The Role of Perennial Energy Crops for Biofuels in Reducing Gulf Hypoxia

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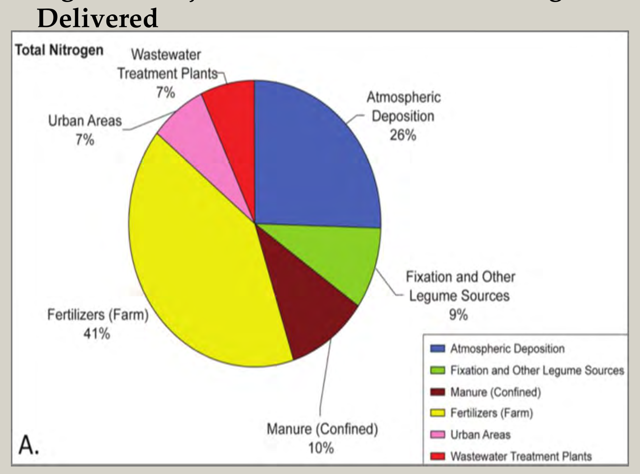
Hypoxia in the Gulf

- Hypoxia in waters describes a condition of low dissolved oxygen that affect aquatic life and water quality
- Gulf of Mexico has the 2nd largest hypoxic zone in the world (Khanna, 2017)
- The size of Gulf hypoxic zone in the summer of 2017 equaled that of New Jersey (Khanna, 2017)
- Gulf hypoxic zone is primarily attributed to nutrient loads from agricultural sources

Agriculture and Hypoxia in the Gulf

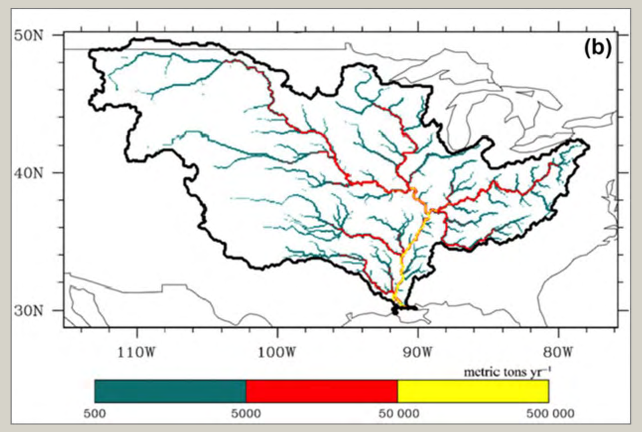
- Fertilizer application and tillage are major factors of nutrient run-off in Mississippi-Atchafalaya River Basin (MARB)
- MARB contributes 80% of delivered nitrogen; >60% of delivered phosphorus to the Gulf of Mexico (white et al 2014)

Figure 1: Major contributors of total Nitrogen Delivered



Source: Robertson and Saad, 2013

Figure 2: Annual Nitrogen Delivered to the Gulf of Mexico



Source: VanLoocke et al, 2017

Demand for Food and Fuel Affect Gulf Hypoxia

Donner et al. (2008) shows how increased corn ethanol to meet fuel targets can contribute to nitrogen leaching in **MARB**

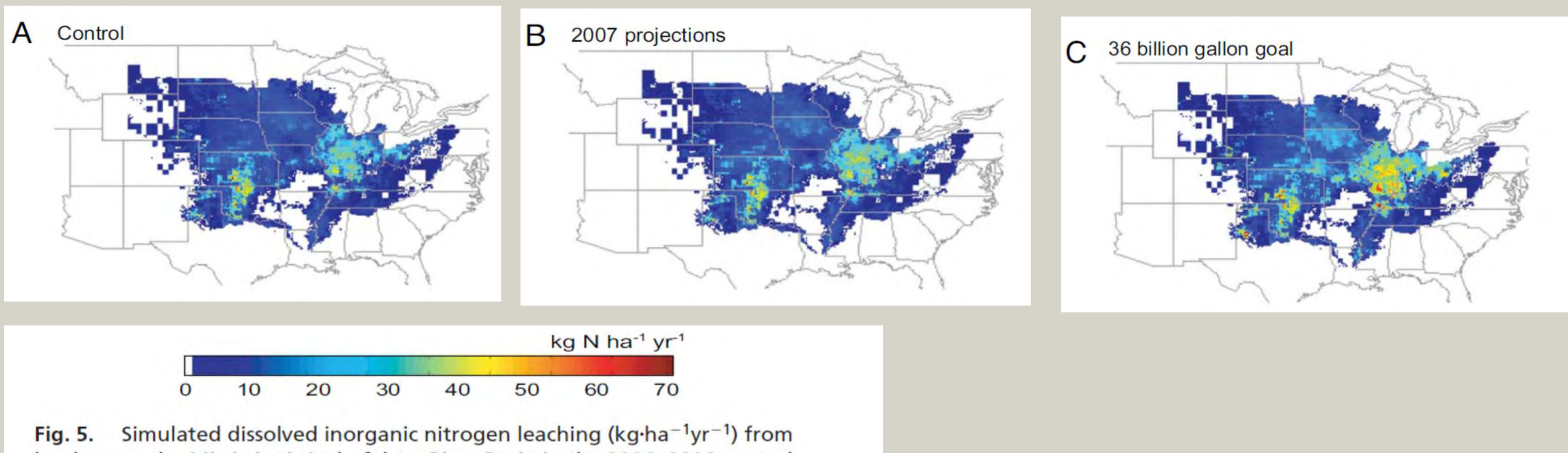


Fig. 5. Simulated dissolved inorganic nitrogen leaching (kg·ha^{-1}yr^{-1}) from land across the Mississippi–Atchafalaya River Basin in the 2004–2006 control (*A*), the 2007 projections (*B*), and the 36 billion gallon goal scenario (*C*).

Source: Adapted from Donner et. al 2008

Strategies for Meeting the Demand for Food and Fuel with Reduced Nutrient Run-off

- Improved agronomic practices and efficient fertilizer use
  - Reduced Tillage; Riparian buffers
  - Conservation Reserve Program
  - Fertilizer management: timing, rate & method
  - Switching from annual to perennial crops (Khanna, 2017)

Least cost approach to reduce size of hypoxic zone by 60% would cost $2.7 billion annually (Rabotyagov et. al., 2014)

- Require large coverage of improved agronomic practices and fertilizer management in Mississippi River Basin
- Average cost of $62 per acre

Potential of Perennial Energy Crops to Provide Renewable Energy and Reduce Nutrient Loss

Key Attributes

- Low input requirements
- High yielding
- Can be grown on low quality land
- Ability to accumulate belowground carbon
- Reduce nitrogen leaching compared to corn/soybean rotations
  - Replacing 40% of land under corn with miscanthus or switchgrass reduces N run-off by 5-15% (VanLoocke et. al., 2017)

Energy Crops Reduce Nitrate Run-off Compared to Corn

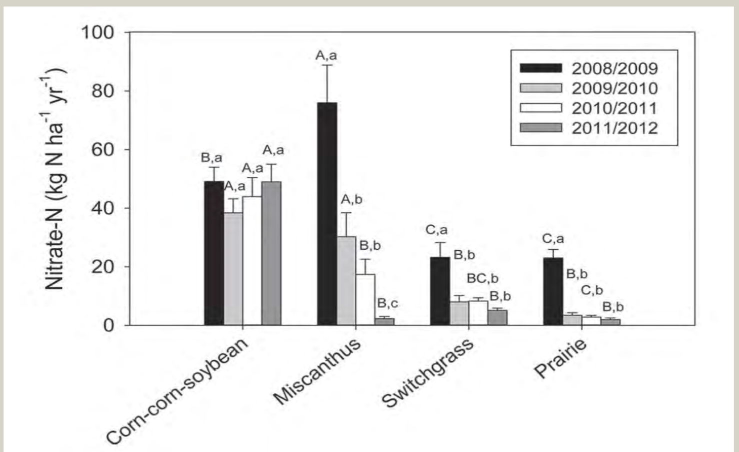


Fig. 1. Annual nitrate N leaching (April to April) at 50 cm soil depth using resin lysimeters for all biofuel crops (mean ± SE). Means by year across crop types with the same capital letter are not significantly different at the 0.05 level. Means by crop type across years with the same lowercase letter are not significantly different at the 0.05 level.

Smith et al 2013

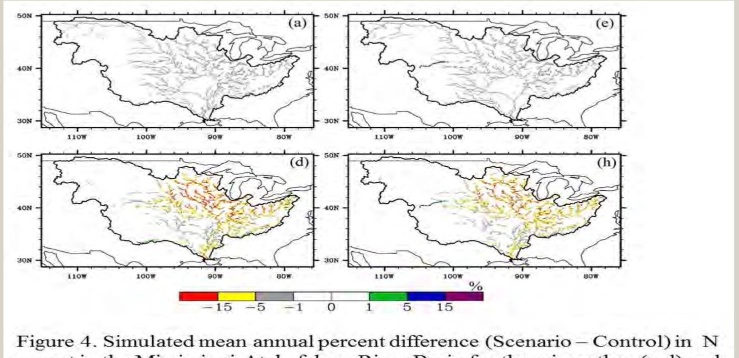


Figure 4. Simulated mean annual percent difference (Scenario – Control) in N export in the Mississippi-Atchafalaya River Basin for the miscanthus (a,d) and switchgrass (e, h) scenarios at 5% (a,e) replacement levels and at levels where 40% of maize is replaced by miscanthus (d) or switchgrass (h) for the 33-year period spanning 1970 to 2002 (Vanloocke et al., 2016).

Source: VanLoocke et al, 2017

Barriers to energy crop adoption

- High establishment cost
- High cost of conversion to biofuels
- High opportunity cost of land

Policy Incentives Needed

- Biofuel mandate
- Biomass Crop Assistance Program
- Payments/taxes for nitrate run-off reduction
- Energy crop insurance

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IOWA STATE UNIVERSITY Department of Agronomy

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research under Award Number DE-SC0018420.

U.S. DEPARTMENT OF ENERGY

Plantwide Integration of Struvite Crystallization Processes with Kinetics Based Dissolution

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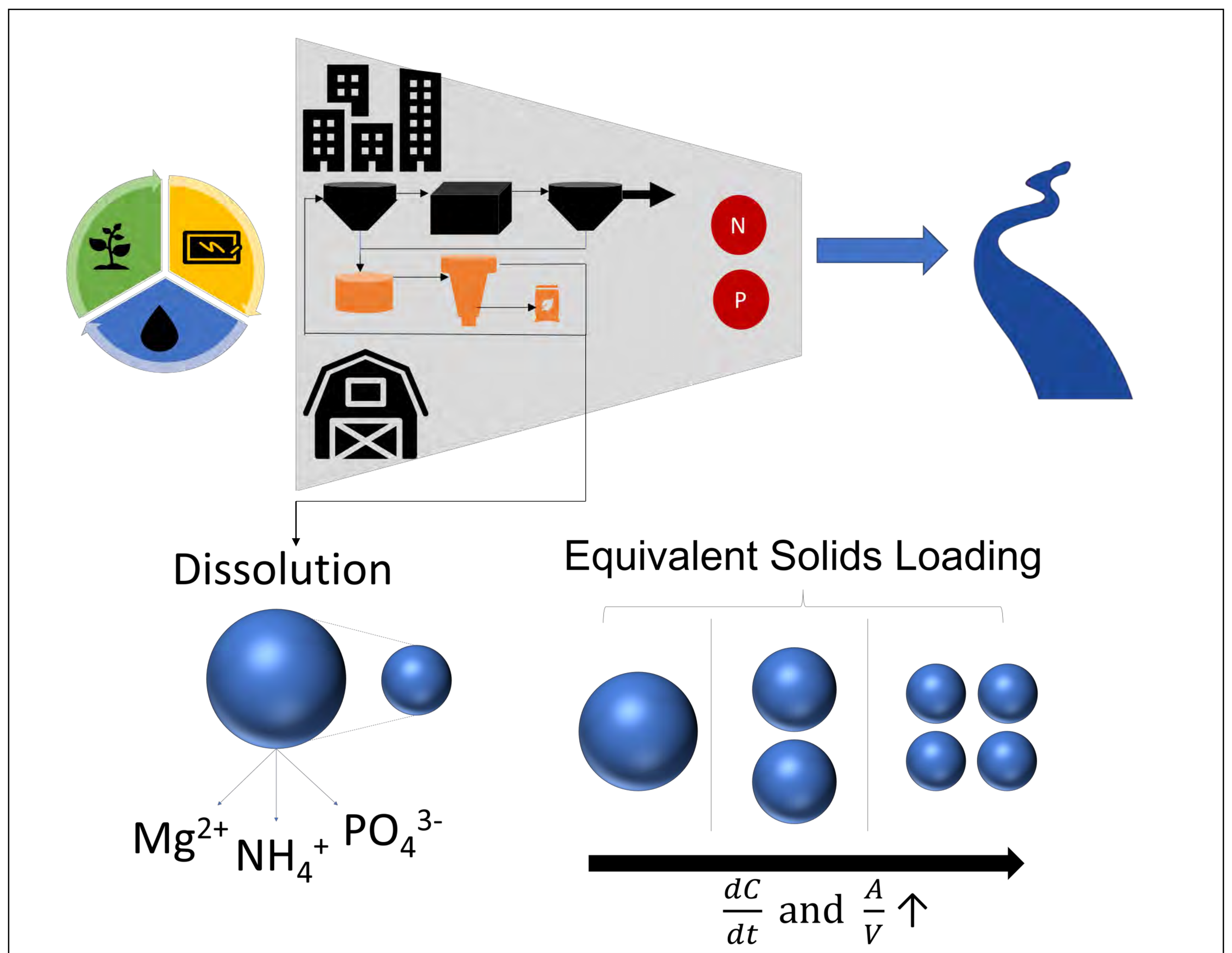
Abstract



Objectives

- Understand the phosphorus (P) mass flows for municipal wastewater water treatment plants (WWTP) for differing sizes, influent compositions, and process configurations.
- Determine field recovered struvite dissolution rate constant to understand the hidden failure of fines production.
- Integration of kinetics based dissolution processes with plantwide modelling.

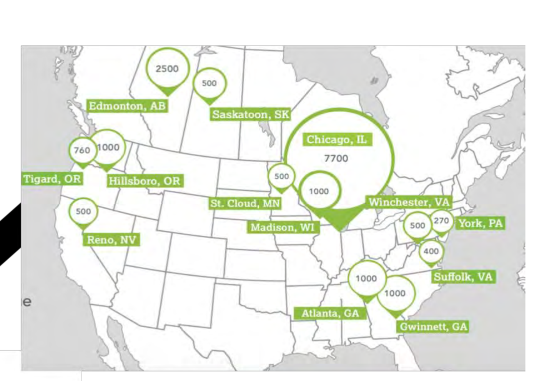
Background

To reduce the contribution of point-source nutrient discharge to major U.S. coastal hypoxic zones water resource recovery facilities (WRRFs) are facing increasingly stringent regulations of P in treated effluent. Enhanced Biological Phosphorus Removal (EBPR) combined with controlling phosphate mineral formation within crystallization reactors is gaining momentum as an efficient means of reducing nutrient cycling and scaling potential, while also offsetting operating costs through the sale of recovered fertilizer. To fully realize plant specific benefits associated with sidestream P removal, precipitation reactors must be designed and operated to not only convert soluble P to struvite but also collect all of the solids that form.

Though models have been developed for many common WRRF processes, characterizing struvite ($MgNH_4PO_4 \cdot 6H2O$) recovery potential for varying plant sizes and configurations has not been well explored. Determining struvite recovery under differing conditions allows informed decision making for implementation at WRRF based on struvite recovery and P removal. Another underlying issue in struvite crystallization process models is the absence of fines loss from crystallization reactors and dissolution in the process chain. Unfortunately, modelling dissolution along the process train is not commonplace because of the limited data surrounding pure and field grown struvite's dissolution rate. No data has been reported for the dissolution rate of struvite seeds from full-scale fluidized bed reactors in the literature. Integrating struvite dissolution kinetics in struvite crystallization process models will demonstrate the effects of dissolution on overall plant function.

Operating Ostara Facilities in United States

- 10 Ostara reactors installed in the United States since 2005 demonstrating the need for confidence in modelling P removal and recovery.
- The majority of struvite loss in fluidized bed reactors (FBR) comes from the production of fines.
- Dependency on fines makes accurately modeling FBRs difficult.



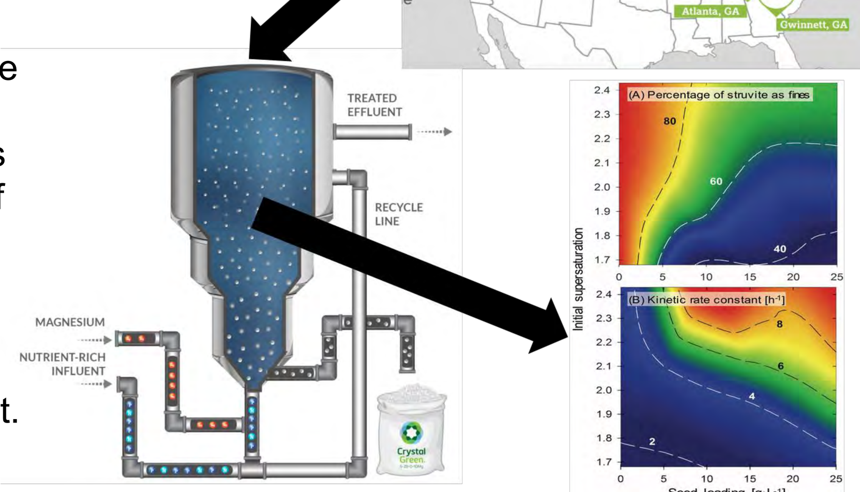


Fig. 1. Map of current struvite recovery facilities operated by Ostara and the experimental fines production in fluidized bed reactors.

Methods

Plant-Wide Modeling

- Modeled municipal waste treatment systems using GPS-X software.
- Base plant follows treatment from primary clarifier, biological treatment, and secondary clarifier with sludge thickening and/or anaerobic digestion solids handling.
- P removal and recovery is assessed comparing the base with 5-stage bardenpho enhanced biological phosphorus removal (EBPR), side-stream ferric chloride ($FeCl_3$) addition and struvite precipitation.
- Conducting Monte Carlo simulations of varying wastewater influent characteristics using MATLAB tracking the total P effluent concentration, P mass flows throughout the plant, and struvite production.

Parameter	Range	Units
Flow	0.1-50	MGD
Total P	3.5-20	mg/L
Total TKN	20-80	mg/L
Total COD	10-20	mg/L
Ortho-P	3.5-20	mg/L
Total K	3.5-20	mg/L
Total Ca	3.5-20	mg/L
$FeCl_3$ Addition	0-10	Kg/d
$MgCl_2$ Addition	0-10	m^3/d

Table 1. Model influent parameter ranges applied to each WRRF configuration assessing the P removed and recovered as struvite.

WRRF Configurations

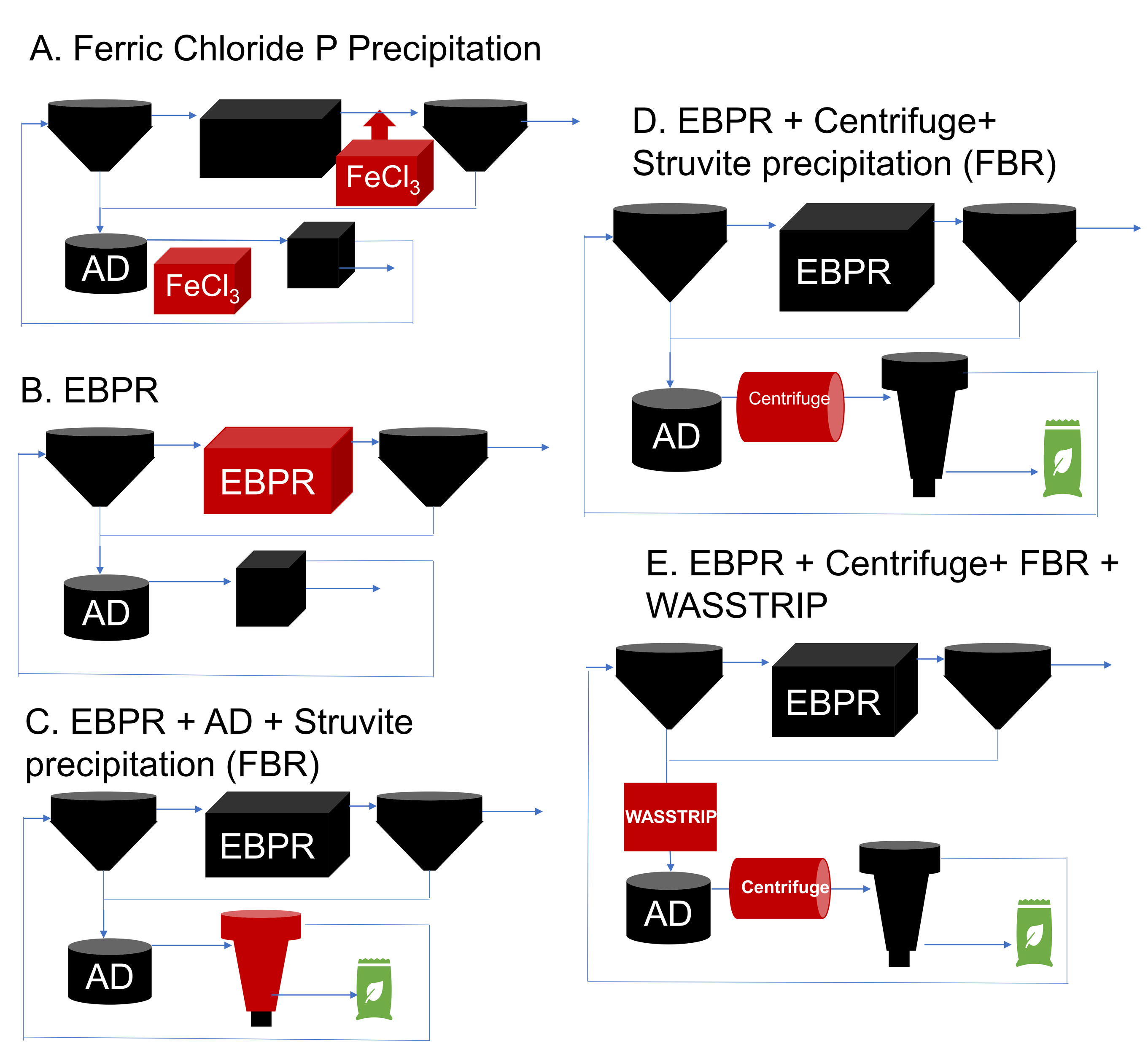


Fig. 2a-e. Treatment configurations modeled in GPS-X to achieve P removal and recovery representative of WRRF within the United States.

Struvite Dissolution

- 300 mM aqueous Tris buffer acidified to pH 7.5 with HCl
- Solvent is degassed with N_2 to remove any CO_3^{2-}
- 450 mL total solvent volume
- Ionic Strength nearly constant at 0.25 M
- 10 g/L solids loading
- Seed diameters range from 0.9 to 4.5 mm
- Temperature = 21.5 C
- 2 mL sample taken every 10 min for IC analysis (ortho-P)
- Ca^{2+} and NH_4^+monitoring
- (5 sec interval) with ISEs

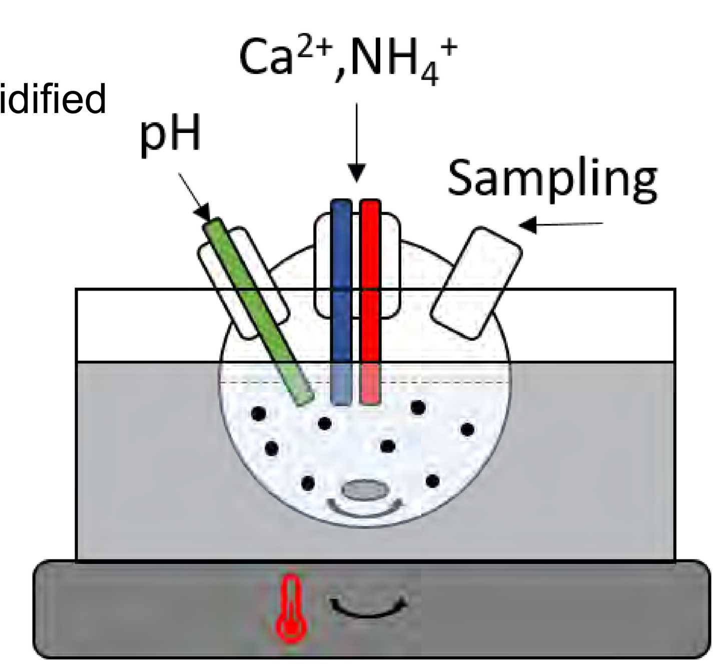


Fig. 3. Dissolution apparatus. The pH probe shown is only inserted at t = 0 min and t = 60 min to check for pH drift.

Shrinking Object Model

The dissolution reaction was modelled using the linearized shrinking object model as follows,

$$-\ln\left(1-\frac{c}{c_{sat}}\right) = k * \frac{A}{V} t$$

Where c and c_{sat} are the concentrations of orthophosphate in solution and at equilibrium respectively, k is the rate constant , A the total surface area of the solids, and V the volume of the solution.

Given the high solids loading in the reactor and limited dissolution measured (see figure 4), it was assumed A was constant. Over the course of the experiment 14 mL is removed leading to a ~3% change in volume – because of this V was assumed constant.

Solution Chemistry Simulation

Visual MINTEQ 3.1 was used to simulate the solution chemistry at equilibrium in the dissolution reactor. This step was necessary to estimate c_{sat}.

Results

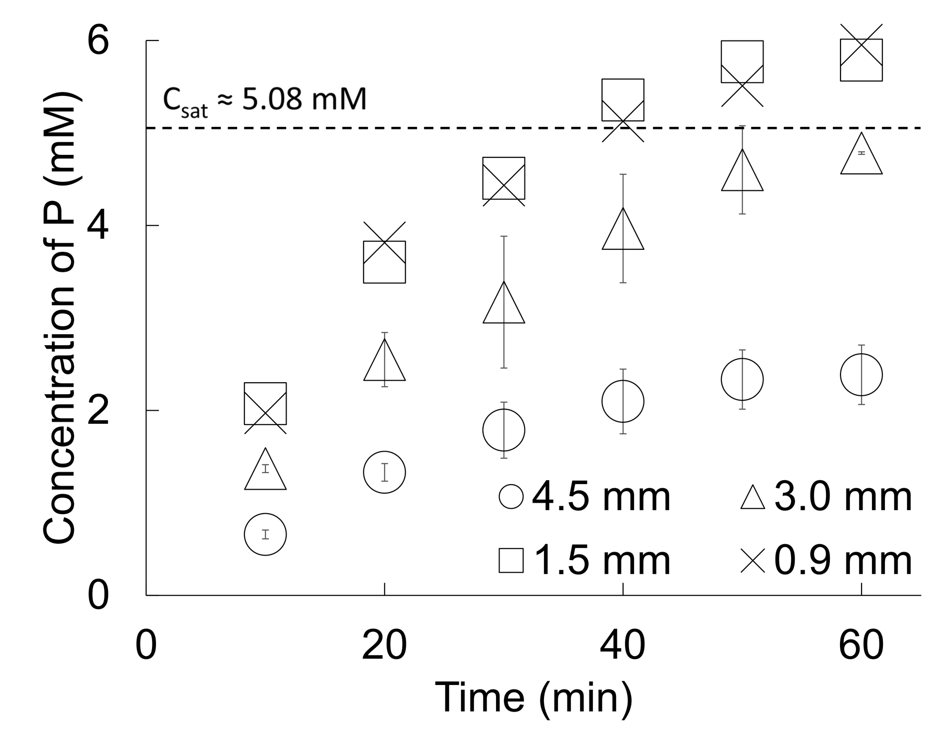


Fig. 4. P release during dissolution. Both 0.9 mm and 1.5 mm are single run data sets.

Seed Diameter (mm)	Final Ca^{2+} Conc. (mM)
4.5	0.026
3	0.035
1.5	0.036
0.9	0.037

Table 2. Ca^{2+} concentrations measured at t = 60 min.

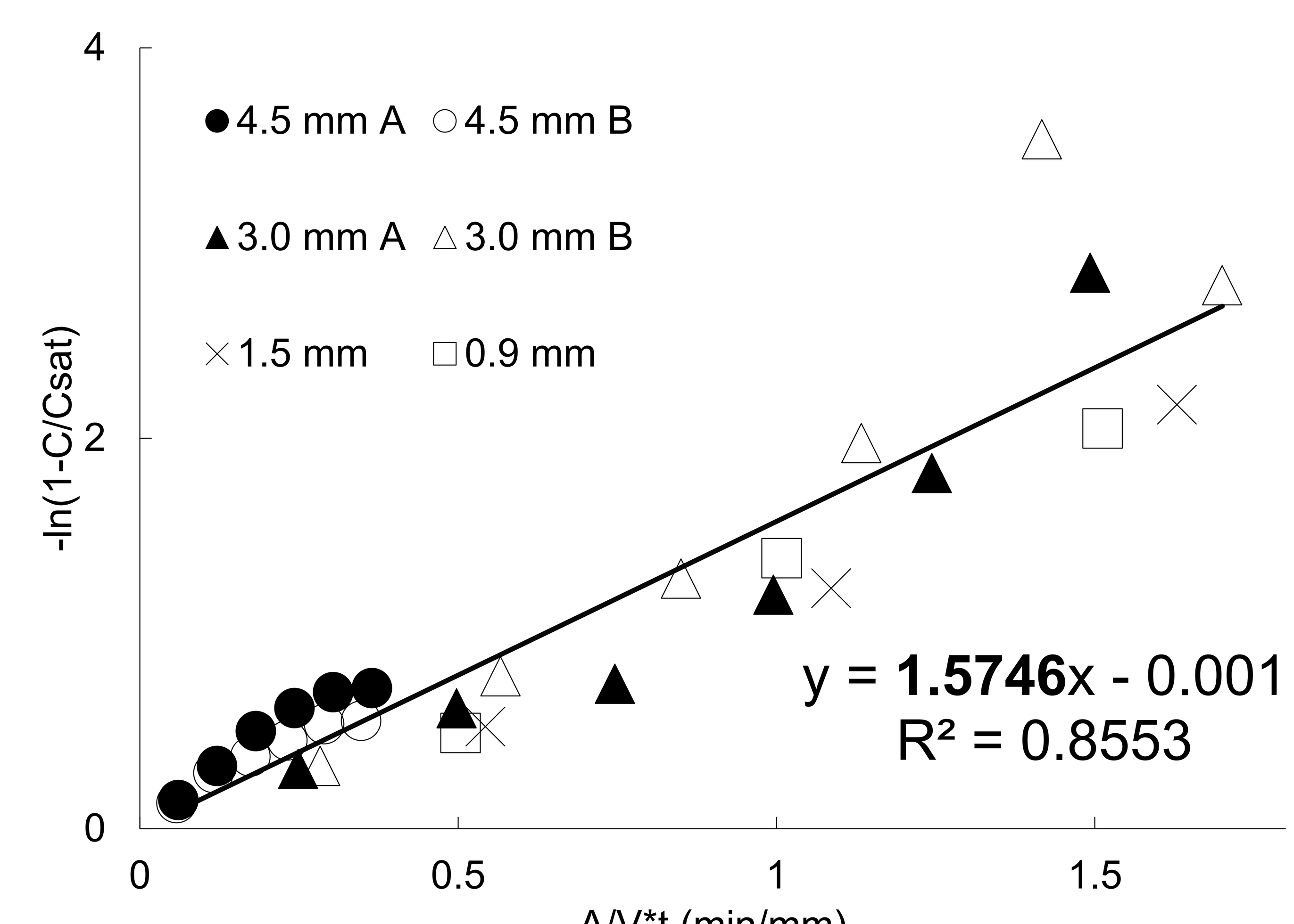


Fig. 5. P dissolution fit according to the linearized shrinking object model. The slope of the line of best fit is the dissolution rate constant of field recovered struvite seed crystals.

Conclusions

- The dissolution rate constant k of field recovered struvite is 1.57 mm/min and appears to be size independent as predicted by the shrinking object model
- Underestimation and differences in C_{sat} seen in figure 4 are likely due to compositional differences in different size seeds and the presence of organic ligands
- Calcium phosphates are not a major contributor of soluble P in field recovered struvite at the time scales studied (60 min)

Future Work

- Determine k for pure struvite and at various WRRF relevant temperatures.
- Determine the inorganic composition of field recovered struvite
- Build out life cycle costing and environmental assessment of plant wide models.

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Citation: Agrawal, S., Guest, J. S., & Cusick, R. D. (2018). Elucidating the impacts of initial supersaturation and seed crystal loading on struvite precipitation kinetics, fines production, and crystal growth. Water research, 132, 252-259.

Funding Source: NSF Award Number:1739788, INFEWS/T1: Advancing FEW System Resilience in the Corn Belt by Integrated Technology-Environment-Economics Modeling of Nutrient Cycling

DEVELOPING INNOVATIVE TRAINING PROGRAMS TO BUILD CAPACITY FOR CONSERVATION ON AGRICULTURAL LANDS

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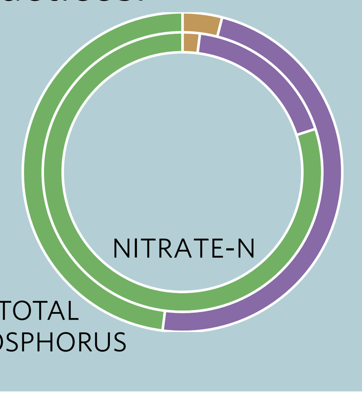
BACKGROUND AND CONTEXT

The **Illinois Sustainable Ag Partnership (ISAP)** is a coalition of organizations working collaboratively on agriculture programs that promote whole system conservation solutions to meet sustainability goals.

Through ISAP, staff from the Illinois Chapter of The Nature Conservancy led efforts to expand two training programs designed to give agricultural community professionals technical knowledge, tools, and resources to be ambassadors for ***soil health*** and ***conservation drainage*** practices within their networks. The training sessions have several common elements, and both can be adapted for use in other geographies to achieve increased adoption of sustainable ag practices.

In Illinois, **80% of the nitrate** and **48% of the total phosphorus** lost to surface waters comes from agricultural sources



Widespread adoption of in-field and edge-of-field practices is needed to reduce nutrient and sediment losses from agricultural lands.

PROCESS AND KEY ELEMENTS

FORM LEADERSHIP TEAM → ESTABLISH GOALS & OBJECTIVES → RECRUIT PARTICIPANTS → DEVELOP WORKSHOPS → EVALUATE & ADAPT

Clear roles for LEADERSHIP TEAM members:

- Lead Facilitator: Keeps everyone on track, leads steering committee, sets agendas, coordinates program logistics, and facilitates workshops.
- Lead Technical Expert: Serves as content expert for training series, typically delivers workshop content, identifies other experts and speakers, research articles, learning materials, and project sites.
- Steering Committee: 10-15 person group helps training leads identify overall program goals, recruit trainees, and develop workshop content.

Build a diverse steering committee comprised of members who can (1) contribute specific expertise to the training program (2) attract training participants, and (3) connect participants to current and relevant opportunities to apply their knowledge.

PROGRESSIVE training sessions with emphasis on peer learning:

- Workshops increase in topic complexity over time.
- Repeated interactions help participants establish relationships and enhance development of a peer network. Accepted applicants commit to attending all (or a majority) workshops in the series.

The entire training group benefits from the knowledge and expertise of each participant. Communicate the knowledge sharing and peer learning aspects of the program up front, and be intentional about working toward that goal throughout the series.

LIMITED NUMBER of dedicated, high quality participants:

- Invite interested participants to apply to the training program. They should articulate their motivations for participating and describe how they will connect the knowledge gained to their work.
- Use the steering committee and other contacts to identify a pool of desirable applicants.

A group size of 20-25 participants is ideal. Participants can comfortably offer perspectives, but there is enough diversity in viewpoints to illicit discussion and promote learning.

INFORMATIVE and INTERACTIVE workshops:

- Utilize discussions over lectures, and include small group exercises.
- Build in time for unstructured, but still topical discussions among trainees, presenters, and guests.
- Incorporate field visits, equipment demonstrations, and practice installations.

For the Soil Health series, include a visit to a working farm in each session's program. Insight into a farmer's Equipment and management set up is invaluable for the group.

Frequent opportunities to PROVIDE FEEDBACK:

- Invite participants to provide candid feedback on each session, and adapt future sessions accordingly.
- Plan to follow up with trainees in 6-12 months after the training to assess impacts and identify additional needs.
- Consider inviting graduates of the training program to contribute as a steering committee member, speaker, or mentor in a future iteration.

Use the first training session in the series as an opportunity to collect input on future session agendas, speakers, and materials.

AKNOWLEDGEMENTS: Jen Filipiak (American Farmland Trust) and **Dan Towery** (Ag Conservation Solutions) were awarded SARE funding to develop the initial *Advanced Soil Health Training.* Their efforts and learning informed development of current programs and of this summary. **Maria Lemke** and **Krista Kirkham** (The Nature Conservancy in Illinois) contributed to development of the conservation drainage training sessions and associated field components. Funding for these programs comes from the **Walton Family Foundation** and the **Midwest Row Crop Collaborative**.

Illinois Sustainable Ag Partnership (https://ilsustainableag.org)

Focus on SOIL HEALTH

Transitioning to a **conservation cropping system** (utilizing no-till, cover crops, and adaptive nutrient management) is an intense undertaking. In Illinois, the lack of **trusted technical assistance** was a major barrier to adoption. The six-part *Advanced Soil Health Training* was developed around two main goals:

- To teach the **basics of soil health management**
- To create a **cadre of professionals** sharing this consistent knowledge across the state.

Twenty-two individuals completed the first round of soil health training from March 2017-June 2018. A second round began in March 2018.

78% of trainees were inspired to create new outreach events in their communities.

3,000+ farmers and landowners have attended events led by training graduates.

"I hope to bring this knowledge back to our landowner clients. Personally, I hope to meet a lot of people and broaden my network of folks that have a lot more knowledge about this than I do, so I can learn from them."
-Ag Professional

"I look forward to learning from some of the industry's top leaders and drivers of this regenerative ag movement as well. I believe that this opportunity will help better explain soils function and how to improve the functionality of the soil."
-Retailer

"I especially like hearing from other growers, I think that's where I learn the most. There's just so many different techniques they're using, different equipment, different ways they're examining their soil to try to measure what they've done; this course is helping me to measure things environmentally."
-Agronomist

Soil Health Workshops
Workshop #1, March 2018
Soil Health and Sustainability

Workshop #2, June 2018
Adaptive Nutrient Management for Soil Health

Workshop #3, September 2018
Cover Crops: Becoming a Master Adopter

Workshop #4, January 2019
Measuring Soil Health

Workshop #5, March 2019
Equipment Needs for Soil Health Management

Workshop #6, June 2019
Soil Biology and Communicating Soil Health

A soil health training session incorporates use of a soil pit to provide hands on demonstration of concepts.

PARTNERS: Illinois Corn Growers Association; Soil Health Partnership; ACS Ag Conservation Solutions, LLC

Focus on CONSERVATION DRAINAGE

The *Advanced Conservation Drainage Training* was a three-part series designed to:

- Provide **technical training** on a suite of edge-of-field tile treatment practices
- Establish a **network** of experts and practitioners involved with various aspects of drainage water management and edge of field practice implementation
- Share consistent, **coordinated messages** and information

Twenty individuals completed the training.

"I want to be better educated about the effects of nitrogen in our waterways and have the tools to communicate to my customers about how to manage this problem."
- Tile drainage contractor

"This training opportunity will expand my knowledge and skillset, and help me serve farmers and stakeholder groups better throughout my territory."
-Practitioner

"In order for these conservation drainage practices to be implemented in an area, there must first be a local advocate with experience."
- Farm leader

Individual sessions included:

- Science behind each practice
- Conservation practice standards
- Small group application exercise
- In field demo or site visit

Throughout the series, trainees also discussed:

- Barriers to edge-of-field adoption
- Communicating with landowners
- Economics and cost share programs

Conservation Drainage Workshops
Workshop #1, June 2018:
Saturated Buffers

Workshop #2, July 2018:
Constructed Wetlands

Workshop #3, August 2018:
Denitrifying Bioreactors

The saturated buffer training included a live installation of the practice at Illinois State University Farm.

Trainees visited two constructed wetland sites in Central IL as part of the second training session.

PARTNERS:

Cover crop and tillage effects on greenhouse gas emissions

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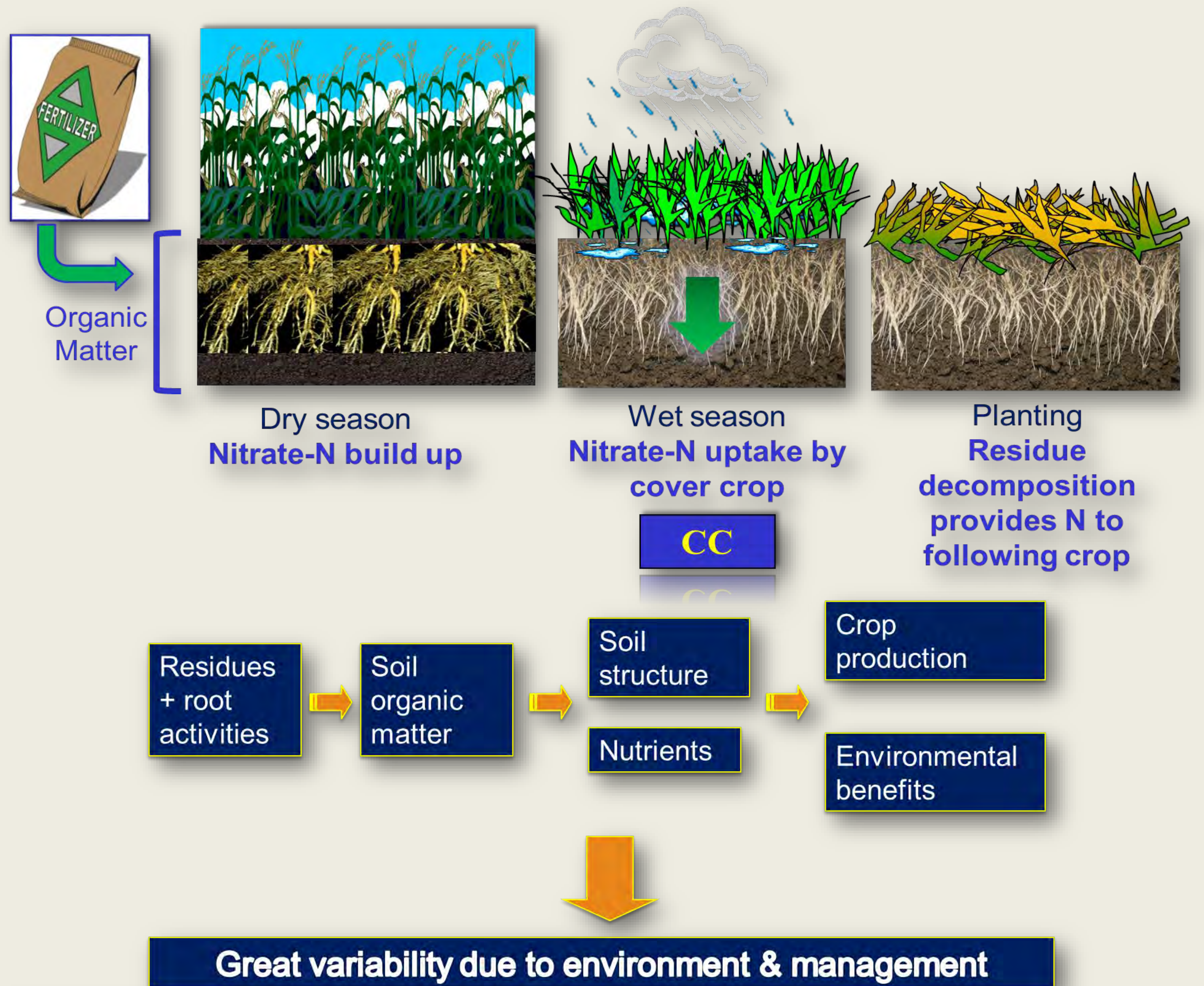
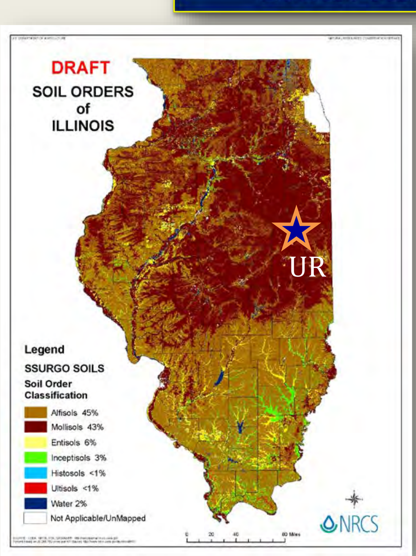
BACKGROUND





- Marginal area for CC
  - Shorter growing season
  - Narrow window for plant growth in the fall
    - Less biomass accumulation & associated benefits
  - Spring growth generally suppressed
    - Less biomass accumulation & associated benefits
- Use of tillage could negate the benefits form cover crops
  - Or not…

OBJECTIVES

- Evaluate the effects of five different cover crop species, and tillage practices on greenhouse gas (GHG) emissions and their relation to soil properties, biomass, and crop yields

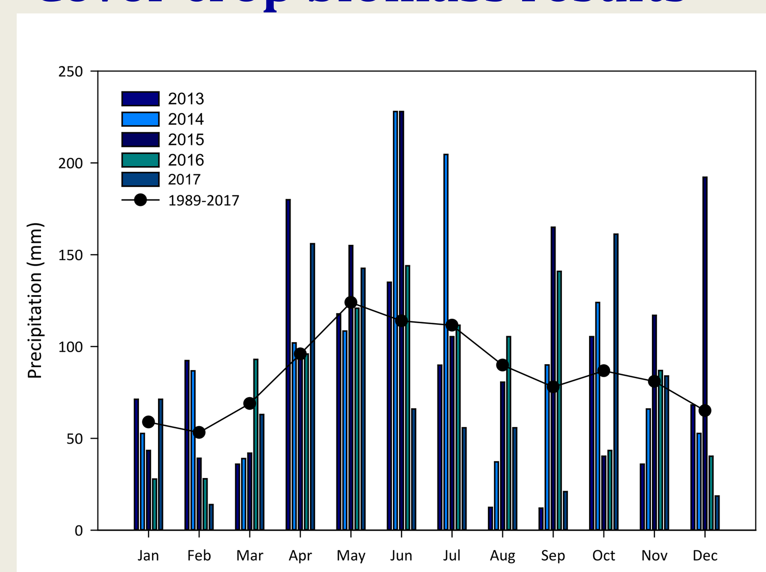
MATERIALS AND METHODS

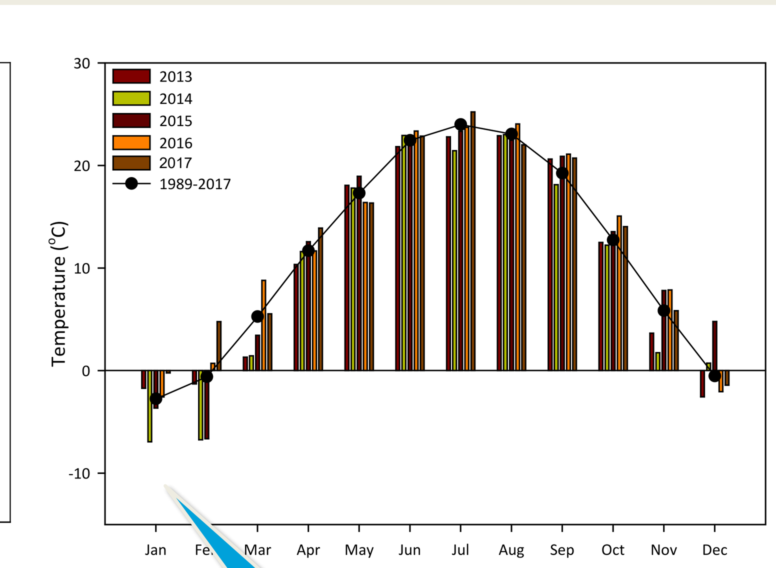
Plots were established in the fall of 2012 in Savoy, IL.
The experimental design was a split-block in an RCB design with four replications within the corn phase of the corn-soybean rotation. Two levels of tillage were present, chisel plow and no-till. Cover crop treatments had six levels. The effects of cereal rye [*Secale cereal*], spring oats [*Avena sativa*], rapeseed [*Brassica napus*], daikon radish [*Raphanus sativus*], and annual ryegrass [*Lolium multiflorum*] were tested, along with an unseeded control plot. Soil samples were taken to 1ft depth in the fall and spring; in addition soil samples taken to 10 cm were taken each GHG sampling event. All soil samples were analyzed for nitrate and ammonia levels by flow injection with a Lachat Quickchem Analyzer. GHG sampling followed the vented chamber method of Parkin and Venterea (2010). Data was analyzed using the GLIMMIX procedure in SAS (Version 9.4).

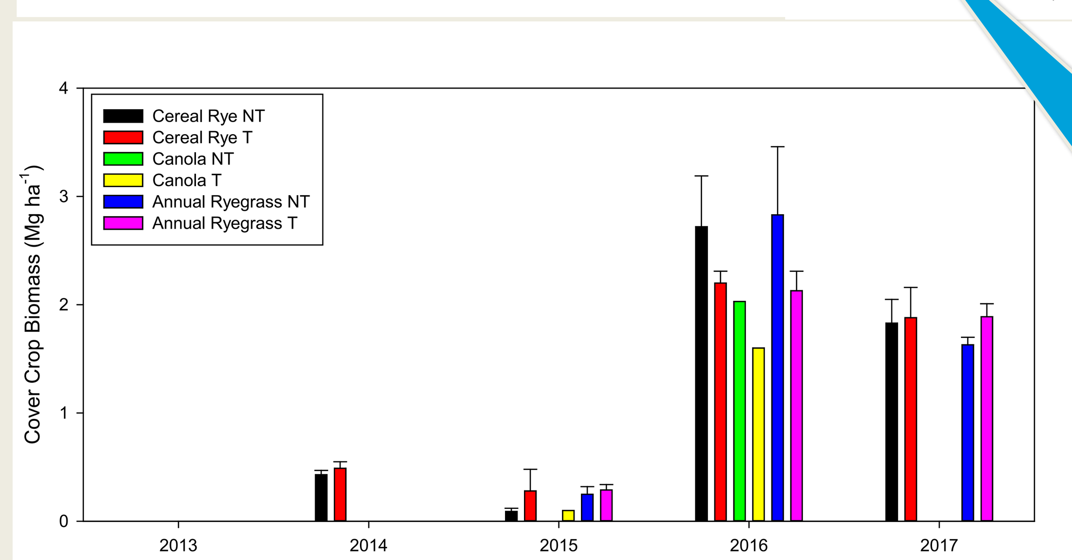
Images of cover crop plots one month after broadcast seeding into corn.
From left to right: Spring Oats, Ryegrass, Rapeseed, Control, Daikon Radish, and Cereal Rye

RESULTS

Cover crop biomass results

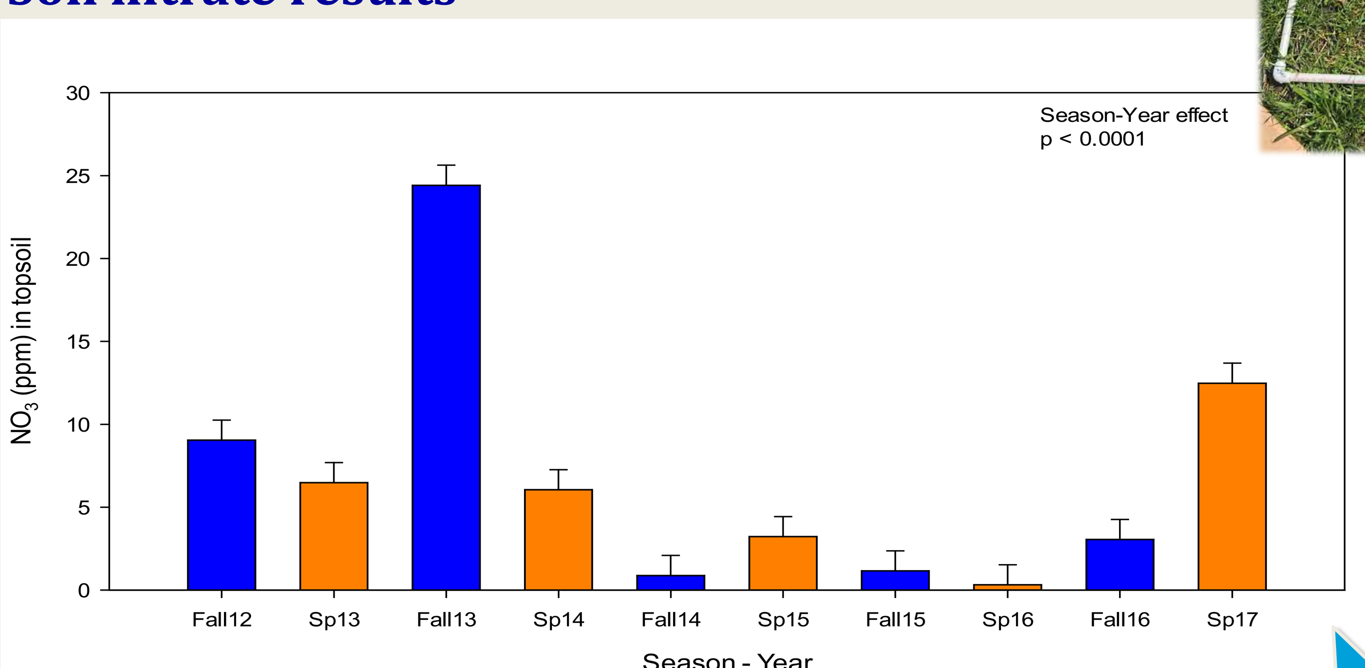






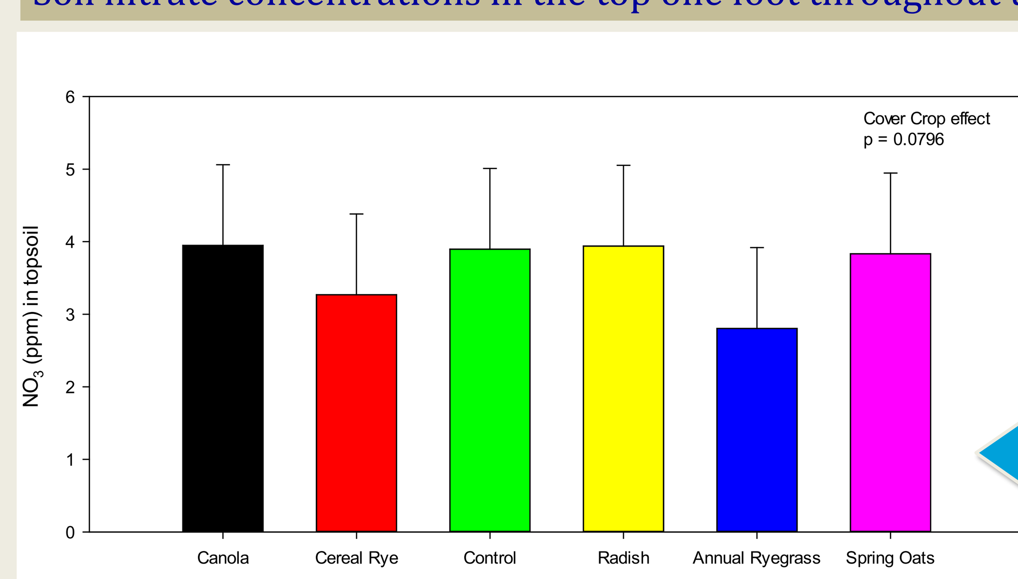
Winter temperatures were well below the average and this resulted in failed cover crop growth in 2013 and poor growth in 2014 and 2015.

Soil nitrate results



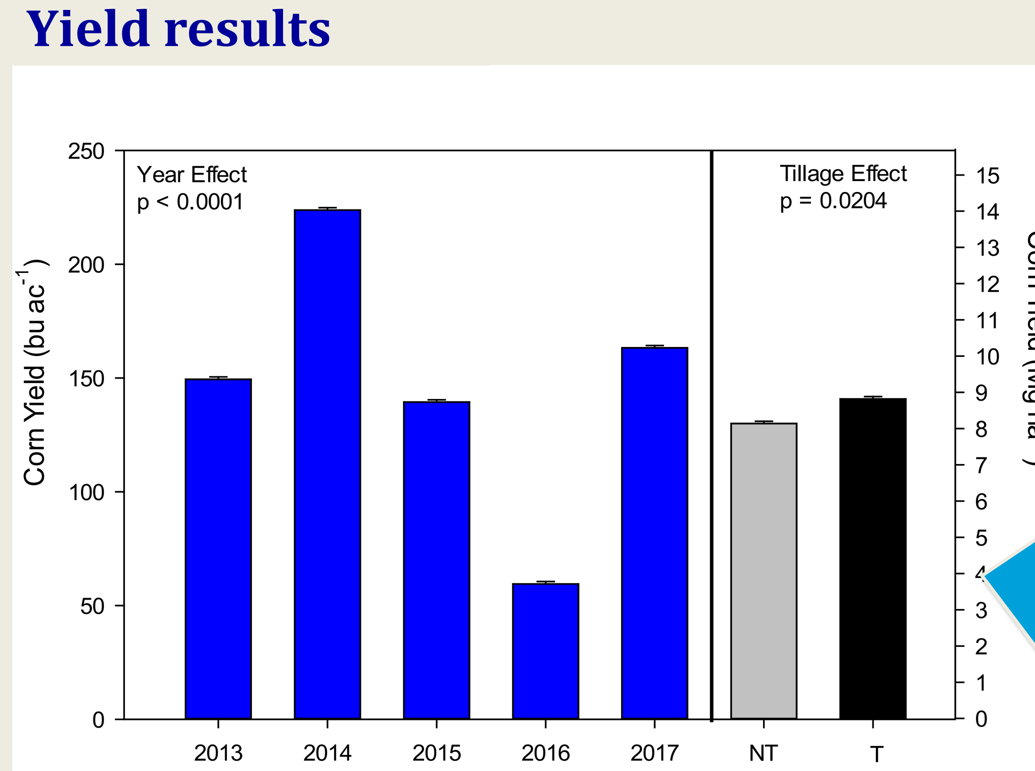
Soil nitrate concentrations in the top one foot throughout the study.

Levels of soil NO_3 included a season-year effect. Means and Standard Errors are back transformed from ls means



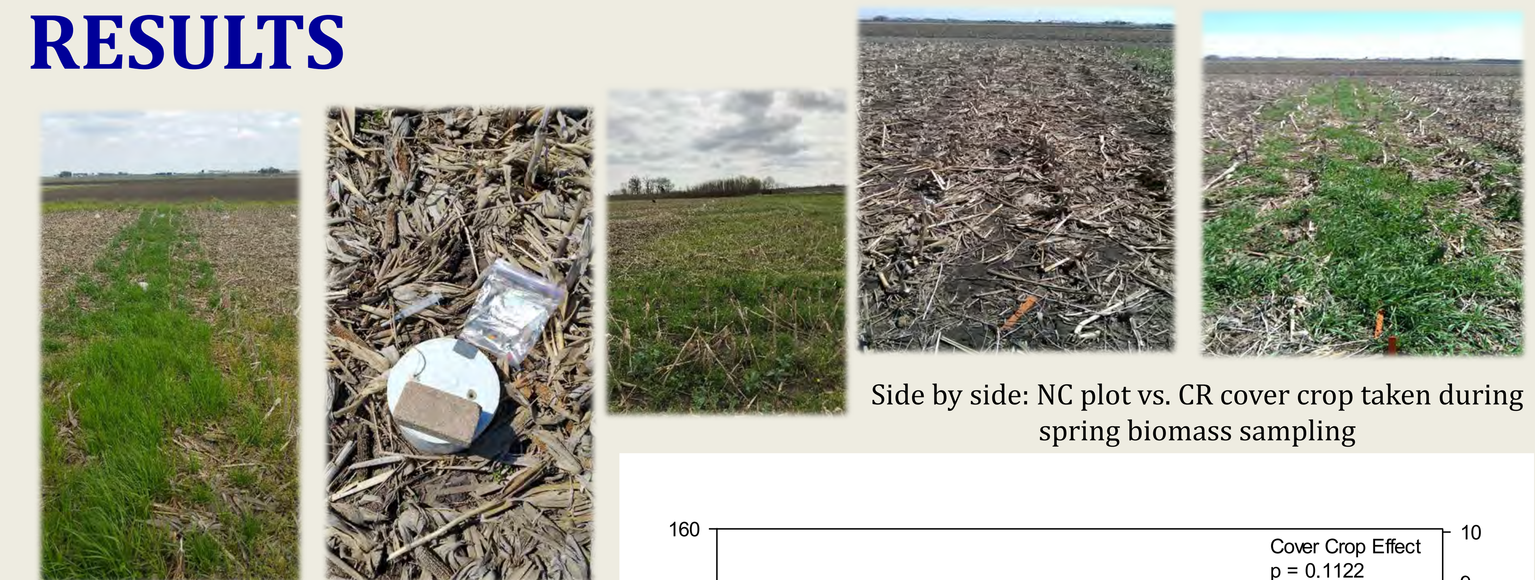
Levels of soil NO_3 included an effect of cover crop type. Slight reduction on the soil NO_3 levels caused by the inclusion of annual ryegrass. Means and Standard Errors are back transformed from ls means

Yield results



Corn yield from 2013 - 2017 included single effects due to year and tillage. Yield in 2016 was very low due to an herbicide application error. Tillage showed a yield increase of 10 bu ac^{-1} (0.7 Mg ha^{-1}). Means and Standard Errors are back transformed from ls means.

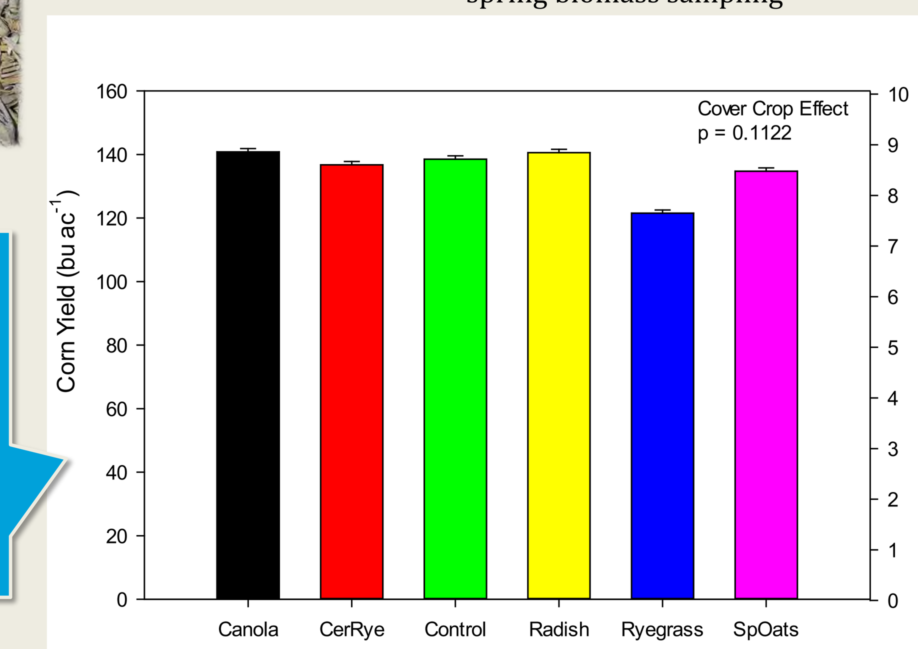
RESULTS



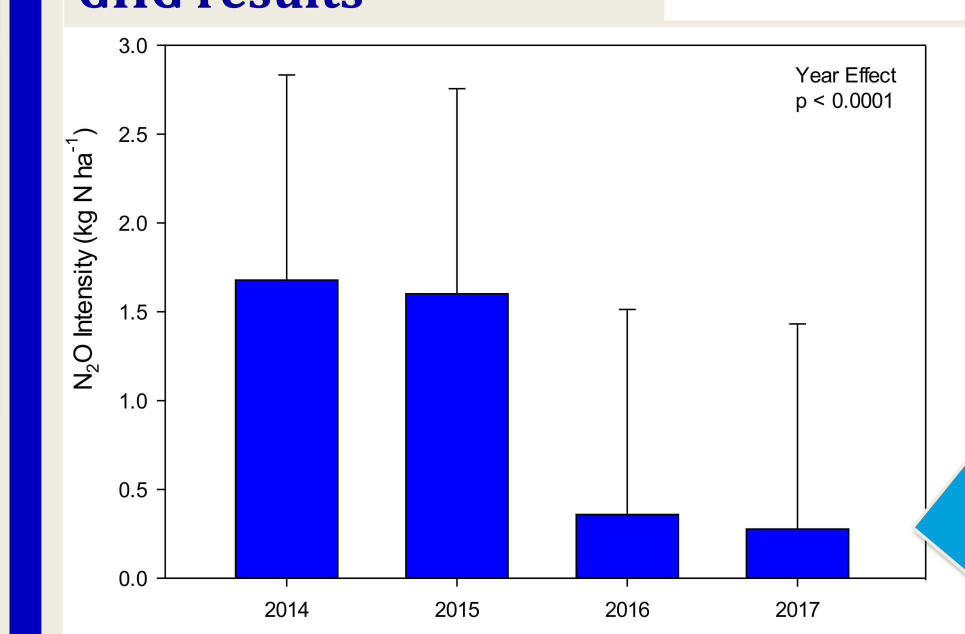
Side by side: NC plot vs. CR cover crop taken during spring biomass sampling

Yield results

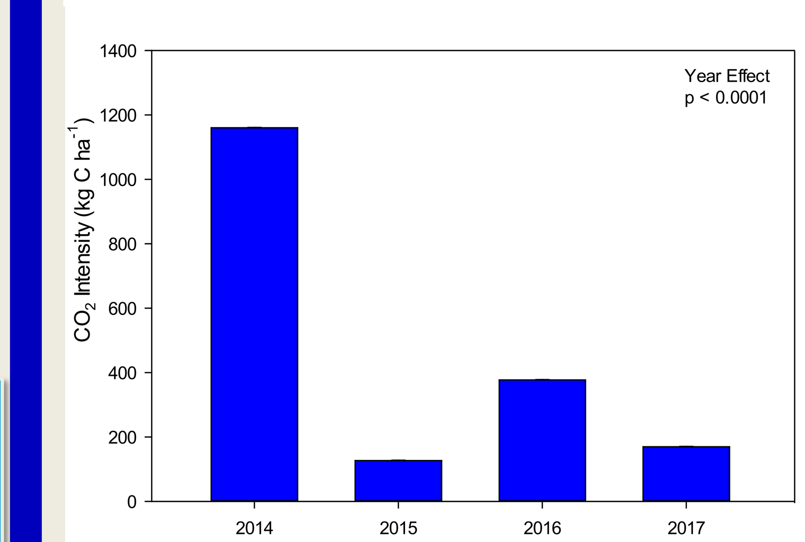
Corn yield across 2013-2017 showing a slight effect of cover crop type. Annual ryegrass slightly decreased corn yields. Means and Standard Errors are back transformed from ls means

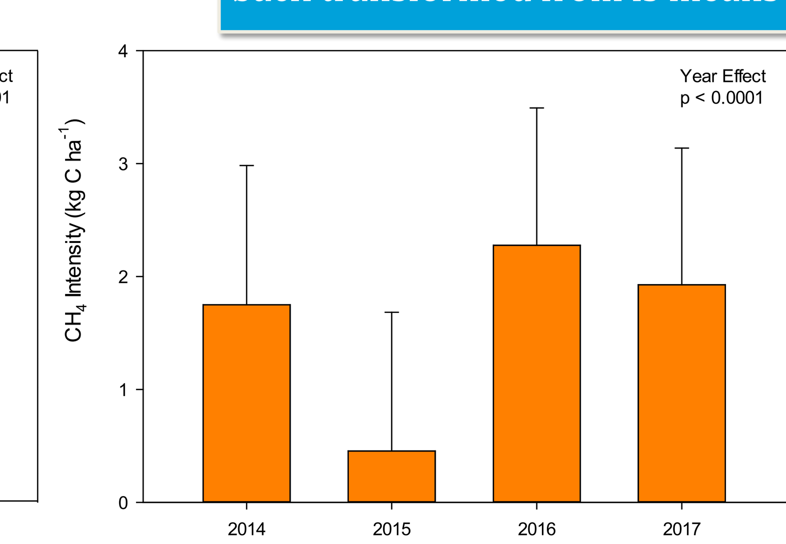


GHG results



N_2O intensity across fall 2013-spring 2017. There was only an effect due to year. Years where cover crop growth was present (2016 & 2017) showed lower N_2O emissions. A multivariate analysis confirmed that low biomass results in increased emissions. Means and Standard Errors are back transformed from ls means





CO_2 & CH_4 intensity across 2013-2017 a year effect only. Means and Standard Errors are back transformed from ls means

PRELIMINARY FINDINGS

- Weather greatly affects the potential benefits that cover crops can offer in Illinois.
- These benefits include reductions in soil inorganic N and lowered N_2O emissions when spring biomass occurs.
- Annual ryegrass has the ability to survive most winters in Illinois and can reduce soil N; however, there is a slight yield penalty.

ACKNOWLEDGEMENTS

Illinois Nutrient Research & Education Council

We appreciate the help of our Commercial Ag Educators, Angie Peltier, Dennis Bowman, Russ Higgins, and Robert Bellm. Many thanks to Brian Mansfield, Marty Johnson, Greg Steckel, and Jeff Warren for maintaining our research plots. Likewise, many thanks to all the graduate and undergraduate students for their field and lab work help.

Removing Dissolved Phosphorus with Edge-of-Field Phosphorus Filters

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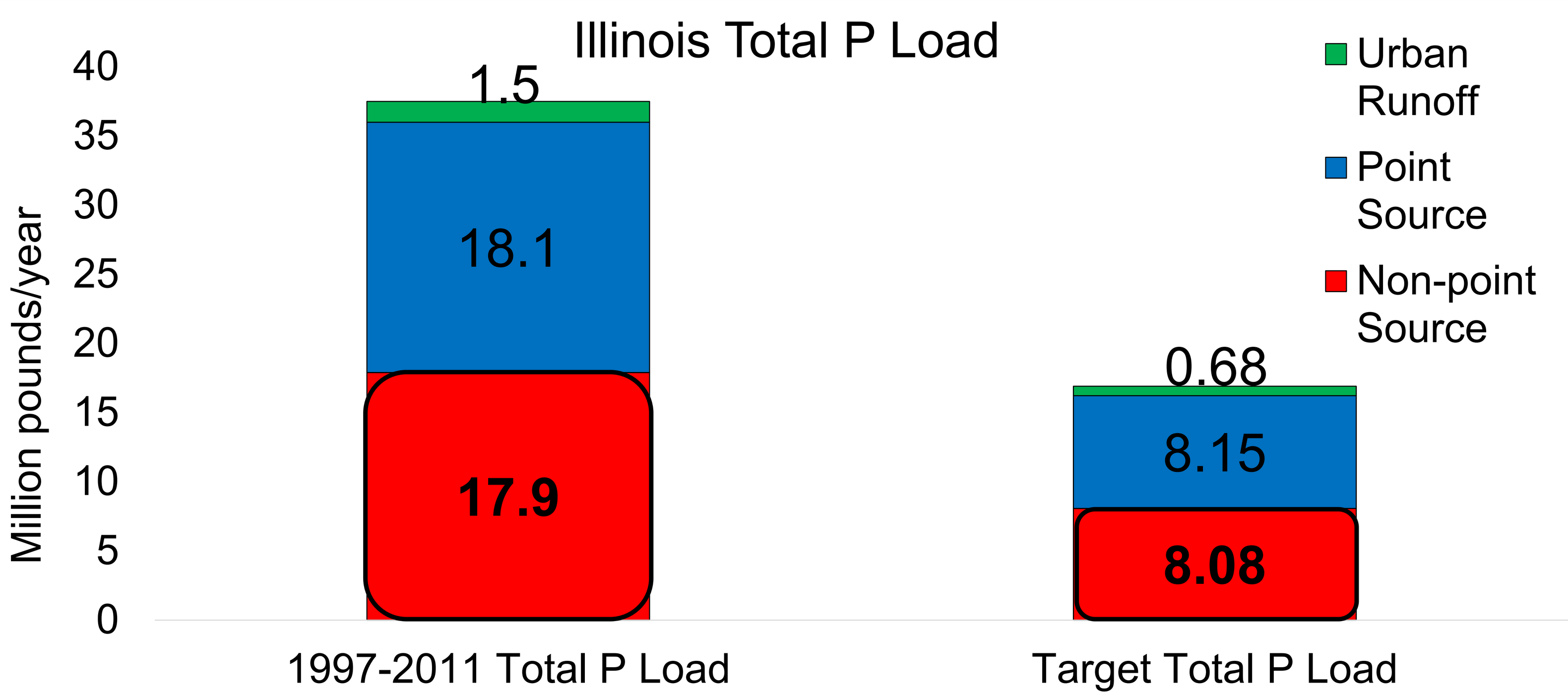
Department of Crop Sciences, University of Illinois at Urbana-Champaign, Urbana, IL

Introduction

- The Illinois Nutrient Loss Reduction Strategy calls for a 45% reduction of total P load into the Mississippi River
- Non-point source additions account for 50% of the total P load
- Current mitigation practices include cover cropping, conservation tillage/no-till, 4 R's



Edge-of-field P filters

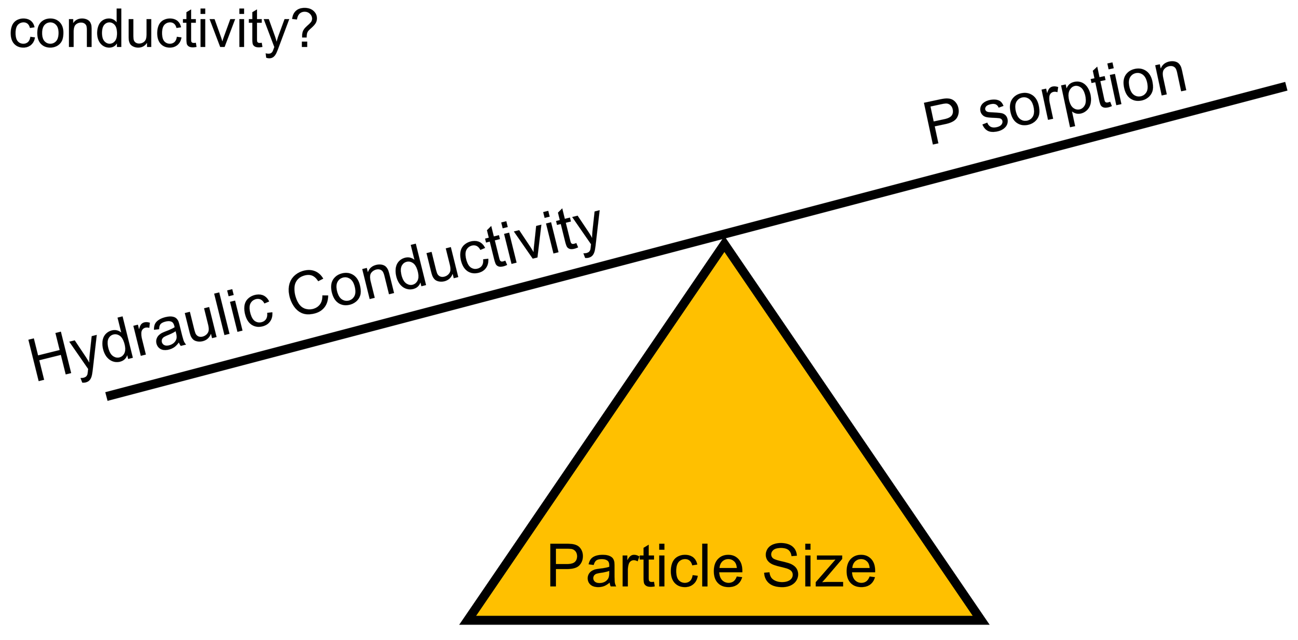
- Placed in an area of diverted surface runoff and/or tile drainage
- Filled with industrial waste by-product

Research Objectives

Research Goal: Determine best-suited P-sorbing material (PSM) to be used in an edge-of-field P filter

Questions:

1. What is the tradeoff between P sorption capacity and hydraulic conductivity?



2. Can pXRF be used as a rapid in-situ assessment tool to determine filter longevity?

Candidate P Sorbing Materials (PSM)

Calcium and/or Magnesium Based

Steel Slag

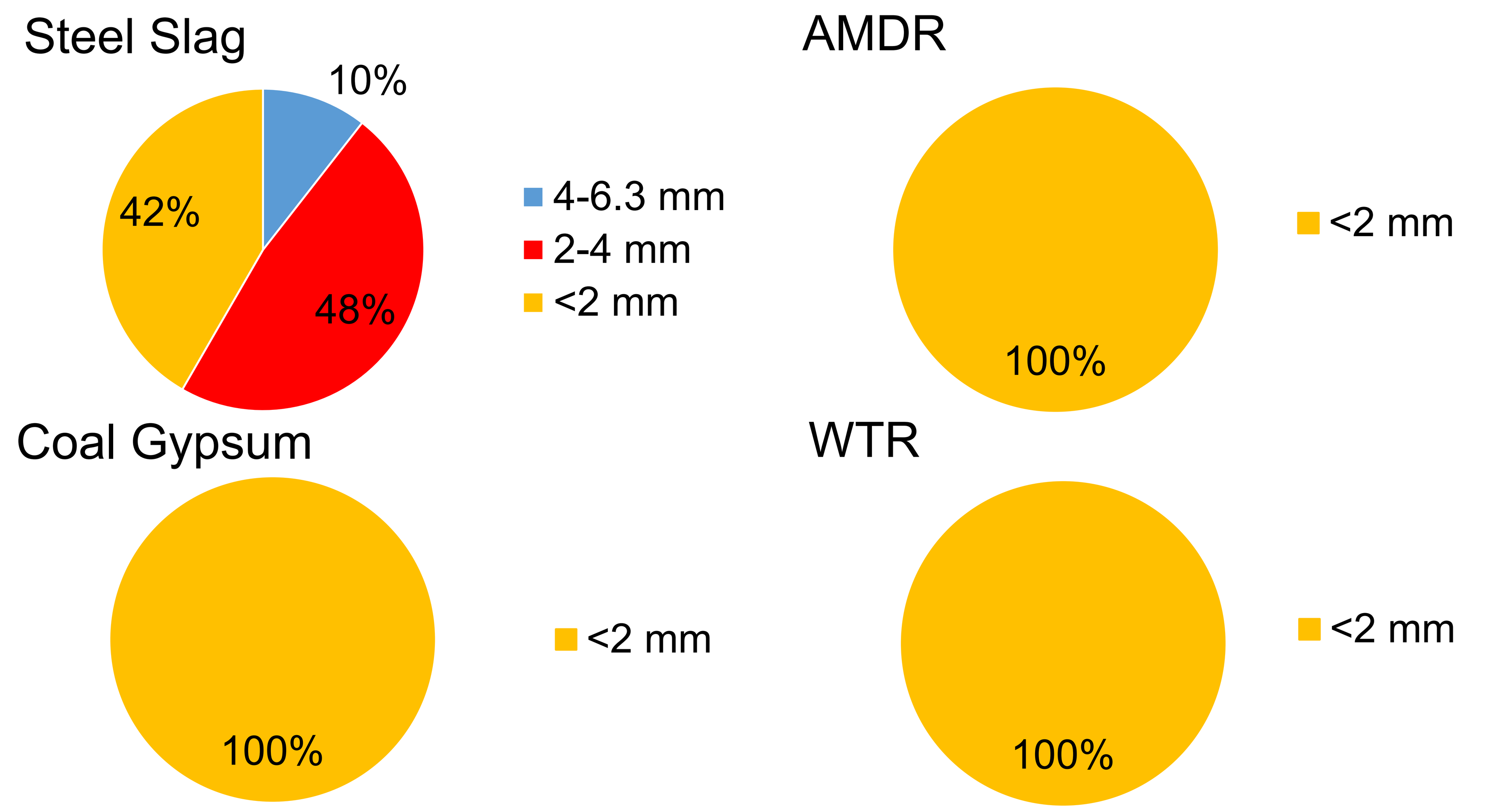
Coal Gypsum

Iron and/or Aluminum Based

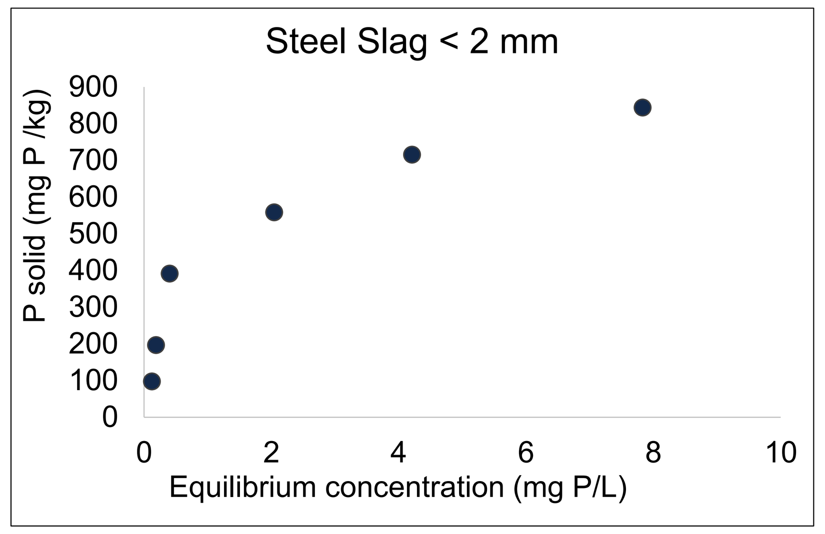
Acid Mine Drainage Residuals (AMDR)

Municipal Water Treatment Residuals (WTR)

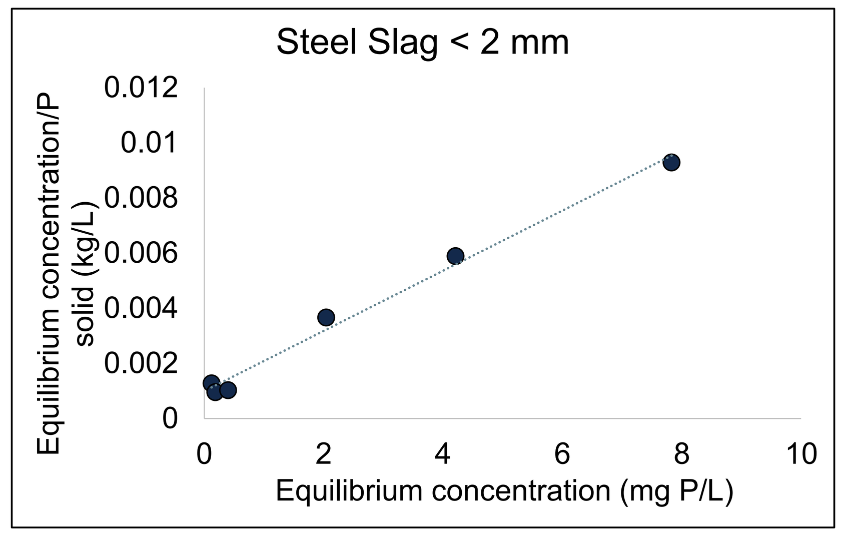
Dry Particle Size Distribution



Batch Isotherm Data

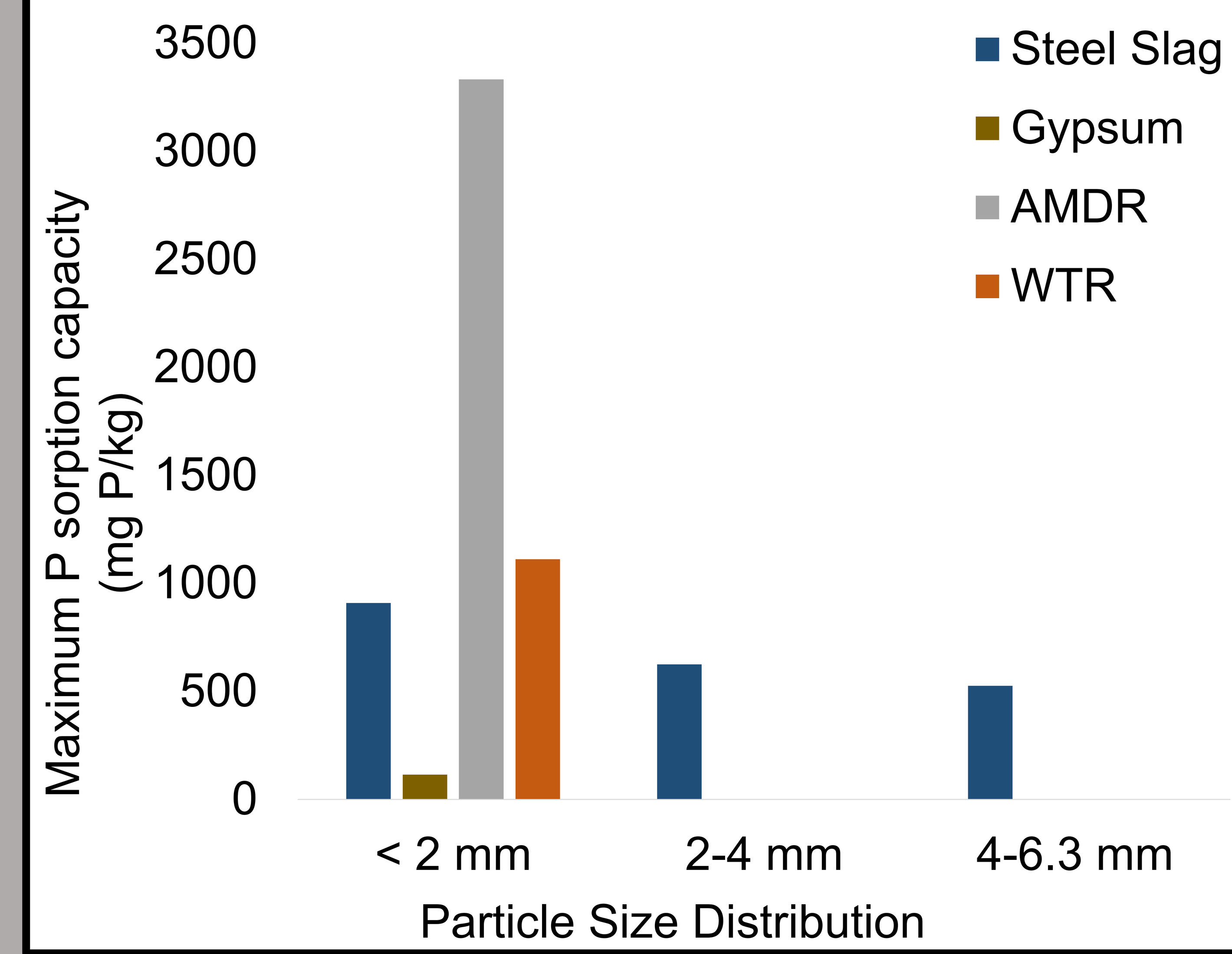


The P concentration of the supernatant plotted against the P concentration sorbed on the PSM



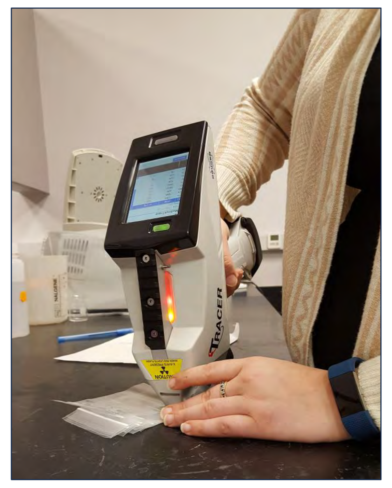
Transformation (Langmuir) of isotherm data to determine the maximum P sorption capacity.

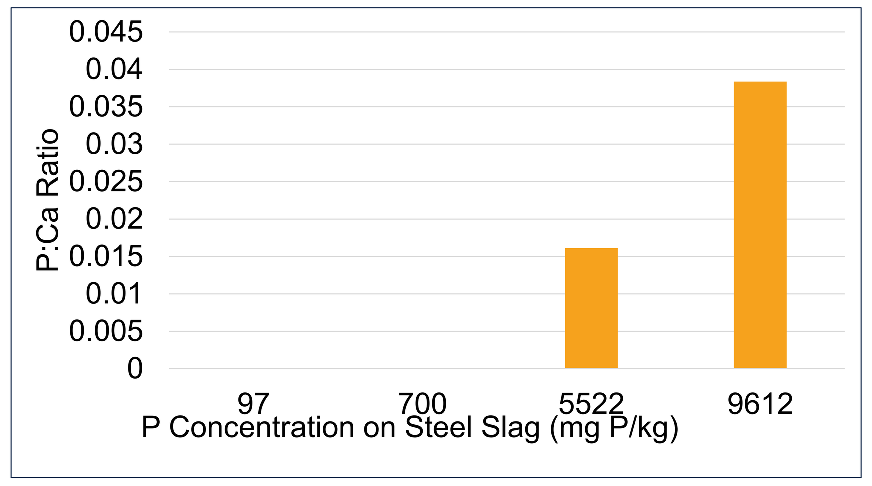
PSM Trade-offs



Portable X-Ray Fluorescence Spectroscopy (pXRF)

- Use in-situ to analyze sorption capacity left for material (i.e., filter longevity)
- Measures total elemental Fe, Al, Mg, Ca, and P





Key Points

- **Tradeoff between high P sorption and flow rate**
- **PXRF shows potential, but needs calibration for PSM**

Future Work

- Hydraulic Conductivity on remaining candidate PSM
- Flow through columns
  - Field realistic P concentrations
  - Less contact time
- Material Characterization
- Field-Scale evaluations in Southern IL

Acknowledgments

Financial support is provided by:
Award number 2018-4-360340-646

Using Unmanned Aerial Vehicles to assess Drainage Water Management Practices: Preliminary Ideas

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Drainage water management (DWM) and saturated buffers are two methods to potentially reduce tile drainage nutrient loss. Sites with these practices are being monitored to determine nutrient reduction effectiveness and potential inclusion in the Illinois Nutrient Loss Reduction Strategy. A remote sensing approach will be used with Unmanned Aerial Vehicle (UAV) imaging, Geographic Information Systems (GIS), and digital elevation modeling.

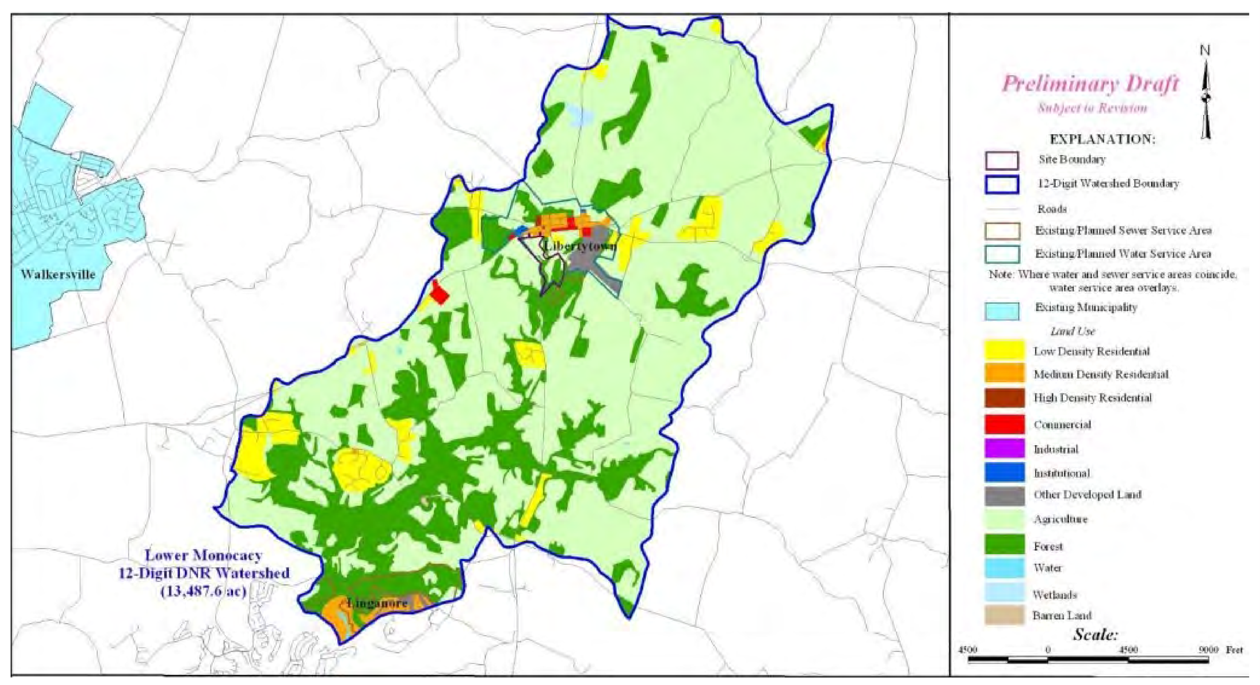


Figure 1. GIS map showing various components of an area (http://www.alwi.com/hydrogeologist/services/gis-mapping/)

GIS is a mapping technology that allows the user to create and interact with a variety of maps and data sources. With the use of GIS, captured photos can be used to determine the overall layout of a watershed including drainage paths, elevation changes, and spots containing higher moisture concentration.

Figure 2. Small drone using sensor to detect desired data (https://www.technologyreview.com/s/601935/six-ways-drones-are-revolutionizing-agriculture/)

While the use of UAVs (aka drones) allows for an aerial mapping of fields, watersheds, and landscapes, the camera/sensor is the major determinant in what can be observed and detected in the area of interest.

Figure 3. Drone surveying planted corn field (https://cropwatch.unl.edu/2017/sare-grant-aids-farmers-using-drones-test-n-applications)

UAVs are currently experiencing a rapid growth in usage throughout the agricultural sector. As farmers become more accustomed to the usage of UAVs and the multitude of advantages, an increasing number of new applications will likely present themselves. Many of the same concepts used in surveying crops and monitoring crop health can likely also be used towards water quality management. Geographic Information Systems (GIS), multi-spectral imaging, and other remote sensing techniques can be used to more accurately determine the effectiveness of various techniques used for water quality management.

Figure 4. Soil core samples being taken for testing (http://www.blacksandgranary.com/soil-testing/)

Soil core samples will be collected and tested for moisture content. This will be compared with results obtained from remote sensing techniques to determine the effectiveness of the drainage and determine if the amount of water being retained in the field is adequate. Soil cores will be taken from various locations throughout the field and compared with drone imagery to accurately determine the amount of water being retained in the field.

Figure 5. Sectioned plot for biomass sampling (https://iowalearningfarms.wordpress.com/2014/05/14/spring-cover-crop-biomass-sampling/)

Biomass sampling of a saturated buffer will be compared to NDVI and sense biomass growth observed by aerial imaging to determine the effectiveness of the buffer. This will provide a dual method of testing whether proper functionality is occurring as expected.

Figure 6. Drone with the attached RedEdge-M sensor (https://www.amazon.com/MicaSense-RedEdge-Multispectral-Camera-Kit/dp/B01BE8A8NA)

Sensors such as the MicaSense RedEdge-M sensor, shown above in Figure 6, can be used to take imagery and help to quantify various characteristics of the field being analyzed. Many of these sensors are easily compatible with commercially available UAVs.

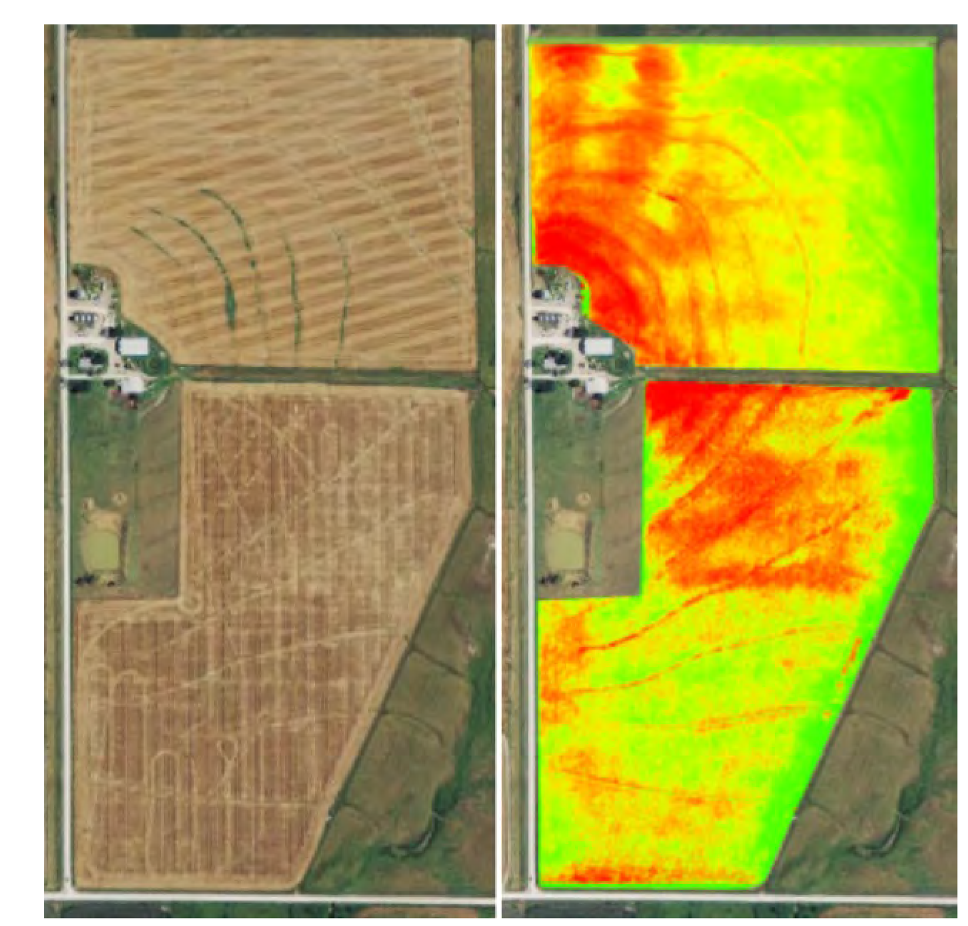


Figure 7. RGB vs. NDVI (https://botlink.com/blog/ndvi-vs-false-ndvi-whats-better-for-analyzing-crop-health)

Using methods such as the Normalized Difference Vegetation Index (NDVI) as shown above, vegetation can be quantified through measuring the difference between near-infrared and red light.

DEPARTMENT OF AGRICULTURAL AND BIOLOGICAL ENGINEERING
College of Agricultural, Consumer and Environmental Sciences

ACKNOWLEDGEMENTS:

The Illinois Nutrient Research & Education Council

The Two-Stage Saturated Buffer: Integrating the Use of Cover Crops into Saturated Buffer Designs for Nitrogen Mitigation

John Gale, Jon Schoonover, Karl Williard, Jackie Crim

Department of Forestry, College of Agricultural Sciences, Southern Illinois University, Carbondale, Illinois

Introduction

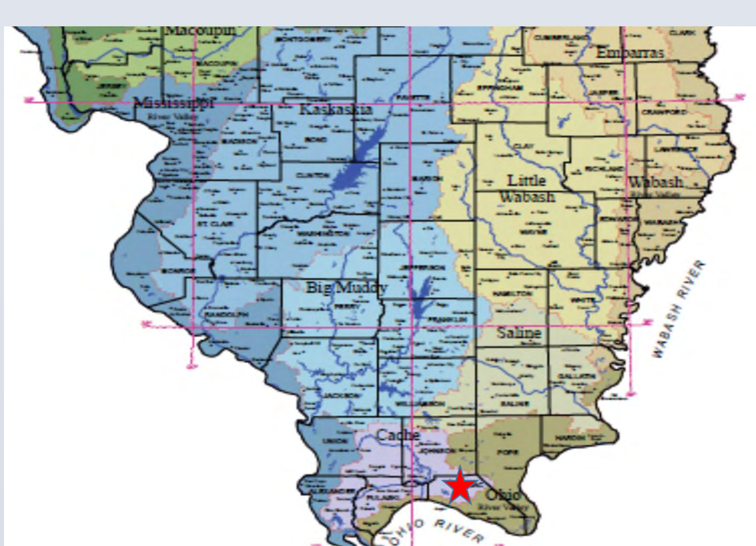
Both saturated buffers and cover crops have proven to be effective Best Management Practices (BMPs) for nitrogen management in row crop agricultural areas. This project is one of the first to blend the two BMPs into one management design for assessing nitrogen management in row crop agriculture.

Objective

To compare nitrate leaching among drainage tiles managed with a grass strip (control), a saturated buffer with a grass strip (treatment 1), and a saturated buffer with a grass strip coupled with a cover crop strip (treatment 2).

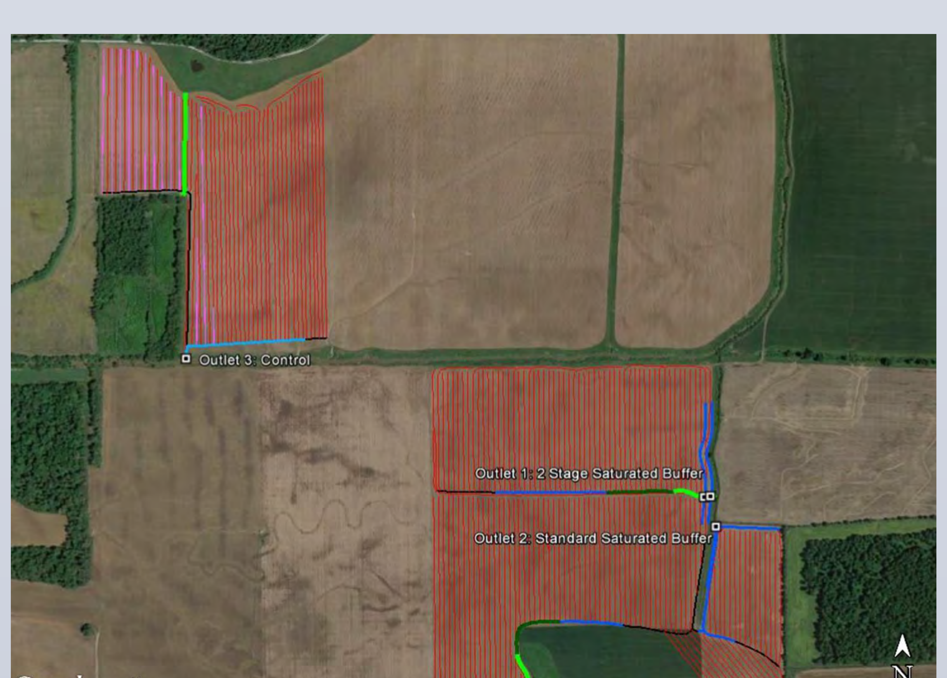
Study Area

This study takes place on a privately-owned farm in Massac County, IL



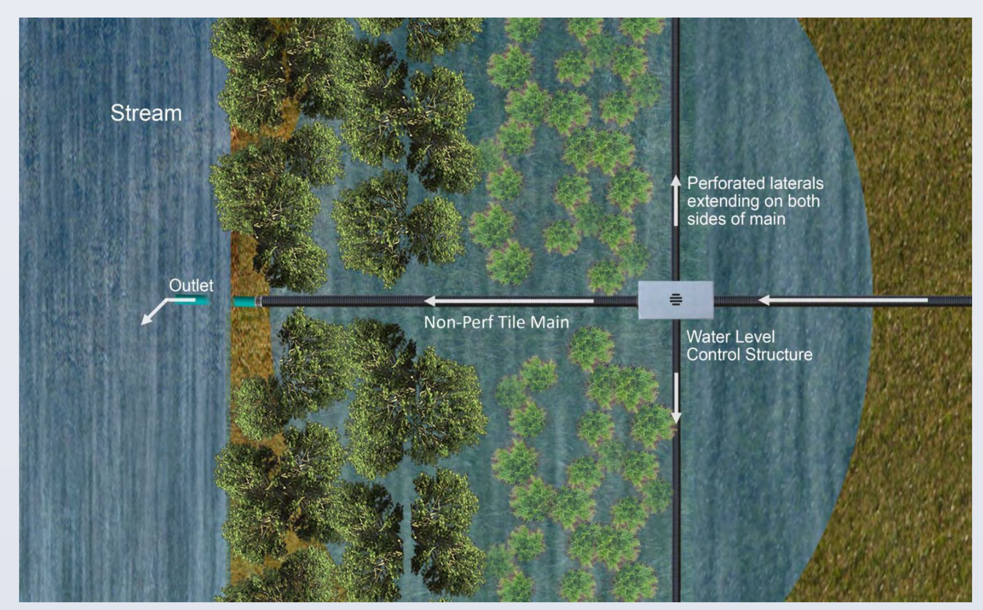
Existing Tile Lines
40 foot spacing
4 inch corrugated tile
0.24 mi/ac

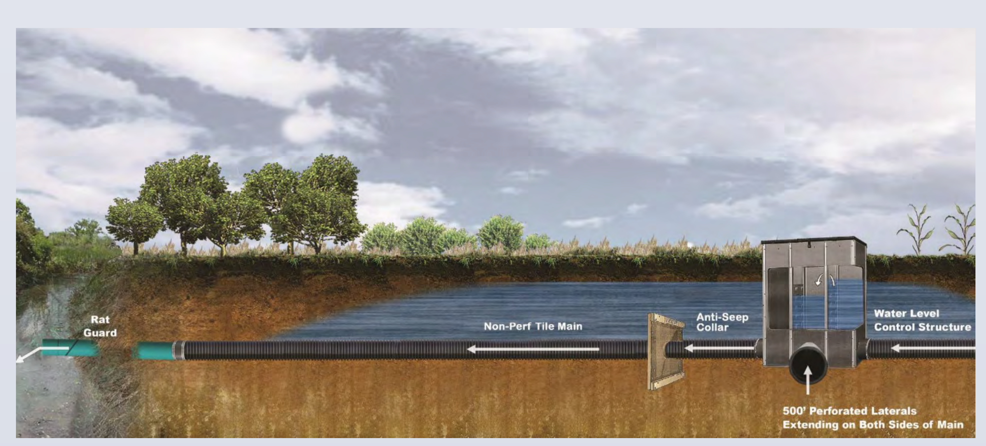
Drainage Areas
Outlet 1 – 52.4 ac
Outlet 2 – 29.0 ac
Outlet 3 – 62.2 ac



Materials & Methods

- Three similar tile lines were chosen based on their similarities in nutrient leaching and discharge from the outlets
- Tile outlets were instrumented with a control structure, v-notch weir, and a pressure transducer to monitor outlet discharge
- All buffers had a perennial grass strip 30 ft. wide planted adjacent to the stream
- An additional 50 ft. wide cereal rye strip was planted in the two-stage buffer treatment

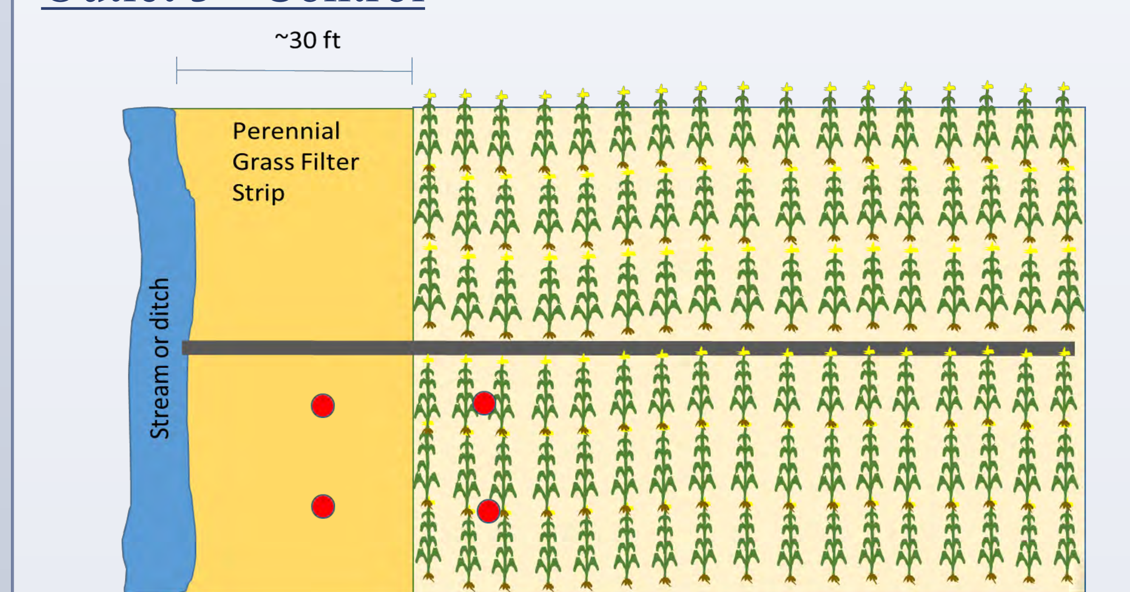




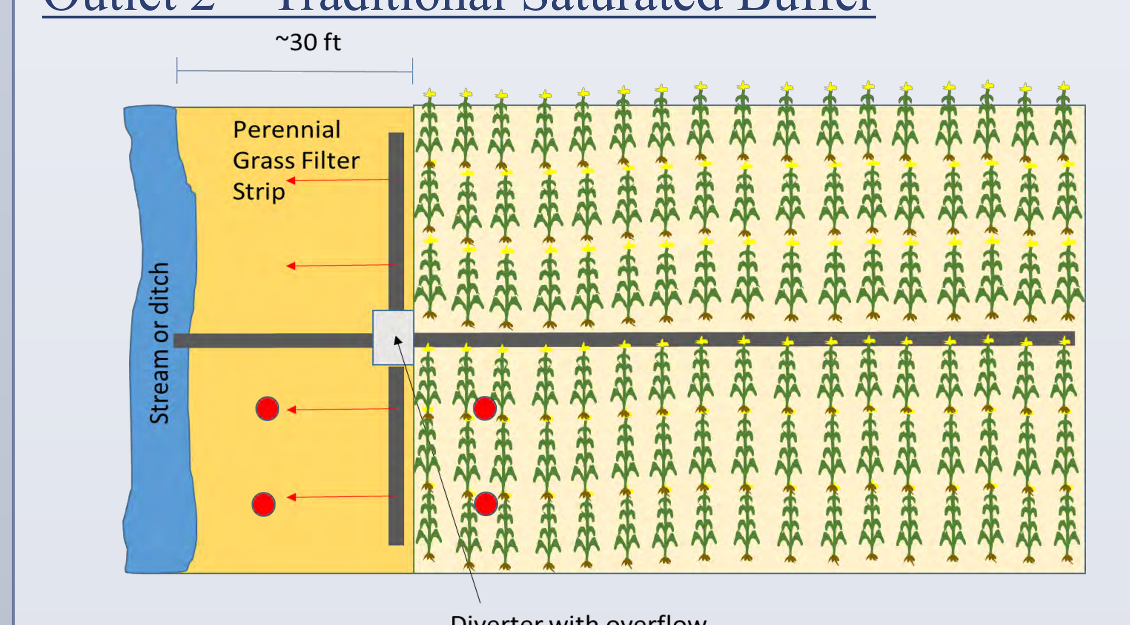
- Water samples have been collected from the control structures and groundwater monitoring wells bi-weekly
- Water samples are analyzed for nitrate, dissolved reactive phosphorus, pH, and other anions
- Soil samples are collected during the spring of each year prior to fertilization and planting

Materials & Methods Cont.

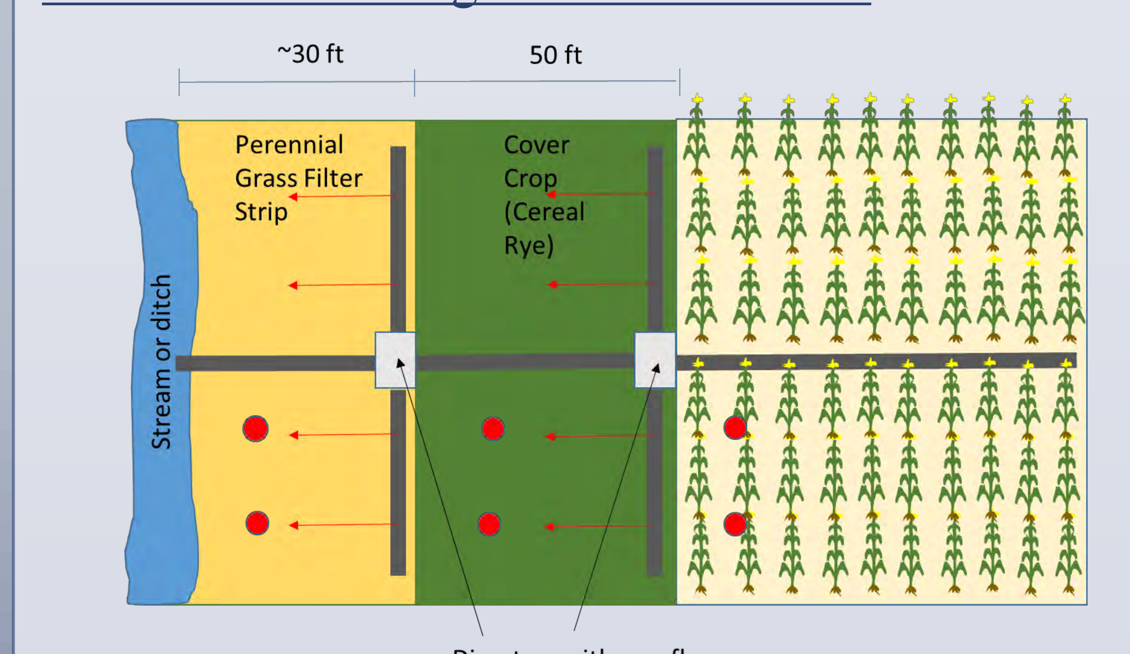
Outlet 3 - Control



Outlet 2 – Traditional Saturated Buffer



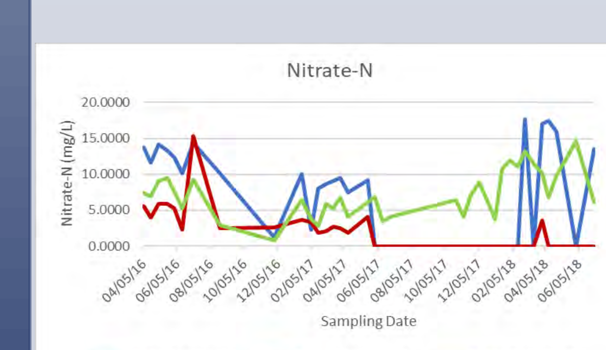
Outlet 1 – Two-Stage Saturated Buffer

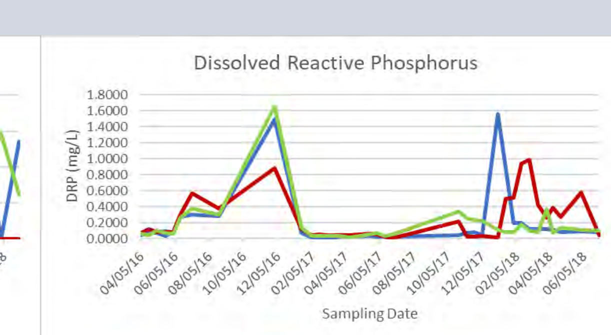


● = Monitoring Wells

Preliminary Results

Outlet: Nitrate-N (mg/L) and DRP (mg/L)

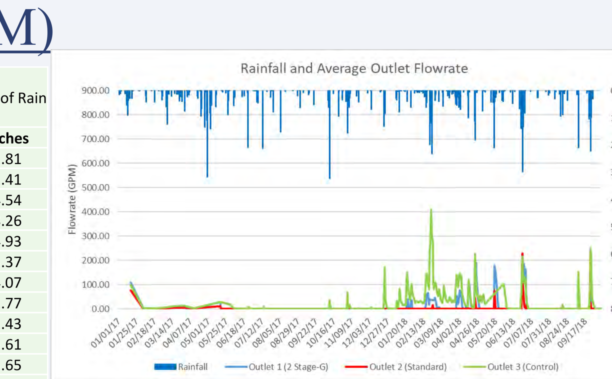


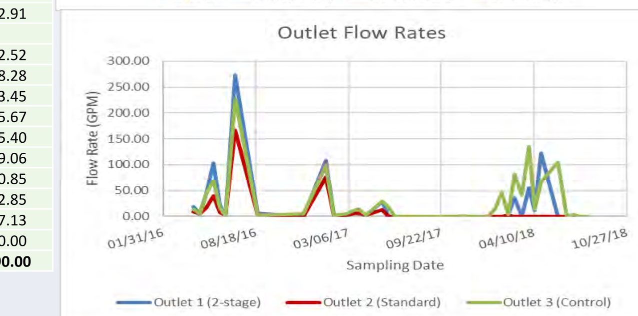


Preliminary Results Cont.

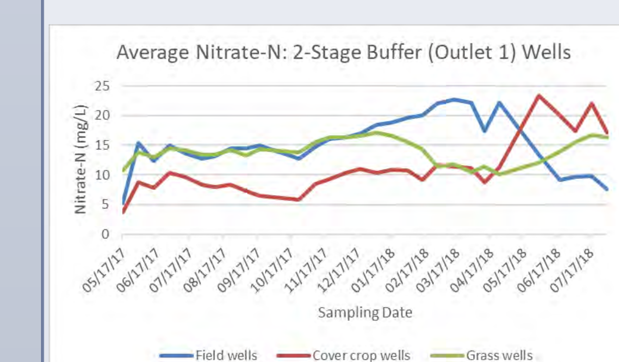
Outlet: Discharge (GPM)

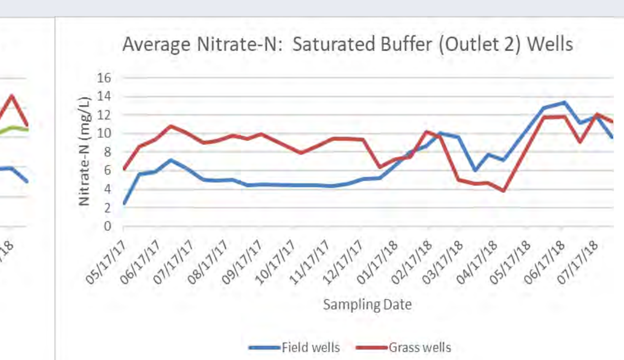
Date	Outlet 1 (2 Stage) Avg. Flow	Outlet 2 (Standard) Avg. Flow	Outlet 3 (Control) Avg. Flow	Sum of Rain
2017	**GPM**	**GPM**	**GPM**	**Inches**
January	108.56	75.84	97.84	2.81
February	2.18	1.61	2.66	1.41
March	4.71	4.24	9.94	4.54
April	1.22	1.97	1.79	8.26
May	1.85	0.83	23.80	4.93
June	0.00	0.00	1.96	3.37
July	0.00	0.00	0.39	4.07
August	0.00	0.00	0.00	1.77
September	0.00	0.00	0.00	1.43
October	0.00	0.36	1.88	5.61
November	0.00	0.00	3.61	3.65
December	0.02	0.00	8.63	2.91
2018				
January	5.12	0.00	39.34	2.52
February	12.79	0.55	100.90	8.28
March	5.91	0.00	58.26	3.45
April	51.96	3.48	59.59	5.67
May	44.84	13.17	39.17	5.40
June	30.99	12.42	34.95	9.06
July	0.63	0.00	1.42	0.85
August	0.00	0.00	0.75	2.85
September	3.24	1.06	26.09	7.13
October	0.00	0.00	0.10	0.00
Total				**90.00**

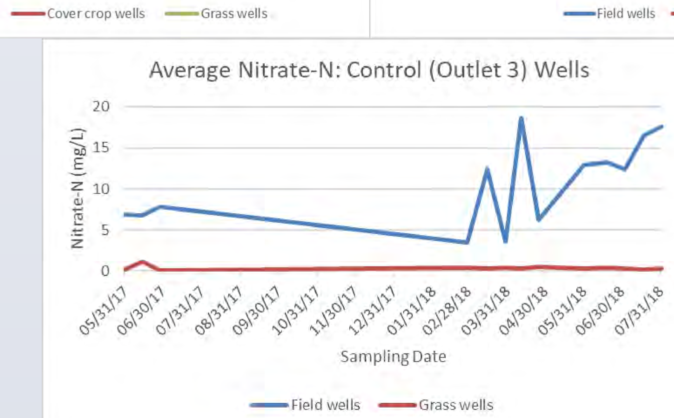




Well: Nitrate-N (mg/L)







- The predominate form of nitrogen leaving the fields have been in the nitrate form
- Cover crop and grass buffers had higher nitrate-N concentrations than the field wells due to the lateral lines in the saturated buffer systems conveying water towards the wells in the vegetated buffers
- Control structures have stabilized outflows and reduced outflow volumes
- The reduction in outflow alone will greatly reduce the load of nitrate-N leaving entering the stream via the tile outlets

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Jaynes, D.B., and T.M. Isenhart. 2014. Reconnecting tile drainage to riparian buffer hydrology for enhanced nitrate removal. Journal of Environmental Quality, 43:631–638. doi:10.2134/jeq2013.08.0331

Kaspar, T.C., Jaynes, D.B., Parkin, T.B., Moorman, T.B. and Singer, J.W. 2012. Effectiveness of oat and rye cover crops in reducing nitrate losses in drainage water. Agricultural Water Management, 110:25-33.

Tile nitrate loads are not simply a matter of “excessive” N fertilization

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[2]Illinois Fertilizer & Chemical Association, Bloomington, IL
[3]Department of Crop Sciences, University of Illinois, Urbana, IL

Replicated Tile Drainage Study


Objective: to evaluate when and how nitrate and phosphorus are lost from tile drained fields

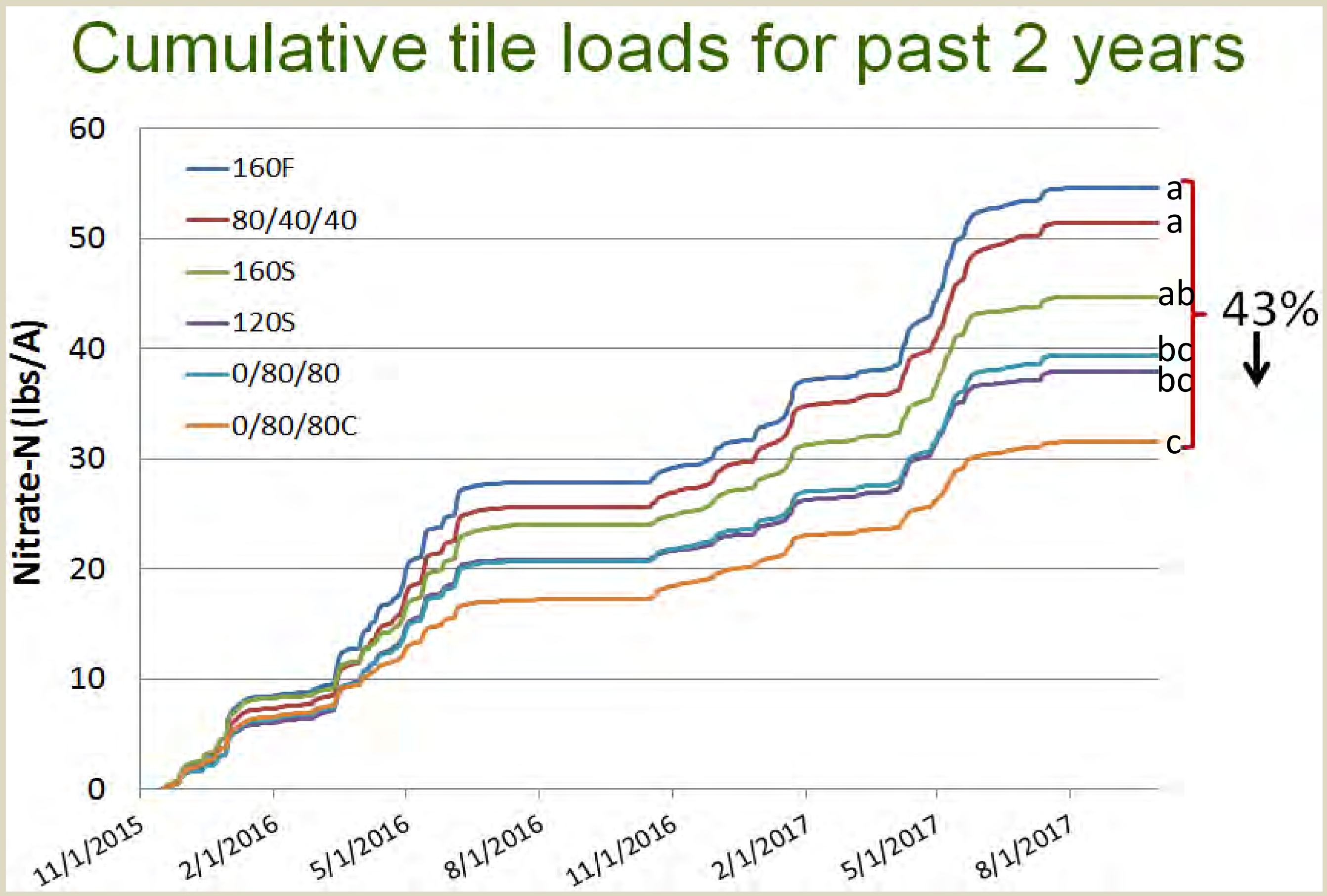
Methods

- 36 monitored tile lines (18 corn / 18 soybean)
- Average plot area is 4.2 acres and is 100 ft wide (50 ft on either side of a 5 inch lateral)
- Randomized complete block (6 N treatments with 3 replicates)

Six N Treatments	
160F	160 lb N/acre in fall
80/40/40	80 lb N/acre in fall, 40 at planting, and 40 side-dressed
160S	160 lb N/acre in early spring
120S	120 lb/acre in early spring (reduced rate)
0/80/80	80 lb N/acre in spring and 80 side-dressed
0/80/80 C	80 lb N/acre in spring and 80 side-dressed + cover crop

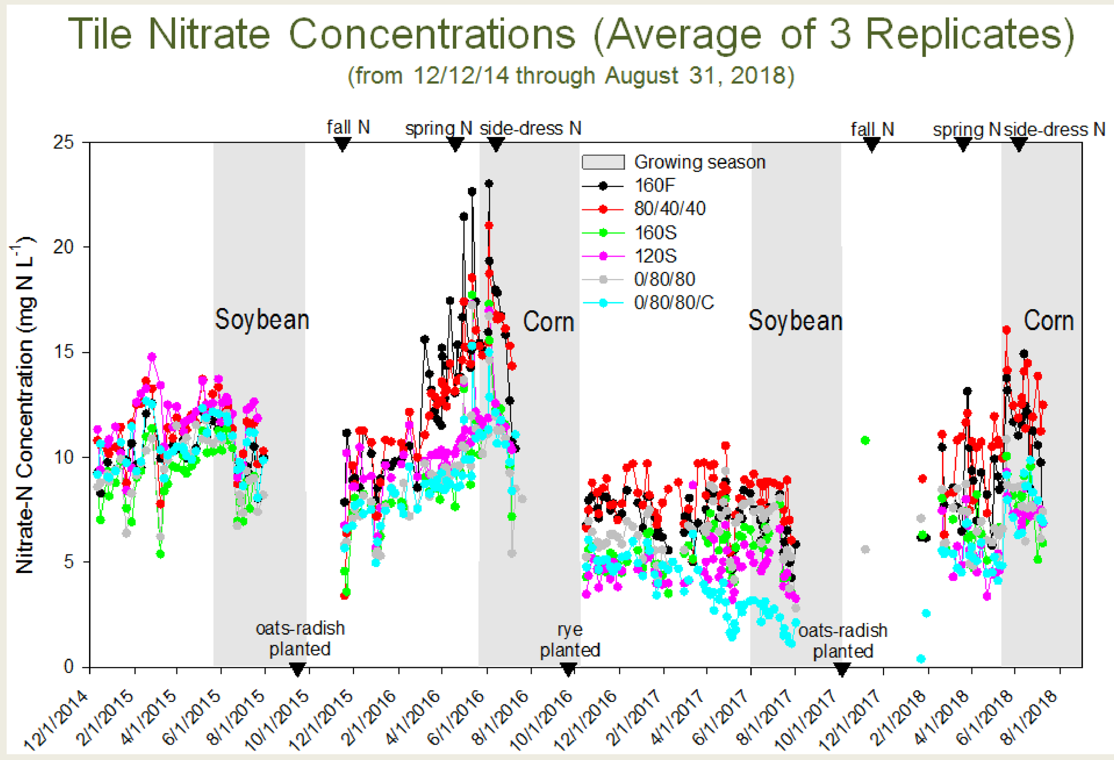
Results

In two years, the cumulative tile nitrate loads have separated among the N treatments in response to timing of N application. Fall N treatments lost the most tile nitrate, while the split applied N treatment (80 lbs/A in spring and 80 lbs/A at side-dress) with cover crops lost the least. See graph below:

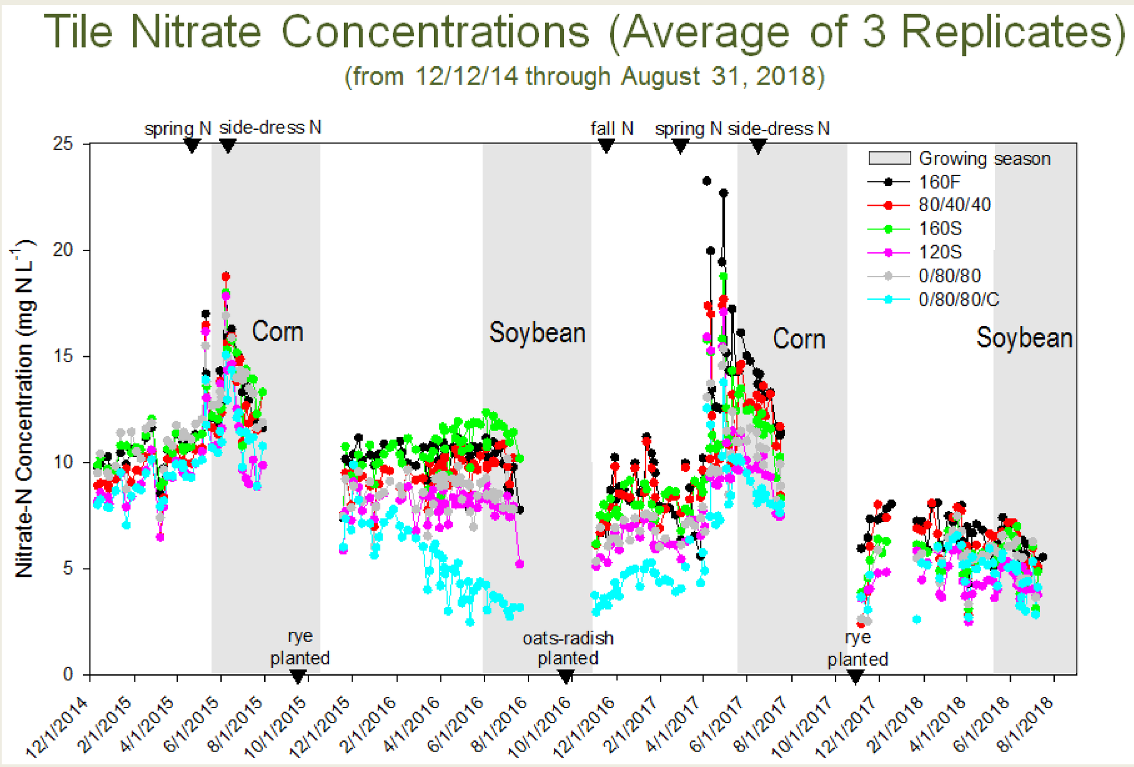


Over the 2 year period, tile nitrate loss was the same (approx. 20 lbs/yr) for the 80/80 split and the reduced rate treatment (120S), yet the lower rate decreased corn yield by 10%.

This data demonstrates that tile nitrate loss is not simply a matter of excessive fertilization and that timing of fertilizer N application is important when managing against tile nitrate loss.

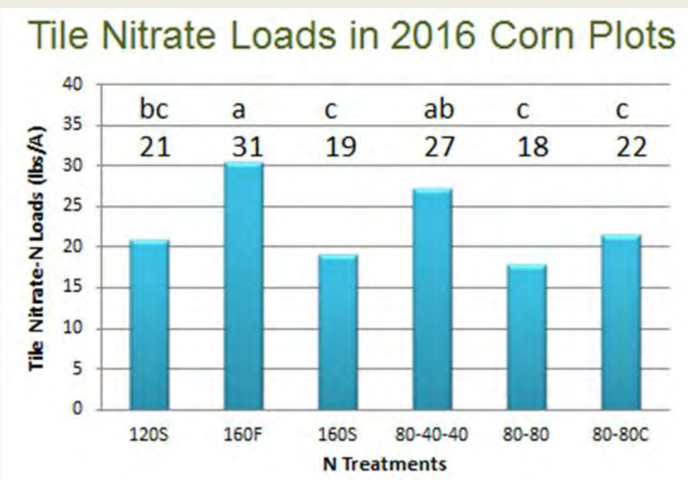


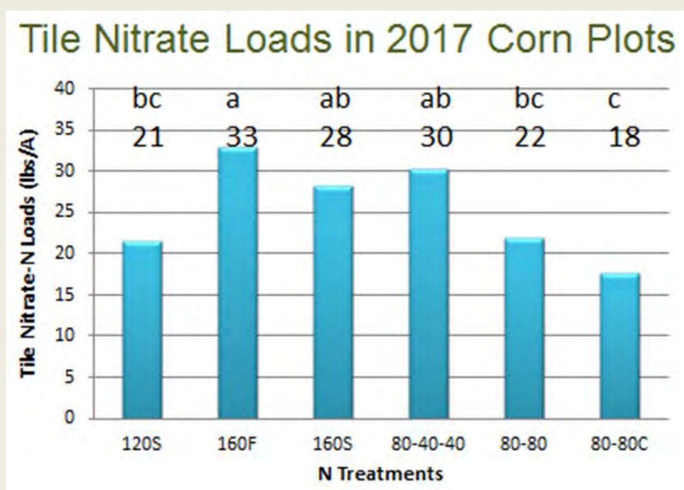
Fall N treatments have greater tile nitrate losses (black and red dots) and nitrate remained higher the next year.



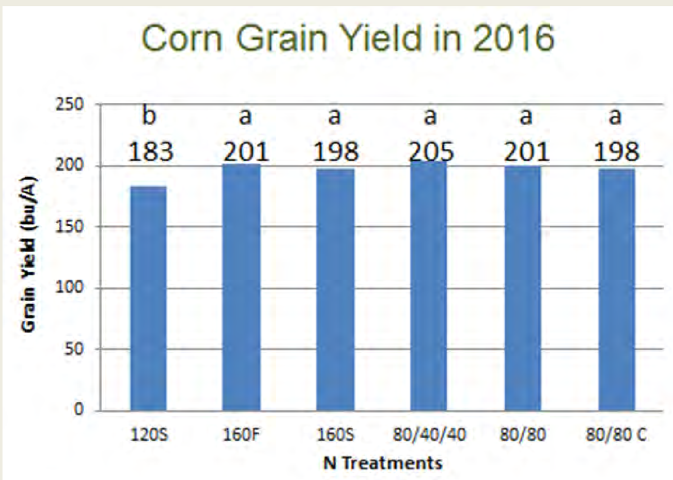
In 2017, we experienced the warmest February on record and many farmers applied fertilizer N before March 1 that year. We applied N on Feb. 28 and found that tile nitrate loss was similar to the fall N treatments (black, red, and green dots) (Note: fall N with inhibitor; spring N without).

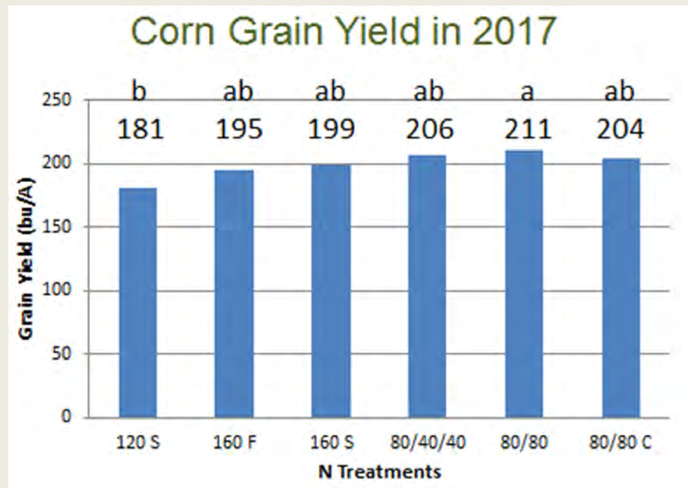
In addition, we found that cereal rye after corn (light blue dots) reduced tile nitrate load by 40%.





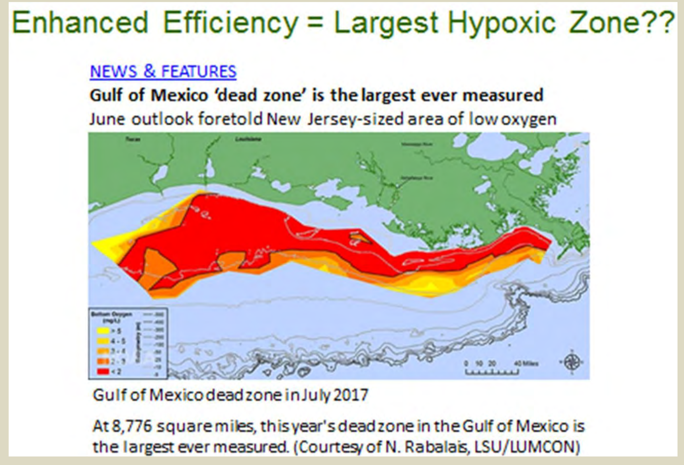
Fall fertilizer N loss was 10 lbs/A more than spring N or split application. This amount of loss represents just 7% of the full fertilizer rate but accounts for 30% of the annual tile load.

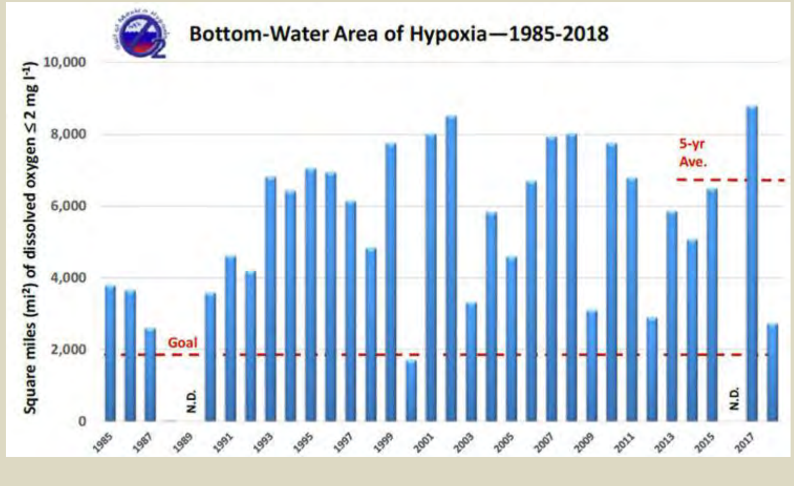




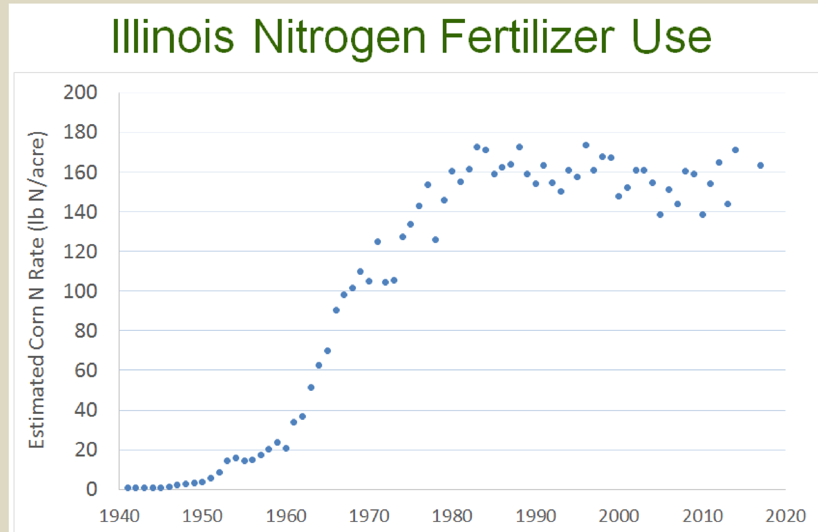
Although fall N treatments lost more tile nitrate, corn grain yields were not significantly lower in either year. The reduced N rate treatment significantly lowered yields in both years.

Record Crop Yields and Record Hypoxic Zones: How and Why?





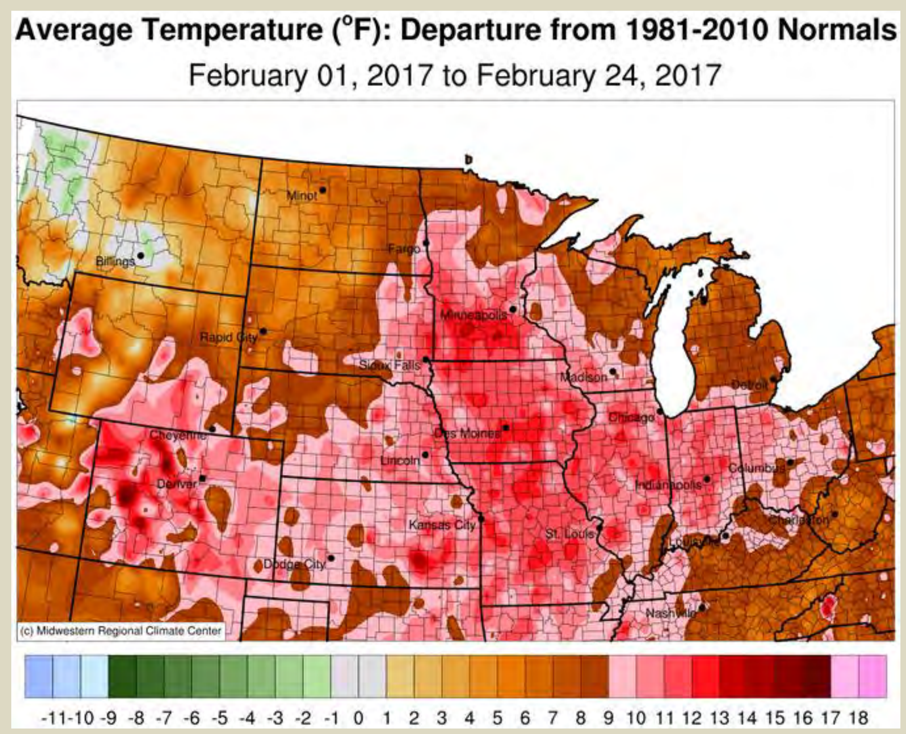
Record crop yields in IL and IA in 2016 and 2017 were achieved, yet Gulf hypoxic zone grew to largest ever recorded in 2017. Due to a high nitrate load in the Mississippi River in May, LSU researchers had predicted the hypoxic zone to be the third largest in the 25 year period of record. They had also predicted a large hypoxic zone in 2018, but strong winds limited the size.



It is interesting to note that IL fertilizer use has remained steady for the past 40 years, while crop yields have nearly doubled.

Why doesn’t improved efficiency equate to smaller hypoxic zone?

- <u>Net mineralization (controlled by weather)</u>
    - <u>Precipitation</u> (timing and quantity?)
    - <u>Temperature</u> (warmer winters)
- <u>Timing</u> of N fertilizer (fall, spring, side-dress)



Warmest February on Record in 2017

In warm winters, soil mineralization can lead to increased tile and river nitrate loads. Is it possible that the warm winter of 2017 released tons of mineral N from across the Corn Belt and masked any water quality benefits from improved field N balances that come with high crop yields?

Warmer winters will speed up soil organic matter loss and the release of mineral N. Winter cover crops may be the best strategy to capture and recycle mineralized soil N, keeping it from heading to the Gulf of Mexico.

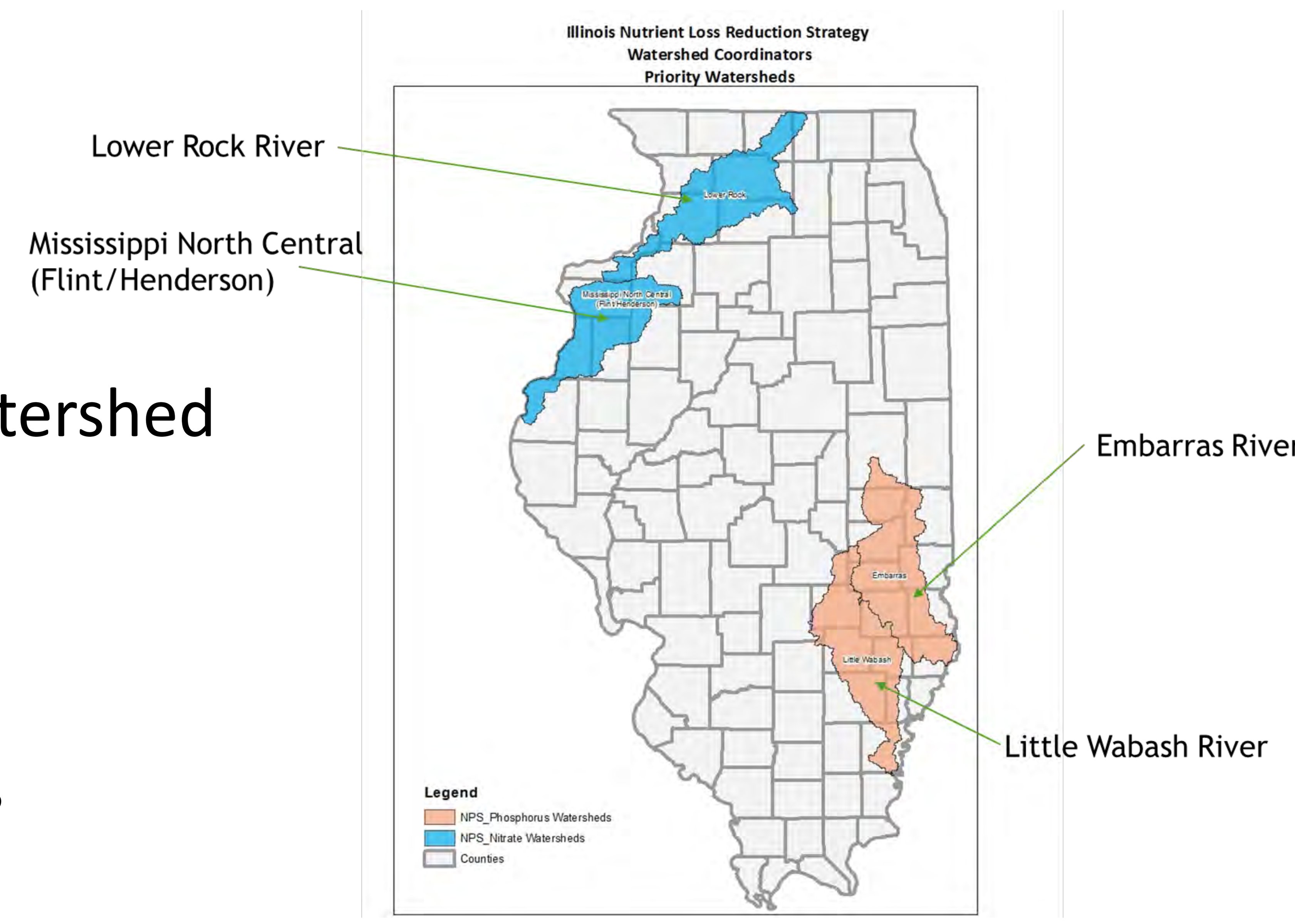
University of Illinois Extension

ILLINOIS
Extension
COLLEGE OF AGRICULTURAL, CONSUMER
& ENVIRONMENTAL SCIENCES

Haley M. Haverback
University of Illinois

Who We Are

Two Watershed Outreach Associates were hired in April and May of 2018 by University of Illinois Extension through a grant awarded by the Illinois Environmental Protection Agency. These individuals were tasked with serving as educators and technical advisors on the Illinois Nutrient Loss Reduction Strategy (NLRS) and the best management practices within it in order to reduce agricultural nutrient loss.

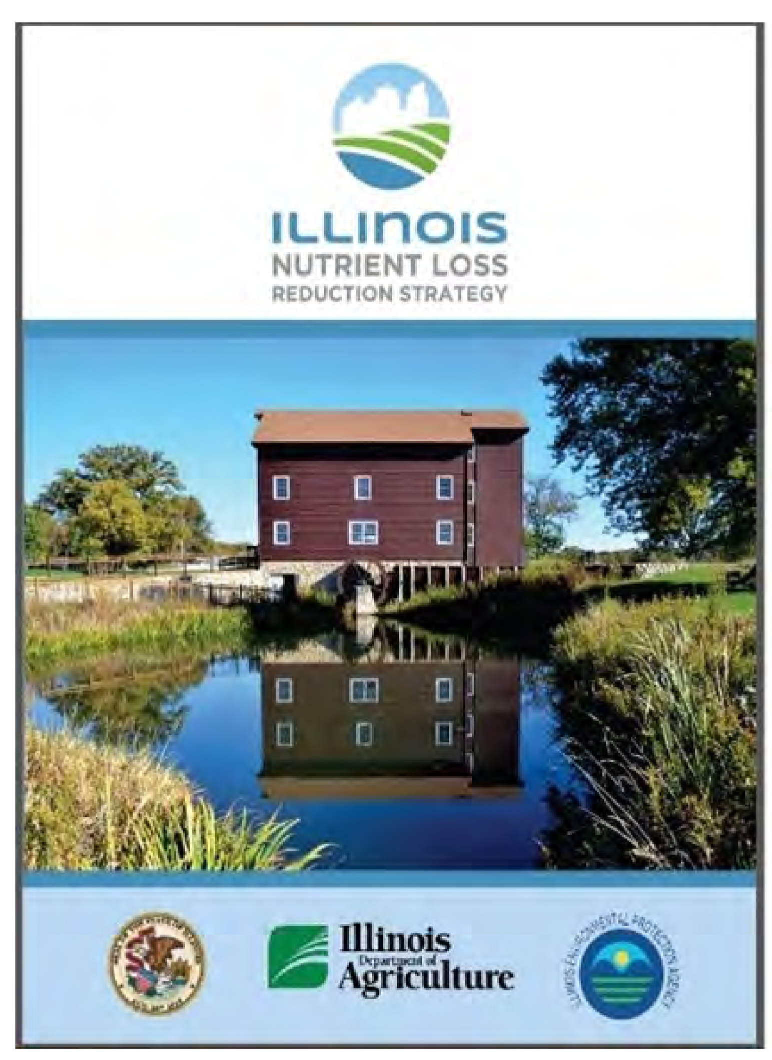


- Haley Haverback
  - Located in Galva, IL, Extension Office
  - Works in 2 Nitrogen priority watersheds
    - Mississippi Central/Henderson Creek Watershed
    - Lower Rock River Watershed
- Jennifer Woodyard
  - Located in Effingham, IL, Extension Office
  - Works in 2 Phosphorus priority watersheds
    - Embarras River Watershed
    - Little Wabash River Watershed

Current Agricultural Best Management Practices to Reduce Nutrient Loss

NITRATE
- IN FIELD PRACTICES
  - NITROGEN MANAGEMENT
    - MRTN, INHIBITORS, SPLIT APPL.
  - COVER CROPS
- EDGE OF FIELD PRACTICES
  - BIOREACTORS
  - BUFFERS (NON-TILE DRAINED)
  - WETLANDS
- LAND USE CHANGE
  - PERENNIAL/ENERGY CROPS

PHOSPHORUS
- IN FIELD PRACTICES
  - REDUCED TILLAGE SYSTEMS
  - SOIL TESTS/NUTRIENT MANAGEMENT
  - COVER CROPS
- EDGE OF FIELD PRACTICES
  - BUFFERS
- LAND USE CHANGE
  - PERENNIAL/ENERGY CROPS



Why We Are Here

The state of Illinois is targeting a 15% reduction in nitrate-nitrogen and 25% reduction in total phosphorus by 2025, with an eventual reduction goal of 45% for both nutrients. The Watershed Outreach Associates' targeted outcomes to aid in reaching those goals include:

- Short Term
  - Increased Knowledge on Best Management Practices
  - Greater Appreciation for Water Quality
- Medium Term
  - Increased Use of Best Management Practices
  - Increase in Environmental Stewardship
- Long Term
  - Reductions in Nutrient Levels at Watershed Monitoring Sites
  - Improved Water Quality and Increase in Soil Health

How can *you* help protect and restore Illinois waters from nutrient losses?

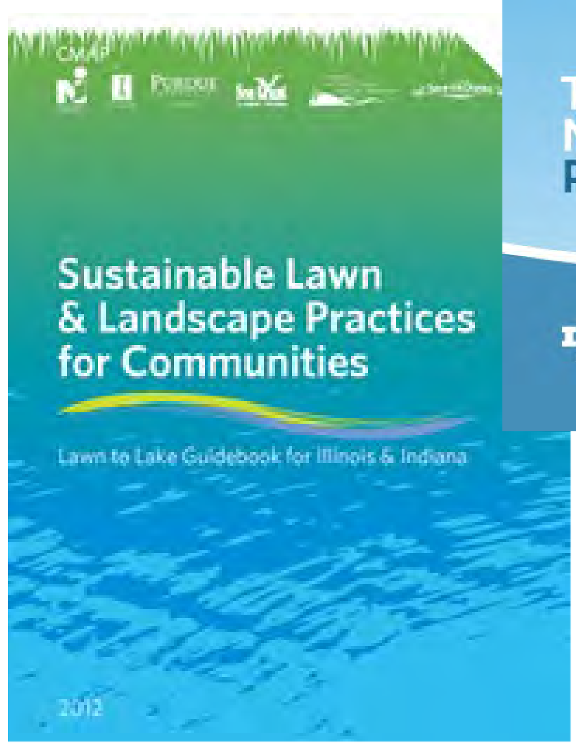
Watershed Outreach Associate Update

and Jennifer D. Woodyard
Extension

What We Do

Types of Programming

- Field Days
- Educational Series
- Site-Based Direct Education
- Factsheets
- Lawn to Lake Program
- Podcast



Illinois Nutrient Loss Reduction Podcast

- **Episode 1** - "Nutrient Loss Reduction Strategy"
- **Episode 2** - "Cover Crops: the why and how for this fall"
- **Episode 3** - "Bioreactors: How to Chip Away at Nitrogen Runoff"
- **Episode 4** - "Bioreactors: A Farmer's Perspective"
- **Episode 5** - "Fall Tillage and Fertilization Do's and Don'ts"
- **Episode 6** - "Conservation Tillage, Cover Crops, & Side Dressing Nitrogen
- **Episode 7** - "Handling Livestock Waste: Part 1 Confinement"
- **Episode 8** - "Handling Livestock Waste: Part 2 Pastures & Lots"
- **Episode 9** - "Handling Livestock Waste: Part 3 Best Management Practices"
- **Episode 10** - "Handling Livestock Waste: Part 4 Certified Livestock Manager Training

Year One Conclusions

Discussions with priority watershed stakeholders have yielded many conclusions in reference to the present and ongoing issues occurring with nutrient loss. We found that some producers have an awareness for the NLRS, but possess minimal technical knowledge needed to choose and implement nutrient loss reduction practices on an individual field basis. Creating learning opportunities for stakeholders to gain these skills will drive our programing in subsequent years.

Our Collaborators

- Local Soil and Water Conservation Districts
- Local Natural Resource Conservation Service Staff
- Local Farm Bureau Offices
- Illinois-Indiana Sea Grant Personal
- University of Illinois Campus-based Faculty and Staff
- University of Illinois Extension Educators

ILLINOIS NUTRIENT LOSS REDUCTION STRATEGY
Improving our water resources with collaboration and innovation
ILLINOIS Extension
COLLEGE OF AGRICULTURAL, CONSUMER & ENVIRONMENTAL SCIENCES
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
Illinois Department of Agriculture

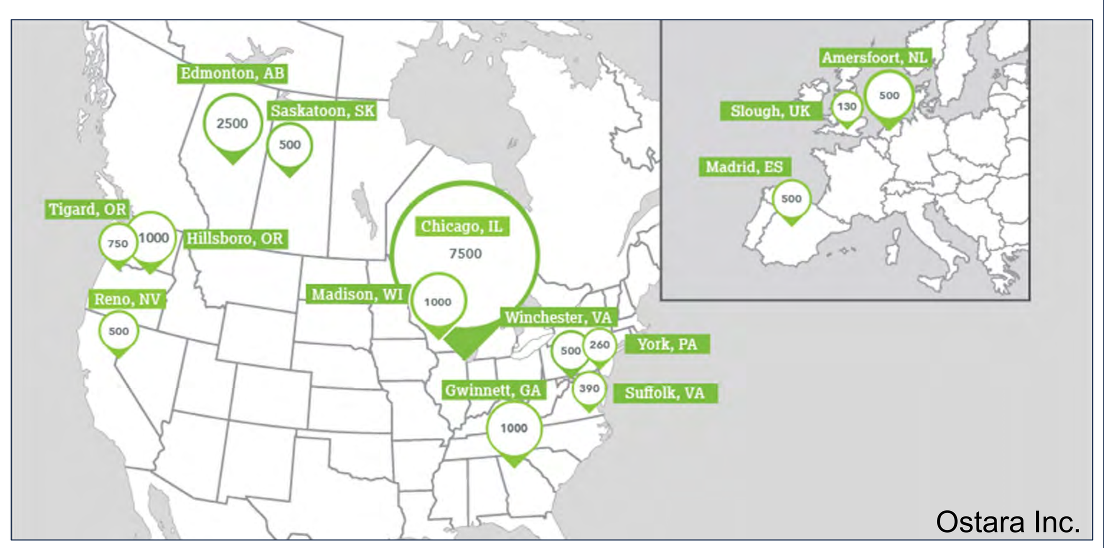
Utilizing Struvite as a slow release phosphorus fertilizer to mitigate agricultural P losses

Allan Hertzberger[1], Roland Cusick[2], Andrew Margenot[1]

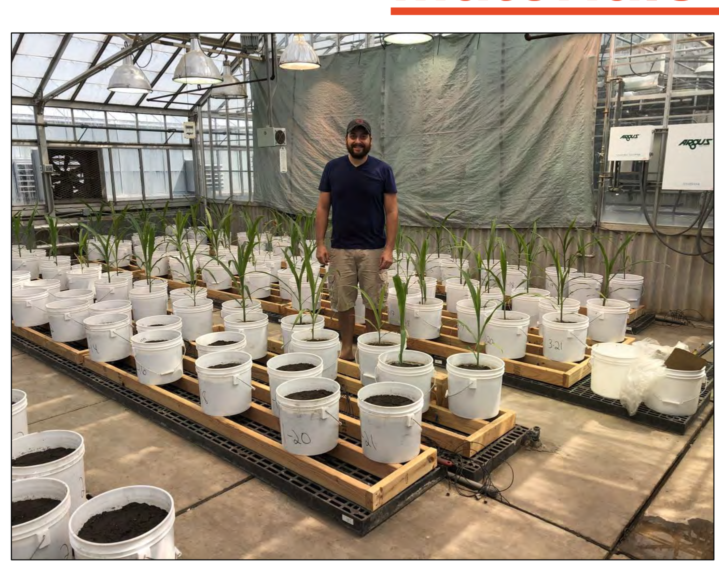
[1]Department of Crop Sciences, [2]Department of Civil & Environmental Engineering

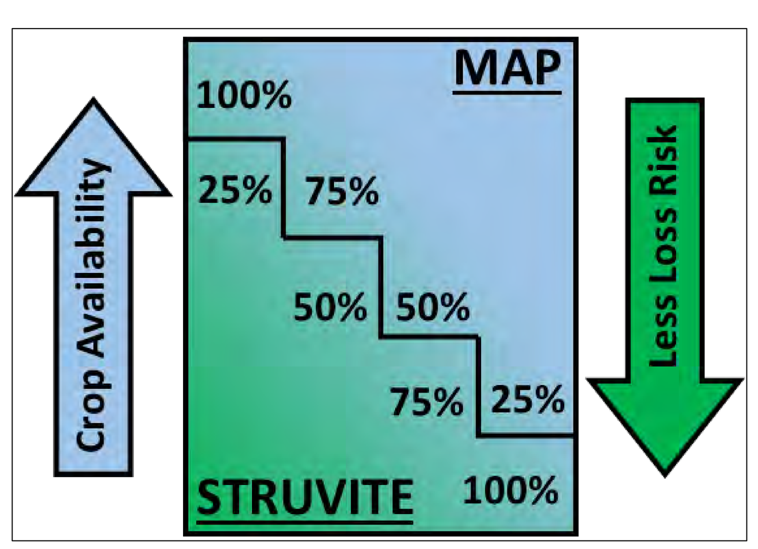
Introduction

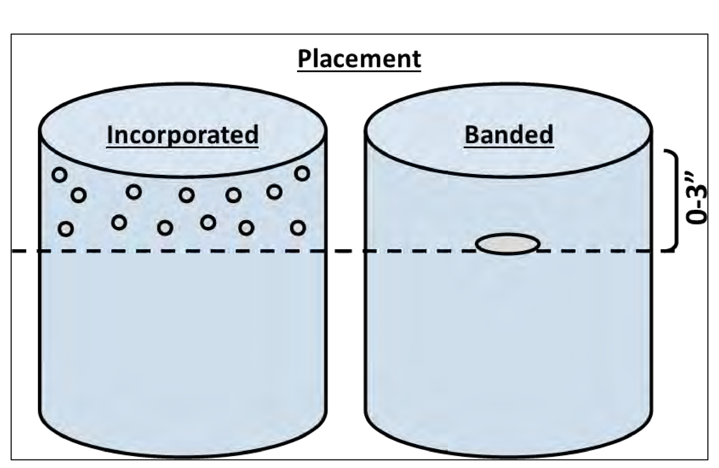
- The Illinois Nutrient Loss Reduction Strategy (NLRS) has set a goal of a 25% reduction in total P losses to the Mississippi River by 2025 and 45% by 2035.
- Struvite (NH_4MgPO_4; NPK 5-28-0) recovered from wastewater streams is a candidate renewable P source that has the potential to reduce P losses from agricultural systems.
- Struvite production in the United States is currently concentrated in the Midwest, overlapping with the region of intensive.
- The low water solubility but high citrate-solubility suggests its potential to better synchronize P dissolution with crop demand compared to highly water-soluble P fertilizers such as monoammonium phosphate (MAP).
- There are limited assessments specific to the soil and crop types of this potential agricultural sink for P recovered as struvite.
- Struvite, combined with the right fertilizer rate, placement, and timing may be optimal candidates to meet all of the 4R's for nutrient stewardship.

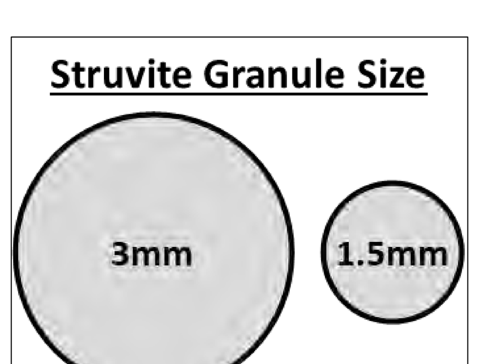


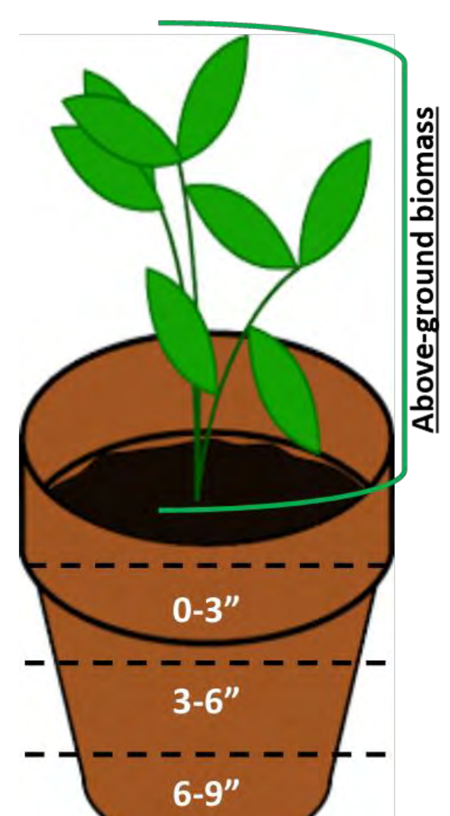
Materials and Methods











Crop Response

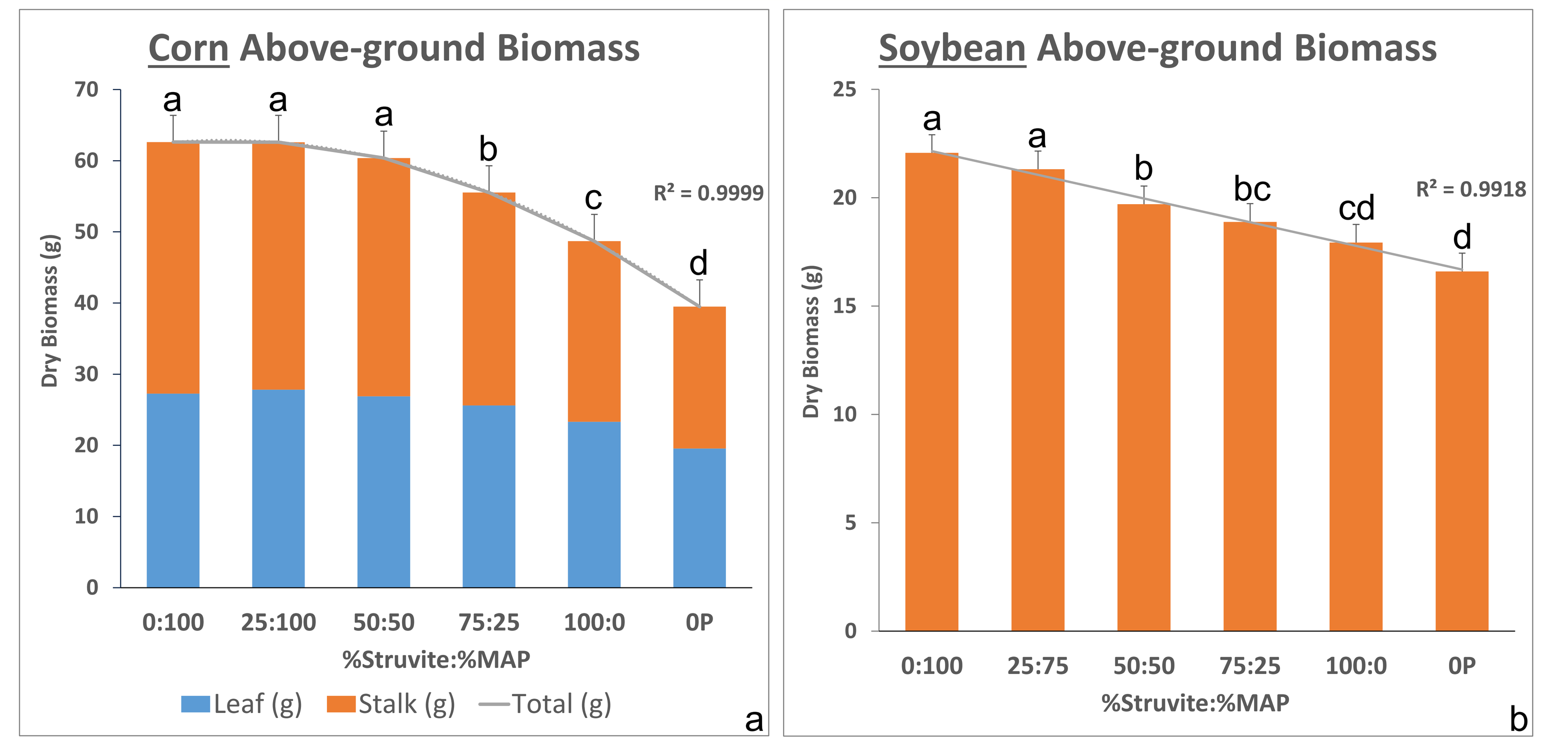


Figure 1. Mean above ground dry biomass for greenhouse corn (a) and soybean (b) for each struvite:MAP across all placements and granule sizes. Treatments with the same letter are not significantly different α=0.05.

Available Soil P Concentration by Depth

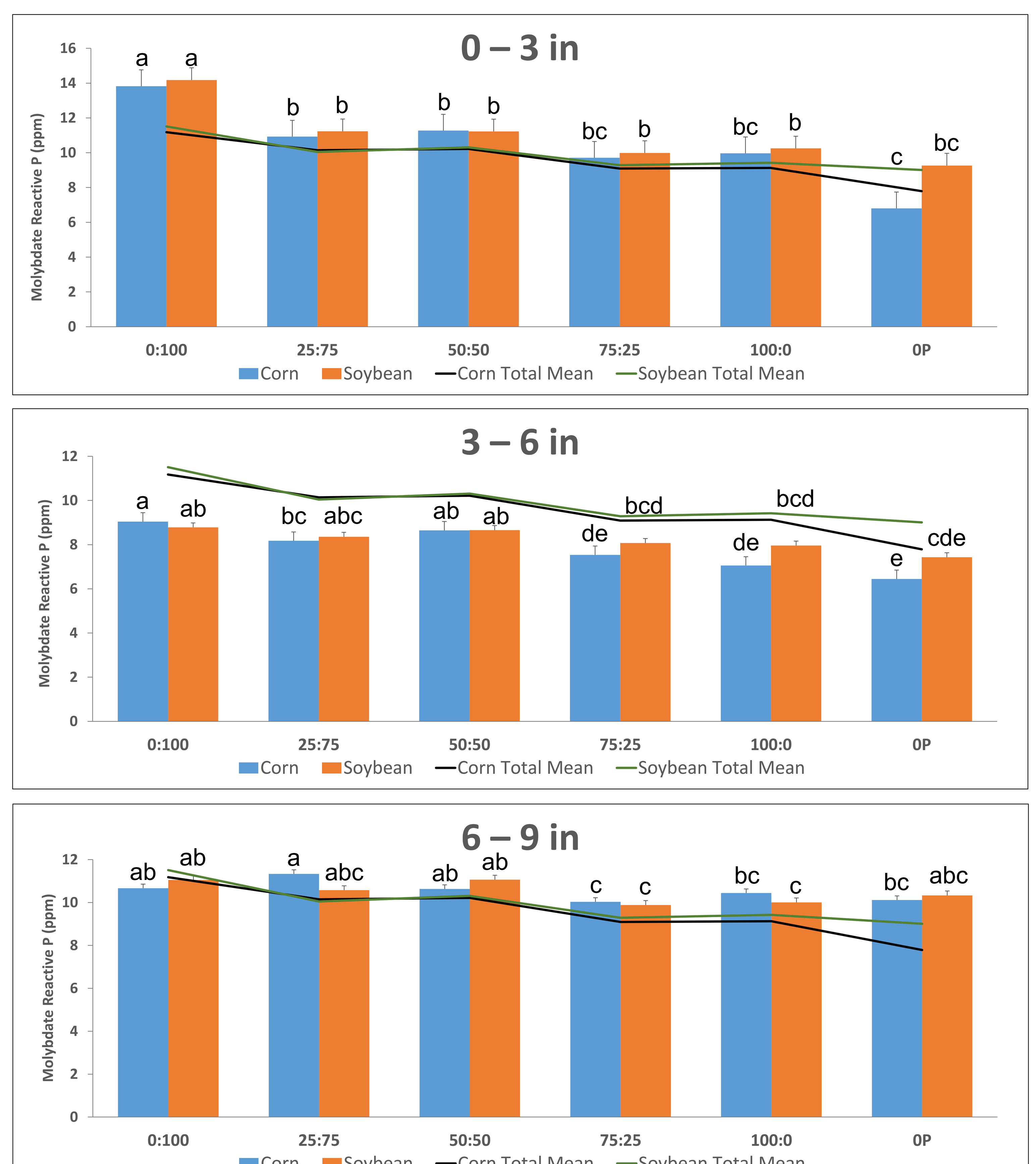


Fig 2. Mehlich III molybdate reactive P concentrations at each depth. Treatments with the same letter are not significantly different α=0.05. Lines represent the mean concentration across all depths for corn (black) and soybean(green).

Results

Corn and Soybean

- No significant differences in above-ground biomass between placement or granule size

Corn

- Above-ground corn biomass was not significantly different for 0:100, 25:75, and 50:50 struvite:MAP
- Mehlich III P concentrations in the top 3" were significantly higher for 0:100 compared to those treatments supplemented with struvite
- Mehlich III concentrations in the middle third of pots (3-6") were on average lower than the top or bottom thirds

Soybean

- Above-ground corn biomass was not significantly different for 0:100 and 25:75
- Mehlich III P concentrations in the top 3" had significantly greater concentrations in pots that received the 0:100 treatment
- Concentrations in the middle third were not significantly different for 0:100, 25:75, and 50:50 treatments

25% to 50% of MAP usage can be replaced with struvite, decreasing P loss risk without hurting crop productivity.

Future Work

- Greenhouse information used to design a field experiment starting spring 2019 at the University South Farm
- Corn crop will be planted to 6.5m X 18.3m plots receiving **0:100, 25:75, 50:50, and 75:25 struvite:MAP treatments**.
- **Placement** will be tested with fall and spring broadcast as well as spring banded treatments
- Treatments replicated in **conventionally tilled and no-till plots**.
- Treatments will also be tested in a soybean crop spring 2020 to test effects over a traditional **corn/soybean rotation**.

ACKNOWLEDGMENTS

Funding for this work was provided by the Illinois Nutrient Research and Education Council (NREC - 2018-4-360731-385)

Recovery of Phosphorus from Corn Wet Milling Industry: A Techno-economic Evaluation

Ankita Juneja[1], Navneet Sharma[2], Roland Cusick[2] and Vijay Singh[1*]

[1]Agricultural and Biological Engineering, University of Illinois Urbana Champaign; [2]Civil and Environmental Engineering, University of Illinois Urbana Champaign

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Objective

- Study the flow of phosphorus and perform a technoeconomic analysis to assess the economic feasibility of its recovery as a coproduct in the corn wet milling process

Introduction

- Excess phosphorus (P) in animal food can lead to high P in manure eventually causing non-point surface runoff.
- Corn gluten feed (CGF), a coproduct from wet milling plants, has ~12 mg/g P, where ruminant requirement is ~3 mg/g.
- Economical way to reduce P in CGF is to recover it upstream.
- All of the P in CGF comes from corn kernel, 70% of which leaches in steepwater, from where it can be recovered.

Method

- Process model of a wet milling plant processing 2544 MT/day with an operational run time of 7,920 h was developed in SuperPro Designer (figure 1) (Ramirez et.al., 2008).
- Six main sections were modeled in 'base case': grain handling and cleaning, steeping, germ separation and recovery, fiber separation and recovery, gluten separation and recovery and starch washing and recovery.
- P flows were modeled from values published in literature (Rausch et. al., 2005, Noureddini et al., 2009).
- Another section 'Phosphorus recovery' was added for modified model referred here as 'P recovery case', where P was recovered from steepwater.
- Fraction of P recovered by determined with in-lab experiments.
  - Light steepwater was centrifuged at 2 speeds (3000 g and 5000 g) and for 2 times (3 minutes and 5 minutes).
  - $CaCl_2$ was added after changing the pH of the centrate.
  - Two pH (8 and 9), and three ratios of Ca:P (1:1, 1.5:1 and 2:1) were investigated for maximum precipitation of P.
  - 1-way ANOVA and Fisher's least significant difference (LSD) tests were used to compare the phosphorus concentration
- Experimental results were added to the model to perform technoeconomic analysis.
- The cost of all the equipment & supplies, revenues from coproducts, and prices of chemicals and utilities for this model were obtained from literature.
- Composite purchase factor of 3.0 was used.

Results

- Maximum P partitioning in centrate of 88.8% was observed after 1st centrifuge at 3000 g for 3 minutes.
- Maximum P recovery (92.9%) was obtained (figure 2).
- Ca:P ratios 1.5:1 and 2:1 gave statistically similar P recoveries (table 1)

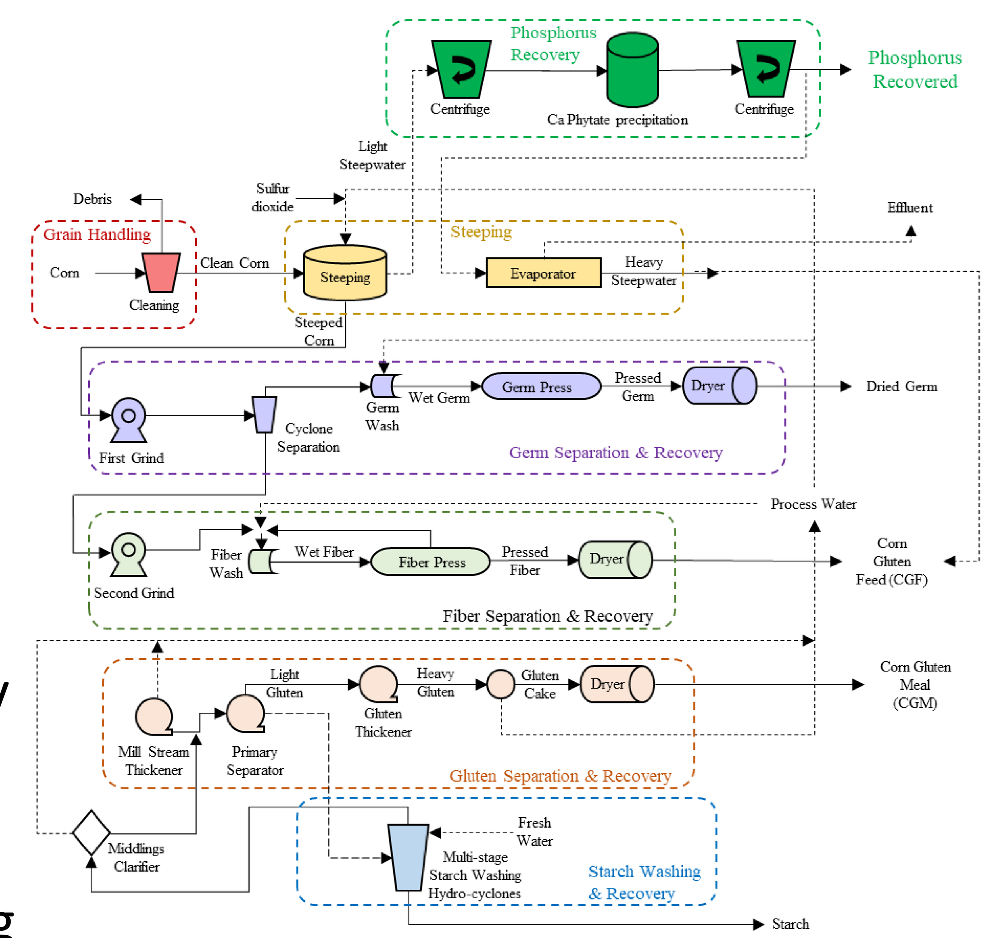

Figure 1: Schematic illustration of modeled wet milling plant with phosphorus recovery section.

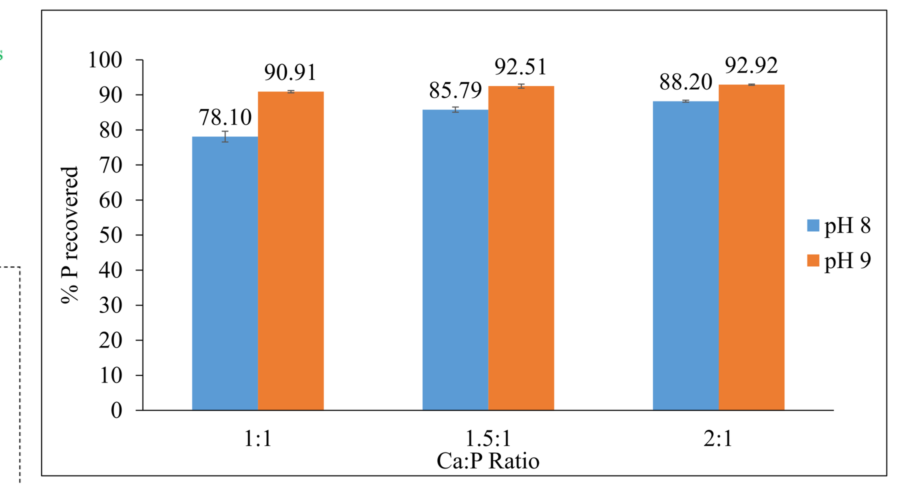

Figure 1: Phosphorus recovery achieved at three Ca:P ratios and two pH conditions.

Table 1: Statistical analysis for phosphorus recovery at two pH and three Ca:P ratios.

Treatment number	Conditions		Statistical difference*
	pH	Ca:P Ratio	
1	8	1:1	e
2	8	1.5:1	d
3	8	2:1	c
4	9	1:1	b
5	9	1.5:1	a
6	9	2:1	a

* Similar letters represent no significant difference ($p<0.05$)

- Addition of phosphorus recovery unit to a wet milling plant would incur an additional direct fixed capital cost (DFC) of 6.94 $MM
- Increase in operational cost with P recovery unit were 2.76 $MM/year
- Amount of $CaCl_2$ accounted for more than 99% of the extra material cost.
- All the P recovered lead to a reduction in P in CGF (flow of P in a conventional wet milling plant and one with P recovery section are shown in figure 3 & 4).
- A total of 165 kg/h P was recovered with operating cost of $1.23/kg-P removed.

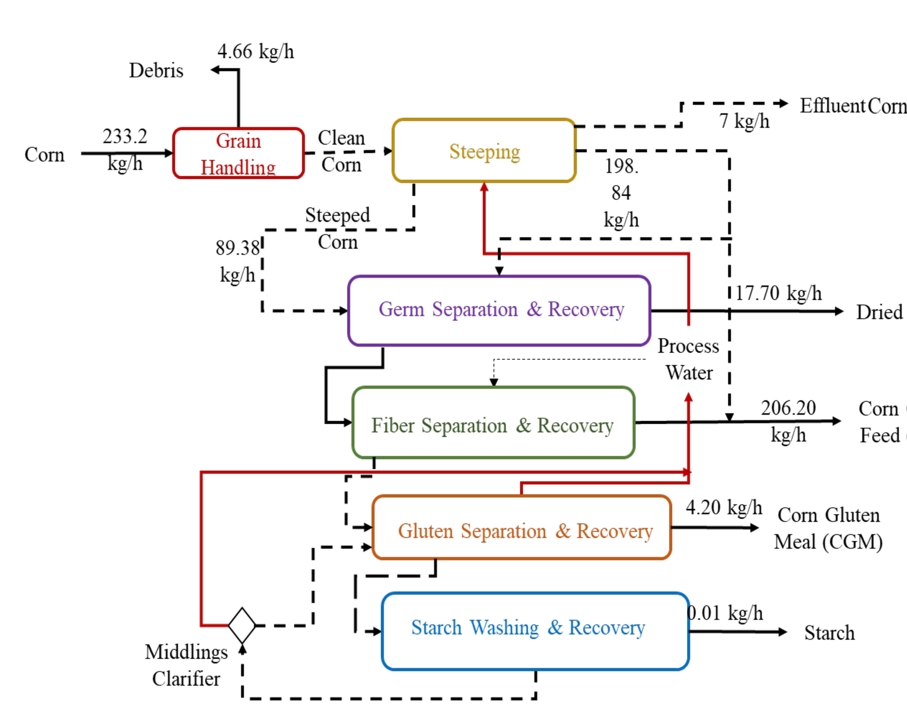

Figure 3: Flow of P in modeled conventional wet milling plant.

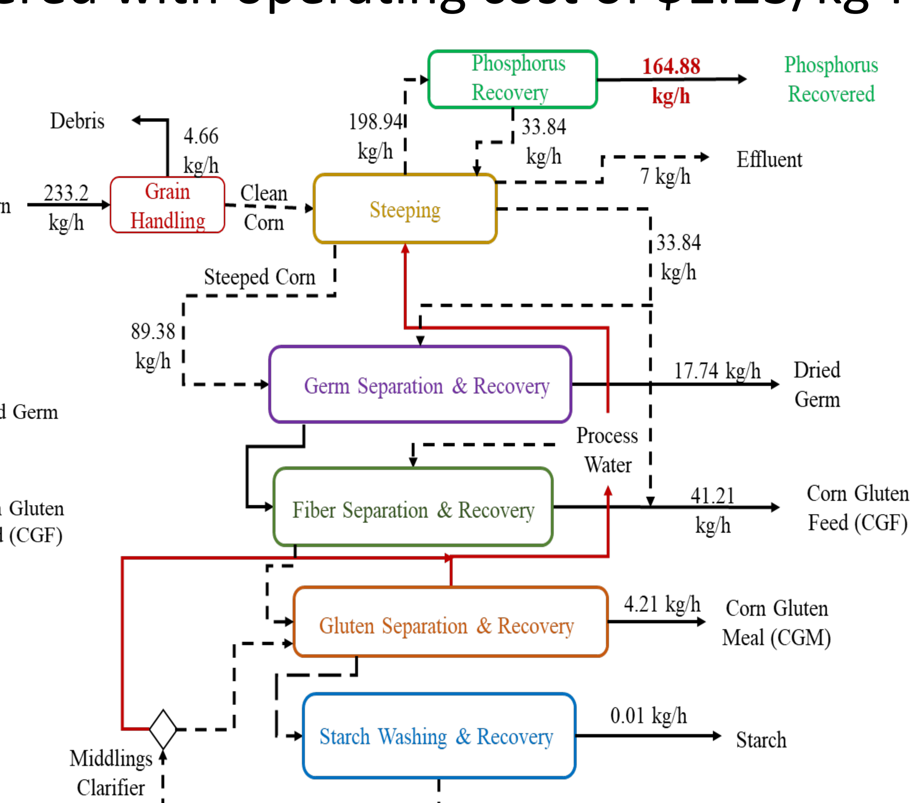

Figure 4: Flow of P in modeled wet milling plant with P recovery section.

- The amount of P in CGF was reduced to 2.44 mg/g (db).
- Sensitivity Analysis
  - Performed with two parameters: Ca:P ratio and P removal efficiency
  - With increase in Ca:P ratio, the amount of P recovered increases, and the cost per unit P recovered also increased, mainly due to amount of Ca used (figure 5).

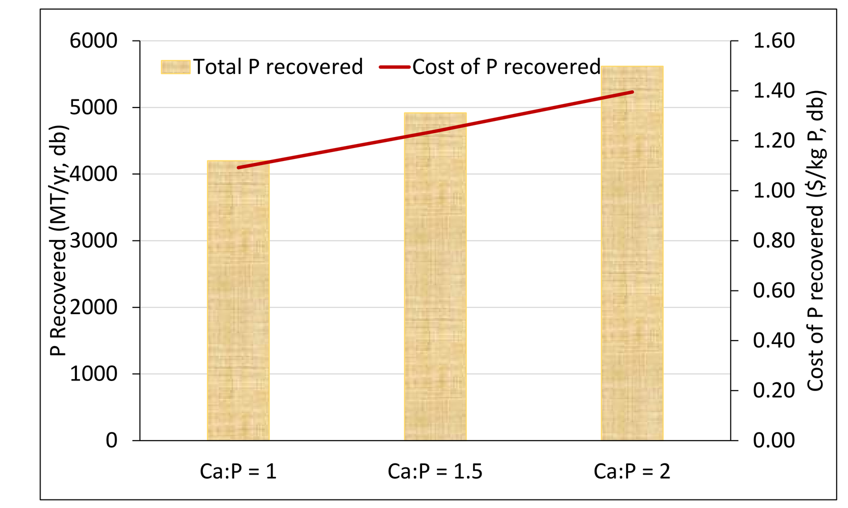

Figure 5: Effect of Ca:P ratio on total P recovered and cost of P recovered.

  - Since all the P recovered from steepwater would conventionally be added to CGF, increase in P removal efficiency reduced the P in CGF (figure 6).

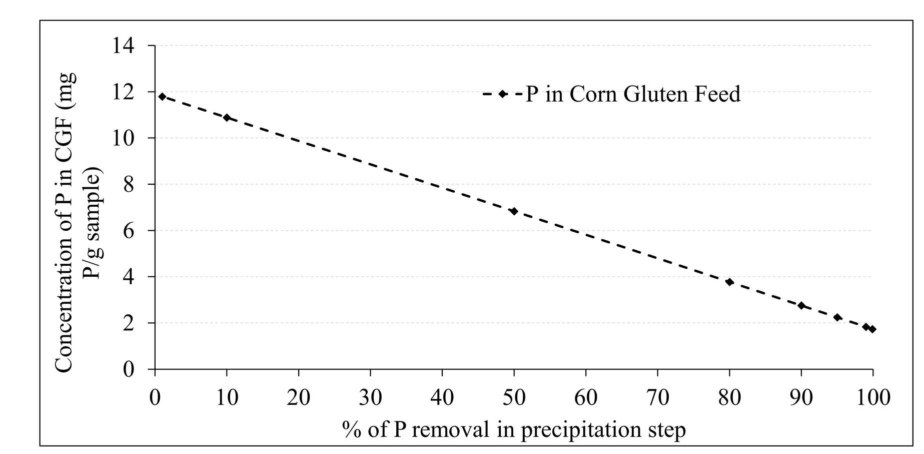

Figure 6: Effect of P removal efficiency on phosphorus distribution in CGF .

Conclusions

- Techno-economic analysis was performed to evaluate the feasibility of phosphorus recovery from corn wet milling plants to reduce the amount of phosphorus in CGF
- The amount of phosphorus in CGF was reduced from 12.94 mg/g (db) to 2.44 mg/g (db), consistent with ruminant
- P recovered (1306 MT/y) can be used as fertilizer on more than 96,000 acres of corn per year.

References

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- Rausch, K.D., Raskin, L.M., Belyea, R.L., Agbisit, R.M., Daugherty, B.J., Clevenger, T.E., Tumbleson, M. 2005. Cereal chemistry, 82(4), 431-435.

Acknowledgement

- National Science Foundation, Division of Earth Sciences. Award number 1739788.

Irrigation with Runoff and Drainage Water as a Strategy to Mitigate Nutrient loss and Increase Crop Yields

O. Oladeji*[1], G. Tian[1], A. Cox[1], R. Cooke[2], L. Lurkins[3], E. Stone[4], A. Echols[5], H. Zhang[1], and E. Podczerwinski[1]

Background

- Nutrient export from agricultural fields enter freshwater through surface runoff or subsurface transports
- The use of runoff and drain flow for irrigation can:
  - improve nutrient use by crops
  - mitigates nutrient loss - recycle nutrients for crop use
  - reduce fertilizer needs – reduce cost
- Irrigation through drainage tile is an inexpensive option compared to conventional irrigation practices
  - enhance adoption by farmers
- There are over 10 million acres of tiled-drain fields in Illinois
  - an opportunity to implement drainage water reuse
  - the practice can benefit farmers' bottom line and dramatically improve water quality.

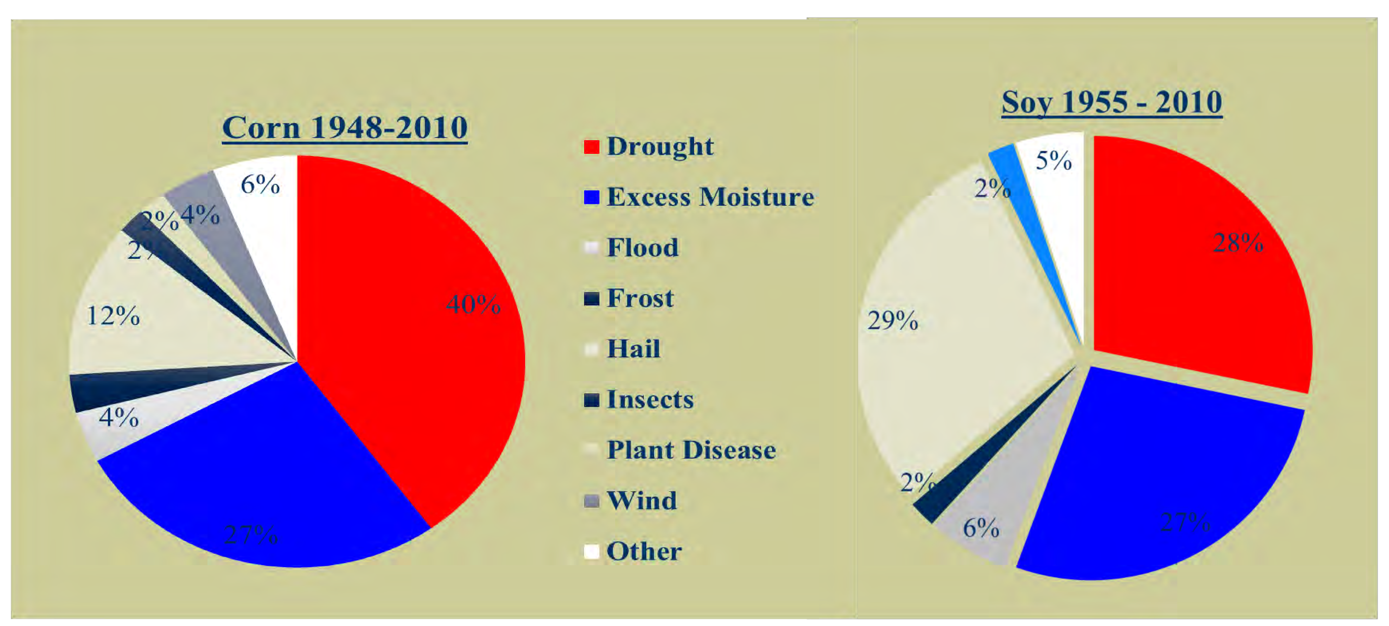


Fig. 1. Causes of Crop Loss Iowa (*Data courtesy of Chad Hart, Managing Risk in Agriculture, Iowa State University, June 2013)*

Objective

To demonstrate water and nutrient recycling through irrigation as a best management practice to reduce nutrient loss and optimize crop yield at reduced fertilizer use

Preliminary Surface Irrigation Study

Study Layout and Treatments

- The 250 ft by 180 ft experimental block is located in a MWRD's field at Fulton County
- The block divided into three 250 ft by 60 ft plots to receive the following treatments:
  - T1: Irrigated plot with 50% fertilization
  - T2: Non-irrigated plot with 50% fertilization
  - T3: Non-irrigated plot with 100% fertilization

Preliminary Findings

- Irrigation increased corn N and P uptake
- Runoff irrigation Increased Nutrient Use Efficiency (NUE)
- Optimized corn yield at reduced fertilizer rate

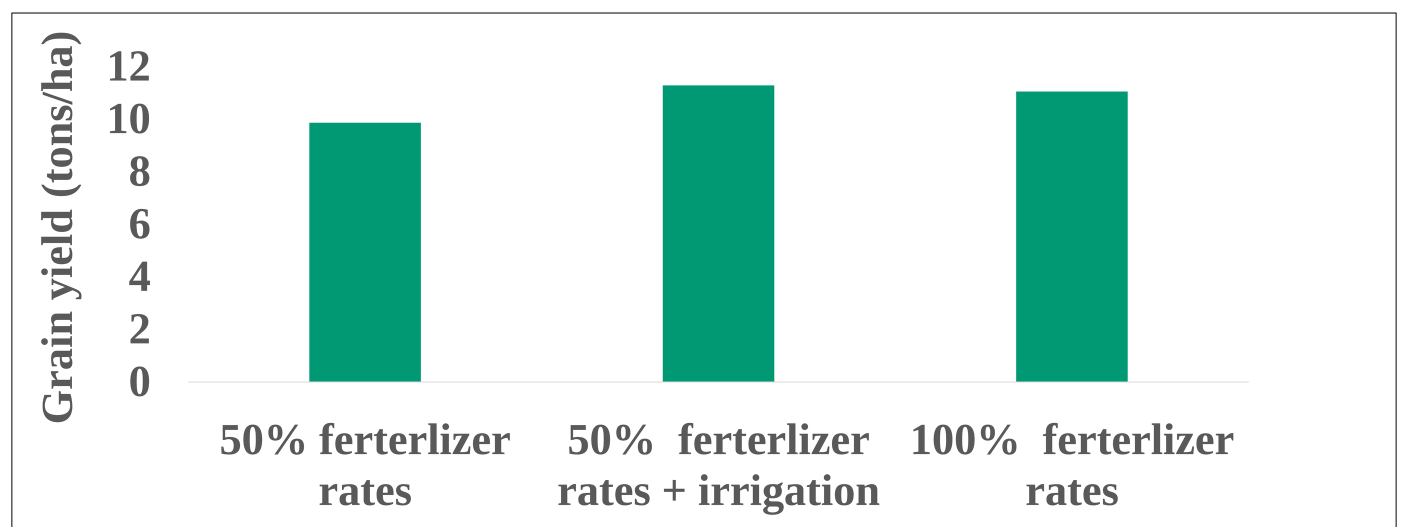


Fig. 2. Mean corn grain yield harvested during the study

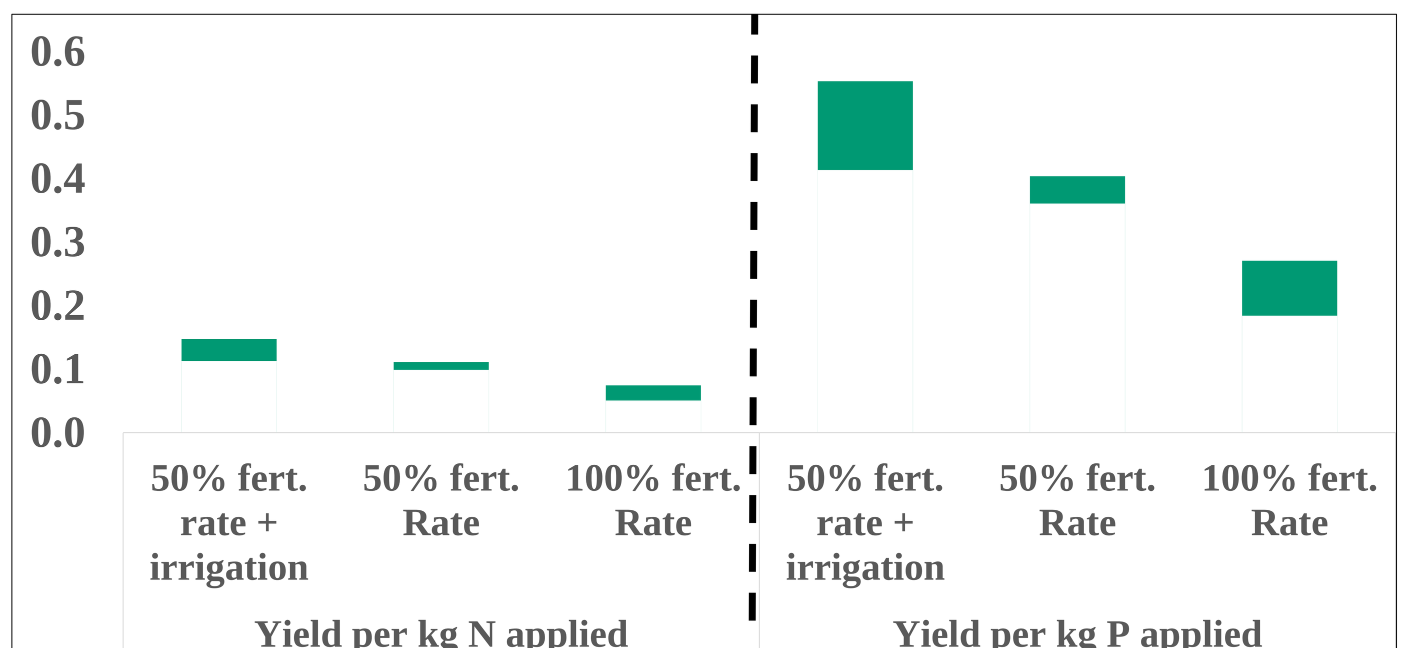


Fig. 3. Nutrient use efficiency (NUE) of corn estimated as corn total biomass per kg of N and P applied

Drainage Water Management & Sub-irrigation (Illinois NREC Sponsored Project)

Study Layout and Treatments

- The 20 ac field tiled and divided into four subfields to receive the following treatments:
  - T1: Conventional drained with 100% fertilization
  - T2: Conventional drained with 50% fertilization
  - T3: Drained/sub-irrigation with 50% fertilization
  - T4: Drained/sub-irrigation with 100% fertilization
- Each subfield equipped with control structure

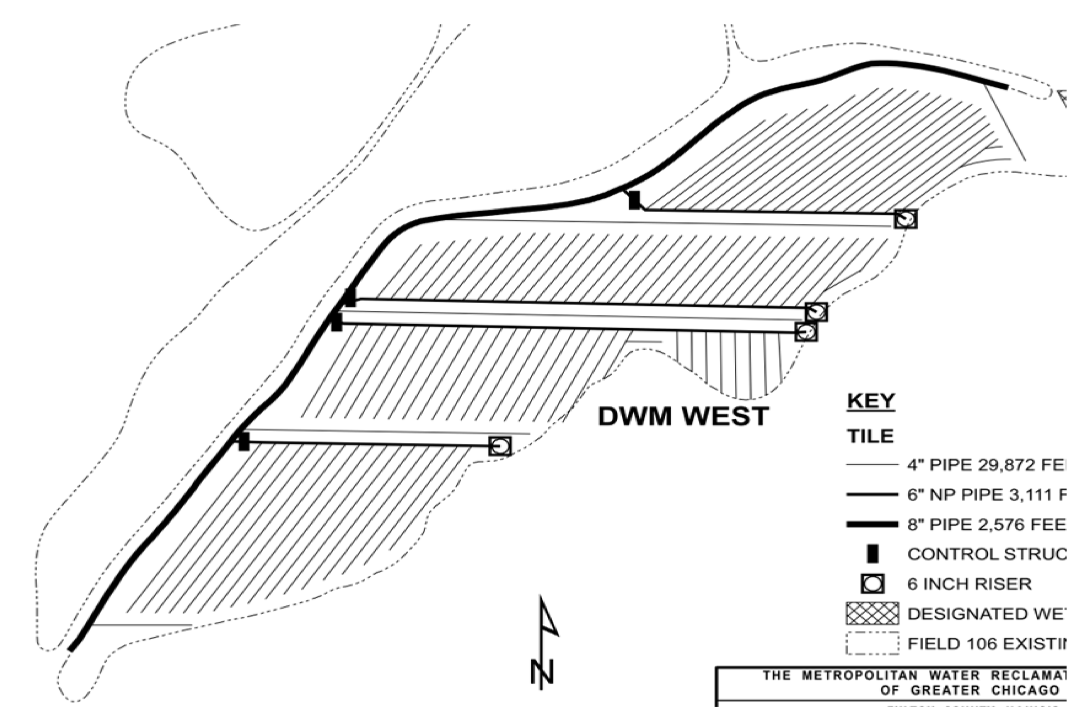


Fig. 4. Site map and field layout – Drainage water management project

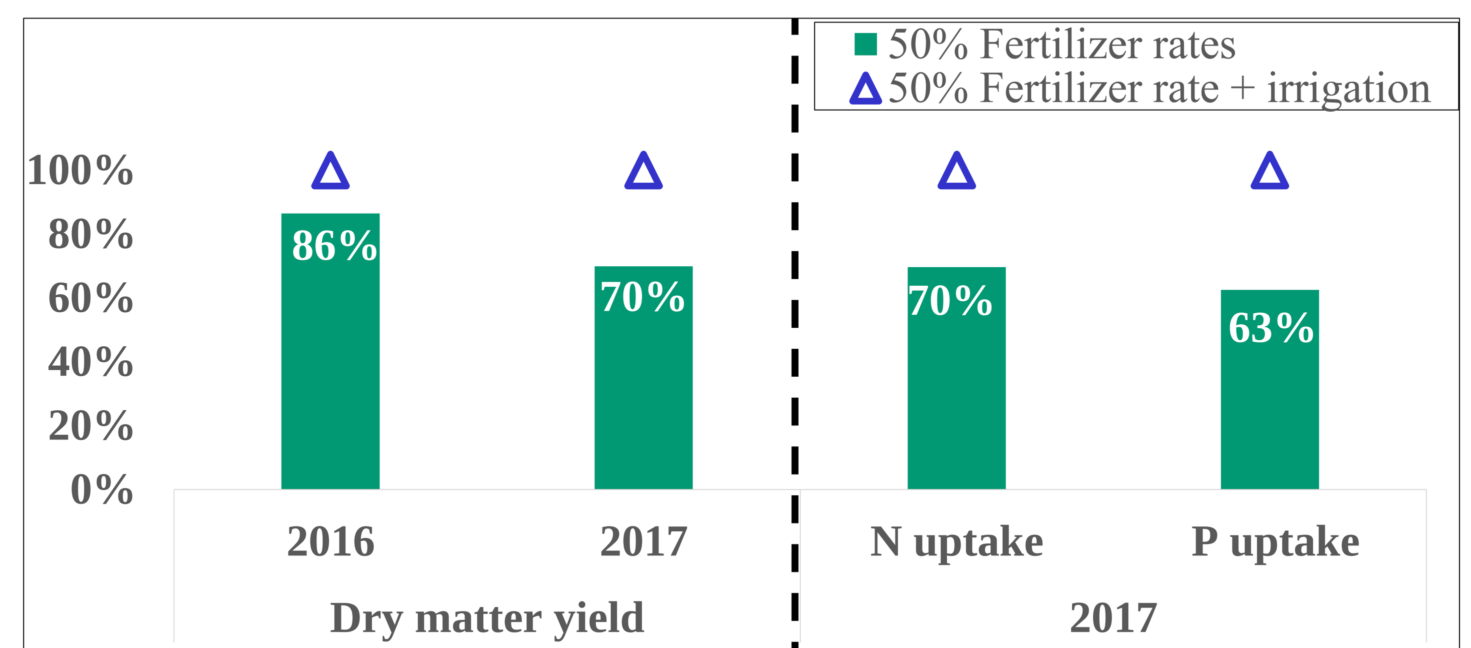


Fig. 5. Percentage corn total biomass yield and N & P uptake of non-irrigated relative to irrigated fields during the study

Drainage water management

- Spring - Water table lowered for planting
- Summer - Irrigation to supply water to crops
- Fall - Water table lowered for harvest
- Winter - Water table raised to
  - create dormant season water table
  - reduce nutrient losses

Ongoing Monitoring

- Water flow, N and P in weekly water samples
- Plant yield and nutrient uptake

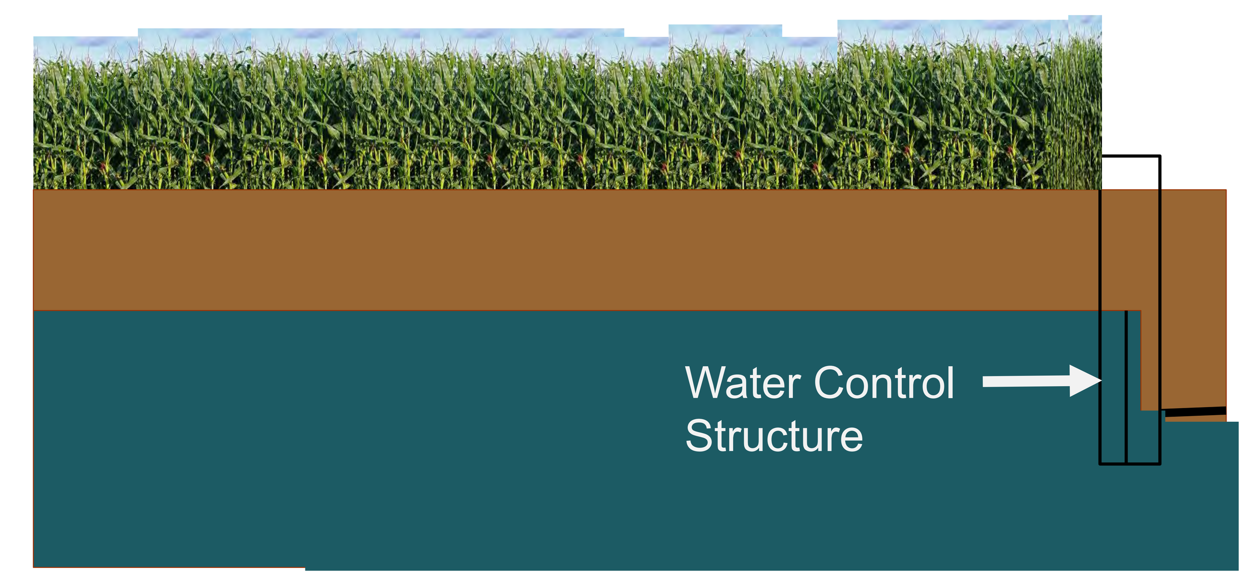


Fig. 6. Control structure for Drainage water management

Partnership:

1. MWRDGC
2. UIUC, Urbana-Champaign
3. Illinois Farm Bureau
4. Fulton County Farm Bureau
5. Ecosystems Exchange Services

Encouraging Adoption of Best Management Practices

Kendra Zeman and Dr. Luis F. Rodríguez
University of Illinois Urbana-Champaign

Abstract

Agriculture is a major non-point source of nutrient pollution which results in hypoxia and eutrophication in US water bodies. Understanding how farmers make management decisions and identifying their motivations for adopting BMPs is important in reducing nutrient loss.

A computer model, NitroShed, was created to model the environmental and human factors that result in nitrogen pollution. An improved farmer decision-making algorithm was created to better simulate the behavior of farmers in choosing investments in environmental infrastructure and management practices. **Ensuring the model is useful to stakeholders engaged in increasing adoption practices is an important step in building the model.**

The updated model includes a typology of famers based on decision-making factors. The model is then run under conditions to test adoption rates of BMPs through the use of policy changes and financial influences. Typologies can then be calibrated to accurately represent the behavior of farmers in a region. This will help policy-makers and extension services determine the most effective action plan in increasing farmer adoption of BMPs.

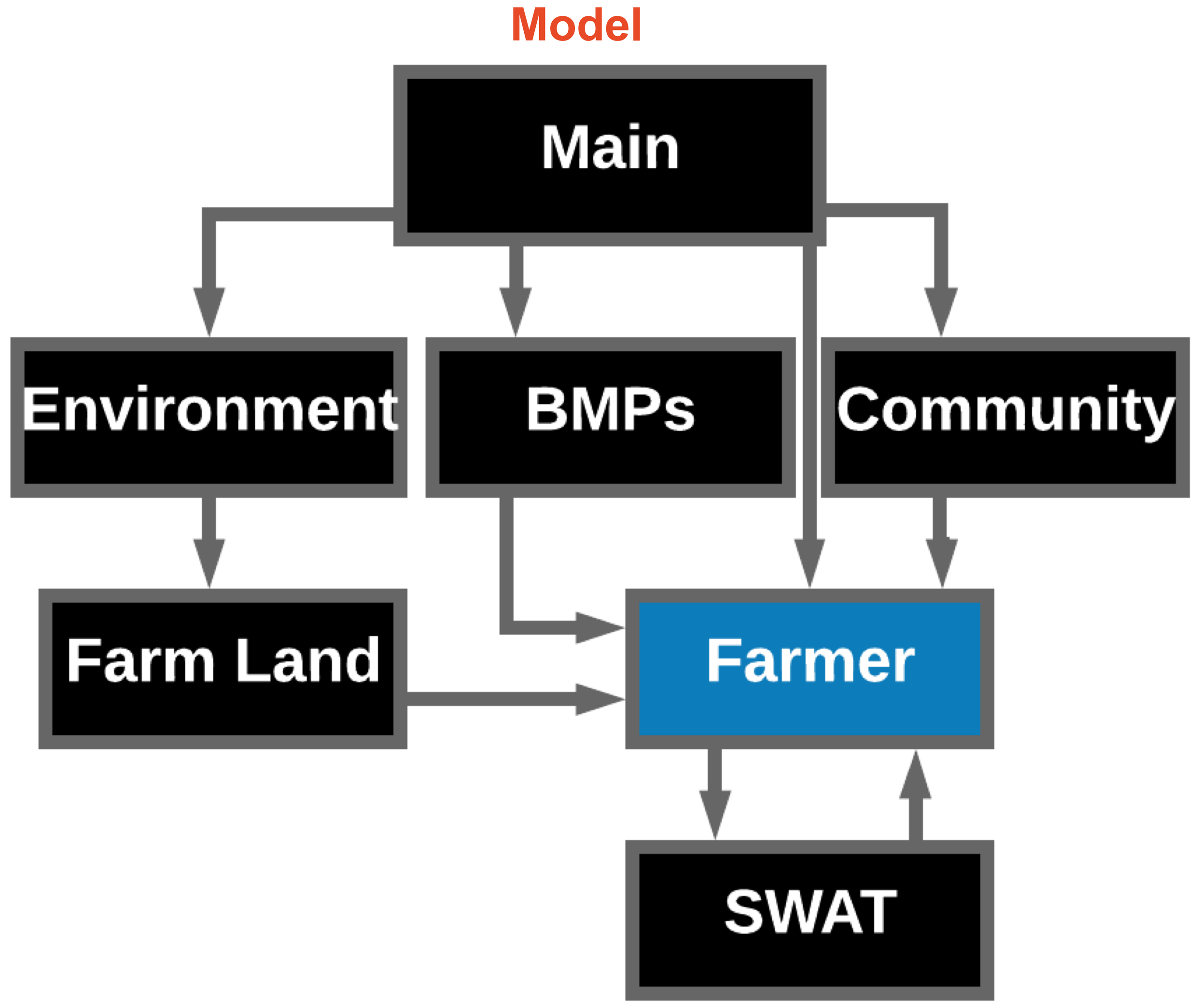
Methods

This model is designed to identify the policy options which will and decrease nutrient loss from crop fields and potentially improve farmer adoption rates of best management practices. The model is run in MATLAB and Soil and Water Assessment Tool (SWAT).

Assumptions

- Farmers are generally risk averse with a significant economic influence
- Farmers can be separated into typologies with unique decision-making parameters
- Farmer decision-making is done entirely by the farm operator
- Farmers are satisficing decision-makers
- All non-farmer stakeholders are represented in a single community agent
- The only cash crops grown are corn and soybean
- Types of BMPs simulated are 4 Rs, controlled drainage, and cover cropping

Model

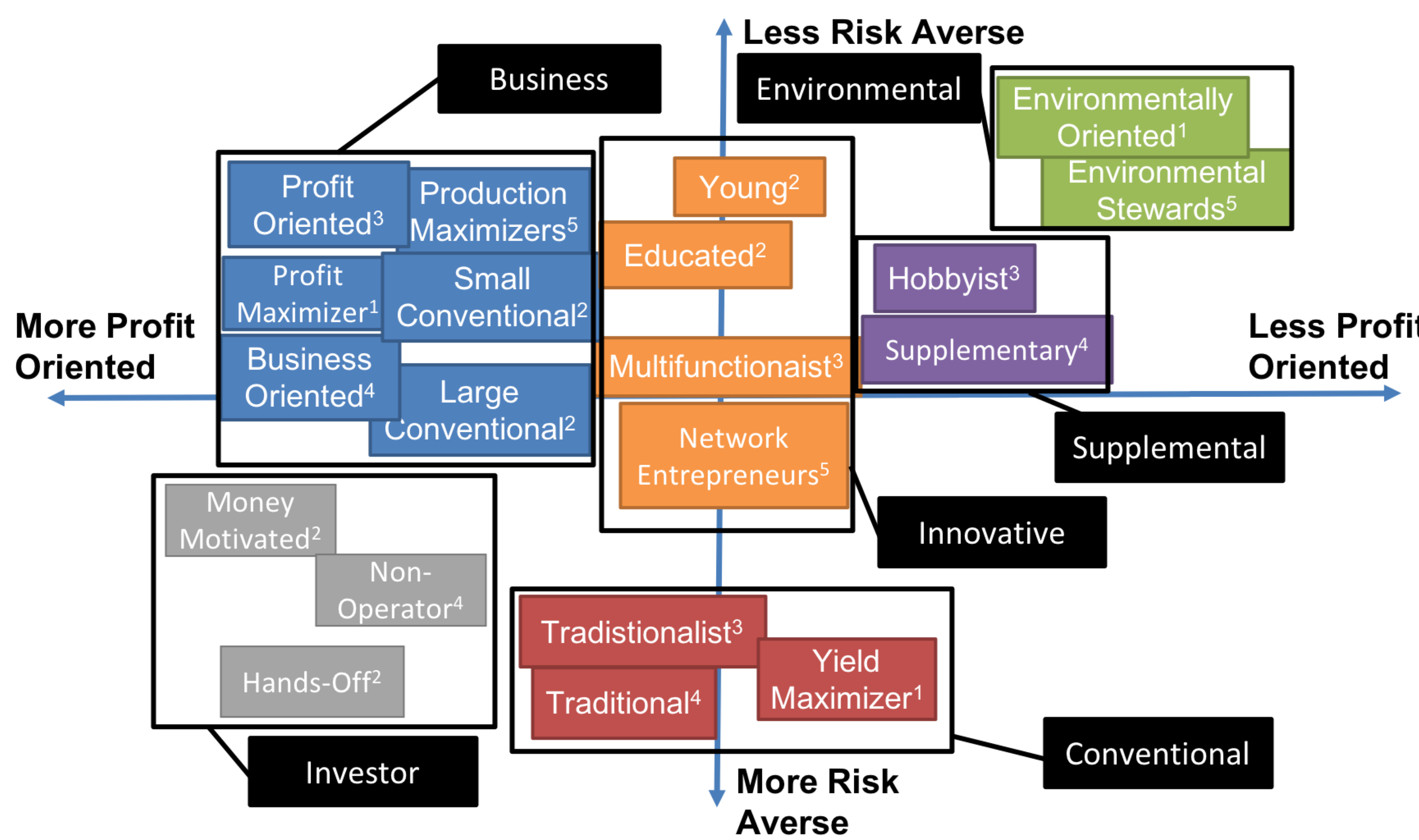


Parameters Influencing Farmer Decision-Making

Economic Concern	Social Concern	Environmental Concern	Risk Aversion	Interest in Innovation
• Available Capital • Cost of Investment • Taxes • Expected Income • Available Cost-Share • Available Credit	• Neighbor Behavior • Neighbor BMP Opinion • Attitude Towards Social Network	• Perceived Impact on Environment • Soil Erosion • Stewardship • Available Education	• Perceived Risk of Non-Compliance • Failure of Practice • Success of Practice by Neighbors • Crop Failure	• Available Education • Available Technology • Access to Internet

Typology

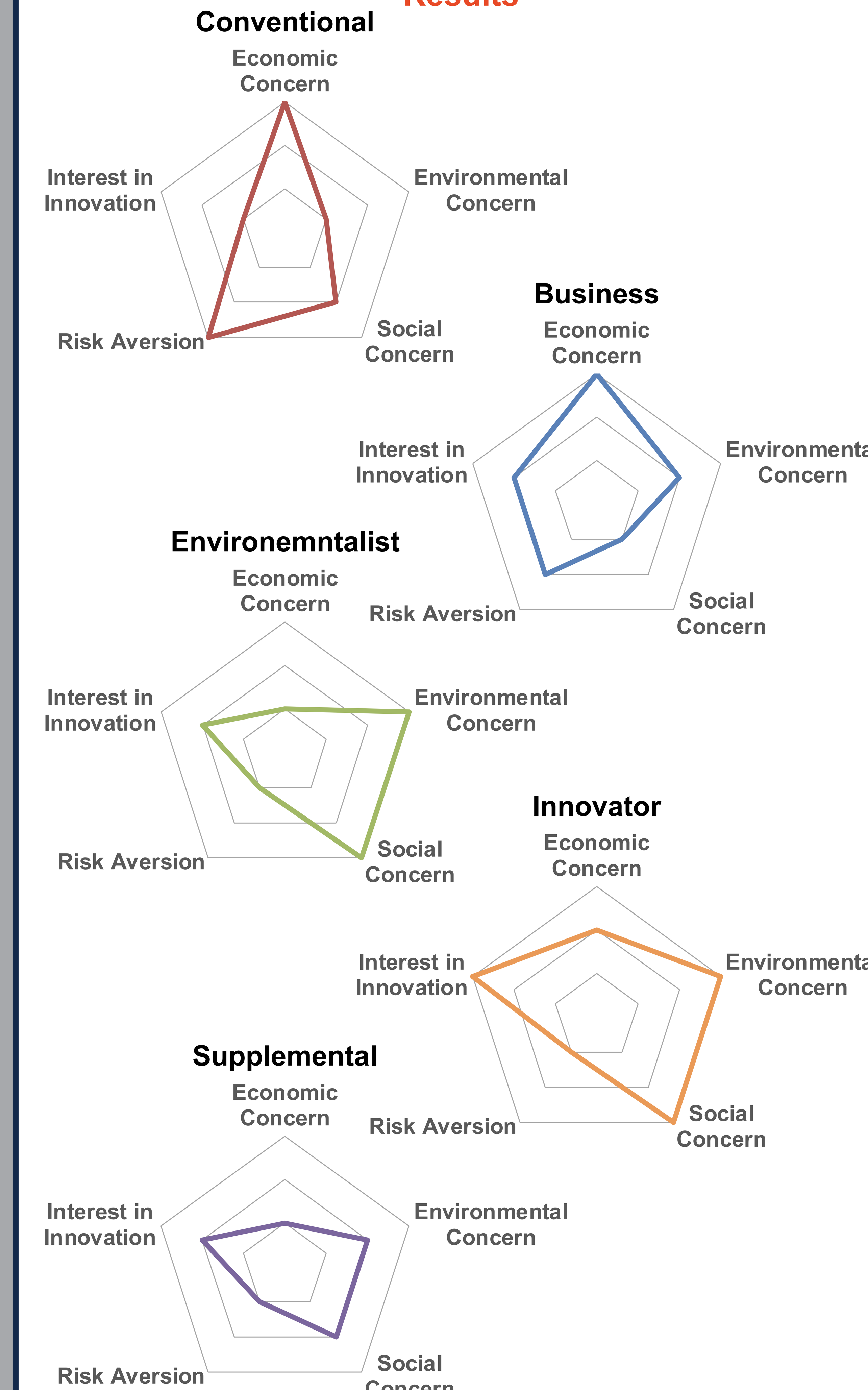
Distinct groups of farmers were identified using survey studies. These typologies will be used in the model as a means of testing the factors which farmers consider when making decisions about management practices and infrastructure investments on their farm.



1. Malawska and Topping, 2016
2. Mattia et al. 2016
3. Guillem et al. 2012
4. Dalaglu et al. 2014
5. Brodt et al. 2006

	Conventional	Business	Environmentalist	Innovator	Supplemental
Summary Description	• Strong farming identity • Multigenerational farmers • Value traditional practices	• Large farms • View farming from primarily economic perspective	• Willing to sacrifice profit and take risk to protect environment	• Willing to seek and make changes in their practice	• Secondary income • Tend to be smaller • Less capital available

Results



Conclusions and Questions

The Nitroshed model created using the farmer typology will aim to simulate farmer decision-making in BMP adoption. In order for this model to be beneficial, it must meet the needs of stakeholders and the assumptions made must accurately represent farmers. It is therefore the goal of the researchers at this time to seek input from people involved with the Nutrient Loss Reduction Strategy to ensure that the model design meets these criteria.

- Are there gaps in our knowledge?
- What information would be beneficial for stakeholders?
- Does the typology represent your experience in the field?

DEPARTMENT OF AGRICULTURAL AND BIOLOGICAL ENGINEERING
College of Agricultural, Consumer and Environmental Sciences

ACKNOWLEDGEMENTS:
Thank you to IDOT, the University of Illinois Urbana-Champaign, NSF #1833225, Graham Kent, BioMASS Lab Group, and Contextual Engineering Research Group