Economics of HABs: Benefits and Costs of Prevention

Presentation prepared for the "Global Solutions to Regional Problems: Collecting Global Expertise to Address the Problem of Harmful Algal Blooms"

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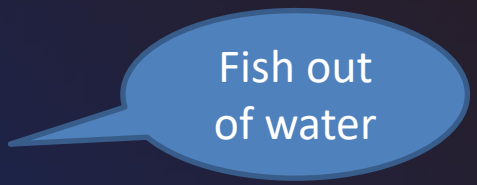
April 14, 2015



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Environmental economics

- Nutrients leaving fields and entering waterways are a classic “externality”
- Externality = unintended side effect of production that imposes costs on others
- Overall, people are not as well off as they would be if these effects were incorporated in decision making
- Can be thought of as "missing market"

Role of environmental economics

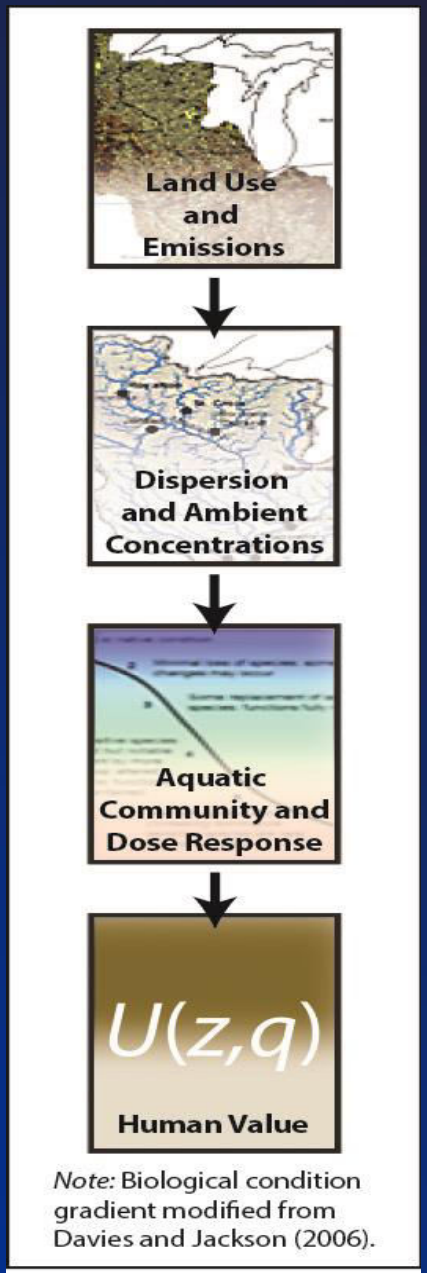
- Demand: benefits of avoiding nutrient over-enrichment
- Supply: costs of avoiding nutrient over-enrichment
- Policy Design: design and evaluate policies tol bring these costs and benefits into decisions

Fundamentally interdisciplinary

1. Demand (benefits) come from reducing impacts to ecosystem services: ecological sciences

2. Supply (costs) come from changes in land use and agricultural production: agronomic sciences, hydrology, agricultural engineering, etc.

3. Good policy design depends on physical processes of both prevention methods and ecosystem impacts



Note: Biological condition gradient modified from Davies and Jackson (2006).

Figure 3. Integrated Assessment Model

Action Taken on Land

- Fertilizer quantity and timing
- Wetlands, saturated buffers
- Bioreactors
- Cover Crops, perennials, etc.

Change in Water Quality

- Nitrogen
- Phosphorus
- Sediment

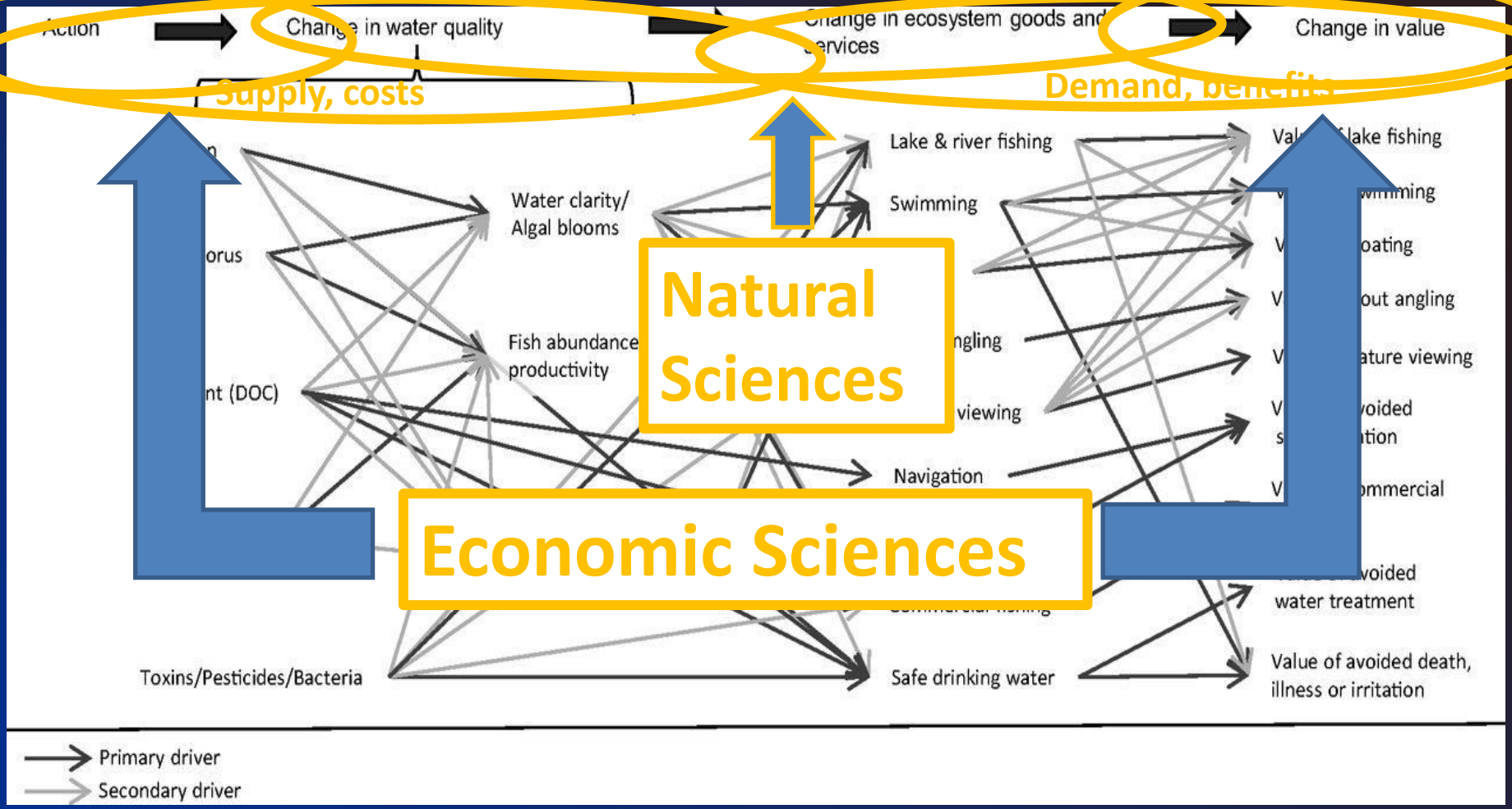
Change in Ecosystem Services

- Fishing, boating, nature viewing
- Drinking water, swimming
- Navigation
- Nonwater related services (carbon, etc.)

Change in Value

- Willingness to Pay (if monetizable)
- Physical units (if not)

Relationships between water quality change, multiple ecosystem goods and services, and associated changes in values



Bonnie L. Keeler et al. PNAS 2012;109:18619-18624

Costs of Achieving HAB reductions

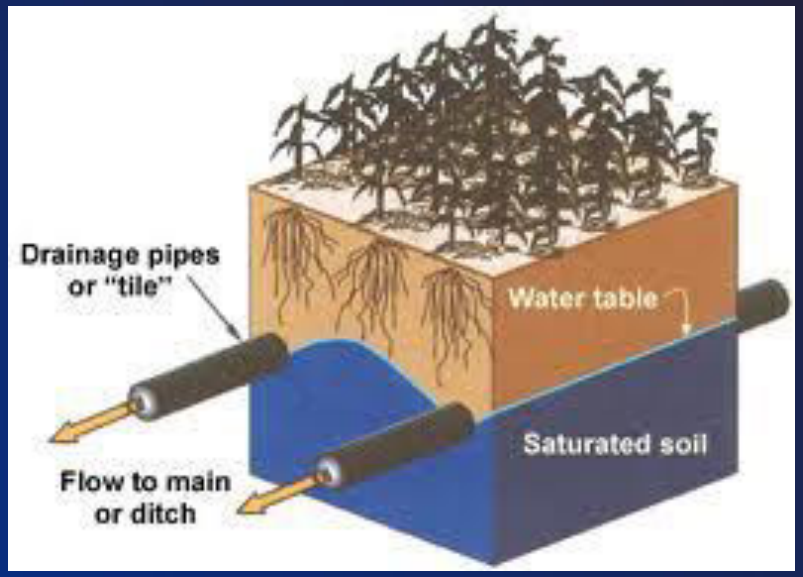
What are the lowest cost ways to reduce nutrients coming from row crop agriculture?

Costs = direct out of pocket expenses +
lost yield – lower input costs +
increased management time +
increased risk +
aesthetics

Approaches to Reduce Nutrient Runoff

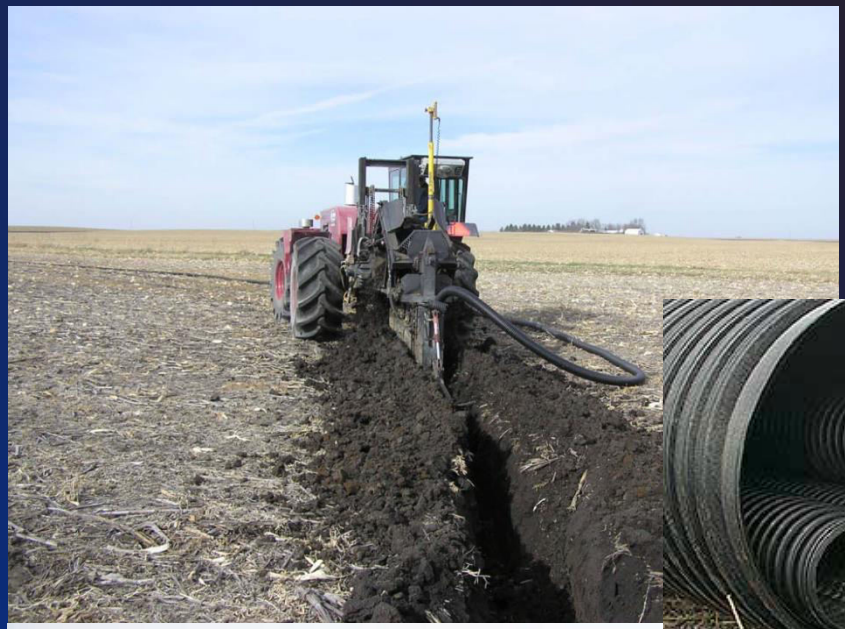
- Reduce application/change timing
- Reduce tillage
- Buffers
- Denitrification, controlled drainage
- Cover crops, rotation changes
- Wetlands
- Land retirement (CRP)
- New technologies?

Tile Drain Landscapes



Lowell Busman and Gary Sands

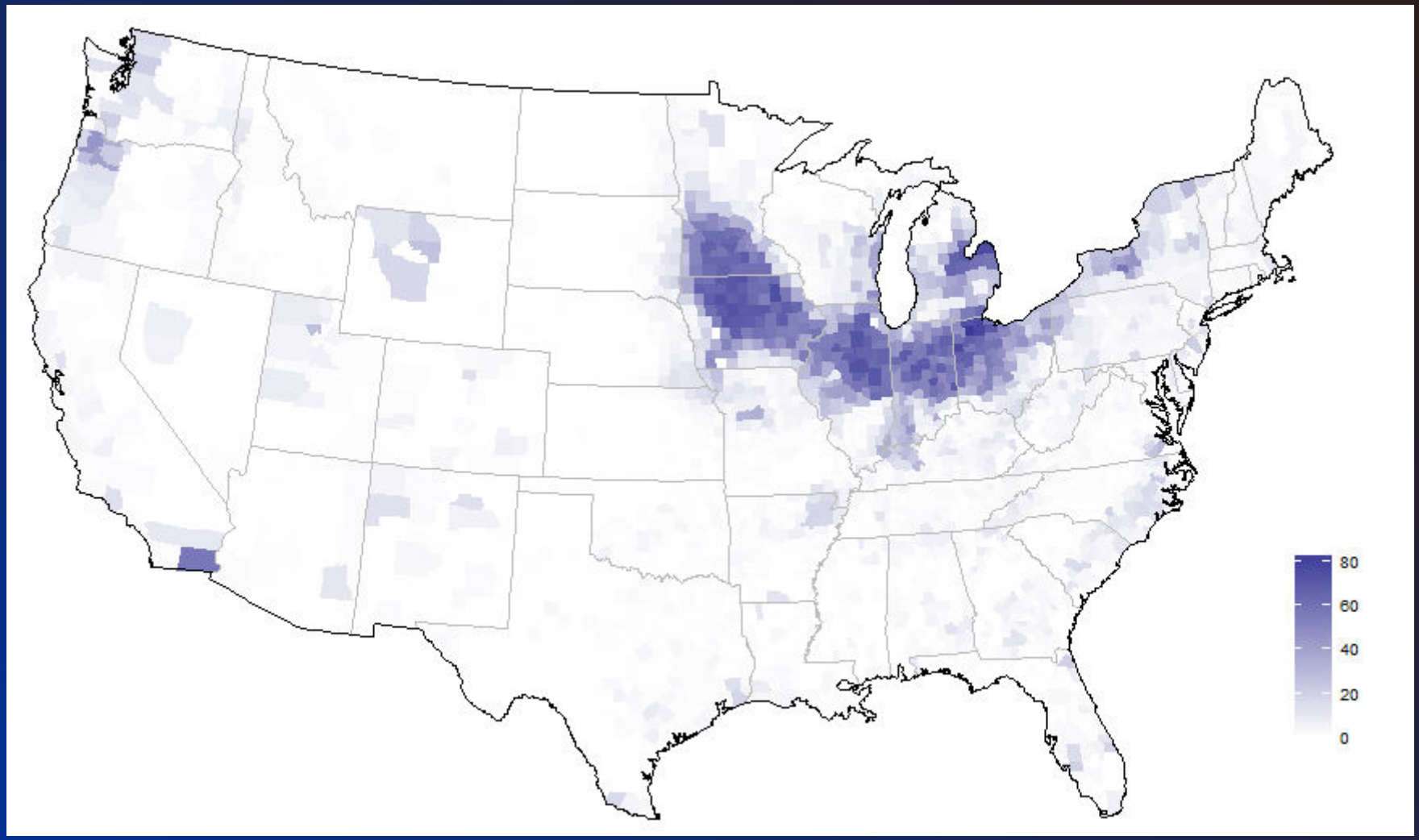
Tile drains:
Is this a point source?



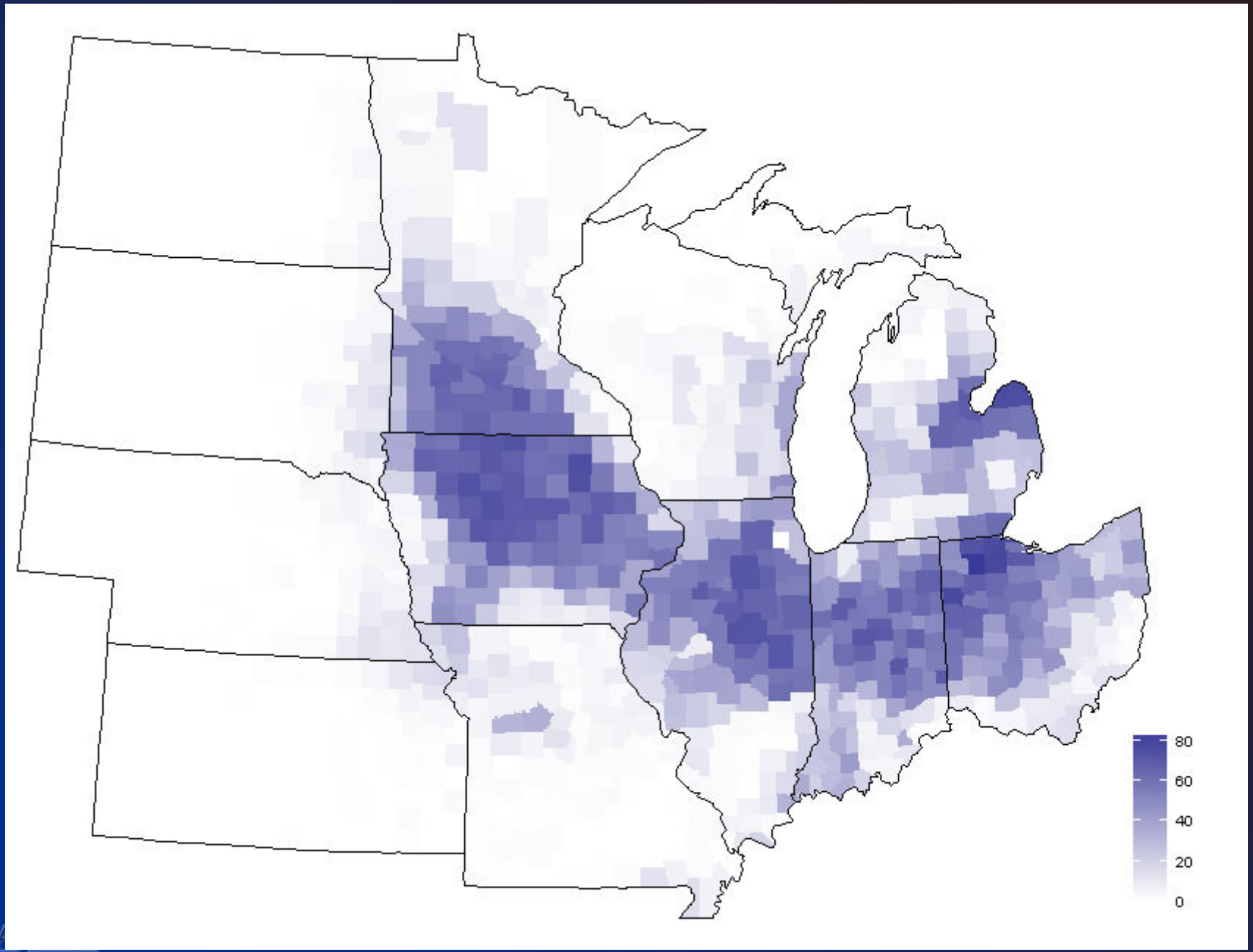
Photos: Matt Helmers

Photo: USDA-ARS

Tile Drainage: A game changer in movement of nutrients from the land to the waterways



Source: 2012 US Census of Agriculture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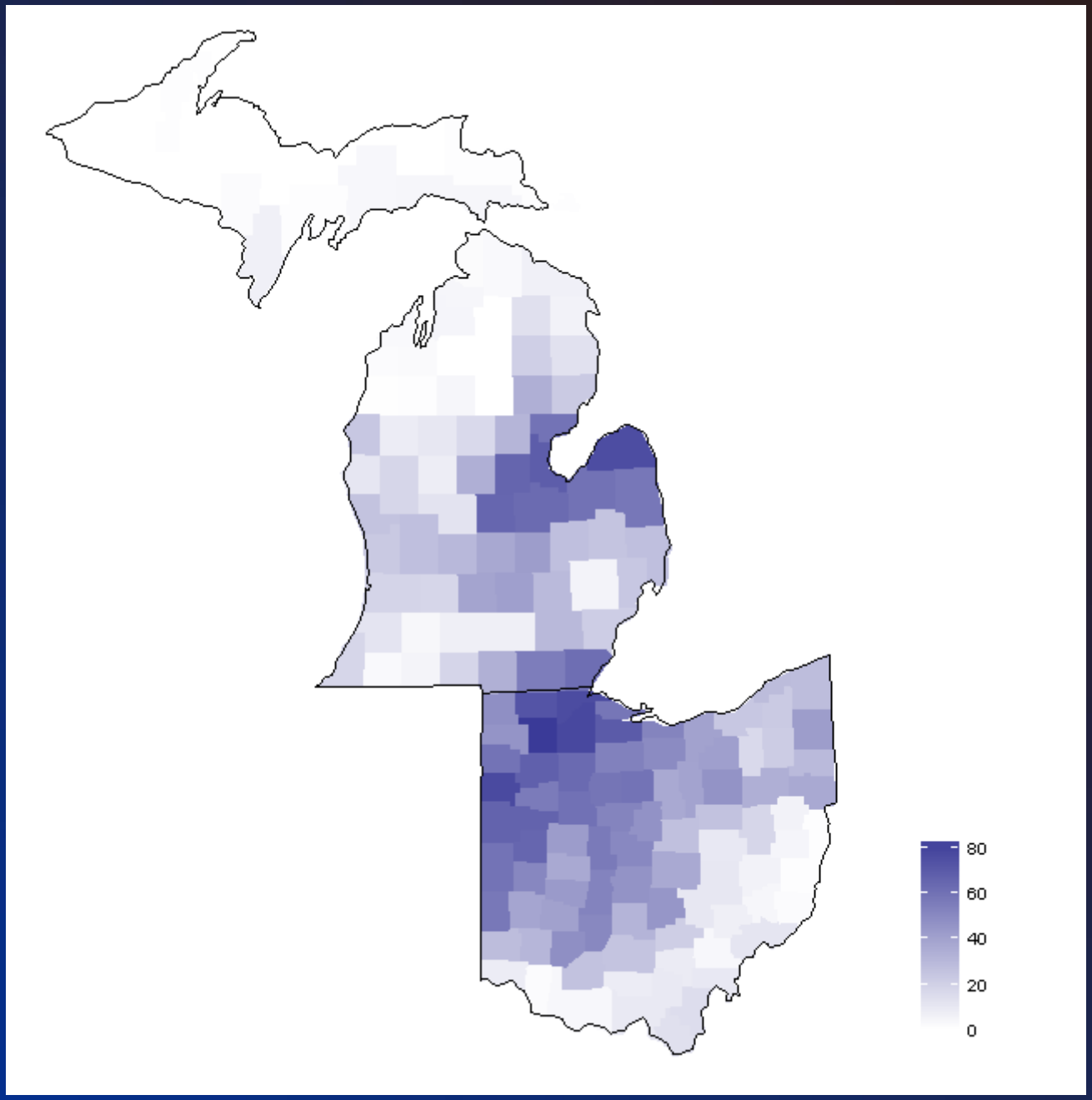
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Alternatives for Tile-drained Landscapes?

Nutrient-Removal Wetland

Bioreactor

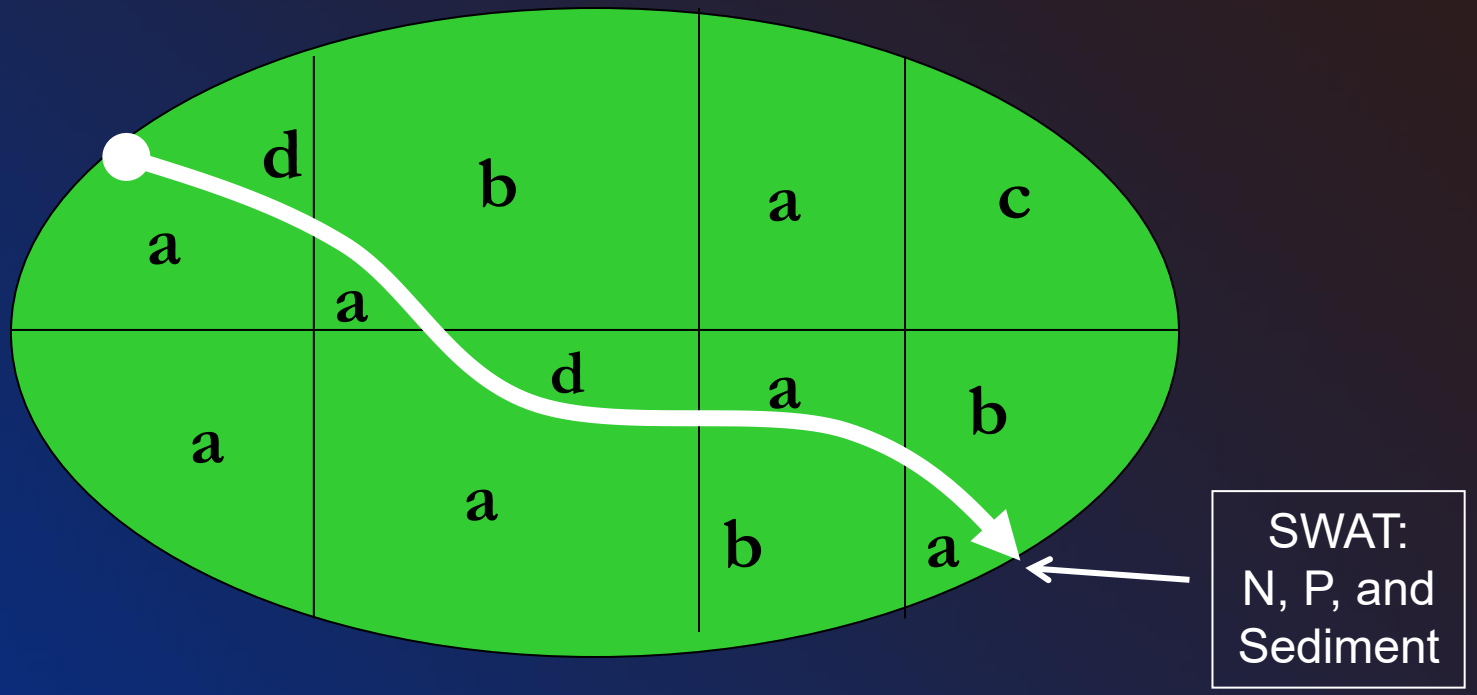

Saturated Buffer
Tile drainage into buffer

Land Retirement

Panoramic view of gamma grass-big blue stem planting

http://www.fsa.usda.gov/Internet/FSA_Image/ia_767_15.jpg

Optimization of the landscape to achieve specific goals for sediment, nutrients, other



13 Fields, 4 land use/abatement options: a, b, c, d

Solutions mapped in "decision space"

Rabotyagov et al.
PNAS, Dec 2014

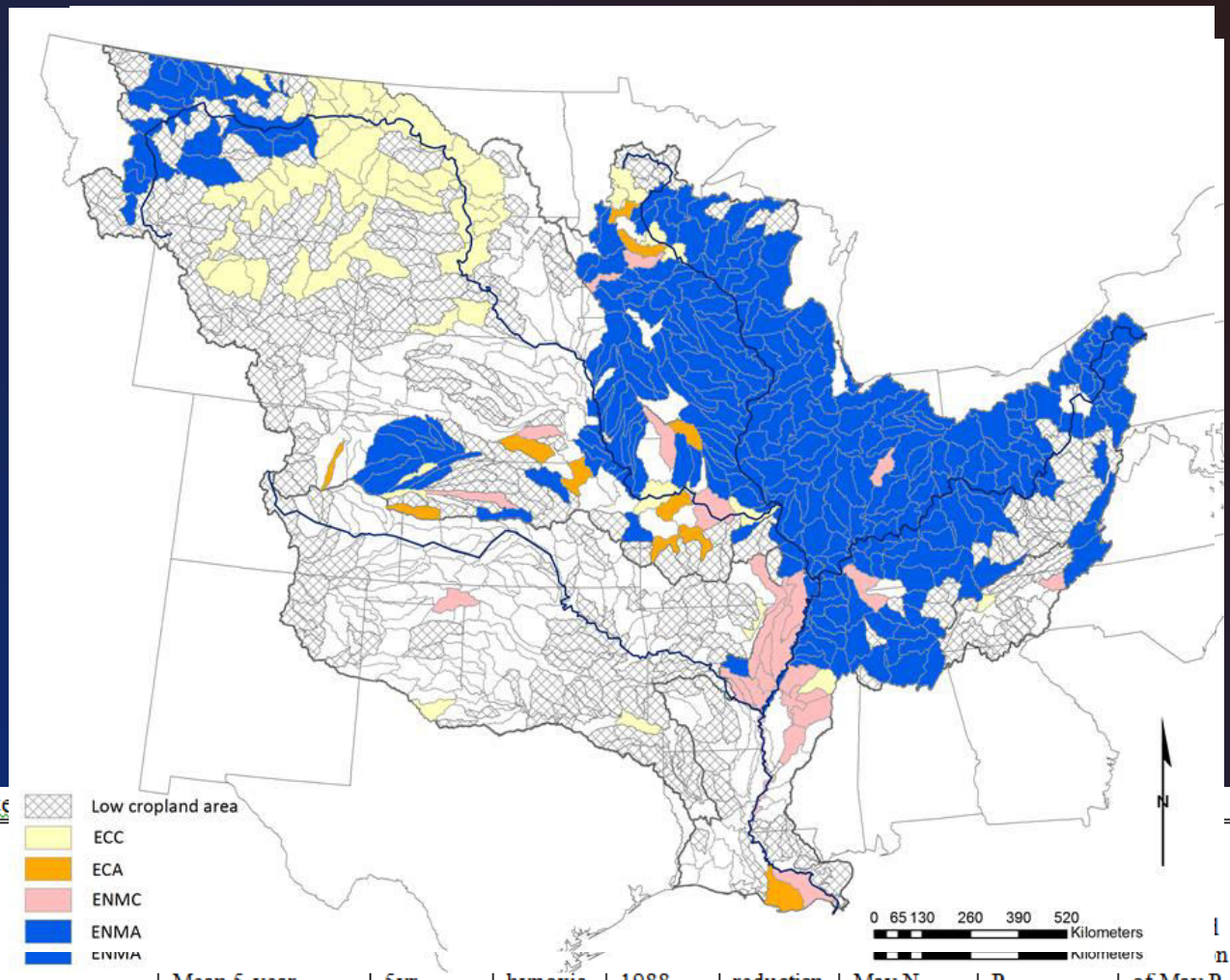
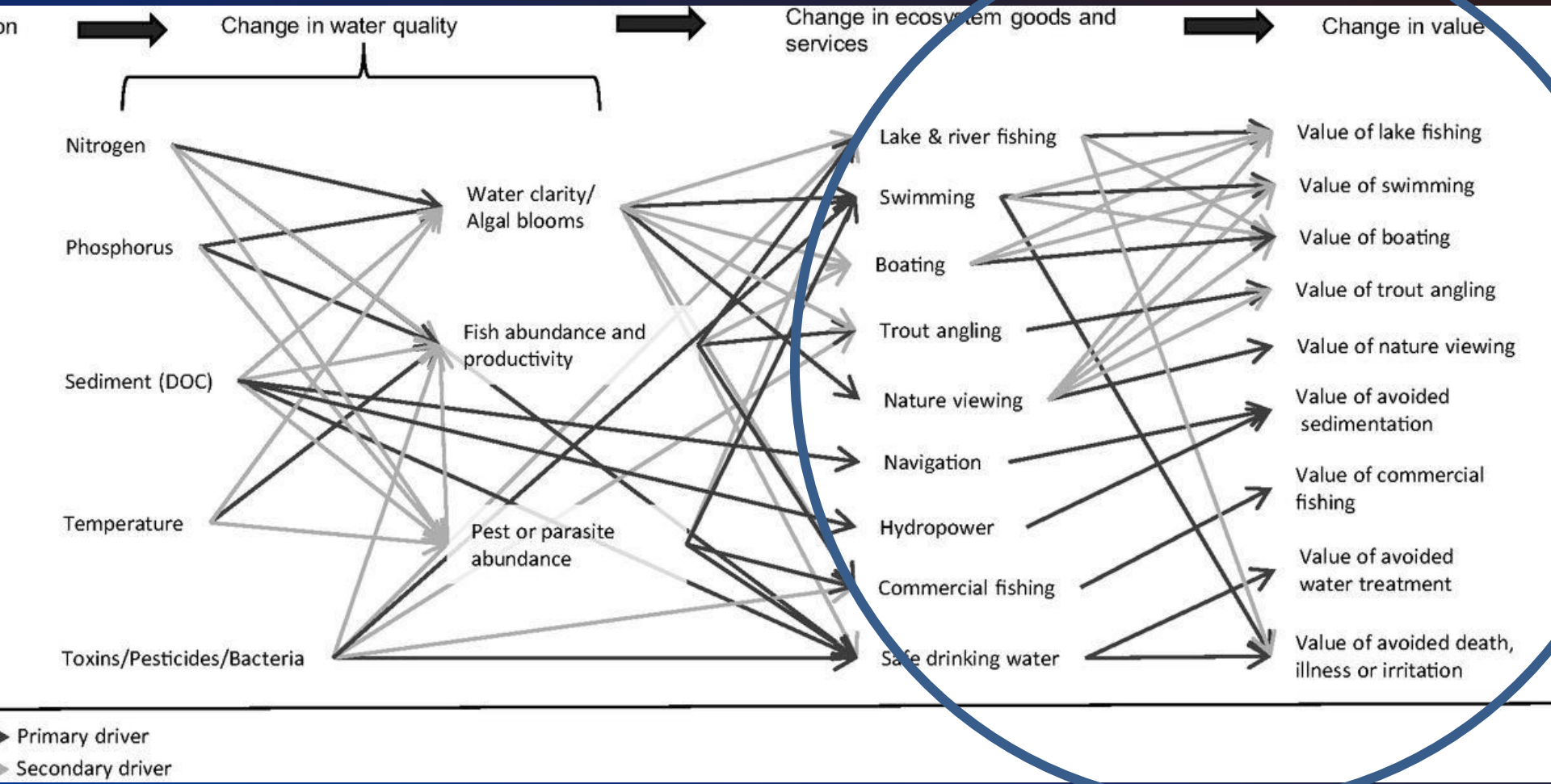


Table S4. Selecte

Percent reduction in mean 5-year hypoxia‡‡‡	Cost, $/year	Mean 5-year hypoxia, km²	5yr hypoxia	hypoxia level	1988-2006	reduction, %	May N reduction,%	P reduction,%	of May P reduction,%
0	0	12521.0	4026.4	250	5.3	0	0	0	0
10.0	280,157,155	11273.8	4222.5	225	15.8	2.6	1.5	5.5	3.1
20.9	704,808,376	9903.0	4004.2	198	21.1	6.3	2.3	8.6	3.9
31.0	1,081,050,060	8639.0	3913.1	173	21.1	9.0	3.0	12.2	4.7
40.8	1,541,367,866	7410.9	3501.4	148	26.3	12.4	3.5	14.2	5.0
52.5	2,310,022,852	5944.0	3121.2	119	31.6	16.1	4.7	17.2	6.3
60.2	2,731,814,534	4983.8	2877.6	100	47.4	18.7	5.3	19.2	7.1
70.2	3,970,484,639	3736.8	2468.1	75	63.2	22.4	5.3	22.8	6.9
76.7	5,572,462,555	2916.2	2156.1	58.3	84.2	25.1	4.9	24.6	7.2

Demand Benefits from Reduced HABs



Value from Ecosystem Services

- Concept of “Economic Value” applies to all goods
  - Private, public, nonmarket, market, environment, etc.
  - Marshall (1890, “Principles of Economics)

- Premise: people take their personal resources (time, income) and allocate it to make themselves and families as well off as possible
  - They consider their likes, time, concern for nature, altruism etc.
  - To do this, they make trade-offs

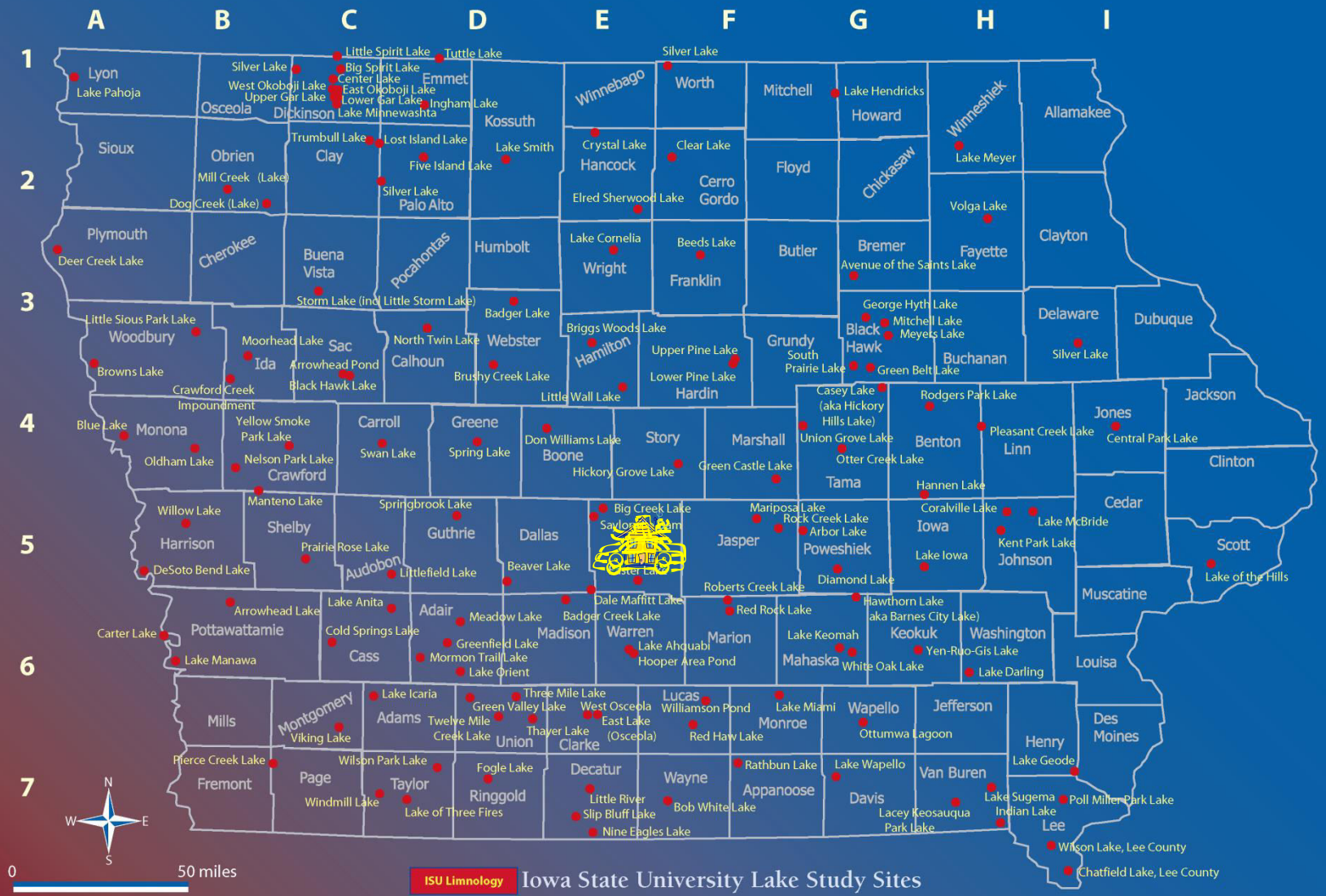
- Economic value of a good measures how much people are willing to give up to of other goods to attain or keep the good in question

Methods for Empirically Measuring the Value of Changes in Ecosystem Services

1. Revealed Preference Studies
   - Look for behavior and changes in behavior that reveal tradeoffs
   - Recreation demand studies
   - House prices related to ecosystem amenities
   - Wage studies

2. Stated Preference Studies
   - Direct questioning about tradeoffs
   - Contingent Valuation
   - Choice Experiments

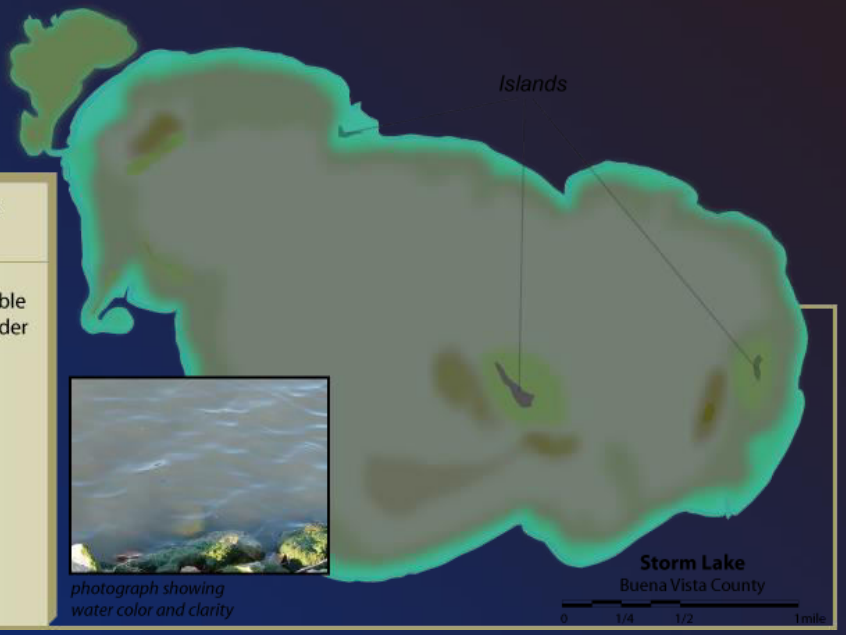
Using Travel Patterns to Reveal Valuation



Stated Preference Question: Would you be willing to pay $25/year in property taxes to support a project to improve the conditions of Storm Lake to those described below?

Current conditions of Storm Lake can be summarized as:

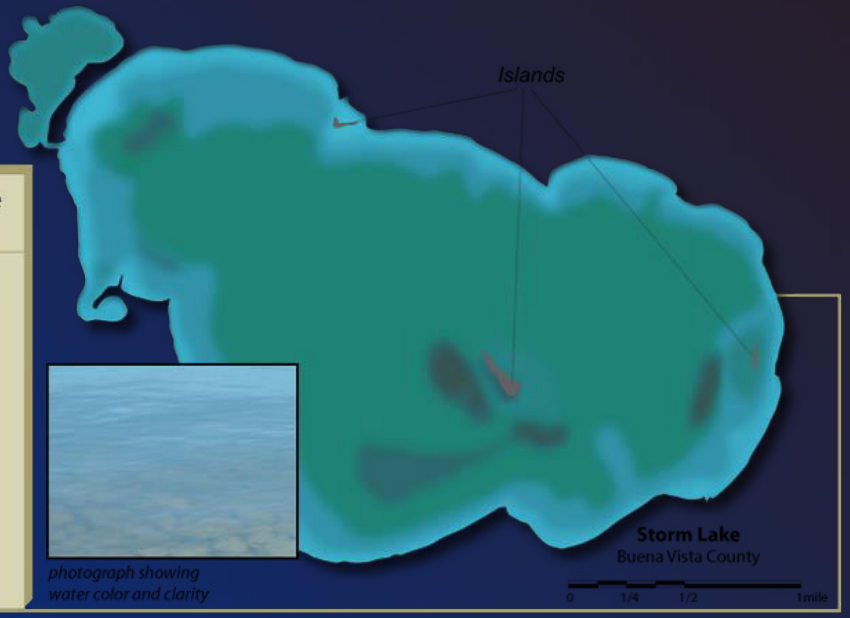
Water Clarity:	objects distinguishable 8 inches to 3 feet under water
Algae blooms:	2 to 5 per year
Water color:	brown to green
Water odor:	mild to strong odor
Bacteria:	possible short-term swim advisories
Fish:	low diversity



photograph showing water color and clarity

Improved conditions of Storm Lake can be summarized as:

Water Clarity:	objects distinguishable 6 to 8 feet under water
Algae blooms:	Rarely more than 1 per year
Water color:	green to blue
Water odor:	usually fresh
Bacteria:	rare swim advisories (most years none)
Fish:	high diversity



photograph showing water color and clarity

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Ecosystem Services

- Economists have methods to incorporate the value of these services into Benefit-Cost Analysis

- Critically depends on natural science, ability to characterize and roughly measure ecosystem services

Ecosystem Service Questions

- What do nutrients do to other ecosystem services: wildlife? Commercial and recreational fisheries? Mix of species? Flora impacts?
- Are there potential irreversibilities in the system?

Policy Design

- Taxes
- Subsidies
- Voluntary approaches (not subsidized)
- Regulations (required practices)
- Standards (tradable permits)
- Conservation compliance

Taxes

- On what? Fertilizer inputs, water quality?

- Fertilizer taxes
  - Historically small, used for revenue generation
  - Much larger would be needed to alter quantity

- Effectiveness depends on answers tonatural science questions

Subsidies

- On what? Practices, reductions in pollutants?
- Major federal subsidy programs (practices)
  - Conservation Reserve Program
  - Wetlands Reserve Program
  - EQIP (working lands)
  - Conservation Security Program
  - EPA 319 funding
- Lots of state programs

Voluntary Approaches

- Encouragement of use of BMPs

- Ex: State Nutrient Reduction Strategies developed under Hypoxia Taskforce
  - Infield options will only reduce nutrients in water by less than 10%
  - 90+ percent of crop acreage will need to be treated with cover crops, wetlands, bioreactors or other

Environmental Regulations in Agriculture

- Nonpoint Sources exempt from Federal Clean Water Act, but states can regulate
- Winter bans on manure spreading: Vermont, Maine, others NOW Ohio
- Vegetative buffer requirements: Minnesota, agricultural areas near waterways require 50’ buffer strips --- EWG identified lack enforcement
- California: zoning and more

Maryland: Chesapeake Bay

- Spring 2013

All farmers must incorporate organic nutrients into the soil within 48 hours of application.

- Fall 2013

Farmers are required to plant cover crops when applying organic nutrient sources to fallow ground in the fall. New limits for fall nitrogen applications on small grains take effect for all farmers.

- January 1, 2014

A 10 to 35 ft. “no fertilizer application zone” must be in place adjacent to surface waters and streams. Pasture management practices must be installed to protect streams.

- July 1, 2016

Nutrient applications are prohibited between Nov 1 and March 1 for Eastern Shore farmers and between Nov15 and March 1for Western Shore

http://mda.maryland.gov/resource_conservation/counties/NMPqanda.pdf

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BMPs: Everglades Agricultural Area

Everglades Regulatory Program

- goal 25% P reduction overall
- mandatory BMPs, 1995
- Implemented via points
  - flexibility in BMPs, 25 points/farm
  - expert judgment set point values
  - must implement and monitor WQ

Wikipedia

Natural science questions

- Which nutrient needs to be reduced, N, P, or both? How much? What time of year?
- Can we achieve reductions in HABs with reduced application/timing alone?
- What other conservation actions (BMPs) keep N and P out of waterways?
- Are there likely to be new conservation actions that can achieve reductions?

Natural science questions

- How important is it to pay attention to differences across watersheds? Especially heavily tiled?

- How extensively do these practices need to be implemented to achieved desired reductions

Questions about nutrient reductions critical for policy design

- Can disproportionate gains accrue from placement of these practices on landscape (geographic targeting)?

- Will practices that achieve reductions in N and P produce other ecosystem services? What are they? What is their magnitude?

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Maximum Willingness-to-Pay (WTP)

- Economic Value of a good or service = maximum amount an individual is willing to pay for a good or service
  - Do people want to pay this? No, but they would rather pay it than be forced to live without the good
  - Do they have to pay it? No, but would be willing to rather than be forced to do without the good
  - If they get it for less, then they get surplus.

- Asides on WTP
  - Anthropocentric
  - Values are not intrinsic to a good
    - Units of “energy” or “species richness” intrinsic to a good doesn’t work unless they translate into something valuable to people
    - this DOES NOT mean mere existence preservation of natural world is not valuable (I value it, do you?)

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