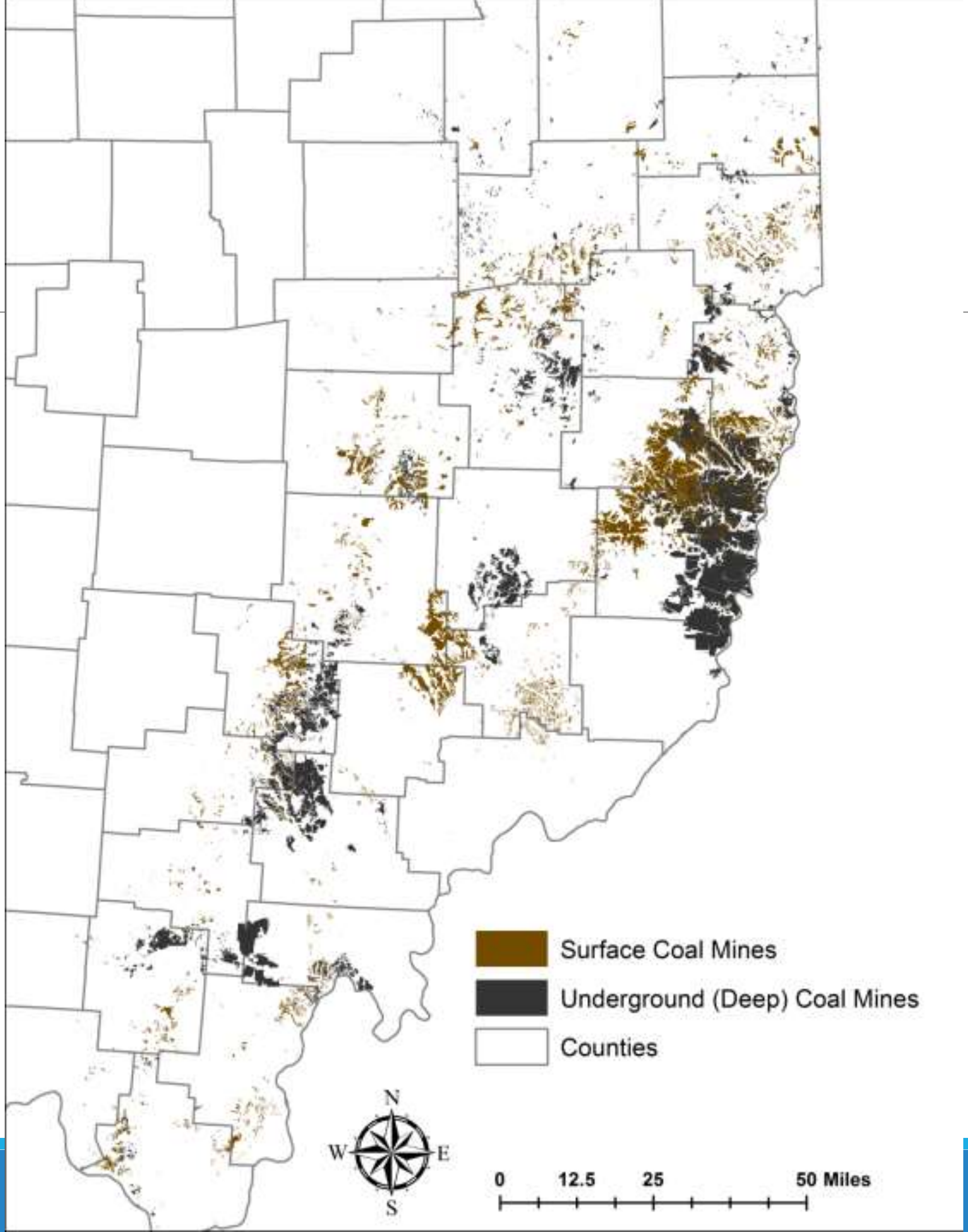
Relationship between water quality and stream recovery

DR. NATALIE KRUSE DANIELS

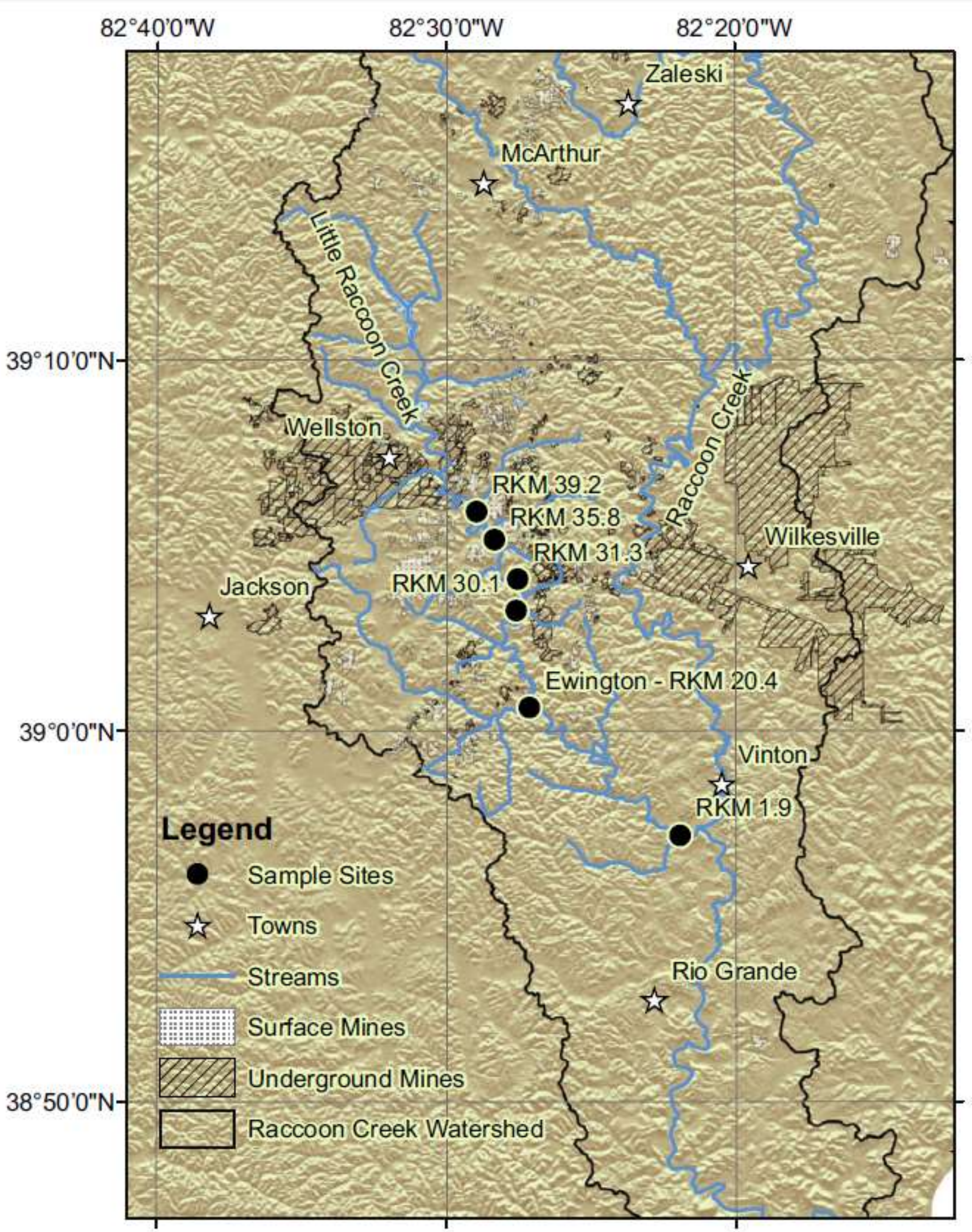
OHIO UNIVERSITY



Surface Coal Mines
Underground (Deep) Coal Mines
Counties
N
W
E
S
0
12.5
25
50 Miles


Restoring Ohio's Watersheds
Coal mining and agriculture have taken their toll on the pristine waterways of Ohio. Abandoned mine drainage (AMD), pesticides, fertilizers, erosion, and livestock waste seep into rivers and streams disrupting the delicate balance of their ecosystems. This site compiles and tracks changes in Ohio's watersheds to measure the success of ongoing reclamation efforts.
26,309
Samples Collected Since January 1, 1995
Acid Mine Drainage
Livestock Waste
OHIO
1
2
Huff Run
inset 1
Monday Creek
Monday C.
Sunday C.
Sunday Creek
Leading Creek
Raccoon C.
Leading C.
Raccoon Creek
N
inset 2

Little Raccoon Creek



LRC Biological Recovery Over Time

Table 2 Little Raccoon Creek MAIS Regressions, with location of sample site indicated by river kilometer (RKM) (modified from Bowman 2011)

RKM	2005	2006	2007	2008	2009	2010	2011	Trend	No. of years	*p* value
39.2	8	10	11	11	9	9	13	NC	7	0.246
35.8	8	10	10	9	10	10	10	NC	7	0.165
31.4	–	7	–	9	11	12	13	IMP	6	<0.001
30.1	14	9	12	9	13	11	11	NC	7	0.726
20.4	3	11	13	13	14	14	14	IMP	7	0.041
1.9	14	14	13	15	17	16	16	IMP	7	0.046

NC no change, *IMP* improved

Underwood et al 2014

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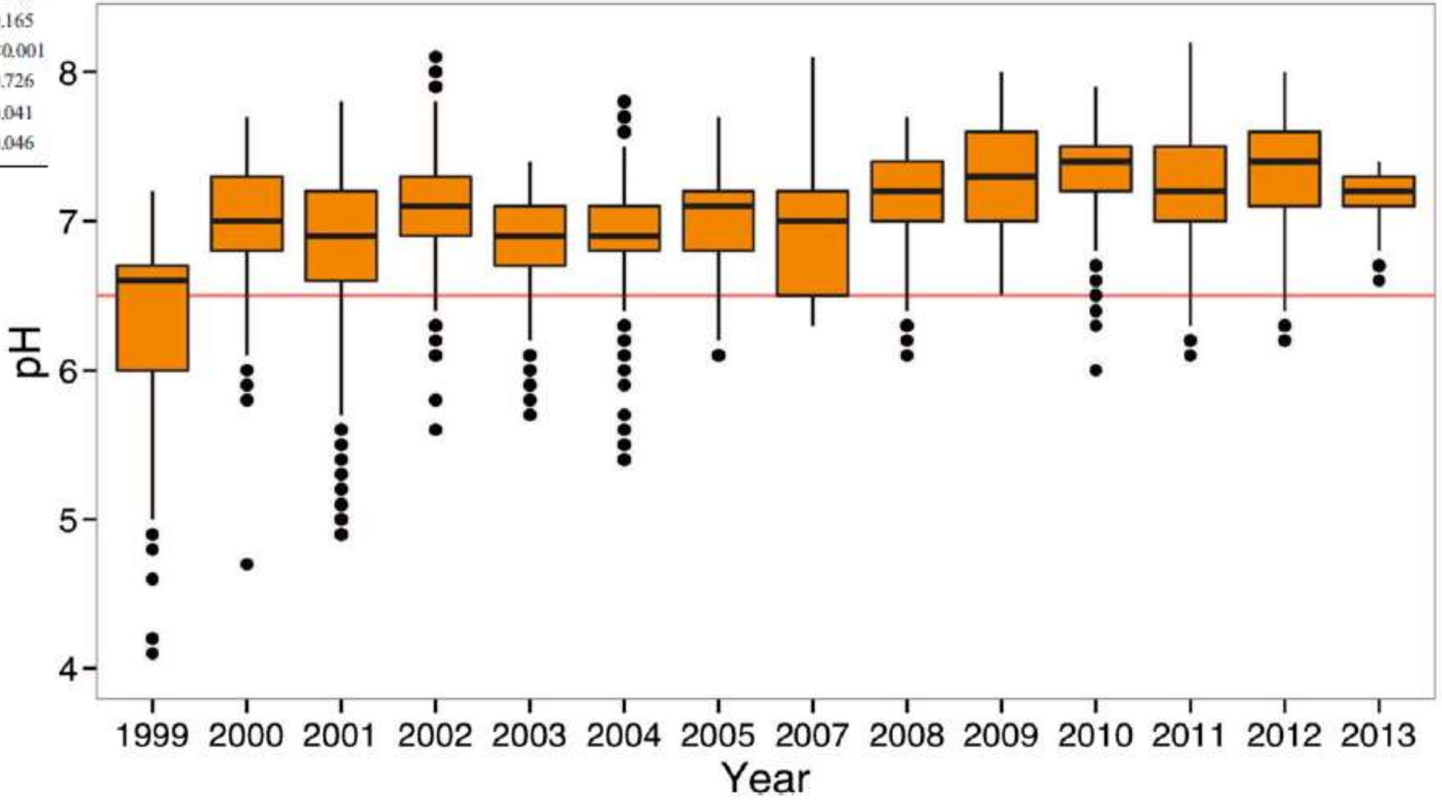

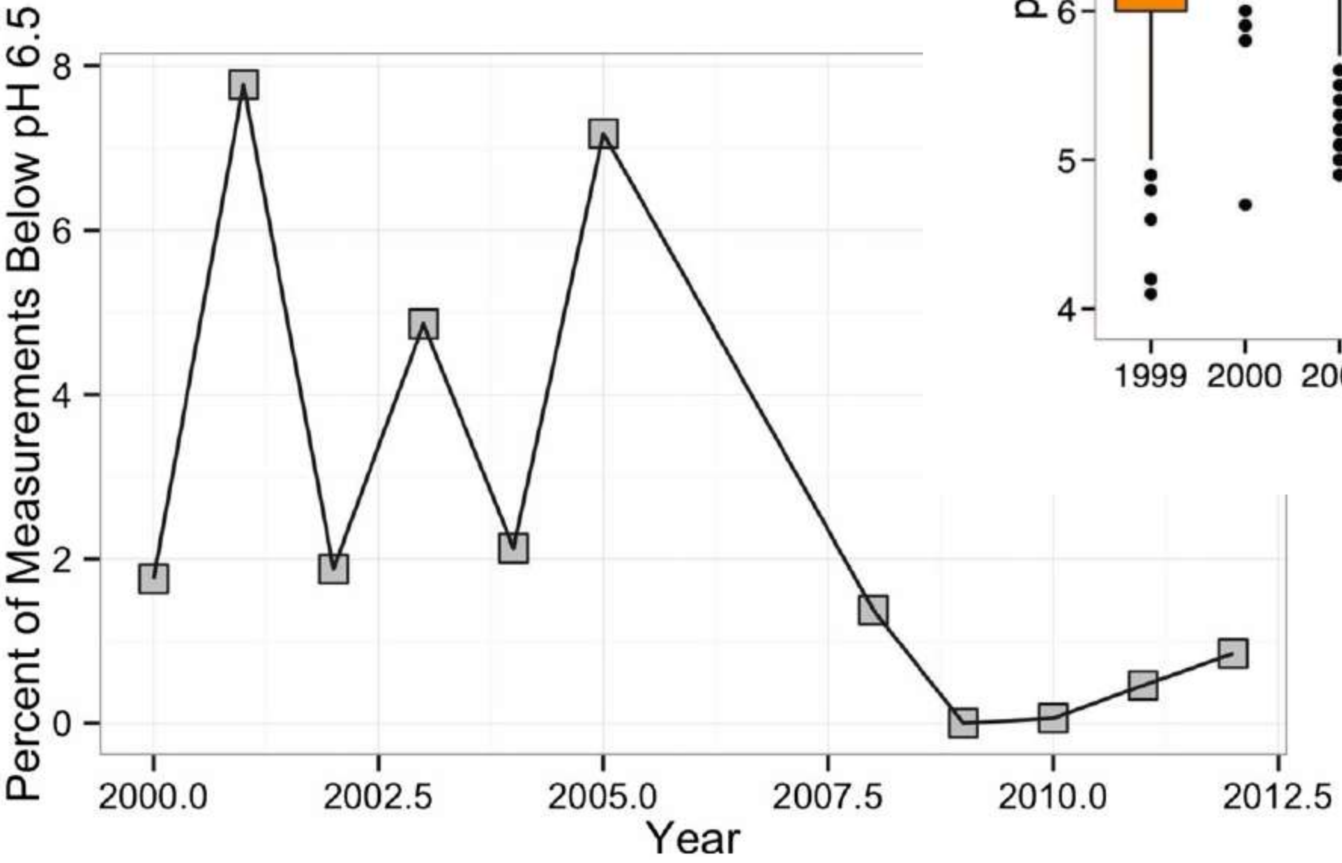

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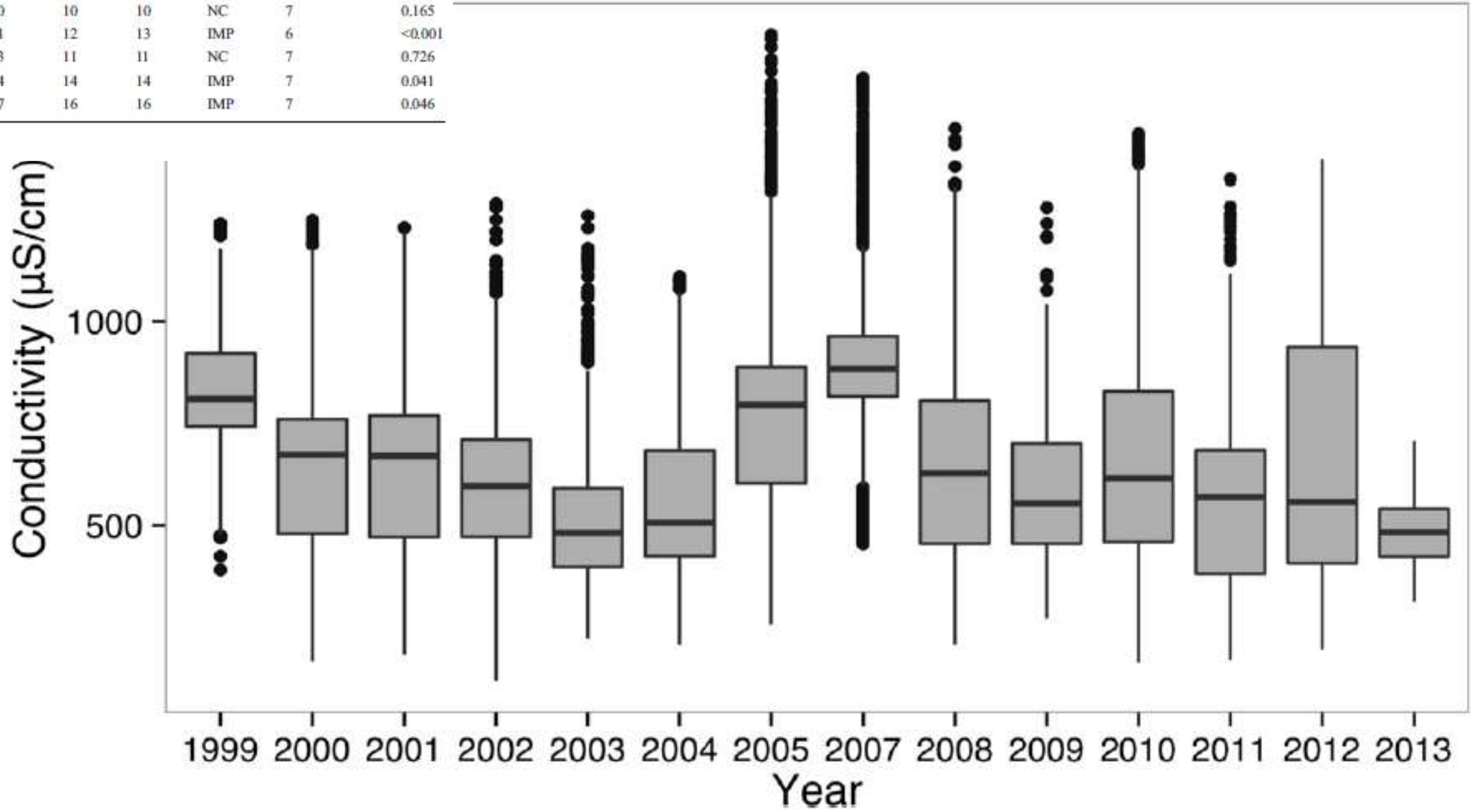

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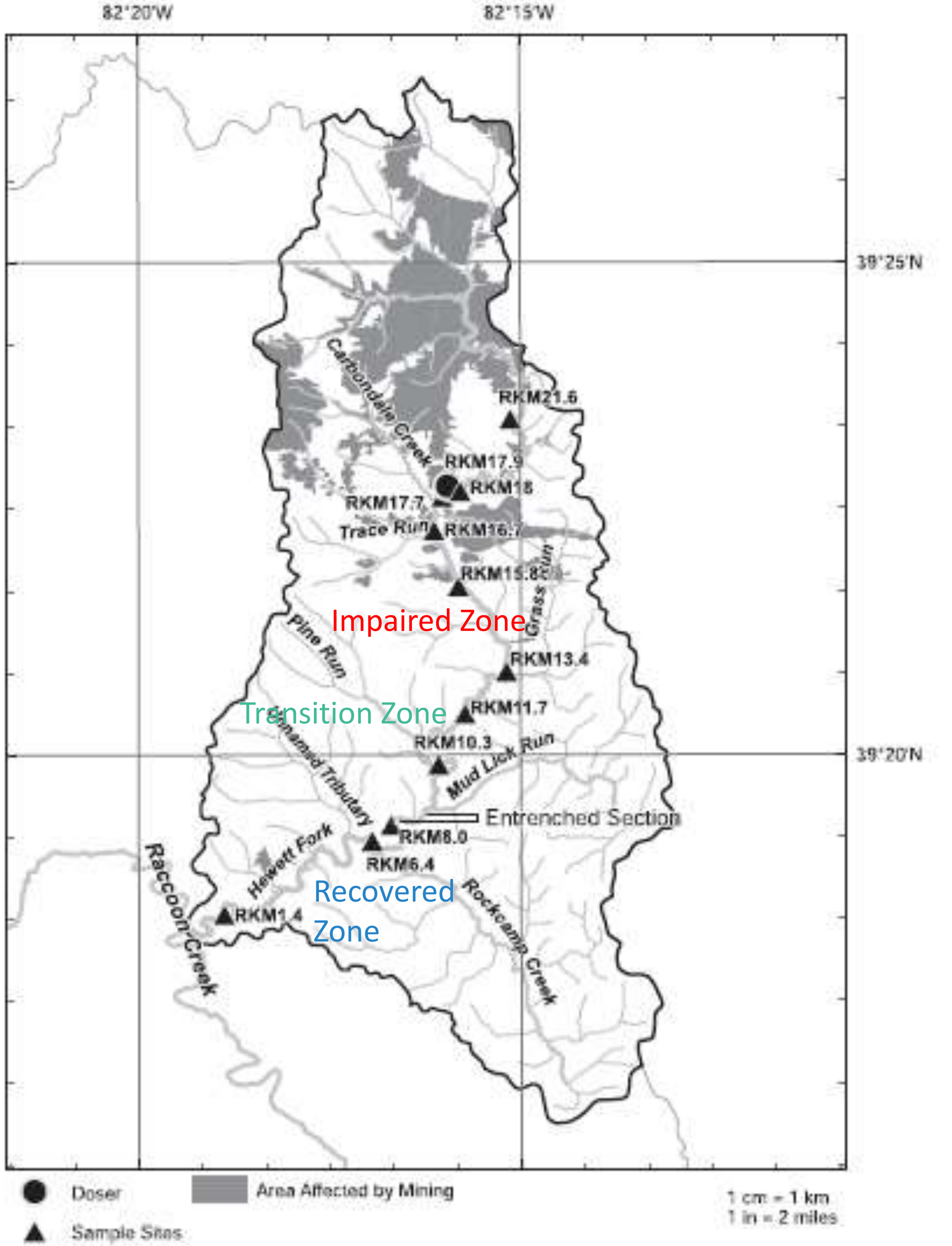
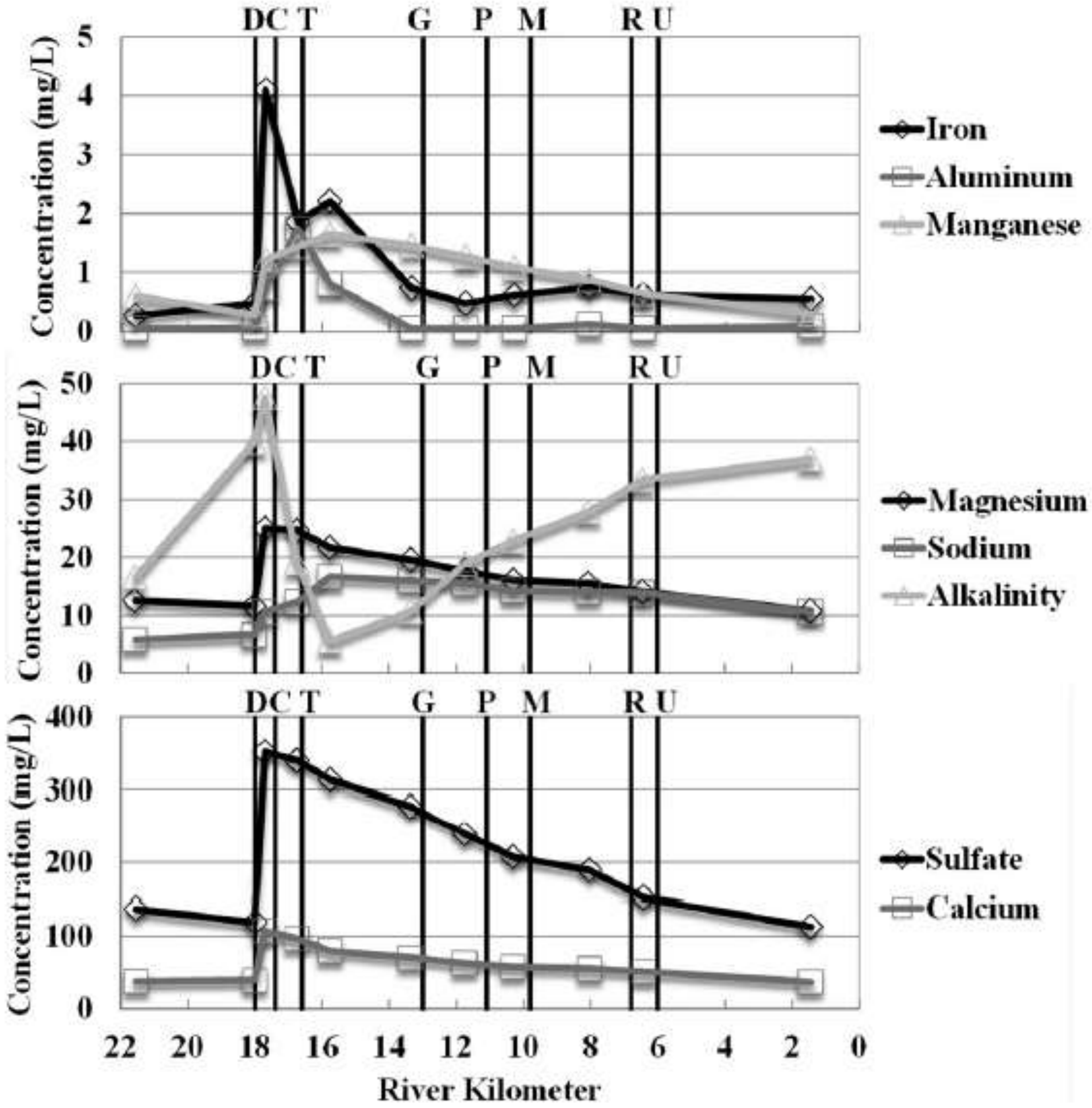
Hewett Fork Headwaters of R.C.

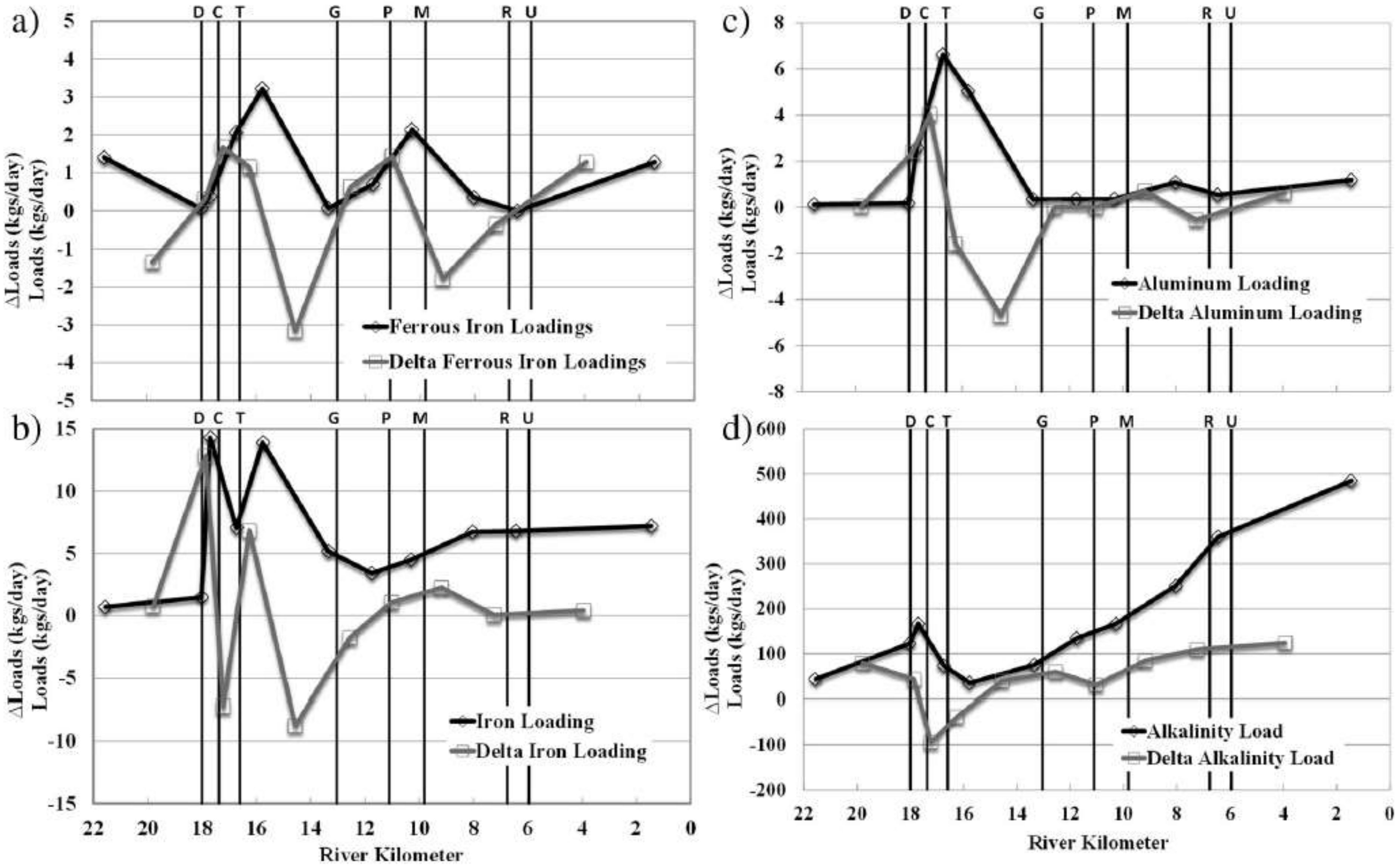


Water Quality Improvement



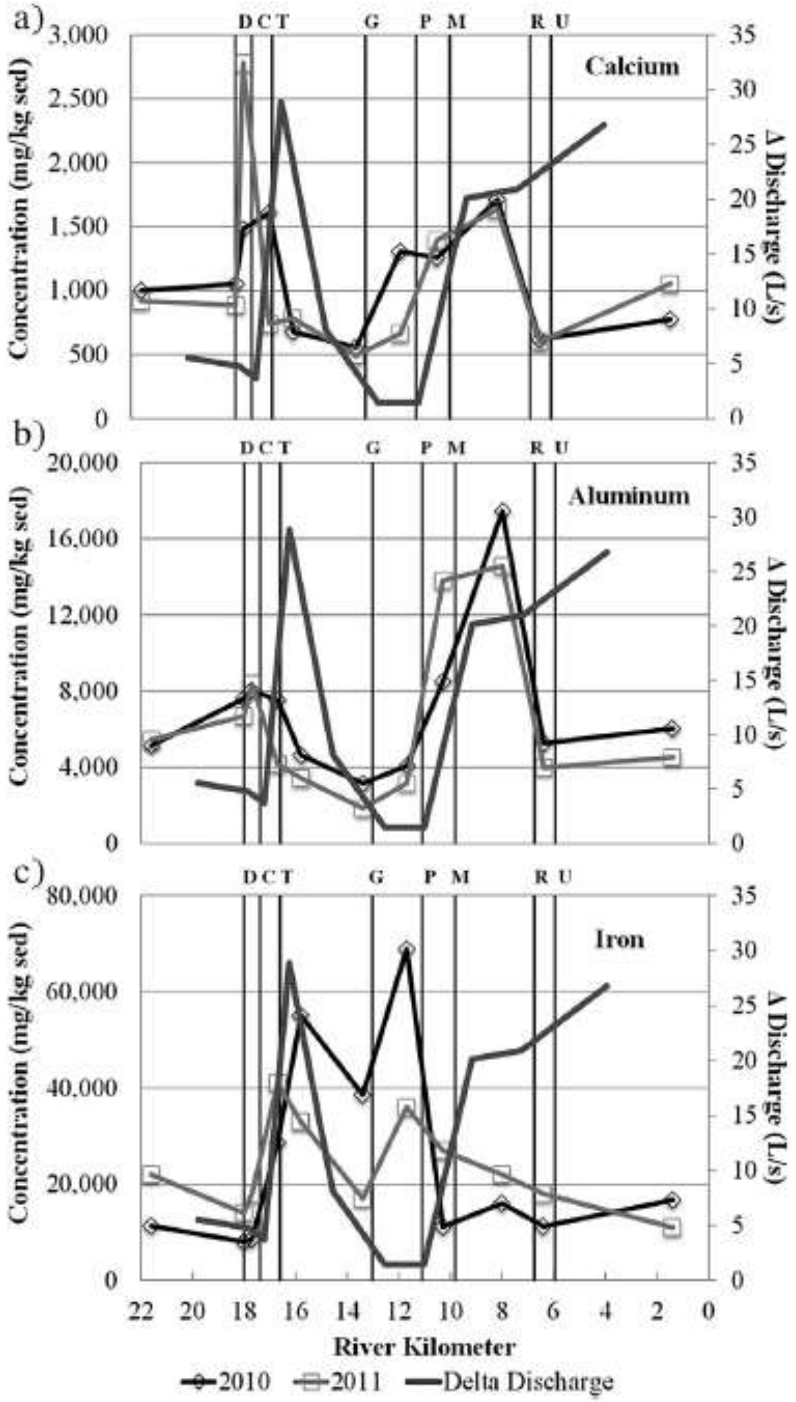
Kruse et al 2013

Metal Flux



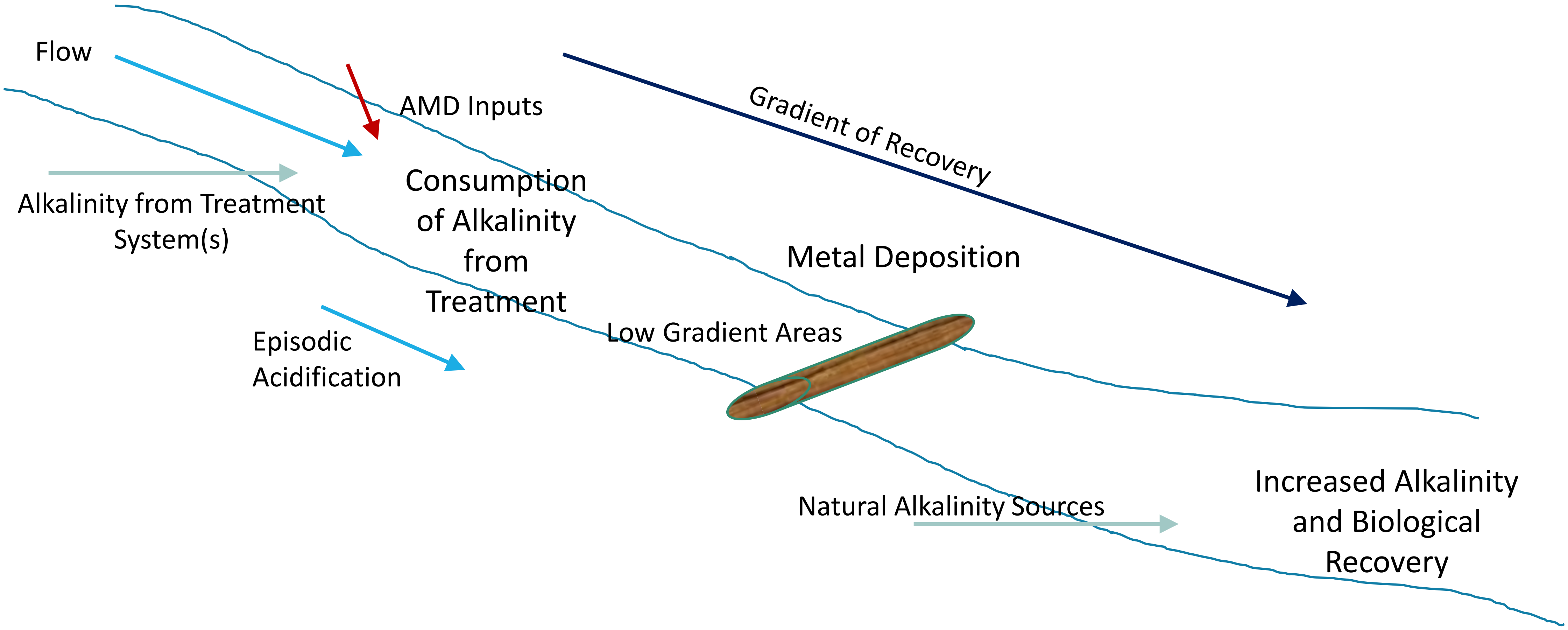
Kruse et al 2013

Sediment Chemistry

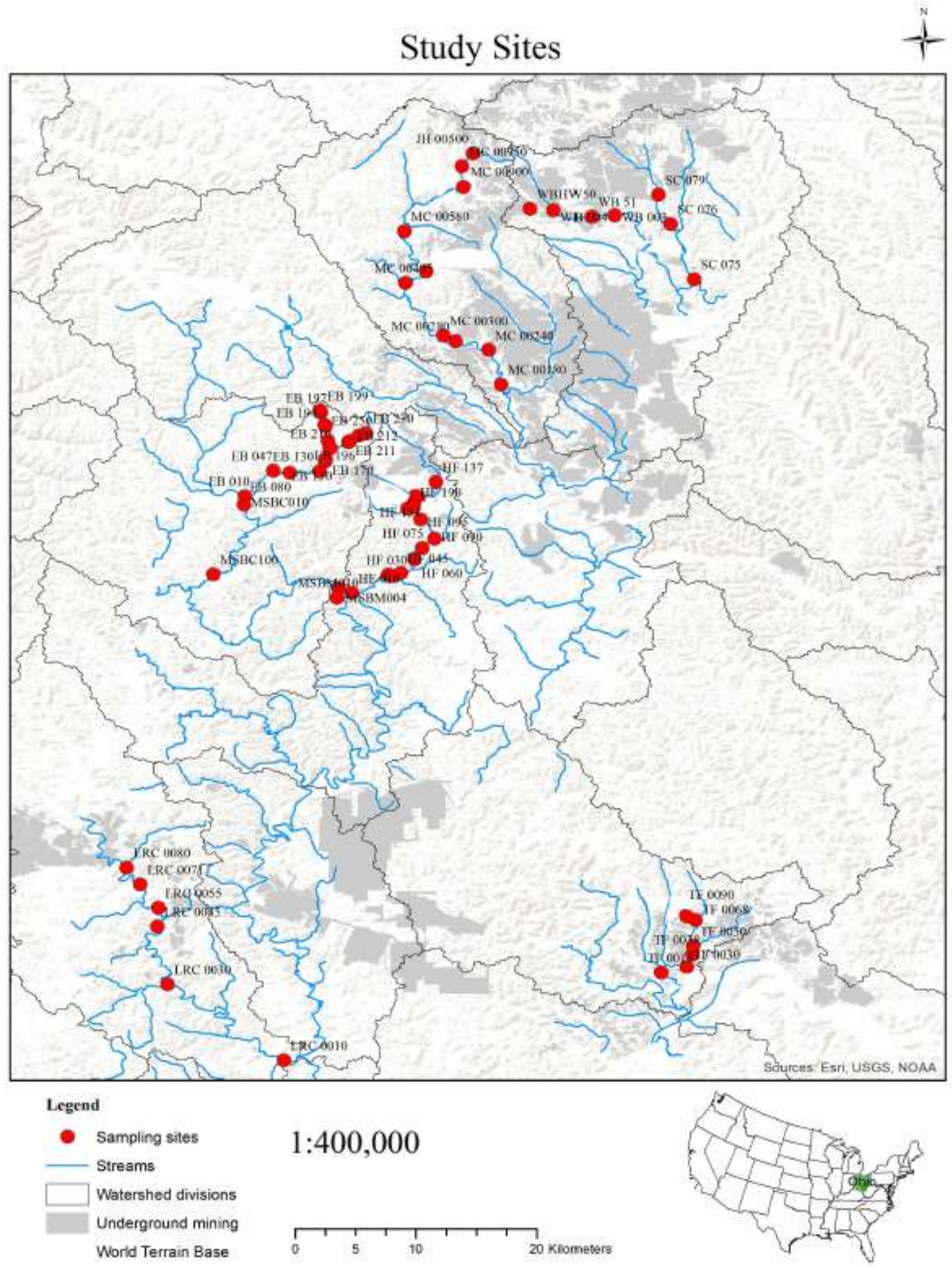


Kruse et al 2013

Conceptual Model of Recovery



How does this conceptual model test across watersheds?



Exploring Patterns Across Watersheds

62 sites across a gradient of impairment

All have aqueous and sediment chemistry measurements and over 5 years of macroinvertebrate assessment

Damdimbal 2016

Aqueous Chemistry vs. Macroinvertebrates

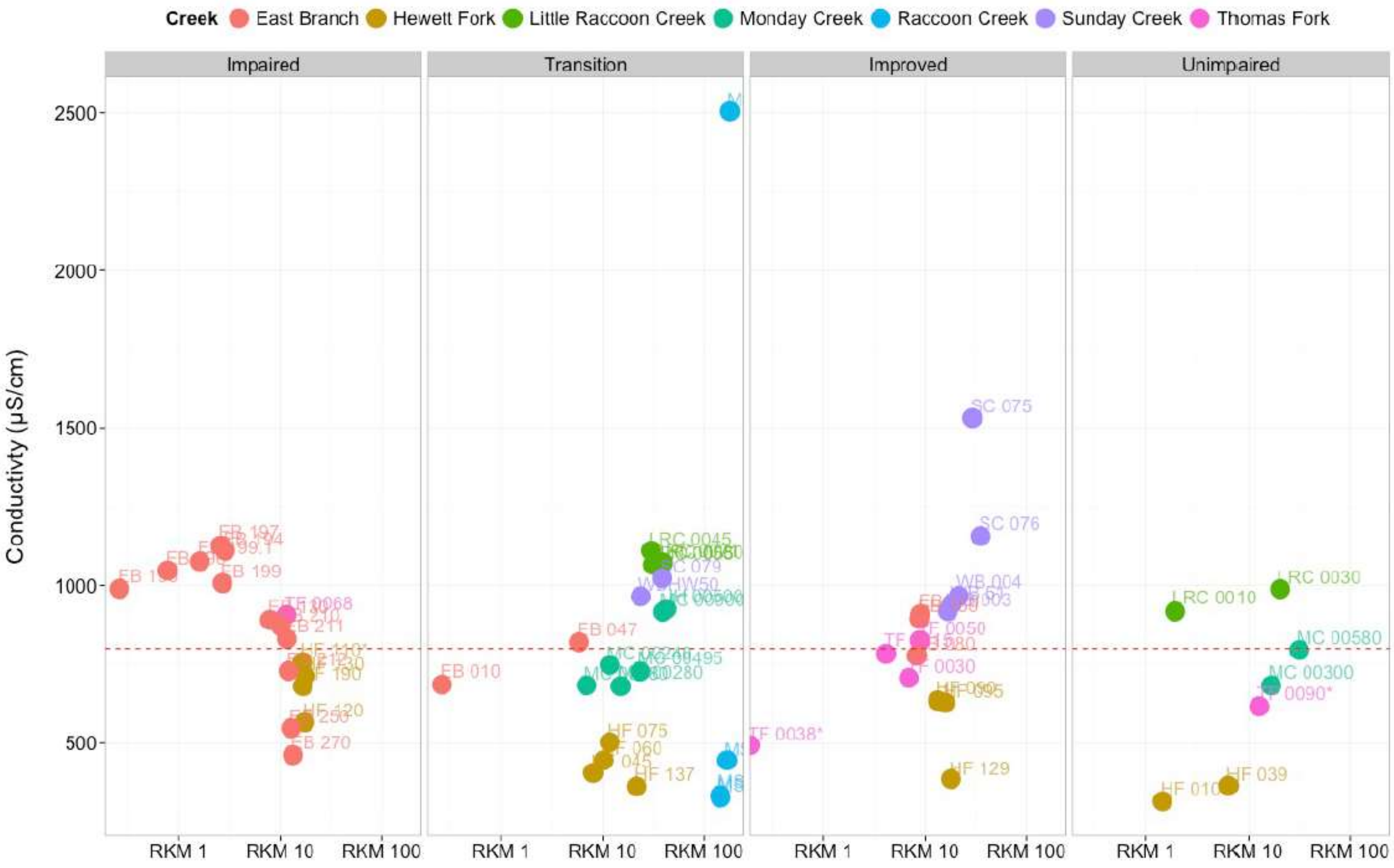
Statistically significant relationships between Fe, Al, Mn, and Acidity with MAIS (Macroinvertebrate Aggregrate Index for Streams) metric

Water quality parameters with significant differences between zones of recovery:

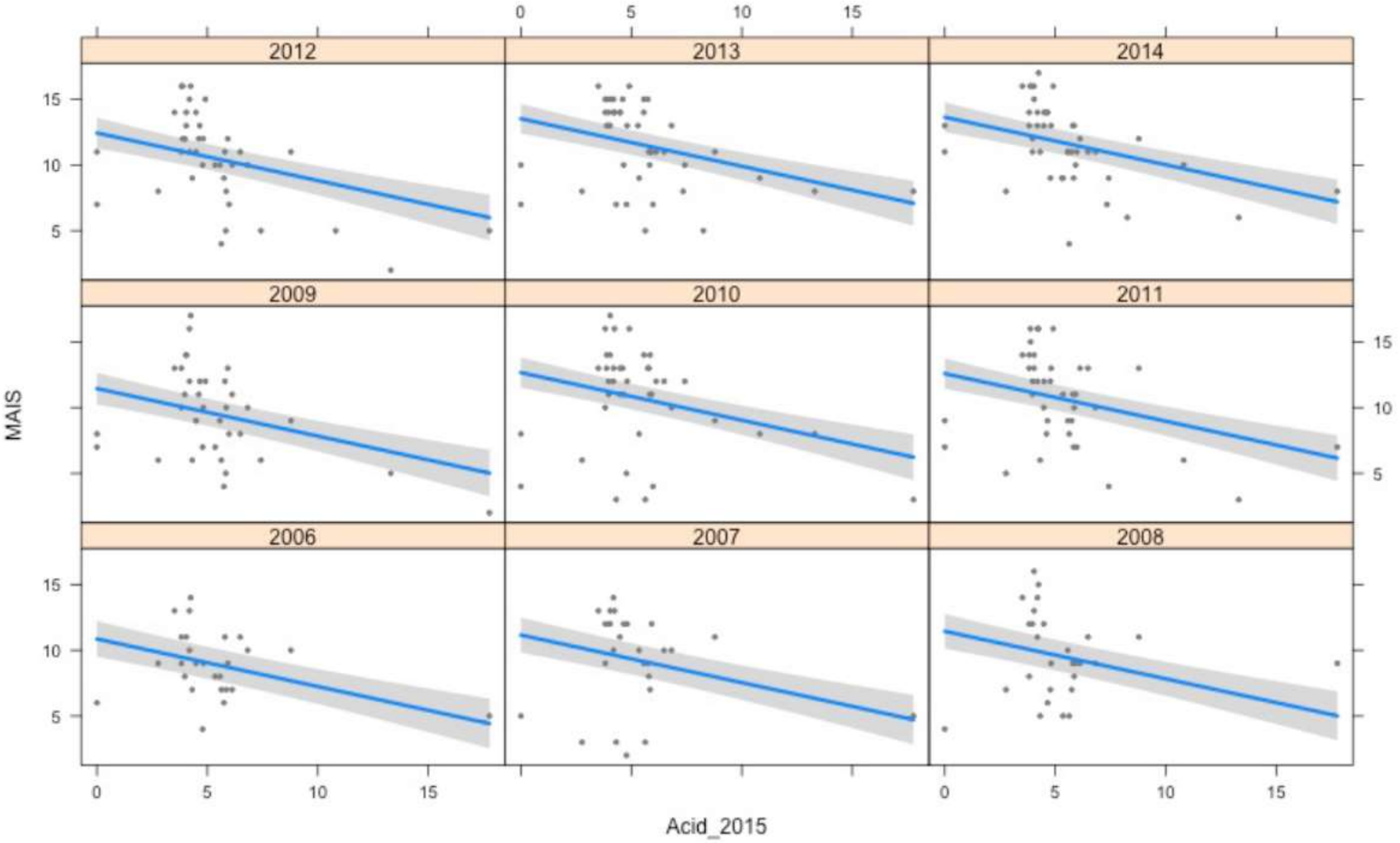
Parameters: 2014 - 2015	pH field	Conduct	Acidity	Alkalinity	ORP	TDS	TSS	Sulfate	Al	Ca	K	Mg	Mn	Fe	Na
P-value (Significance):	0.0059	0.0215	0.02629	0.06037	0.2499	0.0093	2.744e-05	0.0005475	3.451e-07	1.359e-05	0.2051	0.0339	1.256e-06	0.008147	0.005826
Different in 4 zones:	differs	differs	differs			differs	differs	differs	differs	differs		differs	differs	differs	differs
Similar in 4 zones:				same	same						same				

Damdimbal 2016

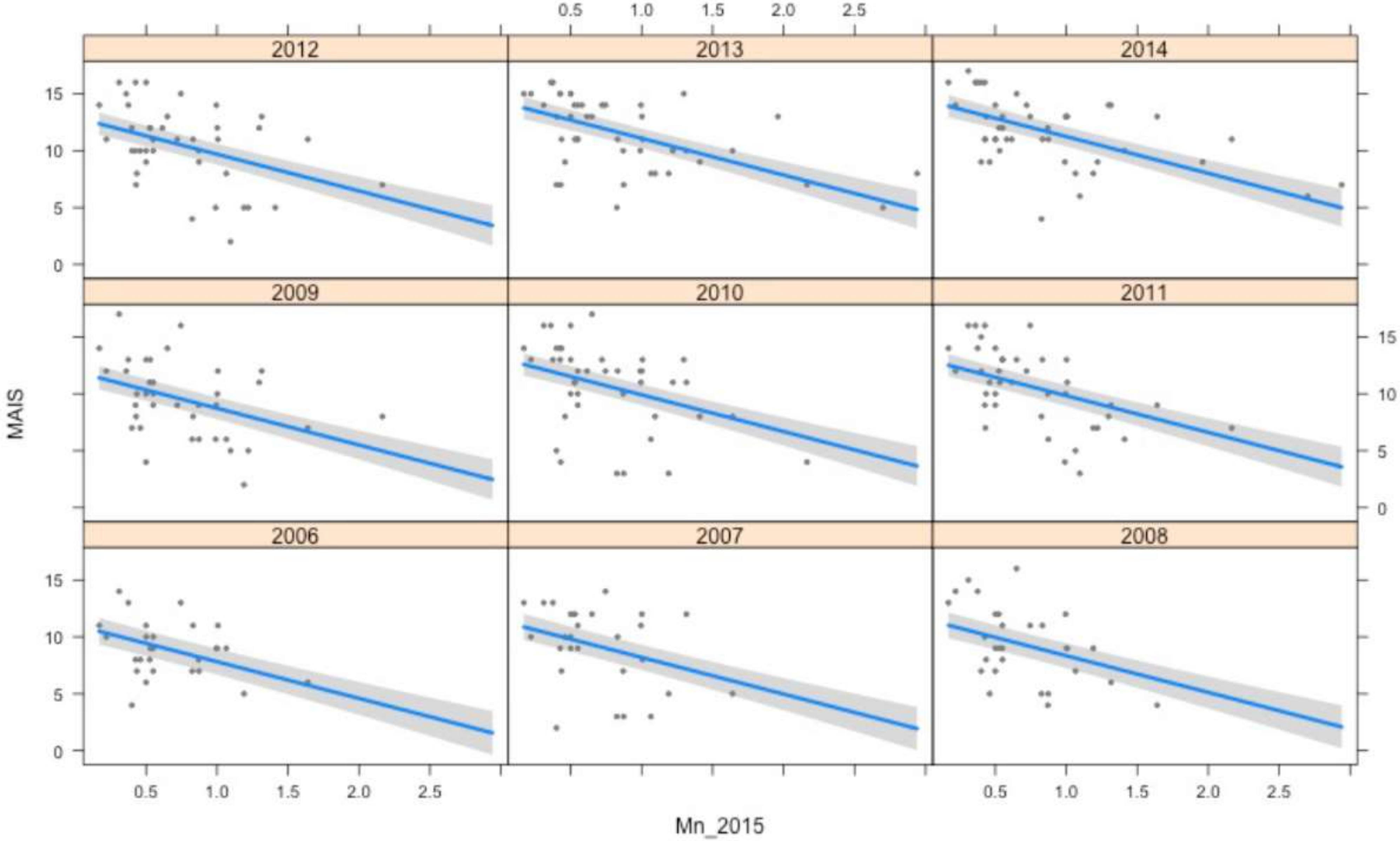
Damdimbal 2016



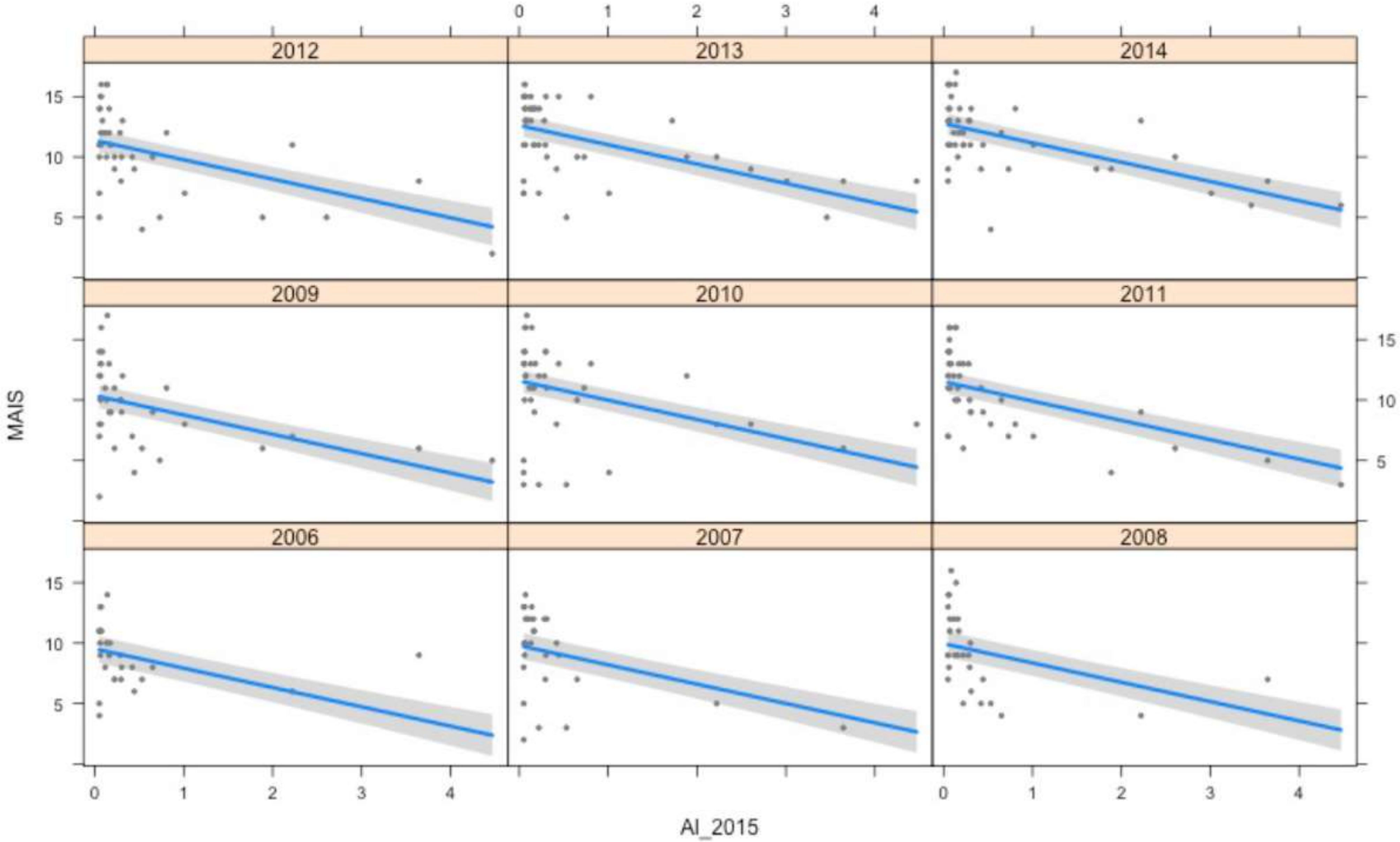
Damdimbal 2016



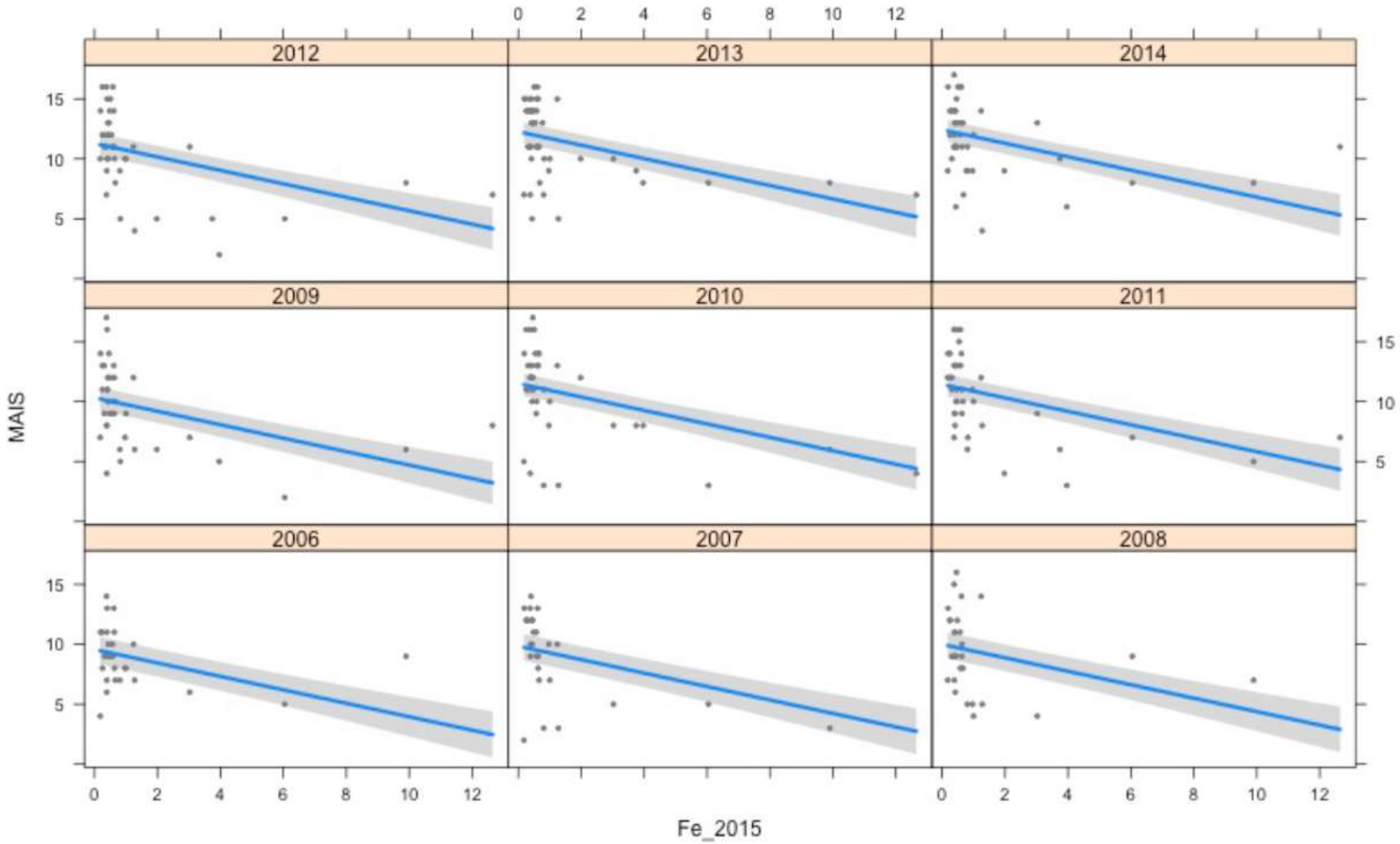
Damdimbal 2016



Damdimbal 2016



Damdimbal 2016



2012
2013
2014
2009
2010
2011
2006
2007
2008
MAIS
Fe_2015
0
2
4
6
8
10
12
15
10
5

Sediment Chemistry vs. Macroinvertebrates

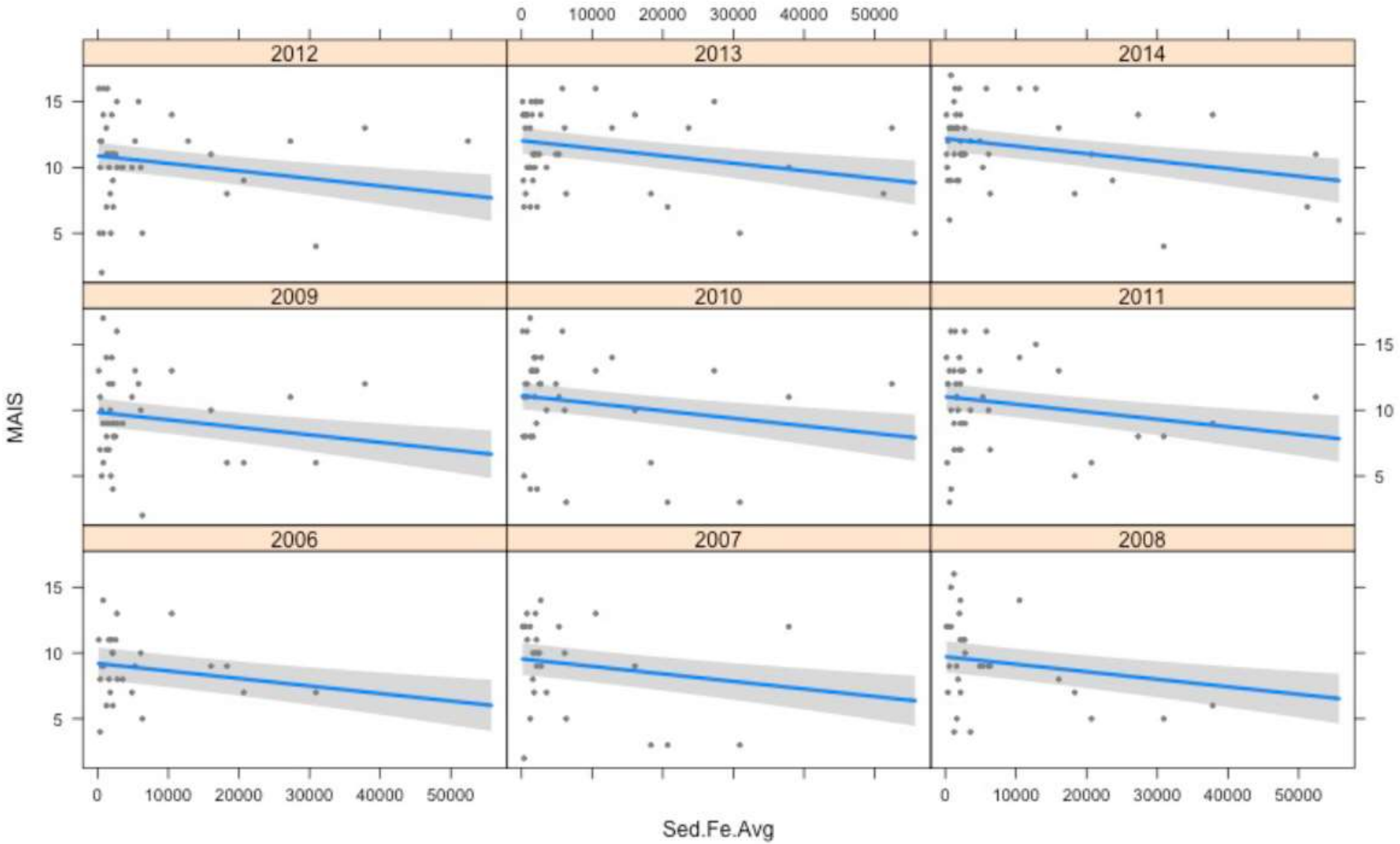
Statistically significant relationships between Fe, As, Mn, Cu, and Ca with MAIS (Macroinvertebrate Aggregrate Index for Streams) metric

Mn, Cu, Ca regressions are nearly flat, so the relationship isn't suggestive

Sediment chemistry parameters with significant differences between zones of recovery:

Parameters	Al	Ba	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Pb	Ni	Si	Sr	Zn
P-value:	0.0001293	0.0002428	0.0008985	1.64e-05	1.249e-05	7.05e-06	0.0001011	0.0004948	5.668e-05	9.547e-05	0.01608	3.032e-05	3.642e-05	0.0005837	0.000139	0.0001852
Different in 4 zone:	differs	differs	differs	differs	differs	differs	differs	differs	differs	differs	differs	differs	differs	differs	differs	differs
Similar in 4 zone:	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Damdimbal 2016



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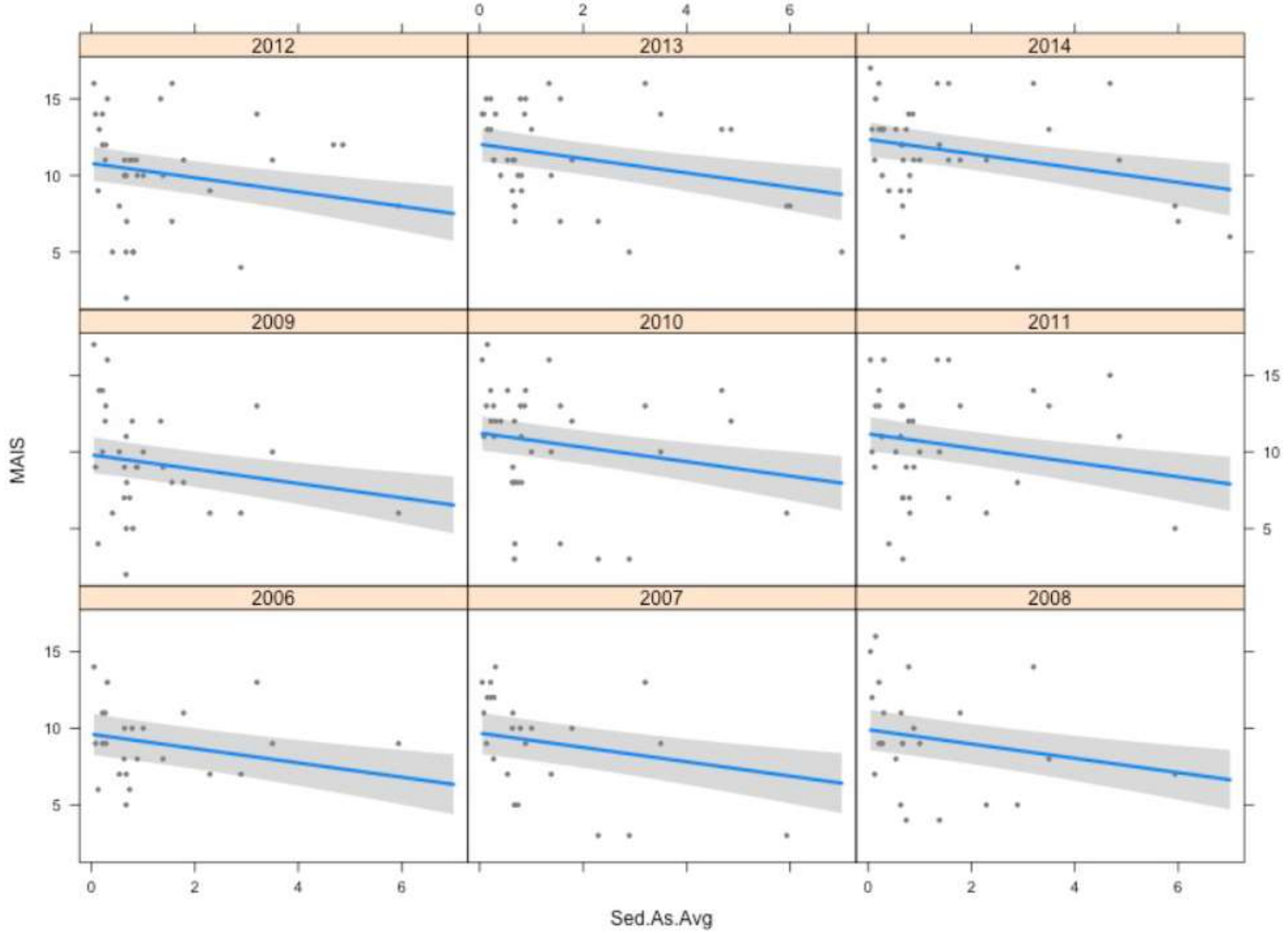


Damdimbal 2016

Metal attenuation remains a significant factor in biological recovery when we test our model against a larger dataset.

Variations Downstream of Similar Treatment Systems

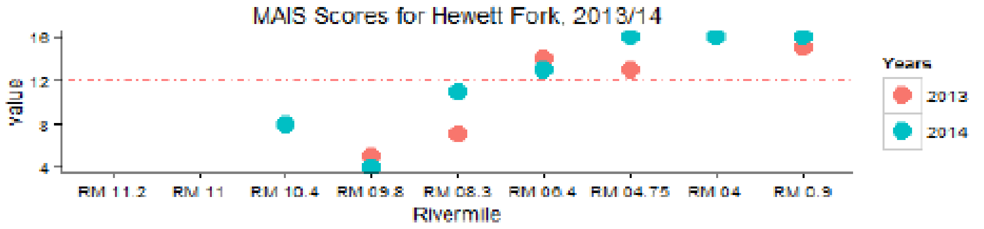
Lime dosers in:

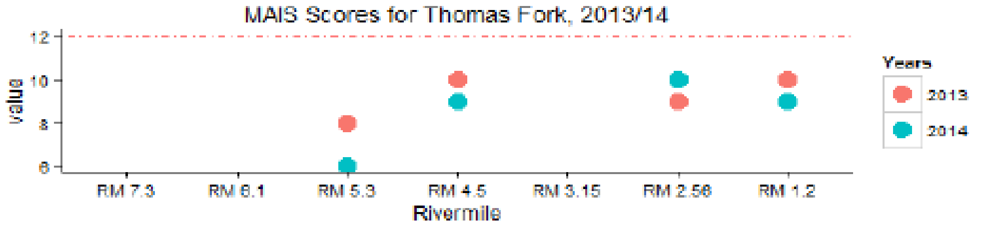
Hewett Fork, Raccoon Creek

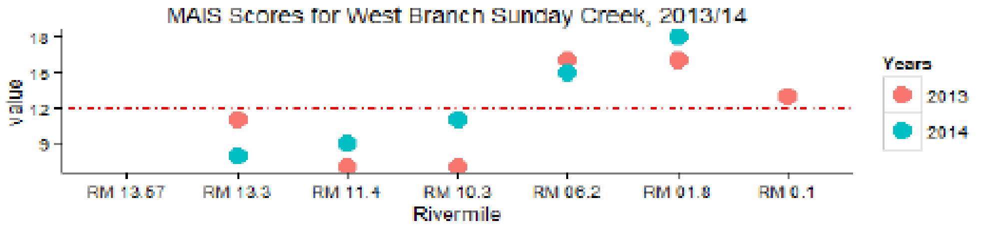
Thomas Fork, Leading Creek

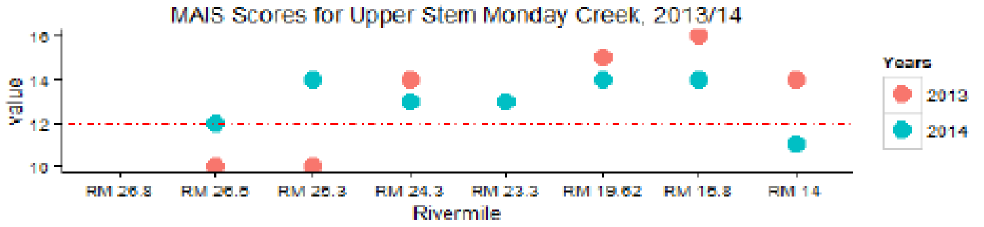
West Branch Sunday Creek

Jobs Hollow, Monday Creek









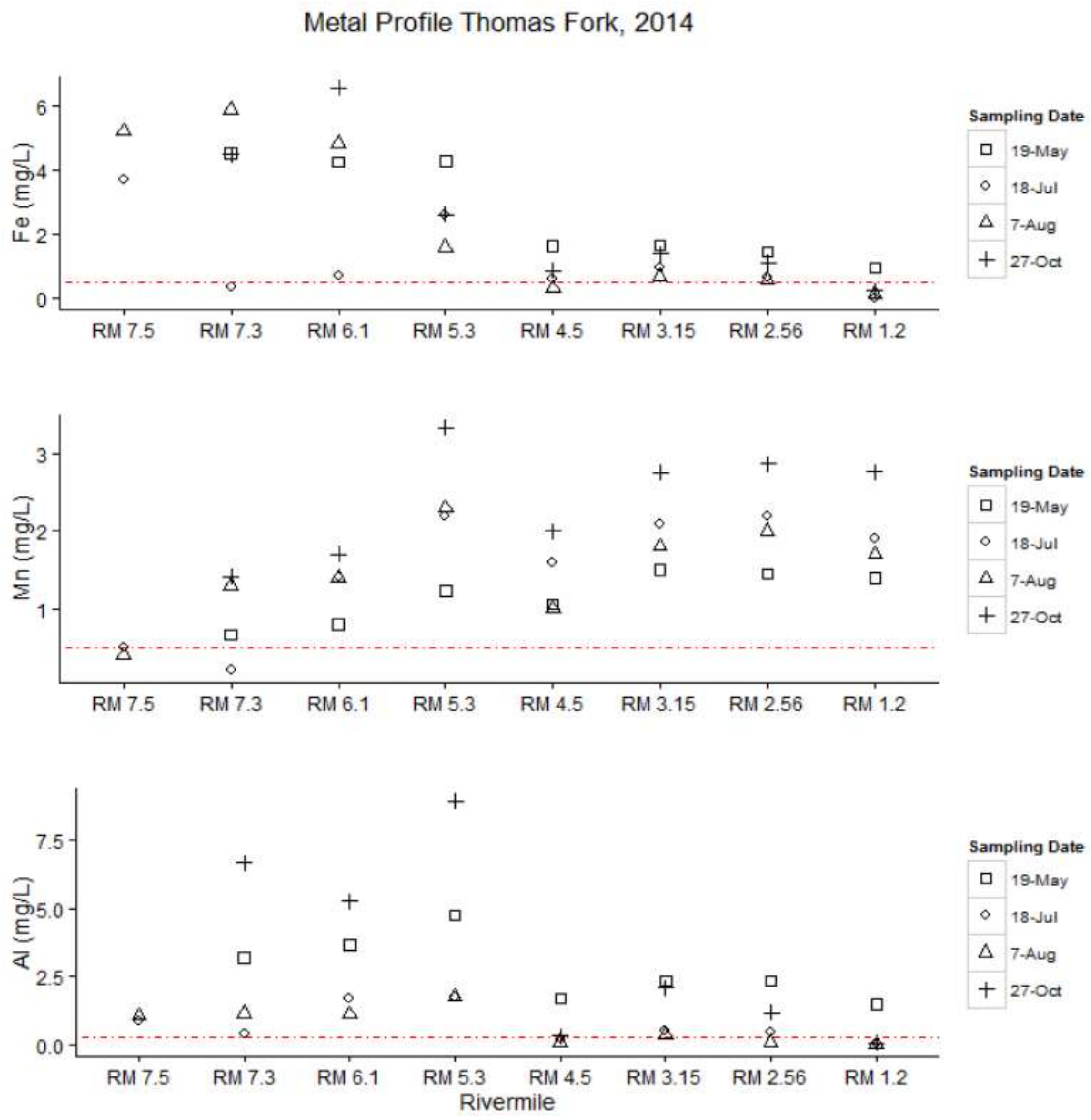
Statistically Significant Parameter Relationships

Spearman Correlations Coefficient (R) Matrix of MAIS Scores, Field Parameters and Stream Chemistry

(Shaded boxes indicate significant correlations)

	MAIS	pH	Conductivity	Sulfate	Acidity	Alkalinity	Fe	Mn	Al
MAIS	.								
pH	0.232	.							
Conductivity	-0.307	0.151	.						
Sulfate	-0.452	0.034	0.765	.					
Acidity	-0.374	-0.458	0.177	0.195	.				
Alkalinity	0.24	0.504	0.069	-0.201	-0.415	.			
Fe	0.511	0.041	0.093	0.307	0.019	-0.181	.		
Mn	0.682	-0.204	0.424	0.589	0.356	-0.473	0.571	.	
Al	0.463	0.015	0.256	0.425	0.037	-0.149	0.809	0.581	.

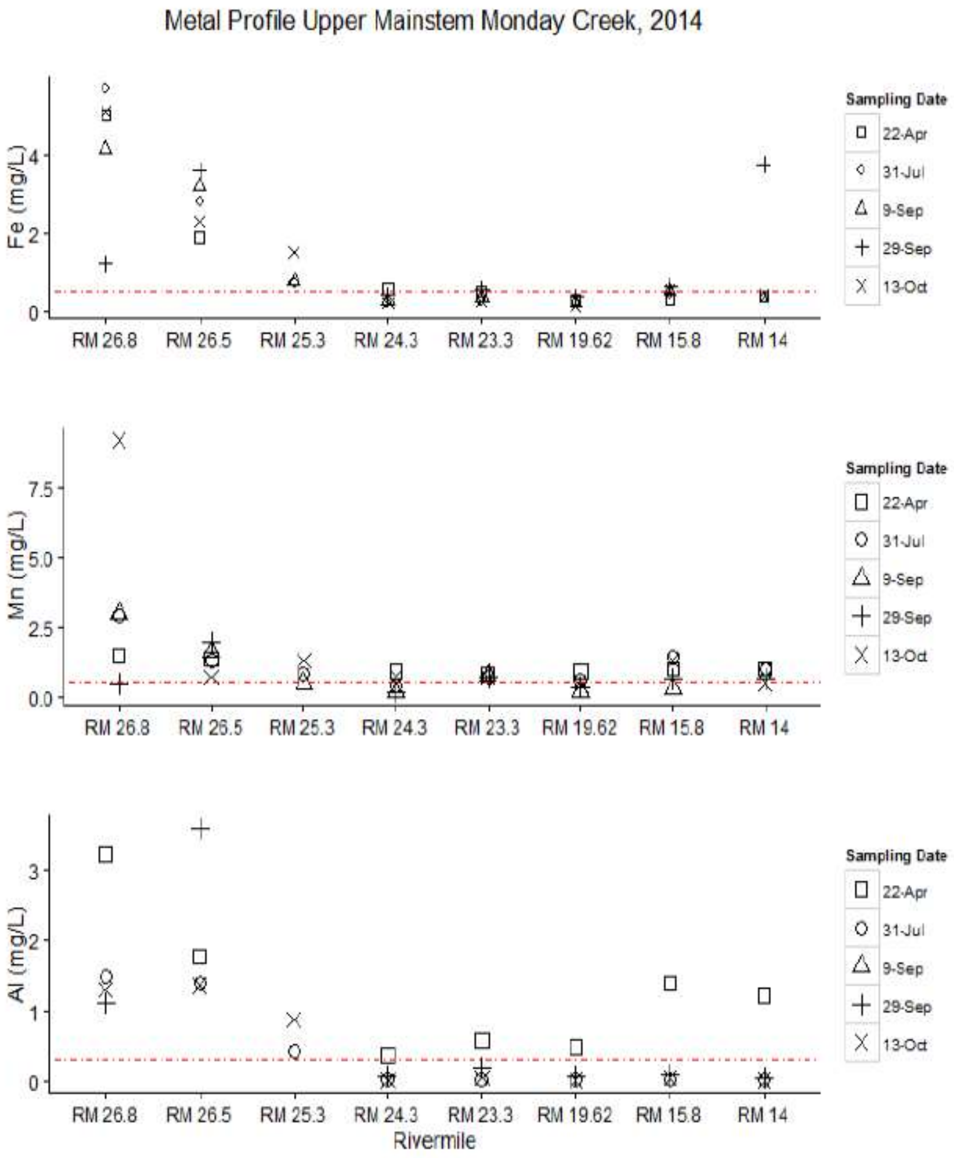
Bedu-Mensah 2015



Poor Recovery

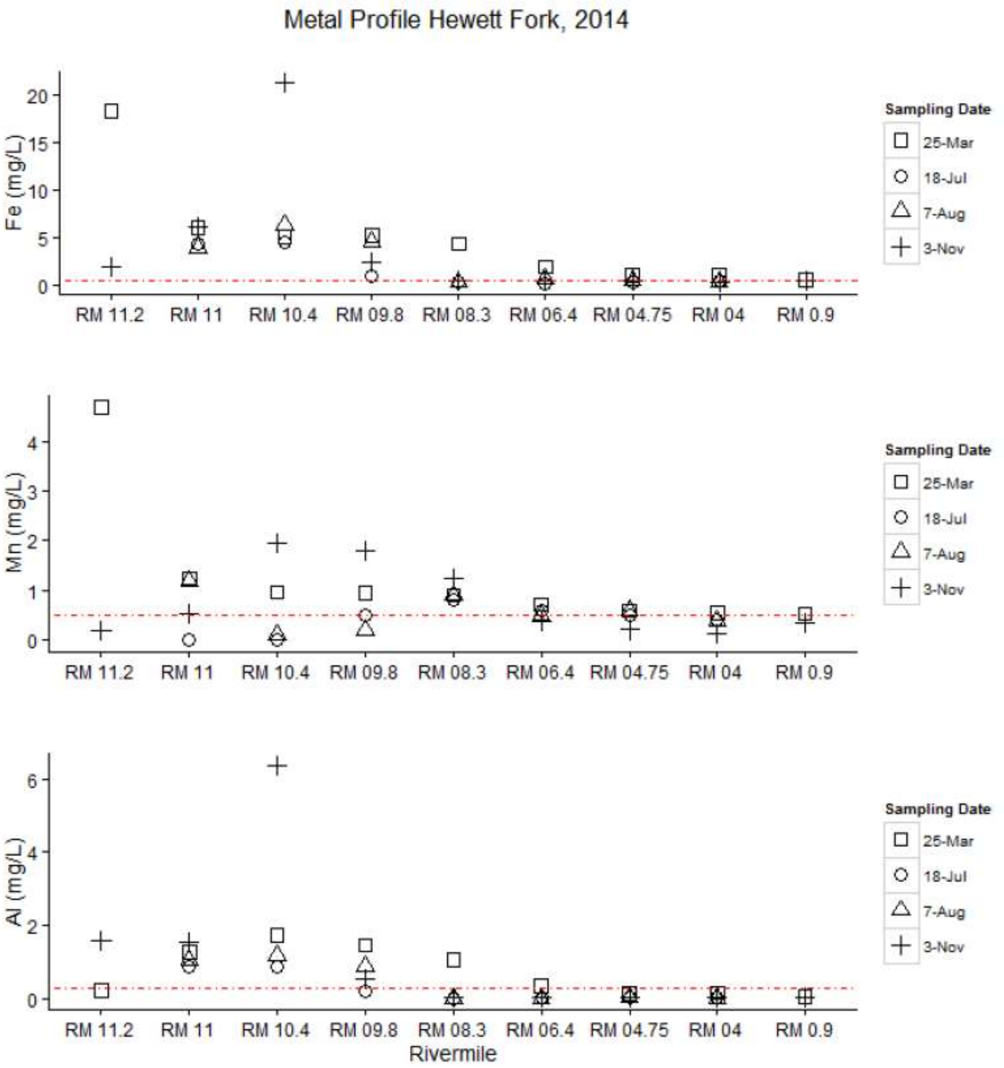
Bedu-Mensah 2015

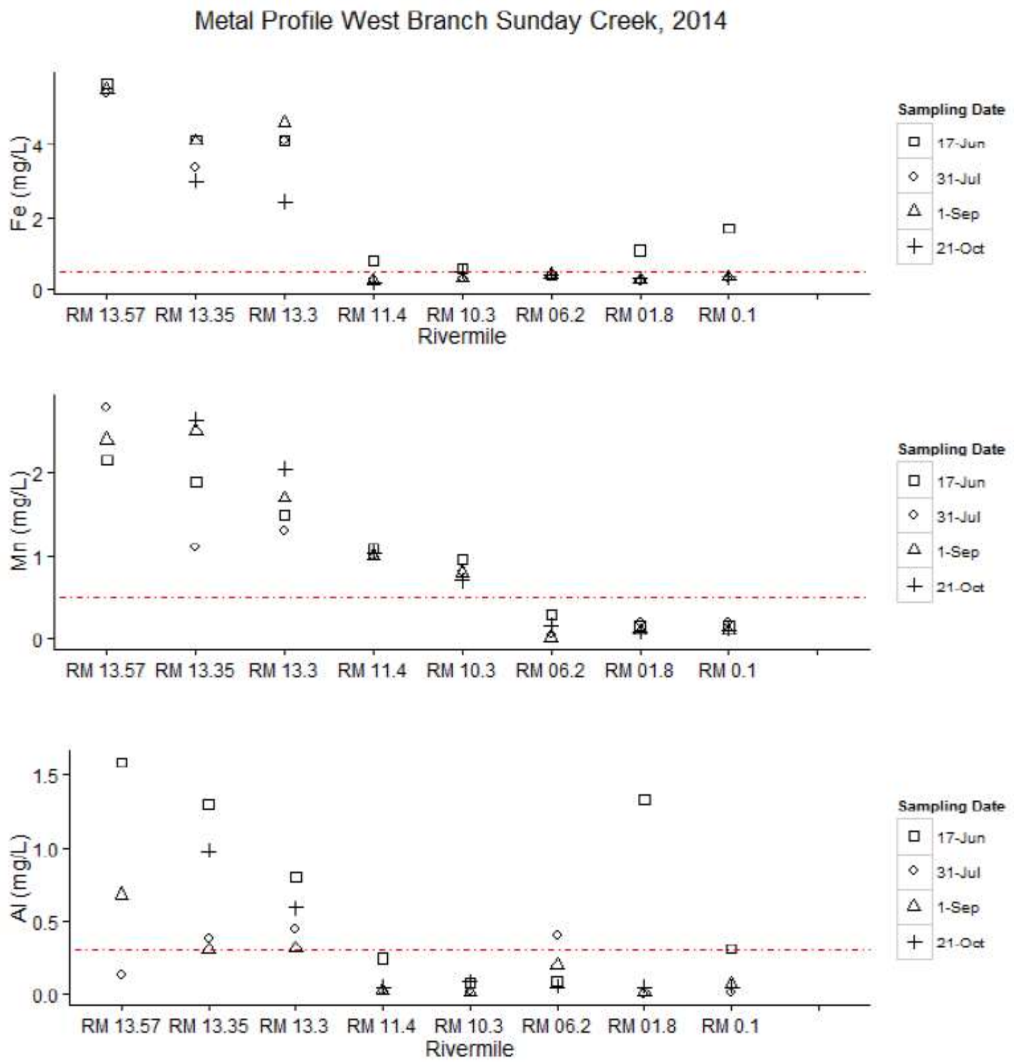
Varied Recovery (between years)



Bedu-Mensah 2015

Meeting Biological Targets



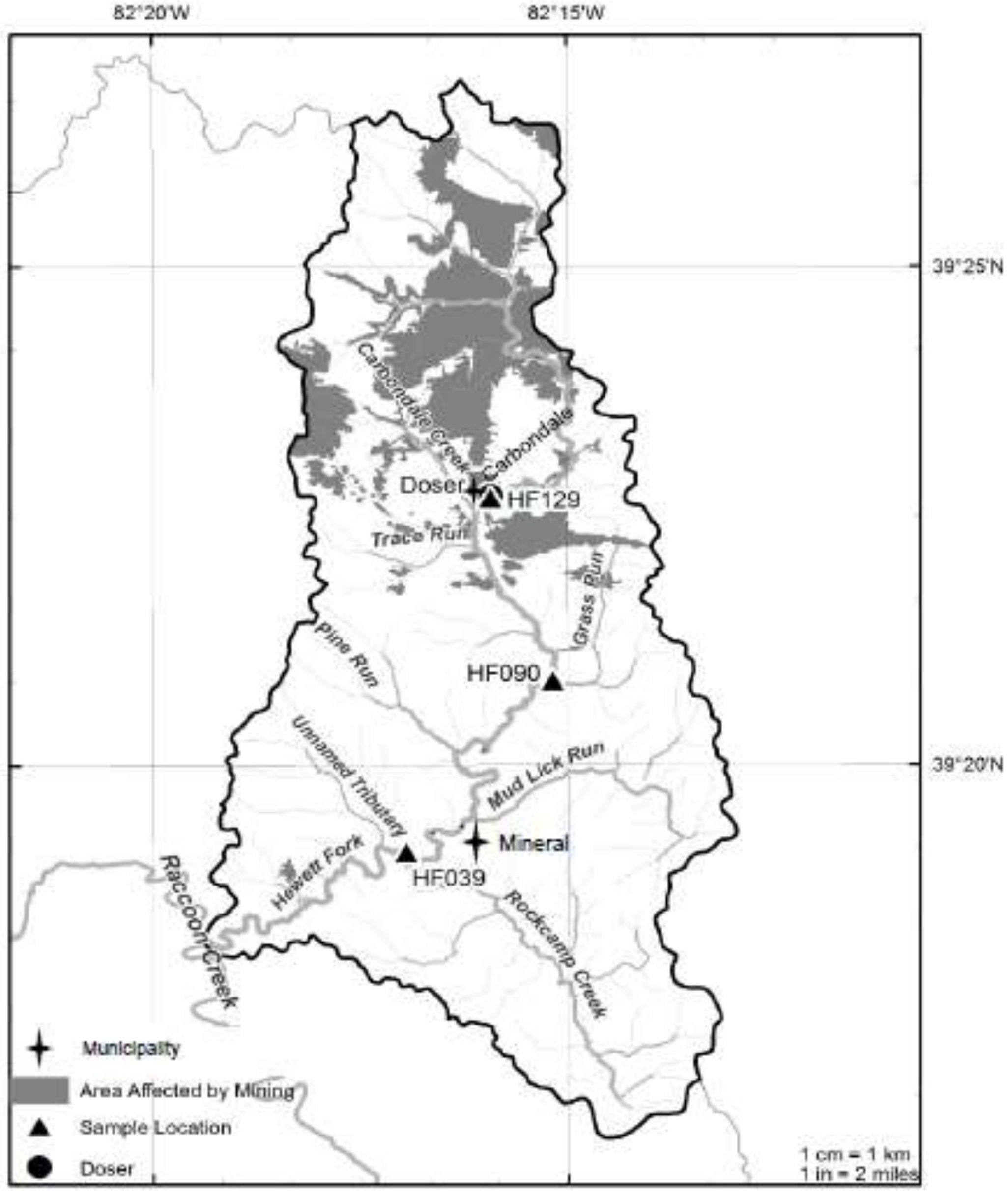


Bedu-Mensah 2015

Supports metal deposition as a key factor in biological recovery.

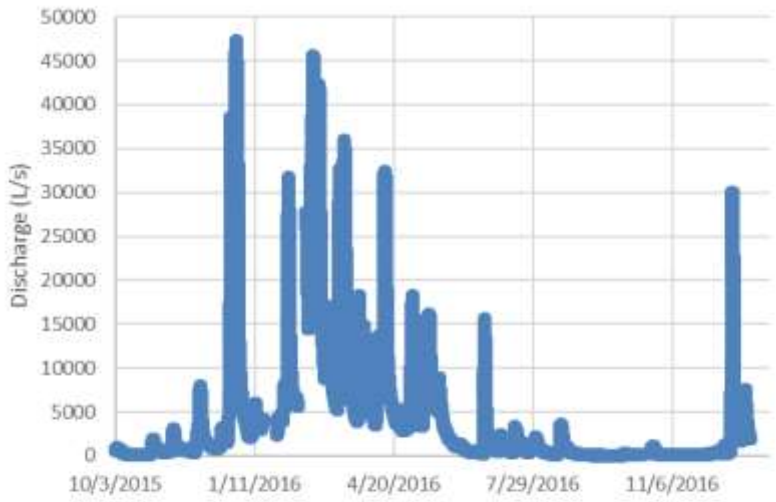
But what about pulses of poor water quality?

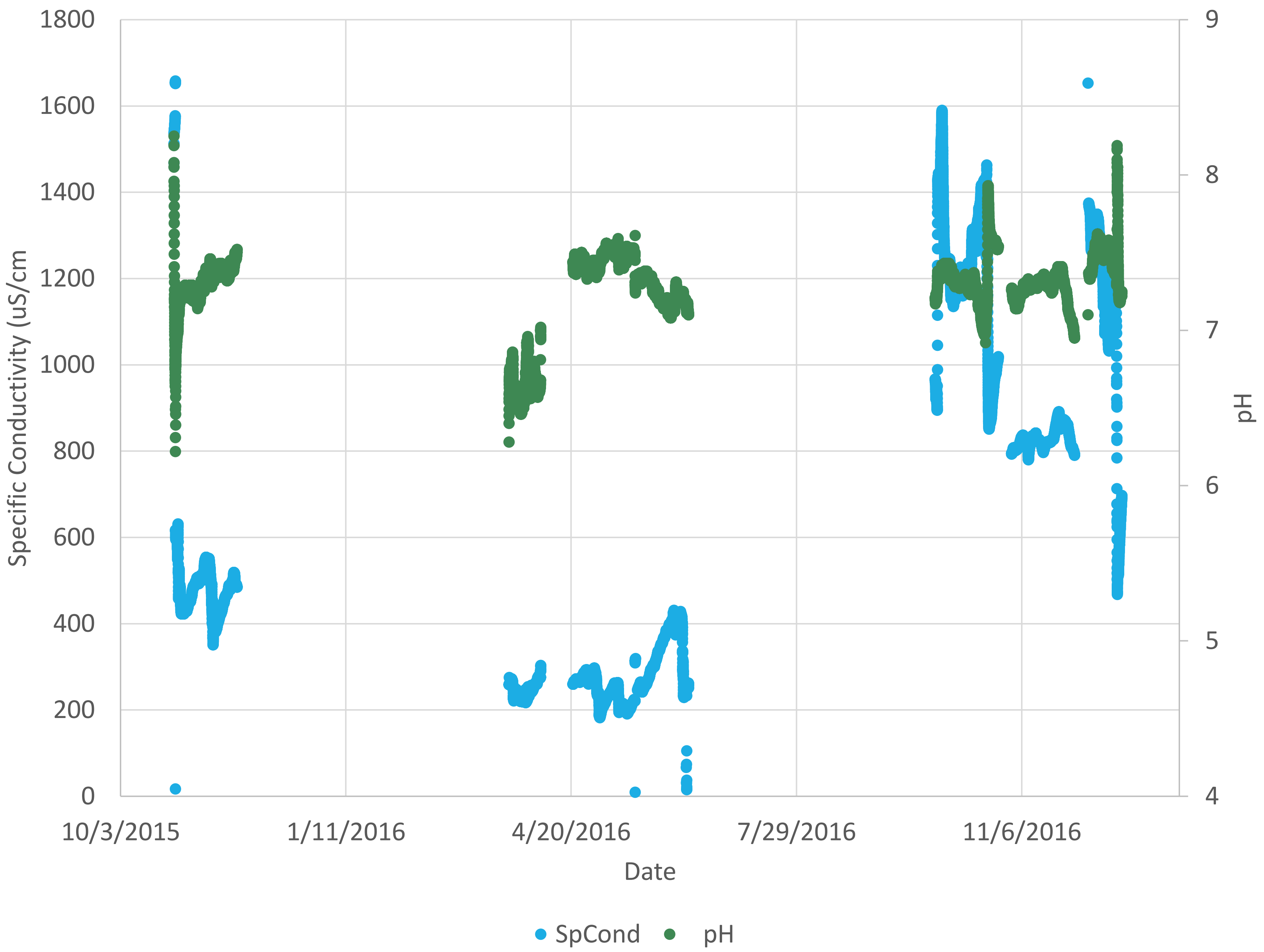
Episodic Acidification/ Poor Water Quality



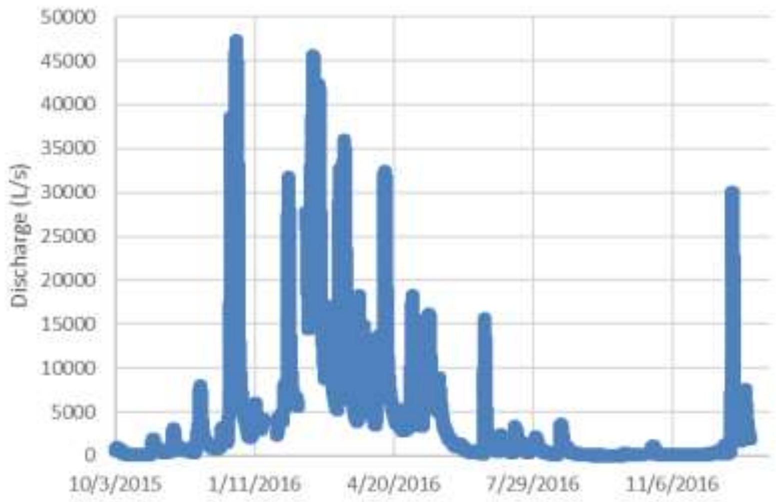
Martin 2017

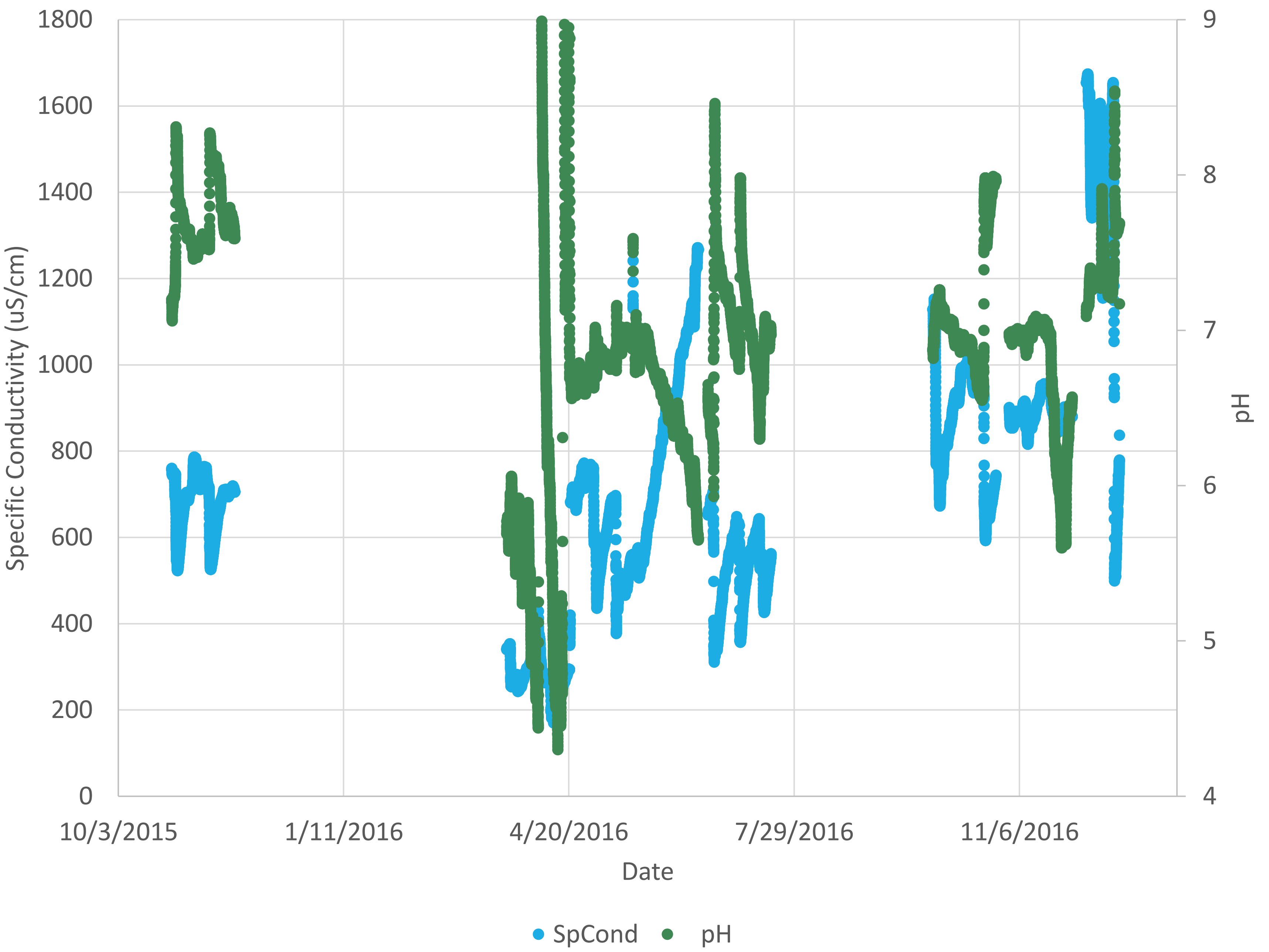
Recovered Zone





Impaired Zone





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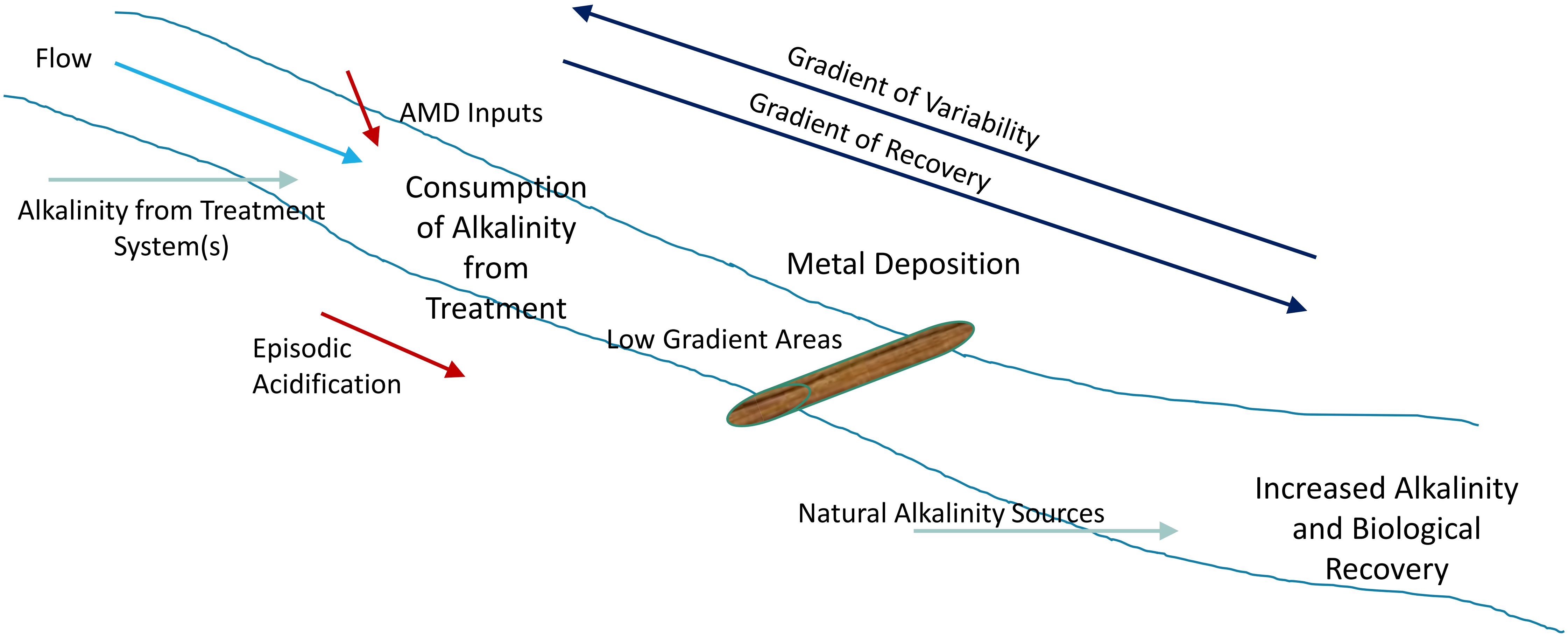
Suggests that variability and episodic poor water quality may play a role in recovery.

Summary and Conclusions



Thank you

Appalachian Watershed Research Group

- Jen Bowman
- Kelly Johnson
- Morgan Vis
- Dina Lopez
- Amy Mackey

Environmental Studies Students

- Henry Bedu-Mensah
- Saruul Damdimbal
- Zeb Martin
- Bruce Underwood

VOINOVICH SCHOOL *of* Leadership *and* Public Affairs

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AEP AMERICAN ELECTRIC POWER FOUNDATION