Application of the Soil and Water Assessment Tool (SWAT) Model to Assess Mitigation Strategies for Diffuse Nutrient Pollution in Iowa, United States

Philip W. Gassman, Tássia Mattos Brighenti, Yongjie Ji
Center for Agric. & Rural Development, Iowa State Univ., Ames, IA, USA

Janette Thompson
Dept. of Natural Resource Ecology & Manage., Iowa State Univ., Ames, IA, USA

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Tássia Mattos Brighenti · Postdoctoral Research Associate

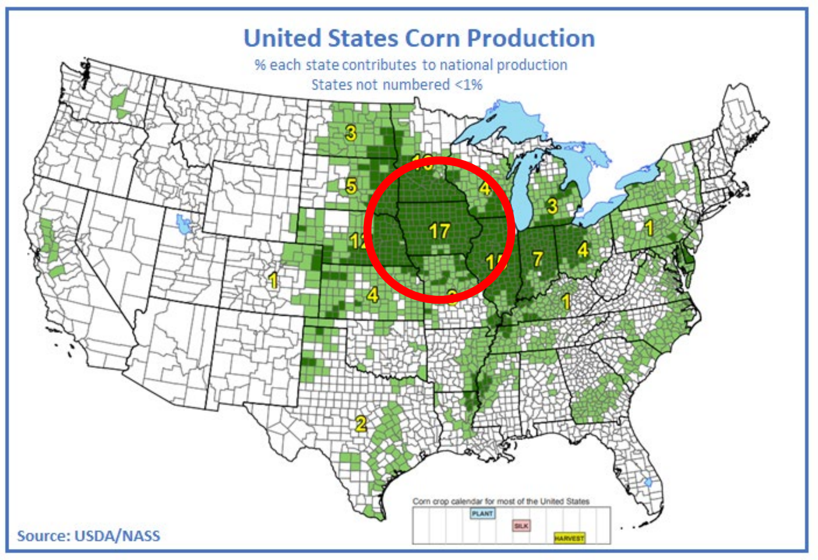
Tássia Mattos Brighenti
Iowa State University
571 Heady Hall
518 Farm House Lane
Ames, IA 50011-1054

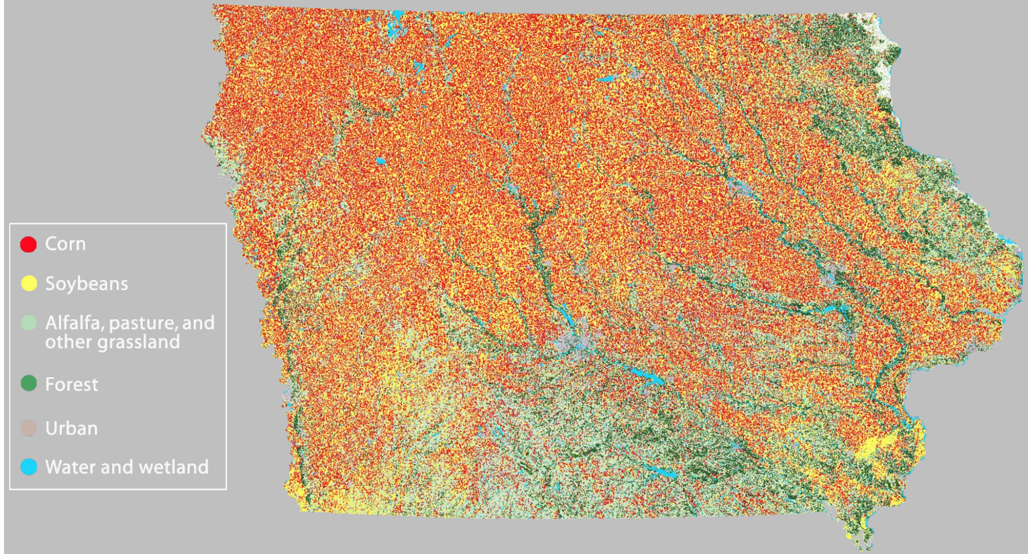
tassiab@iastate.edu

Dr. Tássia Mattos Brighenti is a Postdoctoral Research Associate at the Center for Agricultural and Rural Development at Iowa State University, in the Iowa UrbanFEWS project. Her work involves the use of the SWAT model to evaluate the environmental and agronomic performance of a suite of cropping systems, including row crops, and perennial grasses and/or horticultural crops, across multiple watershed scales in the Des Moines area.

Tássia has M.S. (2013–2015) and a Ph.D. (2015–2019) degrees in Environmental Engineering from Federal University of Santa Catarina, Brazil.

Location of Iowa in the Corn Belt Region; 2002 Iowa Land Use Map (Still the Same)





Source for U.S. map: Maps on the Web. 2017. Created by the USDA National Agricultural Statistic Service. https://mapsontheweb.zoom-maps.com/post/167277601486/us-corn-production-by-malleebull-as-the.

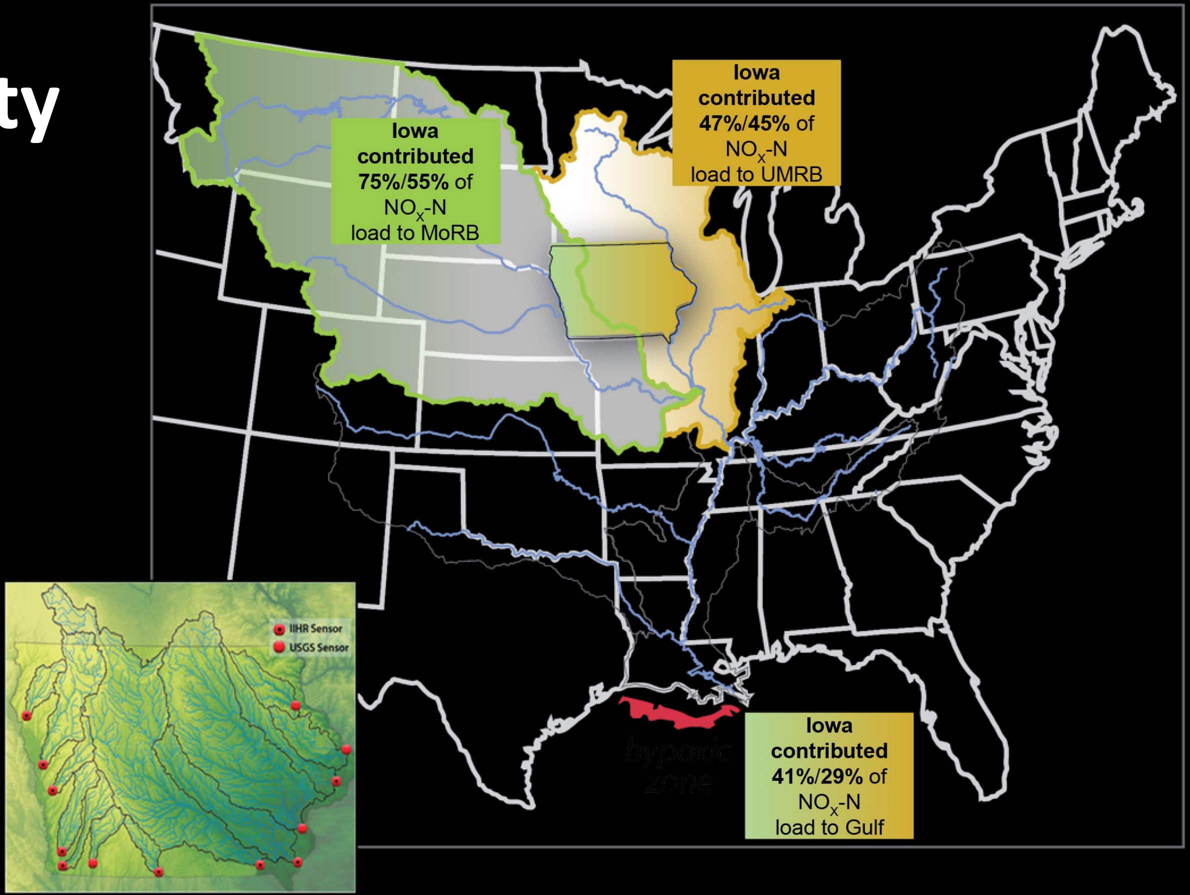
2023 Iowa Agricultural Rankings

Crop/livestock	Rank	% of U.S. total
Corn (grain)	1	16
Soybean	2	14
Harvested cropland	1	8
All hogs	1	33
Cattle & calves on feed	4	8
Egg layers	1	12

Source: USDA-NASS. 2024. Iowa's Rank in United States Agriculture. USDA-NASS, Upper Midwest Regional Office, Des Moines, Iowa. https://www.nass.usda.gov/Statistics_by_State/Iowa/Publications/Rankings/index.php.

Iowa Water Quality Impacts on the Gulf of Mexico

Percentages to the left of each "/" are for 2016; Percentages to the Right of each "/" are averages over 1999 to 2016



Sources: Jones et al. 2018. Iowa stream nitrate and the Gulf of Mexico PLoS ONE, Https://doi.org/10.1371/journal. pone.0195930; Jones et al. 2018. Iowa Statewide Stream Nitrate Load Calculated Using In Situ Sensor Network. JAWRA. https://doi.org/ 10.1111/1752-1688.12618

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Determination of accurate baseline representation for three Central Iowa watersheds within a HAWQS-based SWAT analyses

Tássia Mattos Brighenti [a,*], Philip W. Gassman [a], Keith E. Schilling [b], Raghavan Srinivasan [c], Matt Liebman [d], Jan R. Thompson [e]

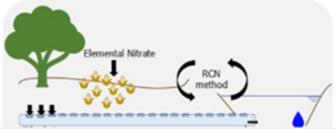
[a] Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa 50011, United States
[b] Iowa Geological Survey, University of Iowa, Iowa City, Iowa 52242, United States
[c] Departments of Ecology and Conservation Biology, Biological and Agricultural Engineering, Texas A&M University, College Station, TX 77843, United States
[d] Department of Agronomy, Iowa State University, Ames, Iowa 50011, United States
[e] Department of Natural Resource Ecology and Management, Iowa State University, Ames, Iowa 50011, United States

HIGHLIGHTS

- The number of monitoring gauges is novel compared to previous SWAT applications.
- The RCN method improved the estimation rate between baseflow and surface runoff.
- The quantity and spatial variability of monitoring gauges improved model

GRAPHICAL ABSTRACT

Parameter modification



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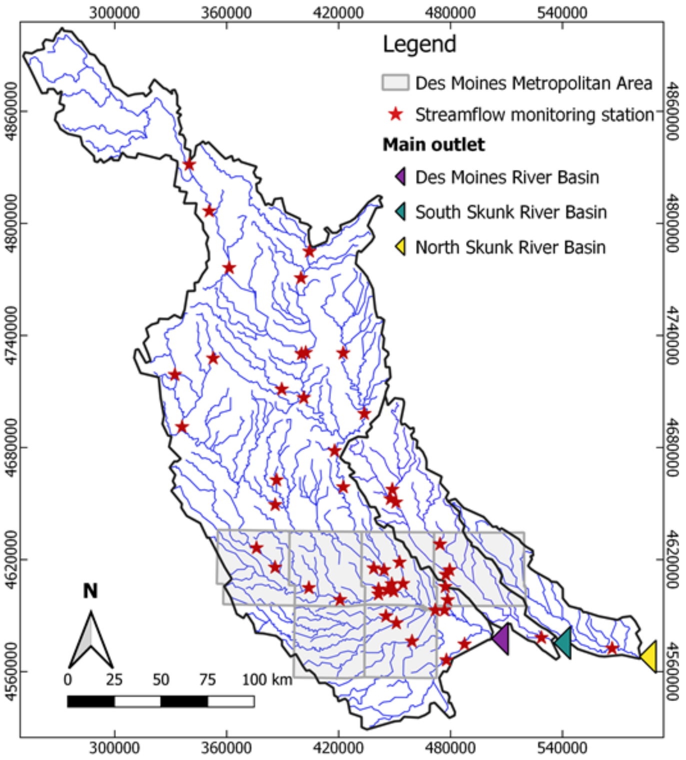
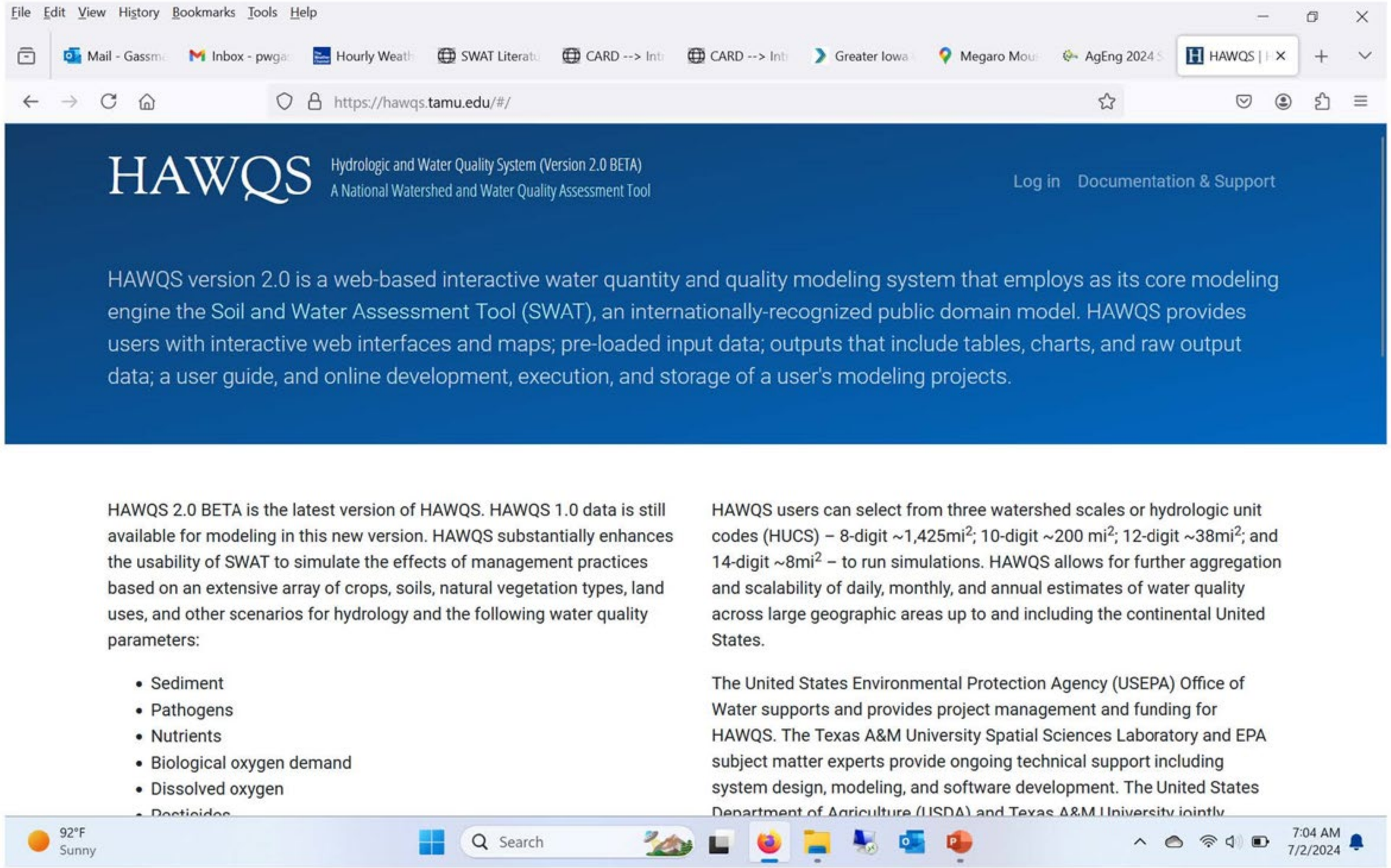
Study Regions Configured for NSF-Funded Iowa UrbanFEWS Project

Des Moines (DMRB) 31,892 km²
South Skunk (SSRB) 4,593 km²
North Skunk (NSRB) 2,259 km²

- **Land use**: soybean and corn fields representing together 70%, 71%, and 61% of the DMRB, SSRB, and NSRB.
- **Soil type**: Loamy Wisconsin Glacial Till (tile drainage represent 54%, 51% and 44% of the DMRB, SSRB and NSRB)



Hydrologic & Water Quality System (HAWQS)



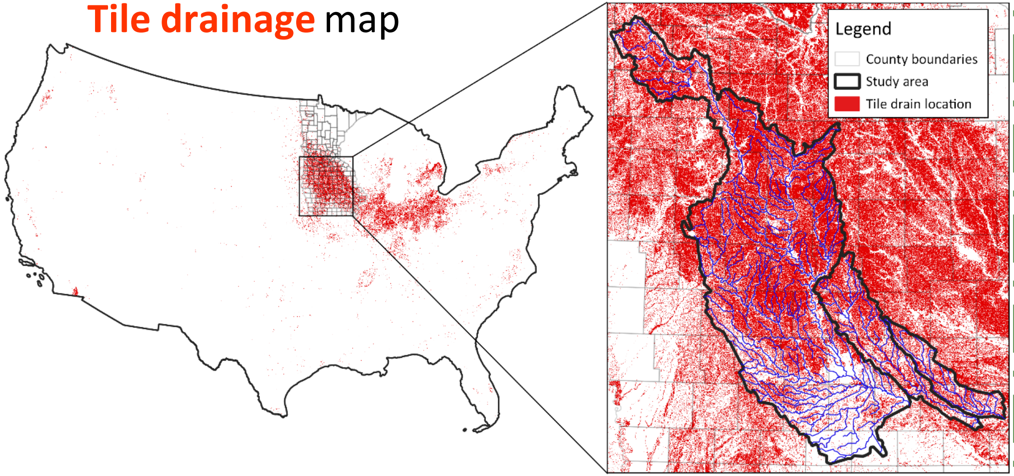
Collaborative effort between The U.S. EPA & the Texas A&M Univ. Spatial Sciences Lab.

The **alternative CN** method calculated as a **function of ET** using a CN coefficient (CNCOEF):

$$S = S_{prev} + E_0 * exp\left(\frac{-CNCOEF - S_{prev}}{S_{max}}\right) - R_{day} - Q_{suf}$$

where *Sprev* is the retention parameter for the previous day (mm), *E0* is the potential ET for the day (mm/day), *CNCOEF* is the weighting coefficient used to calculate the retention coefficient for daily CN calculations dependent on plant ET, *Rday* is the rainfall depth for the day (mm H2O), and *Qsuf* is the surface runoff (mm H2O).

Tile drainage map



Updated fertilizer – Elemental nitrogen

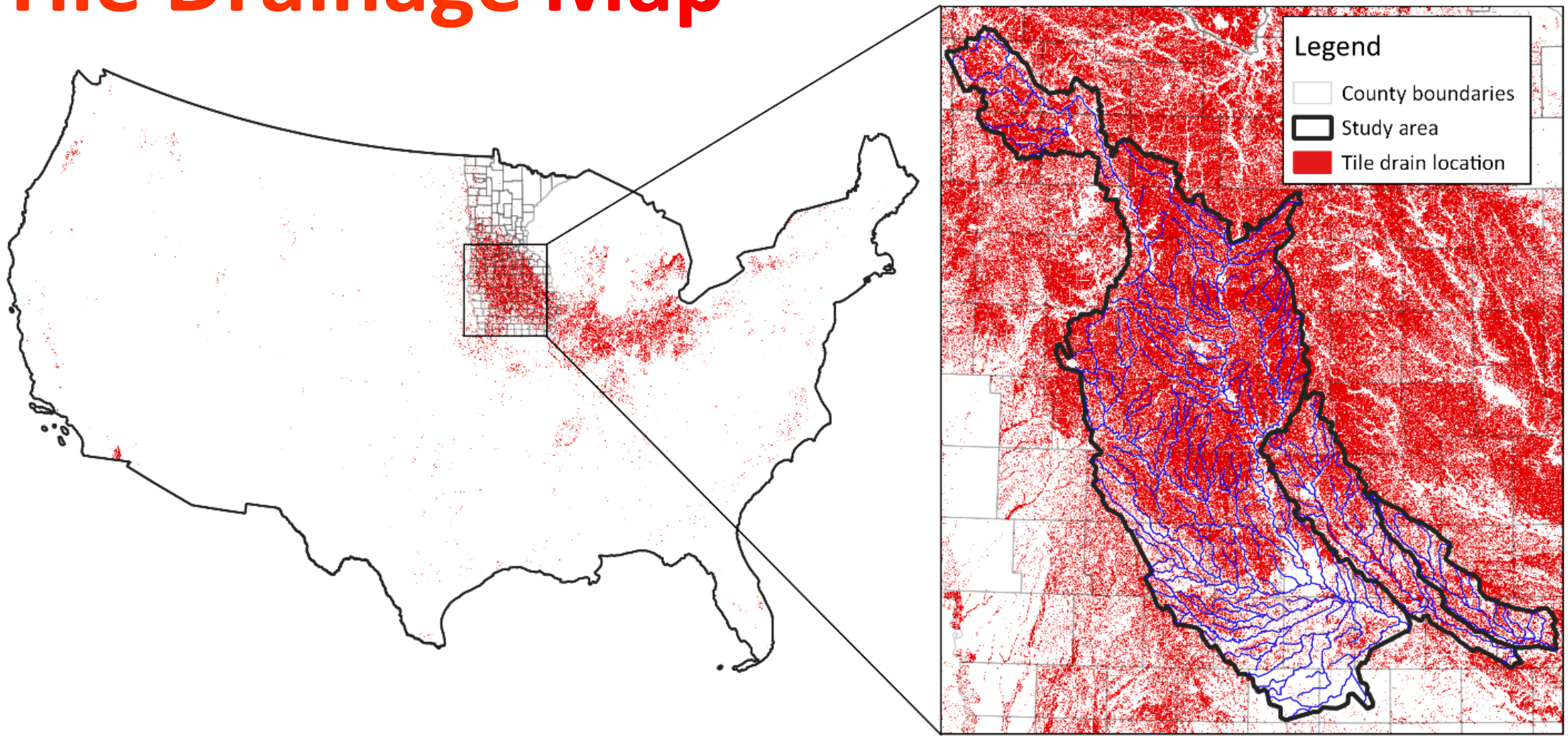
Time of the Year	Crop Rotation	Application Rate (Kg/ha)
Fall	Corn-soybean	183
Spring	Corn-soybean	172
Spring	Continuous corn	196

←

Default HAWQS data

Kg/ha of elemental nitrogen applied	% of Area		
	DMRB	SSRB	NSRB
64-79	15.0	7.1	20.9
80-99	27.1	39.2	37.0
100-159	13.5	2.6	11.4
160-176	44.4	51.1	30.8

Tile Drainage Map

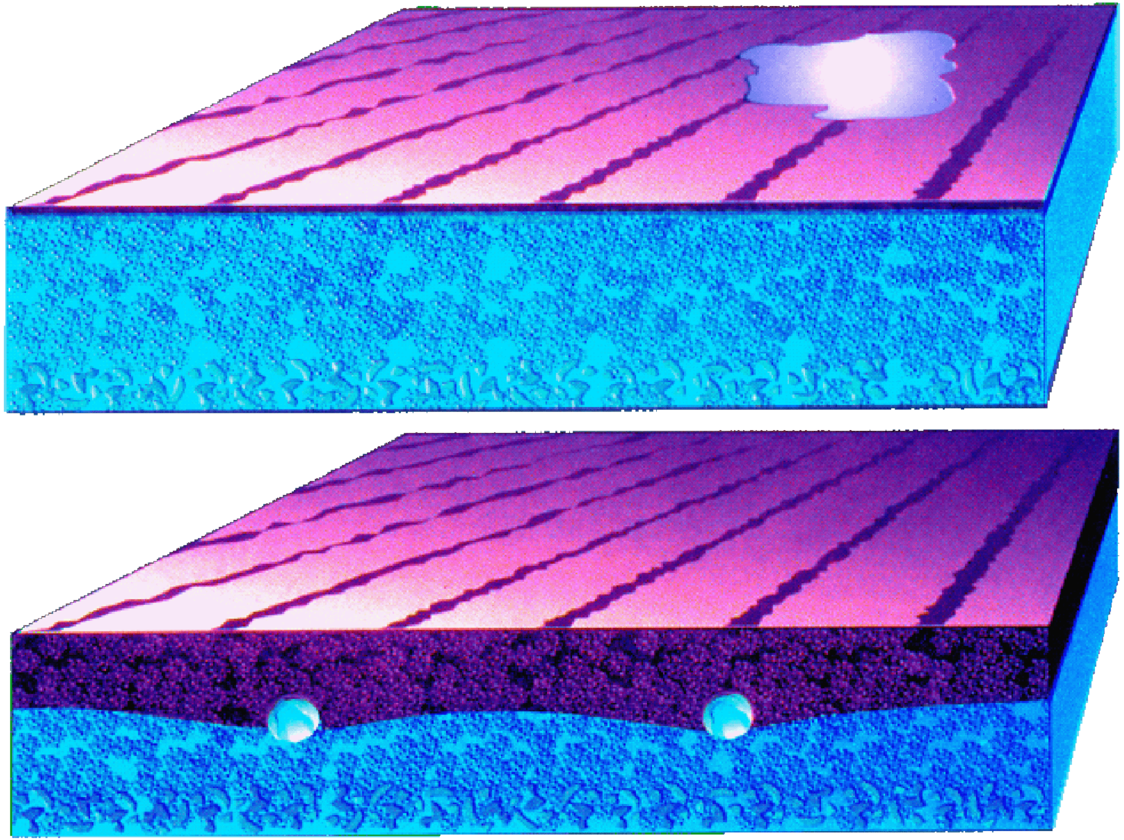


Tile drain layer developed by: Valayamkunnath et al. 2020. Mapping of 30-meter resolution tile-drained croplands using a geospatial modeling approach. Scientific Data. 7:257. https://doi.org/10.1038/s41597-020-00596-x.

Plastic Tubing used for "Tile Drains"

Effects of Tile Drainage on Soil Water

Typically installed at a depth of 1.2 m in the Western Corn Belt region (depths can vary)

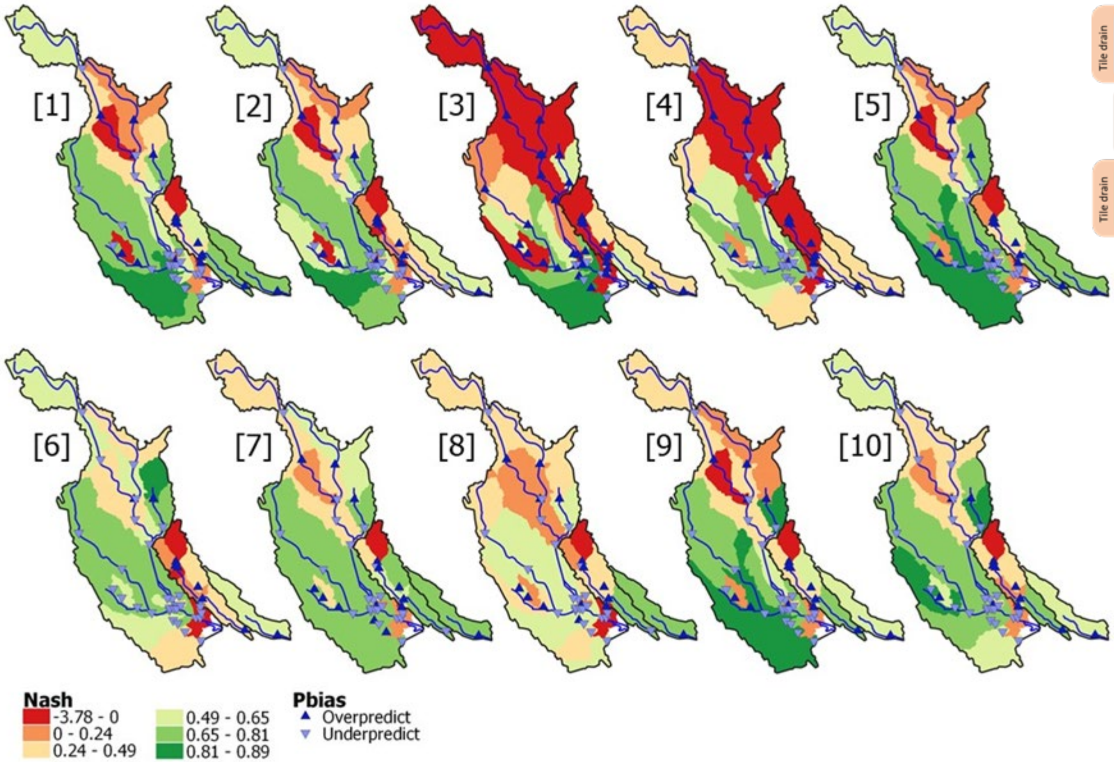


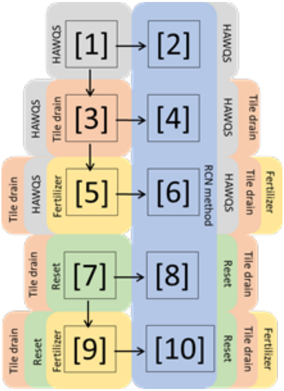
Adapted from: Zucker, L.A. and L.C. Brown (eds.). 1998. Agricultural Drainage: Water Quality Impacts and Subsurface Drainage Studies in the Midwest. Ohio State University Extension Bulletin 871. The Ohio State University.

Spatial Statistical Results for 10 Alternative Baselines

Provide valuable spatial information about model dynamics for the different baselines:

- More accurate comparison between baselines (see 3 and 6).
- reveals simulation problems at the subbasin level (see SSRB)





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Comparison of Two Tile-Drain Methods in SWAT via Temporal and Spatial Testing for an Iowa Watershed

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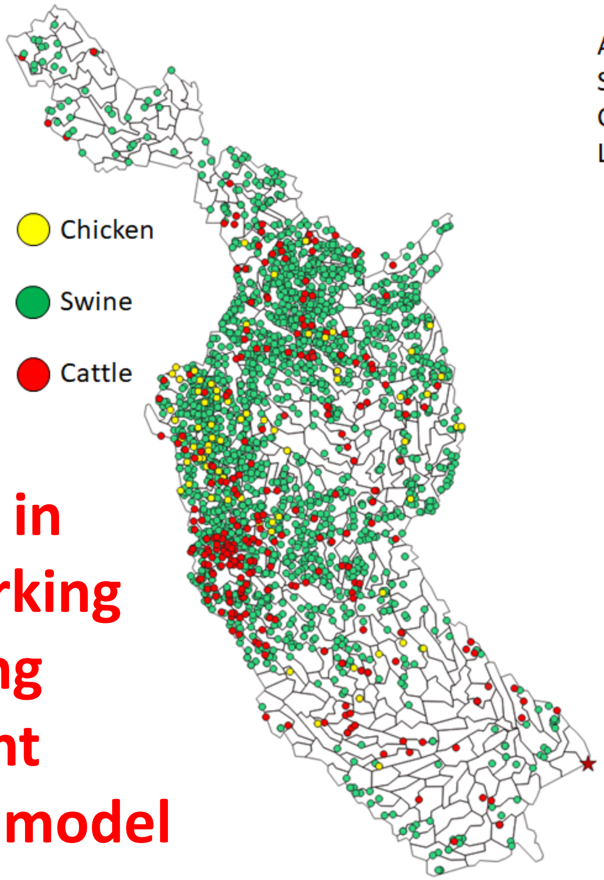
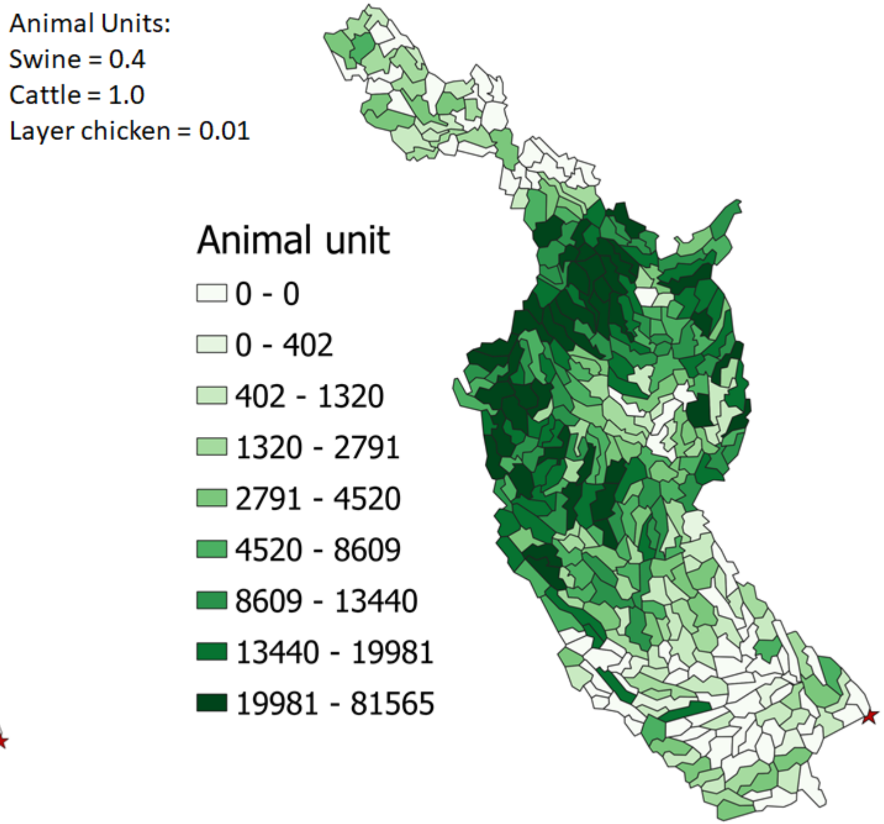
Authors: Tassia Mattos Brighenti, Philip W. Gassman, Jeff Arnold, Jan Thompson
Keywords: Hooghoudt and Kirkham equations, Spatial validation, SWAT model, Temporal calibration, Tile-drain equations, Uncertainty analysis.

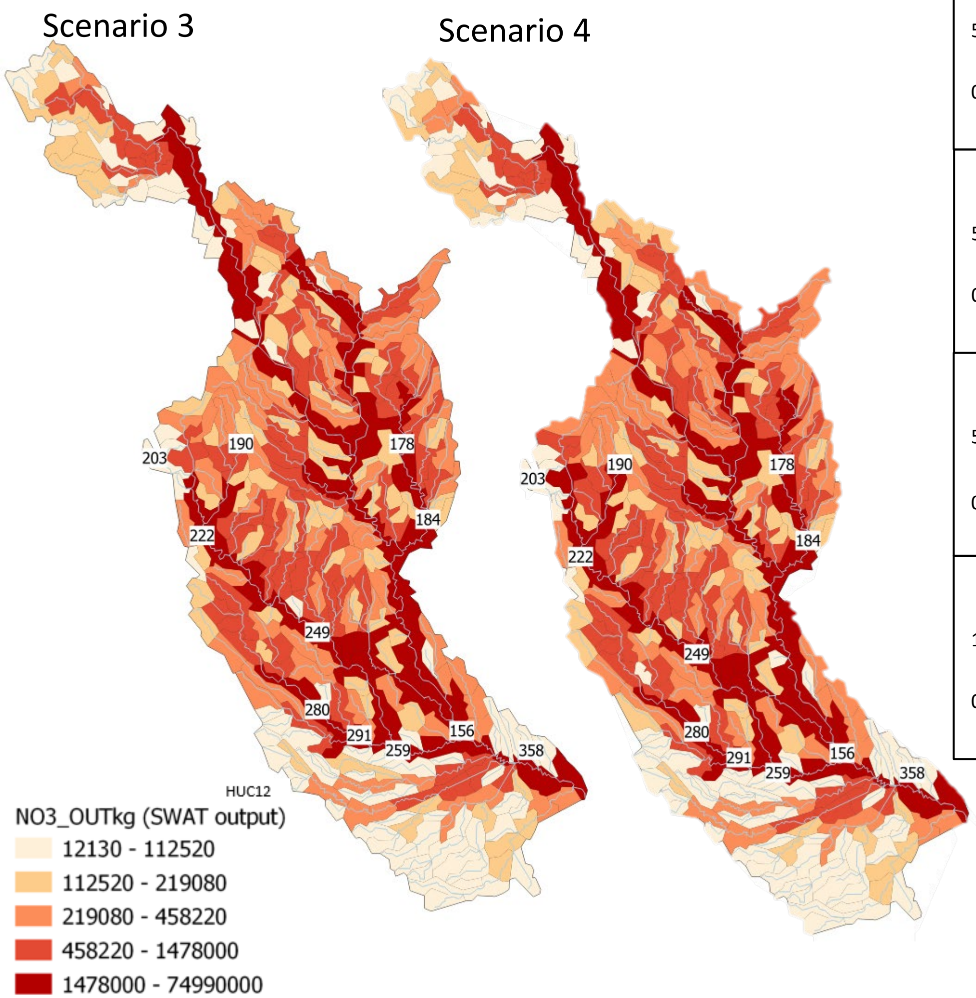
Highlights

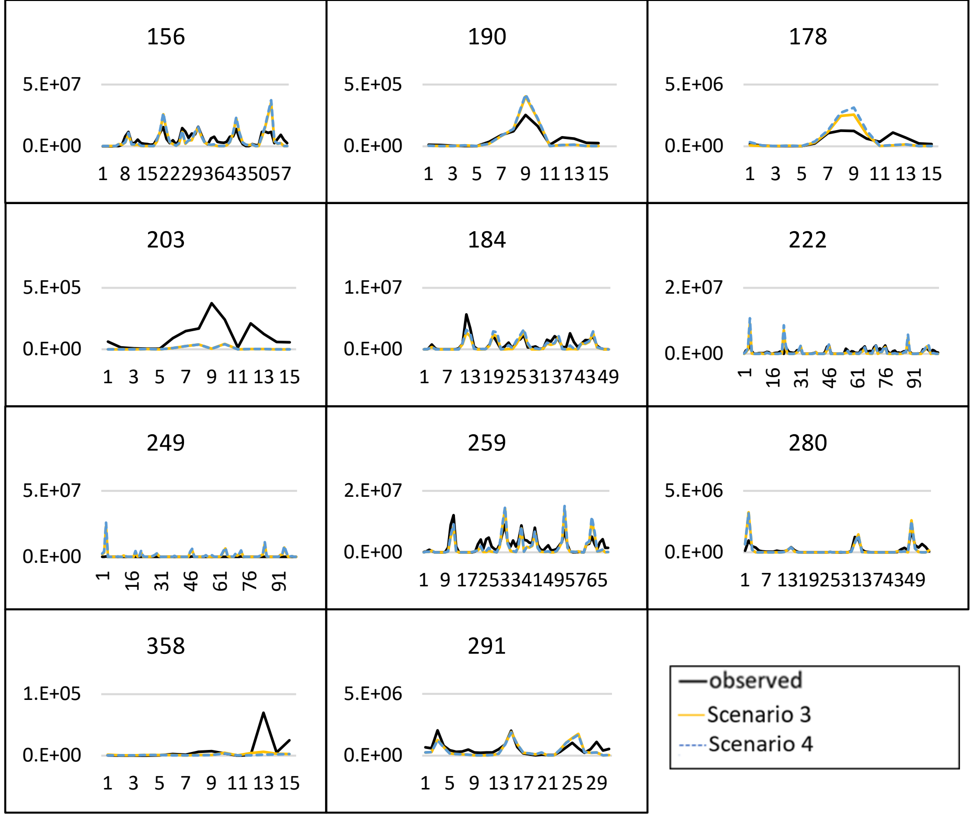
Distribution of Livestock Operations in the DMRB





> 3 million AUs in the DMRB; working on incorporating manure nutrient applications in model



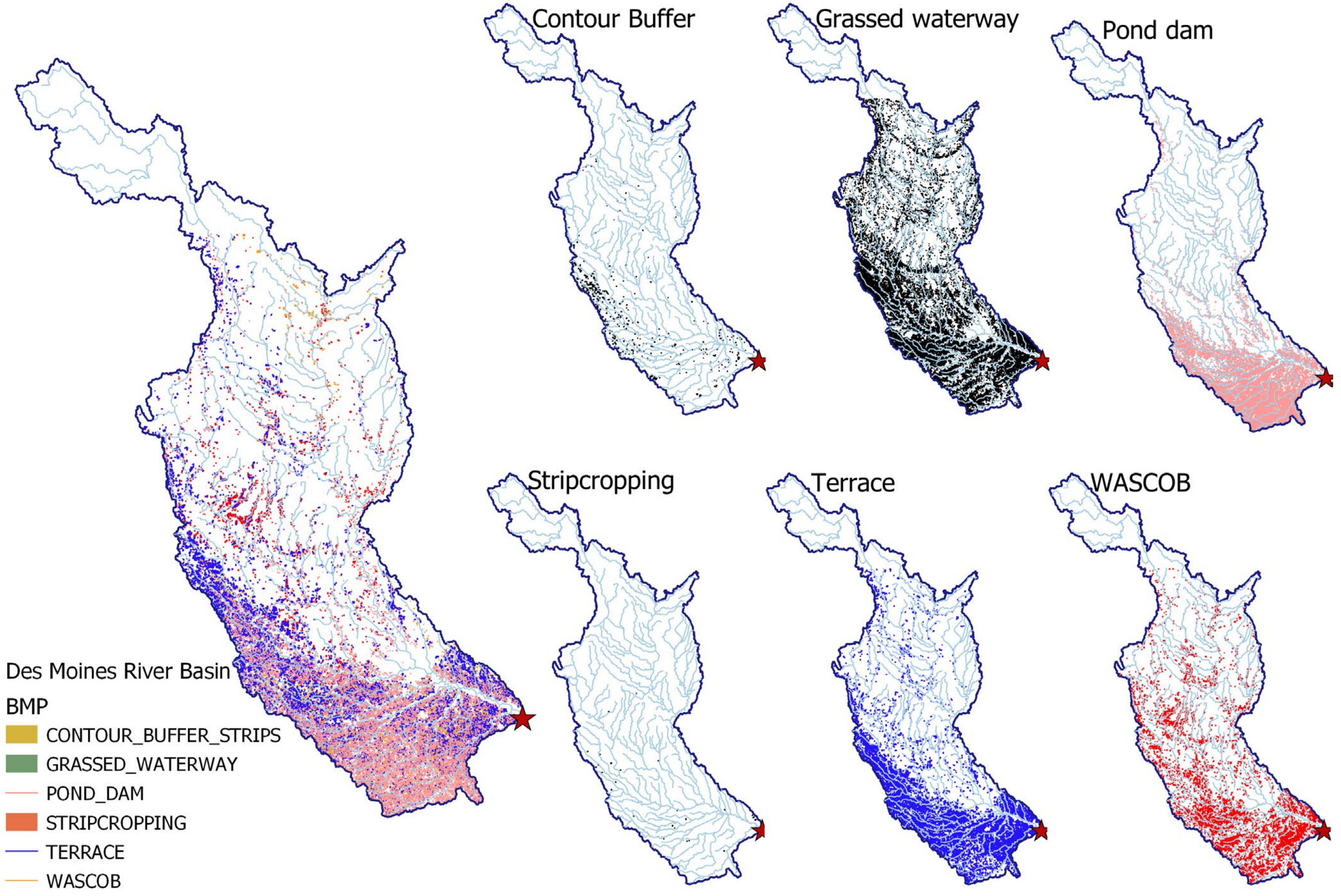


Fertilizer input

Scenarios	kg/ha year (N manure)	kg/ha year (P manure)	land applied	kg/ha year (N elemental)*	kg/ha year (P elemental)*
3 (map)	50.2	18.8	100% corn	196	24
4 (map)	Calculated per subbasin	Calculated per subbasin	Subbasins with facilities (corn)	196	24

*elemental N and P are applied in 100% of corn

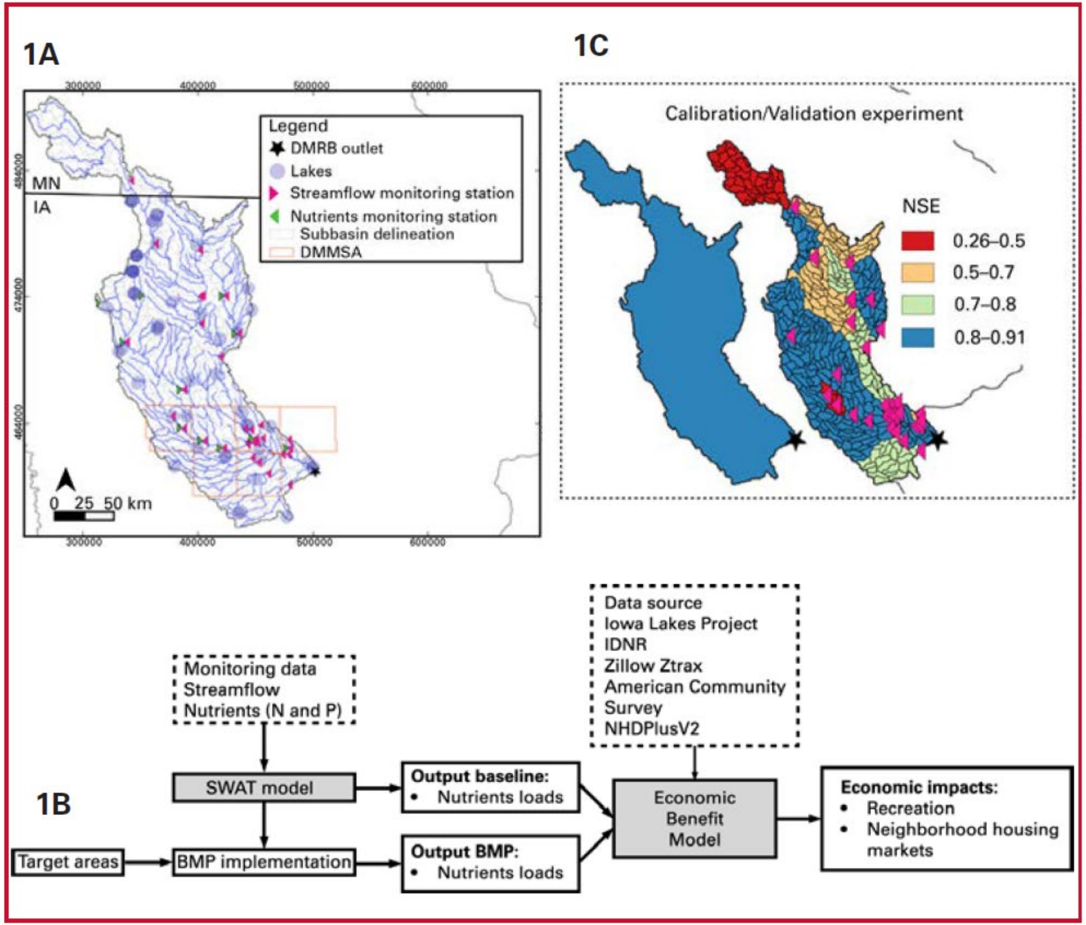
Location of Existing Control BMPs in DMRB



DMRB SWAT Model Interfaced with Economic Benefit Model

Evaluated four BMPs in SWAT (100% of cropland):

1) Notill
2) Cover crops
3) Field borders
4) Extended 5-year rotation (CSAAA)



Gassman et al. 2023. Linking water quality improvement with economic benefits to the Iowa population. Agricultural Policy Review. CARD, Iowa State University, Ames, IA. https://www.card.iastate.edu/ag_policy_review/.

Notill

Cover Crop

Field Border

BMP Impact on Nitrogen/Phosphorus Indicators

% Reduction	Notill	Cover crop	Field border	Extended rotation
Organic N	8	24	61	56
Organic P	-1	23	67	60
Nitrate (NO_3)	-3	34	2	63
Mineral P	-6	-6	10	20
Total N	4	28	37	59
Total P	-1	22	65	59

Conclusions

- Successful SWAT hydrologic testing completed
- Still need to complete nutrient/sediment calibration and validation
- Results of preliminary BMP scenario execution:
  - Model responses are generally logical
  - Widespread adoption could have large impacts
  - Need to complete pollutant loss testing