Considering sunscreen as a factor limiting freshwater mussel recovery: Establishing a risk assessment framework for waterborne chemicals

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U.S. Fish and Wildlife Service*

* Perspectives of the presenters do not necessarily represent the views of the U.S. Fish and Wildlife Service.

We'll cover…

How mussels' life history make them vulnerable to pollutants

Framework for examining the interaction of mussels and sunscreens

Risk assessment approaches for threatened and endangered species

Freshwater mussels

Bivalve mollusks; shell comprised of two valves connected by a ligament

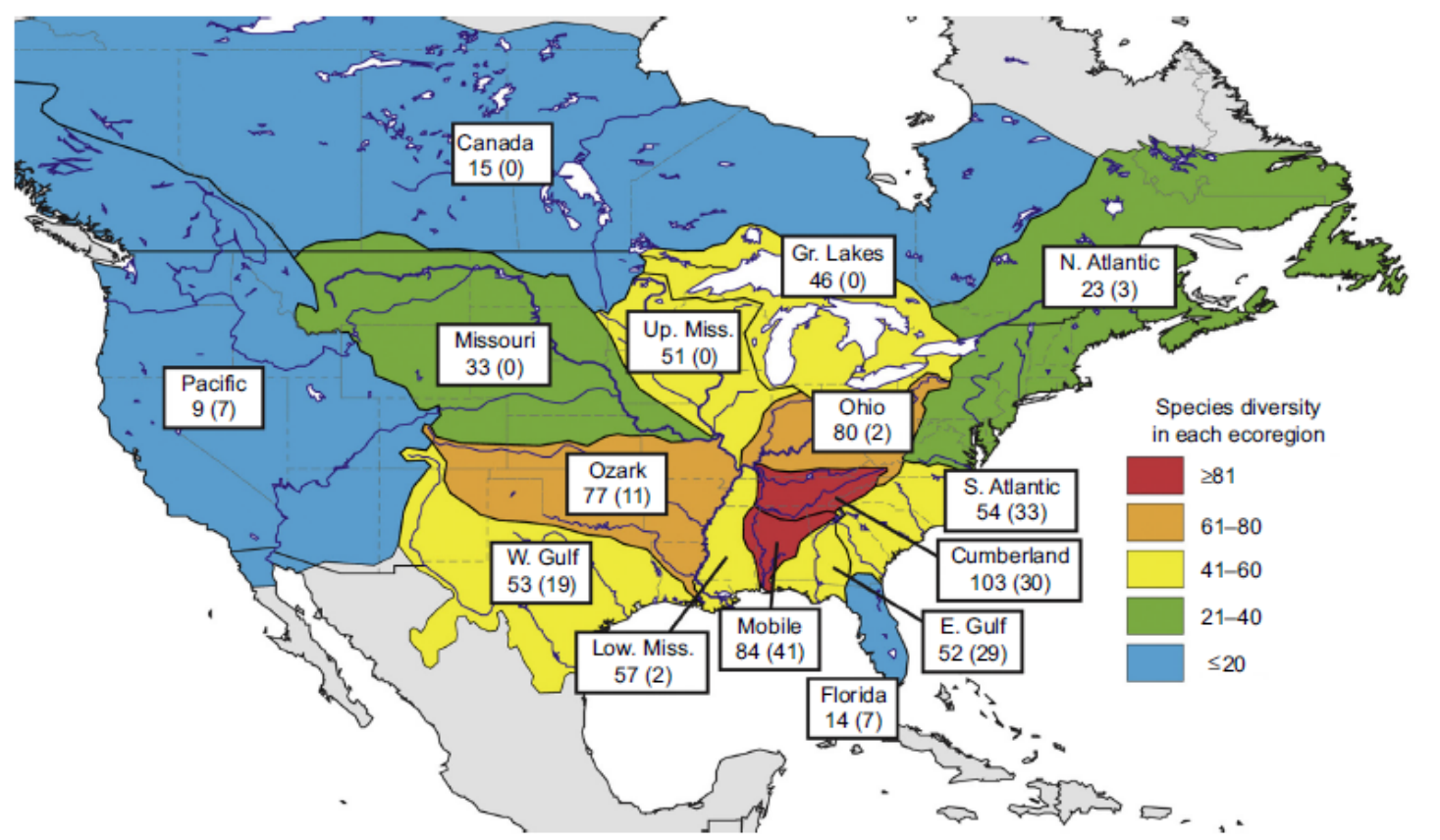
300 species in North America

Many are rare and protected by US and states

Mussel midden Verdigris River, KS

http://unionid.missouristate.edu

Mussels - Where do they occur?



Cummings and Graf. 2015. Class Bivalvia. In Thorp and Covich's Freshwater Invertebrates. Thorp JH, Rogers DC (eds). Elsevier, NY.

With permission of Kevin Cummings, Illinois Natural History Survey

Mussels are of significant management concern

91 federally-listed as threatened or endangered

Many more "at-risk"

Number of imperiled mussel taxa

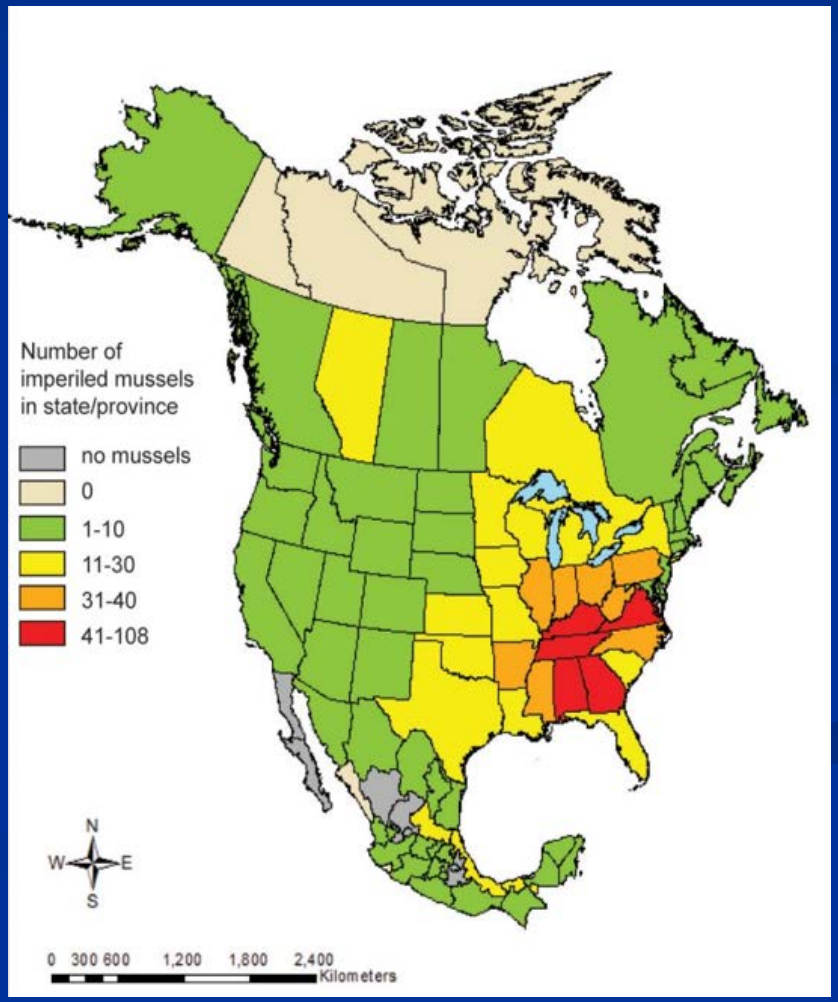


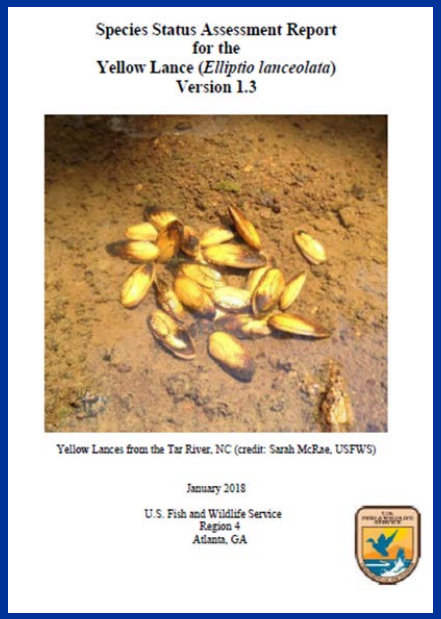
Image from Paul Johnson, Alabama Aquatic Biodiversity Center, with permission

Explaining mussel declines, from 45 studies

Cause	Percentage
Pollution, water quality degradation	47
Habitat destruction and alteration	47
Damming and impoundment	33
Introduction of exotic species	29
Hydrologic change	20
Exploitation and harvesting	18
Recruitment failure, lack of fish hosts	13
Watershed alterations	13
Riparian alterations	7
Predation	7

Strayer et al. 2004. Changing perspectives on pearly mussels, North America's most imperiled animals. BioScience 54: 429-439.

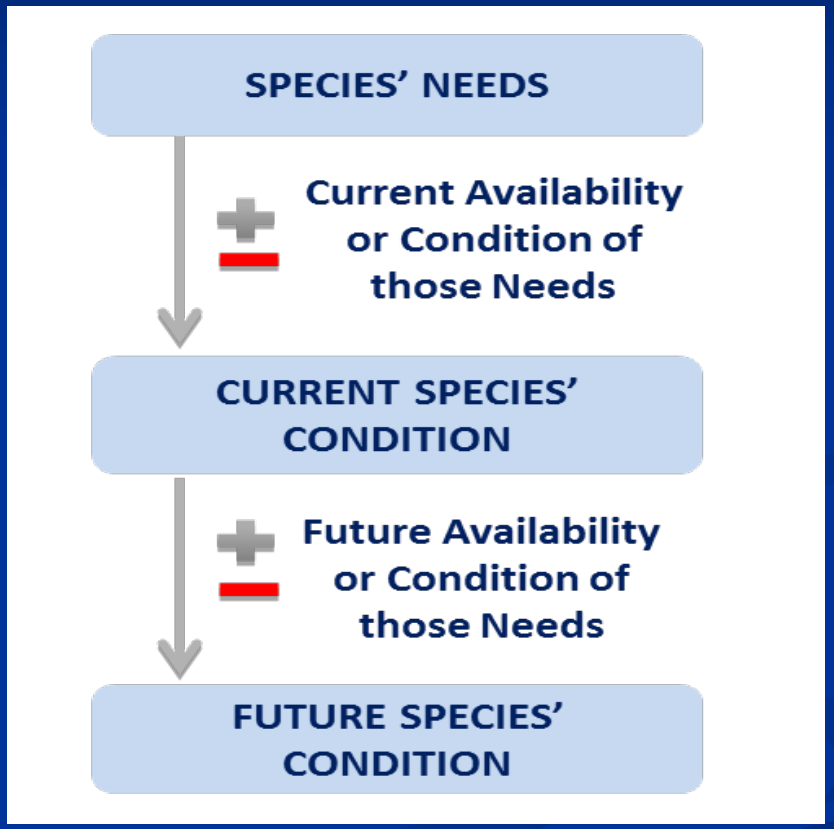
Species Status Assessments


Species Status Assessment Report
for the
Yellow Lance (*Elliptio lanceolata*)
Version 1.3

Yellow Lances from the Tar River, NC (credit: Sarah McRae, USFWS)

January 2018

U.S. Fish and Wildlife Service
Region 4
Atlanta, GA



SSAs and threat evaluation

Consider past, current and plausible future impacts

Threats with population and species-level impacts will carry into species viability assessment

Document available data and describe uncertainty

- Use range of plausible future scenarios to capture and consider uncertainty

Update throughout listing and recovery

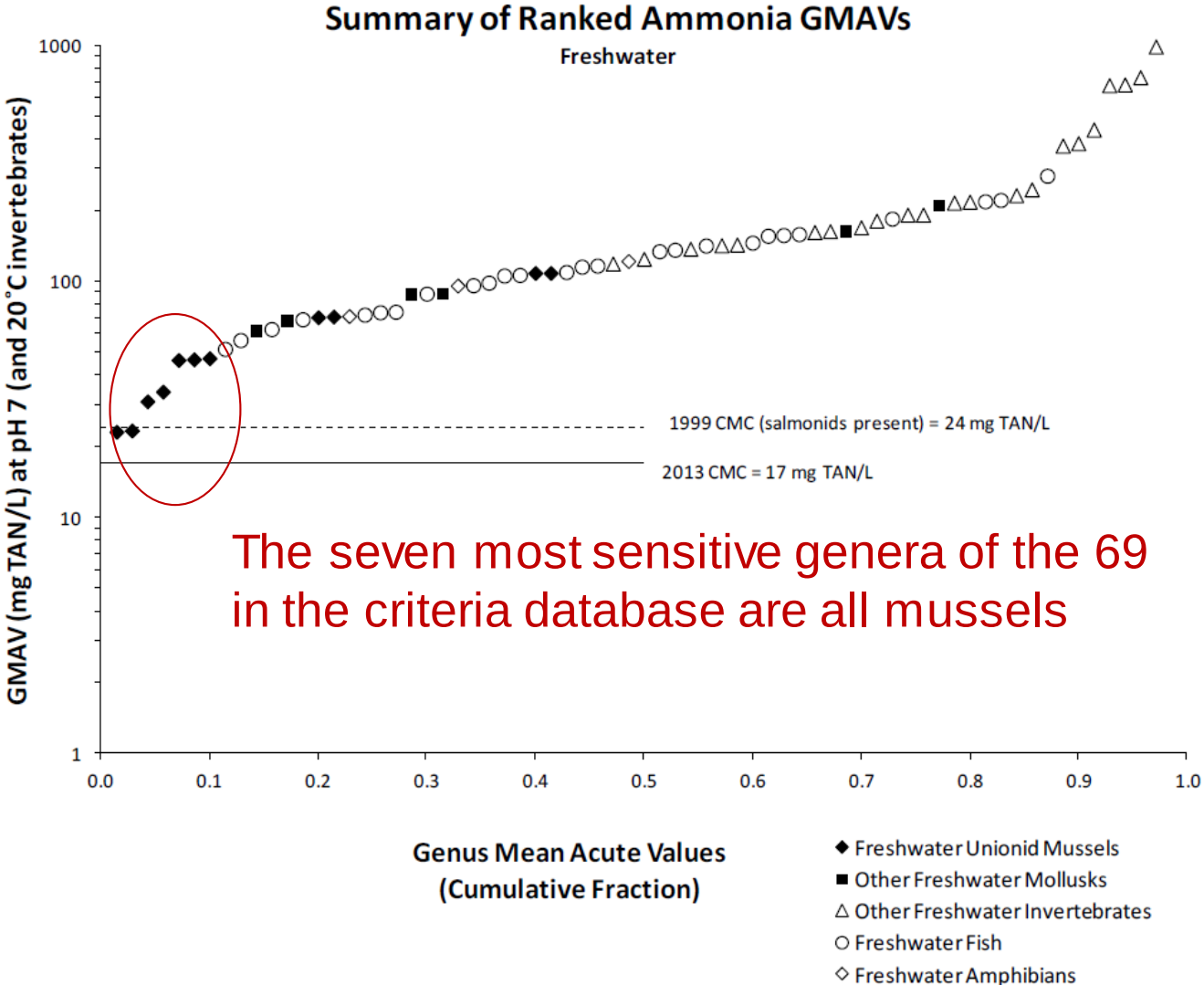
Identification of threats can drive recovery actions

Mussels provide key ecosystem services

- Biofiltration
- Nutrient cycling and storage
- Habitat modification
- Food for other animals

Endangered freshwater mussels from the Allegheny River, USFWS, NCTC Image Library

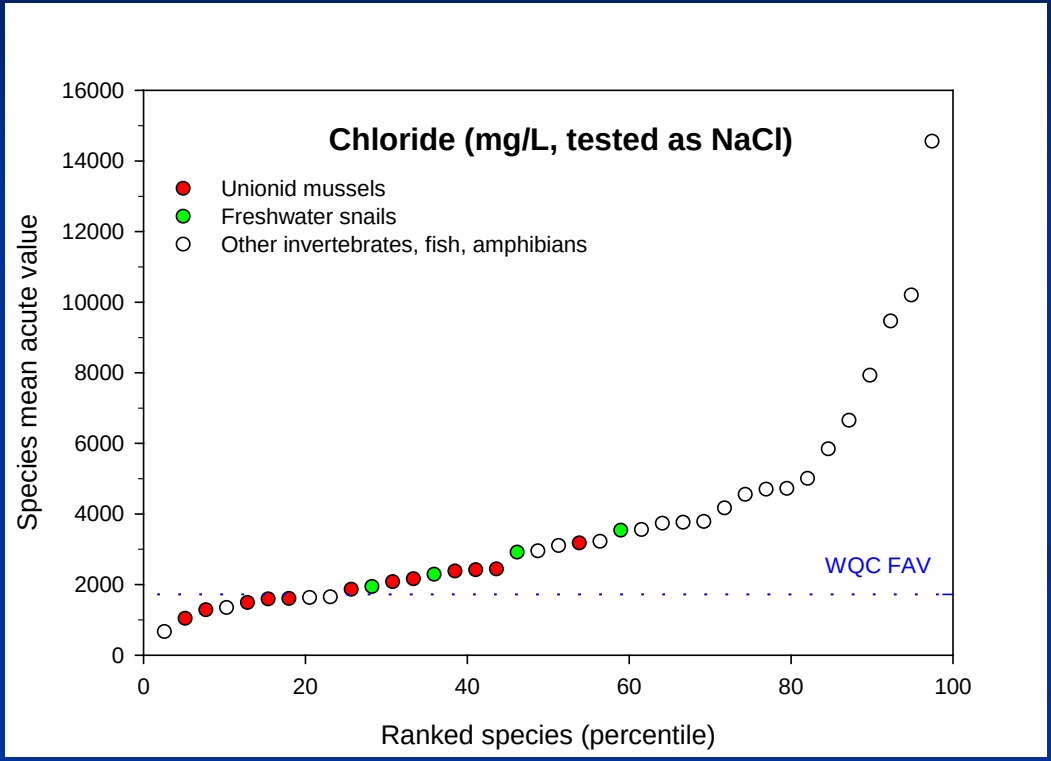
Mussels are sensitive to some pollutants



The seven most sensitive genera of the 69 in the criteria database are all mussels

Figure 3 from USEPA 2013. Aquatic life ambient water quality criteria for ammonia - Freshwater

Chloride – mussels sensitive



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ACUTE SENSITIVITY OF A BROAD RANGE OF FRESHWATER MUSSELS TO CHEMICALS WITH DIFFERENT MODES OF TOXIC ACTION

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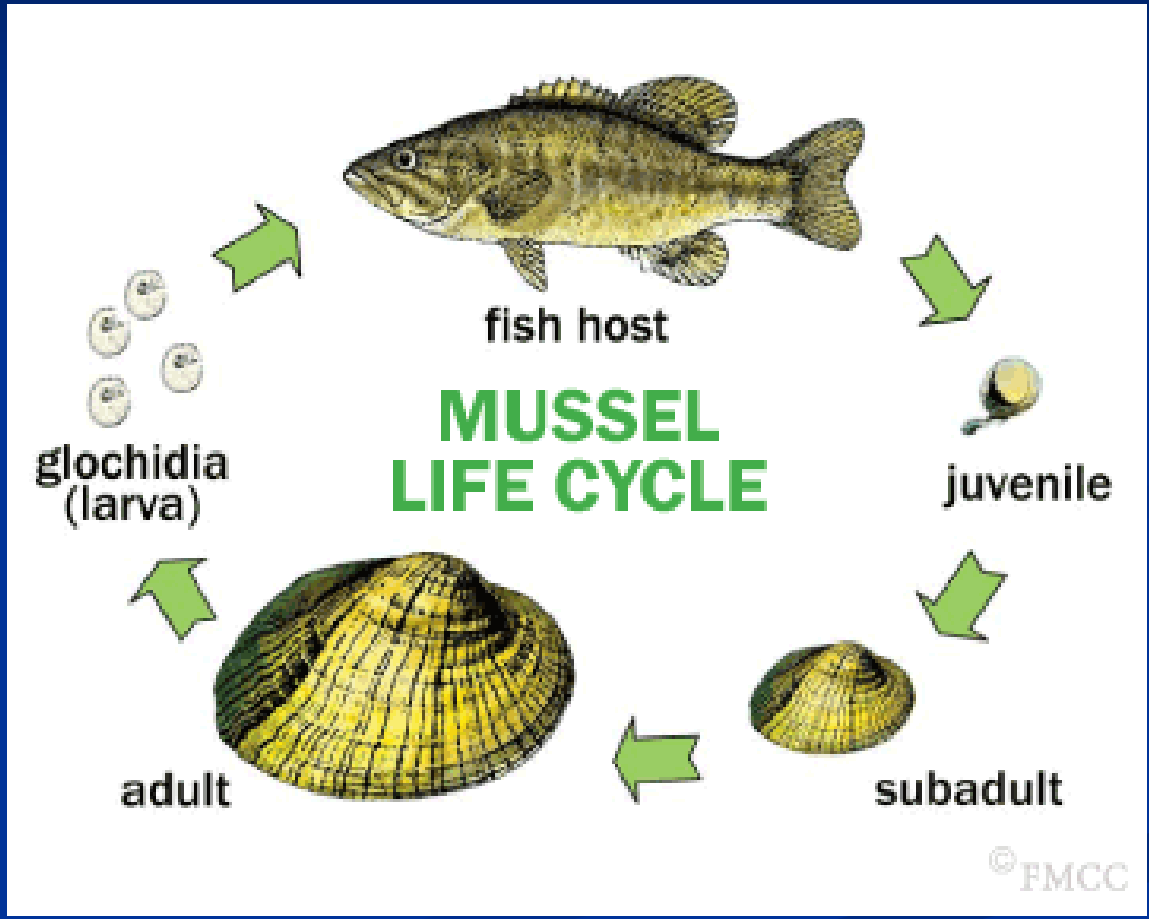
Mussel acute sensitivity:

Chemicals for which mussels are in lower quartile of aquatic species sensitivity distributions

Alachlor	Yes
2,4-D	No
Metolachlor	Yes
Molinate	No
4-Nonylphenol	No
Azoxystrobin	No
Bifenthrin	No
Carbaryl	No
Malathion	No
Ammonia	Yes
Potassium	Yes
Chloride	Yes
Nitrate	No
Sulfate	Yes
Aluminum	No
Arsenic	No
Cadmium	No
Chromium (VI)	No
Copper	Yes
Lead	No
Nickel	Yes
Zinc	Yes

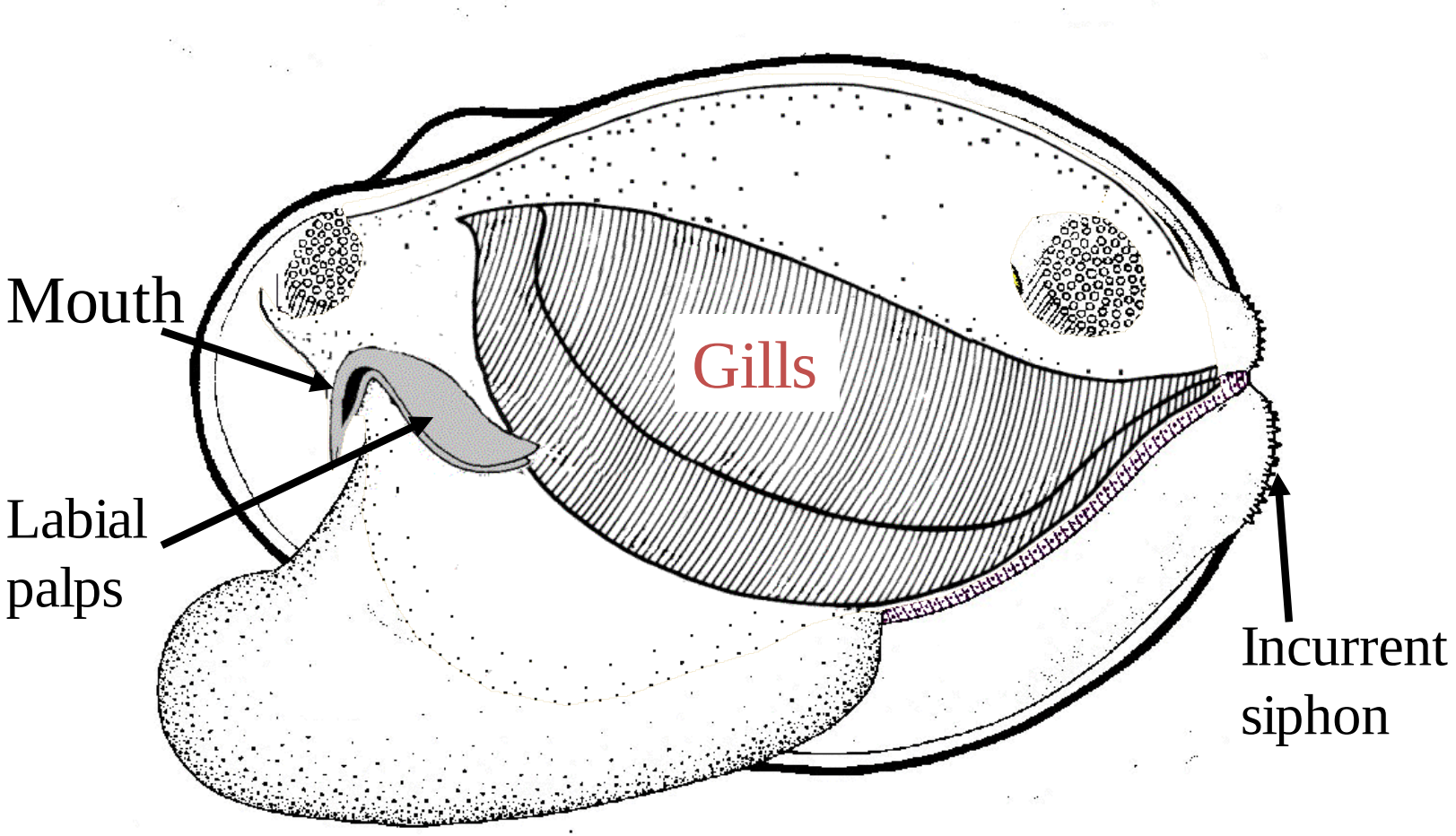
Freshwater mussel biology

- Adults live in sediment, filter feed, respire with gills
- Larvae need fish host
- Juveniles feed with cilia on their foot

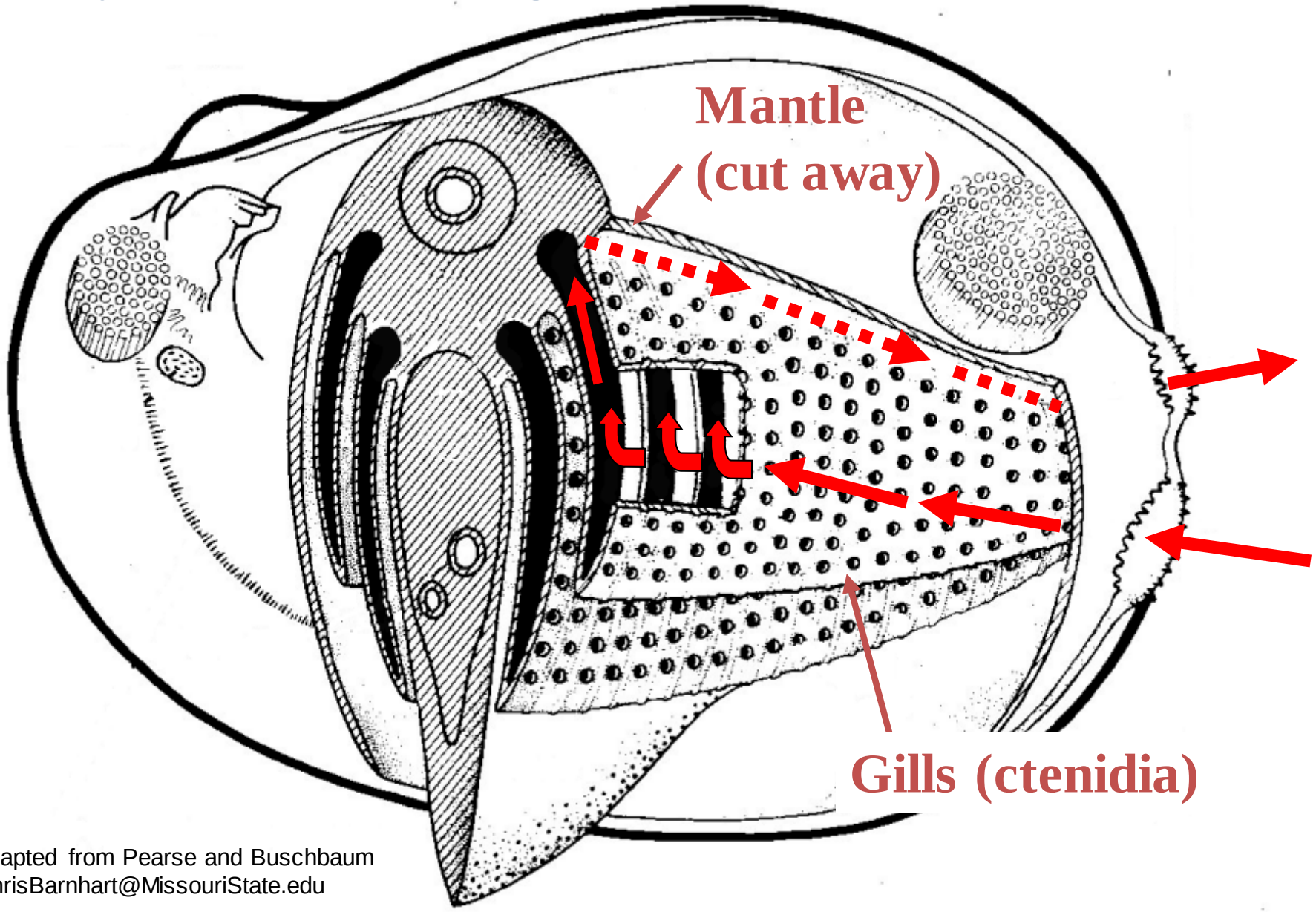


Mussel life cycle, Freshwater Mussel Conservation Center, Virginia Tech

Mussel Life Cycle – 1 minute video


Mouth
Labial palps
Gills
Incurrent siphon

Suspension feeding



Adapted from Pearse and Buschbaum
ChrisBarnhart@MissouriState.edu

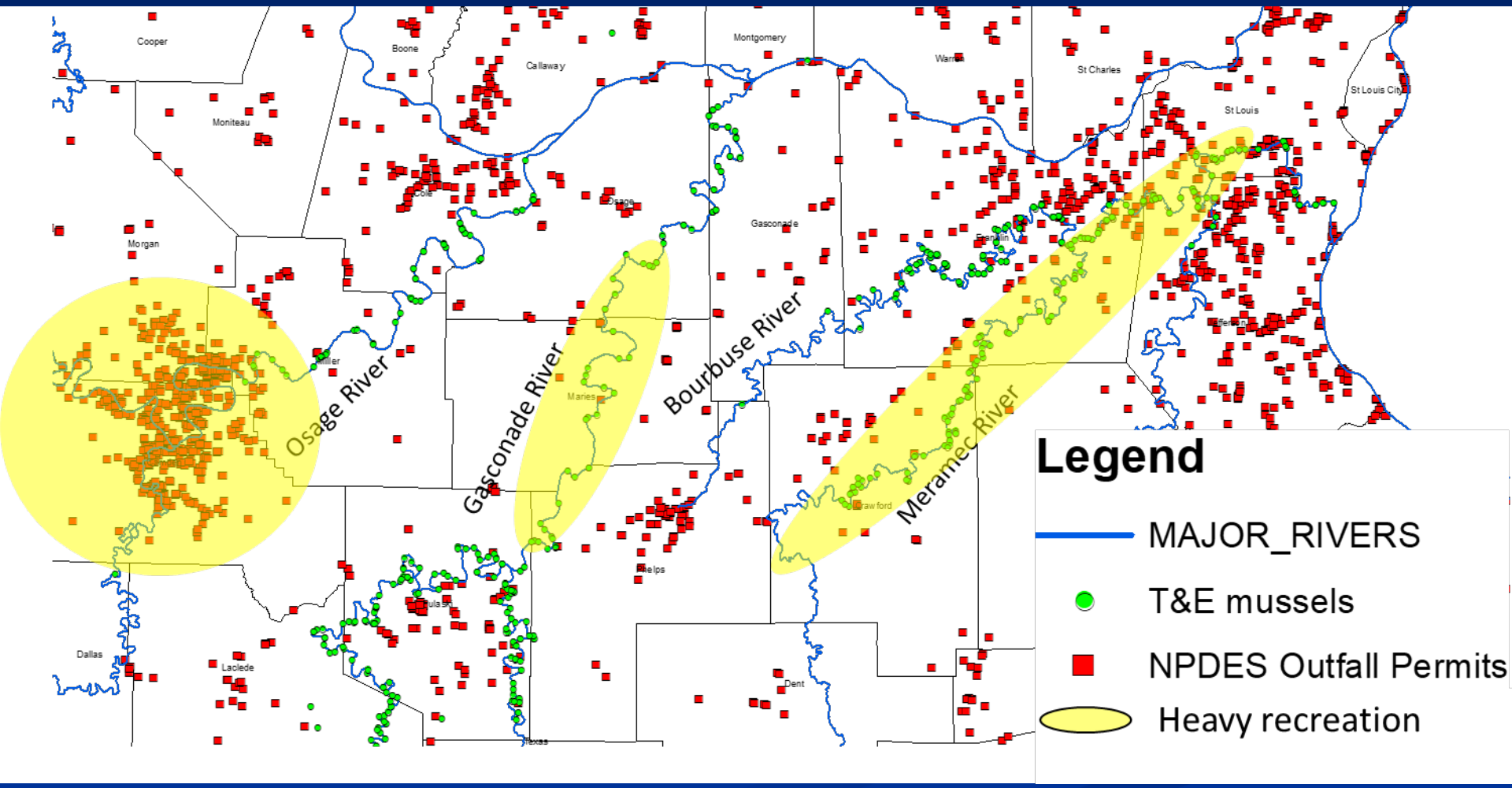
Is there any basis for concern?

Mussels occupy most rivers, streams lakes, and ponds

Aspects of their life history (benthic suspension feeders) make them vulnerable to waterborne and sediment-associated pollutants

Juvenile Tar River spinymussels, Chris Eads, NC State University, Aquatic Epidemiology Conservation Laboratory

East/Central Missouri

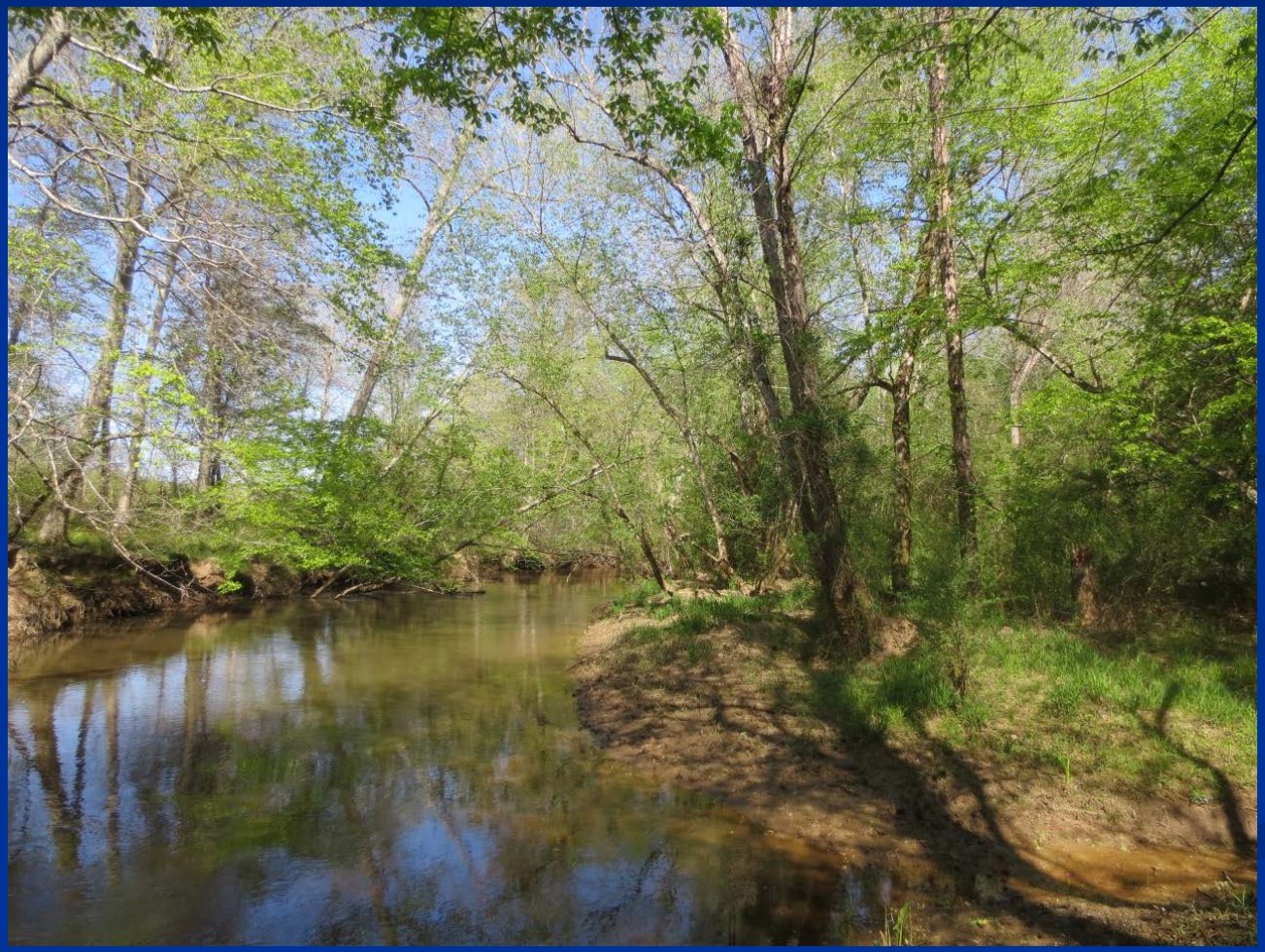


Lake of the Ozarks

A few mussel species in the Lake of the Ozarks

A diverse mussel community downstream of the dam

Fishing Creek Watershed, North Carolina



Tar River Land Conservancy, with permission

Half of risk evaluation framework

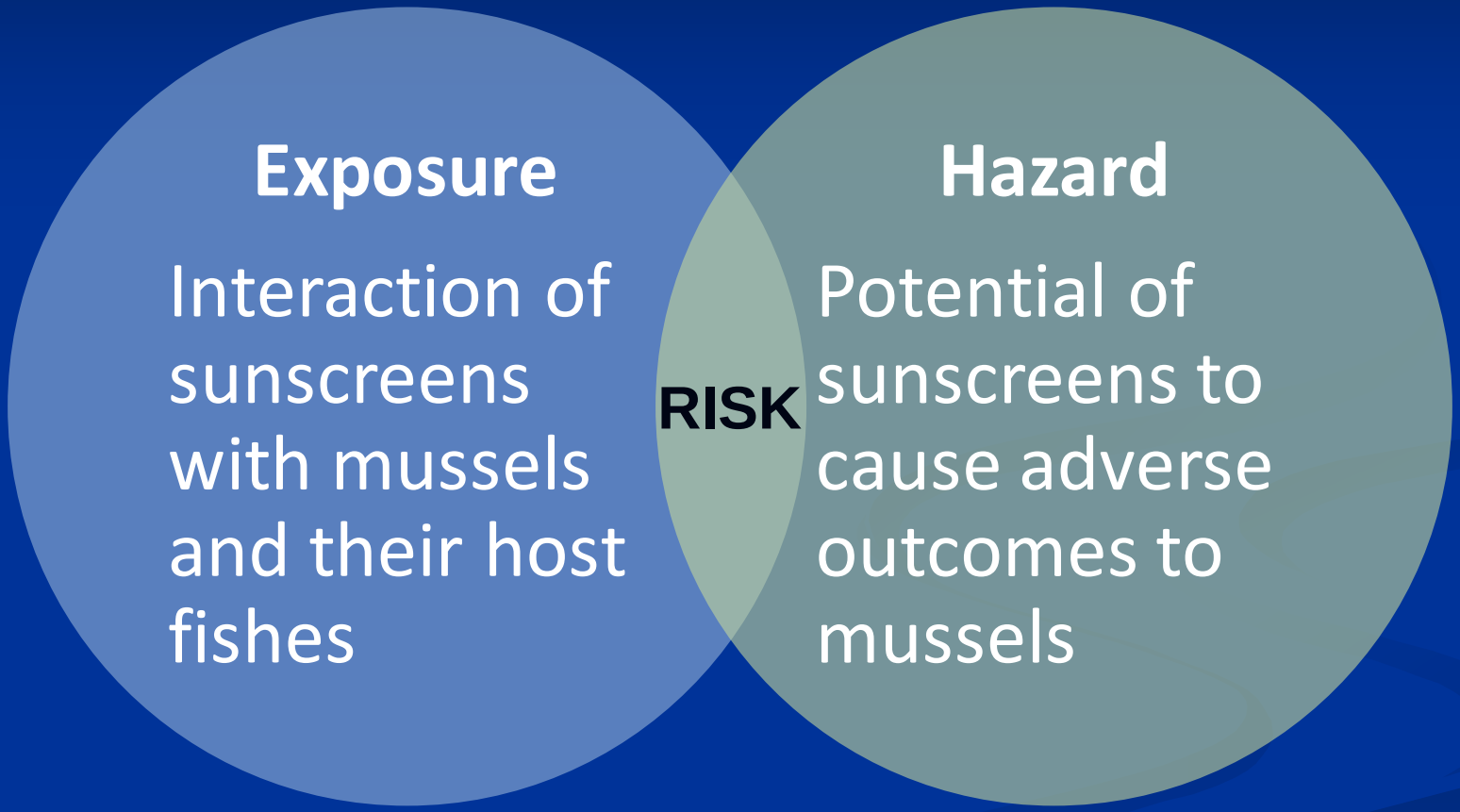
Measures of sunscreen exposure

Exposure

Interaction of sunscreens with mussels and their host fish

No mussel specific measures of exposure were retrieved from literature, but those for other aquatic life will do

… but exposure is only part of risk



… also need data on hazard (potential to cause harm)

… other half of the risk framework

Measurable mussel responses to sunscreens

Of the active ingredients of interest to NAS, we found toxicity data for only ZnO to *Elliptio complanata*

Hazard

Potential of sunscreens to cause adverse outcomes to mussels

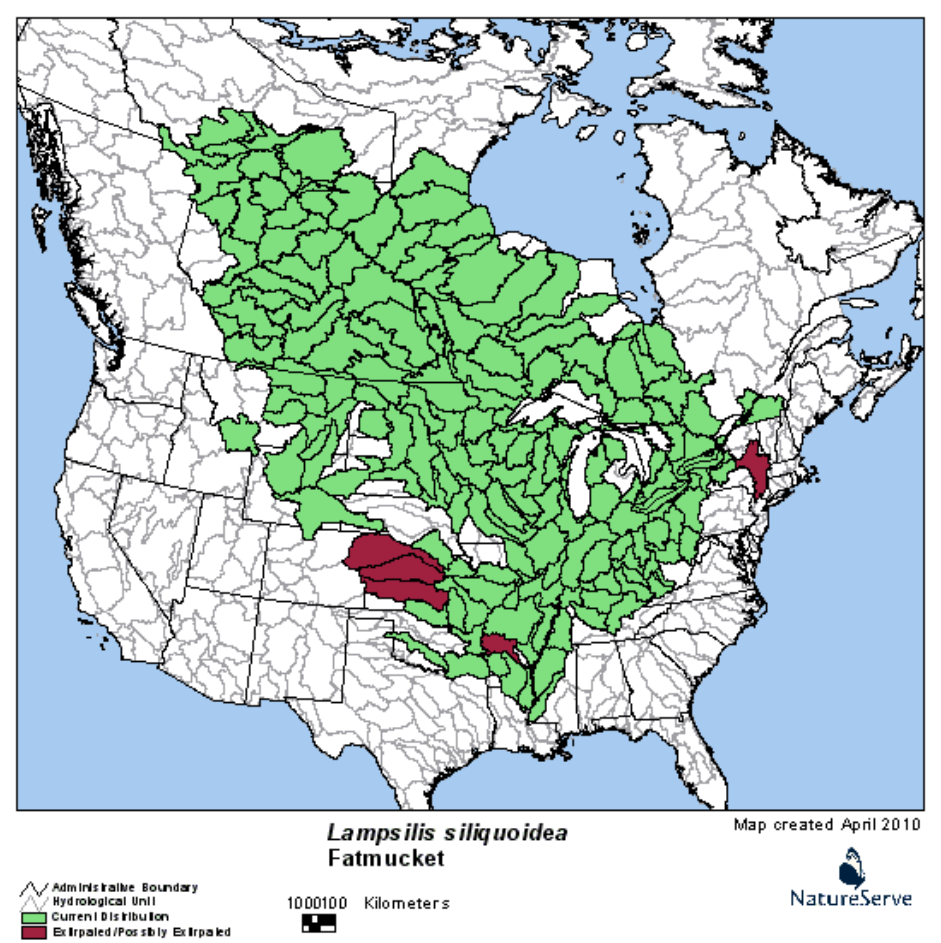
Very feasible to get needed data

Sub adult fatmucket from hatchery culture, USFWS, NCTC Image Library

Fatmucket

Amenable to culture in the lab

Very feasible to get needed data



Fatmucket

Amenable to culture in the lab

Widely distributed in North America

Adequacy of surrogate species

But is fatmucket a good surrogate to represent the sensitivity of other mussels?

FWS, EPA and USGS assembled database of 598 mussel records for 49 species and 50 chemicals

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Environmental Toxicology

ASSESSING VARIABILITY IN CHEMICAL ACUTE TOXICITY OF UNIONID MUSSELS: INFLUENCE OF INTRA- AND INTERLABORATORY TESTING, LIFE STAGE, AND SPECIES

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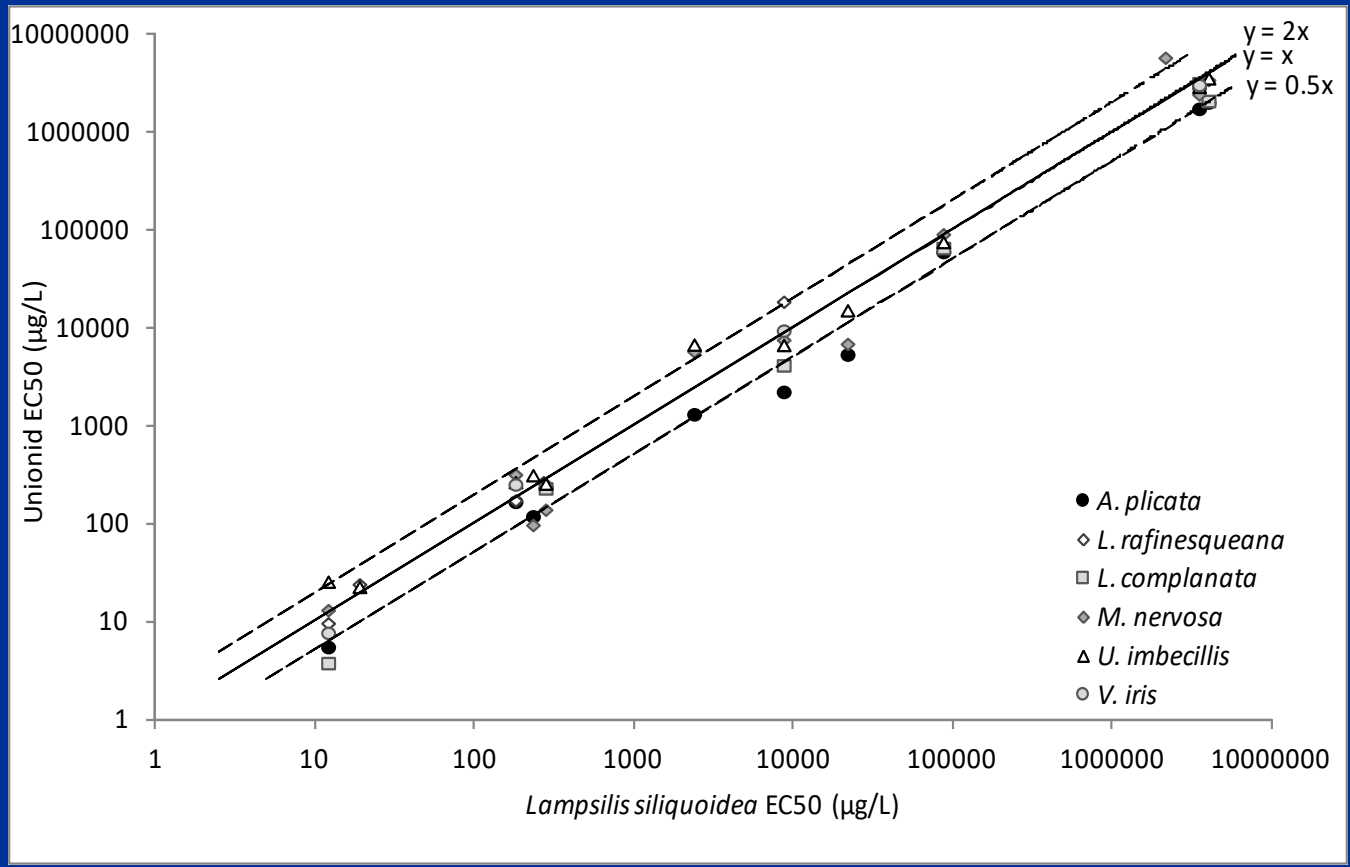
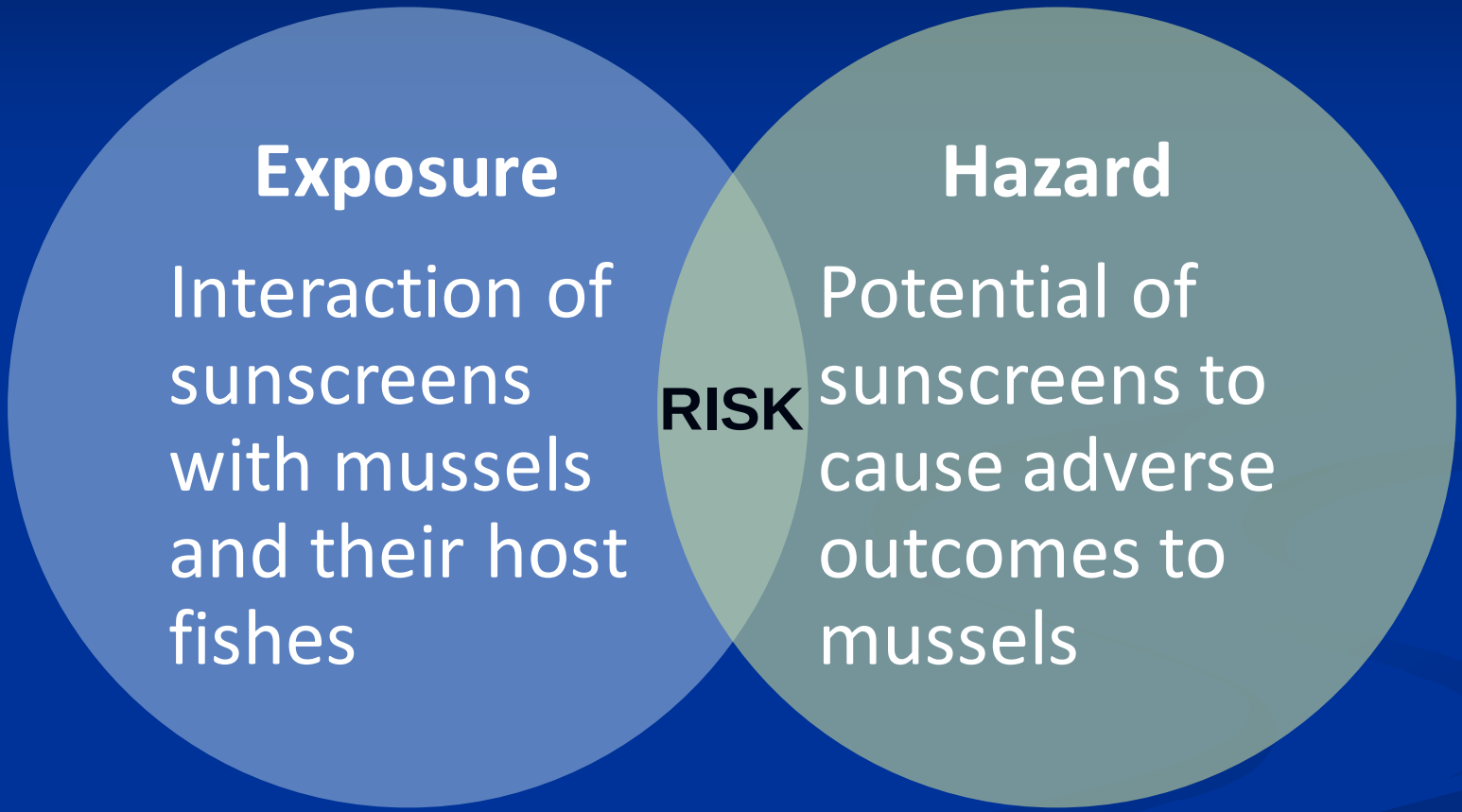
(Submitted 11 May 2015; Returned for Revision 24 June 2015; Accepted 11 September 2015)

Adequacy of surrogate species

Yes: Fatmucket EC50s were within a factor of 2 of other mussels 73% of the time and always within a factor of 5 of other mussels



Risk = probability of amounts or timing of sunscreens causing adverse effects



Assessment of listed species

Generation of species- and site-specific data can reduce uncertainty

Goal is to avoid Type 2 error (i.e., missing an effect where one is occurring)

Where data are lacking, conservative assumptions are often made

Estimated exposures

Modeled concentrations

Targeted monitoring

General monitoring

Where site-specific data are unavailable, consider available data in context of habitat being assessed.

- Are magnitude, duration, frequency, and timing likely similar?
- Factors that enhance or lessen expected concentrations?

Estimates of Hazard

Toxicity data for mussels

→ Toxicity data for other aquatic invertebrates

→Toxicity data for other aquatic species

Other approaches

Species sensitivity distribution

Most sensitive species

Application of safety factors

Other risk considerations for mussels

- Data typically limited to survival and growth, without much on other aspects of fitness
- Most endangered aquatic animals are also vulnerable because of small population sizes
  - Small stretches of stream critically important
  - Few individuals to sustain populations
  - Few surplus populations to re-colonize an impact area
- Other physical, chemical and biological stressors

Assessing risk to mussels

When little data are available for taxa in question, we can perform a qualitative assessment

- Does the species occur in areas where it is expected to be exposed to sunscreen?
- What factors would make the exposure greater or lesser (e.g., environmental, behavioral, life history)?
- Based on information from other species, what types of effects can occur from exposure?
- Are these types of endpoints relevant to the species under consideration and would they be likely to impact fitness?

Identify information needs

Thanks for the invitation, and let us know how else we might help

Captively-propagated Yellow Lance, Chris Eads, NC State University, Aquatic Epidemiology Conservation Laboratory