

Freshwater mussel contributions to ecosystem services



David Strayer (strayer@caryinstitute.org)

Cary Institute of Ecosystem Studies

Graham Sustainability Institute, University of Michigan

Outline

- What are ecosystem services?
 - How I will organize them
- Introducing freshwater mussels
- Possible values of freshwater mussels
 - Market and direct-use values
 - Indirect-use values
 - Existence values
 - Option values
 - Bequest values
 - Replacement values
- Conclusions



Ecosystem services and values

(“the benefits people obtain from ecosystems”)

- Provisioning services (e.g., food, fresh water, wood for humans)
- Regulating services (e.g., regulation of climate, or air or water quality)
- Cultural services (e.g., recreational, aesthetic, religious, spiritual, or educational opportunities to people)
- Supporting services (structures or functions that support any of the other three classes of services; examples include soil formation and nutrient cycling)
- Market and direct-use values
- Indirect-use values
- Non-use-values
 - Existence values
 - Option values
 - Bequest values

Costanza, R., et al. 2017. Twenty years of ecosystem services: how far have we come and how far do we need to go? *Ecosystem Services* 28: 1-16.

Goulder, L. H., and D. Kennedy. 1997. Valuing ecosystem services: philosophical bases and empirical methods. Pages 23–47 in G.C. Daily, editor. *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press, Washington, D.C.

Estimating the value of ecosystem services

- Multiple methods used, depending on the nature of the service; e.g.,
 - Market prices
 - Revealed expenditures (e.g., travel costs for recreation)
 - Hedonic models
 - Surveys of willingness to pay
 - Replacement costs
- Estimates may be difficult and imprecise
 - Just because it's hard to estimate doesn't mean it's zero
- Value \neq price
 - many things that have no market price have value; price is a minimum estimate of the value to consumers

Introducing freshwater mussels

Native



“Freshwater mussels” (Unionoida)



Fingernail and pea clams (Sphaeriidae)

Non-native



Zebra and quagga mussels (*Dreissena*)



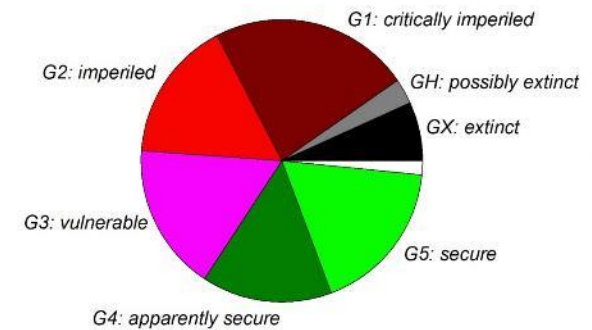
Corbicula

A few interesting things about freshwater mussels

- North American fauna was diverse (~300 species) and endemic
- Many populations and species are declining or gone
- Larvae of almost all freshwater mussels are parasitic on fish (leading to bizarre adaptations – see the movie!)
- Many species are long-lived (10 to 100+ years)



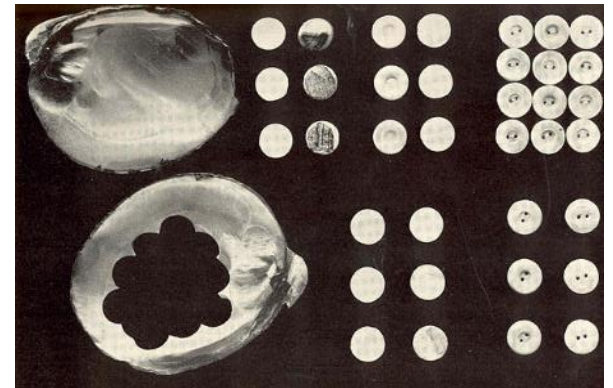
North American mussels



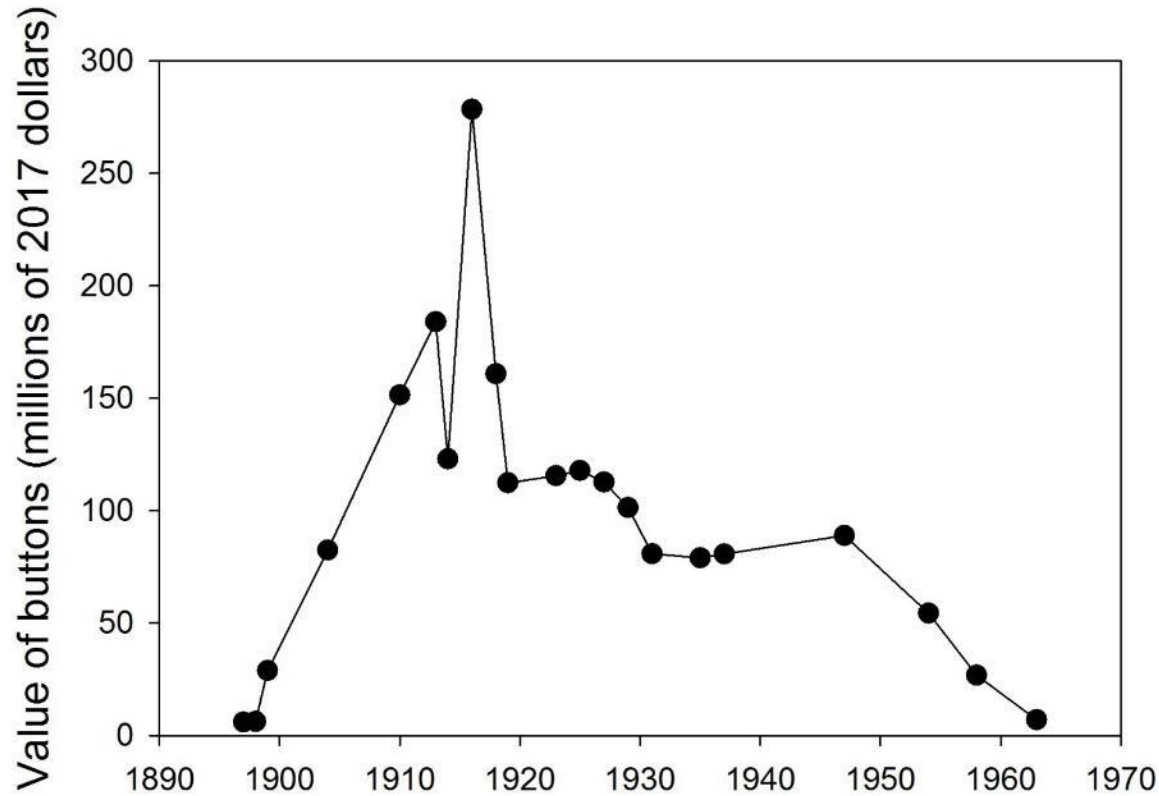
Chris Barnhart, NatureServe, NYSDEC

Direct-use values

- Products sold on the market
 - Natural pearls
 - Buttons
 - Cultured pearls and nuclei
- Other direct uses
 - Water-quality indicators



Shell and pearl harvest was valuable



- Total value of buttons (1893-1963) in US ~\$6 billion
- I haven't seen good figures on pearls, but probably about as valuable as buttons
- Total value of fishery in the US in the range of \$10 billion
- Fisheries still exist, but are much smaller (\$10⁶/yr)

Indirect-use values arising from ecosystem functions

- Ecological activities may change an ecosystem, which may affect its value to people
- Related to supporting and regulating services in the framework of the Millennium Ecosystem Assessment

Ecological activity



Joel Berglund

Change in ecosystem structure or function



USFS/Holly Krake

Change in value to people



Suspended particles

(clearer water, more growth of submerged vegetation, more littoral fishes and invertebrates, pathogen removal, toxicant removal?)



Mussel tissue and gametes

(nutrient stores, food for fishes and other consumers)



Soluble N, P

(local algal production, local invertebrate and fish production, denitrification?)



Sediment mixing

(interstitial oxygen and habitat?; nutrient exchanges?)



Biodeposits

(invertebrates, fish, bacteria, denitrification?, C sequestration?)

Physical structure, including dead shells

(attachment and shelter for invertebrates and algae, spawning sites and shelter for fish, information for environmental monitoring, near-sediment water flow?, sediment stabilization?, C sequestration?)



Cautions about indirect-use values

- Ecological activities may not change the ecosystem, or have different effects in different ecosystems
- The same change to ecosystems may have different values in different places and times
- May apply to a wide range of direct-use values, including some that are hard to estimate
- Can be substantial, even if they are hard to estimate

The link from ecological activities to ecosystem state may be negligible or variable

- Mussels filter particles from the water
- ...but whether the water gets clearer depends on the amount of water filtered and other processes affecting clarity
 - Zebra mussels filtered 75% of the silt from the Hudson River each day, but the amount of silt in the water didn't change
- ...so merely showing that an ecological activity occurs is not sufficient to show that indirect-use values are important

Ecological activity



Joel Berglund



Change in ecosystem structure or function



USFS/Holly Krake



Change in value to people



Ecosystem states may have different values in different places and times

*Absorbs nitrogen and
wave energy*

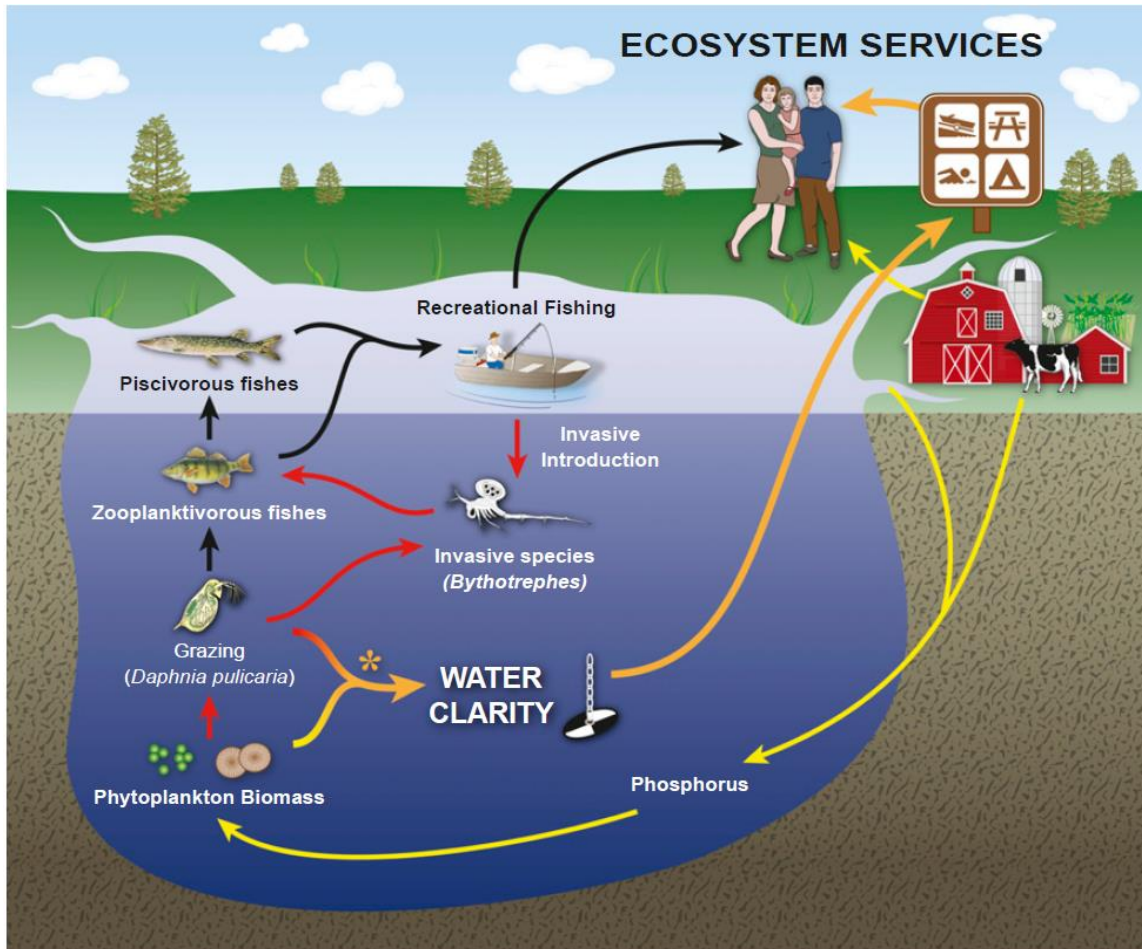


\$\$\$?

Indirect-use values may arise from a wide range of direct-use values

- Contributions to consumptive uses (higher fish populations, better water quality for drinking)
- Contributions to non-consumptive uses (recreation)
- Some of these values may be hard to estimate
- ...but

Indirect-use values can be substantial



Walsh et al., PNAS, 2016

- Invasion of a non-native zooplankter can make lake water less clear
- This cost ~\$100 million in just one lake!
- Cost estimated by asking people how much they valued clear water and from the cost of reducing P enough to make the lake clear again

\$\$\$?

Suspended particles
(clearer water, more SAV
growth, more littoral fishes and
invertebrates)

\$\$\$?

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- We have measurements of some mussel activities in ecosystems, others are still unstudied
- Indirect-use values of mussels haven't been estimated, but we are probably at the point where indirect-use values of mussels could be estimated as a special study, though not routinely
- Indirect-use values of mussels probably are sometimes important
- Indirect-use values of mussels are probably highest where
 - Mussel densities are high
 - Ecosystems are sensitive to mussel activities
 - The property of the ecosystem that is changed by mussels is valuable to people

*invertebrate production,
?denitrification)*

\$\$\$?

Non-use values: existence value

- The value of knowing that something exists, even if you don't "use" it (e.g., snow leopards)
- May have aesthetic, ethical or religious origins
- Recognized in legal proceedings (Exxon Valdez)
- Hard to estimate precisely, but may be large
 - US contributions to WWF in FY 2016 were \$226 million



Existence values of freshwater mussels

- Existence values typically are higher if item is
 - Rare or unique
 - Imperiled
 - Charismatic
 - Interesting
- Education can greatly change non-use values
- I don't know any estimates of non-use values of mussels

Non-use values: Option and bequest values



- The value of keeping something (even if you're not using it now) in the expectation that you may want it in the future (option value)
 - Or your descendants might want it (bequest value)
- May be high if you don't yet know the full value of something, or if you know that your descendants may have different values than you do
 - “To keep every cog and wheel is the first precaution of intelligent tinkering” - Aldo Leopold

Option and bequest values of freshwater mussels

- We certainly don't yet fully understand freshwater mussels and their possible utility
 - Future shell or pearl industries?
 - Development of nacreous materials, fabrics, or underwater adhesives?
 - New understanding of roles in ecosystems?
- We know that values about nature have changed greatly across generations



Replacement cost*

- A practical approach taken in the American Fisheries Society's *Investigation and monetary values of fish and freshwater mussel kills*
 - (“you broke it, you bought it”)
- Does not necessarily correspond to other values discussed here
 - “the true costs associated with a fish or mussel kill cannot be fully accounted for using replacement costs alone” (AFS, 2017)
 - Can be either lower or higher than costs estimated using other methods
- Assumes that restoration will be successful (this assumption has been problematic for stream and wetland restoration)

Investigation and Monetary Values of Fish and Freshwater Mussel Kills



Robert I. Southwick and Andrew J. Loftus, editors

American Fisheries Society
Special Publication 35

Replacement costs can be high

Body of water	Kill	Replacement cost*
Yellowleaf Creek, AL	>250 mussels	\$85,000
Clinch River, VA	18,000	\$6,100,000
Dunkard Creek, PA, WV	>45,000	\$15,000,000
Ohio River, OH, WV	>1,000,000	\$340,000,000

*replacement costs are probably too low because they do not include investigation, monitoring, administrative, transportation, or habitat restoration costs, assume that no endangered or threatened species were involved, and are based on the median cost of propagation

Summary

- Freshwater mussels may provide a wide range of ecosystem services, and have a correspondingly wide range of values
 - Market value of shells and pearls
 - Indirect-use values linked to water clarity, waterborne pathogens, food webs, physical changes to habitats, nutrients
 - Non-use values
- The value of these ecosystem services has not been estimated, nor can it yet be estimated routinely, but it may be possible to do so as a special study
- This value must range widely among ecosystems, and be substantial (at least millions of \$\$\$) in some of them
- To be credible, an estimate should include all ecosystem services
 - Partial estimates can be misleading and lead to poor decisions
- Replacement costs can be estimated, and will often exceed 1 million \$\$\$, (but do not necessarily equal the value of ecosystem services)

For more information

- ***Vaughn, C.C. 2018. Ecosystem services provided by freshwater mussels. *Hydrobiologia* 810: 15-27.
- Strayer, D.L. 2017. What are freshwater mussels worth? *Freshwater Mollusk Biology and Conservation* 20: 103-113. (open access)
- Strayer, D.L., J. Geist, W.R. Haag, J.K. Jackson, and J.D. Newbold. 2019. Essay: Making the most of recent advances in freshwater mussel propagation and restoration. *Conservation Science and Practice* 1: e53, doi: 10.1111/csp2.53. (open access)
- ...and references cited in these papers