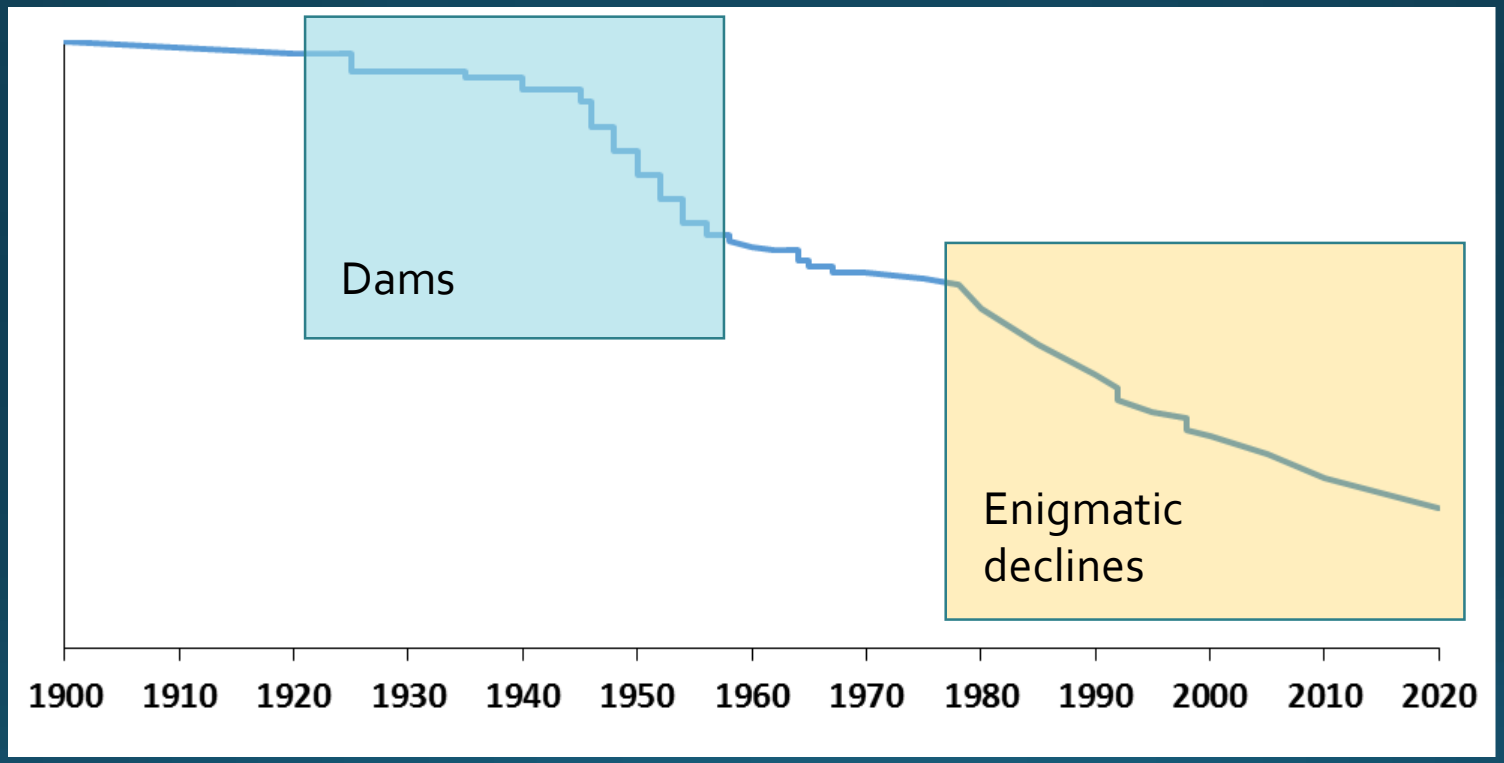
Back to the drawing board: assessing causes of freshwater mussel declines

Wendell R. Haag
U.S. Forest Service
Southern Research Station
Frankfort, KY

General condition of North American mussel fauna



Enigmatic mussel declines

- Loss of nearly the entire mussel assemblage in 10–30 years; most or all species affected

Red River, TN

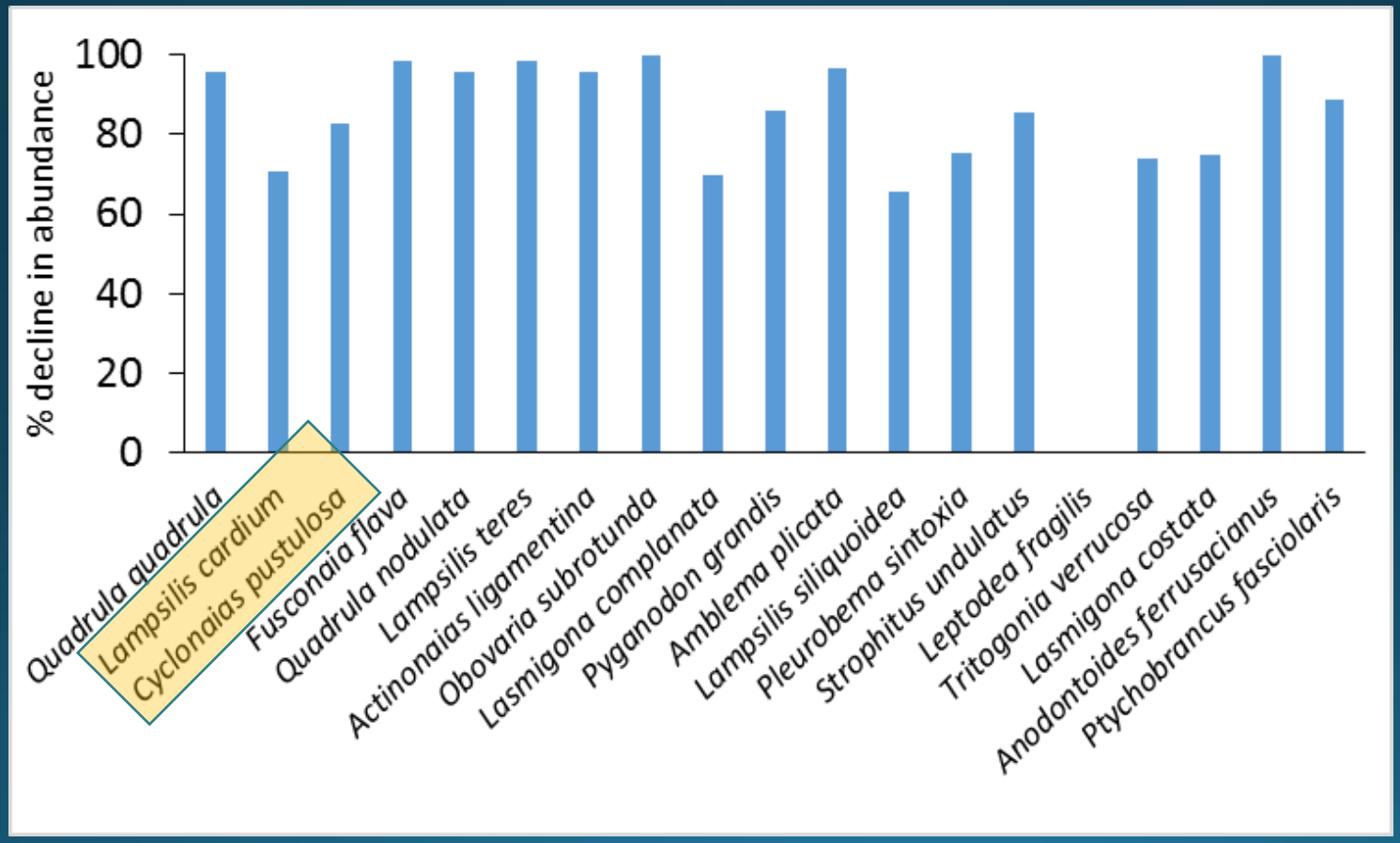
Data from Ohio State University Museum of Biological Diversity; Hubbs 1993; Ray 1999

Species	1966	1990	1998
Amblema plicata	49	66	25
Cyclonaias tuberculata	12	22	7
Tritogonia verrucosa	2	3	5
Elliptio crassidens	5	14	3
Lampsilis fasciola	24	1	2
Eurynia dilatata	209	13	1
Alasmidonta marginata	11	0	0
Actinonaias pectorosa	11	6	0
Epioblasma triquetra	5	0	0
Epioblasma walkeri	376	0	0
Lasmigona costata	57	2	0
Medionidus conradicus	18	0	0
Pleuronaia dolabelloides	3	0	0
Obovaria subrotunda	420	1	0
Ptychobranchus fasciolaris	22	1	0
Strophitus undulatus	15	0	0
Cambarunio iris	10	0	0
Cambarunio taeniata	32	0	0
Leaunio lienosa	11	0	0
Leaunio vanuxemensis	69	0	0
Total individuals	1379	137	50
Total species	25	14	9

Embarras River, IL

Data from Cummings et al. 1988

86% decline in overall mussel abundance from 1955–1987



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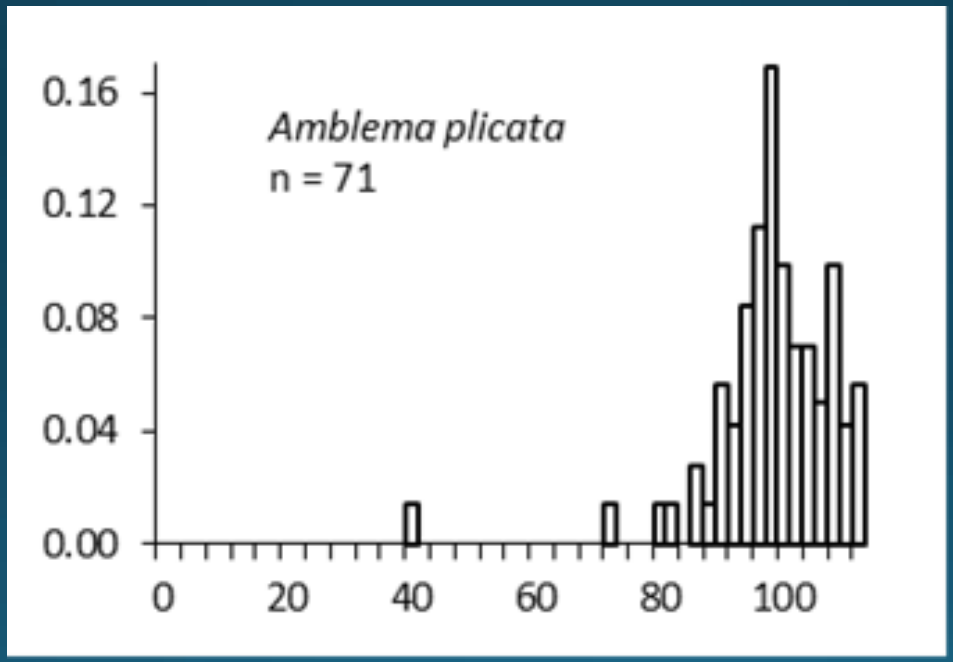
Big Sunflower River, MS

Haag, unpublished data



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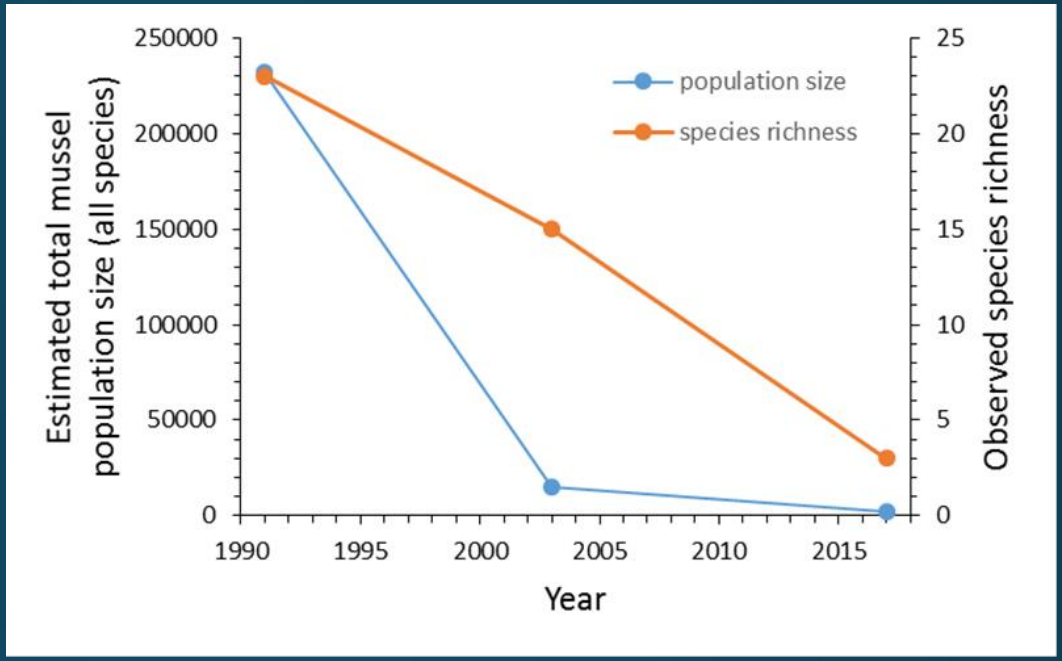
Horse Lick Creek, KY



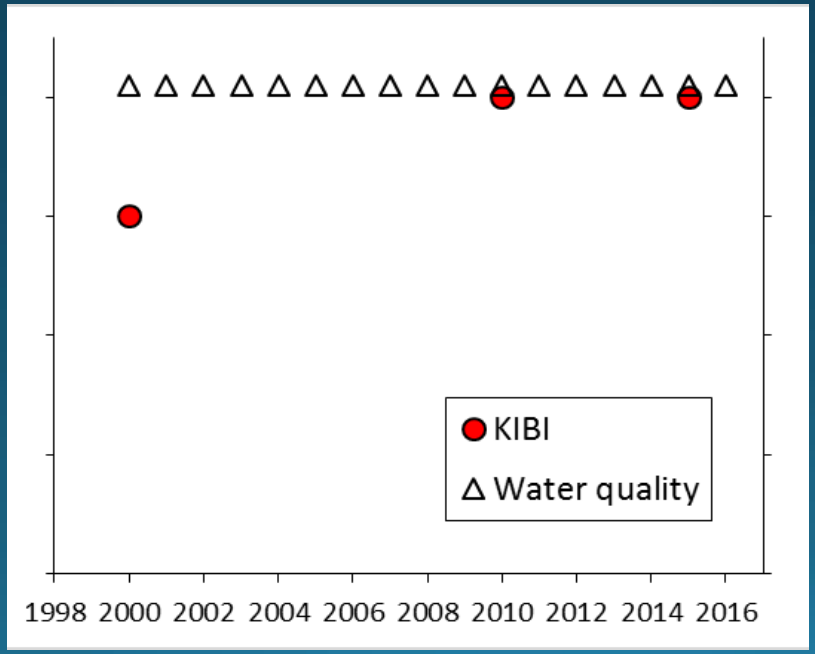
KIBI

Excellent

Good

Fair

Poor



Fully supporting aquatic life

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Timeline: when did it start?

Cumberland River below Cumberland Falls, KY

Data from Cicerello and Laudermilk 1997

		Year	
Species	**1910**	**1961**	**1987**
Eurynia dilatata	122	113	7
Lampsilis fasciola	16	20	0
Medionidus conradicus	present	154	0
Ptychobranchus fasciolaris	81	35	5
Cyclonaias pustulosa	49	122	10
Tritogonia verrucosa	32	75	4

Rockcastle River, KY

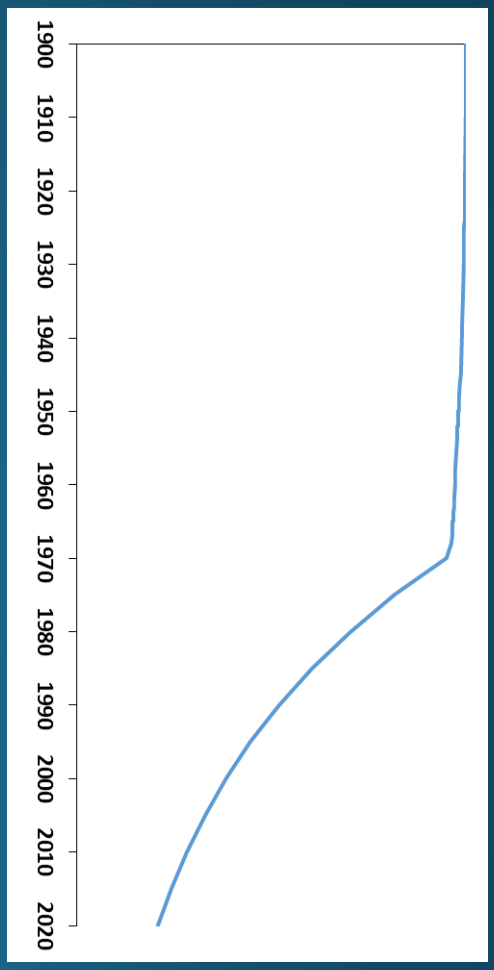
Data from Wilson and Clark 1914; Neel and Allen 1964, Ohio State University Museum of Biological Diversity; KY Nature Preserves Commission

Species				Year			
	1910	1947	1963	1964	1967	1982	1987
Eurynia dilatata	33	abundant	hundreds	-	abundant[2]	2	3
Medionidus conradicus	31[1]	common	28	-	21	0	0
Venustaconcha troostensis	-	common	44	24	7	1	0

[1] "covered the bottom in places"

[2] "several hundred returned to river"

Condition of the fauna in specific streams



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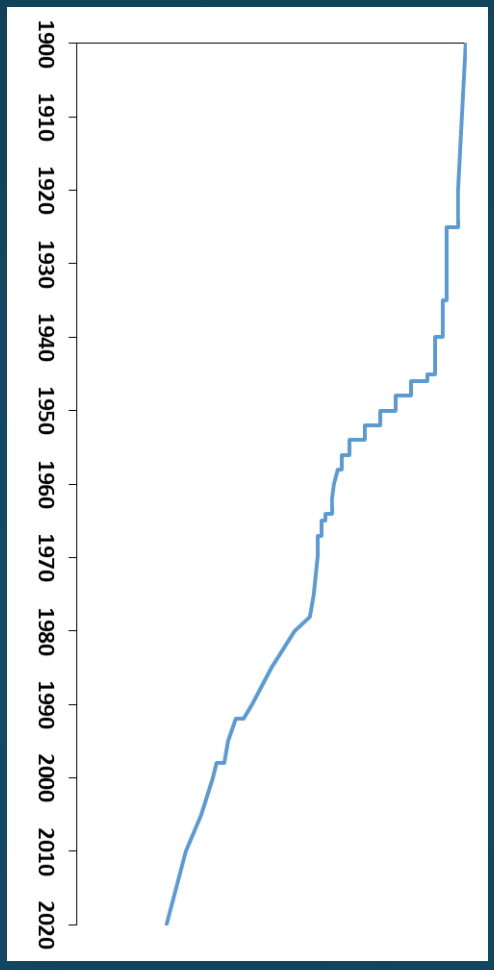

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- Upstream progression or other odd patterns in some cases

Causes of mussel declines: the conventional wisdom

- Dams, Impoundment
- Channelization
- Sedimentation
- "Pollution", "water quality degradation", "contamination"
- Coal mining
- Hydrologic change
- "Poor land use practices"
- Loss of riparian buffers
- Overharvest
- Exotic species
- Loss of fish hosts
- Construction of impervious surfaces
- Eutrophication
- Etc., etc

Problems with the conventional wisdom for explaining enigmatic declines

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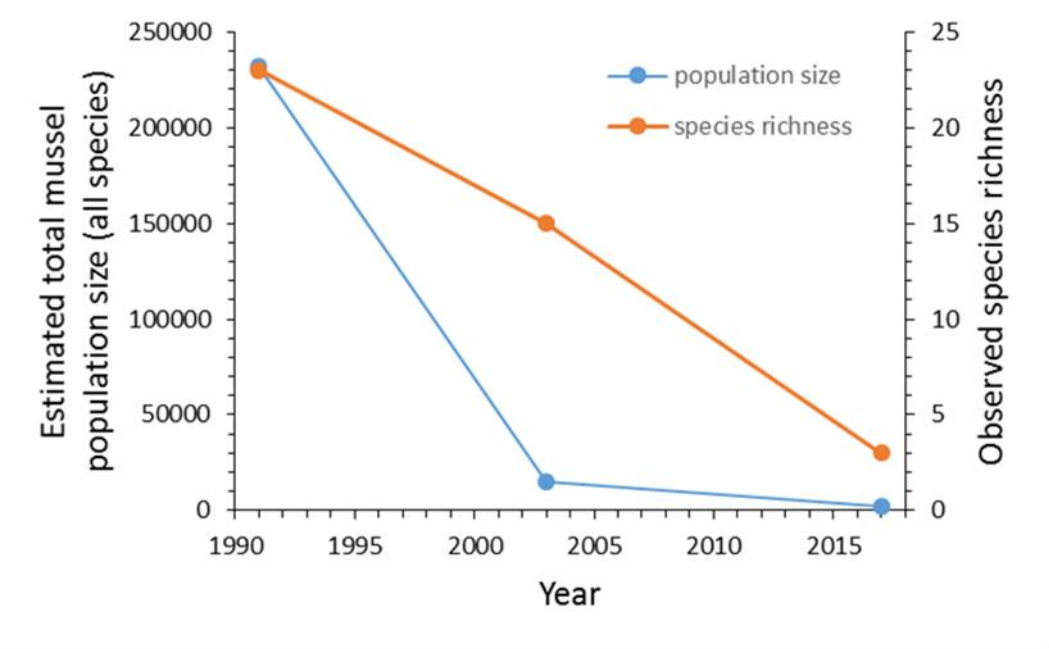

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"…this decline appears attributable to erosion and excessive silt deposition resulting from an increase in poorly managed human activities (primarily agriculture). An apparent destabilization of the substrate and accelerated bedload movement have disrupted stable mussel habitat. Other factors, such as water quality, may also play a role in the decline…"

"The cause of this faunal decline is likely due to several factors, including, most notably, the loss of riparian buffers. High levels of nitrogenous wastes may have also contributed to the decline"

"The decline is likely a result of ongoing contamination from reclaimed and abandoned coal mines, as well as possible contamination from other, unidentified sources…" (Haag and Warren 2004)

Strayer et al. (2004)

- reviewed 45 peer-reviewed papers
- <half invoked a single cause
- up to 8 causes were invoked in a single paper

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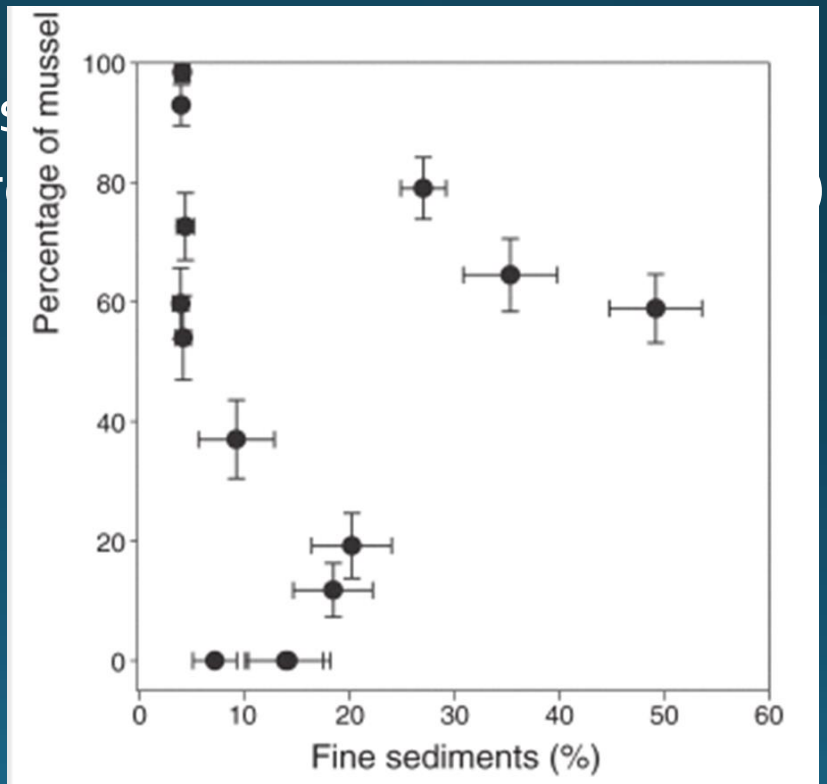
- Most factors not critically evaluated, if at all (see Downing et al. 2010, Anim Biodivers and Cons 33:151-185)

Sedimentation

- "Although the causes of recent mussel declines remain unclear, sedimentation is implicated as a primary cause" (Peacock, Haag, and Warren 2005)

- Little evidence for pervas
  2012, North American Fr

Strayer and Malcom. 2012. Ecological Applications 22:1780-1790.



. 2. Mussel recruitment as a function of environmental vari
s: crayfish density (all species, $r^2 = 0.20$, $P = 0.11$), fine sediments
13), interstitial NH_3 ($r^2 = 0.57$, $P = 0.002$). Error bars show ±SE

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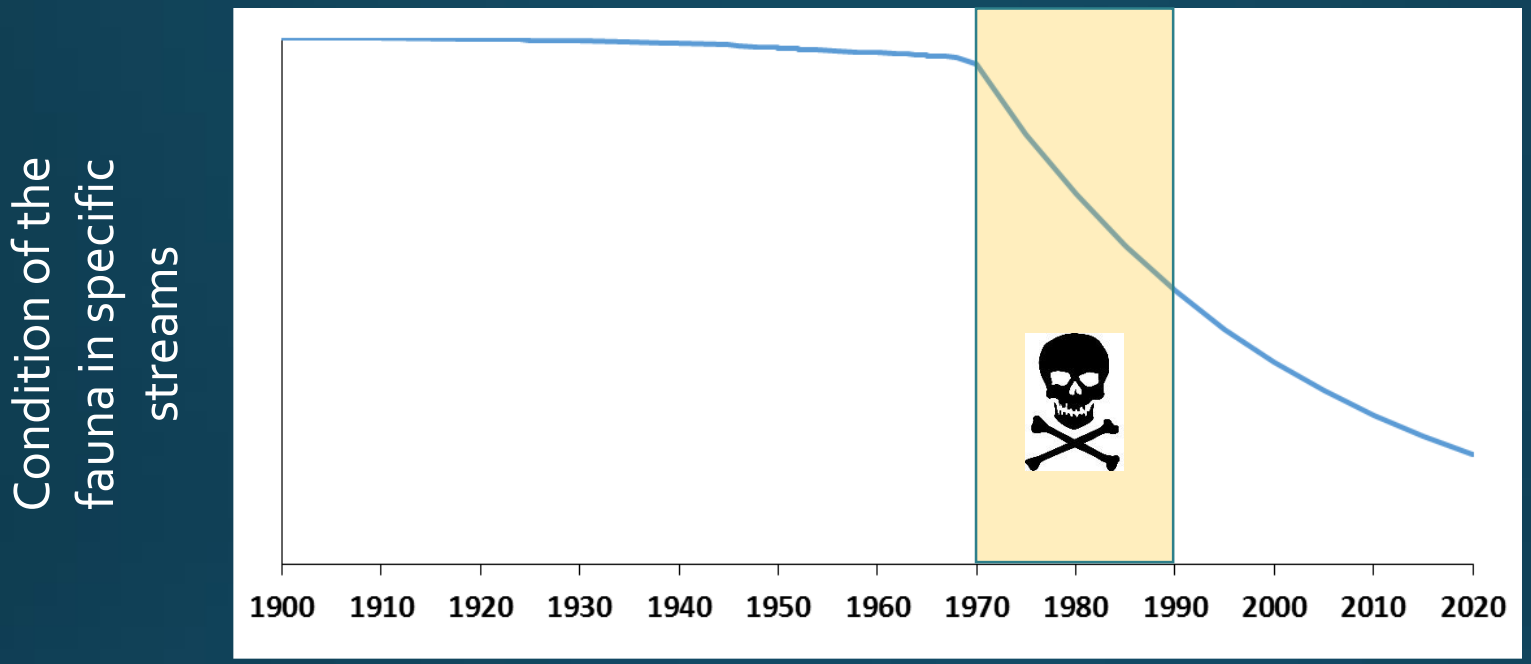
- Characteristics of enigmatic declines don't correspond to these factors: just doesn't add up



- Exponential increase in pesticides and nitrogen application
- Appearance of *Corbicula*

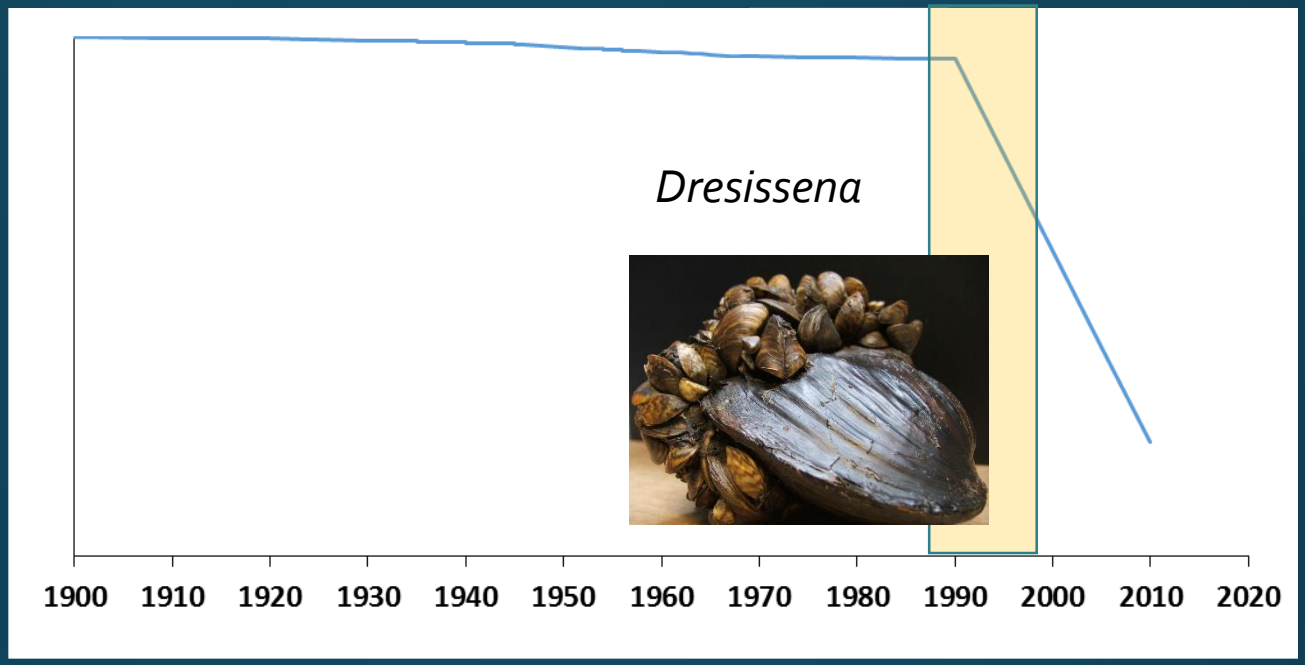
Corbicula

Timing is consistent

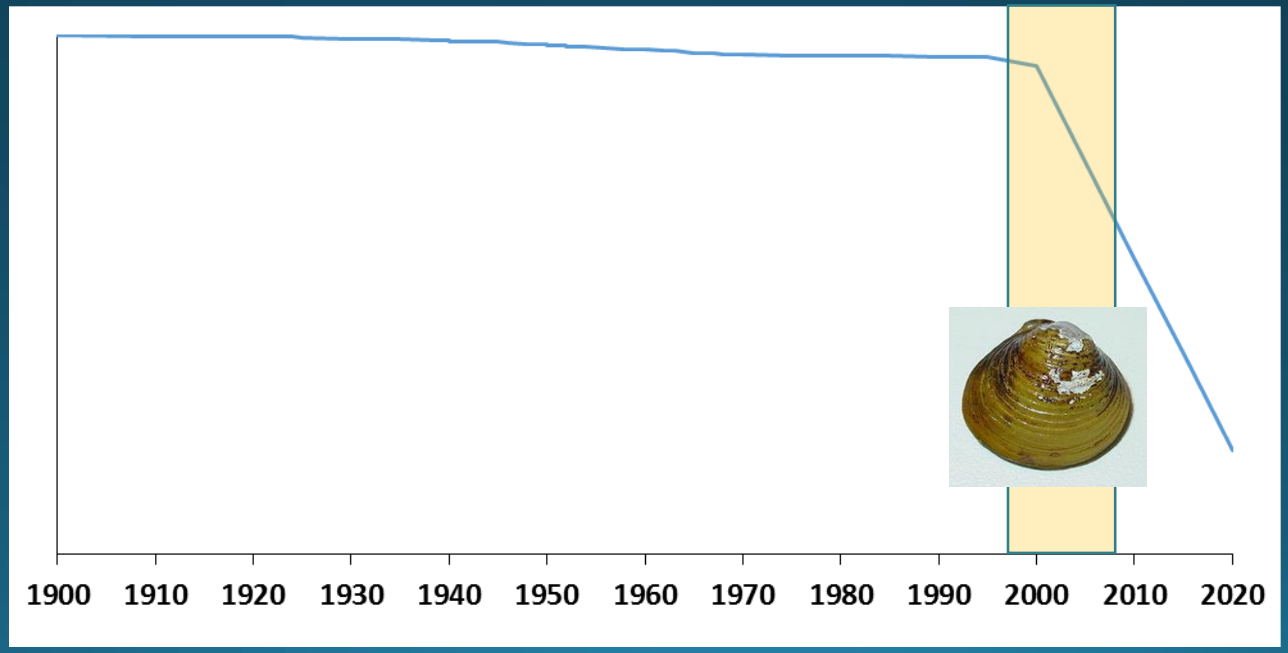
Embarras: ~1965; decline 1955-1987

Rockcastle: ~1967; decline 1970-1982

Lake Erie, Hudson River, etc.



Little Tennessee River, NC



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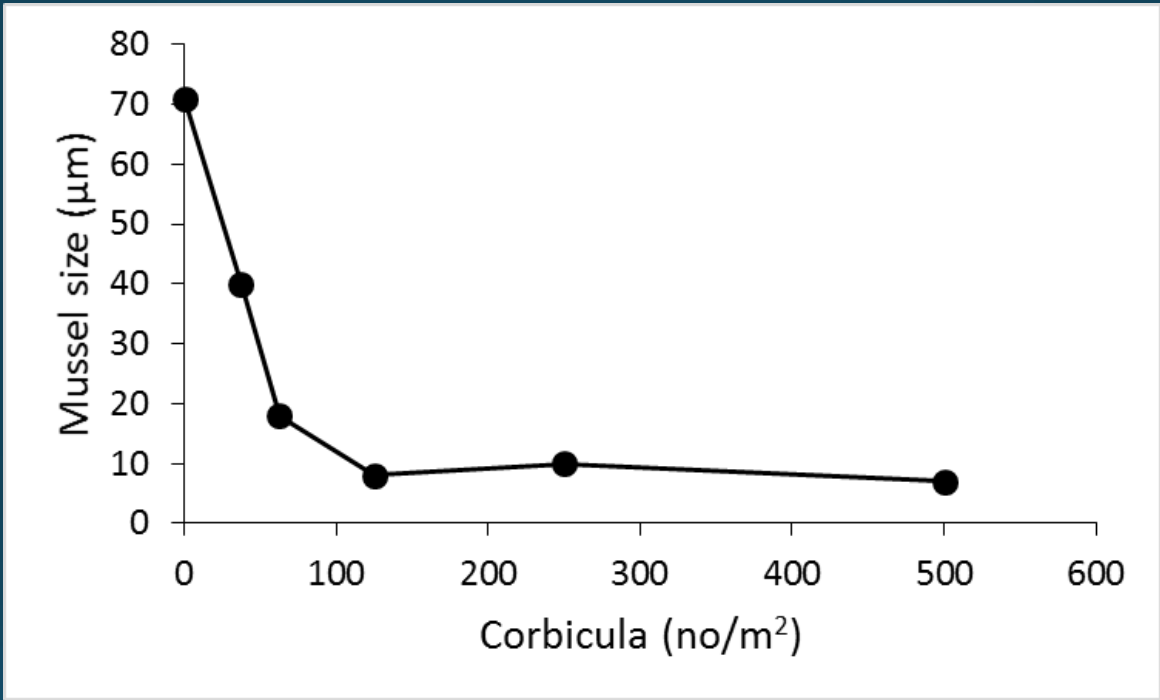
Could explain upstream pattern of decline

Horse Lick: ~1970s-mid 1980s; decline >1990

Happened almost everywhere; notable exception: New England

Some data, not much



Yeager et al., 2000

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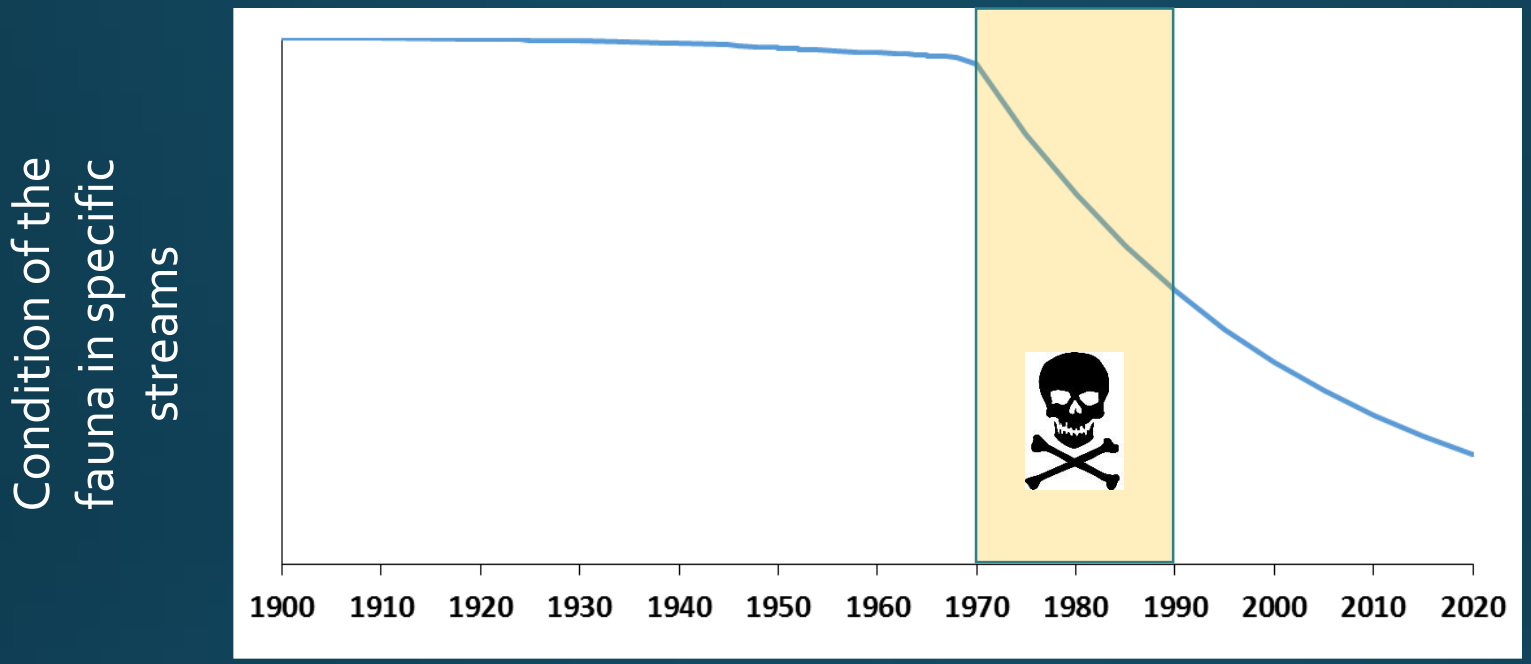
Problem: co-occurrence in many areas



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- Disease, pest, parasite?

  Brought in by Corbicula?

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- Don't walk away from degraded streams