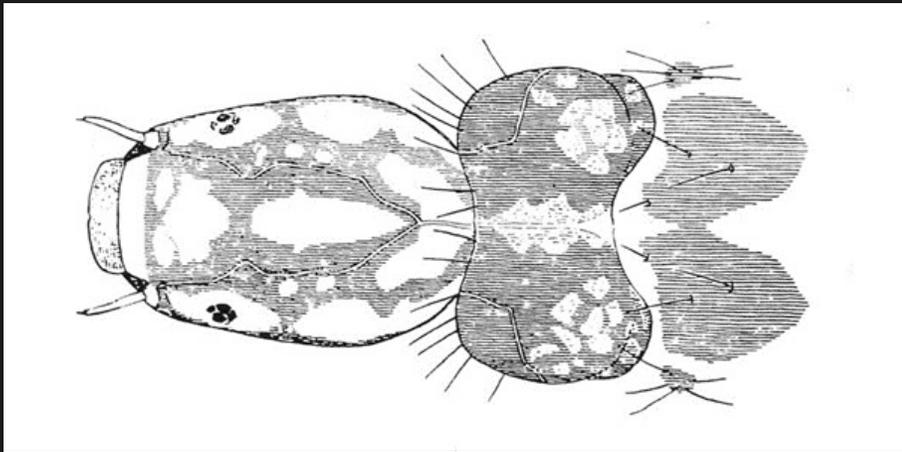


# *General Outline of Presentation*



- **Brief History of Biological Monitoring**
- **What are Benthic Macroinvertebrates and why are they important**
- **Some very basic taxonomic stuff**
- **Sources of variability in the data**
- **Effects of water pollution on aquatic insect populations**
- **Penrose's top ten list for mountain streams**



*The real voyage of discovery consists  
not in seeking new landscapes, but in  
having new eyes.*

Marcel Proust

# *A HISTORY OF BIOLOGICAL MONITORING USING AQUATIC INSECTS*

# *Cleveland, Ohio 1969*

Burn on, big river, burn on  
Burn on, big river, burn on  
Now the Lord can make  
you tumble

And the Lord can make  
you turn

And the Lord can make you overflow  
But the Lord can't make you burn

---

Lyrics by Randy Newman



*The driving initiatives have always been regulations*

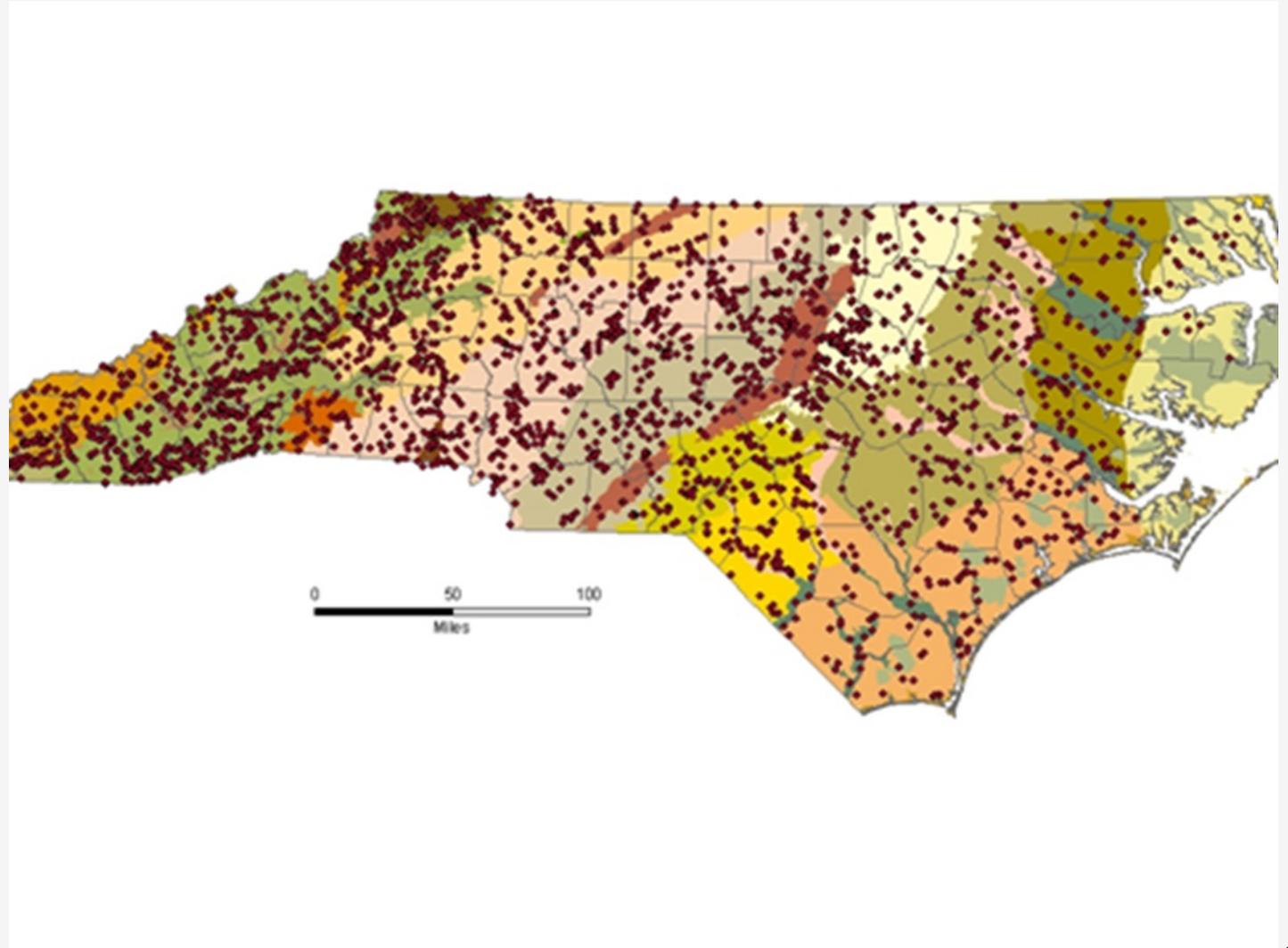
“No important change in human conduct is ever accomplished without an internal change in our intellectual emphasis, our loyalties, our affections, and our convictions.” Aldo Leopold

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- The Clean Water Act - 1972
- Canadian Protection Act - 1999
- European Water Framework Directive (WFD) - 2000

# *The Clean Water Act*

“The objective of this Act is to restore and maintain the chemical, physical, and **biological integrity** of the Nation’s waters.” § 101(a)

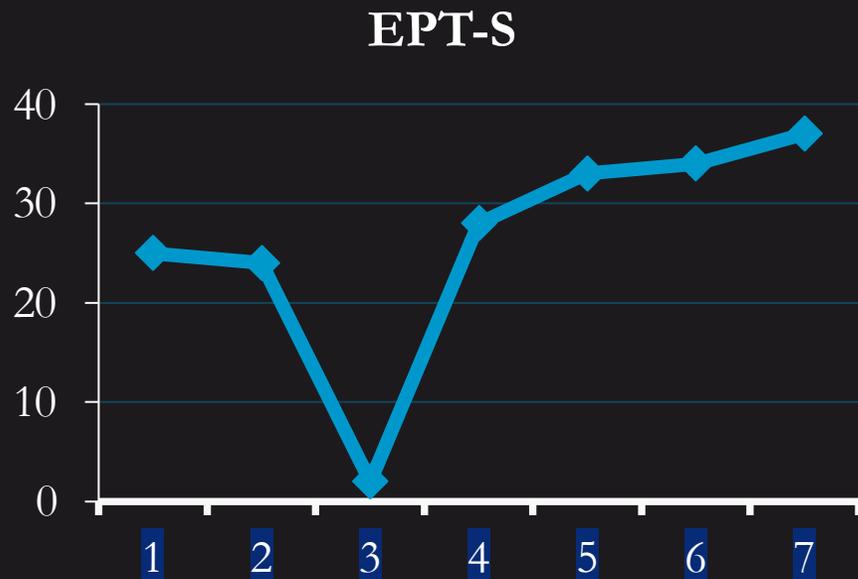


# Bioclassification Criteria in NC

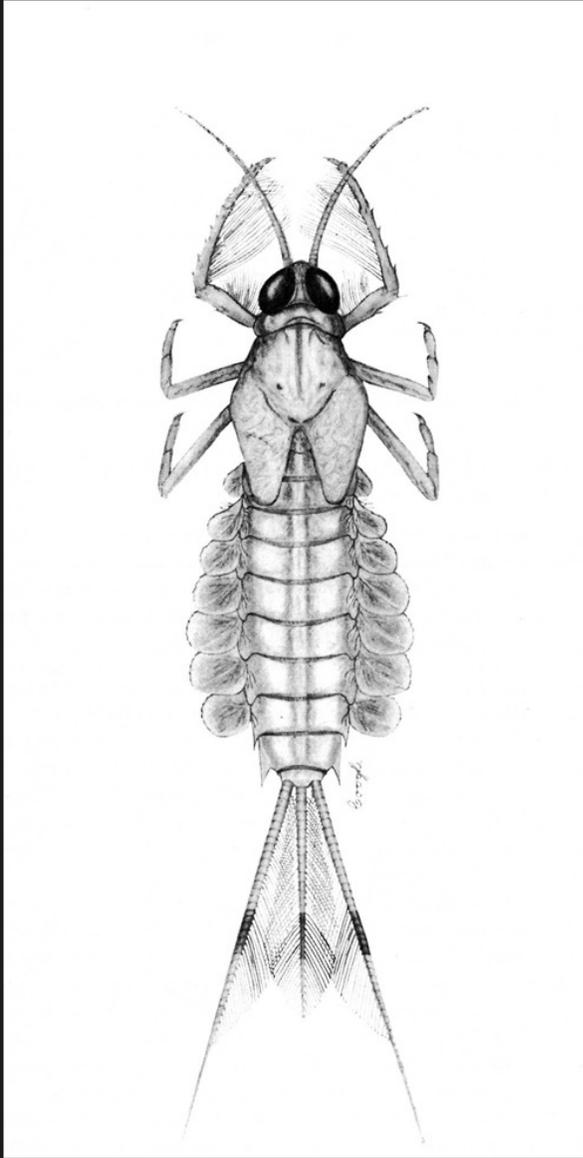
- Standardized for stream size, season, collection protocol
- Stream origin protocols using aquatic insects
- Non-wadable rivers and swamp streams have criteria

EPT (Biotic Index) values for wadable streams by Ecoregion			
Score	Mountain	Piedmont	Coastal A
5.0 (excellent)	>43 (<4.00)	>33 (<5.14)	>29 (<5.42)
4.6	42-43 (4.00-4.04)	32-33 (5.14-5.18)	28 (5.42-5.46)
4.4	40-41 (4.05-4.09)	30-31 (5.19-5.23)	27 (5.47-5.51)
4.0 (Good)	34-39 (4.10-4.83)	26-29 (5.24-5.73)	22-26 (5.52-6.00)
3.6	32-33 (4.84-4.88)	24-25 (5.74-5.78)	21 (6.01-6.05)
3.4	30-31 (4.89-4.93)	22-23(5.79-5.83)	20 (6.06-6.10)
3.0 (Good/Fair)	24-29 (4.94-5.69)	18-21 (5.84-6.43)	15-19 (6.11-6.67)
2.6	22-23 (5.70-5.74)	16-17 (6.44-6.48)	14 (6.68-6.72)
2.2	20-21 (5.75-5.79)	14-15 (6.49-6.53)	13 (6.73-6.77)
2.0 (Fair)	14-19 (5.80-6.95)	10-13 (6.54-7.43)	8-12 (6.78-7.68)
1.6	12-13 (6.96-7.00)	8-9 (7.44-7.48)	7 (7.69-7.73)
1.4	10-11 (7.10-7.05)	6-7 (7.49-7.53)	6 (7.74-7.79)
1.0 (Poor)	0-9 (>7.05)	0-5 (> 7.53)	0-5 (>7.79)

# *How are the data used?*



- State governments were mandated by the newly created EPA to develop both narrative and numeric biological classification criteria.
- Data are used to determine long-term trends in stream health.
- Data are frequently used for water use classifications such as 303 (d) listing, Outstanding Resources Water, etc.
- Intermittent/Perennial Stream calls
- Test the effectiveness of best management practices and/or restoration success.
- Identification of rare benthic insect taxa.
- Education!!



# Aquatic Insects or Benthic Macroinvertebrates

- Invertebrates (without vertebrae, has chitinous exoskeleton) and instar growth stages
- Benthic – living on the substrates of streams, lakes, etc.
- Macro – large enough to be seen with the naked eye

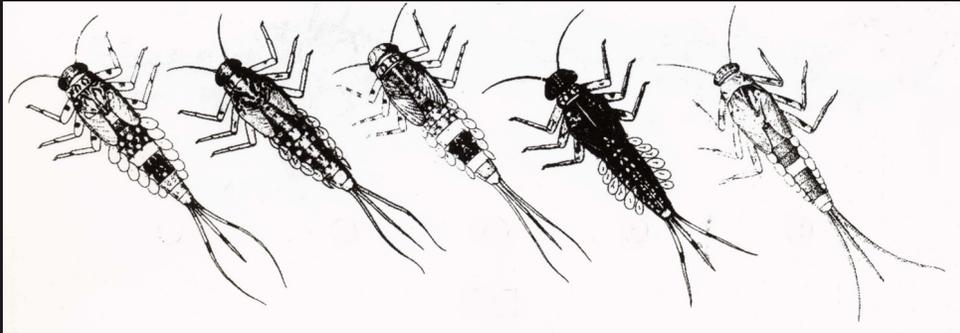


# *Why do scientists use aquatic insects?*

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- They're found in all stream types; ubiquitous
- Large number of species (i.e. Chironomidae = 10,000 species worldwide), spectrum of environmental responses.
- Sedentary nature to allow spatial analyses
- Propensity of some species to enter the water column and drift
- Long life cycles, about 1 year in length
- Easily and inexpensive to collect
- Taxonomy is relatively well described (family and genus)
- Integrate a wide array of potential pollutants
- Important in the diets of fish and other organisms

# *Aquatic Invertebrates*

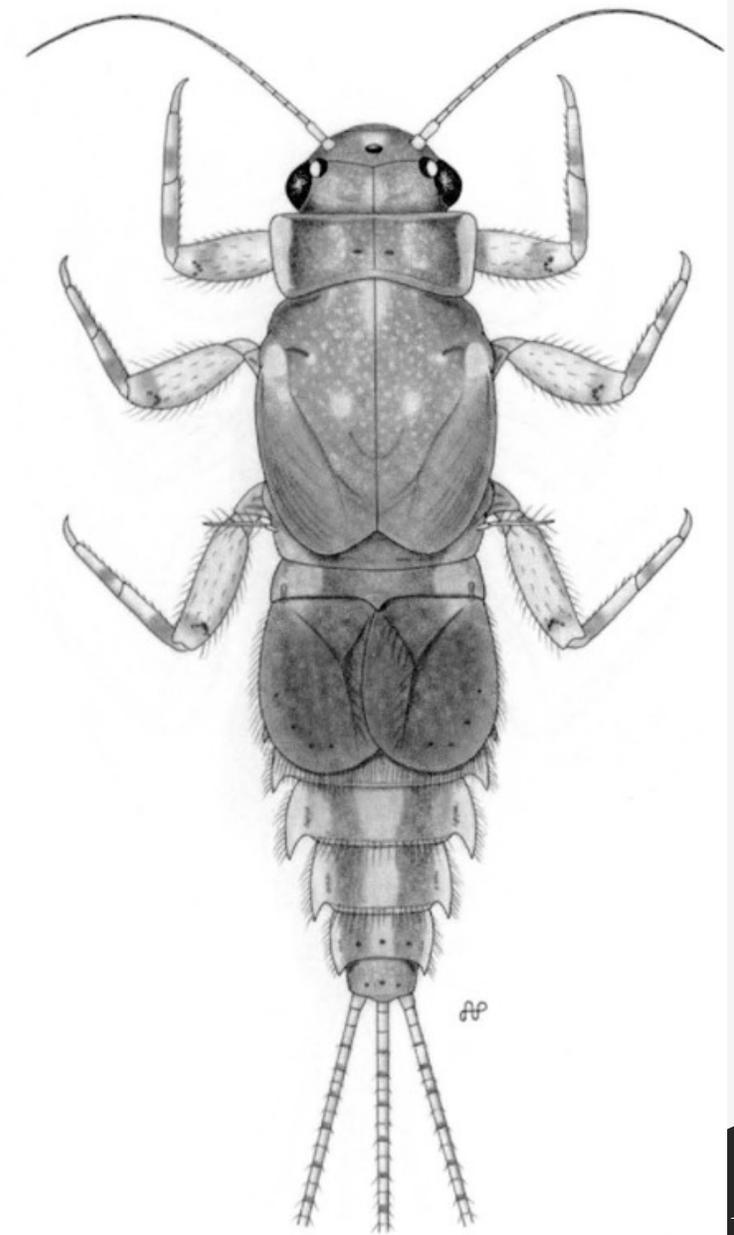


- Ephemeroptera – mayflies
- Plecoptera – stoneflies
- Trichoptera – caddisflies
- **Odonata – Dragonflies and Damselflies**
- **Coleoptera – beetles**
- **Megaloptera – hellgrammites, Dobson flies,  
alder flies**
- **Diptera – true flies**
- **Oligochaeta – aquatic worms**
- **Crustacea – crayfish, amphipods, isopods**
- **Mollusca – clams and snails**

EPT

# Mayflies

- 21 Taxonomic families and roughly 300 species in the SE.
- Most often with 3 tails, but always gills along the abdomen
- Southeastern US is one of the most diverse areas in the world
- Can be numerically dominant in mountain streams



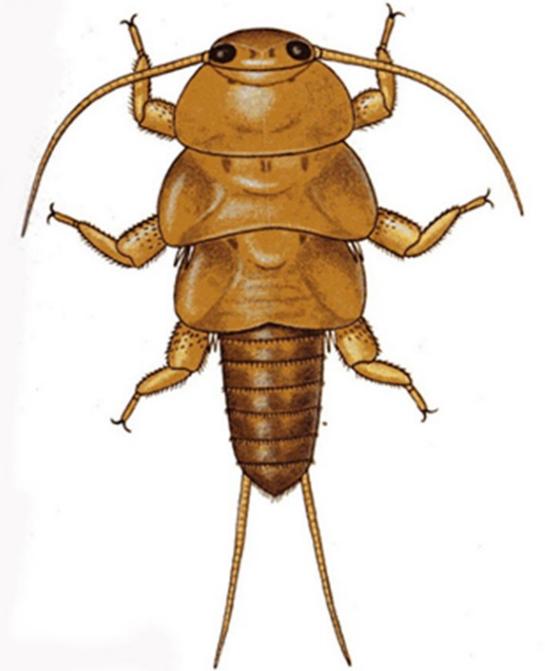
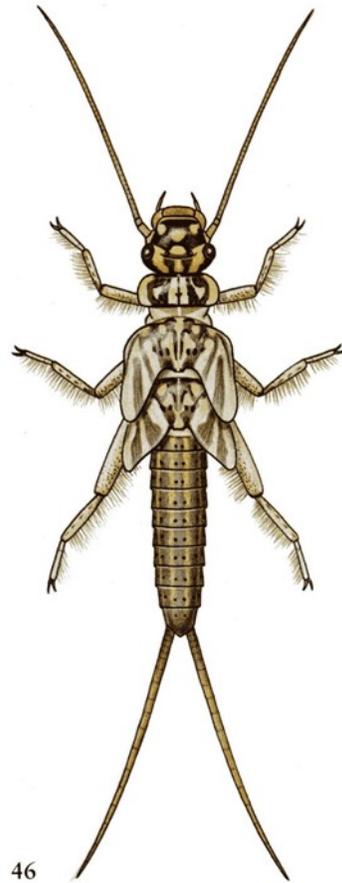
Morse, J.Cl, W.P. McCafferty, B.P. Stark, & L.M. Jacobus, Editors, 2017. Larvae of the Southeastern USA Mayfly, Stonefly and Caddisfly Species. Biota of South Carolina. Vol 9. Clemson University Public Service Publishing, Clemson University, Clemson, South Carolina, USA. 482 pp.

# *SIGNIFICANTLY RARE MAYFLIES<sup>2</sup>*

<u>Family</u>	<u>Genus/Species</u>	<u>Ecoregion</u>	<b>Significantly Rare</b> - Any species which has not been listed as an Endangered, Threatened, or Special Concern species, but which exists in the state (or recently occurred in the state) in small numbers (generally fewer than 100 statewide populations) and has been determined by the NCNHP to need monitoring. Significantly Rare species include species of historical occurrence with some likelihood of rediscovery in the state and species substantially reduced in numbers by habitat destruction, direct exploitation, or disease
AMELETIDAE	<i>Ameletus tertius</i>	Mountains	
CAENIDAE	<i>Amercaenis cusabo</i>	Sandhills	
LEPTOHYPHIDAE	<i>Asioplax dolani</i>	Piedmont	
EPHEMERELLIDAE	<i>Attenella margarita</i>	Mountains	
BAETISCIDAE	<i>Baetisca becki</i>	Piedmont	
BAETIDAE	<i>Baetopus trishae</i>	Mountains	
BAETIDAE	<i>Barbaetis benfieldi</i>	Mountains	
CAENIDAE	<i>Cercobrachys etowah</i>	Mts, Pied	
LEPTOPHLEBIIDAE	<i>Choroerpes basalis</i>	Sandhills, CP	
BEHINGIIDAE	<i>Dolania americana</i>	Coastal Plain	
HEPTAGENIIDAE	<i>Epeorus punctatus</i>	Mountains	
EPHEMERELLIDAE	<i>Ephemerella floripara</i>	Mountains	
BAETIDAE	<i>Heterocloeon bernerii</i>	Mountains	
OLIGONEURIIDAE	<i>omooneuria cahabensis</i>	Piedmont	
HEPTAGENIIDAE	<i>Maccaffertium wudigeum</i>	Mountains	
HEPTAGENIIDAE	<i>Macdunnoa brunnea</i>	Mts, Pied	
NEOEPHEMERIDAE	<i>Neoephemera eatoni</i>	Piedmont	
PSEUDIRONIDAE	<i>Pseudiron centralis</i>	Piedmont	
POLYMITARCYIDAE	<i>Tortopsis puella</i>	Piedmont	
EPHEMERELLIDAE	<i>Tsalia bernerii</i>	Mountains	

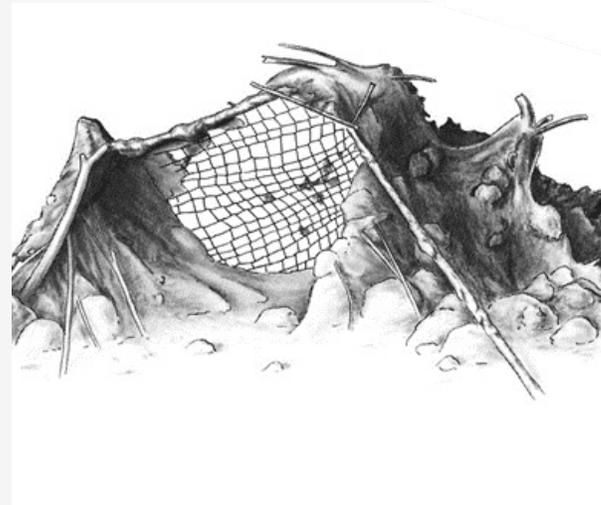
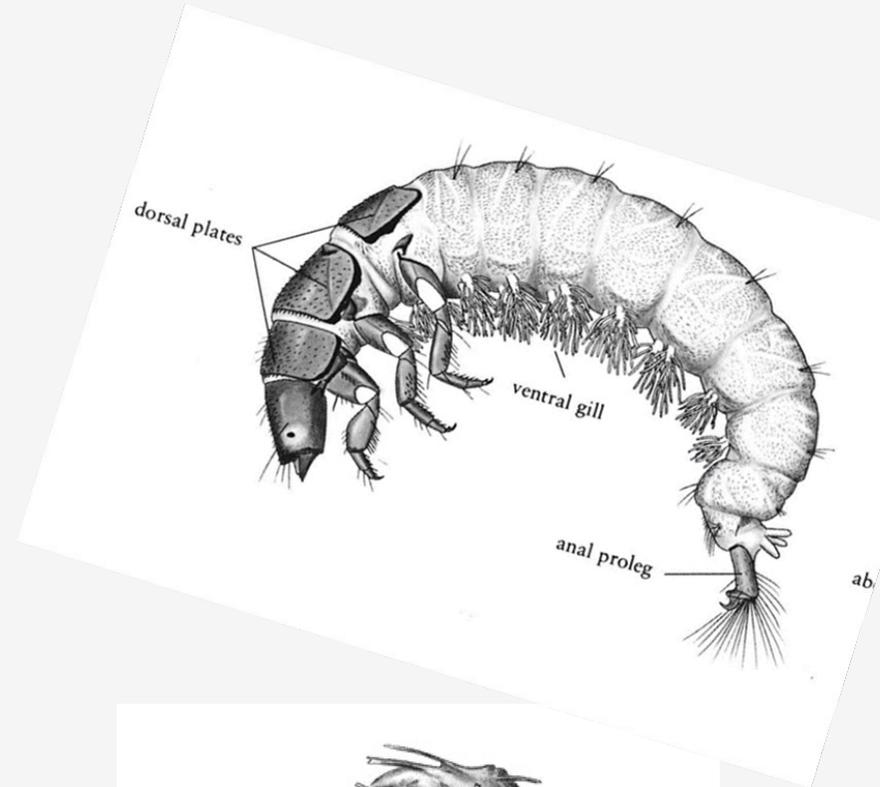
# Stoneflies

- 9 Taxonomic families, but 294 species (very conservative)
- 2 tails and no gills on the abdomen
  - Predators or shredders
  - Stoneflies are generally the most intolerant of aquatic insects
- At least 3 species are considered for the Endangered Species List
- Maybe the most likely to be lost due to climate modifications



# Caddisflies

- 22 Taxonomic families and 663 species.
- Build cases or larval retreats taxonomists can use to ID
- Complete metamorphosis (pupate)



# *Sources of Variability in the Data*

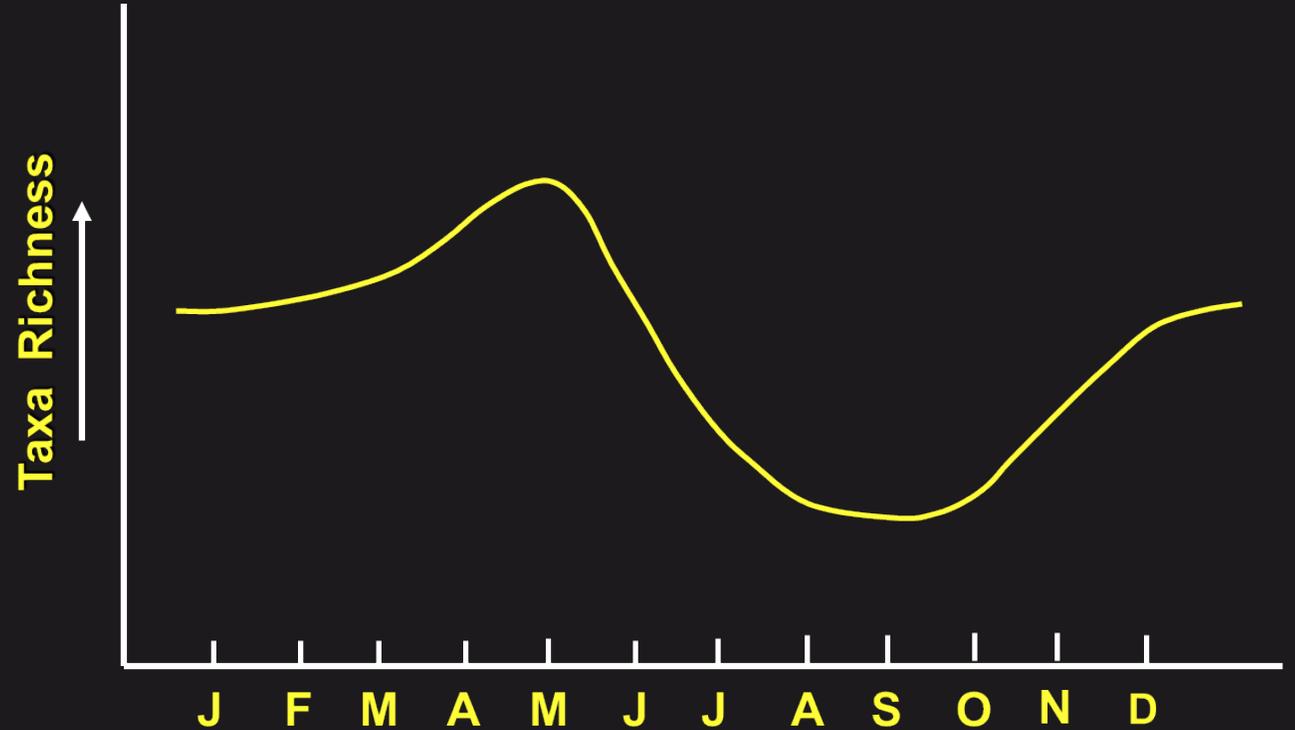
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- **Seasonality, spring vs summer collections**
  - **Effects of stream size and continuum**
  - **Effects of flow (point vs. nonpoint perturbations).**
  - **Taxonomic consistency**
- 

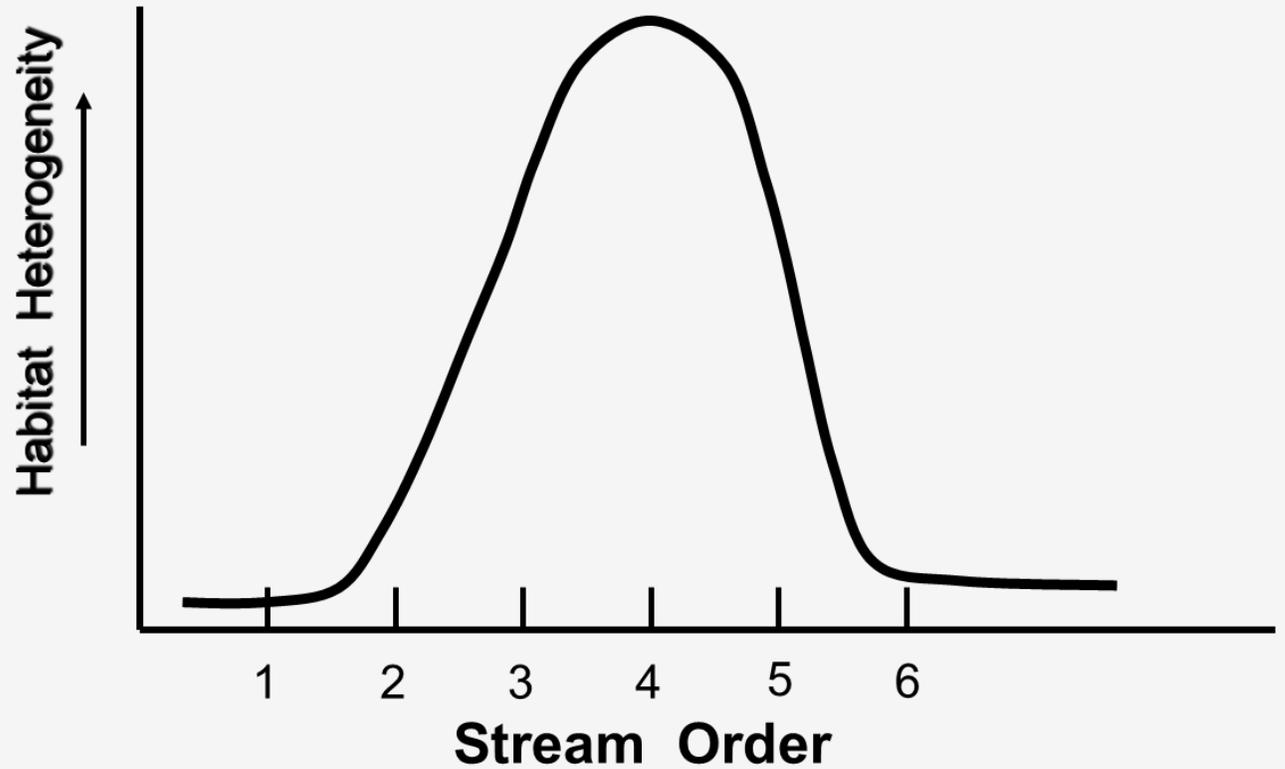
# Seasonality

## Temperate Streams

Live your life, do your work, then take your hat.  
Henry David Thoreau, "Conscience"

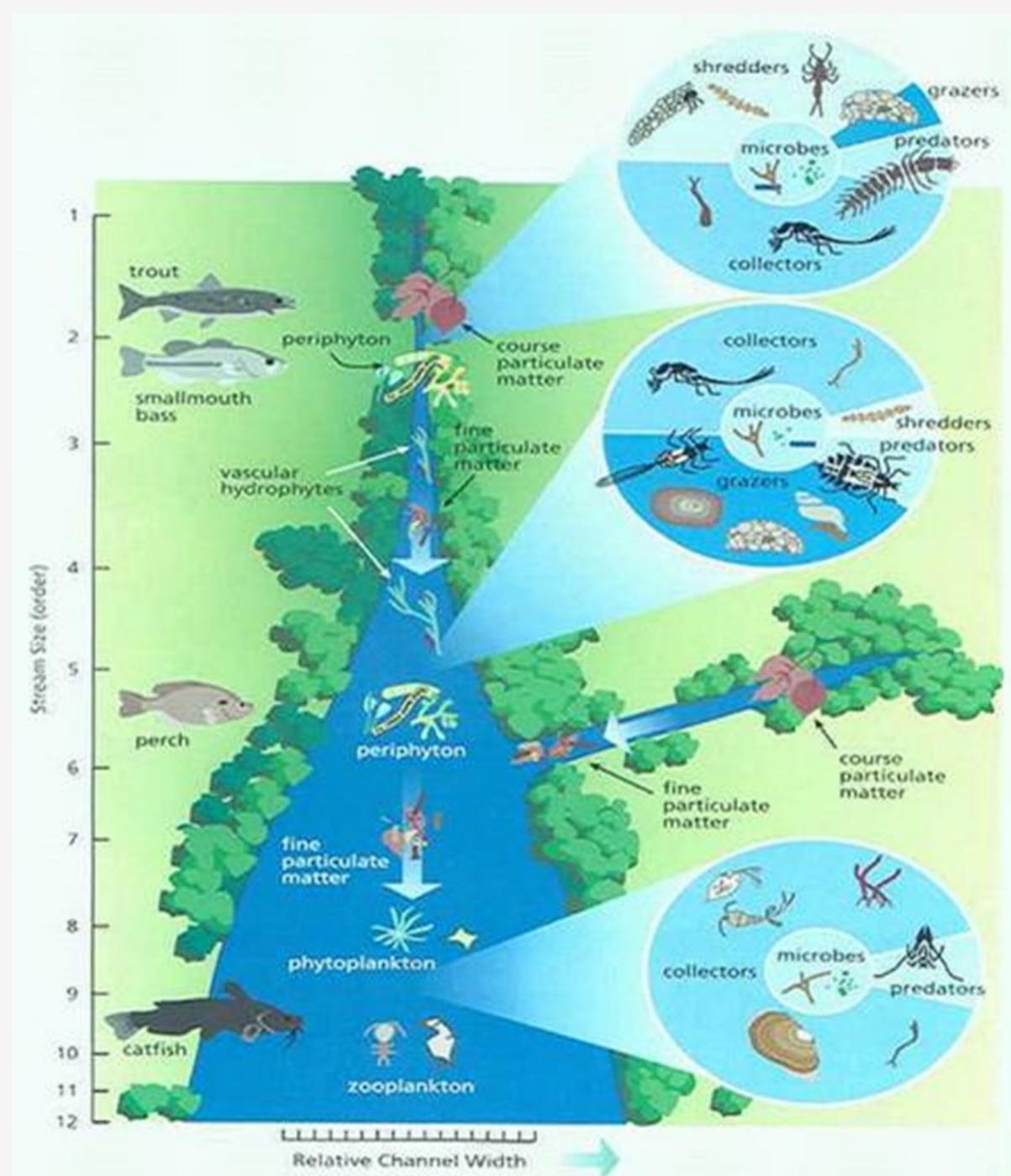


# *Habitat Heterogeneity and Stream Order*



# The River Continuum Concept

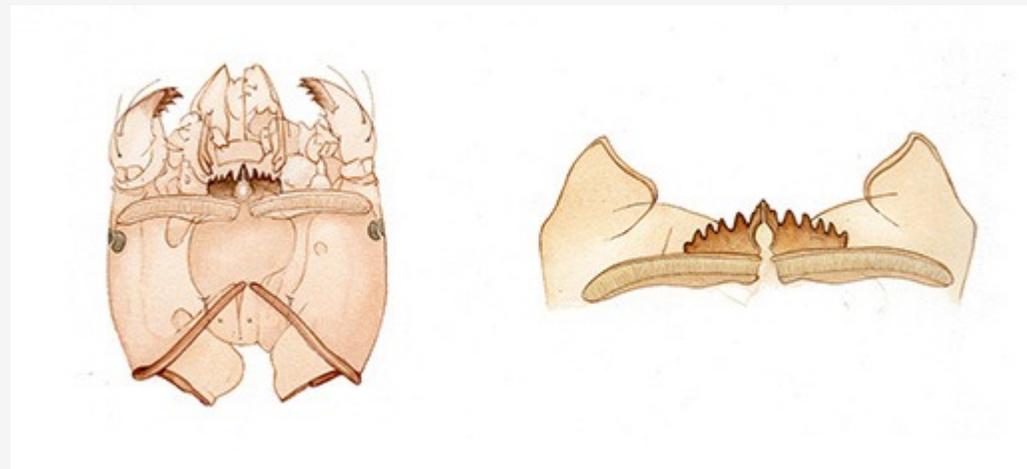
Vannote, R. L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. *Can J. Fish. Aquat. Sci.* 37: 130 – 137.



# *Taxonomic Variability*

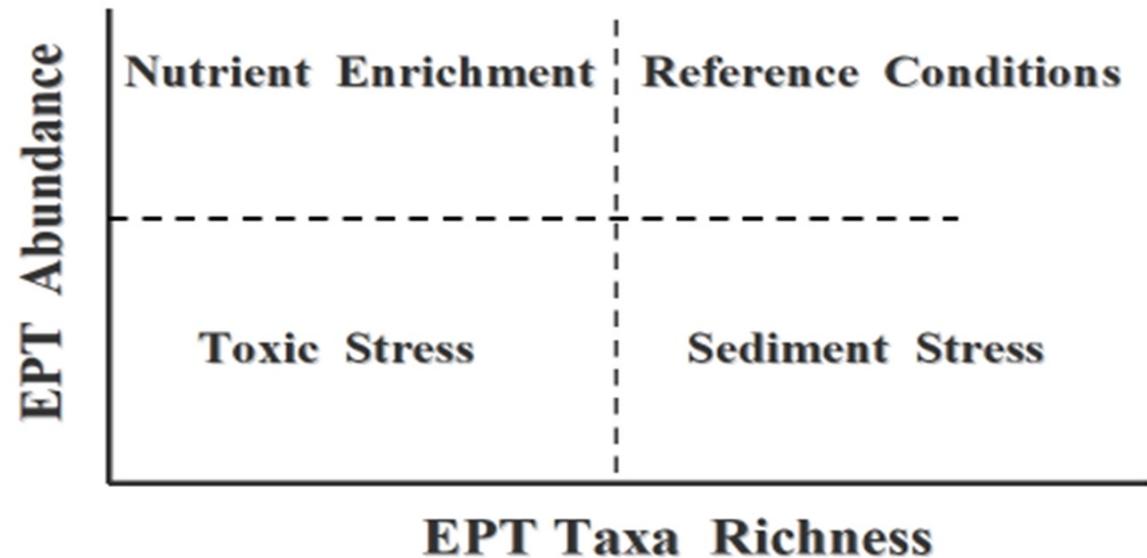
In the first place we usually start with attempting to name our specimens and it is extraordinary how easy this usually is to begin with and how difficult it becomes as we accumulate knowledge."

F. Balfour-Browne, Concerning the Habits of Insects, 1925



*Water  
Pollution  
and Benthic  
Insects*

**Benthic Macroinvertebrate Response  
to Environmental Stress (Hocutt)**

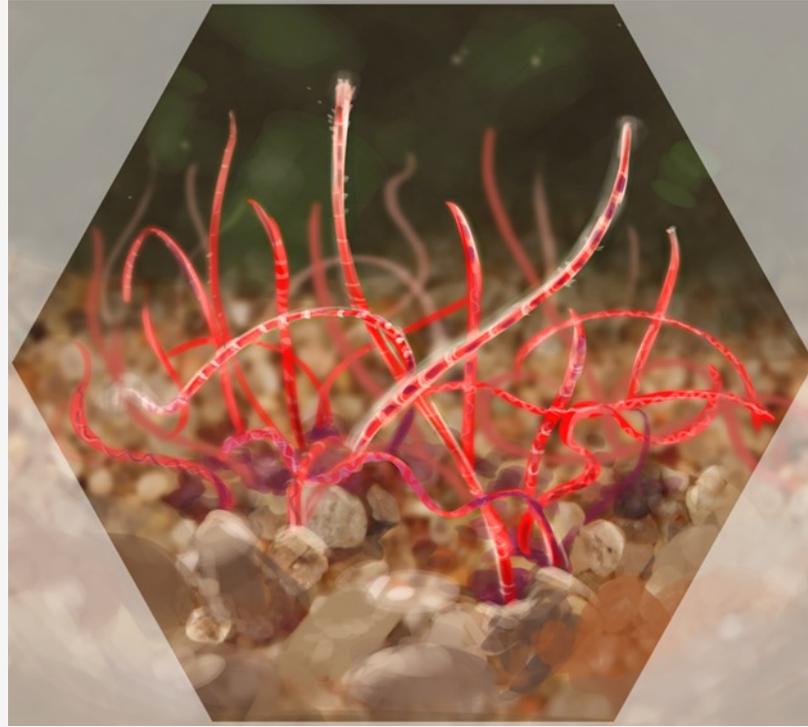


# *Enrichment*

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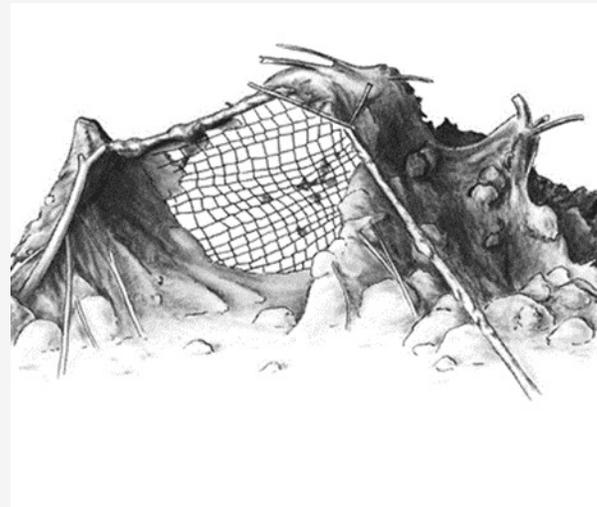


*Benthic  
fauna  
associated  
with severe  
enrichment*

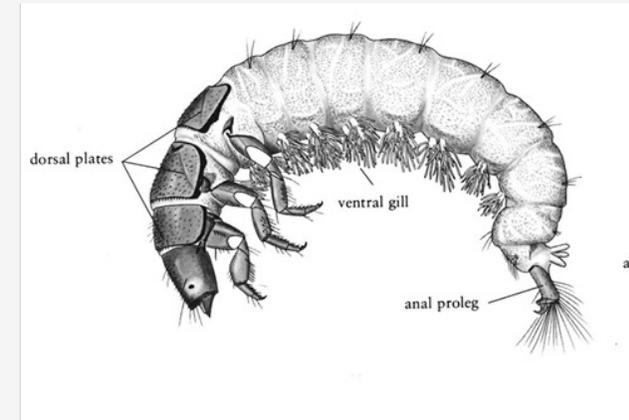
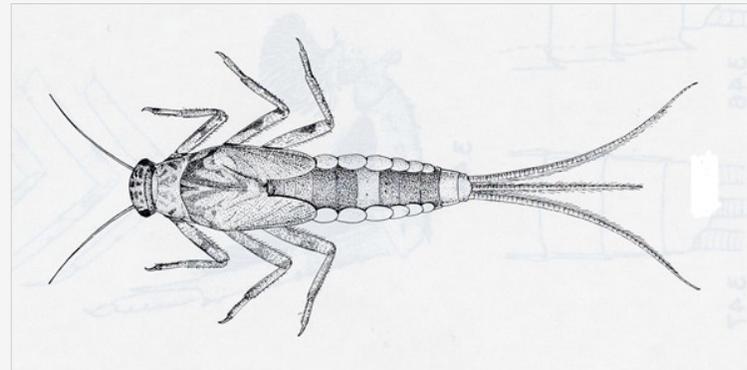
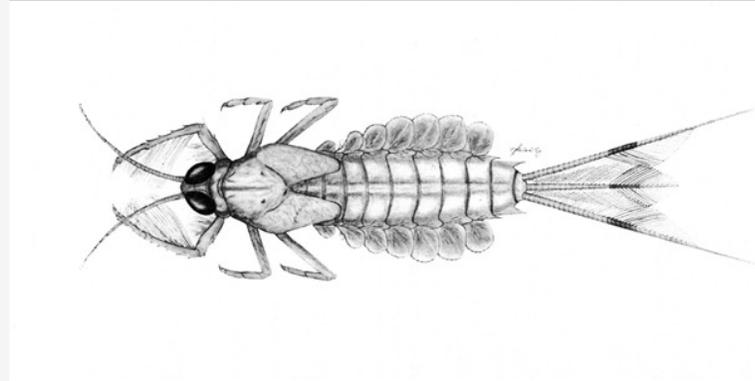


*Benthic organisms associated with severe to moderate enrichment*

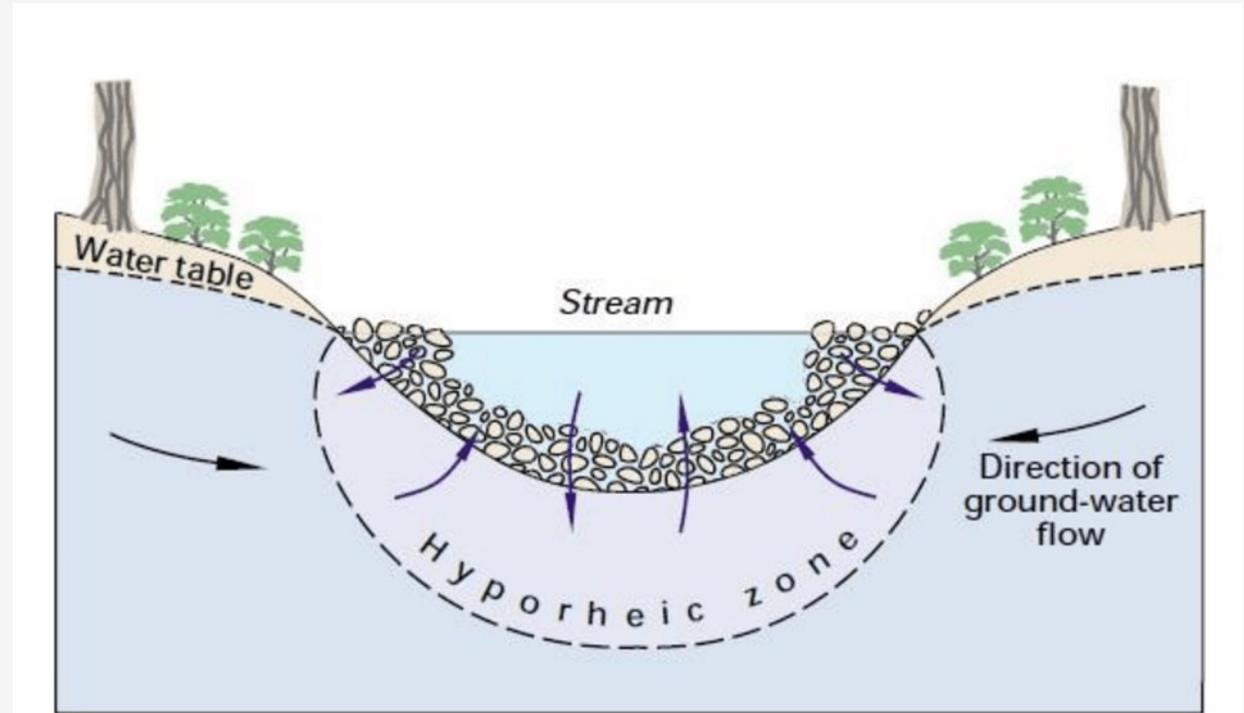
Note anything funny about this caddisfly?



*Organic enrichment, moderate. Increase in the numbers of filter-feeders and scrappers*



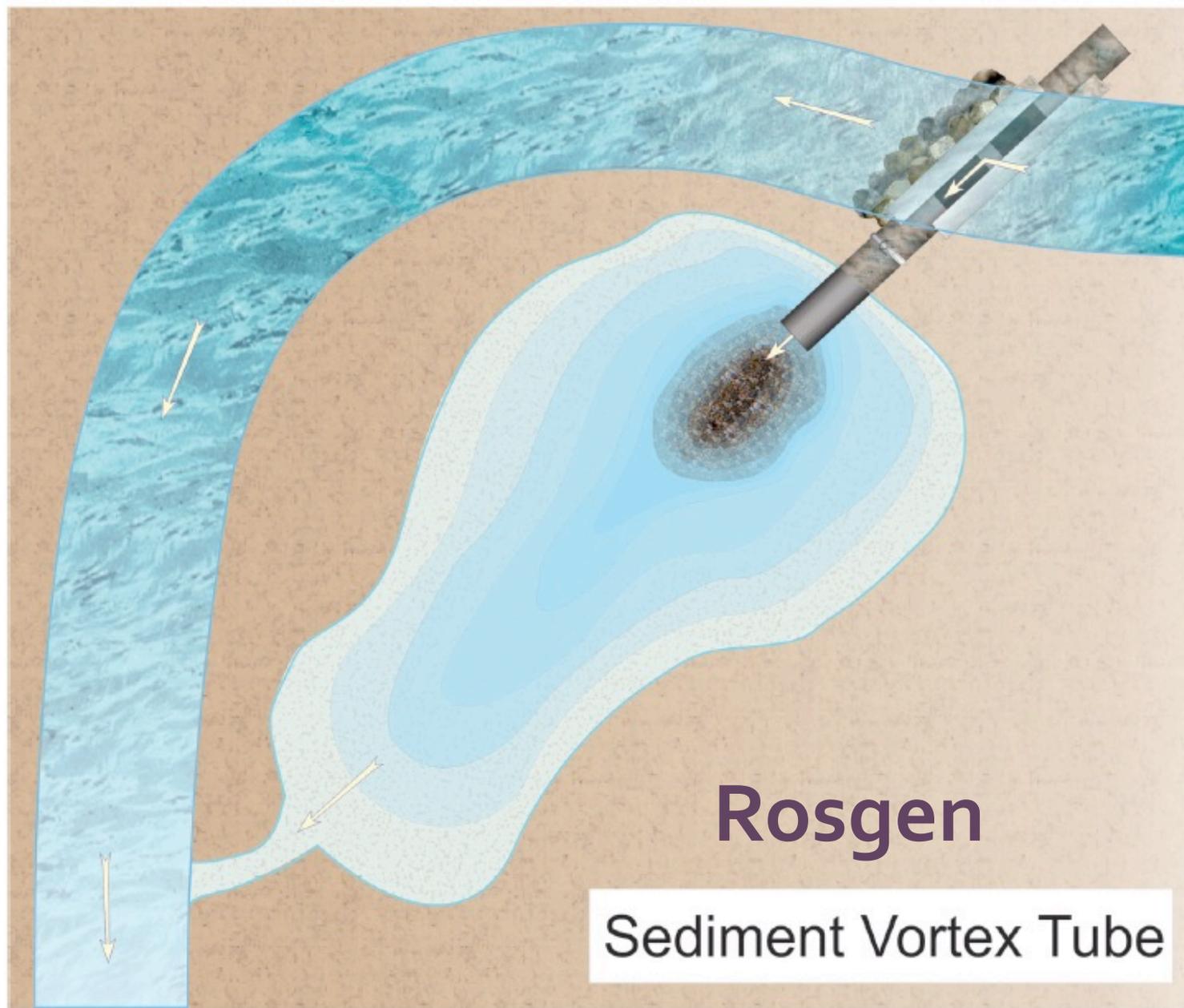
# Sediment Stress in Streams



Hyporheic Zone- area where stream water and ground water intermix.

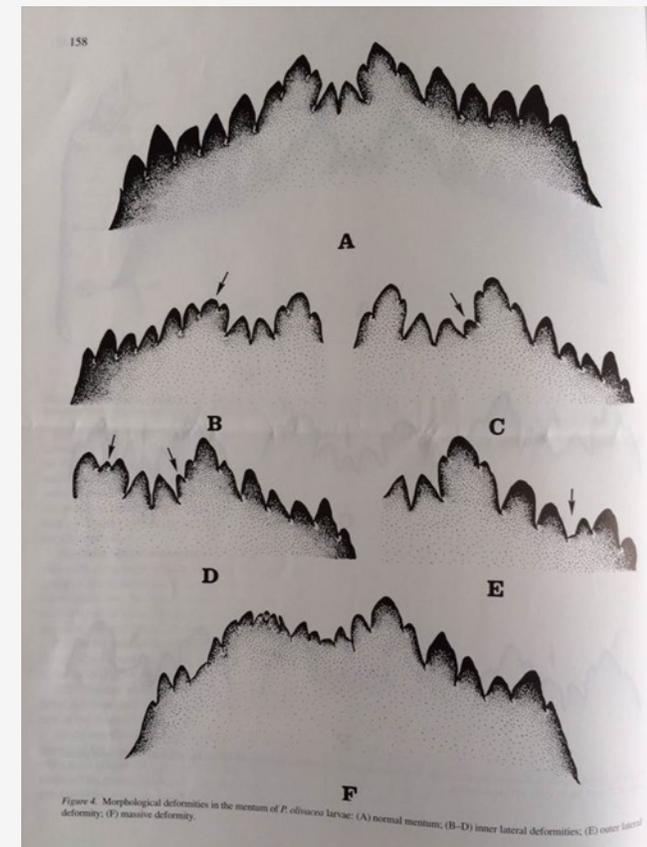
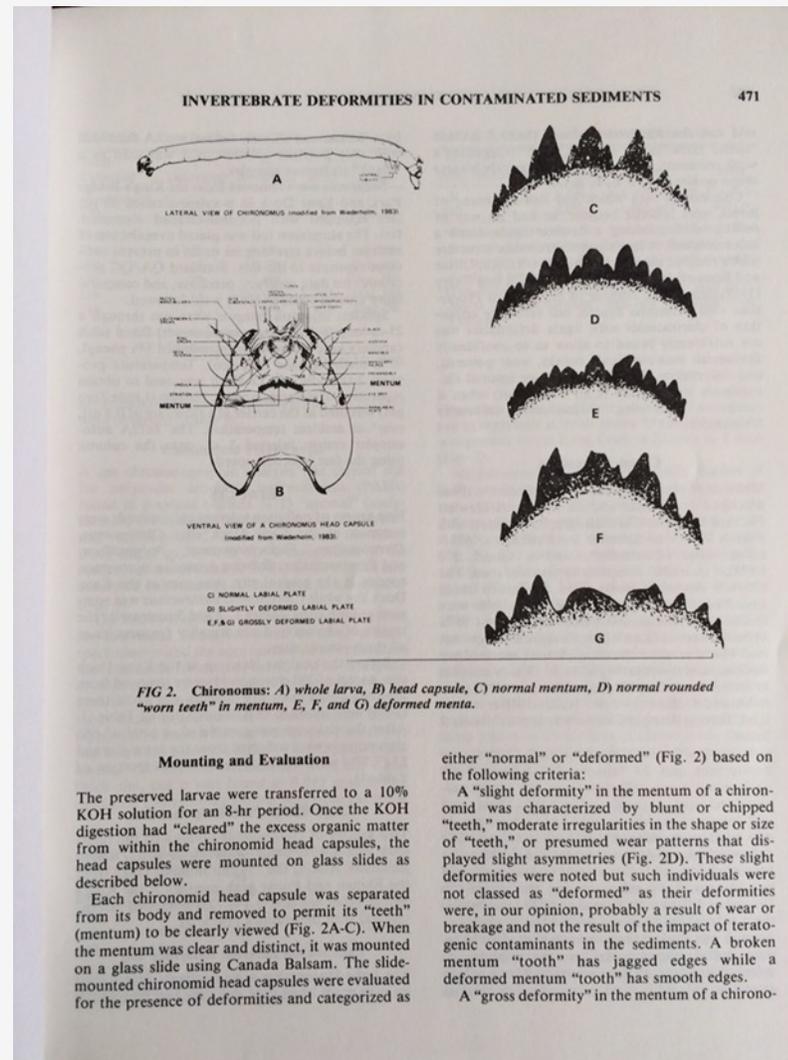
[http://www.bgs.ac.uk/research/groundwater/images/Hyporheic\\_USGS\\_v2.jpg](http://www.bgs.ac.uk/research/groundwater/images/Hyporheic_USGS_v2.jpg)

## Legacy Sediments



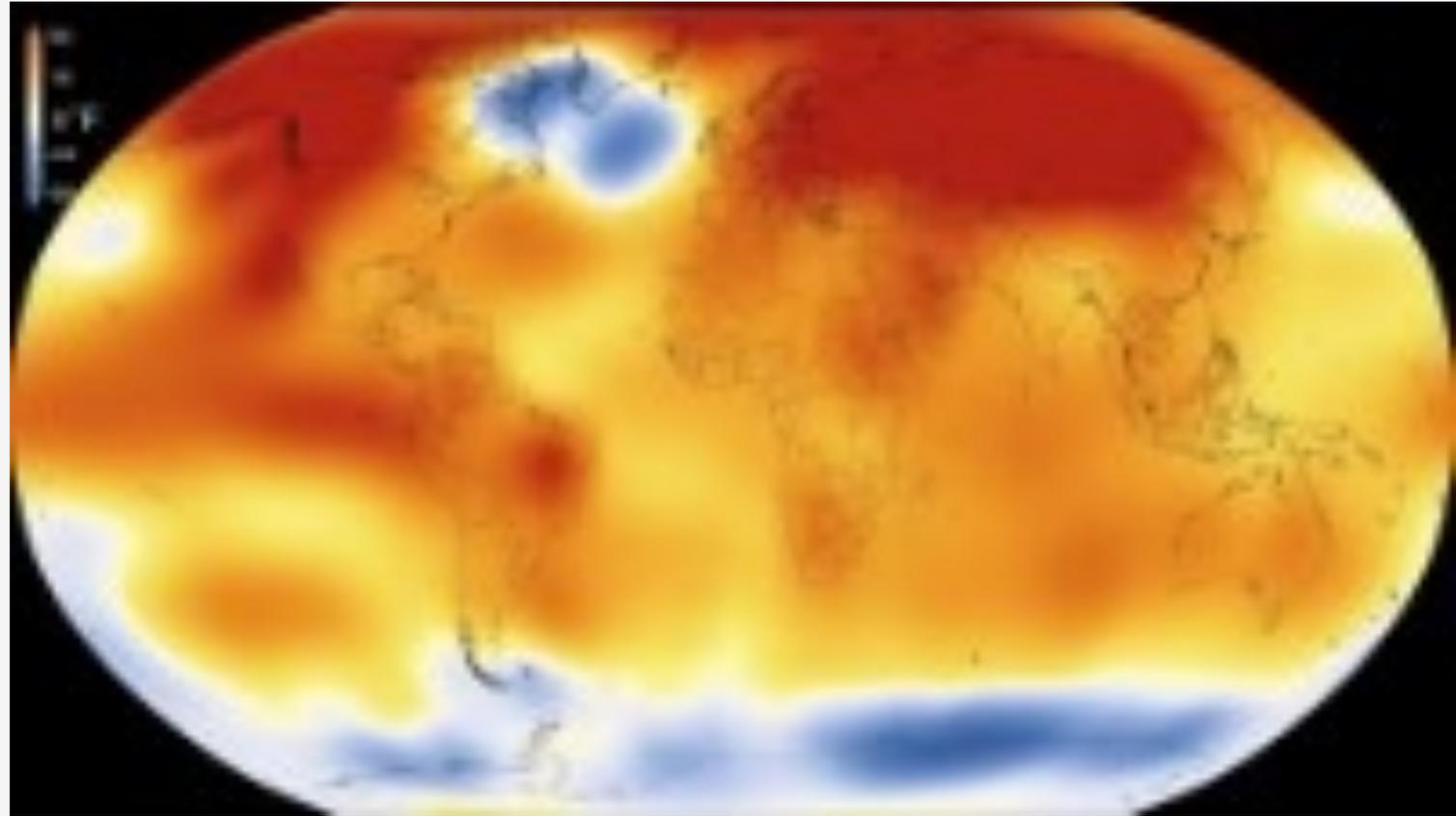
**Figure 9-158.** Longitudinal profile and plan views of the Sediment Vortex Tube.

# Toxicity: PPCPs. Mentum deformities in Chironomidae



*Gorilla in  
the room*

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# *Aquatic Insects and Climate Change*

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- Endemic species – limited distribution
- Habitat Specialists – springs and high altitudes
- Cold Stenothermic species
- Species with short emergence periods
- Species with restricted niches – food resources

*Why adult  
mayflies of  
Cloeon  
dipterum  
become  
smaller as  
temperature  
warms*



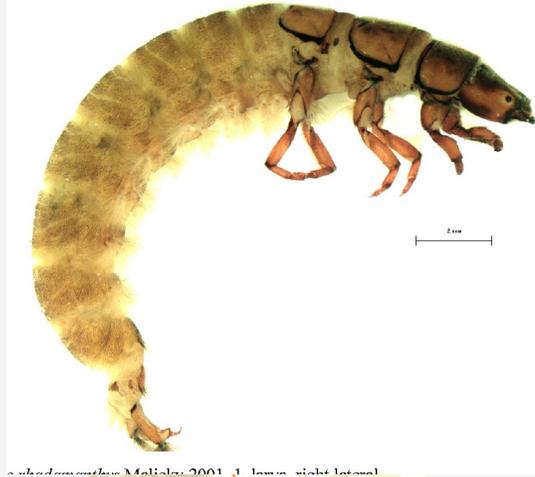
*Brancheria  
sowerbyi*  
(will be  
coming to  
streams  
near you?)

---



*Penrose's  
top 10 list of  
EPT keystone  
species in  
mountain  
streams*

<u>Order</u>	<u>Genus</u>	<u>Why?</u>
Ephemeroptera	<i>Epeorus</i> spp	stable substrate obligate
Ephemeroptera	<i>Paraleptophlebia</i> spp	perennial stream indicator
Ephemeroptera	<i>Isonychia</i> spp	filter-feeder, nutrients
Plecoptera	<i>Tallaperla</i> spp	shredder, organic retention
Plecoptera	<i>Paragnetina imarginata</i>	<i>intolerant predator</i>
Plecoptera	<i>Pteronarcys</i> spp	<i>easy ID, shredder</i>
Trichoptera	<i>Lepidostoma</i> spp	<i>riparian obligate species</i>
Trichoptera	<i>Chimarra</i> spp	<i>early recovery species</i>
Trichoptera	<i>Hydropsyche</i> spp	<i>filter-feeder, nutrients</i>
Trichoptera	<i>Neophylax</i> spp	<i>Common grazer</i>



# Overview of Benthic Macroinvertebrates in Freshwater Systems.

*Evans, R.R., A. Seager, G.C.L. David. 2021. Overview of benthic macroinvertebrates in freshwater streams. U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. White Paper, 64 pages.*

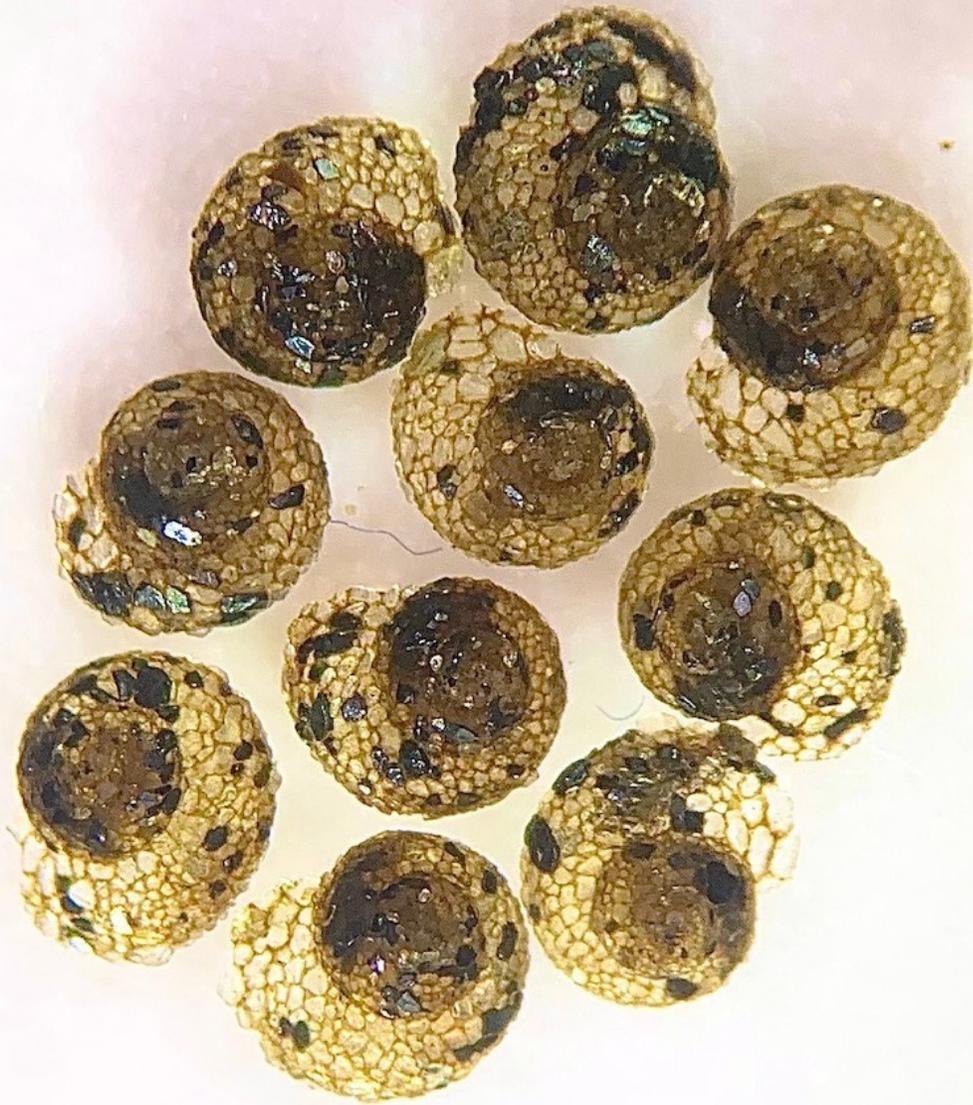
## Overview of Benthic Macroinvertebrates in Freshwater Systems



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# Questions?

Photo credit - Marvin Bouknight. Catawba Nation