Estimating the Gross External Damages of Water Pollution in the United States using a national integrated assessment model

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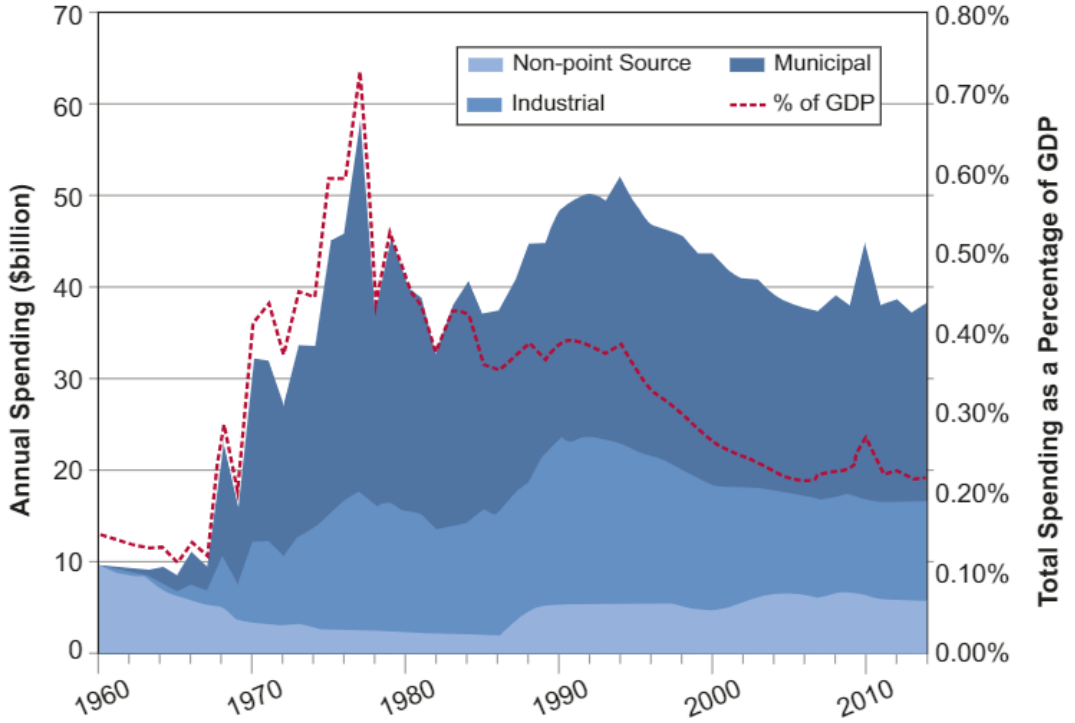
THE SOCIAL COST OF WATER POLLUTION

- Nutrient pollution is one of America's most widespread, costly, and challenging environmental problems (USEPA 2024).
- Water quality is important for outdoor recreation, industrial production, agriculture, housing, commercial fishing, and health.
- The ecosystem services losses from nutrient pollution generate associated social costs that directly affect millions of Americans annually.

COST-BENEFIT ANALYSES

- Since 1960, US public and private actors have spent over $1.9 trillion to abate surface water pollution.
- Regulations are subject to detailed CBAs.
- Benefit-cost ratio of 20 CBAs analyzed by Keiser et al. (2019): 0.37
- Underestimation of true benefits or overestimation of true costs?
- Current analyses exclude potentially important benefits.



Source: Keiser et al. (2019)

PROJECT

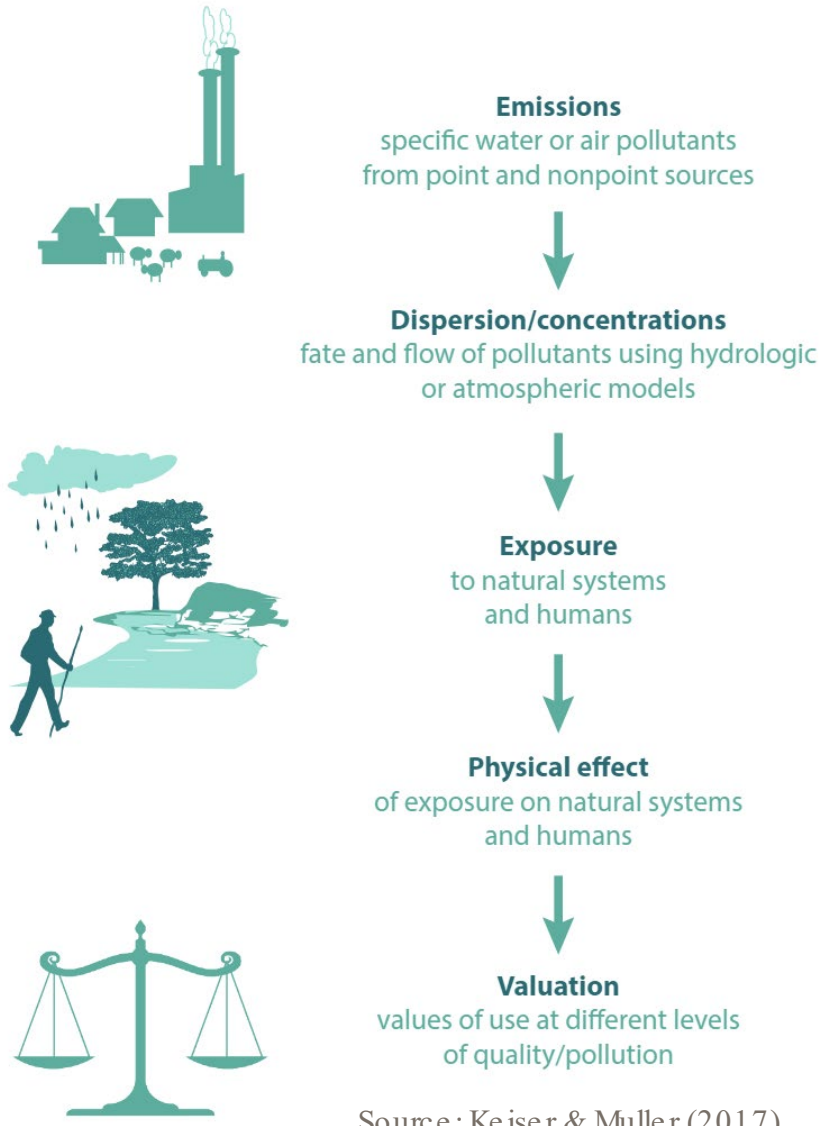
"Measuring the Social Costs of Nutrient Pollution through Integrated Assessment Modeling"

- Funded by USDA-NIFA
- PI: David A. Keiser, University of Massachusetts Amherst
- 2022-2025

- <u>Objectives:</u>
  - Provide national-level estimates of water pollution damages
  - Fill a knowledge and policy gap related to evaluating USDA conservation programs

INTEGRATED ASSESSMENT MODELS

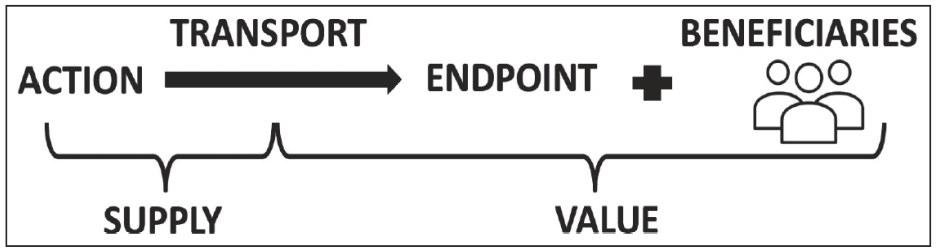
- IAMs combine quantitative descriptions of economic and ecological processes to study environmental problems.
- They connect economic activity with environmental consequences, and ultimately, with valuation.
- They can be used to estimate damages from pollution, but also benefits of pollution reductions



Source: Keiser & Muller (2017)

NUTRIENT FATE AND TRANSPORT

- The damages of water pollution depend critically on the location of emissions and the fate and transport of pollutants.
- Marginal changes in loadings into a single watershed affect concentrations throughout hydrological network.
- Accounting for the linkages from sources to all downstream impacted users is critical to obtaining a full measure of the benefits of water quality improvements.



Source: Keeler et al. (2019)

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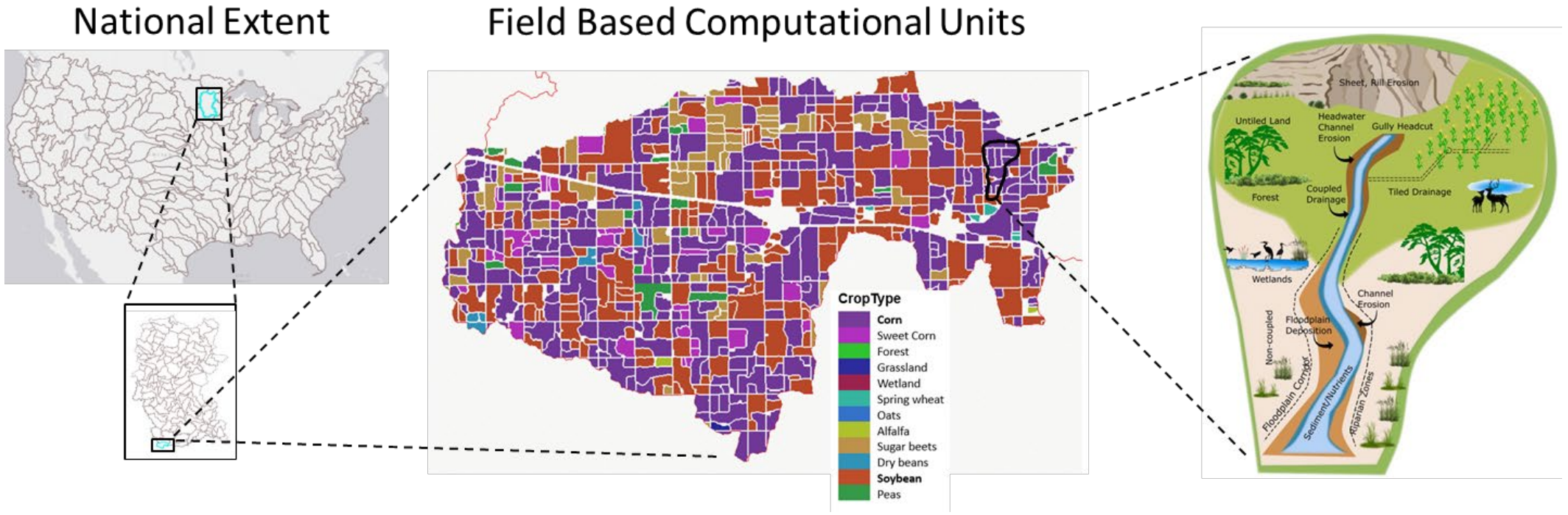
NATIONAL AGROECOSYSTEMS MODEL

A highly detailed national modeling framework developed to predict the effects of agriculture on the environment (86,000 Landscape Units (HUC12), 4 Million Fields, 7.5 Million HRUs)



→ Landscape-level runoff and nutrient loads

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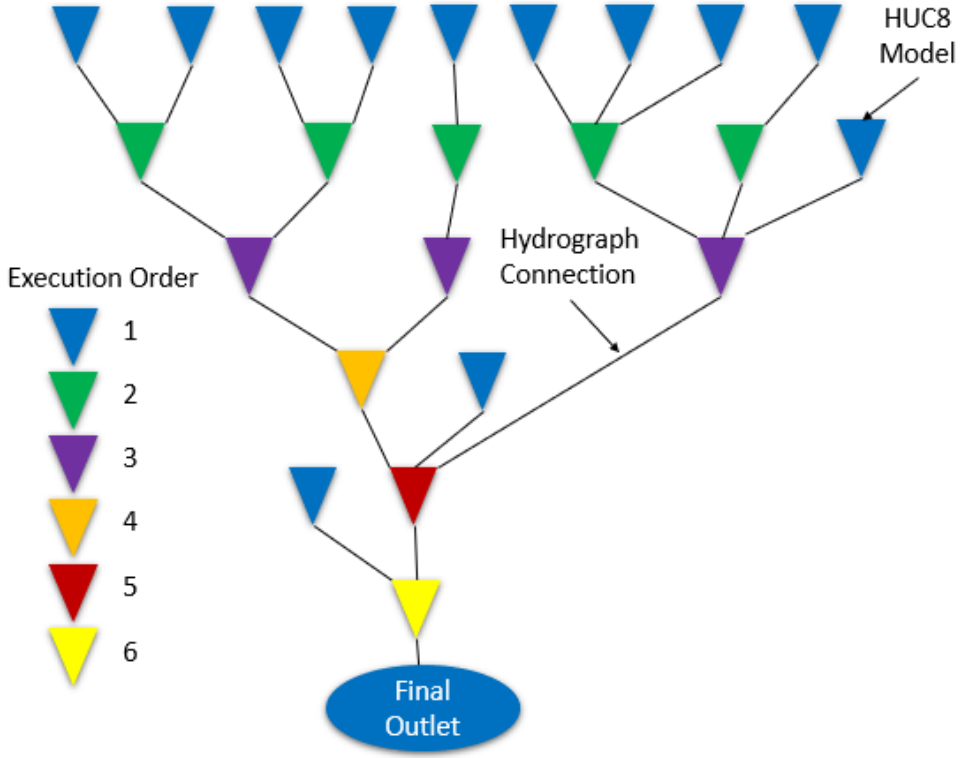
SWIFT

- SWAT+ routing structure (connect files, channel and reservoir inputs)
- Average annual routing considering bank and bed erosion, floodplain deposition, reservoir trapping efficiency
- Model with 10,000 HRUs runs in 10 seconds
- Efficient tool for scenario analyses

- SWAT+ generates SWIFT input data, but outputs from other models or measured data can also be used!



→ Streamflow and nutrient loads

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ECONOMIC VALUATION

Valuation functions for four categories (human uses most likely impacted by nutrient pollution):

- Housing markets
- Water-based recreation
- Drinking water treatment
- Climate change

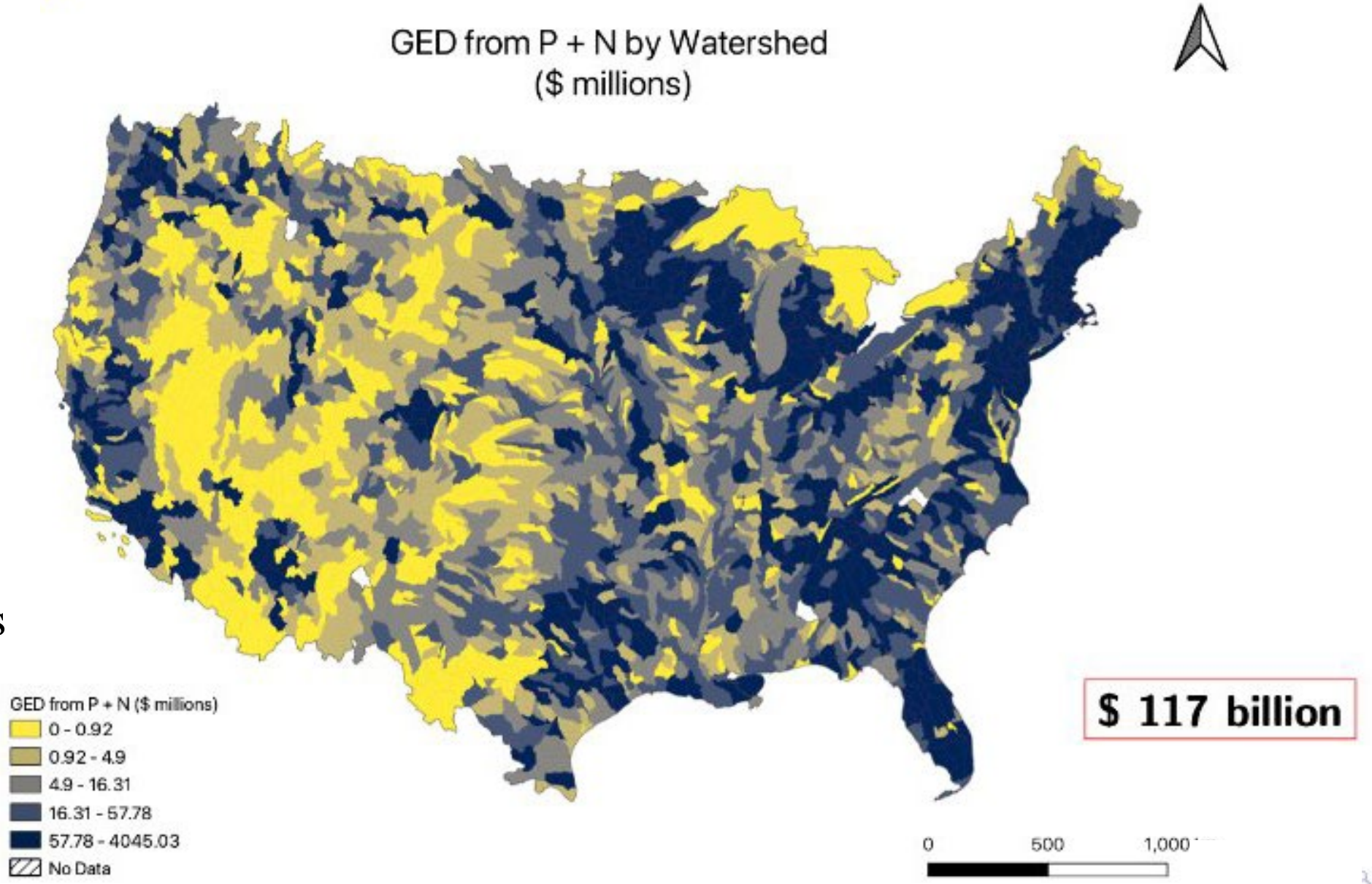
These functions provide estimates of the economic damages that arise from increases in pollution and conversely the benefits from pollution reductions.

→ Estimated Damages (total and by industry)

TOTAL GROSS ESTIMATED DAMAGES

Spatial pattern reflects importance of population in determining total damages.

These maps can help identify the most cost-effective regions for conservation action.



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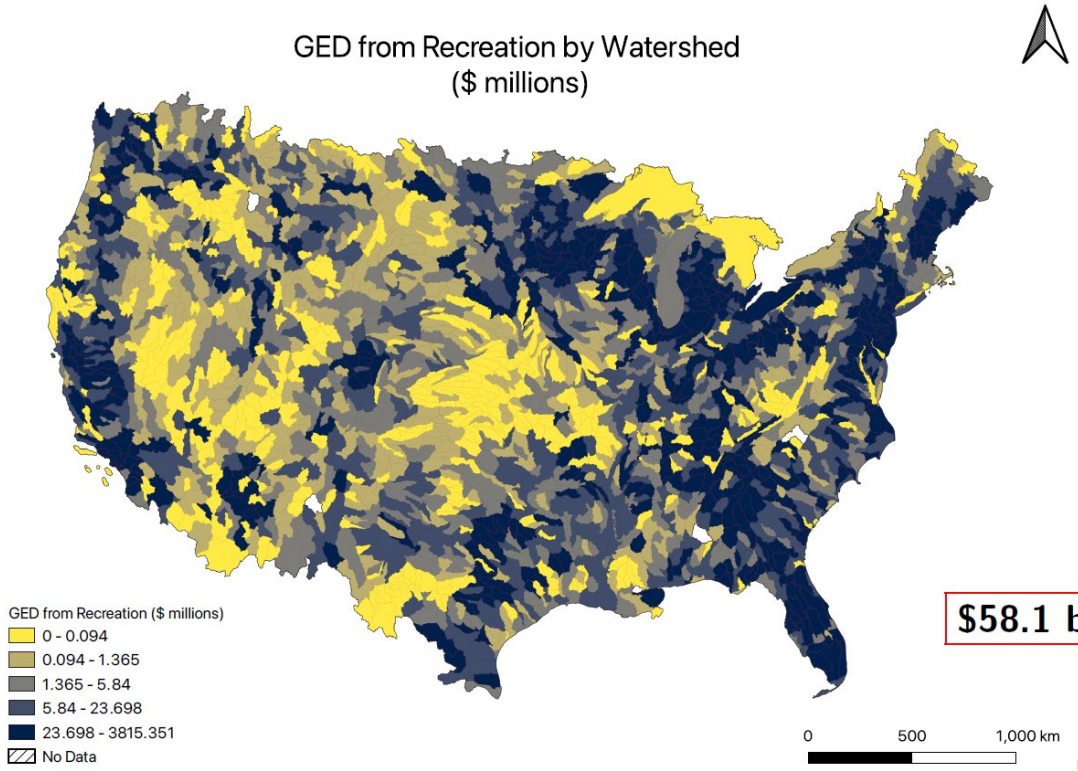
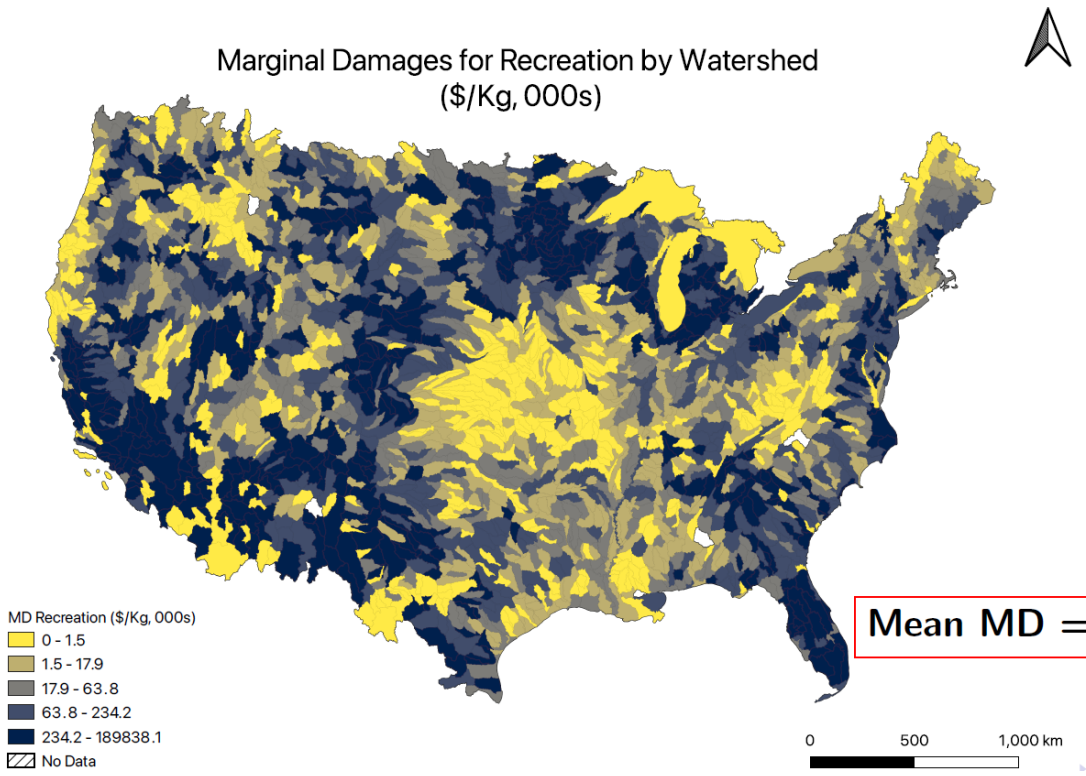
DAMAGES FOR RECREATION

Marginal damages: additional damage caused by additional units of pollution



$58.1 billion



Mean MD =$607K/Kg

NEXT STEPS

- Calibrate SWIFT

- Quantify the current damages from nutrient pollution
- Estimate the marginal damage from emitting an extra ton of phosphorus and an extra ton of nitrogen in each individual watershed
- Analyze distribution of damages/benefits across socioeconomic characteristics (e.g., income, race)
- Estimate the benefits of USDA conservation programs

NBS-SWAT+ Community: Integrating Science, Policy, and Practice in Ecohydrological Modelling

Mojtaba Shafiei, Csilla Farkas, Eva Skarbøvik, Nikolai Friberg, Moritz Shore, Dominika Krzeminska, Anne-Grete Buseth Blankenberg, Christoph Schürz, Lien De Trift
Ann van Griensven and Katrin Bieger

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The Department of Ecoscience at Aarhus University is looking for a **Postdoc for one year starting as soon as possible** The Postdoc will mostly focus on setting up a SWAT+ model for a small, intensely monitored watershed in Denmark and perform a detail analysis of all hydrological and nutrient transport processes. If interested, please send your CV to katrin.bieger@ecos.au.dk.

Thank you!

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