# Real-time nitrate data provides insight into management of nitrate-N export during storms in agricultural watersheds

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## 1. Introduction

Storms are critical times for nitrogen (N) export, and shifts in precipitation patterns in the face of climate change invoke a critical need for better understanding and quantifying N export during storms.

- >50% of N export occurred during high discharge events in agricultural watersheds in the Midwestern US (Royer et al. 2006).

Given the importance of storms, periodic grab samples (weekly, monthly) may miss critical periods of N export.

- As such, short term dynamics may have important implications for watershed management.

Submersible Ultraviolet Nitrate Analyzers (SUNAs) provide high-frequency data that provide insight into nitrate ($NO_3^-$-N) export from two agricultural watersheds, especially during storms.

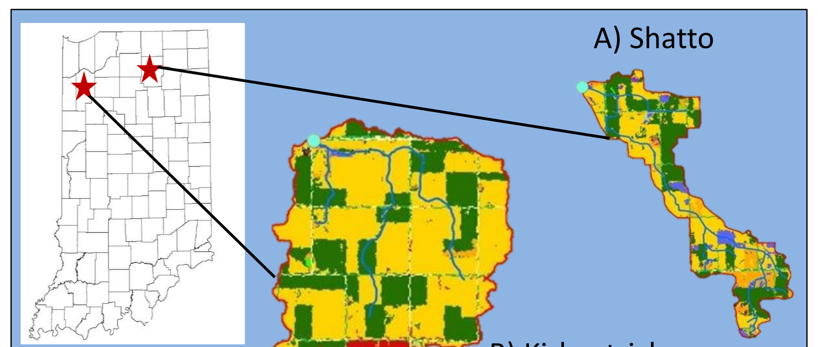


Figure 1. Two agricultural watersheds under row crop agriculture (yellow = corn, green = soy) in the Midwestern US. A) Shatto Ditch Watershed in Kosciusko, IN and B) Kirkpatrick Ditch Watershed in Jasper County, IN.

| | Shatto | Kirkpatrick |
|---|---|---|
| Size | 1333 ha | 2634 ha |
| 2017 Winter Cover Crop Coverage | 65% | 24% |
| Annual Precipitation | 40.7 in | 38.5 in |

Table 1. A comparison of basic study site characteristics.

## 2. Trends in $NO_3^-$-N Concentration and Discharge (2016-2017)

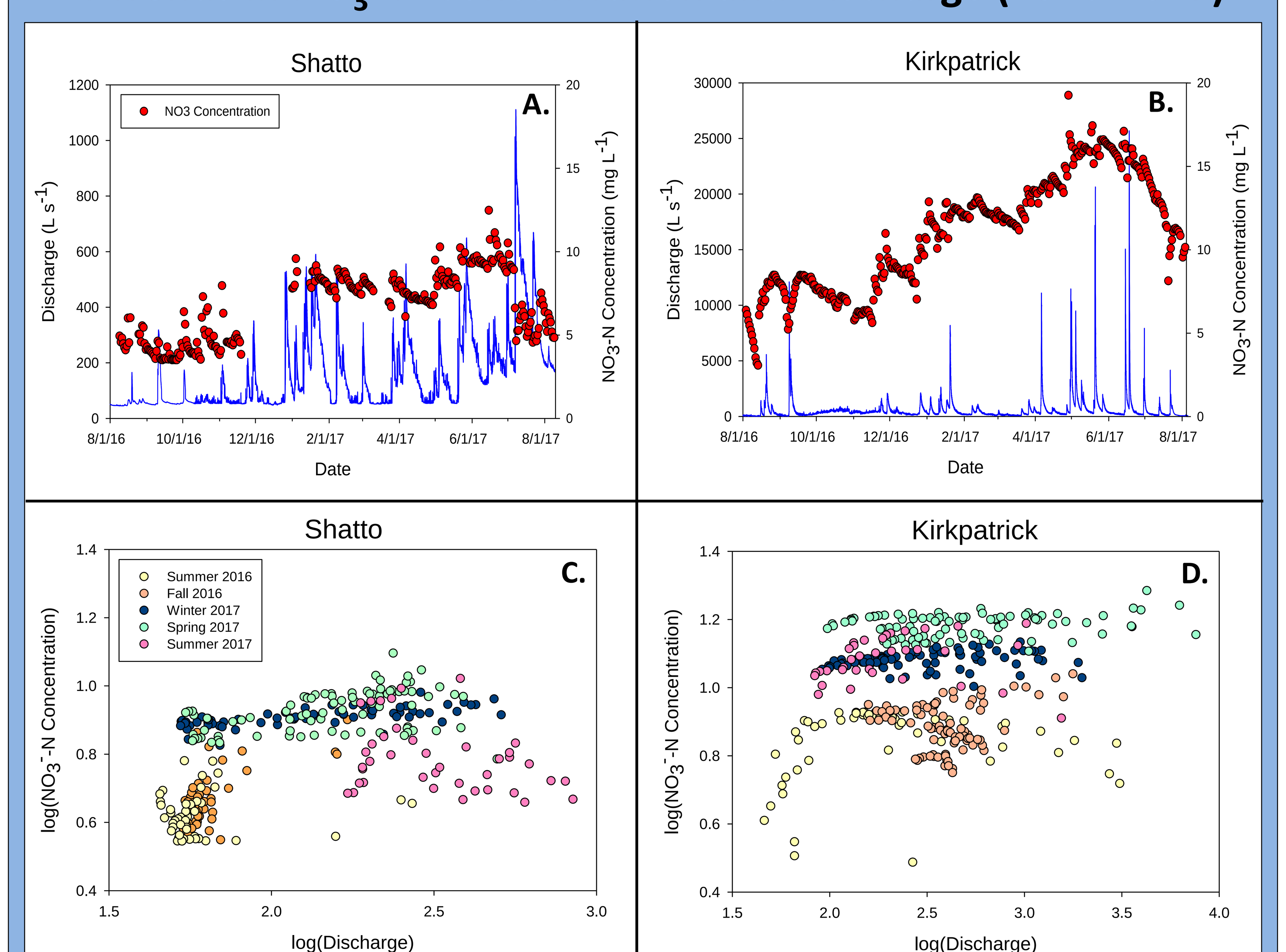


Figure 2. Daily average $NO_3^-$-N concentrations and discharge in A) Shatto and B) Kirkpatrick from August 2016 to August 2017. Seasonal relationship between $NO_3^-$-N concentration and discharge in C) Shatto and D) Kirkpatrick from August 2016 to August 2017.

- The relationship between $NO_3^-$-N concentration and discharge varies among seasons (Fall vs. Spring) and between years (Summer 2016 vs. Summer 2017).

## 3. Cumulative $NO_3^-$-N Export

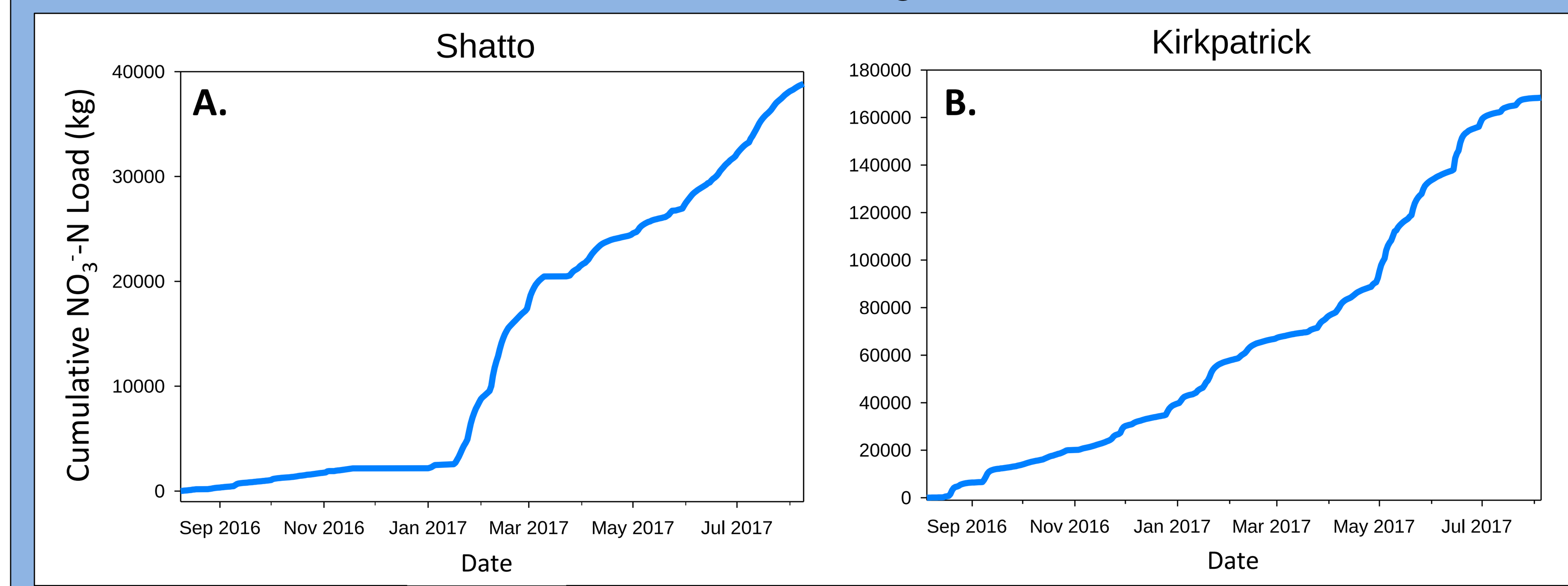


Figure 3. Cumulative $NO_3^-$-N load plots for A) Shatto and B) Kirpatrick from August 2016 to August 2017.

We found 36% of total $NO_3^-$-N export in Shatto and 54% of total $NO_3^-$-N export in Kirkpatrick occurred on days when flow exceeded the 75[th] percentile.

- Flow exceed the 75[th] percentile on 30% of days in Shatto and 36% of days in Kirkpatrick.

Storms play a disproportionate role in $NO_3^-$-N export in Kirkpatrick, possibly resulting from lower winter cover crop coverage in the watershed (Table 1).

## 4. Seasonal Storm Dynamics

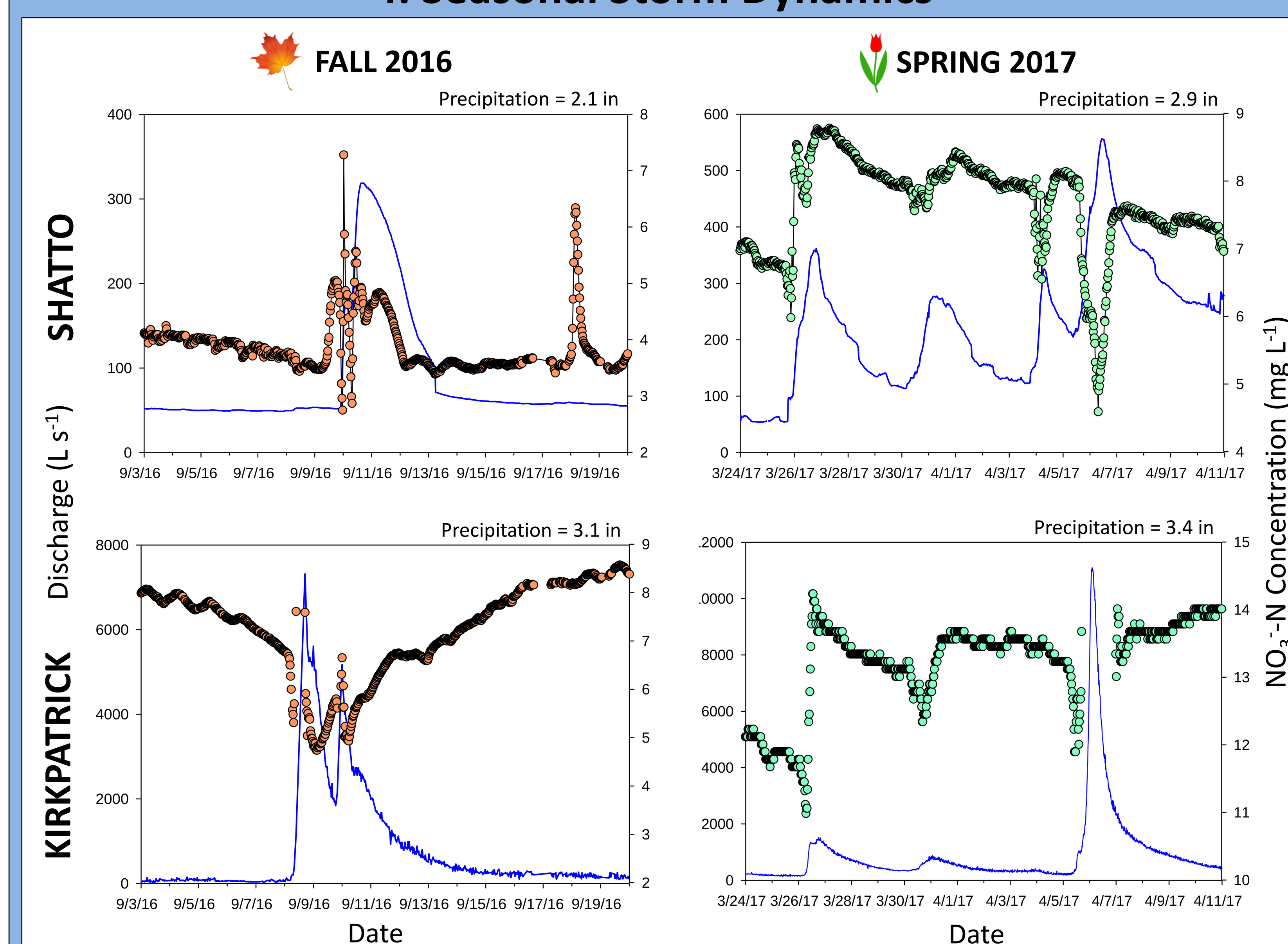


Figure 4. $NO_3^-$-N concentration dynamics of storms in Shatto and Kirkpatrick in Fall 2016 and Spring 2017.

In general, the influence of storms on $NO_3^-$-N concentration can shift from dilution and concentration effects, even within the same storm event.

- The direction of change is likely influenced by antecedent flow conditions.

Total $NO_3^-$-N export during the fall storm event was 0.02 kg $NO_3^-$-N $ha^{-1}$ $d^{-1}$ in Shatto and 0.43 kg $NO_3^-$-N $ha^{-1}$ $d^{-1}$ in Kirkpatrick, while total $NO_3^-$-N export during the spring storm event 0.11 kg $NO_3^-$-N $ha^{-1}$ $d^{-1}$ in Shatto and 0.46 kg $NO_3^-$-N $ha^{-1}$ $d^{-1}$ in Kirkpatrick.

- The greater $NO_3^-$-N export in Kirkpatrick may be the result of reduced cover crop planting in the watershed.

## 5. Seasonal $NO_3^-$-N Export

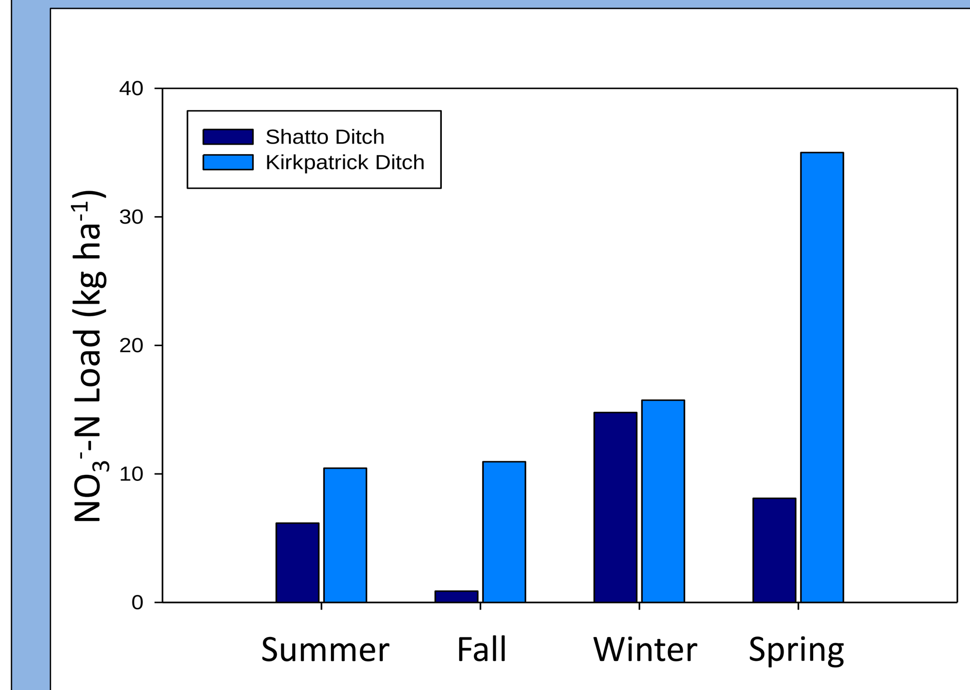


Figure 5. Differences in seasonal $NO_3^-$-N export per hectare in Shatto Ditch and Kirkpatrick Ditch.

- The greatest $NO_3^-$-N export occurred in winter and spring when fields are typically bare in agricultural systems.
- Shatto had less $NO_3^-$-N export in winter and spring that Kirkpatrick, suggesting that increased cover crop coverage acts as a buffer to retain N on fields in winter and spring.

## 6. Load Estimates: Continuous Data vs. Loadflex

| Total $NO_3^-$-N Export (8/16 to 8/17) | Shatto N Export (kg) | Kirkpatrick N Export (kg) |
|---|---|---|
| Continuous SUNA Data | 38,838 | 168,228 |
| Loadflex: Weekly Data | 40,856 (+5%) | 185,150 (+10%) |
| Loadflex: Biweekly Data | 42,502 (+9%) | 200,489 (+19%) |

- Data modeled in Loadflex (Appling et al. 2015) using weekly and biweekly data (subset from continuous SUNA data) overestimated annual $NO_3^-$-N load by 5-19% in comparison to continuous SUNA data.
- Differences between modeled and continuous data may result from the masking of dilution dynamics during storms.

## 7. Conclusions

The relationship between stream $NO_3^-$-N concentrations and discharge varied seasonally in both Shatto and Kirkpatrick throughout the one-year study period.

- Seasonal variation in concentrations may be driven by variation in flow throughout the year, but also by conservation practices such as cover crops.

Periods of stormflow have a disproportionate influence on $NO_3^-$-N export in Kirkpatrick compared to Shatto, and individual storms vary in their influence on $NO_3^-$-N export both within watersheds and seasonally.

- In general, winter and spring had the greatest N export.

Load estimates from continuous vs. modeled data were different, and periodic sampling plus modeling overestimated export. Given these results, continuous data may be needed to accurately assess the effects of conservation, especially as these effects may be subtle at times.

## 8. Literature Cited

Royer, T.V. et al., (2006). "Timing of riverine export of nitrate and phosphorus from agricultural watersheds in Illinois: Implications for reducing nutrient loading to the Mississippi River." *Environmental Sciences & Technology*, Vol. 40, No. 13, pp 4126-4131.

Appling, A.P. et al, (2015). "Reducing bias and quantifying uncertainty in watershed flux estimates: the R package loadflex." *Ecosphere*, Vol. 6, No. 12, pp 1-25.