**Region 5 Harmful Algal Bloom Clean Water Act and Safe Drinking Water Act Workshop**

OHIO SEA GRANT AND OSU STONE LABORATORY

# Current Research Efforts on Nutrient Load Reduction Methods

Dr. Christopher J. Winslow

Interim Director, Ohio Sea Grant College Program

April 28th, 2016

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# What is Causing the Harmful Algal Blooms in Lake Erie?

- Clean Air Act
- Climate change
- Commodity prices
- Conservation Tillage
  - (No/Reduced till)
- Crop uptake
- Equipment size
- Ethanol
- Fertilizer placement
- Fertilizer rates
- Fertilizer source
- Fertilizer timing
- Glyphosate
- GMOs
- Increased soil pH
- Ignoring amounts of P loss
- Larger farm size
- Lower levels of sediment in the water
- Manure
- P Misconceptions by researchers
- Rental agreements
- Products sold to ↑ P solubility in soil
- Soil biology alterations
- Soil testing and analysis
- Tile drainage
- Zebra mussels, "near-shore shunt"

Smith et al., 2014

# Low Phosphorus Loads Per Field

- < 1.7 kg/ha (<1.5 lbs/acre)
- 3 to 5% of application rates

| | DRP (kg P/ha) | TP (kg P/ha) |
|---|---|---|
| **Maumee** | 0.273 | 1.12 |
| **Sandusky** | 0.311 | 1.41 |
| **Honey Cr.** | 0.369 | 1.29 |
| **Rock Cr.** | 0.250 | 1.38 |

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# Projects to Highlight

- Field to Faucet:
  - N and P removal from animal manure --- Y. Li
  - Ohio nutrient management mobile applications --- J. Fulton
  - Geospatial Data Warehouse for Improved Agricultural Water Quality – J. Fulton and S. Shearer
  - Detection of cyanotoxins in irrigation water sources using UAV --- J. Lee, J. Gregory and CK Shum
  - Best strategies to reduce phosphorus loads to Lake Erie from agricultural watersheds --- L. Johnson
  - Organic-P source tracking in Lake Erie watersheds --- P. Mouser
- FACT-Fertilizer Applicator Certification Training (4R Program) --- Senate Bill 150
- Senate Bill 1
- USDA-ARS Edge-of-Field Work --- K. King
- WBLE Multi-Model Project --- Ensemble Model
- Education in the Field (x2)
- Nutrient Stewardship for Cleaner Water; Signature Program from OSU Extension
- Sea Grant / OSU Stone Lab grant management

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# OSU CFAES's "Field to Faucet"

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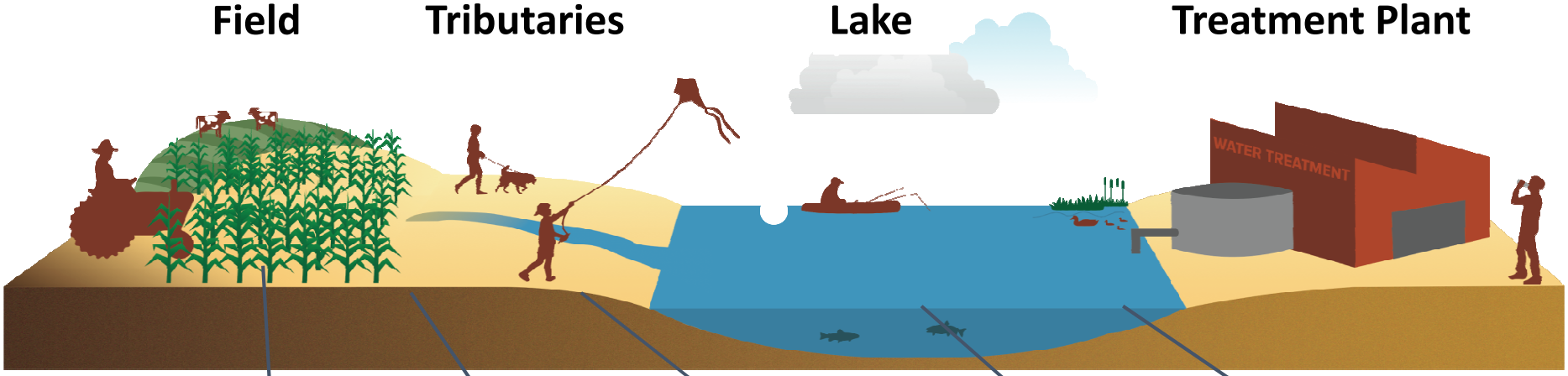


**Field to Faucet Projects**

- **Field Mgt. Apps**
- **Manure Recycling**
- **Data Co-op**
- **Microcystin Detector**
- **Bloom Detection**

# Partners for Field to Faucet:














Heidelberg University



# Integrated system for N and P removal from animal manure (Phosphorus Recovery System)

- Series of **centrifuge** units and liquid **hydrated lime** ($Ca(OH)_2$) facilitate coagulation/precipitation of solids
- A filter press squeezes liquids in one of last steps
- Filtered liquid from press has **P content <1mg/L** (can irrigate)
- Separated lime solids (**lime/P cakes**) can be transported affordably **out of distressed watershed** and/or **soil blended**

http://www.quasarenergygroup.com/pages/prs.html


Lou Brown hosted the Phosphorus Recovery System (PRS) demonstration from Quasar Energy on his farm near New Bremen.

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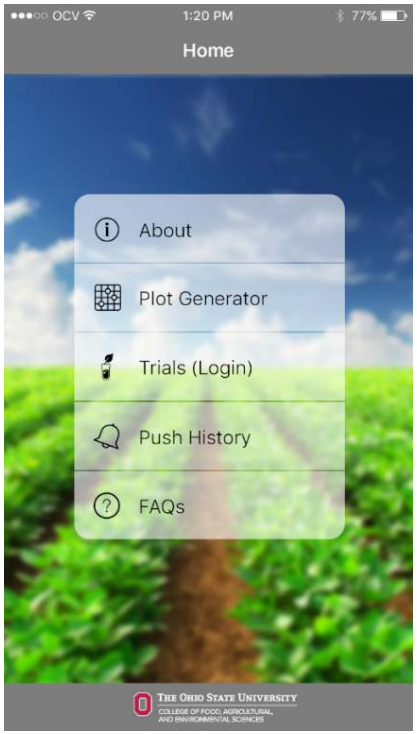
# Ohio Nutrient Management Mobile Applications

- Document field notes about nutrient application with emphasis on N and P management
- Different from **OFBF** “App”; not just to keep farmer **4R compliant** but helps to use information learned in **4R training**
- = Continuous improvement in nutrient stewardship.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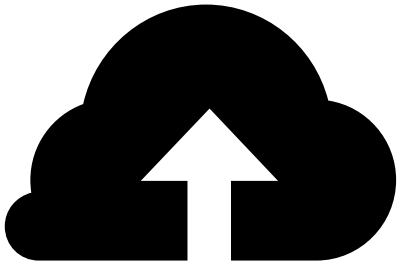
# Geospatial Data Warehouse for Improved Agricultural Water Quality

- Developing access protocols that enable water quality researchers to secure and share data
- Aggregating publicly available base layer data to populate warehouse
- Will expand the database to hydrologic, weather, agricultural production, and water quality and monitoring data
- Will link with parallel efforts to archive production level data provided by agricultural producers (Agricultural Data Cooperative) and remote sensing imagery (OhioView)



**Data Co-op**

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AMERICA VIEW

# Detection of cyanotoxins in irrigation water sources using UAV

- Drone cameras have been acquired and have been integrated into UAV
- Have analyzed various optical images to contrast their water color classifications
- Water collection device has been tested on the ground

# Best Strategy to Reduce P loads to Lake Erie from Agri. Watersheds

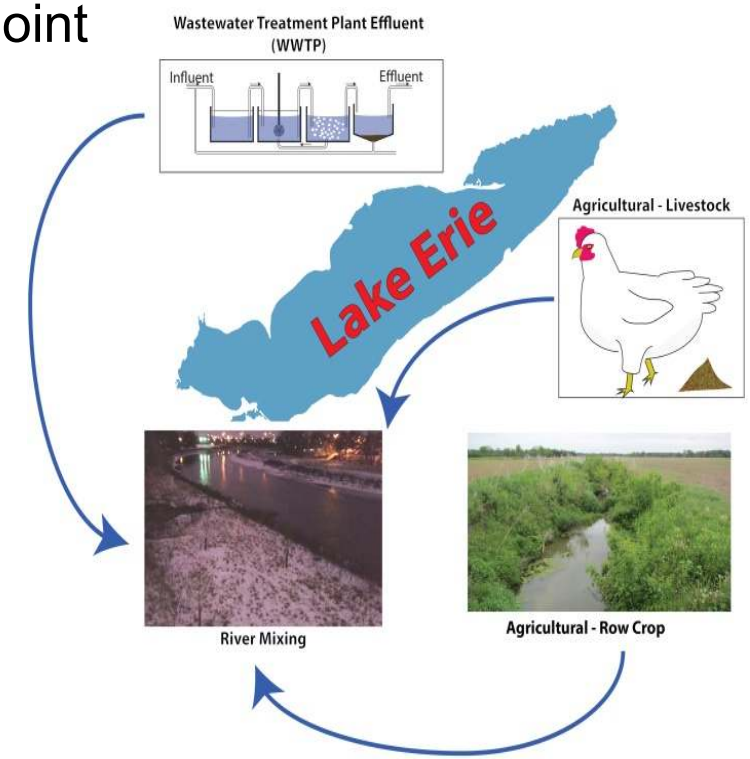
**Goal:** Subwatershed-scale as proof of concept (versus mouth Maumee)

**Objectives:**

1. Intensively monitor and analyze subwatersheds (~90-1000 $km^2$) with high export of dissolved P to (Rock Creek and Honey Creek):
   - Locate sources of P
   - Determine in-stream processing of P
   - Help prioritize BMP implementation
2. Coordinate and update existing watershed models with the results from this project (component “Ensemble Models”; slides soon)

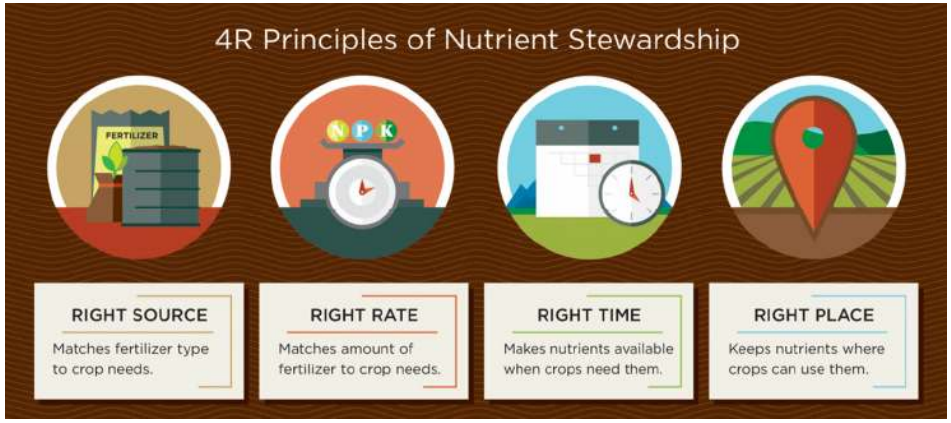
# Organic-P Source Tracking in Lake Erie Watersheds

- **Motivation:**
  - Organic-P from non-point sources and point sources are under-characterized in their respective concentrations
  - Organic sources may contribute significantly to Lake Erie P load
- **Study Objectives:**
  - Apply new analytical tools to distinguish sources of organic-P in Lake Erie watershed
  - Use knowledge on organic-P sources to improve management decisions for P regulation



# FACT-Fertilizer Applicator Certification Training

- Ohio Department of Ag is the issuing authority coming from SB 150 (2014)
- Ohio State University Extension provides required Educational Sessions
- >6,500 persons have been trained in >100 sessions





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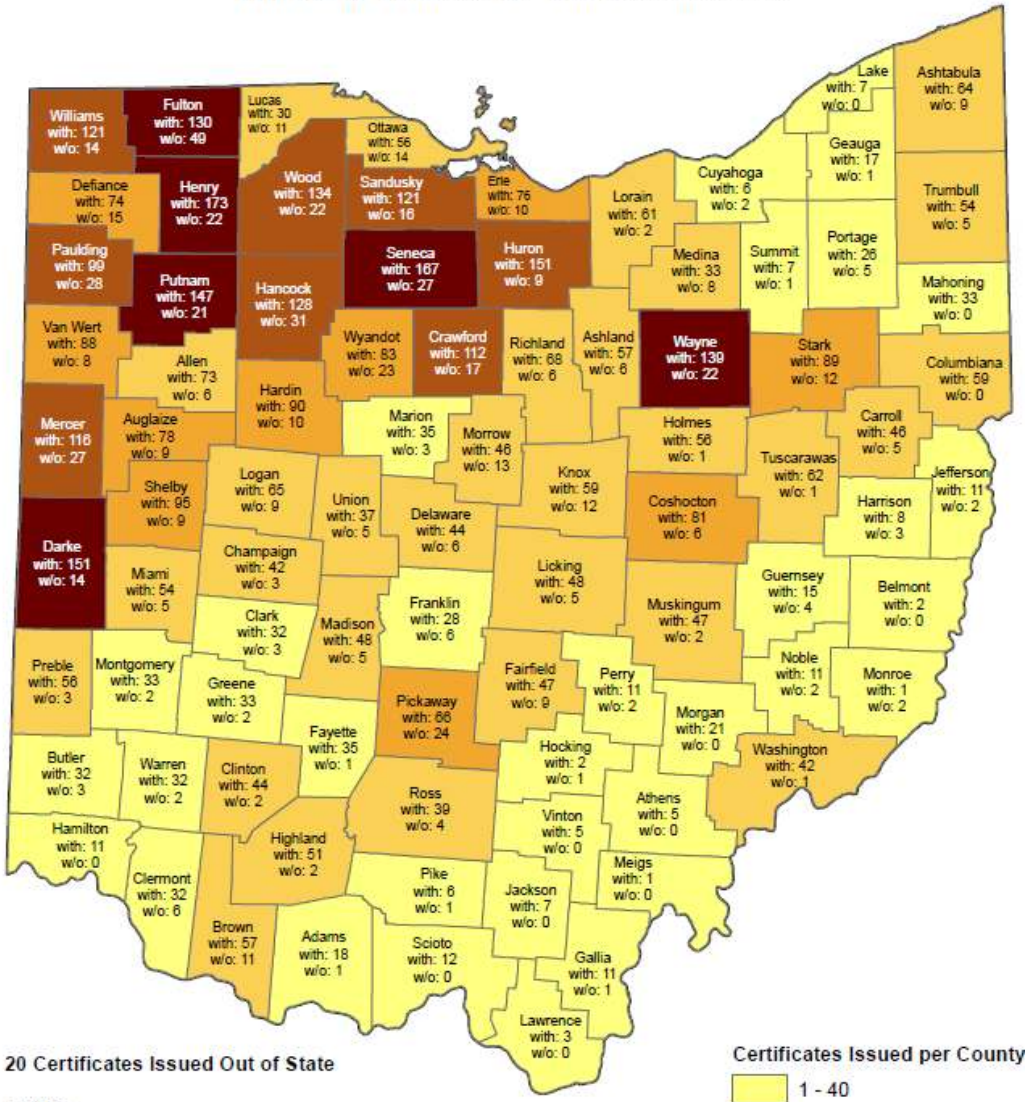
# Agriculture Nutrient Certificates Issued

With and Without a Pesticide License




**20 Certificates Issued Out of State**

**Totals:**

**6,496 Trained as of 4/13/2015**

**5,495 Certified as of 4/20/2015**

**88% Certified with Pesticide License**

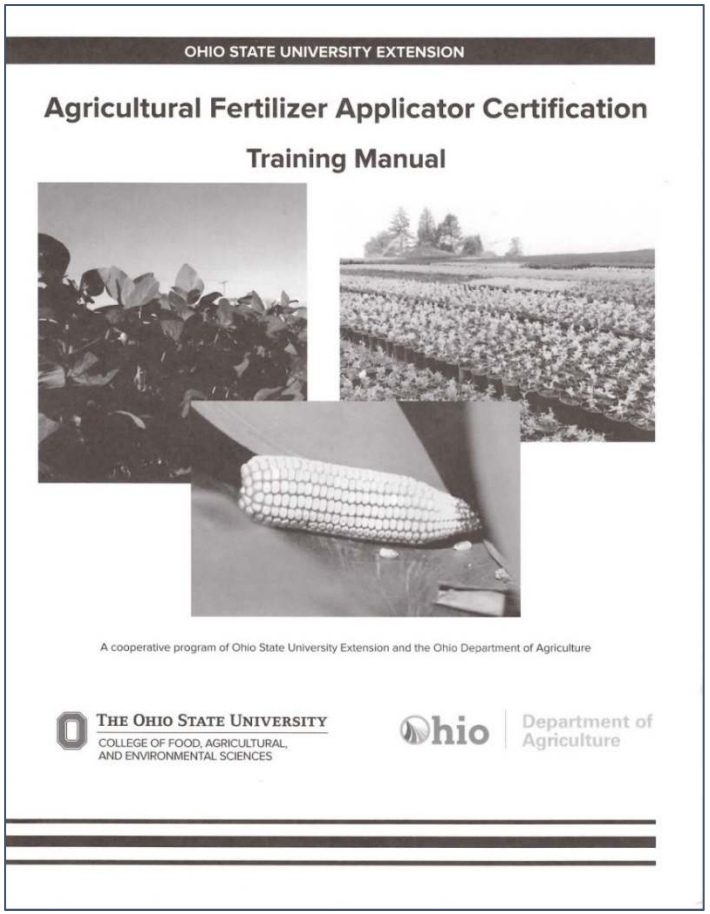
Ohio | Department of Agriculture

**Certificates Issued per County**

- 1 - 40
- 41 - 80
- 81 - 120
- 121 - 160
- 161 - 195
- EERA Regions

# What is Covered in Training

- Current rules for certification
- Nutrient enrichment effects on water quality
- Quality in soil testing
- Phosphorus management for yield and water quality
- Nitrogen management
- Materials used posted at http://go.osu.edu/FACT2015



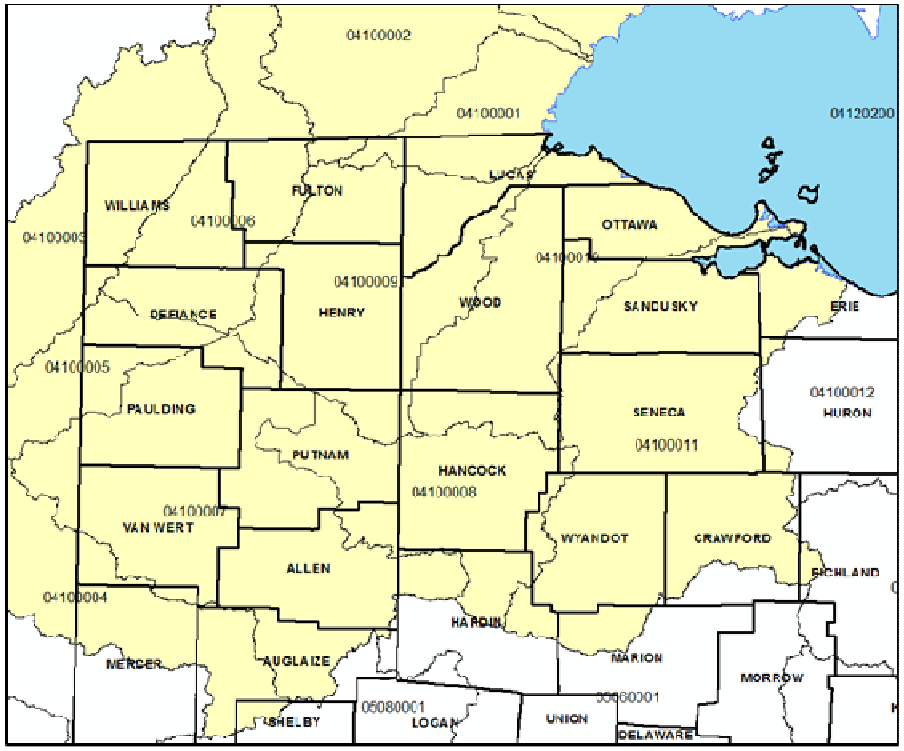
# Survey Results from the Training Tell us…

| Question | Agree or Strongly Agree % answering |
|---|---|
| Farm P is a significant problem to water quality | 76 |
| I have improved my knowledge | 92 |
| I will change my Nutrient Management practices | 51 |
| Training method was appropriate | 91 |

- 2074 Surveys summarized
- 20% had not attended OSUE programs in the past

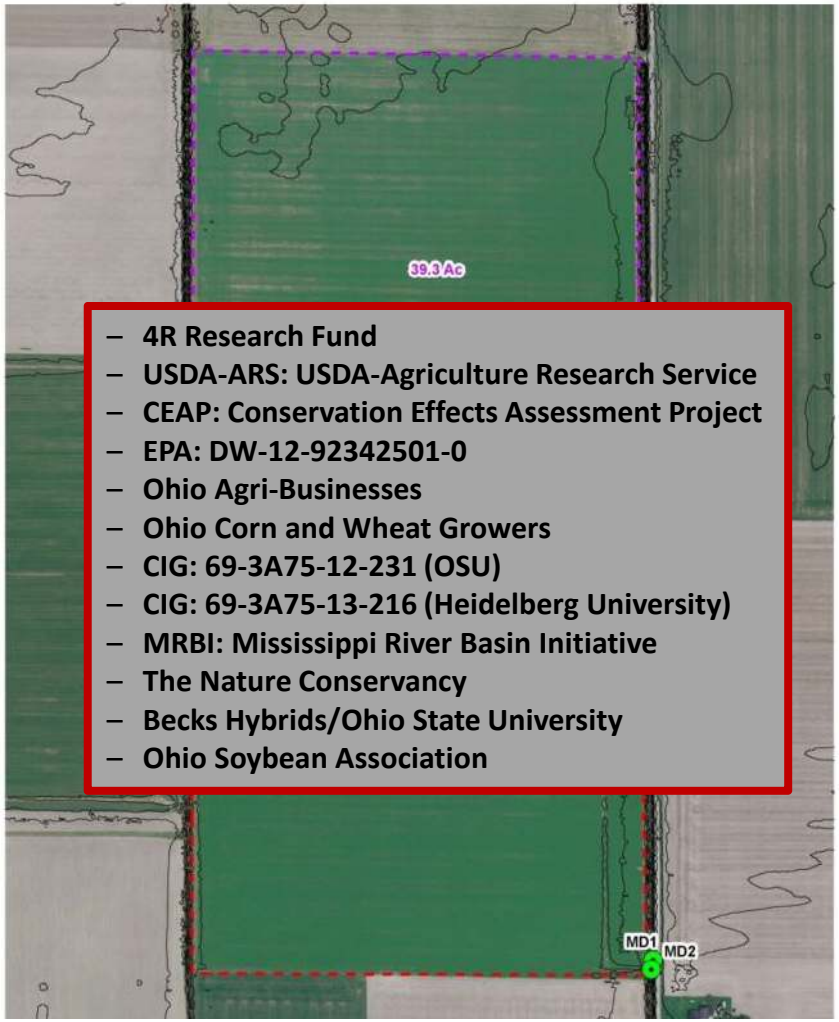
# Senate Bill 1 (2015)

- Came into effect 7/3/2015
- Criteria for manure and granular fertilizer with P and N:
  1. No frozen, snow covered applications
  2. Top 2 inches soil saturated
  3. Account for rainfall forecast 24 or 12 hours after application



# Edge-of-Field Methods

- 40 fields (20 paired fields) representative of Ohio crop production agriculture
- Surface runoff and tile discharge measurements
- Using a before-after control impact study design





- 4R Research Fund
- USDA-ARS: USDA-Agriculture Research Service
- CEAP: Conservation Effects Assessment Project
- EPA: DW-12-92342501-0
- Ohio Agri-Businesses
- Ohio Corn and Wheat Growers
- CIG: 69-3A75-12-231 (OSU)
- CIG: 69-3A75-13-216 (Heidelberg University)
- MRBI: Mississippi River Basin Initiative
- The Nature Conservancy
- Becks Hybrids/Ohio State University
- Ohio Soybean Association

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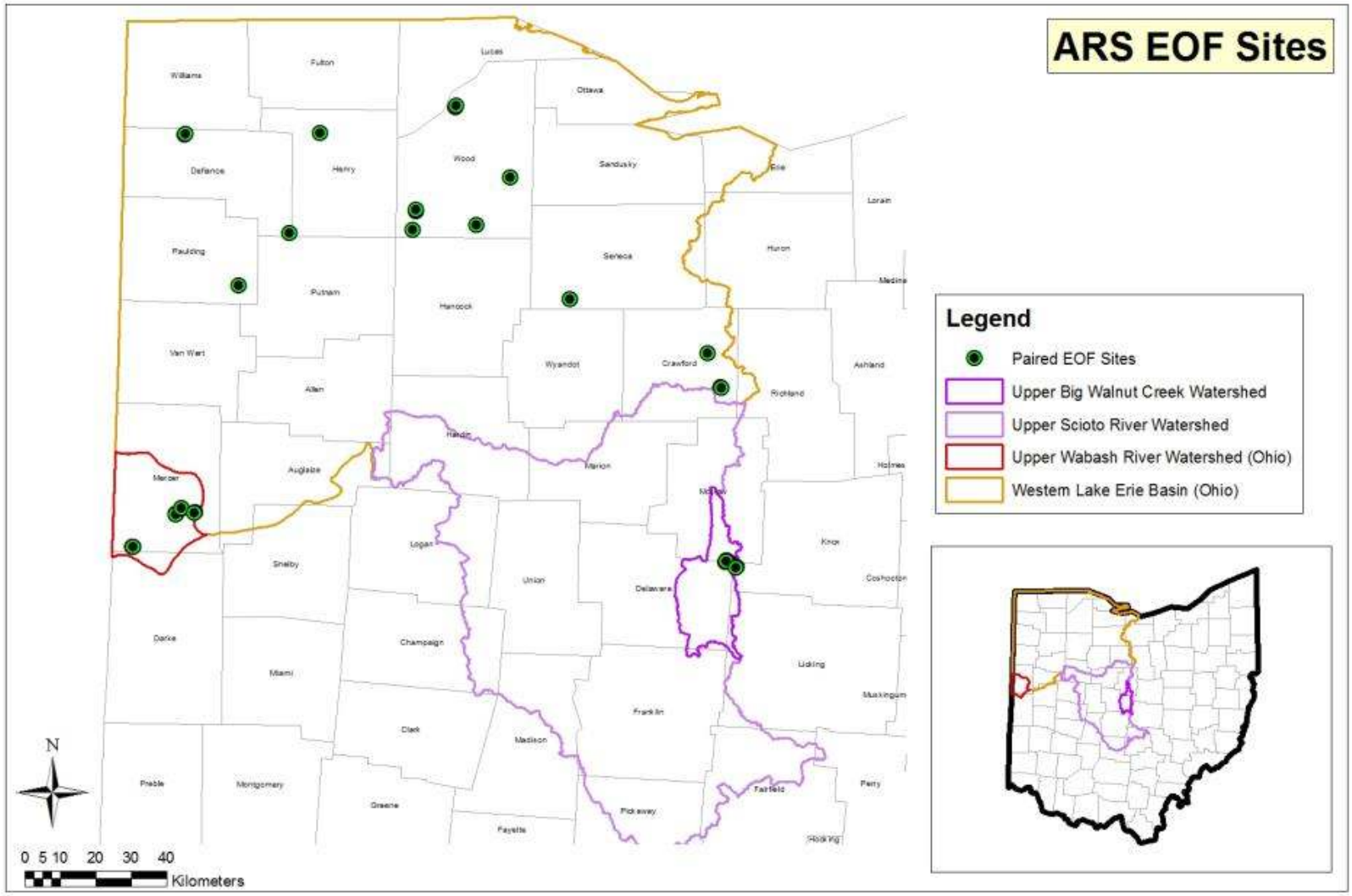


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# Edge-of-Field Instrumentation

- H-flumes for surface runoff
- Thel-mar compound weirs and Isco area velocity sensors for tile

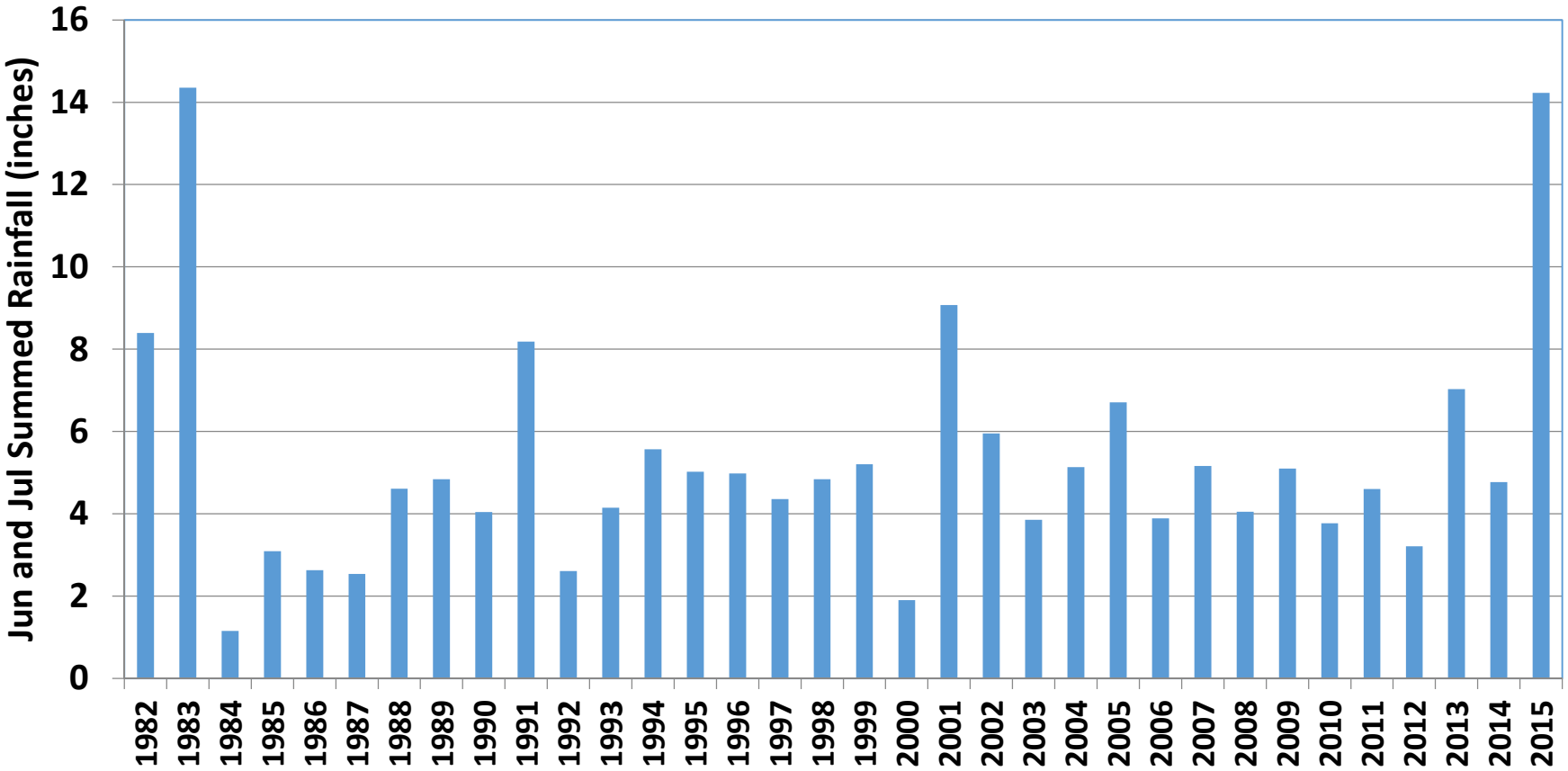
# Data Collection and Analysis

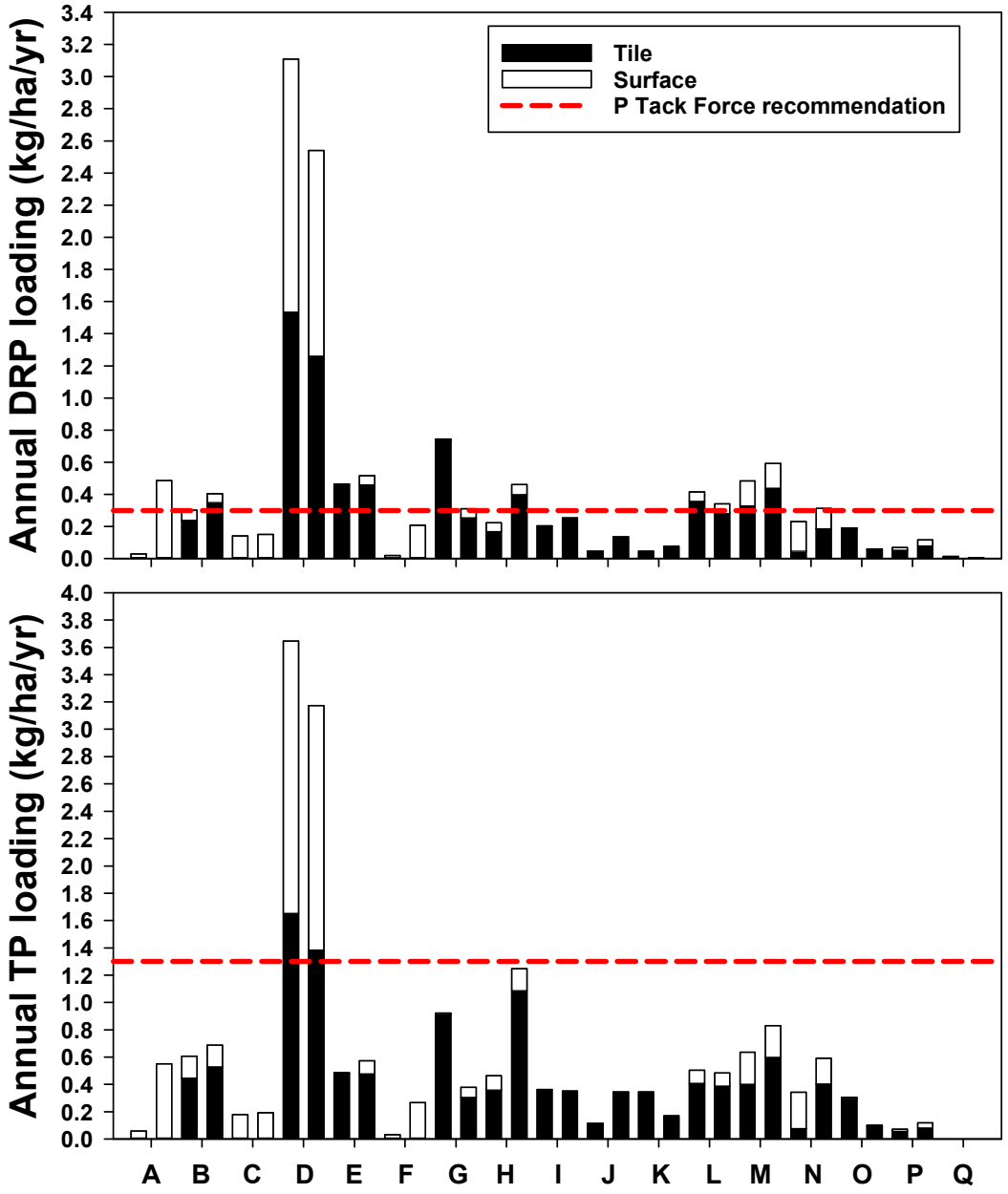
- Precipitation and discharge recorded on a 10 minute interval
- Water quality:
  - Event and daily samples
  - Flow injection analysis (DRP, TP, NO3-N, and TN)

# So What About 2015?


# So What About 2015?


# How does 2015 Compare?



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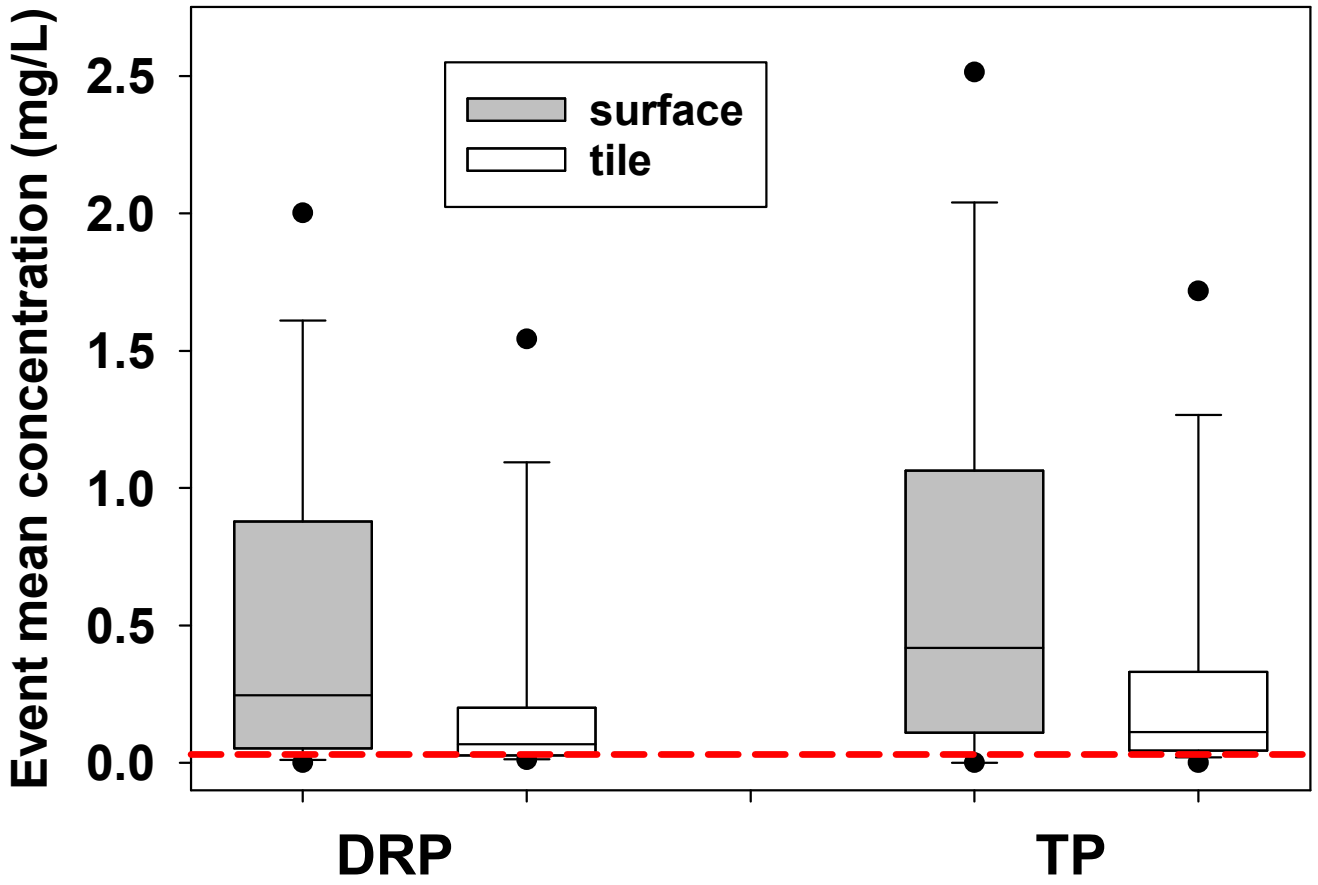
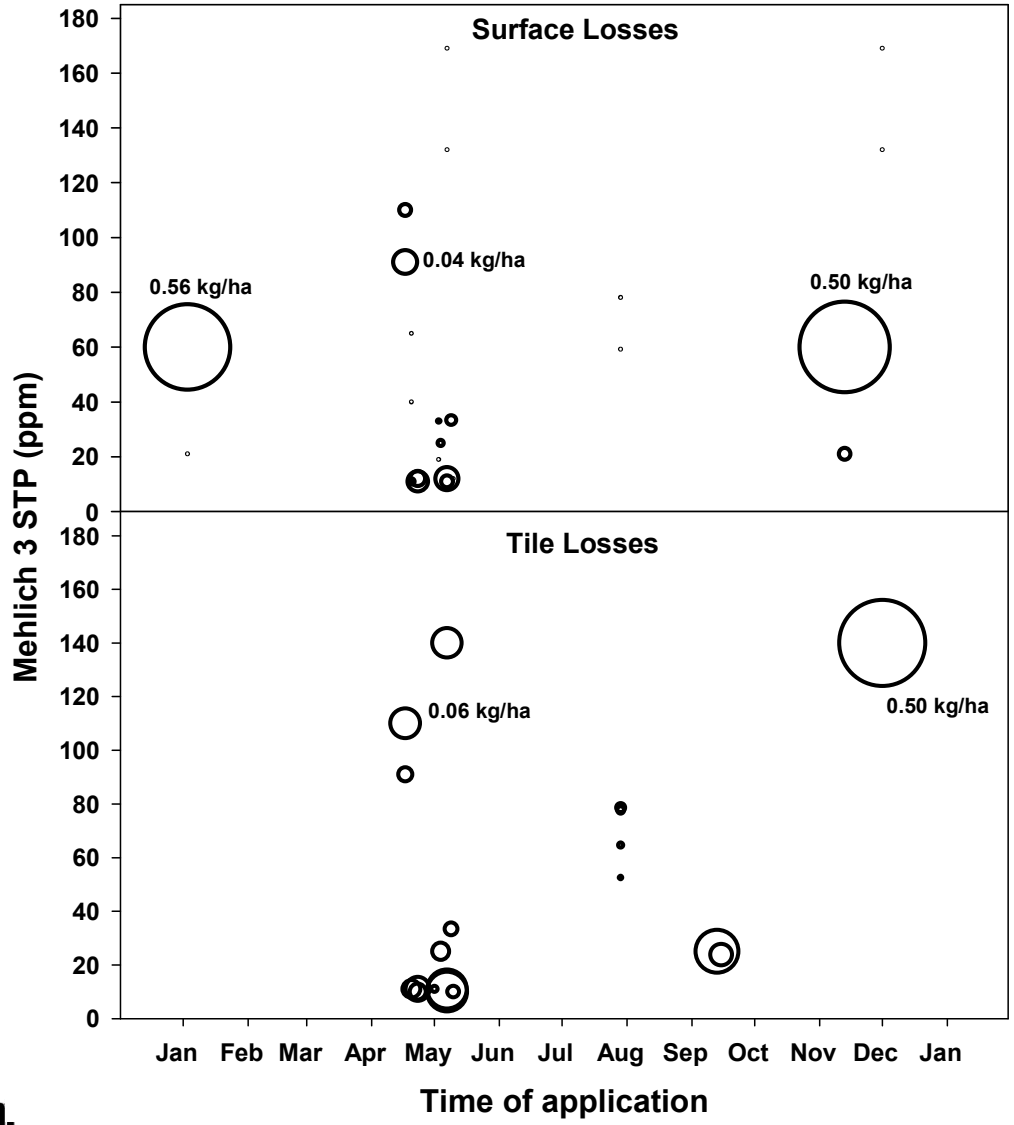
# Phosphorus Concentrations

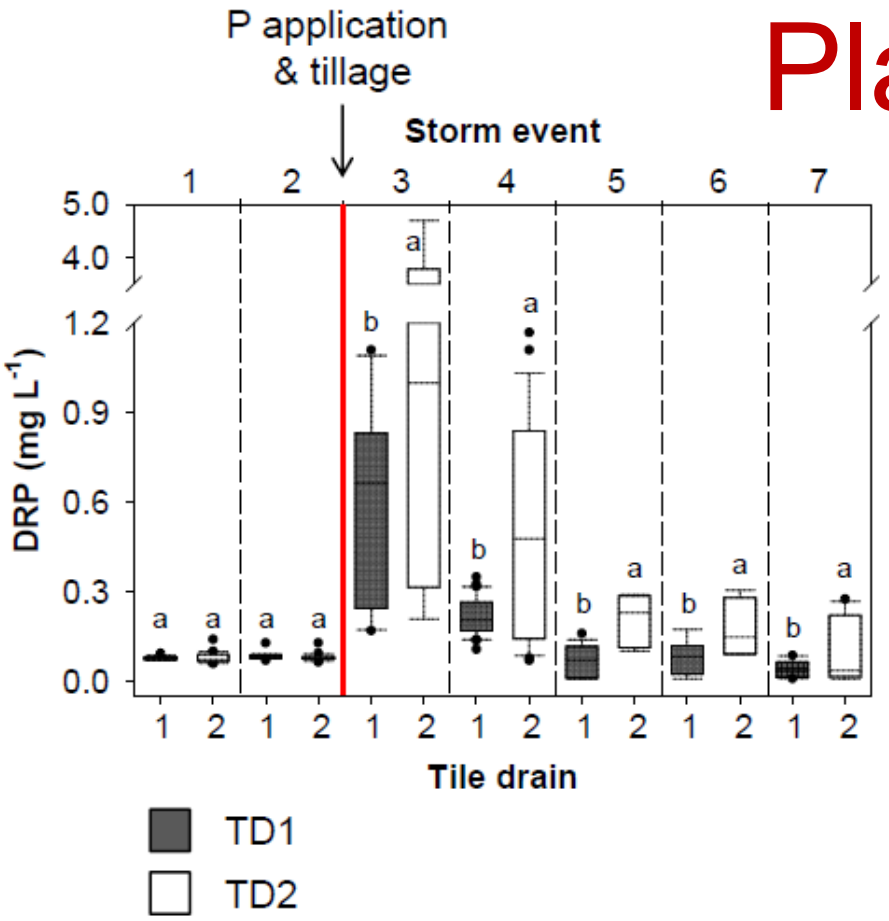


# Time of Application Data

- Greatest potential for surface and tile losses occurs with fall and winter application
- Applying P in spring or after wheat harvest seems to minimize surface and tile losses



# Right Place




| Storm Event | TD1 (tilled) | TD2 (no-tilled) |
|---|---|---|
| | g/ha | |
| 1 | 12.6 | 12.4 |
| 2 | 16.5 | 19.7 |
| 3 | 18.2 | 129.6 |
| 4 | 54.8 | 210.3 |
| 5 | 1.7 | 3.9 |
| 6 | 0.6 | 1.5 |
| 7 | 2.0 | 3.8 |
| **Total** | **106.4** | **381.2** |

Incorporated fertilizer substantially decreased DRP loads from drain discharge

DRP concentrations in tile discharge greater in no-tilled fields even after 5 storm events (>1 month)

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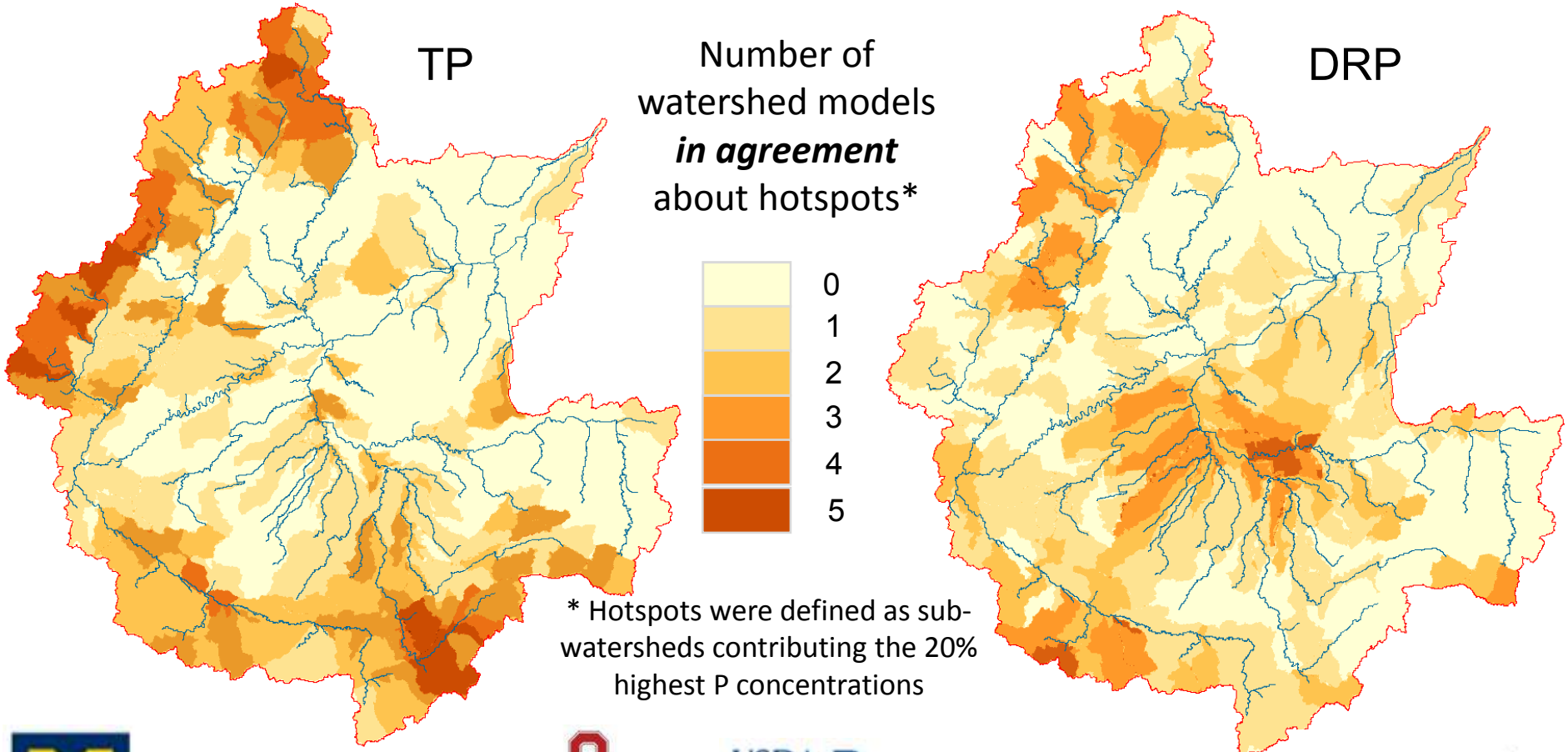
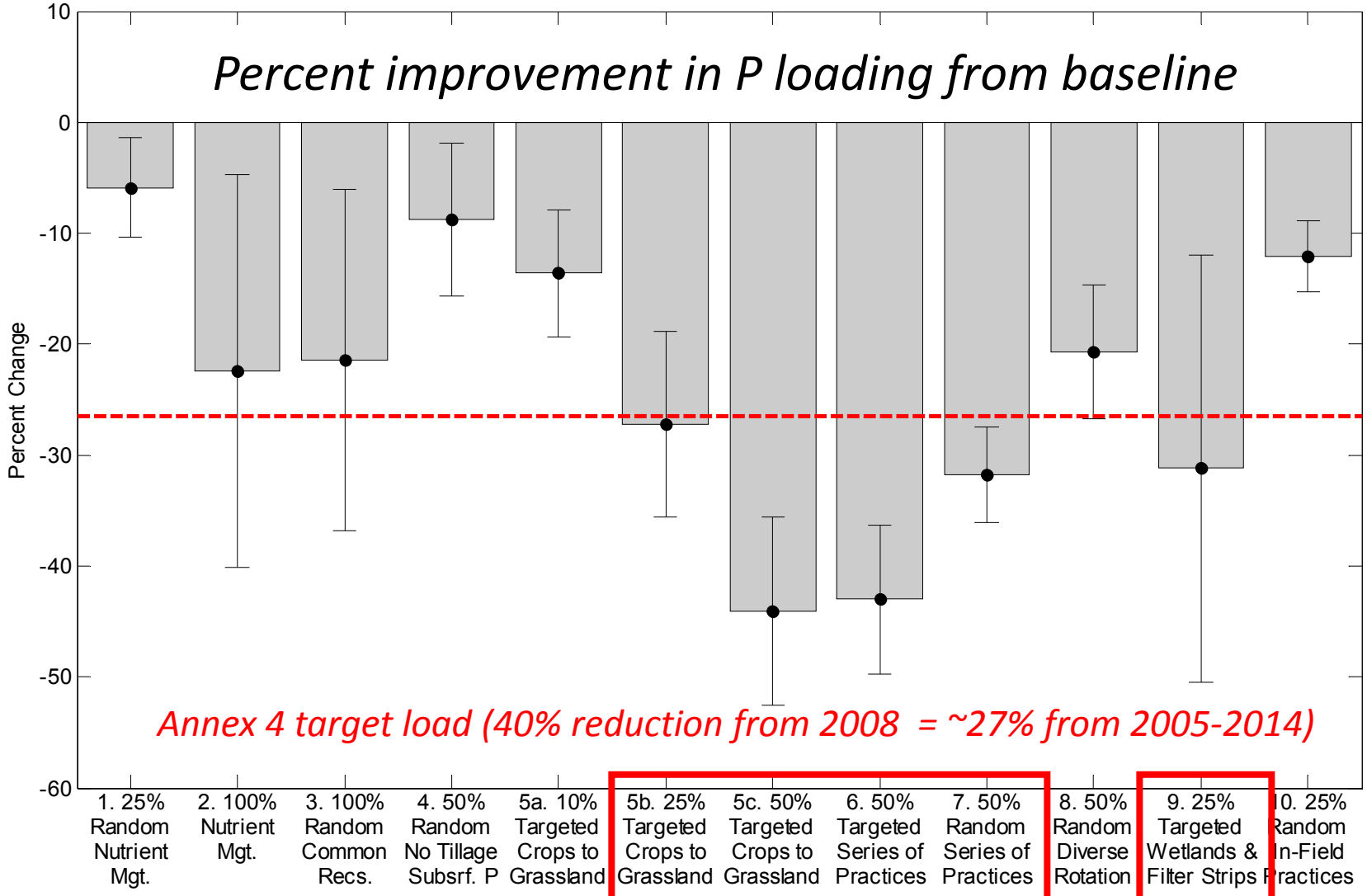
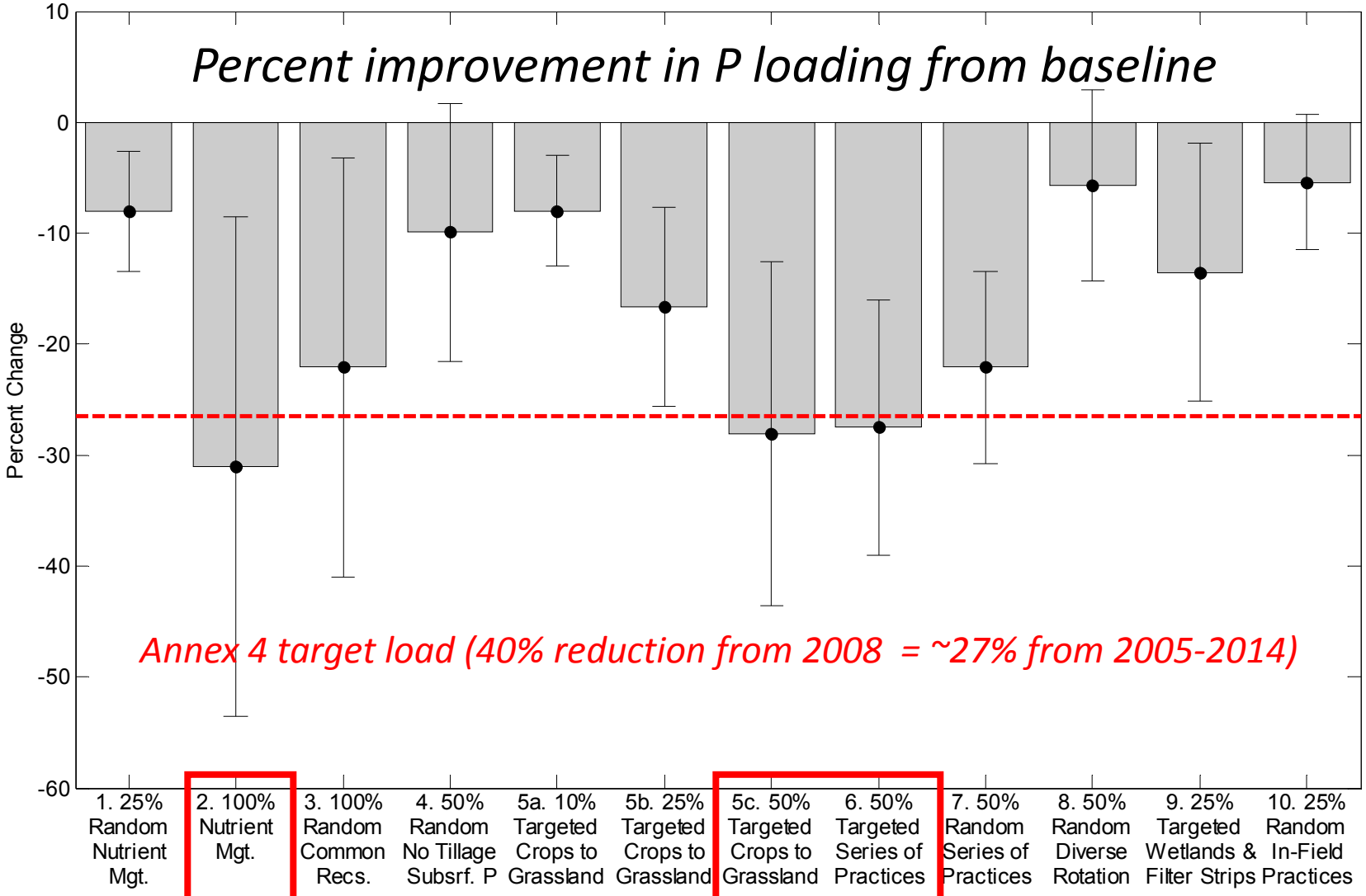
# WBLE Multi-Model Project (Ensemble Model)




University of Michigan
Heidelberg University
The Ohio State University
USDA ARS United States Department of Agriculture Agricultural Research Service
USGS science for a changing world
LimnoTech

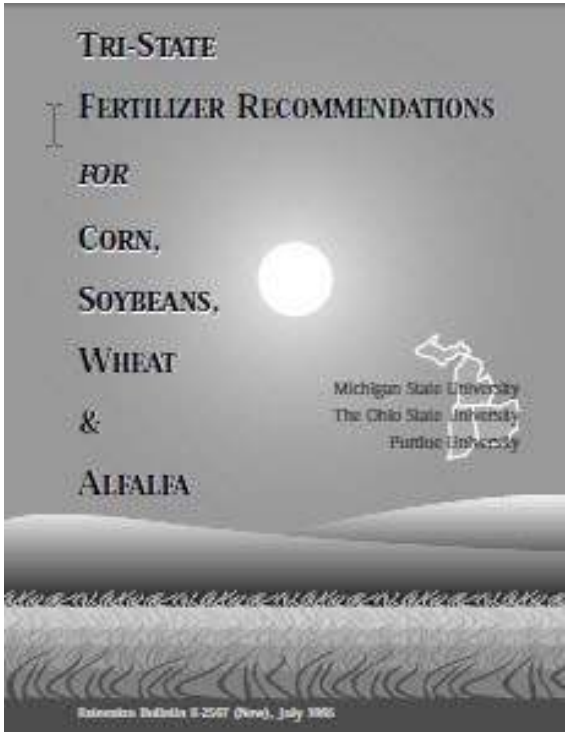




# Education in the Field (x1)

Validation of Ohio Nutrient recommendations

- Goal: Check of Ohio nutrient recommendations in todays production environment using small plot and on-farm plot results for N, P & K.
- Project Led: Dr Steve Culman, SENR
- Time Period: 2014-2018
- Product:
  - Revised Recommendations
  - Guidelines for adaptive management



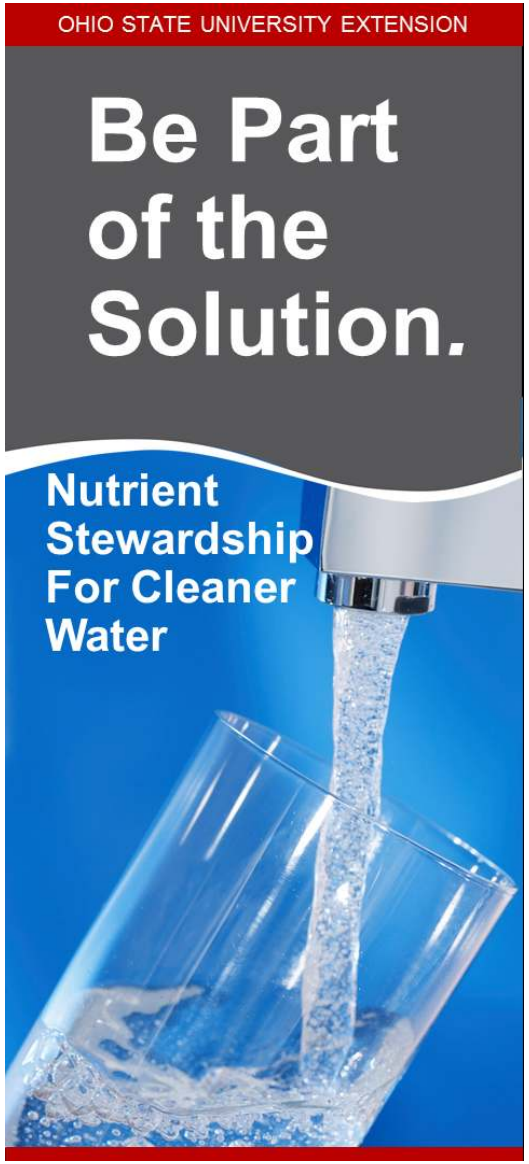
# Education in the Field (x2)

Alternative manure application timing

- Goal: Open up another liquid manure application window close to crop use to replace purchased N input and balanced P application.
- Project Led: Glen Arnold, Field Specialist
- Time Period: 2011 to present
- Product: Recommendations for in crop application of liquid manure

# Nutrient Stewardship For Cleaner Water: 2-3 Year Goals

- Conduct cooperative field trials for BMP
- Adoption of soil testing and utilization of Tri-state fertilizer recommendations
- Mechanism to support adaptive management information
- Improve crop nutrient utilization efficiencies
- Development of voluntary Nutrient Management Plans
- Identify fields with high nutrient loss risk and implement appropriate cost effective BMP's

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# 54 Projects Total

- http://ohioseagrant.osu.edu/research/collaborations/habs
- http://ohioseagrant.osu.edu/research/collaborations

- Ohio Sea Grant Funded Projects = 9 + 9 ($1,821,000)
- OSU CFAES, “F2F” Projects = 5 (~$1,000,000)
- Ohio Department of Higher Education I = 18 (~$2,000,000)
- Ohio Department of Higher Education II = 13 (~$2,000,000)
  - 50 @ $5,728,000
  - 19 @ $2,684,000

ODHE Co-Chaired by OSU and UT

| University | Funded/Submitted |
|---|---|
| OSU | 4 / 6 |
| University of Toledo | 4 / 5 |
| BGSU | 2 / 4 |
| University of Cincinnati | 1 / 2 |
| Heidelberg University | 1 / 1 |
| University of Akron | 1 / 1 |

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# ODHE I and II Driven by Agency Priorities and Annex IV

- Agency Advisory Board consisted of two representatives from each OEPA, ODNR, ODH, and ODA
- Agency representatives on external review panel
- Extremely enjoyable, collaborative, and effective process

# Focus Areas and Priorities

- Focus Areas (ODHE I):
  - Blooms: Sources and Movement
  - Produce Safe Drinking Water
  - Protect Public Health
  - Educate and Engage
- Priority categories (ODHE II):
  - Treatment Optimization
  - Cyanotoxin Toxicity Research
  - Reservoir Management
  - Bloom Dynamics
  - Analytical Methods
  - Nutrient Load Reduction Methods

LimnoTech, U of M, University of Amsterdam, Akron Water Supply, U.S. Geological Survey, Charles River Laboratory, USDA-ARS, and University of Kentucky

| Ohio Sea Grant College Program (Omnibus years 2014-15 and 2016-17) | | | | | |
|---|---|---|---|---|---|
| Year | Project Title | OHSG Funds | Matching Funds | PI Name - Last | Affiliation |
| 2014-15 | Beneficial reuse of dredged material in manufactured soil blending: Economic/logistical and performance considerations | $ 93,404 | $ 46,737 | Dayton | Ohio State University |
| | Impacts of Climate Change on Public Health in the Great Lakes due to Harmful Algae Blooms | $ 20,857 | $ 10,449 | Martin | Ohio State University |
| | Should nitrogen be managed Lake Erie? The potential role of nitrogen fixation by cyanobacteria. | $ 58,596 | $ 30,183 | Bade | Kent State University |
| | Relative contributions of hypoxia and natural gas drilling to methane emissions from Lake Erie | $ 87,507 | $ 48,533 | Townsend-Small | University of Cincinnati |
| | Understanding dam removal impacts on a formerly prolific Great Lake's walleye population | $ 80,000 | $ 40,000 | Vandergoot | ODNR |
| | Linking Agricultural Production and Great Lakes Ecosystem Services: Modeling and Valuing the Impacts of Harmful Algal Blooms in Lake Erie | $ 198,955 | $ 129,051 | Irwin | Ohio State University |
| | Source tracking and toxigenicity of Planktothrix in Sandusky Bay | $ 103,833 | $ 61,949 | Bullerjahn | Bowling Green State University |
| | The role of nitrogen concentration in regulating cyanobacterial bloom toxicity in a eutrophic lake | $ 91,212 | $ 51,068 | Chaffin | Ohio State University |
| | Mapping drain tile and modeling agricultural contribution to nonpoint source pollution in the western Lake Erie basin | $ 76,308 | $ 59,281 | Czajkowski | University of Toledo |
| 2016-17 | What makes Planktothrix bloom? An examination of physiological ecology from a genomics perspective | $ 119,137 | $ 60,068 | Bullerjahn | Bowling Green State University |
| | Can fish see the bait on the hook? Linking effects of algal and sedimentary turbidity on fish vision to the Lake Erie recreational fishery through research and outreach | $ 119,839 | $ 62,263 | Gray | Ohio State University |
| | Determining the role of urban runoff in harmful algal bloom formation in the Western Lake Erie basin | $ 59,573 | $ 29,867 | Gruden | University of Toledo |
| | Opening the black box of nutrient processing in a Great Lakes coastal wetland | $ 113,634 | $ 56,817 | Kinsman-Costello | Kent State University |
| | Sediment nitrogen dynamics in the western basin of Lake Erie relative to cyanobacterial blooms | $ 120,000 | $ 62,256 | McCarthy | Wright State University |
| | Characterizing ammonium dynamics affecting harmful algal blooms in Lake Erie | $ 120,000 | $ 69,169 | Newell | Wright State University |
| | Hydrologic controls on legacy phosphorus release to Lake Erie | $ 119,360 | $ 71,259 | Sawyer | Ohio State University |
| | From the headwaters to the littoral zone: using attached algae as indicators of ecosystem impairment and nutrient processing in the Lake Erie watershed | $ 119,552 | $ 69,634 | Vadeboncoeur | Wright State University |
| | Anthropogenic phosphorus storage, bioavaiability, and cycling in the Maumee Bay and western Lake Erie | $ 119,855 | $ 61,644 | Yuan | Cleveland State University |
| | Title: | $1,821,622 | $542,977 | | |

| Ohio State University's Field to Faucet Initiative | | | |
|---|---|---|---|
| **Project Title** | **F2F Funds** | **PI Name - Last** | **Affiliation** |
| Development of BioFET Sensors for Real Time Monitoring of Cyanotoxins | $100,000 | Lu | Ohio State University |
| Development of an integrated system for nitrogen and phosphorus removal from animal manure | $100,000 | Li | Ohio State University |
| Identifying the best strategy to reduce phosphorus loads to Lake Erie from agricultural watersheds | $199,925 | Johnson | Heidelberg University |
| Ohio Nutrient Management Mobile Applications | $65,000 | Fulton | Ohio State University |
| Geospatial Data Warehouse for Improved Agricultural Water Quality | $250,000 | Shearer | Ohio State University |
| Development of real-time detection of cyanotoxins in drinking and irrigation water sources using unmanned aerial vehicles and validation with laboratory measurements | $205,075 | Lee | Ohio State University |
| Total: | $920,000 | | |

| Ohio Department of Higher Education Research Initiative Round One | | | | | |
|---|---|---|---|---|---|
| **Focus Area** | **Project Title** | **ODHE Funds** | **Matching Funds** | **PI Name - Last** | **Affiliation** |
| Blooms: Sources and Movement | HAB Detection, Mapping, and Warning Network: Maumee Bay Area | $249,597.00 | $118,950.00 | Bridgeman | University of Toledo |
| | HAB Detection, Mapping, and Warning Network: Sandusky Bay | $250,000.00 | $162,409.00 | Bullerjahn | BGSU |
| | Identifying the best strategy to reduce phosphorus loads to Lake Erie from agricultural watersheds | $251,565.00 | $433,996.00 | Johnson | Heidelberg University |
| Produce Safe Drinking Water | Guidance for powdered activated carbon use to remove cyanotoxins | $114,674.00 | $128,526.00 | Lenhart | Ohio State University |
| | Investigation of water treatment alternatives in the removal of microcystin-LR | $199,998.00 | $191,306.00 | Seo | University of Toledo |
| | Transport and Fate of Cyanotoxins in Drinking Water Distribution Systems | $106,209.00 | $126,231.00 | Seo | University of Toledo |
| | Investigation of ELISA and interferences for the detection of cyanotoxins | $75,011.00 | $107,409.00 | Isailovic | University of Toledo |
| | Identifying Bacterial Isolates for Bioremediation of Microcystin-contaminated Waters | $40,000.00 | $20,056.00 | Mou | Kent State University |
| | Development of Microcystin Detoxifying Water Biofilters | $55,000.00 | $78,740.00 | Huntley | University of Toledo |
| | Prevention of cyanobacterial bloom formation using cyanophages | $40,000.00 | $20,328.00 | Lee | Ohio State University |
| Protect Public Health | Method Development for Detecting Toxins in Biological Samples | $55,000.00 | $70,621.00 | Hensley | University of Toledo |
| | Impact of pre-existing liver disease on microcystin hepatotoxicity | $55,000.00 | $213,588.00 | Kennedy | University of Toledo |
| | Fish flesh and fresh produce as sources of microcystin exposure to humans | $162,597.77 | $95,109.04 | Ludsin | Ohio State University |
| | Evaluation of Cyanobacteria and their Toxins in a Two-Staged Model of Hepatocarcinogenesis | $30,000.00 | $32,803.00 | Weghorst | Ohio State University |
| Educate and Engage | Maumee Basin Lake Erie HABS Nutrient Management Options Comparative Analysis | $64,649.51 | $42,481.83 | Haab | Ohio State University |
| | Social Network Analysis of Lake Erie HABs Stakeholder Groups | $65,166.43 | $33,904.16 | Turner | Kent State University |
| | Maumee Basin Lake Erie HABs Stakeholder Informed Decision-Making Support System | $66,501.00 | $134,391.00 | Lawrence | University of Toledo |
| | Farmer/Farm Advisor Water Quality Sampling Network | $148,380.00 | $38,578 | LaBarge | Ohio State University |
| | Total: | $2,029,349 | $2,049,427 | | |

| Ohio Department of Higher Education Research Initiative Round Two | | | | |
|---|---|---|---|---|
| **Project Title** | **ODHE Funds** | **Matching Funds** | **PI Name - Last** | **Affiliation** |
| Characterization of recreational exposures to cyanotoxins in western Lake Erie basin | $21,213 | $54,655 | Ames | University of Toledo |
| HAB Avoidance: Vertical Movement of Harmful Algal Blooms in Lake Erie | $206,145 | $211,072 | Bridgeman | University of Toledo |
| Seasonal quantification of toxic and nontoxic Planktothrix in Sandusky Bay by qPCR | $31,571 | $65,159 | Bullerjahn | Bowling Green State University |
| Optimization of carbon barriers for effective removal of dissolved cyanotoxins from Ohio's fresh water | $210,695 | $219,901 | Chae | University of Cincinnati |
| Evaluation of Optimal Algaecide Sources and Dosages fro Ohio Drinking Water Sources | $137,842 | $153,287 | Cutright | University of Akron |
| Discovery of Enzymes and Pathways Responsible for Microcystin Degradation | $95,216 | $119,392 | Huntley | University of Toledo |
| Determining sources of phosphorus to western Lake Erie from field to lake | $199,266 | $251,707 | Johnson | Heidelberg College |
| A comprehensive approach for evaluation of acute toxin responses after microcystin ingestion | $184,292 | $186,568 | Lee | Ohio State University |
| Evaluating Home Point-of-Use Reverse Osmosis Membrane Systems for Cyanotoxin Removal | $99,328 | $146,143 | Lipscomb | University of Toledo |
| Development of the MMPB method for quantifying total microcystins in water edible Lake Erie fish tissues | $156,617 | $156,660 | Ludsin | Ohio State University |
| Kinetic Models for Oxidative Destruction of Cyanotoxins in Raw Drinking Water | $254,306 | $259,658 | MacKay | Ohio State University |
| How quickly can target phosphorus reductions be met? Robust predictions from multiple watershed models. | $255,757 | $255,956 | Martin | Ohio State University |
| Early season (March) phosphorus inventory of offshore waters of Lake Erie | $17,947 | $43,765 | McKay | Bowling Green State University |
| Totals | $1,870,195 | $2,123,923 | | |

# What Can Agriculture Do?

- Avoiding fall and winter **application** of fertilizer and manure (SB1)
- No fertilizer when rain is in **forecast** and **saturated** soils (SB1)
- Eliminate **broadcast application** and **incorporate** fertilizer (i.e., subsurface placement; band/inject)
- **Soil testing** of all fields to prevent application of too much P
  - D
  - A
  - L
- **Drai**
  - D
  - 4
  - Treat as leaves?
- Account for **manure** in nutrient calculations (algae don't care about source)
  - Treat manure and commercial fertilizer the sam
  - The algae don't care about P source

The 4R Nutrient Program (SB 150):
- Right fertilizer **source** (i.e., manure and P free)
- Right **rate** (i.e., amount; Ag need)
- Right **time** (i.e., rain and frozen ground)
- Right **place** (i.e., only where needed)

inlets

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# What Other Levers Can We Pull?

- **Lawn Care** Recommendations:
  - Follow Scott's lead…..all lawn care fertilizer sellers and lawn care applicators meet the zero P goal
- Reduce **property runoff** (e.g., rain barrels, terraces, porous surfaces, etc.)
- S
- V
- M

Immediate Needs:

- Arm water treatment plants with tools, technology, and training to remove toxins
  - Find surrogate for toxin
- Reduce load of P into Lake Erie by 40%
  - Incorporate fertilizer
  - Water management
  - Soil testing (<30ppm)


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# Questions?

- For more information:
  - Dr. Christopher Winslow
  - ***Phone***: 614-247-6684
  - ***E-mail***: winslow.33@osu.edu
- Special thanks to:
  - Kevin King (Acting Research Leader w/ USDA-ARS)
  - Greg Labarge (Field Specialist w/ OSU Extension)
  - All PIs and Co-PIS on grants

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State of the Science Webinars coming soon
(end of May thru Beginning of Sept.)

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