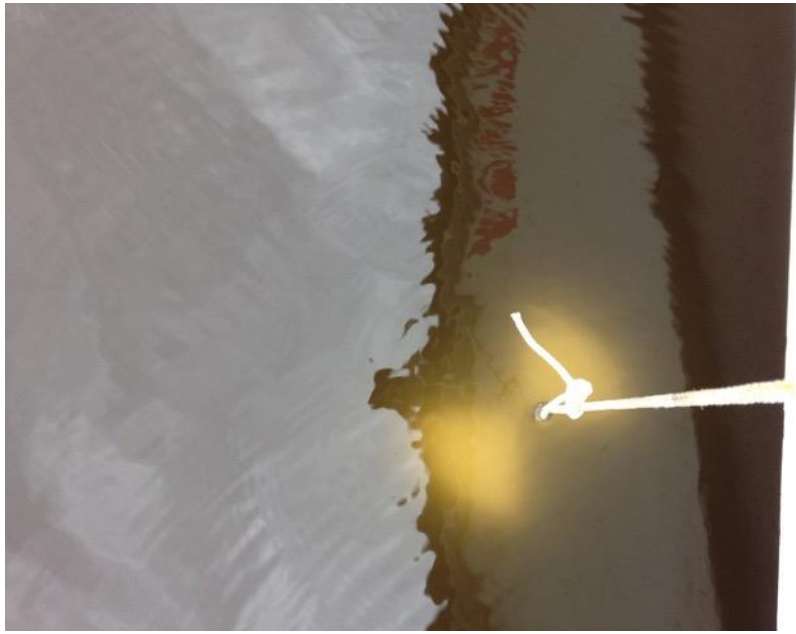
Massive ecosystem services impact by invasive spiny water flea in Lake Mendota, WI



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Center for Limnology
University of Wisconsin

Outline

- Background: The $$$ implications of invasive species & ecosystem services
- Spiny water flea in Lake Mendota: Ecology and Economics

Invasive species' global impacts

- Ecosystem functioning (Ehrenfeld 2010)
- Extinction (Clavero & García-Berthou 2005)
- Economy and human well-being (Pimentel et al. 2005, Charles and Dukes 2007, Keller et al. 2009, Pejchar and Mooney 2009, Rothlisberger et al. 2012)



Ecosystem services

- The benefits humans derive from nature, largely for free

Ecosystem services provide social and economic value

Global value of ecosystem services?

(Costanza et al., *Global Environmental Change*, 2014)

over $100 trillion per year

(greater than Global GDP)

losing $4 – $20 trillion per year

(from 1997 – 2011)

Invasive species & Ecosystem services

- Invasive prevention, control, and eradication protect ecosystem services → protects real economic value

Outline

- Background: The $$$ implications of invasive species & ecosystem services
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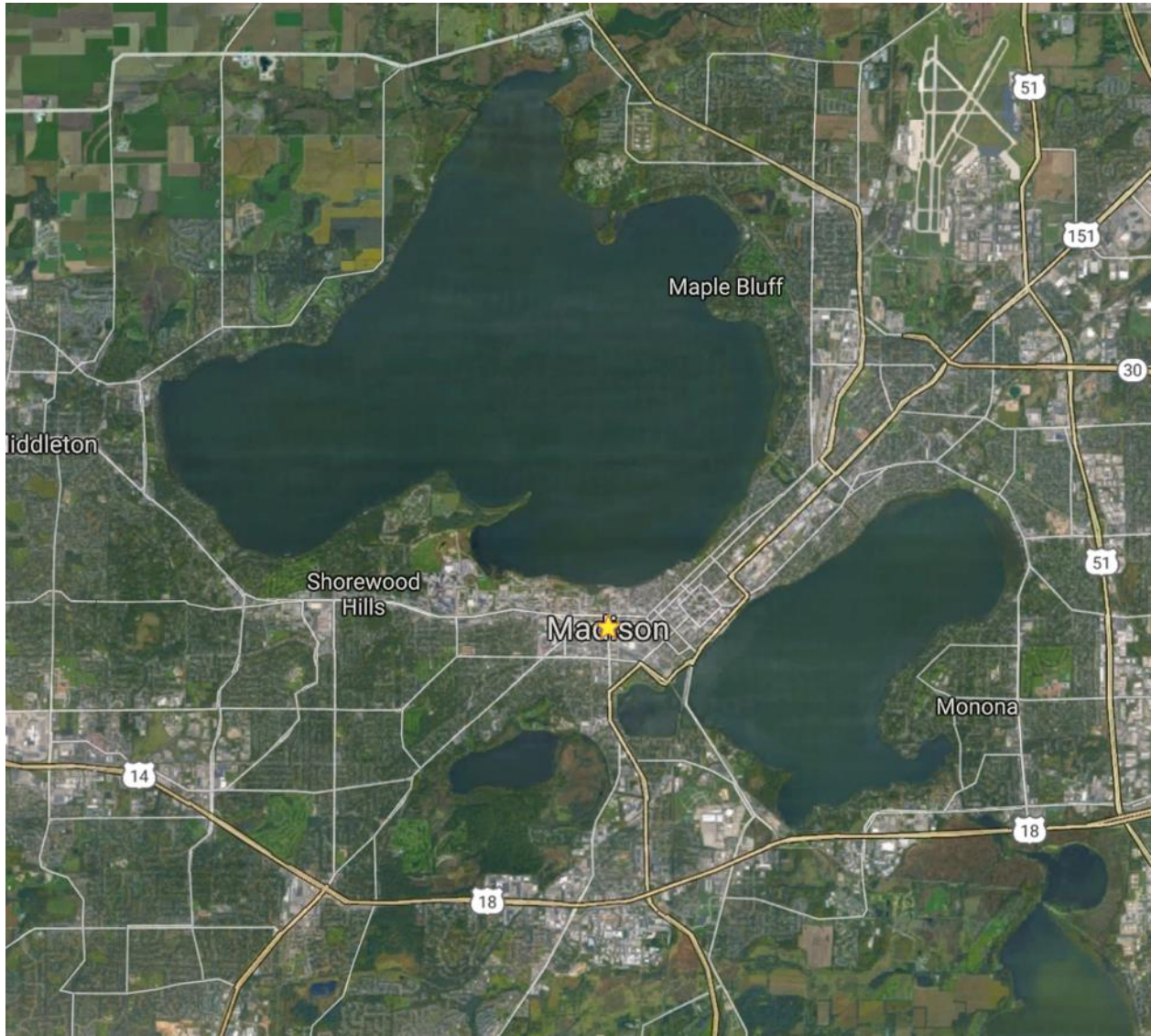
Lake Mendota (Madison, WI)

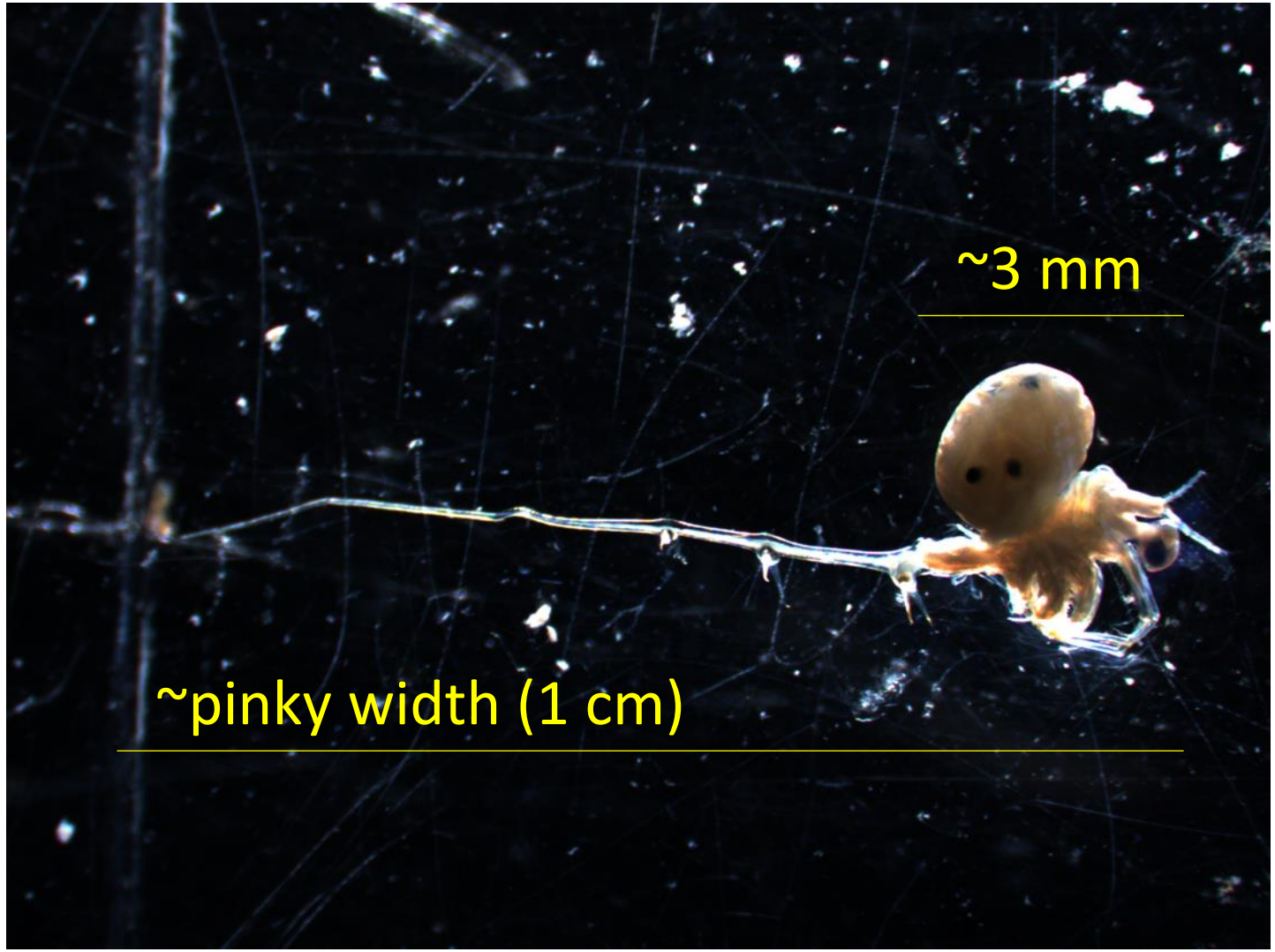
- Eutrophic
- 15 mi^2 (40 km^2) area
- 80 ft (25 m) max depth

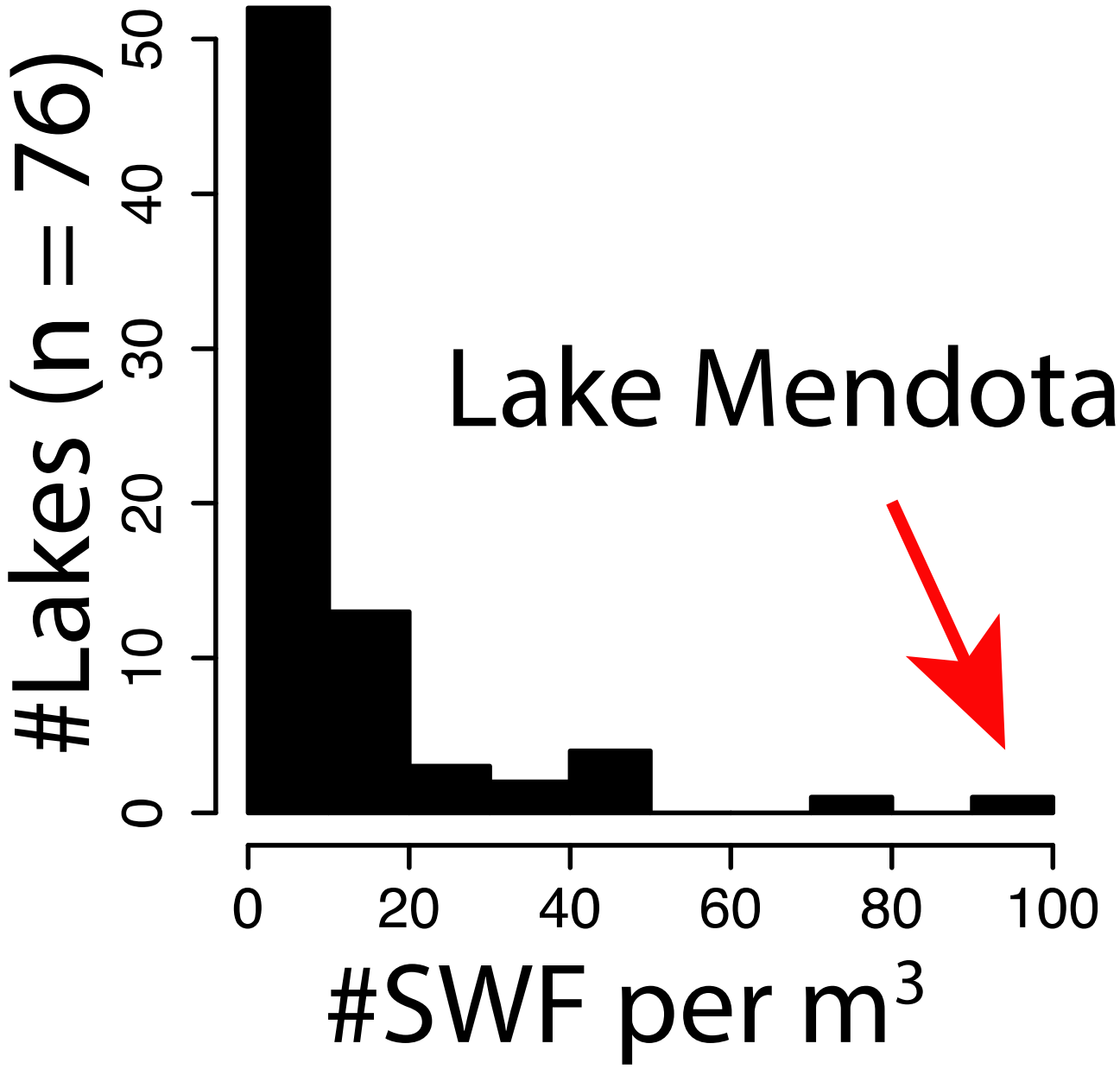
- Agricultural watershed



Spiny water flea (*Bythotrephes longimanus*)

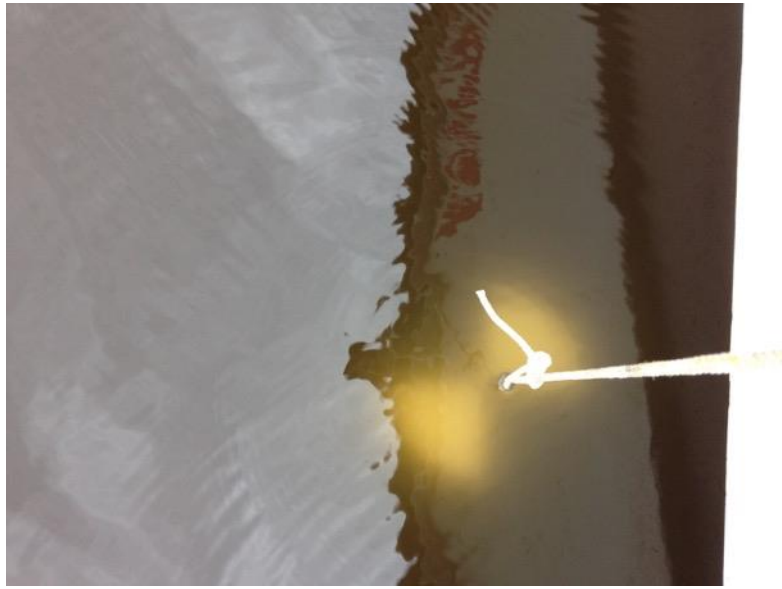
- Invasive predatory zooplankton
- Native to “Eurasia”
- Lake Mendota 2009




#Lakes (n = 76)
0
10
20
30
40
50
Lake Mendota
0
20
40
60
80
100
#SWF per m3

Spiny water flea preys selectively on *Daphnia*

Daphnia:
the unsung heroes of water quality in Lake Mendota



Maintain clear water by grazing algae (Lathrop 1999, 2002)

Water quality in Lake Mendota

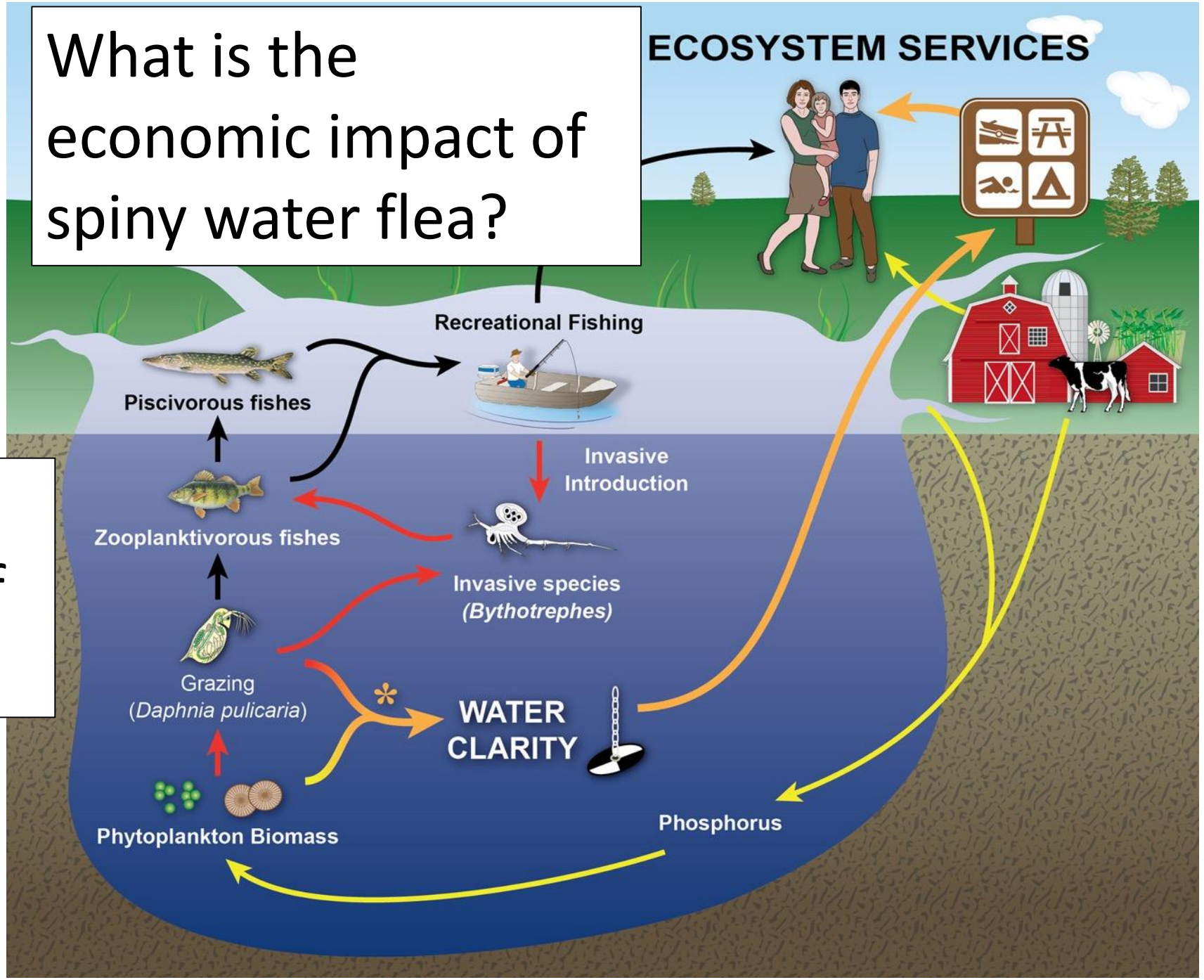
Degraded by nutrient run-off

Improved by grazing *Daphnia*

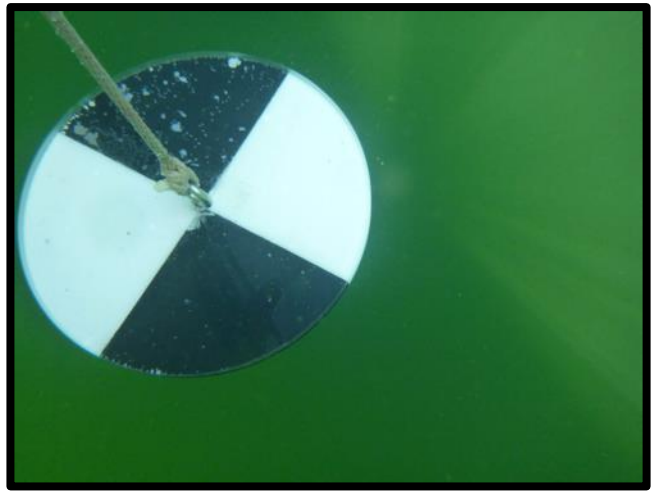
“Socio-ecological system”

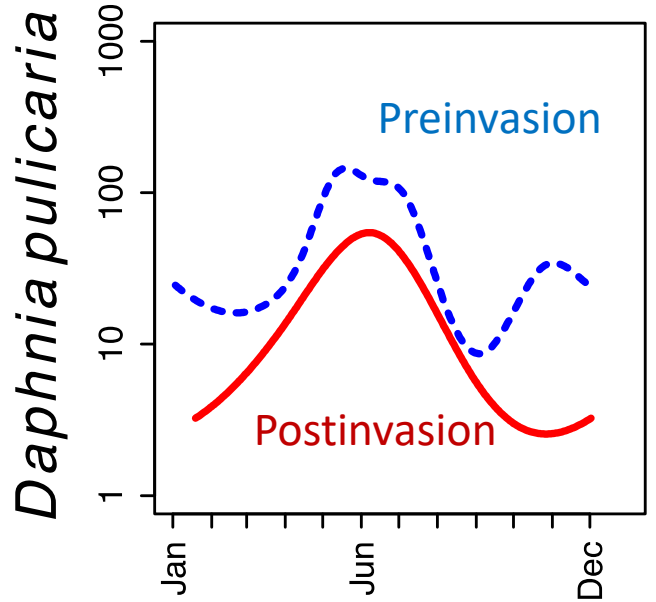
What is the economic impact of spiny water flea?

What is the ecological impact of spiny water flea?

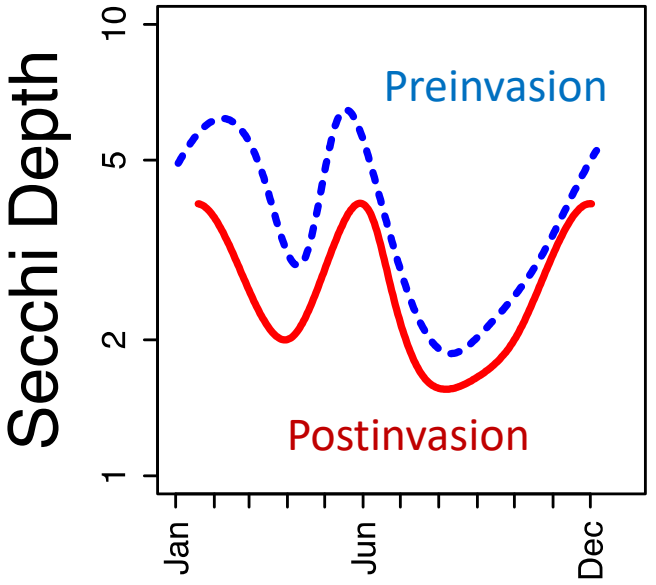


What was lost, ecologically.





-60%



~-1 m

What was lost, economically: Value of 1m of clarity

- 2001: “Willingness-to-pay” survey of 500 randomly selected citizens in Dane County
- **What would you pay for improved water quality in Lake Mendota?**

- $350 per household (2001)

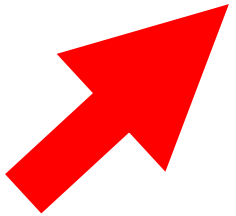
- Updated to present day value, new countywide census data:

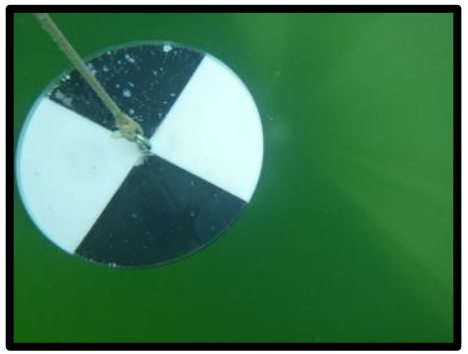
$140,000,000

How do we fix it?

Restoring water clarity

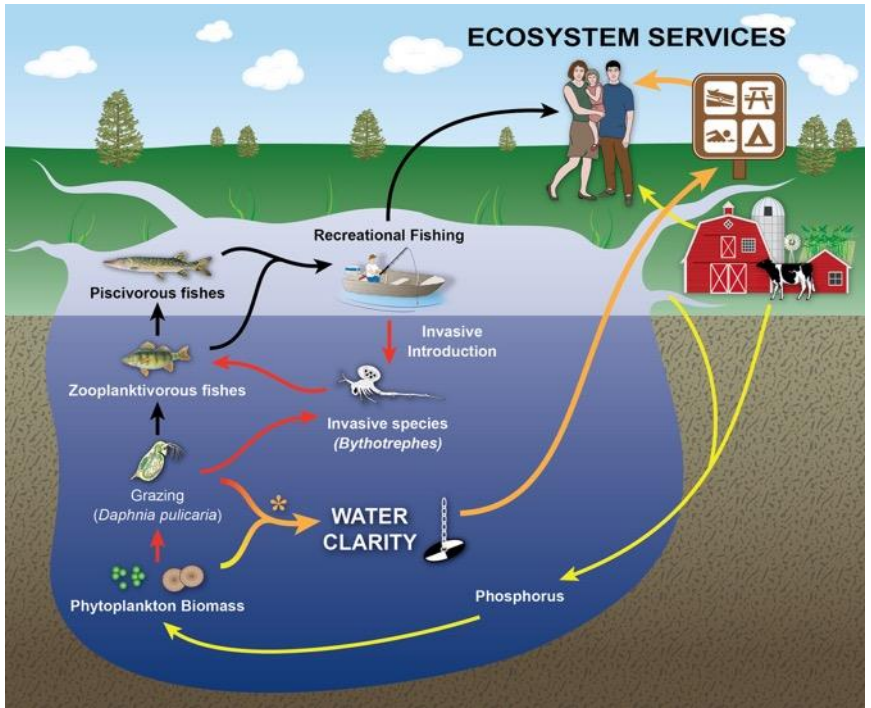
- No known control or eradication methods
- “Turn another dial” → P load reduction



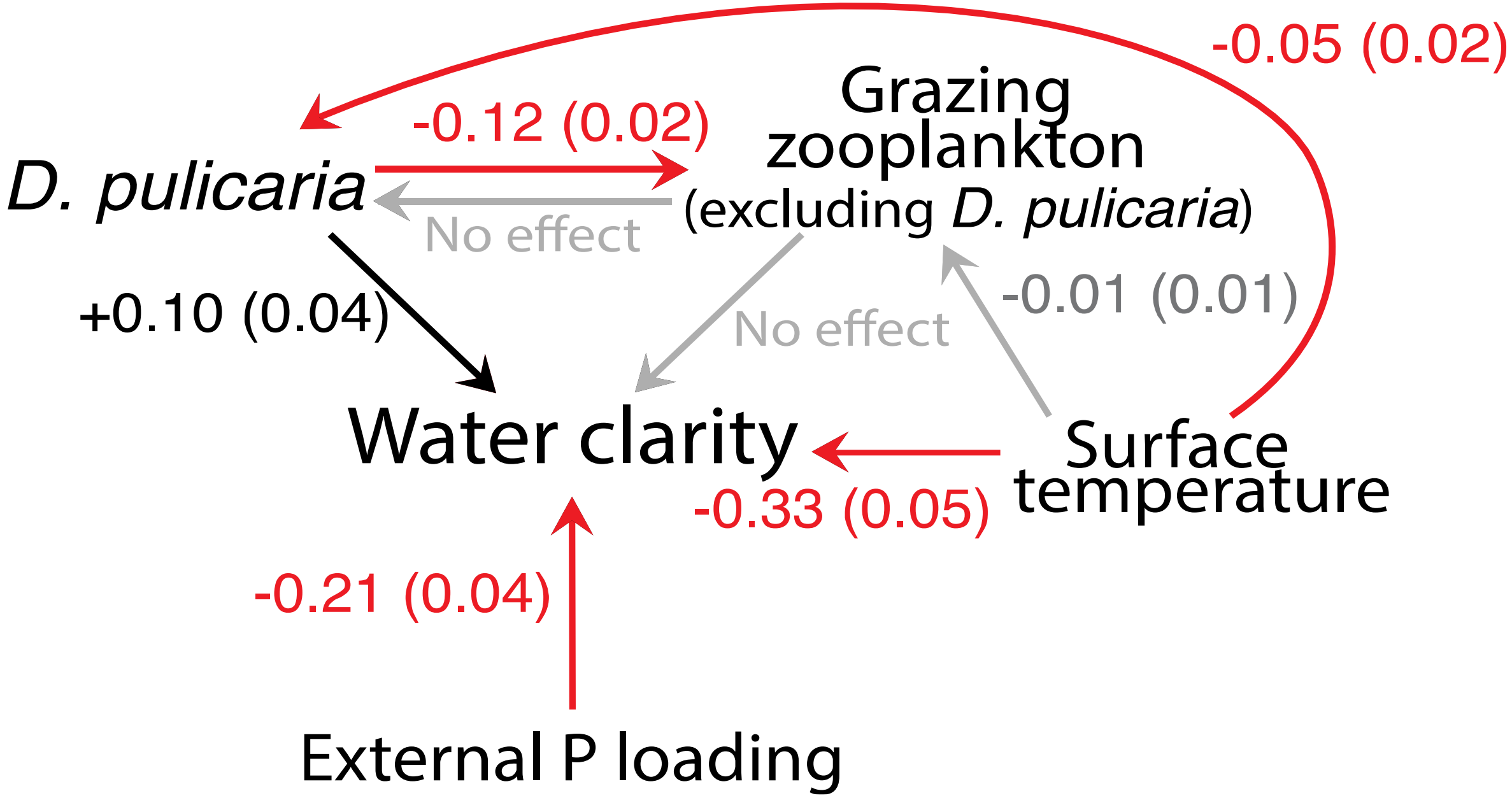


Approach – Statistical Modeling

- How do we know which dials to turn (e.g., P load, Daphnia)?
- What will happen if we turn a dial (e.g., improved or degraded clarity)?
- Build a statistical model (MARSS) using **long-term** data to represent Lake Mendota



The model

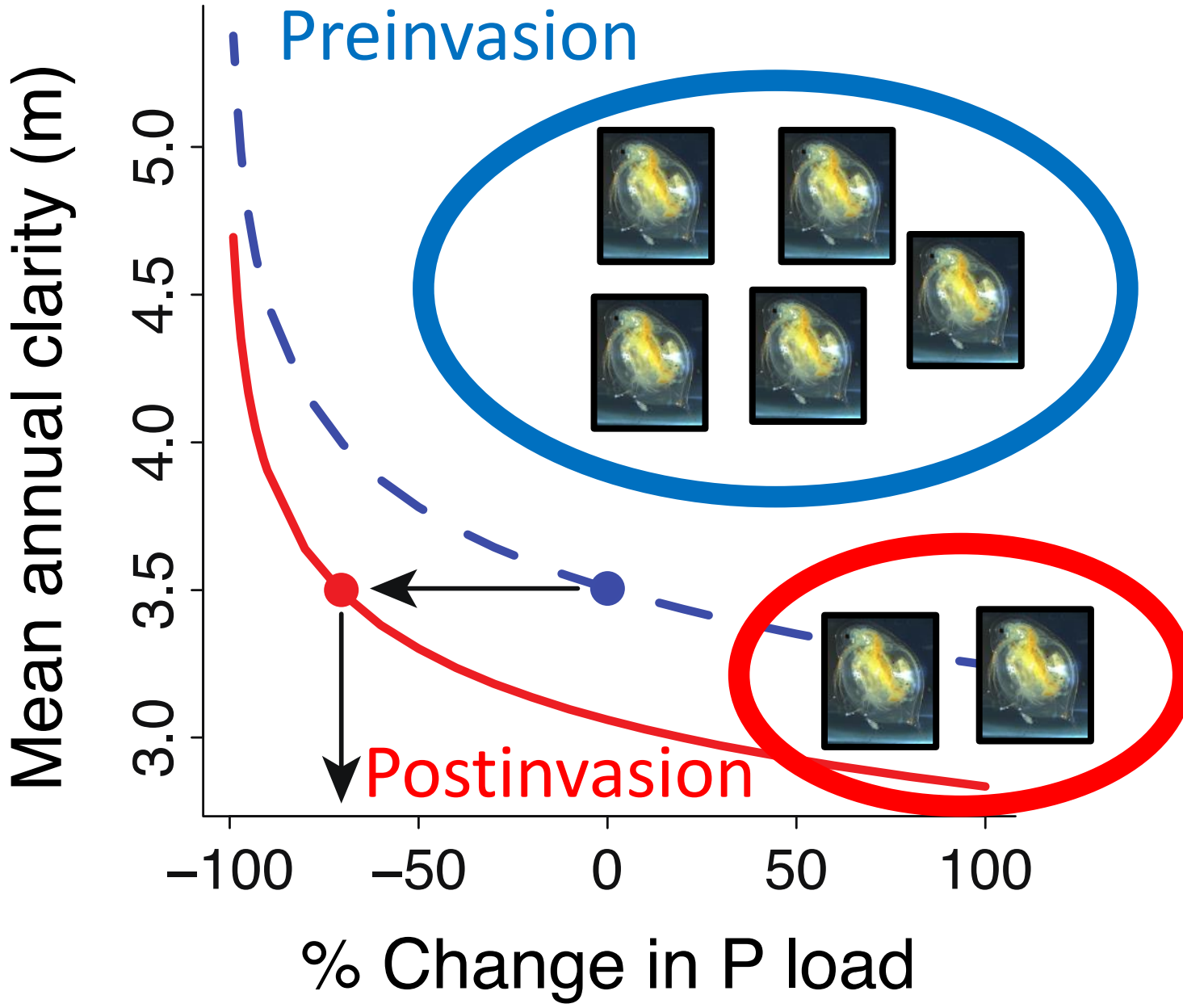

-0.05 (0.02)
-0.12 (0.02)
Grazing zooplankton (excluding D. pulicaria)
D. pulicaria
No effect
+0.10 (0.04)
No effect
-0.01 (0.01)
Water clarity
Surface temperature
-0.33 (0.05)
-0.21 (0.04)
External P loading

Model Prediction

- To get pre-invasion clarity
- Under post-invasion grazing

- Would take a **71%** reduction in P loading

- >> long-term 50% reduction goal



What would a 71% reduction cost?

- Yahara CLEAN Engineering Report (Strand Associates 2013)
- Best management practices and associated costs to achieve P load reduction goals

- Choosing most and least efficient options to get to 71%:

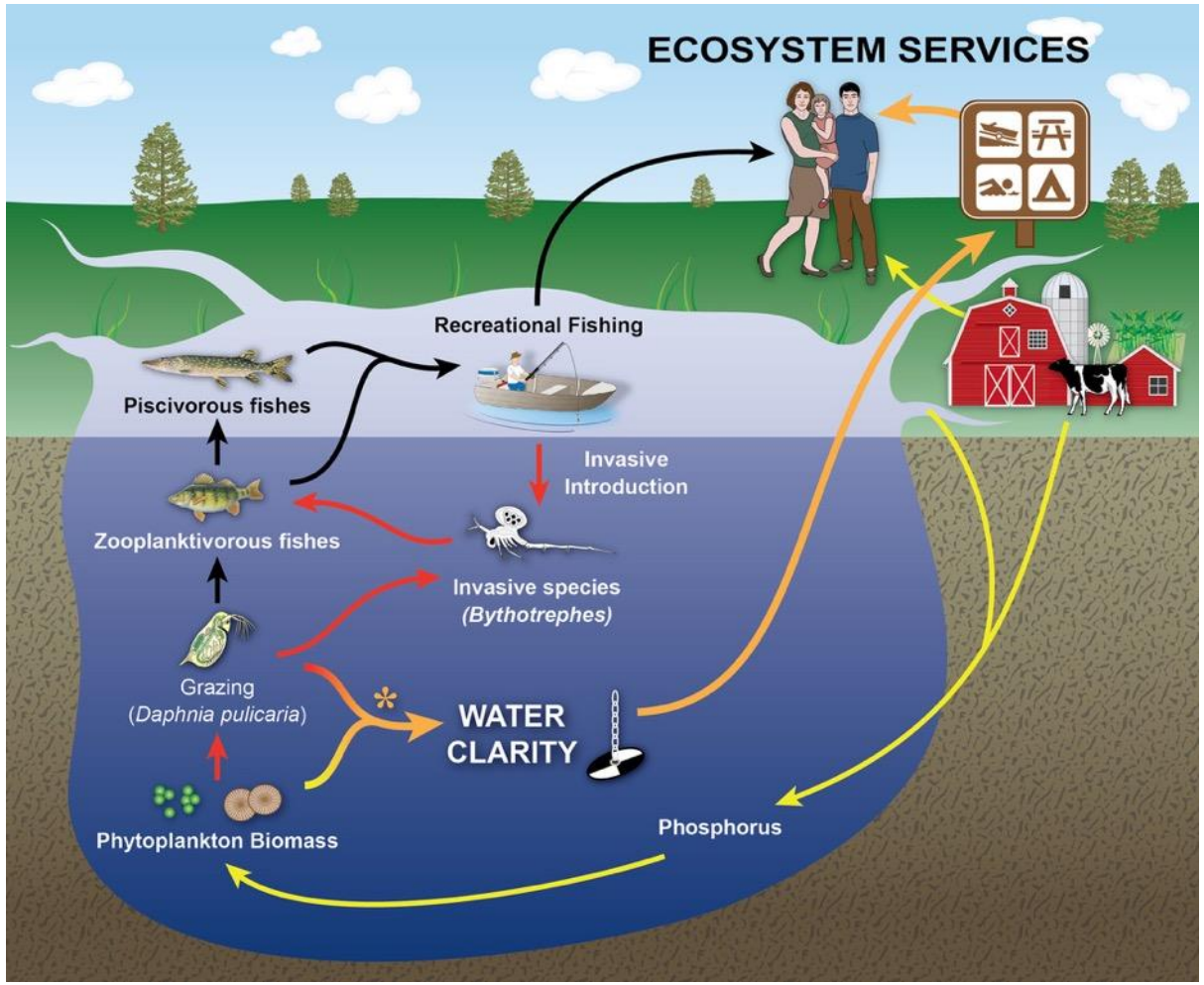
$86.5 million - $163 million

What is the cost of the spiny water flea invasion?

A lot.

- $80M – $160M to restore a service worth $140M

- One invasive species in one lake, affecting one service



Invasive prevention, control, and eradication protect ecosystem services → protects real economic value

- At scale, invasive damages highlight extreme value of prevention
- Researching and implementing control methods can be expensive, but expenses may be small relative to value of protected services
- Need to consider lakes and invasion in a “socio-ecological system” context

Thanks for listening!

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