



**For the love of rivers:
conservation ecology
within an ecosystem
services framework**

Carla L. Atkinson

THE UNIVERSITY OF
ALABAMA
B I O L O G Y



To promote translation between disciplines we need to understand the interaction between organismal and ecosystem-level processes



Why I love rivers



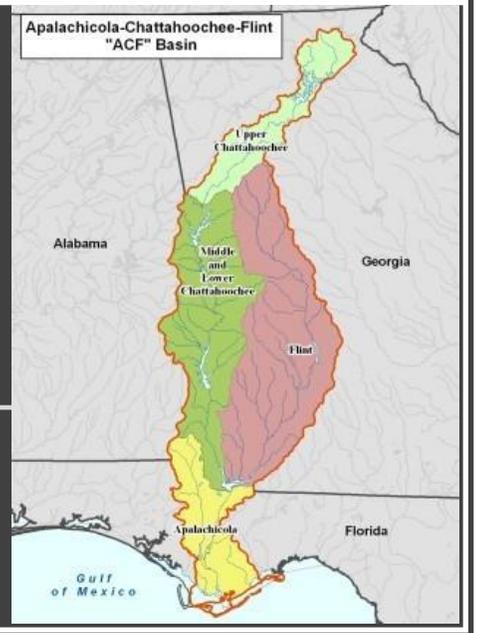
"Water is the critical issue of our lifetime and most our children's lifetime. The health of our waters is the principal measure of how we live on the land."

-Luna Leopold-

Why I love rivers



I came to the ACF
first in 2006

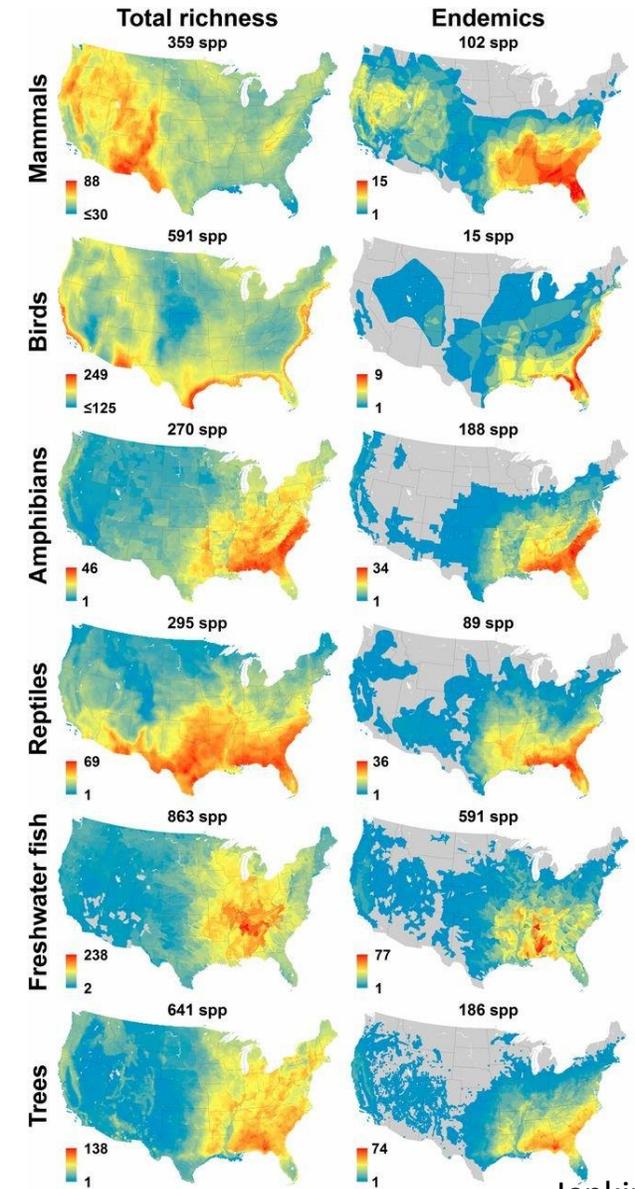


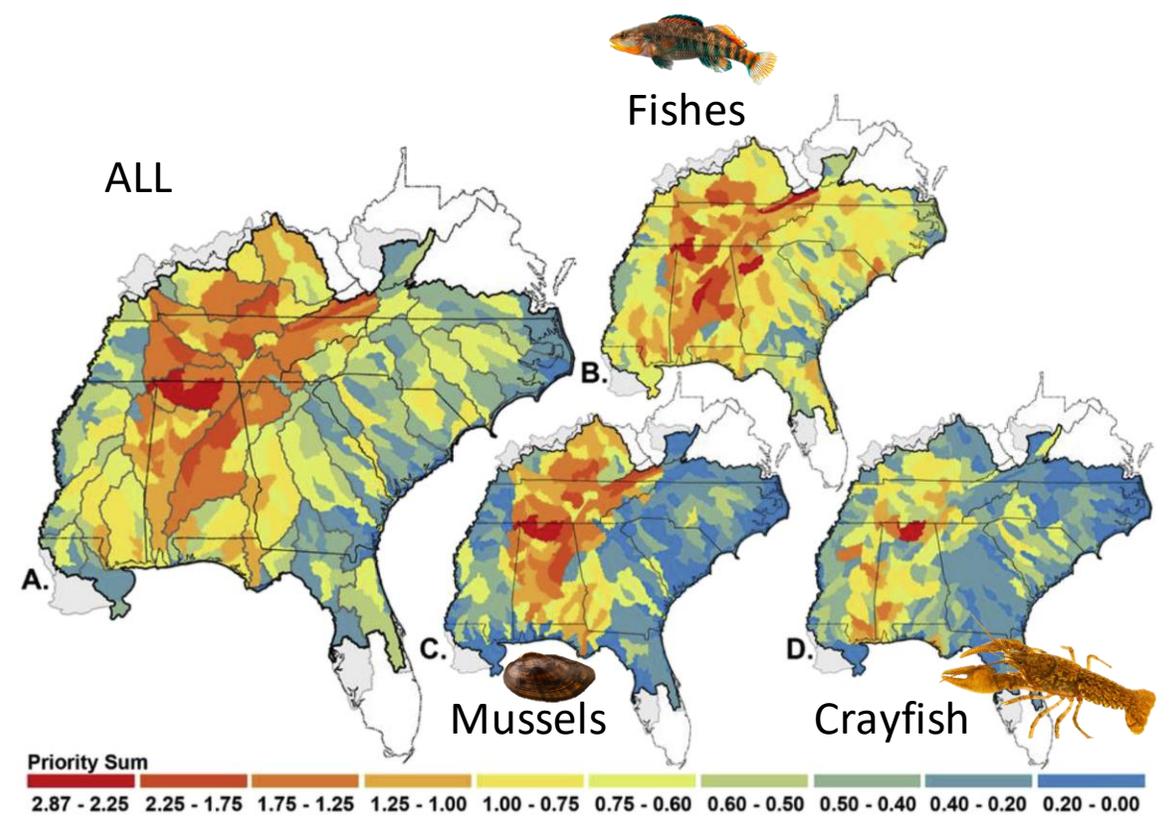
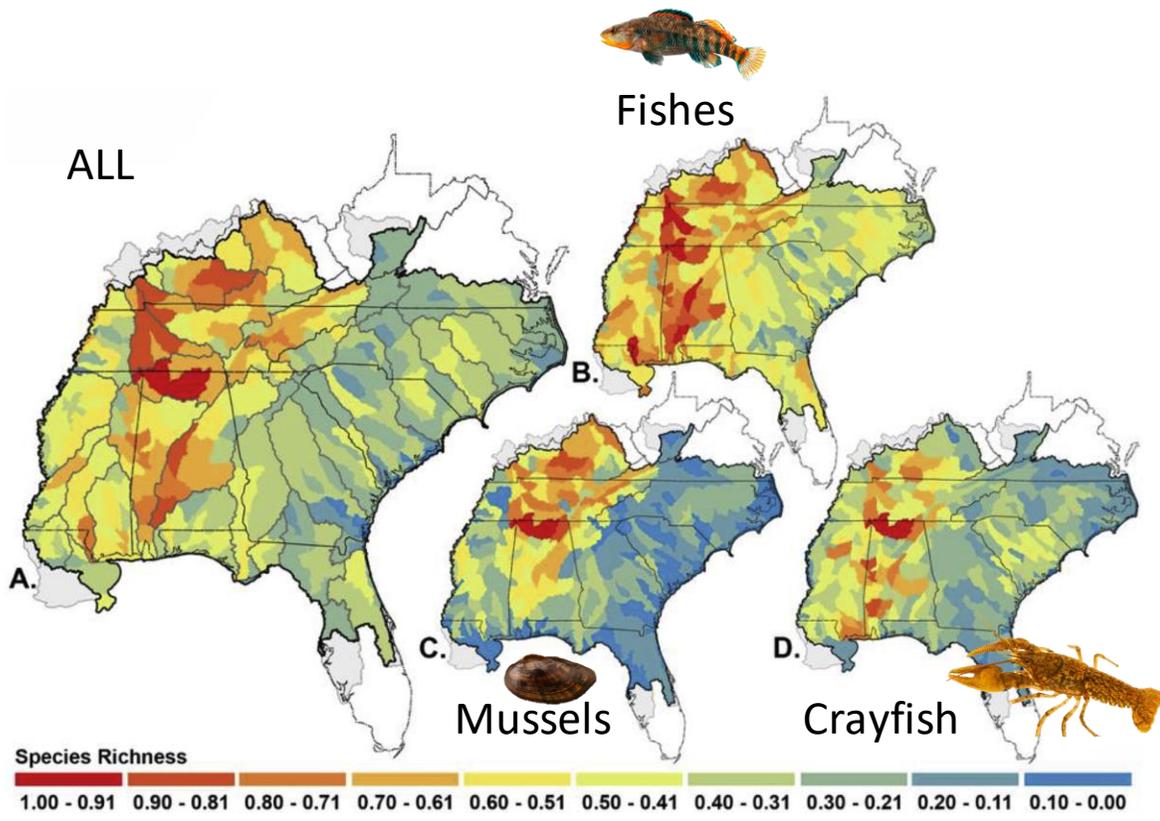
Diversity of habitats





Amazing diversity of the southeast





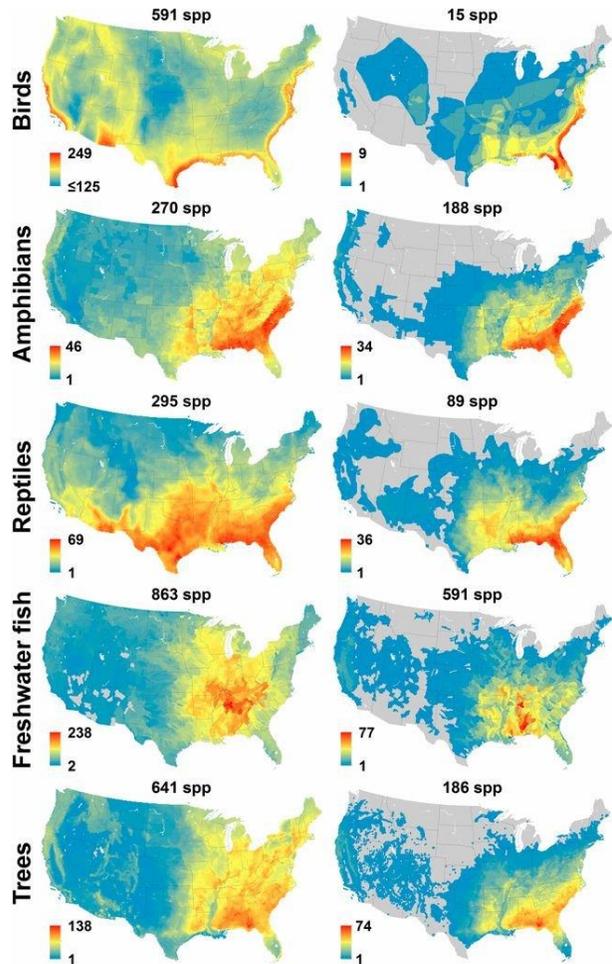
From Elkins et al. 2019

Southeast is a high priority area for species conservation

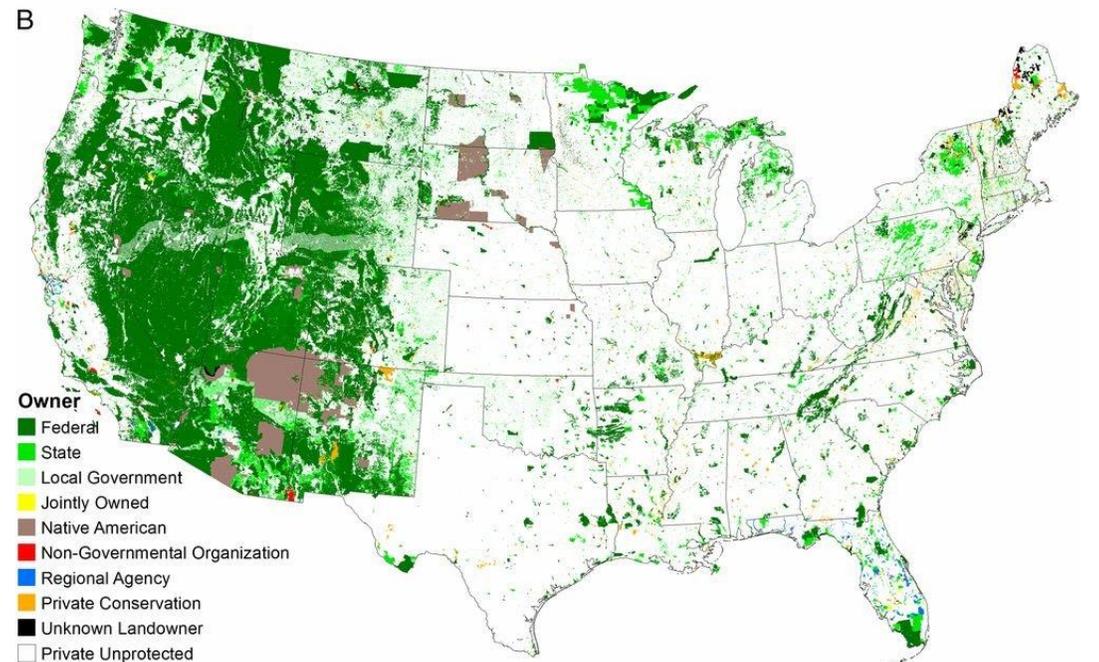
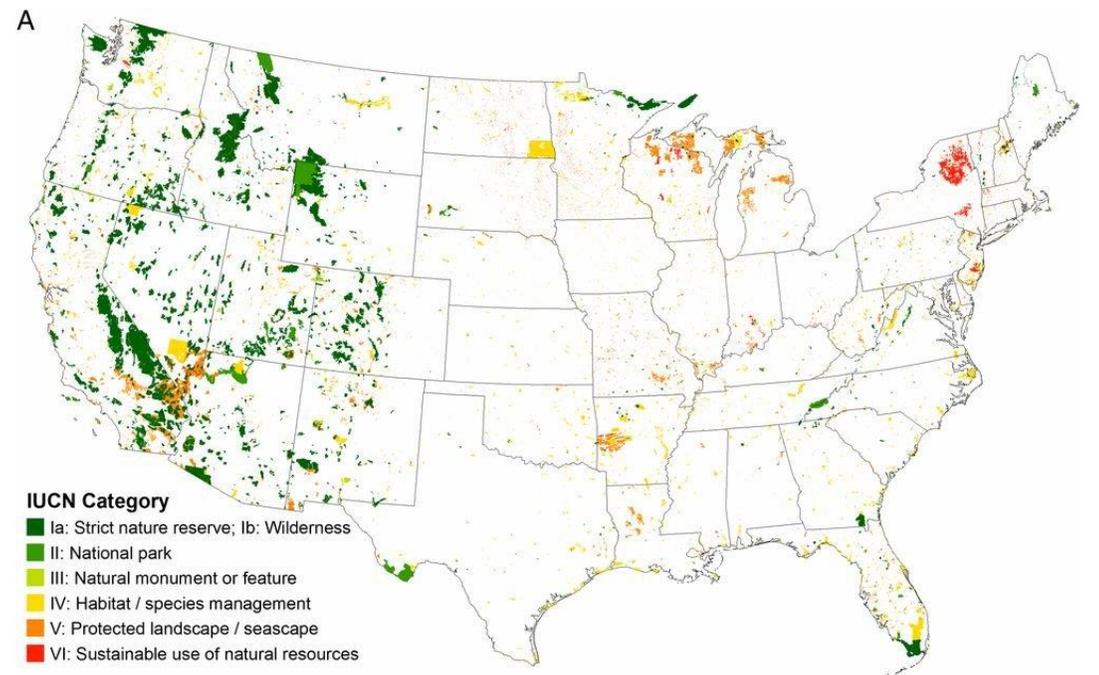
US protected lands mismatch biodiversity priorities

Clinton N. Jenkins  , Kyle S. Van Houtan , Stuart L. Pimm, and Joseph O. Sexton [Authors Info & Affiliations](#)

April 6, 2015 | 112 (16) 5081-5086 | <https://doi.org/10.1073/pnas.1418034112>

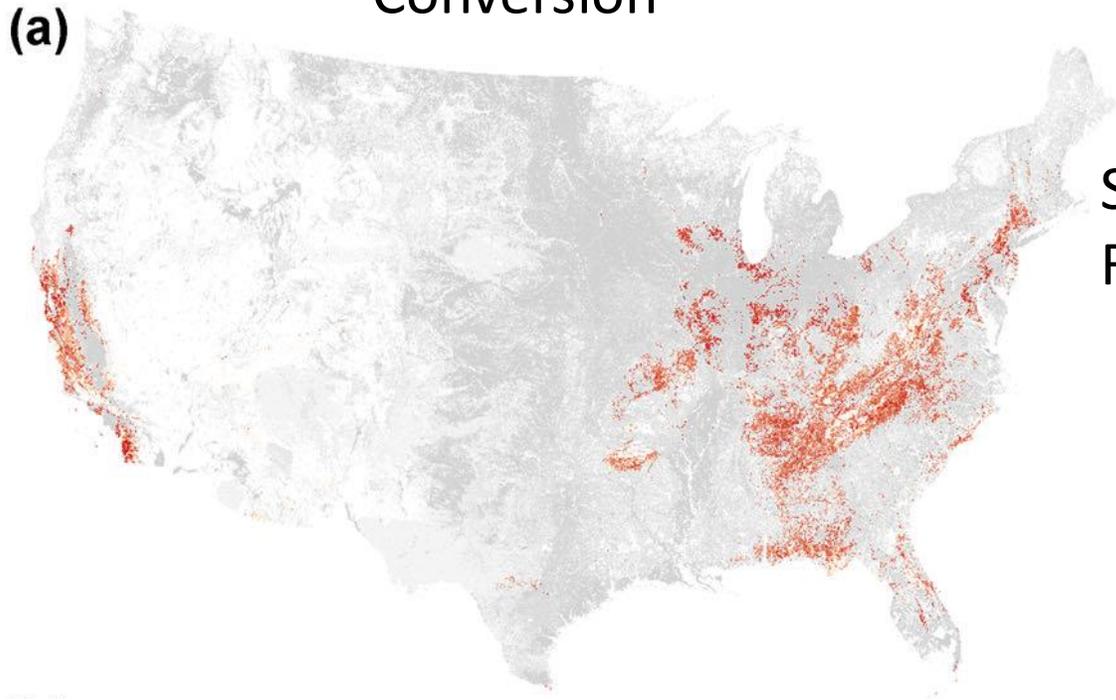


Despite the fact the southeast USA, particularly aquatic systems, harbors the highest biodiversity, the southeast has very few protected lands

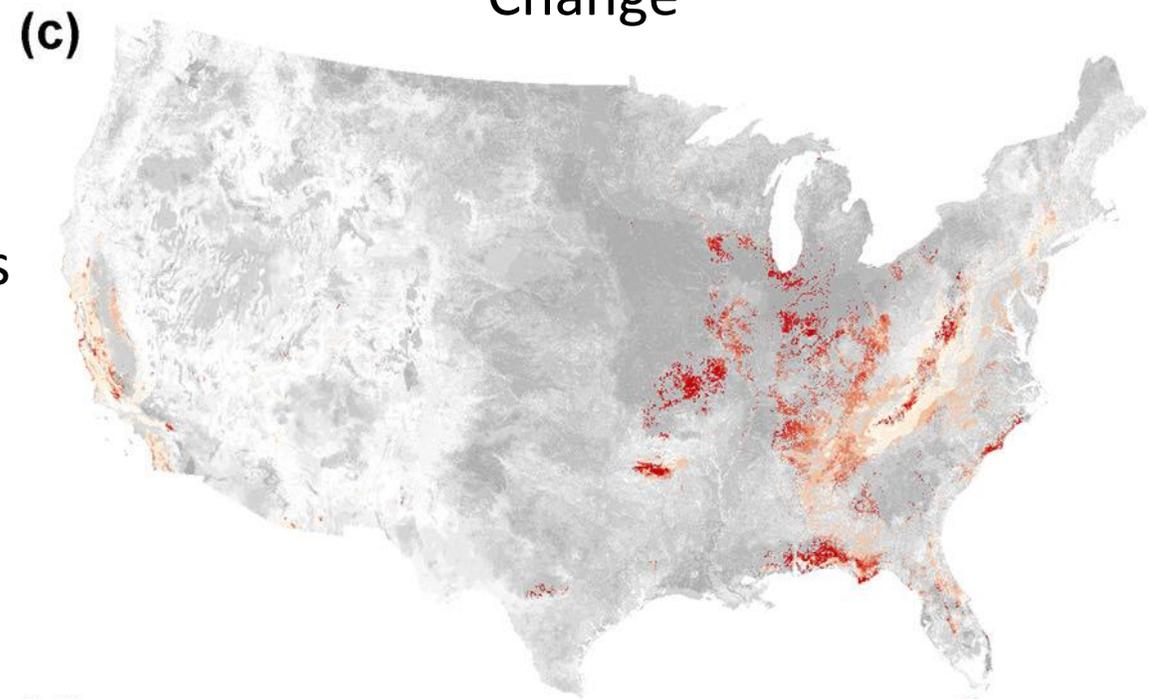


Species richness in this region is at high risk due to both land conversion and climate change

Land
Conversion



Climate
Change

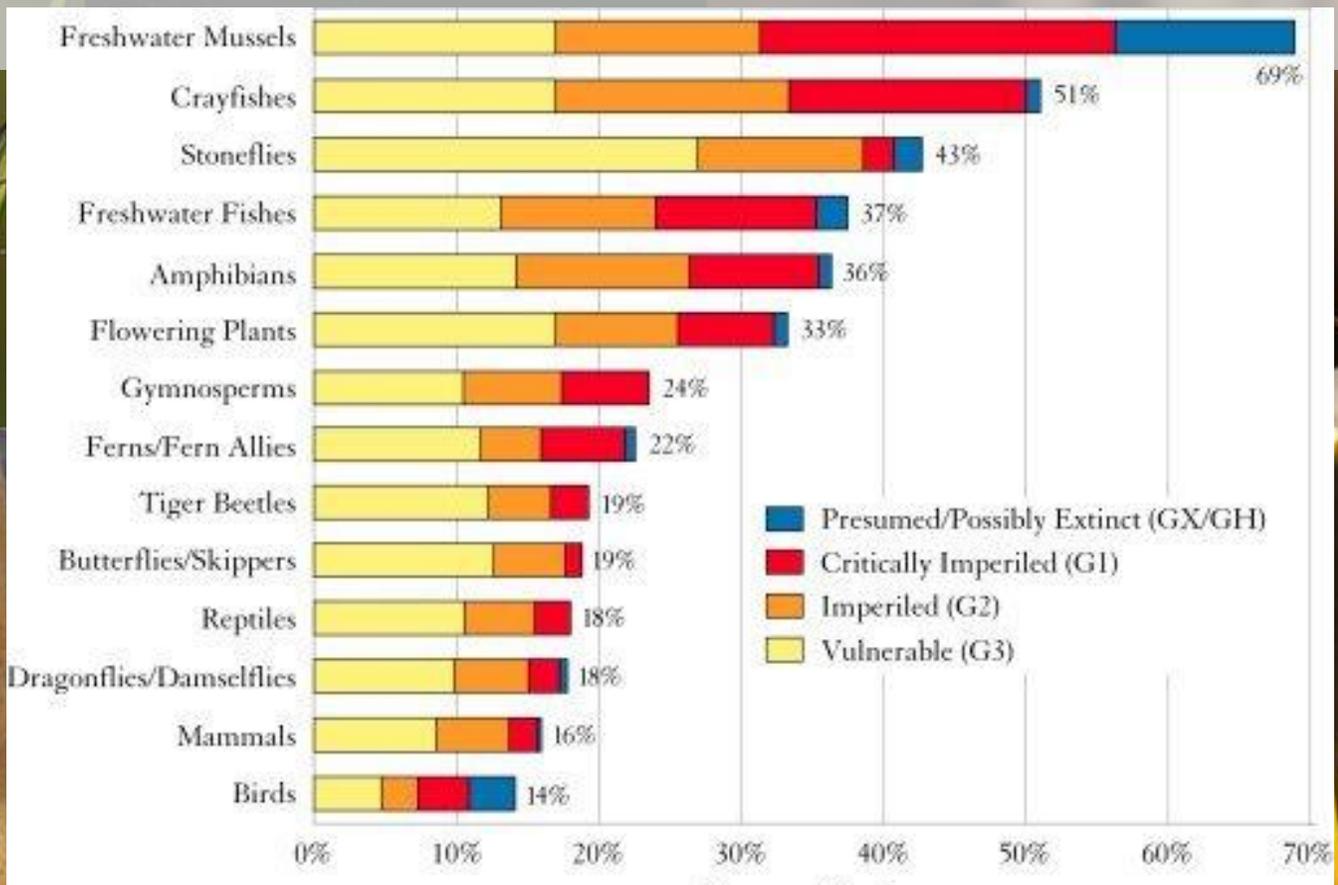


Species
Richness





Freshwaters experiencing declines in biodiversity at rates greater than those in terrestrial systems (extinction rates as high as 4%/decade, 5x > than terrestrial systems)





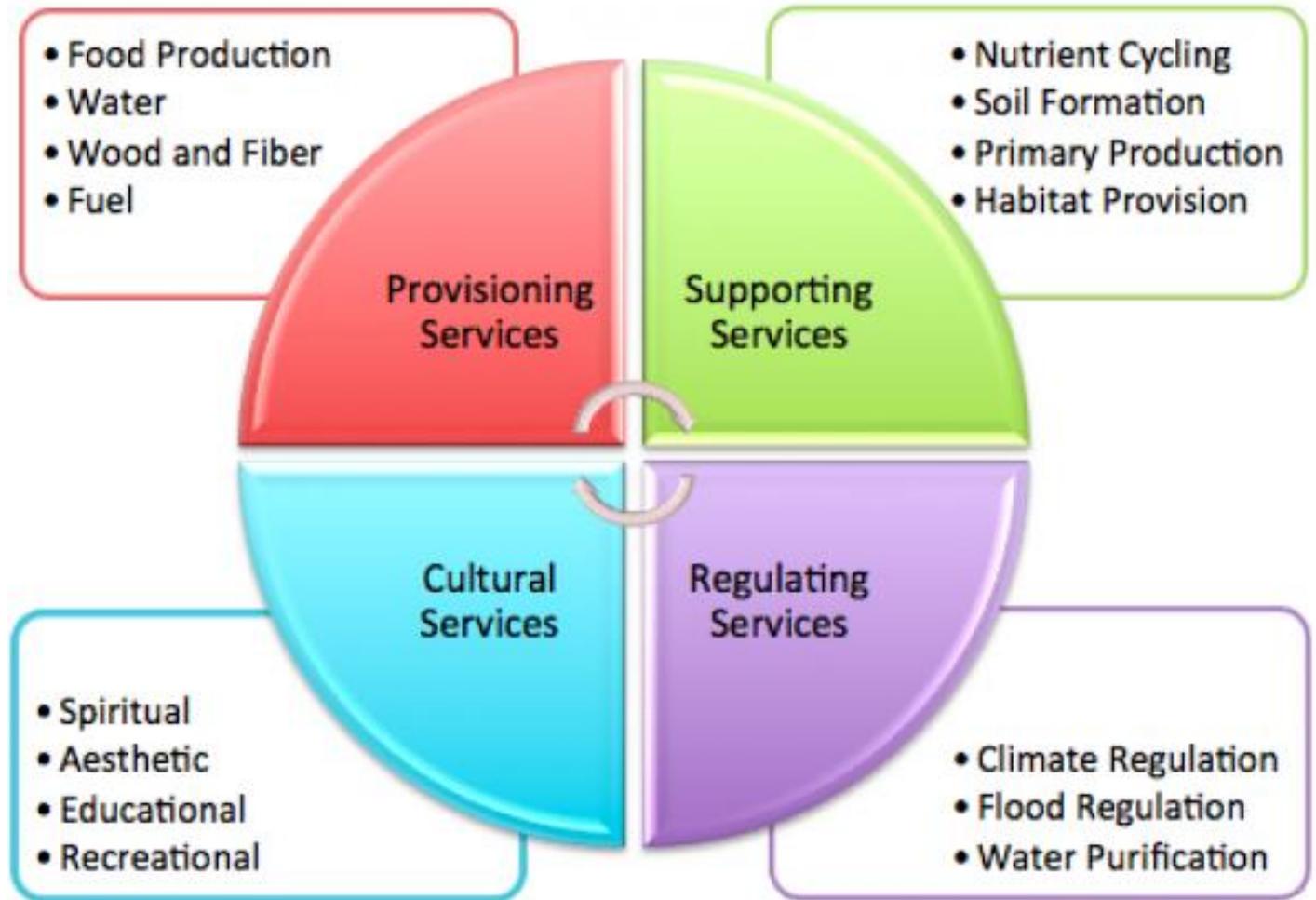
Freshwaters experiencing declines in biodiversity at rates greater than those in terrestrial systems (extinction rates as high as 4%/decade, 5x > than terrestrial systems)



Freshwaters provide essential ecosystem services, and these are also in danger of being lost.

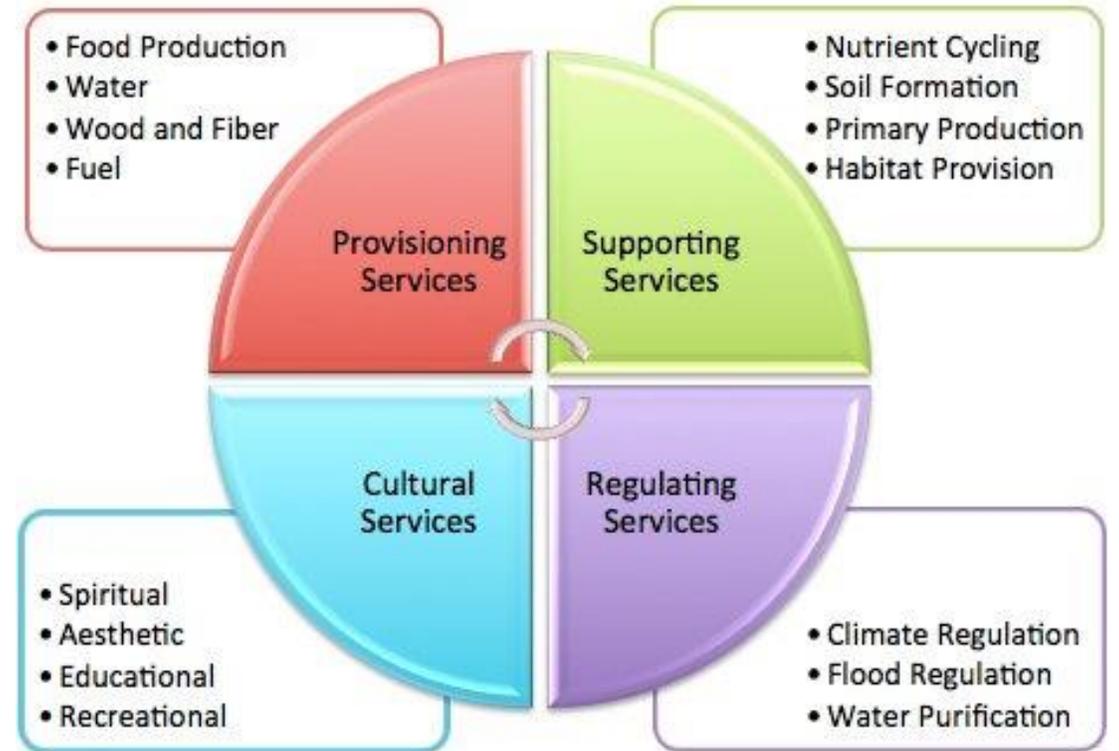


What are ecosystem services?



Source: Millenium Ecosystem Assessment, 2005.

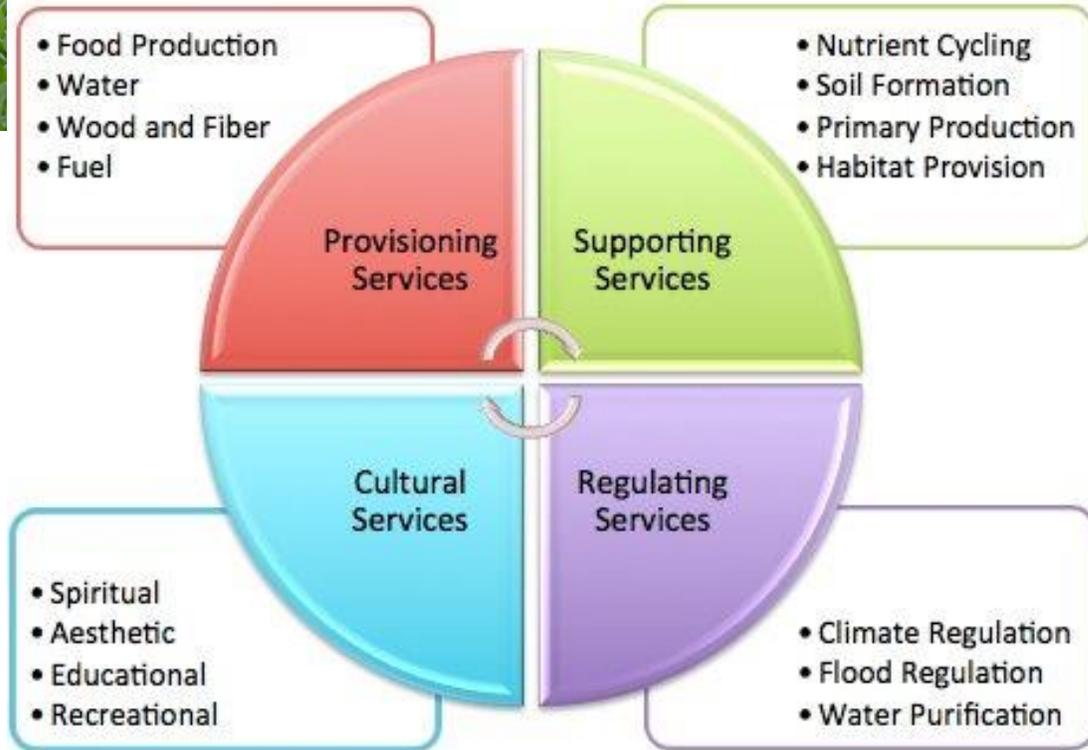
Why does it matter?



Source: Millenium Ecosystem Assessment, 2005.



This watershed supports many important ecosystem services



Source: Millenium Ecosystem Assessment, 2005.





However, tactics for promoting biodiversity and ecosystem services are often not congruent especially when it comes to species management



Biodiversity Conservation

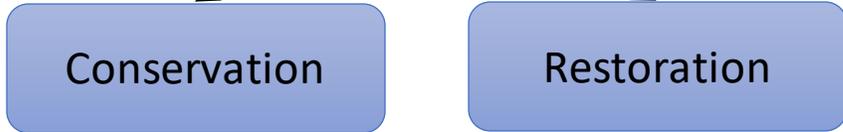
Goals



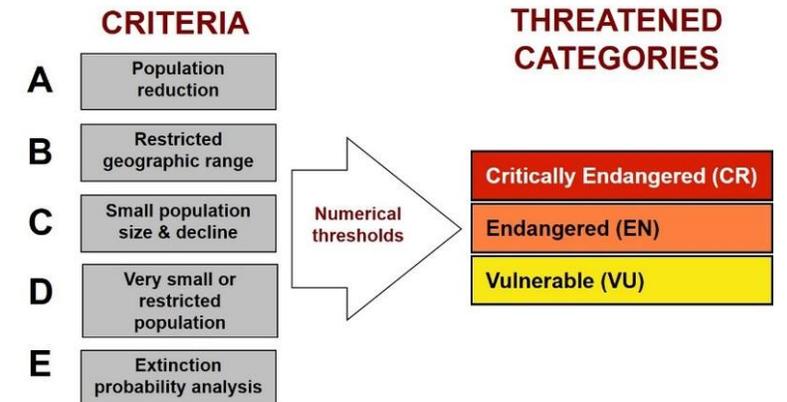
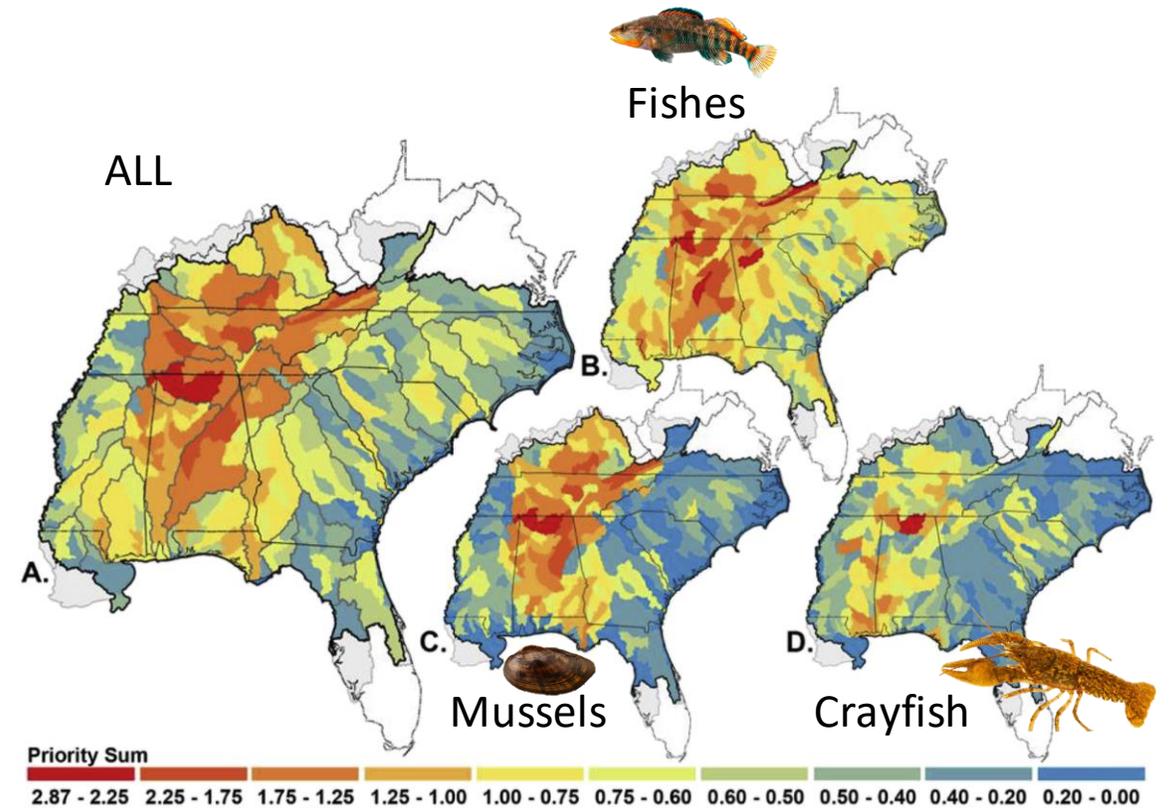
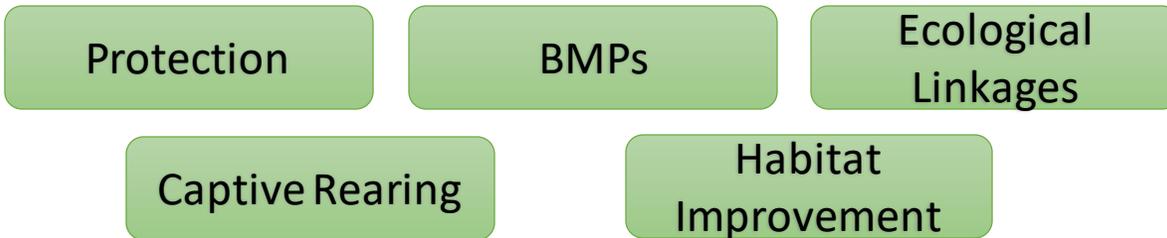
Target



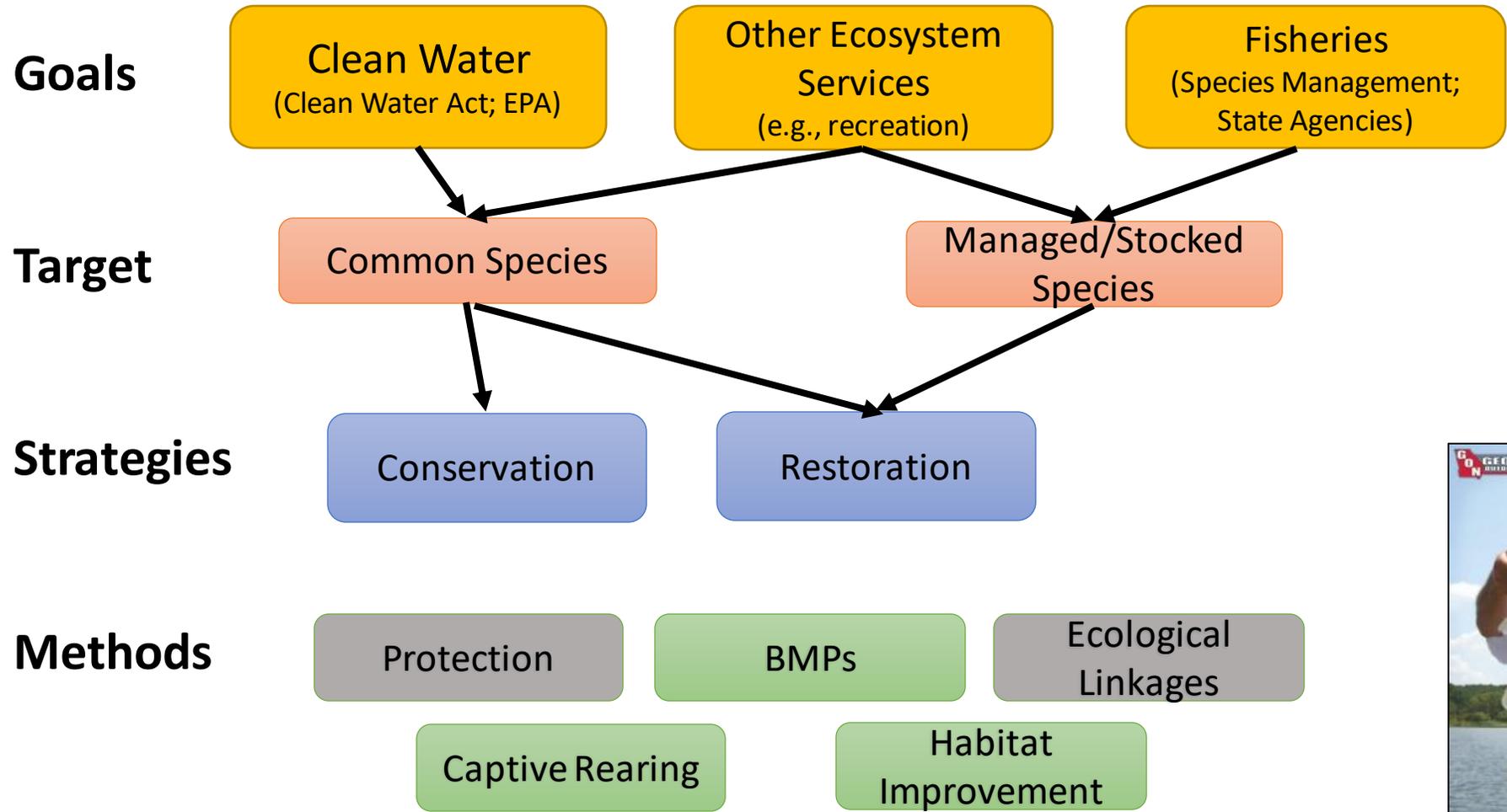
Strategies



Methods



Ecosystem Services – Water quality, Recreation/Fisheries



Freshwater Mussels





Shiny-rayed pocketbook

ACF Harbors High Mussel Diversity

- ~32 species and 8 Endemics
- Six species are listed under the Endangered Species Act



Chipola slabshell

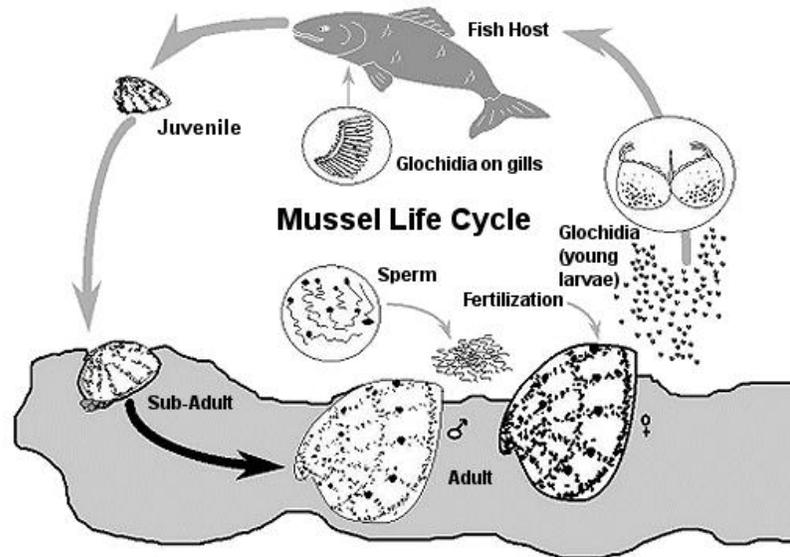


Fat threeridge

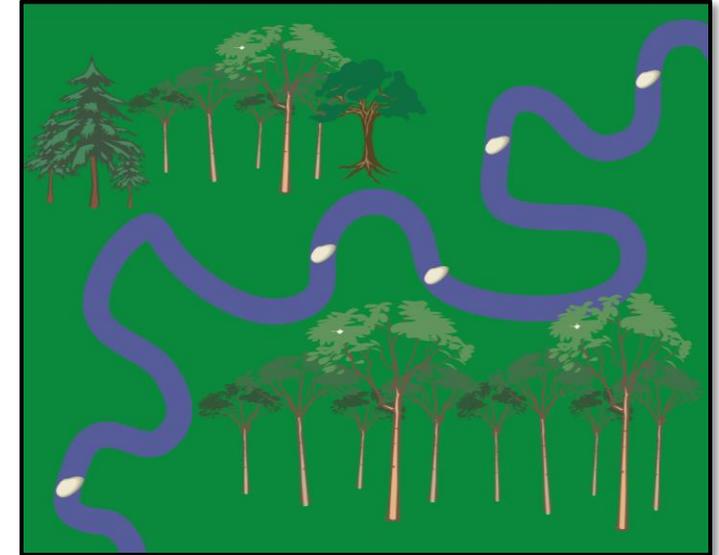
Characteristics of FW Mussels



- Diverse group (~958 Unionoida)
- Long generation times
- Long-lived (6 – 100 yrs)

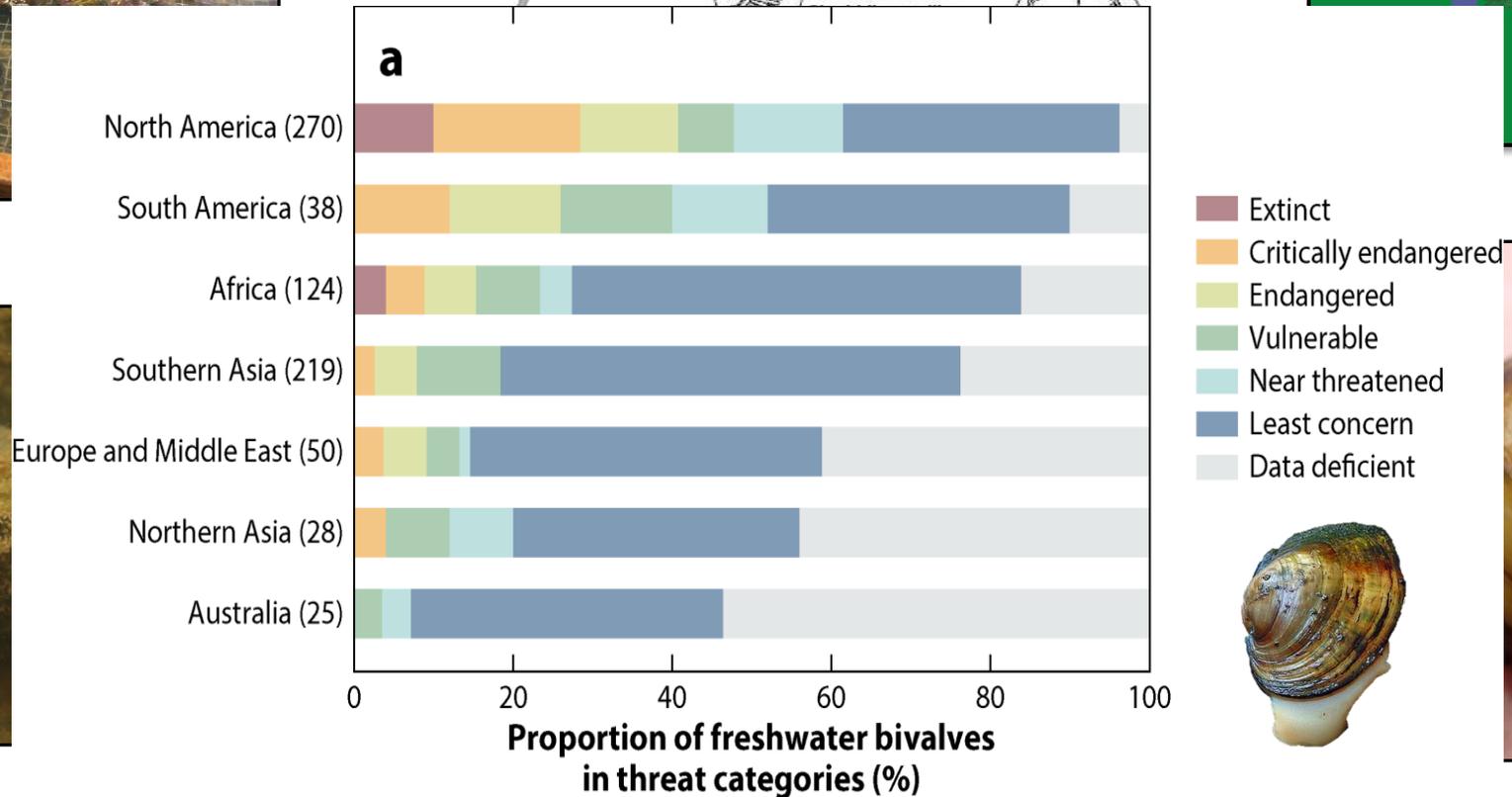
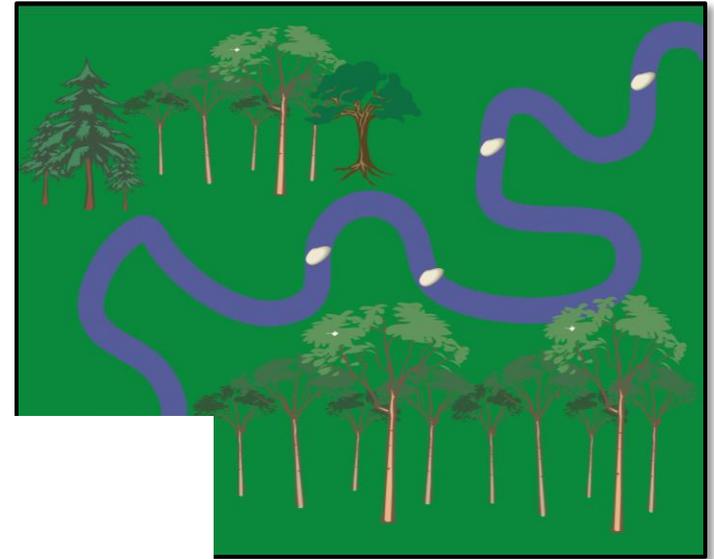
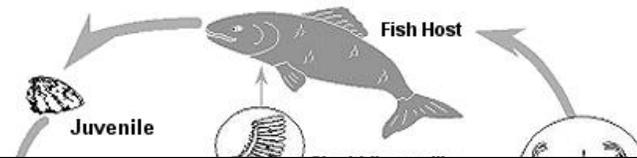
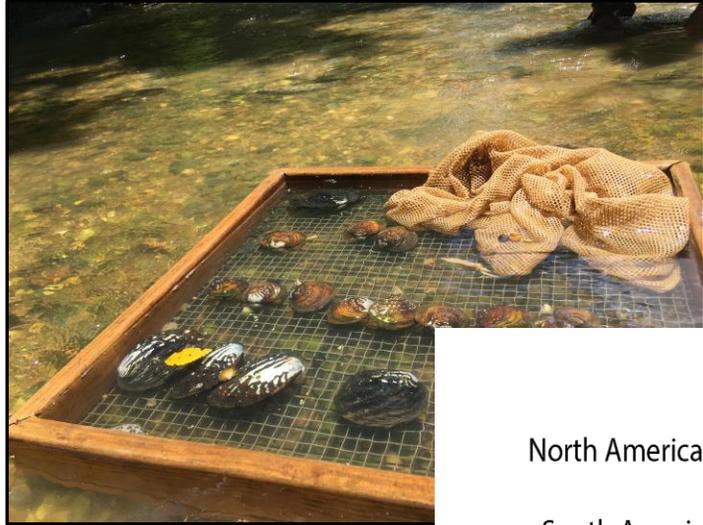


- Occur as dense, multispecies aggregations (mussel beds)
- Sedentary and can't move far
- Depend on fish for dispersal
- Different mussels use different fish



Characteristics of FW Mussels

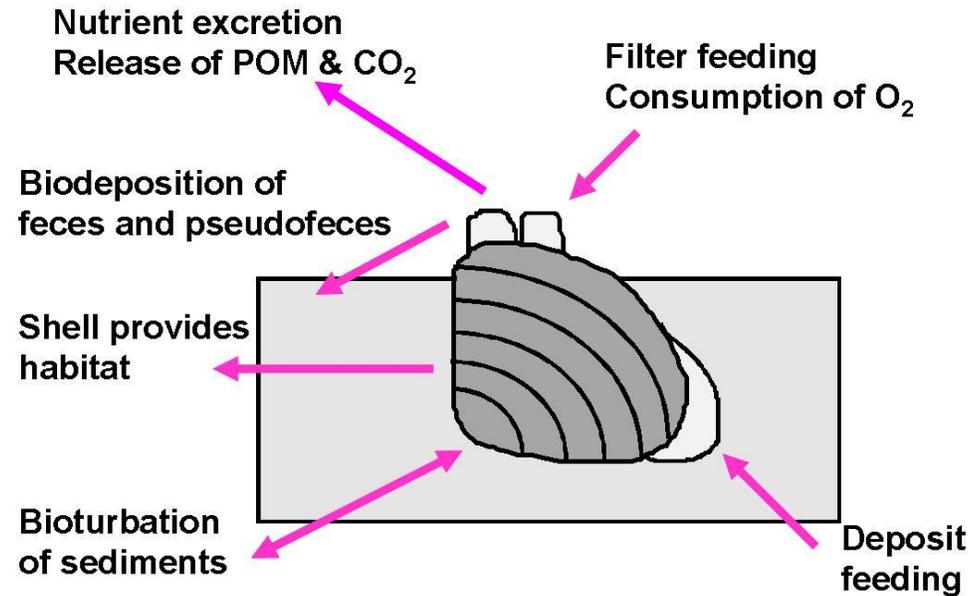
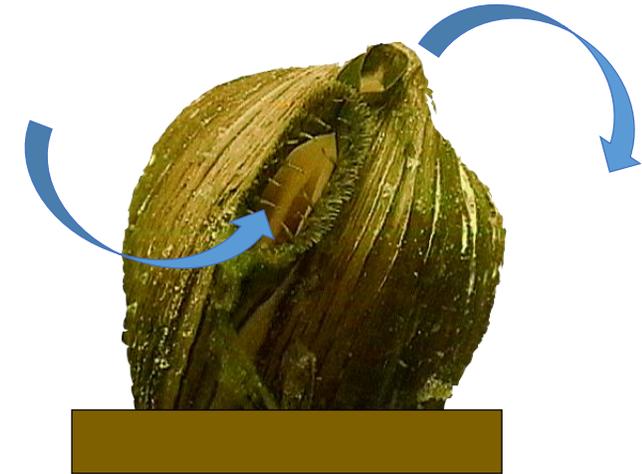
- Diverse group (~958 Unionoida)
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FW Mussels are important and valuable



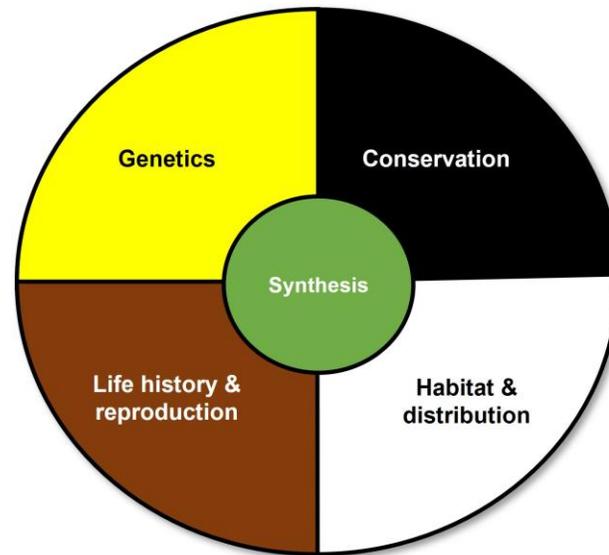
- Water purification (biofiltration)
- Nutrient recycling & storage
- Structural habitat
- Substrate modification
- Food for other organisms



FW Mussels vary in their traits

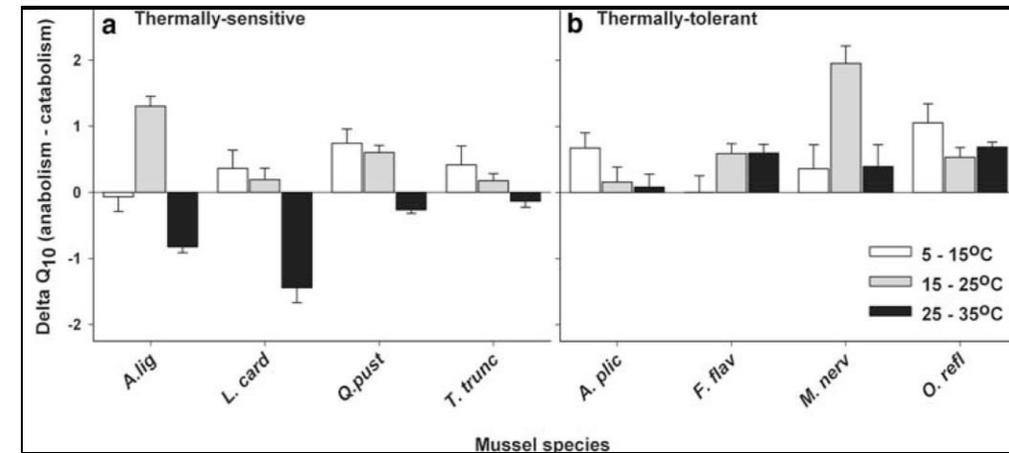


Vary tremendously in their life history traits resulting in variation in community structure and potential ecosystem impacts



Mussel Traits – NA Trait Database

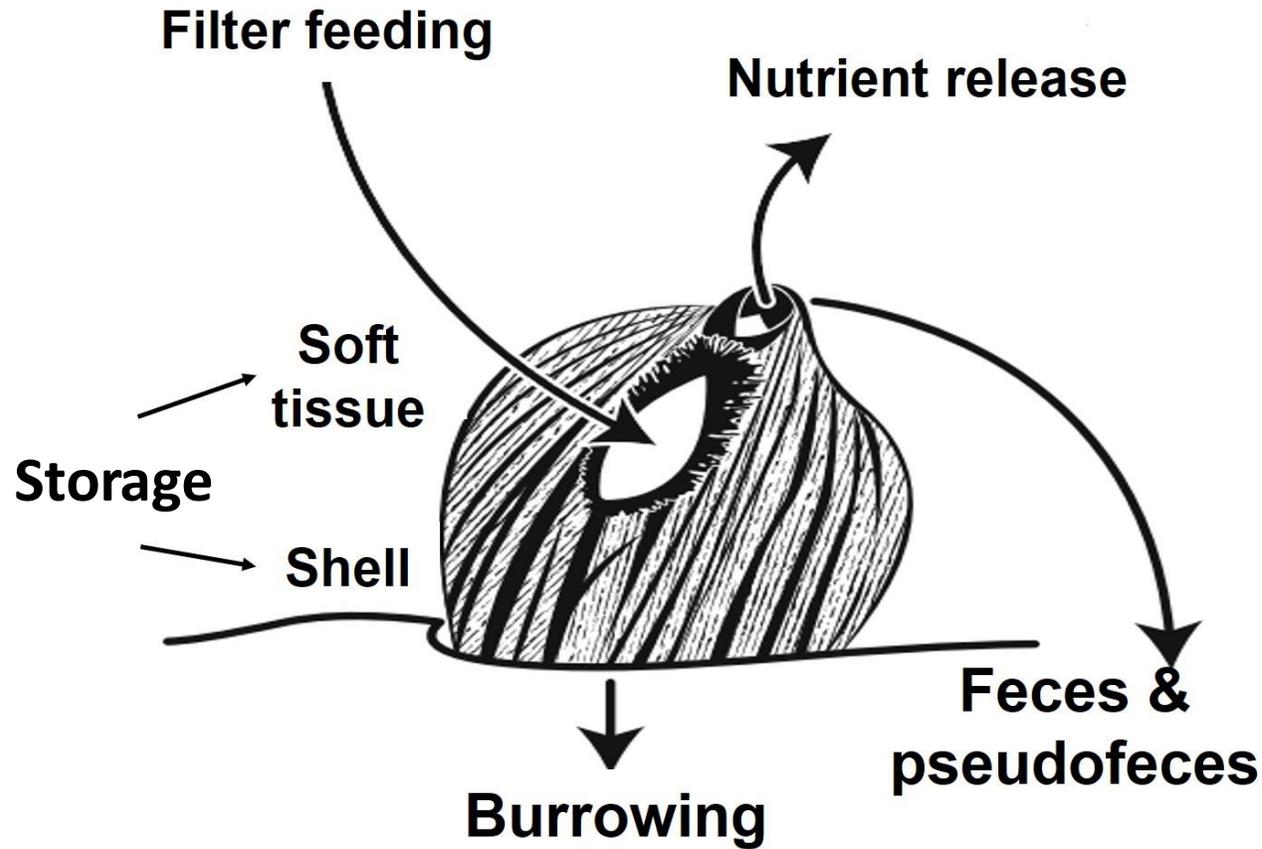
Hopper et al. *In prep*



Spooener & Vaughn 2008, *Oecologia*

Freshwater Mussels = Important Functions = Important Services

How do mussels contribute to the healthy functioning of ecosystems?



Provisioning services

- Pearl culture
- Food
- Products from shell

Regulating services

- Water purification

Supporting services

- Nutrient cycling & storage
- Habitat provisioning
- Primary production

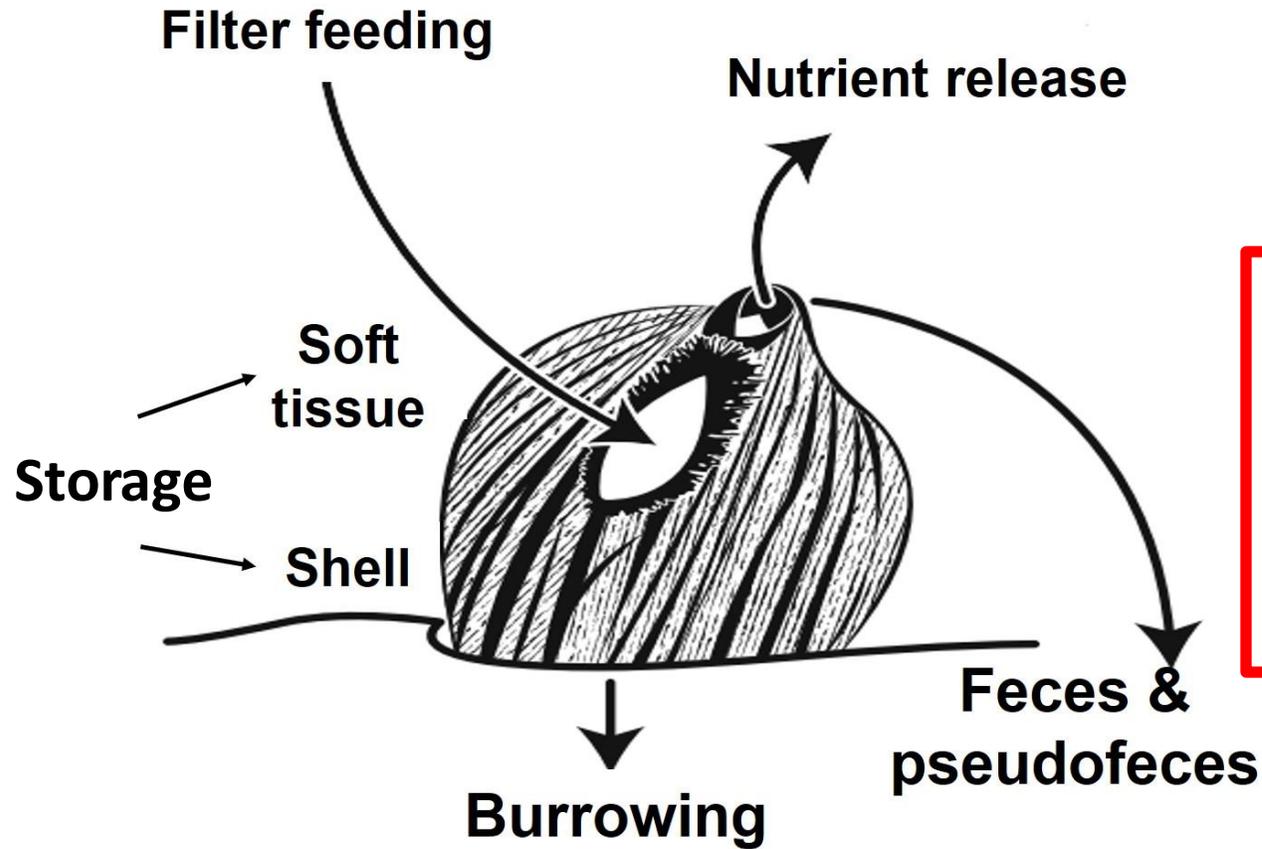
Cultural services

- Spiritual enrichment
- Aesthetic experiences
- Education



Freshwater Mussels = Important Functions = Important Services

How do mussels contribute to the healthy functioning of ecosystems?



Provisioning services

- Pearl culture
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Regulating services

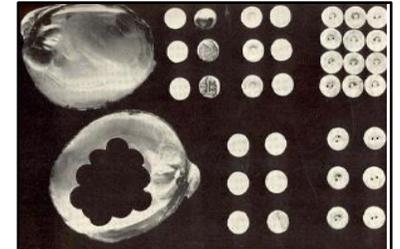
- Water purification

Supporting services

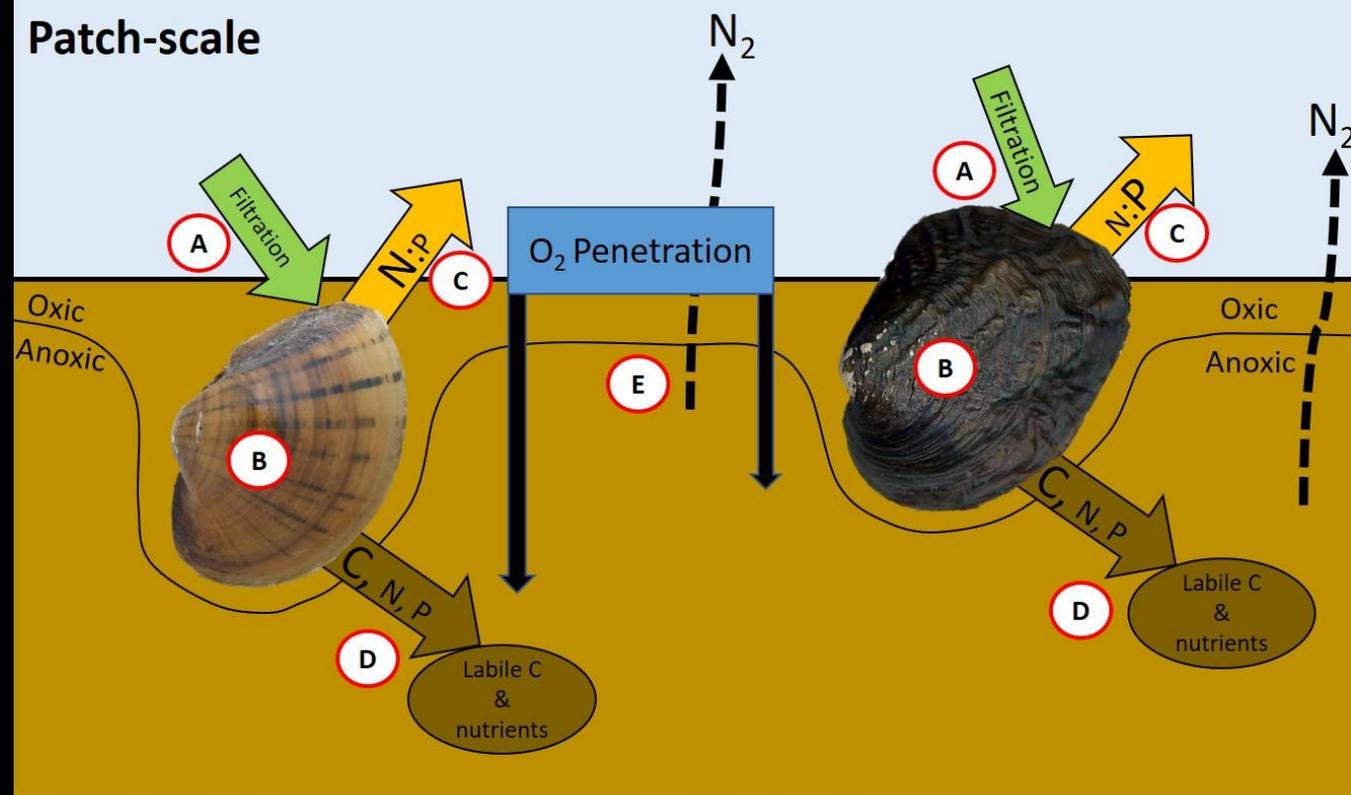
- Nutrient cycling & storage
- Habitat provisioning
- Primary production

Cultural services

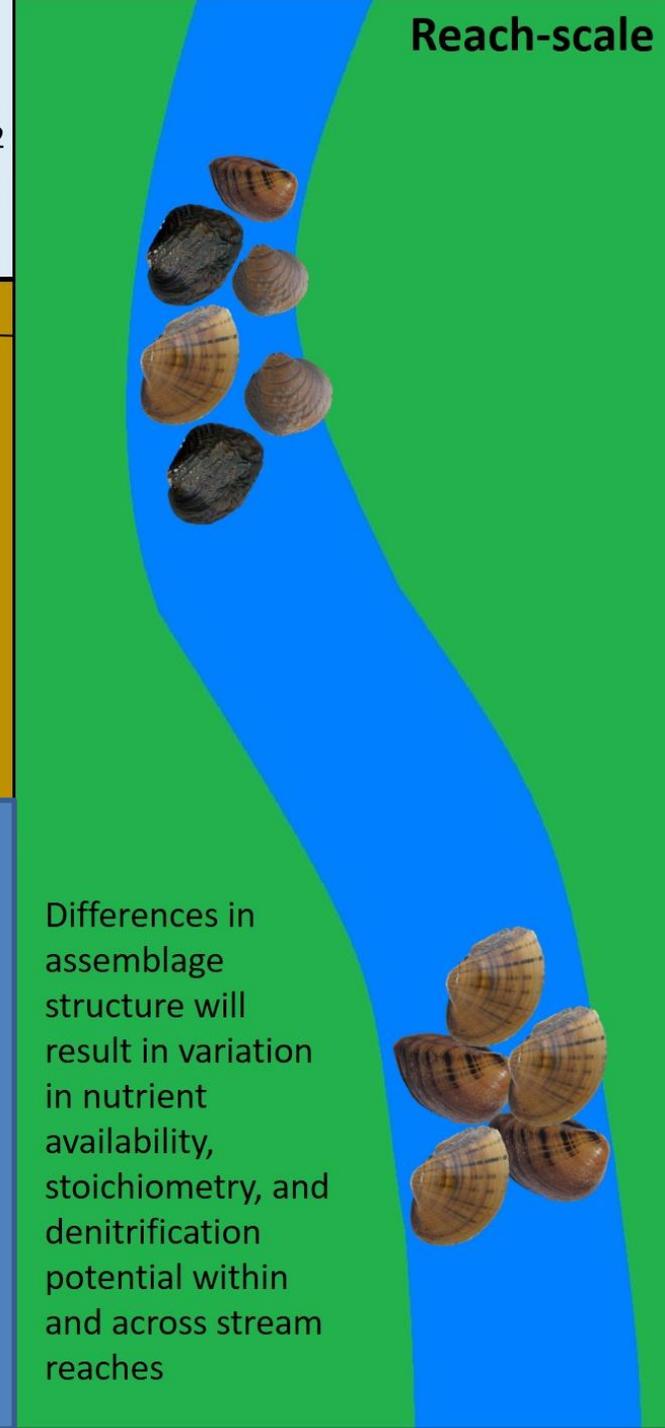
- Spiritual enrichment
- Aesthetic experiences
- Education



Patch-scale



Reach-scale



Mussel function

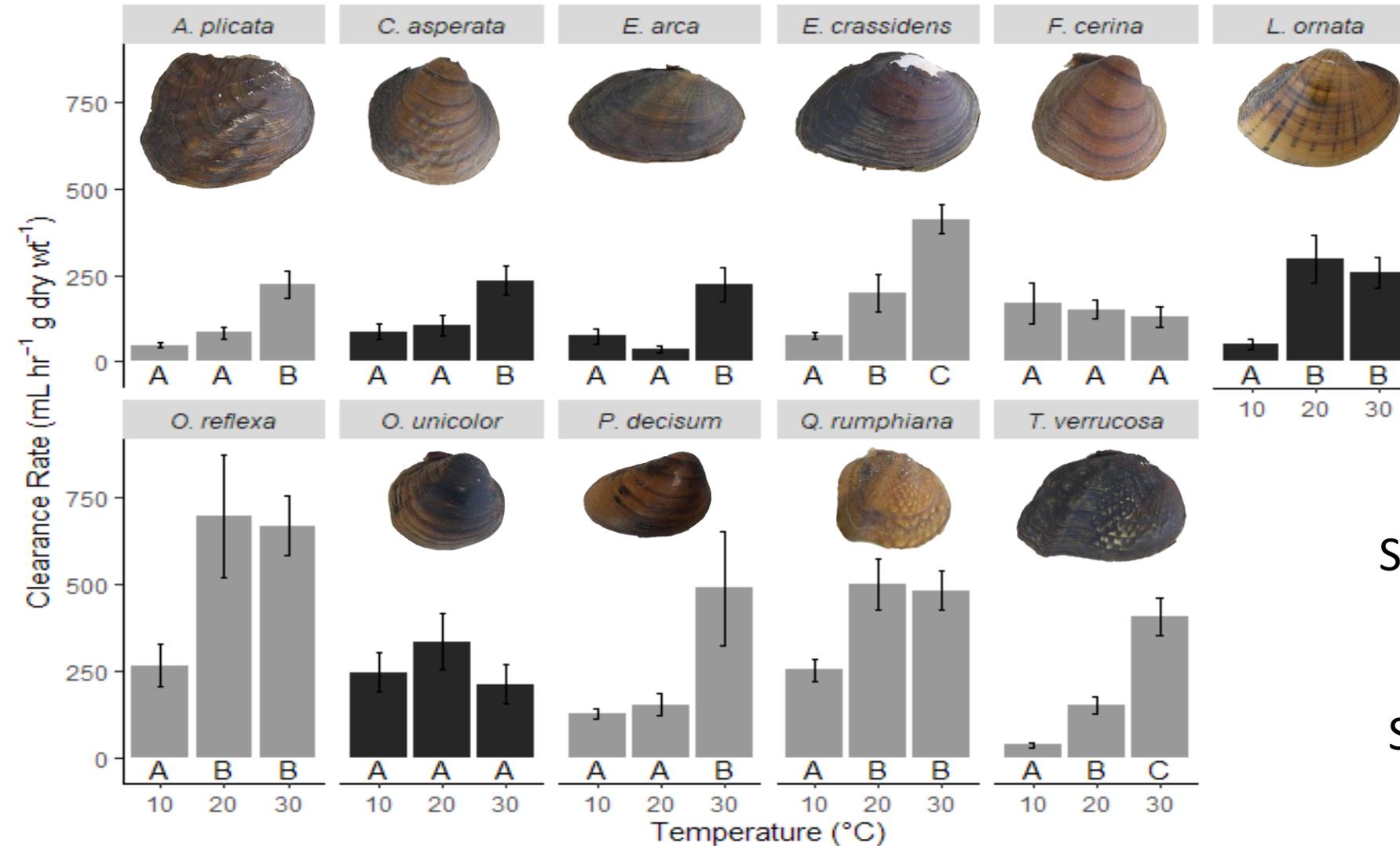
A	Filtration
B	Nutrient storage
C	Excretion
D	Biodeposition
E	Burying

Different species often perform these functions differently – can result in varying provisioning of services

Differences in assemblage structure will result in variation in nutrient availability, stoichiometry, and denitrification potential within and across stream reaches

Filtration – regulating service

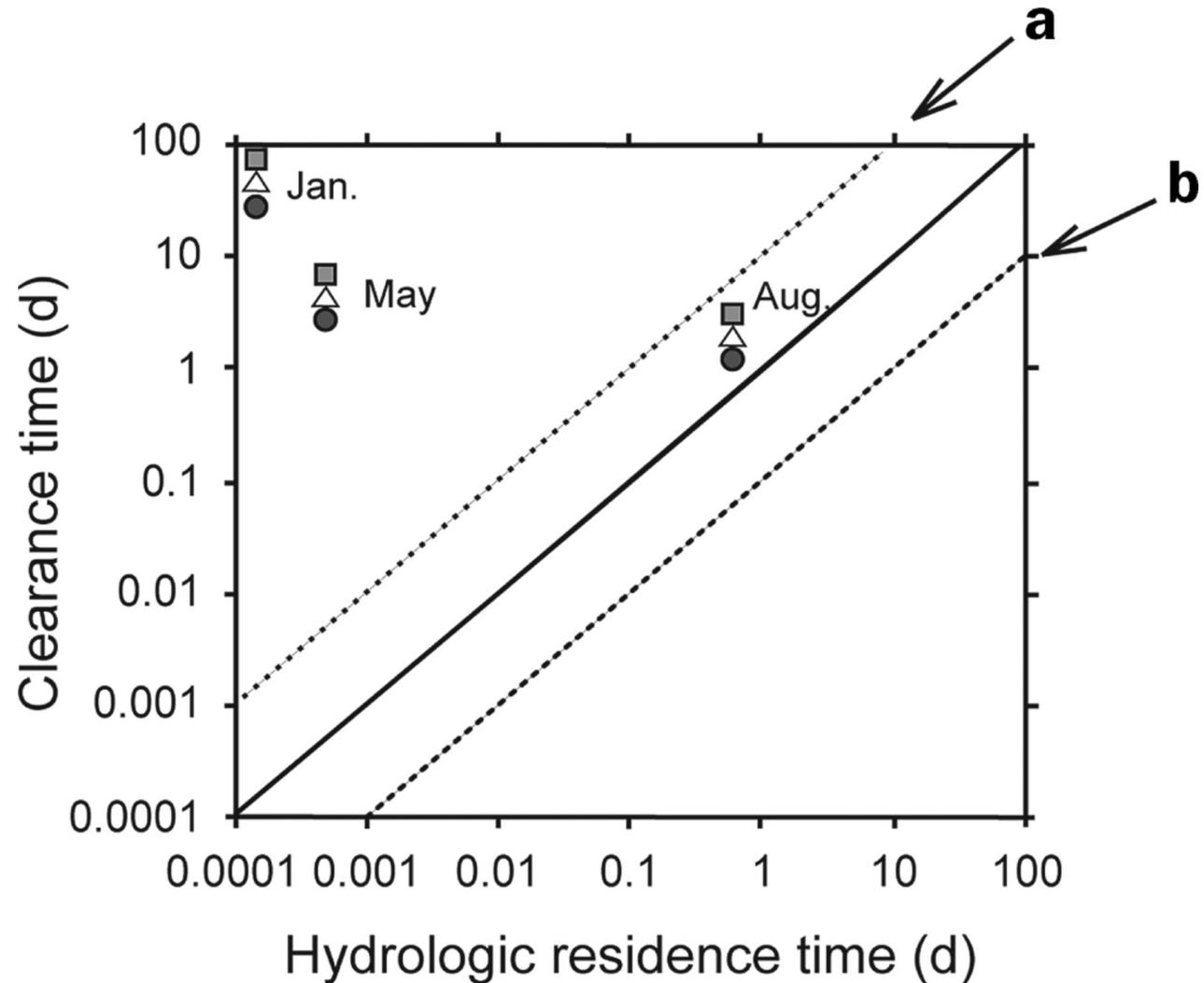
A. Resource Acquisition



Species filter at different rates

Species filter differently across temperature

Filtration – regulating service



Also, biomass and the environmental context shape the importance of these services

Nutrient Storage – supporting service

Niche volumes



● *Lampsilis ornata*



● *Obovaria unicolor*



● *Obliquaria reflexa*



● *Tritagonia verrucosa*



○ *Cyclonaias asperata*



● *Fusconaia cerina*



● *Pleurobema decisum*



● *Elliptio arca*

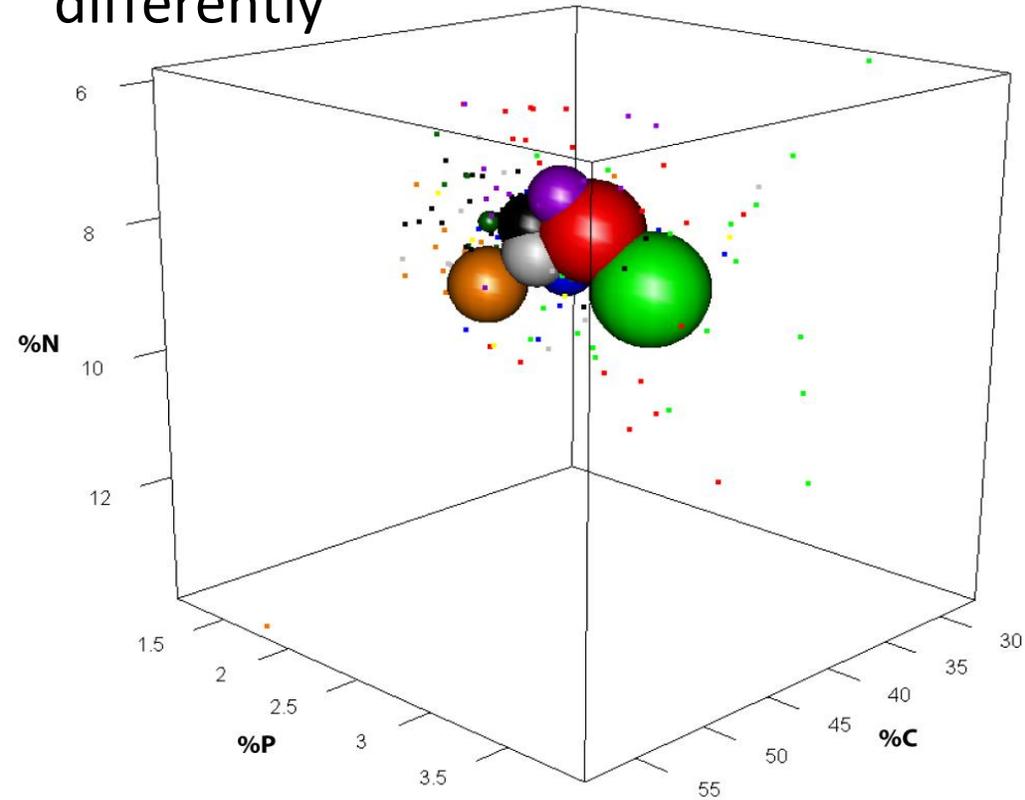


● *Amblema plicata*



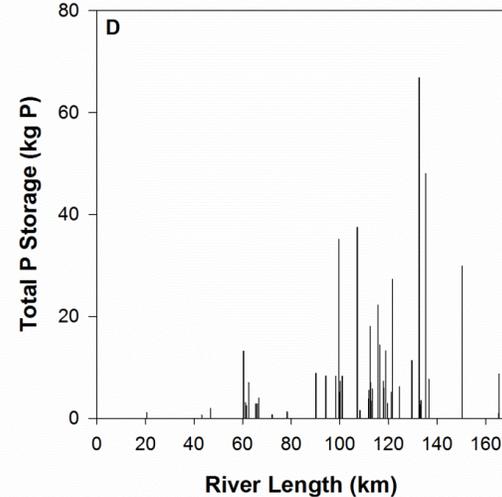
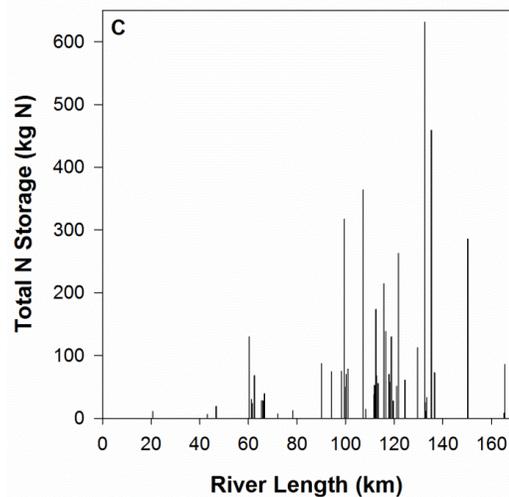
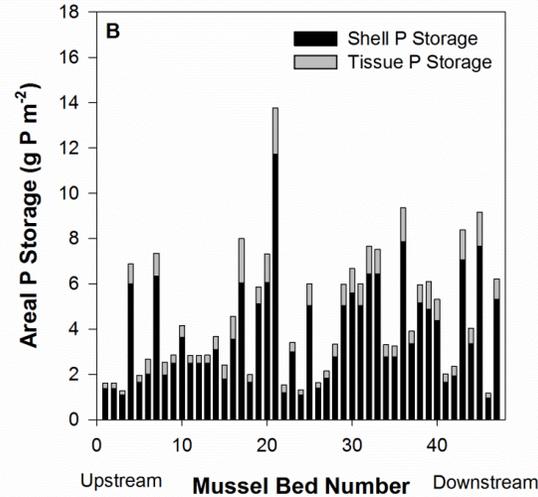
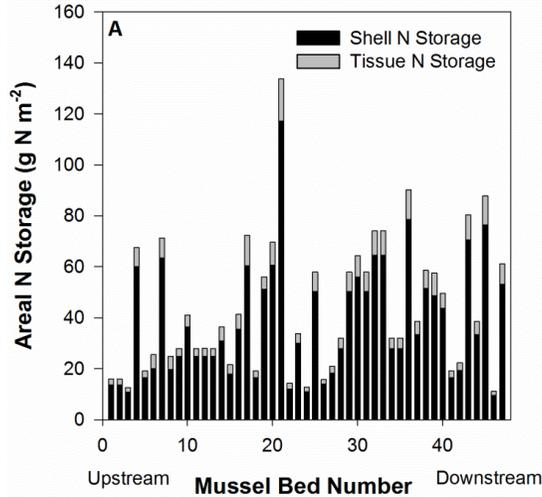
Soft Tissue Storage

Species store nutrients differently



Atkinson, van Ee, and Pfeiffer, 2020 (*Ecology*)

Nutrient Storage – supporting service

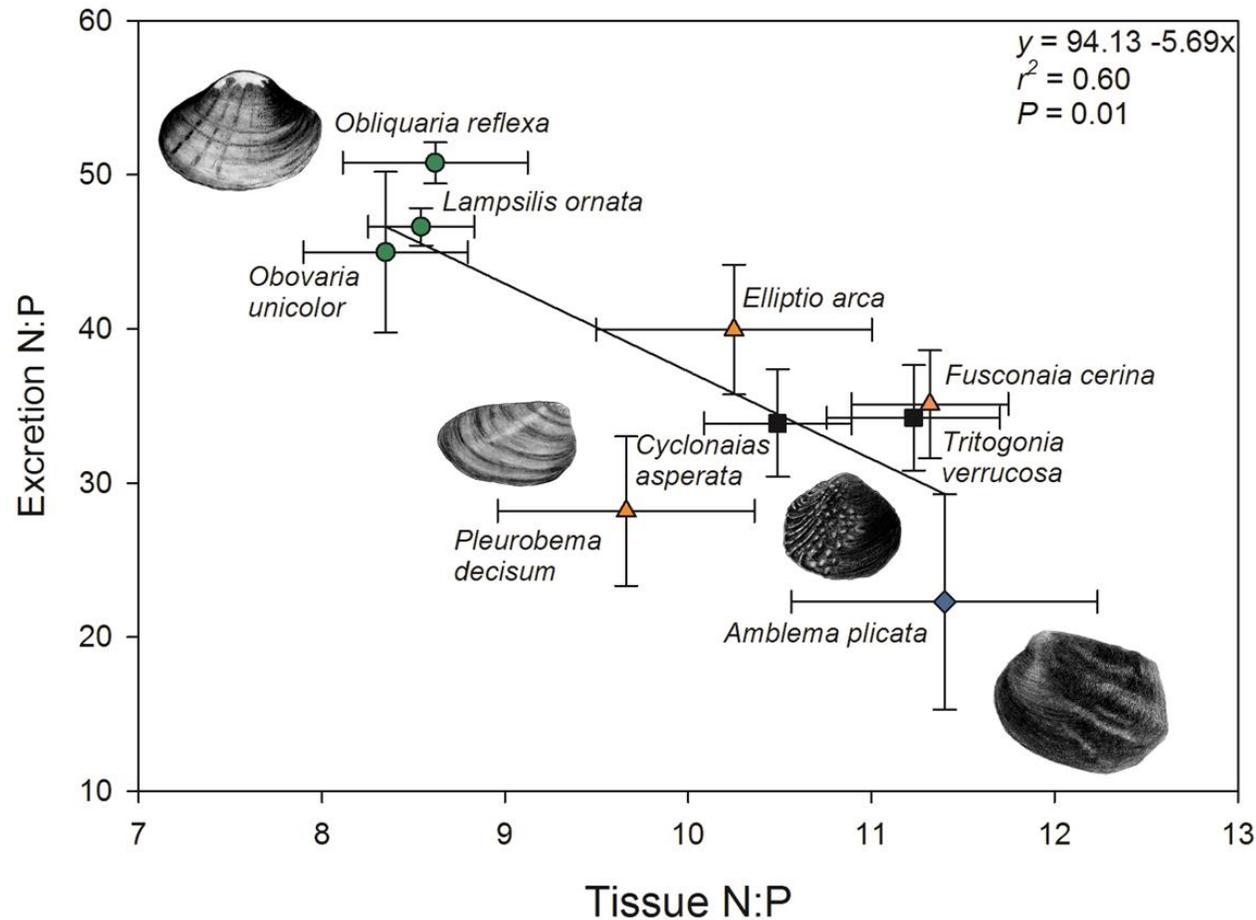


Sequestration

Mussels live 5 to
>50 years

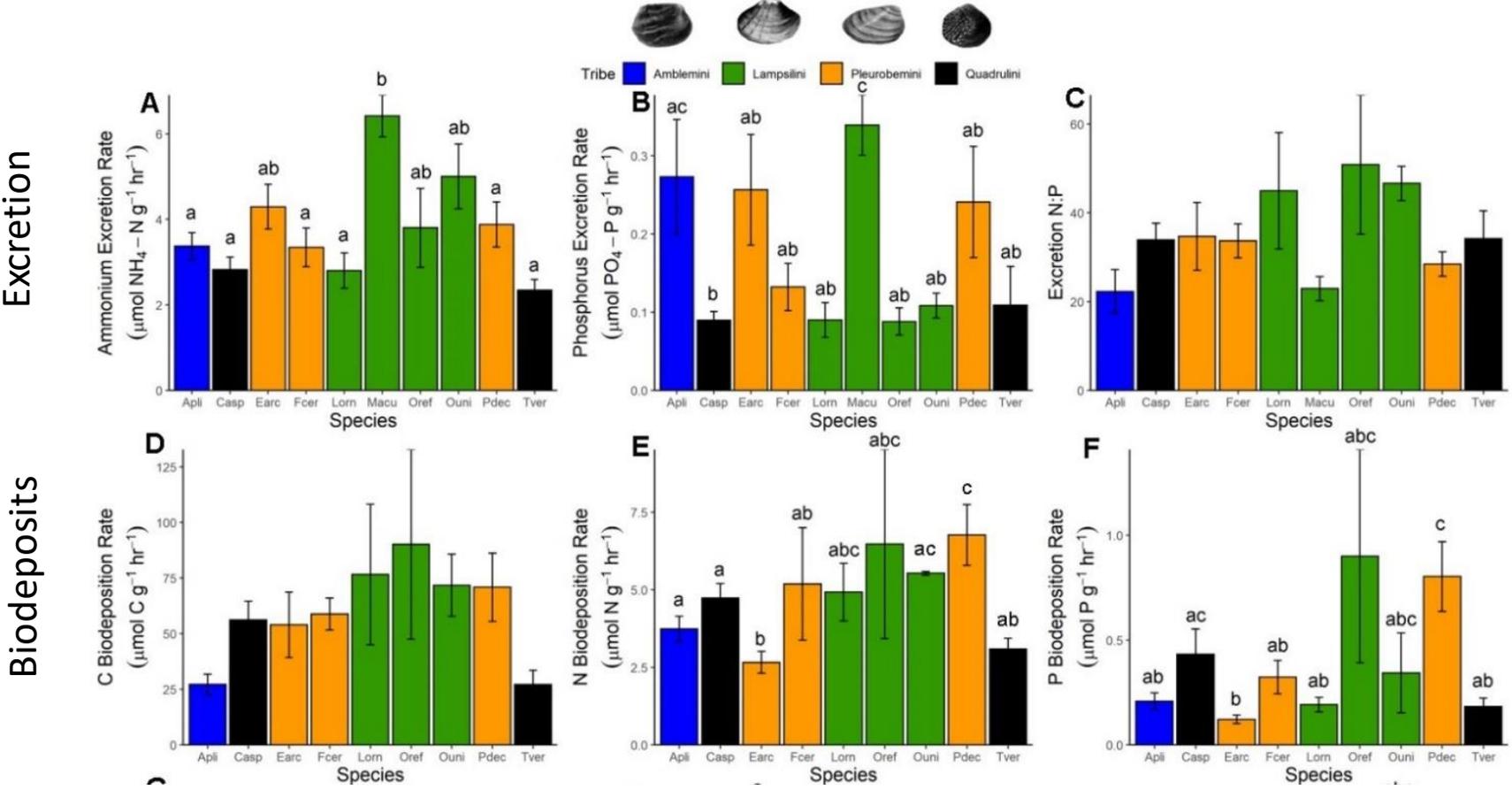
Shell = long term
store, “nutrient
sink”

Concordance between Tissue and Excretion Stoichiometry

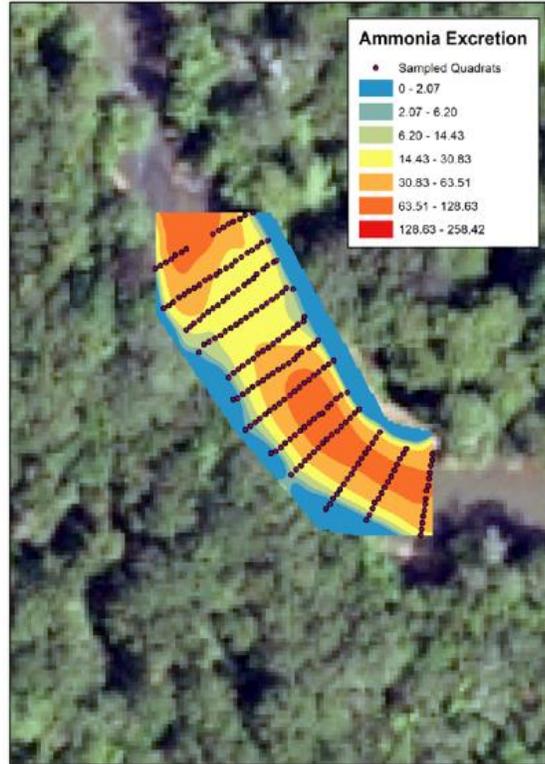


Meets the expectations of ecological stoichiometry

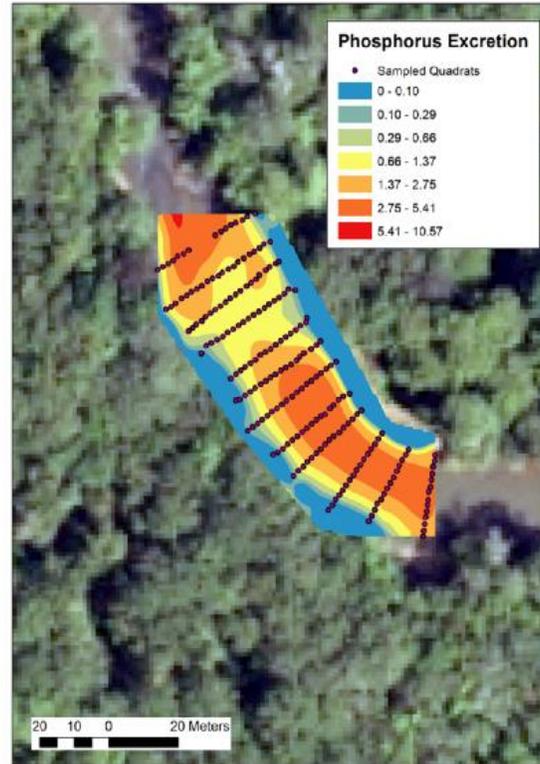
Nutrient Recycling – supporting service



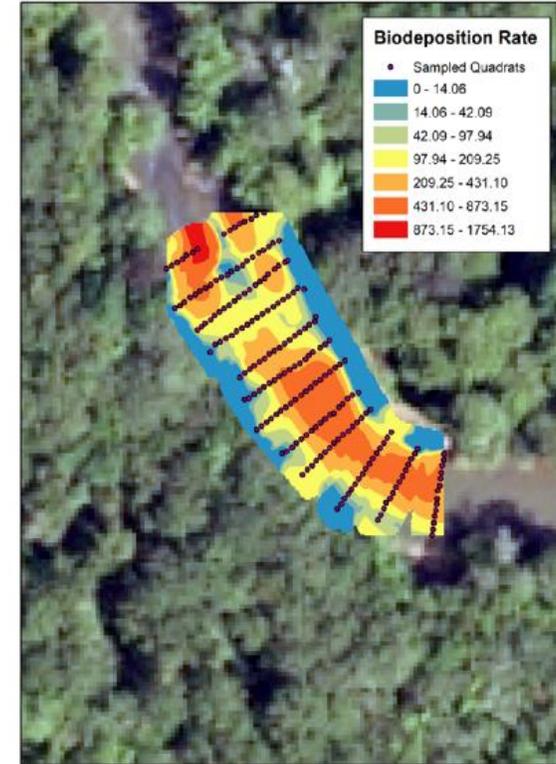
Nutrient Cycling – supporting service



Average = $41 \mu\text{mol N m}^{-2} \text{h}^{-1}$



Average = $1.9 \mu\text{mol P m}^{-2} \text{h}^{-1}$



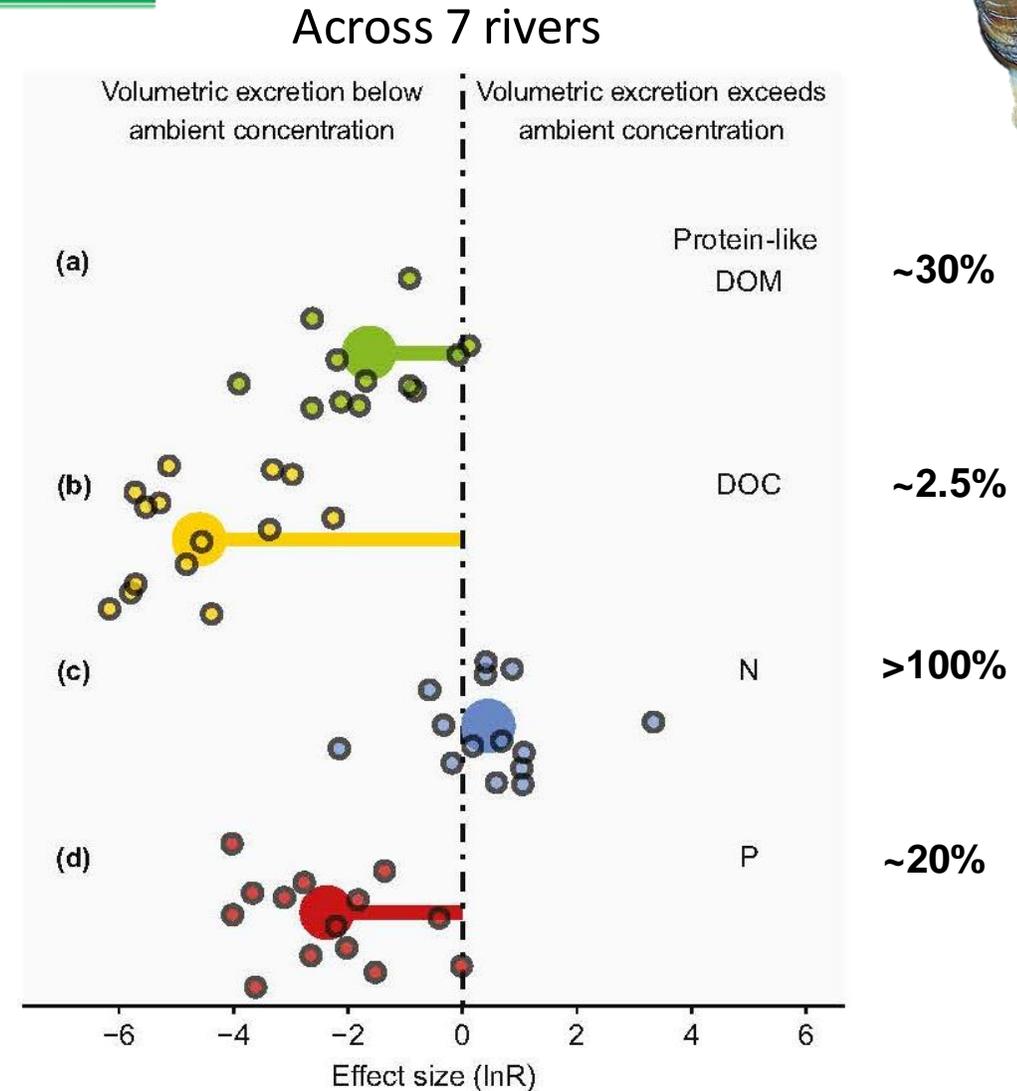
Average = $243 \text{ mg DM m}^{-2} \text{h}^{-1}$



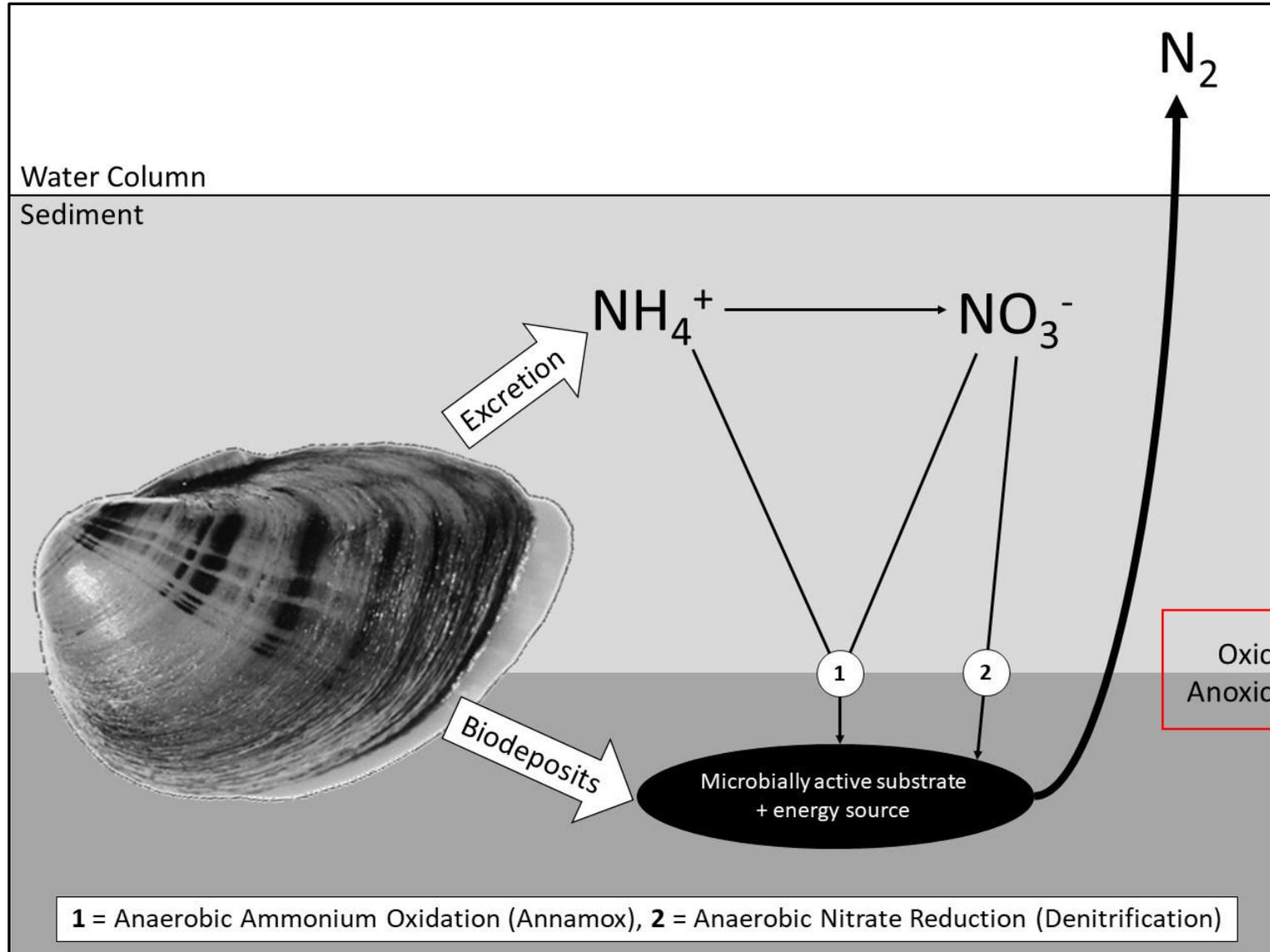
Nutrient Cycling – supporting service



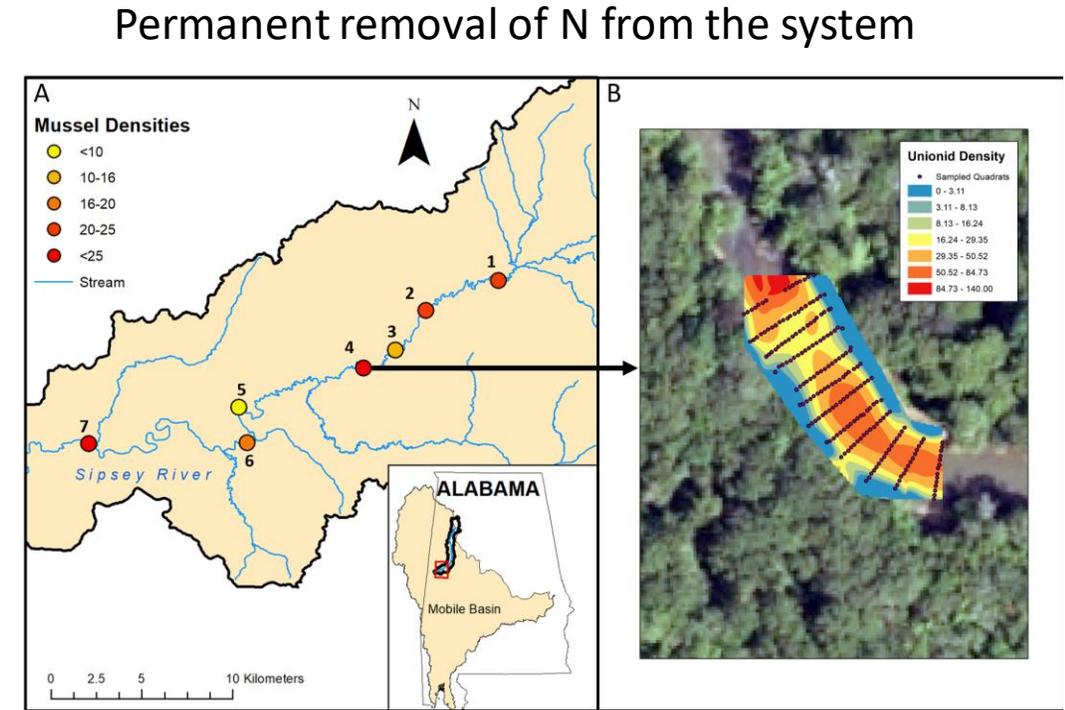
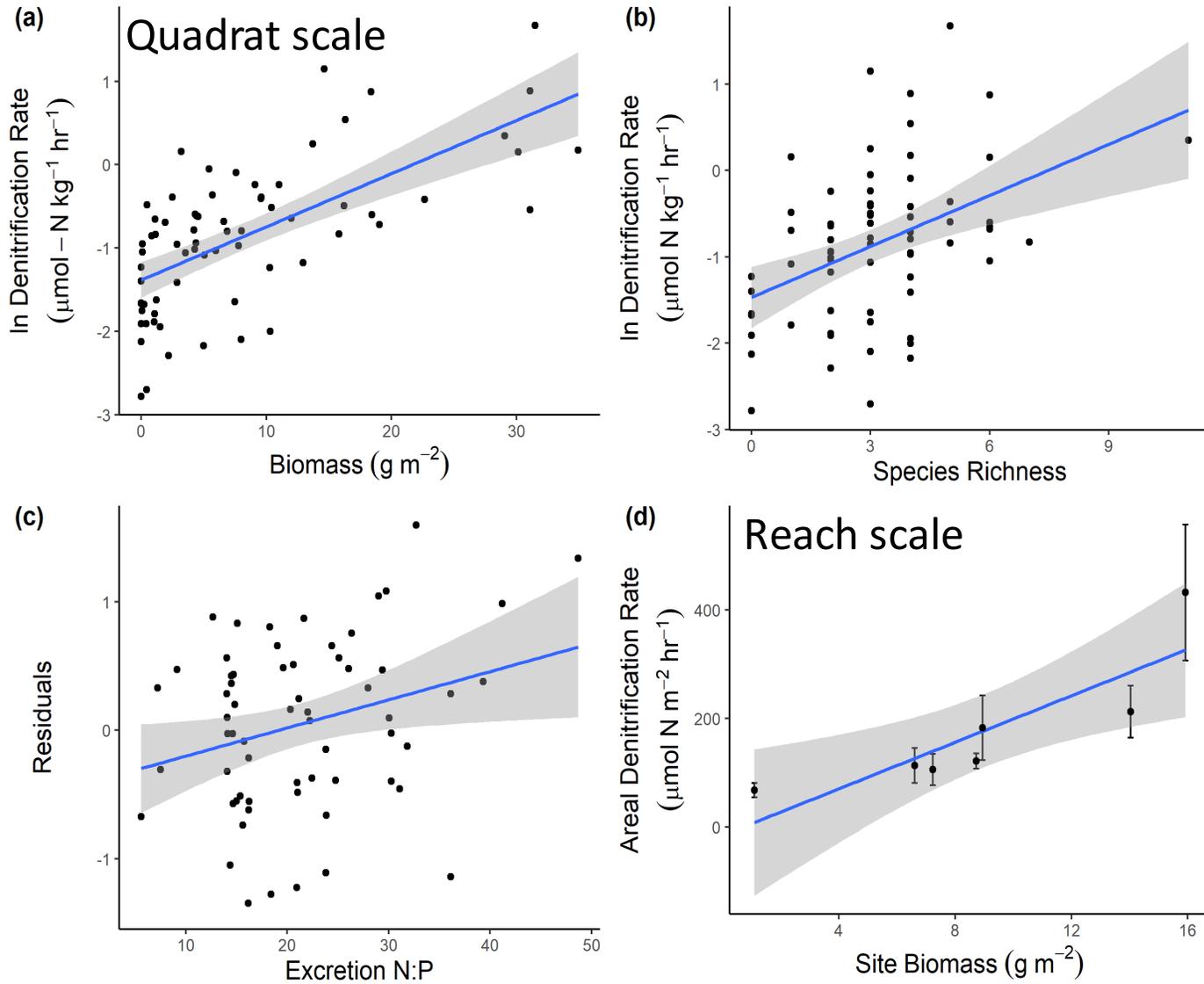
- Excretion can meet or exceed background nutrient conditions & demand
- Mussels are a major source of N, P, and labile DOM
- Labile DOM may be important for heterotrophic microbes that fuel river food webs



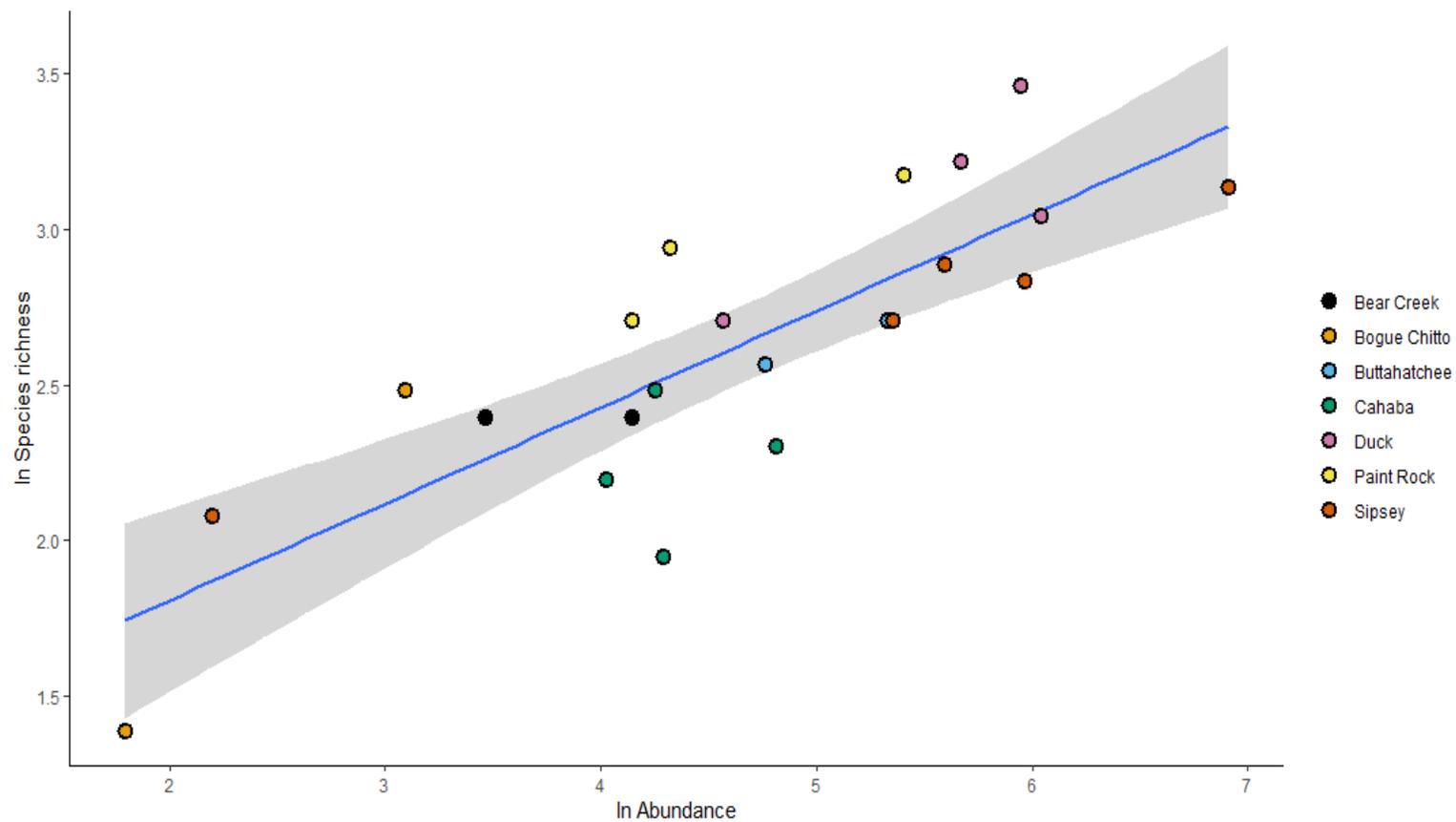
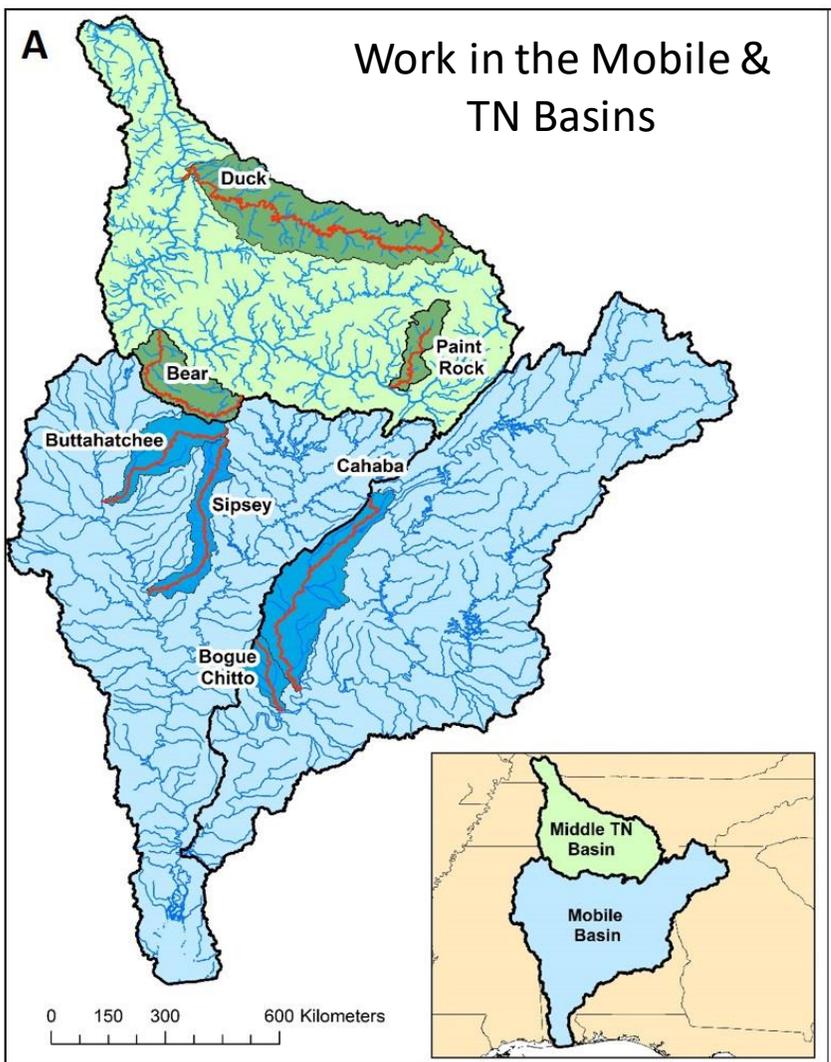
Indirect Effects on Supporting Services



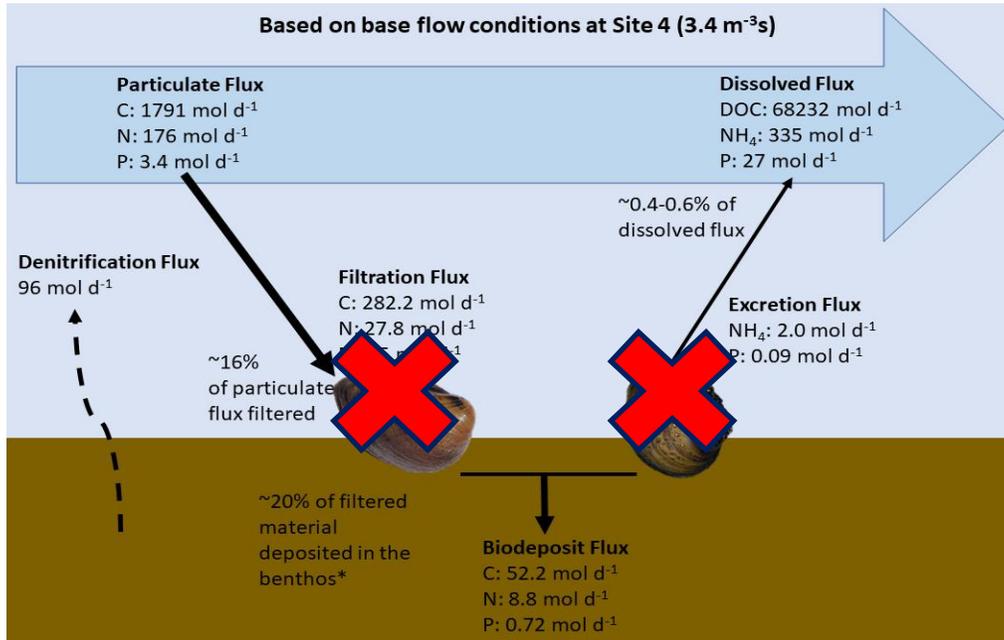
Mussels Enhance Denitrification Rates



Maintain abundance = maintenance of biodiversity = maintenance of function

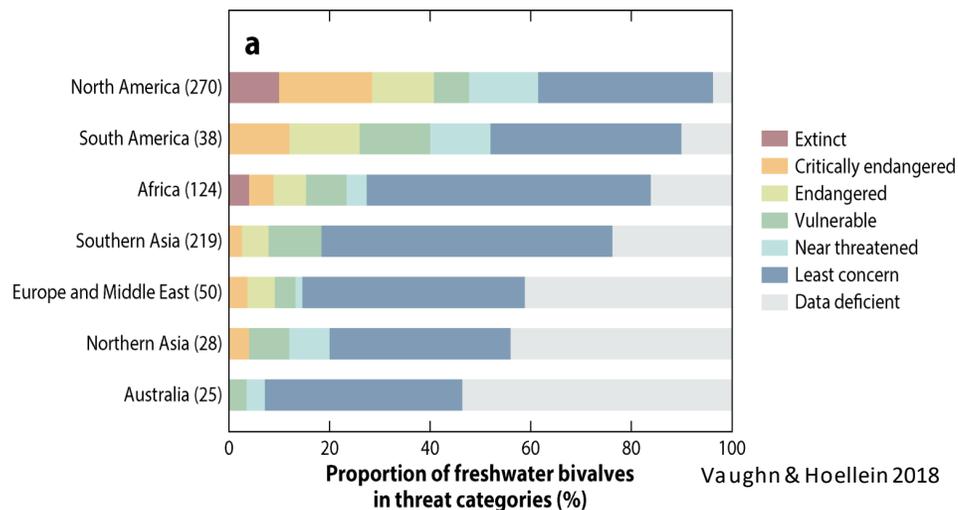


Ecosystem management is important for both biodiversity and ecosystem services

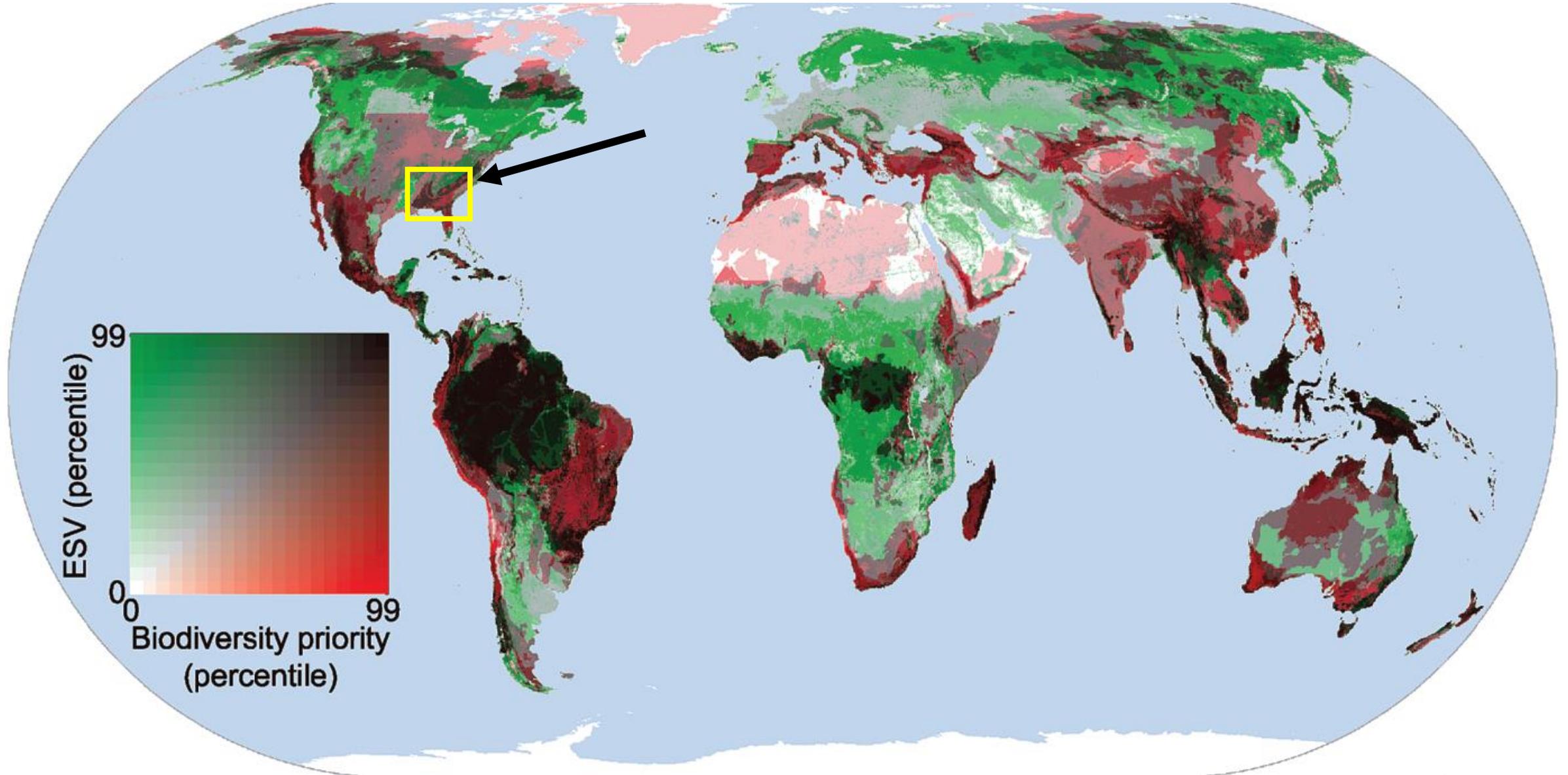


What does the loss of mussels result in for aquatic ecosystem service provisioning in the past/present/future?

Mussels appear to be more prone to declines than many other aquatic organisms.



Both Biodiversity and Ecosystem Services are of High Priority Conservation Value in this Region



What to do to maintain ecosystem services and biodiversity in the ACF?



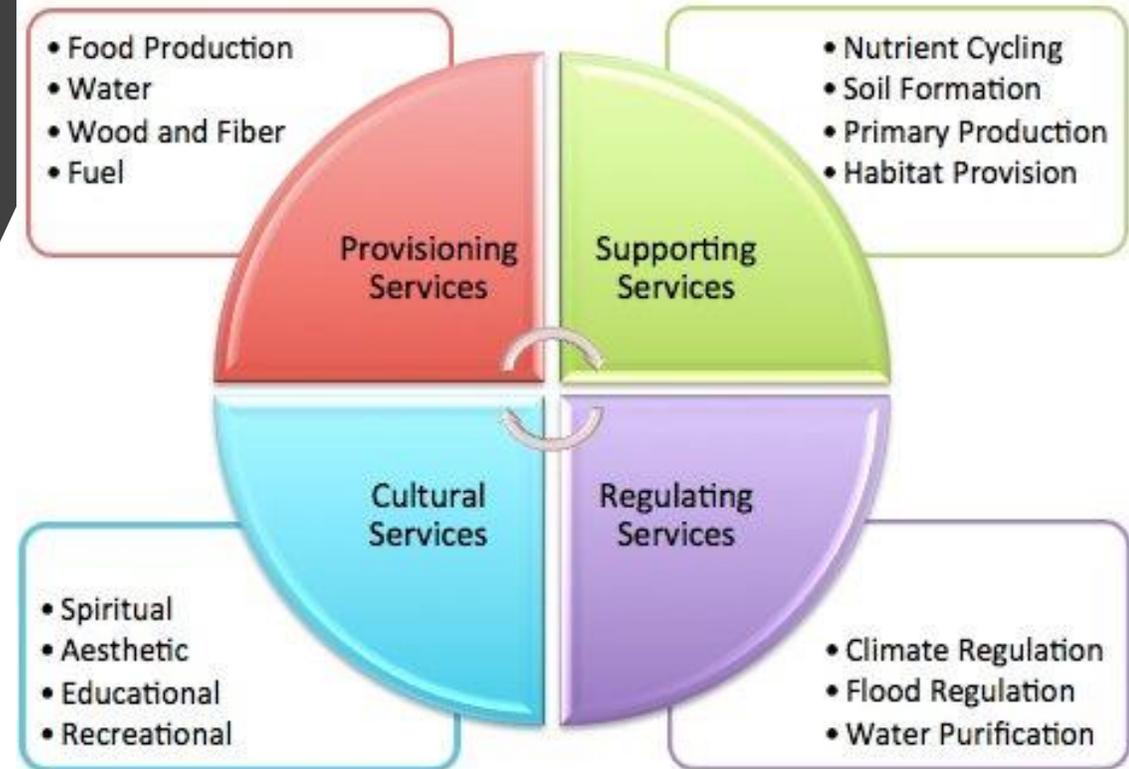
How to maintain ecosystem services and biodiversity in the ACF?

- **Water quantity and conservation**
- Enhancement of riparian zones for sediment and nutrient mitigation
- **Better management that takes a whole system & multi-species approach**
- **Outreach and education**



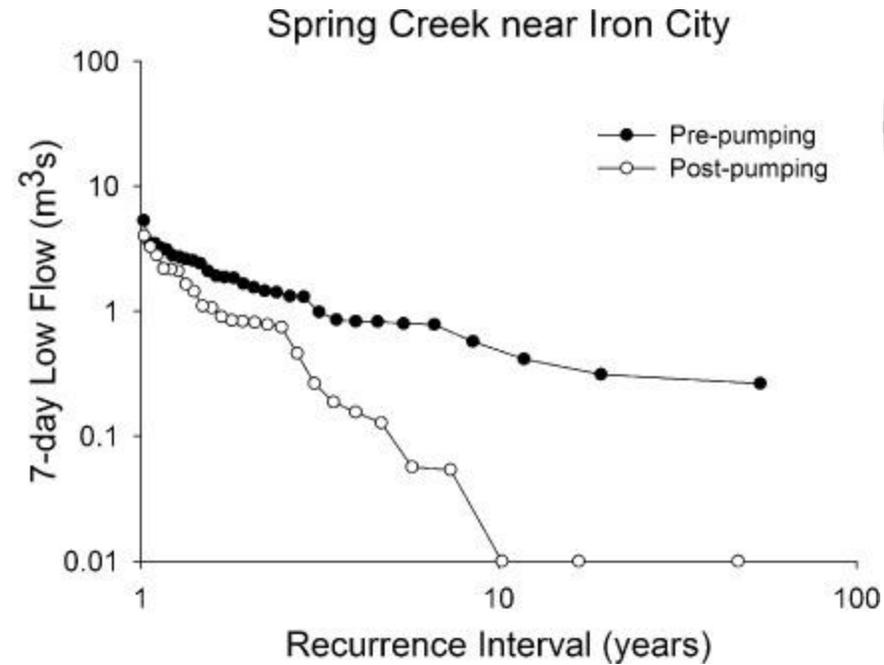
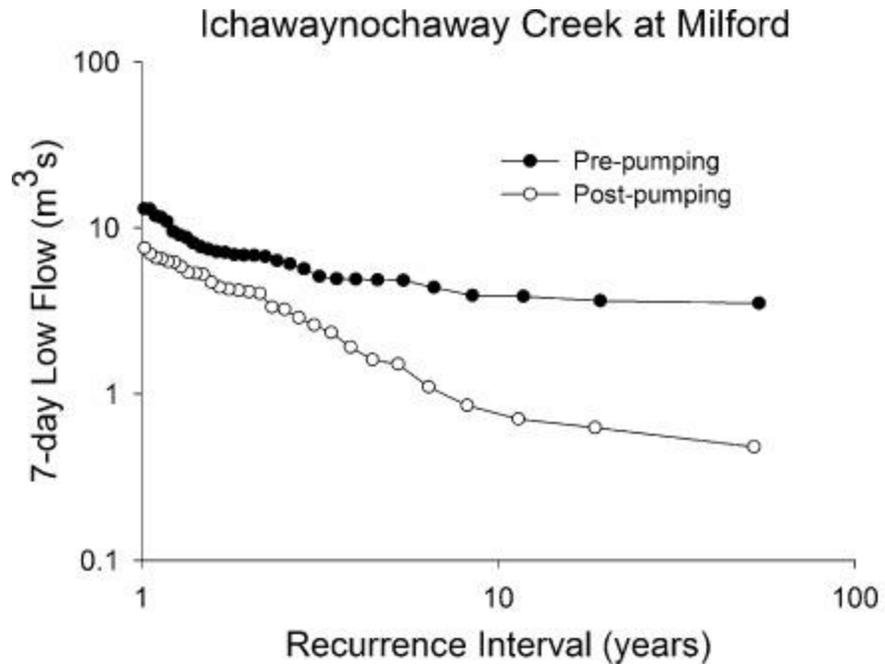


Some of these ecosystem services may result in conflicts among users



Source: Millenium Ecosystem Assessment, 2005.

Need water to secure these ecosystem services



Irrigation is drawing down flows that reduces habitat for aquatic species & increases stream temperature

Need water to secure these ecosystem services

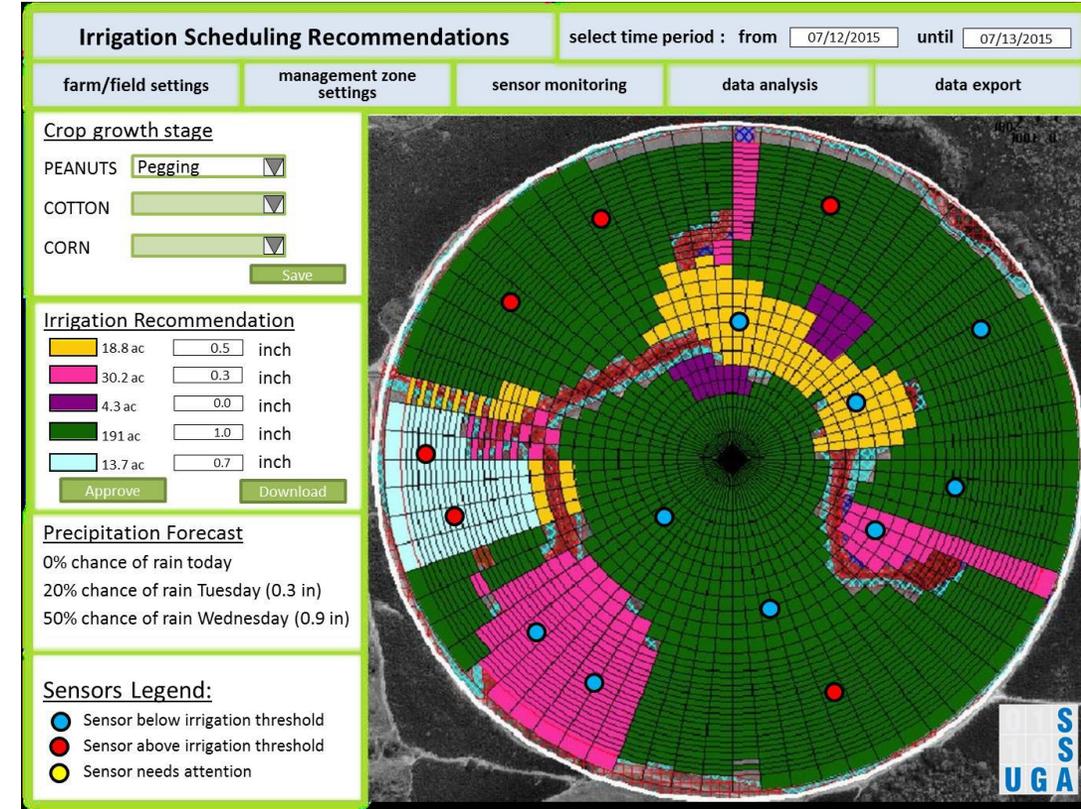
No aquatic organism provided ecosystem services without water!



Need water to secure these ecosystem services



More efficient irrigation systems (e.g., dynamic variable rate irrigation)



Lake
Seminole



Flow and water management strategies need to change and keep evolving based on science



Alosa spp.



*Elliptio
crassidens*



Alosa spp.



Elliptio crassidens

ARTICLE

Passage of Spawning Alabama Shad at Jim Woodruff Lock and Dam, Apalachicola River, Florida

Shawn P. Young

Department of Forestry and Natural Resources, Clemson University, 115 Lehotsky Hall, Clemson, South Carolina 29634-0317, USA

Travis R. Ingram* and Josh E. Tannehill

Georgia Department of Natural Resources, 2024 Newton Road, Albany, Georgia 31701, USA

J. Jeffery Isely

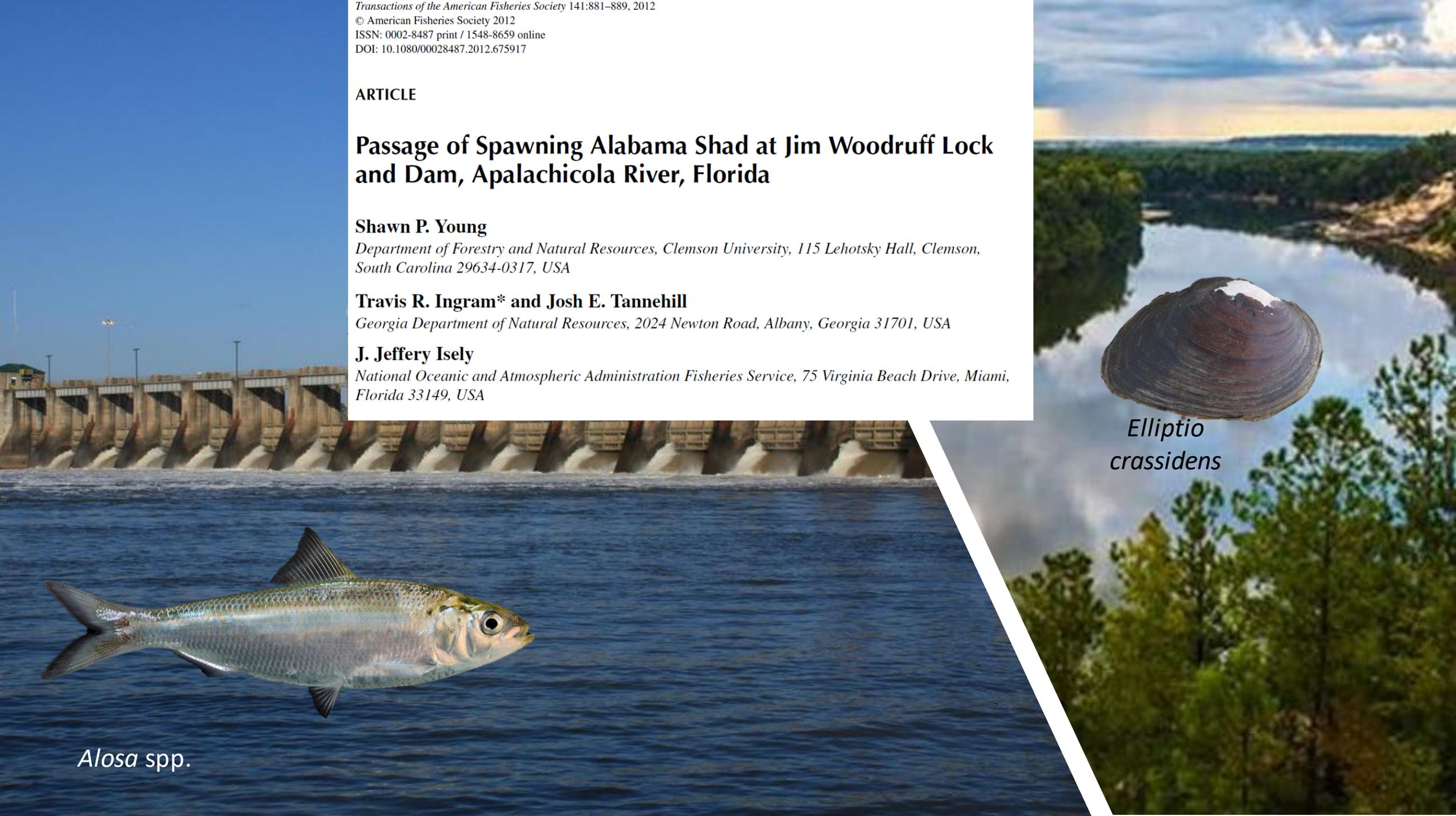
National Oceanic and Atmospheric Administration Fisheries Service, 75 Virginia Beach Drive, Miami, Florida 33149, USA



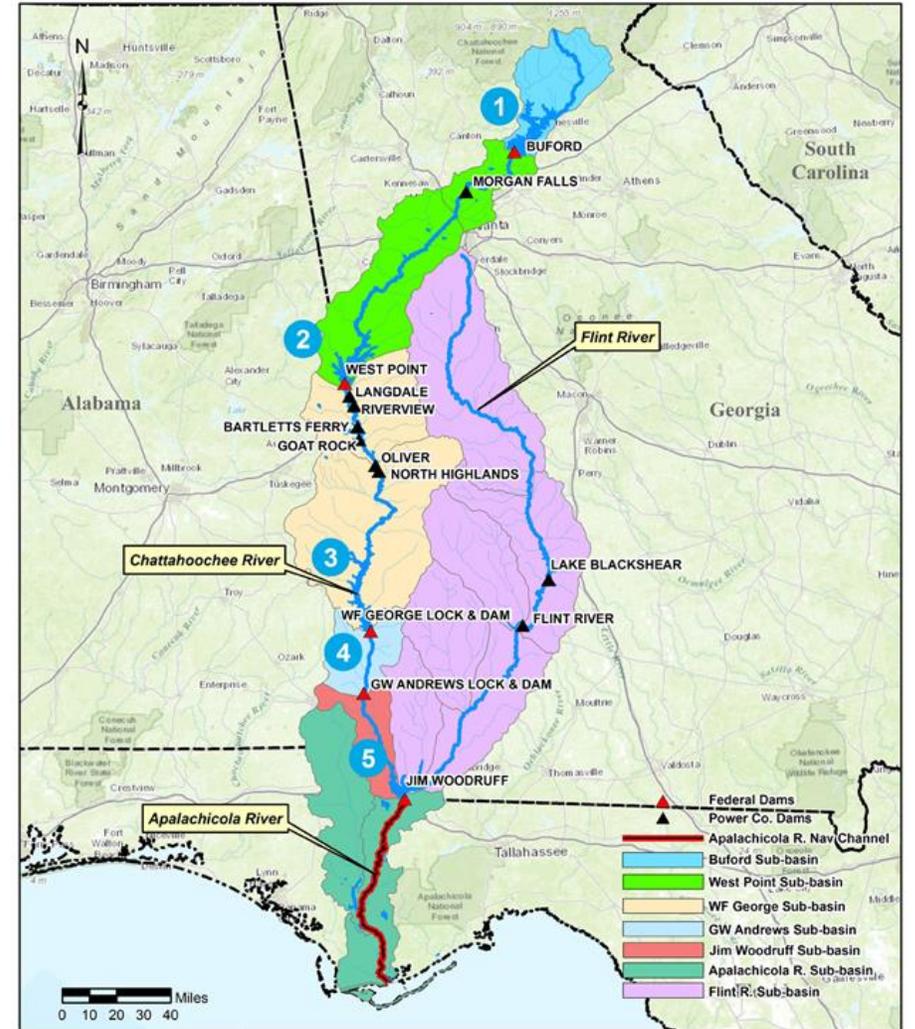
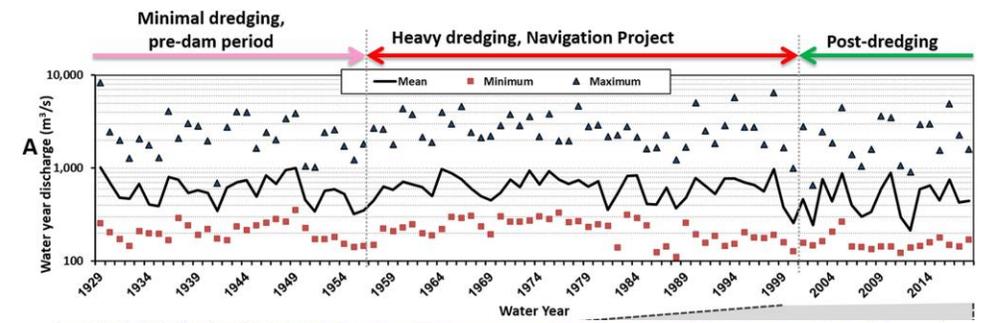
Alosa spp.



Elliptio crassidens



Major channel and habitat modifications





Ogeechee tupelo

RIVER RESEARCH AND APPLICATIONS

River Res. Applic. **29**: 718–733 (2013)

Published online 9 March 2012 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/rra.2567

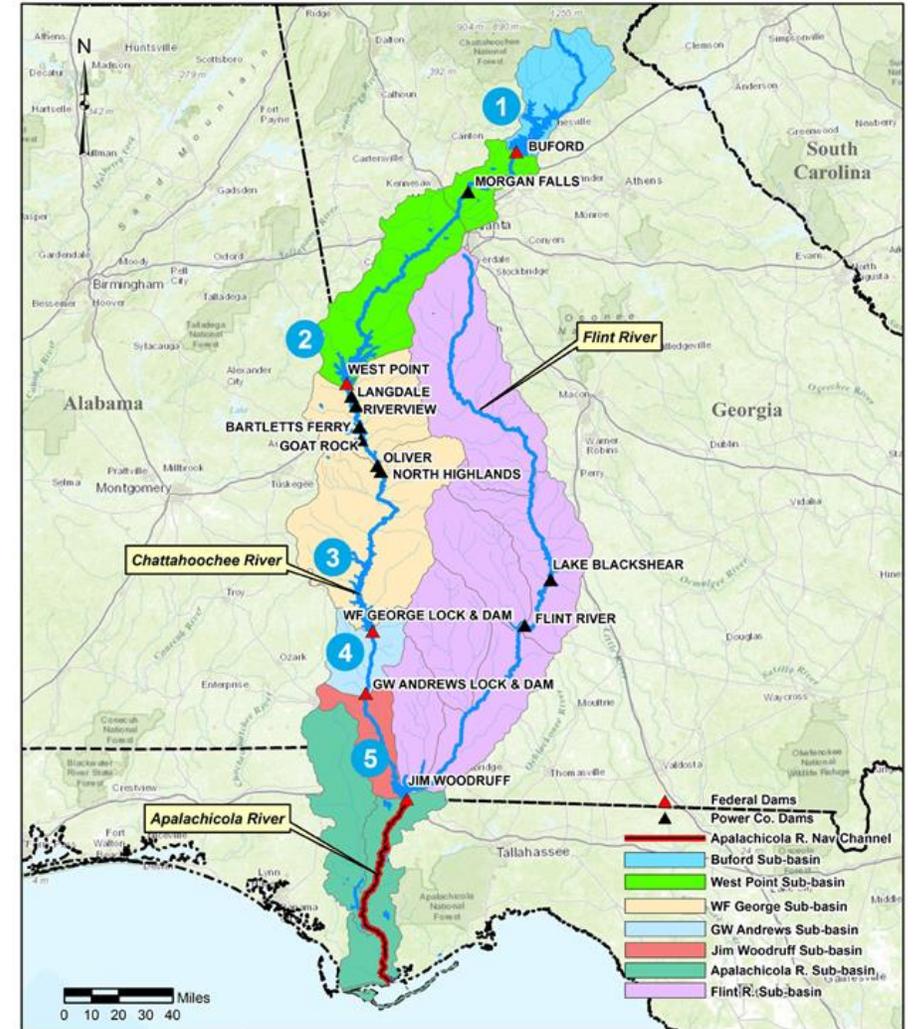
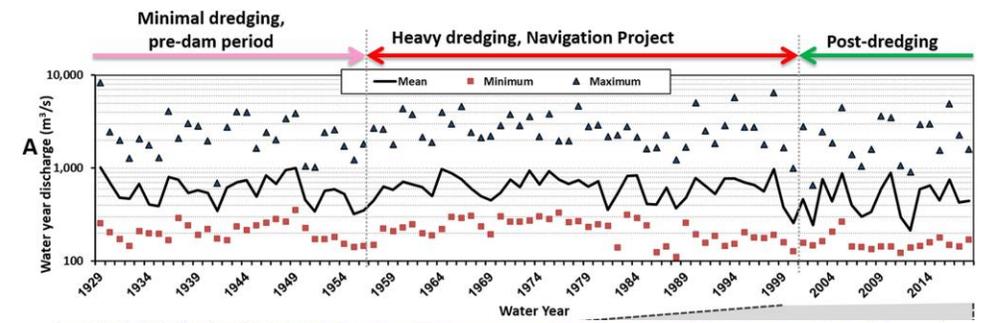
IMPORTANCE OF FLOODPLAIN CONNECTIVITY TO FISH POPULATIONS IN THE APALACHICOLA RIVER, FLORIDA

O. T. BURGESS^a, W. E. PINE III^{b*} and S. J. WALSH^c

^aUniversity of Florida, Fisheries and Aquatic Science Program, Gainesville, Florida USA

^bDepartment of Wildlife Ecology and Conservation, Fisheries and Aquatic Science Program, Gainesville, Florida USA

^cBiological Survey, Southeast Ecological Science Center, Gainesville, Florida, USA



More outreach and education



Existence Value



Ecosystem Services

There are still a lot of issues....



Lake Lanier,
August 2007



Lake Lanier,
October 2016

There are still a lot of issues....

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Camp, E. V., W. E. Pine III, K. Havens, A. S. Kane, C. J. Walters, T. Irani, A. B. Lindsey, and J. G. Morris. 2015. Collapse of a historic oyster fishery: diagnosing causes and identifying paths toward increased resilience. *Ecology and Society* 20(3):45. <http://dx.doi.org/10.5751/ES-07821-200345>



Insight

Collapse of a historic oyster fishery: diagnosing causes and identifying paths toward increased resilience

*Edward V. Camp*¹, *William E. Pine III*², *Karl Havens*³, *Andrew S. Kane*^{4,5,6}, *Carl J. Walters*⁷, *Tracy Irani*^{8,9}, *Angela B. Lindsey*^{9,10} and *J. Glenn Morris, Jr.*^{11,12}



NATIONAL

Florida Closes Iconic Apalachicola Oyster Fishery

July 22, 2020 · 5:03 AM ET
Heard on Morning Edition



3-Minute Listen + PLAYLIST



Concluding Thoughts

The ACF is a really special place that harbors incredible diversity and provides ecosystem services to millions of people

Implementation of policy needs to be more efficient

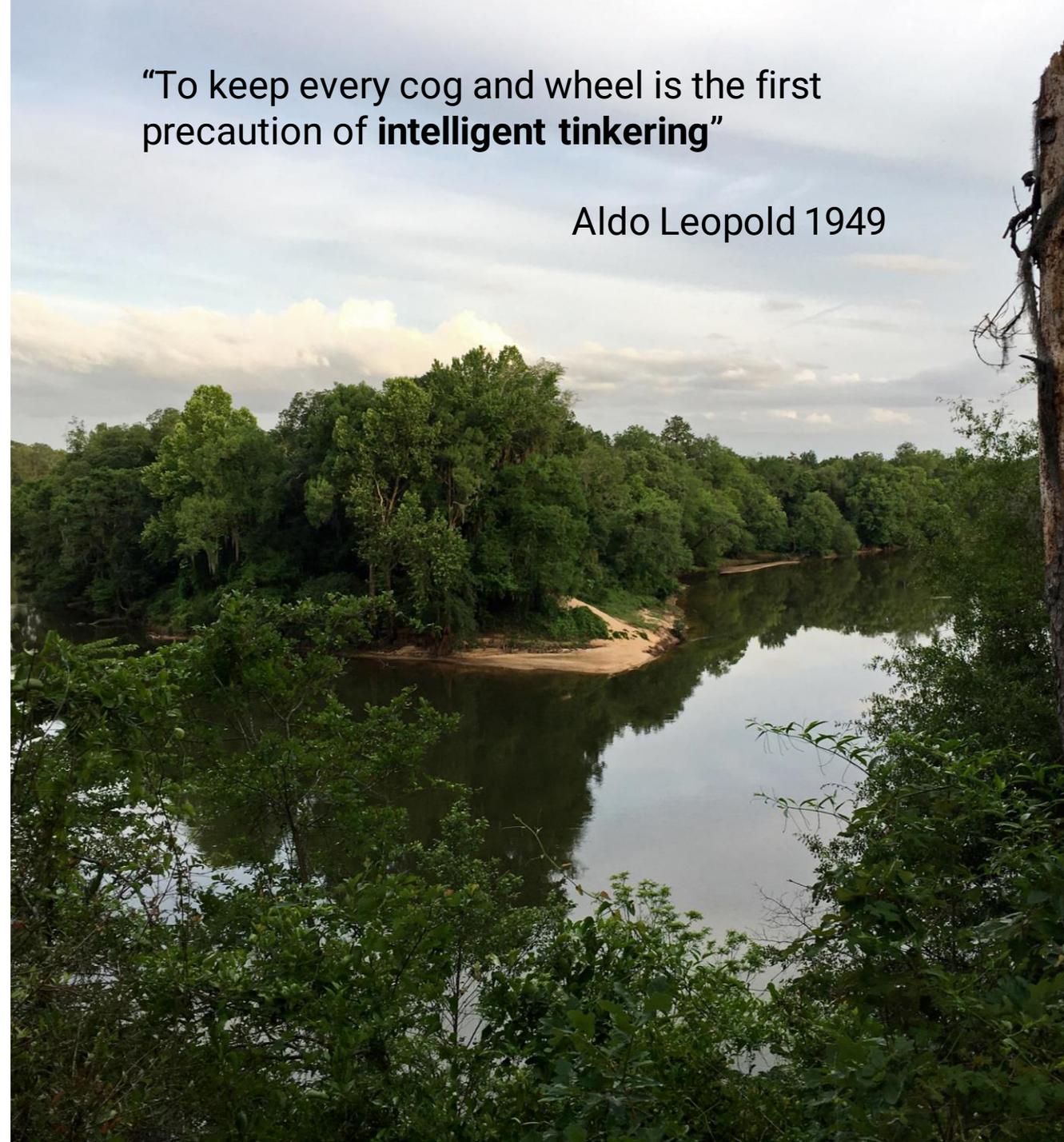
Progress is being made, but we need to work together more to meet common goals

More basic research is needed to understand how management activities influence species recovery and ecosystem services

In the face of climate change and further land conversion, we need to implement protection strategies that will preserve biodiversity and ecosystem services

“To keep every cog and wheel is the first precaution of **intelligent tinkering**”

Aldo Leopold 1949



ANY QUESTIONS?

More info

Email: clatkinson@ua.edu

Website: <https://atkinsonlab.ua.edu>

@carlaLatkinson

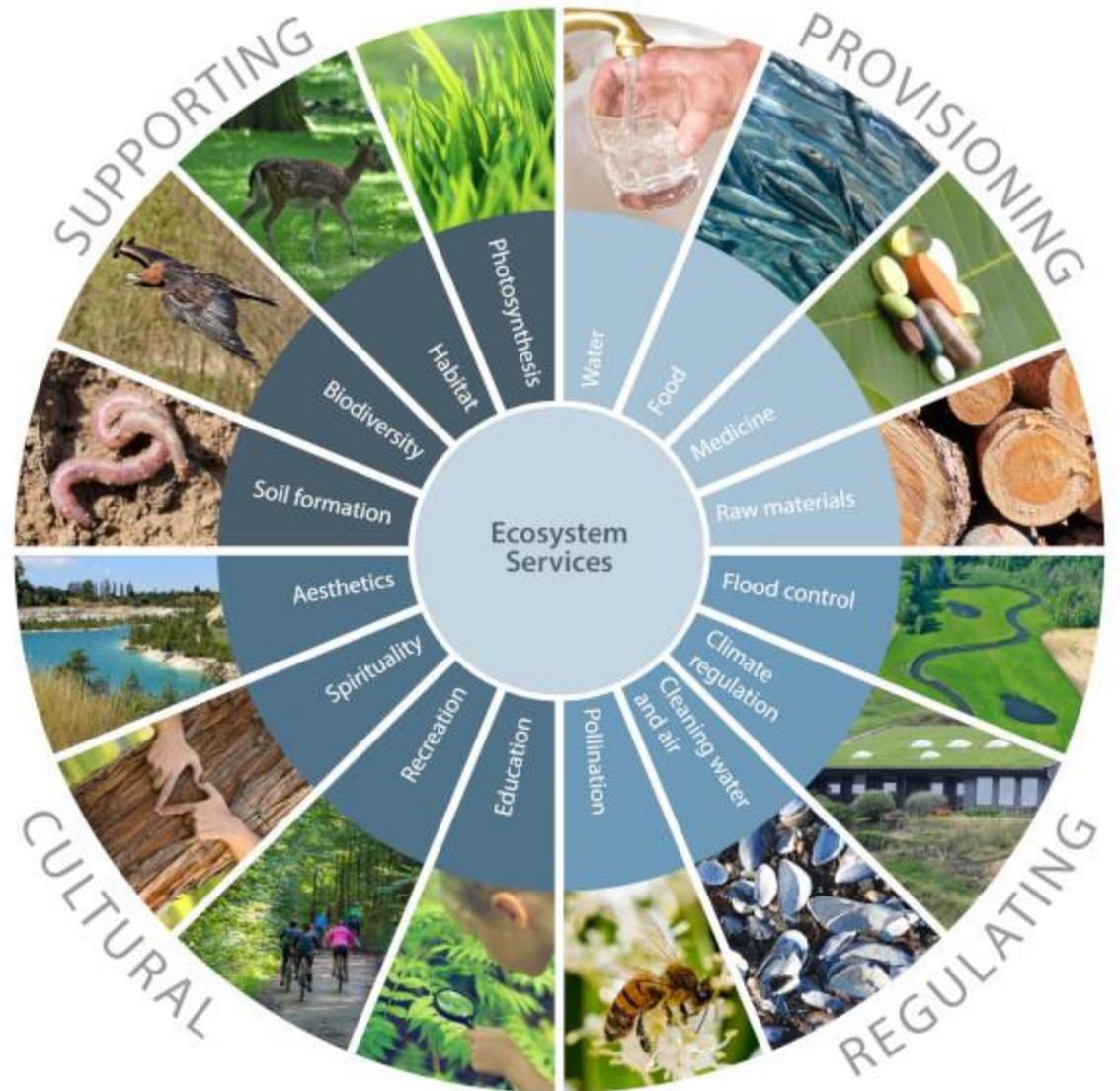


“Mussels are not dismissible, even by those who have little interest in the natural world. Their presence is a signature of healthy aquatic ecosystems, to which they contribute as living water filters.”

- E.O. Wilson

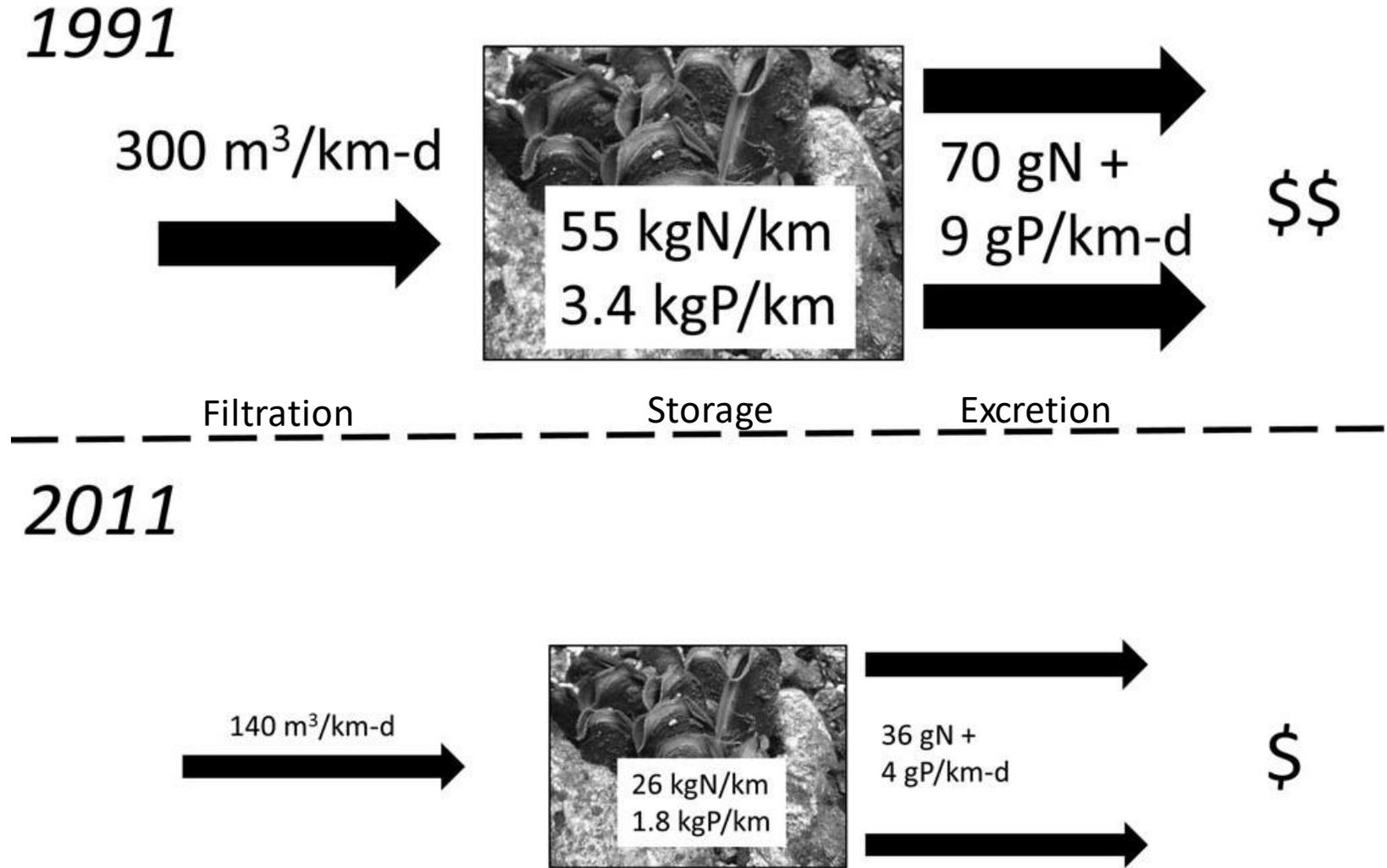
“To keep every cog and wheel is the first precaution of **intelligent tinkering**”

- Leopold 1949



Reduction in Function = Reduction in Services

Species composition also matters!



Value ≠ Price

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IMPORTANCE OF FLOODPLAIN CONNECTIVITY TO FISH POPULATIONS IN THE APALACHICOLA RIVER, FLORIDA

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Water Wars, Eastern Style: Divvying Up the Apalachicola-Chattahoochee-Flint River Basin

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Mussels strongly regulate biogeochemical cycling during base flow

