Modeling Watershed-scale Cover Crop Impact on Nitrate Availability and Transport

Daniel Perkins, Ph.D.[1], Rohith K. Gali, Ph.D.[1], Caroline Wade[2]
Waterborne Environmental, Inc[1] Illinois Corn Growers Association[2]

Project Goal

The goal of this project is estimate potential impact of cover crops on nutrient loss reduction at the watershed scale in the Indian Creek, IL watershed. This estimate is derived from systematic numerical simulations using the SWAT (Soil and Water Assessment Tool) model.

Background

State nutrient loss reduction goals, as mandated by the USEPA, may require a combination of best management practices (BMPs). The Illinois Nutrient Loss Reduction Strategy (NLRS) names a number of potential in-field and edge-of-field BMPs, including: 4R fertilizer management, N inhibitors, cover crops, bioreactors, wetlands, and vegetative buffers. The current project focuses on characterization of the single, potential impact of cover crops to reduce nitrate loss.

The SWAT model has been developed by USDA-ARS to integrate spatial and temporal environmental and management data at the watershed scale. It specifically includes peer-reviewed algorithms for cover crop growth, N uptake, and water uptake (Reference).

Indian Creek Watershed

The Indian Creek Watershed located in Livingston, Mc Lean, Ford County, Illinois covers an area of 201 Km^2 and is a sub-basin of Vermillion River Watershed that flows into the Illinois river. The watershed is primarily farmland (>90%) with over 160 farms. Majority of the watershed is under subsurface tile drainage system and around 18% of the soils in the watershed are Drummer soils. The drummer soils are classified as poorly drained. The corn tillage data from Livingston County reported 22% conventional tillage, 73% reduced tillage, 3% mulch till, 2% no-till. Common agronomic practices in the watershed are Anhydrous Ammonia injection (200 kg/ha) in Fall with nitrogen inhibitors. About 41% of the watershed is enrolled in Conservation Stewardship Program or Environmental Quality Incentive Program.

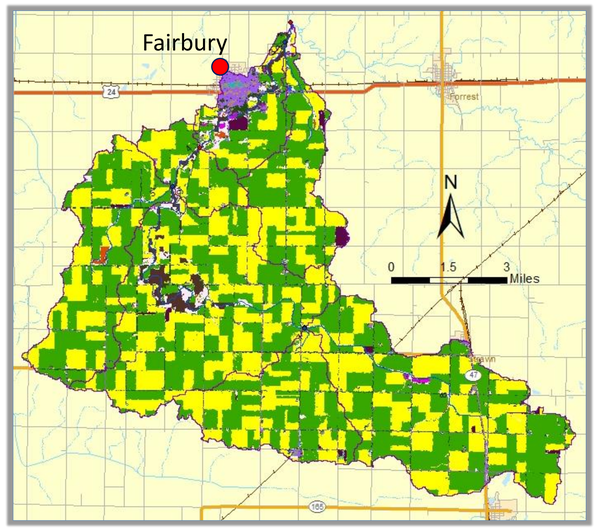


Figure 1. Indian Creek Watershed location and Corn/Soybean landuse distribution.

Soil and Water Assessment Tool

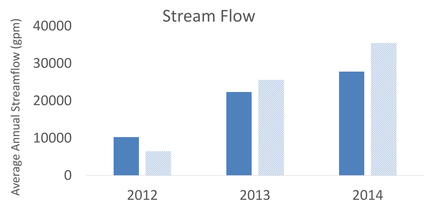
SWAT (Soil and Water Assessment Tool) was used to simulate continuous time series flow and nutrient loads at a high level of spatial resolution through detailed division of watershed into hundreds of hydrologic response units. SWAT operates on a daily time step and can evaluate management effects on water quality, agricultural chemical loads in surface water and crop yields (Arnold et al., 1999).

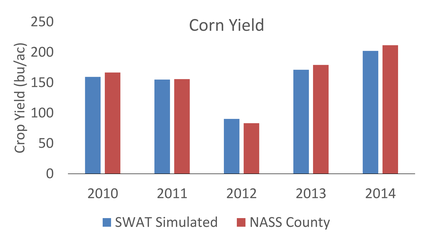
Model Setup

Year 1 **(CORN)**	Apr 10	Anhydrous Ammonia (100 lbs/ac)
	Apr 25	Planting Corn
	Oct 1	Harvest
	Oct 2	DAP (250 lbs/ac)
	Oct 3	Planting Rye
Year 2 **(SOYBEAN)**	Apr 25	Kill/End of Growing Season
	May 1	Planting Soybean
	Sep 15	Harvest
	Sep 16	Planting Oats/Rye
	Oct 30	Kill/End of Growing Season
	Nov 1	Anhydrous Ammonia (100 lbs/ac)

Table 1. Crop management operations in Indian Creek Watershed using Cover Crops and continuous corn-soybean rotation.

Model Calibration





	Flow	Nitrate Load	Corn Yield
Monthly	0.69	-	-
Yearly	0.81	0.75	0.97

Table 2. Comparison metrics (Nash-Sutcliffe coefficient) for flow, nitrate load and corn yield in Indian Creek

Cover Crop Scenarios

Four scenarios were developed based on the % of the proportion of the watershed that uses cover crops (10%, 25%, 50% and 100%).

Cover crops such as oats and cereal rye were selected to represent watershed/farmer interests in the watershed.

SWAT model has been previously tested and used cover crops as N management (Sexton et al., 2010; Saleh et al., 2007)

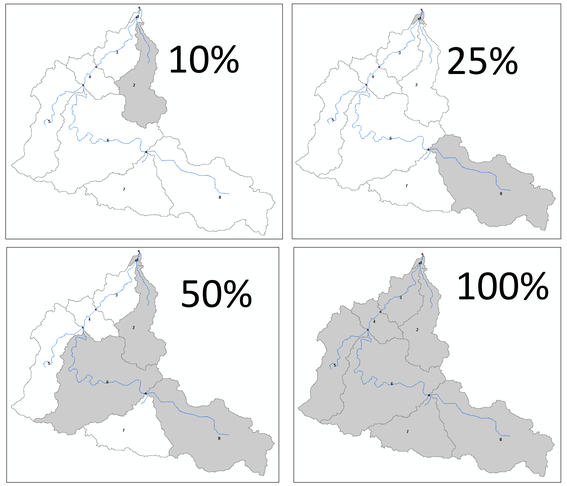
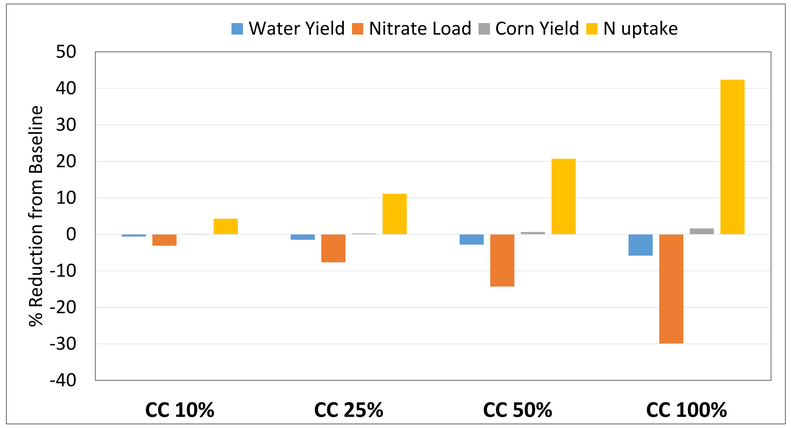


Figure 3. Randomized spatial distribution of cover crop scenarios in Indian Creek Watershed, Illinois.

Model Results



	CC 10%	CC 25%	CC 50%	CC 100%
Water Yield	- 0.6	- 1.5	- 2.8	- 5.8
NO_3 Load	- 3.1	- 7.7	- 14.3	- 29.9
Corn Yield	0.1	0.2	0.6	1.6
N uptake	4.3	11.1	20.7	42.4

Table 2. Statewide Results for nitrate-nitrogen reductions with Cover Crops (Illinois Nutrient Loss Reduction Strategy – Table 3.11)

Practice/scenario	Nitrate-N reduction per acre (percent)	Nitrate-N reduced (million lb)	Nitrate-N reduction from baseline (percent)	Cost ($/lb removed)
Cover crops on all corn/soybean tile-drained acres	30	84	20.5	3.21
Cover crops on all corn/soybean non-tiled acres	30	33	7.9	11.02

Conclusions

- Flow and nitrate loads were well adequately simulated for Indian Creek Watershed using SWAT
- SWAT simulated corn yields were well correlated with NASS County level watershed averaged yields
- Simulation of cover crops estimated a reduction in watershed-scale nitrate-nitrogen load and potential improvement of nitrogen uptake of plants (increased soil N available for crops).
- Increasing acreas of cover crops in the watershed was directly related to decreased nitrogen loss; however, the SWAT model framework offers potential to evaluate multiple BMPs at once across a broad range of environmental conditions

References

Arnold, J. G., R. Srinivasan, R. S. Muttiah, P. M. Allen, and C. Walker. 1999. Continental-scale simulation of the hydrologic balance. *J. American Water Resources Assoc.* 35(5): 1037-1052.

Saleh, A., E. Osei, D.B. Jaynes, B. Du, J. G. Arnold. 2007. Economic and environmental impacts of LSNT and cover crops for nitrate-nitrogen reduction in Walnut creek watershed, Iowa, using FEM and enhanced SWAT models. Transactions of ASABE. 50(4): 1251-1259.

Sexton, A.M., A.M. Sadeghi, A. Shirmohammadi, G. McCarty, W.D. Hively. 2010. Modeling cover crop effectiveness on Maryland's Eastern Shore. Trans. ASABE. Improving Water Quality and Environmental Conference Proceedings. 21-214 February 2010.