Specific conductivity in streams and rivers of the Delaware River Basin

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Online MWS and sensor station owner Workshop

Presenter:

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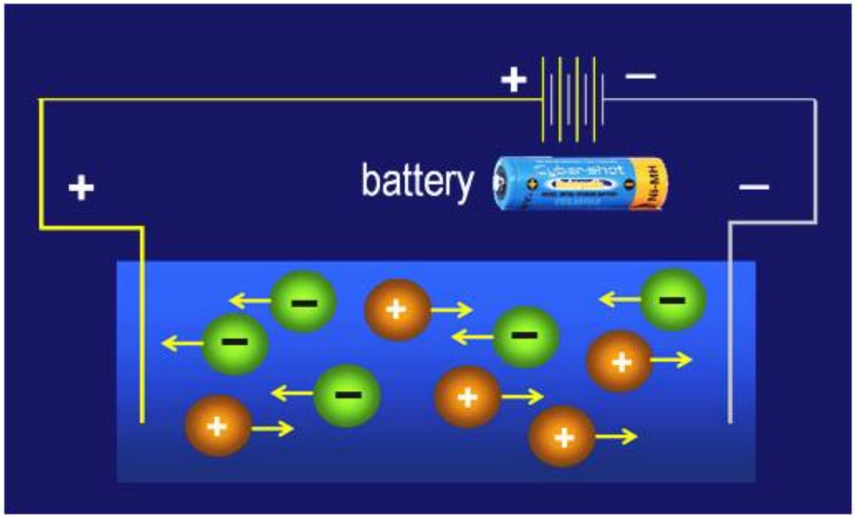
Electric conductivity (conductance)

- Measurement of the capacity of water to conduct an electric current as a result of the movement of ions through the solution. It depends on:
  - Temperature
  - Amount of dissolved ions

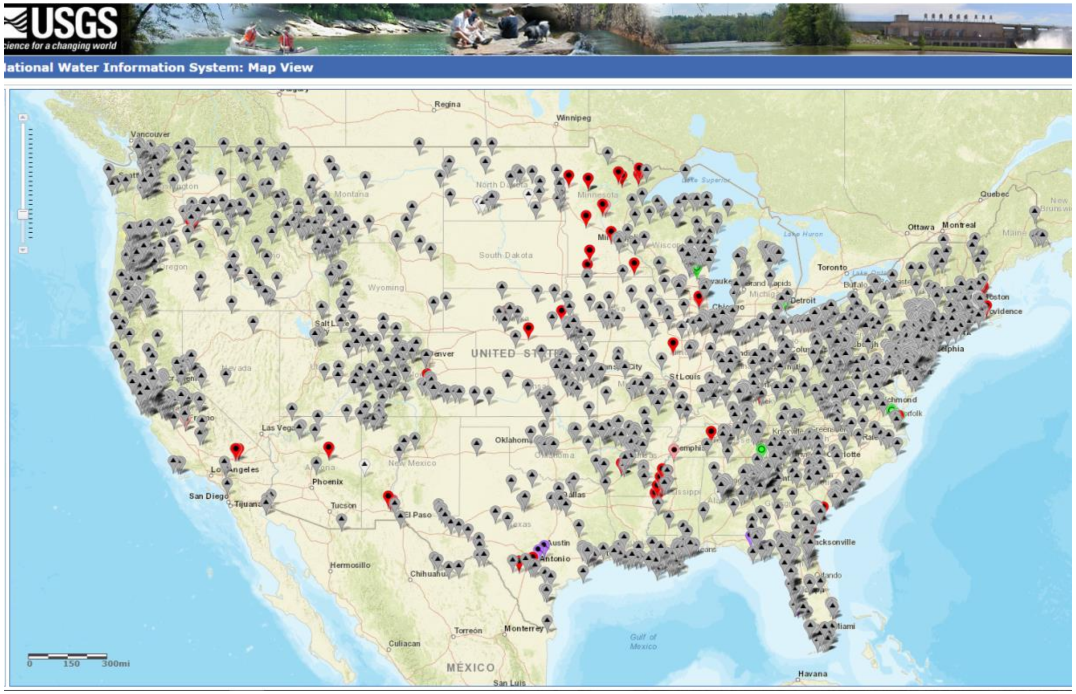


- What your sensor measures is **Specific conductivity**, already corrected for temperature (25 ºC)
- Units are (micro- mili-) Siemens per centimeter (S/cm)
- https://pubs.usgs.gov/tm/09/a6.3/tm9-a6_3.pdf

Electric conductivity (conductance)

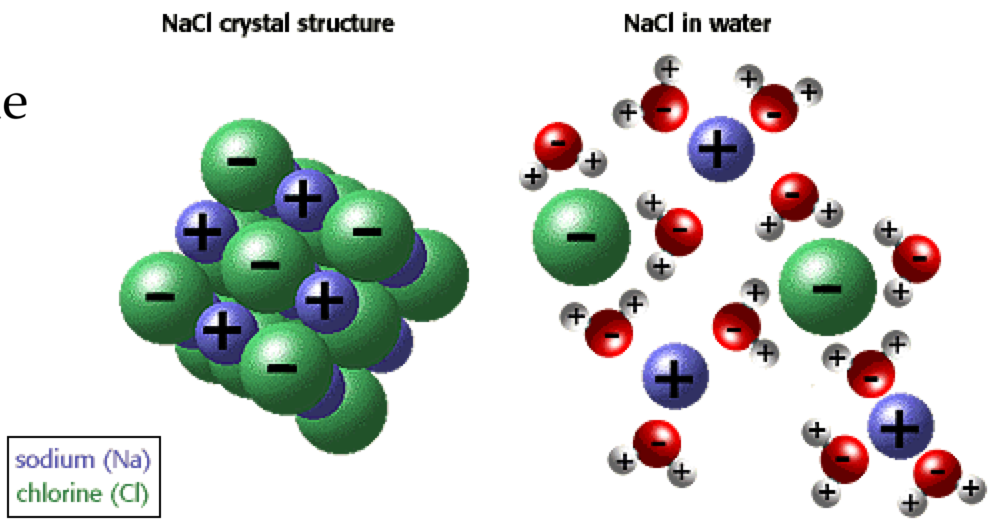
- Regularly measured during laboratory and field experiments by aquatic scientists as a rapid indicator of water chemistry and water quality.

- Often measured continually at USGS stream gauges
- https://waterdata.usgs.gov/nwis/rt



Specific conductivity (SC)

- Depends on the amount of dissolved ions in the water
- Concentration: mass of solute per unit of volume (e.g., mg/L)
- Ions: atoms or molecules with a charge (positive, negative), salts.
- NaCl, sodium chloride

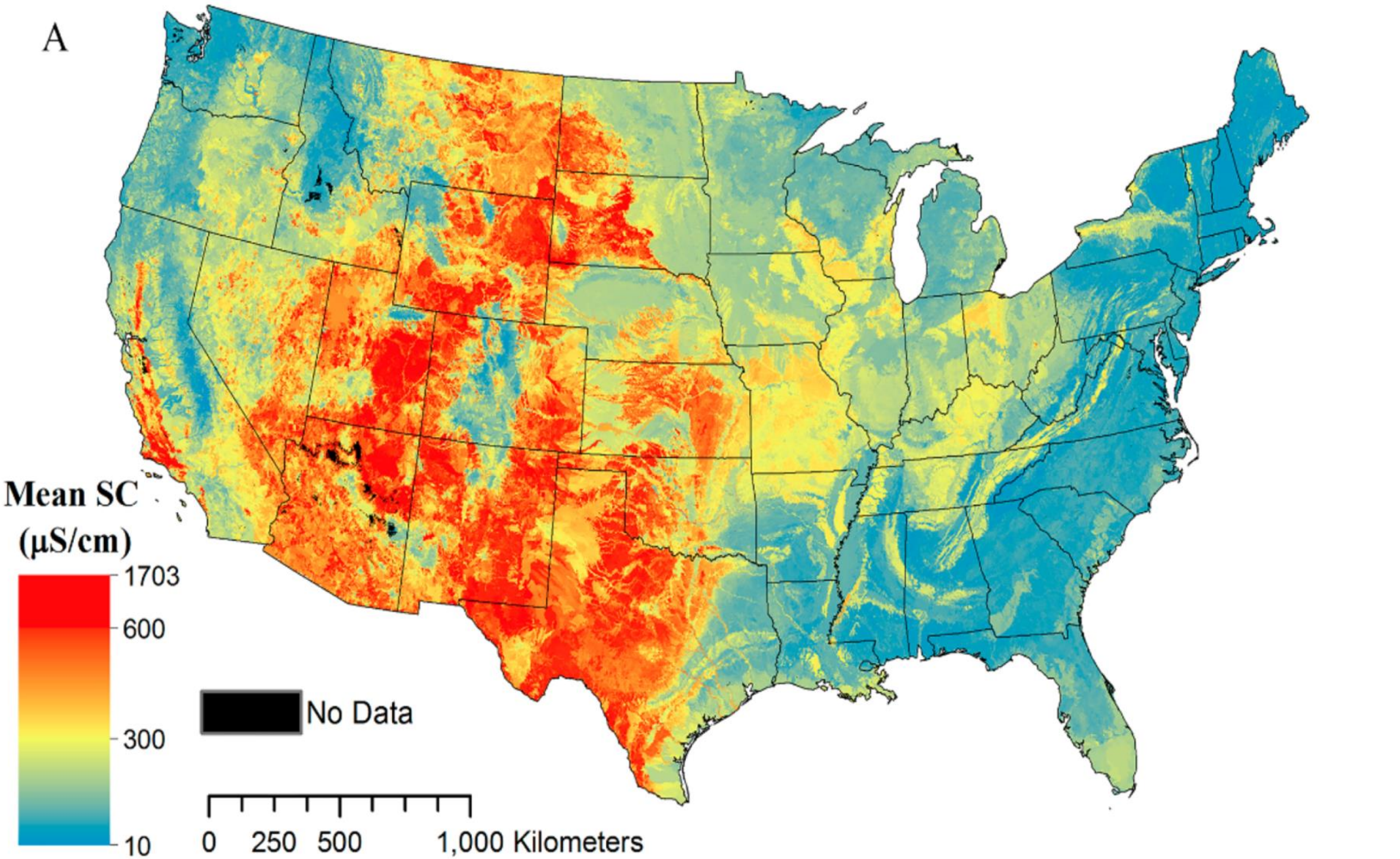


Specific conductivity (SC)

- Many more ions besides Na and Cl in natural waters:

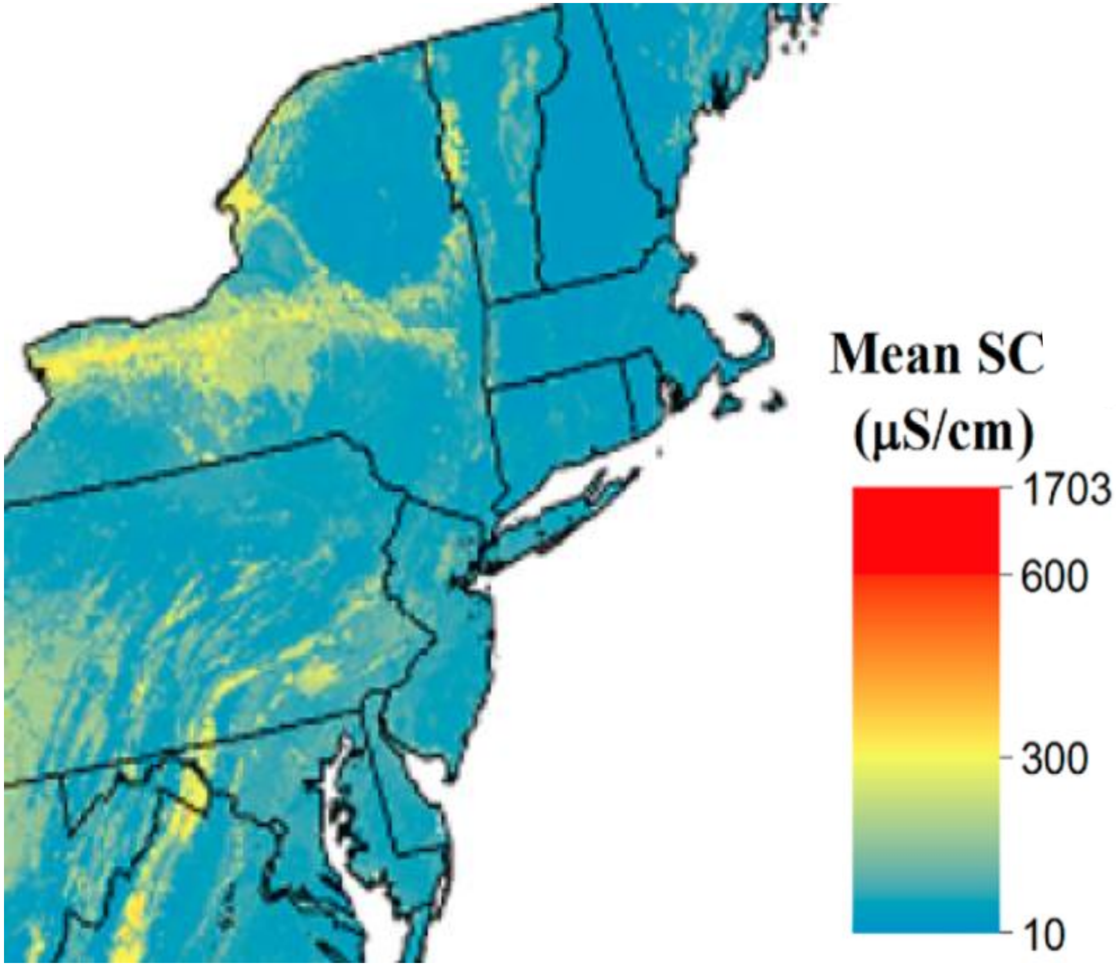
Major Cations	Formula
Calcium	Ca^{2+}
Magnesium	Mg^{2+}
Potassium	K^{+}
Sodium	Na^{+}
Major Anions	**Formula**
Bicarbonate/carbonate	HCO_3^{-}/CO_3^{2-}
Sulfate	SO_4^{2-}
Chloride	Cl^{-}
Silicate	$HSiO_3^{-}$

Natural Specific Conductivity in the US



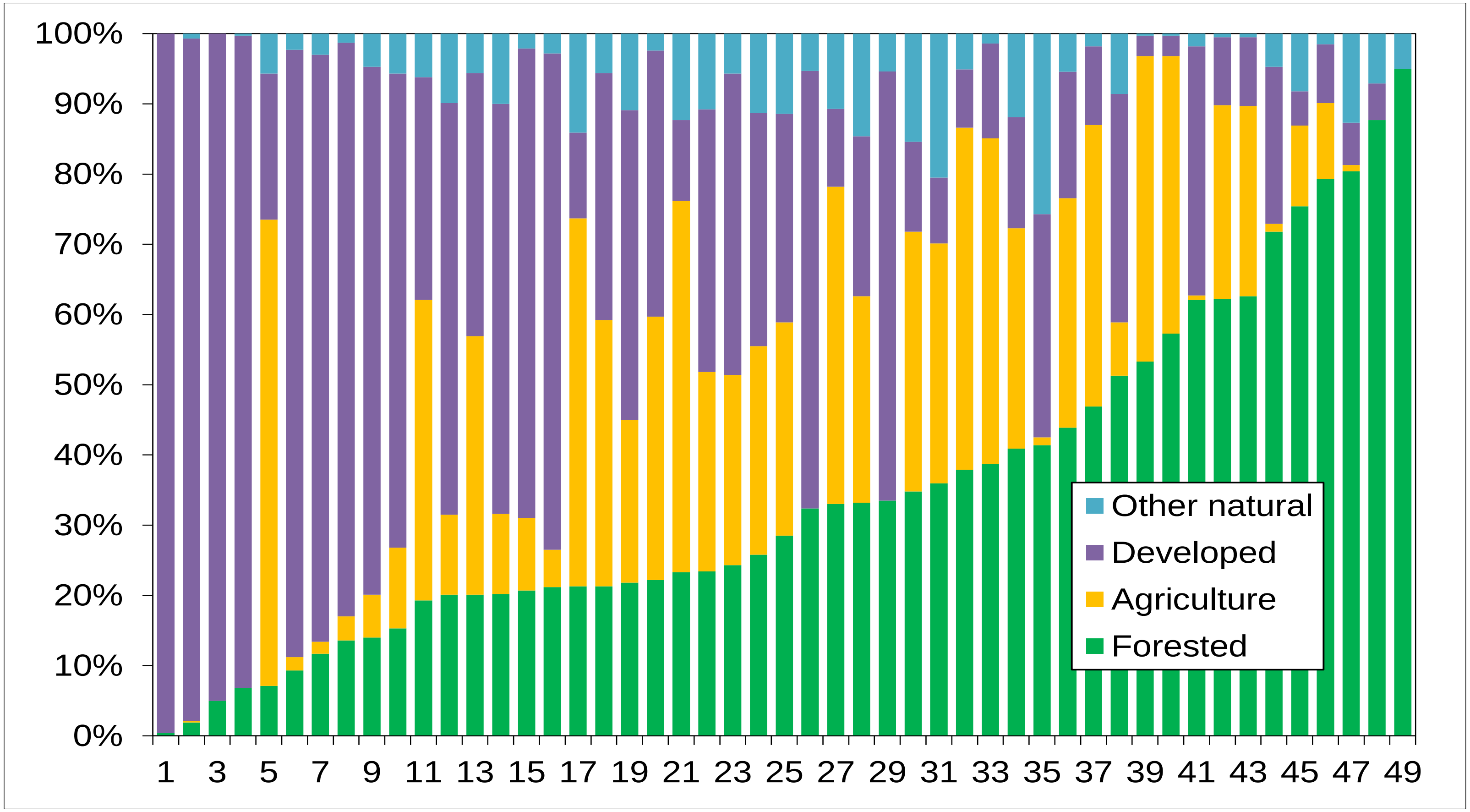
Olson, J.R. and Cormier , S.M., 2019. Modeling Spatial and Temporal Variation in Natural Background Specific Conductivity. *ES&T*, *53*.

Natural Specific Conductivity in the DRB



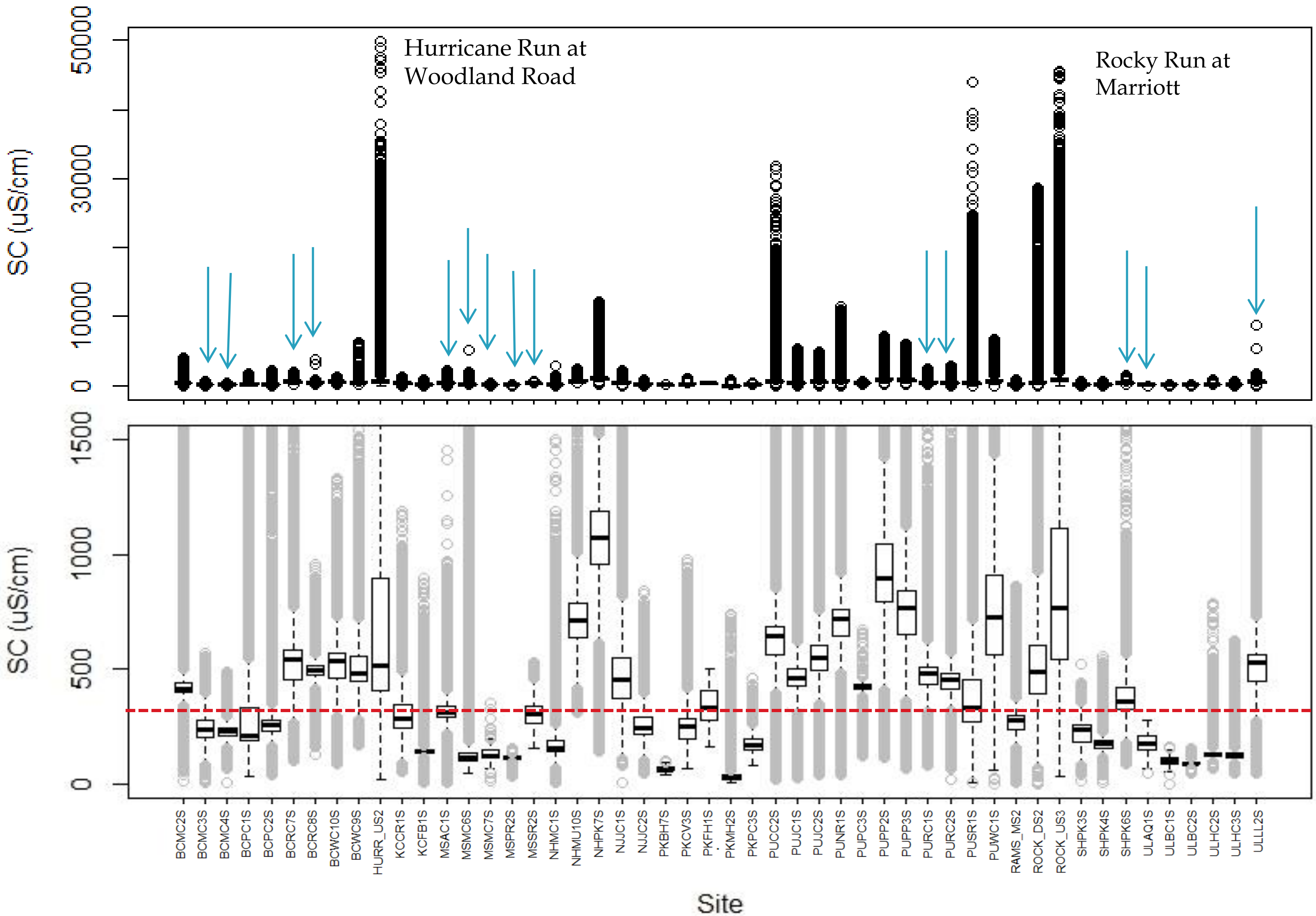
Olson, J.R. and Cormier , S.M., 2019. Modeling Spatial and Temporal Variation in Natural BackgroundSpecific Conductivity. *ES&T*, *53*.

DRWI study sites land-use



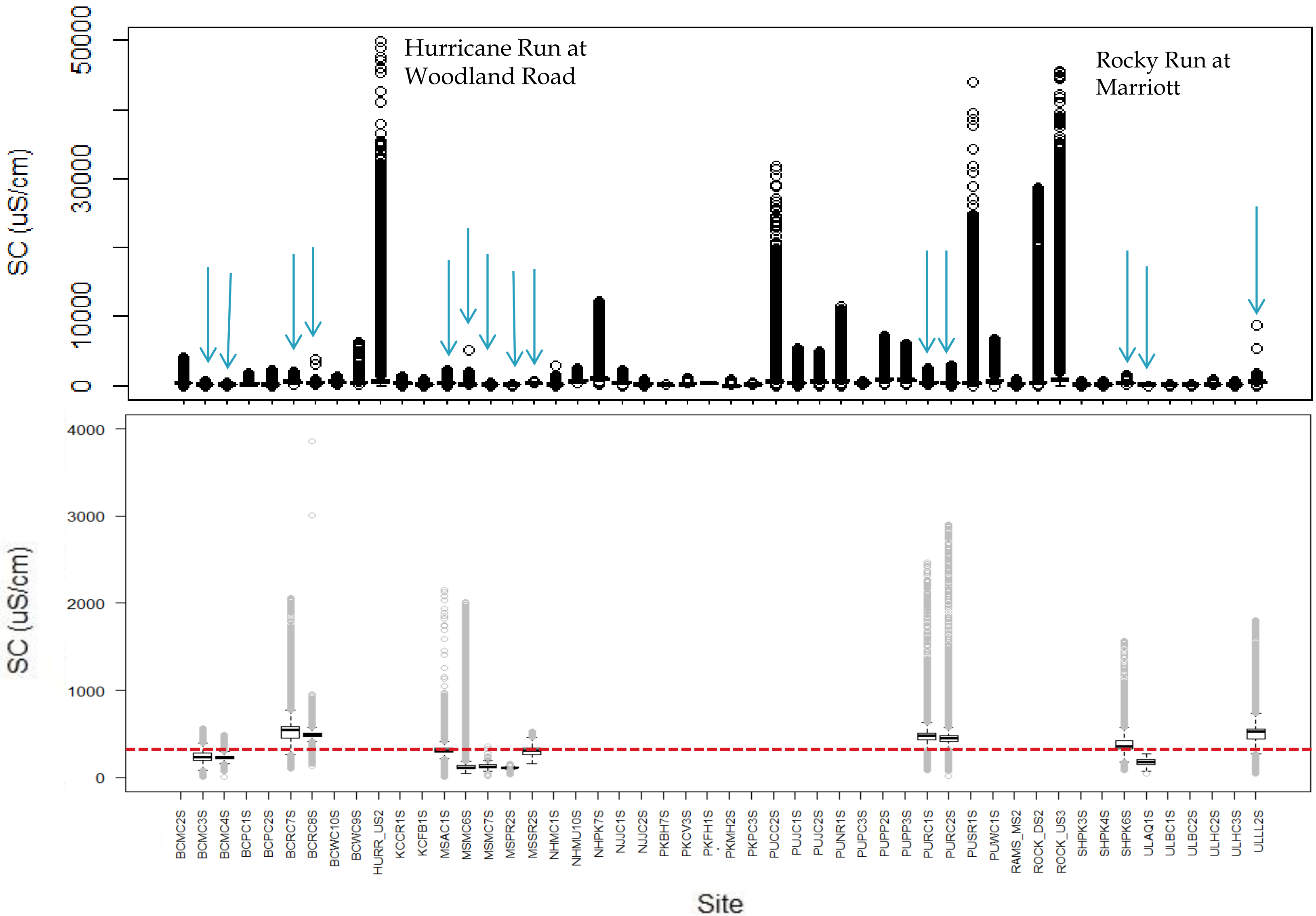
Land use data from the National Land Cover Database 2011 (NLCD2011)

Specific conductivity (µS/cm)



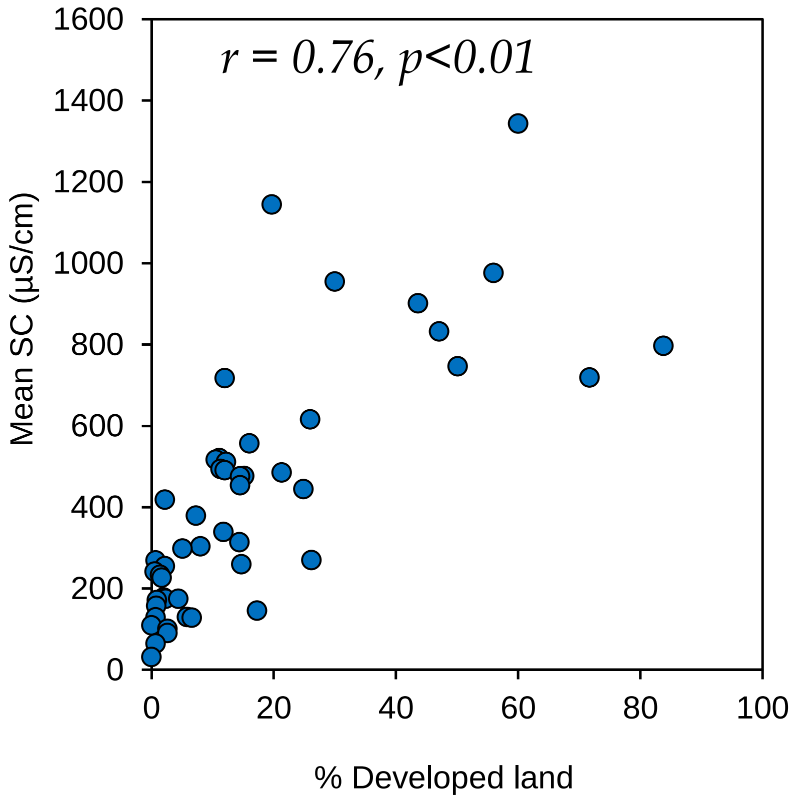
- All available data in 2017-2018

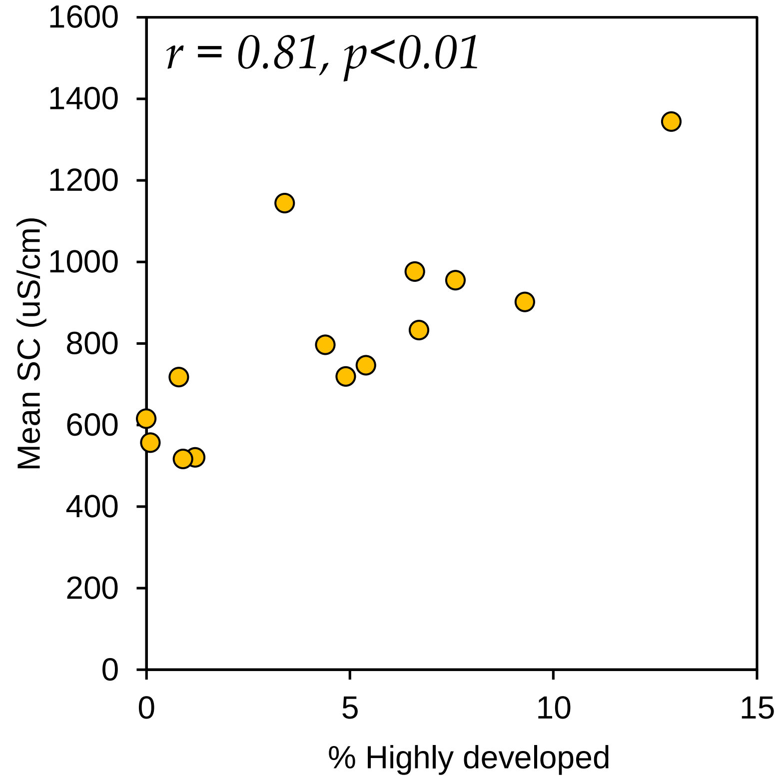
Specific conductivity (µS/cm)



- All available data in 2017-2018

Specific conductivity and land use

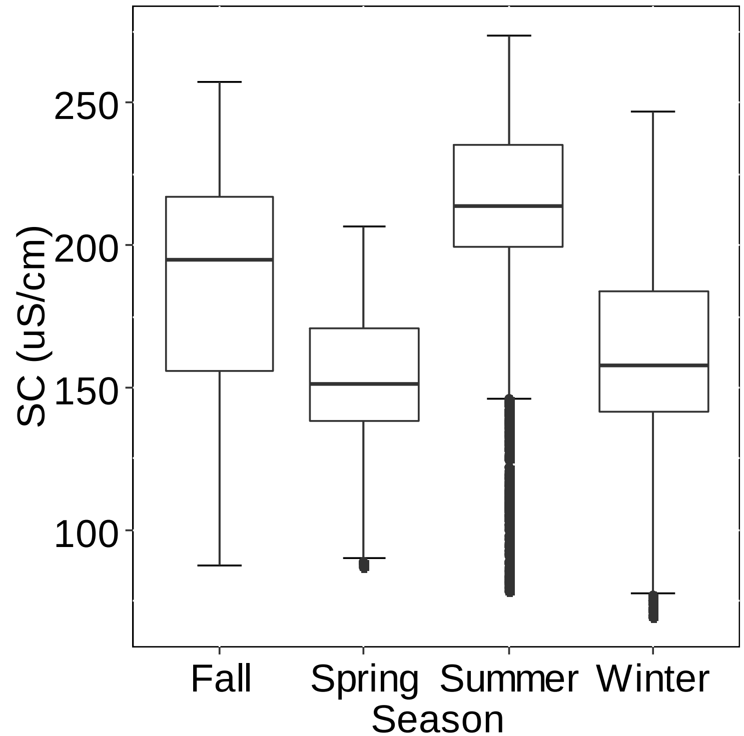




- % developed land in the WS was the best land-use predictor of mean SC across the study period
- For sites with highest mean SC, it was best explained by % highly developed land-use

Seasonal trends: forested streams

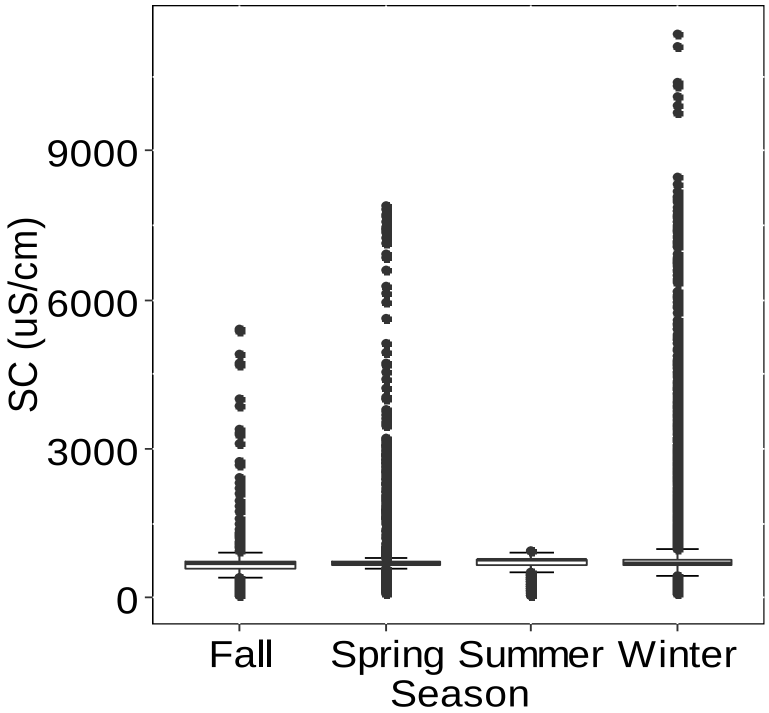
Aquashicola Creek, Monroe Co, PA
17 km^2



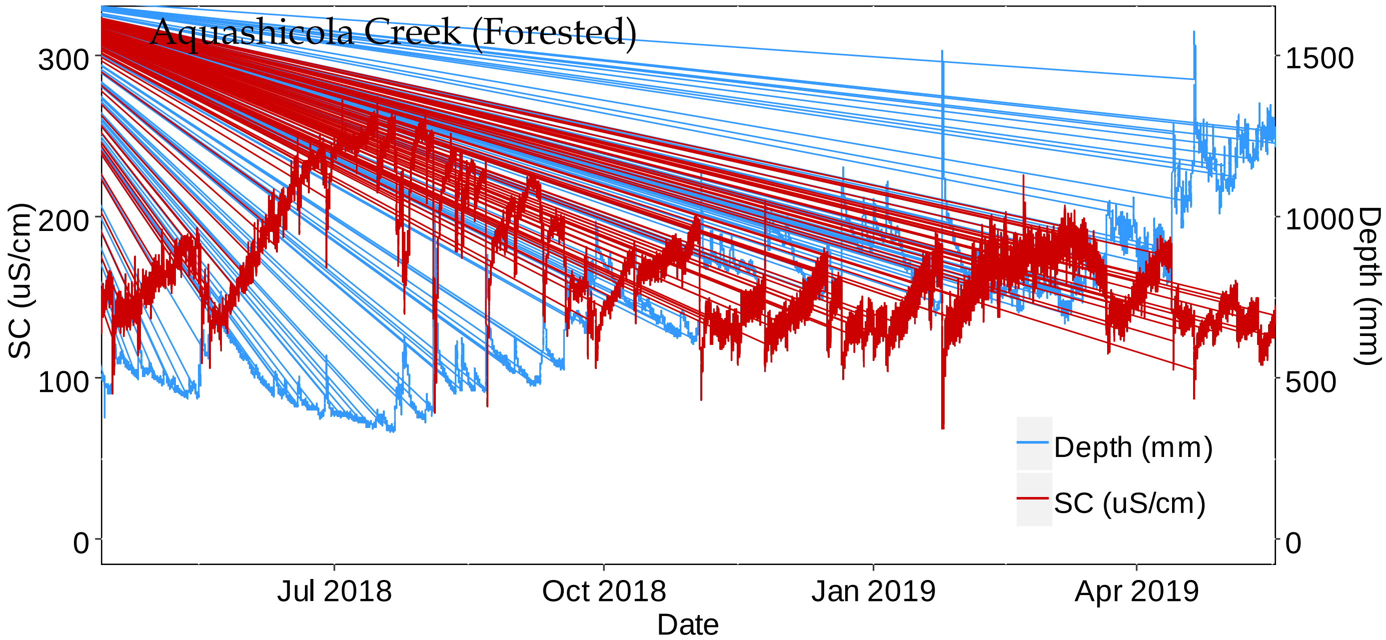
- 80% Forested
- Highest in summer – drier, no groundwater dilution with low-conductivity surface water
- Frequent low extremes, no high extremes

Seasonal trends: urban streams

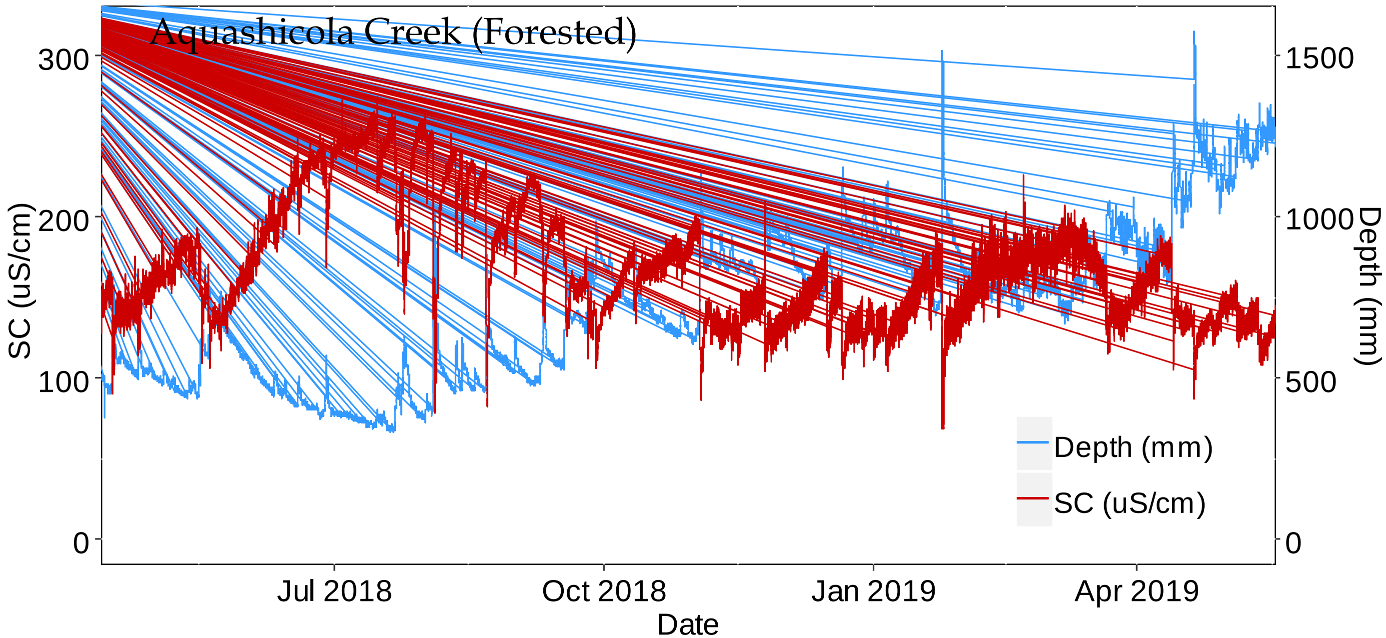
Naylors Run, Delaware Co, PA, 7 km^2

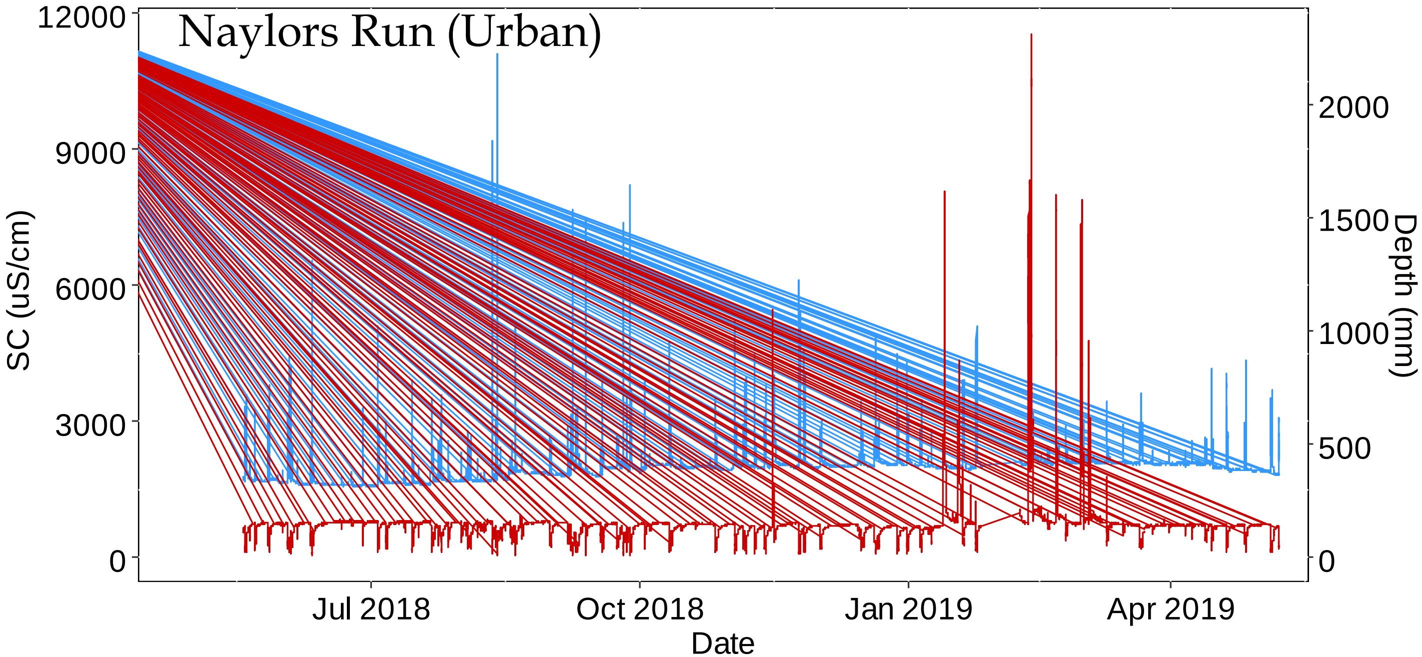


- 71% Urban
- Much higher SC relative to forested and agricultural
- Extreme SC in the winter but also in the fall and spring



Aquashicola Creek (Forested)
SC (uS/cm)
Depth (mm)
0
100
200
300
500
1000
1500
Jul 2018
Oct 2018
Jan 2019
Apr 2019
Date
Depth (mm)
SC (uS/cm)


Aquashicola Creek (Forested)
SC (uS/cm)
300
200
100
0
Depth (mm)
1500
1000
500
0
Depth (mm)
SC (uS/cm)
Jul 2018
Oct 2018
Jan 2019
Apr 2019
Date


Naylors Run (Urban)
SC (uS/cm)
12000
9000
6000
3000
0
Depth (mm)
2000
1500
1000
500
0
Jul 2018
Oct 2018
Jan 2019
Apr 2019
Date

Salinization of freshwater

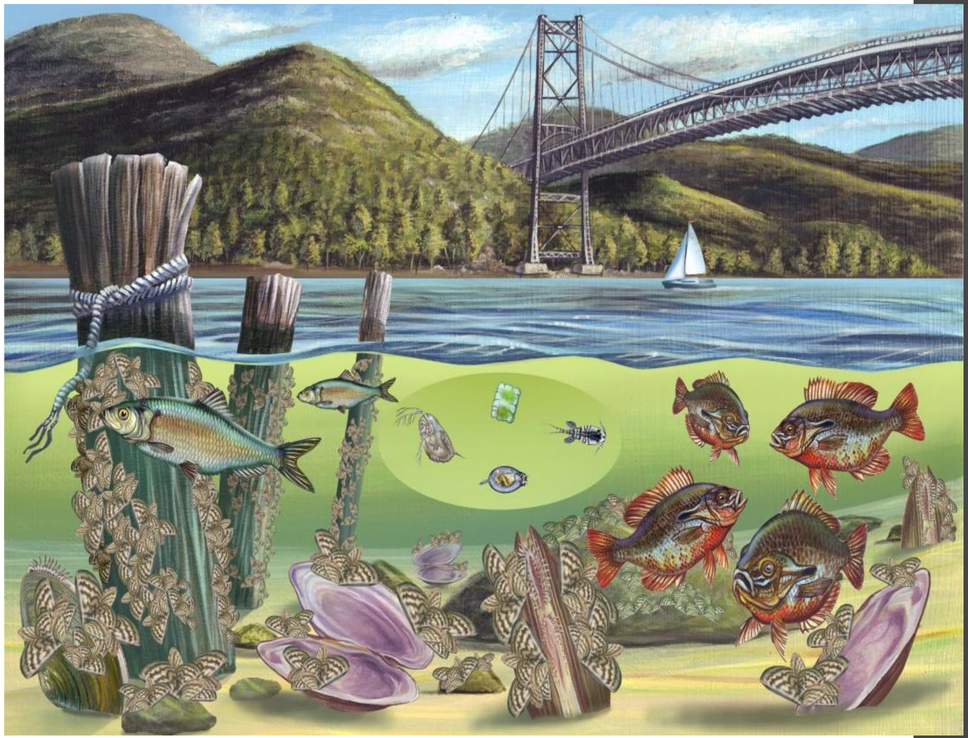
- Sources of ions to freshwaters:
  - Natural: soils and geology
  - Anthropogenic:
    - GW extraction->Salt water intrusion
    - Irrigation and fertilizer application
    - Mining
    - Demineralization of concrete
    - Road salt application
    - Sewage and industrial waste discharge

Brandywine Town Center, winter 2018
Road salt pile

REF: Kaushal, S.S., Likens, G.E., et al. 2018. Freshwater salinization syndrome on a continental scale. *PNAS*, *115*

Salinization of freshwater

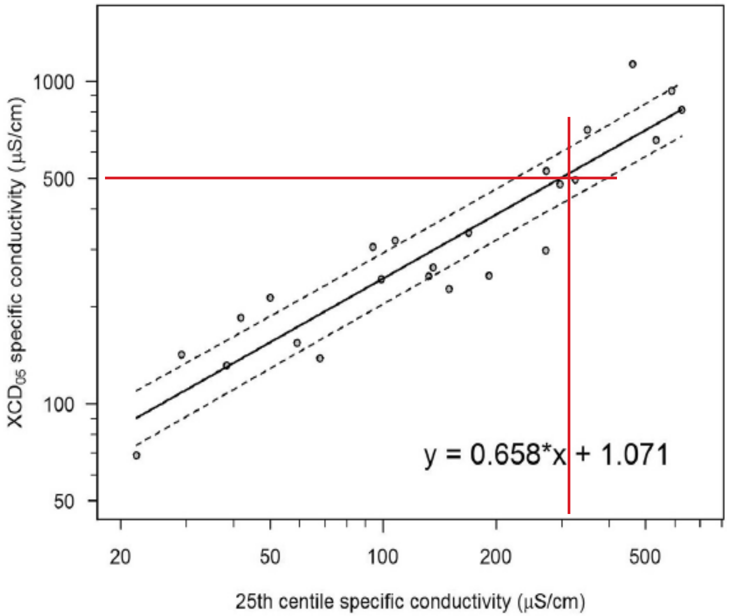
- Environmental implications of are still poorly understood.
- Symptoms can include changes in biodiversity due to osmotic stress and desiccation.
- Emerging threat to freshwater biodiversity



Source: https://www.haikudeck.com/streams--rivers-science-and-technology-presentation-V85aFFyFRe#slide5

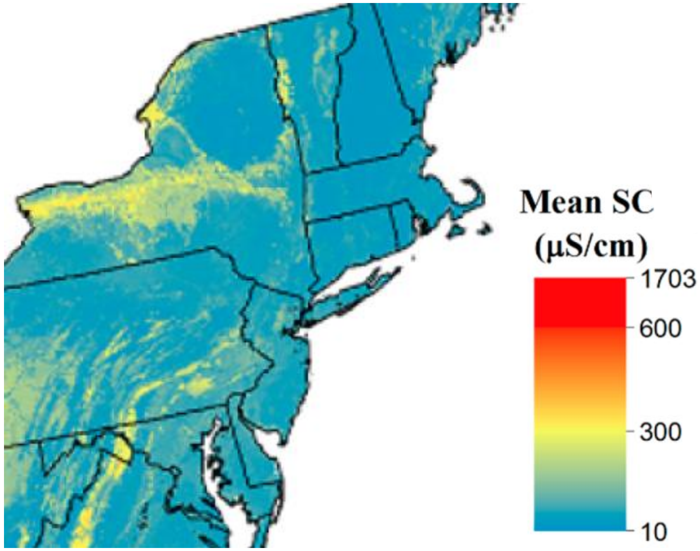
- Kaushal, S.S., Likens, G.E., et al. 2018. Freshwater salinization syndrome on a continental scale. *PNAS, 115*
- Reid, A.J., Carlson, A.K., et al. 2019. Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biol Revs, 94*

Potential effects on stream health



Cormier, S.M., Zheng, L. and Flaherty, C.M., 2018. A field-based model of the relationship between extirpation of salt-intolerant benthic invertebrates and background conductivity. *Science of The Total Environment*, 633

- Linear model that predicts SC at which 5% of benthic invertebrate genera will be extirpated (XCD_{05})
  - 95% will be protected
- Based on background SC



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

- Background SC ~ 300 uS/cm
- XCD_{05} ~ 500 uS/cm

In summary:

- Some tributaries of the DRB are experiencing increased salinity likely affecting stream biota.
  - Related to land use, urbanization
    - Winter extremes likely related to road salt application
    - Increased SC year-around in agricultural and urban streams

Acknowledgments

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  - Marc Peipoch
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