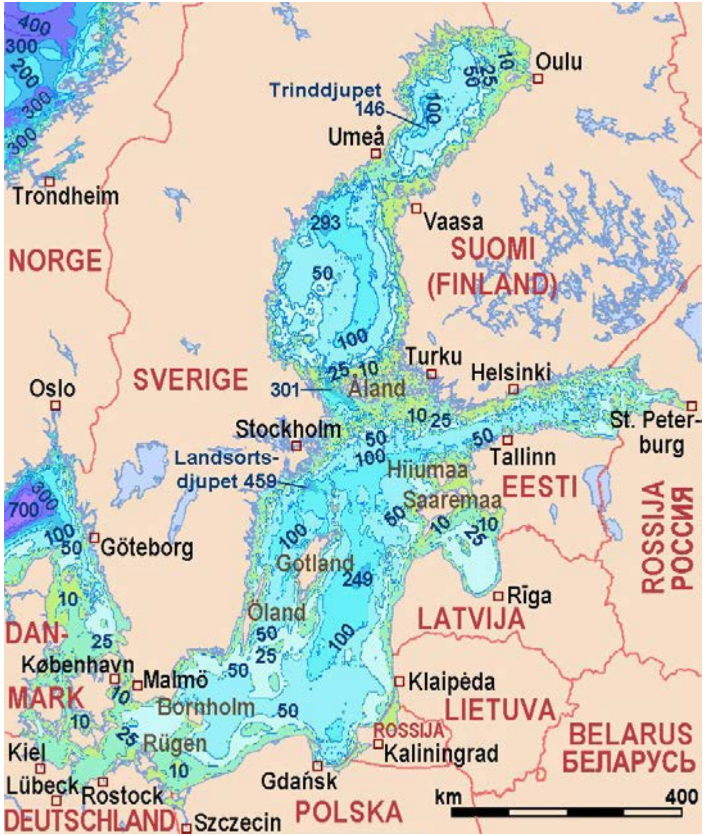
Emeis et al. 2015. *Journal of Marine Systems*

OSPAR 1987: reduce river loads of N and P by 50% between 1985 and 1995
By 2010 -81% P, -45% N



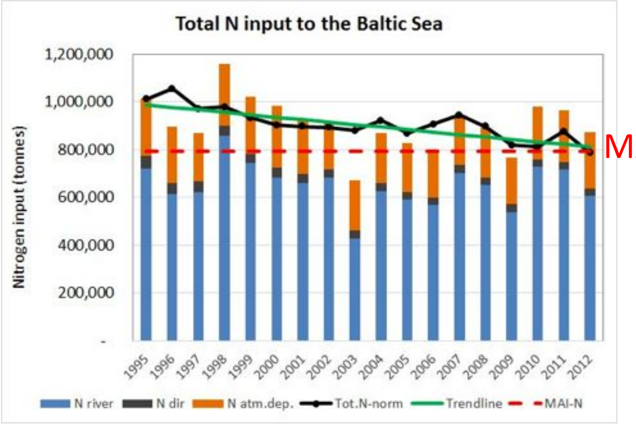
Annual loads from Elbe, Weser, Ems, Ijssel, Rhine, Scheldt & Meuse rivers

Baltic Sea – the World Class Campaign

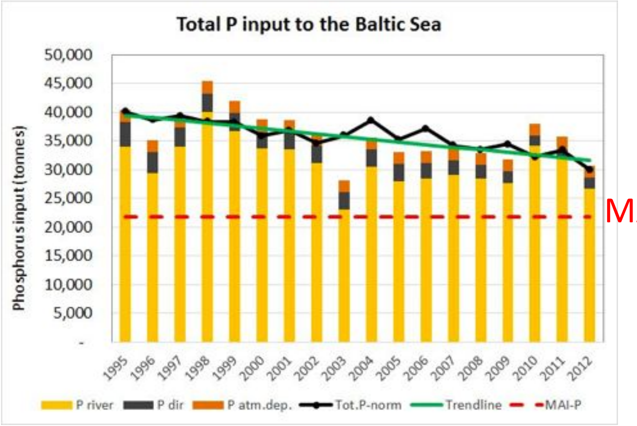


HELCOM 1988
-50% N&P by 1995
✓-24% N & -50% P
>80s

Baltic Sea Action Plan
2013
Max. **A**llowable **I**nputs
-16% N & -70 % P by
2015 based on
1997-2003 loads



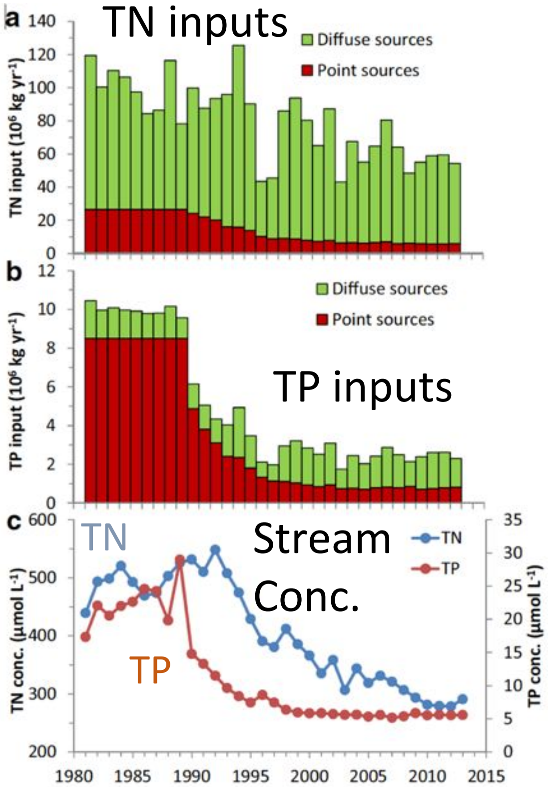
MAI



MAI

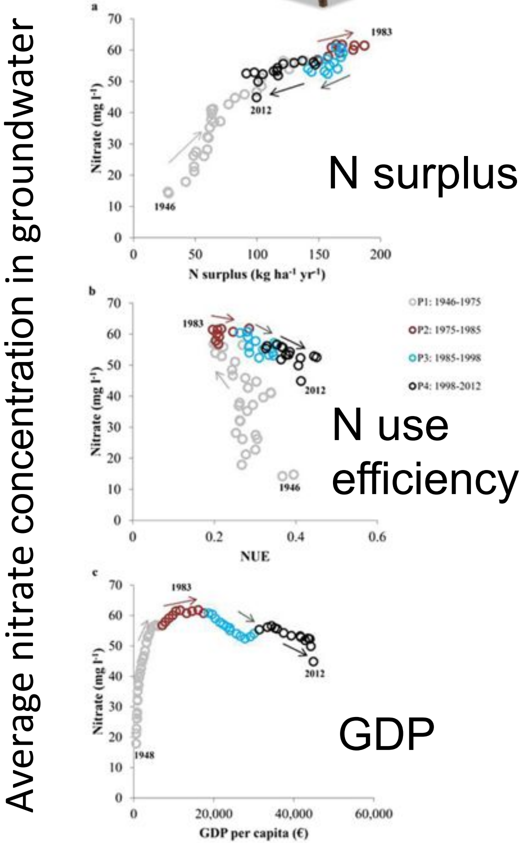
The Danish Experience

- 1987 National Action Plan on Aquatic Environment: -50% N & -80% P
- Additional agricultural measures, including N application 85-90% of economic optimum & mandatory cover crops
- Sustained & coupled monitoring & assessment
- Inputs to coastal systems -50% N & -70% P



Riemann et al. 2016. *Estuaries & Coasts*

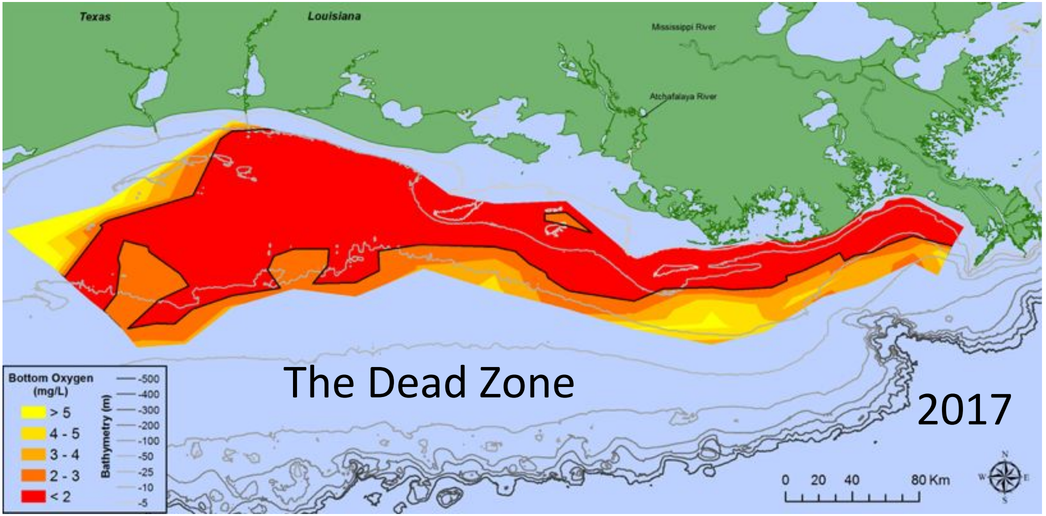
Hansen et al. 2017. *Scientific Reports*

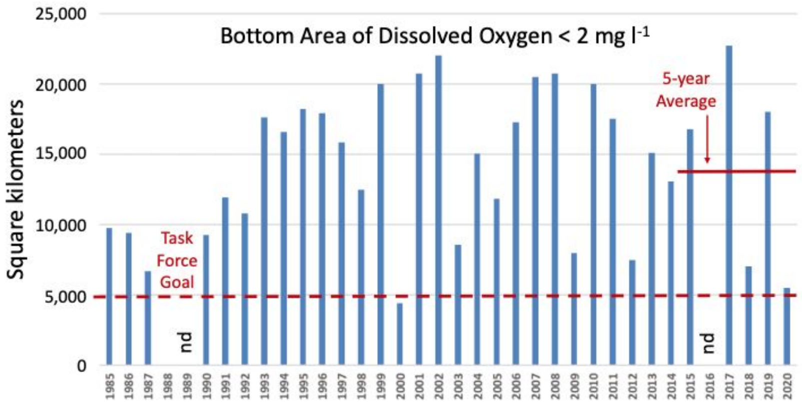


Northern Gulf of Mexico Hypoxia

2000 Integrated Assessment
2001 Action Plan
2007 EPA SAB Report
2008 Action Plan

<5,000 km^2 by 2015 □ 2035
~-45% N & P, interim goal -20% N by 2025
Voluntary Action (no TMDL)
Task Force – 12 states & Federal agencies

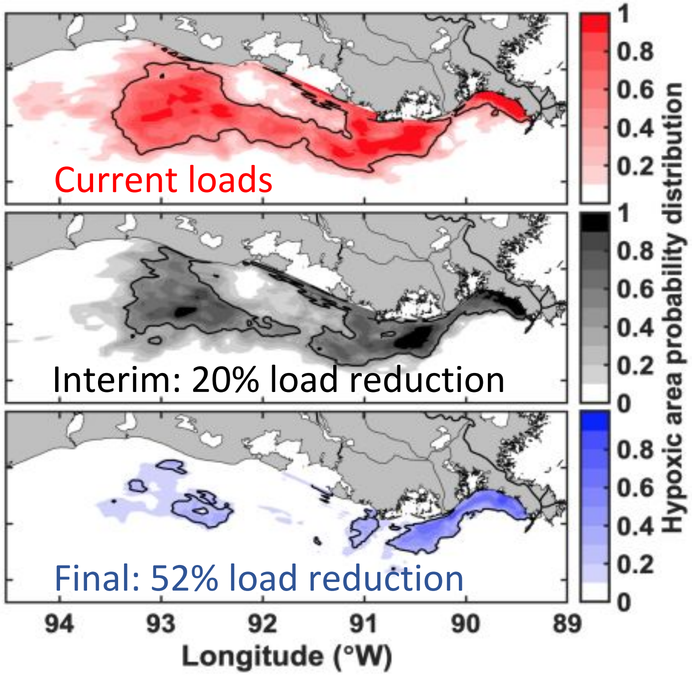




gulfhypoxia.net

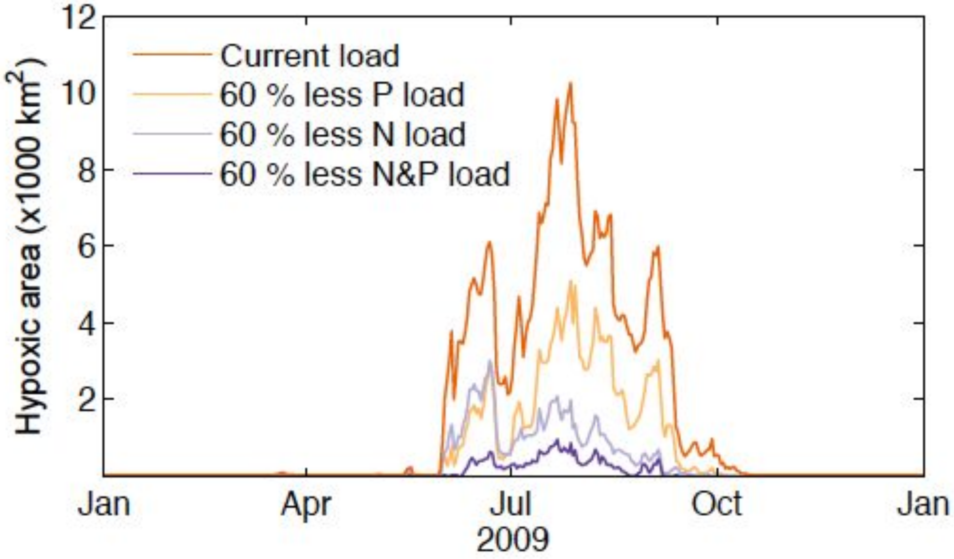
Effects of Reducing N & P Loads on Gulf Hypoxia

Reducing nitrogen loads by ~52% could achieve hypoxia abatement goal



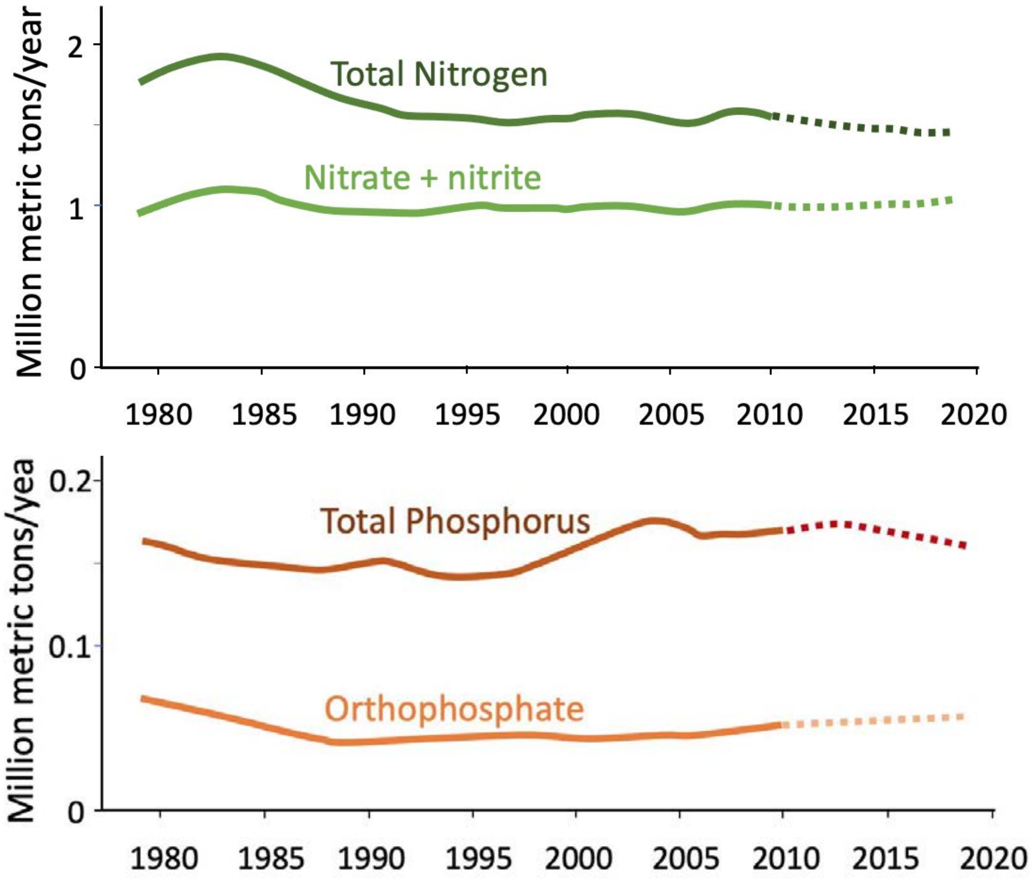
Laurent & Fennel. 2019. *Environ. Sci. Tech.* 53:14449

- P is a proximal limiting nutrient, but P is the ultimate limiting nutrient
- Reducing N loads has greater effect on shrinking hypoxic zone, reducing both nutrients even more
- Reducing P but not N does not expand hypoxic zone



Fennel & Laurent. 2018. *Biogeosciences* 15:3121

Mississippi-Atchafalaya Basin Nutrient Load Trends

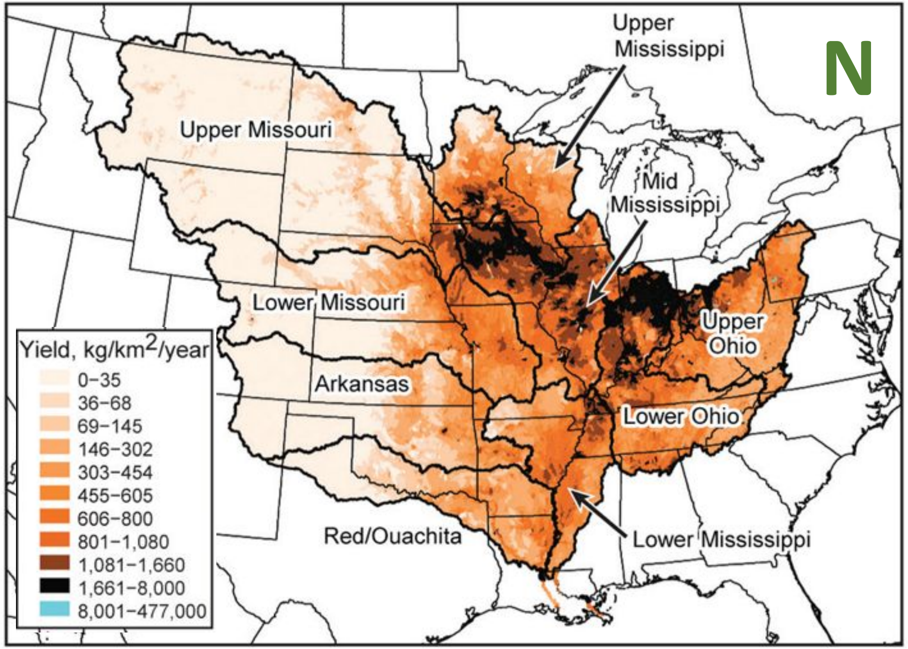


- Trends in flow-normalized loads based on WRTDS model
- Hypoxia Task Force's interim goal 20% N reduction by 2025
- Over 20 years under the Action Plan loads have essentially been level, after adjustment for variations in river flow, particularly for DIN & DIP
- In U.S. Heartland no change in **PUE** & slight decline in **NUE** between 1987-1997 and 2002-2012 (Swaney et al. 2018, Swaney & Howarth 2019)
- Lag times?

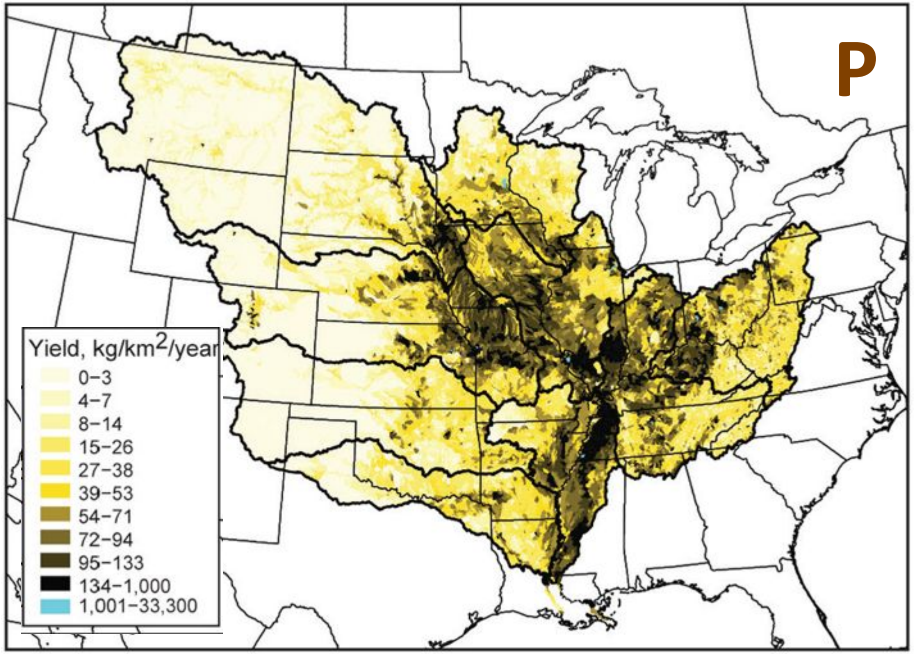
https://nrtwq.usgs.gov/nwqn/#/GULF

Mississippi River Basin Delivered Yields

Delivered Incremental N Yield

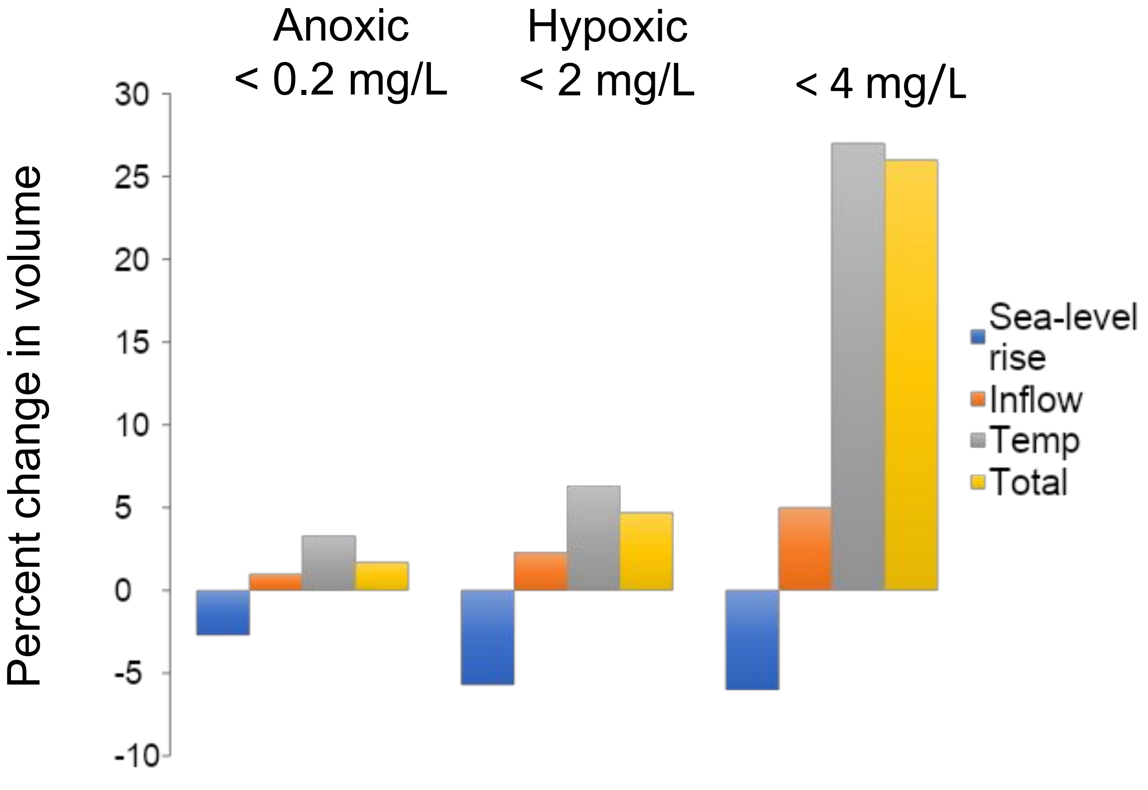


Delivered Incremental P Yield



Spatially Referenced Regression on Watershed Attributes (SPARROW) Model
Robertson & Saad 2014 *Journal of Environmental Quality* 42:1422

Climate Change Effects Are Complex



Irby et al. 2017. *Biogeosciences* 15: 2649

Chesapeake Bay

- ✔ TMDL achieved
- ✔ 0.5 m SLR
- ✔ changed river flow & nutrient flux
- ✔ + 1.75° C

- Hydrologic & nutrient flux changes difficult to project
- Changes in ocean end-member forces?

Key Points

- Abating coastal eutrophication typically requires reducing N loads, but reducing both N and P is more effective and, in some cases, essential.
- Model estimates of load reductions should be reconciled with observations, with consideration of lag-times in an adaptive management framework.
- Wastewater point sources of P and N have been most readily reduced, with rapid results.
- There are few cases where loads form diffuse, agricultural sources have been significantly reduced, demonstrably and at scale.
- Reducing diffuse sources of nutrient pollution will require performance compliance or regulation.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www.umces.edu/don-boesch
@DonBoesch

Agenda (all times ET)

12:00-12:20	Welcome from the Alliance (Drs. Jim Elser and Matt Scholz)
12:20-12:50	Dr. Don Boesch, Professor and President Emeritus, University of Maryland Climate Change and Coastal Eutrophication
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2:30-2:50	Closing discussion & Raffle!

Keynote Speaker

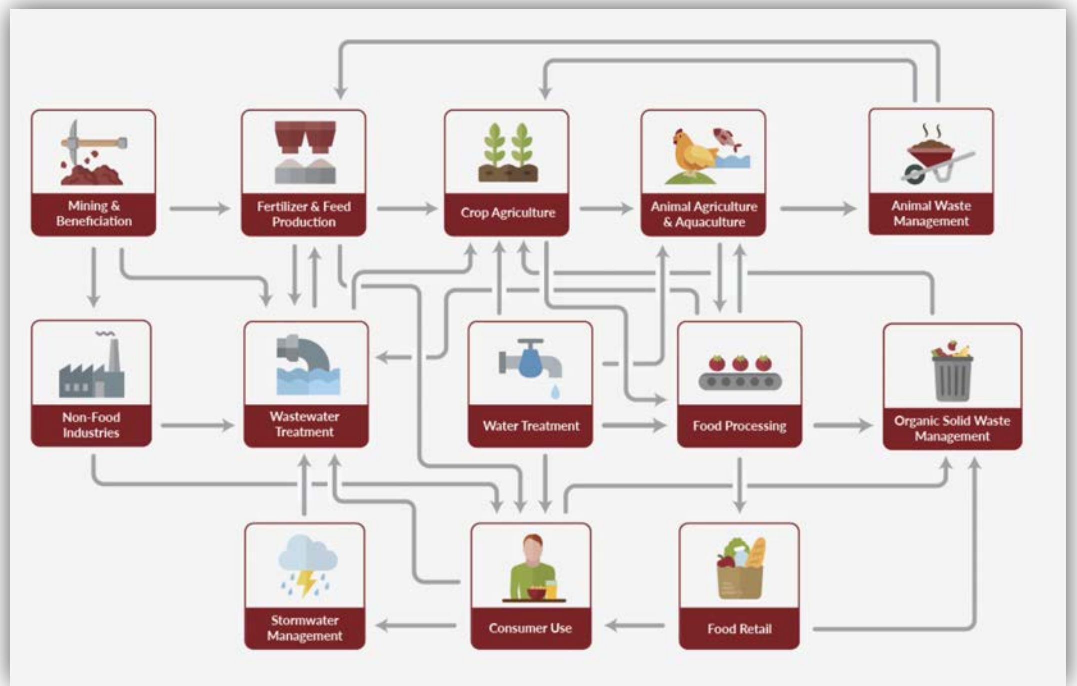
Mr. Kerry McNamara
CEO
OCP North America, Inc.

Kerry is Chief Executive Officer of OCP North America, Inc. He has held various roles in the OCP Group since 2010, including Advisor to the Chairman & CEO, and Executive Director of OCP Research, the predecessor to OCP North America.

The OCP Group:
A global partner in P sustainability

Phosphorus Forum 2020| October 1, 2020

A Systems Approach to P Sustainability



The Sustainable Phosphorus Alliance, Sustainable Phosphorus Challenge website

Complex challenges require **collaboration**. We need to come at the challenge from **multiple angles**, harness our **collective intelligence** and encourage **cross-sector innovation**.

Mined phosphorus may be finite, but **phosphorus in our world is abundant**. All phosphorus requires good management, regardless of the source. We will need to work together to ensure this life-giving resource is **available where it is needed,** and only where needed.

About OCP

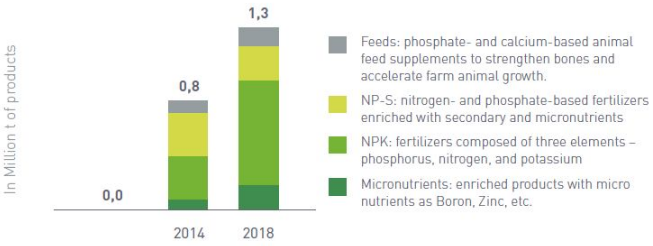
#1 exporter worldwide of phosphate rock and phosphate derivative products

Supplying the world's fertilizers

Types of products

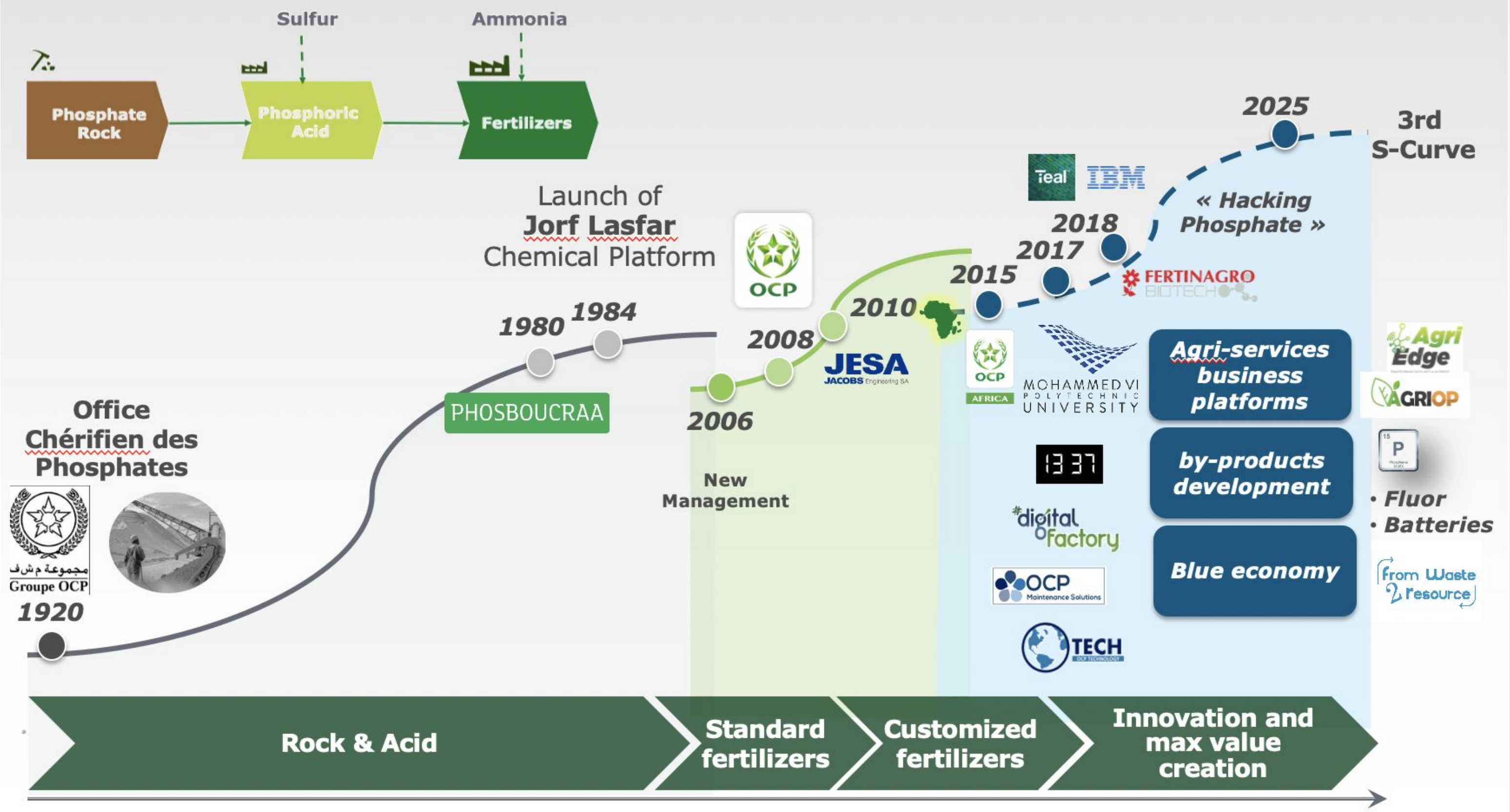
- **DAP**: most commonly used binary fertilizer
- **MAP**: a commonly used binary fertilizer
- **TSP**: phosphate fertilizer
- **NPK**: compound fertilizers
- **Performance Phosphate Products**
- **NP+**: enriched with secondary and micronutrients
- **Soluble fertilizers**
- **DCP/MDCP**: phosphate- and calcium-based animal feeds

Evolution of OCP's customized fertilizers production (Africa - excluding Morocco)



About OCP

A century of knowledge and expertise



Mining in Morocco

Extraction & Washing: The first step for phosphorus availability

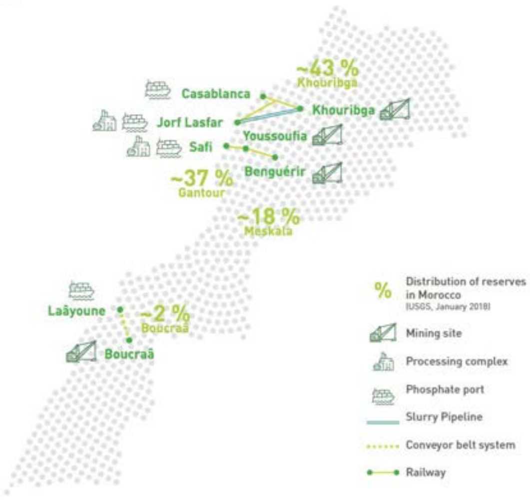
Morocco holds more than 70% of the world's resources of phosphorus, according to the USGS. OCP is continuously working to preserve them through recovery of **low phosphorus content phosphates** and **recycling by-products** as well as **phosphorus recovery technologies** in the production process. P "reserves" refer to those that form the basis of currently economically viable mining.

An **integrated group** across the entire value chain

4 mining sites

2 processing platforms

4 phosphate ports



From Rock to Fertilizers

Processing and transport & storage

Transformation Towards Digital Optimization
Advanced analytics, automation and digital services allow predictive maintenance and optimization of storage, loading, wharf logistics as well as product quality and traceability solutions

Optimized Transportation by Pipeline
The first P slurry pipeline replaced transport by rail and has reduced water consumption by 3M mt and emissions by 620,000 CO_2e tons – relying on gravity to move slurry and eliminating additional drying processes

Energy cogeneration
Recovering waste heat released during the sulfuric acid production process now produces electrical energy on site. New units are equipped with a thermoelectric power station and heat recovery systems. Cogeneration has covered 80% of electricity needs at processing sites in 2019 and displaced 60% of the OCP group's carbon footprint.

OCP NORTH AMERICA

Sustainable Production Commitments

A sustainable expansion plan

100% Clean Energy by 2030
86% of electricity from clean sources (wind, solar, or co-generated production), with 25% of all clean energy in Morocco produced by OCP

Zero Conventional Water Consumption by 2030
30% of water usage today from desalination and local wastewater treatment facilities (see photo)

Carbon Neutral by 2040
Carbon capture technologies, cutting SO2 emissions in half and rehabilitating old mine sites to maximize soil carbon sequestration

Climate change is a core component of our risk management planning – see the 2019 annual sustainability report for details.

OCP NORTH AMERICA

A Global Plant Nutrition Company

Providing technical support for product stewardship to farmers

A Vision for Sustainable Growth in Africa…

In 2019:
Customized fertilizers, soil nutrient mapping and agronomic testing
- 256,000 farmers reached by OCP School Labs
- 64 million acres of soil mapped
- 20,000 soil analyses in Morocco through farmer outreach programs

Holistic, farmer-centric support
- 168,404 participating farmers in OCP Africa's flagship program "Agribooster"
- Rollout of digital "tmar" platform for Moroccan farmers

Collaborative 4R training for impact
- 80,000 women smallholder farmers to be empowered with 4R agronomic training through 4R Solutions for Africa

… And Commitment to Grow in Partnership with North American Farmers

A voice for nutrient management
- Committed 4R Partner in industry
- Field to Market member for Education & Outreach
- Partner for US Farmers & Ranchers in Action Forum in 2020

4R nutrient stewardship PARTNER

HONOR THE HARVEST FORUM

Field to Market

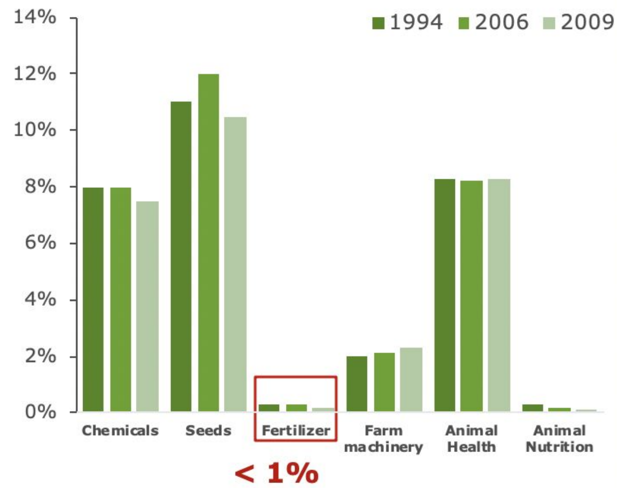
OCP NORTH AMERICA

Research and Innovation

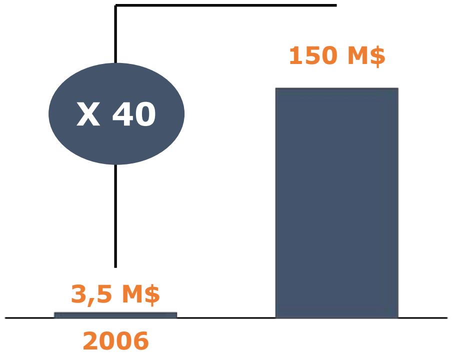
Innovation is a Driver for the Next S-Curve

Low Investment in R&D by the fertilizer industry

Research spending as % of sales



OCP has significantly increased its R&D spending



MOHAMMED VI POLYTECHNIC UNIVERSITY

Areas of research include:

- Water, agriculture and the environment
- Natural resource management
- Food security
- Agricultural economics & development
- Renewable energy

Strong corporate interest in supporting research on sustainable phosphorus:

- Phosphorus use efficiency
- Field to watershed flows
- Nutrient recovery & recycling
- The 4Rs & local BMPs
- Nutrients & soil health

Source: USDA, Economic research service, via Deck Retail

OCP NORTH AMERICA

Innovation in Phosphorus

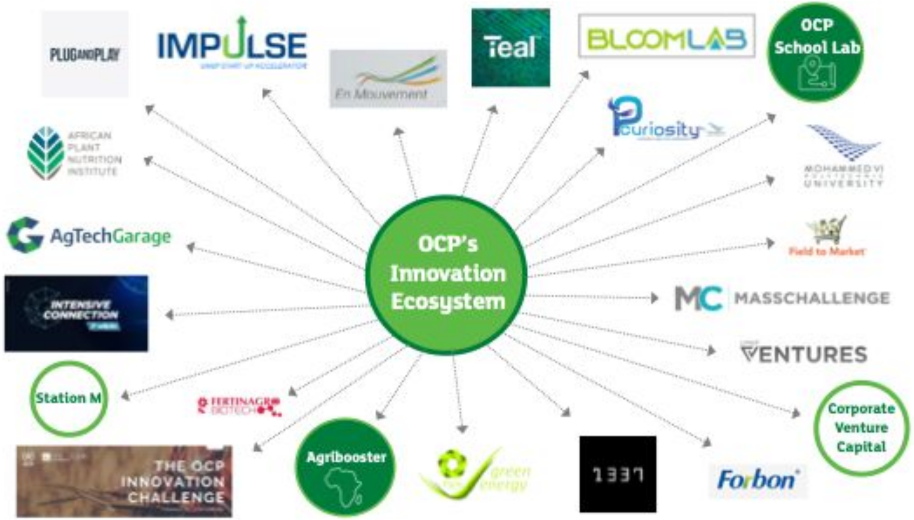
Bringing phosphorus to life

OCP is undergoing major transformation, without losing focus on the core business, on both ends of the value chain:

- Harnessing the power of phosphorus in **new ways**, though research and innovation, in partnership with others around the world
- Putting the **farmer at the center** – providing them with the best product, services and solutions to sustainably maximize their value creation.

How?

- Build internal capabilities at OCP and UM6P
- Acceleration programs, hubs, and support for outside innovators
- Pilot innovations with commitment to scale successes
- Dedicated funding and resources



A Sustainable Phosphorus Future

SPA: The ultimate collaboration

Where we've been together


Arizona State University
ASU Home My ASU
Sustainable Phosphorus Alliance
Membership Activities People Industries Get Involved Resources Blog

USDA and OCP North America Jointly Fund Phosphorus Research

OCP North America has provided matching funds to support a two-year postdoct
research fellow in the lab of Dr. Carl Bolster, research hydrologist at the USDA-ARS
Animal Environmental Systems Research Unit in Bowling Green, Kentucky. The
postdoctoral researcher will work on topics directly related to the Sustainable Pho
Alliance's Phosphorus Transport Modeling Group and in collaboration with resea
the ARS Soil Drainage Research Unit and Ohio State University.

The unique collaboration leverages a combination of public and private sector fu
advance the study of phosphorus flows from agricultural fields in the Western La
Basin, a significant eutrophication hotspot. Research will focus on the developme
testing of a model to determine the relative contributions of legacy and incidental
phosphorus losses from agricultural fields.

…and where we're going next

phosphorus sustainability challenge

"What is now proved was once only imagined."
- William Blake

OCP NORTH AMERICA

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Next Speaker

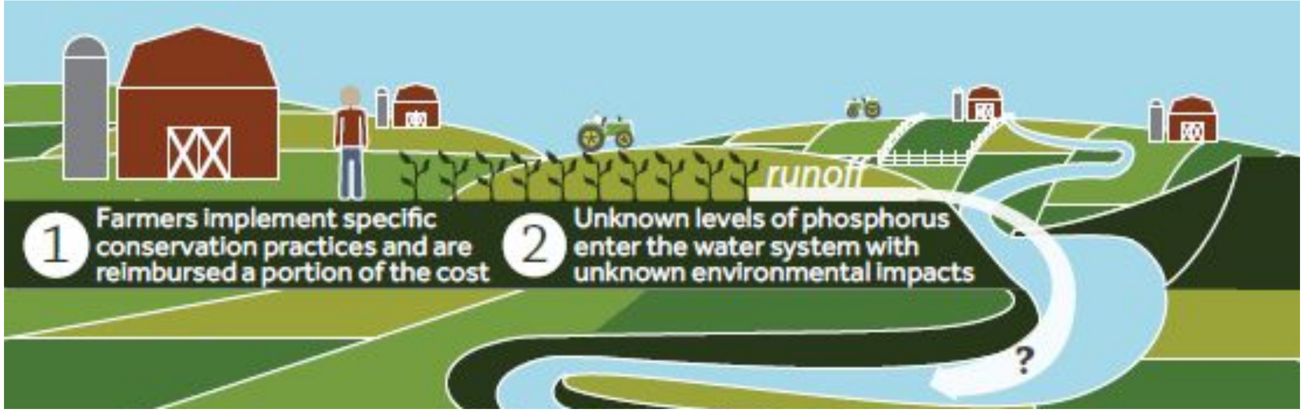
Dr. Jon Winsten
Agricultural and Environmental Economist
Winrock International

Jon Winsten is an agricultural and environmental economist with more than 20 years of experience working on issues of agriculture and the environment. At Winrock International, Winsten leads several projects related to agri-environmental policy, economic incentives for environmental performance from agriculture and sustainable livestock production systems.

Using Pay-for-Performance Conservation to Address Phosphorus Loss from Agricultural Land

Jonathan Winsten, Ph.D.
Winrock International
October 1st, 2020

Current Approach: “Pay-for-Practice” Conservation

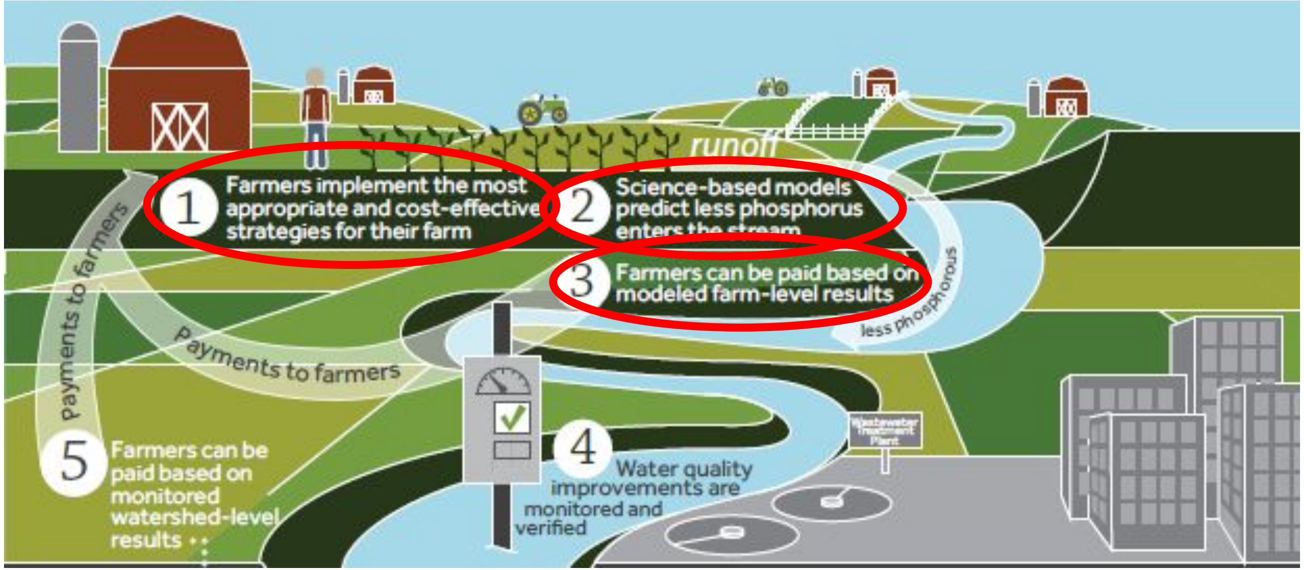


- USDA spends >$5 Billion/Year on practices
- Field-specific outcomes are not quantified
- Does not motivate farmers to solve problem

Landscape is Diverse: BMP Performance is Highly Variable

- Field-specific information is essential

Alternative Approach: “Pay-for-Performance” Conservation



- Payments based on estimated outcome from specific fields

Why Pay-for-Performance?

1. Address market failure
2. Motivate farmers
   a. Create specific goals
   b. Increase farm profits
3. Quantify outcomes
4. Cost-effective outcomes more likely

Key Program Design Questions: What, How, and Where?

What ecosystem service(s) do we target?

How do we quantify environmental performance?

Where do we quantify environmental performance?

- Need performance measures that are closely related to ultimate water quality concern **AND** directly influenced by farm management decisions.

Work with Farmers to Help Develop Ideas and Provide Specific Information

Steps:

- **Identify actions for specific fields (scenarios)**
- **Estimate nutrient loss reductions and costs**
- **Provide information to farmers for decision-making**

Pilot-Testing Pay-for-Performance

- Iowa, Vermont, Wisconsin, Ohio
- Focus on P loss; also N loss (Ohio)
- Models: P Index, Snap-Plus, NTT
- WQ Measurement (Ohio)

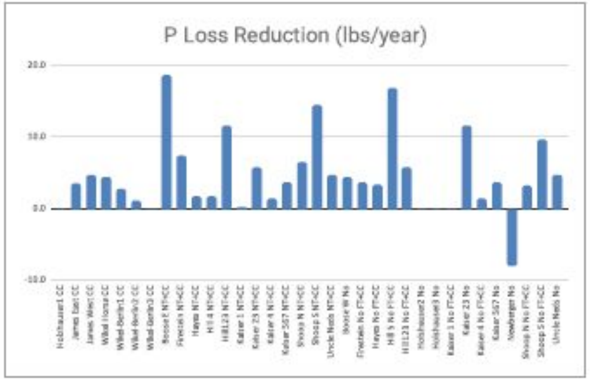
- Ohio: Offering $35/lb P and $5/lb N

Information Created for Farmer Decision-Making

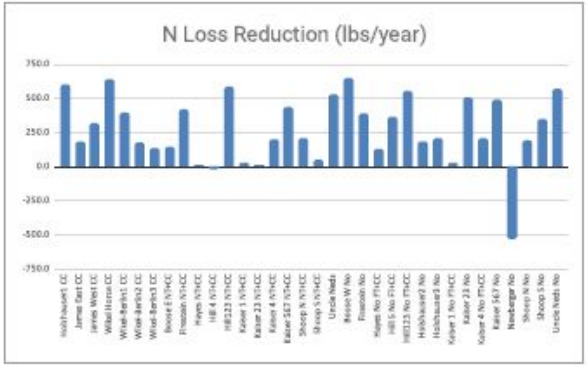
- Graphs of field-specific:
  - Nutrient loss reduction
  - Payment
  - Full economic cost
  - Profit or loss
- Table with each scenario

Provide Results to Each Farmer: P and N Loss Reductions

P reduction

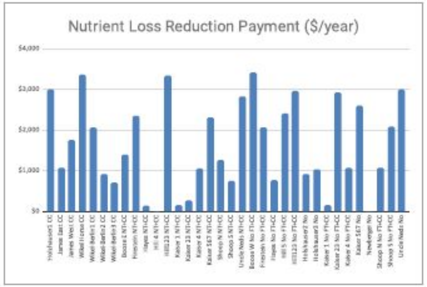


N reduction

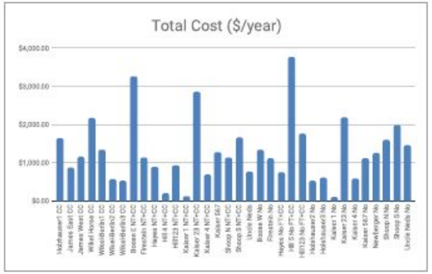


Provide Results to Each Farmer: Payment, Cost, and Profit/Loss

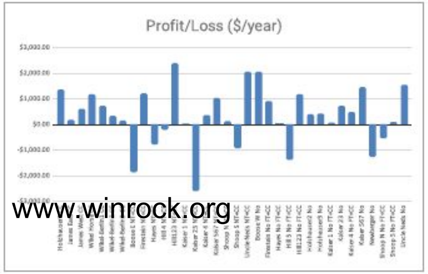
Payment



Total cost



Profit or loss



Ohio Project

Pilot-testing Pay-for-Performance Conservation in the Old Woman Creek Watershed

PROGRAM SIGN-UP SHEET FOR 2019

Farm Name: ________________________________

Farmer Name(s): ____________________________

Mailing Address:____

City:______________________________ Zip:__________________________

County:____________________________Township:______________________

Telephone #:_______________ Social Security or Tax ID#:____________________

I understand that I am eligible for up to $250 for soil testing done at the farm to increase the accuracy of data entered into NTT. I understand that the successful implementation of the changes listed on the attached sheet, with no other that affect phosphorus (P) or nitrogen (N) loss from my farm, will result in an estimated reduction of ______ lbs of total P loss and an estimated reduction of ______ lbs of total N loss from my farm for the 2019-20 crop year. I understand that I will receive a $35 per lb of total P loss reduced and $5 per lb of total N loss reduced from my farm's baseline. This will result in a nutrient loss reduction payment of $______.

In addition to the above, I also understand and agree to the following:

- That I am making the listed changes voluntarily and am in no way obligated to make the listed changes on my farm.
- That any changes that I make on my farm will be my choice and my responsibility and I will not hold the project or its implementers responsible for any impacts caused by these changes.
- That any changes I make on my farm must be verified by staff of the Erie Soil Conservation District, which may include obtaining copies of seed purchase receipts, performing site visits, taking photographs, or requesting other records from the farmer to demonstrate practice implementation.
- That if I make additional changes during the crop year, other than those listed, which further reduce the estimated loss of N or P from my farm, the project or its implementers are not responsible for paying the incentive for those additional nutrient loss reductions.
- That if I make additional changes during the crop year, other than those listed, which increase the estimated N or P loss from my farm, this will be accounted for and the total incentive payment will be adjusted to reflect the net change in estimated N+P loss from the farm. The payment rates will remain the same, but the lbs. of N+P reduced will be adjusted.
- That the only information specific to my farm that will be released will be the type of BMP(s) implemented and the township in which my farm is located, which the project funder (U.S. EPA) requires. The project will only make other results available in an anonymous fashion, including the nutrient runoff reductions and cost-effectiveness of the field management changes analyzed. All other information, such as individual soil test results, fertilizer application rates, and field-specific nutrient or sediment runoff estimates, will be held as confidential within the project team and will not be released to any persons or entities without the prior written permission of the farmer.

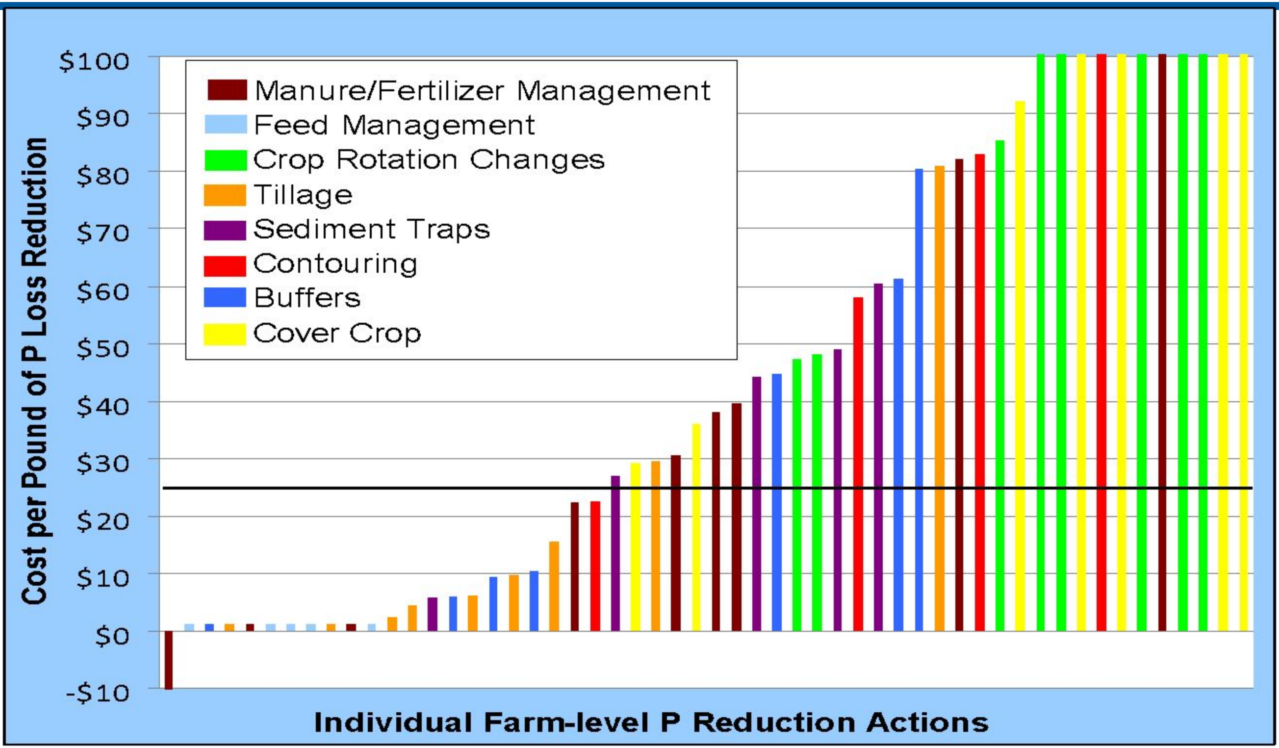
Signature: ______________________________ Date: ______________

Great Lakes RESTORATION | Erie Conservation District | WINROCK INTERNATIONAL | National Center for Water Quality Research Heidelberg University

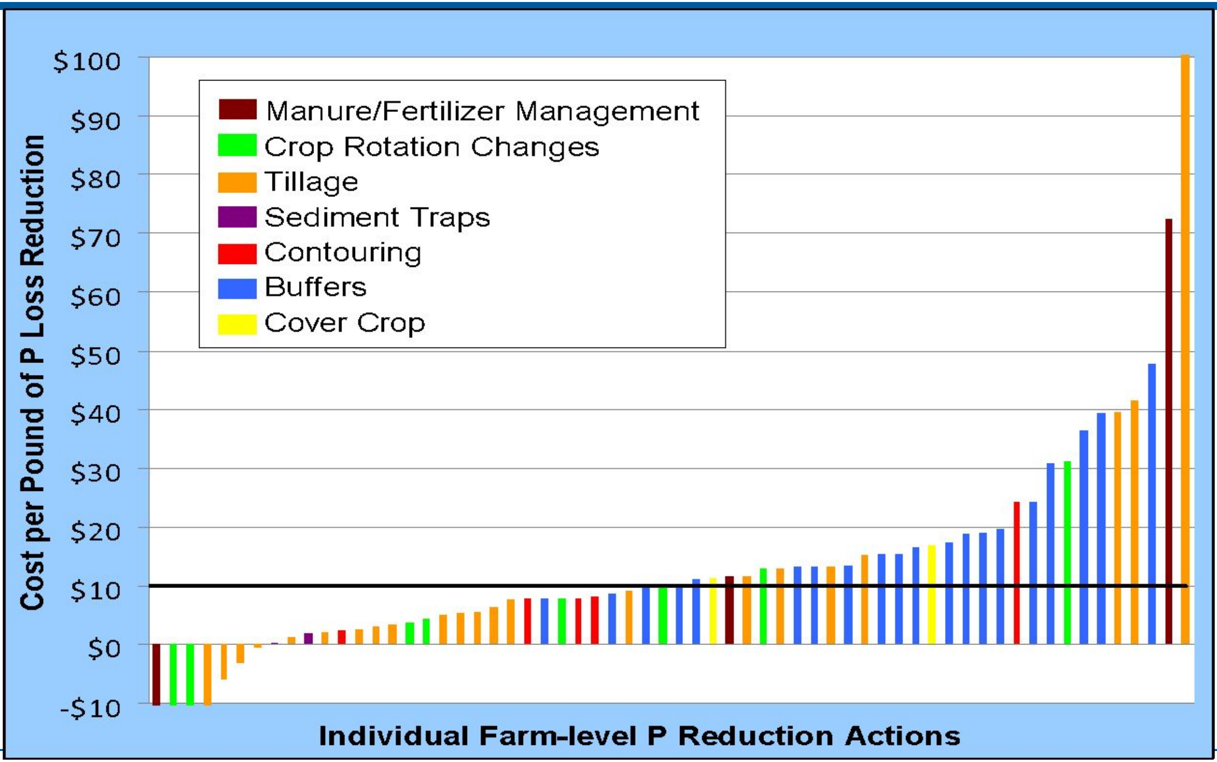
One-Page Sign-up Form

WINROCK INTERNATIONAL

Cost-effectiveness ($/lb P loss reduction) Scenario Results Across **Vermont** Farms



Cost-effectiveness ($/lb P loss reduction) Scenario Results Across **Iowa** Farms



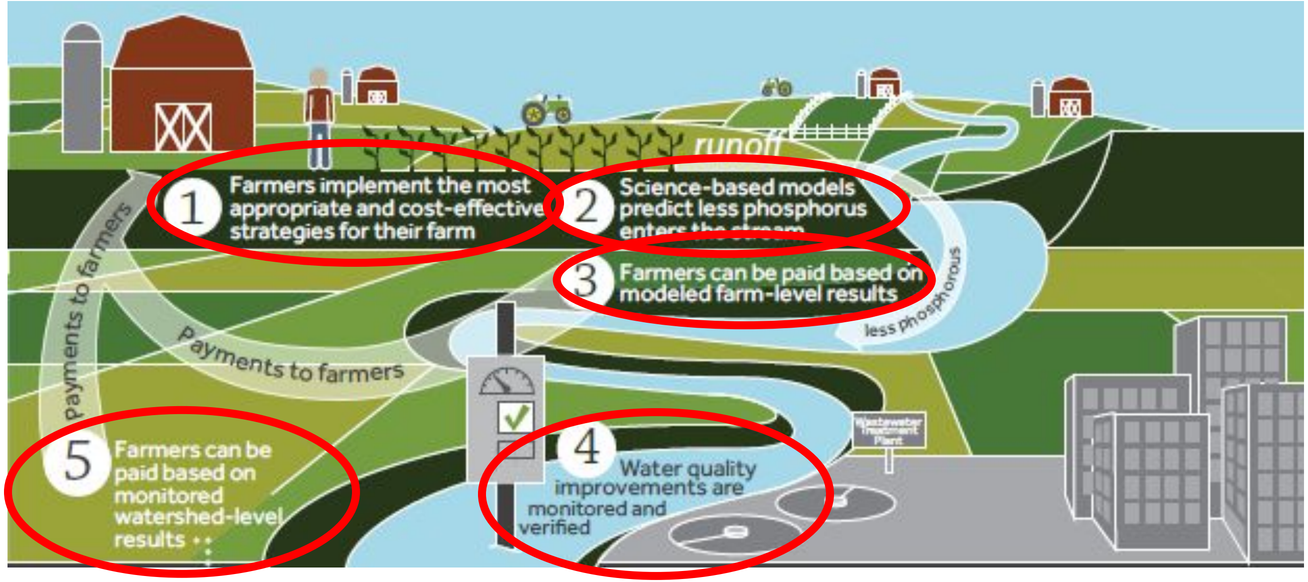
Results of Good Business Decisions

Watershed	P Loss Reduced (lbs/acre/yr)	Farm Cost ($/lb P)	Farm Profit ($/lb P)	Sediment Loss Reduced (tons/acre/yr)
Iowa	0.88	-$0.61	$10.61	1.58
Vermont	0.26	$4.86	$20.14	1.01

Lessons Learned

- Low-hanging fruit remains
- Perf-based incentives inspire new ideas
- Farmer motivation varies
- Boots on the ground is essential
- Transaction Costs < Program Benefits
- Models: necessary and difficult
- Policy change is slow

"Model-at-the-farm, measure-at-the-watershed"



Model at the Farm – Measure at the Watershed

- Modeling farm performance
  - Triggers primary incentive payment
- Measuring watershed performance
  - Provides a focal point and real report card
  - Triggers a secondary incentive payment
  - Farmer-to-farmer peer pressure for participation
- Winner of U.S. Nutrient Challenge (2015)

Pay-for-Performance Conservation: A How-To Guide

- Describes steps and data needs
- Goals:
  - Reduce transaction costs
  - Create opportunities for scale
- Funded by Great Lakes Protection Fund

https://www.winrock.org/project/running-off-pollution-paying-midwestern-farmers-to-improve-water-quality/

Contact Information

Jon Winsten

Senior Agricultural Economist

Winrock International

Email: jwinsten@winrock.org

Tel: (802) 343-3037

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Next Speakers

Dr. Carl Bolster
Research Hydrologist
USDA-ARS

Dr. Carl Bolster is a research hydrologist with USDA-ARS. His research interests include modeling P fate and transport in the environment. His recent research has focused on improving models for describing soil P cycling and comparing predictions of field scale P loss from models with differing levels of complexity.

Dr. Barret Wessel
Postdoctoral Research Soil Scientist
USDA-ARS

Dr. Barret Wessel is a postdoctoral Research Soil Scientist with the USDA-ARS in Bowling Green, Kentucky. His current research focuses on modeling phosphorus dynamics in agricultural landscapes to improve water quality in aquatic ecosystems. His research interests also include the use and management of urban and anthropogenic soils (SUITMAs), and pedology with a focus on hydric, coastal, and subaqueous soils.

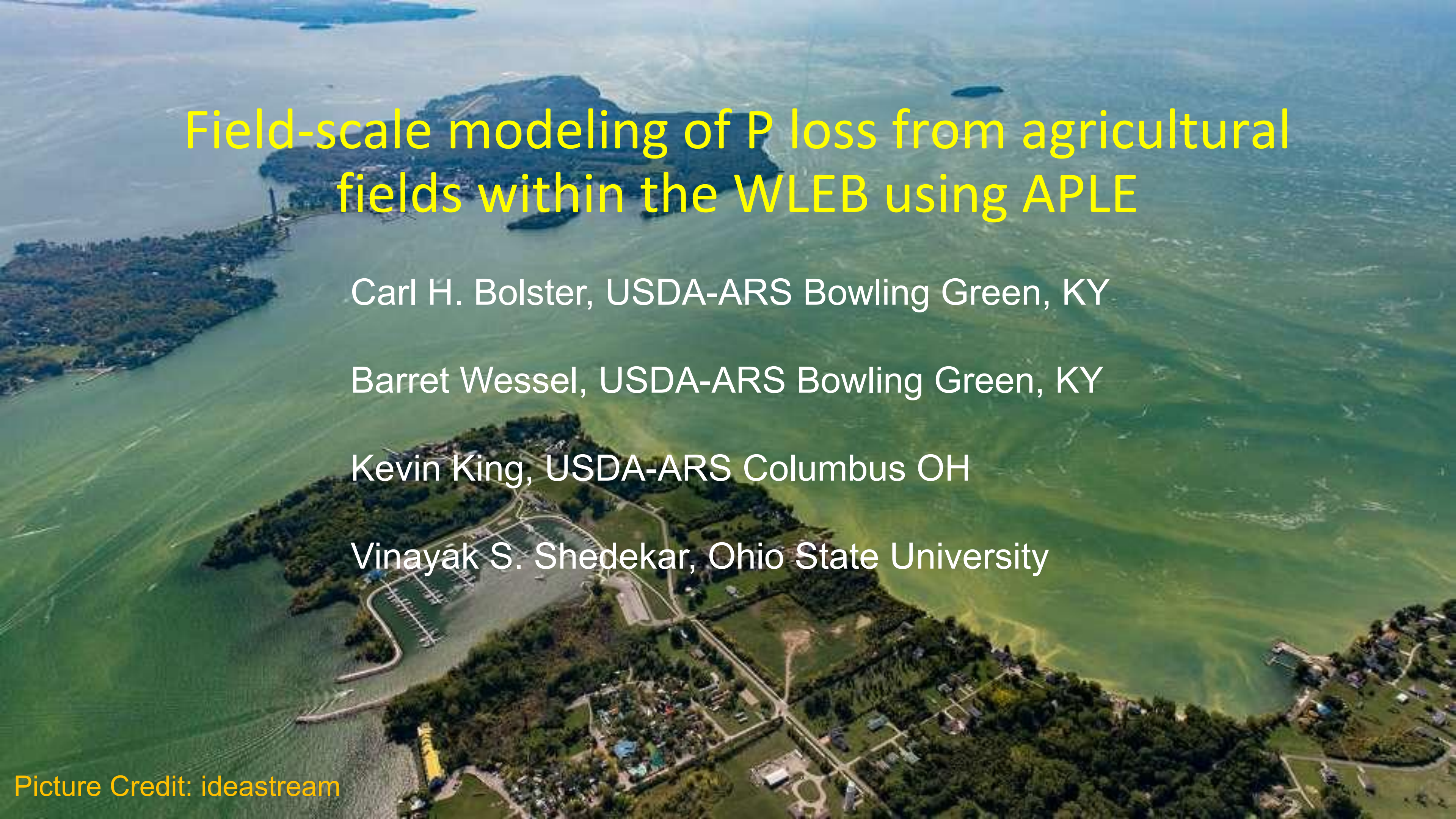
Field-scale modeling of P loss from agricultural fields within the WLEB using APLE

Carl H. Bolster, USDA-ARS Bowling Green, KY

Barret Wessel, USDA-ARS Bowling Green, KY

Kevin King, USDA-ARS Columbus OH

Vinayak S. Shedekar, Ohio State University



Picture Credit: ideastream

Phosphorus Transport Modeling Group:

Steering Committee

- Margaret Kalcic, Ohio State University
- Rebecca Muenich, Sustainable Phosphorus Alliance
- Matt Scholz, Sustainable Phosphorus Alliance
- Pete Vadas, USDA-ARS
- Céline Vaneeckhaute, Université Laval

Members

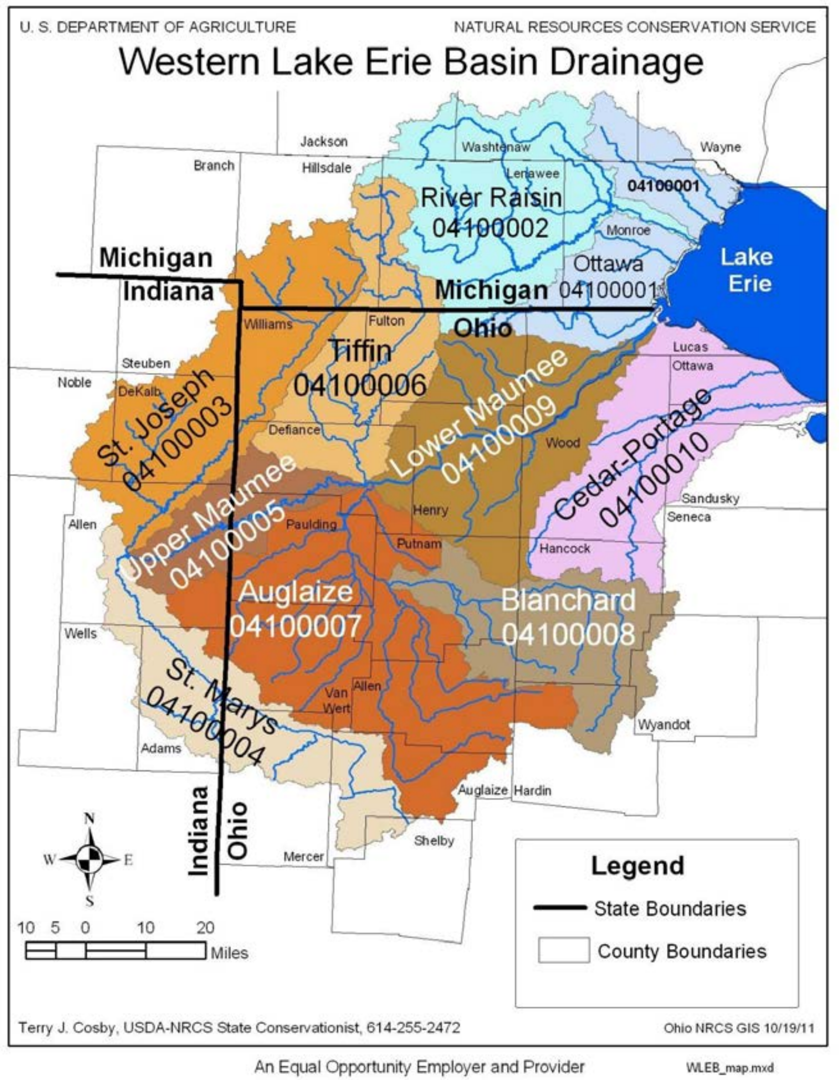
- Carl Bolster, USDA-ARS
- Rem Confesor, Heidelberg University
- Laura Johnson, Heidelberg University
- Kevin King, USDA-ARS
- Josh McGrath, University of Kentucky
- Chad Penn, USDA-ARS
- Don Scavia, University of Michigan
- Vinayak Shedekar, Ohio State University
- David Vaccari, Stevens Institute of Technology
- Barret Wessel, USDA-ARS

Current Modeling Activities

- P uptake by plants
- Precision ag
- Large animal operations
- Impacts of climate change on nutrient loadings
- Nutrient recovery in wastes
- Nutrient budgets
- P modeling within the Western Lake Erie Basin
  - Using watershed models to inform policy
  - Developing decision support tools
  - Legacy P
  - In-stream processes
  - Stacked BMPs

WLEB

- 11,900 sq. mi
- ~73% cultivated cropland
- Corn, soy, wheat
- Problematic soils



Poorly Drained Soils

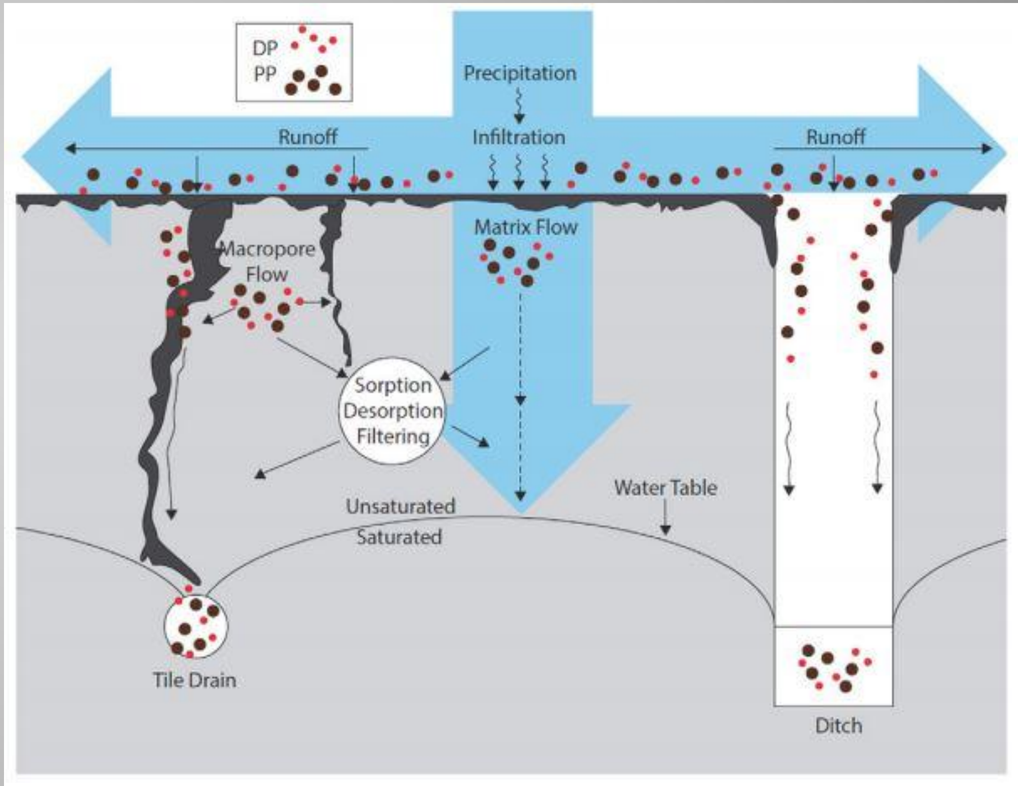
- Ancient glacial lakebed
- Glacial till and fine sediments - K_{sat}
- Low elevation and slope
- Shrinks growing season and rooting depth
- Can cause a lot of runoff

Runoff

- Drives erosion
- Carries sediment and P
- Long assumed to represent majority of P
- Decreased in WLEB due to CT, NT, and subsurface drainage

Drainage Drives Eutrophication

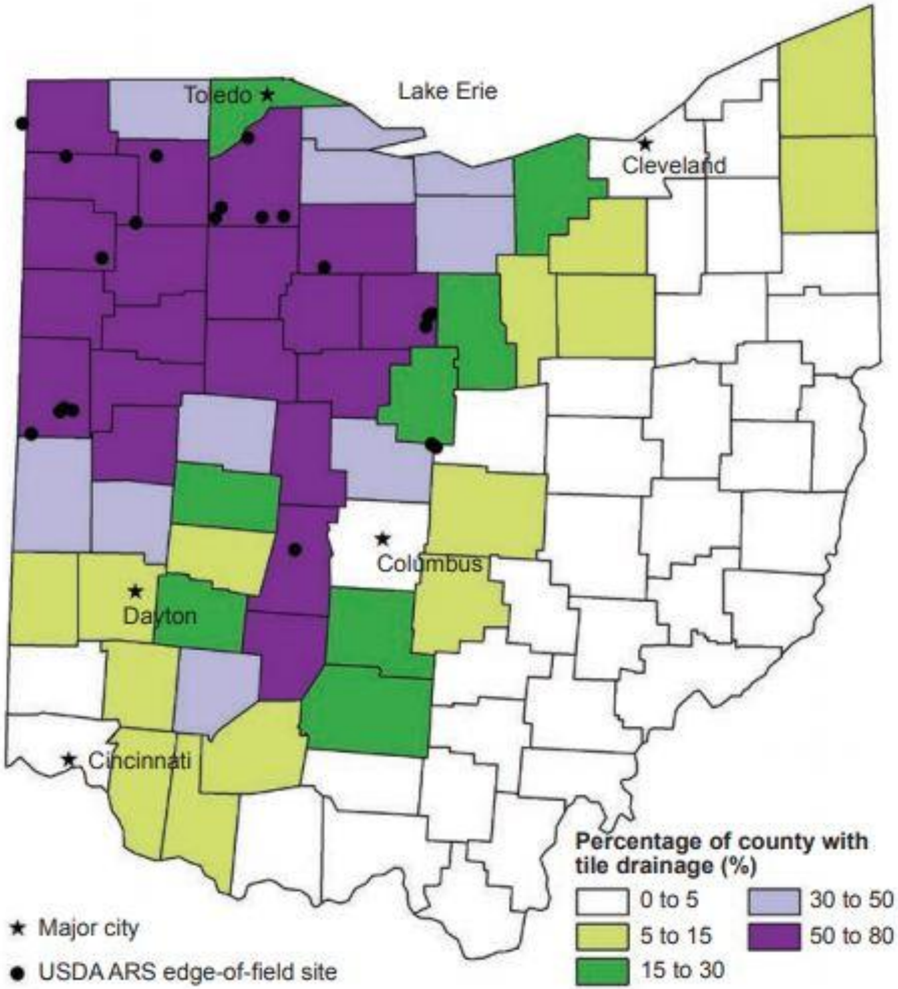
- ~50% tile drained over 150 years
- Short-circuits the hydrology
- Can carry more P than runoff
- Drives HABs, impacts water quality for millions



Balancing Acts

- Agricultural production vs water quality
  - Two vital natural resources
- Soil health vs P management
  - What is the proper role for tillage and other management practices?
- Complex issues, so we need good data to do good science here

The USDA Agricultural Research Service (ARS) edge-of-field monitoring network in central and northwestern Ohio.



Edge-of-Field Network

- 40 paired sites at 20 farms
- Multi-year monitoring
- Surface and tile monitoring
- Before-After Control-Impact (BACI) design

Williams et al. (2016). J. Soil & Water Con., 71(1), 9A-12A.

Monitoring Stations

a. Solar Instrumentation
b. H-flume
c. Compound weir in tile outlet

Williams et al. (2016). J. Soil & Water Con., 71(1), 9A-12A.

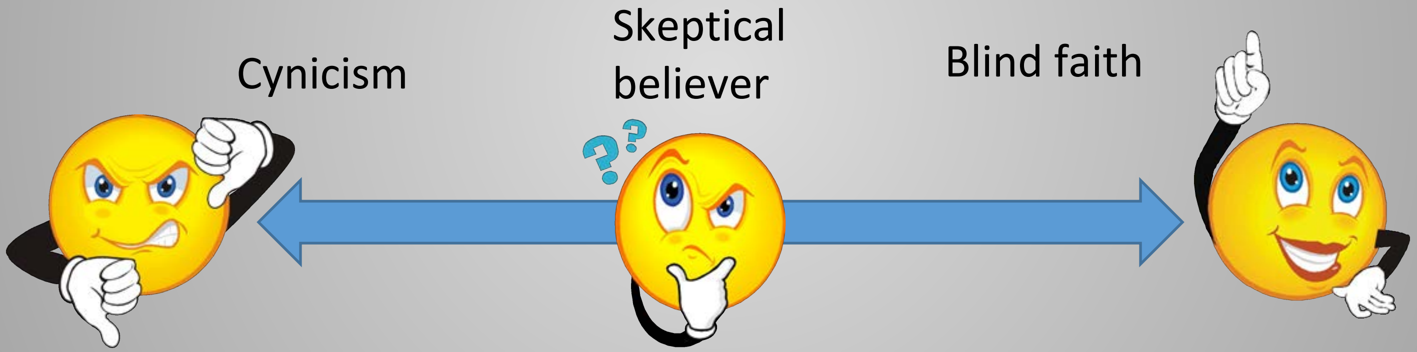
Data Drives Models

- Goal: Make field-scale recommendations to address regional issues
- Not practical to monitor every field in WLEB
- Models needed to apply monitoring lessons to unmonitored fields
- Models need to be relatively user-friendly and run on available data if they are to be adopted

Models

- Model is a simplified representation of reality
- Many different models exist
  - Different perceptions of the important processes involved
  - Different time and spatial scales
  - Empirical ⟷ process-based
- Best model depends on:
  - available data
  - goals of modeling effort
  - experience

Trust/acceptance of models, modelers, and modeling results varies

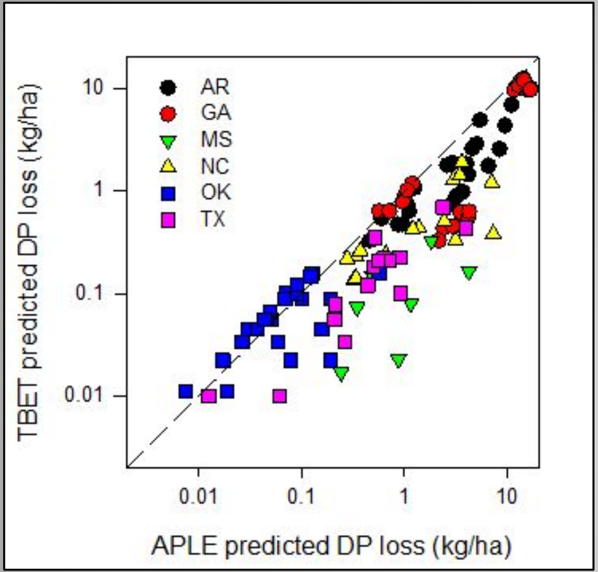


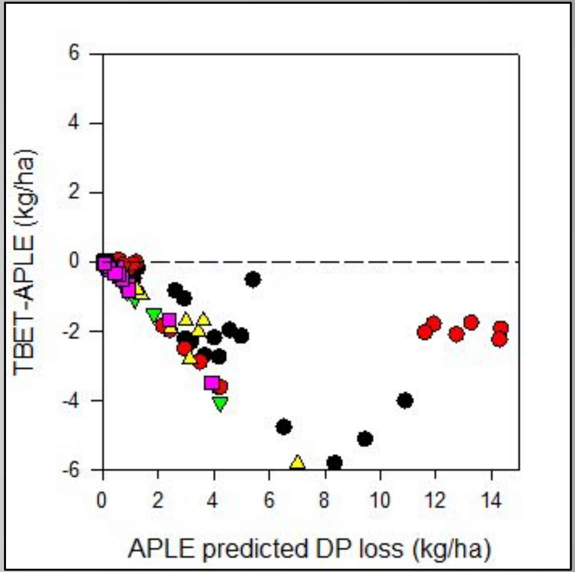
“ALL MODELS ARE WRONG…BUT SOME ARE USEFUL!” (George Box)

Research Objectives:

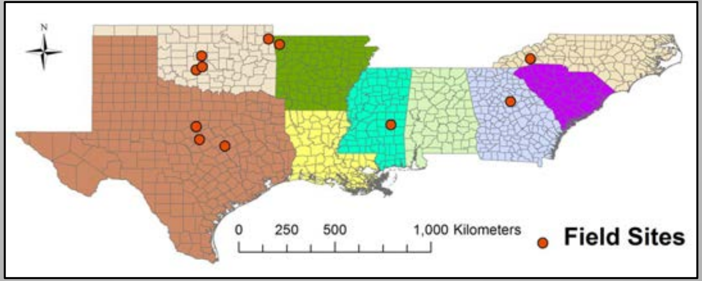
- Evaluate Annual P Loss Estimator (APLE) for predicting field-scale P loss in WLEB
  - APLE – annual time step
    - Does not calculate erosion or runoff
- Compare results with a daily time step model (TBET, SurPhos)
- Incorporate uncertainty analysis in model evaluation
- Use APLE to simulate different management practices

Comparing APLE and TBET Predictions of DP Loss



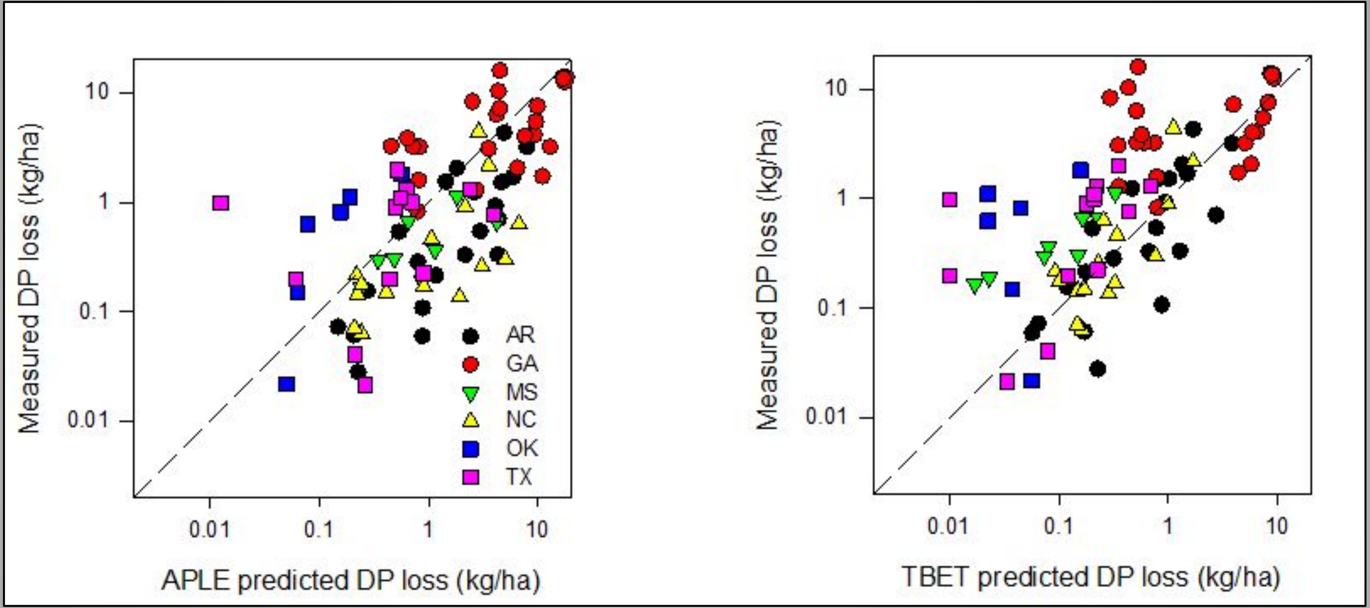


r = 0.92
E = 0.75
PBIAS = 45%



Bolster et al. 2017. JEQ

Comparing APLE and TBET Predictions with Observed DP Loss

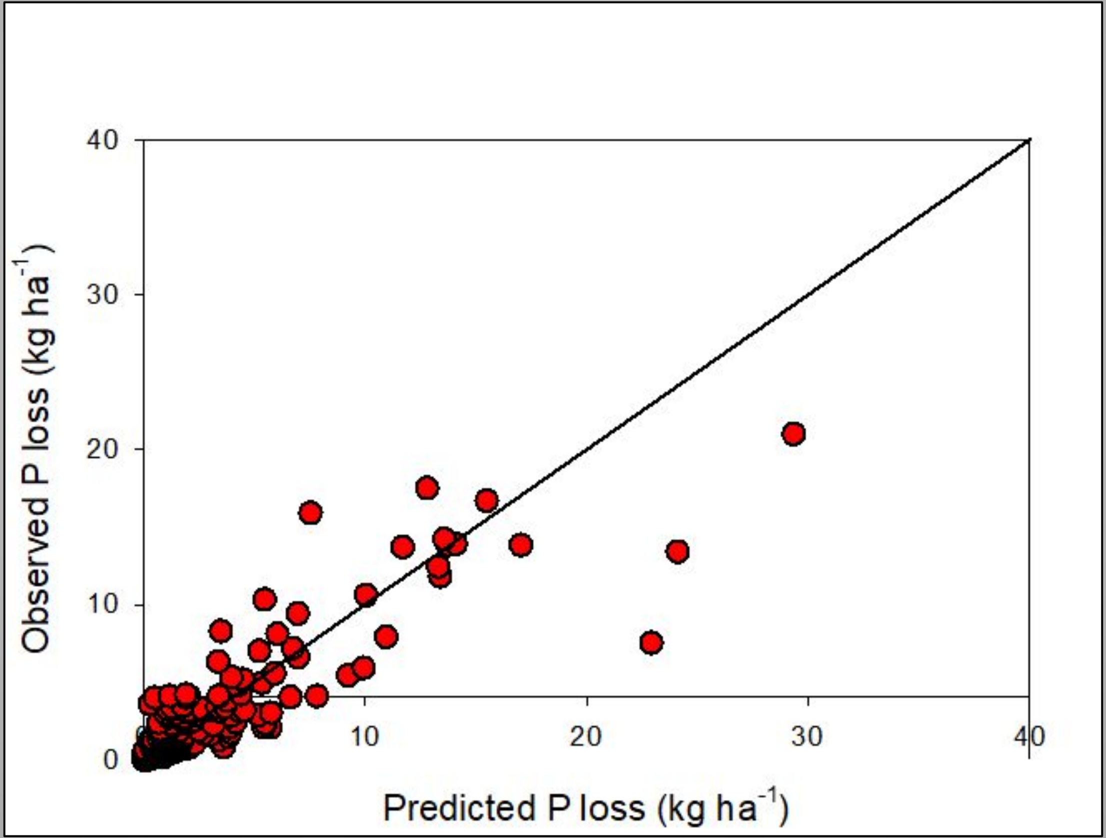


r		E		MAPE (%)		PBIAS (%)		RMSE (kg ha^{-1})	
APLE	TBET	APLE	TBET	APLE	TBET	APLE	TBET	APLE	TBET
0.68^{***}	0.70^{***}	0.52	0.41	81	71	-9.6	40	2.4	2.6

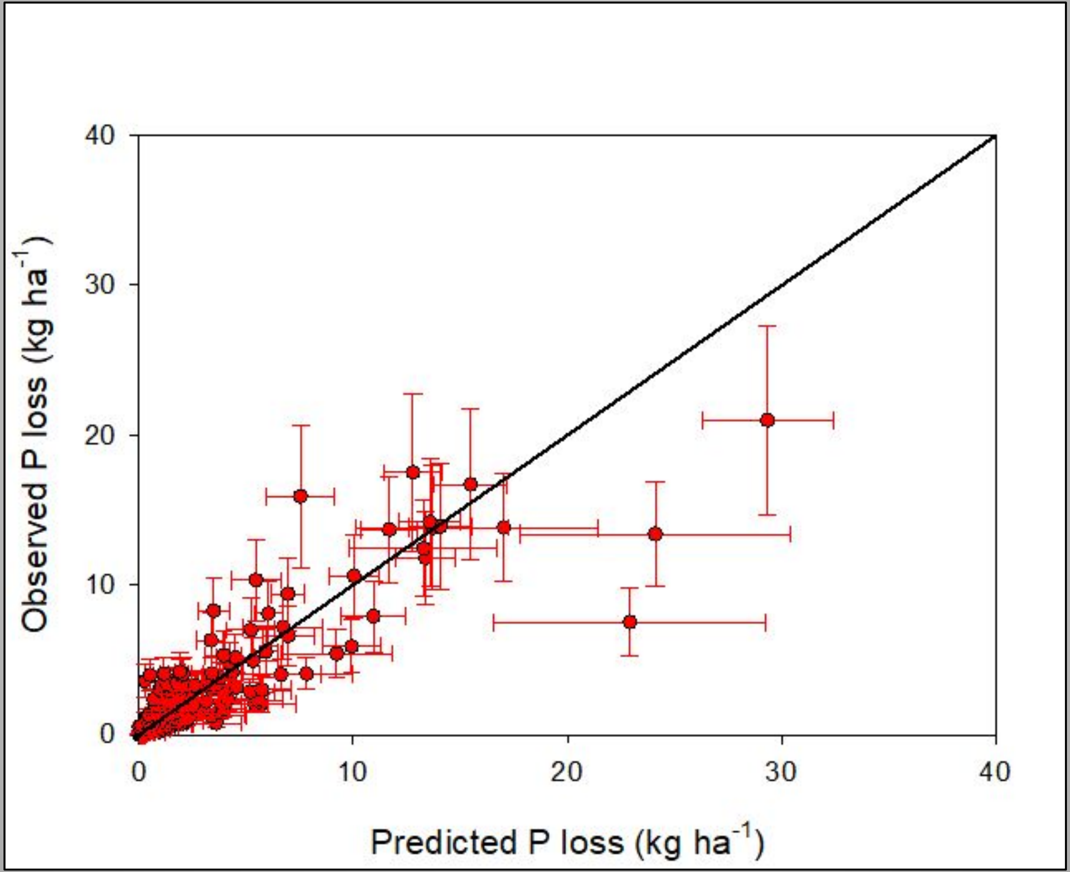
Bolster et al. 2017. JEQ

Evaluate APLE model predictions when uncertainties in both model inputs, model parameters, and measured runoff and P loading are included

Comparing observed with predicted



Comparing observed with predicted



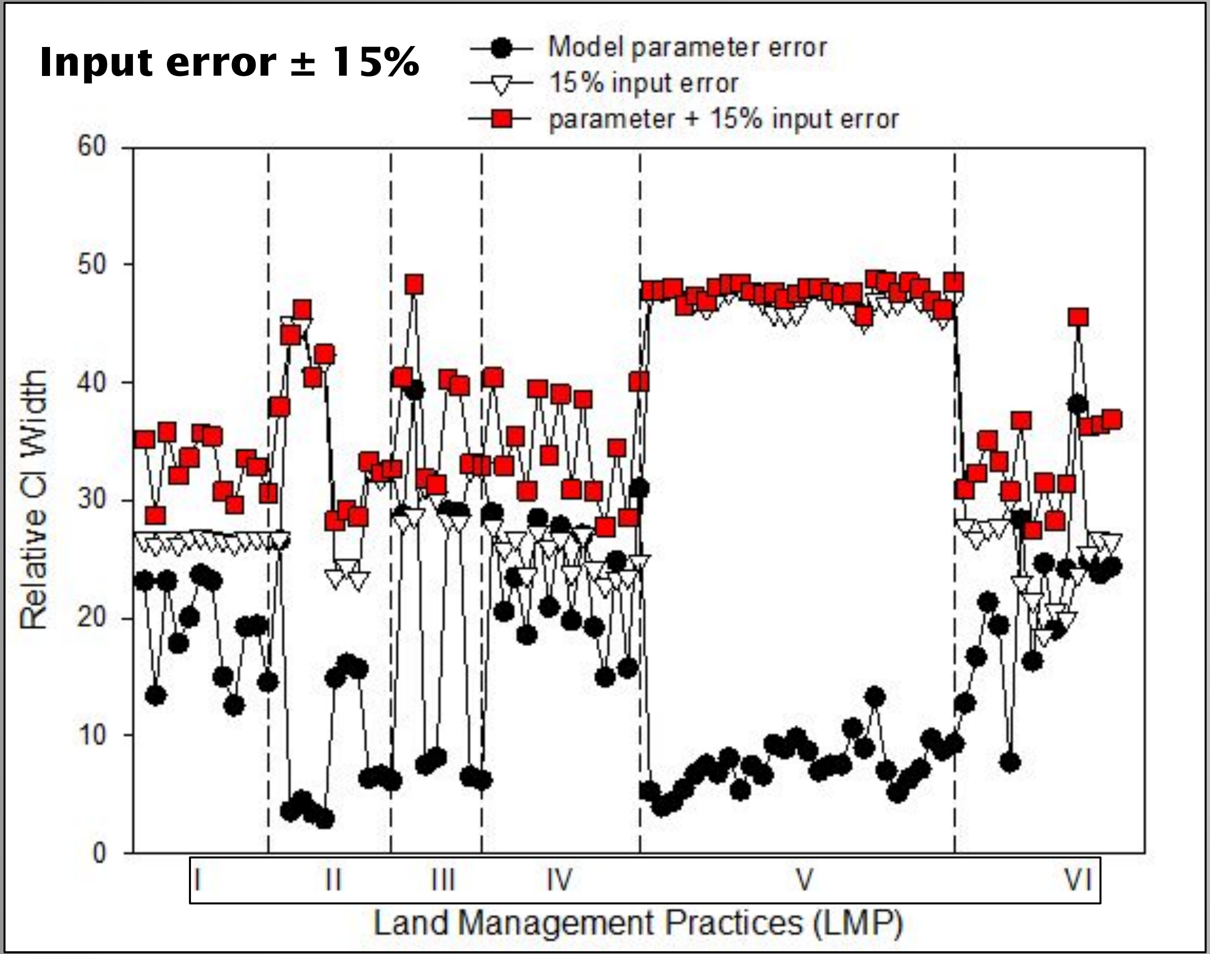
Uncertainty about Uncertainties

- Hard to calculate
- Many sources…which ones to focus on?
- Lack of training/expertise/access to uncertainty analysis
- How to communicate to lay audience?
- Fear that uncertainties may undermine credibility of the model

Uncertainty about Uncertainties

- BUT....
  - Uncertainties in model predictions are a fact of life
  - Ignoring them may do more harm than good

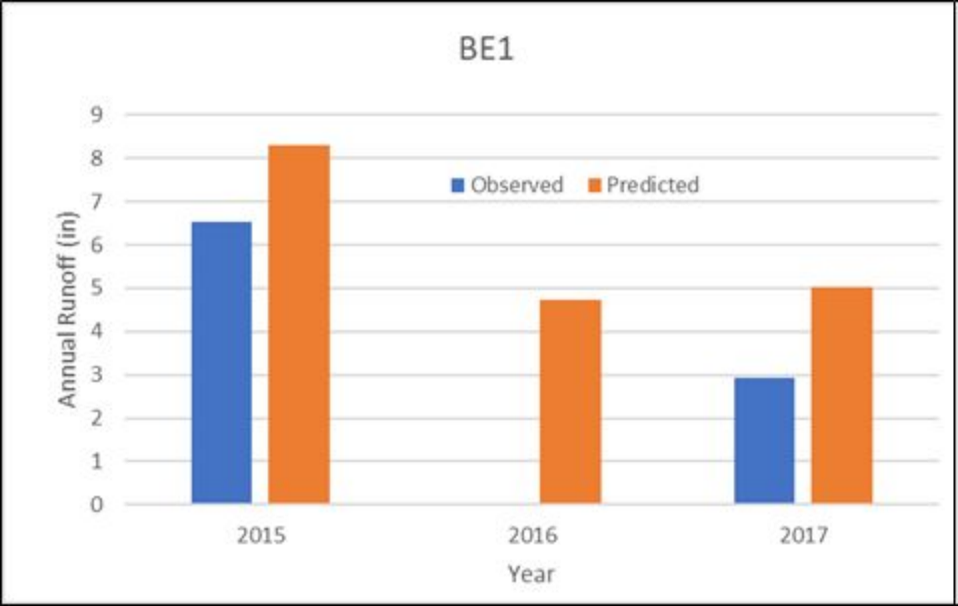
Contribution of model parameter and input error

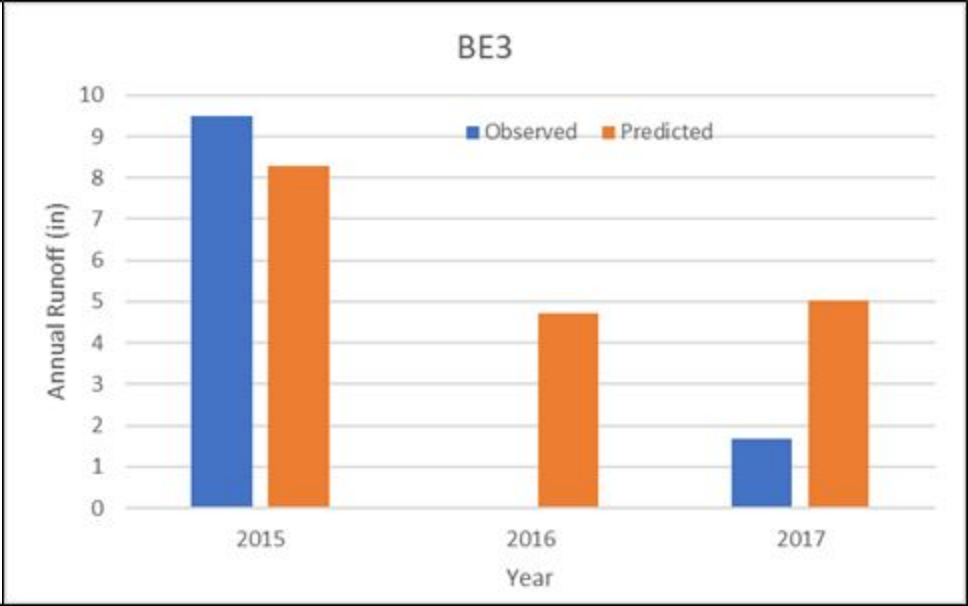


I. no P applied
II. inorganic fertilizer
III. manure to fields w/o erosion
IV. manure to fields with erosion
V. fertilizer and manure to fields w/o erosion
VI. fertilizer and manure to fields with erosion

Bolster et al. 2016. J. Hydrol

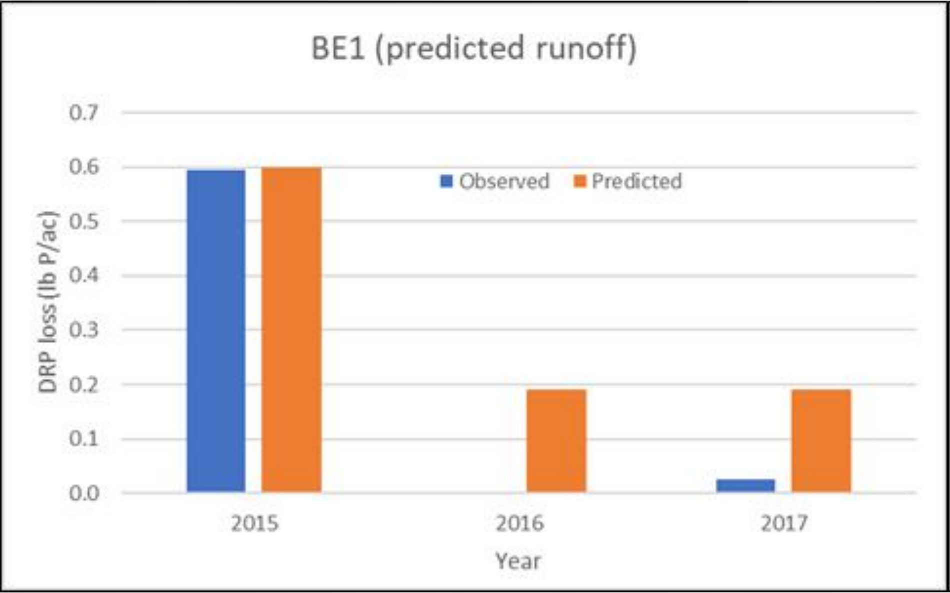
Preliminary modeling results in WLEB

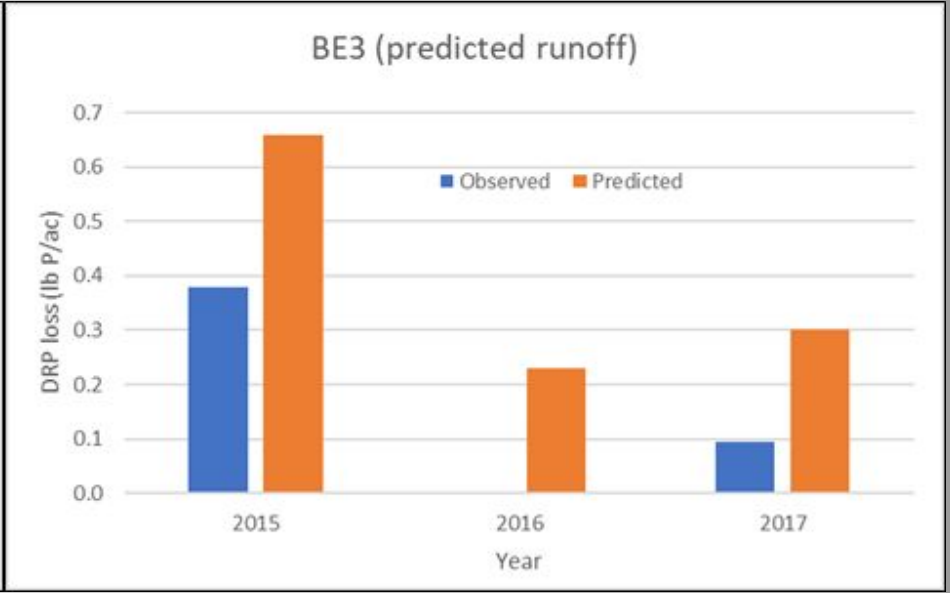




SCS (NRCS) curve number method tends to over-estimate runoff

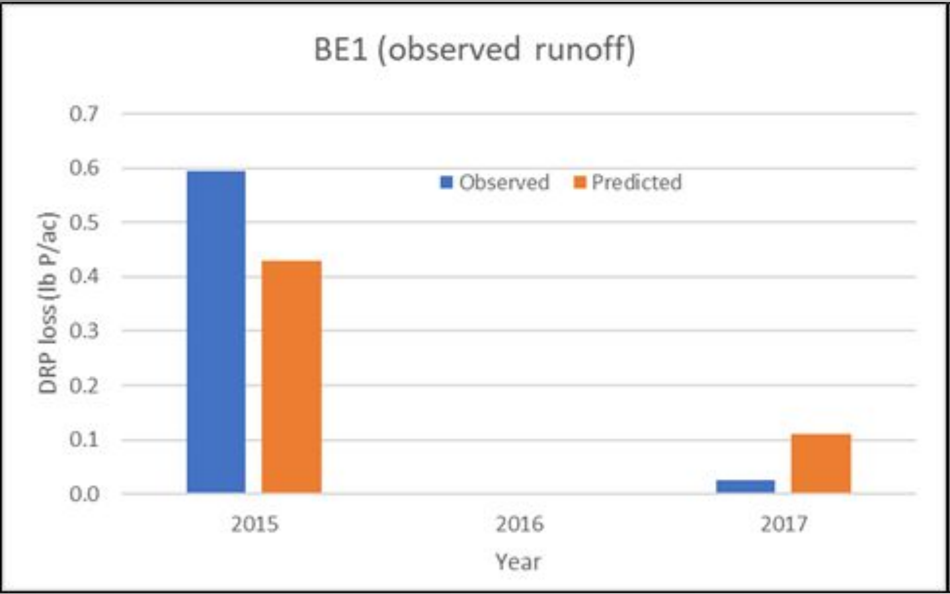
Preliminary modeling results in WLEB

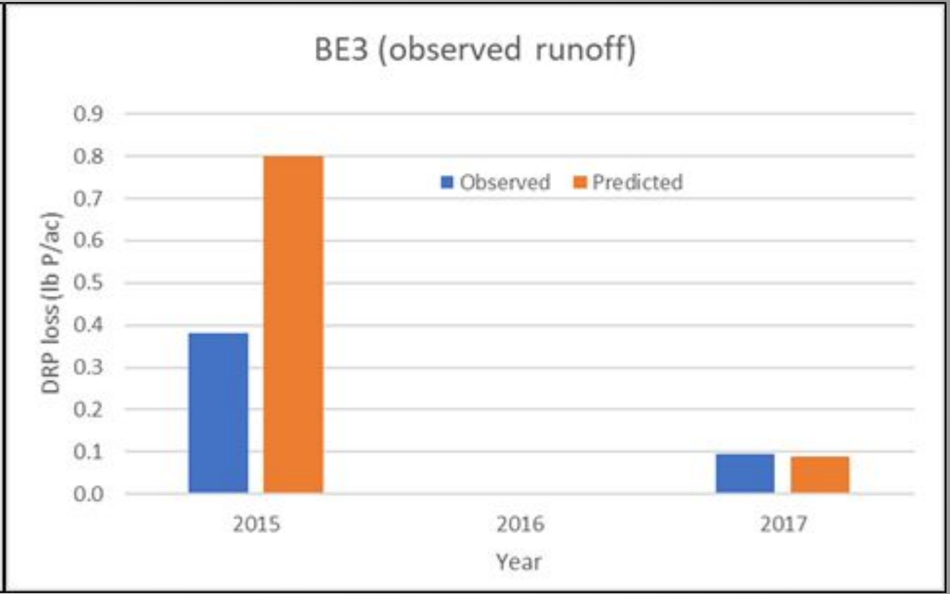




Overestimating runoff leads APLE to overestimate DRP surface loss

Preliminary modeling results in WLEB





- Using observed runoff values in APLE leads to better DRP loss predictions in low-runoff years
- Stresses the value of EOF data!

Questions?

This research was conducted as part of USDA-ARS National Program 212: Soil and Air

Partial funding provided by OCP North America

USDA Agricultural Research Service

OCP NORTH AMERICA

Sustainable Phosphorus Alliance

Agenda (all times ET)

12:00-12:20	Welcome from the Alliance (Drs. Jim Elser and Matt Scholz)
12:20-12:50	Dr. Don Boesch, Professor and President Emeritus, University of Maryland Climate Change and Coastal Eutrophication
12:50-1:10	Mr. Kerry McNamara, CEO, OCP North America Perspective on Phosphorus Sustainability
1:10-1:40	Dr. Jon Winsten, Agricultural and Environmental Economist, Winrock International Pay-for-Performance Program for Nutrient Pollution Mitigation
1:40-2:10	Drs. Carl Bolster and Barret Wessel, USDA-ARS Phosphorus Transport Modeling Group Report
2:10-2:30	Breakout rooms
2:30-2:50	Closing discussion & Raffle!

Breakout Groups

You will be split into rooms of 7-8 for 20 minutes.

Please identify a facilitator from among your group.

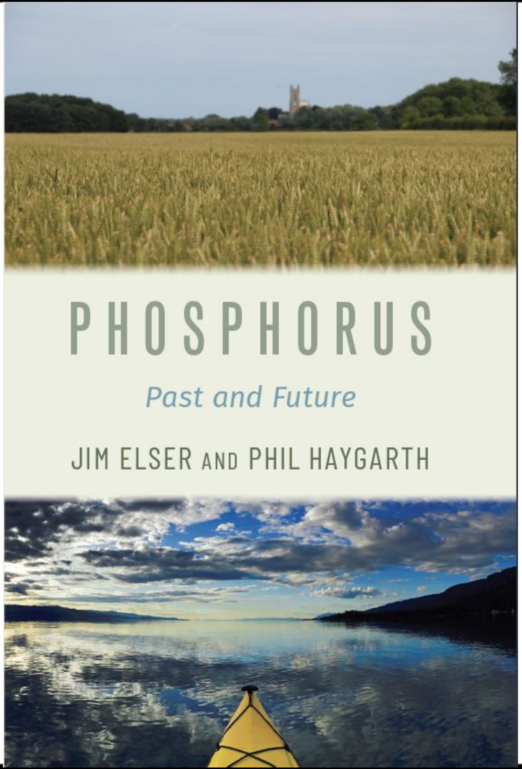
Tasks:

1. Introductions: Name, affiliation, very short description of area of interest, and where is your next vacation spot?
2. What topic would you like to see us cover in a webinar during the coming year and who would you like to see participate?

Report Out

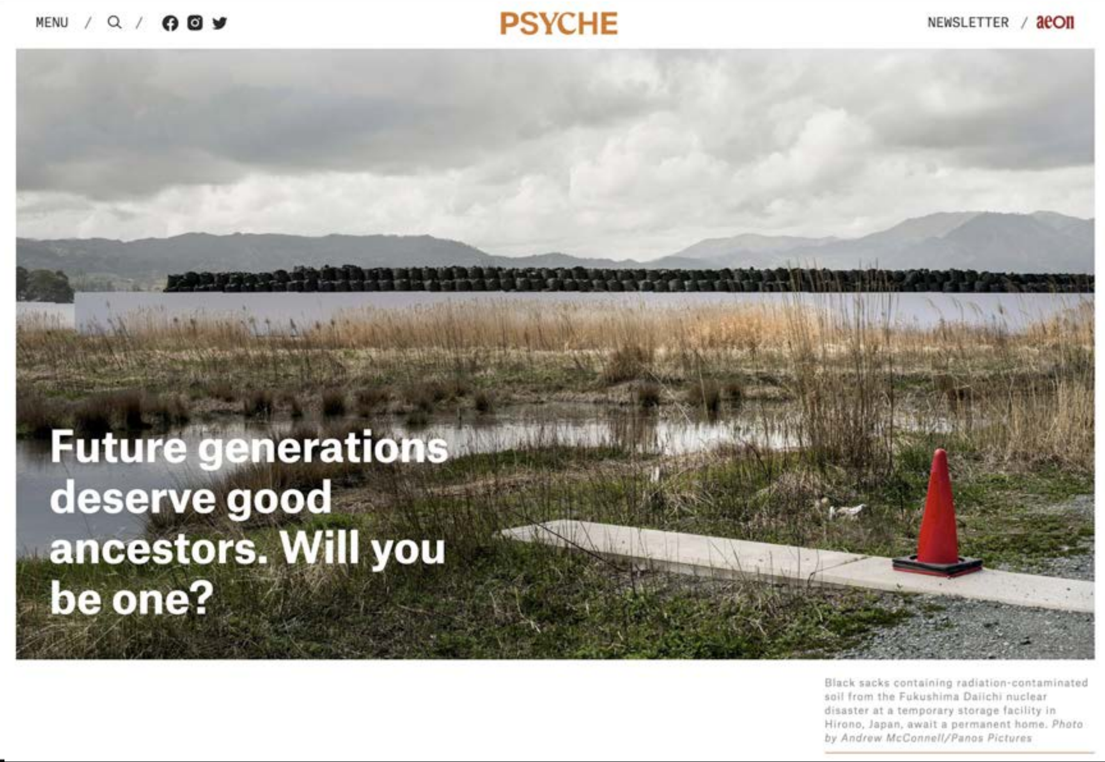
What idea(s) for a SPA webinar topic / presenters did you come up with?

Raffle


PHOSPHORUS
Past and Future
JIM ELSER AND PHIL HAYGARTH


ENTER TO WIN!

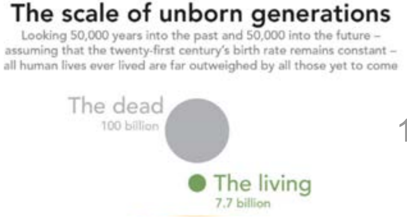
Concluding Remarks



“**Humankind has colonised** the future. We treat it like a distant colonial outpost devoid of people where we can freely dump ecological degradation, technological risk and nuclear waste – as if nobody will be there.”

author Roman Krznaric

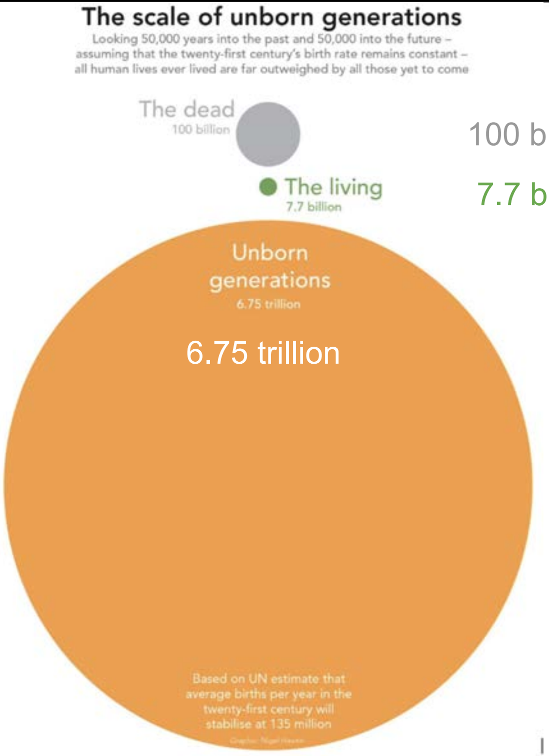
Concluding Remarks



100 billion (dead)

7.7 billion (currently alive)

Concluding Remarks



100 billion (dead)

7.7 billion (currently alive)

All of these people will need food and clean drinking water.

How can we be caretakers of phosphorus so this can happen?

Concluding Remarks

Taanit 23a
The William Davidson Talmud

אבהתי שתלי נמי לבראי

One day, he was walking along the road when **he saw a certain man planting a carob tree.** Ḥoni **said to him: This** tree, **after how many years** will it **bear** fruit? The man **said to him:** It will not produce fruit **until seventy years** have passed. Ḥoni **said to him: Is it obvious to you that you will live seventy years,** that you expect to benefit from this tree? **He said to him: That man** himself **found a world** full **of carob trees. Just as my ancestors planted for me, I too am planting for my descendants.**

'Just as my ancestors planted for me, I too am planting for my descendants.'

What kind of
phosphorus ancestor
will you be?

Thanks for coming!

Sustainable Phosphorus Alliance

PhosphorusAlliance.org