

# Linking agricultural nutrient pollution to the value of freshwater ecosystem services

“Integrated assessment models for ag practices and ag policies affecting water quality, as well as specific challenges and needs for linking ag practices to valuation of water-related ecosystem services affected by ag pollutants.”

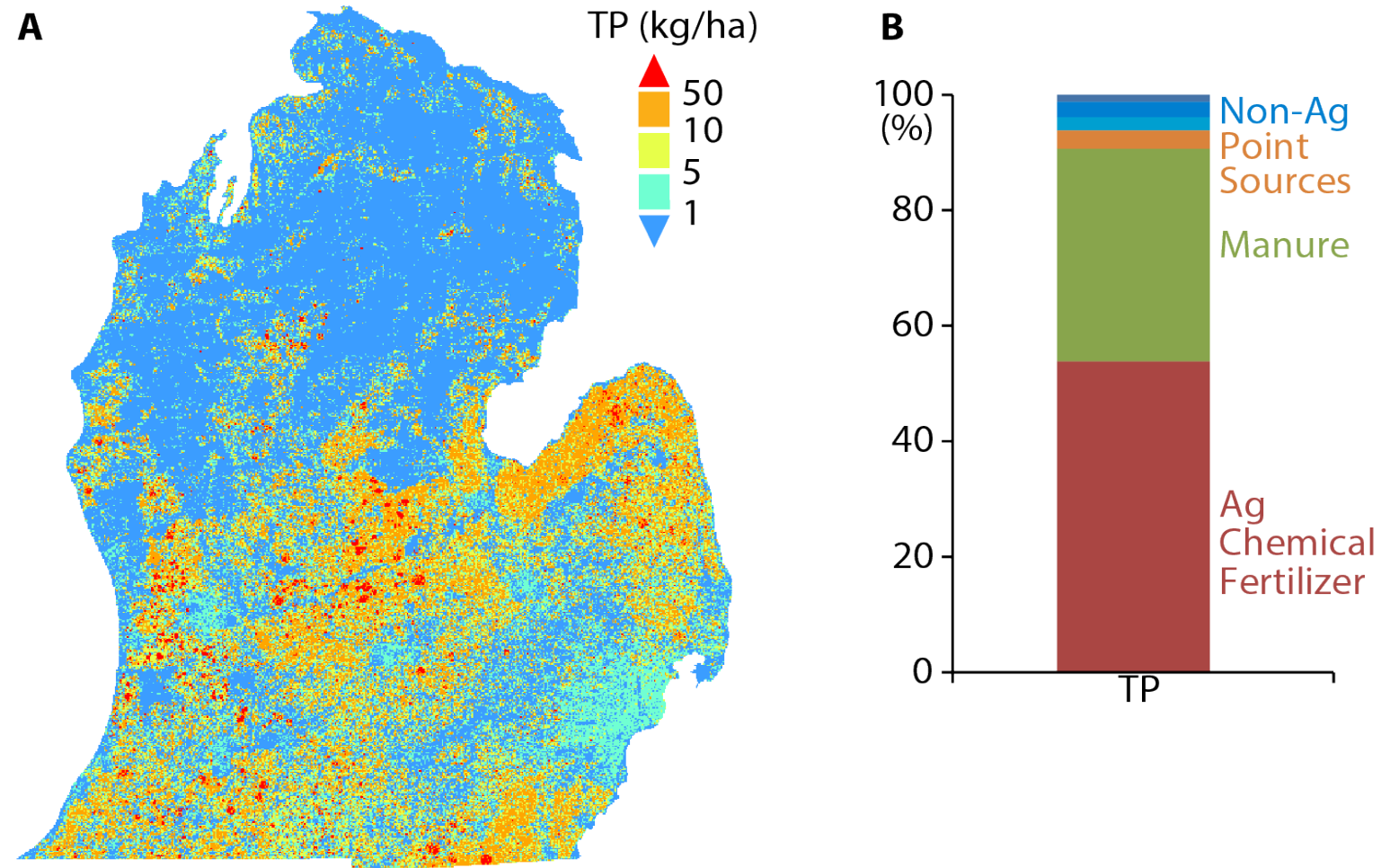
Frank Lupi, Michigan State University

Presented at Heartland workshop in Urbana IL, September, 2019

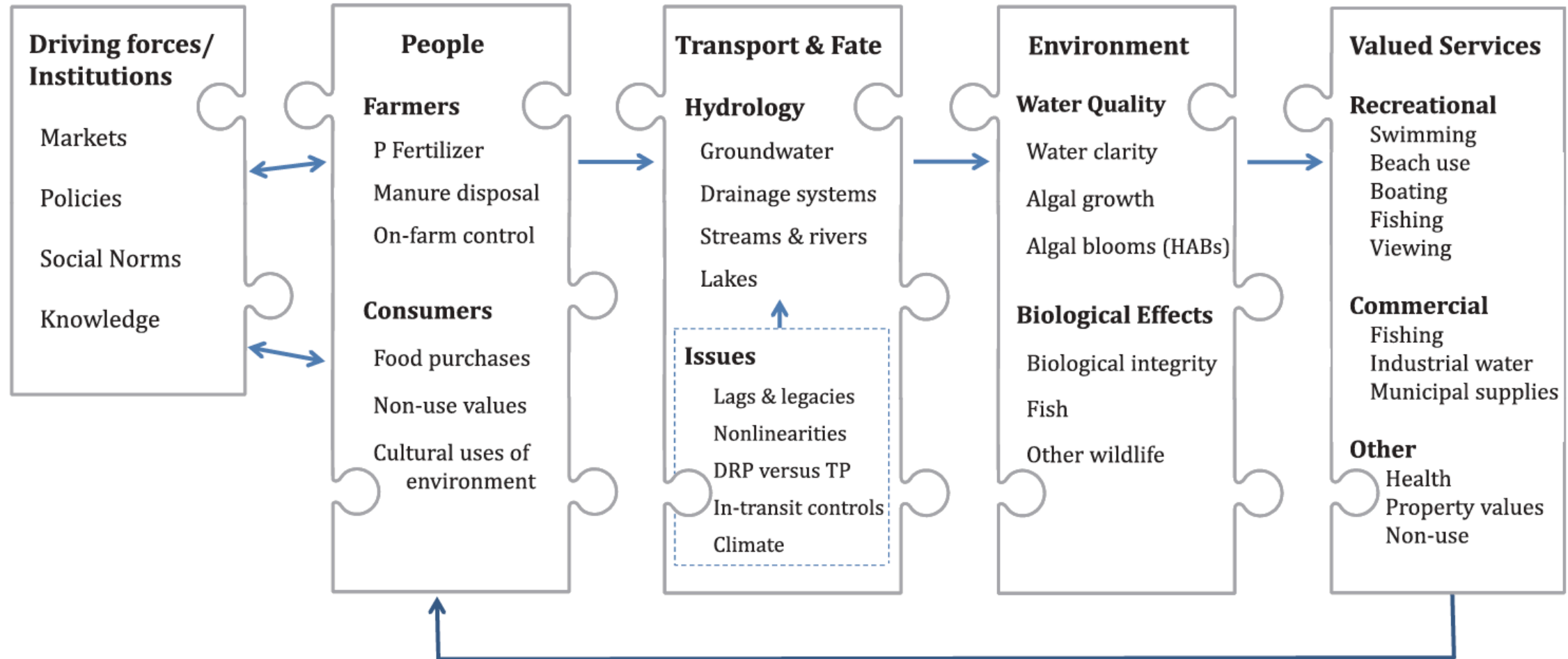


Why care about Ag?

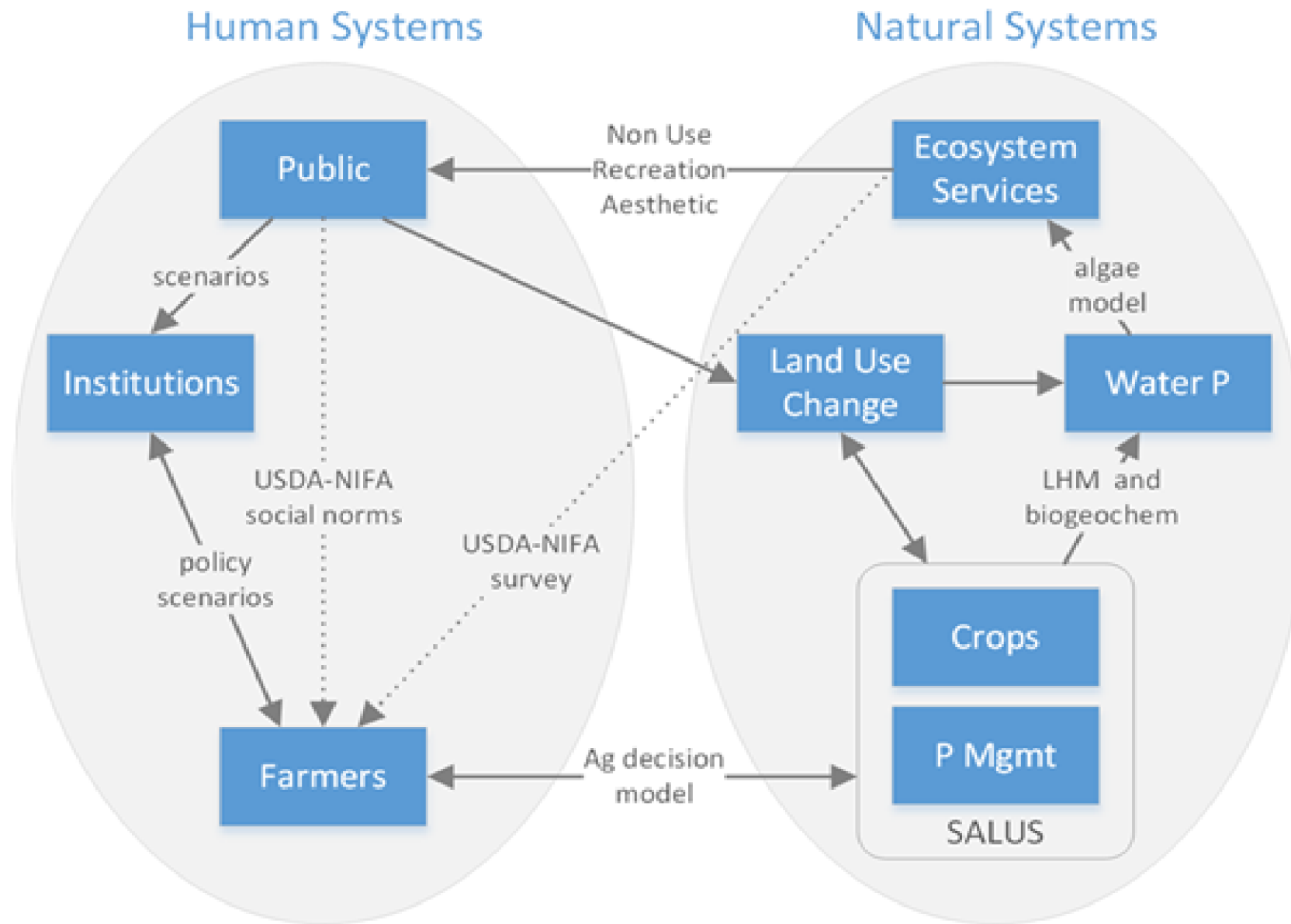
## Total Phosphorus Loadings



Luszcz et a. 2015



**Figure 1. Systems framework illustrating the P puzzle**



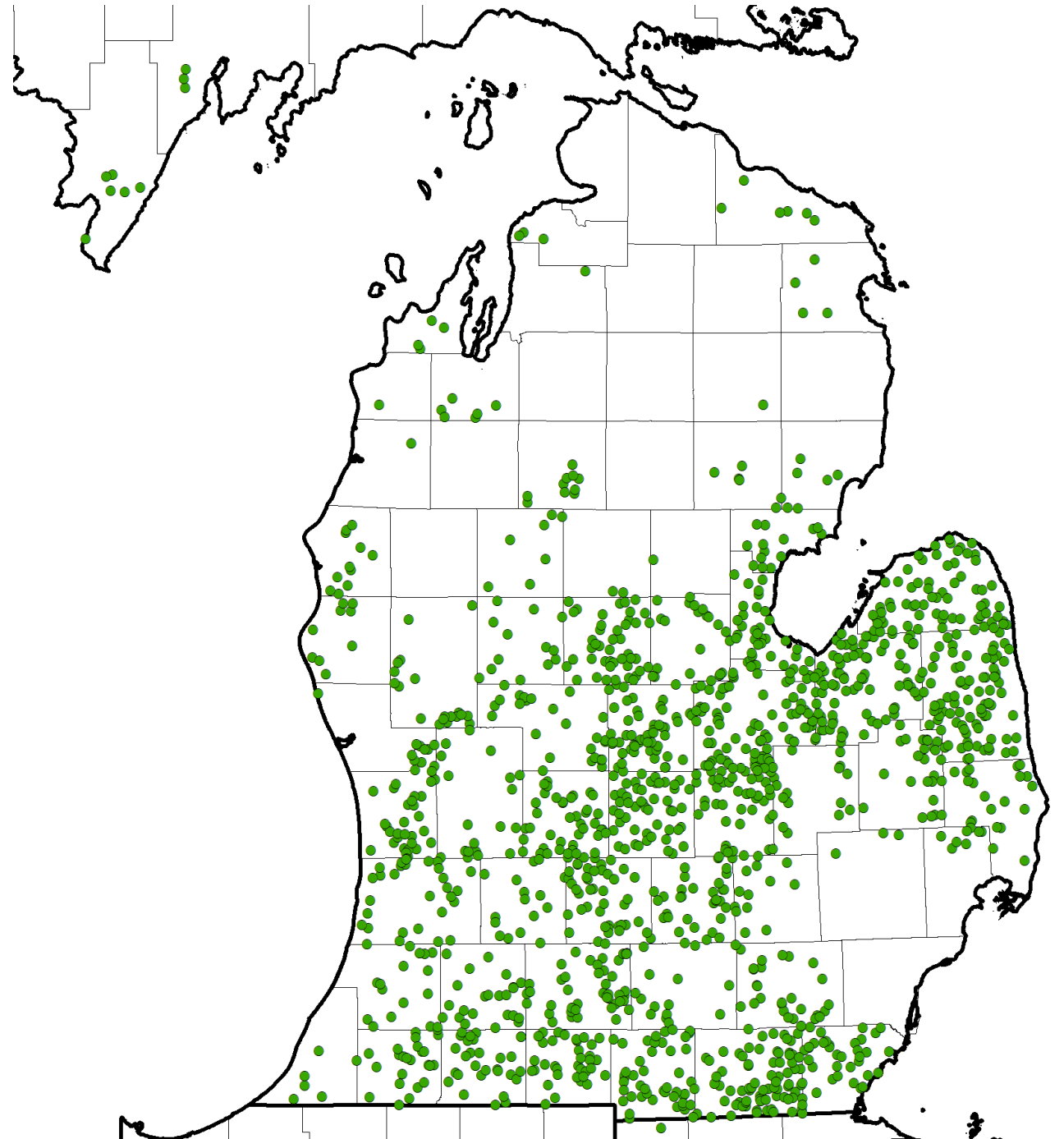
**Figure 6.** *Conceptual diagram of the linked models.*

# Modeling producer behavior

- Want to answer counterfactuals:
  - P tax
  - P regulations
  - P control subsidies
- NPS pollution is a spatially explicitly phenomena
  - Ag data often at larger spatial scale than hydrological model
- Perhaps more challenging: *What behavioral foundation?*

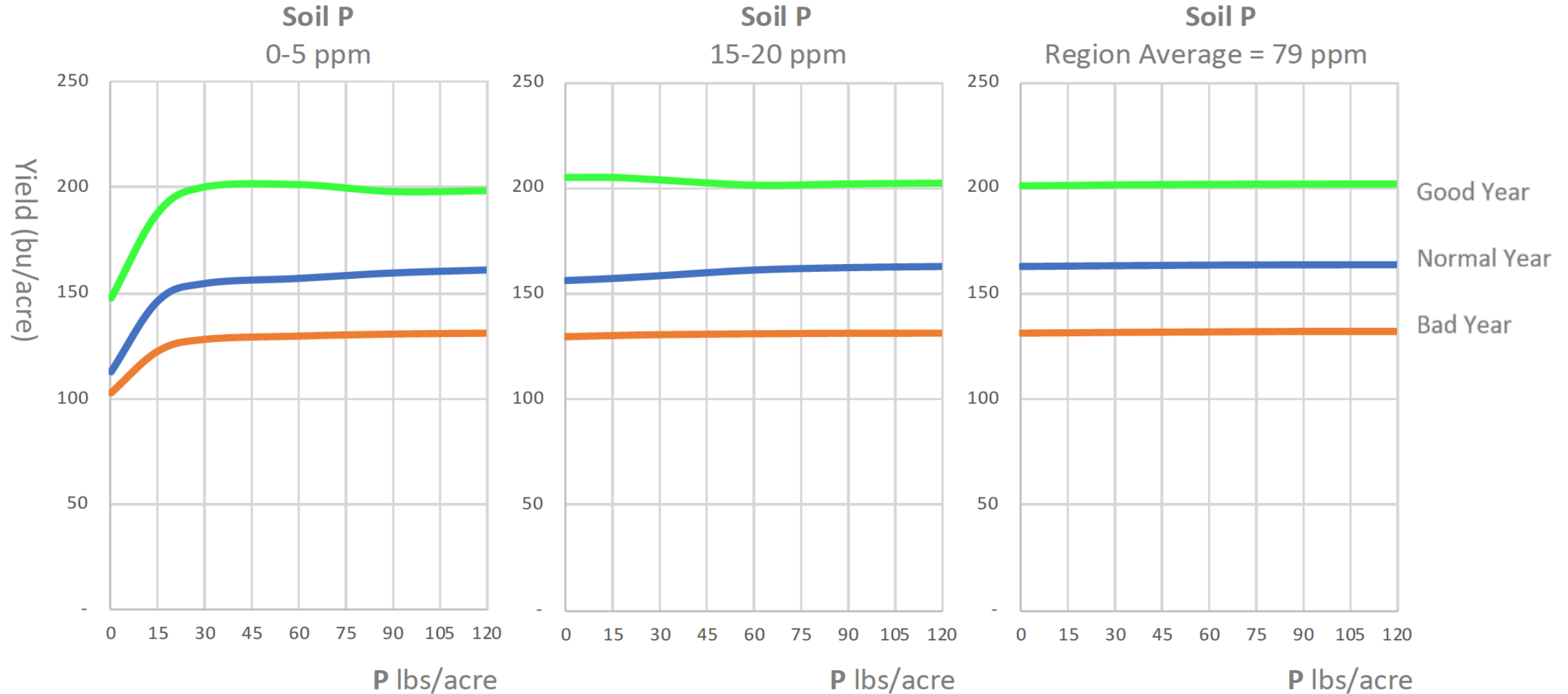
# Why high P?

- Survey of corn farmers
- ~30% response rate
  - 2/3 web
  - 1/3 paper
- Gathered field & mgmt info





**Figure 1:** Corn yield response to P applications for soil P levels and for normal, bad and good years.

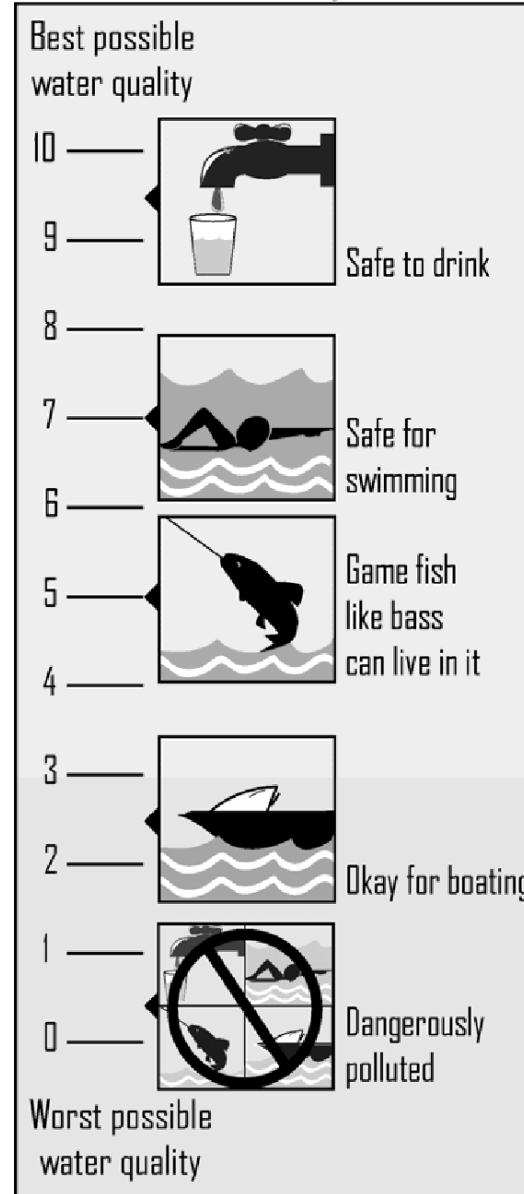


Measuring water quality

# Water quality indices & ladders

- WQI: Water quality index
- EPA's HAWQs-BenSPLASH model

## Water Quality Ladder



## Pool versus bass pond



# Ecological production functions

# Ecosystem Service: Ecological Production Functions

Fish Production Model	Fish biomass = $f(\mathbf{P}$ concentration, water temps)
Algae Production Model	Algae in water and on beach = $f(\mathbf{P}$ concentration, nearshore habitat)
Water Quality Models	WQ = $f(\mathbf{P}$ concentration, e-coli, clarity)
Biological Condition Model	BC = $f(\mathbf{P}$ concentration, natural factors)

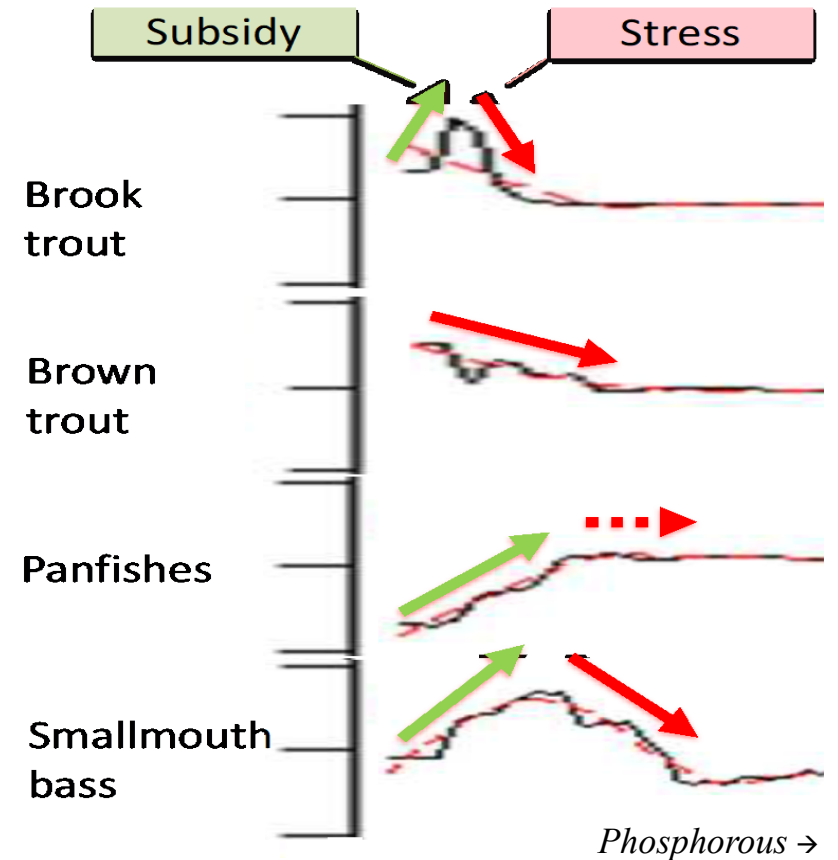
# Ecosystem Services

Fish Production Model

Fish biomass =  $f$  (P concentration, water temps)

- Species-specific game fish biomass related to:
  - Temps, morphology, etc.
  - Phosphorus
- Boosted regression trees
- Partial dependence plots relate P to abundance

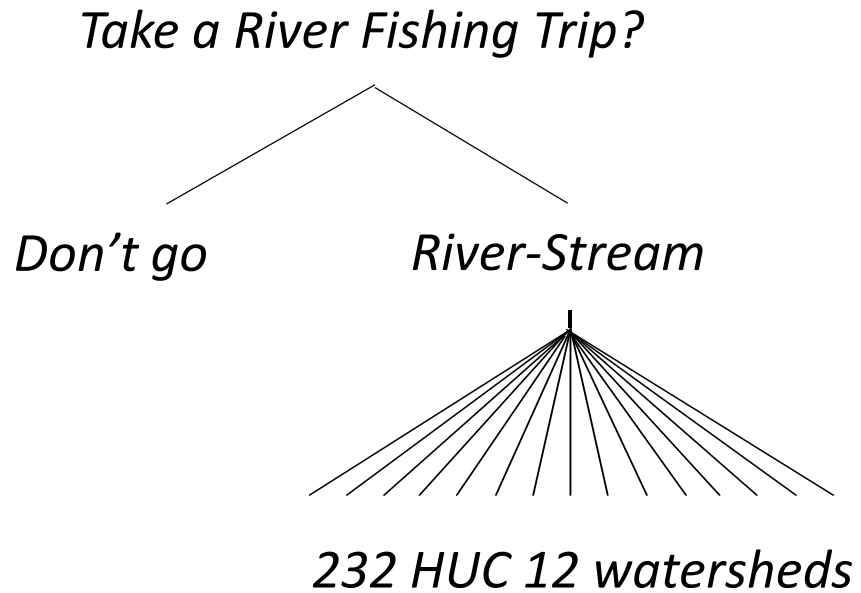
(Esselman et al, 2015)



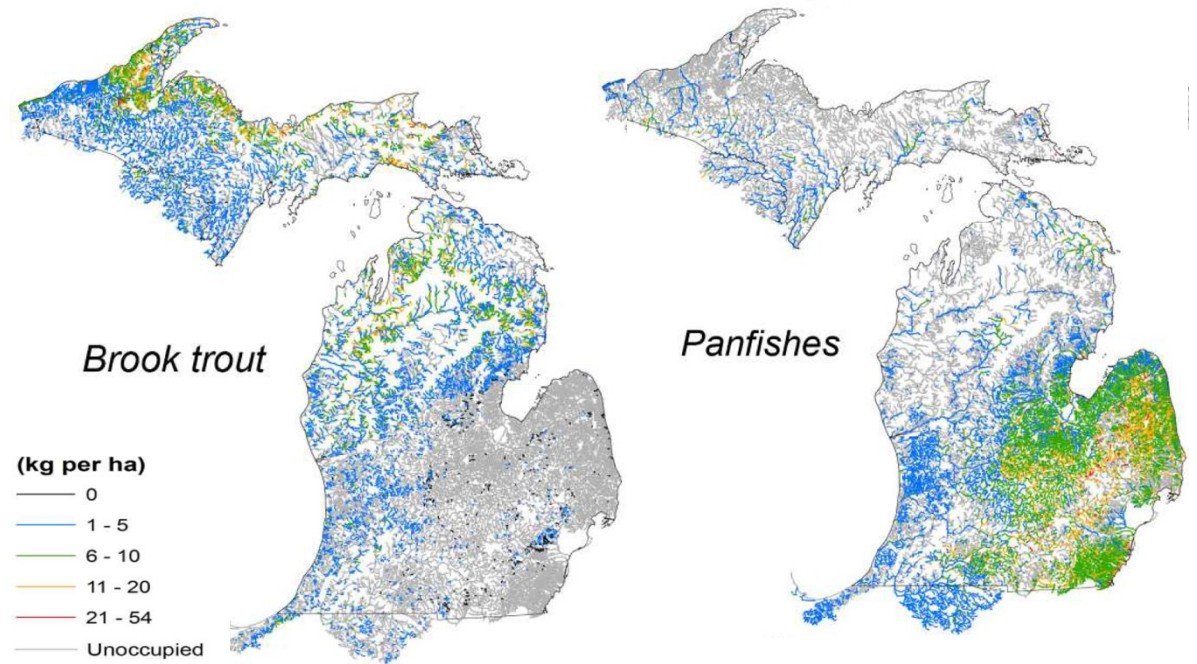
# Demand for Ecosystem Services

Fishing Demand Models	Value = $f$ (fish biomass by species)
Beach Demand Model	Value = $f$ (algae in water and on beach)
Non-use Values	Value = $f$ (safety, clarity, game fish, biological condition)

# Recreation Fishing Demand & Species Biomass



*Melstrom et al. 2015*



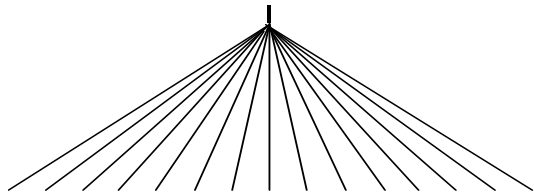
*Esselman et al. 2015.*

# Recreation Fishing Demand & Species Biomass

*Take a River Fishing Trip?*

*Don't go*

*River-Stream*



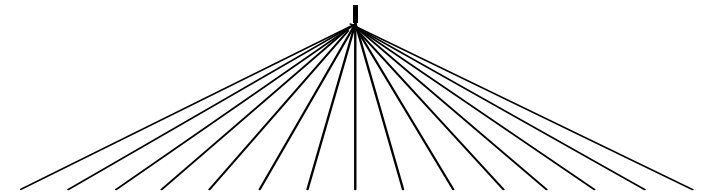
*232 HUC 12 watersheds*

*Melstrom et al. 2015*

*Take a **Lake** Fishing Trip?*

*Don't go*

***Inland Lakes***



*1615 individual lakes >10 acres*

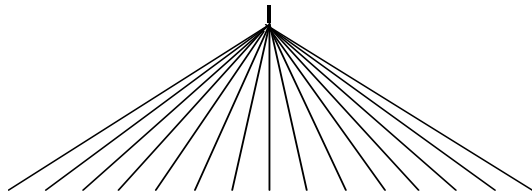
*Klatt et al. in progress*

# Recreation Fishing Demand & Species Biomass

Take a River Fishing Trip?

Don't go

River-Stream



232 HUC 12 watersheds

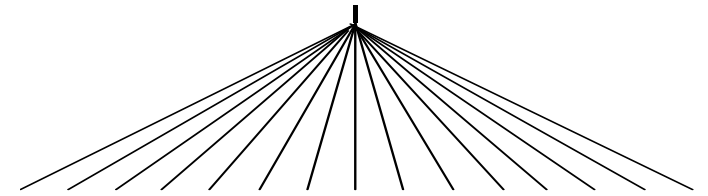
Brook trout, Brown trout  
Bass, Panfish, Walleye

Melstrom et al. 2015

Take a Lake Fishing Trip?

Don't go

Inland Lakes



1615 individual lakes >10 acres

Bass, Yellow perch,  
Panfish, Walleye

Klatt et al. in progress

# Beaches and Algae



# Example: Macroalgae and Plants Foul Beaches

Algae Production Model

Algae in water and on beach =  
 $f(\text{P concentration, nearshore habitat})$

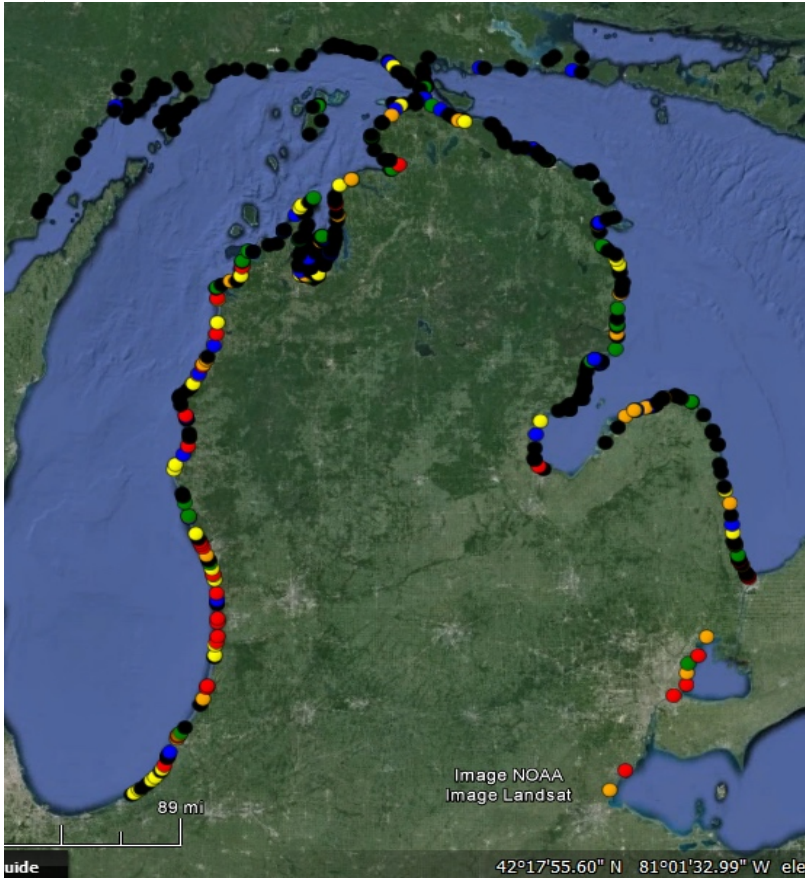
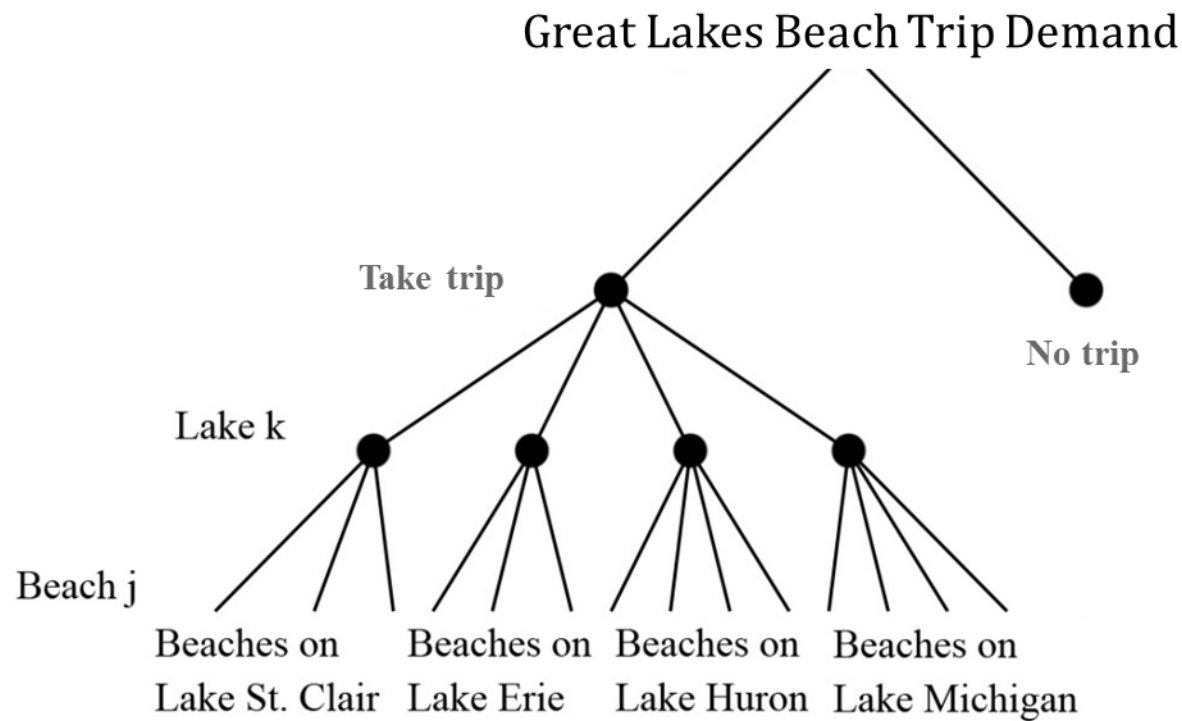




# Demand for Ecosystem Services

Beach Demand Models

Value =  $f$  (algae in water and on beach)



# Challenges...

- Time, effort, foresight, money...
- Mis-match of scales:
  - spatial,
  - temporal
  - ES aggregation
- Never-the-less, still “fine-grain’ valuation  
(site-specific demand models and non-use valuation tied to real metrics for MI)

# The low but uncertain measured benefits of US water quality policy

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Edited by Stephen Polasky, University of Minnesota, St. Paul, MN, and approved September 6, 2018 (received for review March 30, 2018)

**US investment to decrease pollution in rivers, lakes, and other surface waters has exceeded \$1.9 trillion since 1960, and has also exceeded the cost of most other US environmental initiatives. These investments come both from the 1972 Clean Water Act and the largely voluntary efforts to control pollution from agriculture and urban runoff. This paper reviews the methods and conclusions of about 20 recent evaluations of these policies. Surprisingly, most analyses estimate that these policies' benefits are much smaller than their costs; the benefit–cost ratio from the median study is 0.37. However, existing evidence is limited and undercounts many types of benefits. We conclude that it is unclear whether many of these regulations truly fail a benefit–cost test or whether existing evidence understates their net benefits; we also describe specific questions that when answered would help eliminate this uncertainty.**

water pollution | Clean Water Act | cost–benefit analysis | cost effectiveness analysis | environmental regulation

A recent review summarized CBAs of the 112 major federal rules implemented over the period 2002–2012 across the entire US government (10). Summed over all rules and years, the ratio of estimated benefits to estimated costs ranged from 3.5 to 12.3 (lower versus upper bound). Surprisingly, a large majority of these total benefits and costs of major federal regulations came from Environmental Protection Agency (EPA) regulations, even though the EPA was only one of many departments studied. The total benefit–cost ratio for EPA regulations alone ranged from 3.7 to 17.5. Essentially each department had positive net benefits overall for its regulations. (The only exception is the lower-bound estimate for Homeland Security, since its two major regulations have a lower-bound benefits estimate of 0.) Six of the 112 regulations in this Office of Management and Budget (OMB) review focused on surface waters, however, and these regulations had total estimated benefits of \$23 to \$33 million and total estimated costs of \$434 to \$579 million, implying an unfavorable benefit–cost ratio of 0.05–0.06. Apart from these sur-

- Need more CGEs and other ways to capture/quantify other broader effects of improved WQ
- NPS pollution literature since 1988...
  - Still working on targeting controls
  - Still rely on paying farmers
  - Still costly (time consuming) to do site-specific efforts
- Does current NPS pollution approach incentivize development of new or improved, more cost effective approaches?
  - What economic force drives that cost down?
  - Are current forces sufficient?