Quantifying the Economic Benefits of Protecting Freshwater Lakes

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Freshwater Lakes

Freshwater Lakes

Algae Bloom in Freshwater

Source: https://www.palmbeachpost.com/story/weather/hurricane/2020/07/16/corps-warns-of-lake-okeechobee-algae-bloom/41705629/ Photo Credit: Allen Eyestone/palmbeachpost.com

Central Question

**"How do people affect the lakes they love –
and how do those lakes inspire people to act?"**

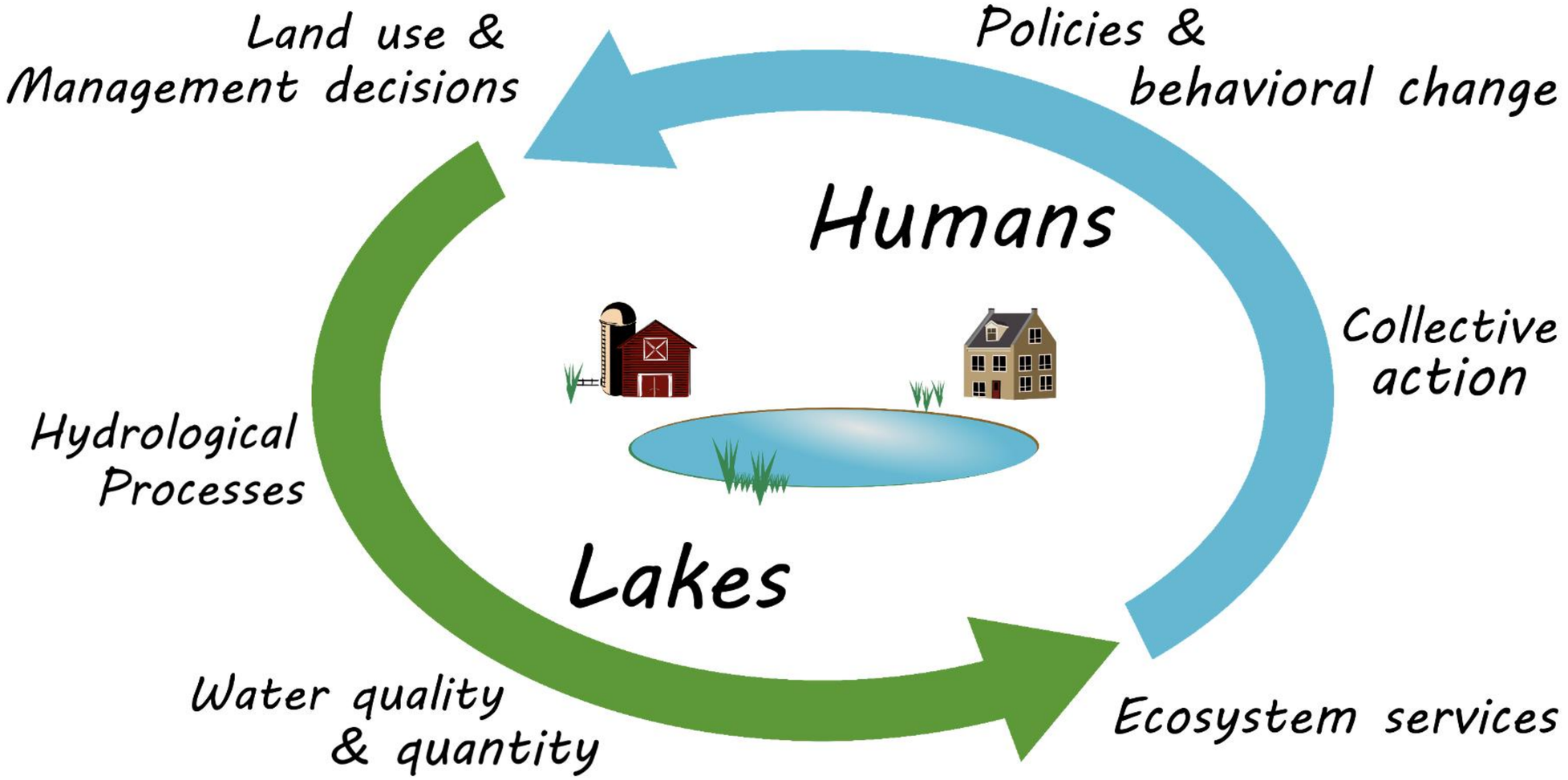
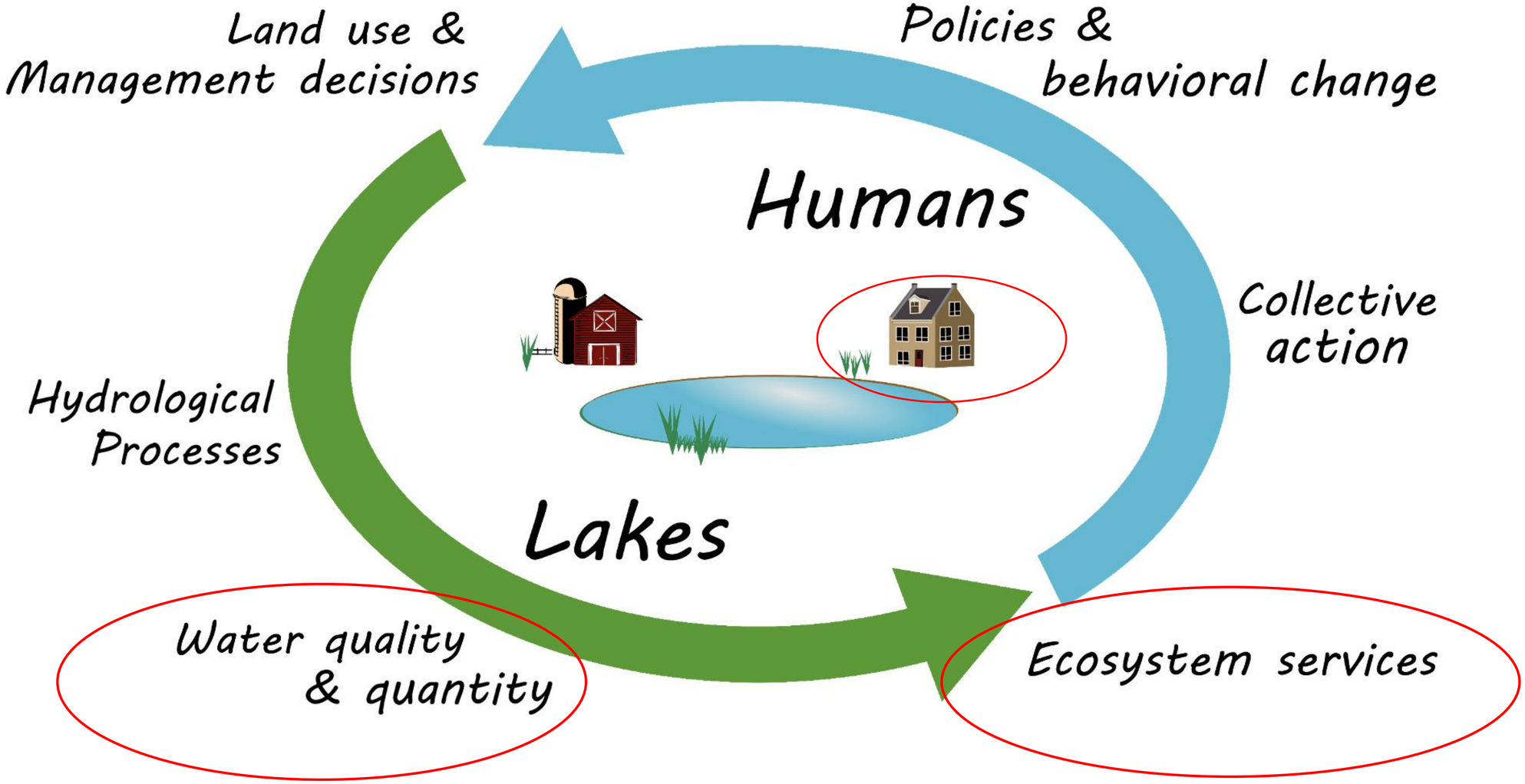


Figure 1: Conceptual framework for a coupled natural-human system in a lake catchment



Weng, W., Boyle, K. J., Farrell, K. J., Carey, C. C., Cobourn, K. M., Dugan, H. A., ... & Weathers, K. C. (2020). Coupling Natural and Human Models in the Context of a Lake Ecosystem: Lake Mendota, Wisconsin, USA. *Ecological Economics*, *169*, 106556.

Motivation

- Nutrient pollution in United States
  - One of America's most widespread, costly and challenging environmental problems (EPA, 2018)
  - Environmental effects:
    - Algal blooms
    - Dead zones and hypoxia
    - …
  - Economic effects:
    - Commercial fishing
    - Drinking water
    - Real Estate
    - Recreation
    - and many more!

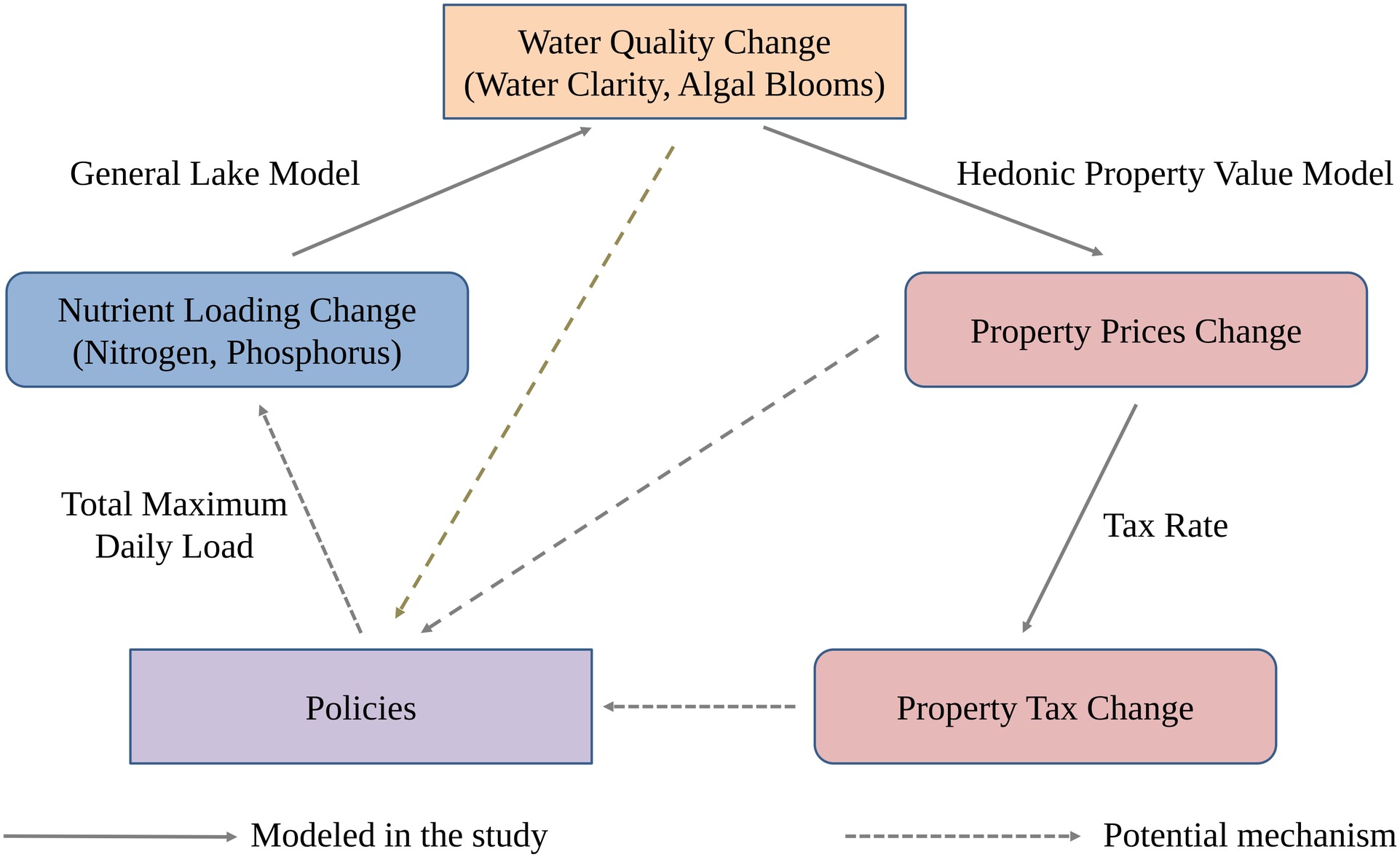
Policy Context

- Nonpoint source water pollution regulations target reductions in nutrient loading to improve surface water quality.

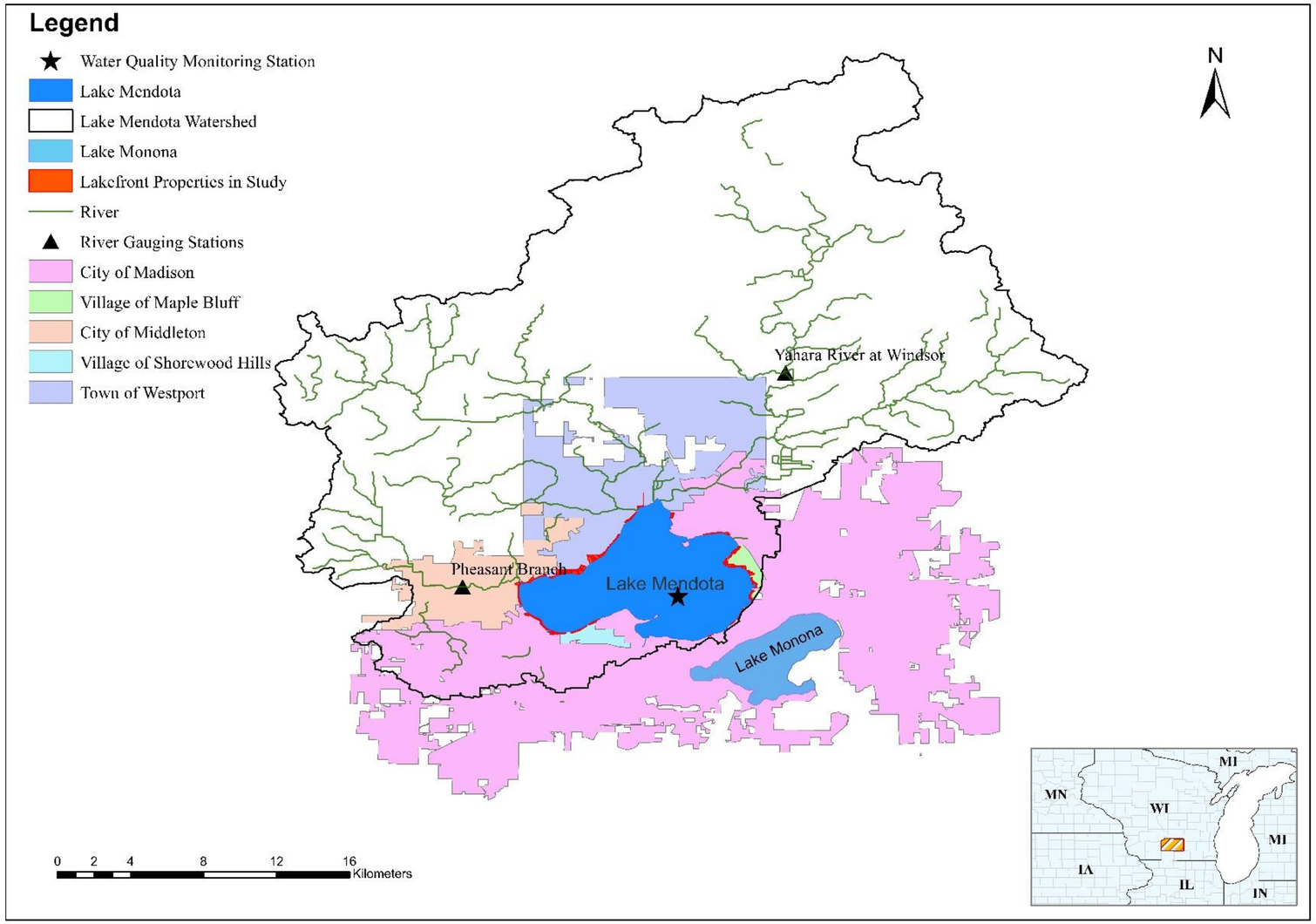
- To develop effective actions, there is a need to translate changes in nutrient loads to changes in water quality

- Modeling is the tool to build the linkage between policy targets and policy outcomes

Modeling Framework

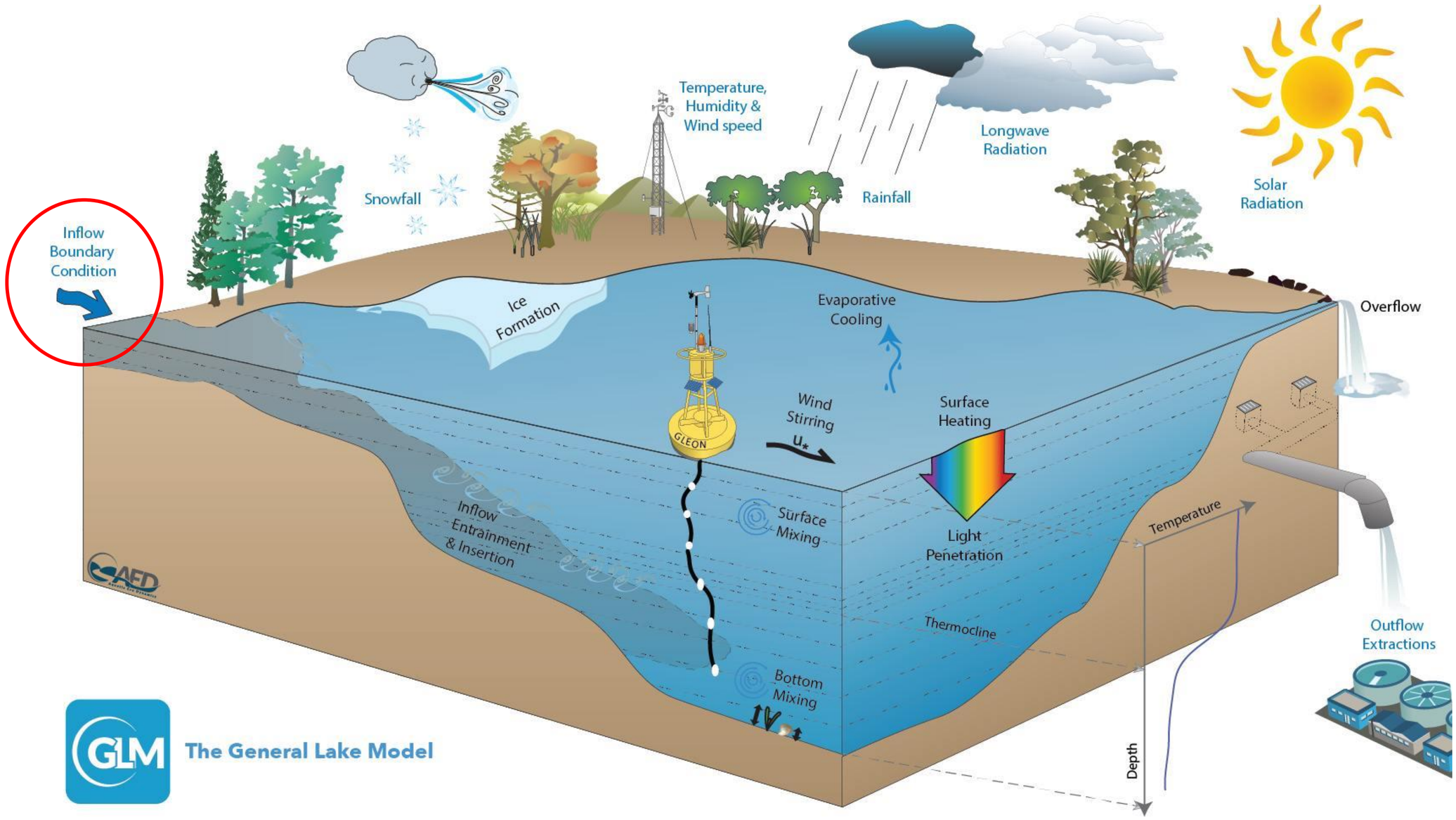


Lake Mendota Watershed



- A eutrophic lake that exhibits algal booms every summer
  - Algal blooms result in noxious odors, large scums, beach closures and the degradation of ecosystem services

Lake Water Quality Model (GLM-AED)



Lake Water Quality Model (GLM-AED)

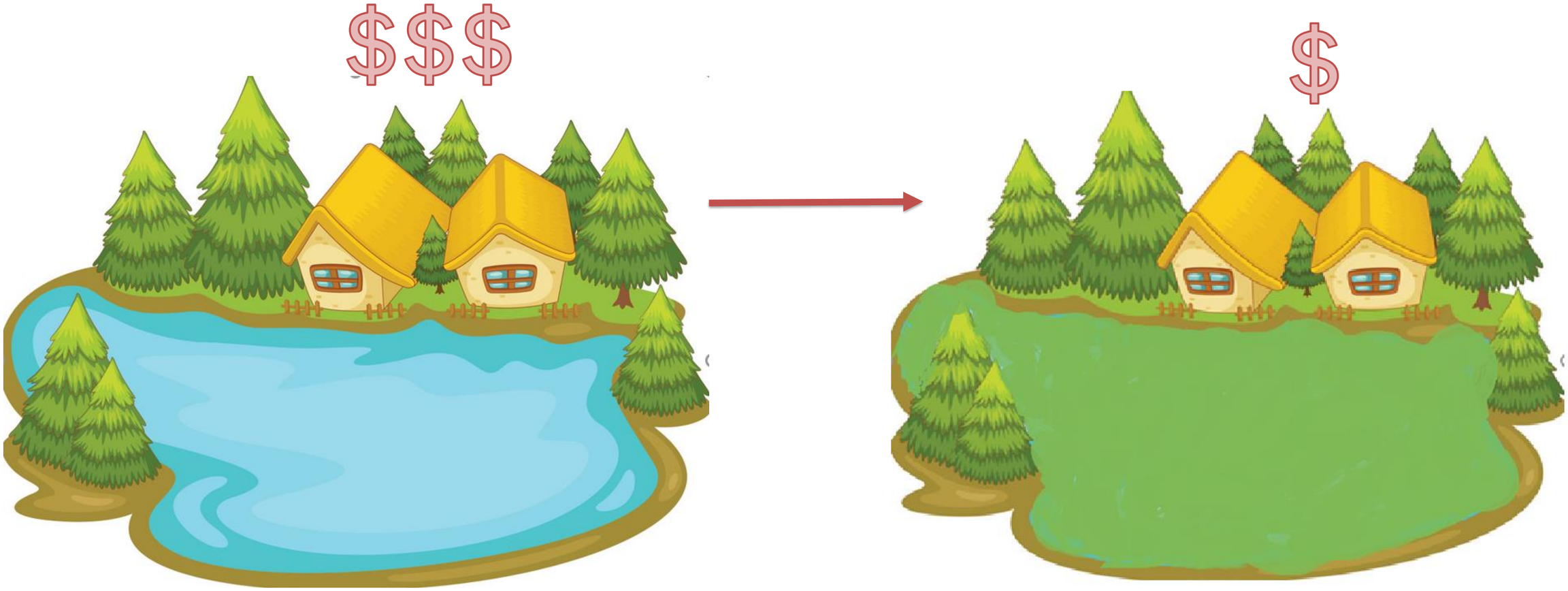
- Simulate water quality for changes in nutrient loadings (N and P)
- Scenarios:
  - Nutrient loadings increases : 25%, 50%,75%,100%
  - Nutrient loadings decreases: 25%, 50%,75%,100%

Lake Water Quality Model (GLM-AED)

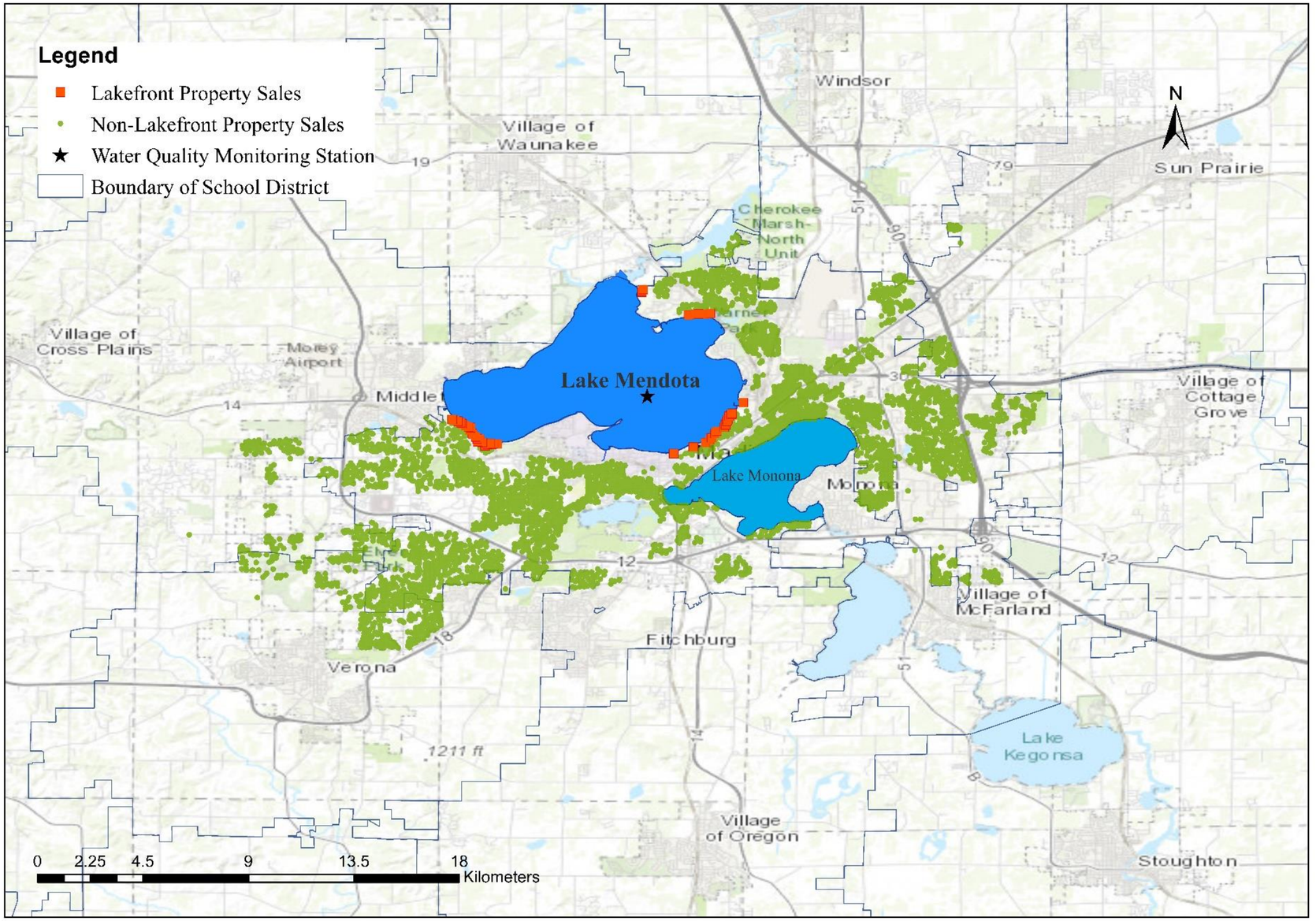
- Input data:
  - Air temperature, short and long wave radiation, relative humidity, wind speed, precipitation, concentrations of N and P, discharge, and inflow water temperature

- Output data:
  - **Secchi depth (meters):** a decrease in secchi depth corresponds to a reduction in water clarity
  - **Surface chlorophyll-a concentration:** an increase in chlorophyll-a corresponds an increase in the growth of surface scums

Hedonic Property-value Model



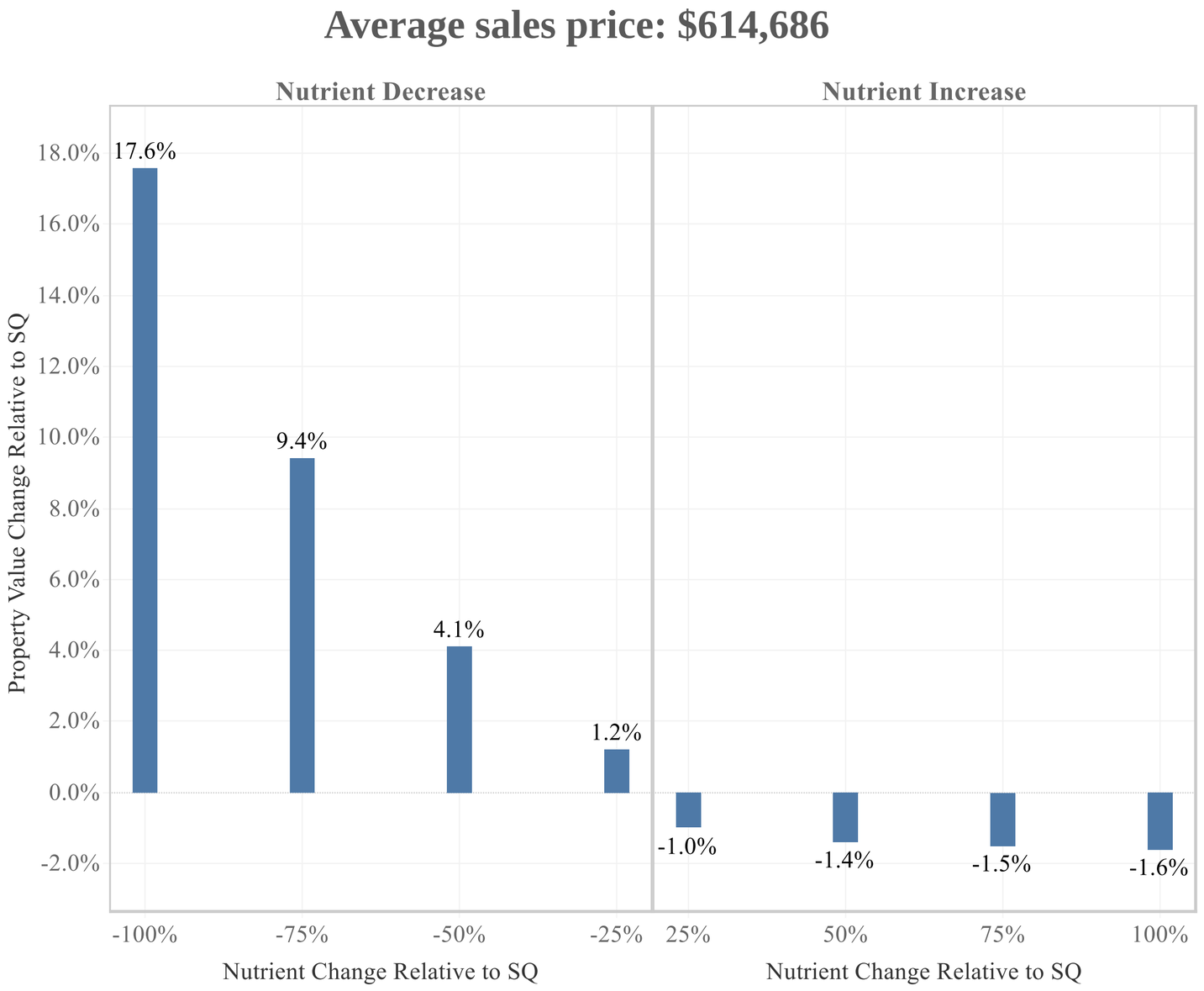
Location of Property Sales



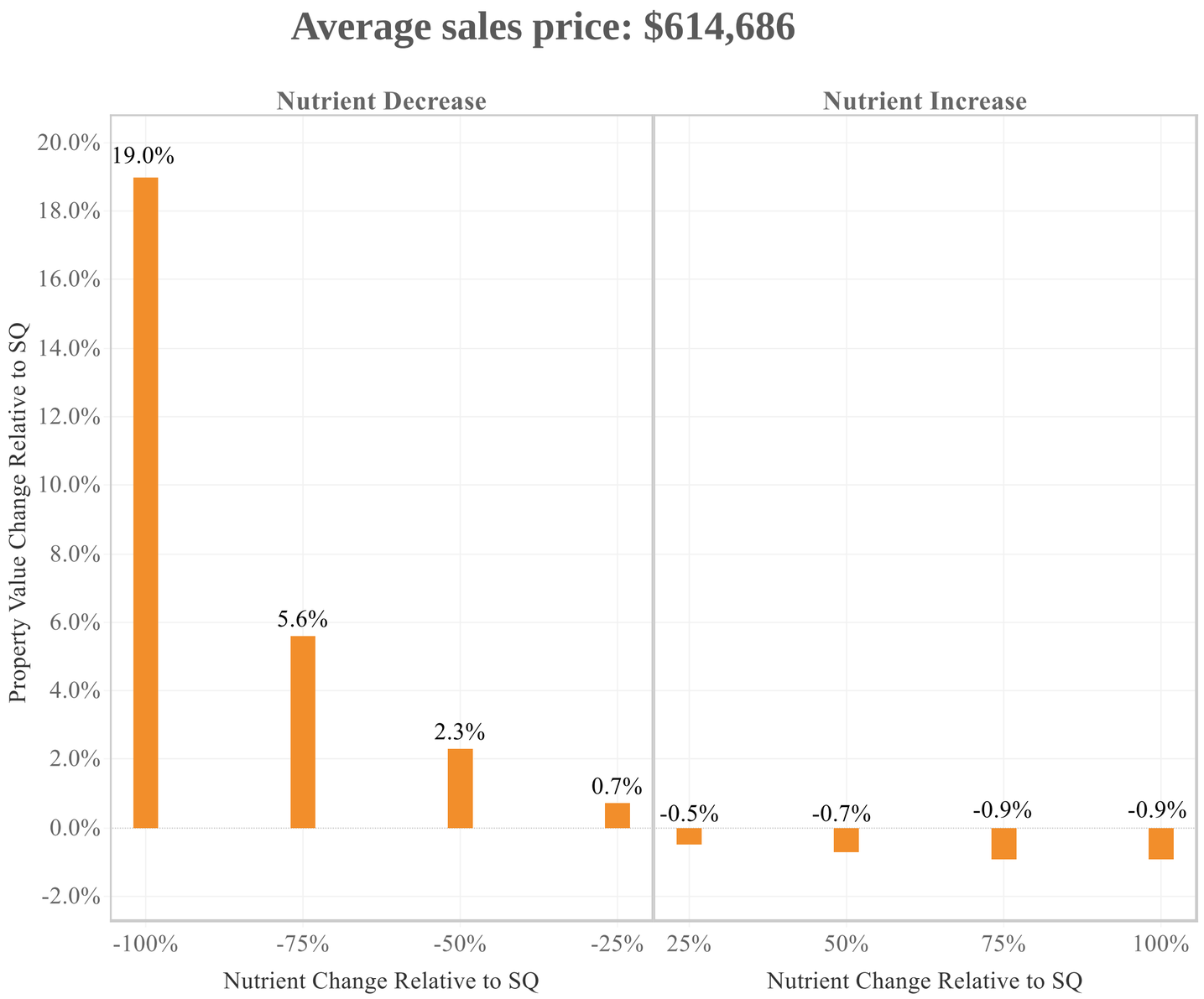
Hedonic Property-value Model

- Input Data:
  - Property sales records, water quality, socio-demographic information, distance to lake
- Output Data:
  - Water quality price premiums
    - Secchi depth: $\beta_{sec}>0$
    - Surface Chl-a: $\beta_{chl}<0$

Individual Property Value Change (Secchi Depth)



Individual Property Value Change (Surface Chl-a)



Aggregate Property Value Change

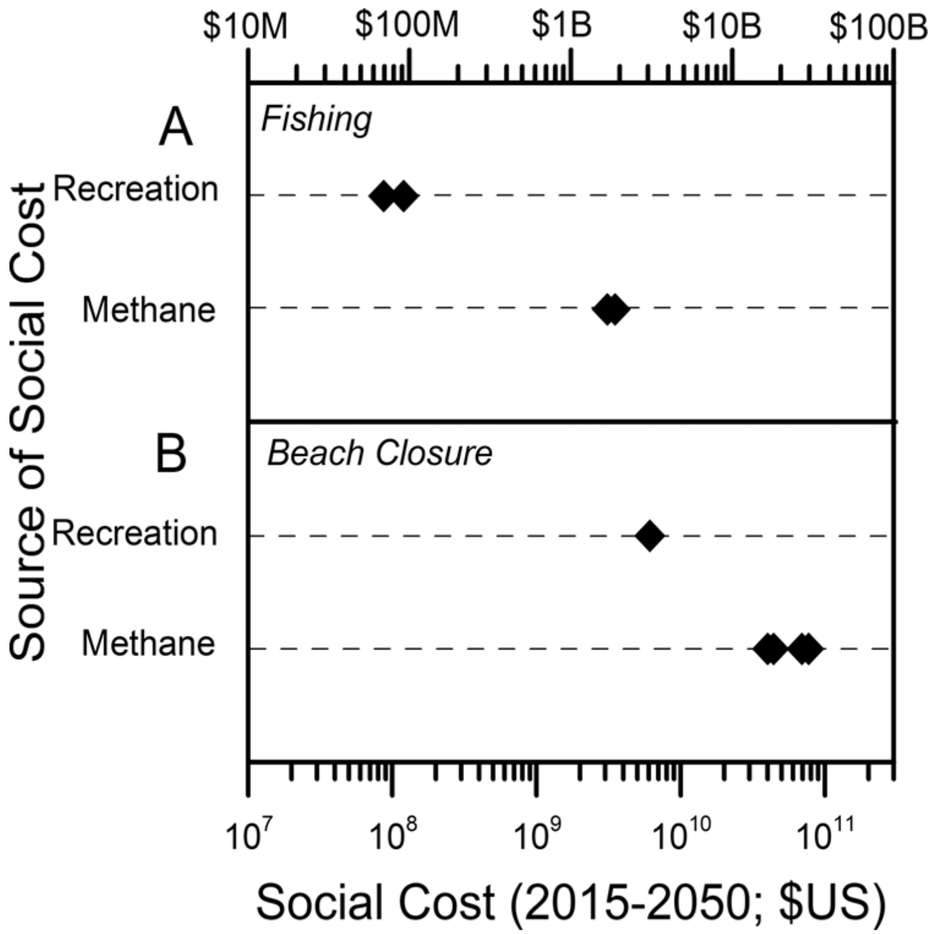
	Secchi depth	Surface Chl-a
Nutrient increase		
25% increase	-$5.03M	-$2.52M
50% increase	-$6.82M	-$3.64M
75% increase	-$7.50M	-$4.37M
100% increase	-$7.99M	-$4.36M
Nutrient decrease		
25% decrease	$6.03M	$3.49M
50% decrease	$20.21M	$11.82M
75% decrease	$46.88M	$27.83M
100% decrease	$87.53M	$94.49M

Tax Revenue Effects

Community	# of lakefront properties	Property tax mill rate ($/1000)	25% nutrient increase		25% nutrient decrease	
			Secchi depth	Surface Chl-a	Secchi depth	Surface Chl-a
City of Madison	304	25.11	-$47,386 (-0.008%)	-$23,731 (-0.004%)	+$56,778 (+0.01%)	+$32,880 (+0.006%)
City of Middleton	189	22.32	-$26,184 (-0.04%)	-$13,113 (-0.02%)	+$31,374 (+0.05%)	+$18,169 (+0.03%)

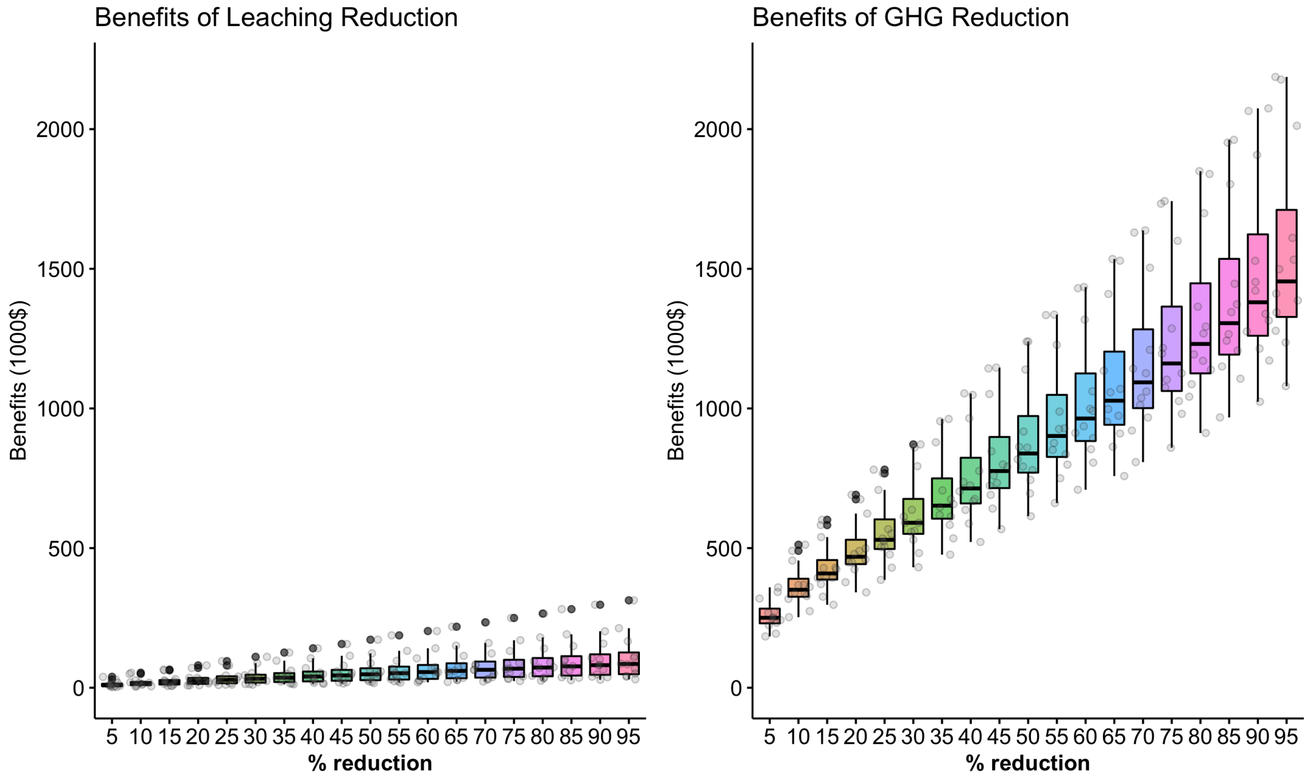
Protecting local water quality has global benefits

Methane (CH_4)



Reference: Downing, J. A., Polasky, S., Olmstead, S. M., & Newbold, S. C. (2021). Protecting local water quality has global benefits. *Nature communications*, *12*(1), 2709.

Nitrous Oxide Emission (N_2O)



Reference: **Weng, W.,** Cobourn, K. M., Kemanian, A. R., Boyle, K. J., Shi, Y., Stachelek, J., & White, C. (2023). *Quantifying Co-Benefits of Water Quality Policies: An Integrated Assessment Model of Nitrogen Management*.

Florida!!!

FLORIDA LAKEWATCH

Florida LAKEWATCH is a citizen volunteer lake monitoring program that facilitates "hands-on" citizen participation in the management of Florida lakes, estuaries, rivers and springs through monthly monitoring activities.

Coordinated through the University of Florida's Institute of Food and Agricultural Sciences/FFGS Fisheries and Aquatic Sciences, the program has been in existence since 1986. In 1991, the Florida Legislature recognized the importance of the program and established Florida LAKEWATCH in the state statutes (Florida Statute 1004.49.). LAKEWATCH is now one of the largest lake monitoring programs in the nation with over 1800 trained citizens currently monitoring 525 lakes, 175 estuary stations, 125 river stations, 20 coastal dune lakes and 10 spring runs in 57 counties.

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