2021 NREC Funded Research Projects
Project Objectives

Project Title	Instit.	PI	2021 Project Budget
A Long-term Evaluation of Nitrogen Application Timing and Cover Crops Impacts on the Fate and Availability of Nitrogen Fertilizer and Crop Production on Tile Drained Fields	Purdue	Armstrong	$ 190,437.00
The effect of cover crops on surface water quality: A paired watershed experiment in the Lake Bloomington watershed	Purdue	Armstrong	$ 211,508.00
Nitrogen placement and application timing for best efficiency, growth, and yield of corn across Illinois.	UI	Below	$ 49,610.00
Watershed-scale response of agricultural systems to drainage water management in Central Illinois	UI	Bhattarai	$ 98,332.00
Assessing tile depth and spacing impact on nutrient losses and crop production	UI	Bhattarai	$ 49,970.00
Drainage water management and saturated buffers for achieving NLRS goals	UI	Christianson	$ 20,581.00
Bioreactors for Illinois: Smaller, Better, Faster	UI	Christianson	$ 14,715.00
On-Farm Evaluation and Demonstration of Reduced Off-Farm Nutrient Transport through Drainage Water Recycling	UI	Cooke	$ 74,804.00
Web-based Decision Support Tool for Cover Crop Management	UI	Coppess	$ 78,000.00
Reducing Nutrient Loads in WASCOBs in Southern Illinois	UI	Gentry	$ 91,688.00
Evaluating nutrient loss reduction strategies: longer rotation with cover crops and bioreactor (Miller Project)	UI	Gentry	$ 128,533.00

Nitrogen management systems in tile-drained fields: Optimizing yields while minimizing losses (Douglas County Project)	UI	Gentry	$ 237,354.00
Assessing Suitability and Benefits of Cover Crops in Illinois	UI	Guan	$20,000.00
Towards Management of Dissimilatory Nitrate Reduction to Ammonium for Nitrate Retention in Agricultural Soils	UI	Kent	$ 90,011.00
Evaluating slow-release P fertilizers to increase crop production and environmental quality	UI	Margenot	$ 41,506.00
Reducing P Loss in Southern Illinois: Producers, Practices, and Productivity	UI	R Christianson	$ 101,338.00
Precision Nitrogen Management of Corn for Improving Farm Profitability and Water Quality in Southern Illinois	SIU	Sadeghpour	$ 174,446.00
Nitrogen Rate Research & NREC Project Partnership	IFCA	Schaefer	$ 313,300.00
Water and Sediment Control Basins (WASCoBs) influence on Crop Yields and Water Quality	SIU	Schoonover	$ 143,507.00
Modelling and Designing Saturated Buffers for Nitrogen and Phosphorus Mitigation in Illinois	SIU	Schoonover	$ 136,191.00
Insect Management in Cover Crop Systems	UI	Seiter	$ 43,192.00
Water quality and agronomic impacts of gypsum applications in Southern Illinois	SIU	Williard	$ 130,398.00
Minimizing phosphorus and nitrogen loss from agricultural systems with cover crops and tillage in Southern Illinois	SIU	Williard	$ 189,917.00
Designer Biochar to Capture and Recycle Phosphorous from Tile Drainage Systems	UI	Zheng	$ 96,833.00
NEW PROJECTS			
Capitalizing on 150 Years of Soil Samples to Determine Legacy P and Improve Water Quality in Illinois	UI	Margenot	$ 226,732.00
Characterizing sub-field variability for efficient phosphorus management: targeting hotspots	UI	Fraterrigo	$ 65,453.00
Managing the maize microbiome for sustainable nutrient retention in Illinois agricultural soils	UI	Kent	$ 127,635.00

Next Generation Cover Cropping in Corn-Soybean Rotation to Improve Farm Benefits and Decrease Environmental Losses in South and Central Illinois	SIU	Sadeghpour	$ 153,824.00
Integrating livestock grazing into the western Illinois corn-soybean cropping system to enhance farm profitability and reduce nutrient loss	WIU	Bernards	$ 84,242.00
Sources and cycling of nitrate in tile-drained corn-soybean rotation systems: A stable isotope approach	UI	Yu	$ 132,475.00
Integrating Tillage, Soil Carbon Dynamics, and Tile Nitrate Loss (Eric Miller)	UI	Gentry	$ 218,242.00
Detection and attribution of recent changes in phosphorus loadings in the Illinois River watershed	Ui	Markus	$ 49,993.00
Knowledge is power: Powering up bioreactors and saturated buffers in Illinois	UI	L Christianson	$ 174,873.00

A Long-term Evaluation of Nitrogen Application Timing and Cover Crops Impacts on the Fate and Availability of Nitrogen Fertilizer and Crop Production on Tile Drained Fields	Purdue	Armstrong

Objectives:

1. Quantify the impact of N application timing (fall and spring) and cover crop inclusion on corn and soybean N uptake and yield, distribution of soil N, and nitrate loss through tile drainage.
2. Investigate the impact of N application timing and cover crop inclusion on N2O release during the year.
3. Utilize 15N methods to identify whether cover crops primarily take up soil or fertilizer N.
4. Determine the impact of cover crops on the fate and availability of fall and spring applied fertilizer N (mineralization, immobilization, nitrification, conversion to soil OM, leaching, and plant uptake) using 15N methodology.
5. Utilize 15N methods to determine the synchrony of the timing and quantity of cover crop residue N release and corn and soybean N demand.
6. Develop an economic model to evaluate the value/risk of cover crops based on 5 years of agronomic and environmental data.
7. Include a final report at the conclusion of this project to address each of the objectives stated above.

The effect of cover crops on surface water quality: A paired watershed experiment in the Lake Bloomington watershed	Purdue	Armstrong

1. To determine the impact of mass adoption of cover crops on nitrogen in tile drainage water.
2. To investigate the impact of mass adoption of cover crops on surface runoff P loss.
3. To quantify the spatial and temporal variation in cover crop growth and N uptake.
4. To relate patterns in nutrient loss to cover crop biomass, nutrient uptake and soil nitrogen.
5. To include a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	**Institution**	**Primary Investigator**
Nitrogen placement and application timing for best efficiency, growth, and yield of corn across Illinois.	UI	Below

Objectives:

The principal objective of this experiment is to investigate the possible improvement in nitrogen use efficiency and corn yield by increasing the concentration of nitrogen (N) near the plant through banding at the time of planting, allowing a greater proportion of total N to be applied later in the season.

1. Evaluate corn N nutrient uptake efficiency, growth, and yield response in native IL soils.
2. Determine fertilizer N nutrient use efficiency over five split-rate applications for plant uptake, growth, and yield,

3. Evaluate the interaction of N placement (broadcast vs. banded) at different up-front rates on uptake, plant growth, and yield,
4. Determine the economic advantage and potential for increased N use efficiency and higher response to N sidedress by increasing concentration of N near the plant and decreasing total N applied at planting time through banding,
5. Communicate results in mid-year reports, presentations at the University of Illinois Agronomy Day and ASA meetings, and online at the Crop Physiology Laboratory website. A peer-reviewed publication in a well-known journal such as Agronomy Journal or Better Crops is also anticipated, and
6. Prepare and present a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	**Institution**	**Primary Investigator**
Watershed-scale response of agricultural systems to drainage water management in Central Illinois	UI	Bhattarai

Objectives:
The overall goal of this project is to observe and communicate new information about the watershed-scale effects of drainage water management (DWM) on water and nitrogen (N) losses, and crop production in Central Illinois. This experiment is the first of its kind to answer the question: how does DWM affect water and N balances and crop production on a watershed scale? What are the long-term environmental and economic benefits of DWM? This project has the following specific objectives:

1. *Monitor the watershed-scale effects of DWM on nutrient reductions, water and N balances, and crop production through a paired watershed experiment.*
2. *Estimate the long-term environmental and agricultural benefits of DWM through a watershed-scale modeling.*
3. *Communicate results to agricultural community stakeholders through field days and extension events.*
4. *To include a final report at the conclusion of this project to address each of the objectives stated above.*

Project Title	**Institution**	**Primary Investigator**
Assessing tile depth and spacing impact on nutrient losses and crop production	UI	Bhattarai

Objectives:
The overall goal of this project is to produce and communicate new information about best practices for balancing drainage depth and spacing, water quality, and crop production goals in Illinois. This experiment is the first of its kind to ask the question: how do current recommendations on drainage depth and spacing influence not only nutrient losses, but also crop productivity, and nutrient utilization? Can drainage depth and spacing be optimized to minimize the nutrient losses and maximize the crop production?

This project has the following specific objectives:

1. Determine the effects of tile depth and spacing on tile drainage nutrient losses, field N and P balances, and fertilizer use efficiencies through a series of field experiments.
2. Assess whether drainage design can be optimized to reduce nutrient loss reductions and increase the crop production.

3. Develop a design tool to optimize the drainage design that can be used by researchers, drainage contractors, and farmers.
4. Communicate results to agricultural community stakeholders through field days and extension events.
5. Include a final written report at the conclusion of this project to address each of the objectives stated above.

Project Title	Institution	Primary Investigator
Drainage water management and saturated buffers for achieving NLRS goals	UI	Christianson

Objectives:
The goal of this work is to evaluate N loss reduction provided by drainage water management and saturated buffers to assess their potential inclusion as recommended practices in the NLRS.

The specific assessable objectives are to:

1. Monitor drainage water management and saturated buffer sites for nutrient loss reduction and crop yield impacts.
2. Develop a water balance at the drainage water management sites to better quantify lateral seepage impacts upon the overall nutrient loss reduction.
3. Perform an economic evaluation of these two practices ($ per acre treated and $ per pound of nitrogen removed).
4. Evaluate if these practices should be added to the IL NLRS. And if so,
    a. Develop an appropriate N loss reduction value to add to the NLRS tables.
    b. Develop a procedure and seek approval for adding drainage water management and/or saturated buffers to the NLRS.
5. Per the RFP, the final objective is *"to include a final report at the conclusion of this project to address each of the objectives stated above."*

Project Title	Institution	Primary Investigator
Bioreactors for Illinois: Smaller, Better, Faster	UI	Christianson

Objectives:
The major goal of this work is to test novel full-size bioreactors intended to maximize nitrogen removal from drainage water while limiting land removed from production.

The specific assessable objectives are to:

1. Design and build four new types of denitrifying bioreactors in Illinois:
    a. Two Ditch Bioreactors
    b. One High-Flow Booster Bioreactor
    c. One Heat-enhanced Bioreactor
2. Compare the nutrient removal efficiency and hydraulic performance of these novel bioreactors to existing conventional bioreactors.

3. Perform an economic evaluation of these novel bioreactors ($ per acre treated and $ per pound of nitrogen removed).
4. Per the RFP, the final objective is *"to include a final report at the conclusion of this project to address each of the objectives stated above."*

Project Title	Institution	Primary Investigator
On-Farm Evaluation and Demonstration of Reduced Off-Farm Nutrient Transport through Drainage Water Recycling	UI	Cooke

Objectives:
The main goal is to evaluate and demonstrate drainage water recycling as an effective management practice that optimizes crop yield at reduced fertilizer application, enhances nutrient use efficiency by crops, and reduces nutrient (N and P) export to riverine water. The specific objectives are to:

1. Evaluate and identify the BMPs for crop recovery and reuse of nutrients in recycled drainage water, which promote farm income and foster broad adoption of such practices.
2. Assess contributions of drainage water management to nutrient (N and P) use efficiency
3. Evaluate crop response to reduced fertilizer use under sub-irrigation with drainage water
4. Study changes in the physical, biological and chemical properties of soil under intermittent drainage and sub-irrigation.
5. To include a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	Institution	Primary Investigator
Web-based Decision Support Tool for Cover Crop Management	UI	Coppess

Objectives:
The ultimate objective of this proposal is to provide farmers with a practical decision support tool that they can use in their fields to manage cover crops effectively. It will put to use existing and future research to demonstrate the potential of cover crops and increase adoption of this important practice. The final tool will be a web-based software application that can provide farmers, researchers, extension educators and others in the industry with data and information about cover crops in a practical, visualized format. Initial seed funding has produced a proof-of concept web interface that was the first step in the overall project (see, Part VIII, page 8).
This proposal to NREC is to advance the overall project through the initial developmental stage. The tool will provide information about cover crop growth integrated into common cropping systems, starting with cereal rye added to a corn-soybean rotation. When completed, the tool will:

- simulate growth of the cover crop, including termination scenarios across multiple fields in the farm operation;
- estimate biomass in the field;
- estimate the carbon-to-nitrogen ratio;
- estimate the amount of carbon, nitrogen and water stored in the cover crop; and
- provide estimates of the impact on soil moisture and field conditions, nutrient loss and

water quality from the cover crop in each individual field.

Project Title	Institution	Primary Investigator
Reducing Nutrient Loads in WASCOBs in Southern Illinois	UI	Gentry

Objectives:
The overall goal of this project is to quantify flow, nutrient, and sediment flux transported by Water and Sediment Control Basins (WASCOBs) in southern Illinois and evaluate practices that further reduce sediment and nutrient loss (especially phosphorus).
The objectives are:

1. To investigate baseline nutrient and sediment loads transported by WASCOBs on individual working farms in southern Illinois.
2. To use pairs of fields with WASCOBs for on-farm evaluations of practices that can further reduce nutrient and sediment loss. Possible practices to evaluate are:

a. tillage vs. no tillage
b. broadcast fertilizer P vs. incorporated fertilizer P
c. manure vs. no manure
d. cover crop vs. no cover crop

Project Title	Institution	Primary Investigator
Evaluating nutrient loss reduction strategies: longer rotation with cover crops and bioreactor	UI	Gentry

Objectives:
The main objective of this study will be to test the effectiveness of a longer rotation with cover crops in combination with a bioreactor to decrease tile nitrate loss and directly examine this potential nutrient loss reduction scenario on a field-scale production system.

Project Title	Institution	Primary Investigator
Nitrogen management systems in tile-drained fields: Optimizing yields while minimizing losses	UI	Gentry

Objectives:
The overall goal of this project is to more fully understand current and new nitrogen management systems on corn yields and nitrate losses from tile-drained fields in Illinois.
The objectives are to:

1. To develop on-farm field trials of current and new nitrogen management systems for typical corn/soybean rotations, evaluating both the yield response and the tile losses of nitrate.
2. To determine when and why tile nitrate losses occur in these management systems, during both corn and soybean rotations.
3. Include a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	Institution	Primary Investigator
Assessing Suitability and Benefits of Cover Crops in Illinois	UI	Guan

Objectives:

1. Empirical analysis of biophysical and yield effects of cover crops at regional scales through data synthesis/literature review.
2. Process-based modeling of biophysical/biogeochemical impacts and yield of current and proposed agroecosystem practices: implementation and validation.
3. Suitability and potential benefit assessments of cover crops using the process-based model.
4. Economic suitability assessments for cover crops.

Project Title	Institution	Primary Investigator
Towards Management of Dissimilatory Nitrate Reduction to Ammonium for Nitrate Retention in Agricultural Soils	UI	Kent

Objectives:

The *overall goal* of the proposed research is to improve understanding of the controls on DNRA in Illinois agricultural soils.

Specific objectives:

1. Quantify drivers of DNRA rates across representative Illinois soil types,
2. Identify controls on DNRA gene expression in soil microbial communities, and
3. Assess identified conditions *in situ* to verify controls on rates of DNRA and evaluate reduction in NO3 leaching.
4. We will produce a final report at the conclusion of this project to address each of the objectives stated above. In this report, we will outline the prospects for future investigations that can capitalize on our results.

Project Title	Institution	Primary Investigator
Evaluating slow-release P fertilizers to increase crop production and environmental quality	UI	Margenot

Objectives:

The goal of this work is to evaluate a specific type of slow-release phosphorus (P) fertilizer, struvite, for the specific soil, crop, and management conditions of Illinois production agriculture, in order to identify conditions in which such fertilizers can increase P crop uptake and minimize P losses.

The specific assessable objectives are to:

1. Determine optimum formulations of slow-release P for testing agronomic and environmental potential under field conditions (greenhouse study #1);

2. Compare the agronomic efficiency and off-farm loss risk of slow-release P with soluble P fertilizers across representative management practices (tillage, fertilizer placement) (field trial);
3. Identify potential soil × crop interactions using major soil types of Illinois for corn and soybean (greenhouse study #2);
4. Perform an economic evaluation of conventional and struvite-based slow-release P fertilizers
5. Conduct a literature review on the actual and potential roles of P fertilizer formulation, timing, and placement to help meet agronomic and environmental P management goals;
6. Synthesize results in a final report to address each of the aforementioned objectives, with an emphasis on context-specific management recommendations.

Project Title	**Institution**	**Primary Investigator**
Reducing P Loss in Southern Illinois: Producers, Practices, and Productivity	UI	R. Christianson

Objectives:
The major goal of this work is to evaluate, refine, and promote both recommended and novel practices to reduce phosphorus (P) losses in unglaciated areas of Illinois. The practices under evaluation are no till/conservation tillage, cover crops, and edge-of-field P filters.

The specific assessable objectives are to:

1. Install surface runoff monitoring plots to measure runoff and P loss from five infield treatments (Ewing Demonstration Center) and evaluate P loss under both:
    a. Natural rainfall over four years
    b. Simulated rainfall events
2. Measure infiltration and water holding capacity as a proxy for runoff (private farms and Ewing Center).
3. Design and construct a novel P-removal filter (On-campus and Ewing Center).
4. Perform rainfall simulations on a cover crop to evaluate runoff and leaching P loss reduction under freeze/thaw conditions (On-Campus).
5. Assess soil P for vulnerability to run-off losses with multiple, complementary measures of P availability and soil loading
6. Perform an economic evaluation and promote these effective P practices.
7. Per the RFP, the final objective is "*to include a final report at the conclusion of this project to address each of the objectives stated above*."

Project Title	**Institution**	**Primary Investigator**
Precision Nitrogen Management of Corn for Improving Farm Profitability and Water Quality in Southern Illinois	SIU	Sadeghpour

Objectives:

1. The main objective of this proposal is to evaluate the precision and accuracy of existing commercially and publicly available nitrogen recommendation systems, while continually improving University of Illinois's recommendations. Systems that will be evaluated in this proposal include:
    a. University of Illinois N guidelines
    b. Pre-plant application versus split application of N

c. GreenSeeker sensor (Trimble)
d. OptRX sensor (AgLeader)
e. CropSpec sensor (Topcon)
f. AdaptN (Yara)
g. Encirca (Pioneer)
h. FieldView (Climate/Monsanto)

2. Develop better nitrogen rate and timing guidance for Illinois corn producers
3. Develop Illinois-specific GreenSeeker algorithm for variable rate or flat rate nitrogen applications in grain corn
4. Develop more advanced nitrogen recommendation system that integrates multiple data streams including, but not limited to, crop sensor readings, EM or EC soil maps, yield maps, climate data, remote sensed data (manned and unmanned systems).
5. If appropriate, modify University of Illinois nitrogen guidance for corn following cover crops.
6. Evaluate the tradeoffs and efficiency of precision N management versus other N recommendation systems to improve air and water quality through decreasing nitrate losses.
7. To provide a final report for the stated objectives above.

Project Title	Institution	Primary Investigator
Nitrogen Rate Research & NREC Project Partnership	IFCA	Schaefer

Objectives:
There are two on-going NREC projects (Evaluating nutrient loss reduction strategies – Gentry and Nitrogen Management systems in tile-drained fields – Gentry) that this proposal seeks to support, plus the continuation of the Nitrogen Rate Trials—Dr. Nafziger (Emeritus, UI) will evaluate the results and update the Maximum Return to Nitrogen recommendation system for Illinois. The goal of this proposal is to expand N rate trials on different soil types and in different regions of the state and to facilitate professional, consistent and reliable implementation of the treatments at NREC research sites to produce viable, useful data to that can be published and communicated across the industry to improve nutrient utilization and reduce nutrient losses.

Project Title	Institution	Primary Investigator
Water and Sediment Control Basins (WASCoBs) influence on Crop Yields and Water Quality	SIU	Schoonover

Objectives:

1. The objective of this research is to evaluate the influence of cereal rye cover crop in a corn-soybean rotation on nutrient losses, water quality (i.e., sediment, nitrogen and ammonium, and total phosphorus and dissolved reactive phosphorus), soil health (physical, chemical and biological soil properties), and crop yields in fields with or without WASCoBs. The treatments compared will be: 1) fields that are drained by WASCoBs 2) fields with WASCoBs plus cover crops, 3) fields containing an ephemeral gully without WASCoBs but containing cover crops, and 4) fields containing an ephemeral gully without WASCoBs or cover crops. The performance of WASCoBs over time for agronomic efficiencies will also be compared among these treatments.

2. Evaluate the performance of WASCoBs combine with or without cover crops over time for hydrologic modification, soil retention, and impacts on crop yields.
3. Disseminate results to farmers and stakeholders and include a final report at the conclusion of this project to address each of the objectives stated above. We will also publish in peer-reviewed literature, grower-oriented newspapers and/or magazines, and relay findings at meetings, conferences, and field days.

Project Title	Institution	Primary Investigator
Modelling and Designing Saturated Buffers for Nitrogen and Phosphorus Mitigation in Illinois	SIU	Schoonover

Objectives:

1. Design, install, and monitor a saturated buffer implementing a new pitchfork design equipped with backflow check valves to test the impact on water quality (nitrogen and phosphorus) and quantity reaching the tile outlet and compare results to a standard buffer in the same field.
2. Assess the potential denitrification rates and the changes in deep soil carbon and nitrogen pools in the area surrounding the saturated buffers.
3. Develop design criteria to guide the installation of saturated buffers in tile-drained fields of Illinois.

Include a final report at the conclusion of this project addressing the objectives above. The overarching goal of this research is to provide farmers and land managers with data pertaining to the design of saturated buffers that would mitigate nitrogen and phosphorus in tile-drained systems.

Project Title	Institution	Primary Investigator
Insect Management in Cover Crop Systems	UI	Seiter

Objectives:

1. Assess the impact of cover crop presence on pest and beneficial insect populations at established (3 years of cover crops) field experiments and on commercial fields in Illinois
2. Determine the effect of cover crop termination timing on pest and beneficial insects in corn at established field sites
3. Determine the effect of cover crop termination timing on pest and beneficial insects in soybean as part of a regional (8 additional locations in 6 additional states) experiment with a common protocol
4. Include a final report at the conclusion of this project to address each of the objectives stated above

Project Title	Institution	Primary Investigator
Water quality and agronomic impacts of gypsum applications in Southern Illinois	SIU	Willard

Objectives:

To assess whether gypsum can be a tool for southern Illinois farmers to limit phosphate loss from their fields, while maintaining or improving yield. Gypsum as a soil amendment has not been well studied in Illinois. Study

results will confirm or limit the applicability of the recent, June 2016, NRCS Federal Conservation Practice Standard 333: Amending Soil Properties with Gypsum Products, to southern Illinois.

Specific Objectives:

1. To determine the effect of flue gas desulfurization (FGD) gypsum application rate (1 ton/acre, 3 ton/acre, and 9 ton/acre) on dissolved phosphate leaching from an agricultural field in southern Illinois.
2. To assess the impact of FGD gypsum, calcium, and sulfur additions on corn and soybean yield at a field scale.
3. To determine the impact of FGD gypsum application on soil physical properties: penetration resistance, infiltration, bulk density, and aggregate stability.
4. To assess the economic cost of the gypsum addition and the practicality of farmer adoption through a partial budget analysis.
5. To develop a final report at the conclusion of the project that addresses each of these objectives.

Project Title	**Institution**	**Primary Investigator**
Minimizing phosphorus and nitrogen loss from agricultural systems with cover crops and tillage in Southern Illinois	SIU	Williard

Objectives:

Our goal is to gain critical knowledge about how long-term cover cropping, tillage practices, and topography contribute to N and P dynamics. Cover crops in no-tillage systems might result in stratification of P and N in the topsoil resulting in the higher availability to the cash crop or might result in increased losses via runoff. This research blends replicated field-scale experiments with paired watershed-scale research that can answer the question of P stratification and build up in corn-soybean rotations with cover crops and two tillage systems or three topographic positions.

Field Plot Study

1. Determine the interaction of cover crops and tillage on uptake/removal of P from soil and cash crop yields. Plant biomass samples at physiological maturity will be collected for calculating P uptake and a plot combine will be used for estimating corn-soybean yield response to cover crops and tillage.

2. Evaluate the potential of P stratification in cover crop and tillage study. Archived (2015 to 2018) and future (2019-2022) soil samples will be used for determining the P stratification potential of cover crops using Hedley's Fractionation Procedure for soil P (Zhang and Kovar, 2009).

3. Evaluate Phosphorus-P and Nitrate-N leaching and N emissions with and without legume/non-legume cover crops and tillage (no-tillage and conventional tillage). This project will evaluate the effects of using cover crops and two tillage systems on P and N loads of soil water and nitrous oxide emissions in the field under corn/soybean rotation. Cover crop rotation followed will be Corn-Cereal Rye-Soybean-Hairy vetch/Oats*Tillage Radish.

Watershed Scale Study

4. Determine the interaction of cover crops and topography on uptake/removal of P from soil and cash crop yields. Plant biomass samples at physiological maturity will be collected for calculating P uptake and a plot combine will be used for estimating corn-soybean yield response to cover crops, and topography.

5. Evaluate the influence of cover crops (hairy vetch and cereal rye) on P and N dynamics in soil and water at different topographic positions. This project will help in understanding mechanism of cover crops in reducing phosphate-P and nitrate-N concentrations at the watershed scale in typical southern Illinois fields (slope variation from 0-20%). This research will serve as a gap between field scale studies and watershed scale studies.

Paired Watershed Scale Study

6. Evaluate the sediment, phosphate, nitrate, ammonia, total N and dissolved organic carbon load losses from the paired watershed experiment. The nutrient loss loads will be reported utilizing the data collected from ISCO samplers for estimating the reduction in sediments, phosphate-P, nitrate-N, and ammonium-N caused by introducing cover crops at the watershed scale (*Results of nutrient loss concentration in stream water for two years of cover crop treatment period are published in Singh, et al. (2018)*.

7. Evaluate the influence of cover crops in improving soil water holding capacity. Soil moisture sensor data will be used for determining soil water holding capacity. This will help in understanding soil moisture availability to the cash crop after cover crop termination.

8. Include a final report at the conclusion of this project to address each of the objectives stated above. We will also publish in peer-reviewed literature, grower-oriented newspapers and/or magazines, and relay findings at meetings, conferences, and field days.

Project Title	Institution	Primary Investigator
Designer Biochar to Capture and Recycle Phosphorous from Tile Drainage Systems	UI	Zheng

Objectives:

This proposal aims to generate designer biochars to effectively capture phosphorus from subsurface tile drainage, recycle phosphorus-captured biochars as a slow-released fertilizer, and keep phosphorus in the closed agricultural loop. The overall goal of the project is to develop an innovative practice to minimize phosphorus loading from subsurface tile drainage to nearby watersheds, improve crop yields by enhancing nutrient use efficiency, and thereby increase Illinois agricultural sustainability. To achieve this goal, the following specific objectives will be addressed:

- Create designer biochars by pyrolysis of biomass pre-treated with lime sludge.
- Conduct a laboratory experiment to evaluate the sorption capacity of designer biochars for phosphorus,
- characterize their properties, and thereby optimize biochar production conditions.
- Construct refillable biochar-sorption-channels and use designer biochars to capture phosphorus from
- subsurface tile drainage by conducting a field study.
- Recycle phosphorus-captured biochars from the channels and apply them as a slow release fertilizer to
- improve soil quality and crop yields through conducting a greenhouse trial.
- To include a final report at the conclusion of this project to address each of the objectives stated above.

NEW PROJECTS

Project Title	Institution	Primary Investigator

Capitalizing on 150 Years of Soil Samples to Determine Legacy P and Improve Water Quality in Illinois	UI	Margenot

Objectives:

1. Determine **how soil P has changed over the last 150 years** in Illinois
    a. Determine how well archived samples and data represent the state of Illinois.
    b. Evaluate soil P stocks across timepoints corresponding to when archived soil samples were taken, using newly measured soil P data and existing NRCS soil survey data.
    c. Re-sample selected locations to determine long-term *changes* in soil P.
    d. Ground truth current agronomic soil databases (USDA input/output, IPNI soil test P values and others, if available) to determine the degree to which soil *test P* values can be used to assess net changes in soil *total P*. This enables accurate inference from routinely used, commercially available soil tests to guide P management and policy.
    e. Publish open-access soil archive database for stakeholders, researchers and the public.
2. Construct **comprehensive soil P budgets** for Illinois
3. **Estimate legacy P** in soil and its ability to explain historical water quality data.
4. Develop basis of **soil degree of P saturation** (DPS) that can be used as a tool to monitor and predict P loss risk and allows for more informed decisions for growers and conservation planners. Unlike many other Midwestern states, Illinois does not have such an index.
5. Per the RFP, the final objective is "*to include a final report at the conclusion of this project to address each of the objectives stated above*."

Project Title	**Institution**	**Primary Investigator**
Characterizing sub-field variability for efficient phosphorus management: targeting hotspots	UI	Fraterrigo

Objectives:

1. Determine the optimal soil sampling scheme for accurately characterizing the amount and spatial distribution of soil P in fields where legacy P and soil depositional areas contribute disproportionately to P exports in tile drains.
2. Investigate the drivers and timing of the release of dissolved and particulate P from P-rich surface soil to tile drains.
3. Evaluate the relationship between grain production and fine-scale spatial variation in STP, other soil elements, and microtopography.
4. Include a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	**Institution**	**Primary Investigator**
Managing the maize microbiome for sustainable nutrient retention in Illinois agricultural soils	UI	Kent

Objectives:

1. Determine if nitrification inhibition in the maize rhizosphere *reduces N losses at the ecosystem level*.
2. Determine if introgression of teosinte genes that confer nitrification inhibition *impacts maize yields*.

3. Building on increasing industry interest in N-fixing inoculants, we will investigate synergy between N-fixing inoculants (generating ammonium), BNI (inhibiting nitrification), and DNRA (transforming nitrate/nitrite back to ammonium), *potentially reducing the need for fertilizer N addition to fields*.
4. To include a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	**Institution**	**Primary Investigator**
Next Generation Cover Cropping in Corn-Soybean Rotation to Improve Farm Benefits and Decrease Environmental Losses in South and Central Illinois	SIU	Sadeghpour

Objectives:

The main objective of this proposal is to evaluate the efficacy of precision cover crop management to optimize agronomic and environmental ecosystem services within the Illinois growing environments. Specifically, we will evaluate altering **planting dates by interseeding** and use precision planting of cover crops to skip the corn/soybean row – known as **"skip row" planting** and evaluate whether **"skip row"** allows for **delayed termination** of cover crop mixtures. Within this main objective, our proposal aims to:

1. Assess the efficacy of interseeder technology for timely cover crop establishment of legumes and winter cereal in Illinois growing environments
2. Determine the impact of clover/rye mixture establishment and termination date on cover crop N uptake, soybean and corn yield and following cash crop production in rotation
3. Evaluate the influence of interseeded, skip row, and conventional cover crop planting and termination date on nitrate leaching in a corn-soybean rotation relative to intensified **cash cropping systems**
4. Assess soil health and economic benefits of each cover cropping systems vs. intensified cash cropping over time
5. Include a final report at the conclusion of this project to address each of the sub-objectives stated above.

Project Title	**Institution**	**Primary Investigator**
Integrating livestock grazing into the western Illinois corn-soybean cropping system to enhance farm profitability and reduce nutrient loss	WIU	Bernards

Objectives:

1. Measure the influence of high-intensity, short-duration grazing of cover crop mixtures in a corn-soybean system or a perennial grain crop on nutrient loss through subsurface drainage tiles (compared to a typical corn-soybean production system).
2. Document economic costs and benefits of incorporating diverse cover crop mixtures and cattle grazing within a Midwestern corn-soybean system or potential perennial grain system.
3. Determine socio-economic factors that may affect producers' adoption of grazing and cover crops in corn-soybean cropping systems.
4. Quantify crop and cover crop productivity and soil health parameters for three distinct cropping systems
5. Include a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	Institution	Primary Investigator
Sources and cycling of nitrate in tile-drained corn-soybean rotation systems: A stable isotope approach	UI	Yu

Objectives:

1. Evaluate the effects of a combined use of split N application and winter cover crops on tile NO_3^- load, soil N availability, and crop yields.
2. Make year-round measurements of NO_3^- stable isotopes in tile drainage to obtain process information that will be used to (i) quantify the sources driving NO_3^- loss in tile drainage and (ii) evaluate the importance of denitrification as a major NO_3^- loss pathway.
3. Establish a robust field N budget using isotope measurements of tile drainage, soil profiles, and crop biomass to examine NO_3^- cycling in the soil-crop system.
4. Include a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	Institution	Primary Investigator
Integrating Tillage, Soil Carbon Dynamics, and Tile Nitrate Loss (Eric Miller)	UI	Gentry

Objectives:

The overall goal of this project is to quantify the effect of tillage, residue management, and cover crop on crop yield, soil C, and tile nitrate.
The objectives are:

1. To investigate tile nitrate loads under various tillage regimes (conventional tillage vs. notill vs. strip-till with and without a cover crop) in a corn/soybean rotation.
2. To investigate C cycling by directly measuring annual C inputs (including below ground measurements of roots) from crop residues and the additional C added to the system with cover crops.

We believe this study will inform producers with intensively tile drained fields of how to best manage their fields to enhance soil C, tighten the N cycle, and improve their bottom line.

Project Title	Institution	Primary Investigator
Detection and attribution of recent changes in phosphorus loadings in the Illinois River watershed	Ui	Markus

Objectives:

1. Detect changes in riverine phosphorus in the Illinois River watershed, including main channel and several key tributaries. The data sets of total phosphorus (TP) and dissolved phosphorus (DP) starting from 1974 and ending with the most recent water year for which the water quality and river discharge data are processed and completed (currently 2019) will be inventoried
2. Identify the areas with high and/or increasing phosphorus loadings. More accurate determination of these hotspots will be made possible by including a higher spatial resolution of results than the most recent study (McIsaac, 2017). This will be achieved by including several additional available long-term monitoring sites in the Lower Illinois watershed.

3. Statistical exploratory analysis tools will be used to identify main contributors to the high phosphorus river segments. The potential contributors (explanatory variables) include weather patterns, unusually high river flows, pH, chloride and point-sources. Potential contribution of legacy phosphorus will be assessed.
4. Include a final report at the conclusion of this project to address each of the objectives stated above.

Project Title	**Institution**	**Primary Investigator**
Knowledge is power: Powering up bioreactors and saturated buffers in Illinois	UI	L Christianson

Objectives:

The overarching goals are to make bioreactors and saturated buffers clean more N from tile drainage and accelerate their adoption across Illinois and the US Midwest. The specific assessable objectives are to:

1. **Design**, **build/retrofit** and **monitor** novel denitrifying bioreactors (2) and a saturated buffer (1) in Illinois.
2. **Create** and **analyze** a database of existing full-size bioreactors and saturated buffers in Illinois to assess current designs and performance with the aim of improving the NRCS design standards and outreach activities for these practices.
3. **Use novel monitoring techniques** (3a: real-time nitrate sensors; 3b: inexpensive thin-film "nitrate disks") at existing bioreactors and saturated buffers to explore avenues toward market-based drivers for adoption of these practices.
4. "*To include a final report at the conclusion of this project to address each of the objectives stated above*."