The Impact of Winter Cover Crops on the Export of Phosphorus from Tile Drains in the Agricultural Midwest

Matt T. Trentman[1], Jennifer L. Tank[1], Todd V. Royer[2], Brittany R Hanrahan[1], Ursula H. Mahl[1], Kara Prior[2], Shannon L. Speir[1]

[1]University of Notre Dame Department of Biological Sciences, Notre Dame, IN
[2]Indiana University School of Public and Environmental Affairs, Bloomington, IN

Contact: mterntma@nd.edu

ENVIRONMENTAL CHANGE Initiative

SCHOOL OF PUBLIC AND ENVIRONMENTAL AFFAIRS
INDIANA UNIVERSITY

Introduction

- Agricultural streams and ditches move excess water, nutrients and sediments away from fields.
- Organic and inorganic fertilizer addition improves crop yields, but also increases leachable phosphorus (P).

Western Lake Erie 7/28/15 (NASA)

- Streams draining row-crop agriculture experience high P loads from subsurface tile drainage and runoff from fields
- Result: Eutrophication of downstream lakes, reservoirs, and estuaries.

Winter cover crops retain nutrients & sediment

- Cover crops are planted immediately after cash crop harvest, providing cover on otherwise bare fields.
  - They act as nutrient 'banks'– storing nutrients in plant biomass during periods of otherwise high nutrient loss (Oct-May).
  - The combination of increased cover and root structures also can prevent loss of sediment from fields.

Bare field

Field with rye grass cover crop

Objective

Investigate the impact of cover crops on phosphorus loss from tile drains (TD) in two distinct Indiana watersheds.

Watersheds

Characteristic	Shatto (SDW)	Kirkpatrick (KDW)
Watershed area (ha)	1333	2634
Prominent soil type	Loamy sands/muck	Silty clay loams
Soil P (mg P kg^{-1})	18	13
Soil Organic Matter (%)	2.5%	3.8%
Tile flow regime	Many flow all year	Few flow all year
Cover crop type	Annual and cereal rye	Cereal Rye, Rapeseed, Alfalfa, Oats/Radish

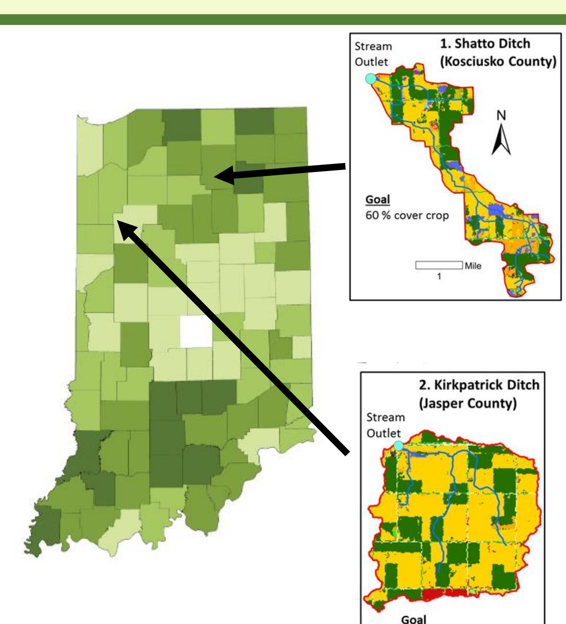

Figure. 1. Watershed locations in Indiana; maps are coded by cash crop, where fields with corn are yellow and fields with soy beans are green. Indiana counties are coded by percentage of cover crops used on croppable acres, with darker shades representing highest cover crop usage

Experimental Design

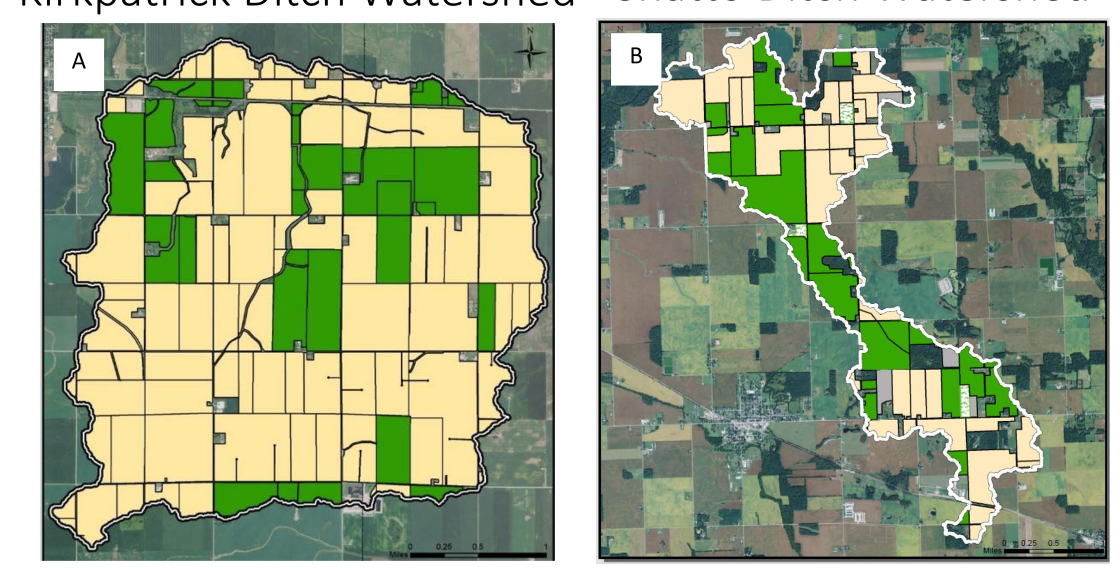

Figure 2. Cover crop usage in both watersheds for the 2016-2017 water year. KDW (A) had 24% coverage and SDW (B) had 65% coverage. Fields with cover crops are green and fields without cover crops are tan.

Sample size and timing

We conducted bi-weekly sampling of TD`s throughout both watersheds to characterize tile soluble reactive phosphorus (SRP) exports.

- We sampled an average of 11 TD outlets in KDW (7 with cover crops, 4 without) and 15 in SDW (12 with cover crops and 3 without) during the 2017 water year (Oct. 2016- May 2017).

At each tile drain:

- We collected 60 mL water samples, which were filtered with a GF/F filter then frozen:
  - Analyzed using molybdate blue method on a Lachat Flow Injection Autoanalyzer.
- Discharge at each TD was measured using a stopwatch and bucket (> 0.1 L/s), or graduated cylinder (< 0.1 L/s).

Results – A. Tile drain SRP concentrations over time

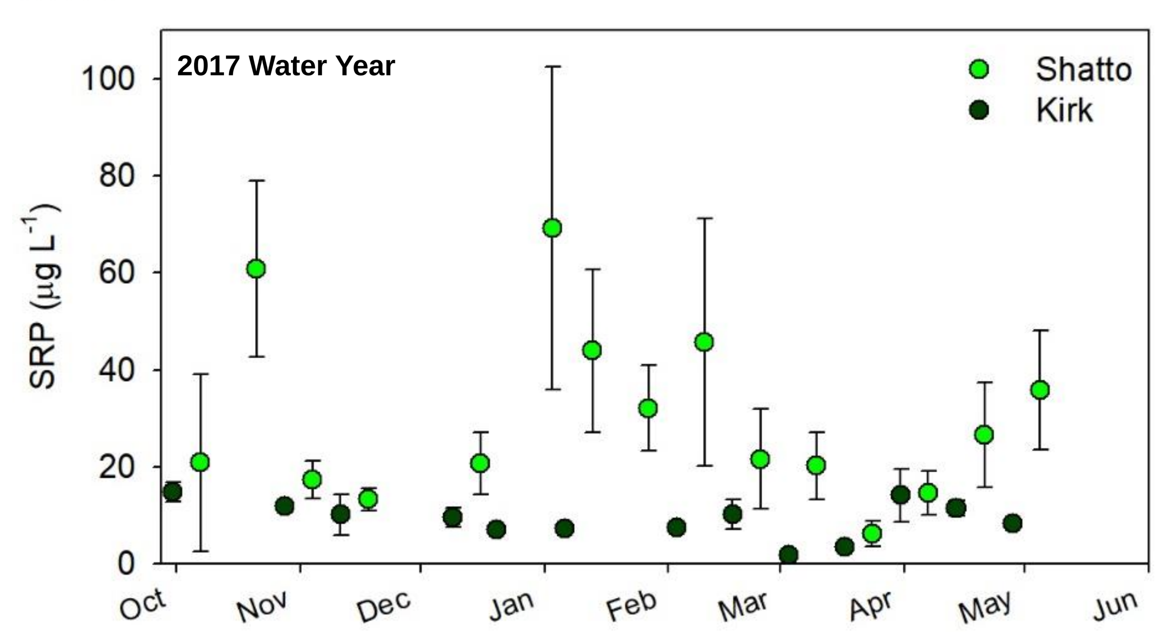

Figure 3. Average TD SRP concentrations from on each sampling date of 2017 WY through May, 2017 (± SE for all sampled drains by date).
Note: One point not shown-- from KDW on 11/29/2016 that averaged 169 ± 134 µg L^{-1}

- Tile drain SRP concentrations were generally higher in SDW compared to KDW, and also more variable.
- On any given date there were not any discernable seasonal trends based on concertation.

Results – B. Monthly tile drain SRP export

- Cover crops did not change SRP export from TD's in either SDW or KDW.
  - For SDW: T-test by month, $p > 0.05$.
  - For KDW: Mann Whitney U test by month $p > 0.05$).

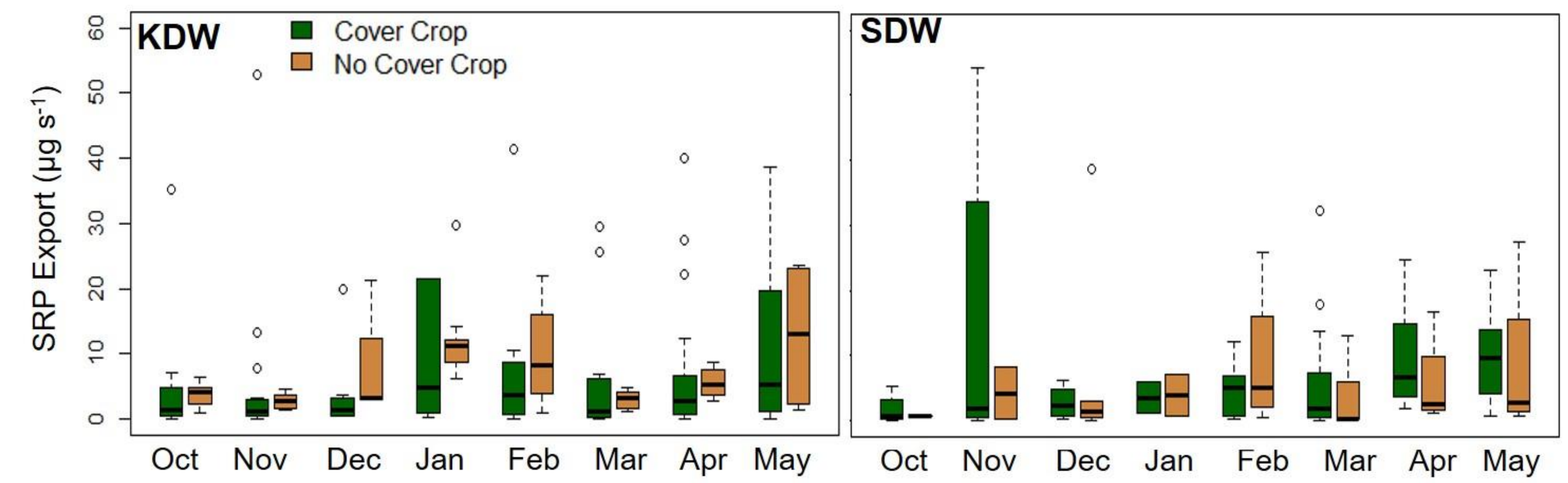

Figure 4. Monthly median SRP export (with interquartile range) from tile drains with and without cover crops for 2017 WY through May

Results – C. Influence of tile drain flow on SRP export

- Tile drain flow strongly influenced SRP export from tile drains in both KDW and SDW.
- But there was no difference between tiles draining cover crop and bare fields (ANCOVA, p>0.05).

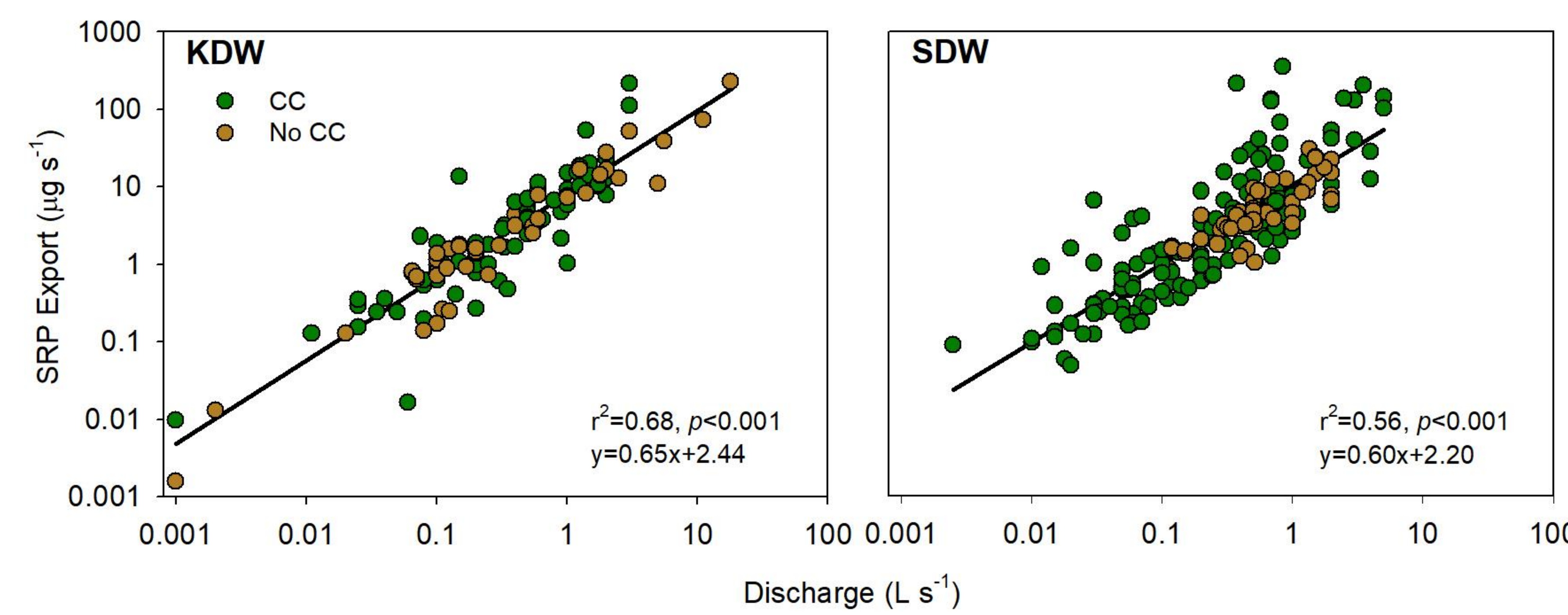

Figure 5. Relationship between tile drain SRP export and discharge from individual tile drains separated by cover crop drainage and watershed.

Results – D. Tile Drain SRP export during storm flow

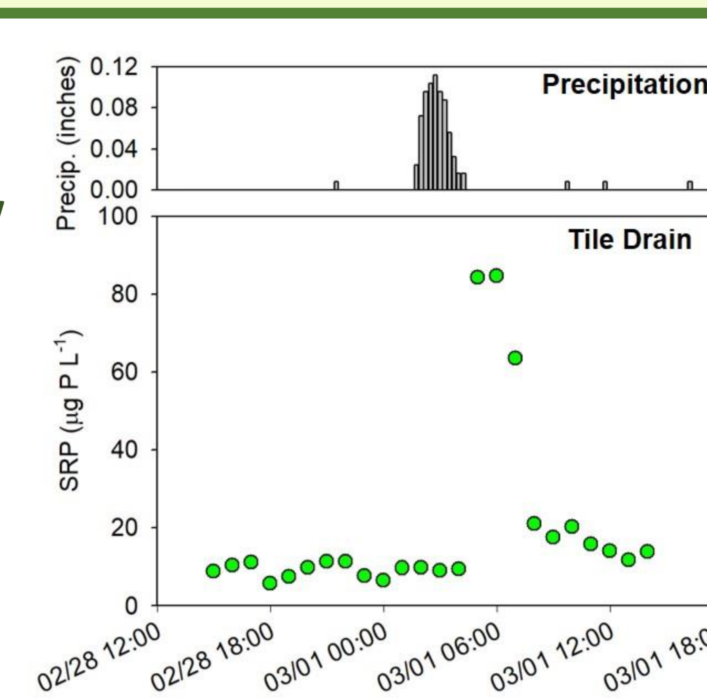

Figure 6. SRP concentration from a single tile drain in SDW during a precipitation event occurring in early March 2017.

- Tile drain SRP concentrations were 8 fold higher in the 3 hours following the most intense precipitation, then return to background concentrations very quickly.

Conclusion & Implications

- Cover crops are not increasing tile drain P export from agricultural fields (Figure 4).
- Instead water loss is a stronger driver of SRP export than cover crop usage, even in two watersheds with distinct soil characteristics (Figure 5).
  - Direct evidence from a TD during a storm provides quantitative evidence flow as a major driver (Figure 6).
- Recent work has linked increased stream SRP concentrations in Western Lake Erie Basin to increased use of no-till agriculture and augmented tile drainage over the past 15 years (Jarvie et al. 2017).
- Our results indicate that the use of cover crops as a conservation practice that does not result in increased dissolved P lost from agricultural fields.

Acknowledgements We thank the many landowners and farmers for allowing access to their property; as well as the field technicians and undergraduates for assistance in the field and lab. Funding was provided by a USDA-RCPP grant, JLT and TVR.

Literature Cited

Jarvie et al. 2017. Increased soluble reactive phosphorus loads to Lake Erie: Unintended consequences of conservation practices? J. of Environ. Qual. 46: 123-132.