



# Overview of North American freshwater mussels: Conservation Challenges and Opportunities

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# What are Freshwater Mussels?

Class Bivalvia (Bivalves)



Order Unionida-native

Family Unionidae

Family Margaritiferidae

Common name-Unionid mussels,  
freshwater mussels



Order Veneroida

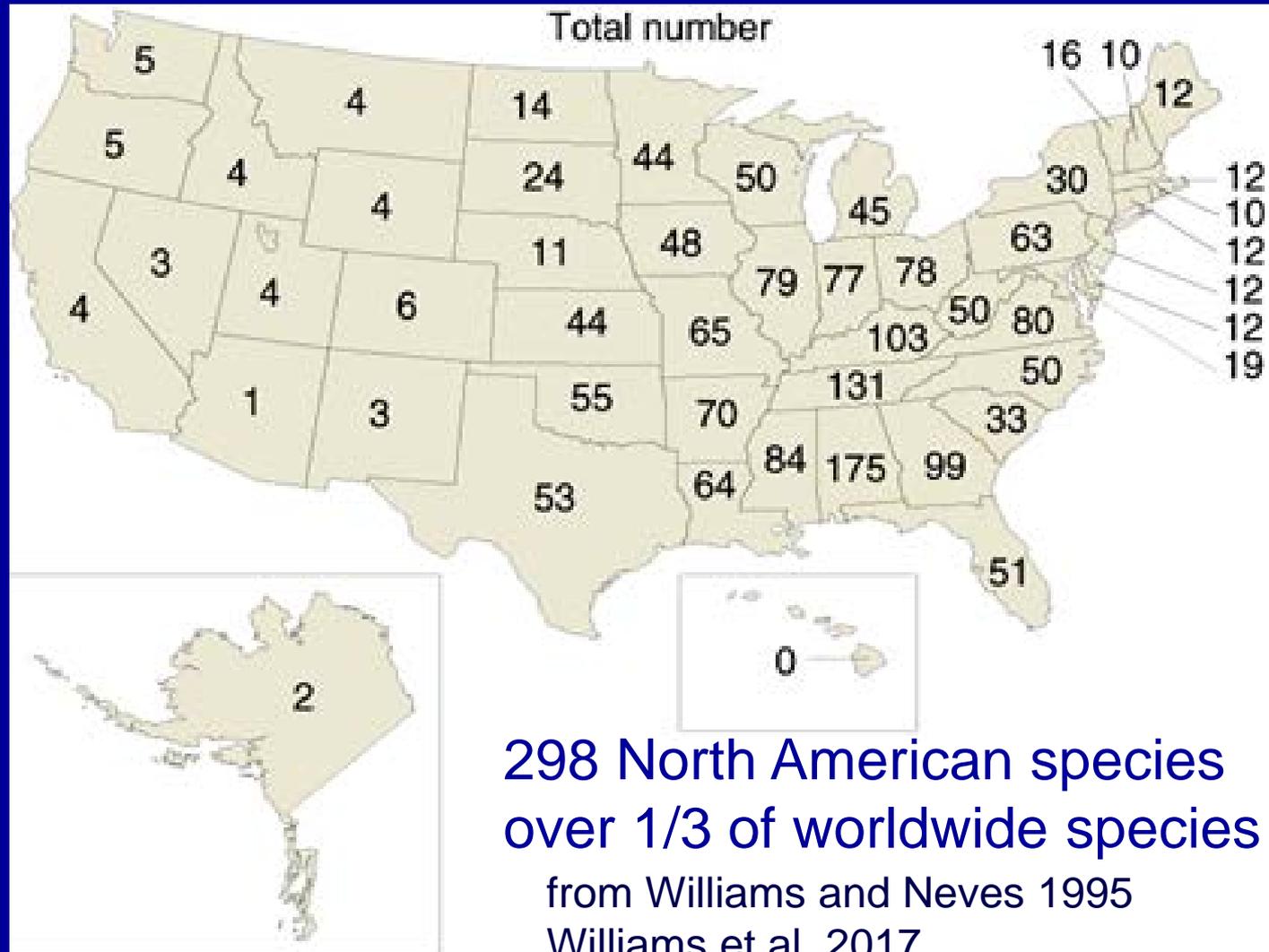
**Family Sphaeriidae (fingernail clams)-native**

Family Corbiculidae (asian clams)-invasive

Family Dreissenidae (zebra/quagga mussel)-invasive



# Unionida Distribution in USA



# Unionids are Unique

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Unio=Pearl in Latin



Evolved in freshwater riverine ecosystems-

Depend on hydrological cycle

- Floods/droughts

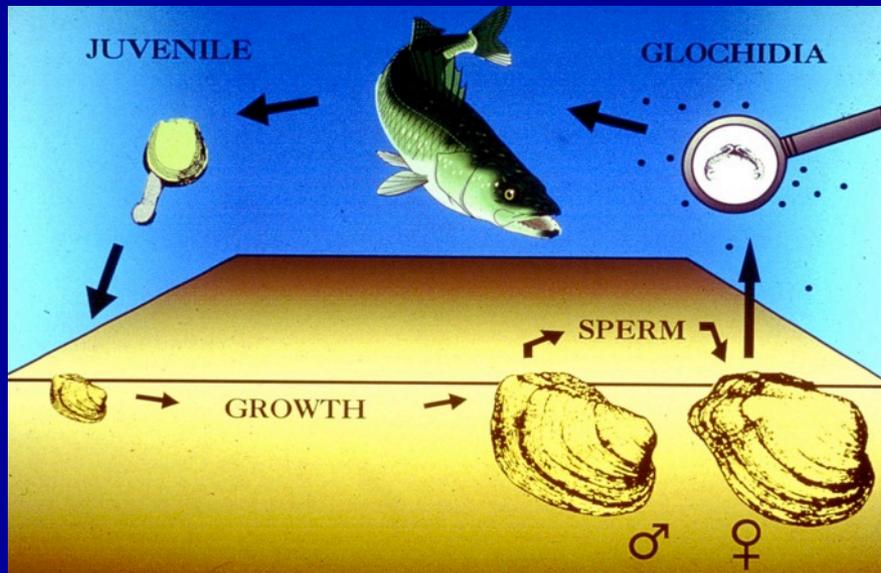
Depend on local hydraulic conditions

- Flow refugia
- Bed stability

Presence of mussels indicative functioning river system –

“Canary in the coal mine”

# Unique Life Cycle



Male releases sperm balls

Female takes up sperm balls

Fertilized eggs develop in gills

Eggs develop into glochidia

(larval unionid mussels)

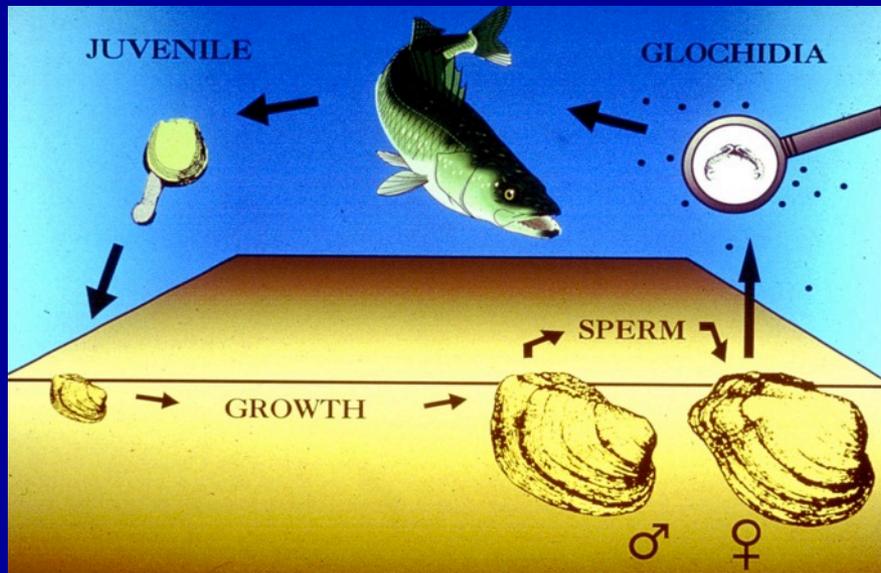
Glochidia attach to fish host

Metamorphosis on fish host

Juvenile drops off

# Why the fish host?

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Downstream migration w  
bedload

Upstream migration on fish

# Very Alluring



Snuffbox snaring a log perch



Ouachita Kidneyshell conglutinates



Orange nacre mucket super-conglutinate



Lampsilis mussel mantle flap

# Where do unionids live?

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- **Most** Species in Mussel Beds in Permanent Streams/Rivers
  - Mussel Community/Assemblage
  - Multiple species
  - Multiple size classes
  - Density greater than surrounding area
  - Physical boundaries



# Habitat Attributes

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- Allows juveniles to settle
  - Shears not excessive
- Provides support
  - Soft enough for burrowing
  - Firm enough to support
- Stable
  - Stays in place during floods
  - No sudden scour or fill
- Delivers food
  - Sediment organic matter (juvs)
  - Suspended food (adults)
- Delivers essential materials
  - Oxygen
  - Calcium
- Provides favorable temperatures
  - Growth
  - Reproduction
- Protection from predators
- No toxic materials
- Habitat for fish hosts

# Physical Habitat

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## Moderate Flow and Stable Substrate

Moderate velocity

Refuge from high velocity

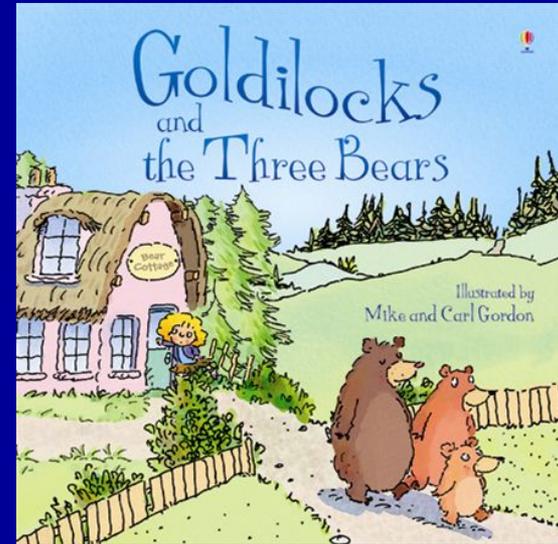
Limited siltation

Low hydrological variability

Heterogeneous substrate

Stable substrate for flow conditions

Loose enough for interstitial flow



# NO Habitat Suitability Index

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Experimental- long way from modeling suitable habitat

General hydraulic principles correlate with presence –  
shear stress, relative shear stress, boundary Reynolds no. -  
combine substrate, depth, velocity at high and low discharge

Evaluate habitat by experience

Nearby similar streams

Upstream areas

...inconsistencies

among models, rivers, and species

among which variables correlate with habitat

among magnitude of variables

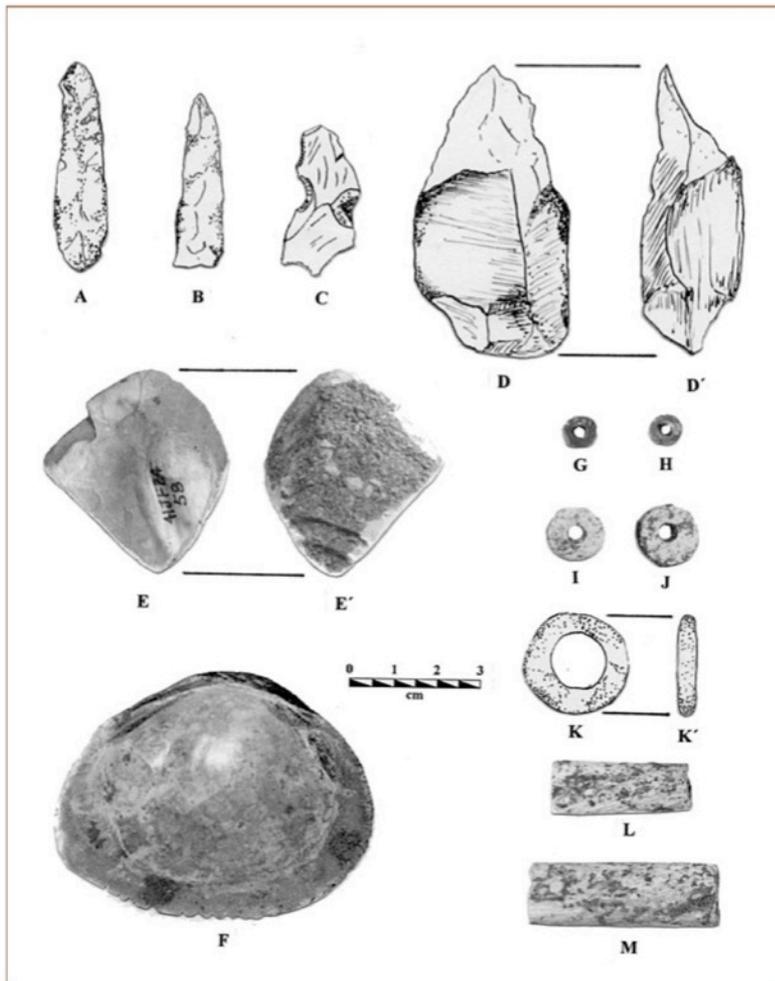
exceedance flow levels, and

Multiple variables and combinations needed for model

# What are they good for?

## Cultural Heritage

Food  
Shell tools  
Beads  
Pearls  
Pottery



# Commercial Value

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Pearl Button Industry  
Late 1800's to early  
1950's  
Raw shell >\$1mil/yr  
Buttons >\$6mil/yr

Cultured Pearl Industry  
Mid 1950's to present

Declined due to declining number  
of mussels,  
Zebra mussel infestation  
Development of alternate nuclei



# Ecosystem Services

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## Supporting Services

Structural habitat

- cover for fish
- substrate for algae, insects, snails

Attract fish

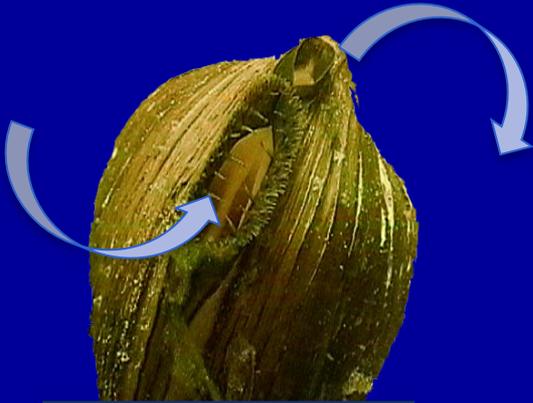
Substrate modification –aeration, stability

Food for other organisms

- fish, muskrats, otters, raccoons



# Water Purification Services



Adult mussel filters 0.1-3L gram dry tissue/hr

or

5-144 L/mussel/day

Mussel filtration in Kiamichi River

\$1,126/mile/day

\$396,352/mile/year

\$31,708,160/river/year

VS.



Based on average species composition & biomass

Filtration rates at 25C for 8 dominant species

Water purification costs of \$3.24 per 1000 gallons

# Nutrient Cycling

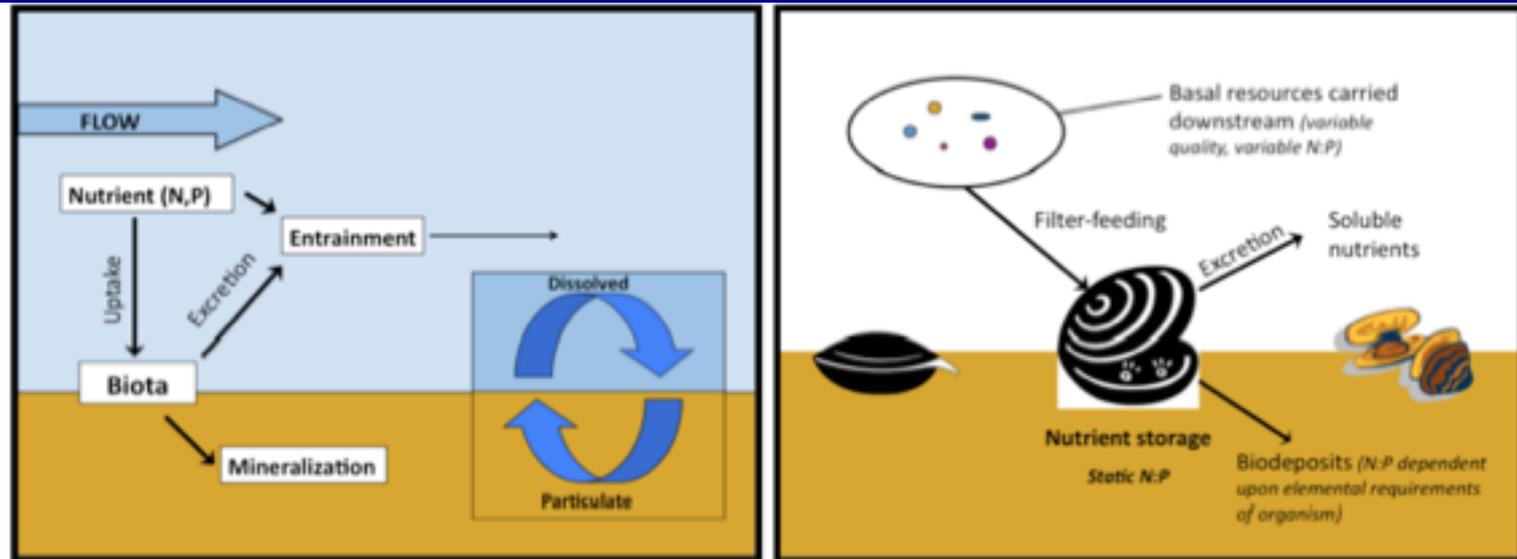


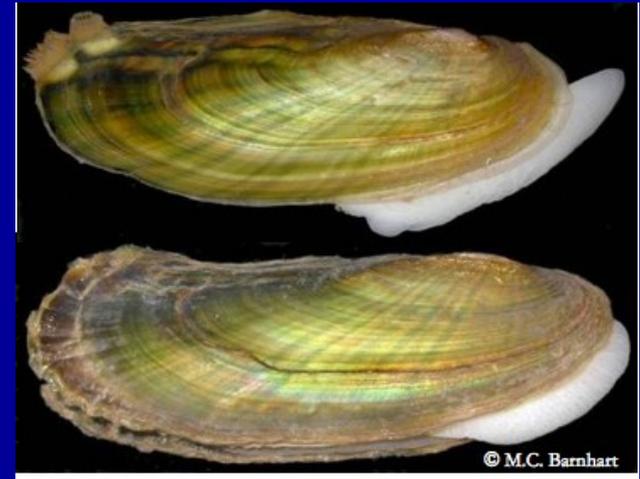
Figure 4. Left panel: nutrient recycling in a stream reach. Right panel: proposed mussel role in nutrient recycling.

Nitrogen storage in soft tissue  
26kg N/km  
42 kg N/mile

# Very Endangered

## United States

- about 298 species
- 29 Extinct
- 83 Federally threatened or endangered
- 65% of fauna imperiled



Male and Female Scaleshell



Male Higgins Eye Pearly mussel

Most states also have Unionida listed as threatened and endangered

# Why so endangered?

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Habitat loss – Modification of rivers/streams

Changes to Hydrologic cycle

Poor water quality

Sedimentation – Siltation

Commercial harvest

Invasive species –  
Zebra mussels, Asian clams



# What are we losing?

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Unique animals

What other animals can fish?

Produce pearls



Biodiversity

River's natural filtering system – increased stream clarity

Habitat for plants and animals – increased fish and fishing

Stream/river stability

Tourism and Recreational opportunities



# How can we help these animals and our rivers?

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Decline recognized turn of the century

pollution  
overharvest

1970s

Endangered Species Act  
Clean Water Act



Early 1990's development of National Strategy

UMRCC St. Louis meetings – 1993, 1995  
Strategy published in 1998

# National Strategy for the Conservation of Native Freshwater Mussels (1998)

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## Identified 10 Problems with goals and strategies

1. No coordinated national strategy for conservation of freshwater mussel resources
2. Quality mussel habitat continues to be degraded and lost
3. Basic life history, reproductive biology, ecology, and habitat requirements of most mussels is unknown
4. Knowledge of current distribution and health of mussel populations is lacking, and much of the historic distributional data are not readily available



# National Strategy for the Conservation of Native Freshwater Mussels (1998)

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## Identified 10 Problems with goals and strategies

5. Habitat alterations, water quality degradation, and other anthropogenic factors continue to negatively affect mussels, but poor documentation exists as to how and at what levels such perturbation are realized
6. Invasion of zebra mussels poses a new and significant threat to the continued existence of many native mussel species
7. General lack of concern, awareness, and understanding by government agencies, legislators, academia, and the general public about the ecological and economic value of native mussels, other aquatic resources, and the anthropogenic impacts that threaten their continued existence

# National Strategy for the Conservation of Native Freshwater Mussels (1998)

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## Identified 10 Problems with goals and strategies

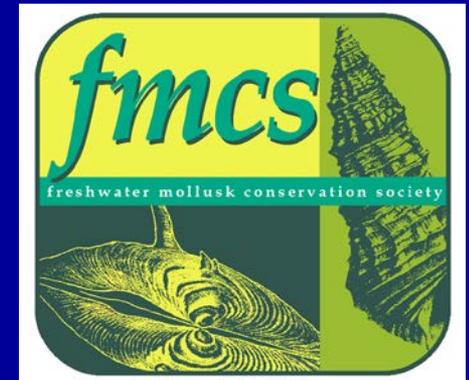
8. Survival and recovery of many mussel species will require the development of artificial propagation and juvenile mussel reintroduction techniques, but these methods have not been perfected
9. Survival of rare mussels will require the ability to hold them in captivity or in refugia and to translocate adult mussels to reestablish populations. However, these techniques are not adequately developed for implementation by resource managers
10. Current funding levels are not sufficient to address identified information needs or to implement this National Strategy.

# 1. Increase coordination and information exchange

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1. National strategy published in 1998
2. Freshwater Mollusk Conservation Society formed to implement the strategy
  - Committees formed to address goals and strategies
  - Biennial workshops to address information needs – 2018 Disease
  - Biennial symposium – 2019 San Antonio, TX; 2021 Pacific NW
  - *Ellipsaria*
  - *Walkerana*/Journal of Freshwater Mollusk Biology and Conservation
3. Creation of mussel biologist positions in many states

Largely in Southeast and Interior Basins – bring in all states



## 2. Protect and reverse the decline of quality mussel habitat

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1. Clean Water Act, Endangered Species Act, National Environmental Policy Act; State equivalents
2. Private land owner incentives – The Nature Conservancy, USFWS, state wildlife easements
3. Habitat restoration
  - Dam removals
  - Reduce hydrologic variability
  - Minimum flows below dams
  - Reduce cold water release
  - Restoring riparian zones
  - Ammonia criteria



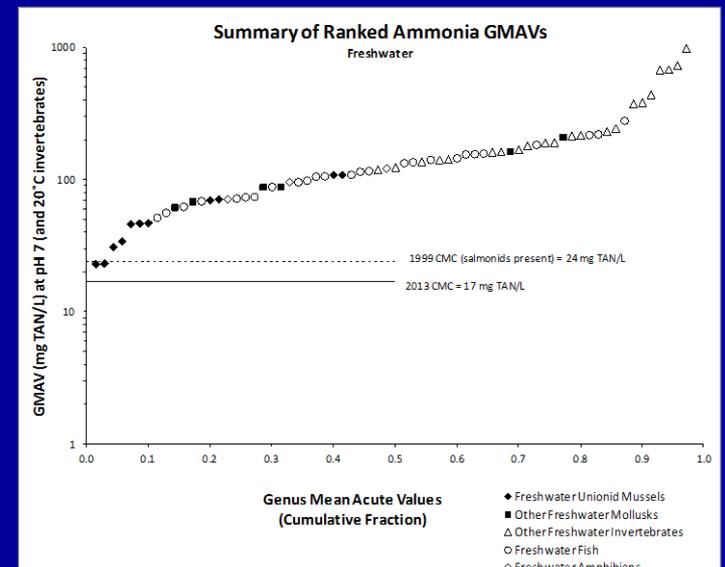
Opportunities - Habitat creation, implement ammonia criteria, add mussels to more water quality criteria, protect and restore riparian zones

# 3. Increase fundamental knowledge of basic biology and habitat requirements of mussels

1. Diet
2. Physical habitat stability
3. Water quality limitation (ammonia, metals)
4. Host fish studies about 1/3 of species – need duplicate studies

Opportunities - Mussel population dynamics, population growth, recruitment levels, limiting factors

modified from Haag and Williams, 2014



## 4. Increase knowledge of status and trends mussel populations

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1. Taxonomic status – Williams et al. 2017, working list on FMCS site
2. Standardized sampling techniques - Strayer and Smith, 2003; state protocols
3. Increased use of diving
4. Statewide surveys, state databases

Opportunities - Taxonomic status, population viability, cryptic species



# 5. Impacts of various perturbations

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## 1. Effects of dams

Host fish blockage, cold water discharge, upstream sedimentation, downstream scour, minimum flows

## 2. Zebra mussel effects

Unionids evolved in dynamic rivers  
Zebras prefer laminar conditions



## 3. Water quality – pesticides, ammonia, metals

Opportunities - Emerging contaminants, effects of temperature increase, hydropower generation impacts to up and downstream habitat stability, climate change

Longterm monitoring, juvenile survival studies

## 6. Develop management options to reduce the threat of zebra mussels

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1. Zebra mussels now cyclic in most big rivers
2. Variable stream conditions prevent over population
3. Limit spread thru education

Increased threat of exotics – black carp, round goby, invasive snails, etc., etc., etc..



## 7. Enhance understanding and support for protecting and enhancing natural ecosystems

1. Mussel biologist positions in state and federal government
2. University positions
3. Ecosystems services message
4. Popular articles in conservation magazines
5. TV specials
6. YouTube videos, social media

Continue outreach to policy makers, school programs, urban areas...

## 8. Develop technology to propagate and reintroduce juvenile mussels

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1. Techniques developed to grow mussels past a few months
2. Several propagation facilities in operation, NCTC class
3. Many T&E species now being propagated
4. In vitro techniques developed
5. Advanced knowledge of behavior, diet, host fish, reproductive strategies

Where do we put all these mussels?

Conservation genetics

Ark populations

Propagation of common species

modified from Haag and Williams, 2014



# 9. Develop, evaluate, and use the techniques to hold and translocate adult mussels

1. Translocate mussels out of impact areas within a river
2. Move adult mussels to new sites

Long term implications of augmentation?

Genetic concerns?

Carrying capacity?

Disease?

Have streams recovered enough to support mussels?



# 10. Increase available funding levels

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1. Mitigation Trust Funds
2. Section 6 grants
3. State Wildlife Grant Programs

Never enough money to do all the work needed

# Answers generate more questions

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New Strategy published in 2016

“Goal of this National Strategy is to identify and clarify issues and actions that are essential to conserving our nation’s **mollusk** fauna and ensure that their ecological, social, and economic values to society are maintained at **sustainable** levels.”

Includes Snails

Recognizes the need for including Sphaeriidae

# 2016 Strategy

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1. Increase knowledge of the distribution and taxonomy of mollusks at multiple scales over time and make information available
2. Address impacts of past, ongoing, and newly emerging stressors on mollusks and their habitats
3. Understand and conserve the quantity and quality of suitable habitat for mollusks over time
4. Understand the ecology of mollusks at the individual, population, and community levels
5. Restore abundant and diverse mollusk populations until they are self-sustaining

# 2016 Strategy

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6. Identify the ecosystem services provided by mollusks and their habitat
7. Strengthen advocacy and build support for the conservation of mollusks and their habitats
8. Educate and train the conservation community and future generations about the importance of mollusks to ensure conservation efforts continue into the future
9. Seek consistent, long-term funding to support mollusk conservation efforts
10. Coordinate a national strategy for the conservation of mollusk resources

# Accomplished a lot in 50 years

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Clean water act – protects habitat, mussels included in revised criteria, mussels considered in permit actions

Endangered species act – protects areas with endangered species

Efforts to restore habitat

Propagation

State, Federal positions for mussel biologists

University programs with mussels

# Accomplished a lot in 50 years

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Developed genetic techniques for evaluation of taxonomic status

Conservation genetics

More standardized sampling techniques

Better understanding of ecosystem services

Economic values assigned to mussels

# Challenges and Opportunities

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More work in all above areas – mussels, snails, fingernail clams

Climate change – increased hydrologic variability

Development activity – decreased permeability, floodplain development, decrease in riparian vegetation

Healthy Rivers = Healthy Mollusks = Healthy People

