Water Quality and Biotic Condition in Mining-Influenced Appalachian Headwater Streams

An Overview of a Long-term Study

S.H. Schoenholtz, E.A. Boehme, D. Drover, R.A. Pence, D.J. Soucek, A.J. Timpano, R. Vander Vorste, K.M. Whitmore, C.E. Zipper
Virginia Tech & Illinois Natural History Survey

ASMR Meeting
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Morgantown, WV

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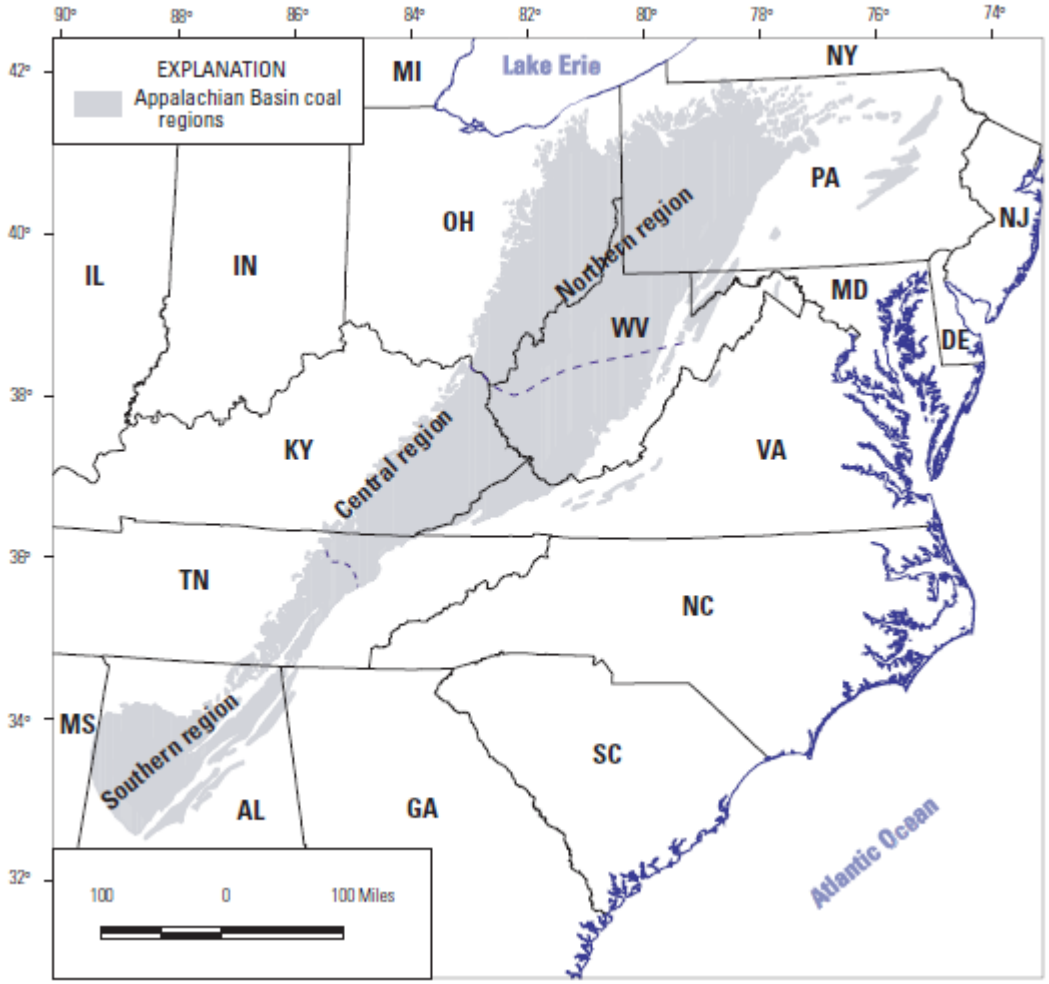
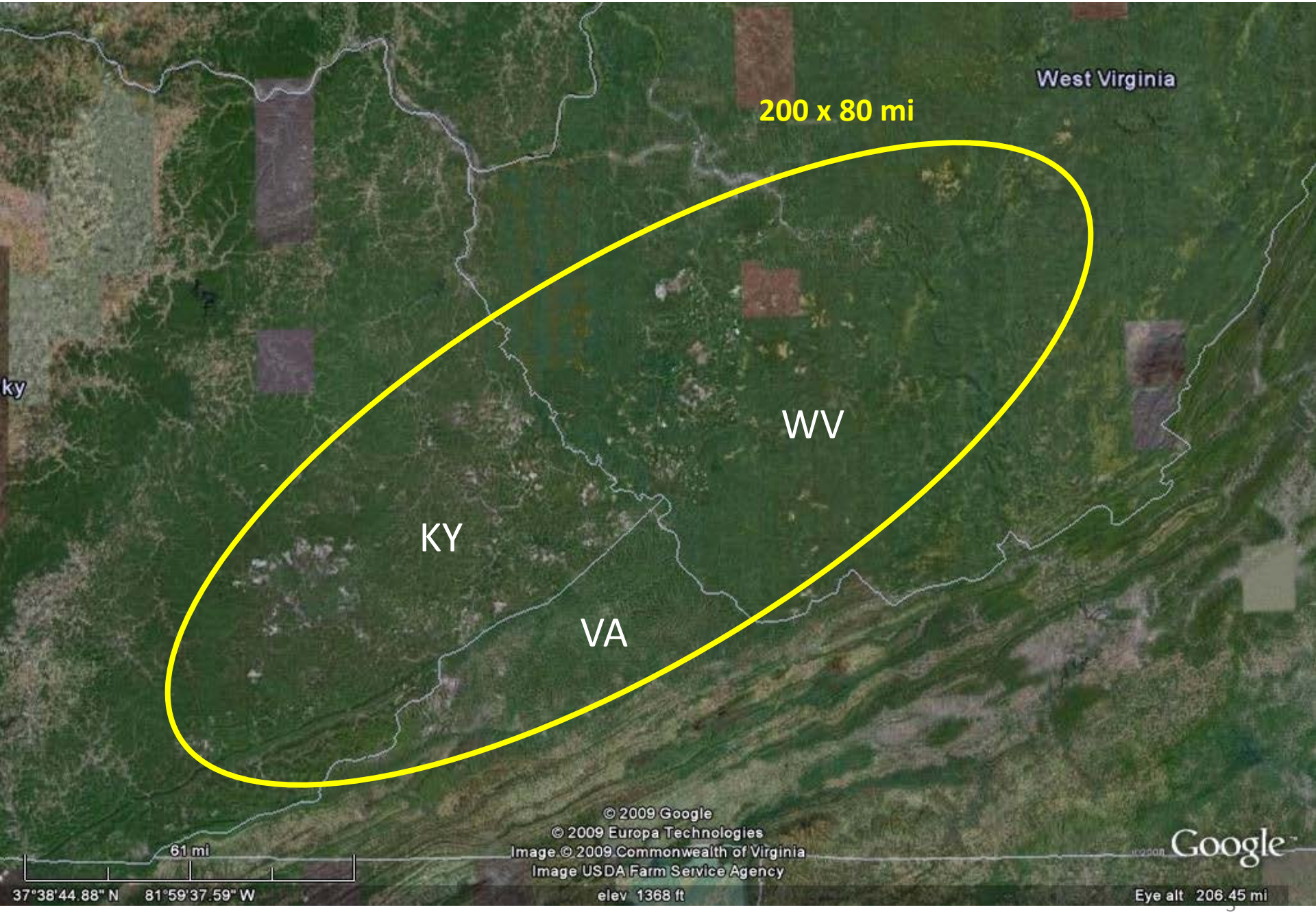
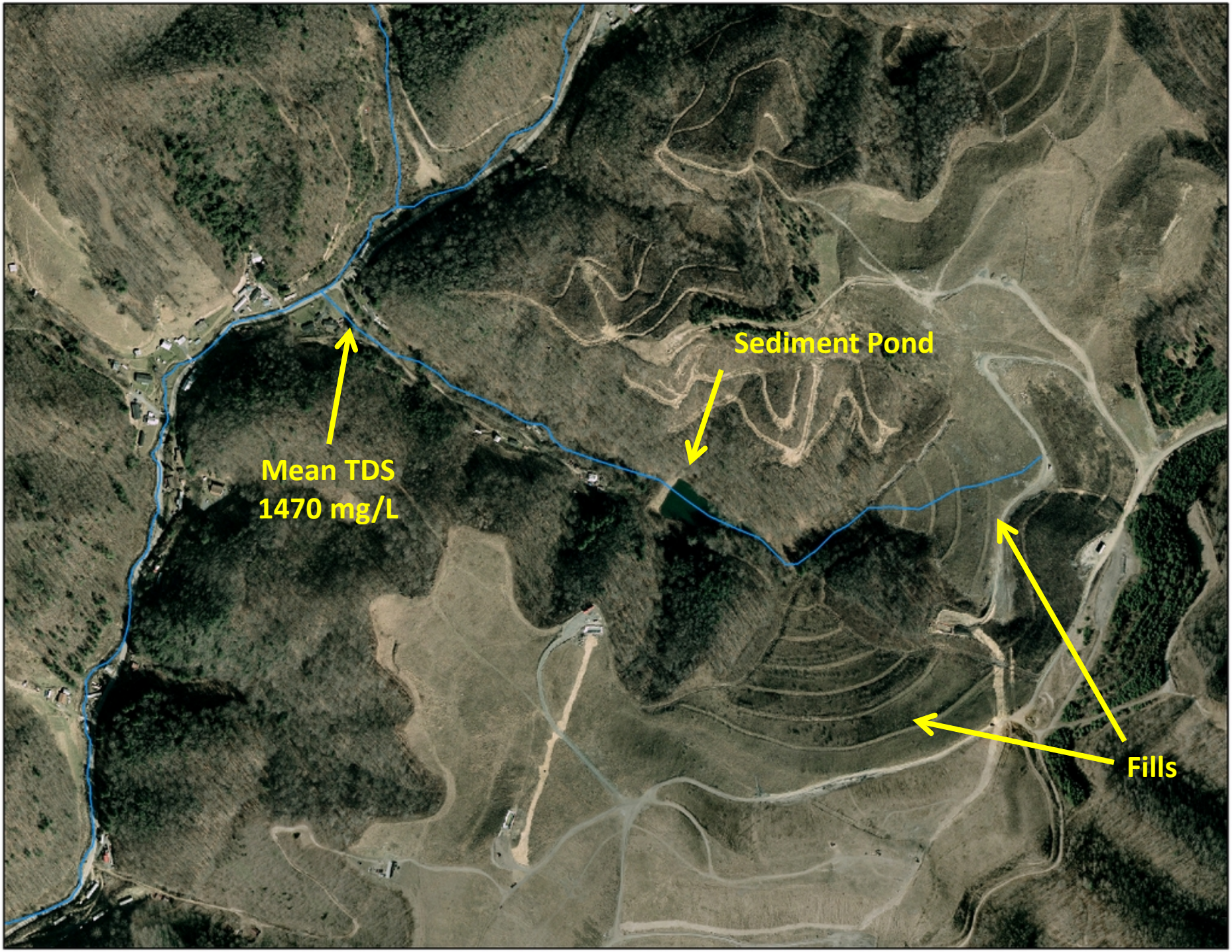
Virginia WATER RESOURCES Research Center

Appalachian Coalfields



from USGS 2000 coal assessment


West Virginia
200 x 80 mi
WV
KY
VA
ky
© 2009 Google
© 2009 Europa Technologies
Image © 2009 Commonwealth of Virginia
Image USDA Farm Service Agency
61 mi
37°38'44.88" N 81°59'37.59" W
elev 1368 ft
Eye alt 206.45 mi
Google


Sediment Pond
Mean TDS
1470 mg/L
Fills

TDS & Benthic Macroinvertebrates in Appalachian Coalfield Streams

- Mine spoil (e.g., 'hollow fills') → salinization
- Stream community structure changes
  - Declines in richness/evenness
  - Mayflies are sensitive
- Major Ions/Total dissolved solids (TDS) suspected cause
- Specific conductance (SC) = easily measured surrogate for TDS

Rationale for Study

- Other studies in WV & KY coalfields found biological effects from salinity
  - Multimetric Index response (e.g. WVSCI, GLIMPSS, KYMBI)
  - Individual genera/groups sensitive (esp. mayflies)
- Our work in VA observed similar patterns of biotic declines with increasing salinity
- Studies were ‘snapshots’; did not account for temporal variability of salinity & biota
- Present study addresses temporal variability, to inform monitoring/assessment of salinity & biota

Questions

- Long-term temporal patterns of chemical & biological changes in salinized Appalachian headwater streams?
- Influences of mining-induced streamwater salinity on leaf breakdown, a key carbon cycling process?

Ephemeroptera
(Mayflies)

Plecoptera
(Stoneflies)

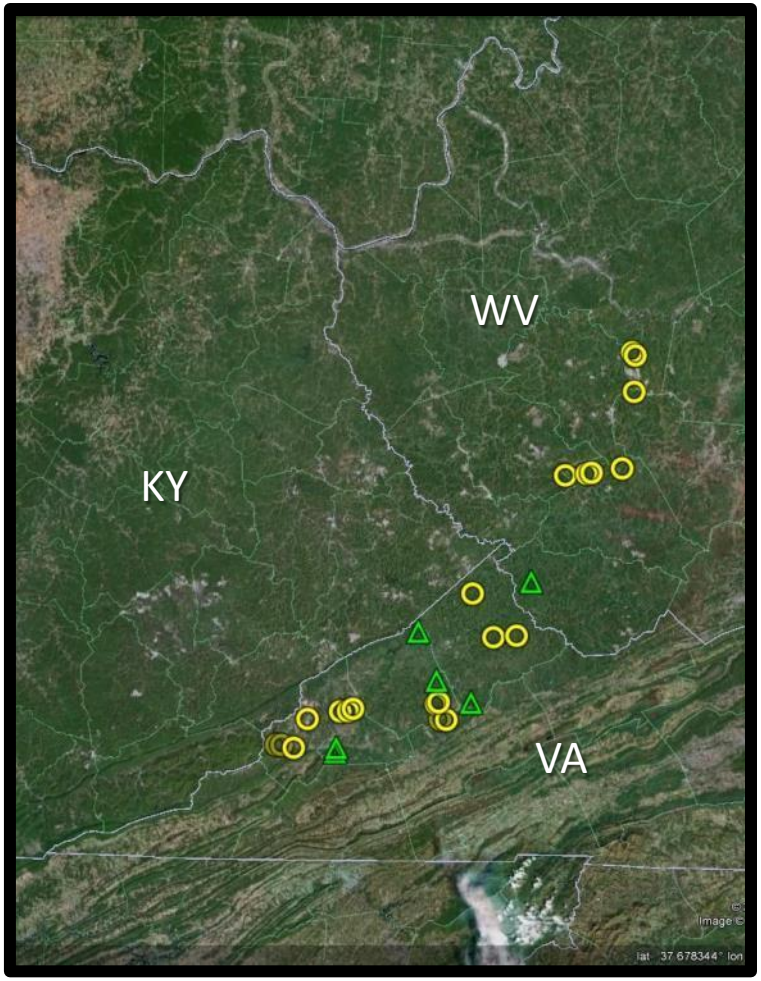
Trichoptera
(Caddisflies)

Methods

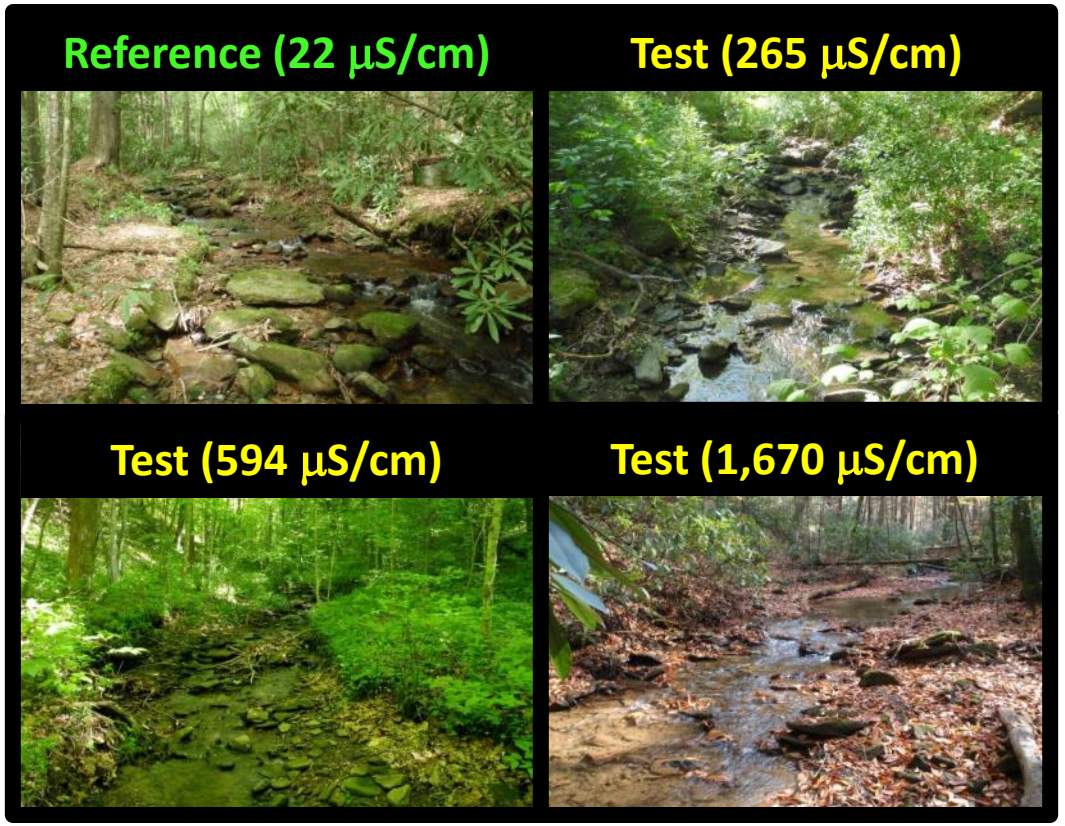
- 2011-2016 study period
- Seasonal SC pattern
- SC trends
- Macroinvertebrate trends
- Consistency of relationship between SC and macroinvertebrates

- *In situ* leaf litter breakdown rate

Research Sites



- 1st & 2nd-order headwater streams (n =25)
- Test sites = elevated SC from mining, with reference-quality habitat



Temporal Variability of Salinity

- Major Ions/TDS – Monthly or quarterly grab samples
- Continuous conductivity data loggers (15/30-min interval Jul ‘11 – Nov ‘16)

Methods - Lab

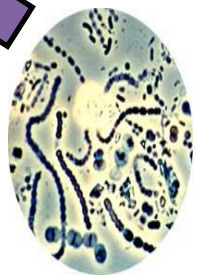
- Chemical Analyses (APHA Standard Methods)
  - TDS
  - Alkalinity (calc. HCO_3^-)
  - Major Anions (Cl^-, SO_4^{2-})
  - Major Cations (K^+, Na^+, Ca^{2+}, Mg^{2+})
  - Trace Elements (Al, Cu, Fe, Mn, Se, Zn)

Temporal Variability of Benthic Macroinvertebrates:
EPA Rapid Bioassessment Protocols, Spring & Fall, 2011-16

Methods - Leaf Litter Decomposition

Invertebrate shredders

Leaf litter as energy source for stream biota



Microbes (bacteria, fungi)

White Oak leaves drying in greenhouse

Litter Breakdown – Lab Prep

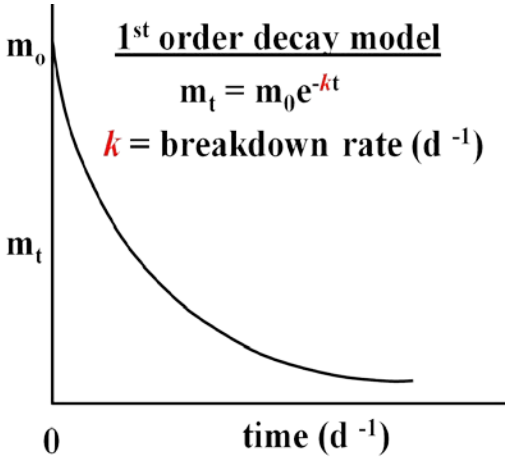
Weighing leaves & filling mesh bags
(6.5 g dry wt per bag)

Finished leaf pack

1200 leaf packs ready to go

Litter Breakdown – Field & k Calculation

Leaf packs anchored to streambed, then covered with boulders



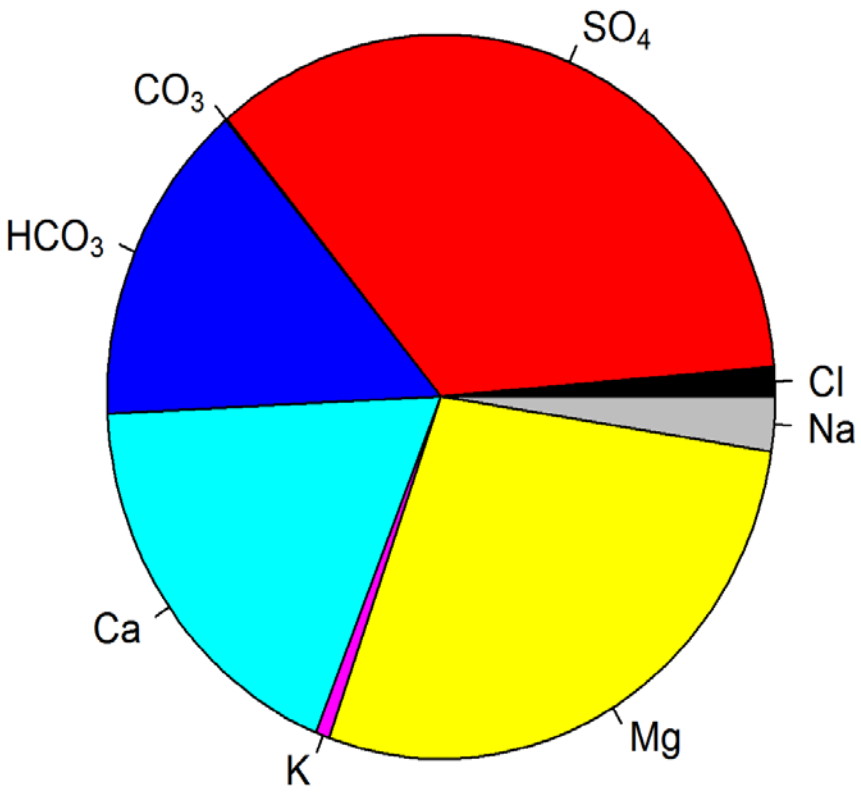
Installing leaf packs: Nov 2015

Retrieving leaf packs: Jan 2016

Results - Typical Ion Matrix
(molar proportions)

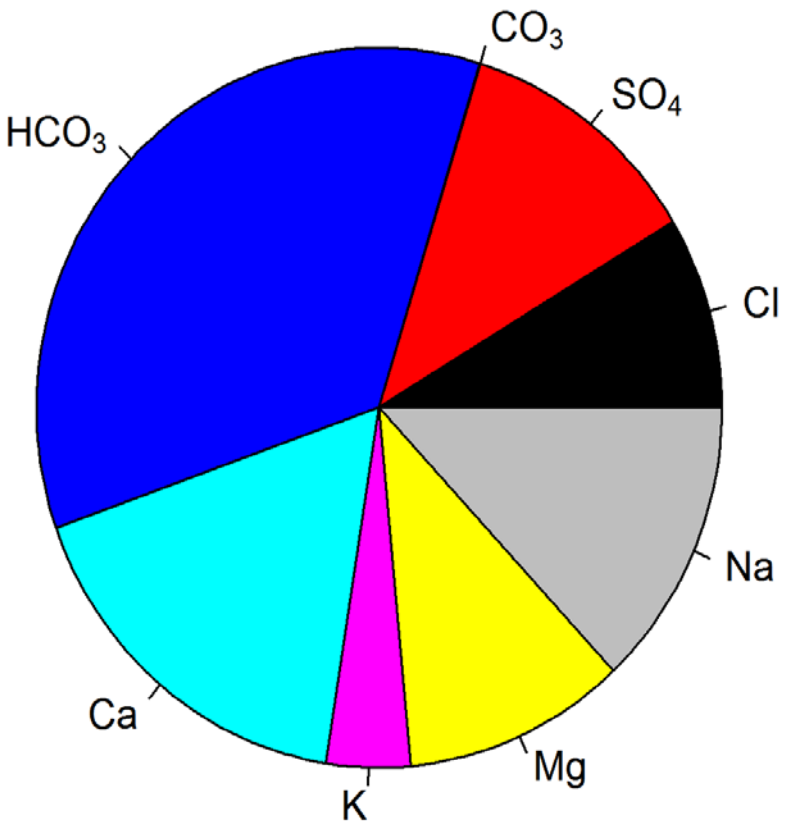
Test Streams

SO_4, Mg, Ca, HCO_3

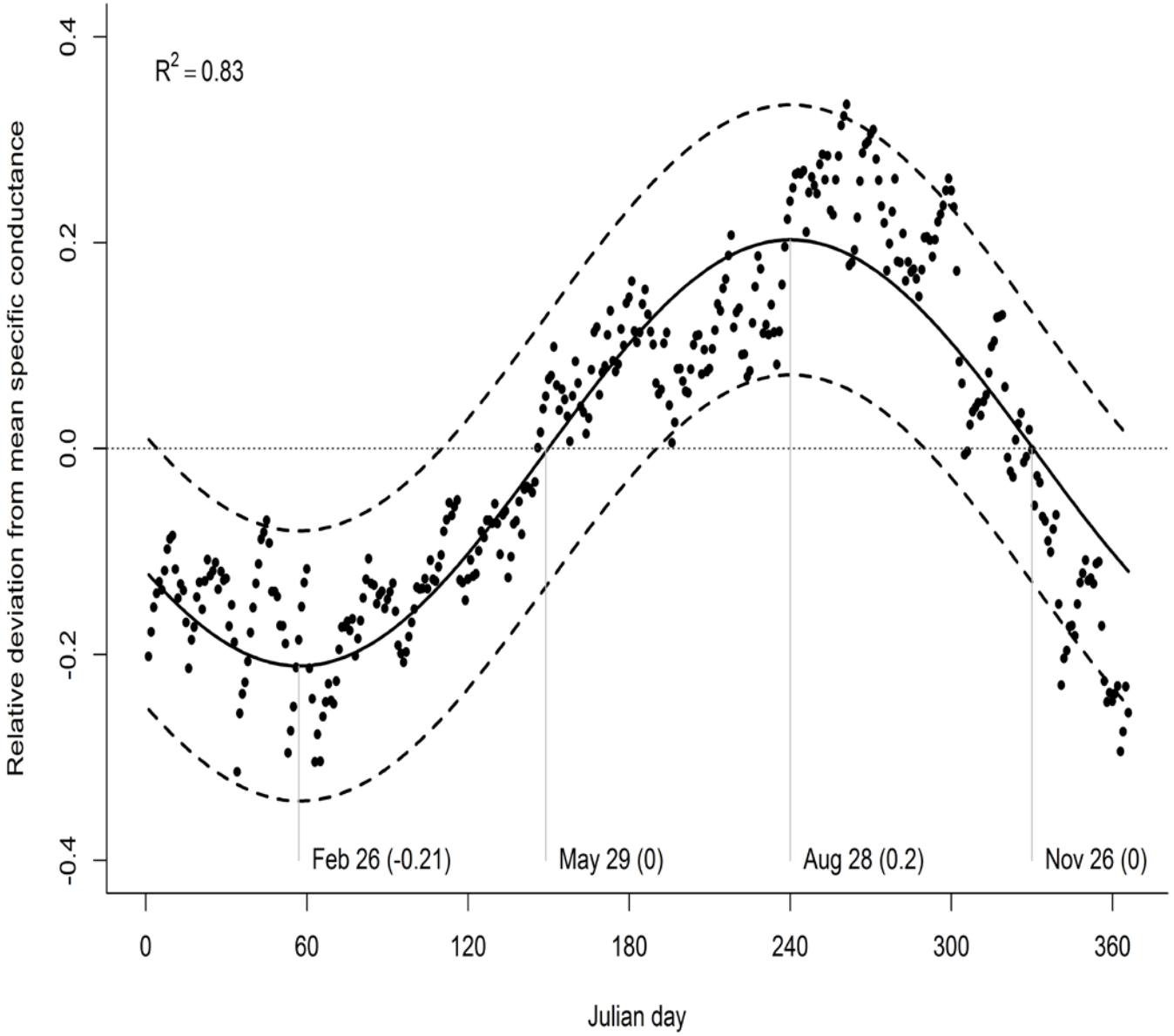


Reference Streams (Unmined)

HCO_3,Ca

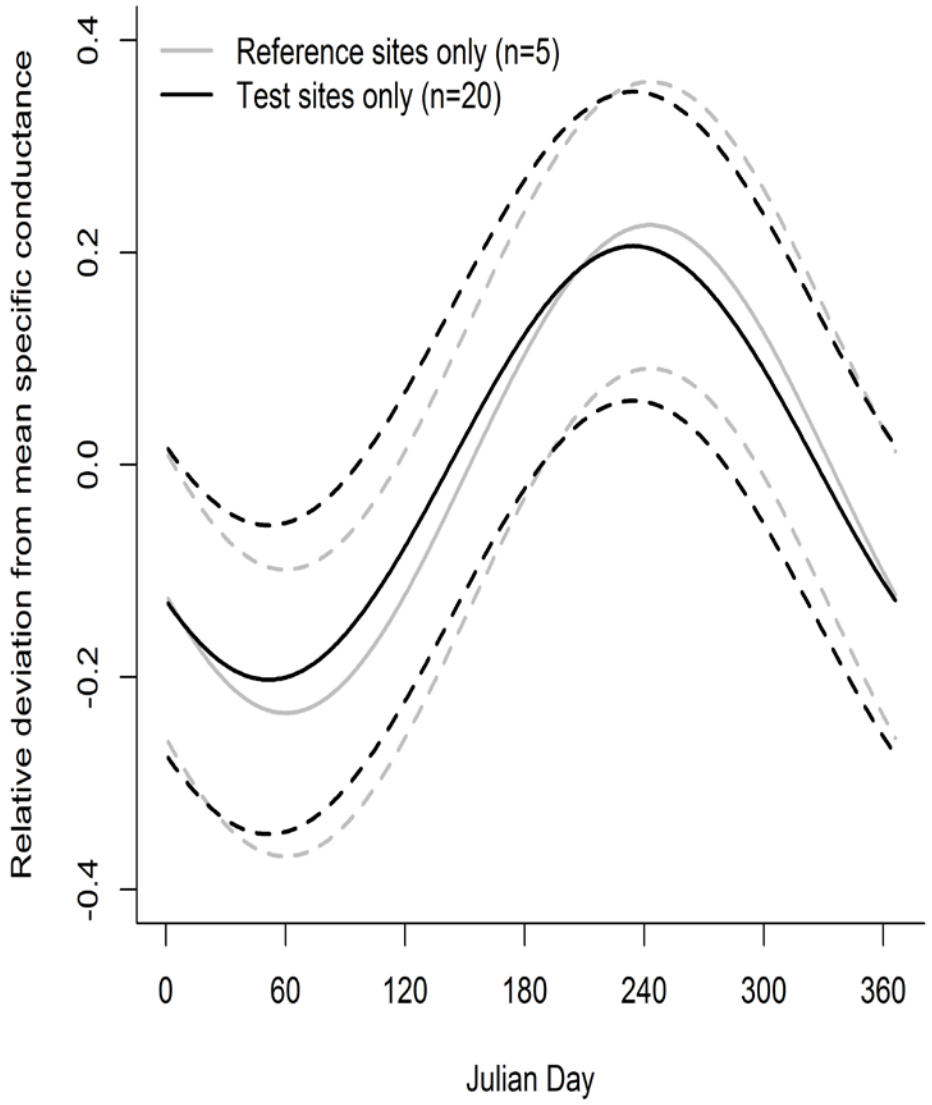


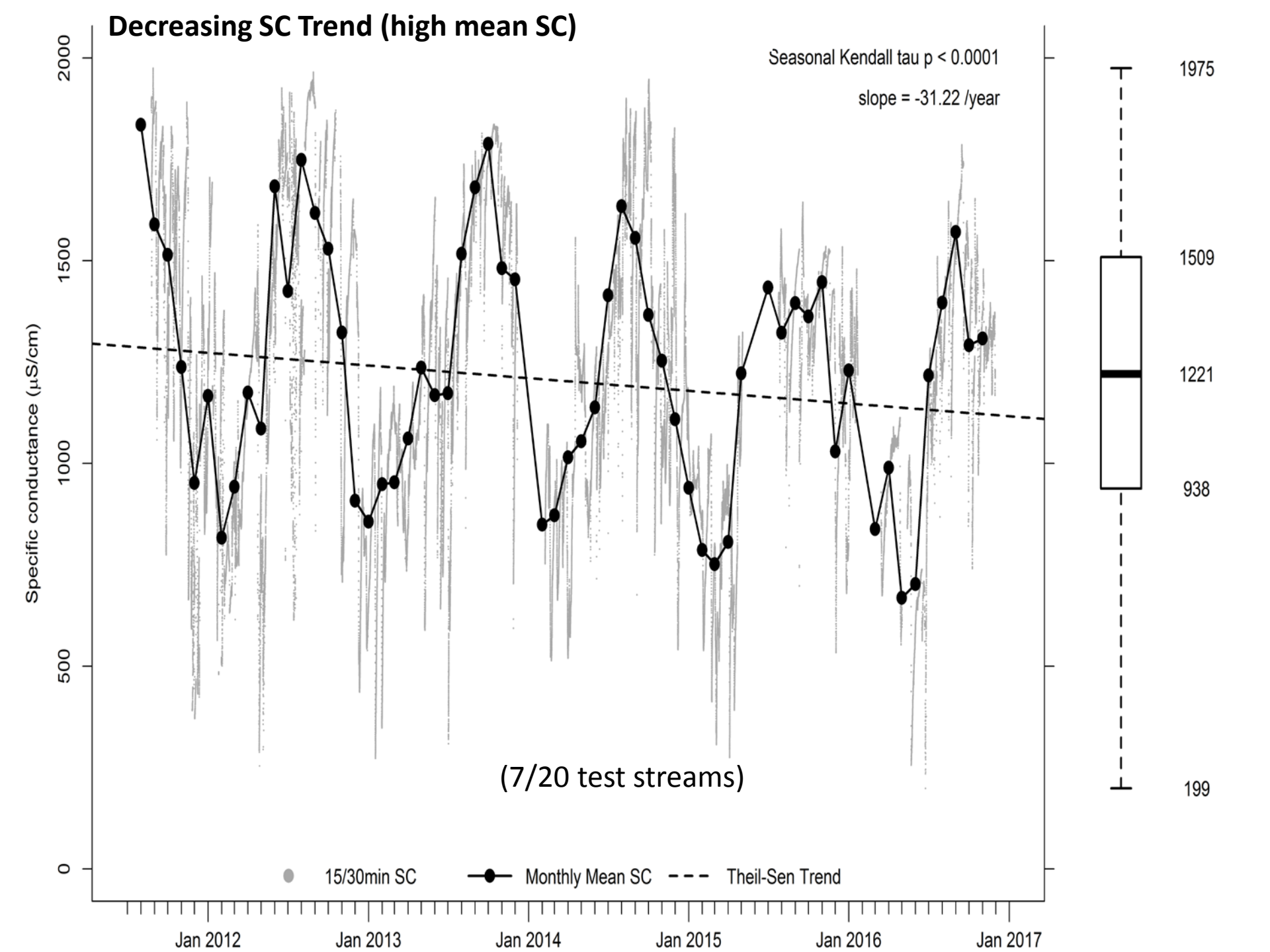
Long-term SC pattern – 2011-16

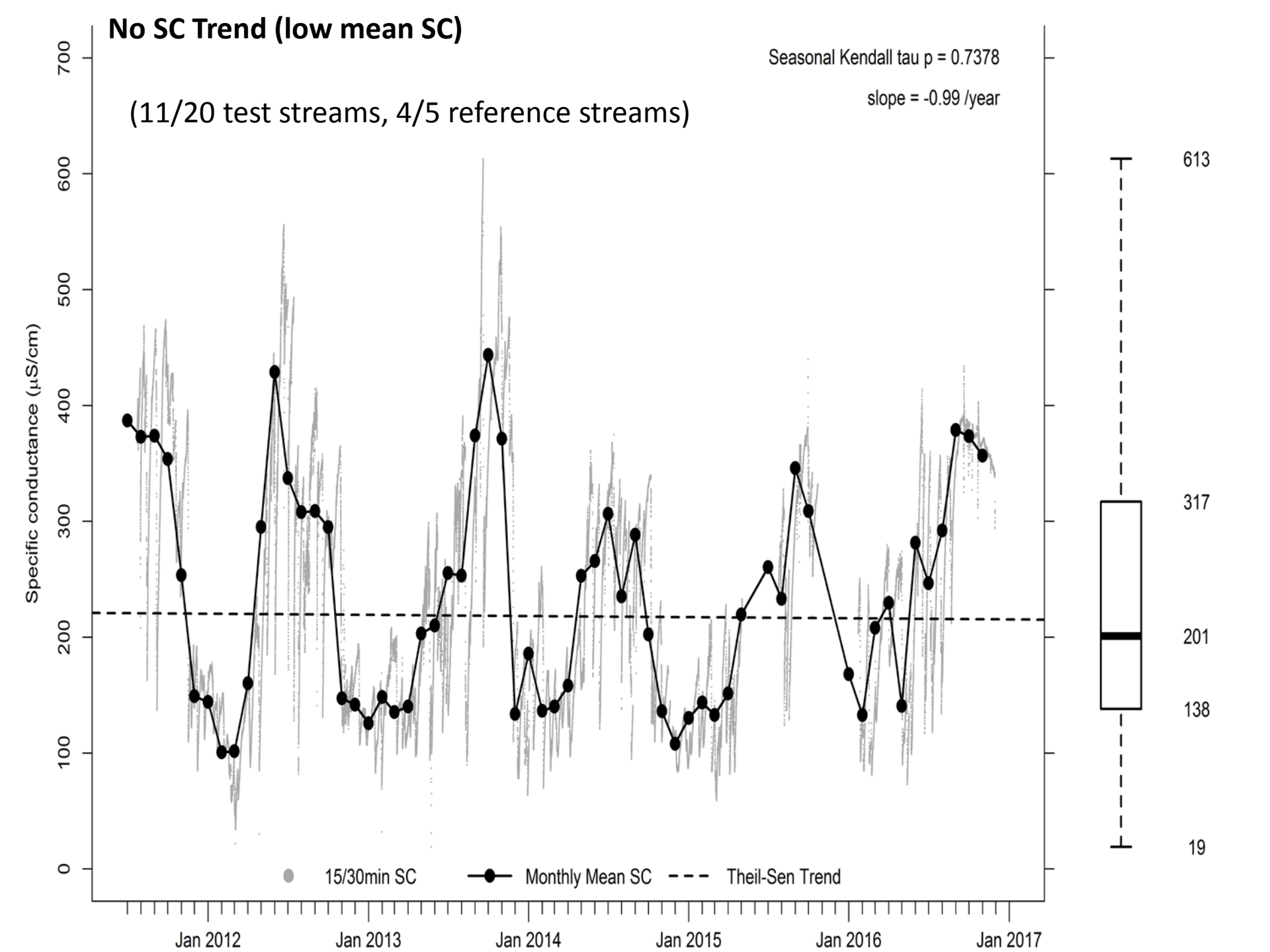


Long-term SC pattern, 2011-15

Reference vs. Test Streams

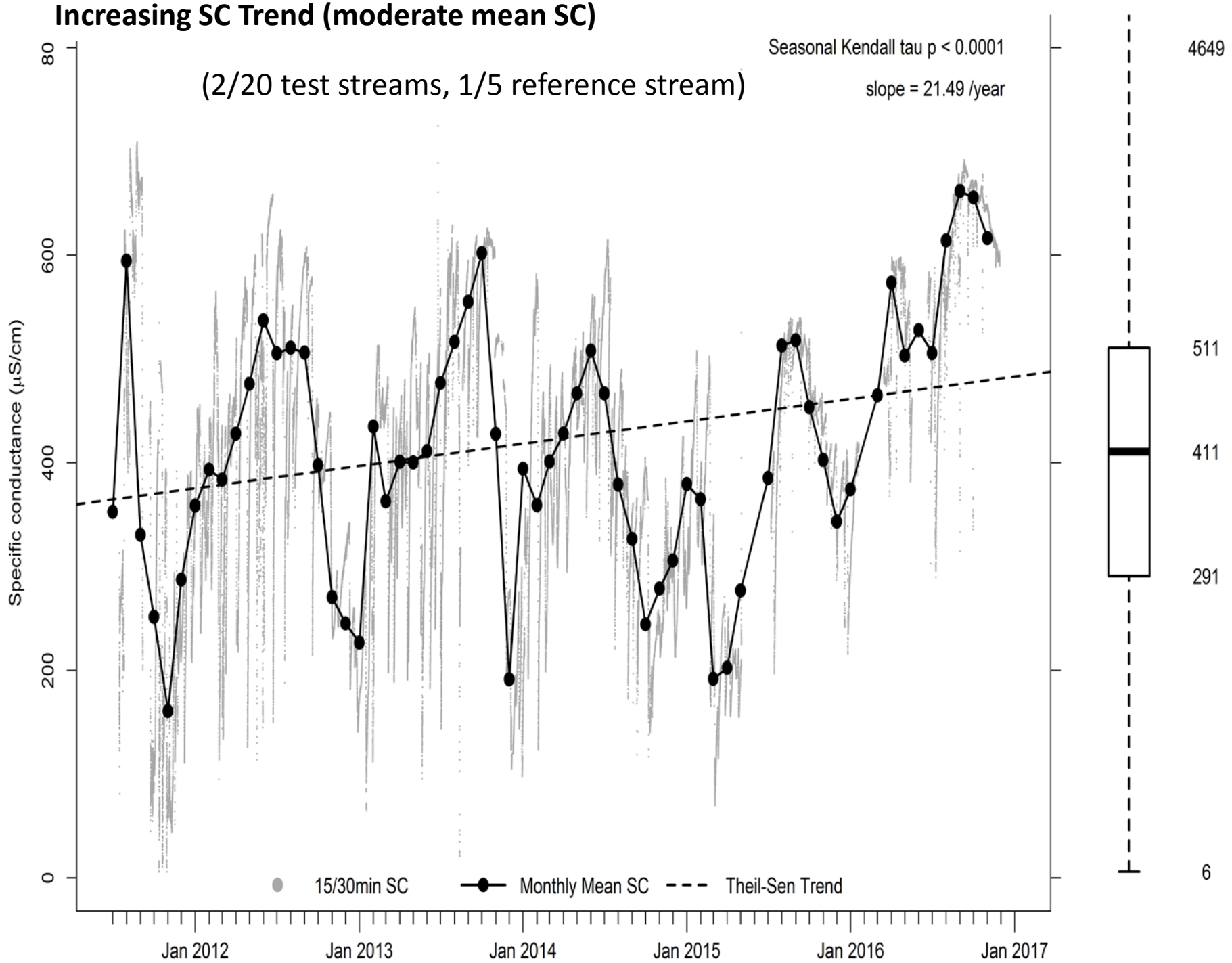



Decreasing SC Trend (high mean SC)
Seasonal Kendall tau p < 0.0001
slope = -31.22 /year
Specific conductance (µS/cm)
2000
1500
1000
500
0
15/30min SC
Monthly Mean SC
Theil-Sen Trend
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
1975
1509
1221
938
199
(7/20 test streams)


No SC Trend (low mean SC)
(11/20 test streams, 4/5 reference streams)
Seasonal Kendall tau p = 0.7378
slope = -0.99 /year
Specific conductance (µS/cm)
0
100
200
300
400
500
600
700
15/30min SC
Monthly Mean SC
Theil-Sen Trend
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
613
317
201
138
19

Increasing SC Trend (moderate mean SC)

(2/20 test streams, 1/5 reference stream)



Consistency of SC-'Bug' Relationship: Snapshot SC vs. 'bug' metrics

	Correlation coefficients					
	Fall			Spring		
Metric	**2012**	**2013**	**2015**	**2013**	**2014**	**2016**
taxa richness	-0.51**	-0.78**	-0.56**	-0.76**	-0.72**	-0.66**
taxa evenness	-0.26	-0.41	-0.38	-0.42*	-0.75**	-0.63**
richness EPT	-0.62**	-0.71**	-0.59**	-0.81**	-0.81**	-0.82**
richness E	-0.76**	-0.79**	-0.82**	-0.88**	-0.83**	-0.93**
richness P	-0.43*	-0.41	-0.40*	-0.60**	-0.70**	-0.53**
percent E	-0.79**	-0.76**	-0.84**	-0.87**	-0.86**	-0.83**
percent predators	-0.41*	-0.48*	-0.25	-0.75**	-0.71**	-0.53**
percent shredders	0.11	0.25	0.27	0.55**	0.70**	0.50**

* $p<0.05$
** $p<0.01$

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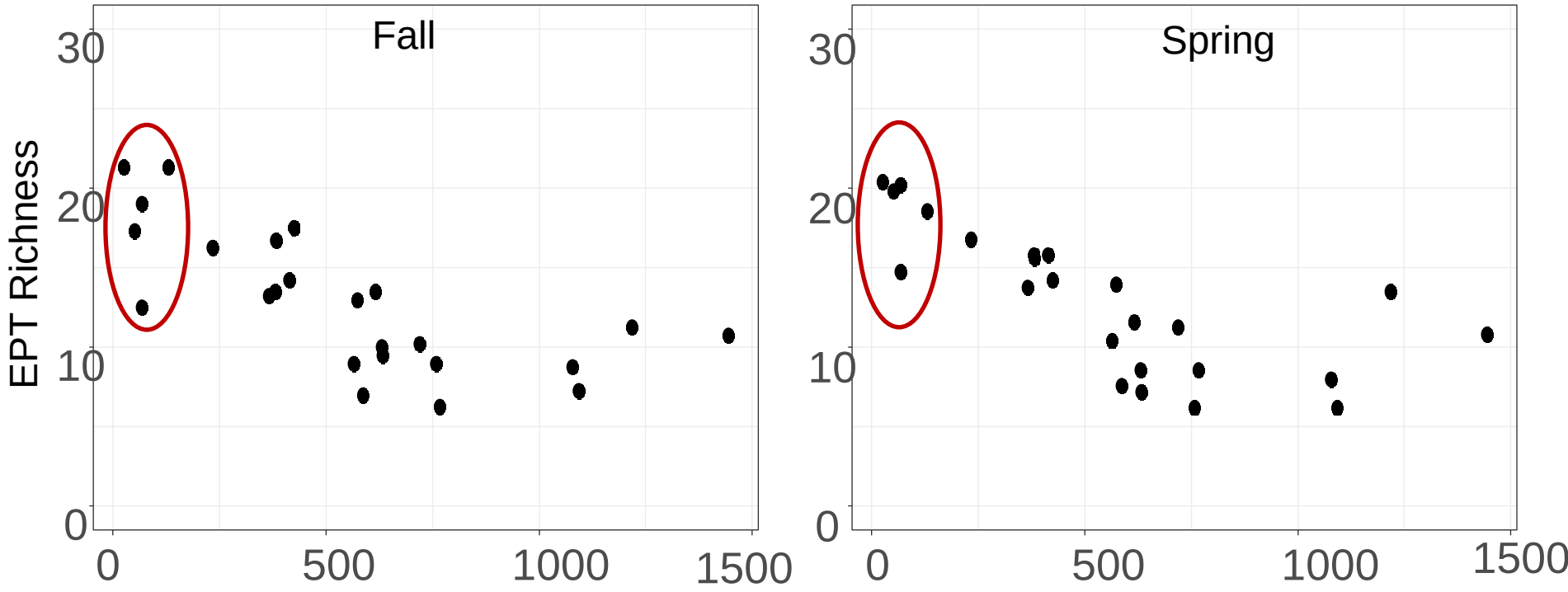
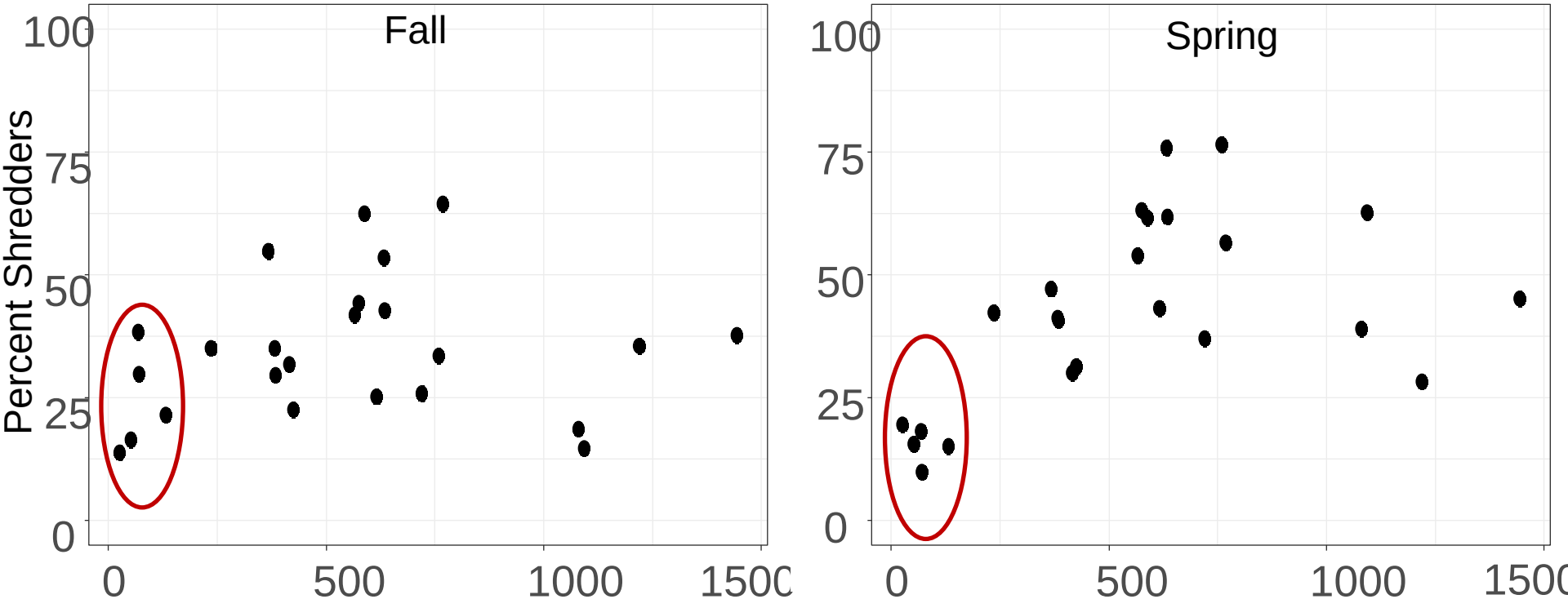
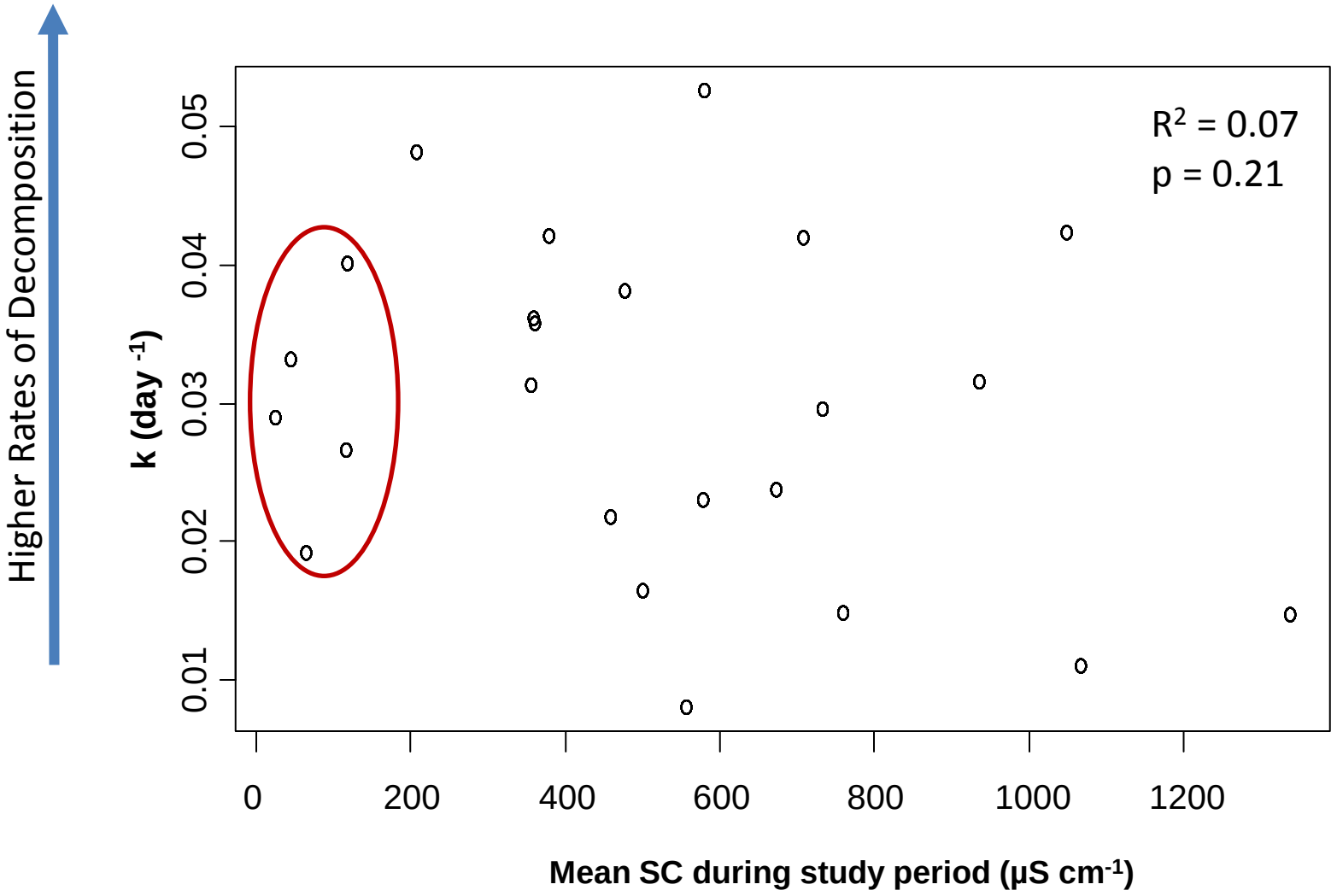
SC vs. EPT Richness



SC vs. Percent Shredders



SC vs. Leaf Litter Decomposition



Conclusions

- Season of sampling salinity & macroinvertebrates matters
- Sinusoidal model provides framework for salinity assessment
- Salinity trends over 5-year period are small – lengthy recovery from salinity stress
- Leaf litter decomposition not affected by salinity - possible functional redundancy in macroinvertebrate community for this carbon-cycling process

Questions?

Sponsors:

US Office of Surface Mining Reclamation & Enforcement
Powell River Project
Virginia Dept. Mines, Minerals, & Energy
Virginia Dept. Environmental Quality
Virginia Water Resources Research Center
VT Institute for Critical Technology & Applied Science