2021 Final Report Summary Sheet

Grantee Information

Project Title:	Characterizing subfield variability for efficient phosphorus management: targeting hotspots
Institution:	University of Illinois, Urbana-Champaign
Primary Investigator:	Jennifer Fraterrigo
NREC Project #	NREC 2021-3-360748-215

Is your project on target from an IMPLEMENTATION standpoint? ☒ **Yes** ☐ **No**
If you answered "no" please explain:

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:

Have you encountered any issues related to this project? ☐ **Yes** ☒ **No**
If you answered "yes" please explain:

Have you reached any conclusions related to this project that you would like to highlight? ☐ **Yes** ☒ **No**
If you answered "yes" please explain:

Have you completed any outreach activities related to this project> Or do you have any activities planned?
If you answered "yes" please explain and provide details for any upcoming outreach: ☒ **Yes** ☐ **No**

Presented a poster at the ASA-CSSA-SSSA International Annual Meeting, November 2021., Salt Lake City, UT
Title: Characterizing Sub-Field Variability for Efficient Phosphorus Management: Targeting Closed Depressions
Authors: Lenarth Ferrari, Lowell Gentry, Luis Andino, Jennifer Fraterrigo

Annual NREC Progress Report (September 2021 – November 2021)

Jennifer M. Fraterrigo, Lowell Gentry, Luis Andino, and Lenarth Ferrari (current graduate student)
University of Illinois at Urbana-Champaign
We are making steady progress toward meeting the overall project goal and specific objectives. We are completing the tasks associated with Objectives 1 & 2 according to the timetable. Our progress is summarized below.

Objective 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.
In this objective, we are conducting research to reveal the patterns and drivers of horizontal heterogeneity in surface soil P. During the reporting period, we performed analyses to quantify subfield variability in soil P using soil samples collected from the study farm in Douglas County. The samples were collected using a 2.5-acre grid sampling scheme, which is broadly used by farmers for generating general fertilization recommendations. Additionally, we sampled hotspots associated with closed depressions and legacy P areas. We refer to the grid plus hotspots sampling scheme as "targeted sampling." We first evaluated how incorporating information about soil P hotspots alters predictions of soil P distribution. To do this, we performed an inverse distance weighted (IDW) interpolation on each dataset in ArcMap software (Fig. 1). The IDW approach uses the measured values of a variable to predict values in surrounding, unmeasured locations, and assumes that each measured point has a local influence that diminishes with distance. We found that IDW interpolation of soil samples collected using a targeted sampling scheme better characterizes soil P variability at the subfield scale compared to samples collected using a 2.5-acre gridded scheme. For example, estimated soil P concentration is appreciably higher in many areas based on the IDW interpolation of targeted samples compared to the 2.5-acre gridded samples (Fig. 2). Our preliminary results suggest the need to reduce the overall P fertilization rate of the study field due to an increase in acreage now determined at P sufficiency (65 lbs of P/A) and suspend fertilization until soil P levels decrease. Our improved mapping of soil P will complement variable rate technology, keeping P fertilizer out of areas that have become P sinks.

We expect that additional improvements in accuracy can be achieved by explicitly accounting for co-variables influencing patterns of soil P. Thus, our next step will be to incorporate information about the spatial distribution of closed depressions and legacy areas to produce a more accurate map of soil P using co-kriging. Using co-kriging, we will estimate the spatial distribution of soil P and predict the total P accumulated in the field for both the 2.5-acre grid and targeted sampling pattern. Calculating the difference in P concentrations between the two interpolated maps will highlight locations where improved estimates of soil P are achieved. Furthermore, we will resample the interpolated map using different schemes to determine the optimal sampling scheme for accurately characterizing the amount and spatial distribution of soil P.

Closed depressions are common in the surrounding area of our study; therefore, to investigate soil P in other closed depressions, we have gained permission to sample soil in closed depressions on the neighboring field to the east. Preliminary data show that these depressions are also high in soil P based on Bray P1 values. Using the farmer's existing soil P map, we will add to our targeted sampling of closed depressions and update the map according to methods described earlier.

During the reporting period, we have also continued to collect weekly water samples from tile drains in Douglas County. Within the next months, we will investigate how estimates of soil P concentration derived from the interpolated maps relate to P loss in tile drains. We expect that accounting for the spatial distribution of soil P hotspots will improve field-scale predictions of P loss in tile water.

Objective 2: Investigate the drivers and timing of the release of dissolved and particulate P from P-rich soil to tile drains.
Vertical heterogeneity in the distribution of soil P is also important for understanding P loss, yet we know much less about the vertical distribution of soil P, especially in hotpots. We are therefore conducting research to elucidate the patterns and drivers of soil P across the soil profile in this objective. During the reporting period, we harvested lysimeters deployed at the beginning of the 2021 growing season to measure nitrogen and phosphorus leaching. The lysimeters will be processed in the next one to two months. In March 2021, we collected deep soil cores in Douglas County. These samples will be used to characterize patterns in vertical soil P distribution in closed depressions and legacy areas in the next three months. We will divide the soil cores to identify the different horizons through the soil profile and analyze physical and chemical characteristics (e.g., pH, texture, bulk density) in 10-cm increments. We will also perform Hedley fractionations on each increment to evaluate the distribution of different types of P and determine the relationship between these variables and P movement in the soil profile.

Current and future work:
In the next month, we will incorporate information about the spatial distribution of closed depressions and legacy areas to produce a more accurate map of soil P using co-kriging. We will resample this interpolated map using different schemes to determine the optimal sampling scheme for accurately characterizing the amount and spatial distribution of soil P. In the next two months, lysimeters will be extracted with KCl and analyzed using a spectrophotometer to determine nitrate and ortho-phosphate concentrations. We will also begin physical and chemical analysis of the deep soil cores to characterize the vertical distribution of soil P in depressions and legacy areas. We will continue to sample tile water and measure tile discharge throughout 2022. Using these data, we will investigate how deep soil P and estimates of surface soil P concentration derived from the interpolated maps relate to P loss in tile drains. We expect that accounting for the horizontal and vertical distribution of soil P in hotspots will improve field-scale predictions of P loss in tile water.

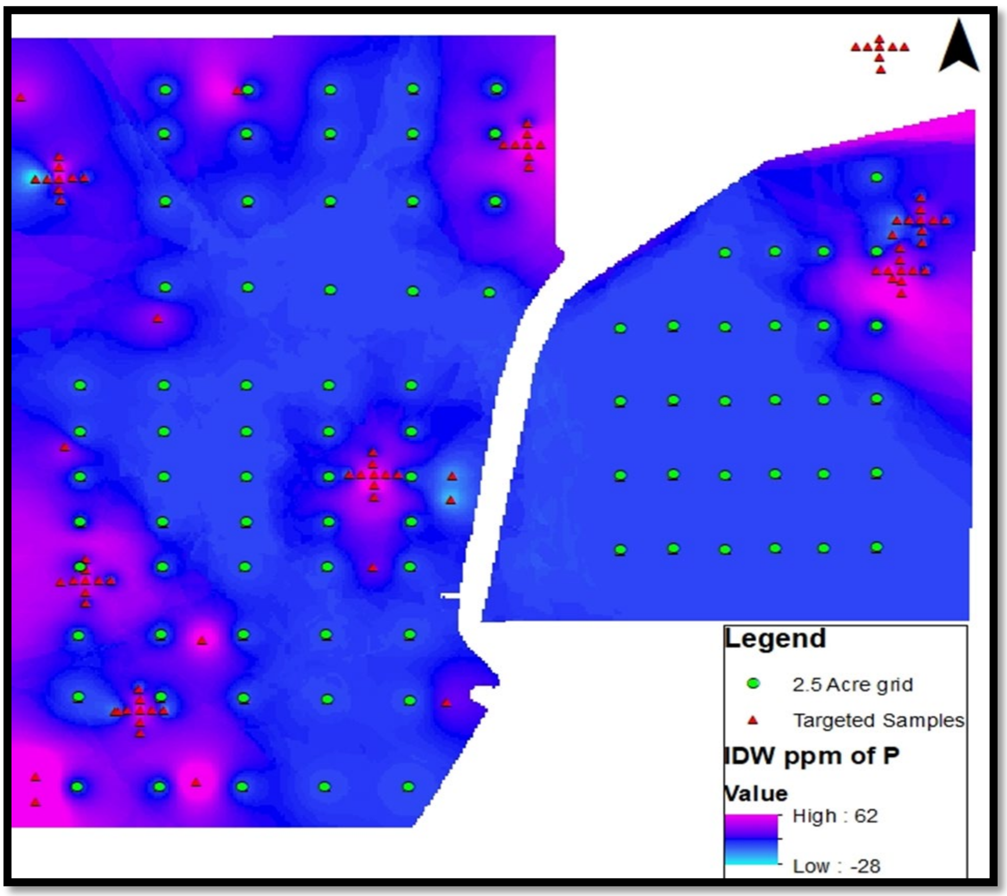

Fig. 1. A map showing soil sampling locations and differences in predicted soil P concentration resulting from interpolations at Douglas County study farm. Interpolations were performed using samples collected from in either a standard 2.5-acre grid pattern, or a standard grid pattern plus hotspots. The fuchsia and pink colors denote areas where soil P was underestimated by the interpolation of samples collected in a standard 2.5-acre grid pattern, highlighting the disproportionate influence of hotspots on subfield soil P distribution.

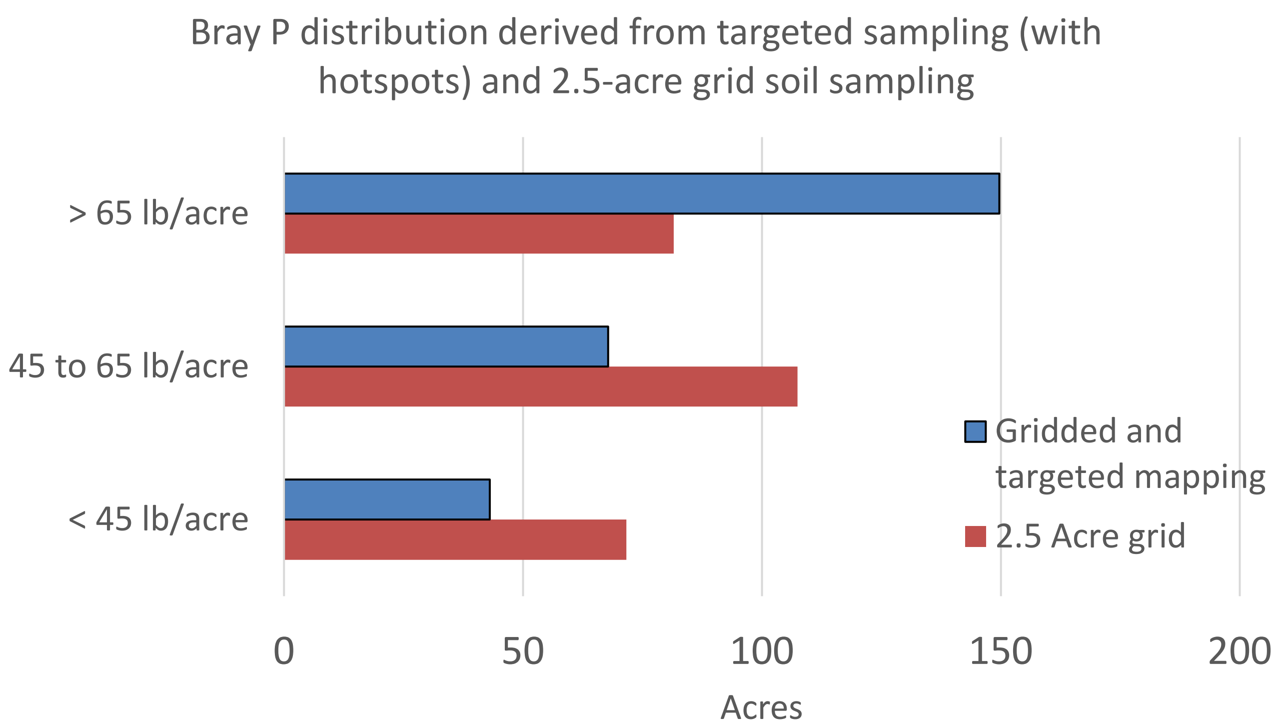

Fig. 2. Bar graph showing the difference in Bray P soil distribution determined from interpolated maps developed using two different soil sampling patterns. Note that targeted sampling results in more acres with high P concentration than a 2.5-acre grid.

Research Summary for the NREC Annual Report:

- Our results to date highlight the importance of accounting for hotspots created by closed depressions and legacy areas when characterizing the spatial distribution of phosphorus in surface soils.
- We found that interpolation of soil samples collected using a targeted sampling scheme that accounts for hotspots better characterizes soil P variability at the subfield scale compared to samples collected using a standard 2.5-acre gridded scheme (Fig. 1).
- Estimated soil P concentration is appreciably higher in many areas based on the interpolation of targeted samples compared to the 2.5-acre gridded samples (Fig. 2).
- Our preliminary results suggest the need to reduce the overall P fertilization rate of the study field due to an increase in acreage now determined at P sufficiency (65 lbs of P/A) and suspend fertilization until soil P levels decrease.
- Our improved mapping of soil P will complement variable rate technology, keeping P fertilizer out of areas that have become P sinks.
- Accounting for variability in the horizontal and vertical distribution of soil P in hotspots is likely to improve field-scale predictions of P loss in tile water.