Stressors of Emerging or Increasing Concern Potentially Affecting Processes and Living Resources

Vicki Blazer, U.S. Geological Survey

Chelsea Rochman, University of Toronto

Andrew Heyes, University of Maryland Center for Environmental Science

Fred Pinkney, U.S. Fish and Wildlife Service

Chemicals of Emerging Concern (CEC)

- **Include many chemicals that have been recognized as having environmental effects for many years**
  - **Pharmaceuticals – human and veterinary**
  - **Hormones – human and agricultural sources**
  - **New and current use pesticides/herbicides**
  - **Chemicals in personal care products**
    - **UV blockers**
    - **Antimicrobials (triclosan)**
    - **Fragrances**
    - **Dyes**
    - **Microplastics**

Pharmaceuticals

- Widely used as human and veterinary medicines and growth promoters in animal production
- Have been detected in natural environments worldwide
  - Surface water, ground water and drinking water
- Consider both human and animal sources
  - Companion animals
- Many are indicative of more urban/suburban areas – exception can be antibiotics used in animal agriculture

Sources

- Excretion of parent compound and metabolites via urine, feces, sweat – WWTP, septic, CSO
- Bathing/recreation – for skin applied PPCPs
- Manufacturing plants
- Disposal of unused pharmaceuticals
- Application of manure and sewage sludge (biosolids) as fertilizer
  - PPCPs can last from days to years in soils

Examples of Effects of Pharmaceuticals on Non-Target Organisms

- **Synthetic estrogens (ethynylestradiol)– intersex and other feminization**
- **Synthetic gestagens (progestogenic) – inhibition of reproduction and masculization of females**
- **Antibiotics – antibiotic resistance, changes in normal (beneficial) bacterial flora**
- **Metformin – diabetic medication – carbohydrate metabolism and intersex**
- **Antidepressants – accumulate in the brains of fish, effect reproduction (dopamine), behavior**

Examples of Effects of Chemicals in Personal Care Products

- **Antimicrobials – triclosan and triclocarban**
  - **Antimicrobial soaps, toothpaste, cosmetic, toys, fabric**
  - **Endocrine disruption (thyroid), antibiotic resistance, degraded to a dioxin-like compound (carcinogen), immune system, effects primary-producers**
- **Chemical UV filters (sunscreens) - estrogenic, coral bleaching**

Some Complexities to Consider

- **These chemicals, unlike many legacy contaminants (PAH, PCB, mercury), were produced to have a biological response at very low concentrations**
- **Unlike the situation of being prescribed a drug – environmental exposures of non-target organism are generally as complex mixtures together with many other legacy contaminants and environmental stressors**

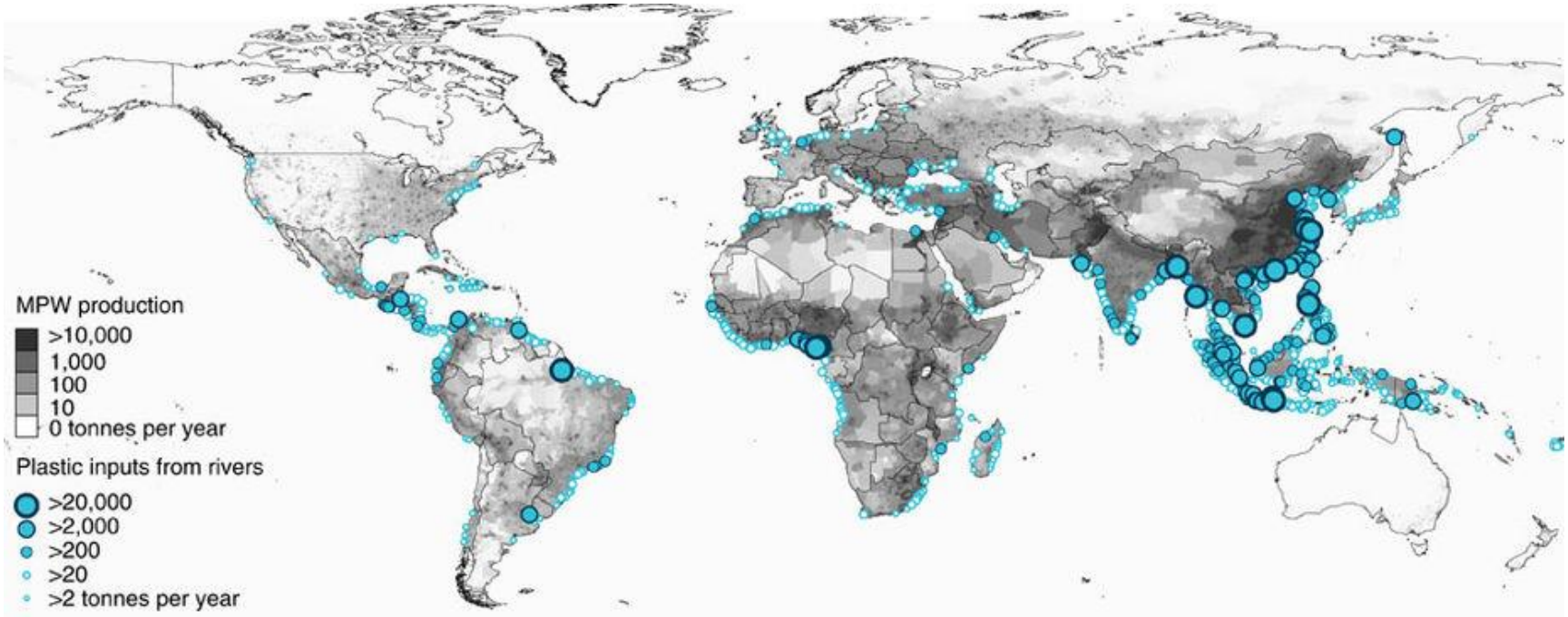
Concerns in Small Tributaries

- **May have higher concentrations due to proximity to sources as well as less dilution**
- **These are often areas used as nursery areas – fish moving into smaller tribs to spawn – means young fish, most sensitive stage for developmental, reproductive and immune effects are exposed**

Another area of emerging concern is microplastics

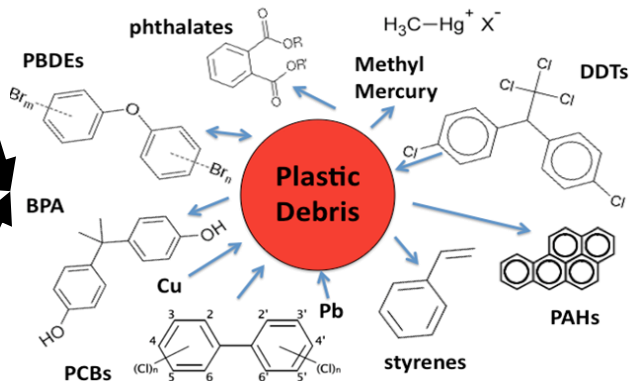
Chelsea Rochman - Microplastics

Rivers are a significant source: ~2 million tons of plastic enters oceans annually from rivers



Lebreton et al., 2017 *Nature Communications*

As with other emerging contaminants the sources of microplastics and associated chemical contaminants are many and varied

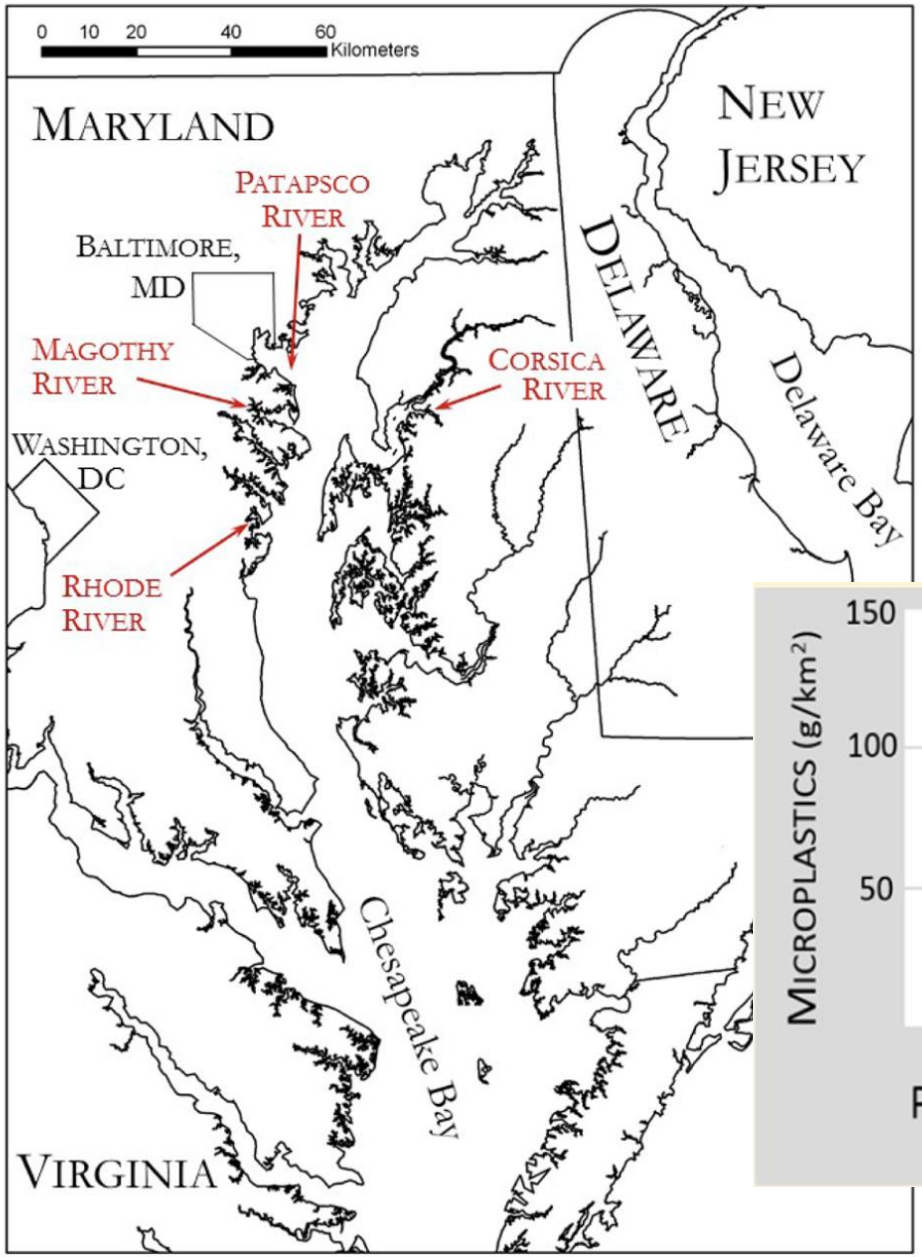


Urban runoff

Agricultural Runoff

Wastewater

Microplastics in 59 of 60 samples taken from surface water in Chesapeake Bay and concentrations correlated with population size and urbanization



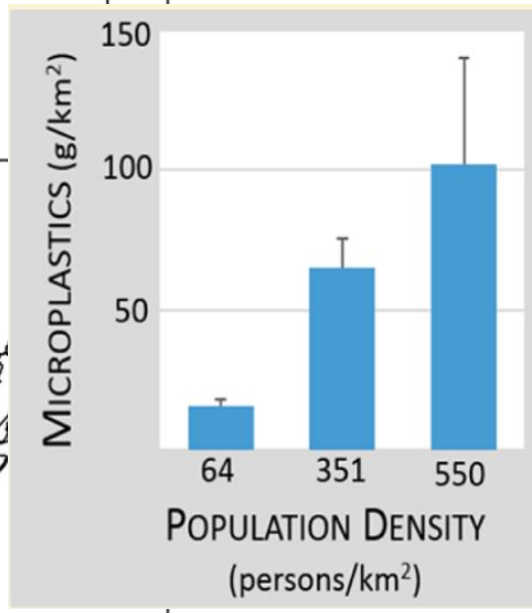


Figure 1. Locations of estuarine sites within the Chesapeake Bay sampled for microplastics between July and December 2011.

Yonkos et al., 2014 *ES&T*

Rochman Lab is sampling water and oysters in the Bay for microplastics 20 µm and above

Future Analysis:

1. Compare microplastics abundance between source types

2. Use regression models to relate microplastics abundance to land-use and hydrology traits

Microplastics

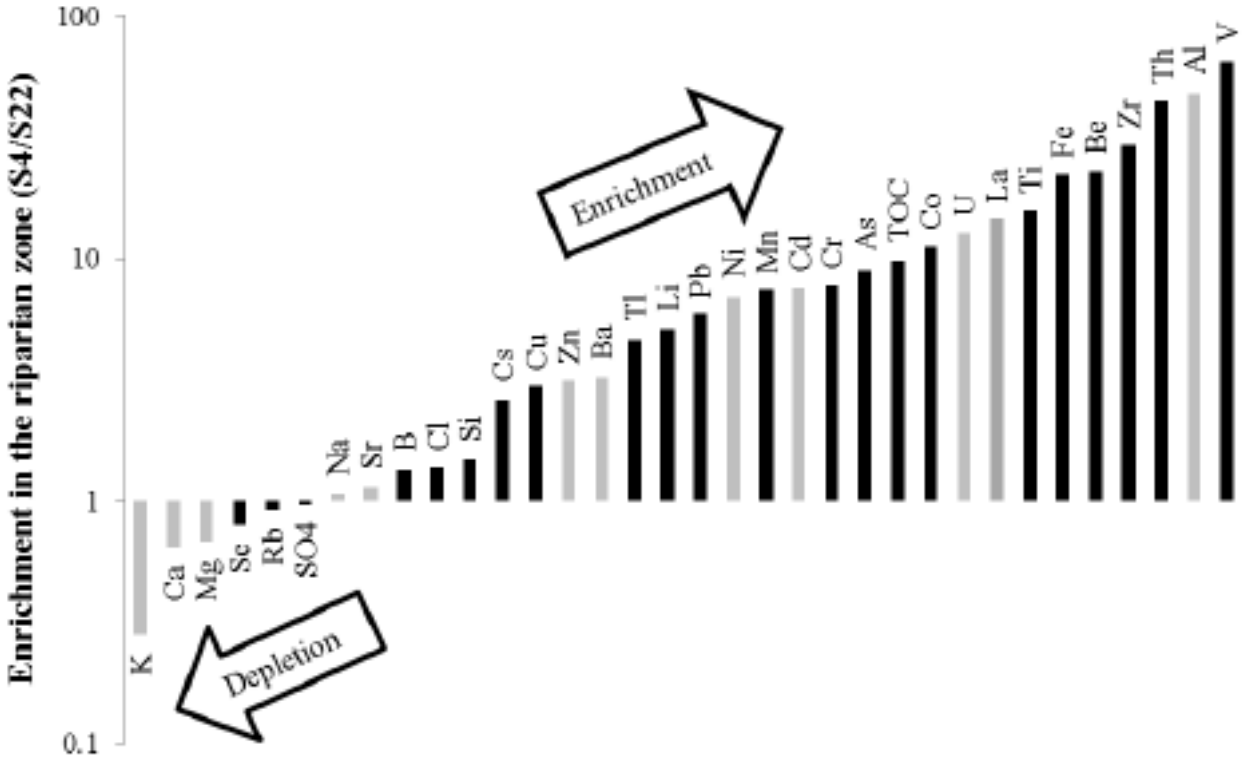
- **There has been much concern about microplastics coming from the breakdown of plastic in garbage**
- **Microplastics are also added to some personal care products as exfoliants/abrasives**
- **Can absorb chemicals such as PCB, PBDE, Cu, Pb**

Emerging Issues and Small Trib Biota

- **Research for these emerging contaminant issues has mainly focused on individual test organisms**
- **Little understanding of effects on primary producers and food web effects**
- **Little understanding of how they may effect nutrient cycling or movement/degradation within the ecosystem of small tribs**

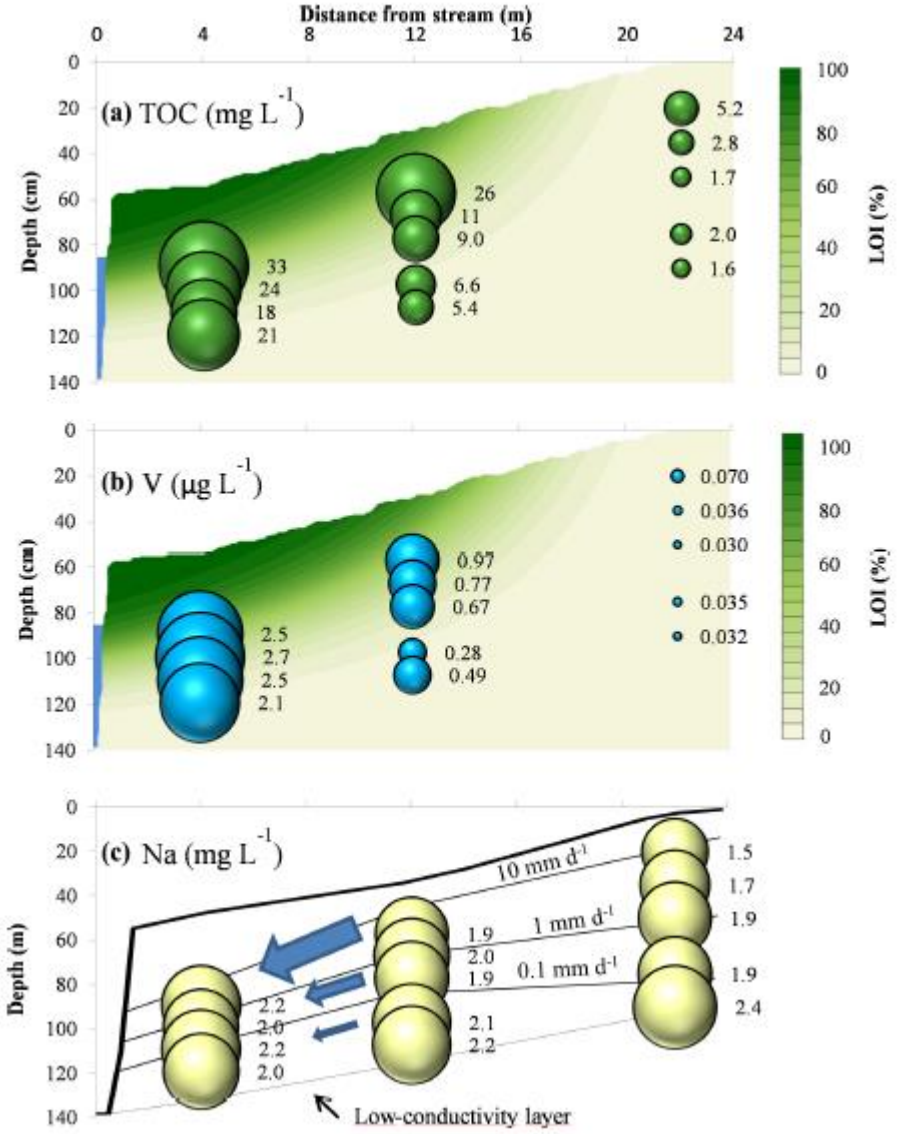
Behavior of Trace Elements in the Riparian Zone

Andrew Heyes UMCES



A general increase in element mobility is observed

F. Lidman et al.: From soil water to surface water Biogeosciences, 14, 3001–3014, 2017



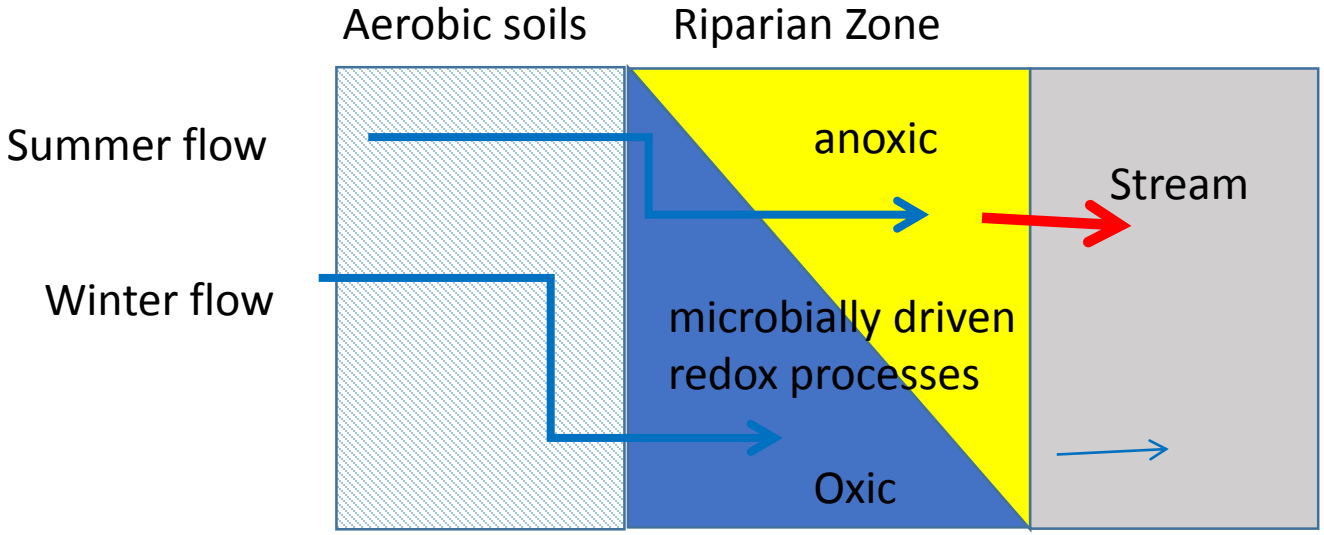
Mobility and speciation changes with

1) Redox
2) Organic matter
3) Microbial activity

F. Lidman et al.: From soil water to surface water

Biogeosciences, 14, 3001–3014, 2017

Cross Section of Small Headwater Stream on Coastal Plain



General idea - Selenium – sequestration by reduction of selenate to selenite under anoxic, low nitrate conditions. This results in Se trapping in mineral layers.

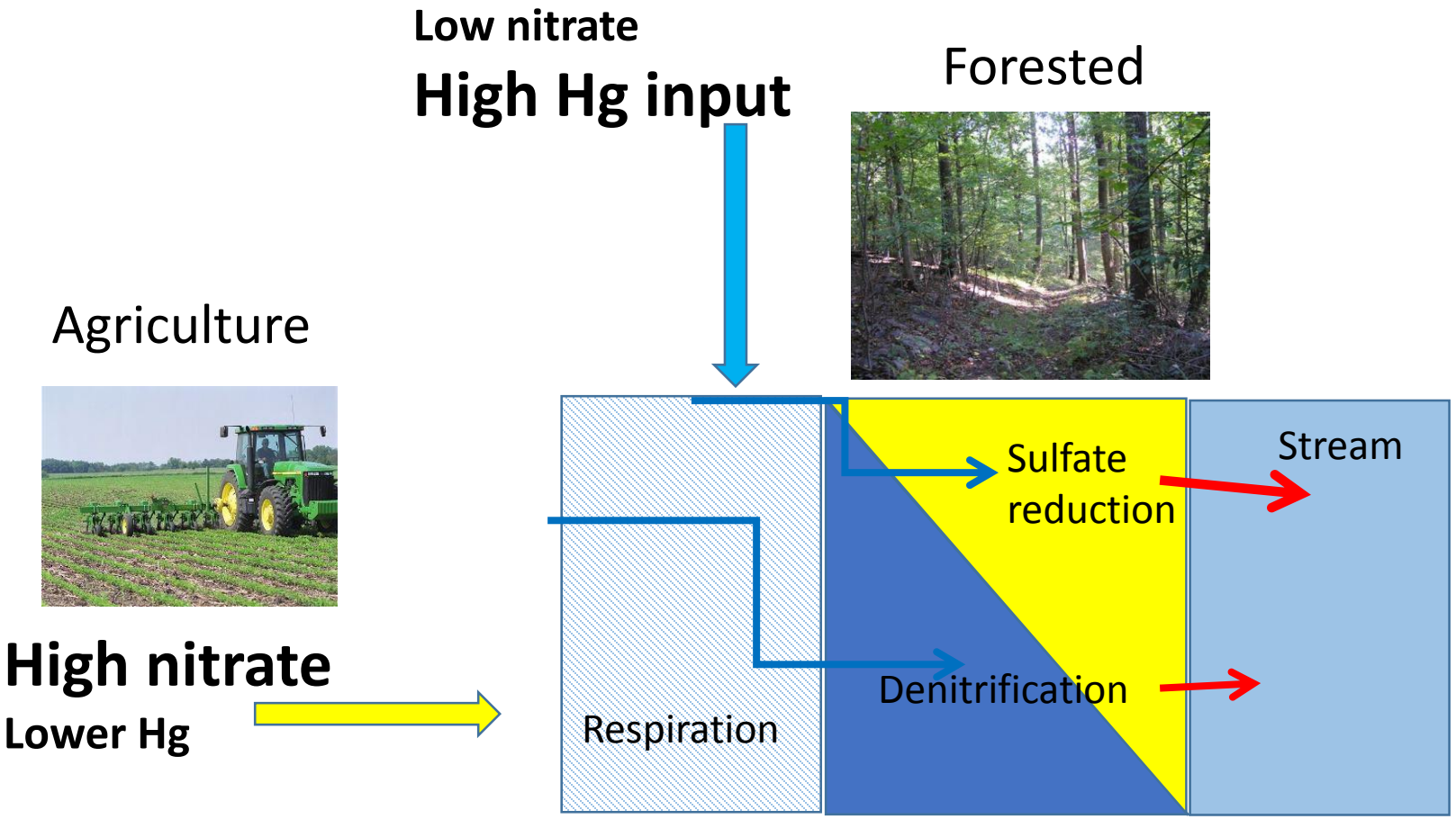
Questions

What is the role of organic ligands in selenium speciation and transport?

What happens to sequestered selenite during low water periods and sediment oxidation?

What happens to Se speciation and sequestration across a nitrate gradient?

Schematic Model of Mercury Biogeochemistry in Two Watershed Types



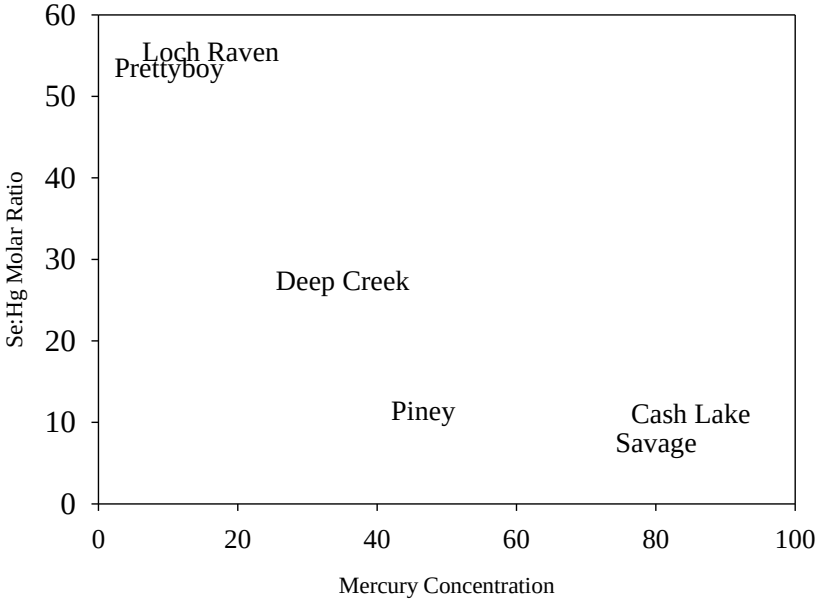
Carbon utilization

In forest – limited denitrification elevated sulfate reduction and thus high Hg methylation

In agriculture – denitrification dominates – limited sulfate reduction and Hg methylation

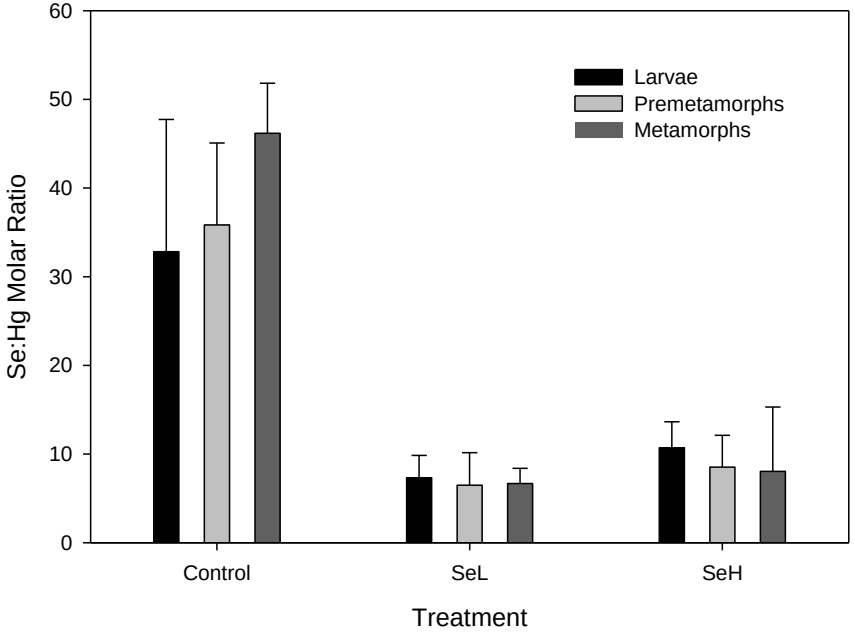
Why is understanding element cycling in Riparian Zones important?

One example is the connectivity between selenium and mercury in food web
Speciation impacts element toxicity, bioavailability and transport
The impacts are element specific, complex and have interactive consequences
Se and Hg cycle differently with regard to mobility and toxicity
Selenium, while toxic at moderate concentrations, inhibits the uptake of Hg and MeHg
When present at moderate concentrations as shown for Young of Year fish in Maryland reservoirs and amphibians that inhabit streams



Relationship between Se and Hg in YOY bass 2017

Heyes unpublished 2018



Impact of selenium on Hg uptake in larval grey tree frogs

Rowe and Heyes Bull Environ Contam Toxicol (2017) 99:182–186

Emerging & Known Contaminants

- In some systems, perhaps of equal concern to nutrients
  - Important in community understanding & buy-in to facilitate increased BMP implementation
  - This implies understanding of effectiveness of our nutrient-related BMPs to limiting these inputs
- Huge effort ahead
  - Groundwater contributions?
  - Impacts of mixtures of low levels of multiple EDCs
  - Legacy pools: Where, what, levels & local threat
  - Microplastics – known impacts on suspension feeders but less on compounds adsorbed & associated impacts
  - Public awareness low