Evaluating impacts of freshwater salinization syndrome on mobilization of nutrients and metals from stormwater best management practices

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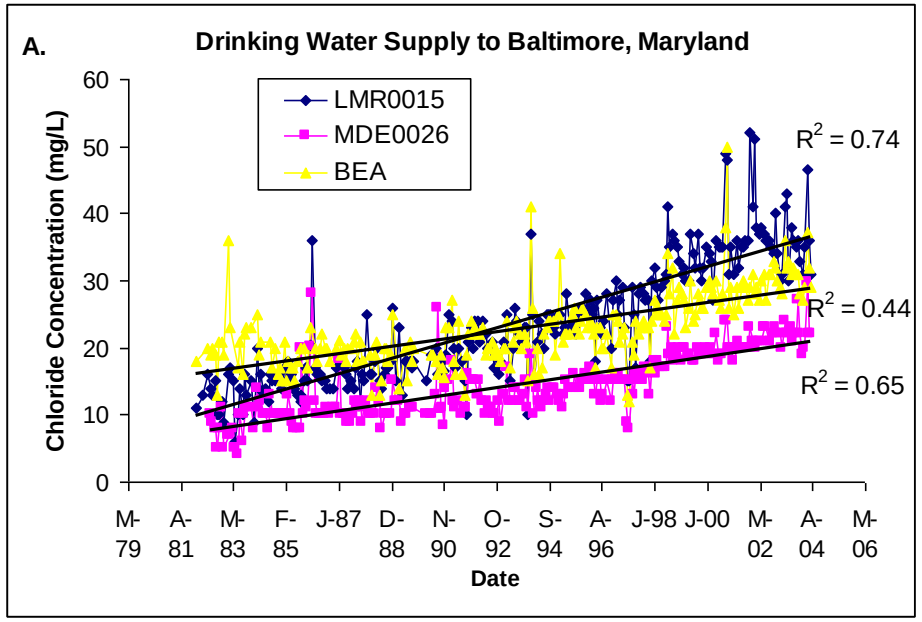
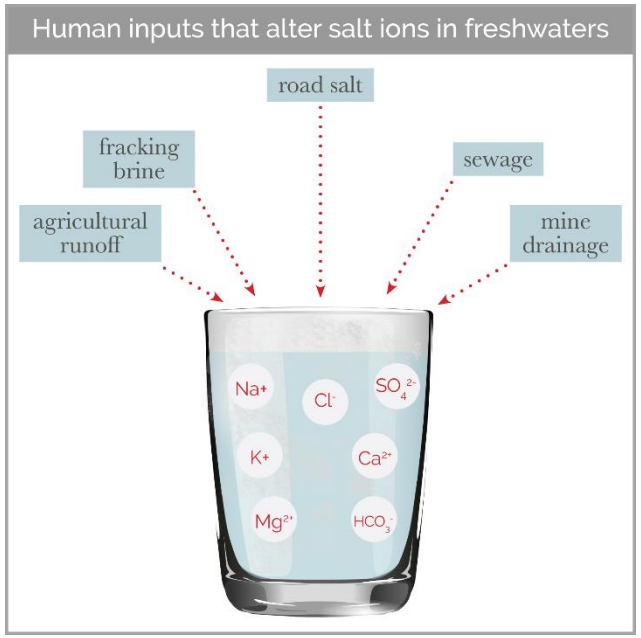
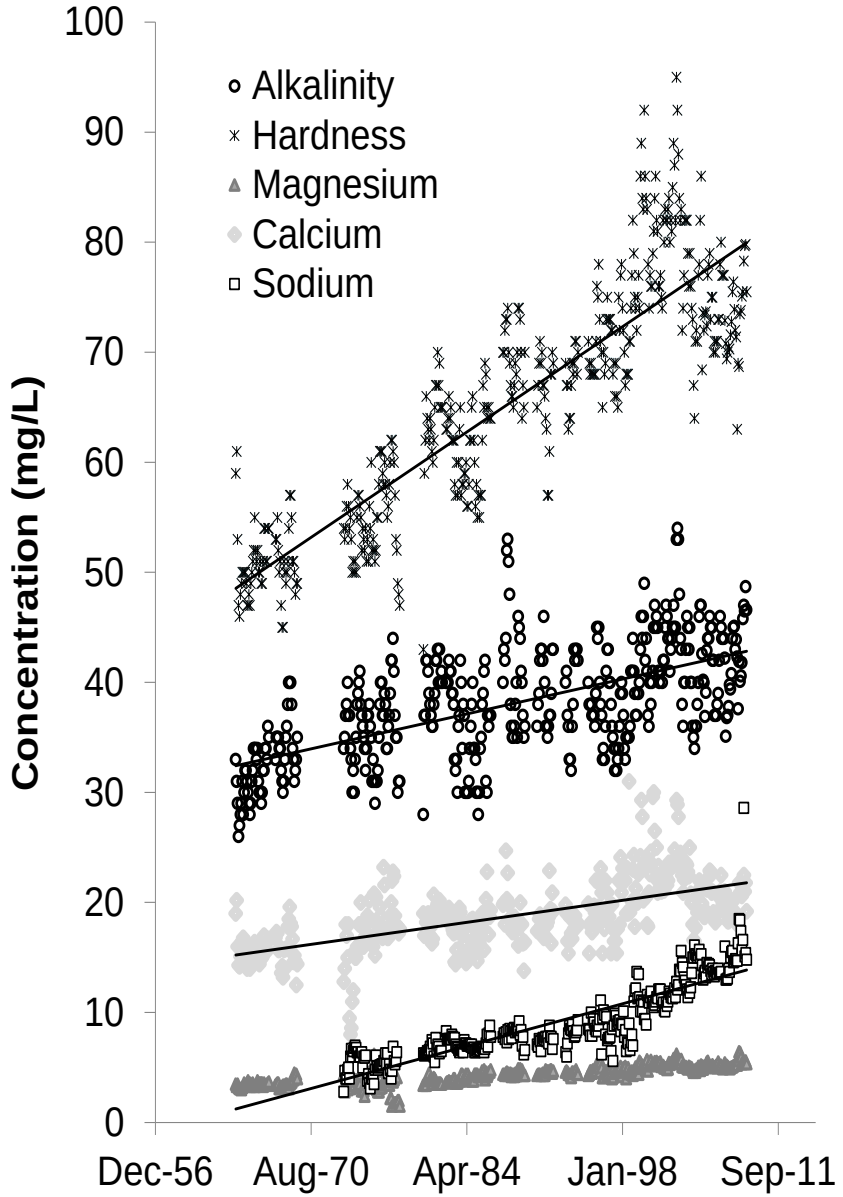
Freshwater Salinization Syndrome Impacts Maryland's Drinking Water



Kaushal et al. (2005) *PNAS*

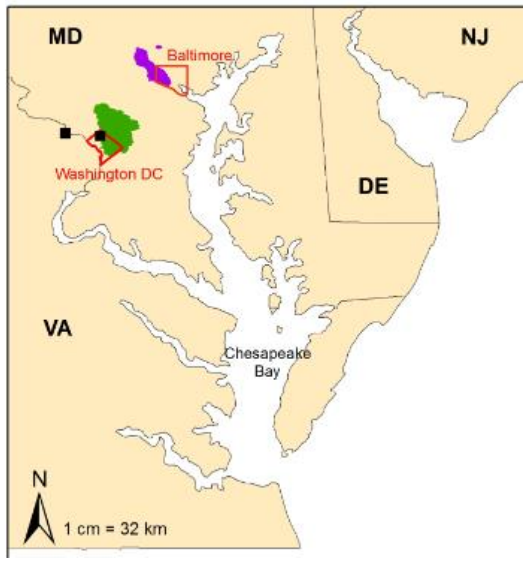


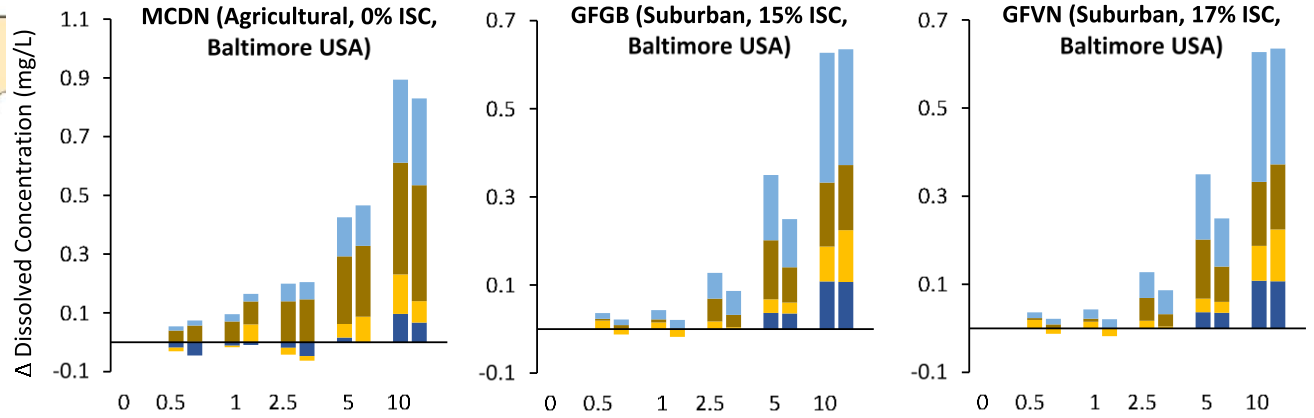
L. Quillen (2018) FSS Press Release

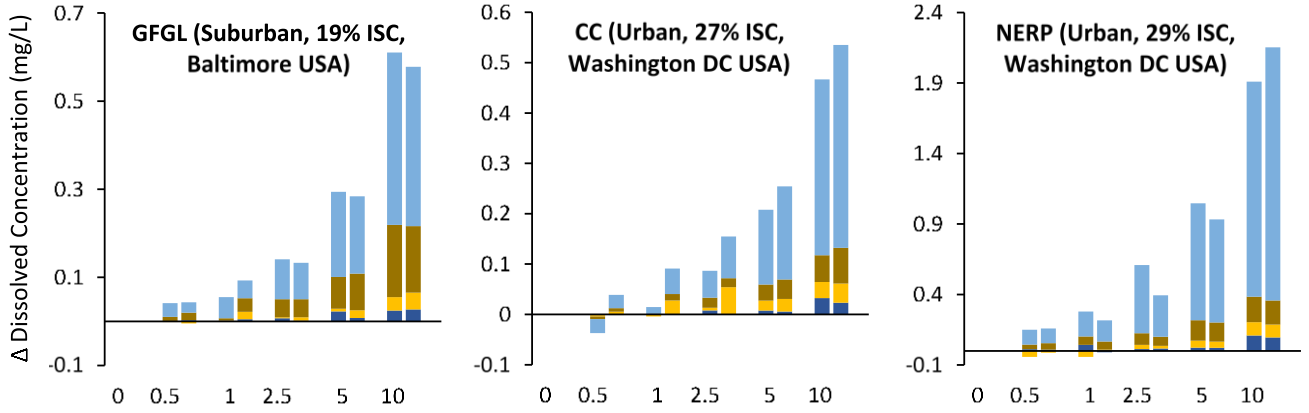


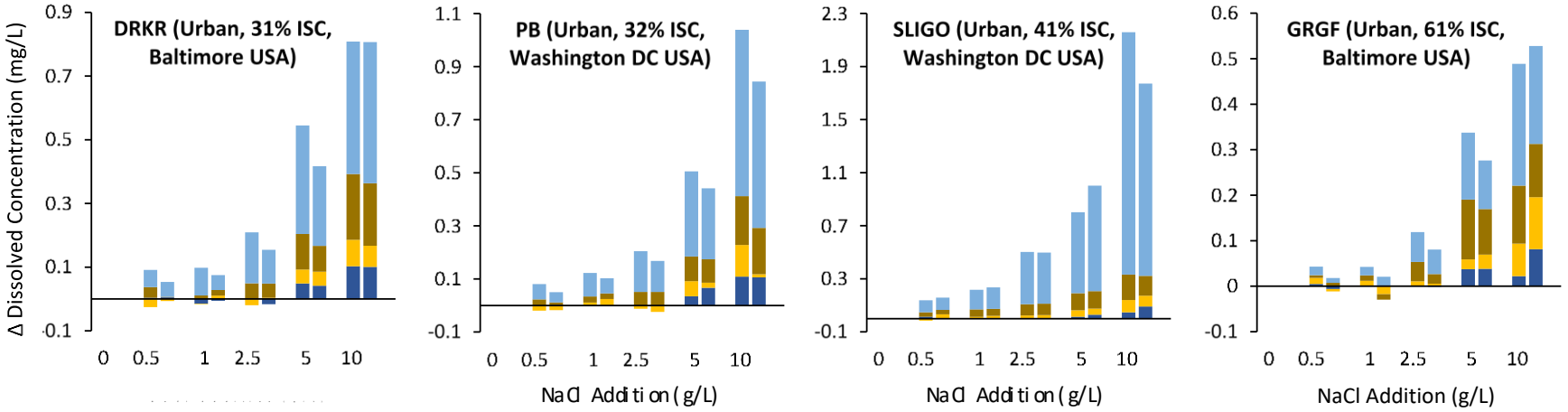
Kaushal et al. (2017) *Appl. Geochem*

Thank You to Early Mentor: Bill Stack





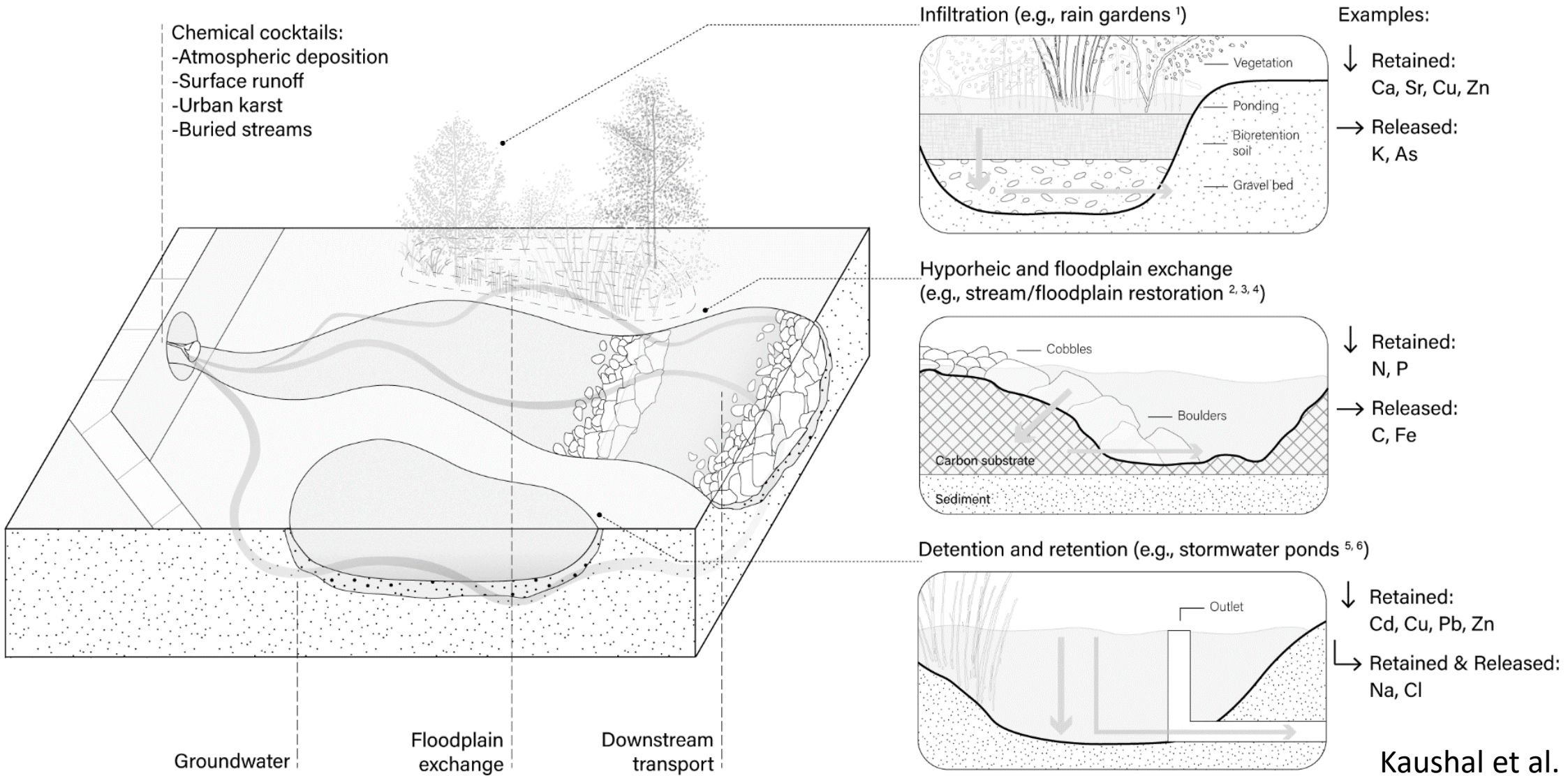




Salinization Mobilizes Metals and Nutrients to Streamwater

Kaushal et al. (2019)
Philosophical Trans. Royal Society

Retention and release of chemical cocktails along stream and stormwater flowpaths



Kaushal et al. (In Press)
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Key Questions

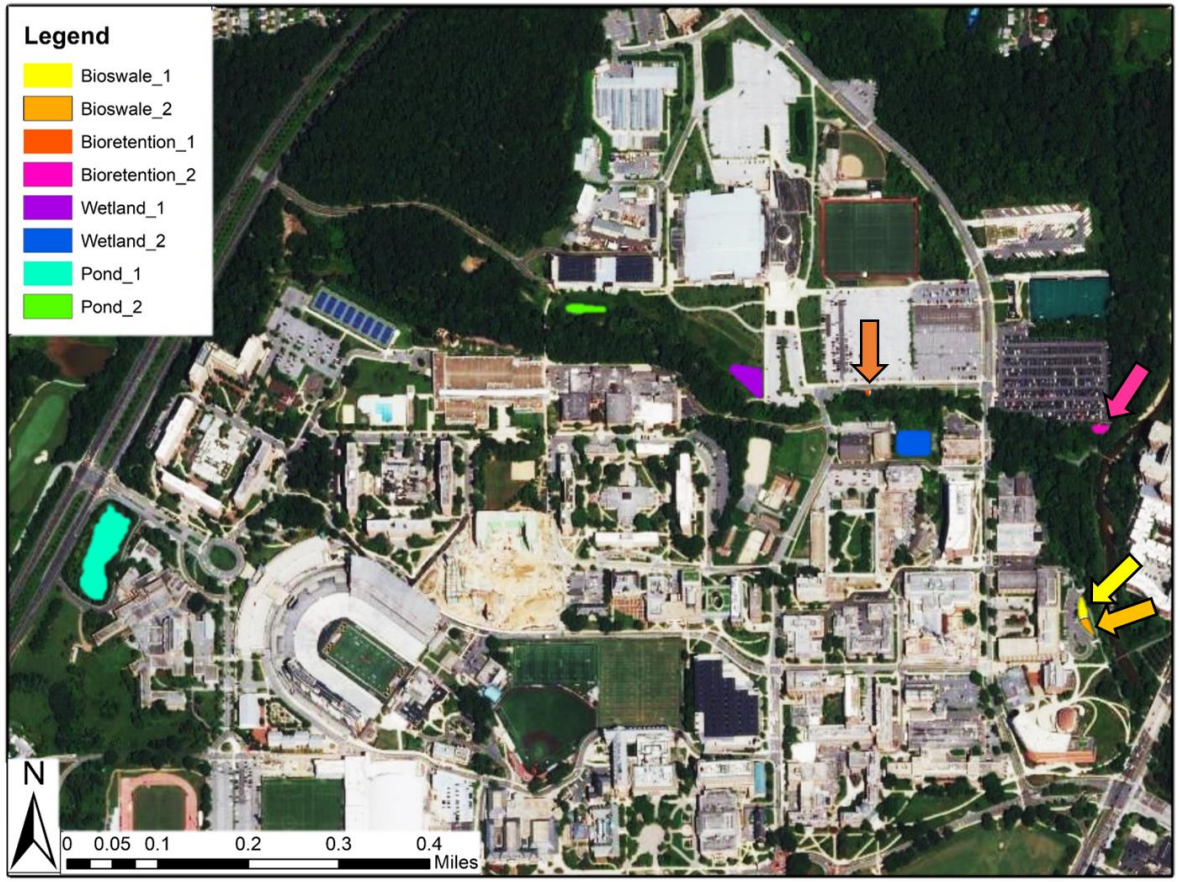
- What are critical thresholds in concentrations of different road salt ions (Na^{+}, Ca^{2+}, Mg^{2+}) which can mobilize nutrients and metals to surface waters across varying stormwater BMPs?

- What are the concentrations and loads of different road salt ions and associated metals and nutrients in nearby stream outfalls before, during, and after deicing events

Study Sites:

- 4 different stormwater management features (with replicates)
- Sites range from 5 to 33 years in age and were almost always constructed concurrently with a building or large area of impervious surface coverage
- Stream restoration sites and regenerative stormwater conveyance (RSC) systems

Galella et al. (In Prep)




Bioswale #1


Bioretention #1


Wetland #1


Pond #1


Bioswale #2

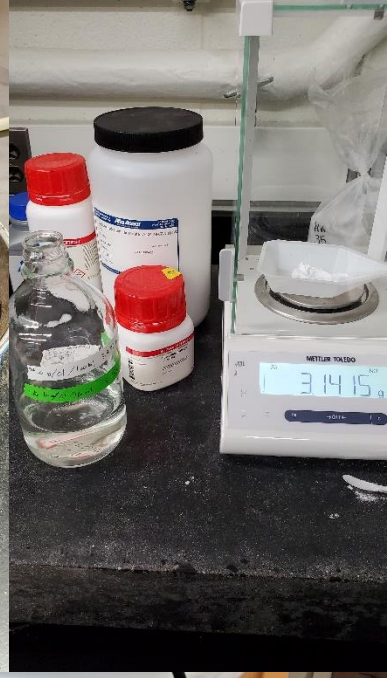

Bioretention #2


Wetland #2


Pond #2

Methods:

Joe Galella



1. Collect water and sediment samples
2. Filter water through 0.7-micron GFF
3. Sieve sediment through a 4 mm sieve
4. Add salt (NaCl / $CaCl_2$ / $MgCl_2$)
5. Incubate water and sediment on shaker table for 24 hours

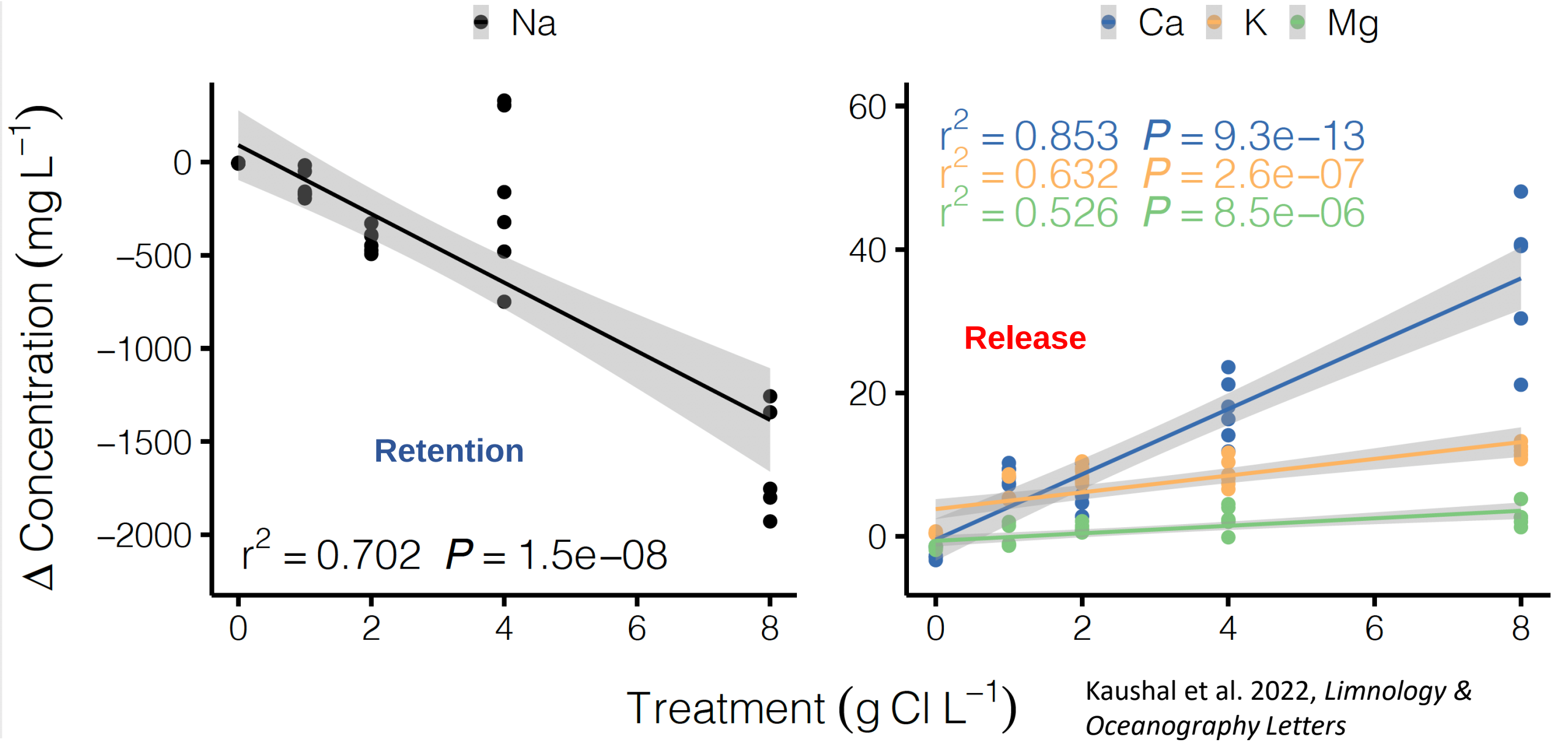
Galella et al. (In Prep)

Hold the Salt: How Much Can Be Retained in Sediments?

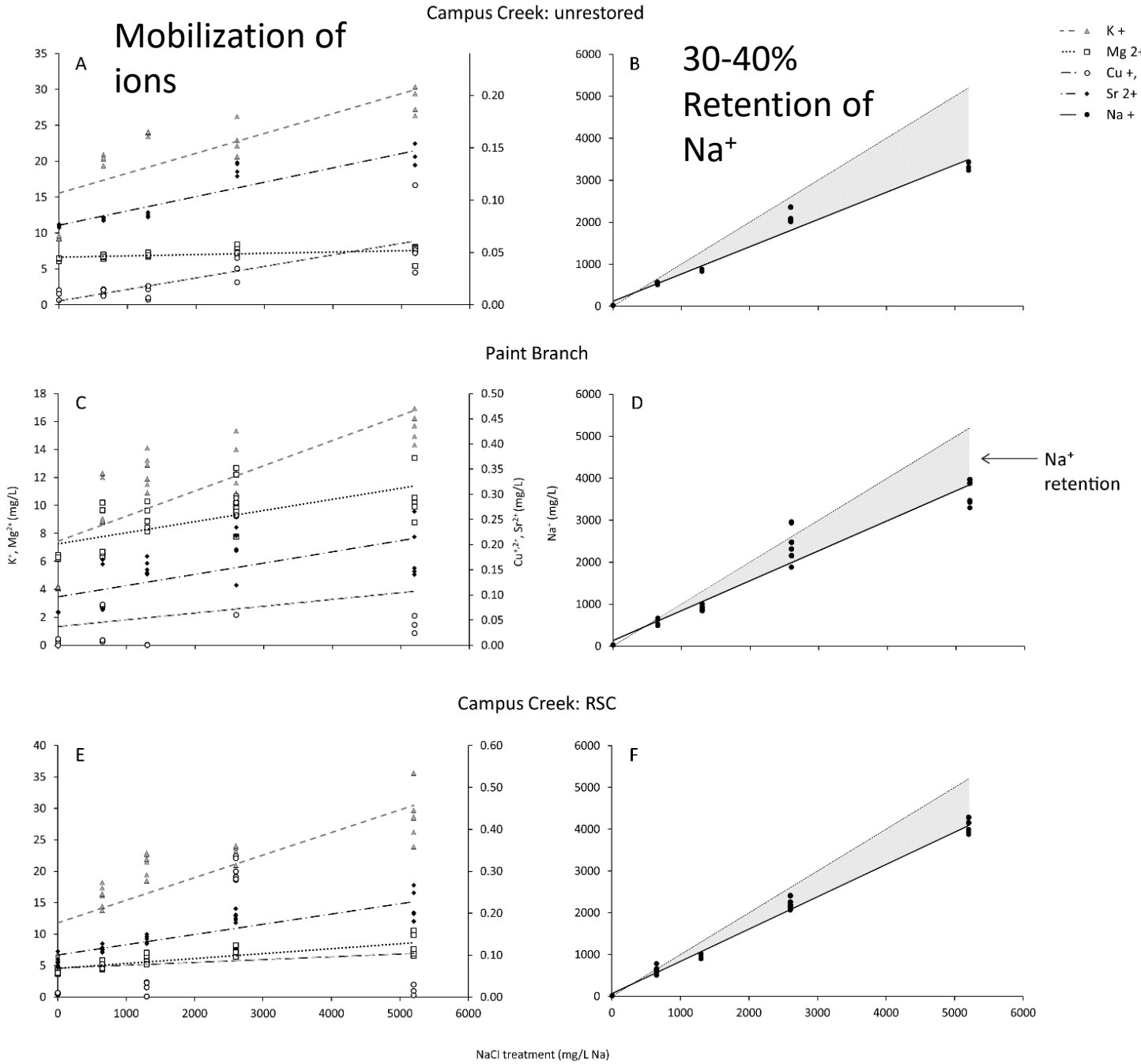
Retention and Release of Salts, Nutrients, and Metals in Different Stormwater Management Features

Photo courtesy of
Kelsey Wood (2019)

High Capacity for Sodium Retention in Restored Stream Floodplain Sediments



Kaushal et al. 2022, *Limnology & Oceanography Letters*



Sediments and soils can retain substantial amounts of salt ions

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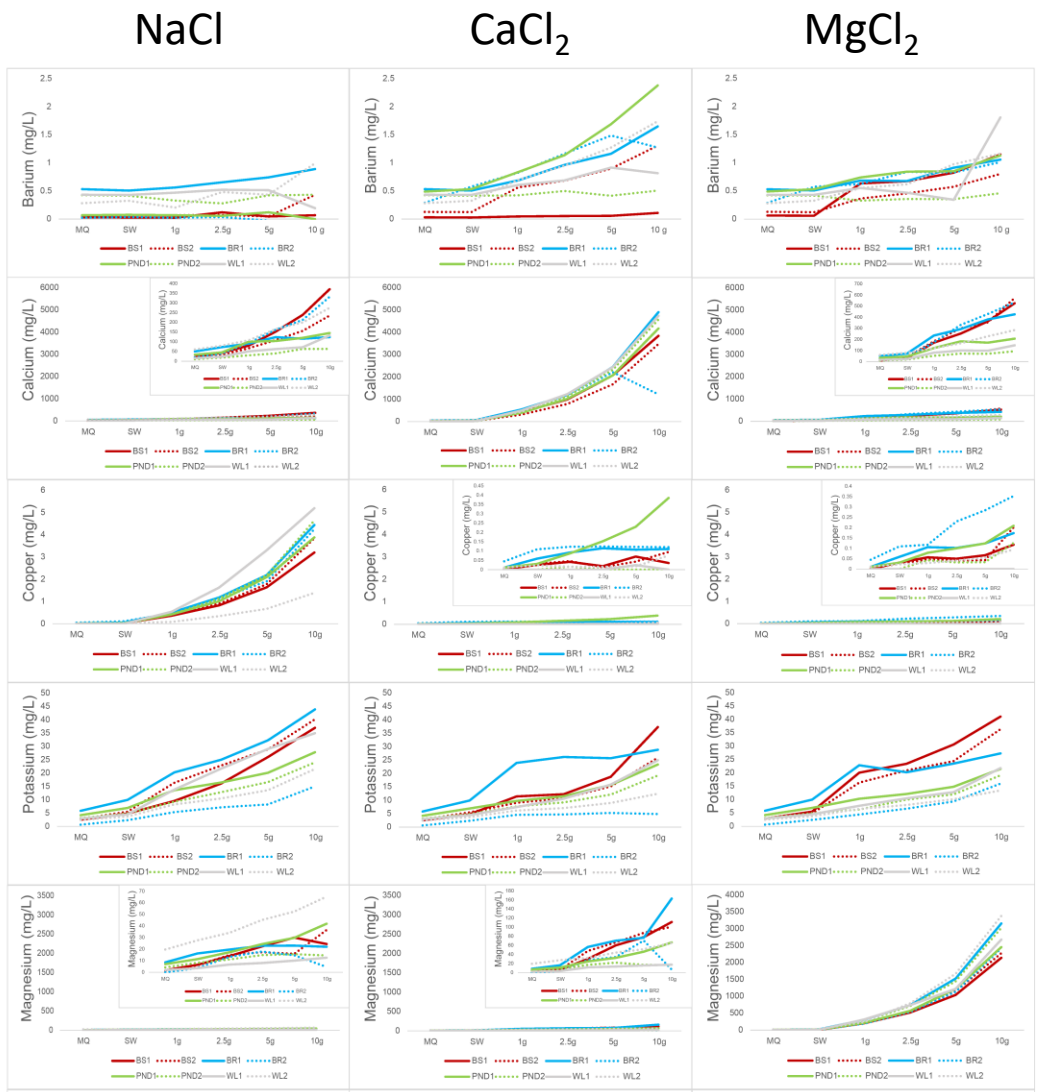
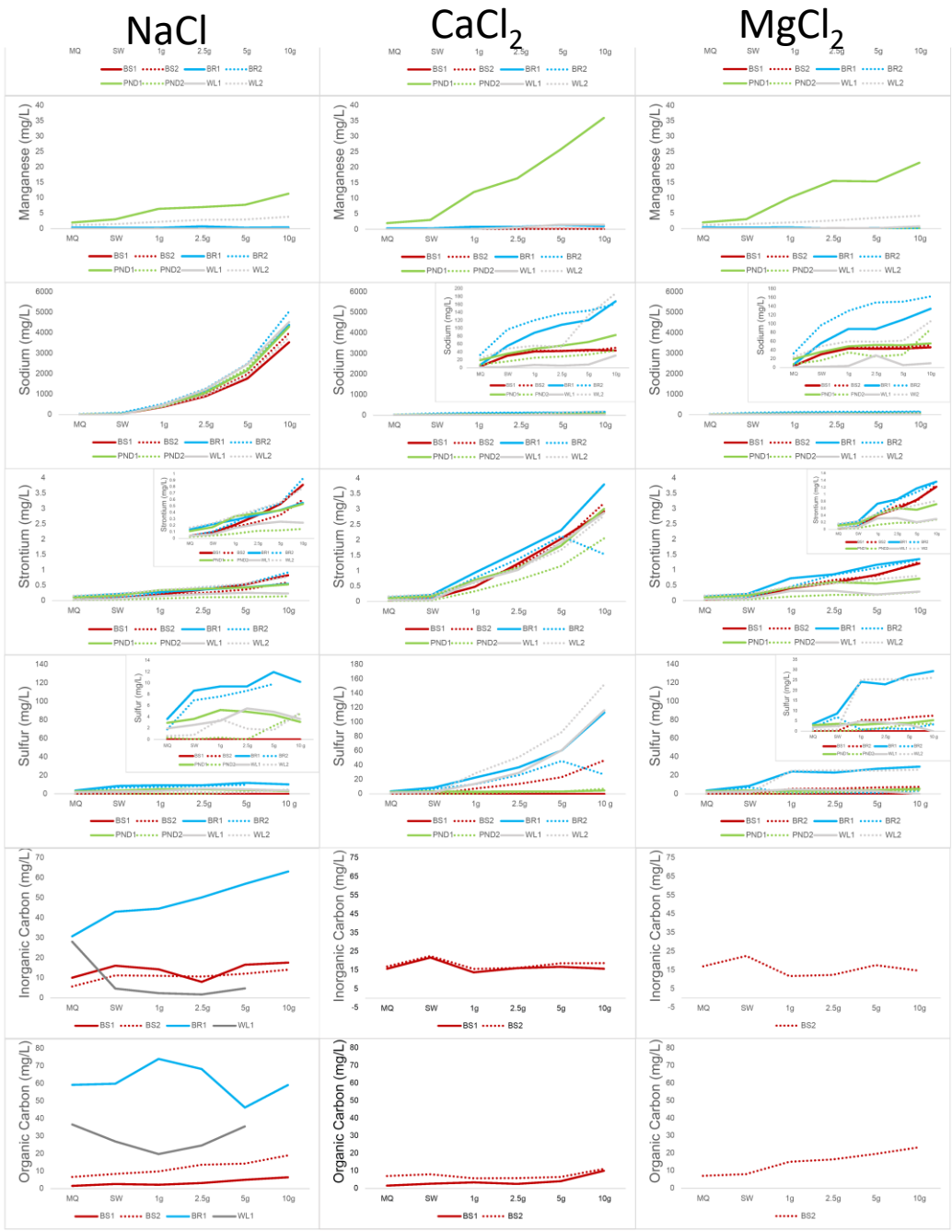
Mobilization of metals, nutrients, and other salts

Galella et al. (In Prep)





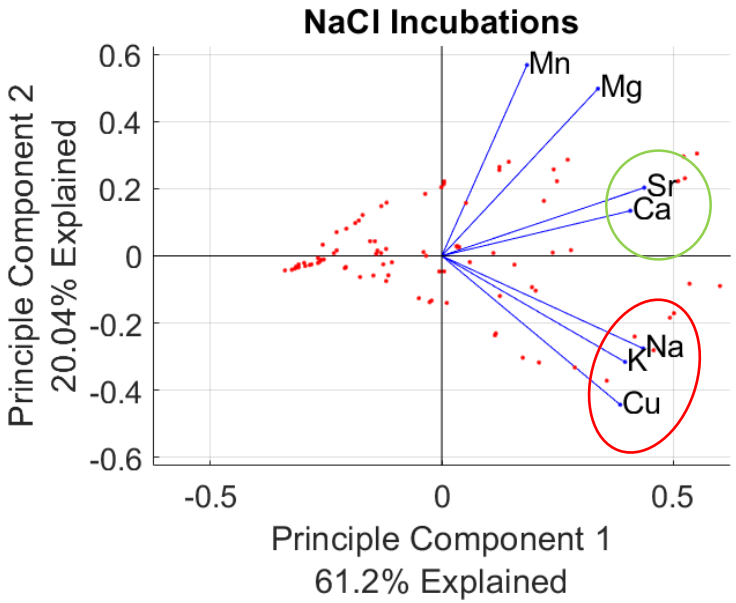
Results: ANOVA Salt type, concentration, and BMP type are significant

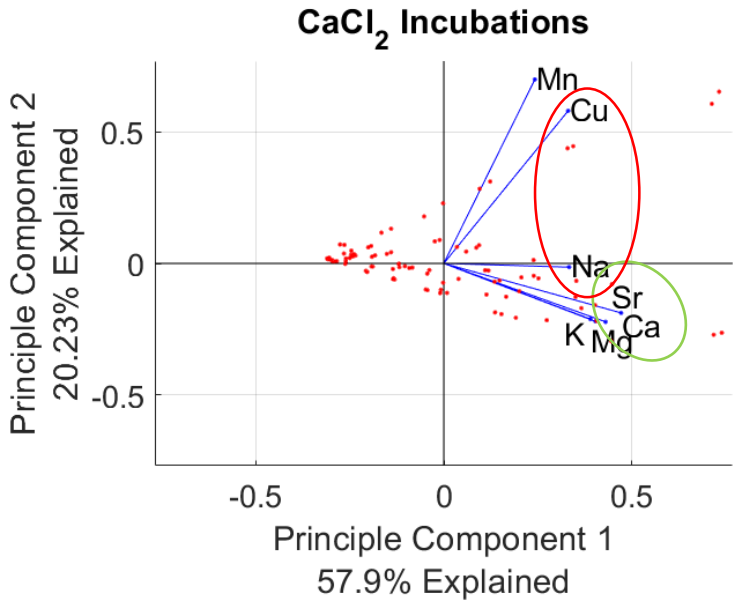
- Site type had a significant effect on the concentration of:
  - B, Ba, K, Mn, and Sr
- Salt type was significantly correlated with all major and trace elements save for:
  - B and Fe
- **<u>Salt concentration was statistically correlated with mobilization of ALL major and trace elements</u>**

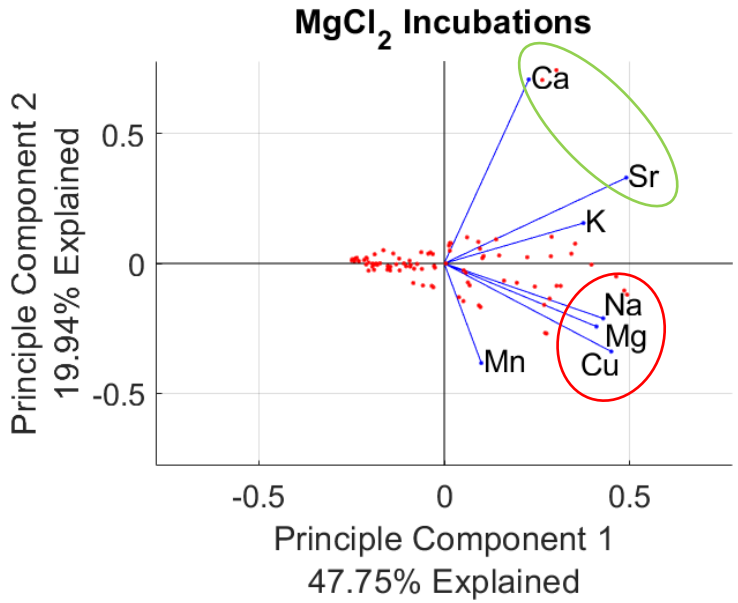
	Site Type			Salt Type			Salt Concentration		
Variable	**N**	**F-ratio**	**p-value**	**N**	**F-ratio**	**p-value**	**N**	**F-ratio**	**p-value**
B	248	10.675	**0.000**	248	1.989	0.139	248	2.722	**0.021**
Ba	248	22.458	**0.000**	248	10.523	**0.000**	248	26.294	**0.000**
Ca	248	0.416	0.868	248	69.988	**0.000**	248	28.744	**0.000**
Cu	241	0.318	0.927	241	72.073	**0.000**	241	25.260	**0.000**
Fe	182	1.784	0.105	182	2.917	0.057	182	2.771	**0.020**
K	248	41.476	**0.000**	248	21.122	**0.000**	248	176.314	**0.000**
Mg	248	0.420	0.866	248	73.466	**0.000**	248	23.883	**0.000**
Mn	245	53.566	**0.000**	245	3.889	**0.022**	245	5.324	**0.000**
Na	248	0.106	0.996	248	77.882	**0.000**	248	24.069	**0.000**
Sr	248	6.264	**0.000**	248	79.050	**0.000**	248	66.406	**0.000**
DIC	X	X	X	36	21.301	**0.000**	36	4.220	**0.006**
DOC	X	X	X	36	22.903	**0.000**	36	12.346	**0.000**
TDN	X	X	X	36	14.548	**0.000**	36	21.124	**0.000**

Galella et al. (In Prep)

Different Salt Ions Mobilize Different Contaminants



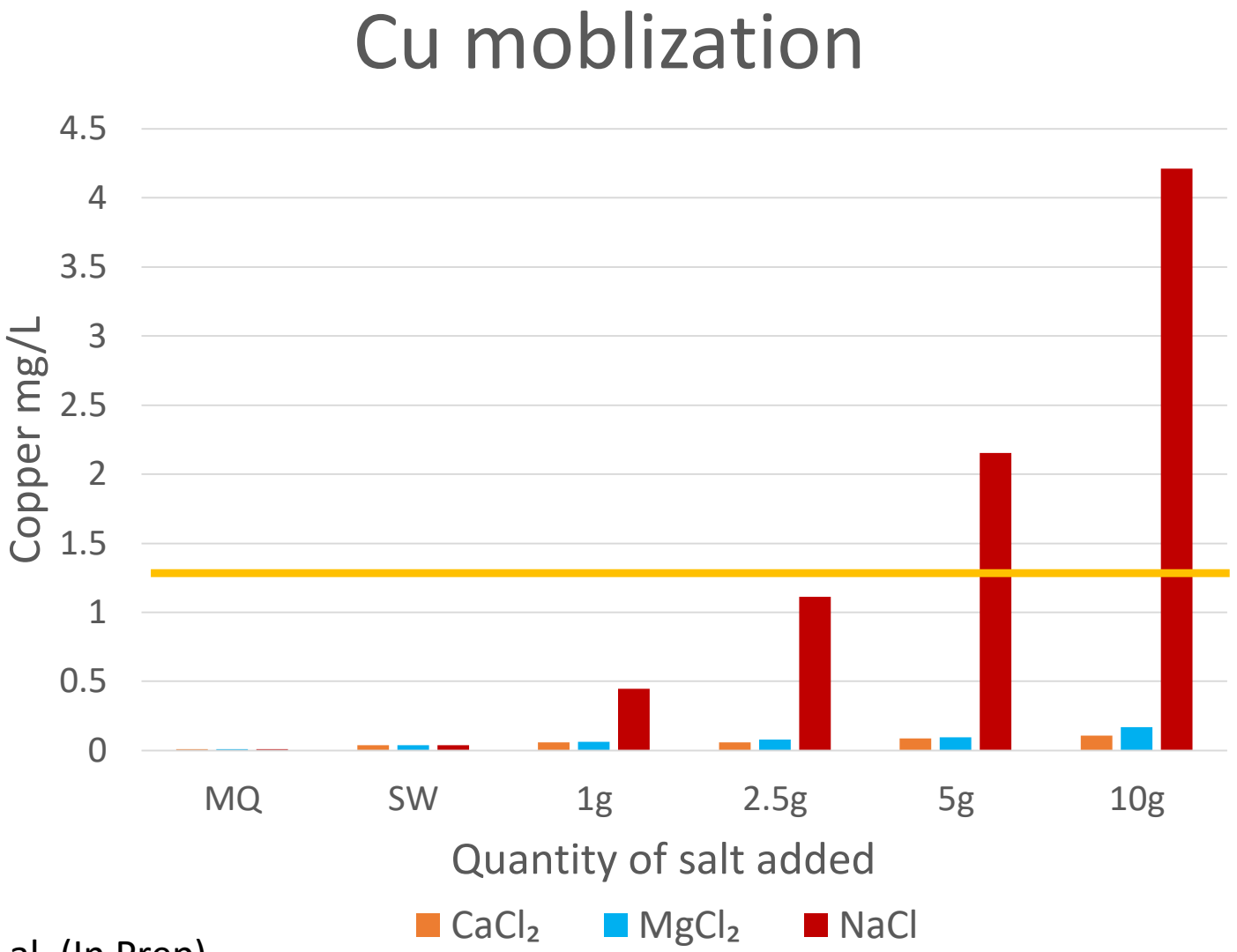




Galella et al. (In Prep)

NaCl Mobilizes More Copper: Implications for Aquatic Ecosystems and Home Plumbing

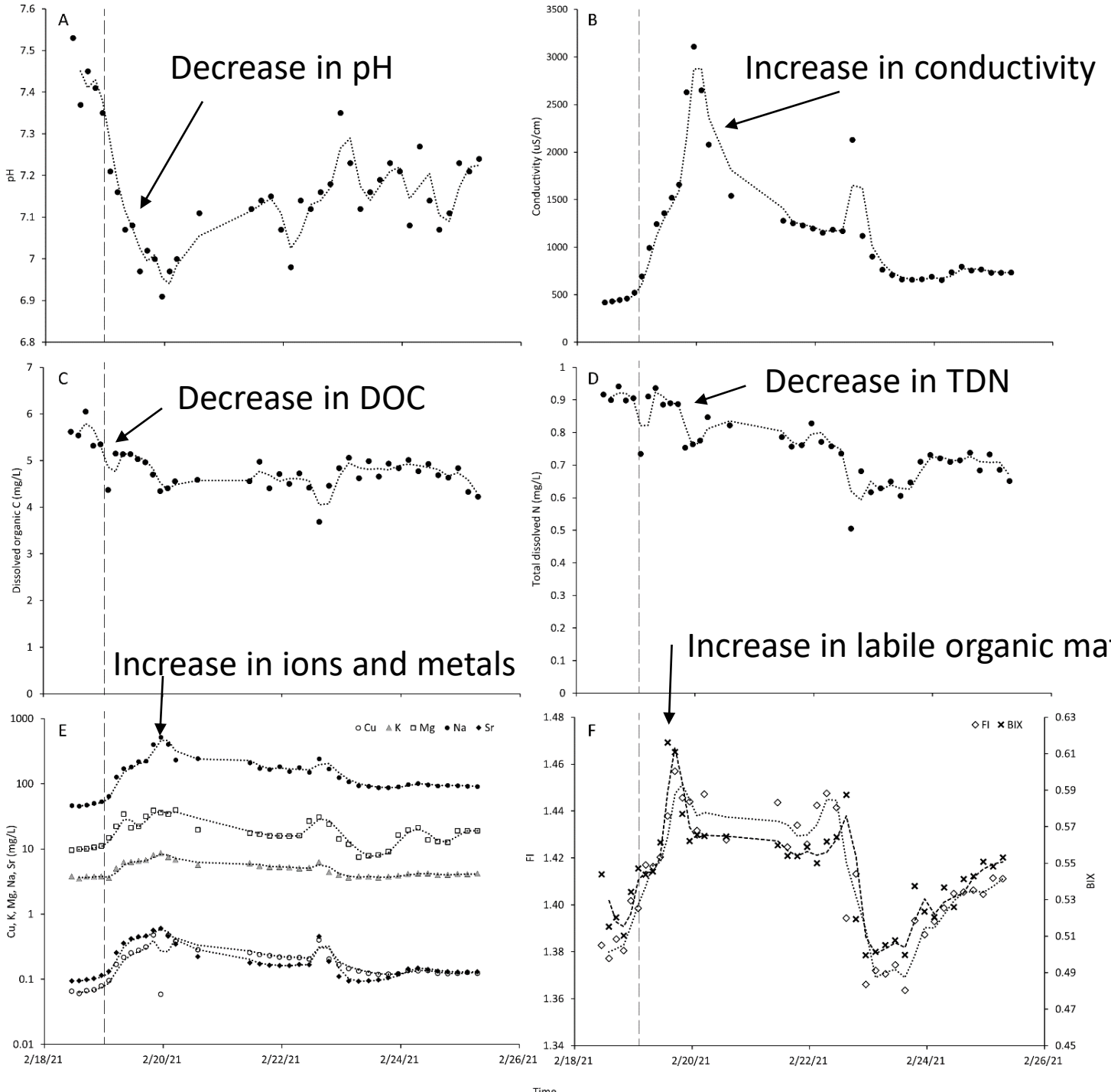
NaCl mobilizes Cu more than an order of magnitude more efficiently than $CaCl_2$ or $MgCl_2$



Galella et al. (In Prep)

Stream and Stormwater BMP Monitoring

Photos Courtesy: Kelsey Wood

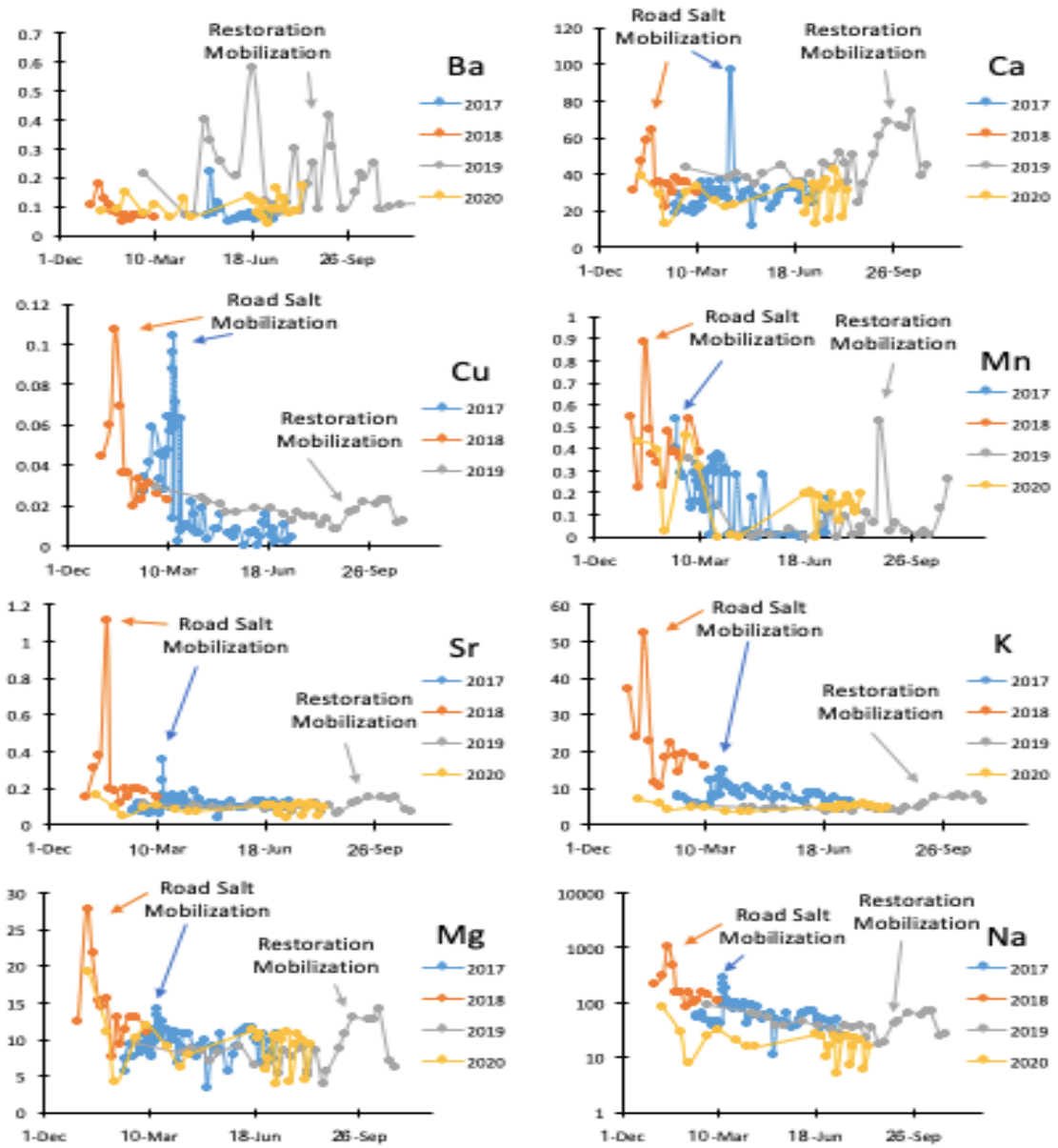


Changes in water quality following road salt events in RSCs

Kaushal et al. (In Press)
Freshwater Science

Mobilizing Chemical Cocktails:

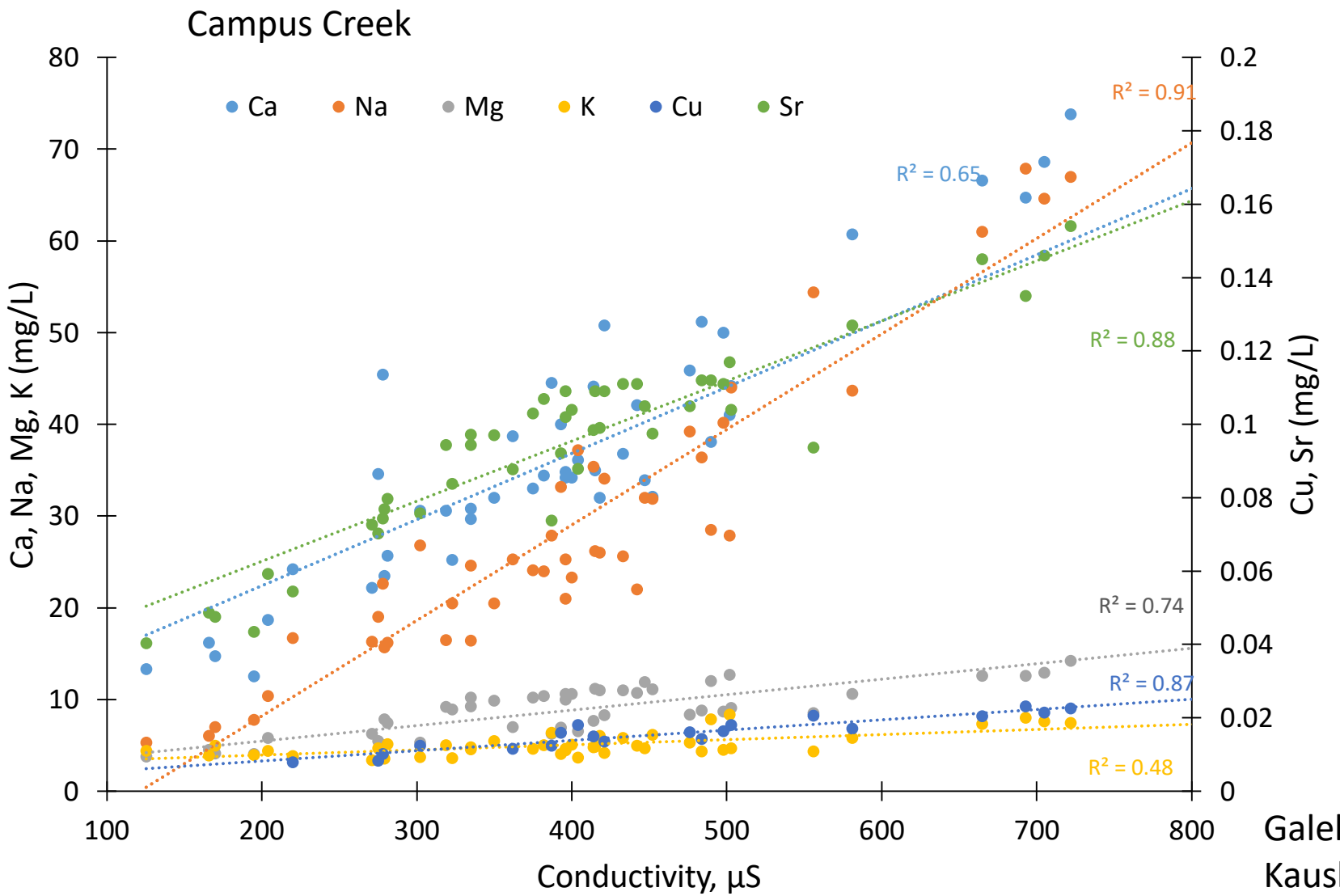
Comparison by Year and Season



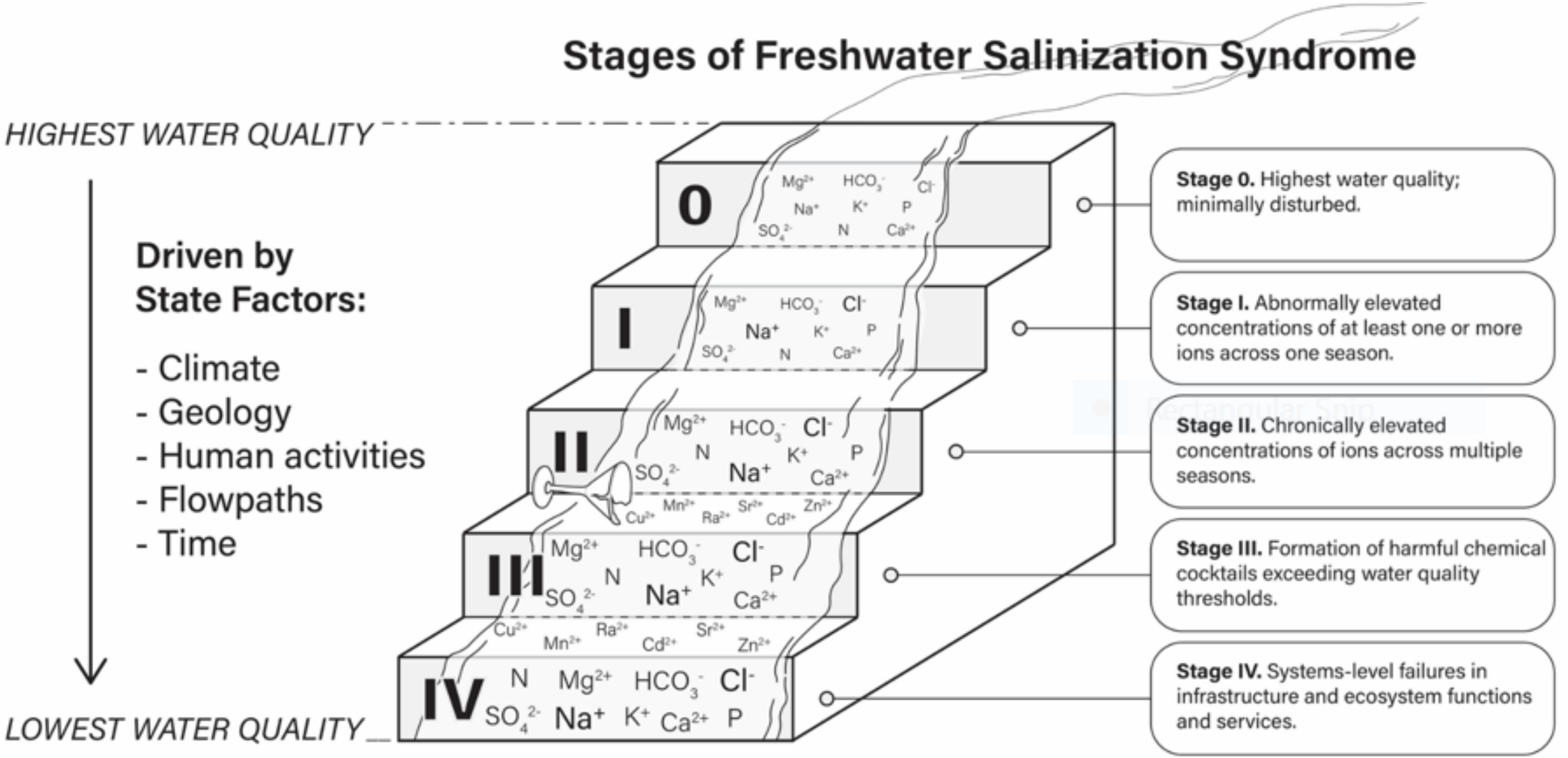
There can be significant recovery and decreases in ion concentrations over years (>50%) depending on amount of road salt use

Kaushal et al. (In Press)
Freshwater Science

New Monitoring Approaches: Specific Conductance as a Proxy for Ions and Metals



Galella et al. (2021),
Kaushal et al. (2021),
Kaushal et al. (2022),
Kaushal et al. (In Press)



Kaushal et al. 2022, *Limnology & Oceanography Letters*

Managing Salinization by the Amounts and Types of Salt Ions along Flowpaths

Summary

- Significant retention of salt ions in stormwater sediments
- Mobilization of contaminants depends on concentration of salt ions, type of salt, and BMP type
- New practical monitoring approaches using proxies

Management Implications

- Stormwater sediments/soils can have very high potential to enhance ion retention and ion exchange
- Reducing winter NaCl inputs can lead to rapid and year long recovery in some ions
- Water quality monitoring approaches using inexpensive proxies such as specific conductance can help predict concentrations of multiple ions and metals

Acknowledgments

- Thanks to the Maryland Department of Transportation, and Maryland Department of Natural Resources for funding along with all the funding partners below.

- Special thanks also to Karl Berger, Steve Bieber, Paul Mayer, and Stan Grant

Translation Slides

Ken Mack

Senior Water Quality Specialist

Montgomery County Department of Environmental Protection

Good News Bad News

Good News

- BMPs and Stream Restoration are sequestering deicing salts

Bad News

- Sequestered deicers are exchanged for other ions (Including environmentally harmful ions)

Good News Bad News

Good News

- Reducing road salt use results in immediate reduction in stream salinization and reduces ion exchange

Bad News

- NaCl results in a likely more harmful chemical cocktail (especially in bioretention)

Good News Bad News

Good News

- Conductivity monitoring can be a good proxy for several ions (not just Na or Cl)

Bad News

- Exchanged ions result in a broad chemical cocktail possibly reducing biological potential

Additional Management Considerations

- Emphasizes the need to reduce the use of all salts (especially NaCl)
- Many second order effects of deicers (acidification, increase in labile organic matter, reduction in DOC). Potential impacts to:
  - Drinking water
  - Stream biota
  - Infrastructure
- Salt type has a major influence on released chemical cocktail
  - Consider using different salts near bioretention
  - Reduce NaCl where copper export is possible
- BMP type and age influences released chemical cocktail
- Stream restoration results in a pulse of nutrients/ions