Dissolved Reactive Phosphorus Losses from Agricultural Fields in the Lake Erie Basin: A Synthesis

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Nutrients from Agricultural Runoff

- Excess nutrient fluxes from agricultural fields have been linked to occurrences of lake eutrophication, leading to harmful algae booms, and hypoxia in the ocean worldwide.
- For nearly three decades, significant federal investment in technical and financial assistance has been provided to implement BMPs/agricultural conservation practices (ACPs) to reduce and prevent applied nutrients from running off agricultural fields.
- Although significant effort has been invested in assessing and implementing BMPs/ACPs to reduce non-point source pollution, nutrient enrichment of the nation’s water bodies has not seen as great an improvement as expected.

Phosphorous in Lake Erie Basin

- Since 1970s, many plans and efforts have been implemented to control phosphorus (P) input to the Lake Erie by mainly limiting point source pollution.
- By early 1990s, HABs have been considerably mitigated in Lake Erie.
- In the mid-1990s, severe eutrophication has been observed and algal biomass has increased again.
- Agricultural conservation practices, including conservation crop rotation, cover crops, no-tillage/conservation tillage, and nutrient management, have been implemented since mid-1990s in the Lake Erie basin to mitigate non-point source pollution.
- Dissolved reactive phosphorus (DRP) loads from agricultural field have doubled in the 2000s compared to the 1990s, while TP loads have been relatively constant over the same period in the Lake Erie Basin.

Science Gaps

- Our current management strategies for non-point source nutrient reductions need to be further advanced to protect and meet the expected increased future demands on water for consumption, recreation, and ecological integrity.
- Information on performance of BMPs/ACPs is critically needed to gain insights on their effectiveness.

Objectives

- This study aimed to improve our understanding of mechanisms controlling DRP fate and transport by synthesizing information from studies of ACP effectiveness on DRP losses across various site-specific conditions in highly managed agricultural landscapes in the Lake Erie basin
  - Review literature and collect data
  - Conduct a generalized linear regression to evaluate the effectiveness of existing ACPs on DRP subsurface and surface losses along with site-specific conditions
  - Identify the dominant mechanisms controlling DRP subsurface and surface losses

Study Area

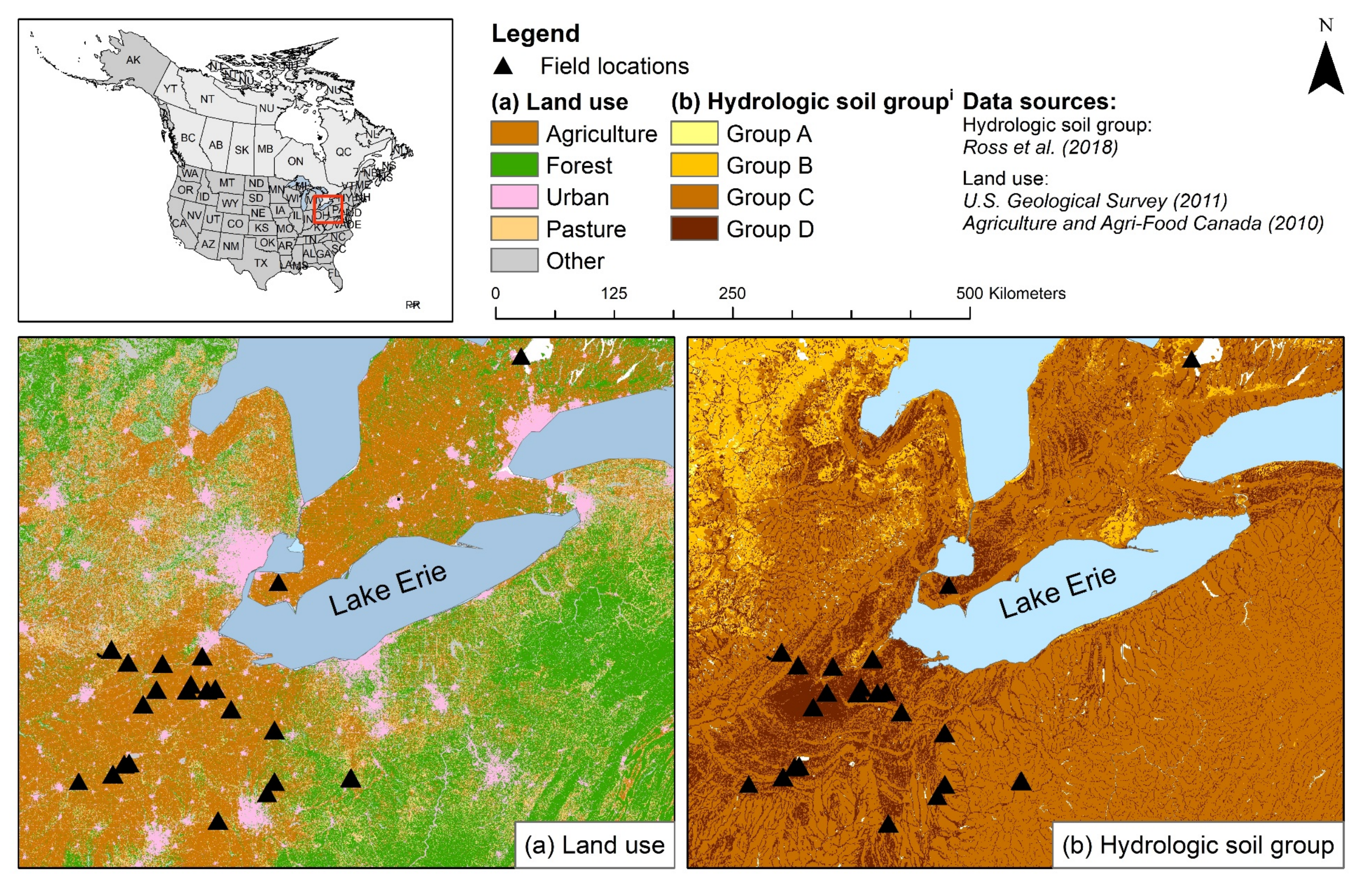


Figure 1. Study area and locations of the fields used in this study: Hydrological soil group A to D: low to high runoff potential

1. Agricultural cropland is the dominant land use and major crops include corn, soybean, and winter wheat
2. Artificial drainage systems, mostly subsurface tile drainage, have been extensively implemented in cultivated croplands in this region

Method and Procedures

- Literature review of peer-reviewed journal articles, published from 2000 to 2018 about Lake Erie Basin.
- Collect annual DRP losses from either subsurface or surface runoff from published papers on Lake Erie Basin along with site specific (e.g. soil properties) and management practice information including land use, tillage and fertilization as well as ACPs implemented.
- Collect weather information.

Parameters Considered

Variables	Description
SOM, %	Soil organic matter, considered constant for each field during study period
STP, mg kg^{-1}	Soil test phosphorus by Mehlich-3 method, indicates the plant-available P pool before the study started, considered constant for each field during study period
Soil Texture (%) (clay, silt, sand)	Considered constant for each field during study period
pH	Considered constant for each field during study period
Rainfall, mm	Annual[i] or annual average[ii] rainfall
Fertilizer application rate, kg P ha^{-1}	Annual[i] or annual average[ii] fertilizer application rate during the year
Cropping system	Crop rotation type of the study, constant for each field during study period
Crop species	Crop planted in the specific year[i] or "mixed crop type"[ii]
Drainage water management	Whether or not a field used a drainage management system in the study year
Tillage type	Conventional tillage, conservation tillage, or No-till
Cover crop	Whether or not a field was planted to cover crops in the study period
DRP subsurface and surface losses, kg P ha^{-1}	Annual[i] or annual average[ii] DRP subsurface and surface losses of the year

[i]: value in specific year if study reported data for each study year;

[ii]: average value in study period if study reported data as annual average;

Data Analysis

- Correlation analyses were performed first to identify collinearity among variables and remove highly correlated variables from the dataset.
- Multiple linear regression was performed to identify important variables associated with DRP subsurface and surface losses.
- Analysis was also performed to assess rainfall and STP interactions and their effects on DRP subsurface losses.

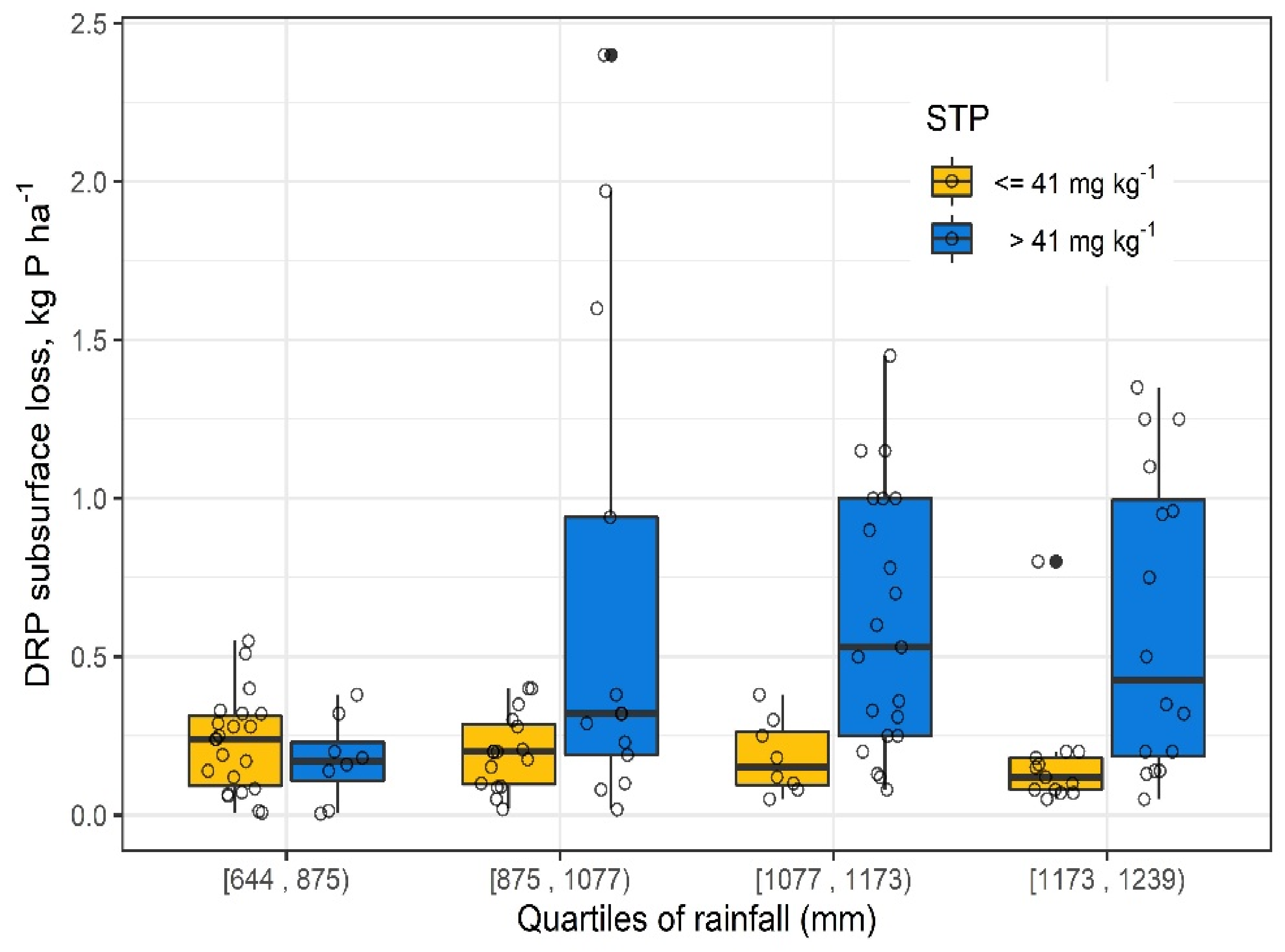
Results and Discussion

Results from multiple linear regression: Significant factors affecting DRP subsurface and surface losses

Variables	DRP subsurface losses	DRP surface losses
Clay	Yes (-)	No
SOM (%)	Yes (-)	Yes (-)
pH	Yes (+)	Yes (+)
STP, mg kg^{-1}	Yes (+)	Yes (+)
Cropping system (C-S)	Yes (-)	No
Cropping system (C-S-W)	Yes (-)	No
Conservation tillage	Yes (+)	No
No-Till	Yes (+)	Yes (+)
Cover crop	Yes (+)	No
Fertilizer application rate, kg P ha^{-1}	No	Yes (+)
Rainfall depth	No	Yes (+)

Impact of annual rainfall and STP on DRP subsurface losses

Boxplots of DRP subsurface loss in different annual rainfall depth and STP groups (the optimal range of STP for crop growth is 30 to 50 mg kg^{-1}). In fields with lower STP (<=41 mg kg-1), rainfall had almost no impact on DRP subsurface losses; whereas higher rainfall substantially enhanced DRP subsurface losses from fields with higher STP (>41 mg kg-1).



Effectiveness of ACPs

- Cropping systems involving soybean could reduce DRP subsurface losses, whereas winter cover crops could cause unintended DRP subsurface losses
- Cropping systems involving soybean and cover crops, however, had no impact on DRP surface losses
- No-till and conservation tillage also enhanced DRP losses compared to conventional tillage, particularly for soils with high SOM and/or high clay content.

Conclusions

- Soil properties significantly impact DRP losses
  - Greater DRP losses were associated with increased soil pH and Soil Test Phosphorus (STP)
  - Soil organic matter (SOM) was negatively correlated with DRP losses
  - Soil clay content was also inversely correlated with DRP subsurface losses, but had no impact on DRP surface losses
- The ACPs evaluated had varied effectiveness on DRP loss reduction
  - Cropping systems involving soybean could reduce DRP subsurface losses
  - Winter cover crops could cause unintended DRP subsurface losses
  - Cropping systems involving soybean and cover crops, however, had no impact on DRP surface losses
  - No-till and conservation tillage enhanced DRP losses compared to conventional tillage, particularly for soils with high SOM and/or high clay content
- Precipitation amount and fertilizer application rate significantly increased DRP surface losses
- Fertilizer application rate, however, had no impact on DRP subsurface losses.
- Precipitation amount on DRP subsurface losses depends on STP levels and precipitation amount significantly increases DRP subsurface losses when STP is greater than 41 mg kg^{-1}).

Selected References

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Questions?

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