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# From concept to practice to policy:
# Modeling coupled natural and human systems in lake catchments

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## BACKGROUND

- People benefit from services provided by freshwater lakes (e.g., drinking water, recreation, fisheries)
- However, human activities in watersheds contribute to pollution and the growth of harmful algal blooms
- **Coupled natural and human systems (CNHS)** modeling can be used to study complex, reciprocal linkages between human actions and ecosystem processes

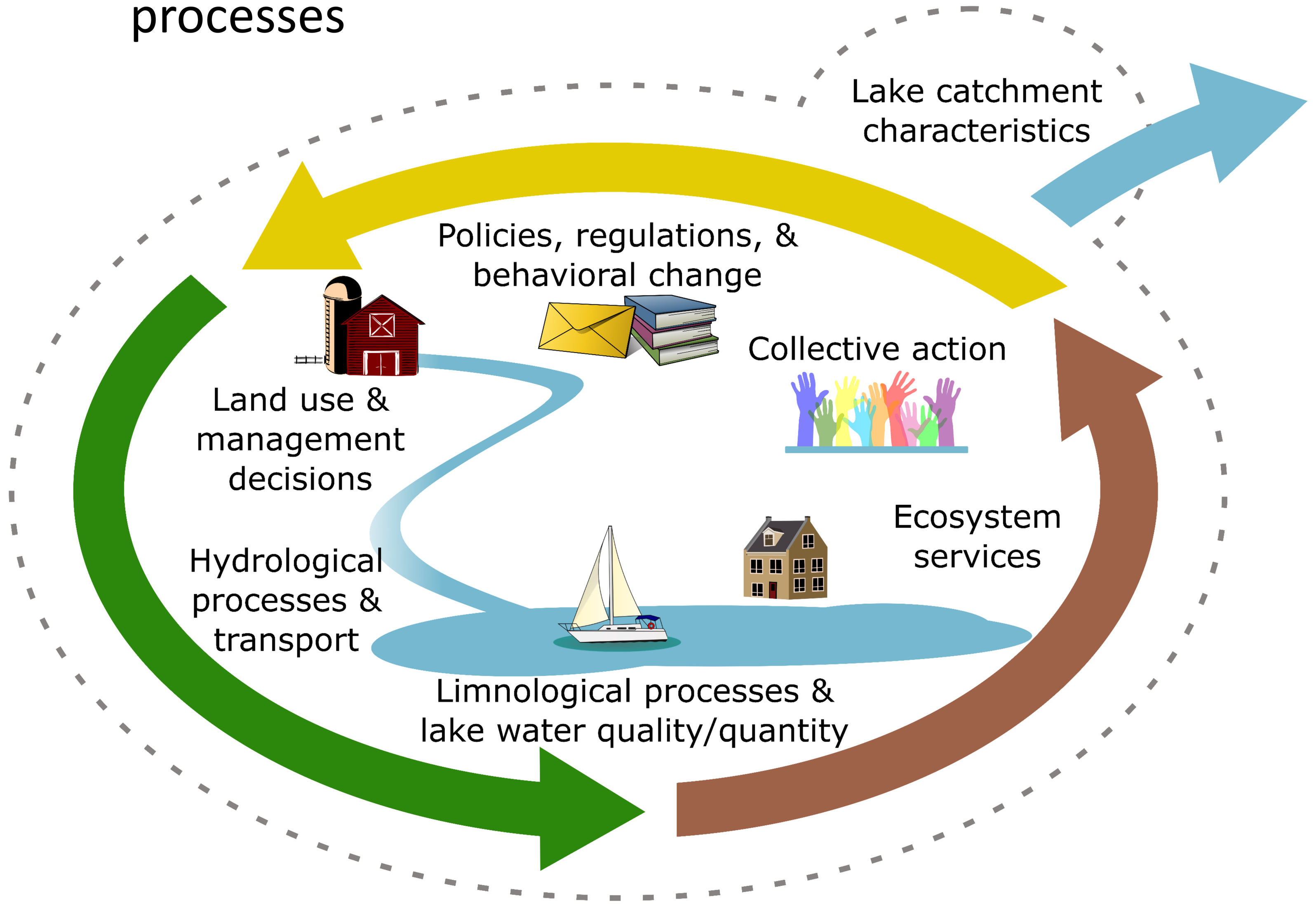


**Fig 1.** Conceptual framework for a lake catchment CNHS.[1]

## RESEARCH OBJECTIVES

- To develop a methodology to capture feedbacks from human actions to the ecosystem and back to human actions in lake catchment CNHS
- To develop a coupling approach for models from diverse disciplines, (e.g., **economics, agronomy, hydrology, limnology, and social psychology**)
- To address challenges in CNHS modeling, which arise from differences in disciplinary approach, model structure, and spatiotemporal resolution

## DATA SOURCES

- This study uses data from three focal lakes (see Fig. 2) with extensive historical data on water quality, including long-term manually sampled records and recent data from high-frequency sensor networks
- It also uses LAGOS, a database of thousands of U.S. lakes, for investigating potential for extrapolation

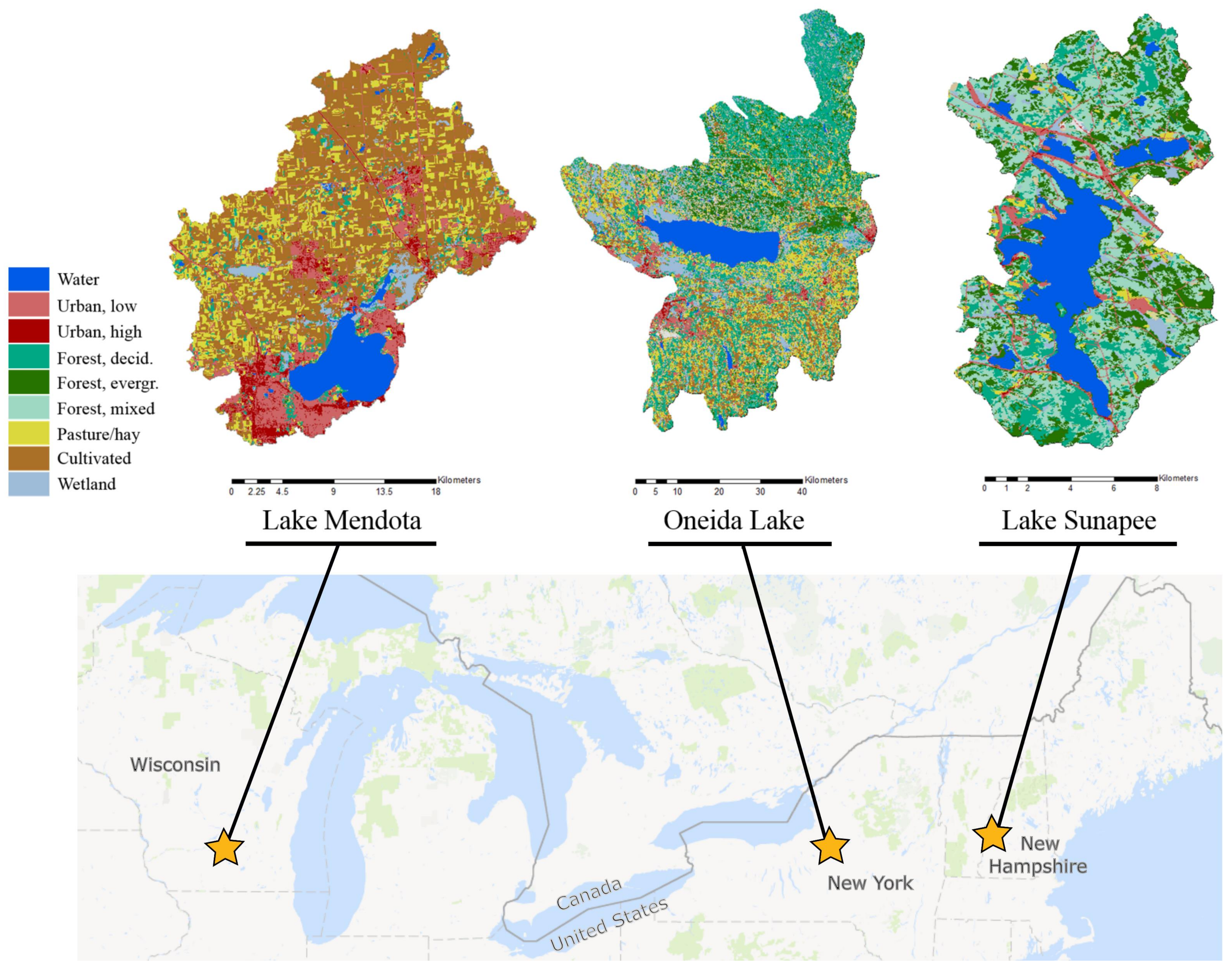


**Fig 2.** Three lake catchment CNHS with surrounding land uses.[1]

## EMPIRICAL WORKFLOW

- We use data from focal lakes to calibrate **flexible, discipline-specific models** that accommodate heterogeneous catchments within the same CNHS framework
- We identify critical variables that link models, and present a **workflow for passing data between models** that differ in approach (e.g., quantitative vs. qualitative) and spatiotemporal resolution

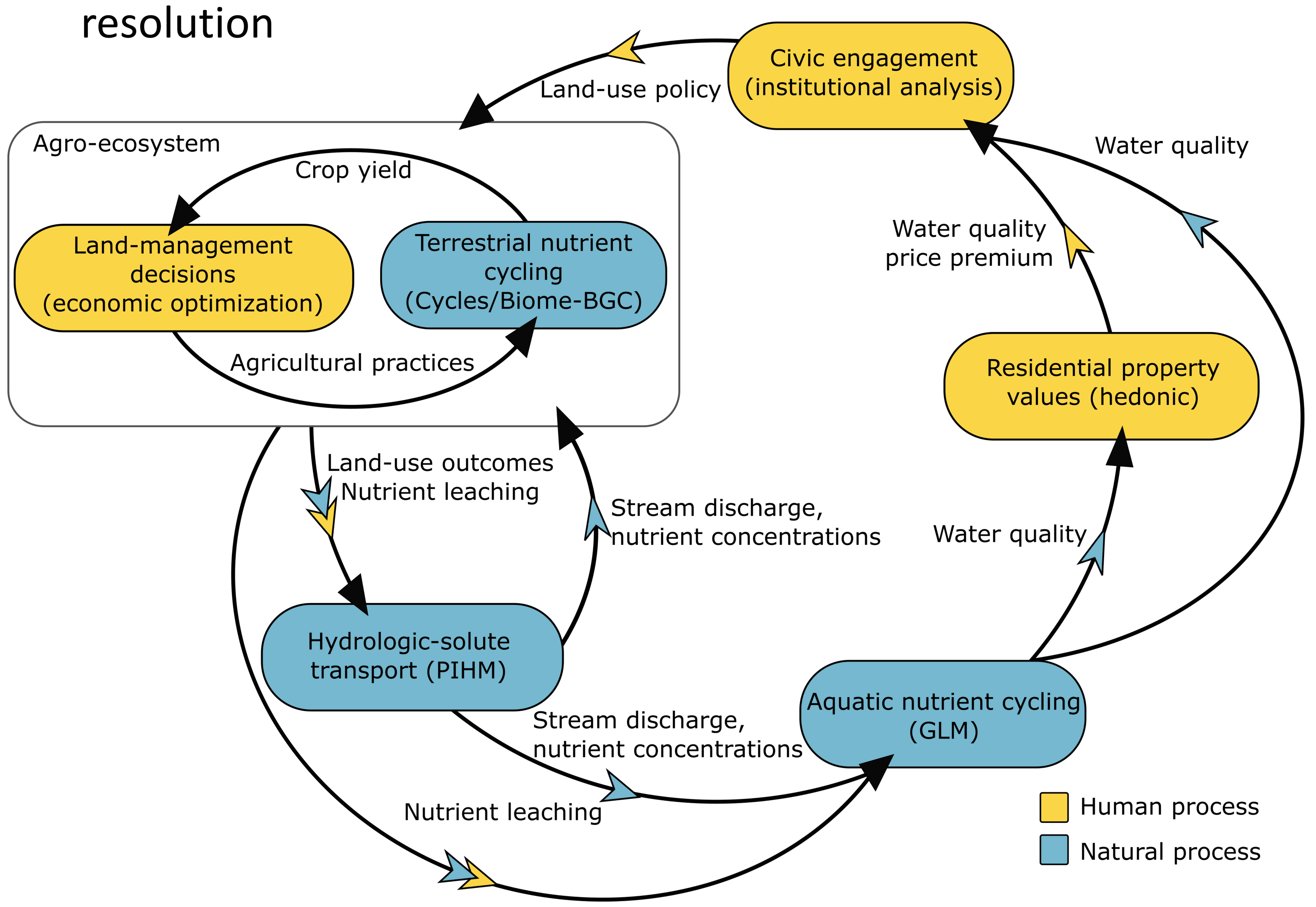


**Fig 3.** CNHS components, models, and data flows that form coupling linkages. [1]

| Model | Resolution | Input data | Focal Output data |
|---|---|---|---|
| Economic optimization | Annual, representative farmer | – Crop yields<br>– Land-use policy | – Ag. land-management practices |
| Cycles/Biome-BGC | Daily, representative land unit, soil depth layers | – Ag. land-management practices<br>– Soil moisture<br>– Land-use policy | – Nutrient leaching<br>– Crop yields |
| Penn State Integrated Hydrologic Model (PIHM) | Minute, mesh grid cell (~100m) | – Nutrient leaching | – Soil moisture<br>– Stream discharge<br>– Water temperatures<br>– Nutrient concentrations |
| General Lake Model (GLM) | Hourly, lake, dynamic depth intervals | – Stream discharge<br>– Water temperatures<br>– Nutrient concentrations | – Water clarity<br>– Cyanobacterial blooms<br>– Anoxia |
| Hedonic property value model | Multi-year, catchment | – Water clarity<br>– Cyanobacterial blooms<br>– Anoxia | – Water quality price premium |
| Institutional analysis | Multi-year, catchment | – Water clarity<br>– Cyanobacterial blooms<br>– Anoxia<br>– Water quality price premium | – Land-use policy |
| Scaling up | Annual, catchment | – Land use<br>– Water clarity<br>– Property values | – CNH linkage |

**Table 1.** CNHS components and models.

## CONCLUSION

This project results in an integrated, multi-disciplinary tool that advances cross-disciplinary dialogue that moves CNHS lake catchment modeling in a more systematic direction and provides a foundation for smart decision-making and policy.

**CITATIONS**

[1]Cobourn, K. M. et al. From concept to practice to policy: modeling coupled natural and human systems in lake catchments. *Ecosphere*, 2018. doi:10.1002/ecs2.2209

[2]Read, E.K., L. Carr, L. De Cicco, H.A. Dugan, P.C. Hanson, J.A. Hart, J. Kreft, J.S. Read, L.A. Winslow. "Water quality data for national-scale limnological research," *Water Resources Research*, 2017. doi:10.1002/2016WR019993

[3]Carey, C.C., B.L. Brown, and K.L. Cottingham.. "Cyanobacterial blooms increase the stability and network complexity of phytoplankton communities.," *Ecosphere*, 2017. doi:10.1002/ecs2.1830

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