

# Characterizing Sub-Field Phosphorus Variability for Efficient Phosphorus Management in Midwest Soils

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## Introduction

Phosphorus (P) is an essential macronutrient for adequate plant growth (Fernández, Mallarino, Greer, & Rudisill, 2013). In addition, it's crucial for energy transfer and root development in the first vegetative states (Schachman, Reid, & Ayling, 1998).

In Lacustrine areas of Illinois, closed depressions can also become enriched with P over time via soil deposition and low crop removal rates due to ponding. Previous results by Andino et al. (2020) at our research site show that Bray P is significantly related to tile P loads and that soil P values are related to depth within the closed depressions (Figure 1). Some studies showed that tile and surface drainage might work as pathways for dissolved reactive phosphorus (DRP) in soils with P concentrations above 32 ppm.

P build-up in topographic depressions can be avoided by focusing samples on closed depression and making more complete P prediction models. Accounting for microtopography variability can enhance P interpolations and reduce overapplication P hotspots; Therefore, reduce eutrophication in aquatic systems.

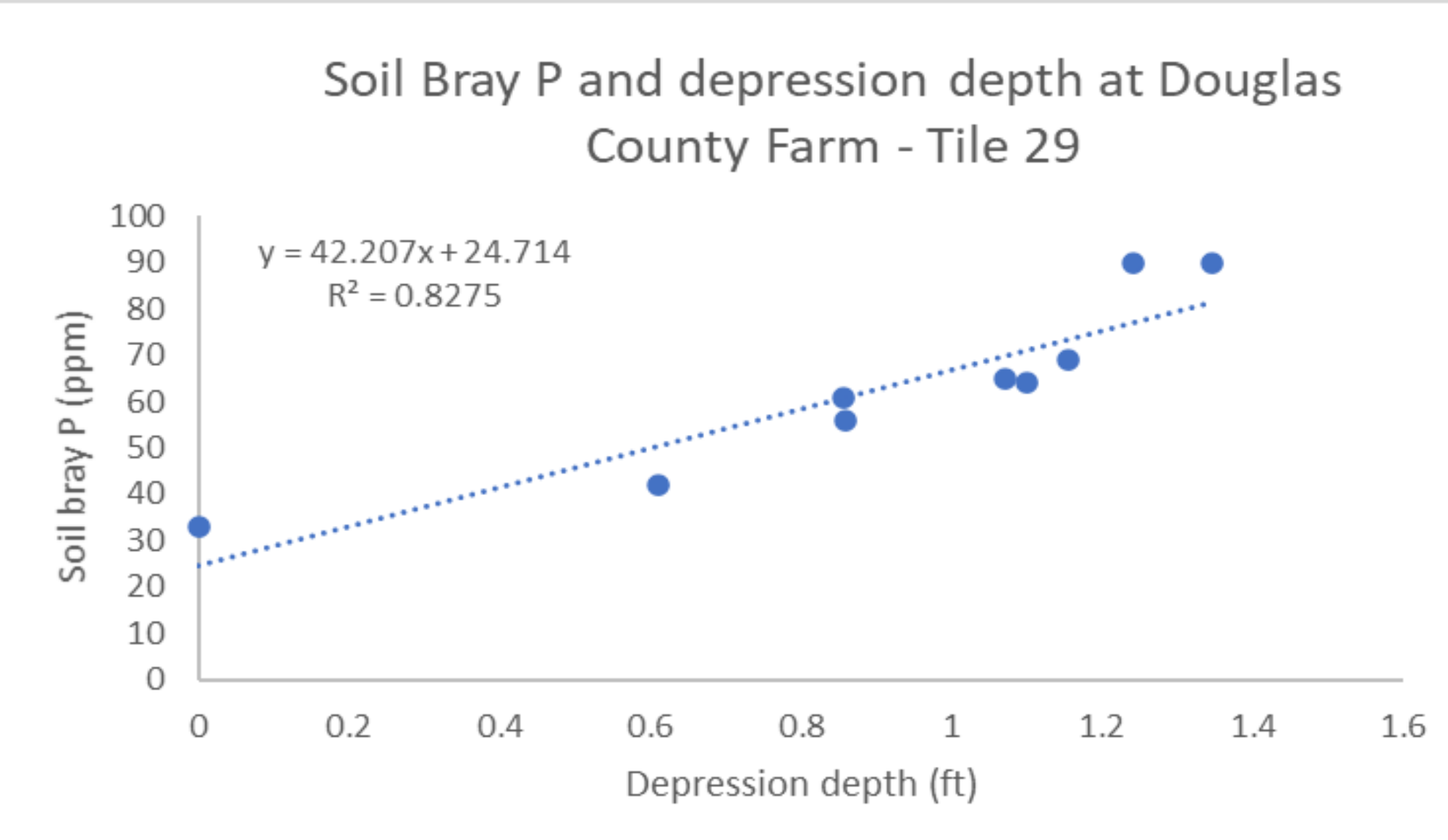


Figure 1. Regression between bray phosphorus concentration and the low microtopography located in Tile 29 in the research area, Douglas County, IL.

## Objectives

Quantify the spatial distribution of soil P in fields where depositional soil areas (closed depressions) contribute disproportionately to tiles.

Evaluate if targeted soil sampling and Universal kriging can improve P mapping and enhance nutrient management by avoiding phosphorus build-up in the topographic depressions.

## Methods

- Using a Digital Terrain Model (DTM), closed depressions (Figure 7) were identified and located using hydrologic modeling tools in ArcMap (ESRI), and choose seven closed depressions.
- Soil cores were collected from the deepest point to the edge of the depression for nine soil samples 15.20 m apart from each other (Figure 4).
- The study had two sample sets; one was collected using a grid-based approach: 100 x 100 m (Figure 3) and targeted soil samples in 2020.
- We also performed ordinary and universal kriging interpolation. I conducted six combinations between sample distribution and interpolation type (Table 1).
- Finally, I calculated the total P mass of 190 plots stratified through the field.

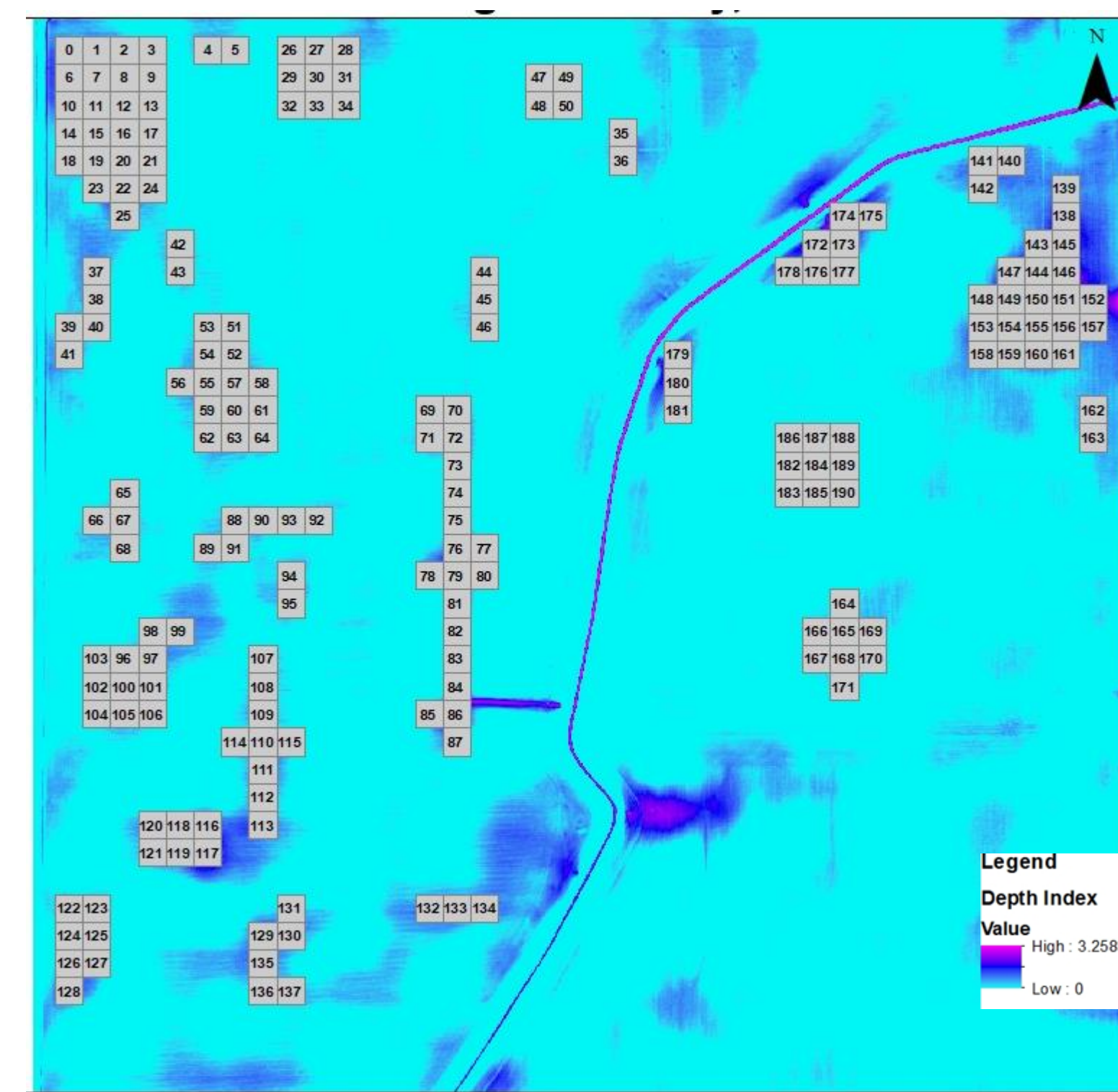


Figure 2 : 190 sampling plots of for P mass quantification.

## Results and Discussion

- The universal kriging uses microtopography as a variable to predict P mass. As a result, the universal kriging with targeted samples (UK\_T) has less error when indicating soil P mass.
- The use of universal kriging takes into count P hotspots related to low elevation áreas; Therefore, more P can be detected.
- Figure 2 represents a 1 Ha-grid sample, and figure 3 represents a 1 Ha-grid plus targeted samples in closed depressions (Figure 3).

Treatment	Interpolation	Number of Samples	Sampling Patter
1. OK	Ordinary K.	88	1 Ha grid
1. UK	Universal K.	88	1 Ha grid
1. OK_T	Ordinary K.	165	Targeted + 1 Ha grid
1. UK_T	Universal K.	165	Targeted + 1 Ha grid
1. OK_NT	Ordinary K.	165	0.5 Ha grid
1. UK_NT	Universal K.	165	0.5 Ha grid

Table 1: Universal kriging with targeted samples; UK\_NT= Universal kriging with a non-targeted sample, OK\_NT= Ordinary kriging with non-targeted samples. 1 Ha grid means the distance between each sample is 100\*100 meters and the 0.5 ha grid has a distance of 100\*50 meters

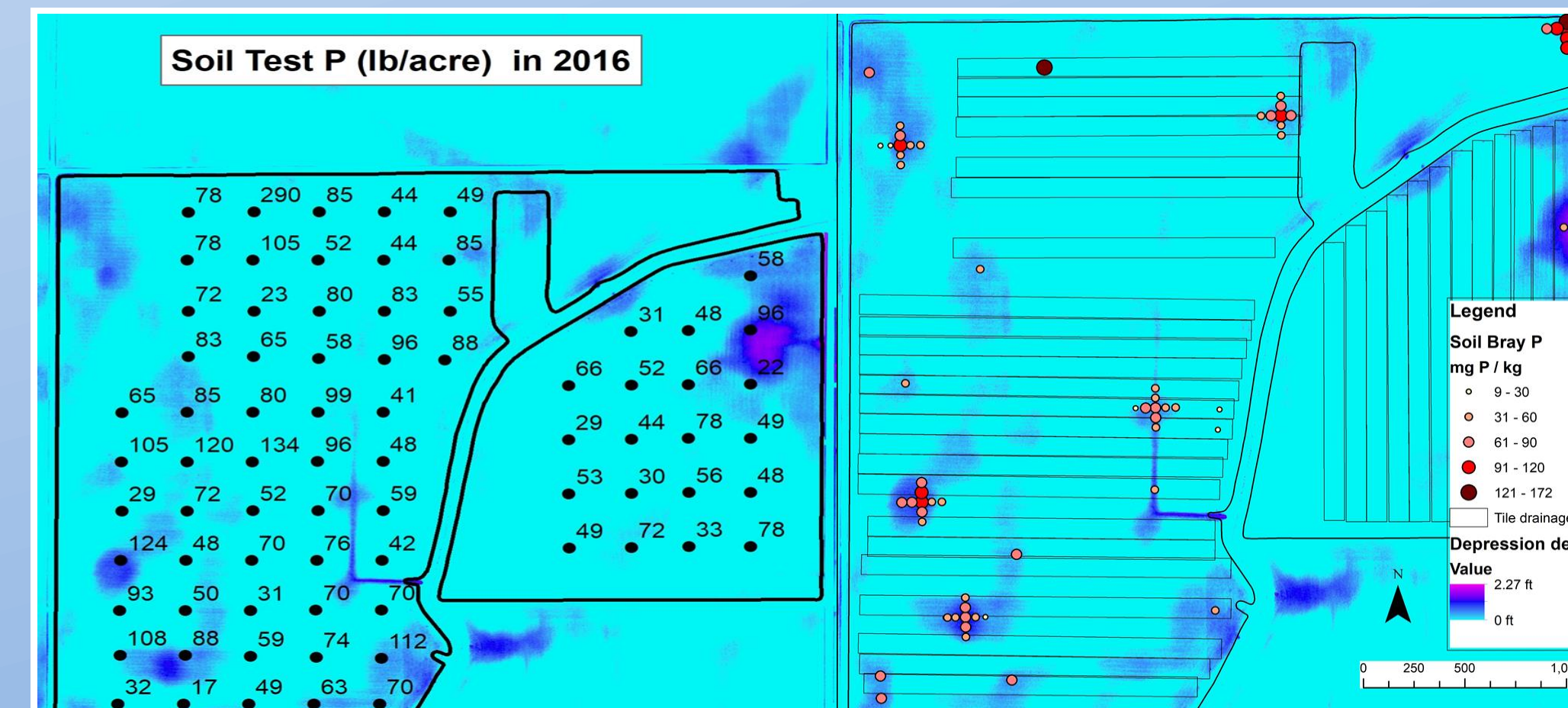


Figure 3 : Map of 1-Ha grid soil sampling. Measured range of soil P was 2-130 ppm.



Figure 4: Map of targeted soil sampling with the respective P concentration. Measured range of soil P was 9-190 ppm.

The plots showed that the location of soil samples and the type of interpolation could affect how much P is predicted through the field. We found differences in soil P mass between the sampling designs and the interpolations types ( $\alpha < 0.05$ )

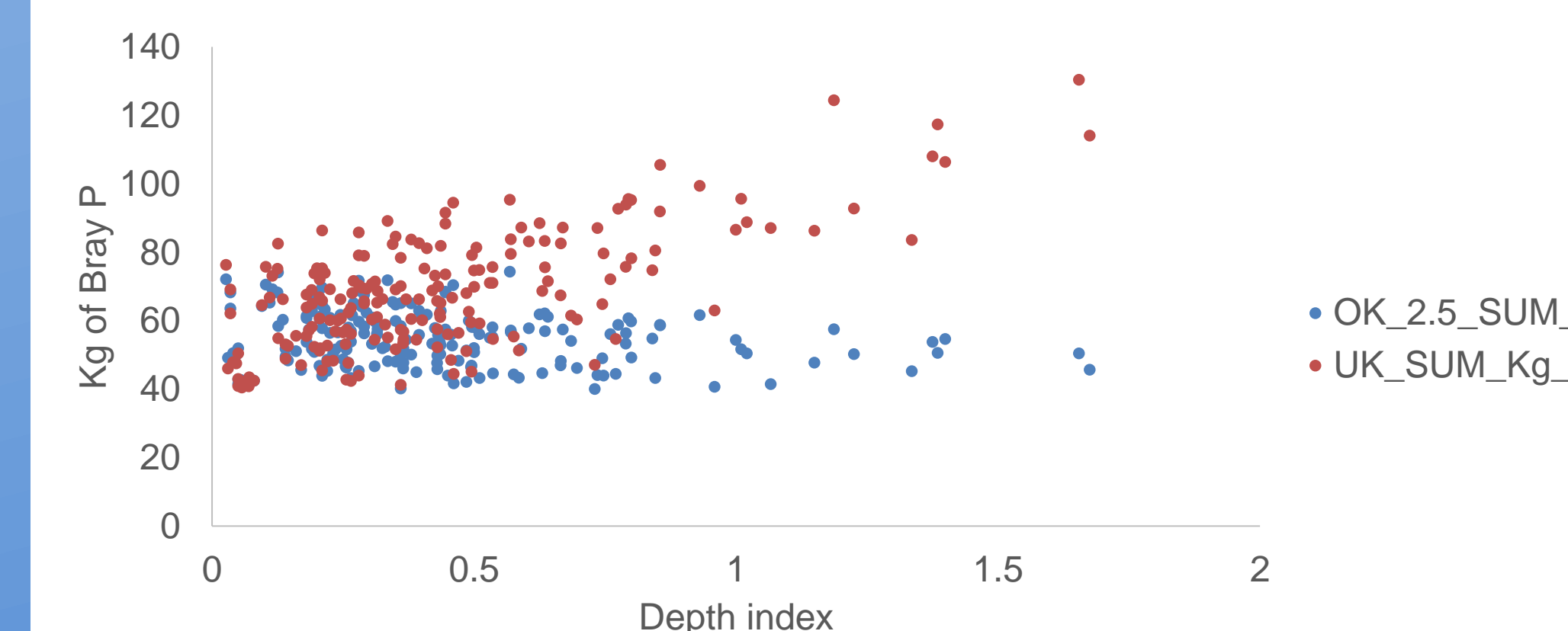


Figure 5: Sum of P in Universal and Ordinary kriging with a 1 Ha grid distribution (88 Samples).

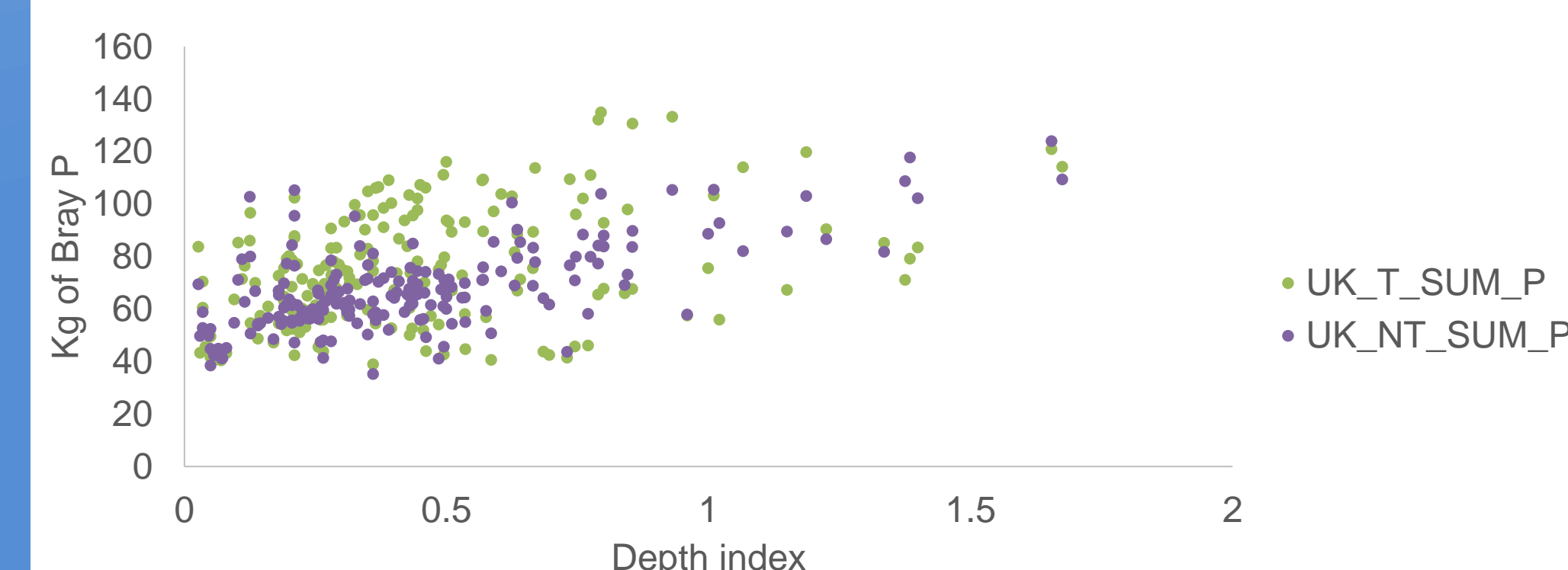


Figure 6: Sum of P in Universal kriging with a targeted and not targeted distribution (165 Samples).



Figure 7: Topographic depressions in the research farm, Douglas County, IL

The targeted samples collect data on how soil P varies through the closed depression. At the same time, the universal kriging used the targeted samples and the DTM to make a correlation model and predict soil P.

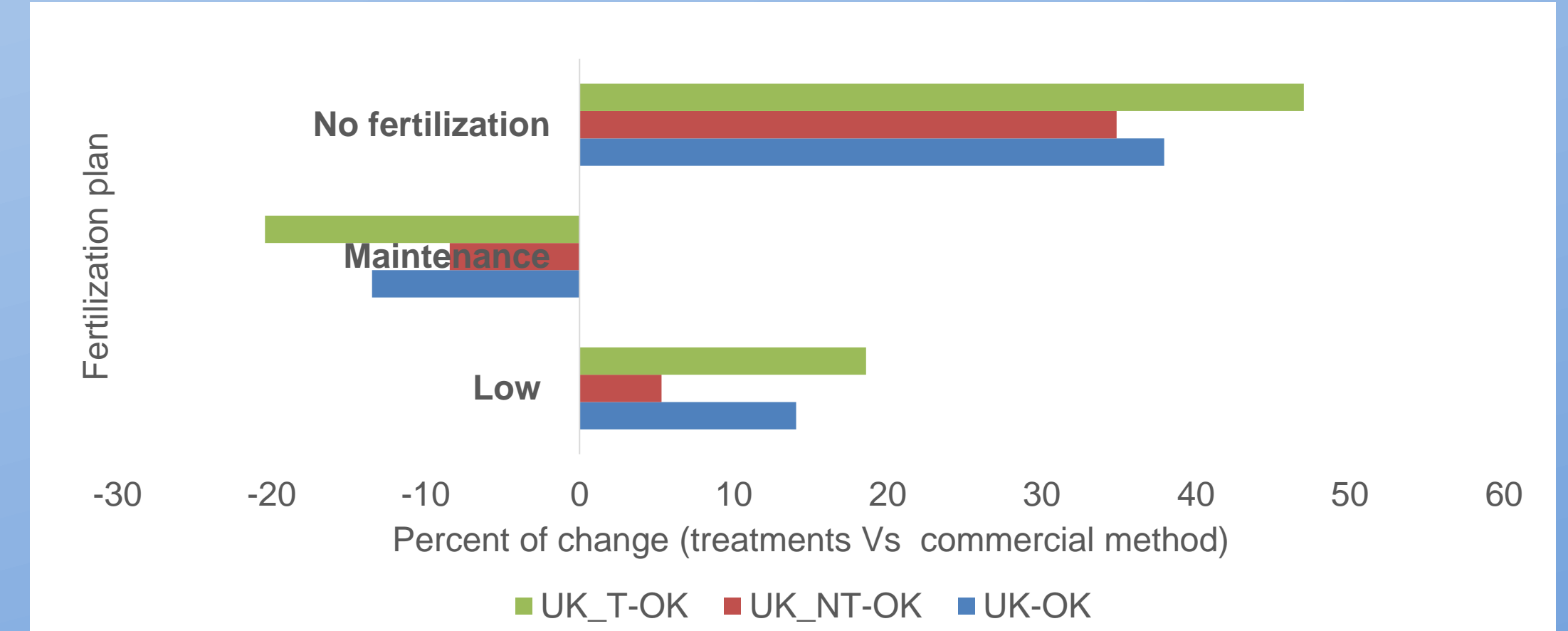


Figure 8: Hectare contrast between treatments(UK,UK\_NT & U\_T) and commercial method (OK)

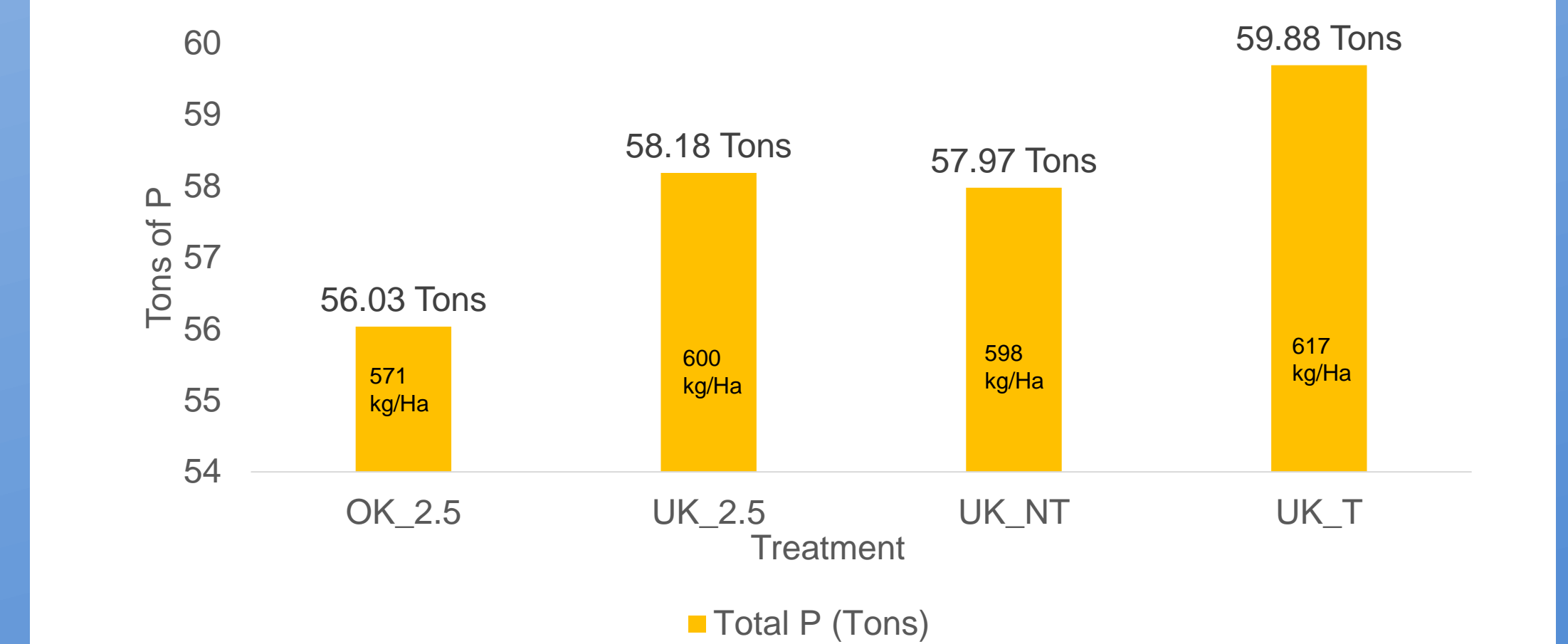


Figure 9: Predicted metric tons of P based on sampling and interpolation strategies.

## Conclusions

- The study demonstrated that universal kriging is more suitable for modeling bray-P predictions in fields with areas prone to prolonged ponding due to subfield variability.
- The universal kriging works the best for all scenarios with and without targeted samples, 88 and 165 sample sets. The targeted samples set proved the usability of Universal kriging to represent P concentrations in soil

## Recommendations

- We recommend incorporating stratified samples that focus on closed depressions to avoid overfertilization and P accumulation in areas with bray-P > 45ppm.
- Consider a blind tile inlet, as surface inlets may worsen water quality by connecting P-enriched, ponded water to drain tiles.

## References

