An integrated Assessment Framework to Evaluate Conservation Practices' Environmental and

Economic Benefits: A case for three Central Iowa watersheds

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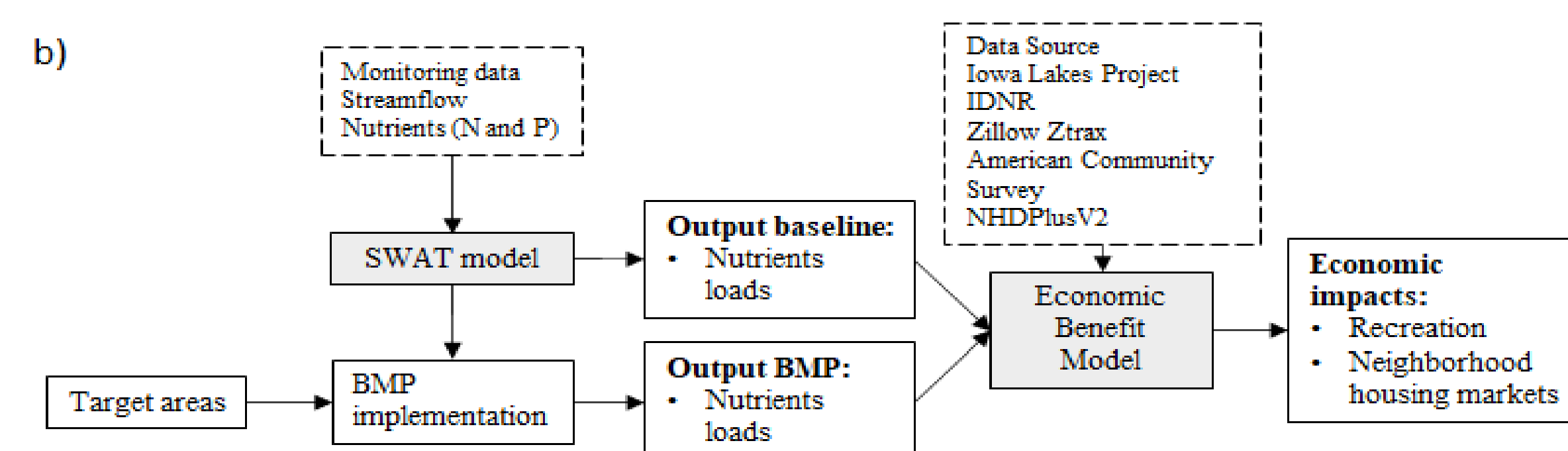
Background

- Iowa, along with other 11 states as required by the Hypoxia Task Force to have nutrient reduction strategies to limit the dead zone in the Gulf of Mexico, published the state strategy in 2013.
- Iowa state legislature allocated more than $500 million budget until 2039 to support the adoption of a broad suite of Best Management Practices (BMPs).
- An integrated assessment framework to evaluate the joint-environmental and economic benefits is absent but needed, especially with the ability to incorporate the gradual and regional nature of the expansion of these practices.
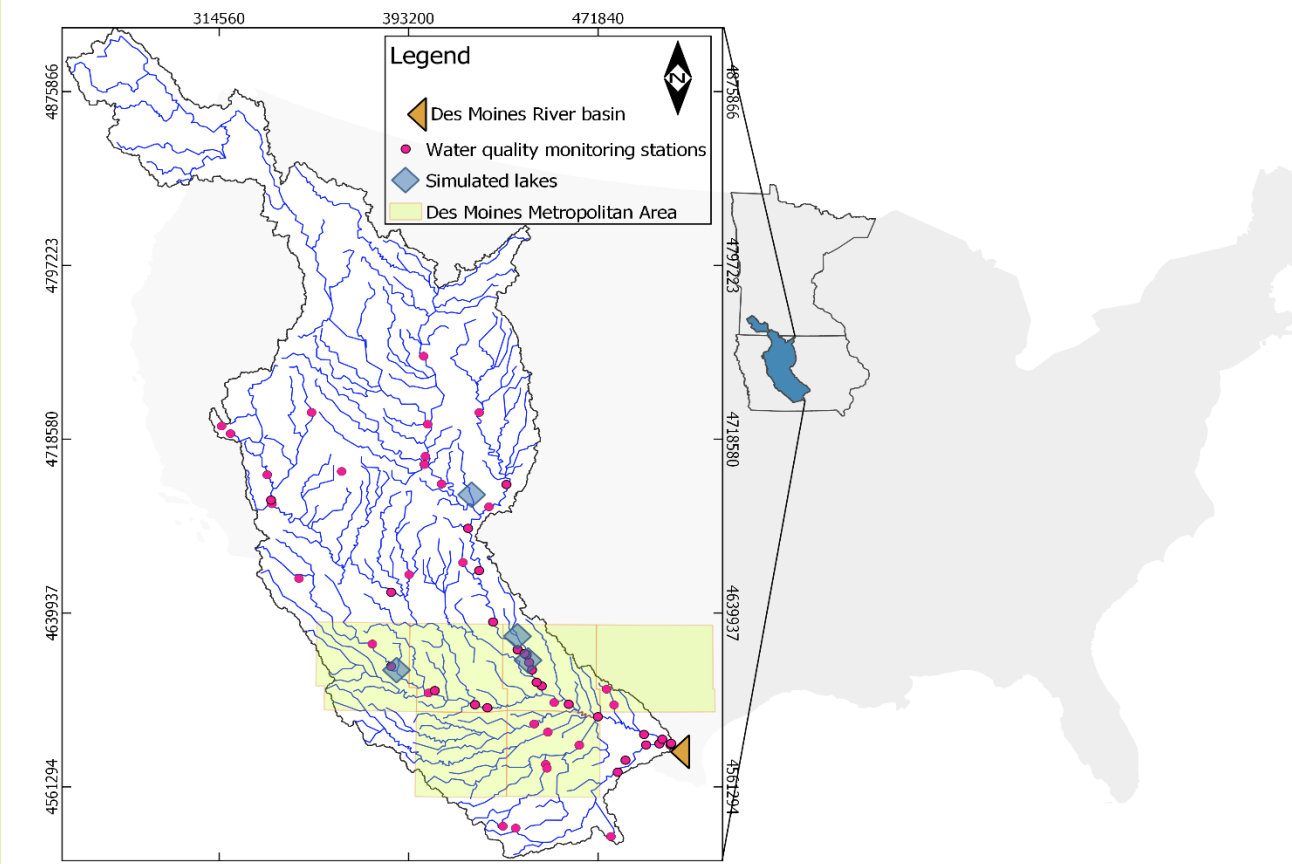
Objectives

- Develop a framework to evaluate both the environmental benefits and economic benefits at a regional watershed scale.
  - Targeted conservation practices:
    1. Filter Strips
    2. Reduced Fertilizer Application
    3. No-til, reduced-till
    4. Other BMP practices
    5. More practices would be included in the future
  - Targeted economic benefits
    1. Recreation
    2. Housing
    3. More benefits would be included in the future

Methods

Research Area

- The central Iowa watershed, the Des Moines River basin (31,892.4 km²). The basin is representative of Iowa landscape, with land use dominated (over than 70%) mostly by row crops (corn and soybean).
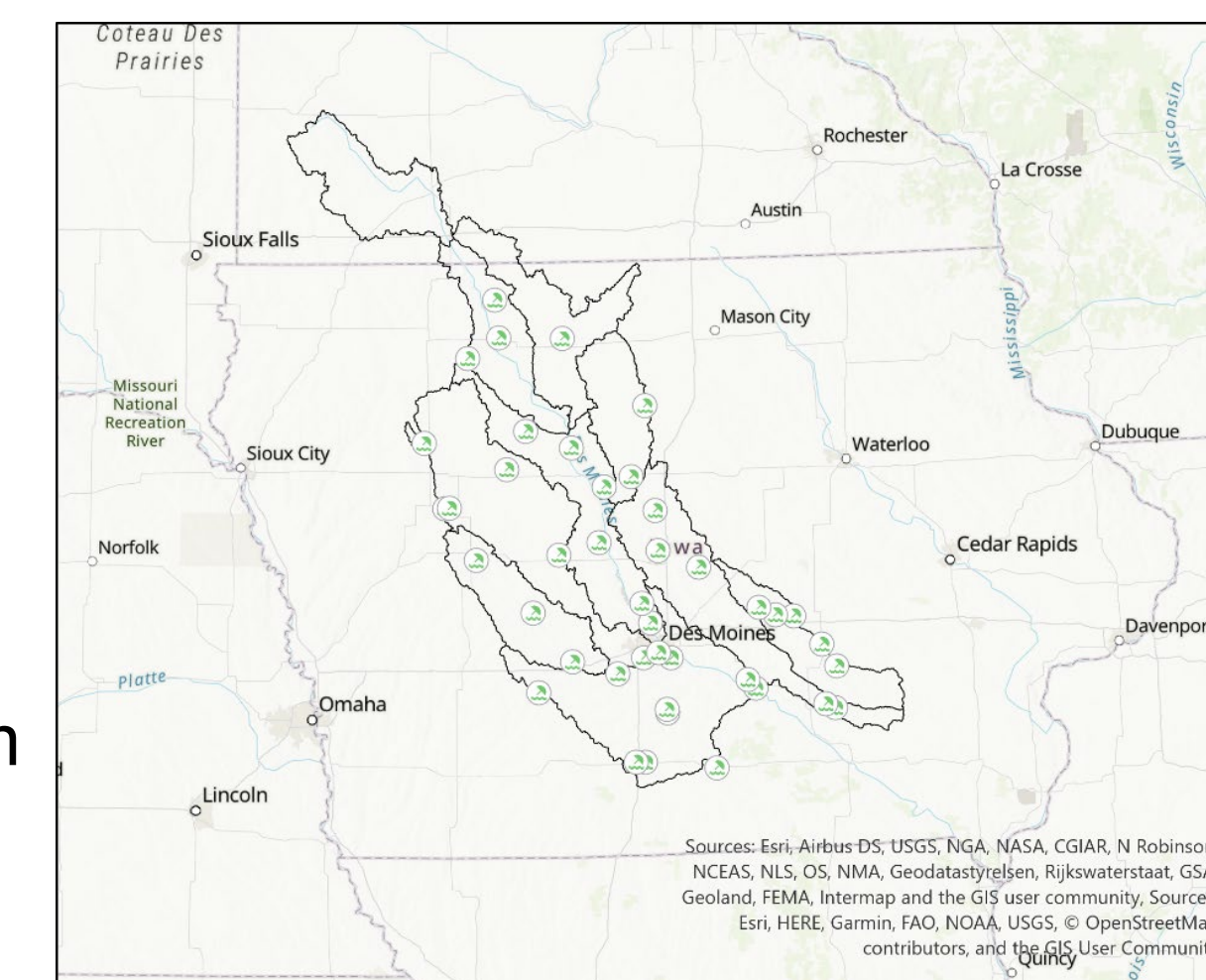
- 42 lakes covered in Iowa Lake Project. Est. 90K trips per lake in 2019.
- Most lakes are local, and small lakes, around 7K SFHs within 500 meters from lakes. Benefit Transfer approach based on Guignet et al. 2022 is used.

SWAT Model

SWAT is a semi-distributed continuous in time ecohydrological model, in this study the SWAT component integrates the **three main steps**:

1. Model **calibration/validation**: automatic algorithm to target model best parameters for streamflow, sediments, and nutrients 5 to 10 years of monitoring data).

2. **Targeting the most vulnerable and intensively cropped landscapes**: the most suitable locations for the BMPs that will meet the criteria of the vulnerable area are defined based on drainage area, slope, soil type, highest sediment and nutrients loads, and **lakes inlets** (critical source areas).

3. **BMP implementation**: the BMP practices of filter strips, no-till, and nutrient management were tested.

Economic Benefit Model

- **Water quality conversion**:

  Secchi or other water clarity related variables are extensively used by economists, while it is seldomly favored by SWAT users, where nutrients, like TN, TP, sediments, are the typical output variables.

  A Random Forest specification is used to convert nutrients to Secchi, which is trained on water quality data from Iowa DNR.

- **Recreation benefits**

  A repeated RUM model is estimated with 2019 survey data from Iowa Lake Project (www.card.iastate.edu/lakes). Among Secchi depth, TN, and TP, only Secchi is found to be statistically significant.

- **Housing market impacts**:

  We estimated a hedonic model with Zillow ZTRAX data. The explanatory variables includes a set of house attributes and neighborhood attributes (nearby lake water quality measures).

  We also use benefit transfer numbers provided in Guignet et al (2022)

Scenarios and Results

- Secchi depth increases 10% at all lakes (S1).

- Fertilizer application rate reduces by 10%. Secchi depth, TN, and TP decrease by 0.15%, 8.5%, and 0.1%, respectively. (S2)

- Full Filter Strips. Secchi depth increases by 38%, TN decreases by 16%, TP decreases by 42%. (S3)

	Recreation Benefits (in Millions)		
	Total	Research Area	Other Counties
S1	2.517	0.774	1.743
S2	-0.14	-0.03	-0.11
S3	7.935	5.423	2.511

- Recreation benefits are significant if the practices can lead to change in Secchi depth. Even the conservation practice are local, the benefit may spread to other regions (the extent of recreation market).

		Housing Markets (in Millions)							
		Linear WQ			Logrithm WQ			Guignet et al. (2022)		
		Secchi (10%↑)	TN	TP	Secchi (10%↑)	TN	TP	Secchi (10%↑)	TN	TP
S1	Total							7.5		
	Waterfront							4.4		
	Non-waterfront							3.2		
S2	Total	7.9			0.6			-0.1	20.4	0.1
	Waterfront	6.6			1.6			-0.1	6.9	0.0
	Non-waterfront	1.3			-0.9			-0.1	13.5	0.0
S3	Total	38.3			0.9			29.5	31.2	0.9
	Waterfront	12.7			2.1			23.8	10.3	1.8
	Non-waterfront	25.6			-1.2			5.7	20.9	-1.0

- With primary hedonic estimates, the conservation program can lead to higher housing prices. The magnitude of benefits differ cross model specifications.

- With the benefit transfer approach, the benefit estimates differ in the choice of target water quality measures. Different targeted water quality measures could give qualitatively different results.

Conclusions and discussions

- We developed an integrated framework connecting the SWAT model to economic benefits, which in principle can evaluate the adoption of conservation practices at regional levels with gradual expansion. There are still some modeling challenges:
  - Coordination between hydrological models and economic models, such as, harmonization of targeted water quality variables
  - Better SWAT modeling to incorporate new practices and more output, like soil carbon
  - More primary studies both in recreation, and housing markets are needed. The shock of recent pandemic may change people's preference on recreation sites, housing choices, thus, the knowledge obtained before would be of less guidance to the future.
  - Some benefits are missing, such as health impacts, drinking water impacts, the impacts on private wells users.