The Effect of Cover Crops on Surface Water Quality: A Paired Watershed Experiment in the Lake Bloomington Watershed: Phase II

February 9, 2018

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(photo from 2016)

I. The effect of cover crops on surface water quality: A paired watershed experiment in the Lake Bloomington watershed

II. Cooperators and Locations

Cooperators

1. Primary Investigator: Catherine O'Reilly, Hydrogeology Program, Department of Geography-Geology, at Illinois State University. Expertise: surface water quality, impacts of land use on streams, climate change
2. Co-Investigator: Shalamar Armstrong, Crops and Soil Science Program, Department of Agriculture, at Illinois State University. Expertise: agronomy, soil science
3. Co-Investigator: Bill Perry, School of Biological Sciences, Illinois State University. Expertise: water quality analyses, high-frequency data management and analysis
4. Co-Investigator: Wondwosen Seyoum, Hydrogeology Program, Department of Geography-Geology, at Illinois State University. Expertise: hydrological models, groundwater
5. Contractors: Nathan Thompson, Agricultural Economics, Department of Agriculture, Purdue University. Expertise: agricultural economics
6. Collaborators: Dan Schafer, IFCA Director of Nutrient Stewardship, Expertise: Best Management Practices, farmer outreach. Bob Fish, Certified Crop Advisor, Expertise: Best management practices, farmer outreach.

II. Background:

Within the Mississippi River watershed, nitrogen loss from agricultural land use is a major contributor to reduced water quality and the hypoxic zone in the Gulf of Mexico. Locally, high nitrate loading to Lake Bloomington has consequences for the drinking water of Bloomington, IL. The contributing drainage area of Lake Bloomington is greater than 90% agricultural land use and seasonal nitrate concentrations of this drinking water reservoir have exceeded EPA nitrate standards of 10 mg/l at least 16 years between 1990 and 2008. There is a critical need to more effectively control nitrogen losses from these agriculture fields to increase the sustainability of row crop agriculture, decrease the degradation of local drinking sources, and reduce the loading of nitrate from the Upper Mississippi River Basin to the Gulf of Mexico. Our project focuses on the potential role of cover crops to improve nitrogen retention in the fields and reduce nitrogen loading to surface water systems.

III. Project objectives:

The goal of this project is to understand how cover cropping at large spatial scales affects nutrient loss, without altering other farming practices. Our objectives are as follows:

1. To determine nitrogen and phosphorous losses by comparing tile drainage water quality from two watersheds, one of which is cover cropped.
2. To relate patterns in nutrient loss to cover crop biomass, nutrient uptake and soil nitrogen.
3. To compare differences in the effectiveness of cover cropping after soybeans relative to after corn.

4. To develop a hydrologic model of the cover cropped watershed that can be used to explore alternative farming practices and climate change impacts.
5. To conduct an economic assessment of large-scale cover crop implementation.
6. To provide information and outreach for local farmers on the use and effectiveness of cover crops.
7. A final objective is to include a final report at the conclusion of this project to address each of the objectives stated above.

IV. Outcomes and activities

Below we provide a brief summary of our activities over the last few months.

Cover crops and crops

We had planted oat/radish and cereal rye/radish similar to the previous years. This year the watersheds were both predominantly soybean. One farmer did not harvest in fall 2018, but did harvest in late winter.

Total cover crop biomass and nitrogen uptake

We sampled for cover crop biomass and N uptake in fall 2018. Data are not reported here.

Soil sampling

We sampled the soils in both watersheds in April 2018 (data shown in last report). We expect to do this again this spring.

Water sampling and instrumentation

We have spent quite a bit of time working on our analyses as we prepare for our manuscript on this project. The data are quite complicated because of the variability in the tile drain flow and the fact that crop rotation means each year should be different. Major points so far are as follows:

- There was no tile flow for several months again this year in fall.
- Nitrate losses at the treatment site appear to have decreased substantially relative to the reference site in spring and summer (Figure 1). We are not able to definitely detect changes in winter and autumn because in some years we have no flow during those seasons. We also know that that period in which most nitrogen is lost is in spring, so this is the most meaningful data.

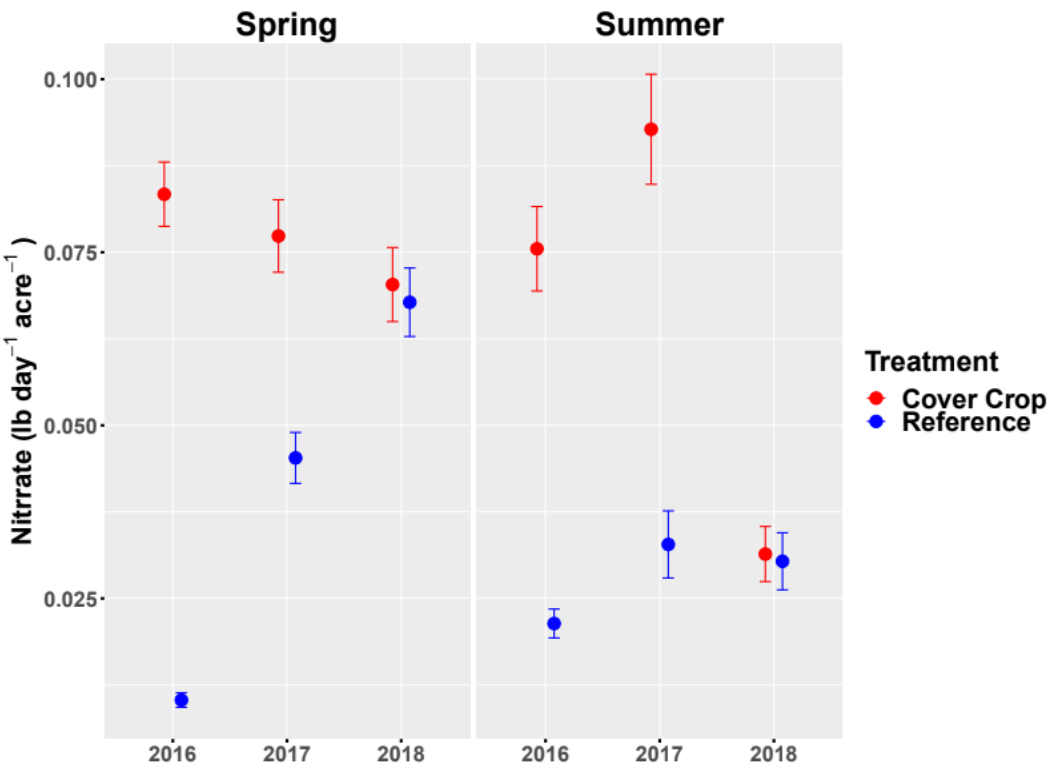

Figure 1. The amount of N loss per acre each day, on average, during spring and summer of each of our project years. There is a decline over time in the cover cropped watershed, but and increase or no change in the reference watershed.

- We also see other changes over time, such as a shift in the cumulative nitrogen loss, with a reduction over the past few years at the reference watershed (Figure 2.)

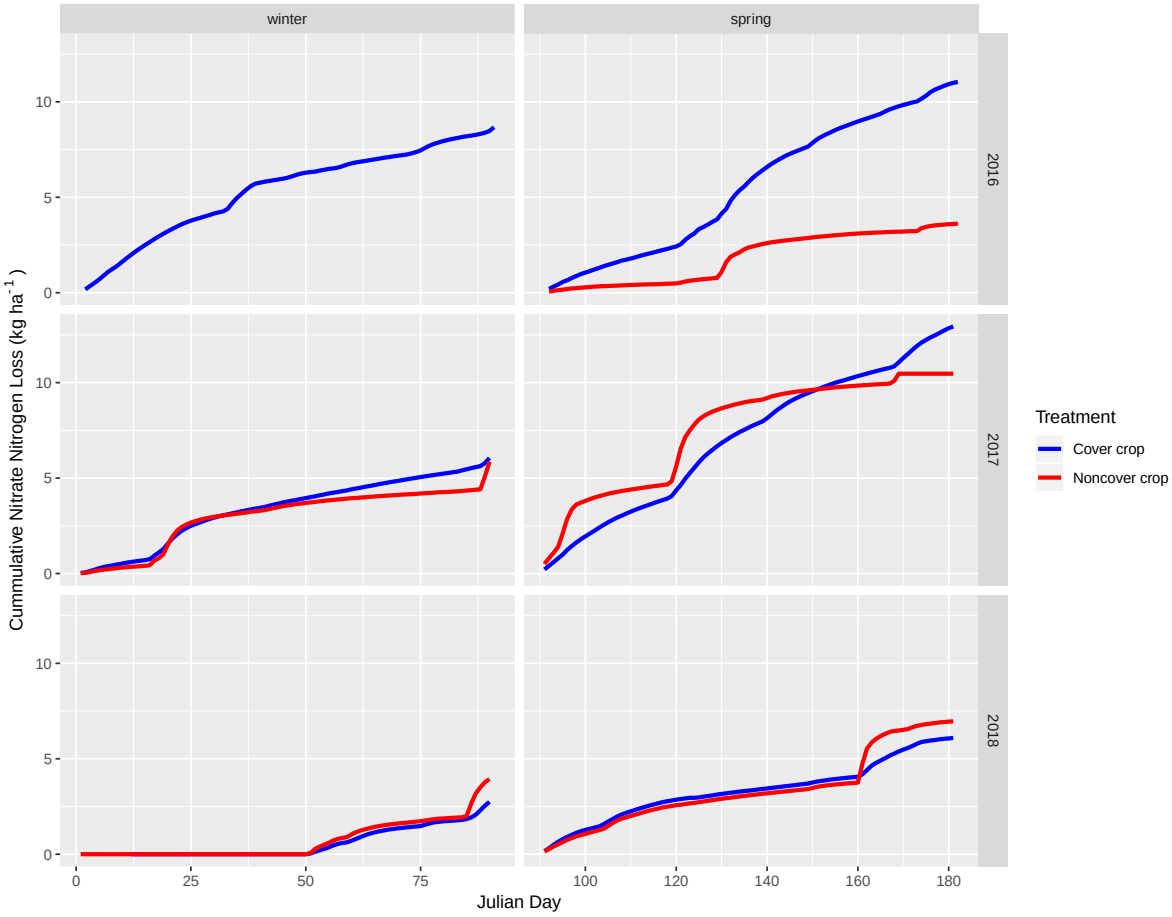

Figure 10. Cummulative nitrate loss per hectare

Figure 2. Cumulative losses of nitrogen during the spring were initially lower at the reference watershed, but now the cover cropped watershed has the same amount of N loss as the reference site.

- Similarly, we see further changes in the relationship between N loss and discharge, with a decrease over the past three years at the cover cropped watershed relative to the reference watershed.
- We see extremely high total phosphorus losses associated with high flow events when the water is very turbid. The phosphorus is adsorbed to these particles. Probably a lot of soil and phosphorus is lost during overland flow events, which we are not currently set up to detect and sample from.

Modeling of Cover Cropped Watershed

Since the last progress report, the following tasks were accomplished:

1. **Creating the crop (agricultural) management** file in the model: this is completed based on data collected from the experimental watershed and literature review. This file contains information such as annual crop use, type and amount of fertilizer applied, date, type, and field of application of the cover crop, tillage application, etc. (Table 1).
2. **Creating tile drainage file** in the model: the model needed information abou the tile drainage in the watershed, such as the diameter of tile drainages, lateral tile spacing, depth to tile, etc. Field observation, remote sensing imageries and google earth, and information from literature were used to create this file in the model.
3. **Calibration of flow**: once the above files are updated, the model was run, and calibration of flow (specifically tile flow) was conducted. We applied both manual and automated calibration techniques. After numerous model runs, the model simulated tile flow matched (Figure 3) with the field collected tile flow data with some discrepancy in specific period of the data. We are studying the causes of this discrepancy. One possibility could be due to limitation in the data (e.g., some of the weather data used in the model are regional, which could be different from local weather condition). We only have the tile flow component measured in the field that potentially limits our ability to verify the closure of the water balance by the model. Another possibility might be that overland flow is substantial, and since we are not currently measuring that in the field, we cannot confirm that this is reason for the model discrepancy.

The next step will be completing the calibration of nutrient loading from the watershed. We will start with by comparing model simulated nitrate load with the field collected load. Once the model is fully calibrated for both flow and nutrients, we will validate the model based on new data collected in 2019.

Table 1. Crop management data used in the model.

Field ID	Model Sub-basin No	Fertilizer applied	code	Amount (gal/L or lb/A)	Amount (Kg/ha)	TN	Season	Approx. date	Date of cover crop	Cover crop
1	1,2,3,4, 5, 6,7,8,9, 11	UAN	33-00-00	86(69)	77.28	236	spring	22-Apr	28-Aug	Cereal /Rye/ Radish
		DAP	18-46-00	200	224		spring	22-Apr		
2	10,14,1 5, 16	AA	82-00-00	225	252	254	spring	22-Apr	3-Sep	Cereal /Rye/ Radish
		UAN	33-00-00	25(20)	22.4	K_250	spring	22-Apr		
		DAP	18-46-00	250	280		fall	15-Oct		
3	17,18,1 9, 20,21,2 2, 23,24,2 5	AA	82-00-00	160	179.2	222	fall	15-Oct	9-Sep	Cereal /Rye/ Radish
		UAN	33-00-00	20(16)	17.92		spring	22-Apr		
		DAP	18-46-00	250	280		fall	15-Oct		
4	12,13	AA	82-00-00	175	196	188.45	fall	15-Oct	9-Sep	Radish / oats
		DAP	18-46-00	250	280	K_250	fall	15-Oct		
3_a	62.5 ha	0	0	0	0	0			9-Sep	Cereal /Rye/ Radish
3_b	60_ha	0	0	0	0	0			9-Sep	Radish / oats

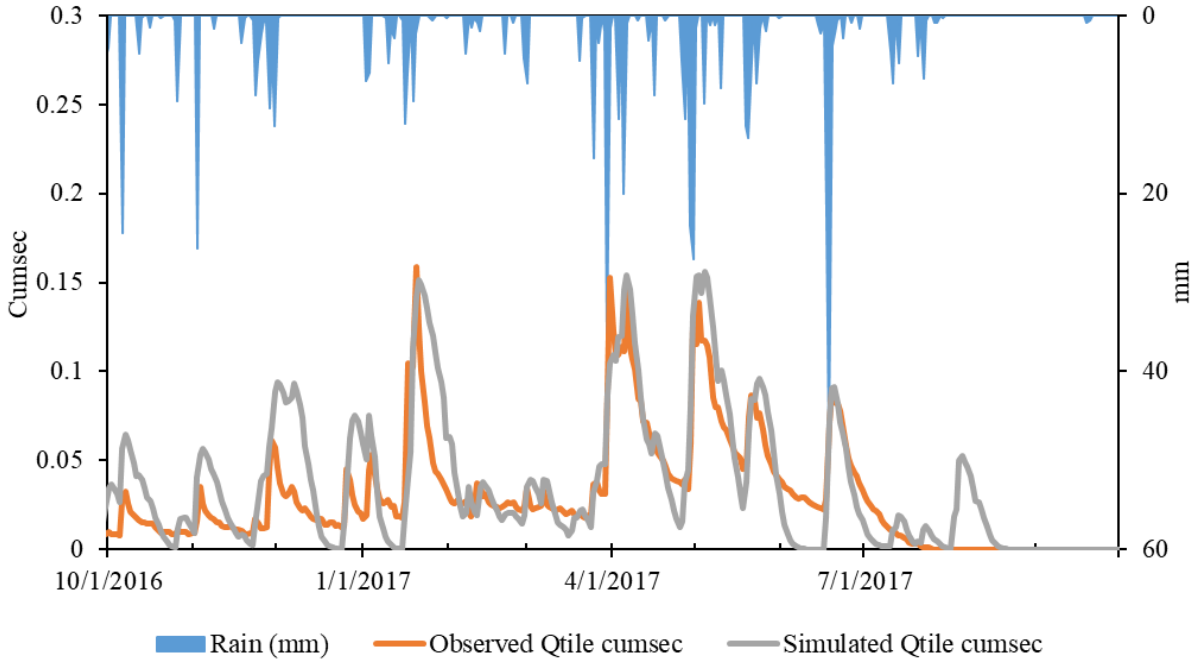

Figure 3. Model simulated tile flow vs observed tile flow. The model does reasonably well but there are some discrepancies at lower flows and in winter months the model predicts more flow than we measure coming from the tile. This could be due to overland flow which we are currently not measuring.

Outreach and education

Several presentations regarding this work have been given since the last report:

- Peoria Academy of Science Geology Section, January 2018. W.L. Perry. Use of cover crops to alter the hydrogeology and nutrient loss from agricultural fields.
- *Farm Weekly* radio and online, December 2018. O'Reilly was interviewed about this project.
- *Illinois Farm Bureau Annual Meeting*, December 2018. O'Reilly, C.M., S. Armstrong, W. Seyoum, and W.L. Perry. What does cover cropping at the farm scale really do?
- *Soil Health Meeting Lake Springfield Watershed*, July 2018.O'Reilly, C.M. Lake Bloomington Paired Watershed study: What does cover cropping at the farm scale really do?
- *Nutrient Loss Reduction Strategy Workshop*, Champaign, November 2018. O'Reilly, C.M., W. Seyoum, S. Armstrong, T. Tewodros, V. Heath, J. Wang, B. Bruening, A. Watson, G. Ambrose-Igho, P. Oware, G. Sieggreen, and W.L. Perry. Using cover crops at the watershed scale to reduce nutrient loss and improve surface water quality, Illinois
- *Geological Society of America* Annual Meeting, November, 2018. Tilahun, T., W.M. Seyoum, C.M. O'Reilly, and W.L. Perry. The effect of cover cropping an agricultural management on surface water quality in a small-scale watershed in Central Illinois.
- We also trained two new students who are involved in the field sampling and processing in the laboratory.

Other activities

- We are finalizing analyses for a manuscript on the water quality results that we expect to submit this spring.
- We have begun planning for the socio-economics component this fall.
- Overland flow: We have mentioned that overland flow may be important to take into account. This spring we are going to pay more attention to when overland flow events happen and do some initial sampling. The photo below shows overland flow in late winter/early spring in 2019 at the reference watershed.