Spatio-temporal patterns of specific conductivity in streams and rivers of the Delaware River Basin

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Watershed Congress

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What is electric conductivity?

- Electric conductivity: measurement of the **concentration of chemicals that can transfer electric current**

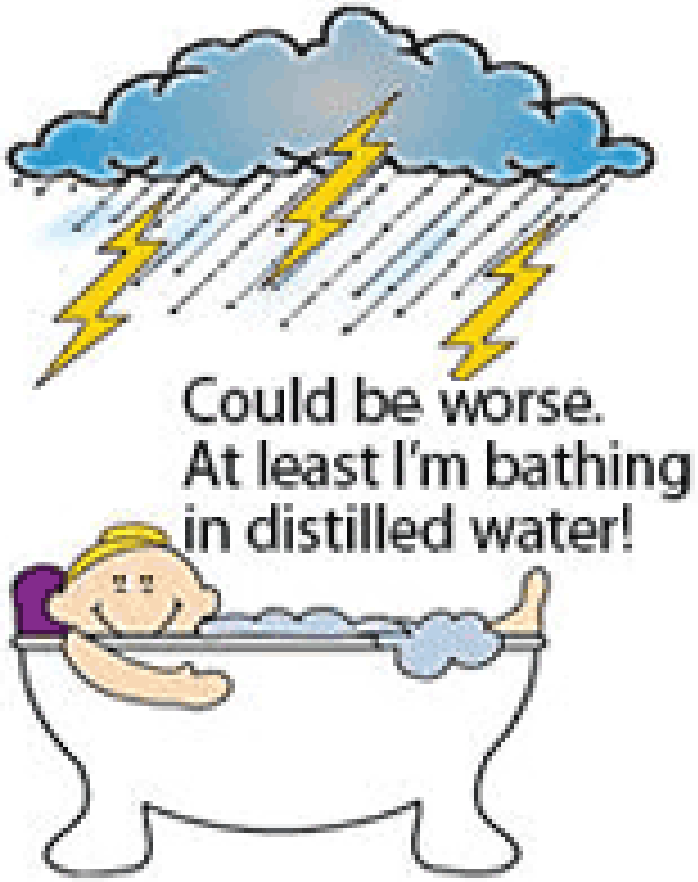
- Measured with a conductivity meter

What is electric conductivity?

- Units: mili- or micro-Siemens per cm (mS/cm or µS/cm).
- Electric conductivity = electric conductance
- Specific conductivity (SC): electric conductivity that **has been corrected for temperature**.
  - Most sensors report specific conductivity.

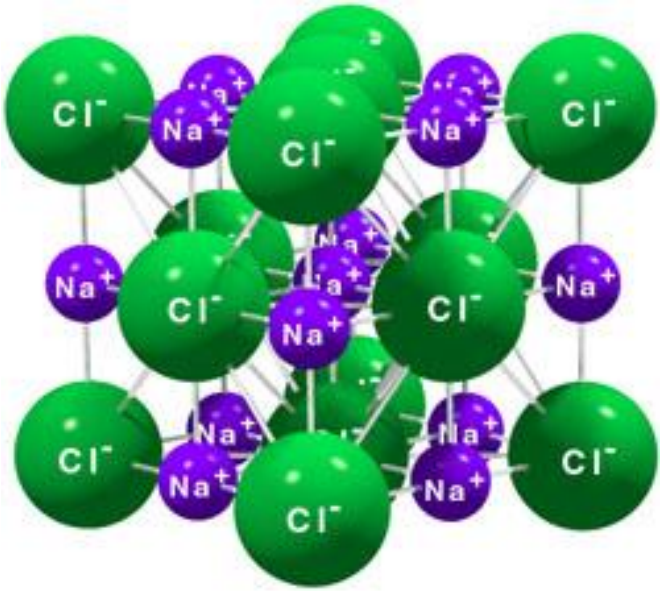
What is electric conductivity?

- Measurement of the **concentration of chemicals that can transfer electric current**.
  - Dissolved salts.



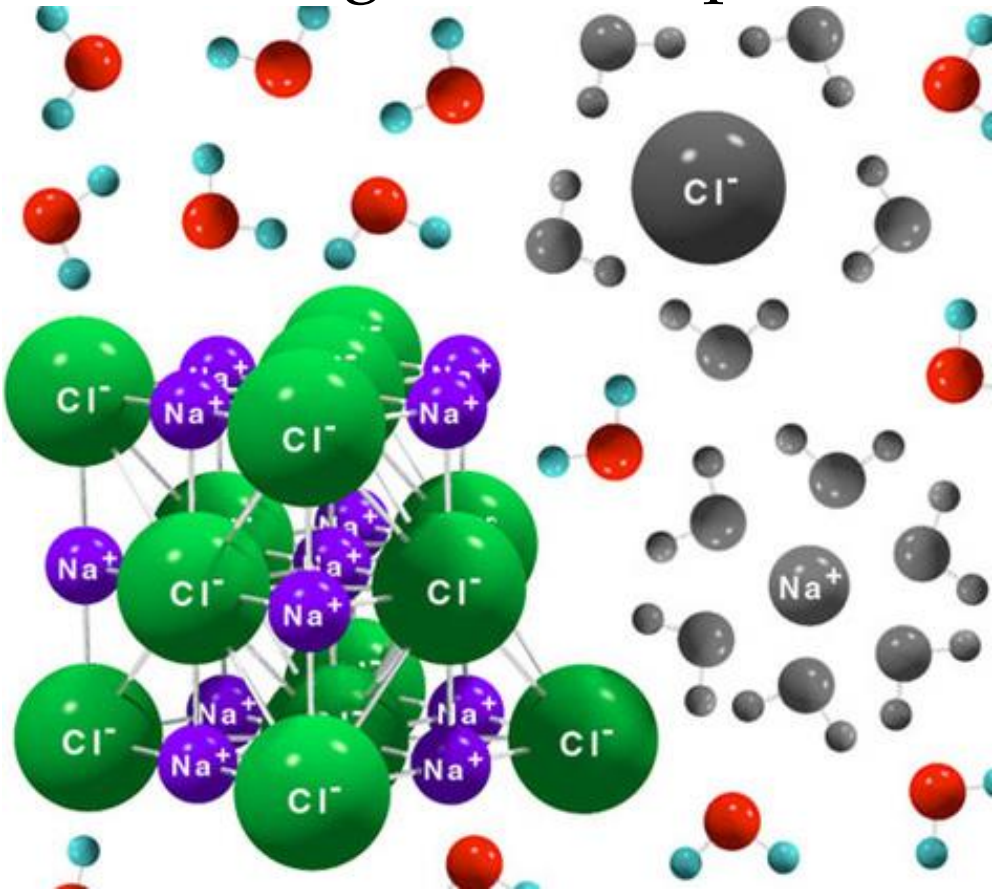
Dissolved salts in freshwater

- What is a salt?
  - Solid chemical compounds made of atoms with negative or positive charges (ions)



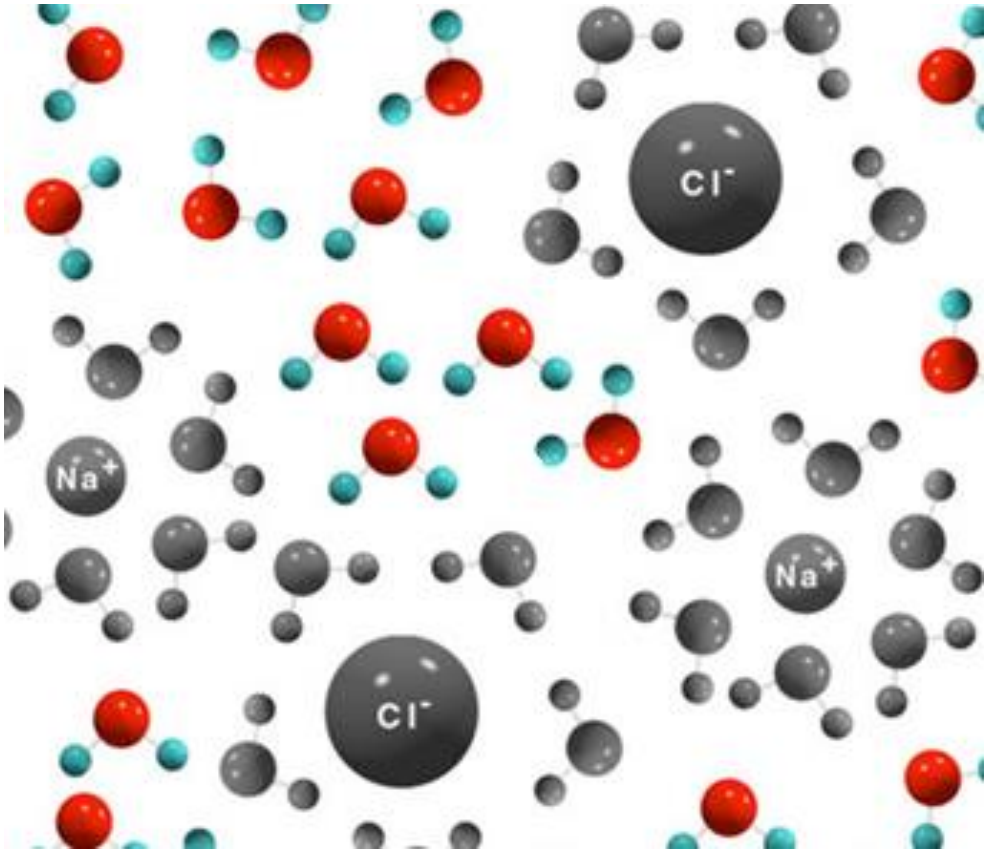
Dissolved salts in freshwater

- Some salts dissolve in water
  - Positive and negative components dissociate:



Dissolved salts in freshwater

- In solution, salts are capable of transferring electricity



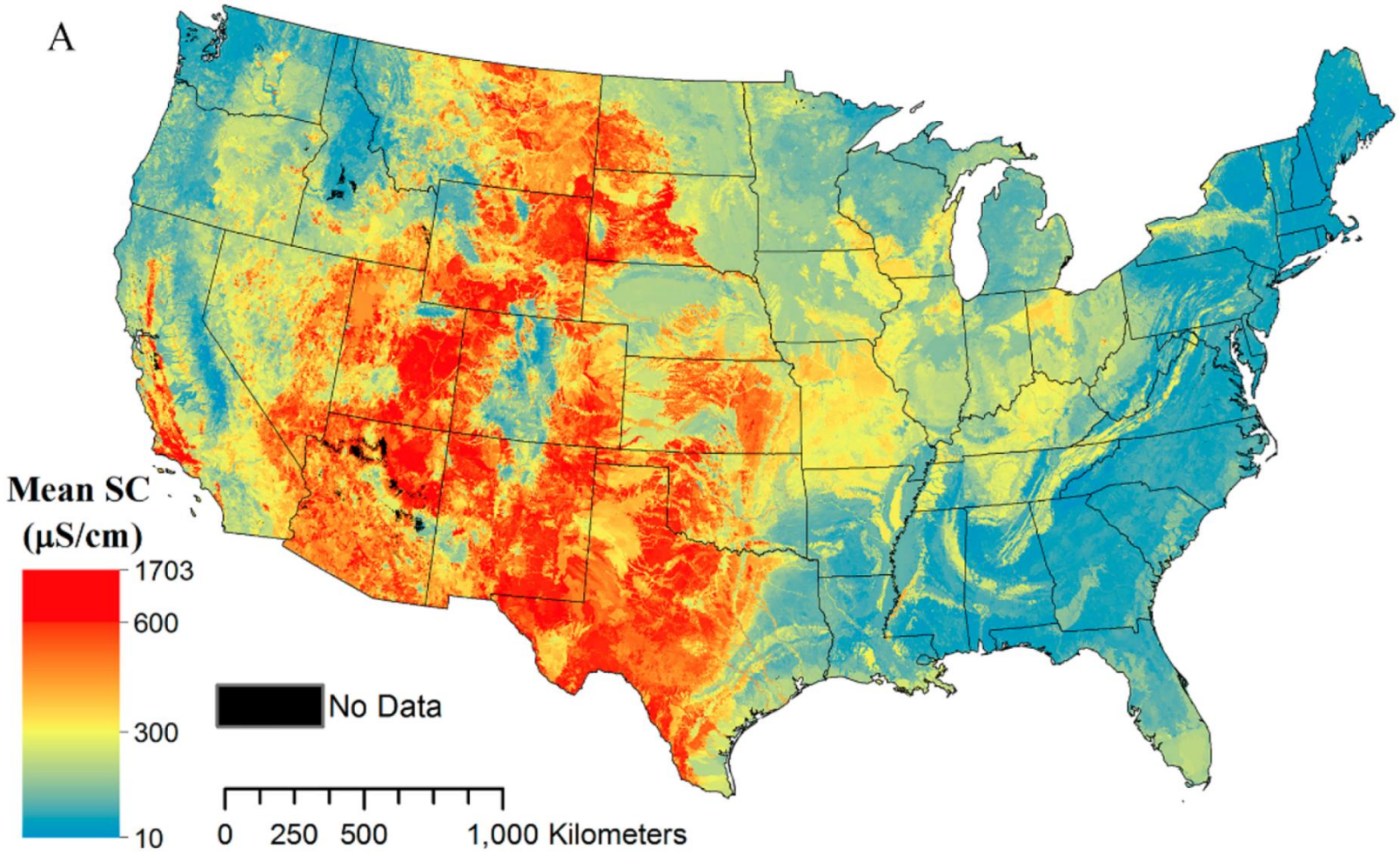
Natural Background SC

- Driven by type of soil and geologic materials in the watershed

Dolores River, Utah (~2000 uS/cm)

Chubb River, Adirondack Mountains (~50 uS/cm)

Natural Background SC in the US



Olson, J.R. and Cormier , S.M., 2019. Modeling Spatial and Temporal Variation in Natural Background Specific Conductivity. *ES&T, 53*.

Freshwater salinization syndrome

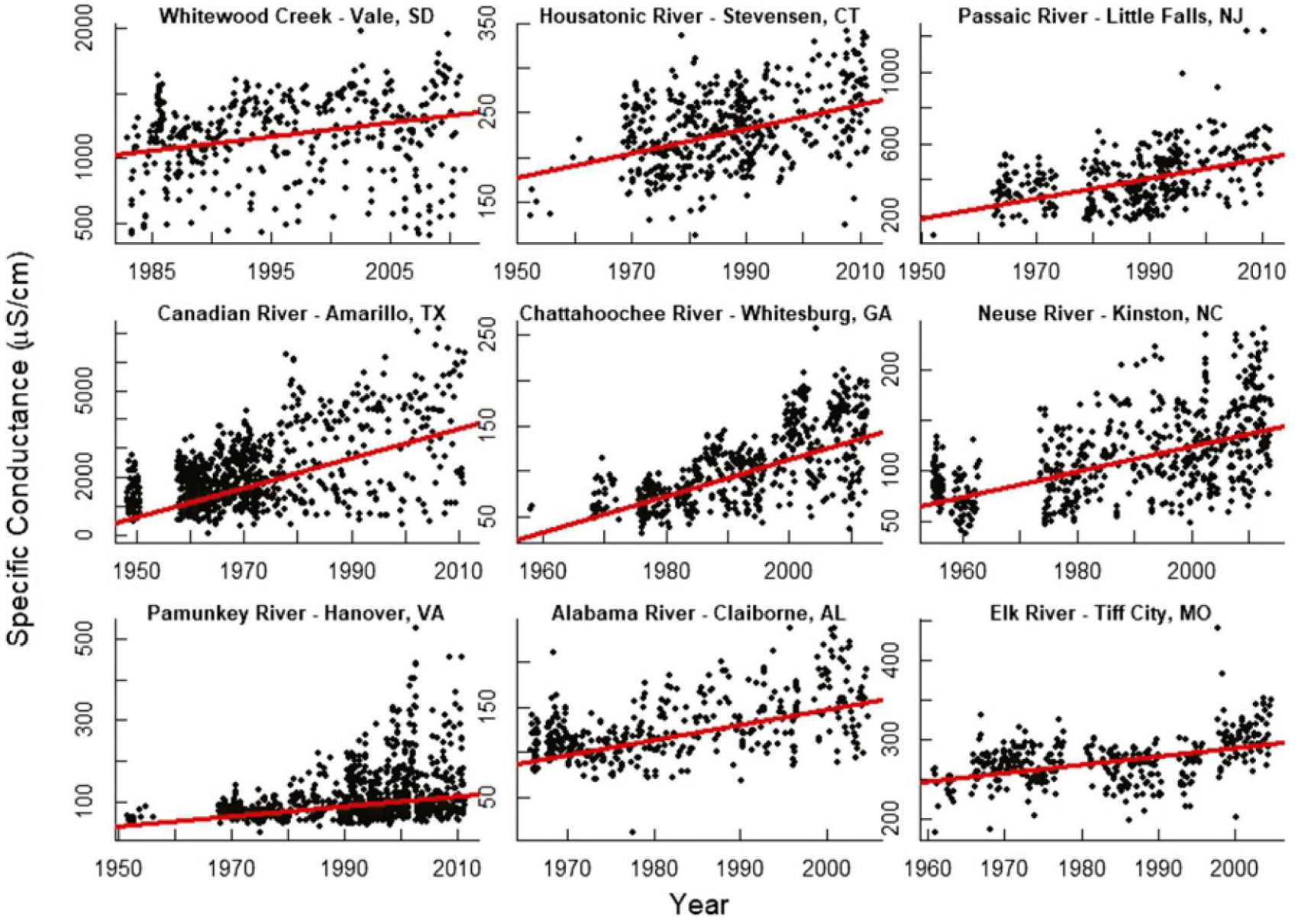
- Increasing concentration of salts.
- Has affected nearly 40% of the drainage area of the contiguous US in last 100 years.
- Most prominent in the densely populated eastern and midwestern US

Freshwater salinization syndrome

- Causes:
  - Salt pollution:
    - Road deicers, irrigation runoff, sewage.
  - Accelerated weathering of natural geologic materials by strong acids (e.g., acid rain, fertilizers, and acid mine drainage)
  - Easily weathered minerals used in agriculture (lime) and urbanization (concrete).

Freshwater salinization syndrome

- Not only table salt (NaCl)
- Also other salts of substances like:
  - Magnesium, Potassium, Sulfate, Carbonate
- So: electric conductivity is an excellent proxy for salt concentration.
  - Sensors for continuous measurements are available
    - Cheap and very reliable.



Freshwater salinization syndrome on a continental scale. Kaushal et al. 2018, PNAS

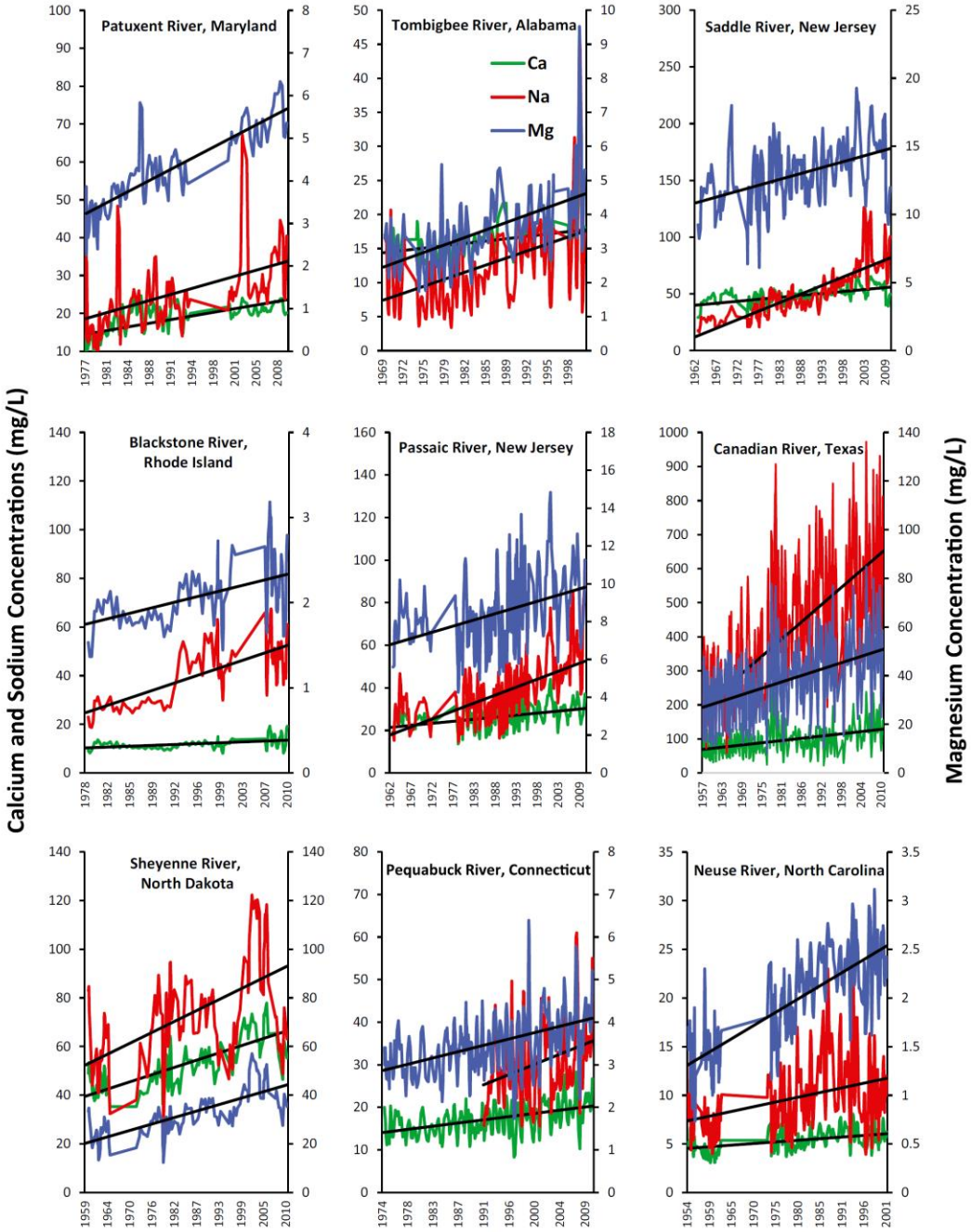
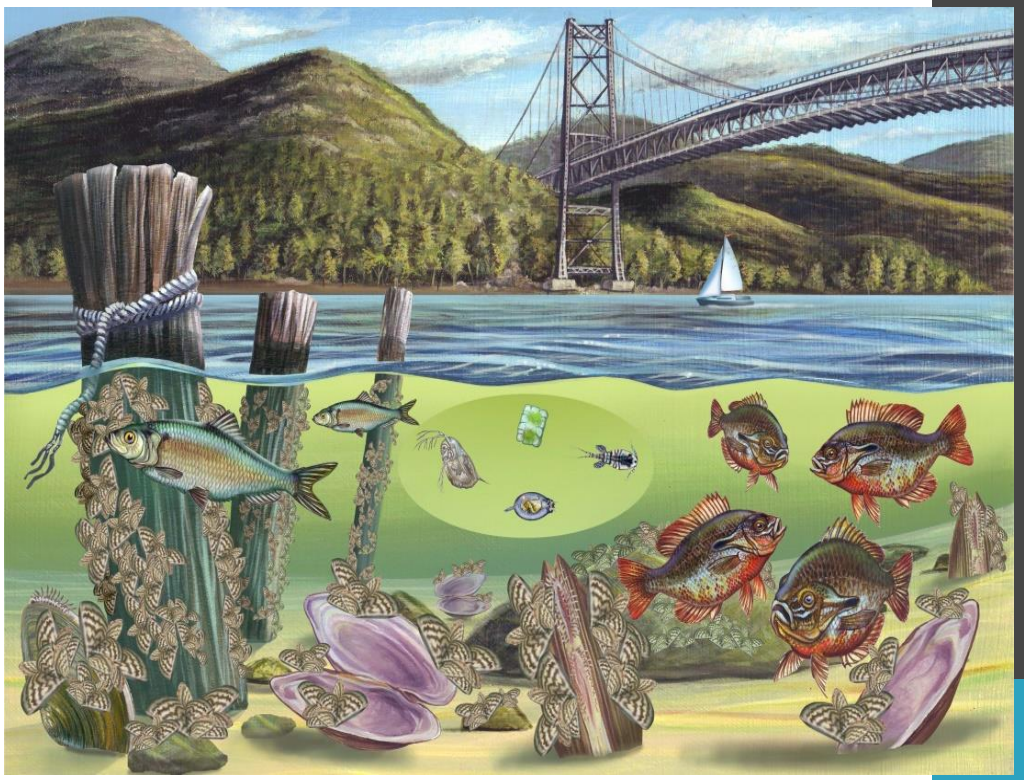


Fig. 5. Examples of increasing trends in base cations (sodium, calcium, and magnesium) in stream water throughout the continental United States. Time series were smoothed as moving averages over every three data points/observations. Please note that vertical axes differ.

- Freshwater salinization syndrome on a continental scale. Kaushal et al. 2018, PNAS

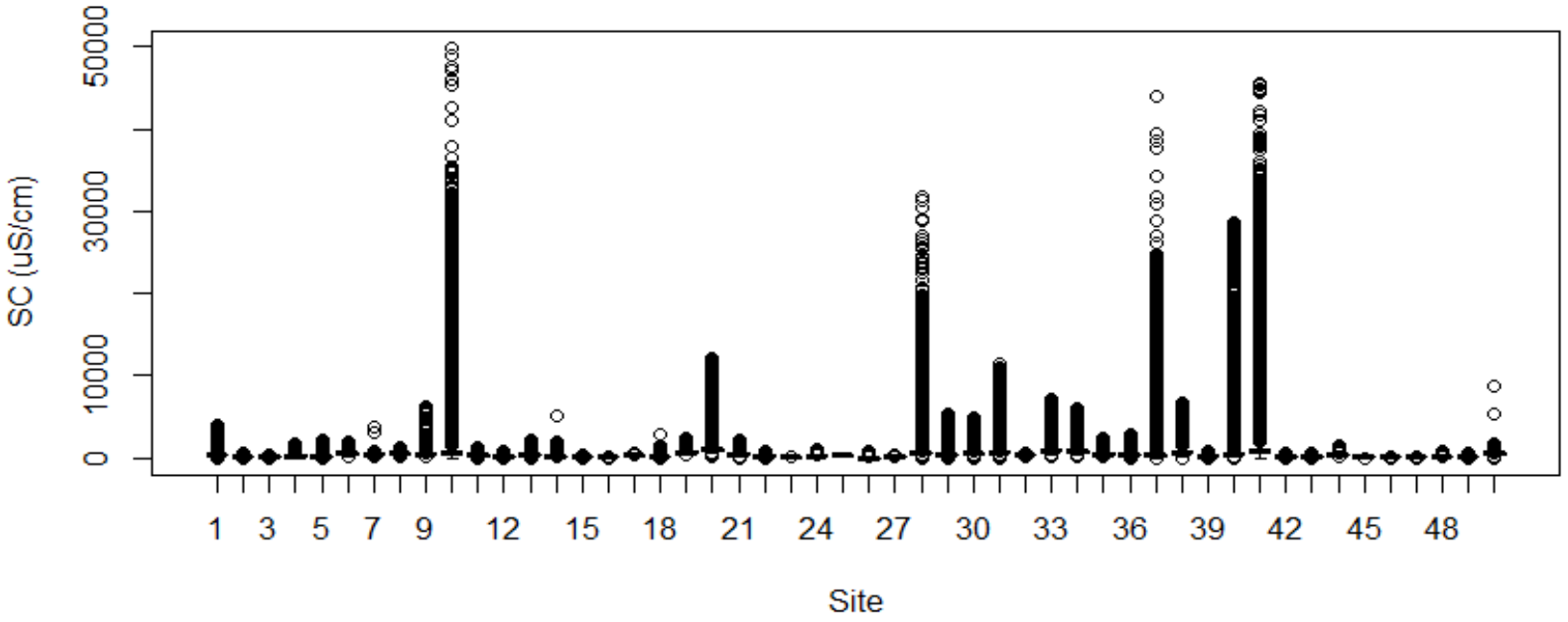
Why is this a problem?

- Variations in salt concentrations make it harder for many freshwater organisms to maintain osmotic balance.
  - Delayed growth
  - reduced feeding efficiency
  - increased drift
  - Alteration
    - trophic interactions
    - biochemical cycles
    - Leaf decomposition.
- Cascading effects on the ecosystem health



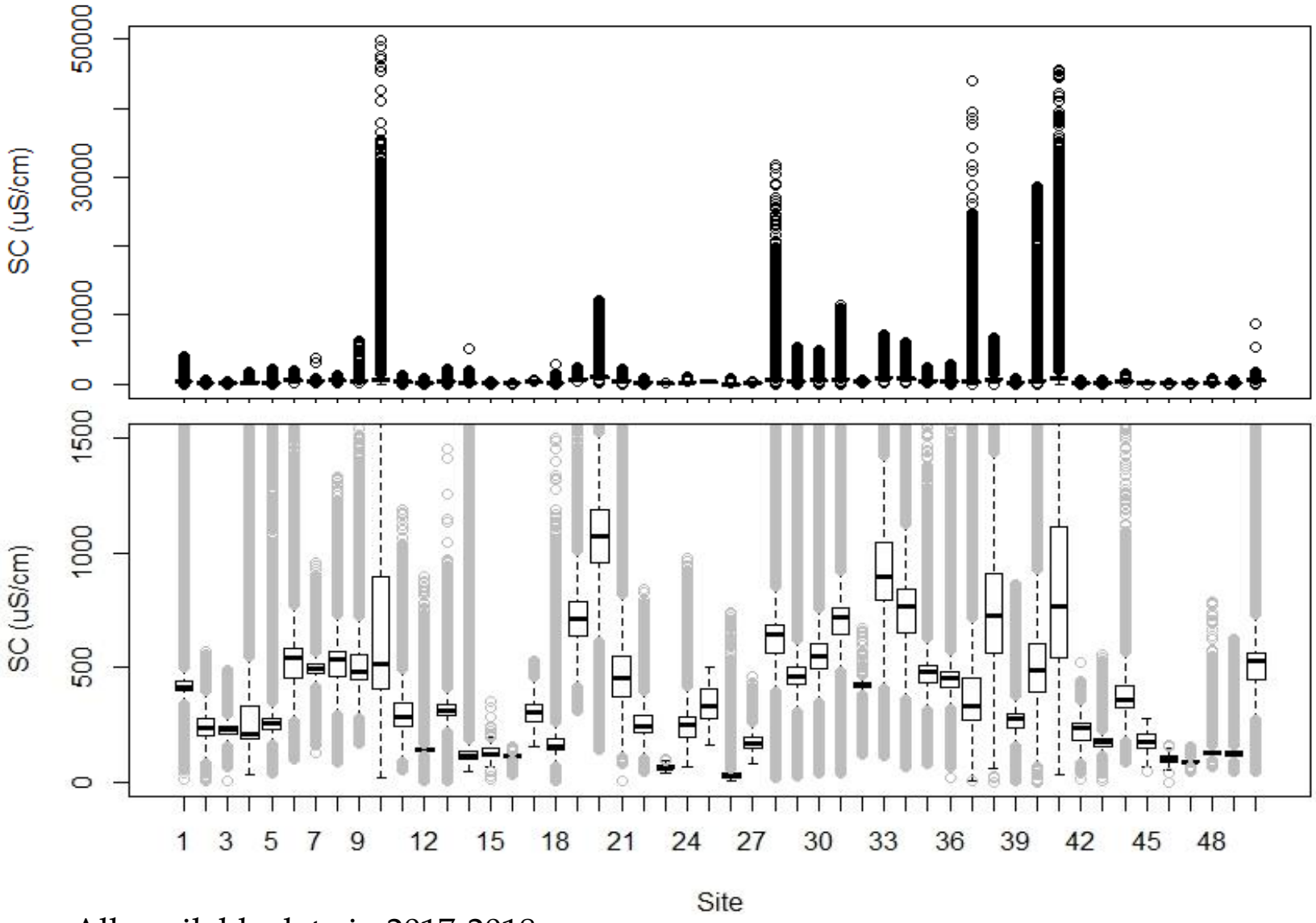
Are tributaries of the Delaware River Basin (DRB) experiencing increased salinization?

Specific conductivity (µS/cm)



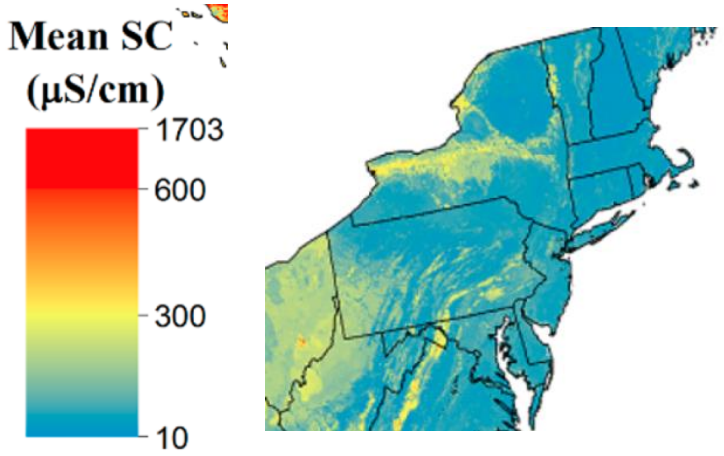
- All available data in 2017-2018

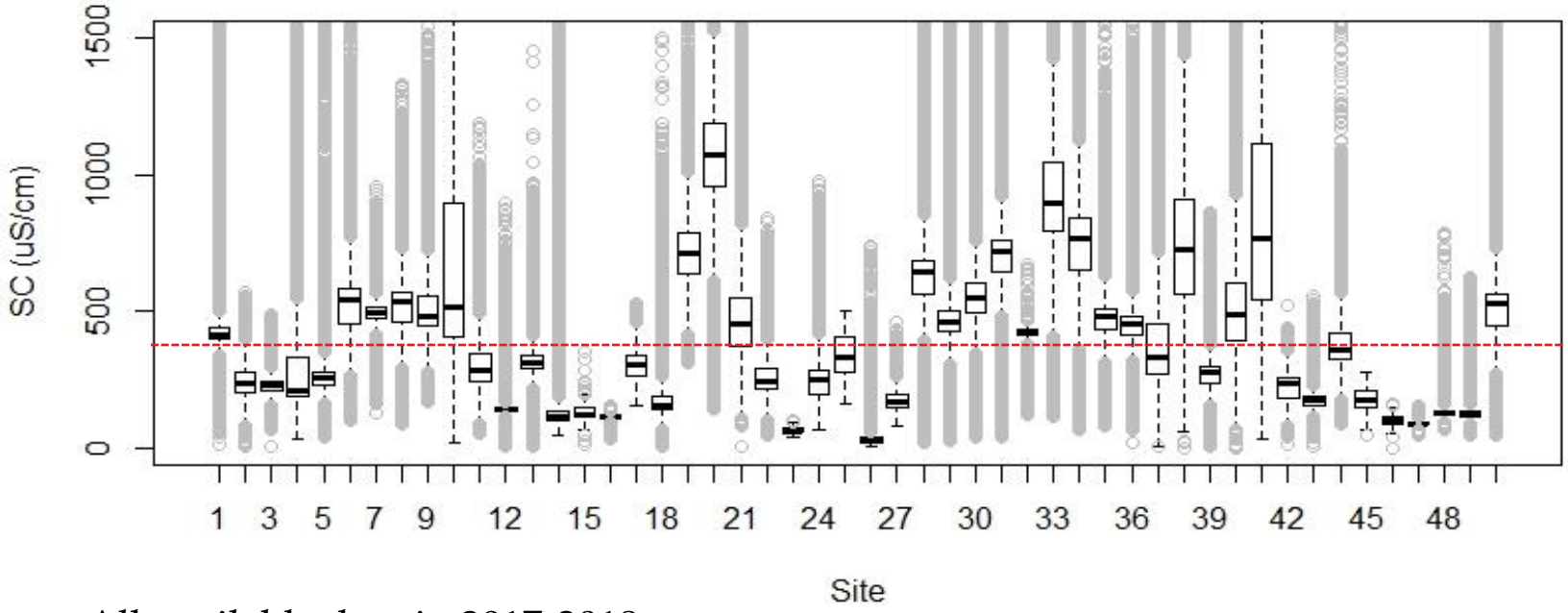
Specific conductivity (µS/cm)



- All available data in 2017-2018

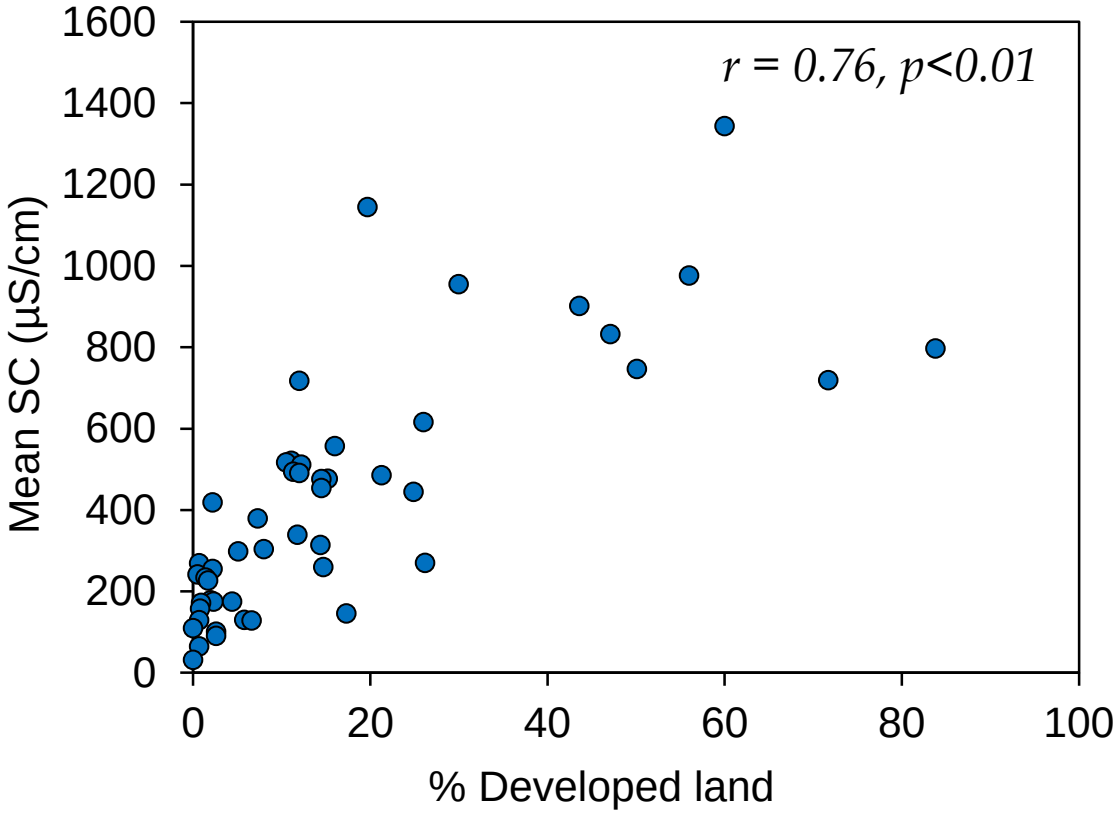
Specific conductivity (µS/cm)





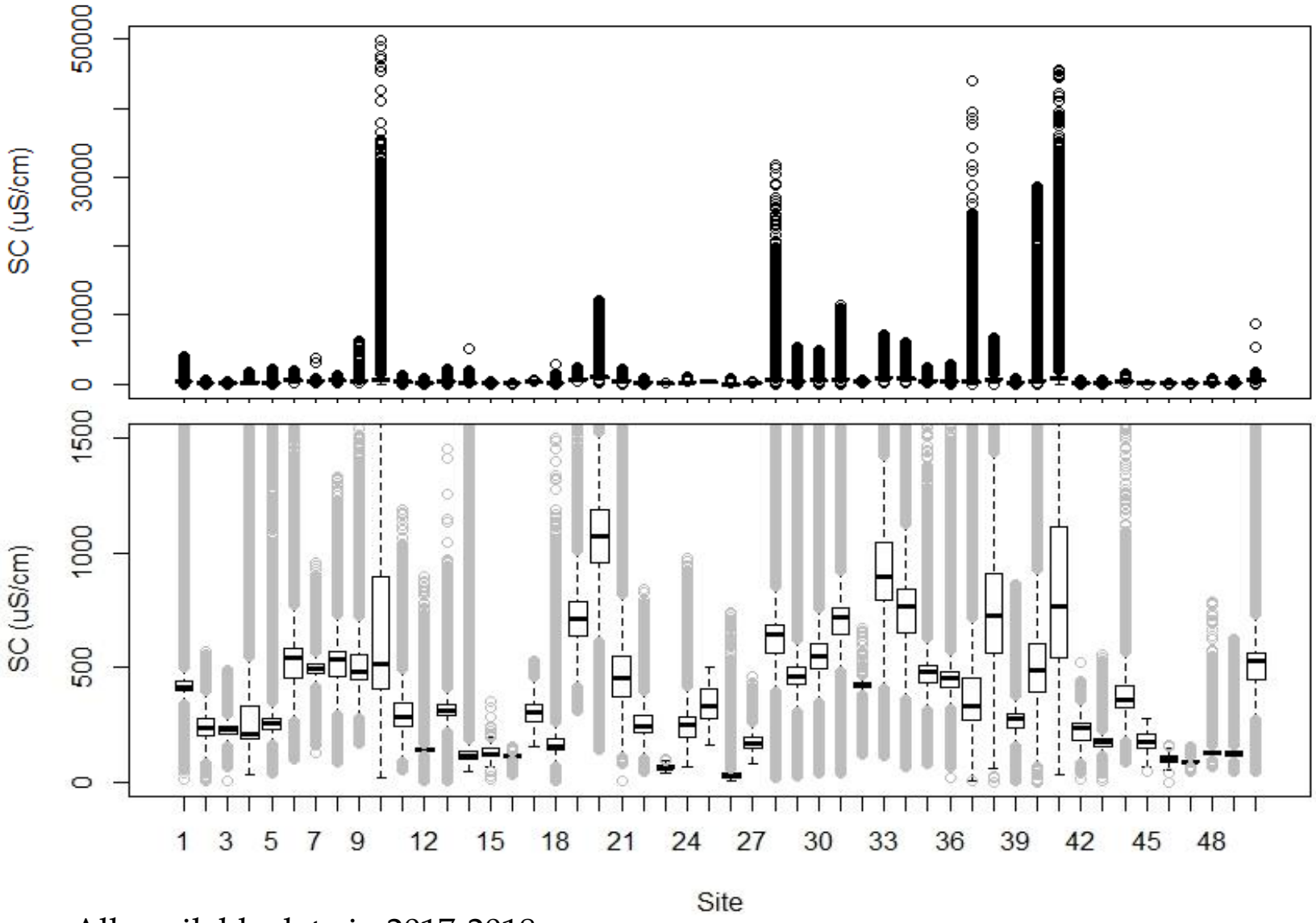
- All available data in 2017-2018

Specific conductivity and land use



- % developed land in the WS was the best land-use predictor of mean SC across the study period

Specific conductivity (µS/cm)



- All available data in 2017-2018


READING
Angelica Creek
Punches Run


READING
Angelica Creek
3 miles
Punches Run

Punches Run, 0.63 km^2

Forest: 88%

Angelica Creek, 20 km^2

Forest 50%

Urban: 14%

Agricultural: 8%

Punches Run, 0.63 km^2

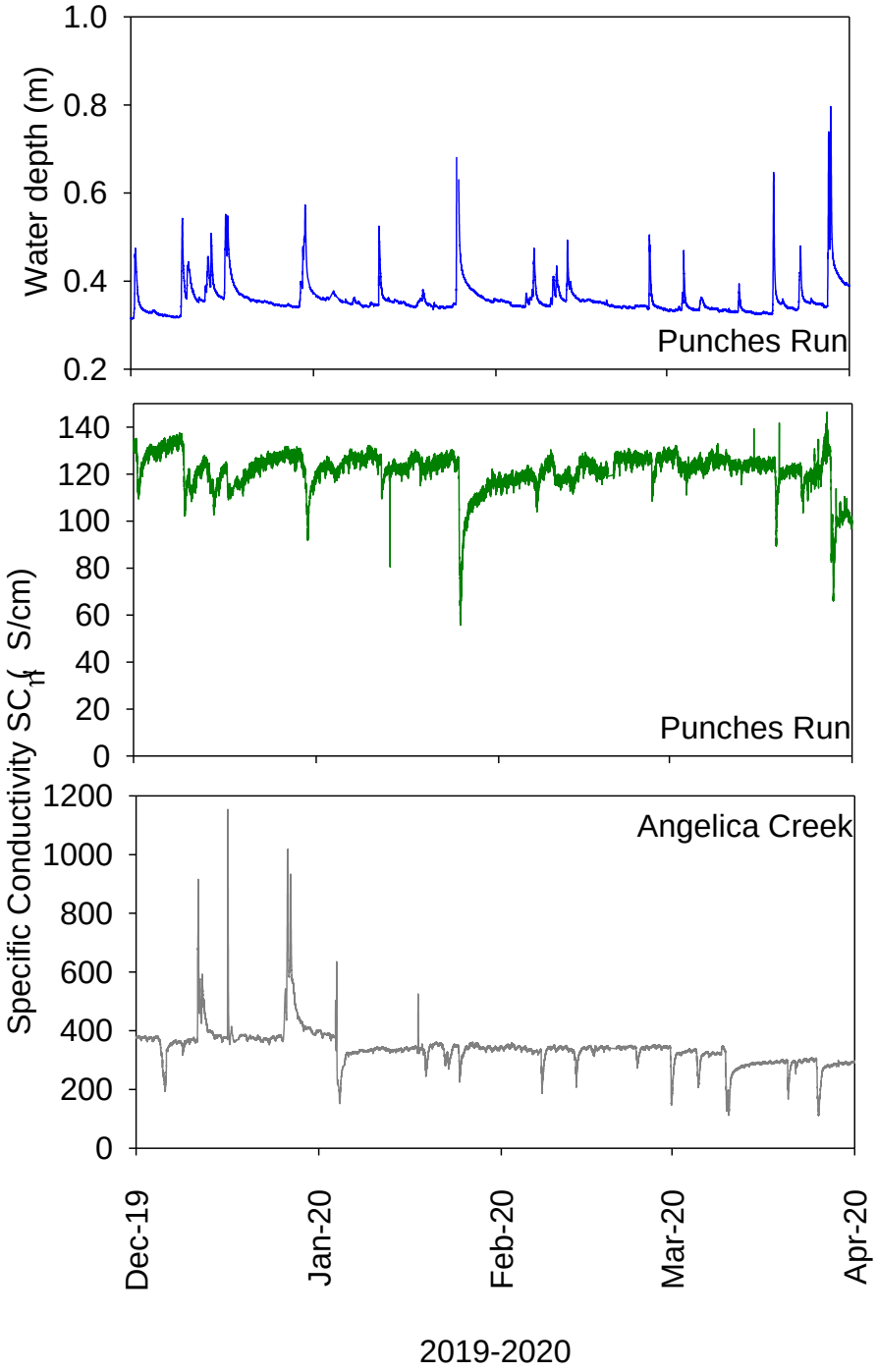
Forest: 88%

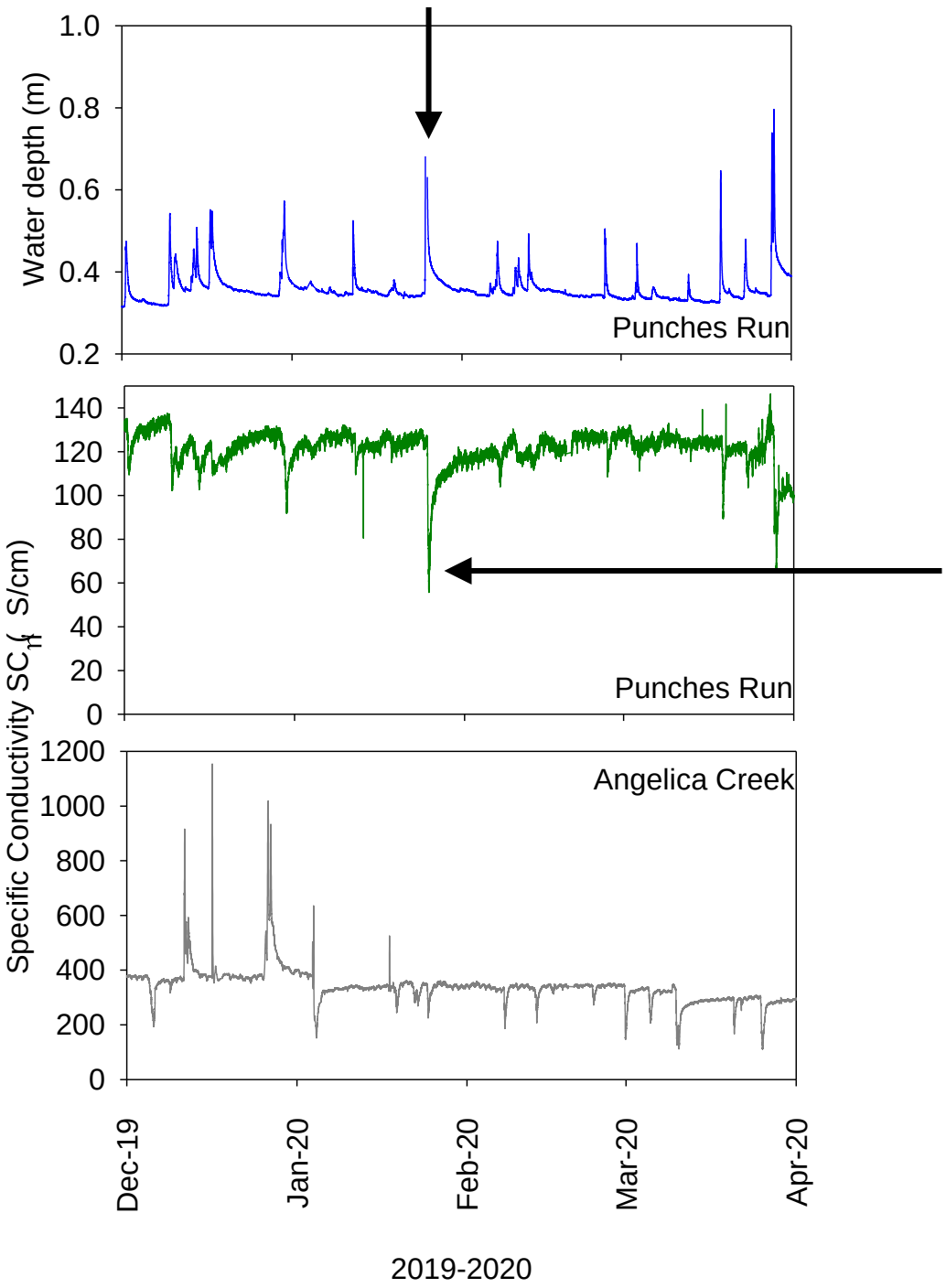
Angelica Creek, 20 km^2

Forest 50%

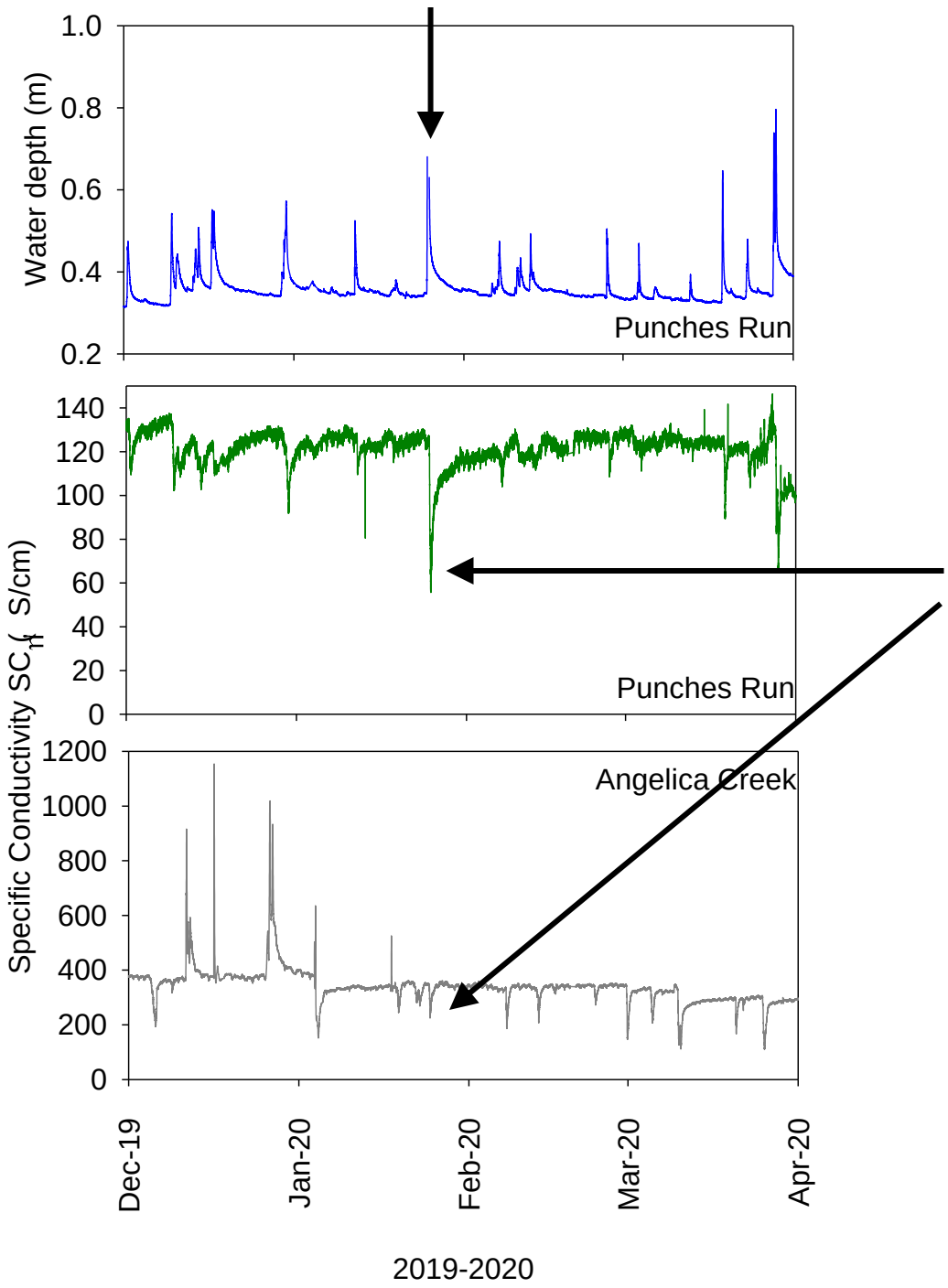
Urban: 14%

Agricultural: 8%

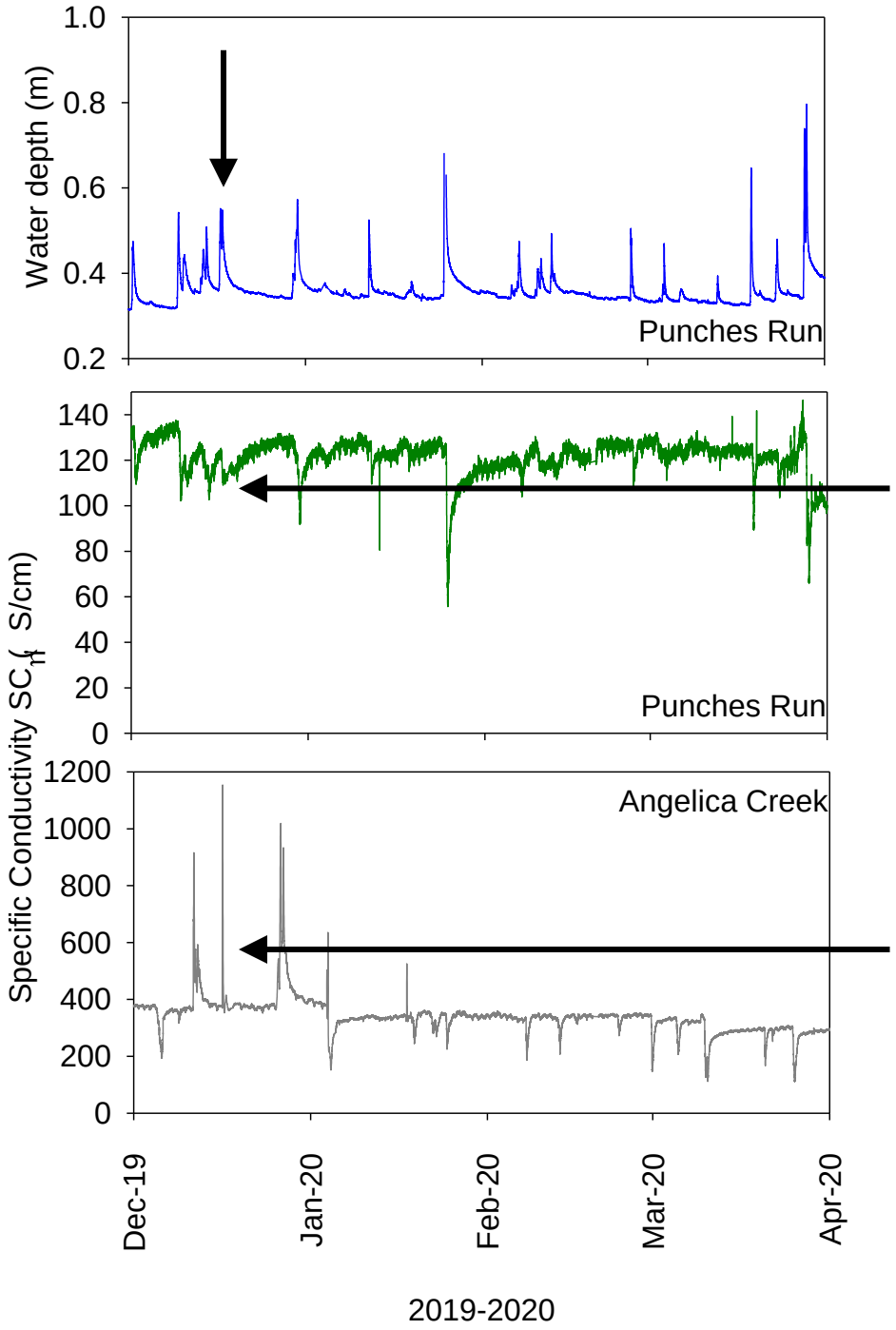

Water depth (m)
1.0
0.8
0.6
0.4
0.2
Punches Run
Specific Conductivity SC25 (µS/cm)
140
120
100
80
60
40
20
0
Punches Run
1200
1000
800
600
400
200
0
Angelica Creek
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
2019-2020



Dilution with surface water of low SC

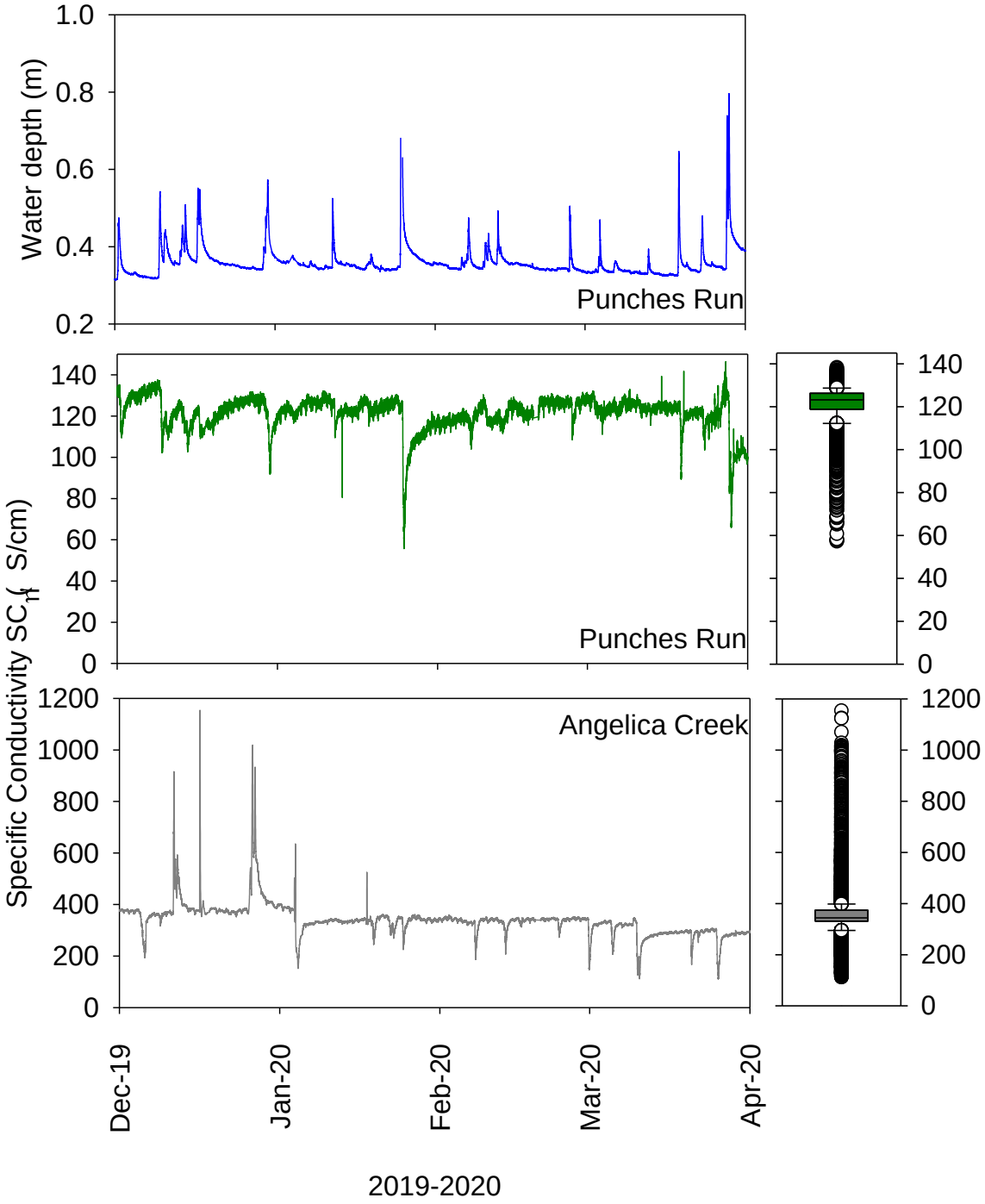


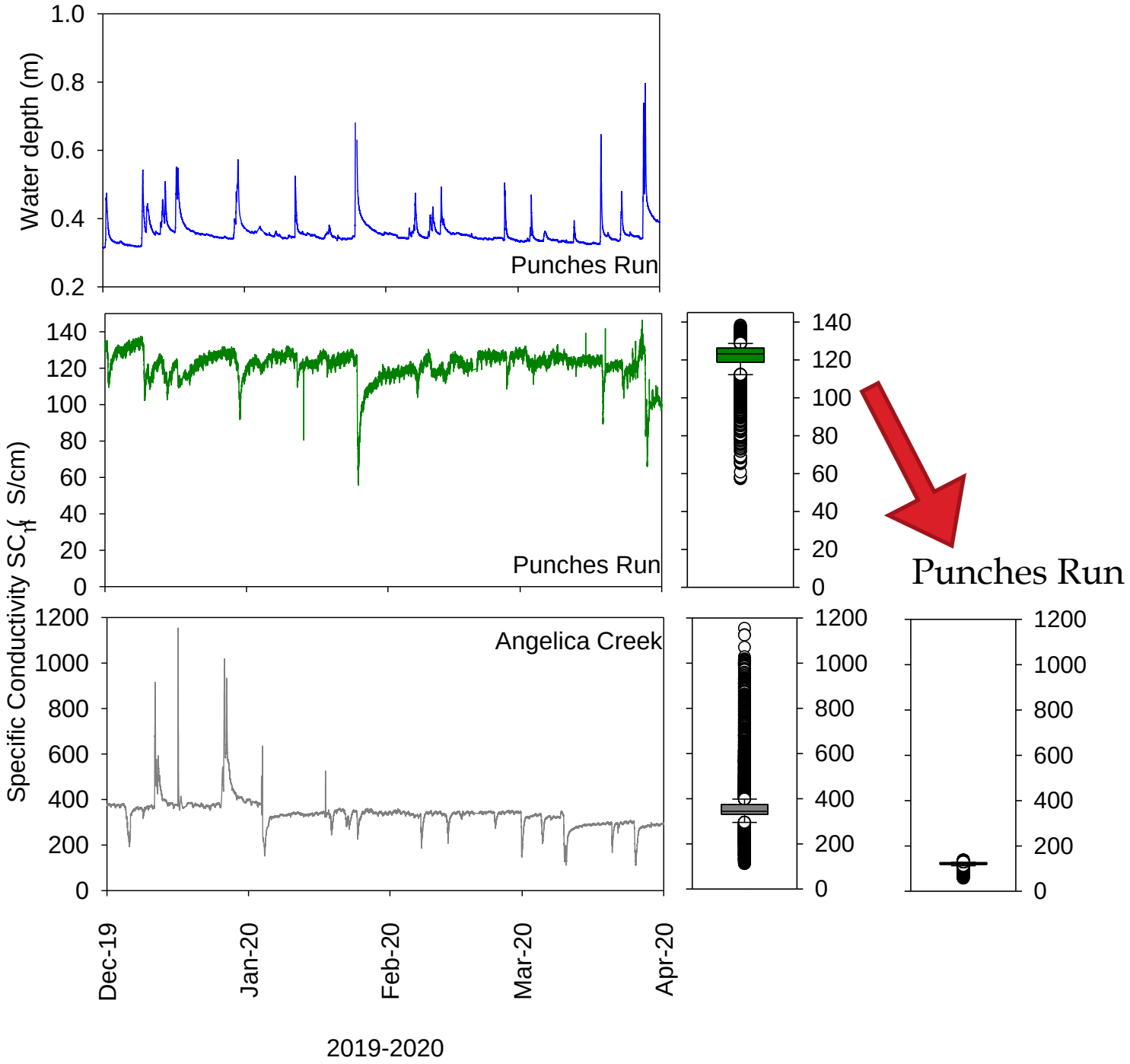
Dilution with surface water of low SC

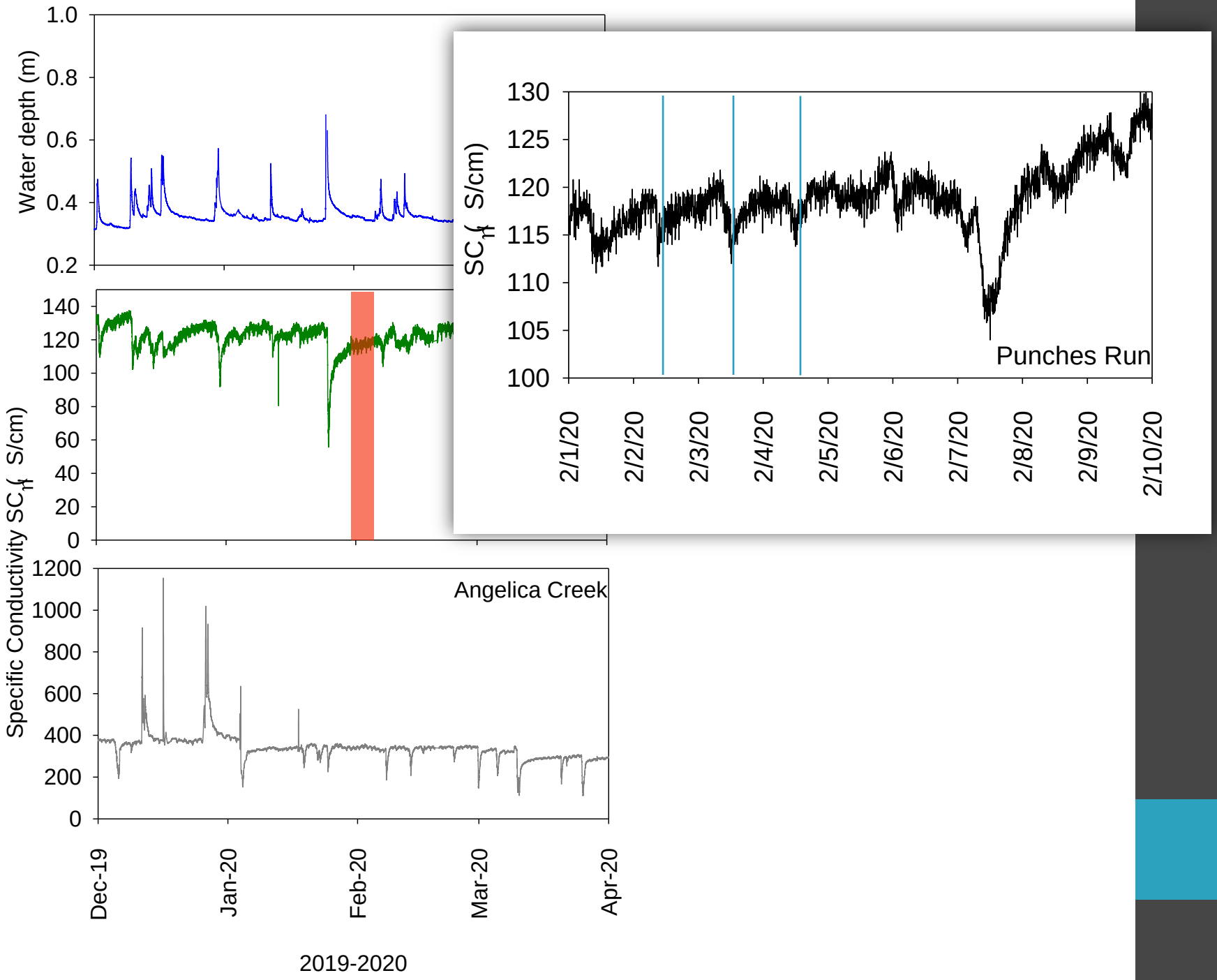


Dilution with surface water of low SC

Introduction of surface water of high SC


Water depth (m)
1.0
0.8
0.6
0.4
0.2
Punches Run
Specific Conductivity SC25 (µS/cm)
140
120
100
80
60
40
20
0
Punches Run
1200
1000
800
600
400
200
0
Angelica Creek
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
2019-2020


Water depth (m)
1.0
0.8
0.6
0.4
0.2
Punches Run
Specific Conductivity SC (µS/cm)
140
120
100
80
60
40
20
0
Punches Run
1200
1000
800
600
400
200
0
Angelica Creek
Punches Run
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
2019-2020


Water depth (m)
1.0
0.8
0.6
0.4
0.2
Specific Conductivity SC25 (µS/cm)
140
120
100
80
60
40
20
0
1200
1000
800
600
400
200
0
Angelica Creek
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
2019-2020
SC25 (µS/cm)
130
125
120
115
110
105
100
Punches Run
2/1/20
2/2/20
2/3/20
2/4/20
2/5/20
2/6/20
2/7/20
2/8/20
2/9/20
2/10/20

In summary:

- Yes, tributaries of the DRB are experiencing increased salinity.
  - Related to land use, urbanization
    - Winter extremes likely related to road salt application
- Knowledge on salt toxicity is rapidly increasing
  - negative additive joint effects of salinity and other stressors
  - Still a lot to learn

Acknowledgments

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Bartrams Garden
Berks County Conservation District
Berks Nature
Brodhead Watershed Assocation
Darby Creek Valley Association
Delaware Riverkeeper
East Stroudsburg University
Eastern Delaware County Stormwater Collaborative
Great Marsh Institute
Green Valleys Watershed Association
Lake Committee, Somerset Lake Community
Lopatcong Creek Initiative; NJ Highlands Coalition
Montgomery School
Musconetcong Watershed Association
Penn State Master Watershed Stewards, Berks County
Pennypack Ecological Restoration Trust
Primrose Creek Watershed Association
Schuylkill River Greenways
Silver Lake Nature Center
South Jersey Land & Water Trust
The Independence School
The Land Conservancy for Southern Chester County
The Nature Conservancy, Delaware
The Nature Conservancy, New Jersey
The Watershed Institute
Tookany/Tacony-Frankford Watershed Partnership
Trout Unlimited
Trout Unlimited, New Jersey
Upper Perkiomen High School
Valley Forge Trout Unlimited
Wallkill River Watershed Management Group
White Clay Wild and Scenic
Wildlands Conservancy
Willistown Conservation Trust
Wissahickon Valley Watershed Association
Woodstown High School

Thank you!