# 2019 Final Report Summary Sheet

## Grantee Information

**Project Title:** Reducing P Loss in Southern Illinois: Producers, Practices, and Productivity

**Institution:** University of Illinois

**Primary Investigator**: R. Christianson

**NREC Project #** 2018-4-360340-646

**Is your project on target from an IMPLEMENTATION standpoint?** ☒ **Yes** ☐ **No**

**If you answered "no" please explain:**

The previous delay of installation of runoff monitoring at the Ewing Demonstration Center due to weather conditions was overcome in Fall 2019 with completion of monitoring equipment. As before, all other facets of the project are on schedule.

**Is your project on target from a BUDGET standpoint?** ☒ **Yes** ☐ **No**

**If you answered "no" please explain:**

**Based on what you know today, will you meet the objectives of your project on-time and on-budget?** ☐ **Yes** ☒ **No**

**If you answered "no" please explain:**

Though we are on-budget financially, we are one full year behind on Objective 1 of 6 (surface runoff monitoring at the Ewing Demonstration Center).

**Have you encountered any issues related to this project?** ☒ **Yes** ☐ **No**

**If you answered "yes" please explain:**

We had weather related issues in the fall of 2018 and much of the working windows of 2019 at the Ewing Demonstration Center.

**Have you reached any conclusions related to this project that you would like to highlight?** ☒ **Yes** ☐ **No**

**If you answered "yes" please explain:**

Phosphorus losses in runoff from the cover crop freezing study showed an increasing trend with freezing severity. Light freezing and rainfall intensity had little impact on phosphorus losses through runoff.

**Have you completed any outreach activities related this project? Or do you have any activities planned?** ☒ **Yes** ☐ **No**

**If you answered "yes" please explain and provide details for any upcoming outreach:**

We have had several outreach events, which include a field day at the Ewing Demonstration Center in July of 2019 and many events (planned and unplanned) showcasing the augmented reality sand table. There have also been several posters and presentations prepared focused on this project. Upcoming events for the sand table are the Explore ACES event on March 27th and the 2020 Stewardship Week at the Dixon Springs Ag Center between April 22nd and 24th.

Please write a detailed summary report that includes: Details of each objective and the progress made towards its competition, planned research activities for 2020, major accomplishments, any preliminary findings or data relevant to the project, relevant budgeting, and any publications or outreach accomplished from the research. Also this year please include a one page summary with relevant data tables or graphs and pictures related to the project that you would like included in the NREC end of the year report.

# Cooperators and Locations

A. PI: Dr. Reid Christianson, Research Assistant Professor, Department of Crop Sciences, University of Illinois, S318 Turner Hall, 1102 S Goodwin Ave., Urbana, IL 61801. (240) 344-8144. ReidDC@illinois.edu. Dr. Christianson has fifteen years of experience focused on water quality and land use management. As PI, he will supervise all project work.
    a. Co-PI: Dr. Laura Christianson, Assistant Professor, Department of Crop Sciences, University of Illinois, S322 Turner Hall, 1102 S Goodwin Ave., Urbana, IL 61801. Dr. Christianson has nine years focused on agricultural water quality. As Co-PI, she will oversee all water sample analysis and supervise a graduate student performing the on-campus cover crop study.
    b. Co-PI: Dr. Andrew Margenot, Assistant Professor, Department of Crop Sciences, University of Illinois, 1011 Plant Sciences Laboratory, 1201 S Dorner Dr., Urbana, IL 61801. Dr. Margenot has six years of experience focused on soil phosphorus management. As Co-PI, he will coordinate soil sampling and supervise a graduate student evaluating phosphorus sorbing materials.
    c. Co-PI: Dr. Talon Becker, Commercial Agriculture Educator, University of Illinois Extension, 1212 Route 14 West, Benton, IL 62812. Dr. Becker has ten years of experience in agricultural research, with approximately three years focused on nutrient management. As Co-PI, he will coordinate activities at the Ewing Demonstration Center.
    d. Mr. John Pike, Pike Ag, LLC, 14453 Canaville Road, Marion, IL 62959. Mr. Pike is a professional agronomist and with several decades of extensive experience in production agriculture. He will be responsible for identifying and coordinating with the private farms for infiltration and water holding capacity testing.
B. Graduate Students working on the project: Taylor Berkshire, MS in Crop Sciences; Ariana Munoz, MS in Crop Sciences (hourly now – starting MS in January 2020).

# Restate Objectives

A. 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. Specifically:
    a. **Install surface runoff monitoring plots to measure runoff and P loss** from five in-field treatments (Ewing Demonstration Center) and evaluate P loss.

b. **Measure infiltration and water holding capacity** as a proxy for runoff (private farms and Ewing Center).
c. **Design and construct a novel P-removal filter** (On-campus and Ewing Center).
d. **Perform rainfall simulations** on a cover crop to evaluate runoff and leaching P loss reduction under freeze/thaw conditions (On-Campus).
e. **Assess soil P** for vulnerability to run-off losses with multiple, complementary measures of P availability and soil loading
f. Perform an **economic evaluation** and **promote these effective P practices**.
g. 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*."

# Continued Work Plan

In short, the three practices of no-till/conservation tillage, winter cover crops, and edge-of-field P-filters will each be studied in at least two locations (private farms, the Ewing Demonstration Center, and/or on-campus). To add additional redundancy, each type of testing (soil P assessments, rainfall simulations and runoff measurement, infiltration and water holding capacity tests) will also be done in at least two of the three locations.

*A.* *Sequence of specific project tasks*

a. **Install surface runoff monitoring plot infrastructure to measure runoff and P loss** from five in-field treatments at the Ewing Demonstration Center (Objective 1; Years 2-4).
    i. The Ewing Demonstration Center in Southern Illinois has fifteen total plots (*n* = 3; 45 m long x 6 m wide) installed and separated with plastic sheeting. An in-ground sump, small pump, and flow meter are at the bottom of each plot, which allows continuous runoff volume measurement whenever runoff occurs. This also serves as the water sampling location.
    ii. The five triplicate treatments are:
        1. No-till without a cover crop.
        2. No-till with a cereal rye cover crop, fully terminated in the spring.
        3. No-till with an annual ryegrass cover crop, fully terminated in the spring.
        4. No-till with an annual ryegrass cover crop with a 12 m fescue buffer at the bottom of the field.
        5. Control: Conventional tillage without a cover crop (on adjacent farm).
    iii. Runoff testing and P loss assessment will be performed under natural and simulated rainfall conditions.

b. **Measure infiltration and water holding capacity** as a proxy for runoff at private farms and the Ewing Demonstration Center (Objective 2; Years 2 and 3). Soils with greater water infiltration rates and water holding capacity will result in less surface runoff than soils with lower infiltration and water holding capacity. Thus, these two tests will be done as follows:
    i. Saturated Hydraulic Conductivity Testing: There are two methods being used for this measure, double ring infiltrometers, which are in the field, and soil core with laboratory testing. Since we have had difficulties with the double ring infiltrometers, and harvest was delayed in fall of 2019, the soil core option has been implemented so far. Compaction (cone penetrometer) will also be measured on-site and soil samples will be brought to campus for analysis as described below.
    ii. Water Holding Capacity Measurement (volume of water held per volume of soil).
        1. These tests will be performed at:
            a. The Ewing Demonstration Center
            b. Up to 32 privately-owned fields in Southern Illinois. Fields will be recruited to broadly replicate treatments being tested at the Ewing Center (*n* = 5-8 sites for each treatment; up to 32 sites total). Private farm treatments will be:
                i. Conventional tillage
                ii. Long term no-till
                iii. Never cover cropped
                iv. Long term cover crop
        1. Mr. John Pike, who has several decades of experience working with farmers in Southern Illinois, will be the point-person with these cooperators. Nearly 50 locations have been identified and soil sampling will commence in spring 2020.

c. **Design and construct a novel P-removal filter** at the Ewing Center (Objective 3). A P-removal filter will intercept and treat surface runoff and tile drainage which culminates at the SE corner. This will require two sub-objectives:
    i. Test P-sorbing media on the UIUC campus in Year 1 and 2 to determine the most cost-effective option to use for full-scale P-filter media. Batch and column laboratory studies will look at material sorption potential (how well a given media removes and retains P from water) and determine how well the various materials convey water. All materials will be screened with an X-ray fluorescence spectrometer (XRF) which will help assess material safety in terms of leaching other pollutants, including heavy metals. Initial testing has been done with feasible materials limited to steel slag and drinking water treatment residuals.
    ii. Once the on-campus testing identifies an optimal P-sorbing media, the structure will be designed based on material sorption and flow

characteristics (fall of year 2) and installed at the Ewing Center (summer of year 3). Further, work is being done with the XRF, which is highly portable, to determine the feasibility of using a device like this to check the status of the in-field device, once operational.

iii. Initial design has been done, and is awaiting final sizing based on extended duration sorption testing of materials in the lab.

d. **Perform rainfall simulations on a cover crop** to evaluate runoff and leaching P loss reduction under freeze/thaw conditions (Objective 4). This focused experiment will answer the question about DP release due to plant cell rupture upon freeze/thaw conditions.
    i. This experiment was completed in winter/spring of 2019, and data analysis is being performed. Initial results will be shared at the American Society of Agronomy meeting in San Antonio, TX in November of 2019.

e. **Assess soil P loading and loss risk** at the Ewing Center and private farms (Objective 5; Years 1-4 and 1-2, respectively).
    i. Soil samples at both the Ewing Center and private farms will be analyzed for three P measures providing complementary data on P crop availability and run-off risk, which will include Bray P, water-extractable P and degree of phosphorus saturation (DPS) (Measured as the ratio of P to iron (Fe) and aluminum (Al) extractable by the Mehlich test). This represents the amount of available P relative to potential binding sites in the soil, and as such, can be used to measure the P loading status of soils.
    ii. The first round of soil test phosphorus at the Ewing Demonstration Center showed high spatial variability across the plots, indicating there are likely no pre-project biases among treatments. Further, indications are that soil phosphorus concentrations show classic increases as we approach the toe slope due to soil movement down the hill.
    iii. Soil samples will continue to be collected at Ewing in each plot (0-3 in depth) to assess soil P availability, loading, and susceptibility to loss via run-off. Prior to sampling, potential hotspots and overall spatial heterogeneity in soil P that may confound assessments will be screened with limited disturbance in the field using a portable XRF spectrometer. By exposing soils to the same, controlled rainfall rate (Objective 1b), simulations will enable accurate comparisons of the relationships between soil P tests and run-off P, which is often not possible in field settings. The Ewing Demonstration Center installed a water main to the farm to facilitate rainfall simulation. Because DPS risk thresholds need to be empirically developed for a given soil type and cropping system, an added benefit of this work lies in relating P run-off concentrations with DPS measurements. This will be a first step toward developing Illinois-specific DPS interpretations and recommendations.

f. Perform an **economic evaluation** and **promote these P practices** (Objective 6).
    i. Economic Evaluation ($ per ha treated and $ per kg of P loss reduced; Year 3-4) will include in-field practices: Major activity costs (crop seed, cover crop seed, fuel, in-season treatments, labor, crop yield, sale of grain, etc.) and edge-of-field P-filter (construction and installation costs).
    ii. Promotion: A mobile augmented reality sandbox was designed and constructed in the fall of 2018 and spring of 2019. This tool allows discussion surrounding how topography and land management can influence erosion and phosphorus loss risk. Several outreach events have been attended including video production in spring of 2019, Crop Sciences Agronomy Day in the summer of 2019, Farm Progress Show in the summer of 2019, Ewing Demonstration Center Field Day in the summer of 2019, and Career Spark, Field and Furrow, and Introduction to Crop Sciences lab in the fall of 2019. A short electronic survey and learning modules are being developed. Much interest has been shown in this activity, with requests continuing to come in.

## Impact of the Research

Ultimately, this work will serve to help support the use of conservation practices across Illinois by evaluating environmental impacts and interactions while also showcasing these activities generally to the public as well as directed towards farmers.

A. Several presentations have been made with data generated from this work:
    a. American Society of Agronomy, Crop Sciences Society of America and Canadian Society of Agronomy Joint Meeting (2018)
    b. Soil Science Society of America International Soils Meeting (2019)
    c. Illinois Nutrient Loss Reduction Strategy Partnership Workshop (2019)
B. The augmented reality sand table serves as a platform to quickly engage audiences of all ages surrounding the topic of water movement, erosion, phosphorus loss risk, and land management in an interactive and thought-provoking way. Several outreach events have been attended with the augmented reality sand table including
    a. Video production for social media in spring of 2019
    b. Crop Sciences Agronomy Day in the summer of 2019
    c. Farm Progress Show in the summer of 2019
    d. Ewing Demonstration Center Field Day in the summer of 2019 where we also talked about soil sampling and soil test phosphorus levels across the plots.
    e. Career Spark in the fall of 2019.
    f. Field and Furrow student club at UIUC in the fall of 2019.
    g. Introduction to Crop Sciences Class lab at UIUC in the fall of 2019.
C. Several more activities, presentations, and papers are being prepared for presentation or submission in 2020.

# Date of Initiation (Jan 2018) and Completion (Dec 2021)

Due to staffing changes in spring 2018 and weather in both fall 2018 and spring 2019, much of the field work was delayed. That said, we were ahead of schedule and on-schedule with the sand table and the rainfall simulation being done on campus. The original timeline was modified (Figure 1) to account for delays in the field. Also, testing of the phosphorus sorption media has gone well, which prompted a few additional lines of inquiry. The timeline for the phosphorus sorption media has been extended to account for this.

| | | 2018 | | | | 2019 | | | | 2020 | | | | 2021 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | W | Sp | Su | F | W | Sp | Su | F | W | Sp | Su | F | W | Sp | Su | F |
| **Obj. #1: Install runoff plots and measure P loss** | Install plot infrastructure at Ewing Center | | | | ✓ | ✓ | ✓ | ✓ | | | | | | | | | |
| | Obj. 1a: Monitor P loss under natural rainfall | | | | | | | | ✓ | | | | | | | | |
| | Obj. 1b: Monitor P loss under rainfall simulations | | | | | | | | | | | | | | | | |
| **Obj. #2: Measure infiltration and water holding capacity** | At the Ewing Demonstration Center | | | | | | ✓ | | | | | | | | | | |
| | On private farms (up to 32 sites) | | | | | | | | ✓ | | | | | | | | |
| **Obj. #3: Design and construct a novel P-removal filter** | On-campus testing and selection of P-removal media | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | |
| | Design and build full-size P-removal filter | | | | | | | | ✓ | | | | | | | | |
| | Monitor P removal by full-size P-removal filter (Ewing) | | | | | | | | | | | | | | | | |
| **Obj. #4: Test cover crop with rainfall simulation** | On-campus rainfall simulation of cover crop runoff/leaching, including soil analysis | | | | ✓ | ✓ | ✓ | | | | | | | | | | |
| **Obj. #5: Assess soil P** | At the Ewing Demonstration Center | | | | | | ✓ | | | | | | | | | | |
| | On private farms (up to 32 sites) | | | | | | | | ✓ | | | | | | | | |
| **Obj. #6: Economic analysis and practice promotion** | Economic evaluation ($/ac treated; $ per lb P saved) | | | | | | | | | | | | | | | | |
| | Design and build aug. reality sand table | | | | ✓ | ✓ | ✓ | | | | | | | | | | |
| | Present at field days; Display aug. reality sand table | | | ✓ | | | | ✓ | ✓ | | | | | | | | |
| | Factsheet development, printing, and distribution | | | | | | | | | | | | | | | | |
| **Obj. #7: Funders reports** | Peer-reviewed manuscript development/submit | | | | | | | | | | | | | | | | |

Figure 1. Revised timeline due to weather and staffing - with progress indicated by checks.

# Project Budget Updates (both annual and total project)

The project budget is still on-track and has not been substantially altered from the initial proposal.

## Short Synopsis

The major goal of this work is to evaluate and promote practices to reduce P loss in Illinois' unglaciated areas. The practices under evaluation are no-till/conservation tillage, cover crops, and edge-of-field P-removing filters, which will each be studied in at least two locations (private farms (Figure 2), the Ewing Demonstration Center, and/or on-campus). At the Ewing Demonstration Center, surface runoff monitoring plots were installed to measure P loss under both natural rainfall and rainfall simulations (Figure 3), and a novel P-removal filter will be constructed and monitored. Because improvements in soil health qualities such as infiltration rate and water holding capacity are practical metrics that resonate with producers, these will be evaluated as a proxy for reduced runoff risk at both private farms and the Ewing Center. Questions about cover cropping P tradeoffs will be answered in controlled on-campus studies (Figures 4, 5, and 6). To date, results have reached other scientists via conference presentations, and outreach including research results at field days and display of an interactive sand table (Figure 7) to show the impact of topography and land management decisions on run-off.

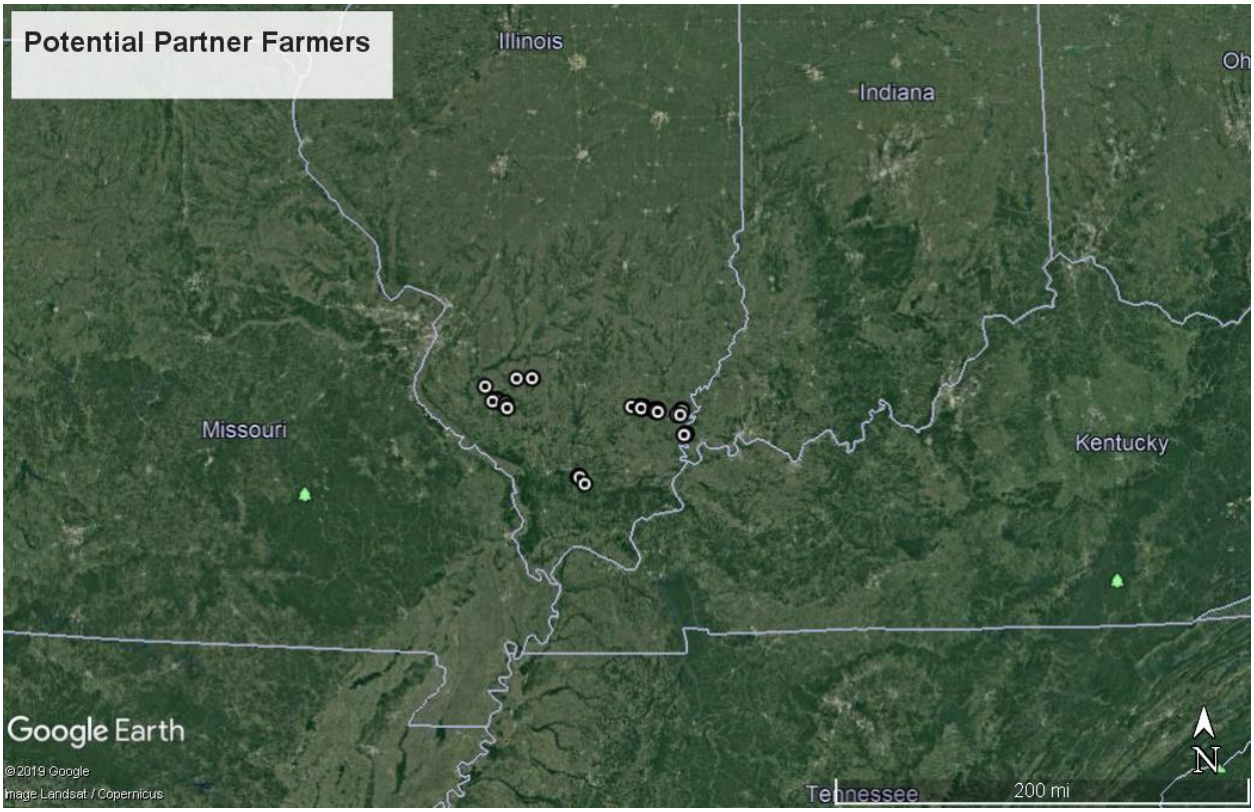

Figure 2. Potential partner farmers for private farm analysis.

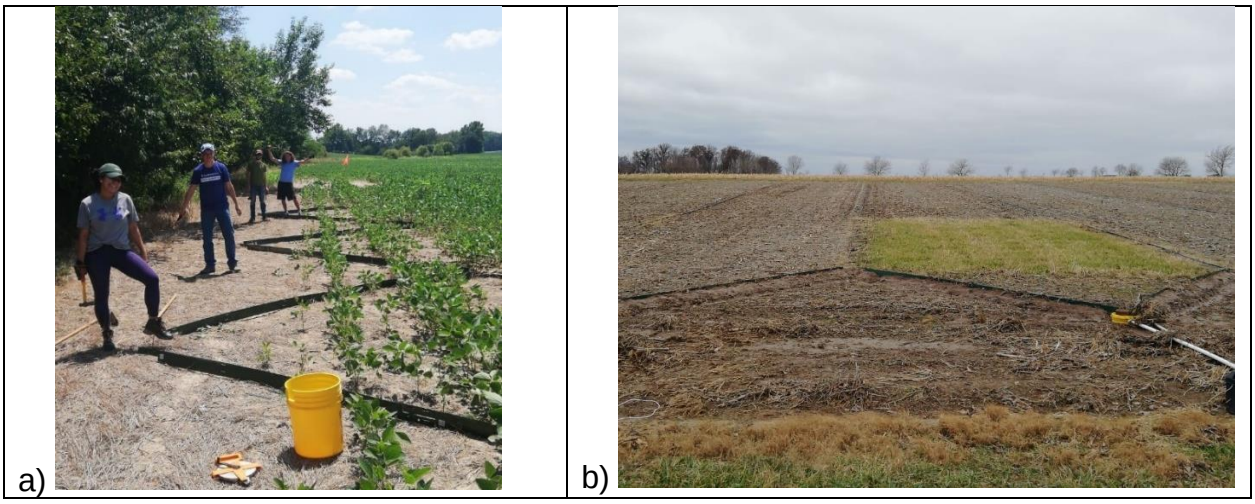


Figure 3. Field crew finishing runoff plot install at the Ewing Demonstration Center (a). Filter strip plot with monitoring setup (b).


Figure 4. Phosphorus sorbing materials being characterized. Image from Berkshire, T., R. Christianson, L. Christianson, A. Margenot. 2018. Removing Dissolved Phosphorus with Edge-of-Field Phosphorus Filters. Illinois Nutrient Loss Reduction Strategy Partnership Workshop. Champaign, IL. Newer results will be shared in San Antonio in November 2019.

Figure 5. Cover crop rainfall simulation to test phosphorus loss after freezing. Initial results show increased dissolved reactive phosphorus loss in run-off for both cover crop types (cereal rye and radish)

when subjected to heavy freeze. There is limited impact on drainage water concentrations. Results were shared in San Antonio in November 2019.

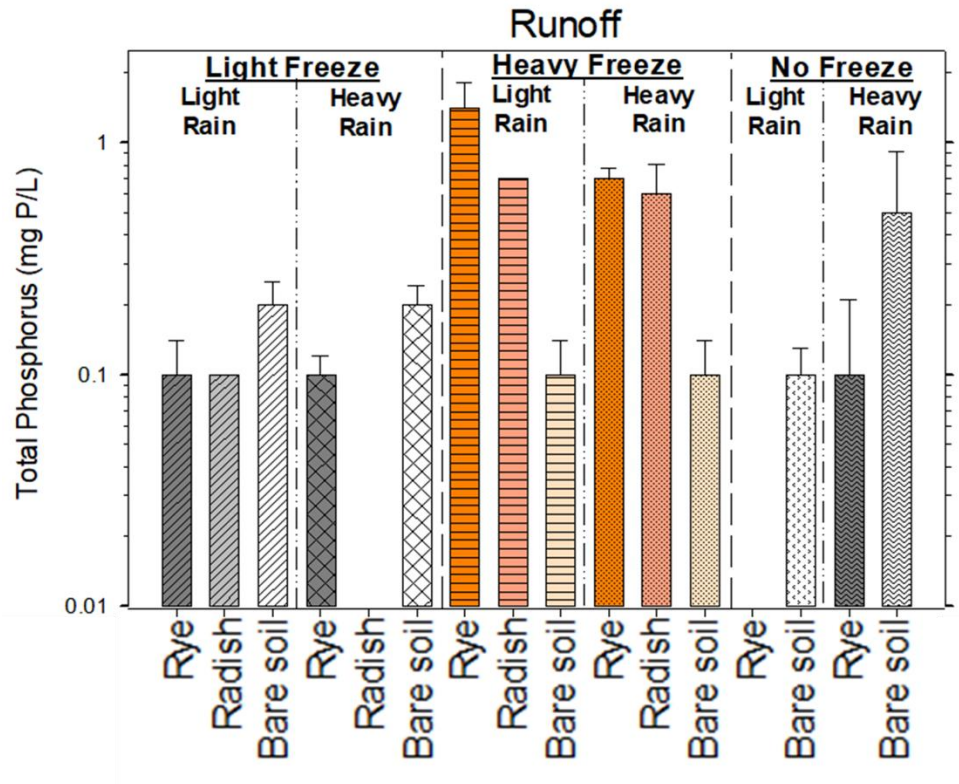


Figure 6. Cover crop rainfall simulation results of phosphorus loss showing increased losses with heavily frozen cover crops (cereal rye and radish). Results shared in San Antonio in November 2019.

Figure 7. Ariana Muñoz with the augmented reality sand table at the Farm Progress Show – summer 2019. Image from the @IllinoisNREC twitter feed from August 29, 2019. The sand table has visited two field days, Farm Progress, and Career Spark in summer and fall of 2019.