Metropolitan Water Reclamation District of Greater Chicago

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TO THE JANUARY EDITION

OF THE 2019

M&R SEMINAR SERIES

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- **STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds ⇒ M&R Seminar Series)**

Guanglong Tian, Ph.D.

- Dr. Guanglong Tian is a Principal Environmental Scientist of MWRD-Environmental Monitoring and Research Division. He leads the Biosolids Utilization & Soil Science Section for providing technical support to MWRD's biosolids utilization program and green infrastructure initiative, and managing regulatory biosolids and groundwater monitoring and agricultural nutrient loss reduction research at MWRD's Fulton County.

- Dr. Tian was an Adjunct Professor at Illinois Institute of Technology (2009-2014). Prior to joining MWRD in 2002, Dr. Tian was the Soil Scientist at the International Institute of Tropical Agriculture, Nigeria (1992-2001) working to develop sustainable agricultural systems.

- Dr. Tian received a Ph.D. in Soil Biology/Fertility from Wageningen Agricultural University, Netherlands in 1992.

- Dr. Tian is on the IPCC Agricultural Soil CO_2 Expert Committee and an Advisor of the World Academy of Sciences. He was a Subject Editor for Soil Biology & Biochemistry (2001-2007). Dr. Tian has published 170 papers.

The Development, Implementation, and Recent Progress of Fulton County Nutrient Loss Reduction Program under Illinois Nutrient Loss Reduction Strategy

Guanglong Tian

Principal Environmental Scientist

Monitoring and Research Department

Metropolitan Water Reclamation District of Greater Chicago

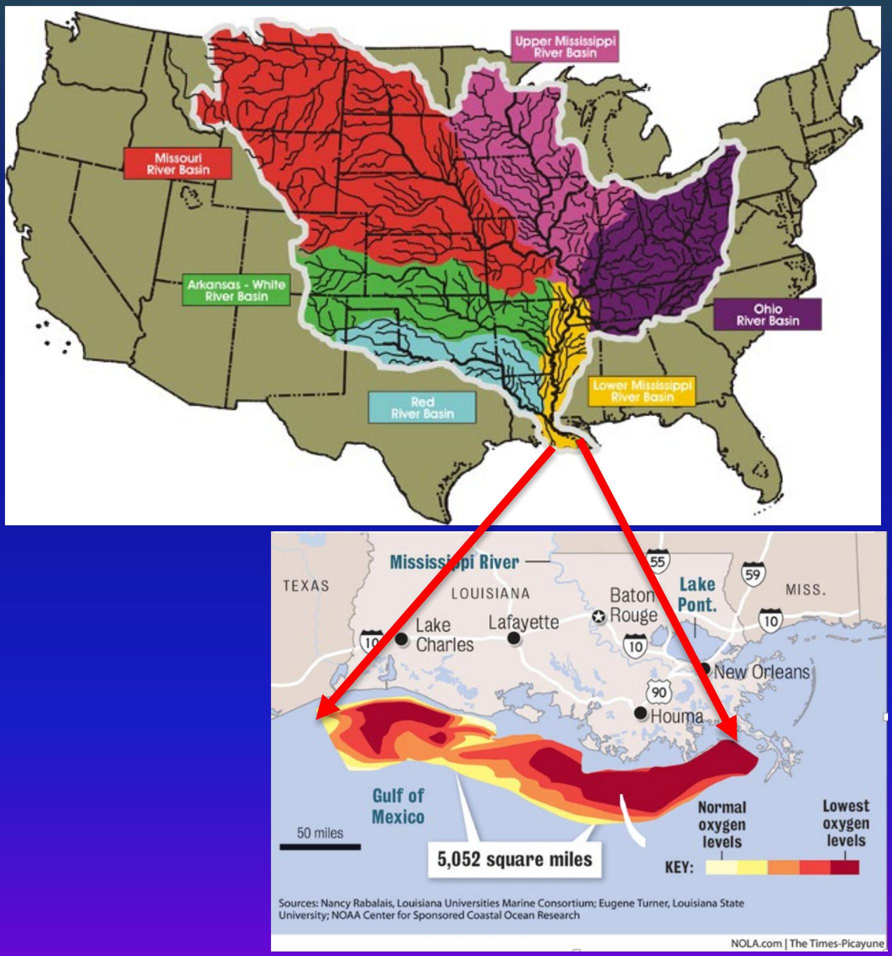
Contributors to the Presentation

- **Dr. Olawale Oladeji, Environmental Soil Scientist, Fulton County Program co-leader**
- **Dr. Albert Cox, Environmental Monitoring and Research Manager, INLR policy working group**
- **Alex Echols**, Executive Vice President of Ecosystem Services Exchange (ESE), Iowa.
- **Dr. Richard Cooke**, Professor and Drainage Extension Specialist at University of Illinois at Urbana-Champaign.
- **Peter Fandel**, Professor of Agriculture and Cover Crop Specialist at Illinois Central College.
- **Dr. DoKyoung Lee**, Associate Professor of Biomass and Bioenergy Crop Production at University of Illinois at Urbana-Champaign.
- **Hyemi Kim** and **Danielle Cooney**: UIUC Graduate students
- **Soo-Hyun Lim**: UIUC Post-doctoral Fellow
- **Dr. Thomas Voigt**, Professor and Extension Turfgrass Specialist at University of Illinois at Urbana-Champaign.
- **Lauren Lurkins**, Director of Natural and Environmental Resources, Illinois Farm Bureau.
- **Elaine Stone**, Fulton County Farm Bureau Manager.

Outline of the Presentation

- Background
  - Hypoxia, need for nutrient loss reduction
  - IL Fundamental Ag conditions for the nutrient export to rivers, potential Best Management Practices (BMP)
- BMPS under testing at Fulton County
  - Cover Crops
  - Field and Landscape Buffer
  - Runoff and Sub-irrigation, Bioreactors
  - Field Based Watershed Measurement
- Summary and Forward-Looking

Gulf of Mexico Hypoxia and Local Water Quality Impairment

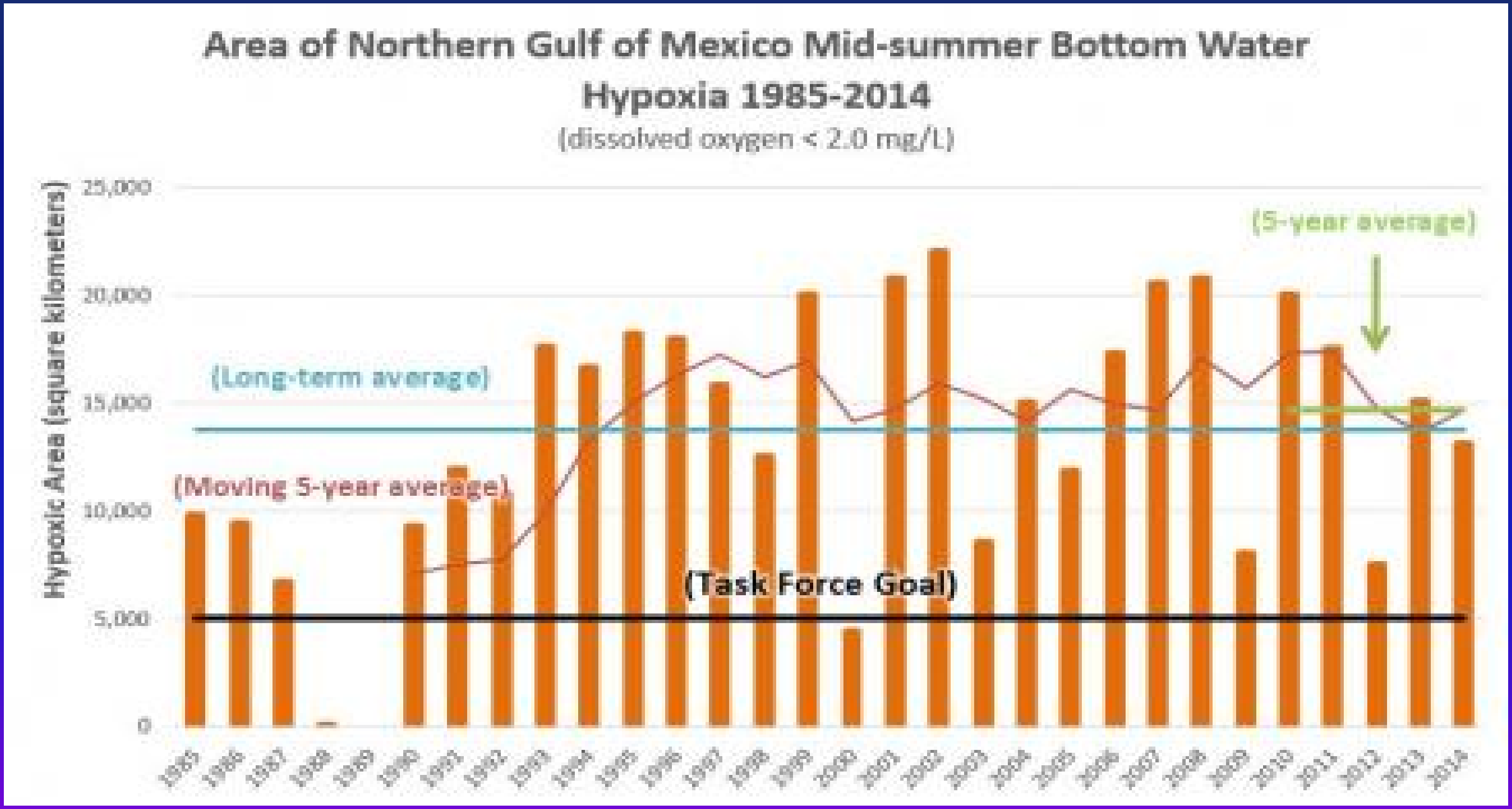


- 14,000 km^2, the size of Connecticut

Gulf of Mexico Hypoxia Reduction

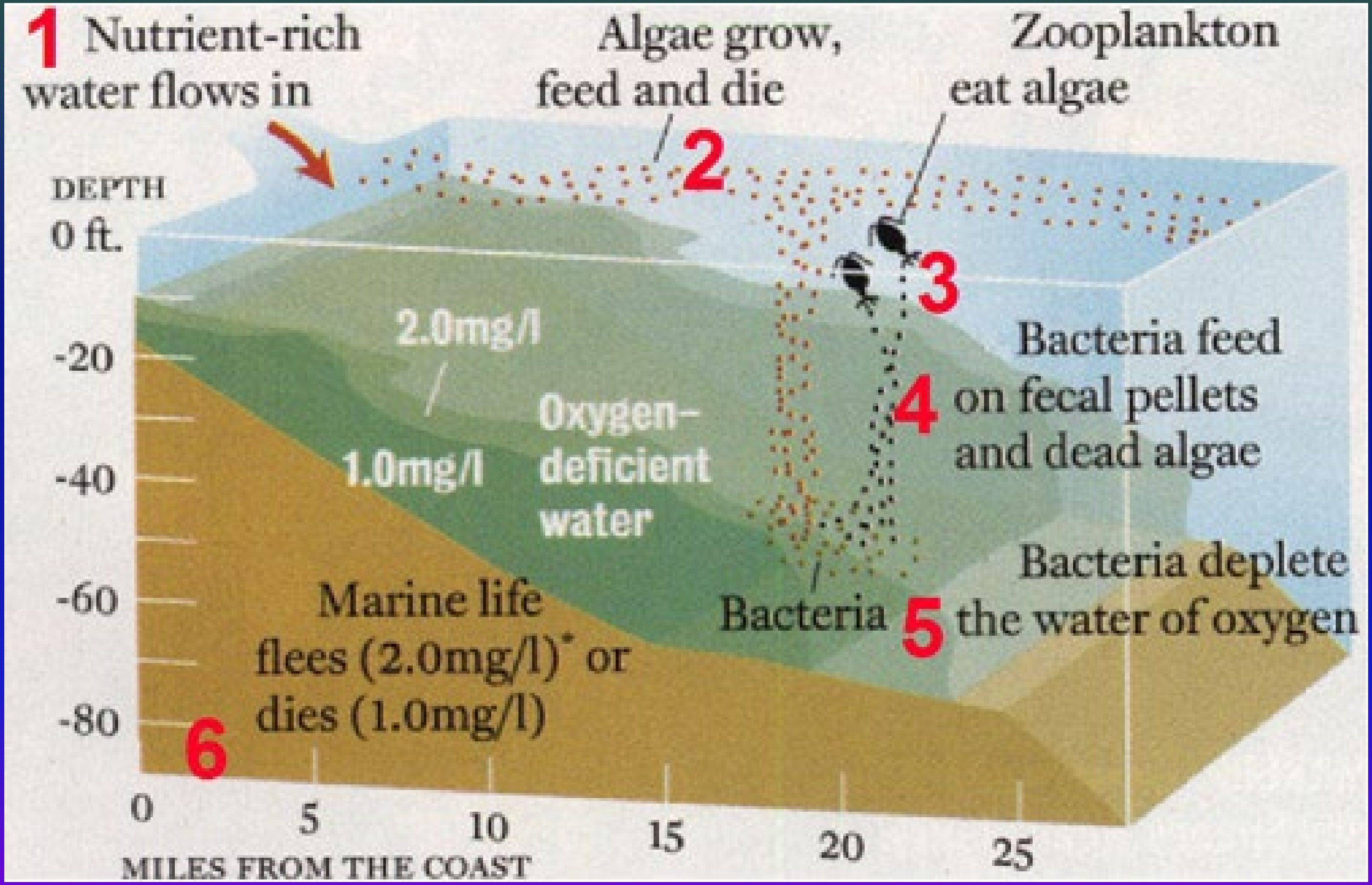
2008 Action Plan Goals:

- Reduce Hypoxia Zone to 5,000 km^2



Sources: R. Eugene Turner (Louisiana State University) and Nancy N. Rabalais (Louisiana Universities Marine Consortium

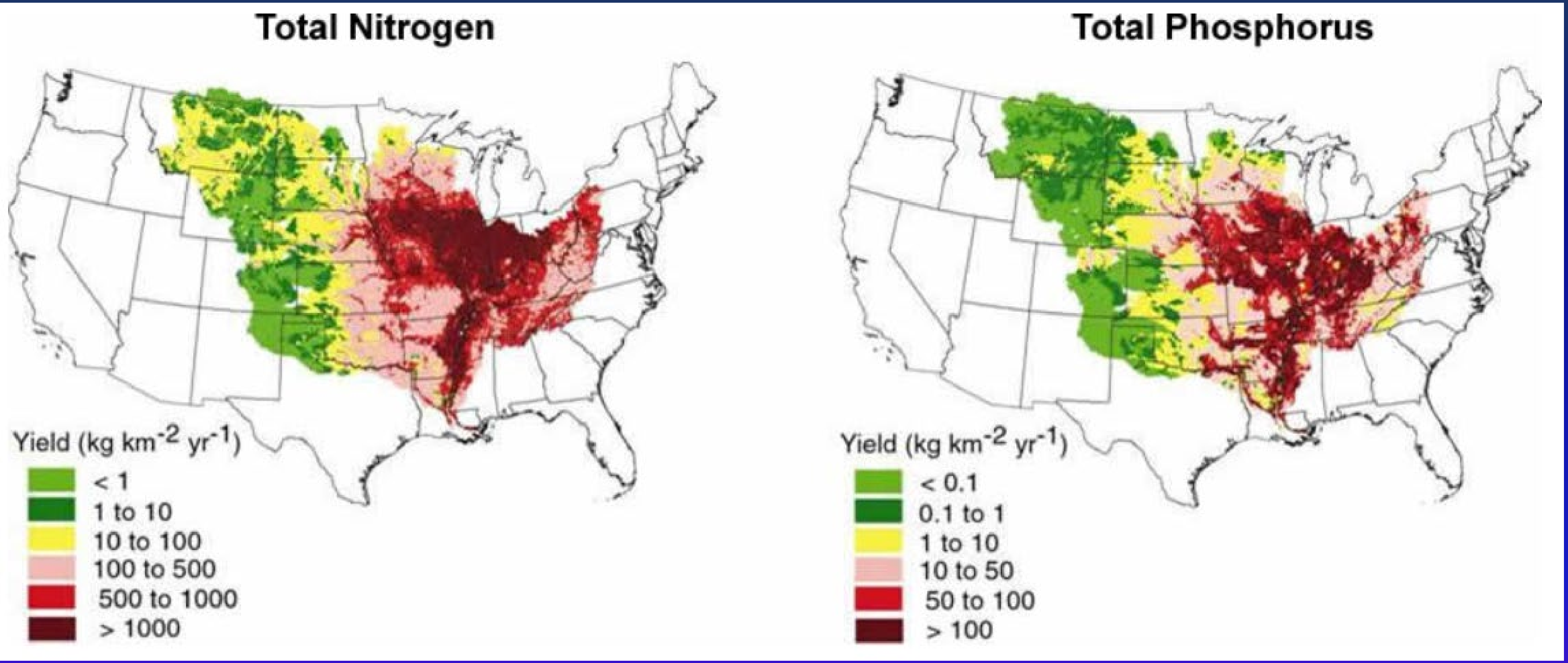
Nutrients Causing Hypoxia



Sources: R. Eugene Turner (Louisiana State University) and Nancy N. Rabalais (Louisiana Universities Marine Consortium

Nutrient Export of Midwest States

Distribution of nitrogen and phosphorus yields throughout the Mississippi River basin



Source: U.S. Geological Survey, http://water.usgs.gov/nawqa/sparrow/gulf_findings/delivery.html

- Everyone (point source, nonpoint source) has contributed to the problem, and now everyone has an opportunity to be part of the solution

Gulf Hypoxia Action Plan 2008

Coastal Goal: Subject to the availability of additional resources, we strive to reduce or make significant progress toward reducing the five-year running average areal extent of the Gulf of Mexico hypoxic zone to less than 5,000 square kilometers by the year 2015….*

Within Basin Goal: To restore and protect the waters of the 31 States and Tribal lands within the Mississippi/Atchafalaya River Basin through implementation of nutrient and sediment reduction actions to protect public health and aquatic life as well as reduce negative impacts of water pollution on the Gulf of Mexico.

Quality of Life Goal: To improve the communities and economic conditions across the Mississippi/Atchafalaya River Basin, in particular the agriculture, fisheries and recreation sectors, through improved public and private land management and a cooperative, incentive-based approach.

To achieve the goal, at least a reduction by 45% in riverine total nitrate-nitrogen (**N**) and total phosphorus (**P**) load, measured against the average load over the 1980-1996 time period (U.S. EPA, 2007).

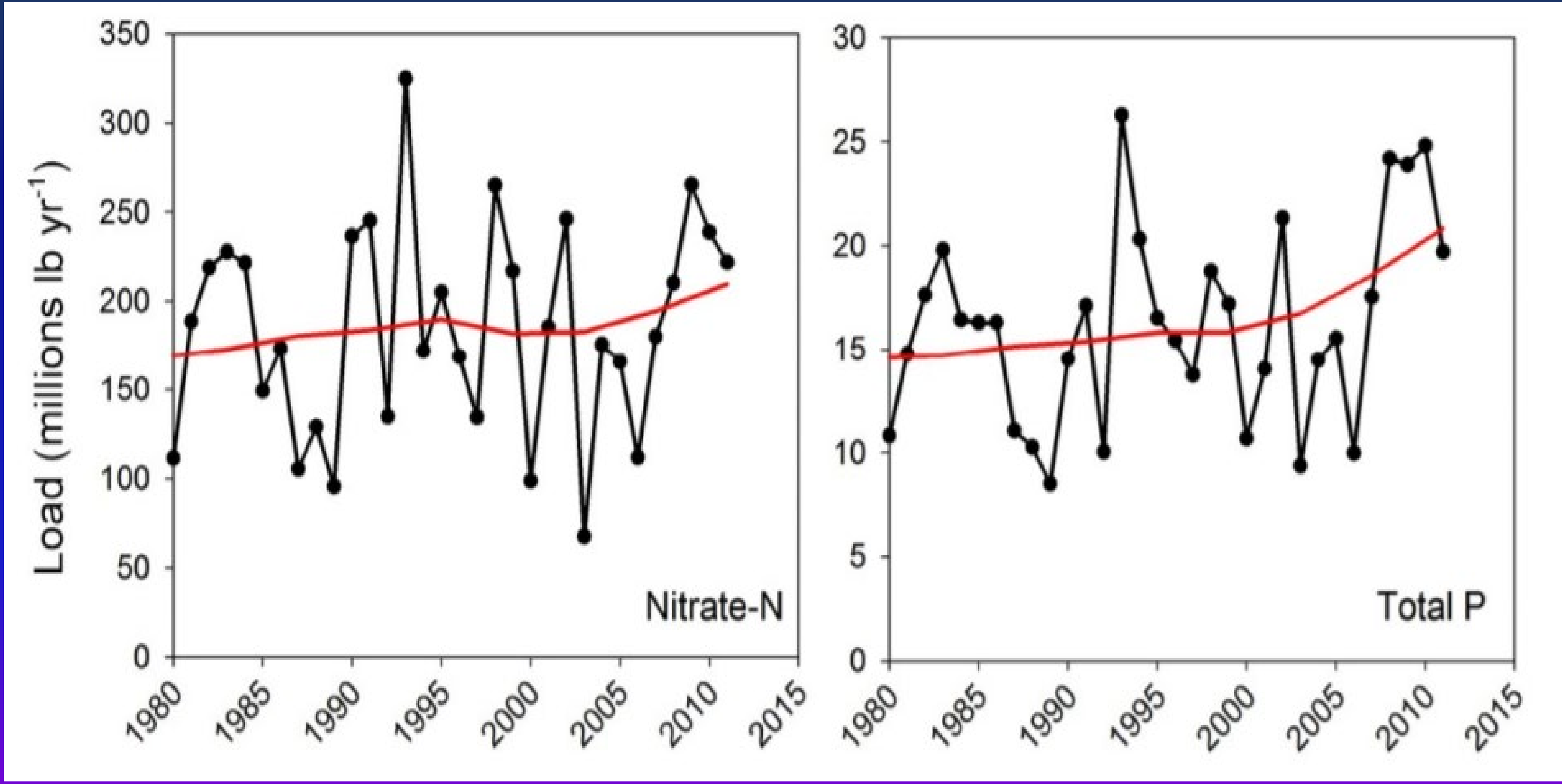
IL Nutrient Loss Reduction Strategy (NLRS)

- U.S. EPA 2008 Gulf Hypoxia Action Plan calls for each of the 12 states in the Mississippi River Basin to produce a plan to reduce the amount of phosphorus and nitrogen carried in rivers throughout the states and to the Gulf of Mexico.
- 2011, U.S. EPA provided a recommended framework for state plans. Illinois' strategy follows that framework.
- Illinois NLRS: reduce **tot P** load by 25% and **NO_3-N** load by 15% by 2025 with the eventual target of a 45% reduction in the loss of these nutrients to the Mississippi River.

Table 2.1. Watershed milestones and targets.

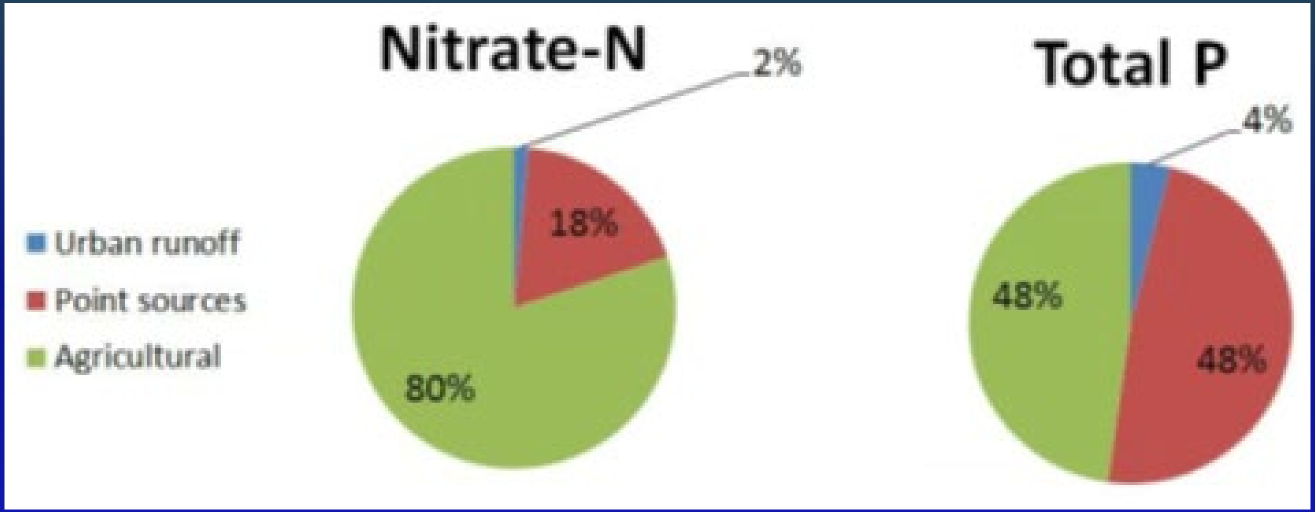
Nutrient	Phase 1 Milestones	Target
Nitrate-nitrogen	15 percent by 2025	45 percent
Total phosphorus	25 percent by 2025	45 percent

Annual Riverine Nitrate-Nitrogen and Total Phosphorus Loads Coming out of Illinois



Source: Illinois nutrient Loss Reduction Strategy, 2015

Source of Illinois Riverine Nutrient Loads



Source: IL nutrient Loss Reduction Strategy, 2015

- N: 80% from agricultural lands
- P: 48% from agricultural lands

- So, the Illinois nutrient loss reduction goal could be achieved most quickly and economically through the collaborative effort of the point and non-point source sectors.

Goal – Fulton County Nutrient Loss Reduction Program (NLRP)

1) Establish the Fulton County site as a model to foster collaboration between the point source and the agricultural sector in addressing nutrient loss reduction.

2) Develop and demonstrate the effectiveness of best management practices (BMPs): cover crops, grass buffer, runoff subirrigation, and denitrifying bioreactor.

3) Characterize a series of paired field-based watersheds with respect to nutrient loss and establish BMPs for watershed-scale nutrient reduction study.

4) Disseminate improved management practices to farmers via field days and various media.

Milestones – Fulton County NLR Program

12.18, INREC grant of $400K for UIUC-MWRD biochar-nutrient reduction research

6.18, field day with IFB

12.17, INREC grant of $350K for UIUC-MWRD subirrigation research

6.17, visit of IL Farm Bureau to FC

2.16, first meeting Ag Partners at FC

6.15, 1st BMP established

3.15, Director of M&R approved 5-yr research plan

9.14, ED approved the program proposal and funding

5.14, ED chaired inter-Depts meeting at FC to kick off the program

11.13, Executive Director (ED) and ESE vice President visited Fulton Co

Metropolitan Water Reclamation District *of* Greater Chicago

Press Release

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For immediate release
February 7, 2018

MWRD research partnership with University of Illinois attracts grant to improve water quality through agricultural innovation

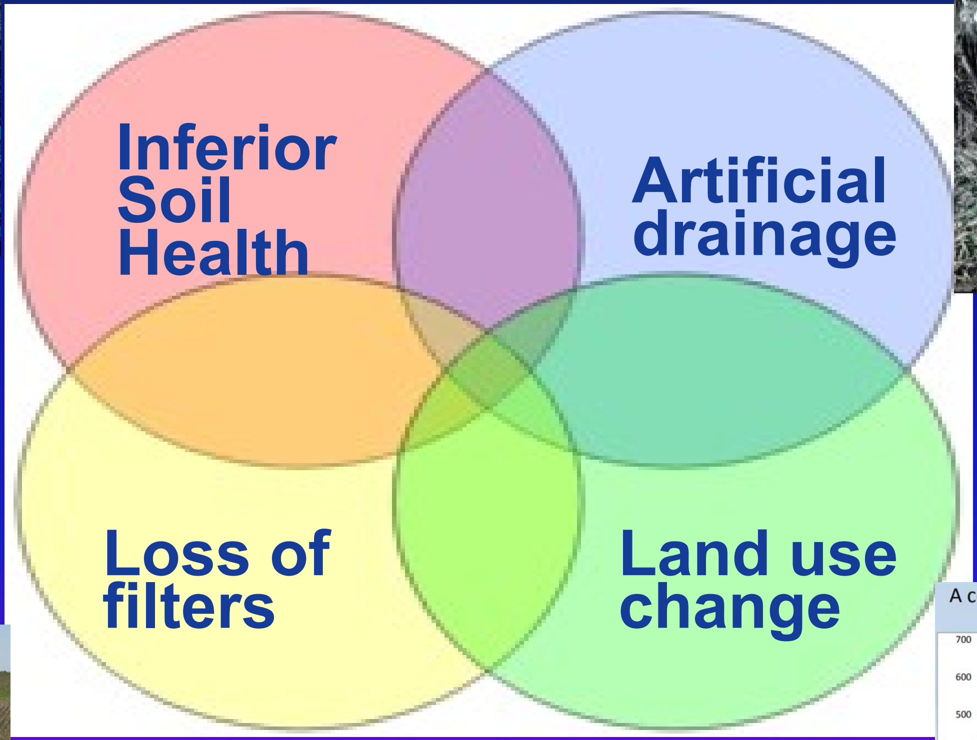
The Illinois Nutrient Research and Education Council (NREC) has awarded a $350,000 grant to research partners at the University of Illinois Urbana-Champaign (UIUC) and the Metropolitan Water Reclamation District of Greater Chicago (MWRD) to address nutrient loss reduction strategies and protect regional and national waterways downstream. The four-year

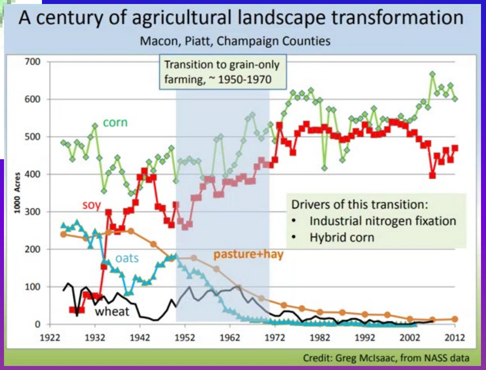
2013, Illinois Policy Working Group formed

2011, USEPA Recommended Elements of a State Nutrients Framework

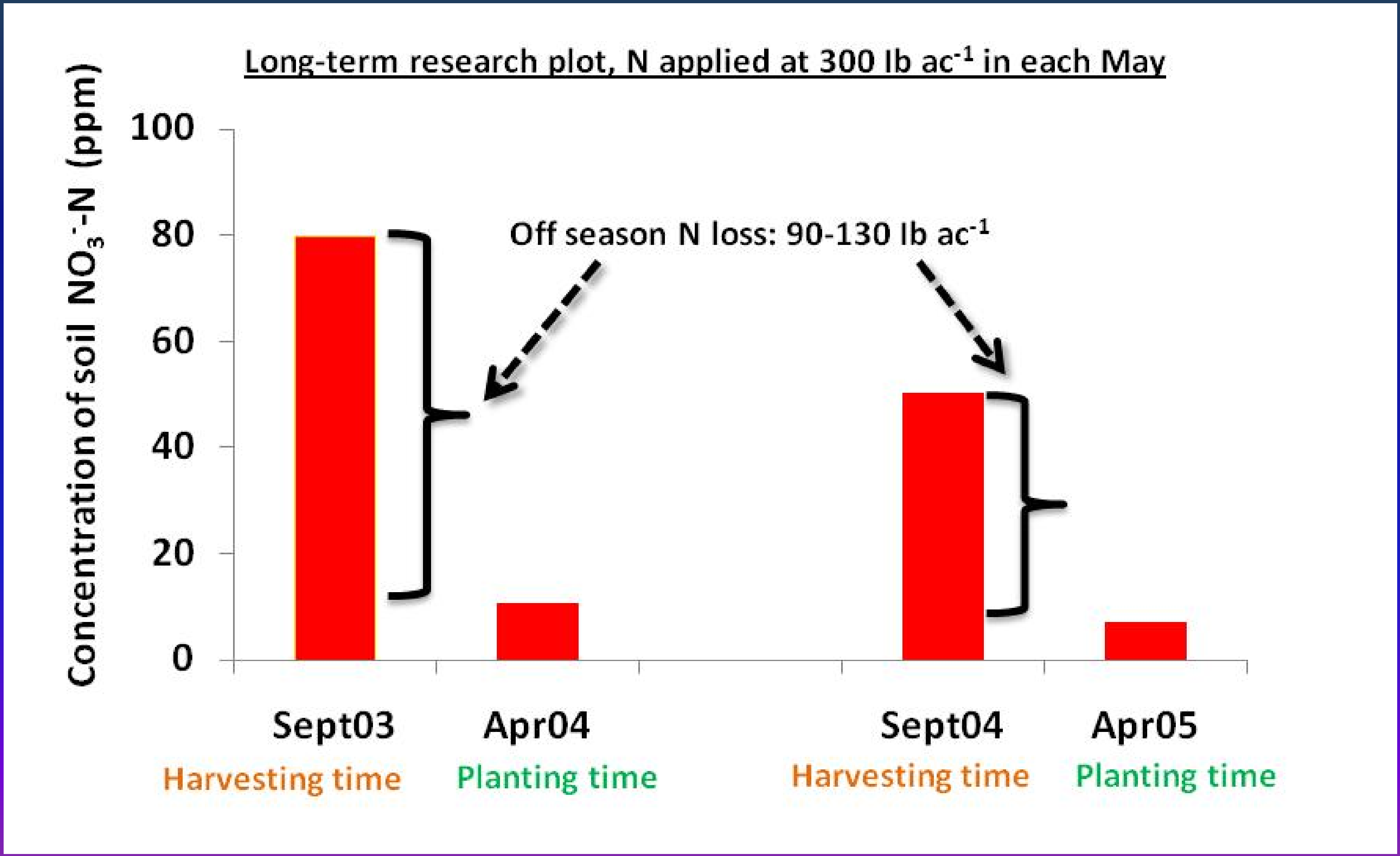
2008, EPA call 12 states for N and P reduction

Major Factors for Nutrient Export from Ag Fields to River





Substantial Field Nutrient Export over the Off-Season (No crops)

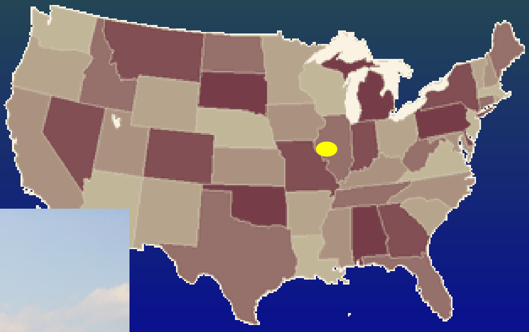


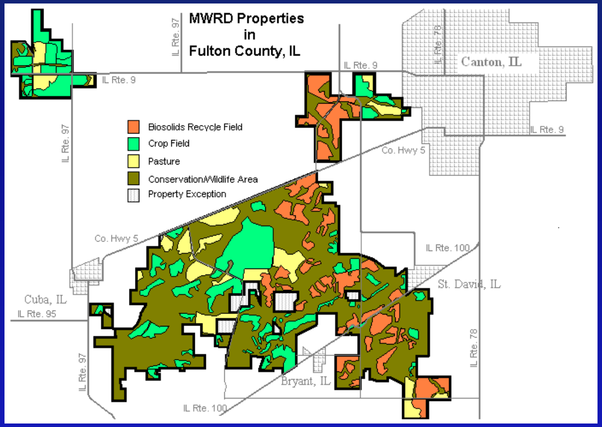
Ag Field Conditions for Nutrient Loss and Possible Solutions

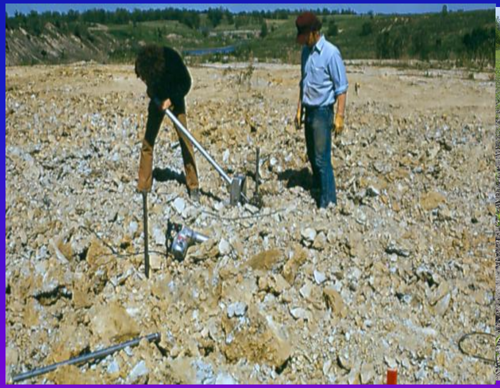
Problems	Possible solutions	BMPs
Lack of winter vegetation to remove residual N	Establish vegetation in field	Cover crop
Soil Degradation, e.g. reduced nutrient holding, soil compaction	Improve soil organic matter and biota	No-tillage, Cover crop
Spring tile-drain exporting nutrients	Reuse water Nutrient removal	Runoff or sub-irrigation, Denitrifying Bioreactors
Loss of field and landscape buffer to intercept/absorb nutrients moving to creek	Vegetation restoration/re-establishment	Multi-functional grass buffer

MWRD Fulton Country, West Illinois

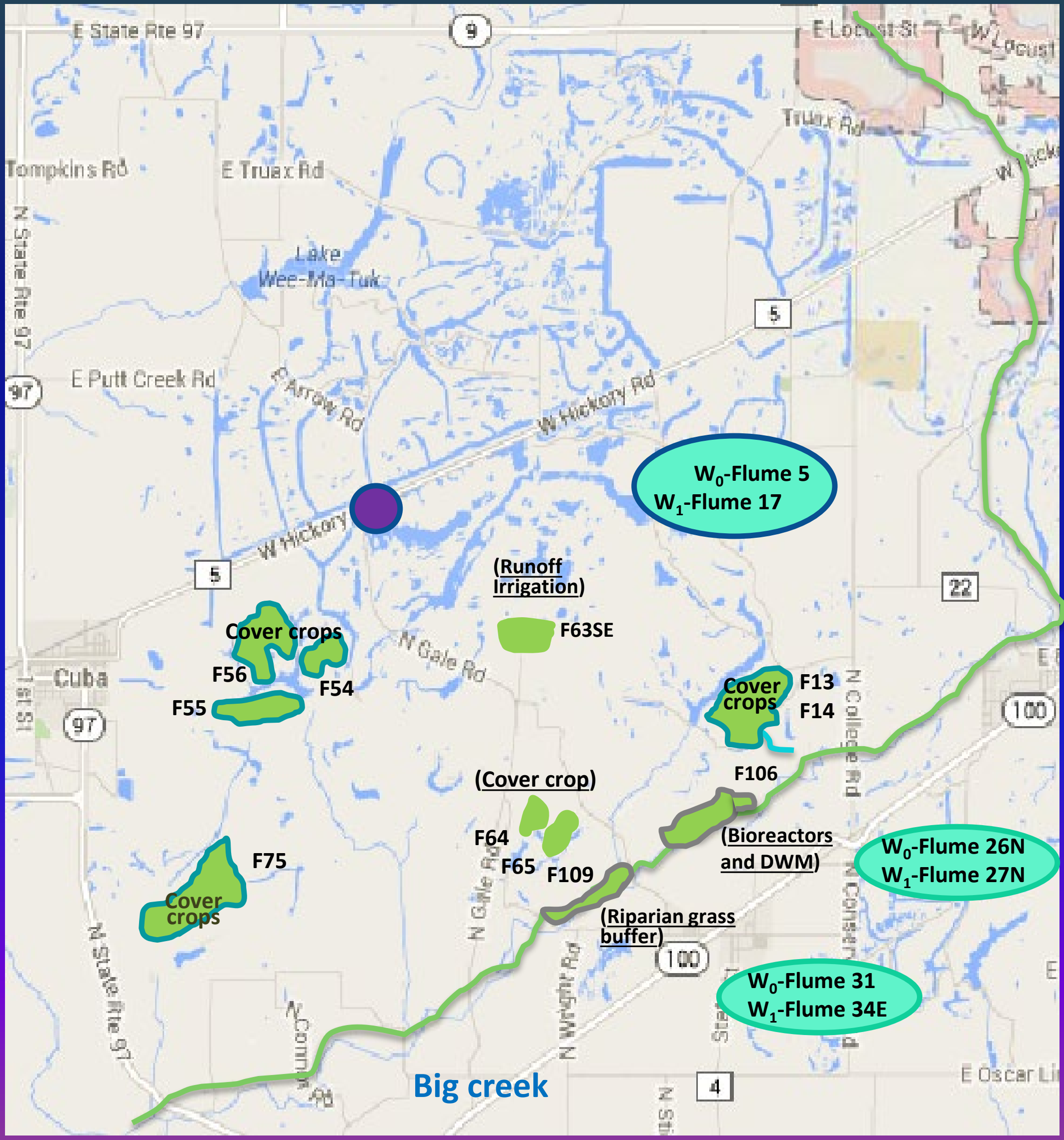
- ~13,000 calcareous strip-mined land, nonmined land, mine lakes, and wooded areas acres.







Overview of Experiments/Projects Established at Fulton County for Nutrient Loss Reduction



Legend

MWRD office

BMPs

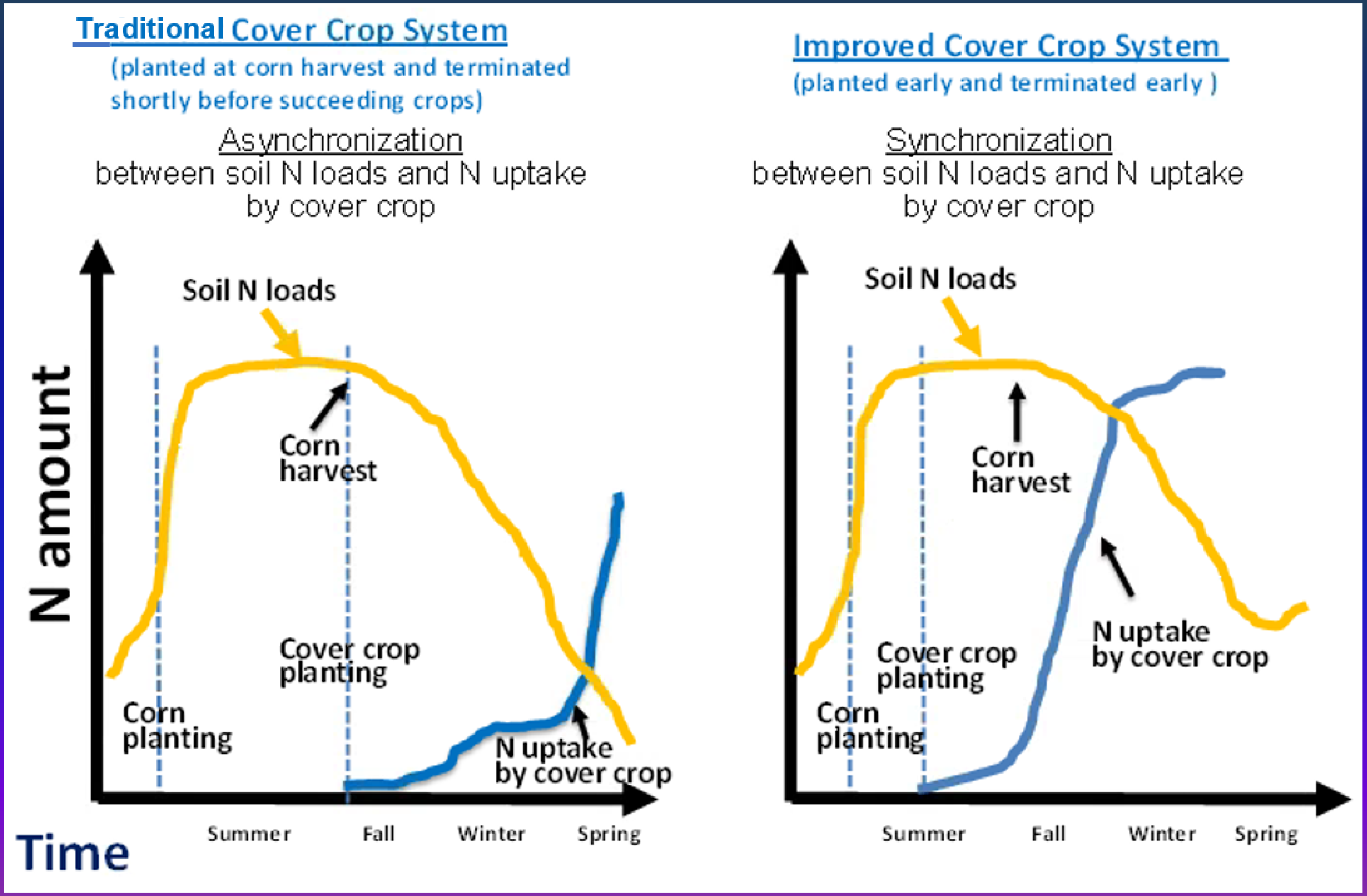
Paired watersheds monitoring

Cover Crops

- Cover crops can reduce leaching of nitrates to groundwater, and contain surface runoff.

- Cover crops well developed in the Southeastern United States. It is still a challenge to work on cover crops in northern US.
- Too short growing period for cover crop planted at/after corn harvested

Timing of Soil N Load and N Uptake by Cover Crop in Two Types of Cover Crop Systems



More Disadvantages of Traditional Winter Cover Crops

- Tile drain for agricultural field is at about 3 feet below ground.
- Roots of cover crop planted in October can not take nitrogen from that depth.
- Roots of cover crop planted by August can take nitrogen from that depth.

---- Research in Mid-Atlantic from S. Hirsh and R. Weil, Univ. Maryland

Ideal Cover Crop System

Cover Crop established prior to corn harvest

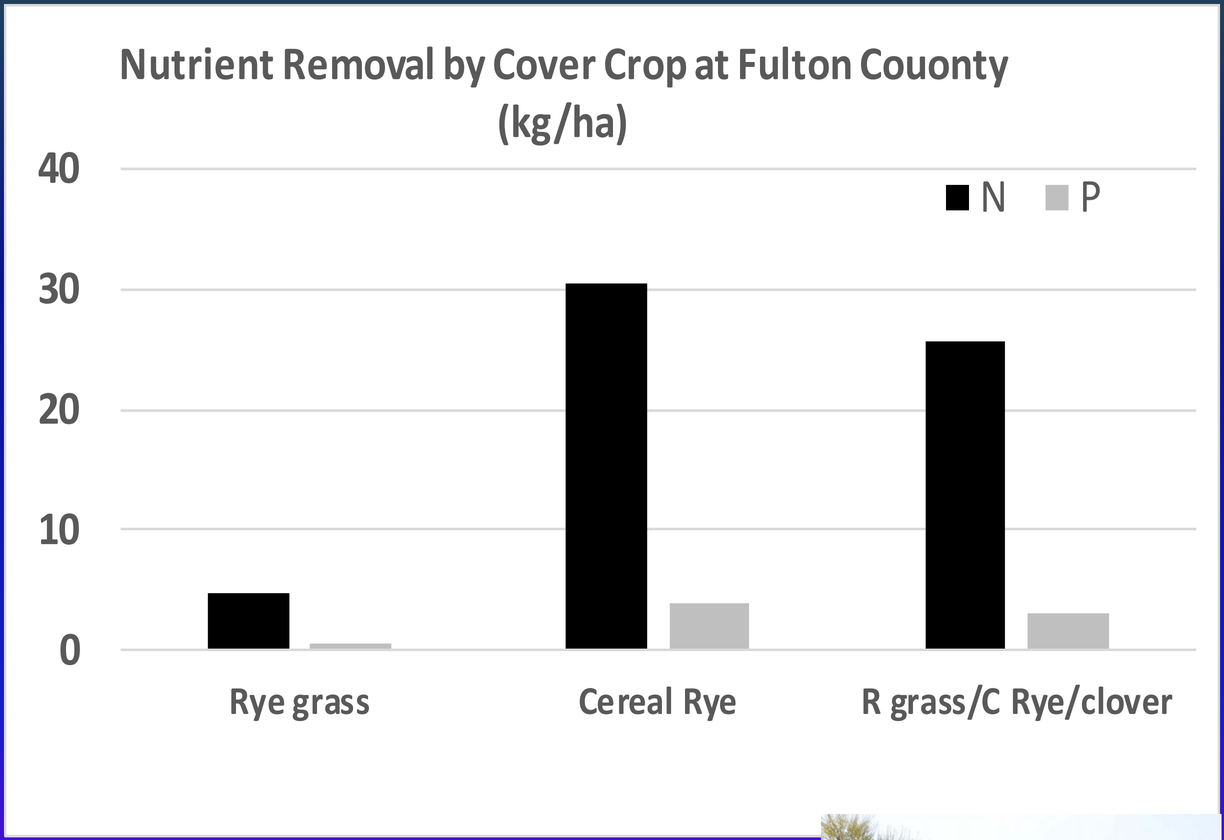
Cover Crop max-grows at off-season

Next growing season

Interseeded Cover Crops - Improved System

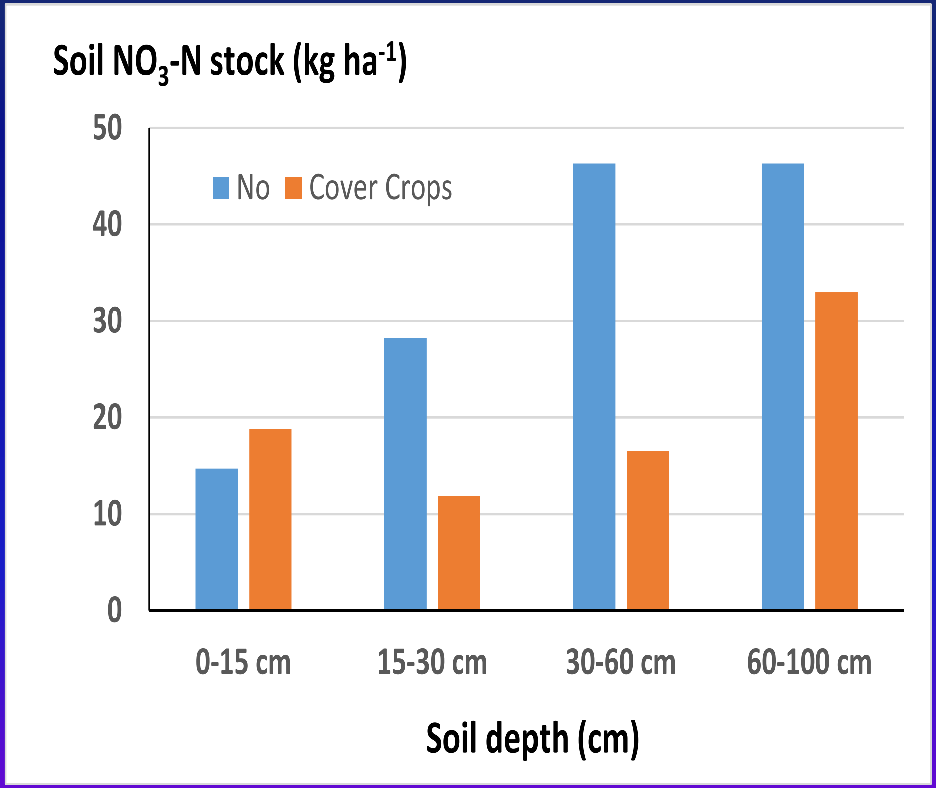
- Interseeded cover crop (cereal rye or rye grass) at 4-5 weeks after corn planting.
- The cover crop grew slowly and even remained dormant until corn harvest.
- After the corn harvest, the cover crop grew rapidly to utilize residual N and to reduce runoff.

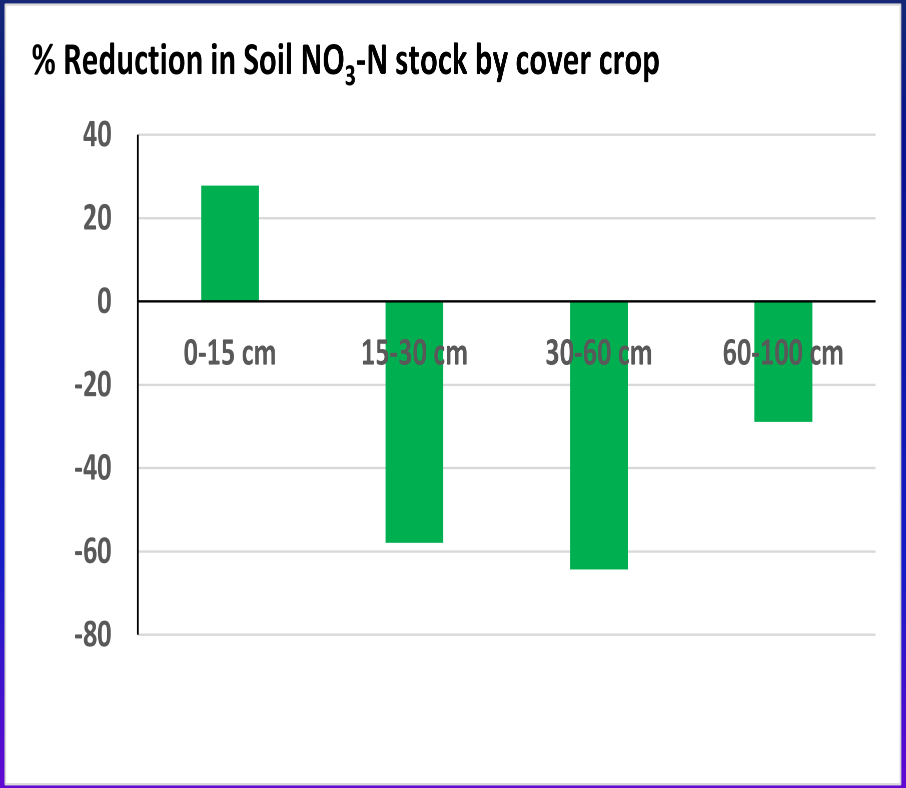
Direct Nutrient Removal via Harvest of Cover Crop in Spring



- Cover crop seeded in May under corn.
- Harvested in following April before planting soybean.

Soil Nitrate Stock in Spring with/without Cover Crop (Cereal Rye)

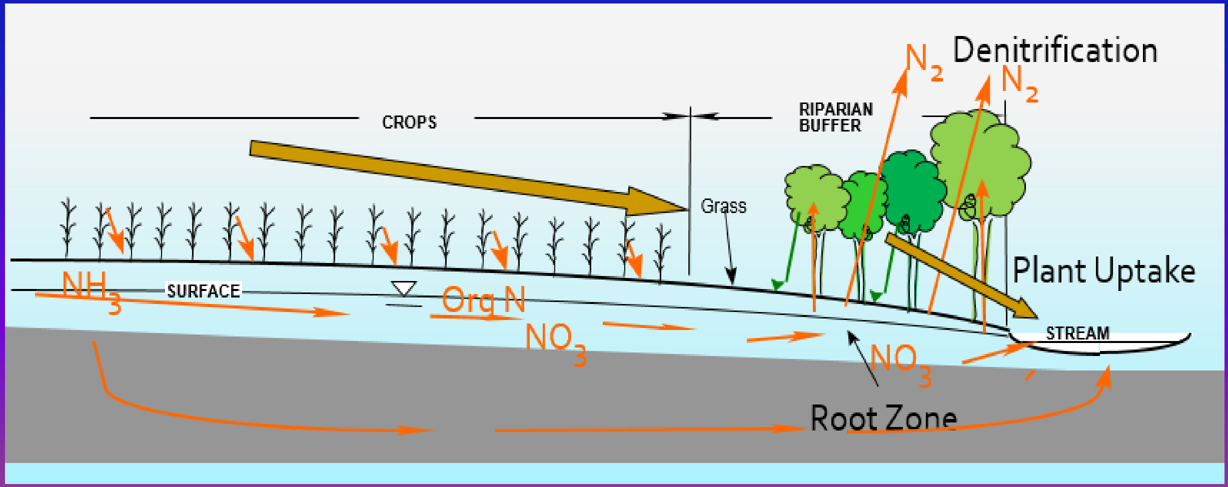




Cover Crop Extension– Collaboration with Pete Fandel, Illinois Central College

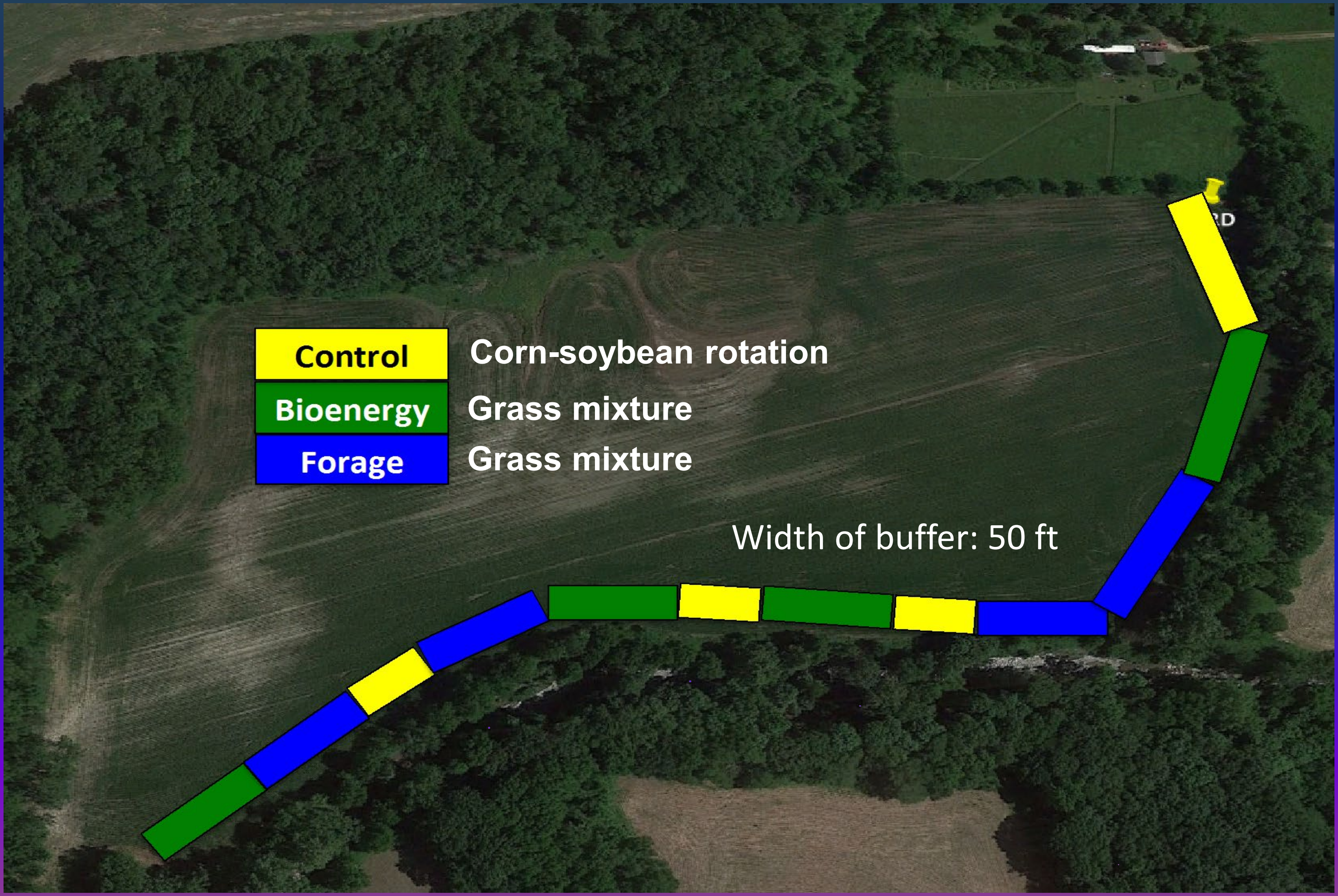
Field and Landscape Buffer

- A strip of grass growing at the field edge and/or next to the creek (riparian zone)
- The mixture of grass
  - C3 and C4 plants
  - Some deep rooting
  - Fast growing and high nutrient uptake
- Intercept runoff and sediment to reduce P loss to water
- Sequester N into soil organic matter
- Remove N by soil denitrifying bacteria
- Remove N via plant uptake
- Grass as animal feeds or for bioenergy

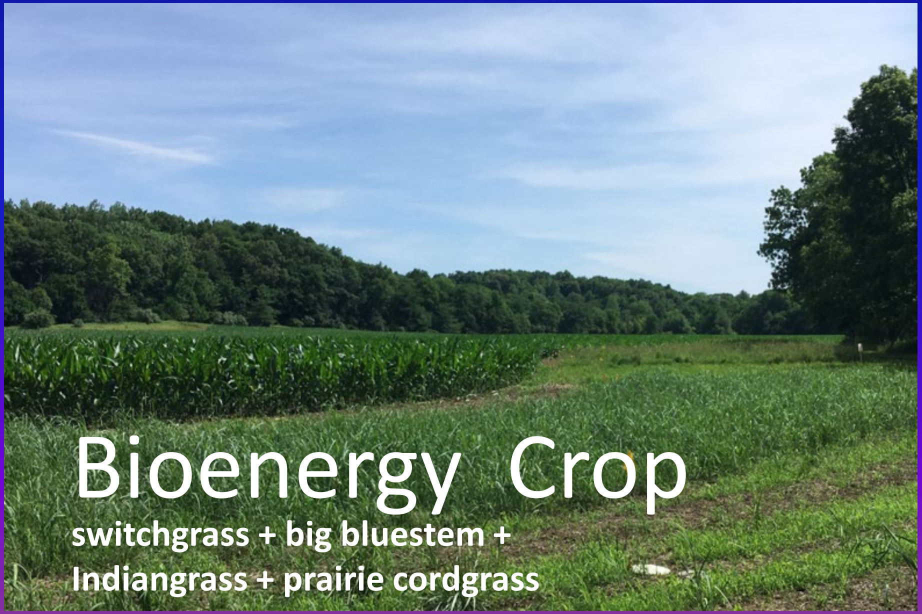


Multifunctional Grass Buffer

In Collaboration with University of Illinois at Urbana Champaign (Dr. DK Kim)

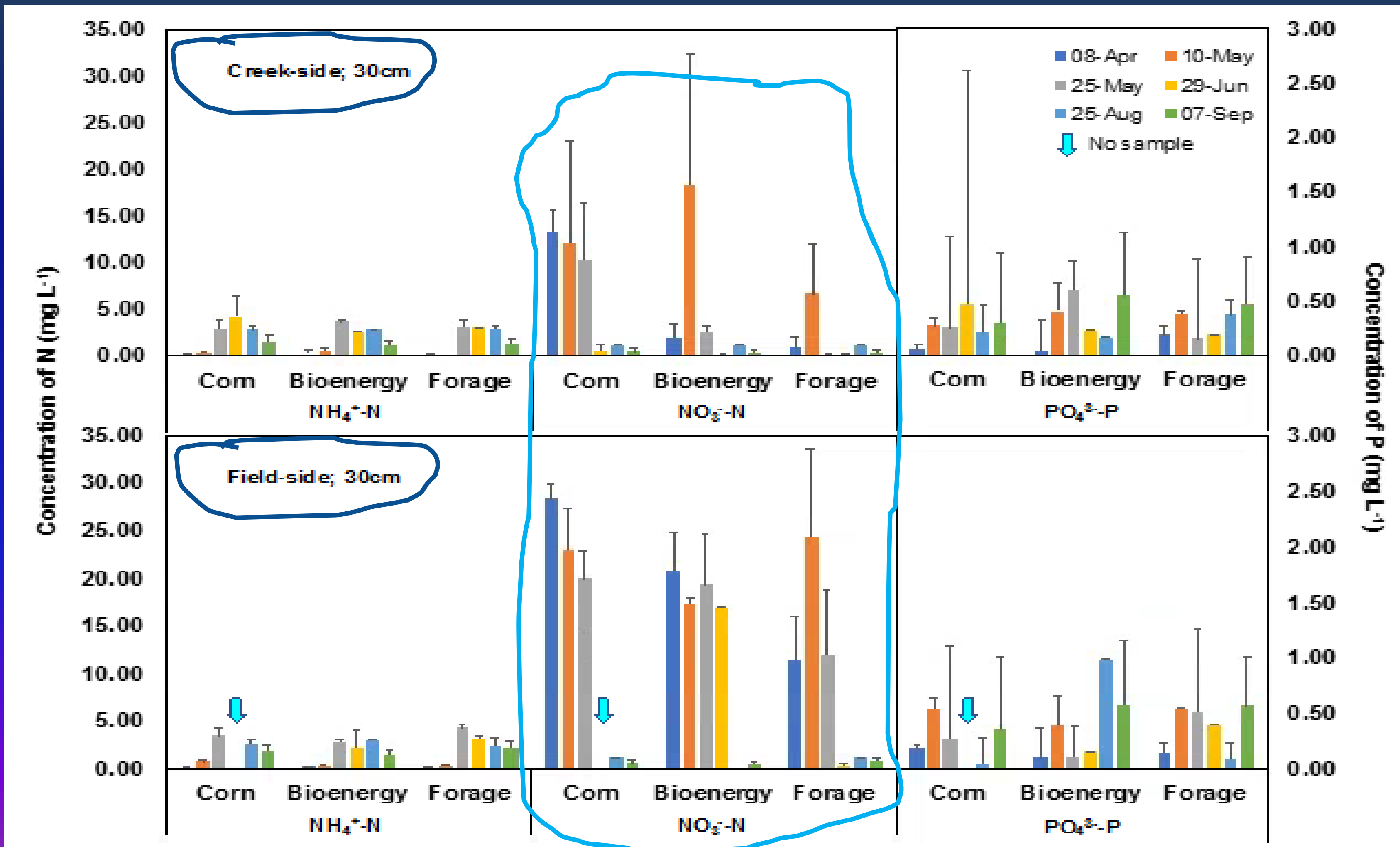


Multifunctional Grass Buffer



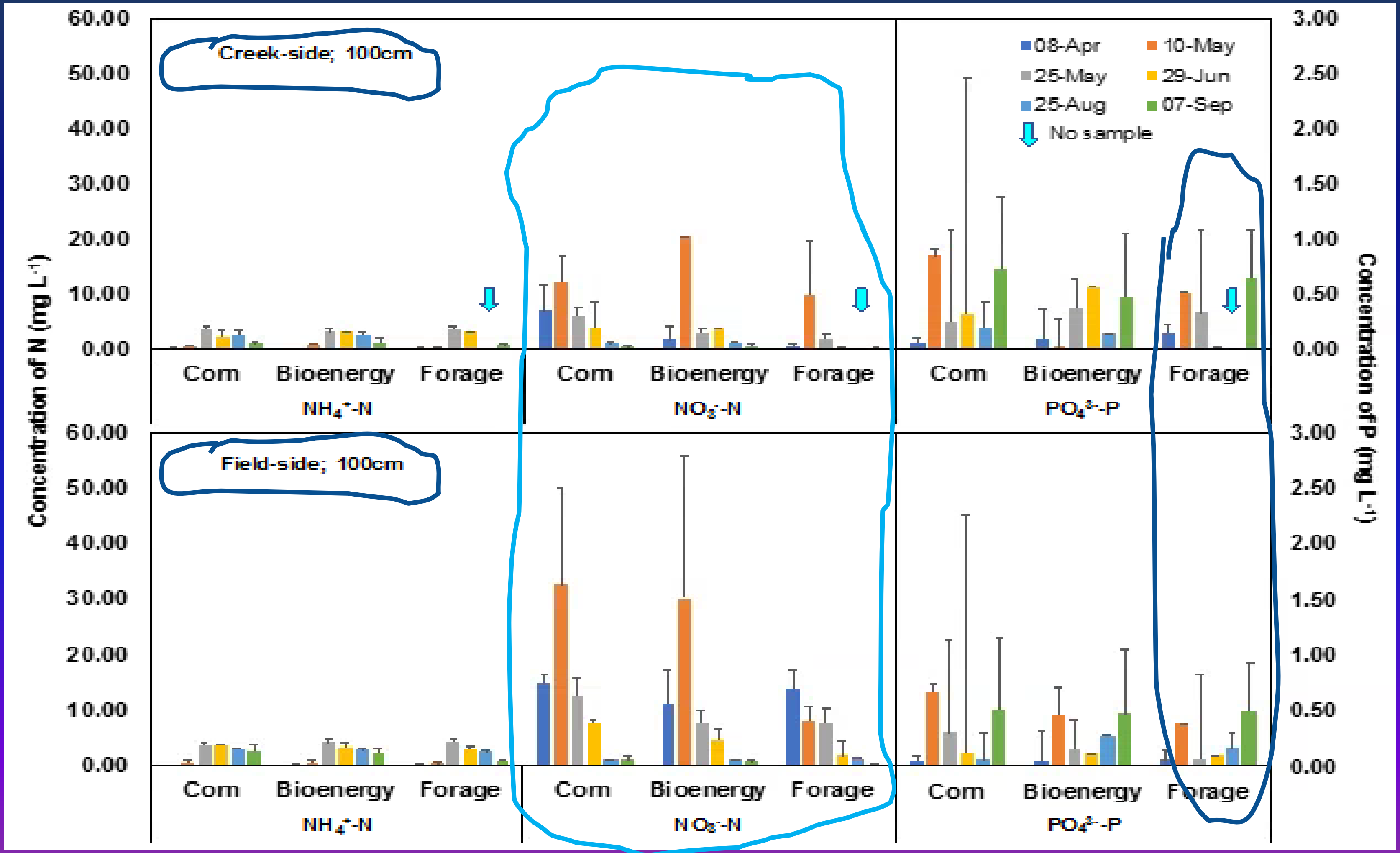
Grass Buffer on Nutrients in Soil Water (30 cm Soil Depth)

Sample: soil water leachates in buffer strip (2018)

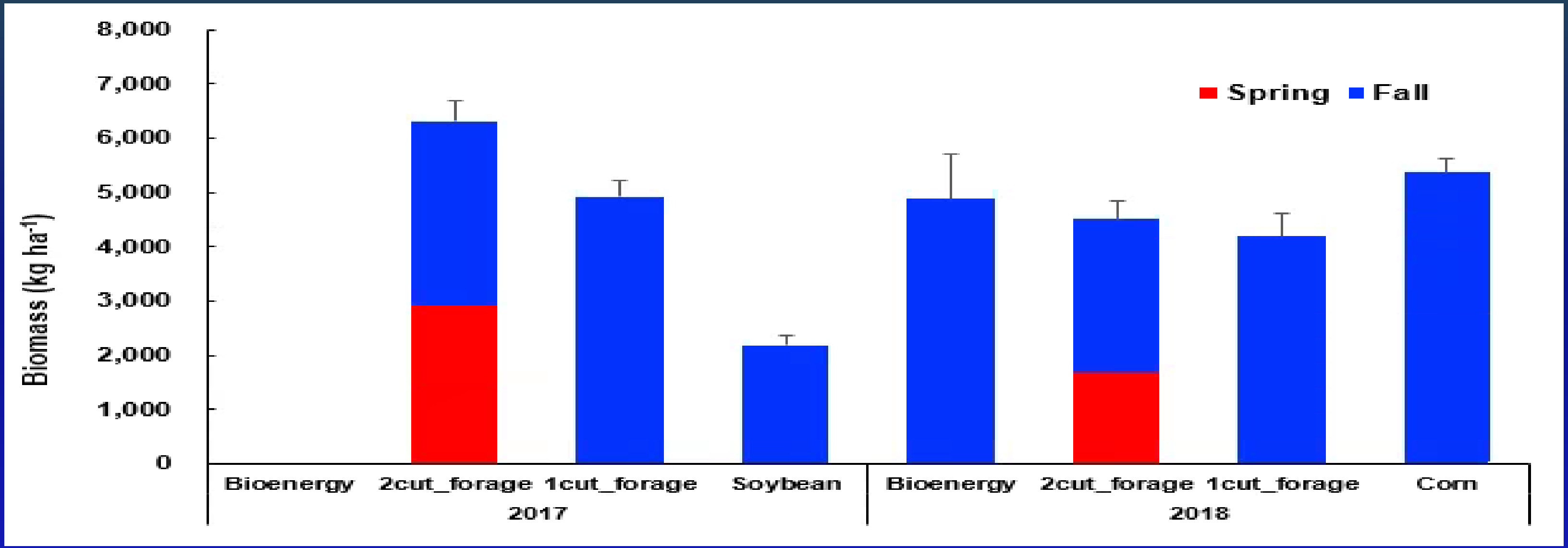


Grass Buffer on Nutrients in Soil Water (100 cm Soil Depth)

Sample: soil water leachates in buffer strip (2018)

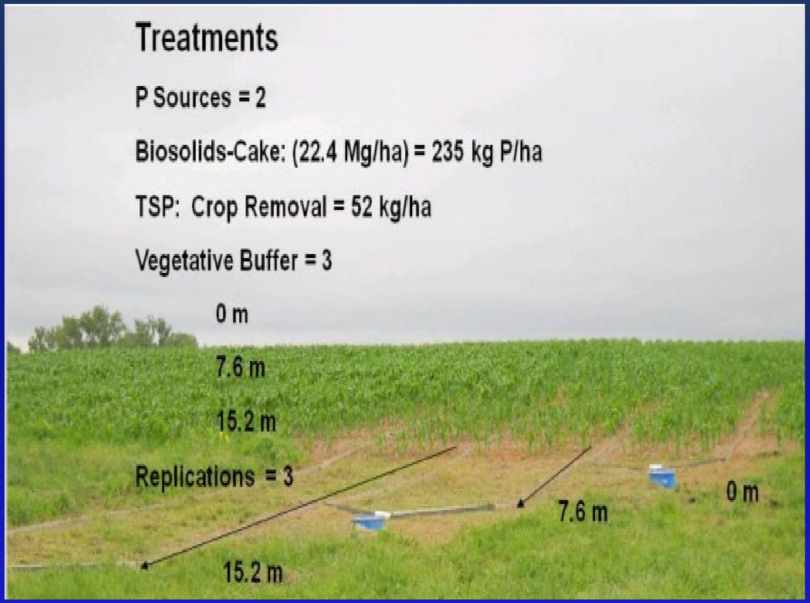


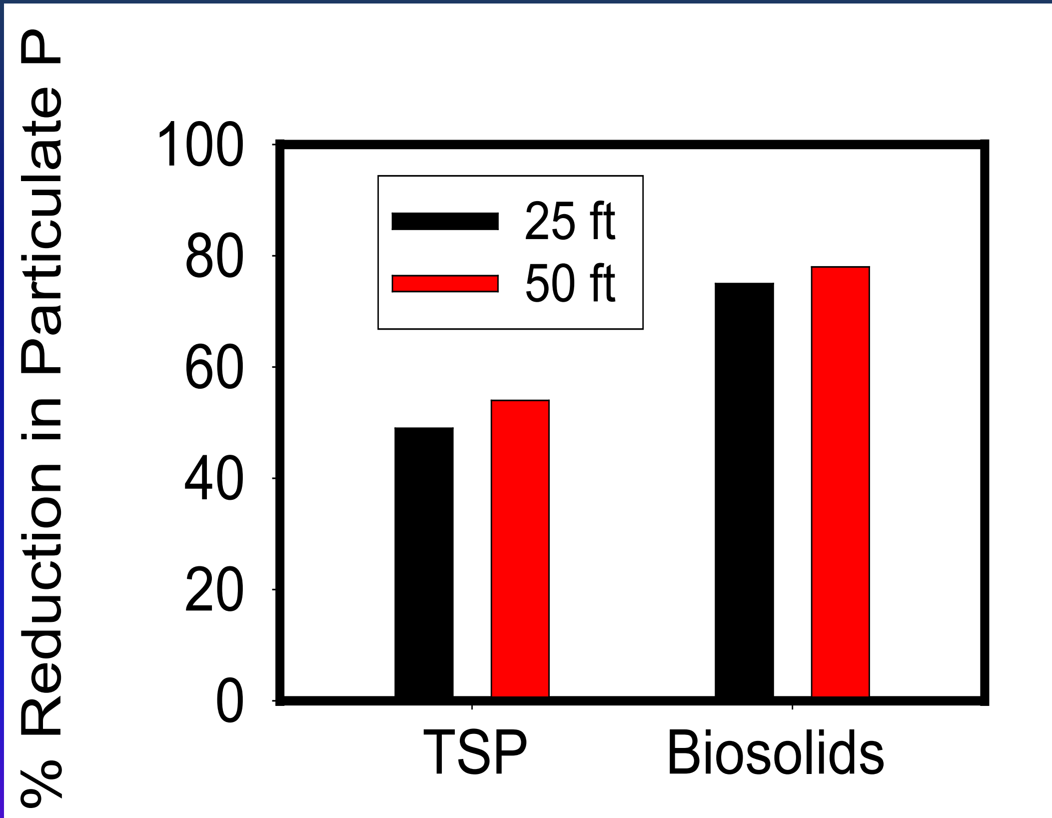
Direct Nutrient Removal by Harvest of Vegetation in Grass Buffer Zone



	N		P		K	
	2017	2018	2017	2018	2017	2018
	kg ha^{-1}					
2cut_forage	106.70	65.10	21.52	13.46	157.18	107.21
1cut_forage	85.77	52.43	15.55	10.90	107.91	85.14
Bioenergy	-	33.19	-	7.32	-	34.17

Grass Buffer on Runoff Particulate Phosphorus





Source: Kumar et al. (2018), Phosphorus Bioavailability and Control of Runoff Losses in Land Applied Biosolids. M&R Research Report.

Denitrifying Bioreactor

- Water from field drainage tiles is routed to flow through a buried trench filled with woodchips.
- Denitrifiers uses the carbon in the woodchips as their food and converts the nitrate into nitrogen gas (N_2)

NO_3^- (nitrate)

↓

NO_2^- (nitrite)

↓

NO (nitric oxide)

↓

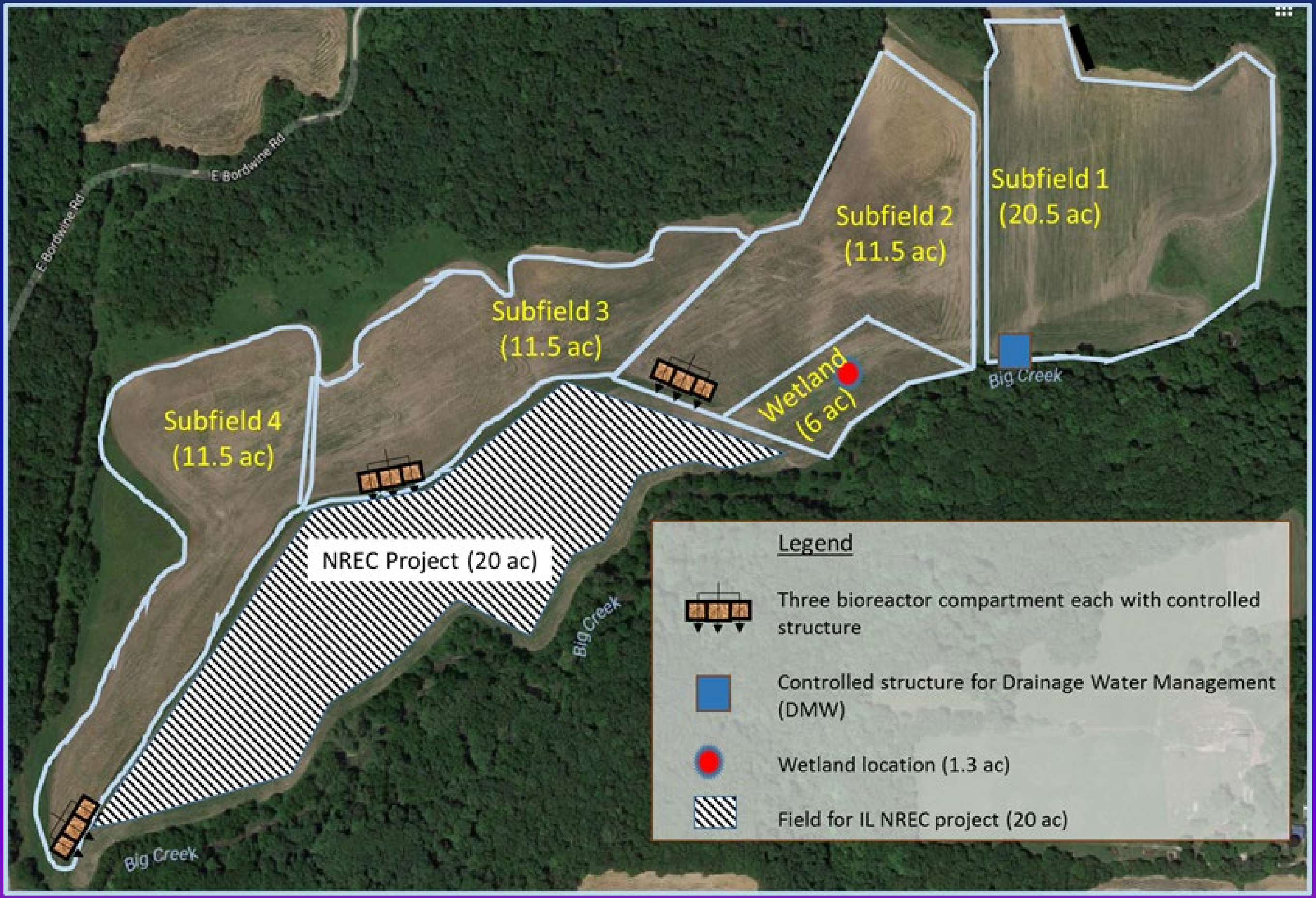
N_2O (nitrous oxide)

↓

N_2 (nitrogen gas)

Denitrifying Bioreactors at 80-acre Field

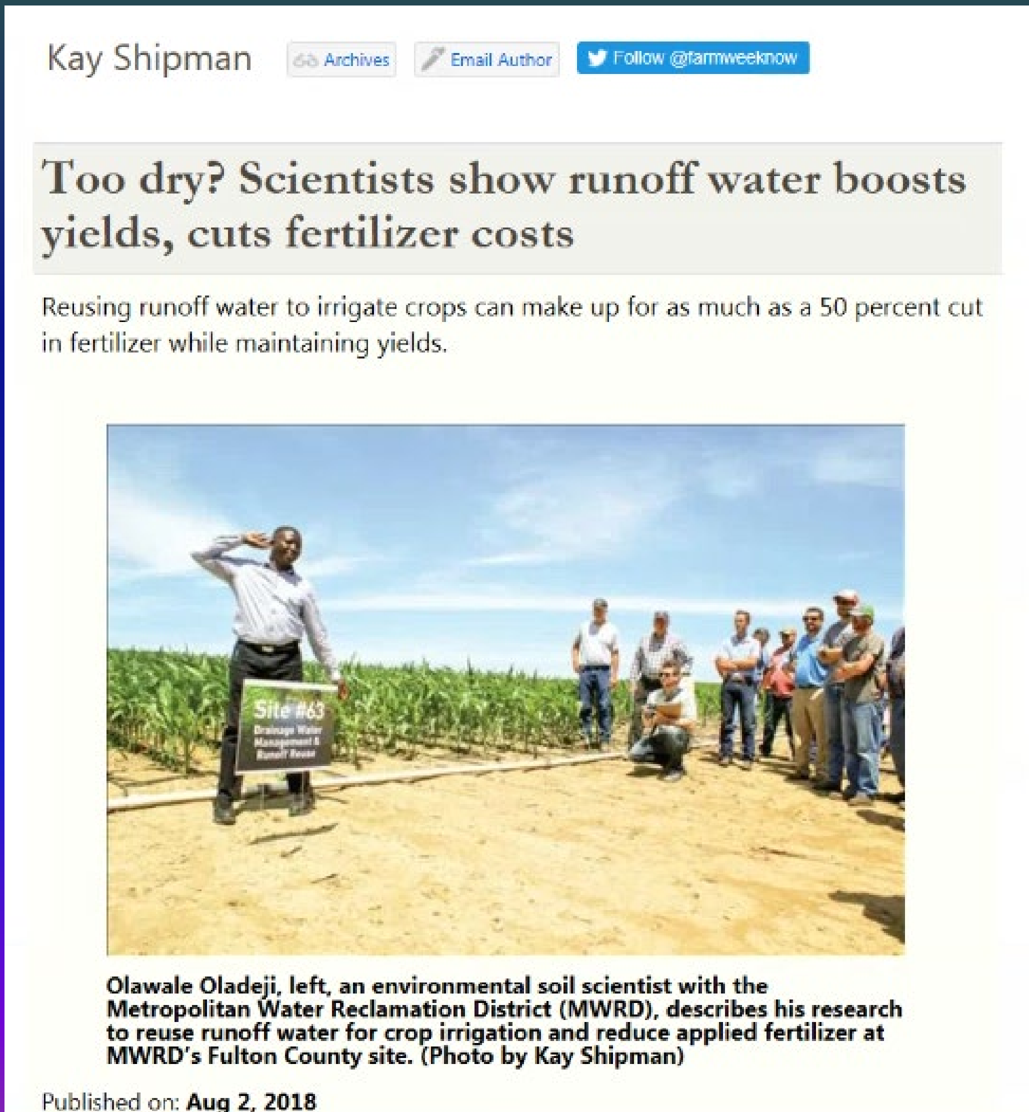
Collaboration with Dr. R Cooke of UIUC



Denitrifying Bioreactors - Sampling

- Weekly sampling until the system stabilizes, then bi-weekly sampling.
- Analyze for NO_3-N and PO_4-P.
- Data will be analyzed in the summer this year.

Runoff Irrigation



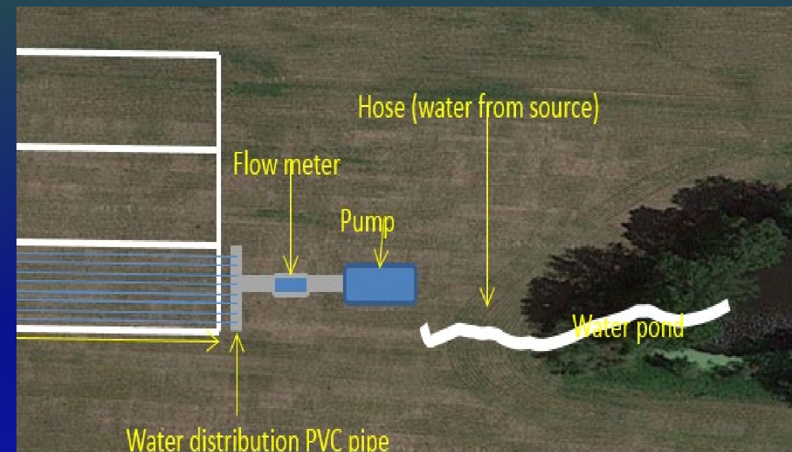
Kay Shipman Archives Email Author Follow @farmweeknow

Too dry? Scientists show runoff water boosts yields, cuts fertilizer costs

Reusing runoff water to irrigate crops can make up for as much as a 50 percent cut in fertilizer while maintaining yields.

Olawale Oladeji, left, an environmental soil scientist with the Metropolitan Water Reclamation District (MWRD), describes his research to reuse runoff water for crop irrigation and reduce applied fertilizer at MWRD's Fulton County site. (Photo by Kay Shipman)

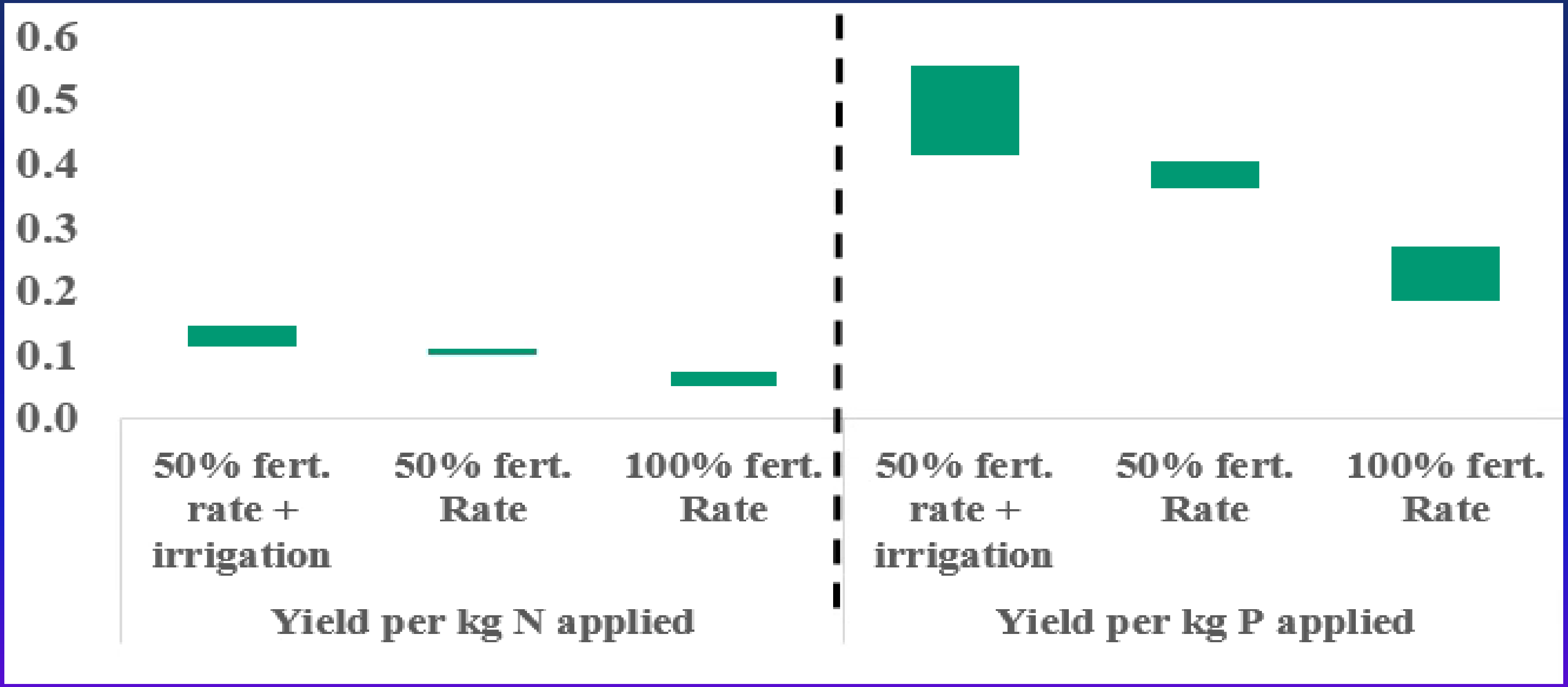
Published on: **Aug 2, 2018**



- Field runoff and/or drainage water collected in a retention basin pumped back for irrigation.
- Soil moisture improvement by irrigation supports greater utilization of fertilizer by corn.

Runoff Irrigation

Nutrient use efficiency (NUE) of corn estimated as corn total biomass per kg of N and P applied



- **Nutrient removal by corn harvest: about 18.7 lb N/ac and 2.9 lb P/ac higher with than without runoff irrigation**

Paired Watersheds Water Monitoring

Progress:

- Background monitoring (2016-2018) to get a coefficient that can represent/explain the exiting difference between two fields in nutrient loss along with surface water.
- From 2019, BMP installed in one field (treatment field) to monitor the impact of BMP on surface water nutrient loss with background difference as co-variable.
- The large-scale measurement of BMP’s effectiveness can also be used as information to facilitate future nutrient trading.

Collaboration - Ag Partnership Development






Established Partnerships with

Drainage Water Management/Reuse

Richard Cooke, University of Illinois at Urbana-Champaign
Alex Echols, Ecosystem Services Exchange, Iowa.

Extension-Cover Crop

Peter Fandel, Illinois Central College

Multifunctional Grass Buffer

DoKyoung Lee, University of Illinois at Urbana-Champaign
Thomas Voigt, University of Illinois at Urbana-Champaign
Gary A. Letterly, University of Illinois at Urbana-Champaign

Phosphorous Adsorption by Designer Biochar

Wei Zheng, Illinois Sustainable Technology Center (ISTC), University of Illinois at Urbana-Champaign

Field Day


fieldDAY
Brought to you by several partners:
FULTON COUNTY FARM BUREAU.
Farm. Family. Food.
ILLINOIS FARM BUREAU.
Farm. Family. Food.
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Fulton County Farm Bureau

Summary and Forward-Looking

- Projects, including cover crop, multifunctional grass buffer, denitrifying bioreactors, runoff and sub-irrigation for contributing to the Illinois nutrient loss reduction goal established at the Fulton County.
- Data obtained so far show early planting of cover crop through interseeding enabled cover crop to extract NO_3^- at lower soil depths, reducing N loss with spring drainage.
- Forage and bioenergy grass buffer reduced nutrient load in soil profile at field edge, thus, less N and P could move to the creek.
- Irrigation of runoff collected from agricultural fields improved the use efficiency of fertilizer N and P, reducing the rate of fertilizer application.

Summary and Forward-Looking (cont'd)

- Scheduled sampling of inlet and outlet of drainage associated with bioreactors and subirrigation are on-going.
- To generate the interest of farmers to BMPS, research needs to accelerate the development of viable cropping systems for greater economic return.
- Conduct large-scale of reusing field tile-drain water as proposed by ESE for wide impact (possibly reduce 50% fertilizer need in Midwest farming, save $$$ + NLR).
- Work with various Ag collaborators to dissimilate BMP information to producers; The good adoption of BPMs by farmers would potentially reduce the burden on the District to reduce nutrient loads discharged from the water reclamation plants for meeting statewide nutrient reduction goals.

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- Laurie Wilcoxen (Fulton County)

Biosolids Utilization and Soil Science Section

- Jacob Baylor (Fulton County)
- Rosali Swango (Fulton County)
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- Richard Adams
- Jeff Simpson
- Daniel Dreger
- Lab personnel (Mina Patel, Maricela Sabido, Andy Scott, Shawn Kowaski, Tiffiany Tate)

Questions?

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