Characterization of Sub-Watershed-Scale Stream Chemistry Regimes in an Appalachian Mixed-Land-Use Watershed

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Introduction

- Studies have linked anthropogenic landscape alteration to streamwater quality degradation.
  - pH
  - Conductivity
  - Temperature
  - Nutrient Loading
  - Trace Element Concentrations

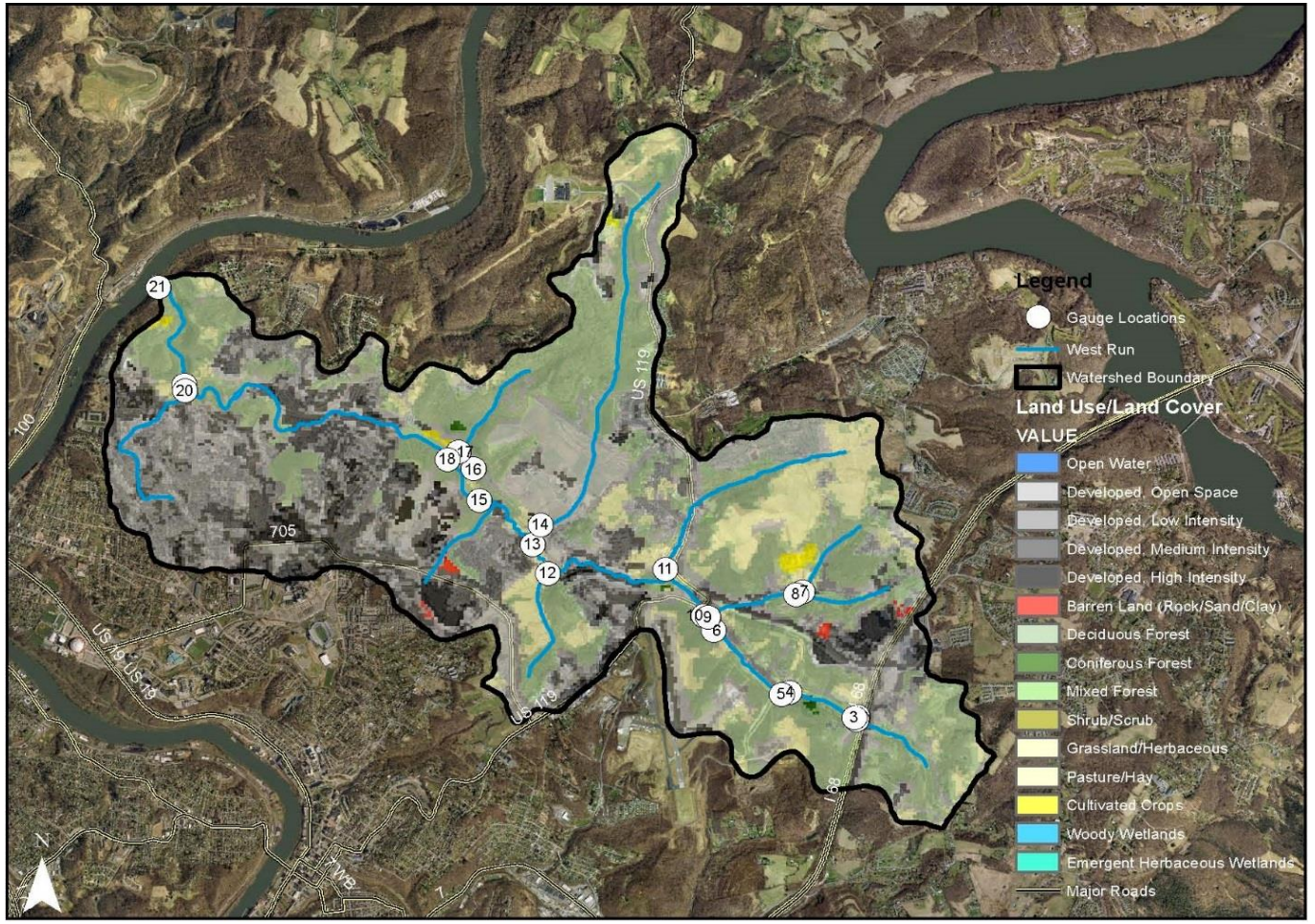
- Water quality regimes are affected by competing natural and anthropogenic factors, and can thus be difficult to manage in contemporary watersheds.

- Few studies have focused on 1st - 4th order streams, which represent approximately 97% of U.S. stream-length.

- Managers need methodological approaches for detailed spatial and temporal characterization of water quality regimes of low order streams.

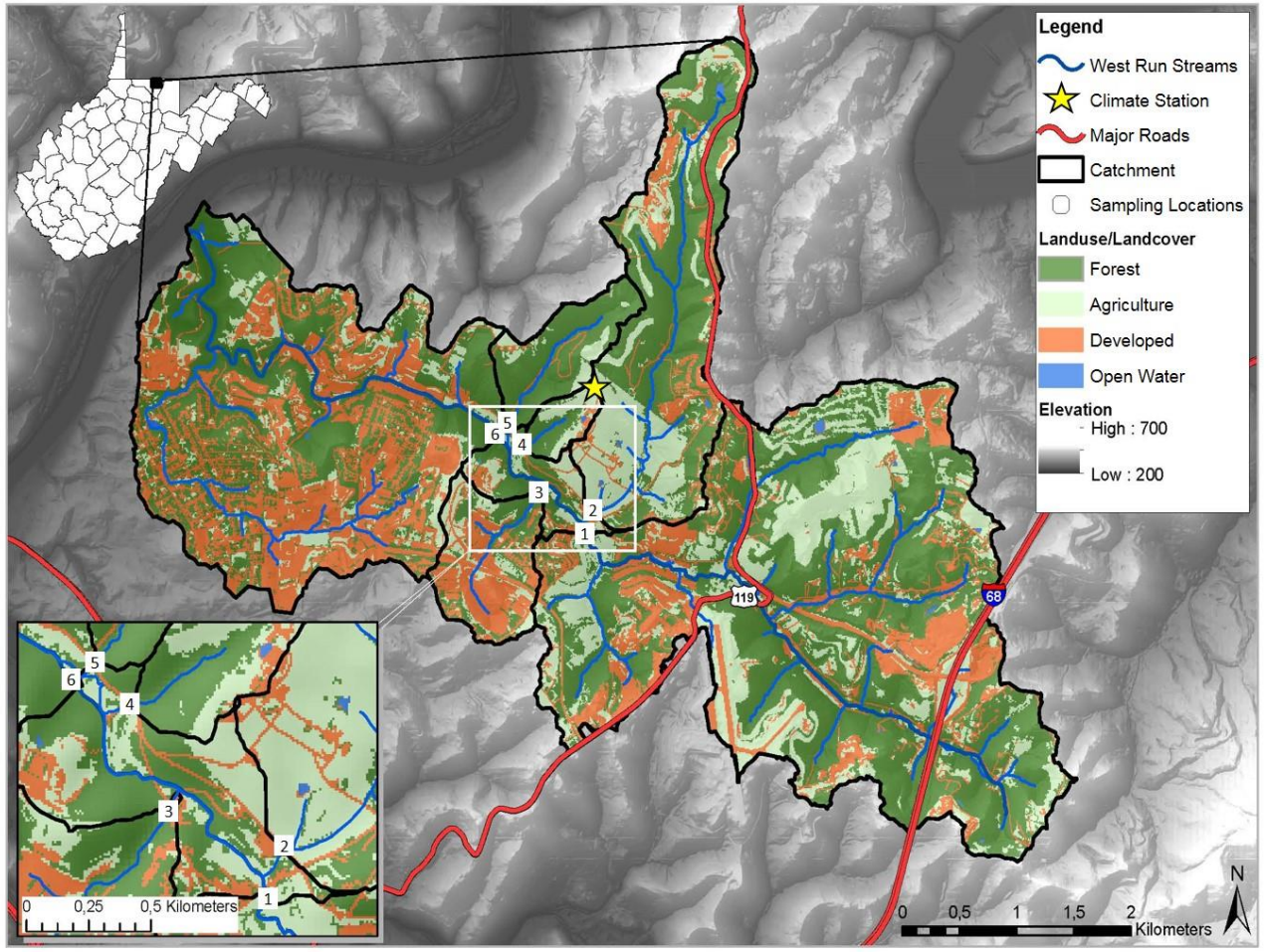
West Run Watershed

- Morgantown, WV
- Mixed-Land-Use, with rapid urbanization
- Experimental Watershed Study
  - Nested-Scale and Paired
  - Begun in Spring of 2016
- Activities
  - Hydroclimate monitoring
  - Stream chemistry analysis
  - *E. coli* monitoring
  - Suspended sediment characterization
  - Physical habitat assessment
  - Microbial dynamics



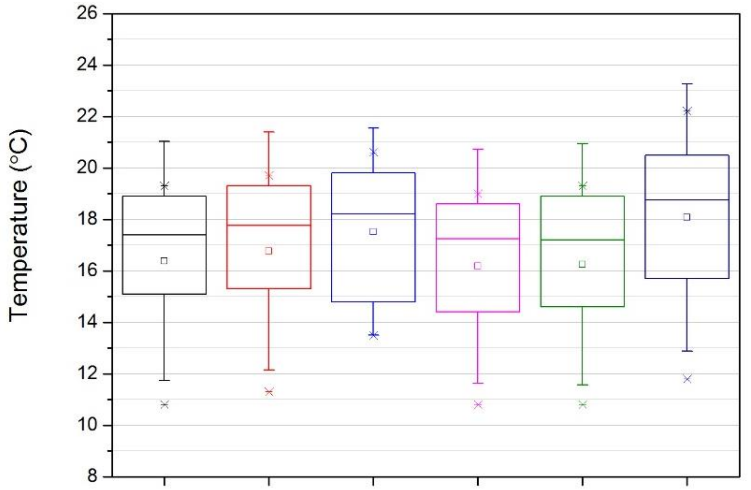
Methods

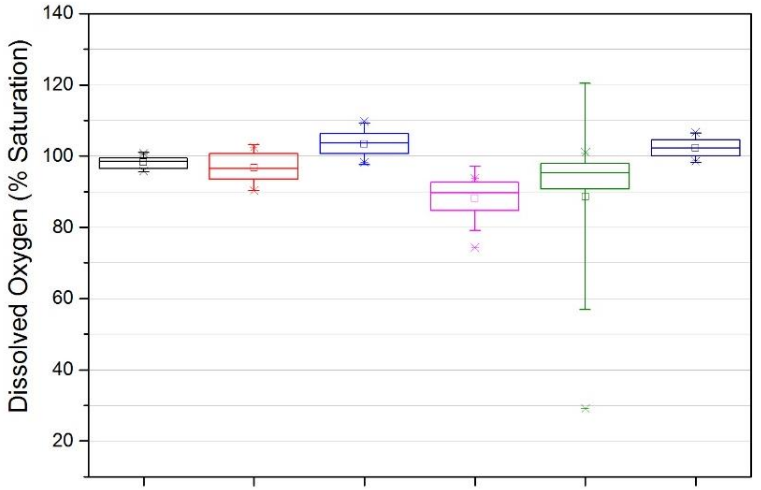
- Study focused on six core sites
  - 1: Upper station on mainstem of West Run Creek
  - 2: Mixed-land-use
  - 3: Urban
  - 4: Agriculture
  - 5: Forest
  - 6: Lower station on mainstem of West Run Creek
- Weekly grab samples
- Analyzed for elemental composition
  - ICP-OES
  - Spectrophotometer
  - 23 separate parameters
- Data analyzed via suite of statistical methods
  - Hypothesis testing
  - Correlation analysis
  - Principle Components Analysis (PCA)

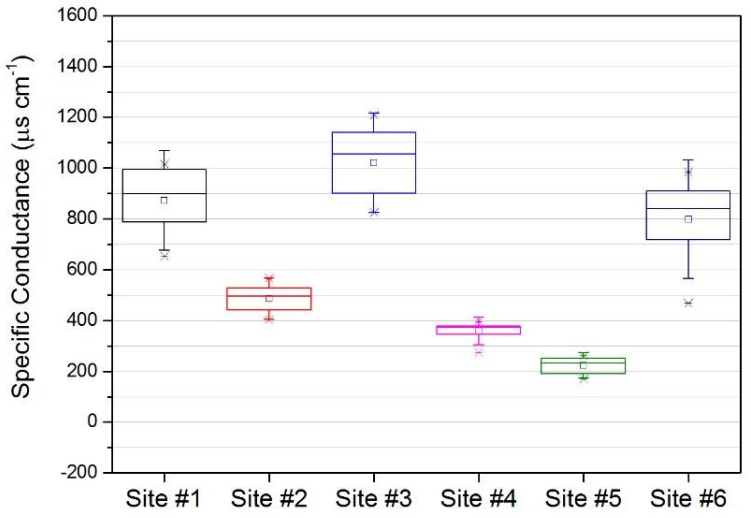


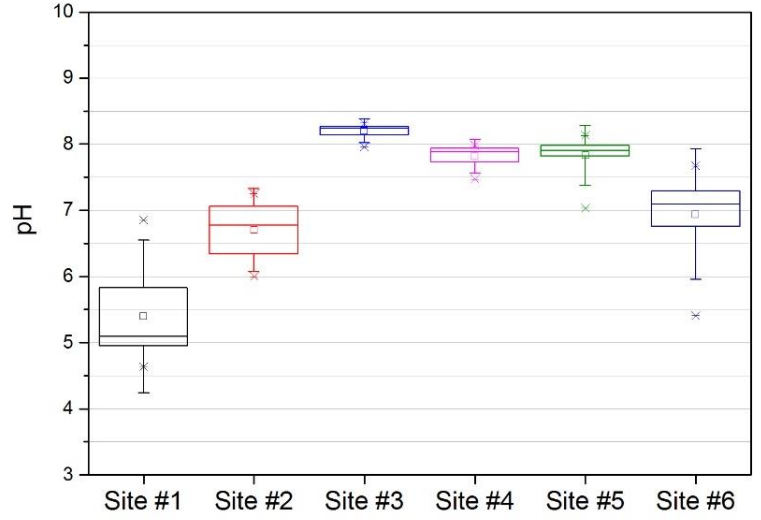
Results

- Increasing streamflow volume with increasing stream distance
- Significant differences ($p < 0.05$) between study sites were identified for every measured parameter except Cu concentration
- Different parameters showed significant differences ($p < 0.05$) between different site pairings
- Sites displayed fairly consistent (i.e. over time) *relative* differences for the measured parameters



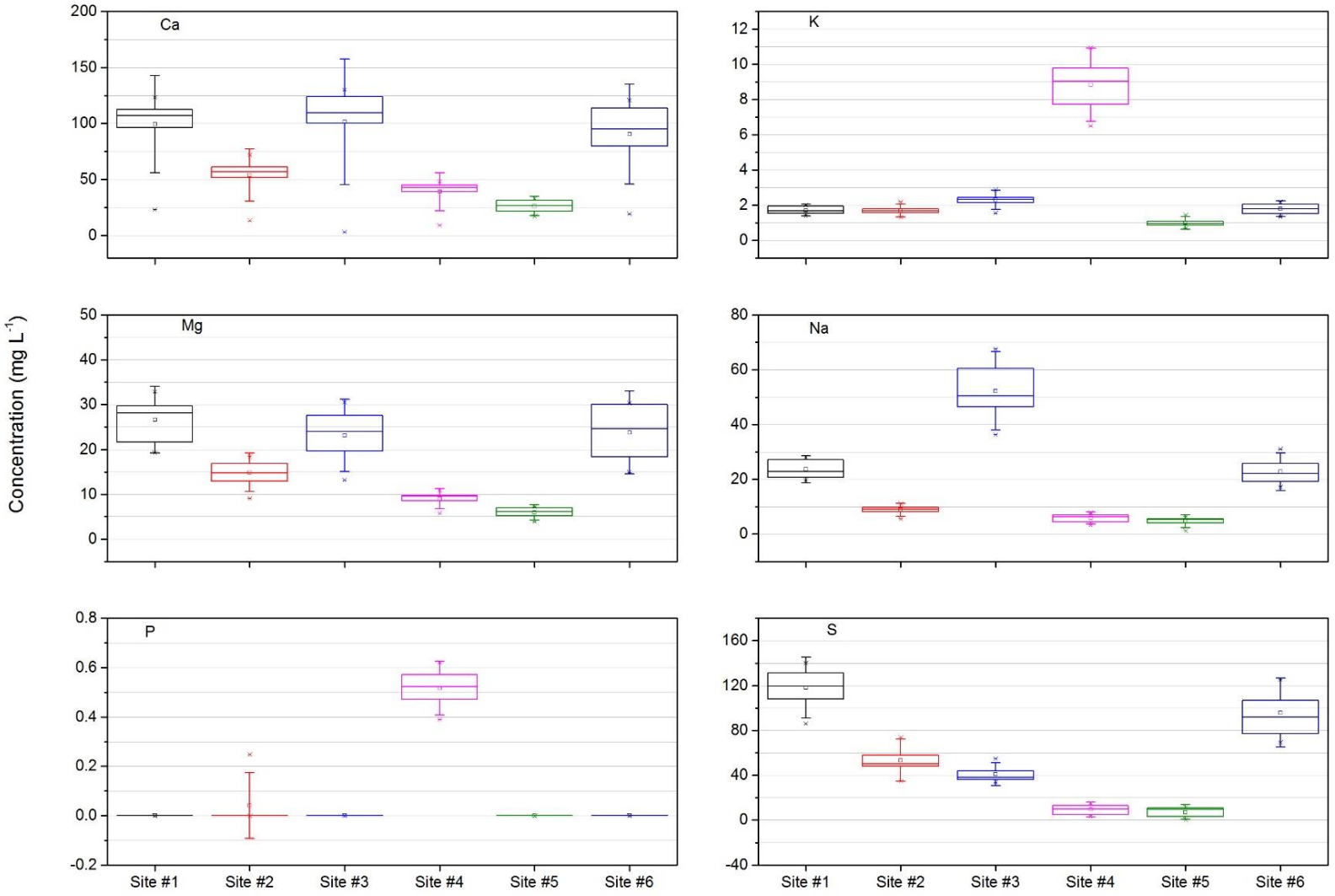






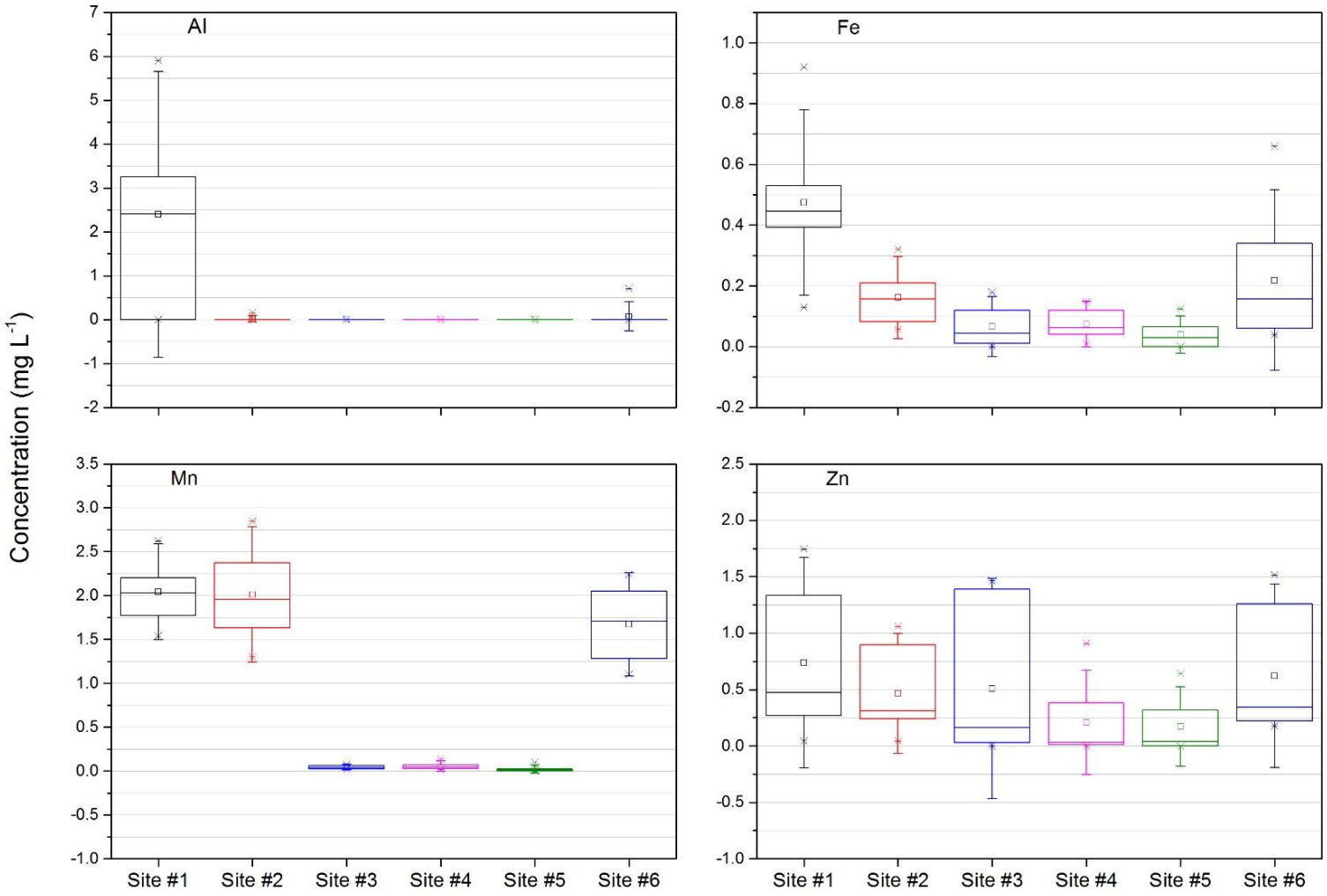
Results

- Site #1
  - Lowest pH (median = 5.1)
  - High Specific Conductance (median = 872 µs cm^{-1})
  - Highest concentrations of Al, Fe, Mn, S, and Zn
  - High concentrations of Ca and Mg
- Site #2 (Mixed-Use)
  - Low pH (median = 6.8)
  - High concentrations of Fe, Mn, and S
  - Highest concentrations of Co (median = 0.03 mg L^{-1})
- Site #3 (Urban)
  - Highest pH and Specific Conductance (median = 8.2 and 1055 µs cm^{-1}, respectively)
  - High concentrations of Ca, Mg, Pb, and Sr
  - Highest concentrations of Na (median = 50.53 mg L^{-1})



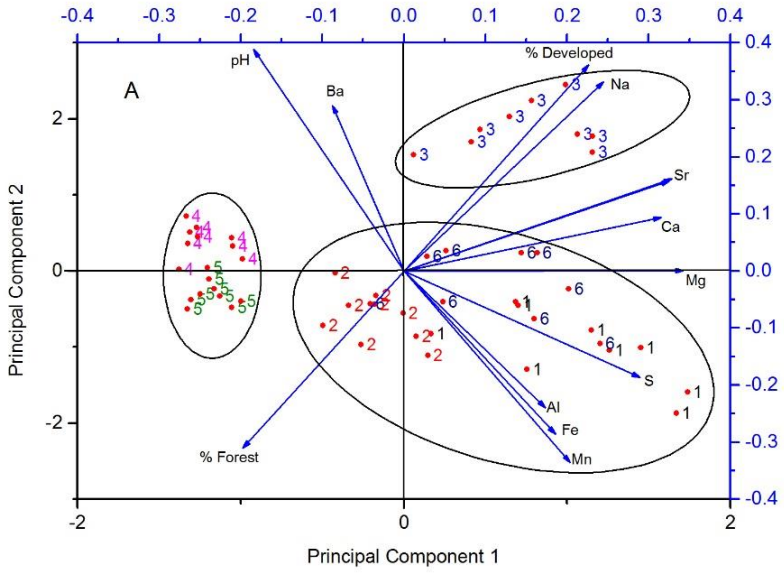
Results

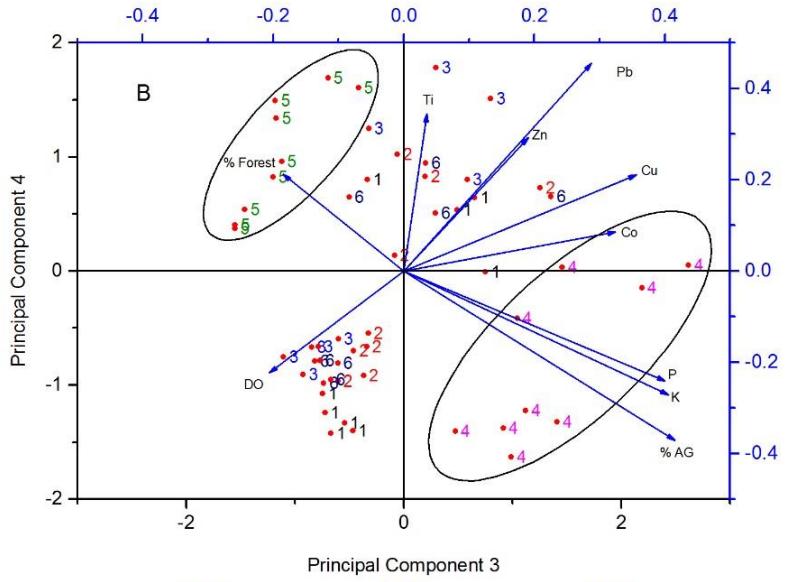
- Site #4 (Agriculture)
  - Highest concentrations of K and P (median = 9.02 mg L^{-1} and 0.52 mg L^{-1} , respectively)
  - Low Specific Conductance and Dissolved Oxygen (median = 372.6 µs cm^{-1} and 89.7 % saturation, respectively)
  - Low concentrations of several elements (e.g. Ca, Fe, Mg, Mn, Na, S, and Zn)
- Site #5 (Forest)
  - Lowest Specific Conductance (median = 232.7 µs cm^{-1})
  - High pH (median = 7.9)
  - Lowest concentrations of several elements (e.g. Ca, Fe, K, Mg, Mn, Na, and S)
- Site #6
  - Intermediate pH (median = 7.1)
  - Concentrations of Al, Co, Fe, Mn, S, and Zn similar to those of sites #1 and #2
  - Specific Conductance and concentrations of Ca, Mg, and Pb similar to those of sites #1 and #3

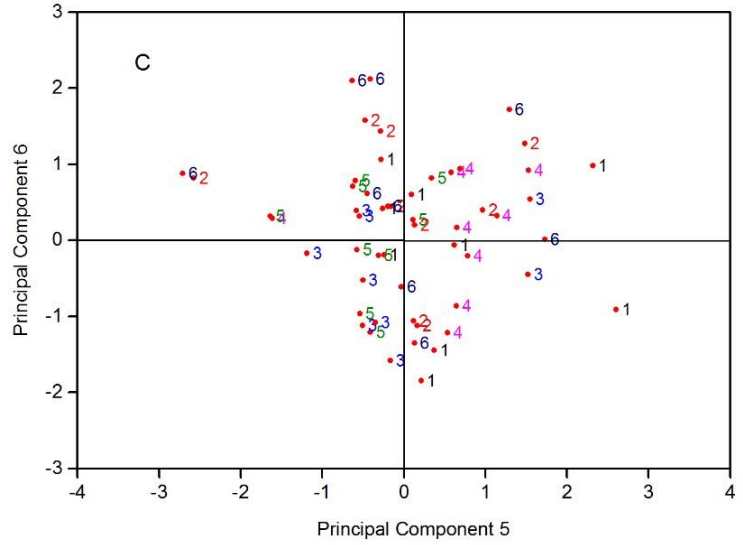


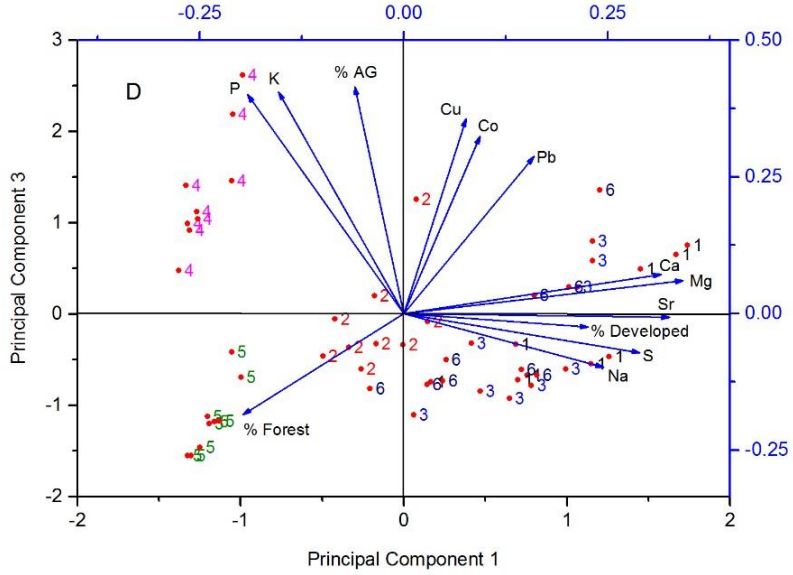
Results

- PCA
  - 6 components explained 86% of the cumulative variance of the water quality dataset
  - Principle components 1 and 2 represent water quality patterns associated with development and AMD, respectively
  - Principle components 3 and 4 represent water quality patterns associated with agricultural and forest land uses
- Correlation Analyses
  - Varying significant ($p < 0.05$) relationships between chemical parameters and hydroclimate metrics
  - Certain parameters (e.g. Ca, Sr, specific conductance) displayed greater sensitivity to hydroclimate at mixed-land-use sites









Discussion/Conclusions

- Land use characteristics and associated hydrologic regime contrasts are likely the primary factors contributing to the observed results.
  - Increased values of various parameters (e.g. Ca, Mg, Na, specific conductance) attributable to developed land use
  - Reduced elemental concentrations attributable to forest cover

- Results demonstrate the utility of Principle Components Analysis (PCA) for water quality research
  - Ability of the method to quickly “map” water quality patterns at the sub-watershed scale
  - Potential mechanistic associations between parameters, such as Na concentration and SPC and developed land uses

- Weak correlations between elemental concentrations and streamflow metrics
  - Non-linear relationships between streamflow and dissolved constituents
  - Contrasting flow regimes between sites

- Results emphasize the utility of the approach for detailed characterization of water quality regimes in low order streams.

- Despite the brief study duration, results describe *consistent* characteristics of the study streams, which can be used to more effectively target sub-watershed-scale remediation and/or restoration efforts

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