

Salty Roads, Saltier Rivers: Causes and Consequences of Freshwater Salinization Syndrome

Sujay S. Kaushal, University of Maryland

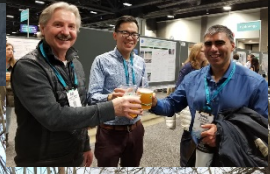
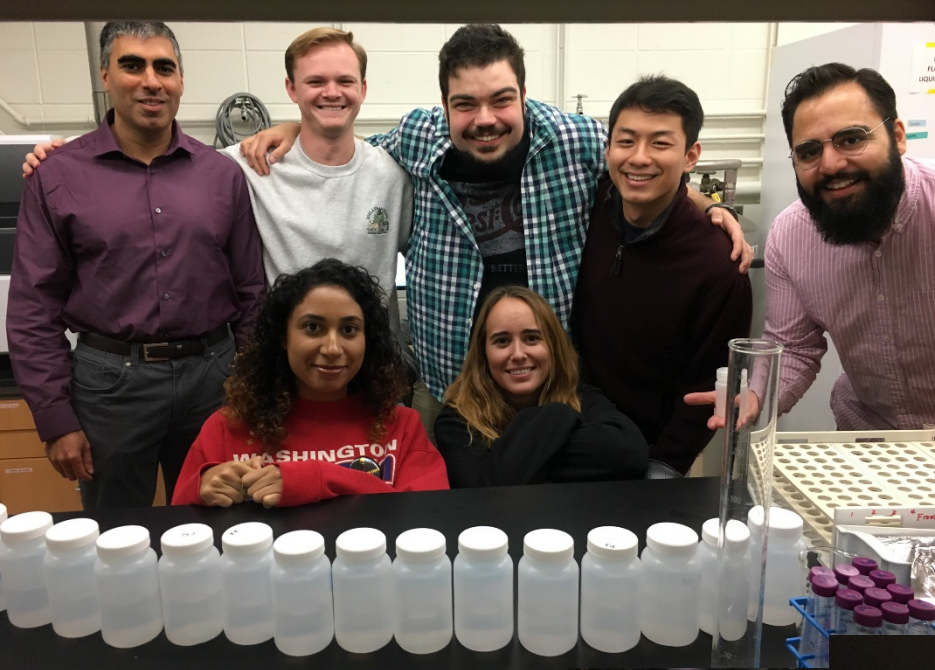
Shahan Haq, RMS Consulting

Kelsey Wood, University of Maryland

Gene Likens, Cary Institute of Ecosystem Studies

Michael Pace, University of Virginia

and friends...



A Wonderful Team
– Thank You!



General view of the Flint River as it passes through downtown on March 17, 2016 in Flint, Michigan.

PHOTOGRAPH BY BRETT CARLSEN, GETTY IMAGES

North America's Waterways are Getting Saltier. That's a Big Problem.

A salty chemical cocktail could make rivers and streams more corrosive, leading to dangerous effects.

BY [ELAINA ZACHOS](#)



PUBLISHED JANUARY 9, 2018

ROAD SALT TURNS STREAMS TOXIC

July 29, 2008 | Environmental Policy | 1 Comment

U.S. rivers are getting saltier, potentially compromising drinking water

The bomb cyclone that hit the northeastern United States last ... could mean compromised drinking water akin to the crisis that struck Flint, Michigan, in 2014 when the city switched its water source ...

Science · 10mon

U.S. Waterways Are Getting Saltier, With Possible Effects on Drinking Water

Streams and rivers across much of the U.S. are getting saltier and ... accelerated weathering of concrete. Saltier water is more corrosive, which can damage pipes and increasing the risk of lead enter...

Yale Environment 360 · 10mon

Freshwater Salinization – An Emerging Environmental Issue

Local

The snow brought out the salt, which caused Montgomery's brown water



Photo Courtesy: M. Williamson/Washington Post

Brown water pours from an opened hydrant on Wednesday in Potomac, Md. Montgomery County residents have been making reports about it since March. Officials blame salt and manganese. (Michael S. Williamson/The Washington Post)

By **Katherine Shaver**
June 17, 2015

If you live in Montgomery County and are wondering why your drinking water has taken on a brownish tinge, blame the winter weather.

The water utility for suburban Maryland said the salt used to treat Washington-area roads and sidewalks during the icy winter probably caused significantly higher levels of sodium chloride in the Potomac River, which provides drinking water for the county.

The Washington Suburban Sanitary Commission (WSSC) suspects the levels — the highest seen in its drinking water system in at least a decade — led to increases in a mineral that the utility says is

Contamination of Drinking Water Hits Home...



Background

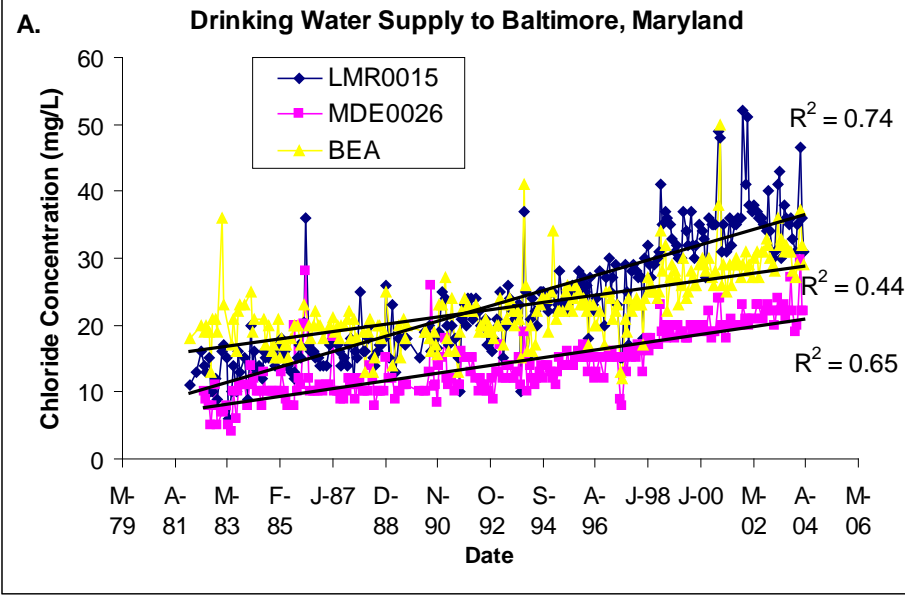
- Freshwater quality has changed in North America over 100 years
- Increased warming, salinization, and alkalization of fresh waters (*e.g.*, Kaushal et al. 2005, 2010, 2013, 2014, 2017, 2018a,b,c)
- Freshwater Salinization Syndrome (FSS) is now a key feature of the Anthropocene

Outline

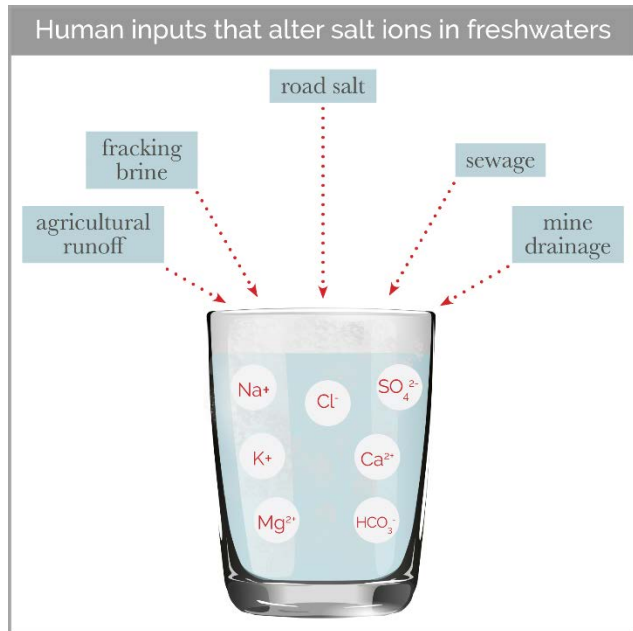
1. Freshwater Salinization Syndrome (FSS)
2. Novel Chemical Mixtures as a Consequence of FSS
3. The Watershed 'Chemical Cocktail' Concept

1. Freshwater Salinization Syndrome

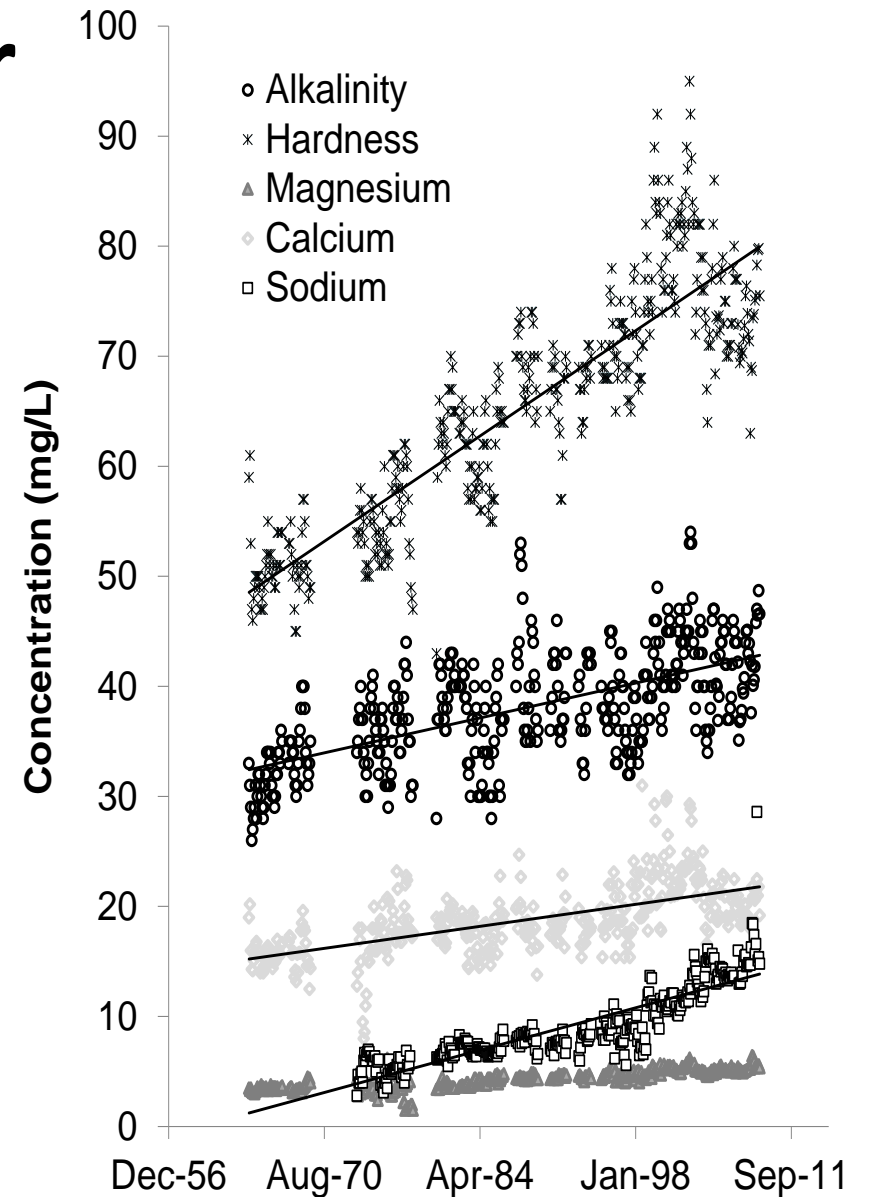
Baltimore's Drinking Water



Kaushal et al. (2005) *PNAS*

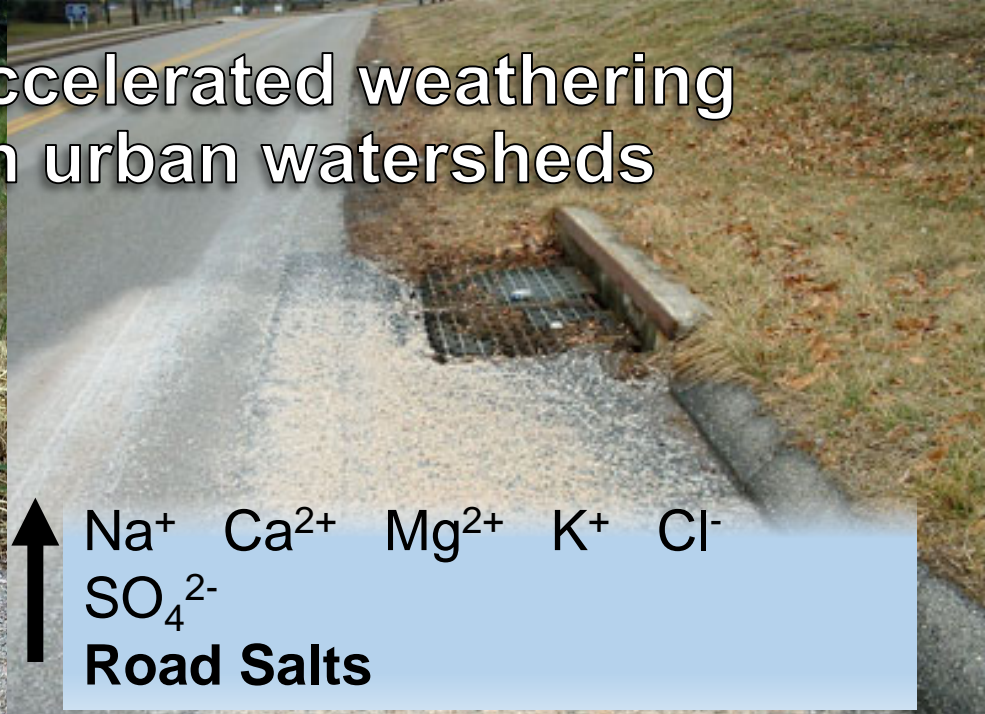
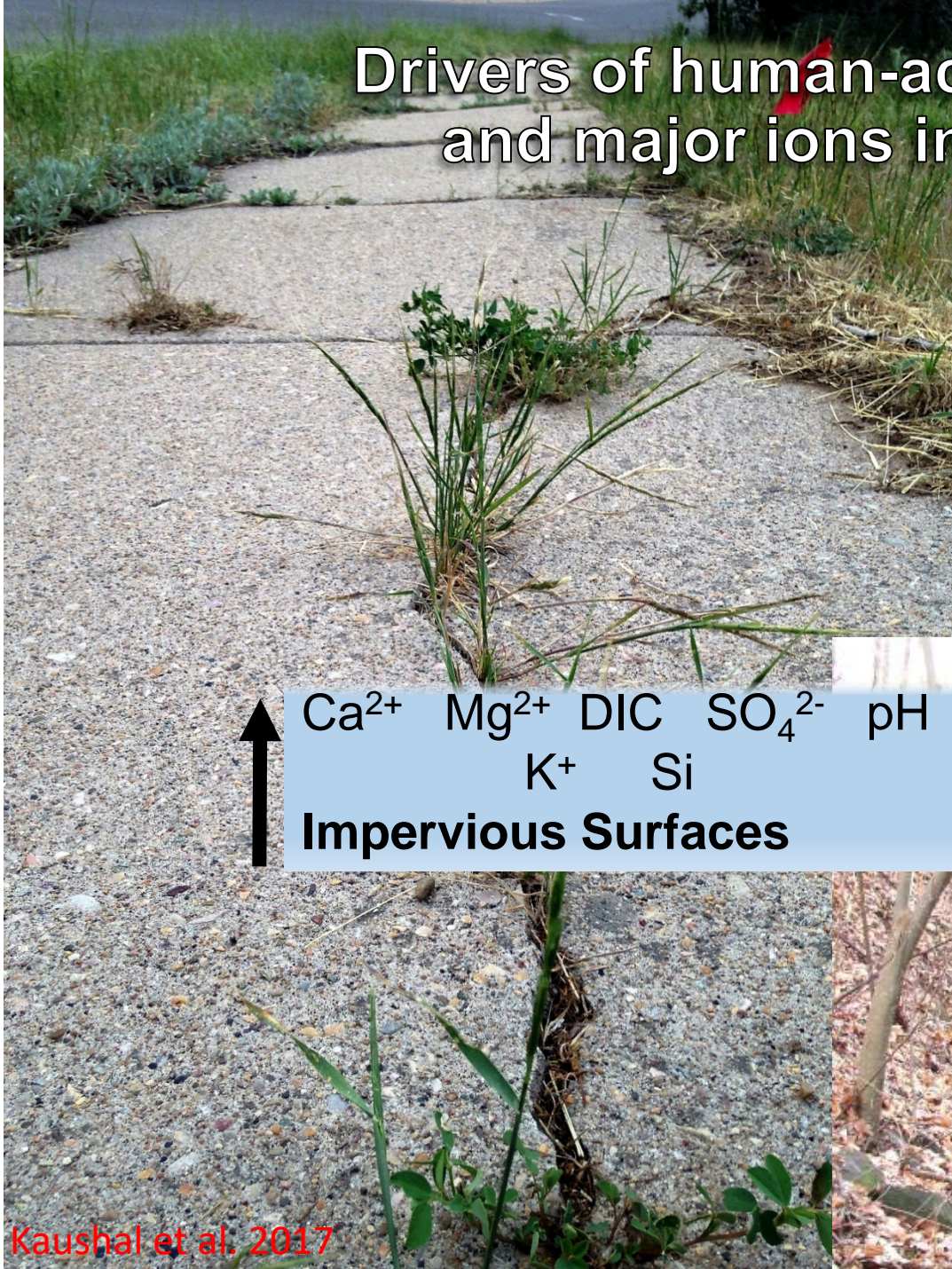


L. Quillen (2018) FSS Press Release



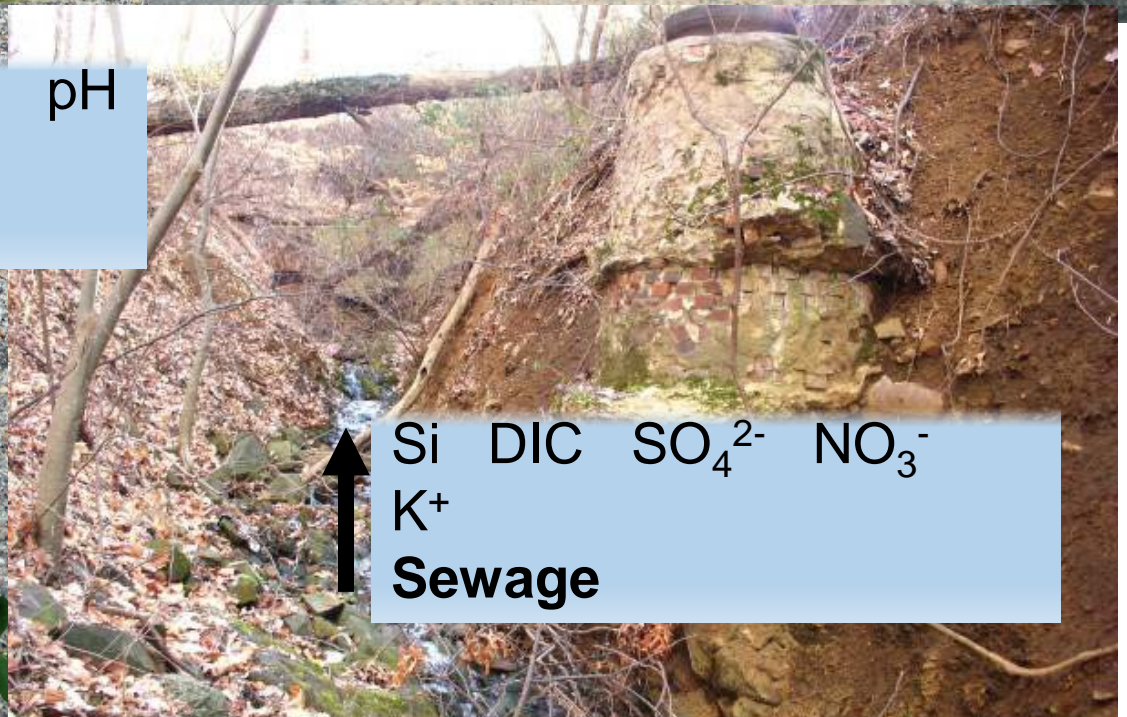
Kaushal et al. (2017) *Appl. Geochem*

Drivers of human-accelerated weathering and major ions in urban watersheds



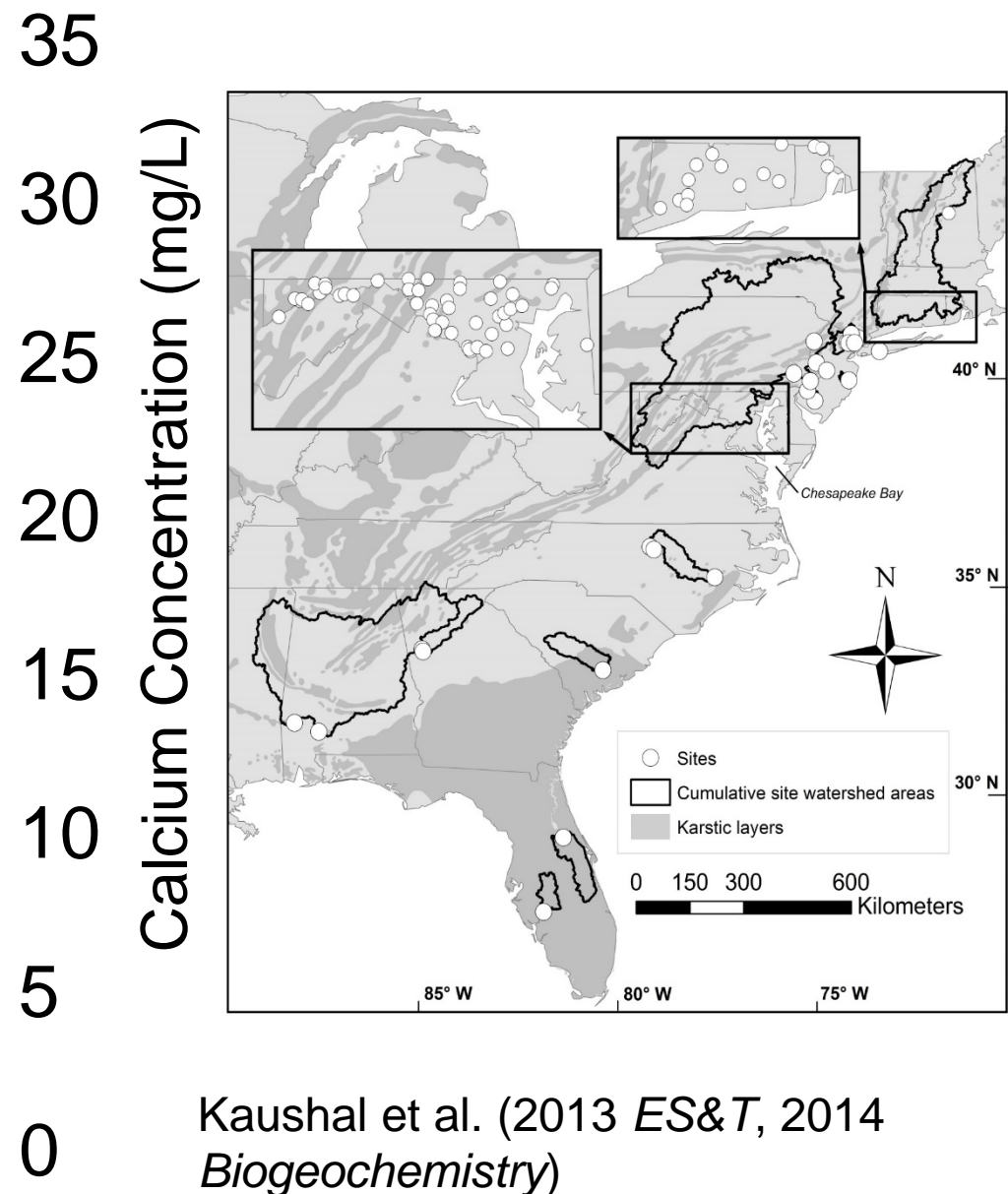
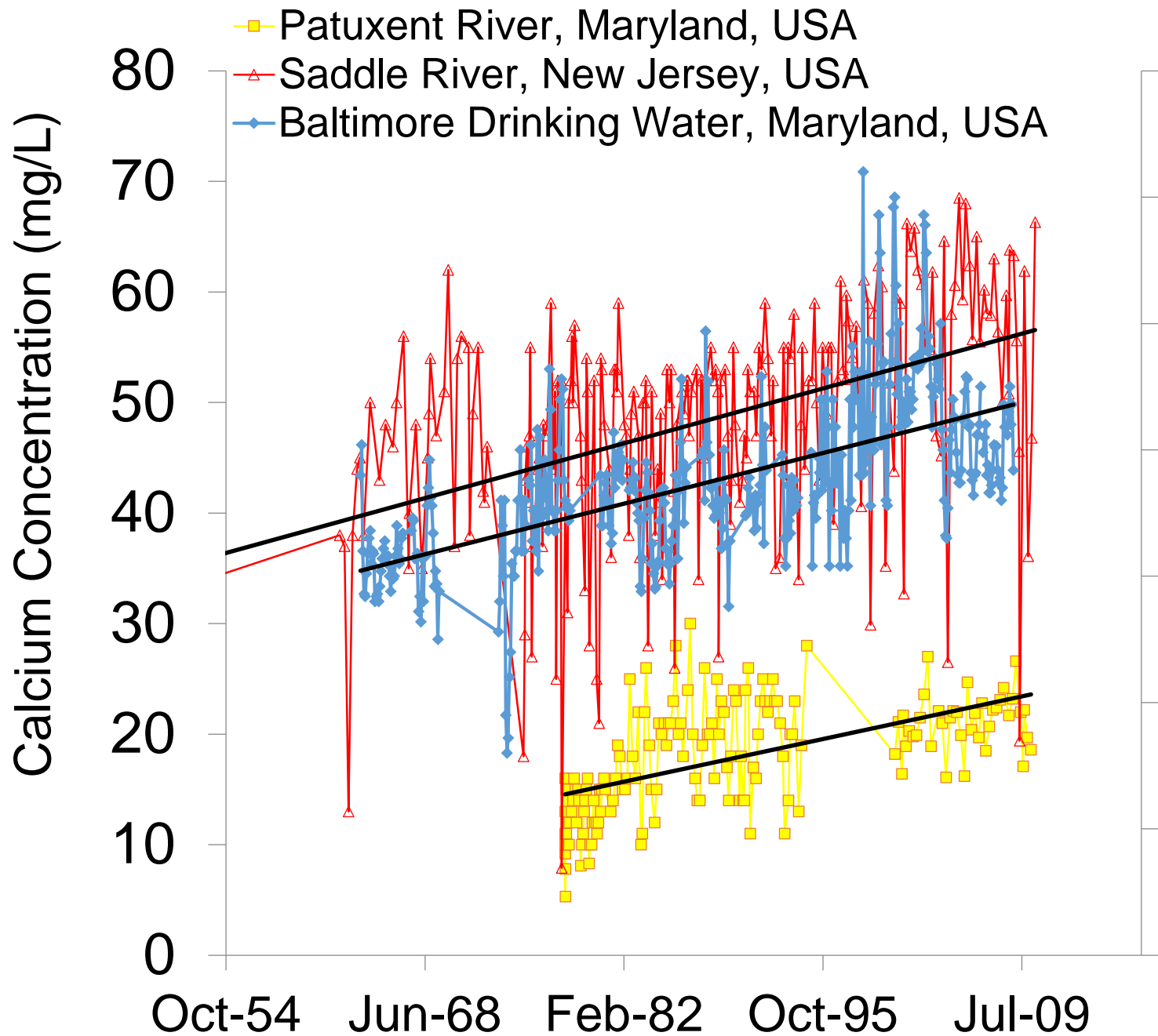
↑
 Na^+ Ca^{2+} Mg^{2+} K^+ Cl^-
 SO_4^{2-}
Road Salts

↑
 Ca^{2+} Mg^{2+} DIC SO_4^{2-} pH
 K^+ Si
Impervious Surfaces



↑
 Si DIC SO_4^{2-} NO_3^-
 K^+
Sewage

Human-Accelerated Weathering and River Alkalinization



Human-Accelerated Weathering



Photo Courtesy: Colin Delzel

Evolving Weathering in Urbanized Watersheds Over Time

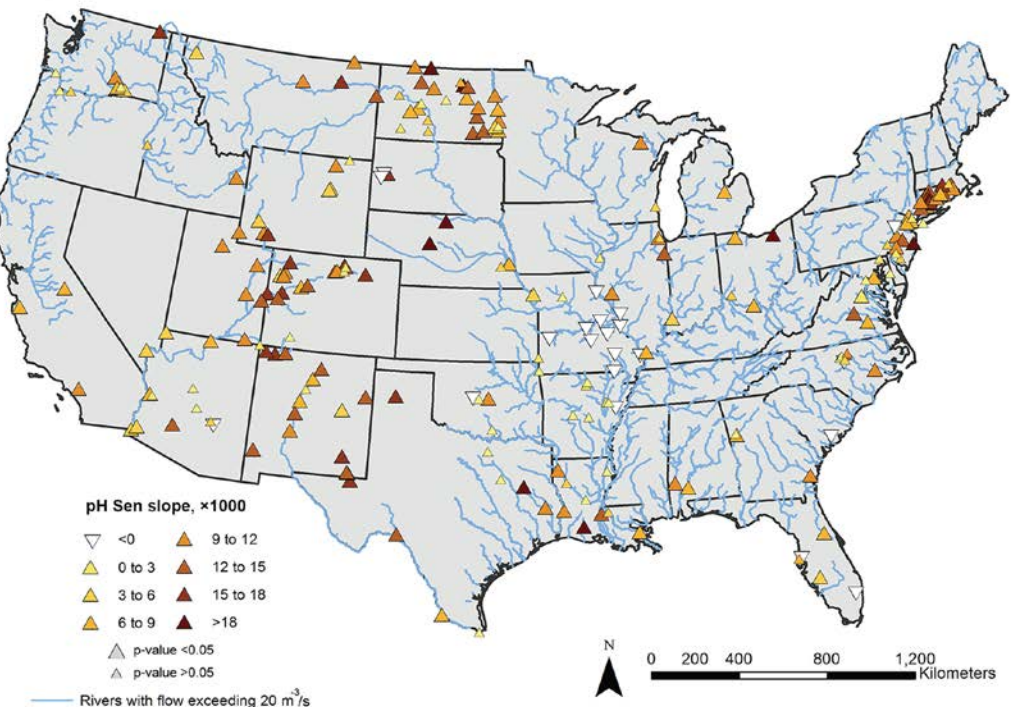
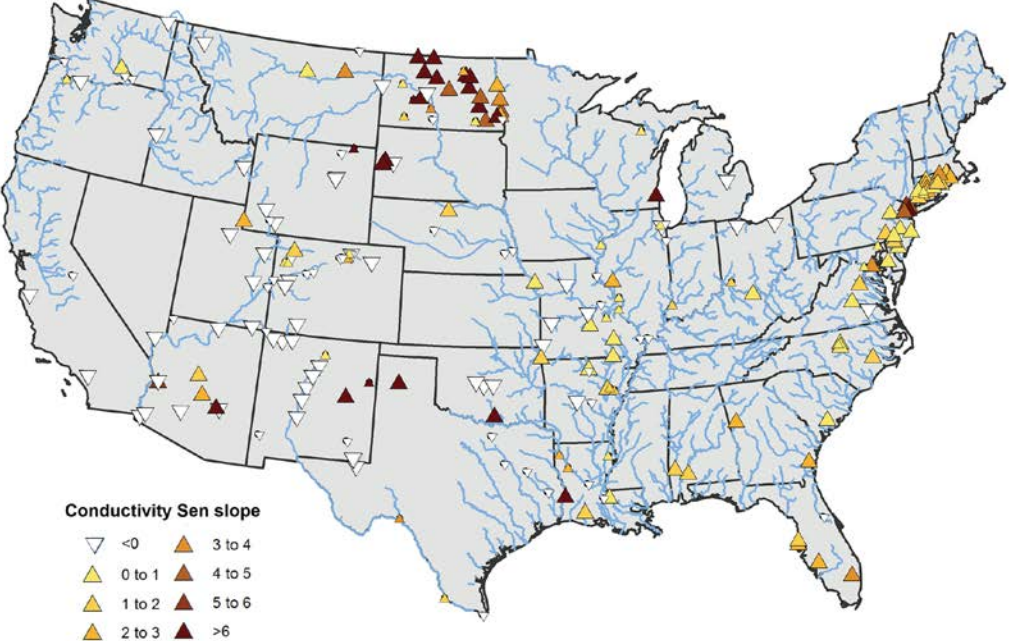
Cities create a distinct urban geology

Weathering of “urban karst”

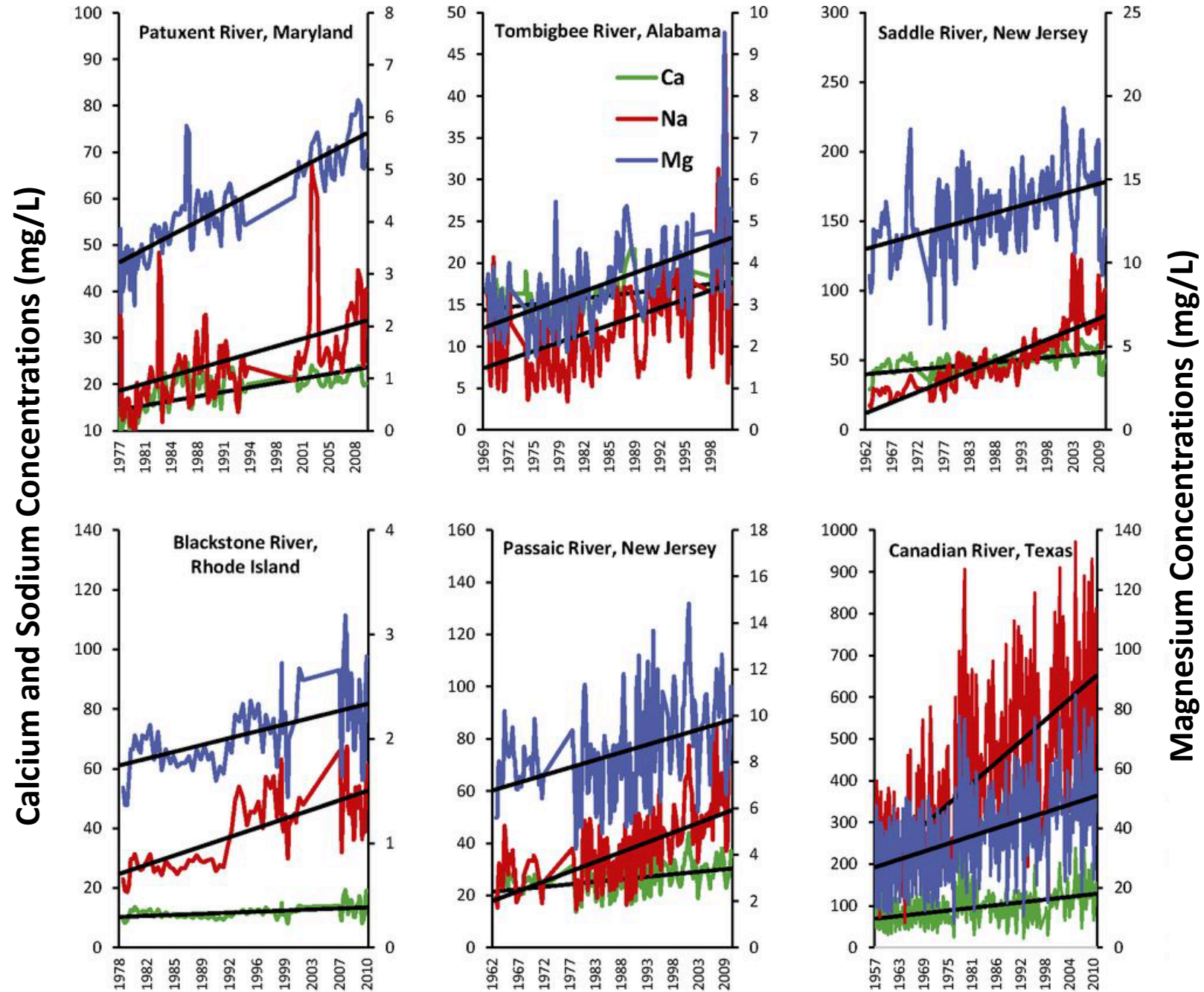
Kaushal and Belt (2012)
Kaushal et al. (2014, 2015)

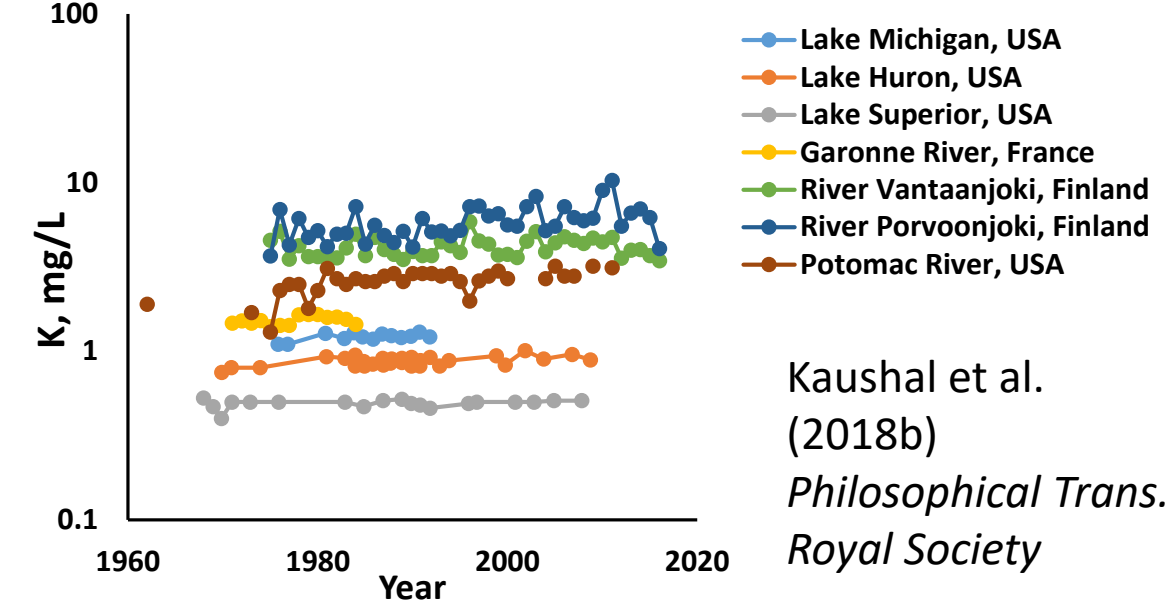
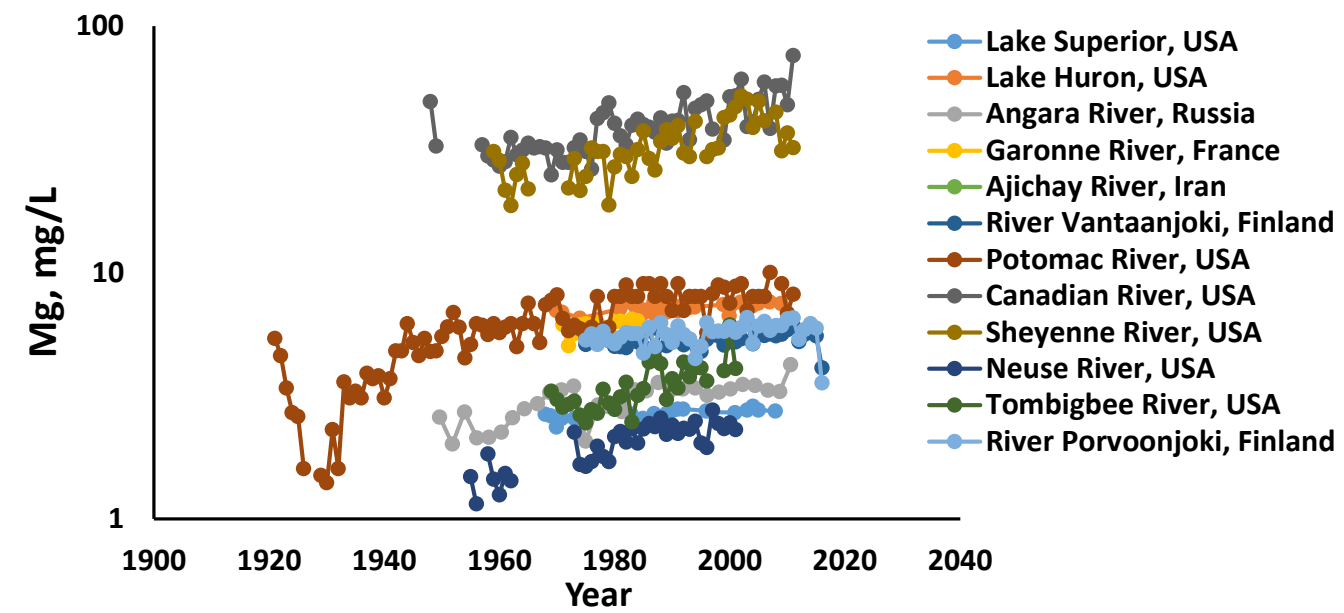
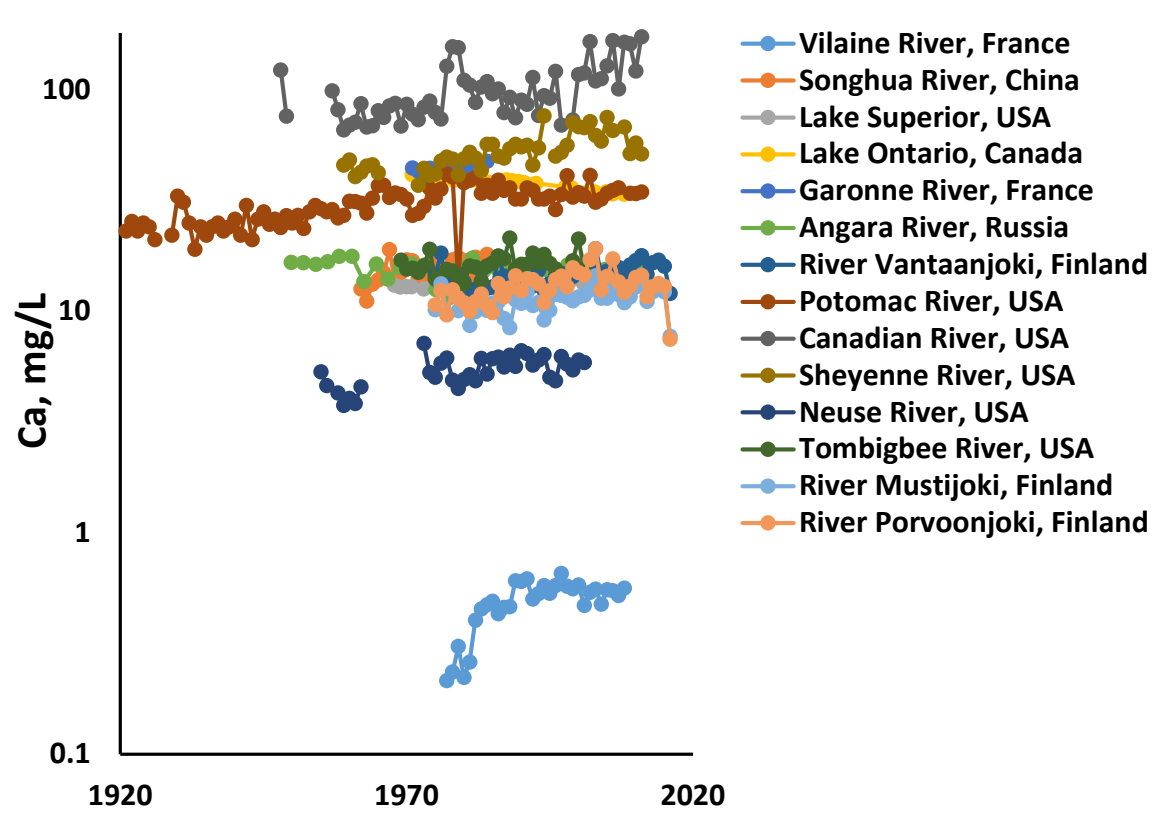
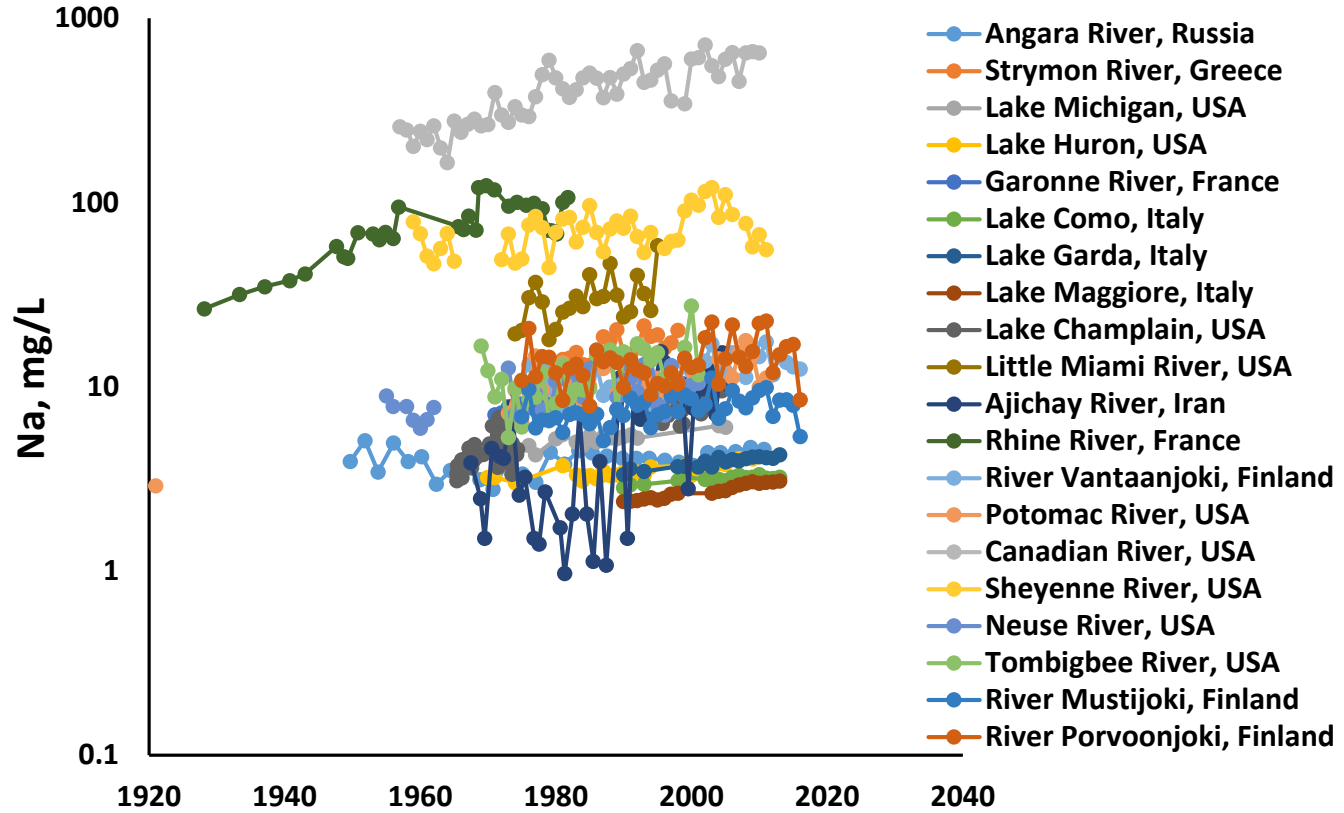
Freshwater Salinization Syndrome on a Continental Scale?

Increased pH and specific conductance over 50 years

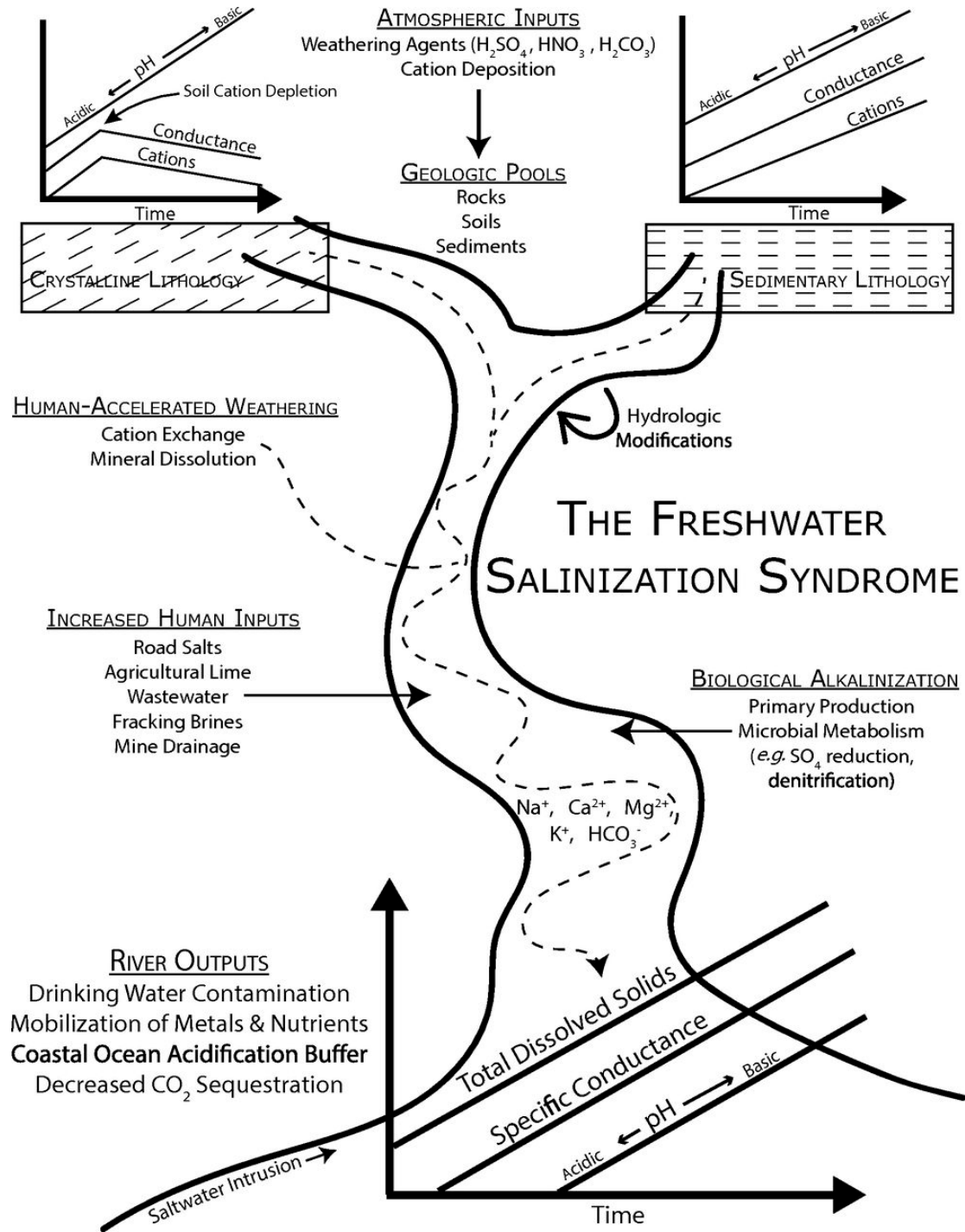


Freshwater Salinization Syndrome- Major Ions on a Continental Scale





Kaushal et al.
(2018b)
Philosophical Trans.
Royal Society



Outline

1. Freshwater Salinization Syndrome (FSS)
2. Novel Chemical Mixtures as a Consequence of FSS
3. The Watershed 'Chemical Cocktail' Concept

Taking water quality with a grain of salt – other effects?

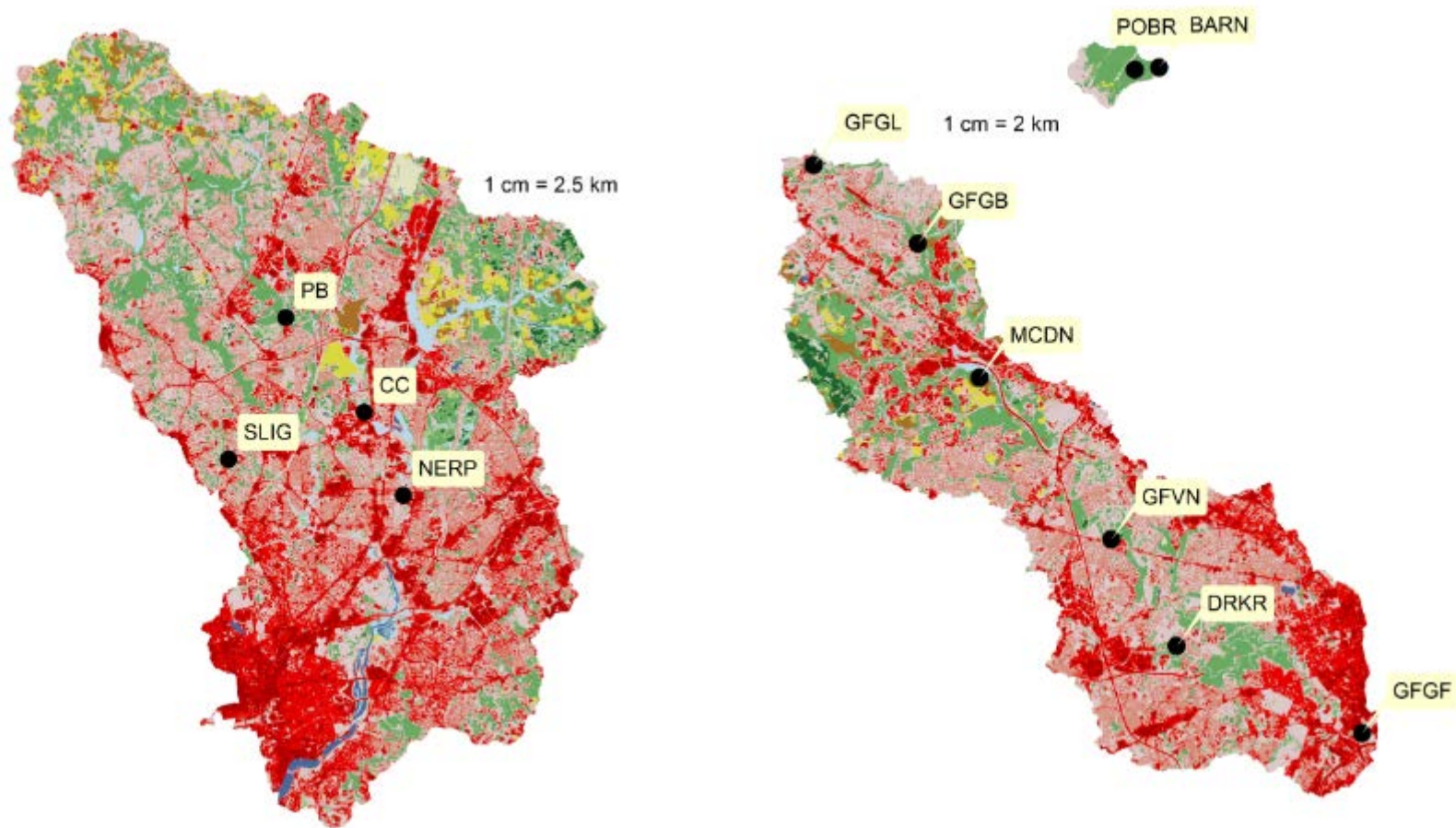
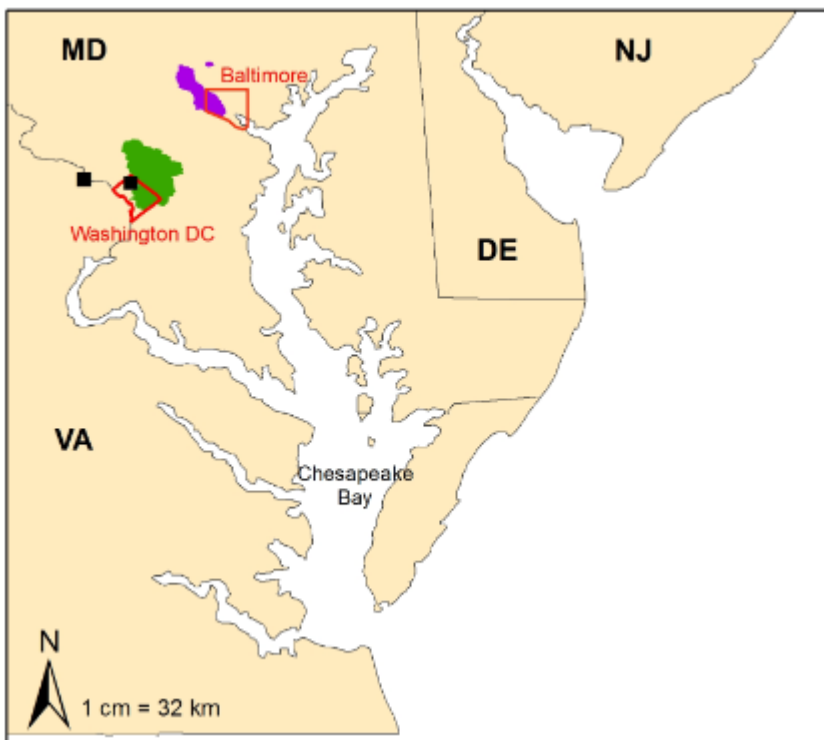


Photos Courtesy: S. Kaushal



Photo Courtesy: J. Galella

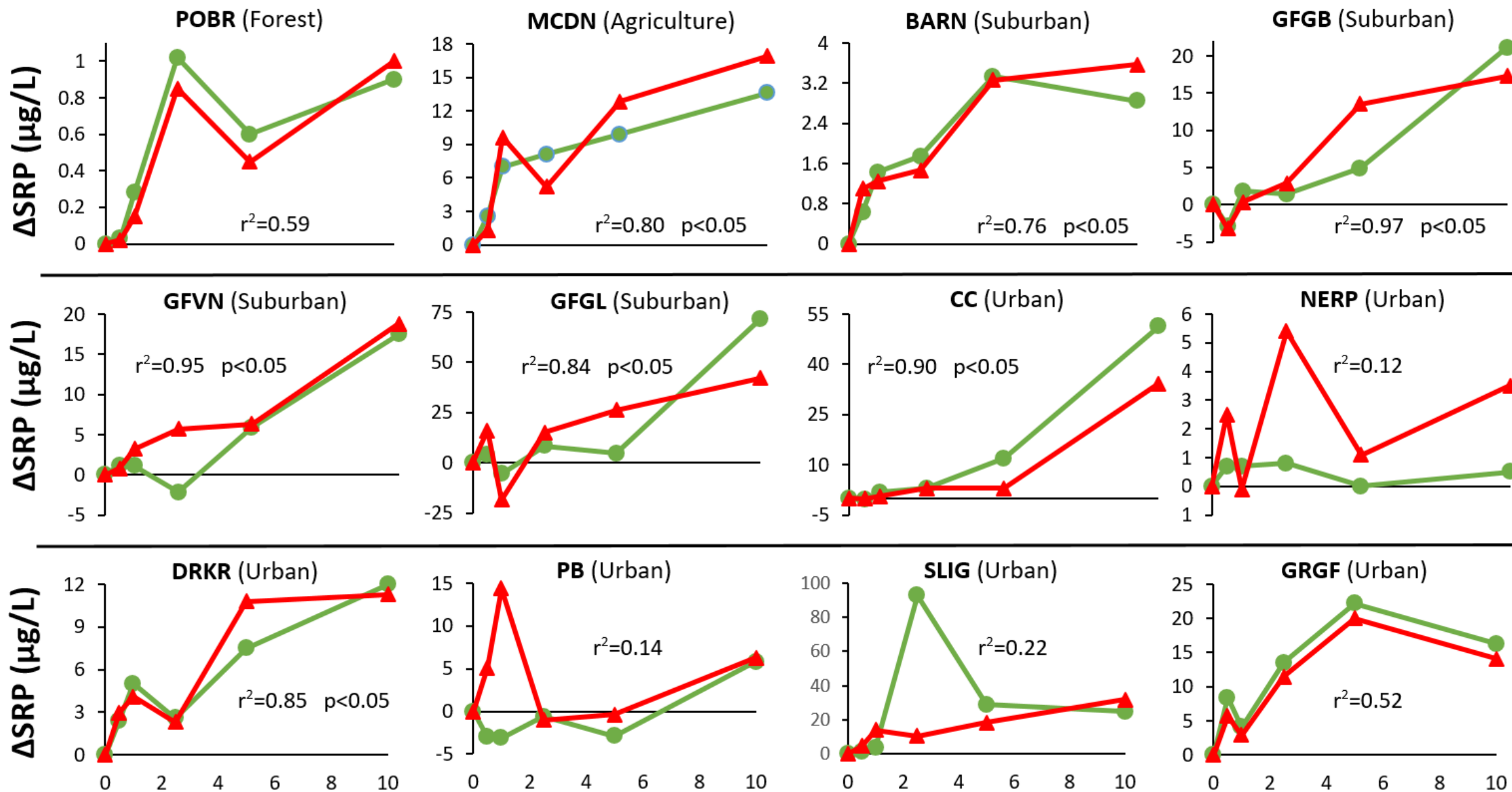
2. Novel Chemical Mixtures Are a Consequence of FSS Experimental Salinization Experiments



Haq et al. (2018) *Biogeochemistry*

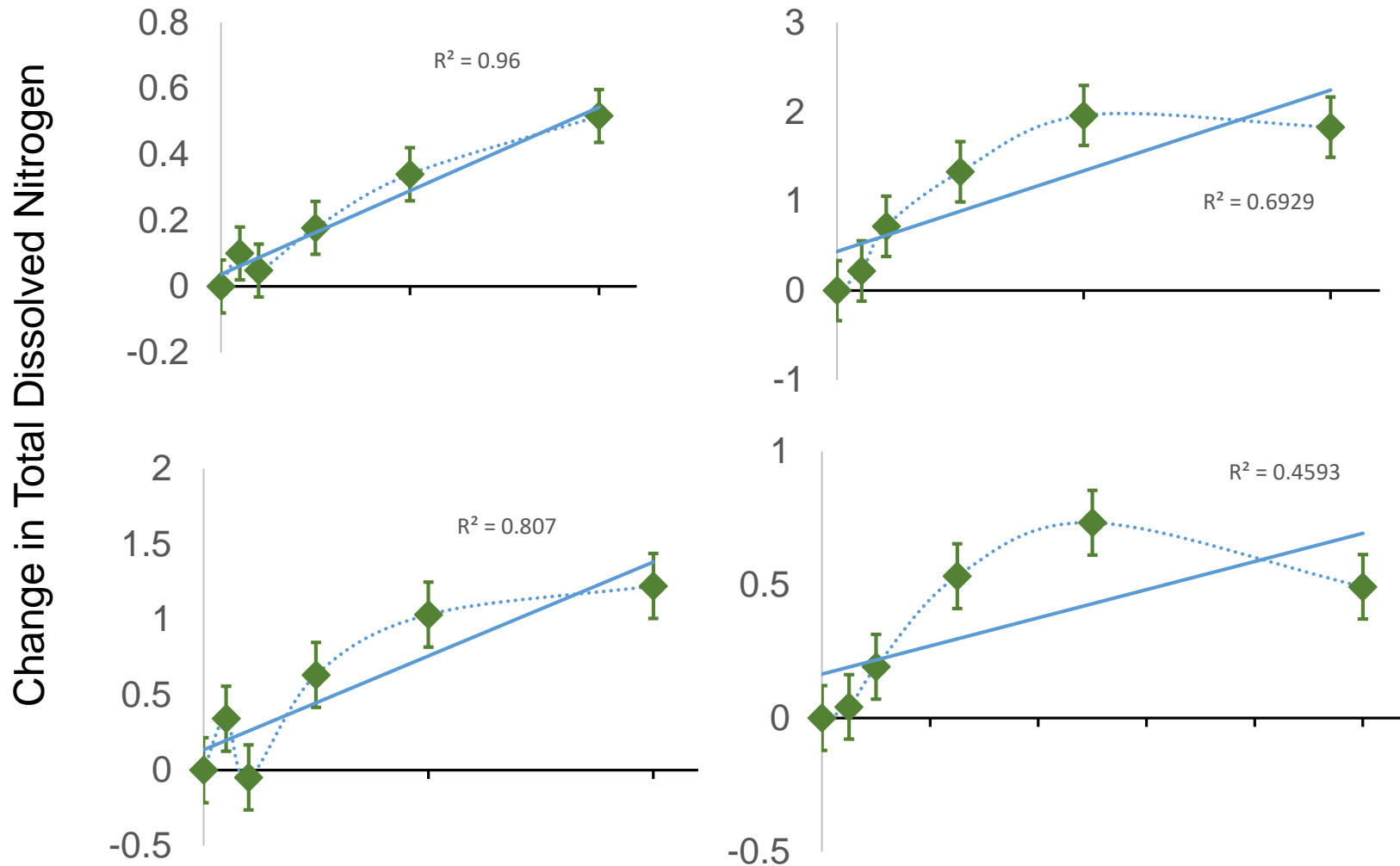
Anacostia River, Washington, DC

Gwynns Falls, Baltimore LTER, MD



NaCl Addition (g/L)

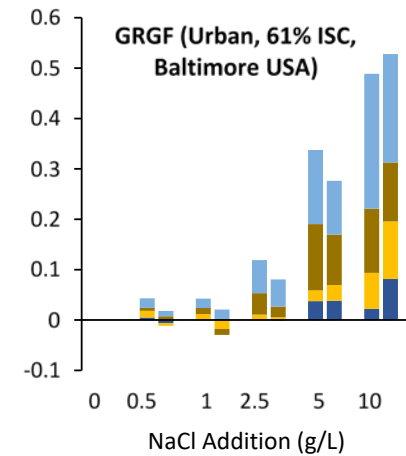
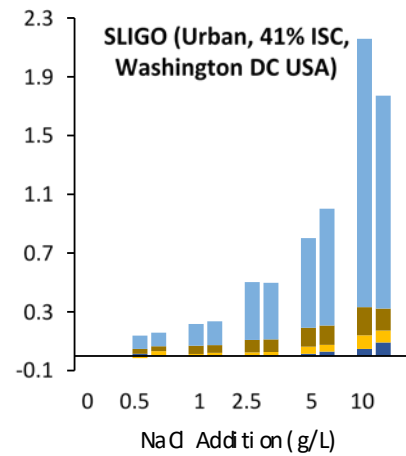
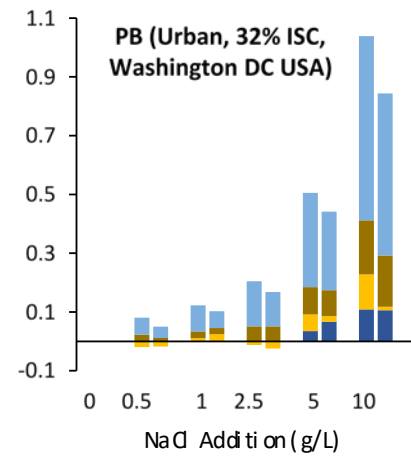
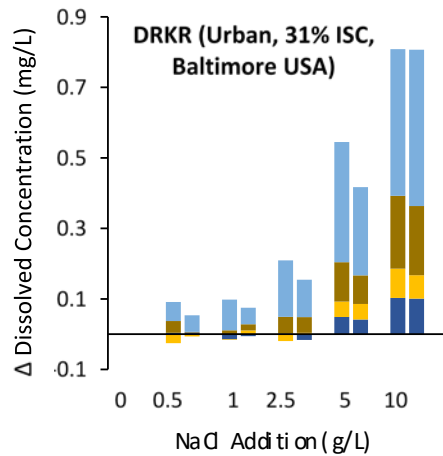
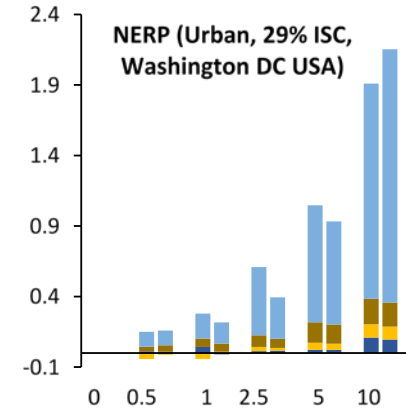
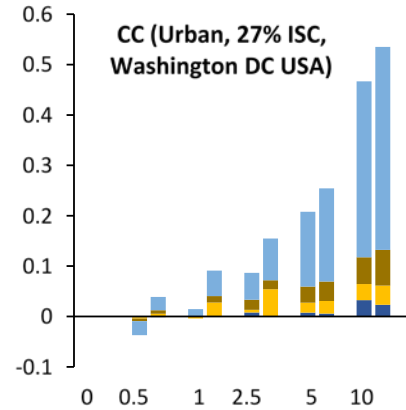
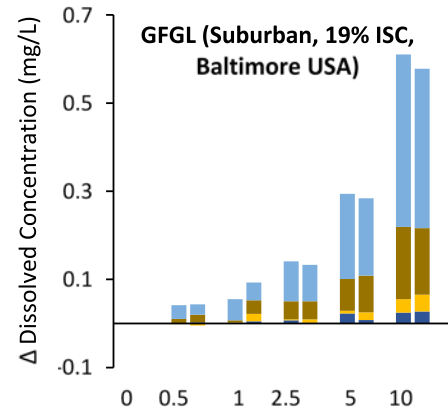
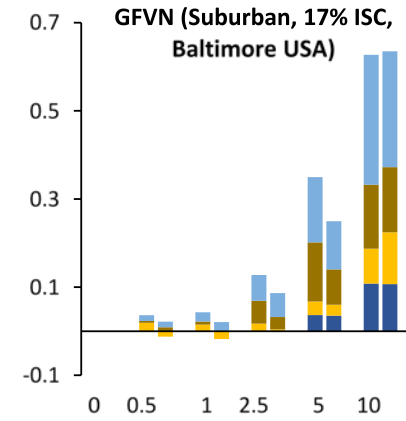
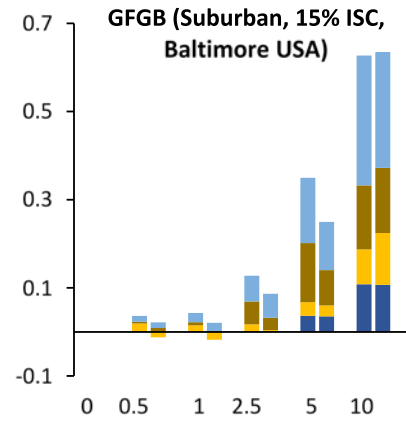
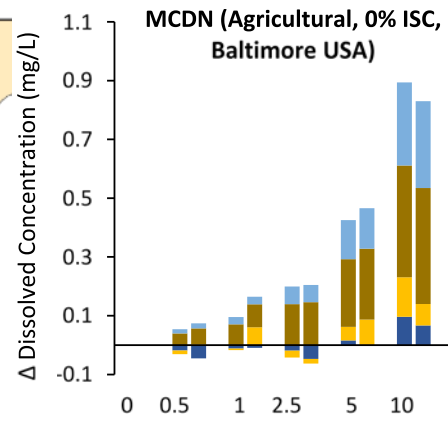
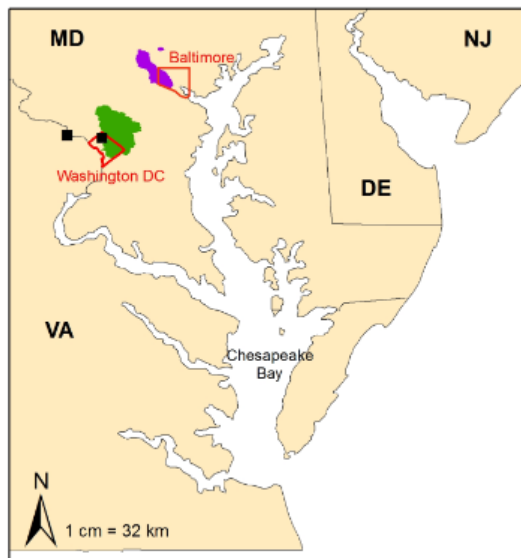
Salinization Mobilizes Nitrogen in Streams



Salt Dosing Experiments: 0 g/L, 0.5 g/L, 1 g/L, 2.5 g/L, 5 g/L, 10 g/L of Na Cl

Haq et al. 2018

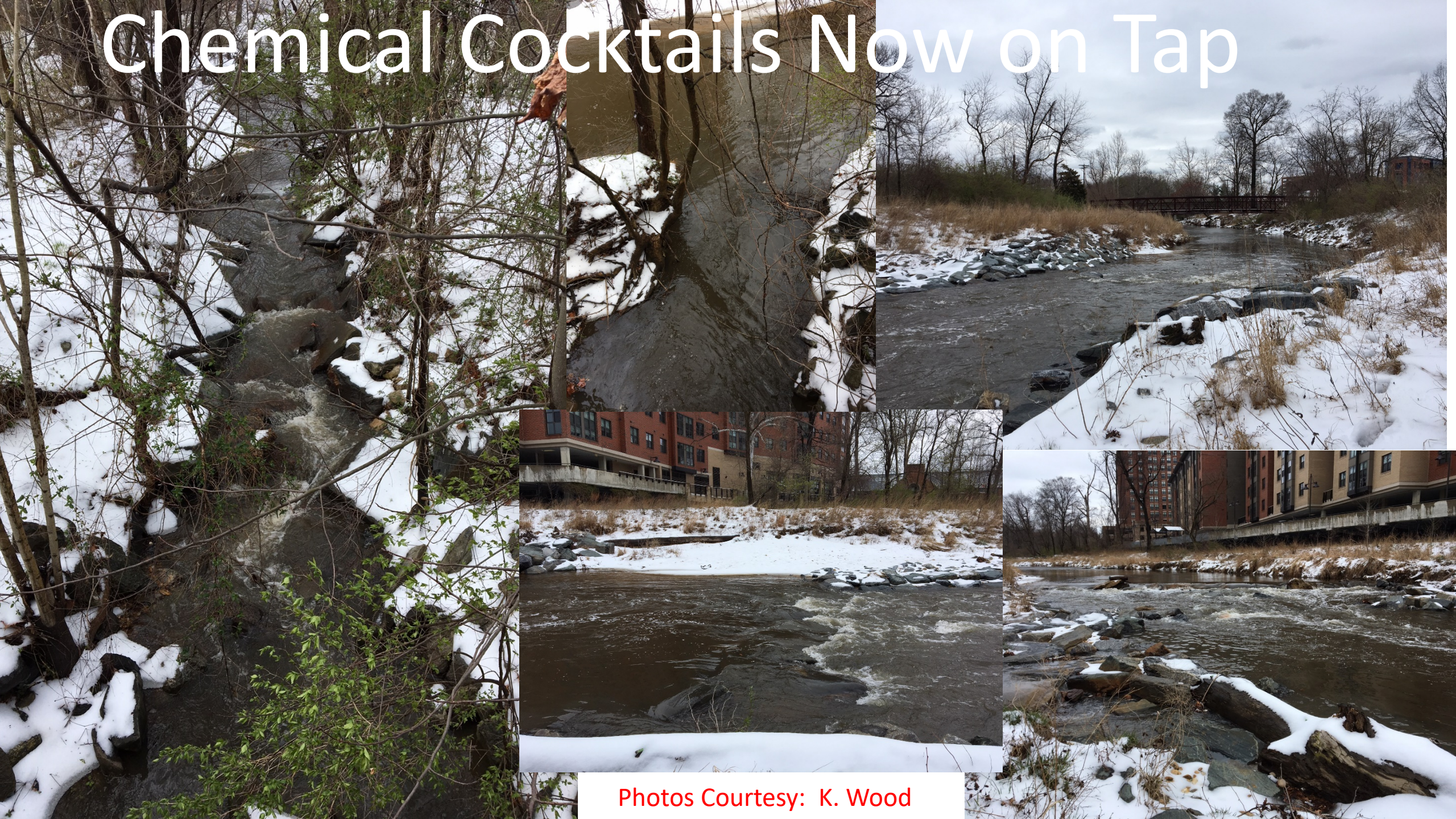




Outline

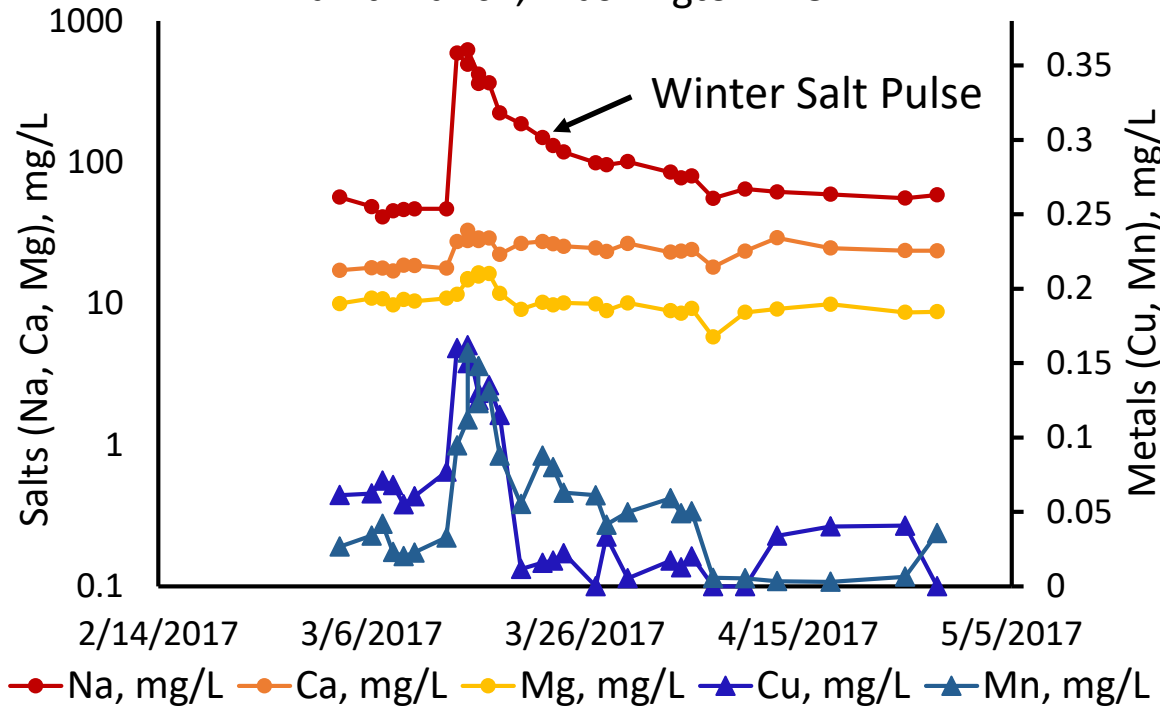
1. Freshwater Salinization Syndrome (FSS)
2. Novel Chemical Mixtures as a Consequence of FSS
3. Watershed 'Chemical Cocktail' Concept

Chemical Cocktails Now on Tap

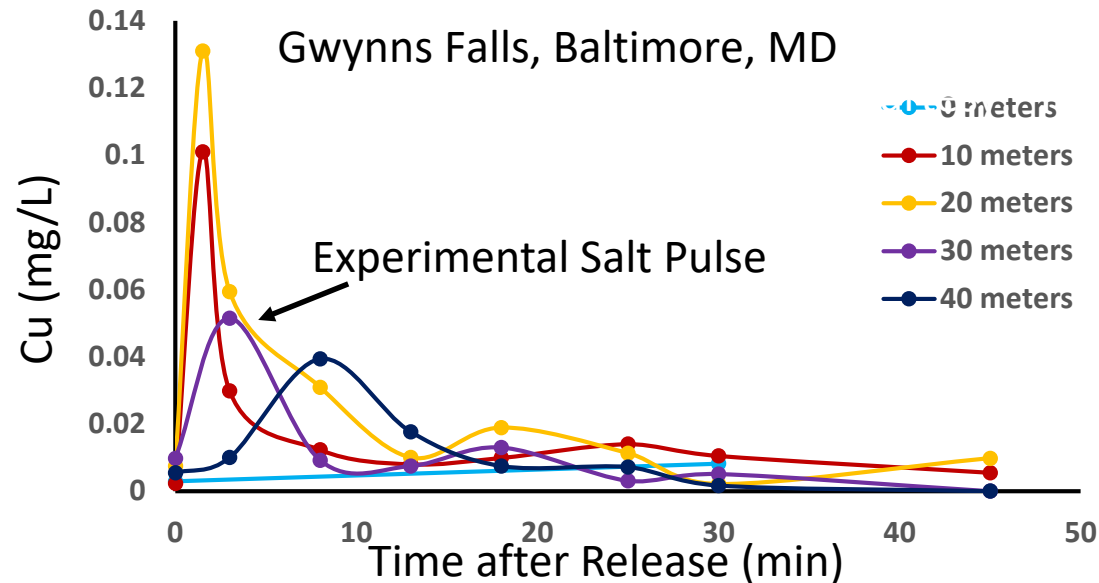
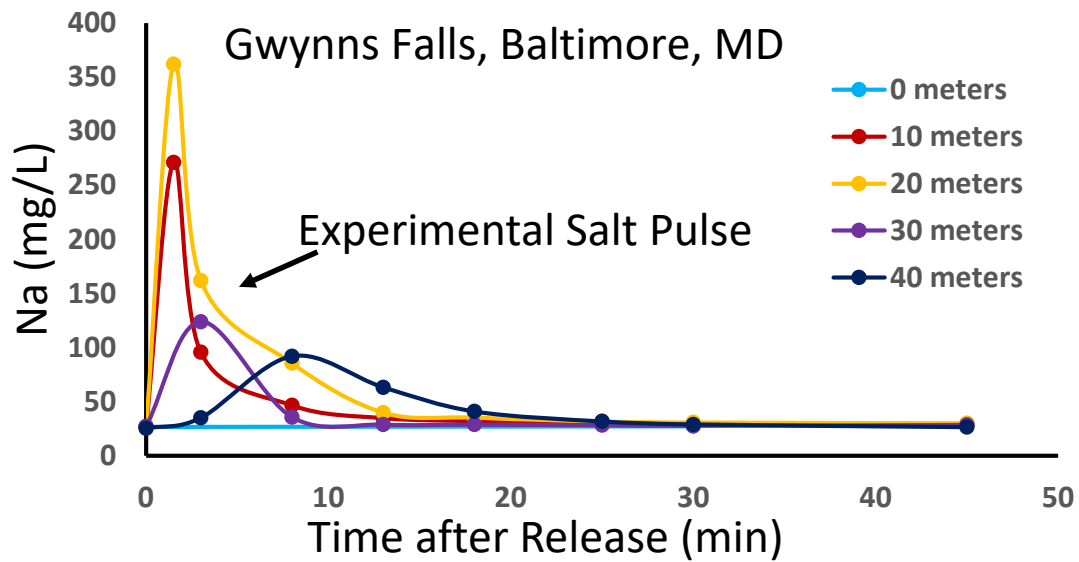
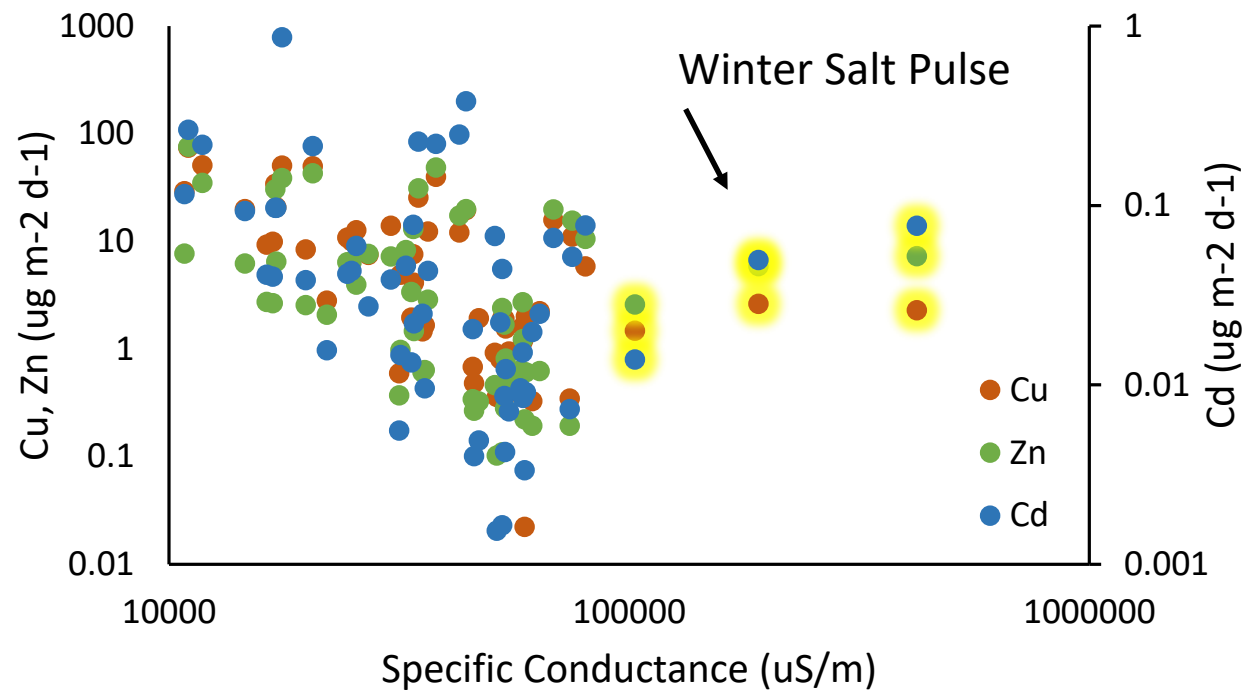


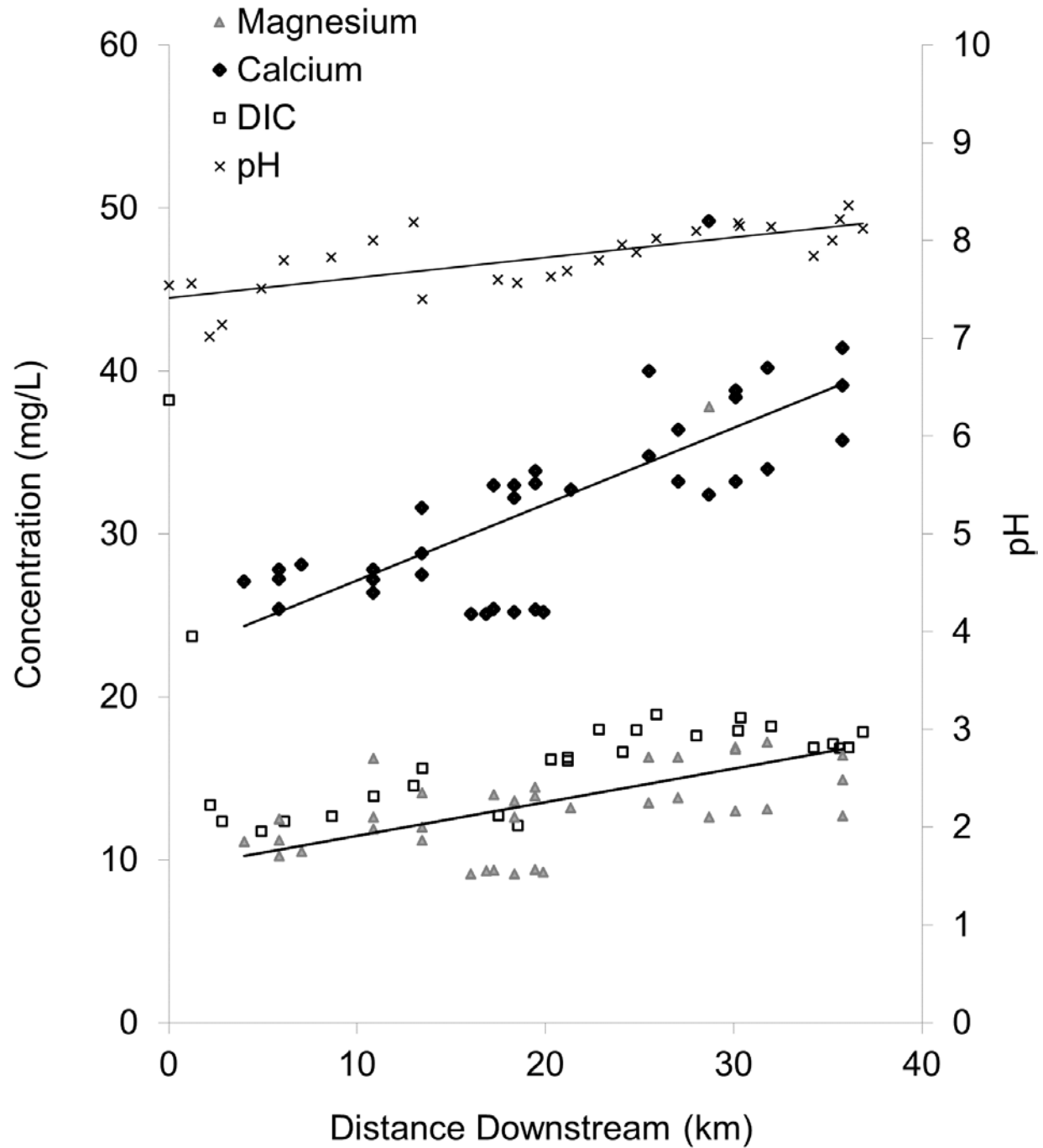
Photos Courtesy: K. Wood

Paint Branch, Washington D.C.



Rock Creek, Washington D.C.

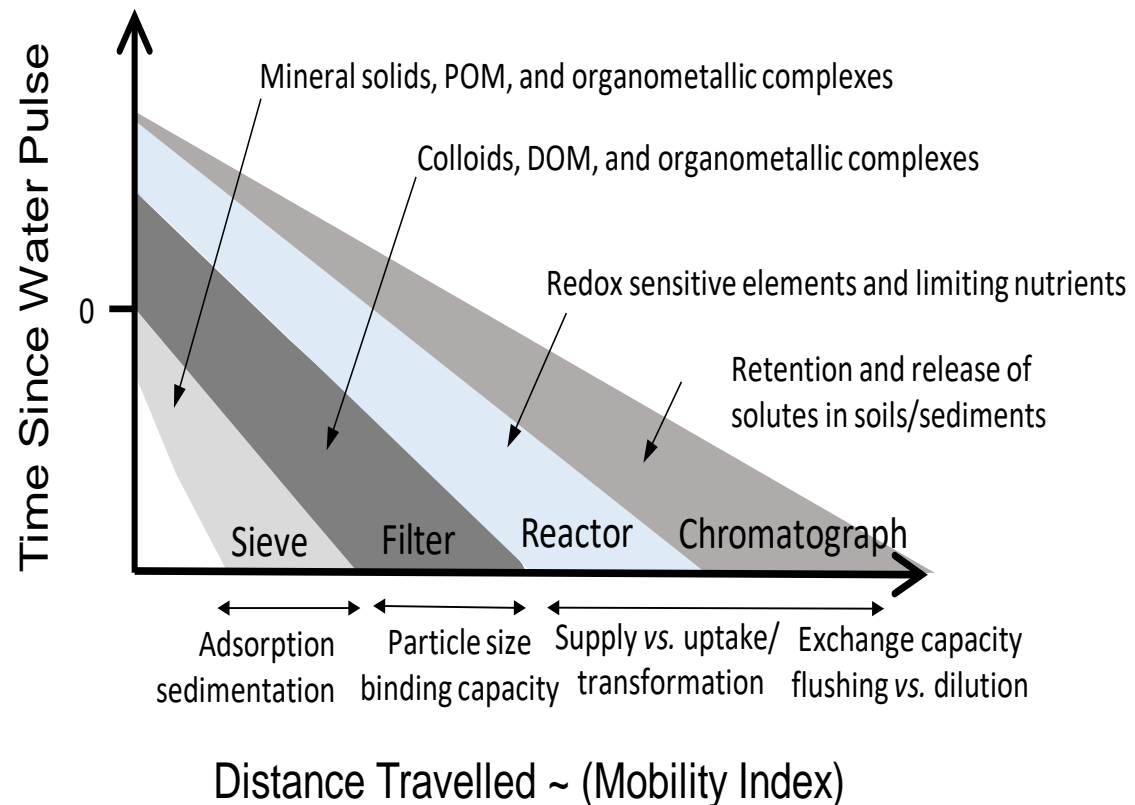




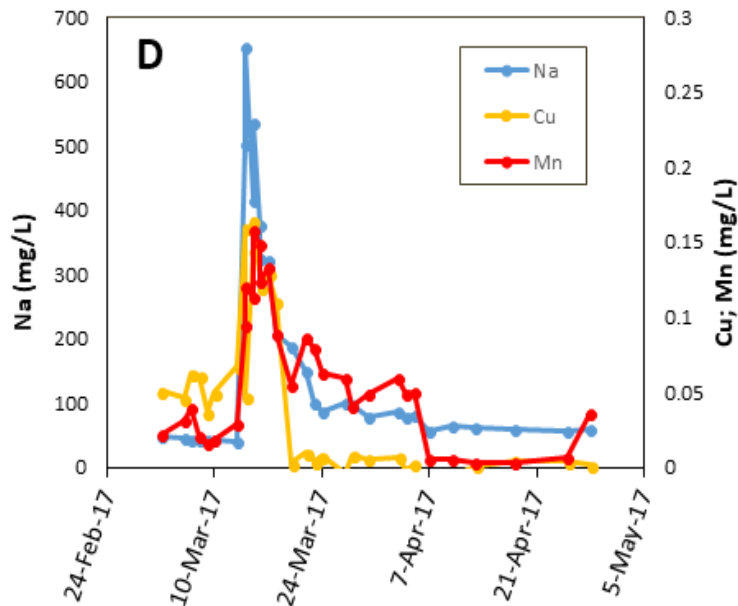
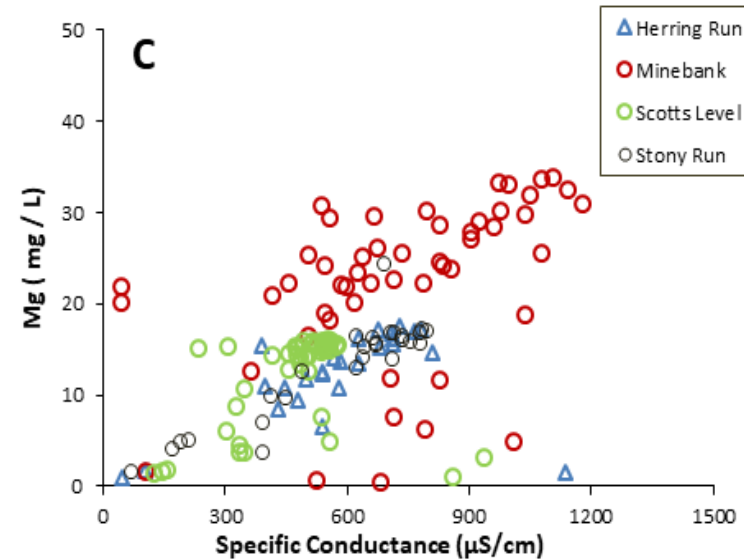
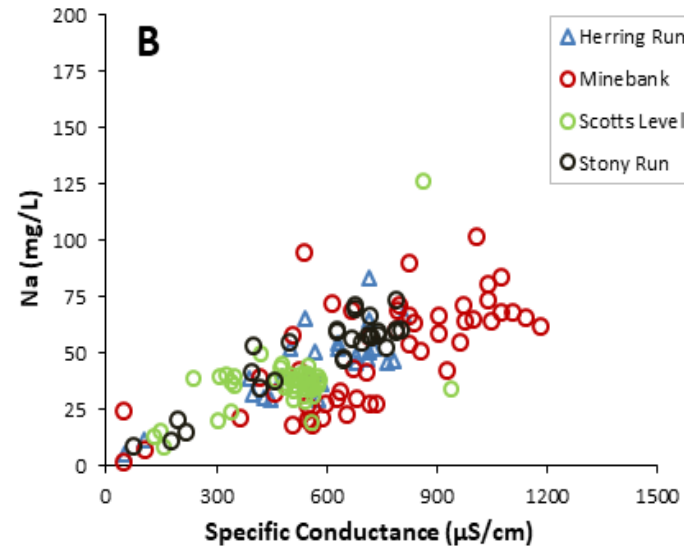
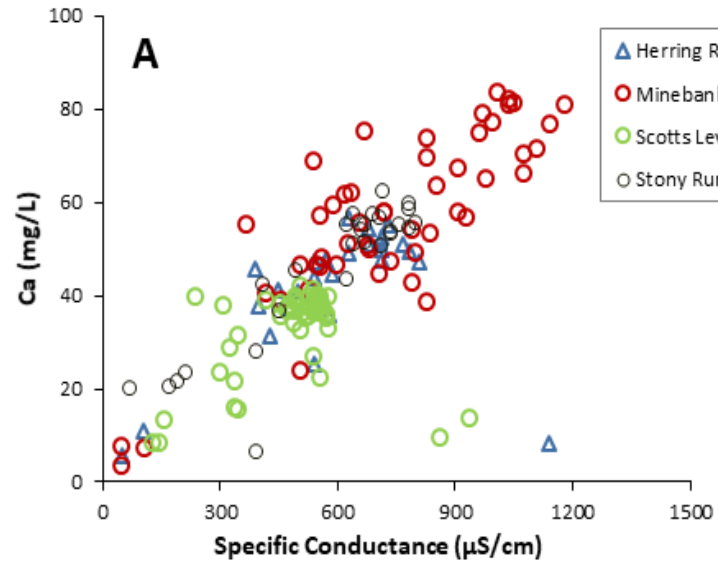
Salts Accumulate along Drainage Networks?

3. Chemical Cocktails are novel chemical combinations transported in fresh waters due to shared hydrologic flowpaths and increased biogeochemical interactions.

Watersheds as Sieves, Filters, Chromatographic Columns, and Reactors



Conductance as a Proxy for Chemical Cocktails



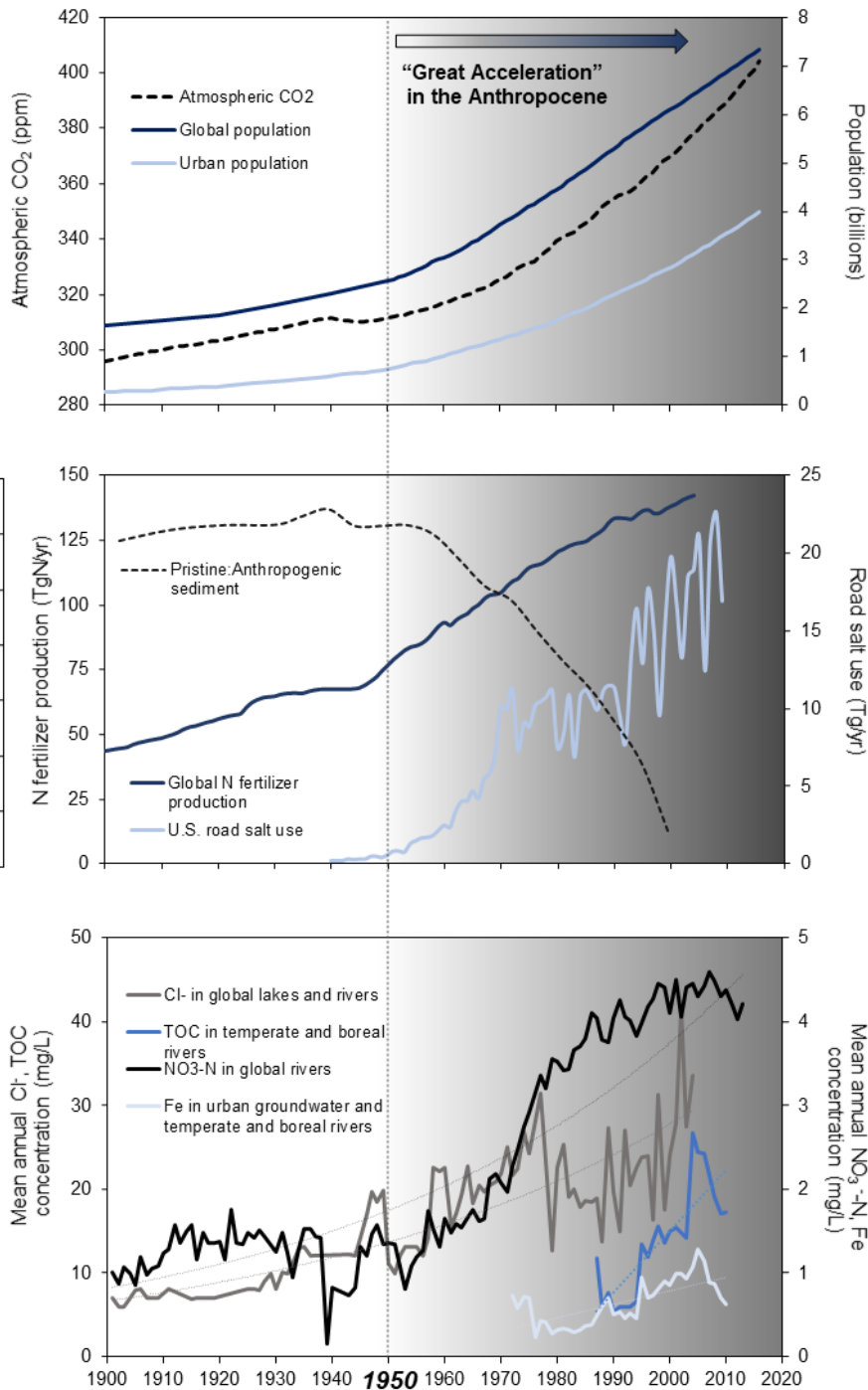
Changes in land use and climate



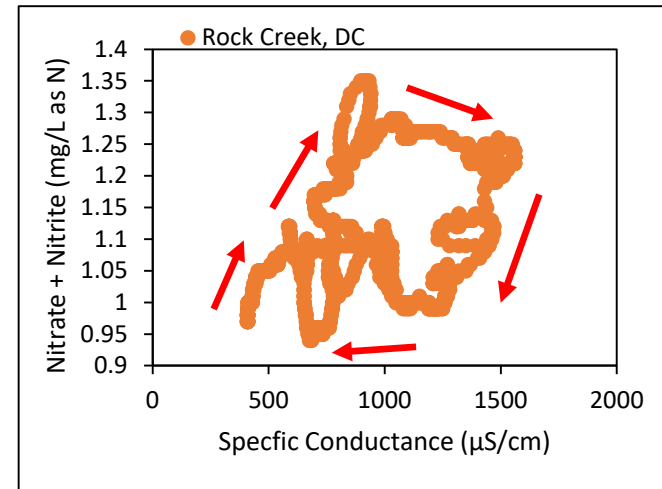
Changes in anthropogenic inputs



Changes in sieved, filtered, chromatographic, and reactive transport behavior



Forming Watershed Chemical Cocktails: Decades to Days



Kaushal et al. (2018b)
Biogeochemistry

Kaushal et al. (2019)
Phil. Transactions of the Royal Society

Conclusions

1. Freshwater Salinization Syndrome (FSS) emerges across local, regional, and continental scales
2. Novel chemical mixtures are a consequence of FSS
3. Watershed 'Chemical Cocktail' approach can be applied to understand changes in freshwater chemistry

Freshwater Salinization Syndrome: An Introduction

by Matthew Wright

- <https://www.youtube.com/watch?v=y-VCYHwpHmE&feature=youtu.be>



Photo Courtesy: K. Belt

