Hinkson Creek:
Collaborative Adaptive Management

Stakeholder Meeting
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Talk Objectives/Context

- Research findings to date
  - Focus on aquatic ecosystem / water quality
- Emerging story
- Needed research

The Approach to any Problem Determines the Outcome

- The problem:
  - 1998, HC was listed on the CWA 303(d) list of impaired waters.
- Solving the problem: How to get HC delisted?
  - Identify and apply a mitigation strategy for the reason it was listed.
- Major problem with solving the problem:
  - HC was listed for “unknown reasons”.

The Approach to any Problem Determines the Outcome

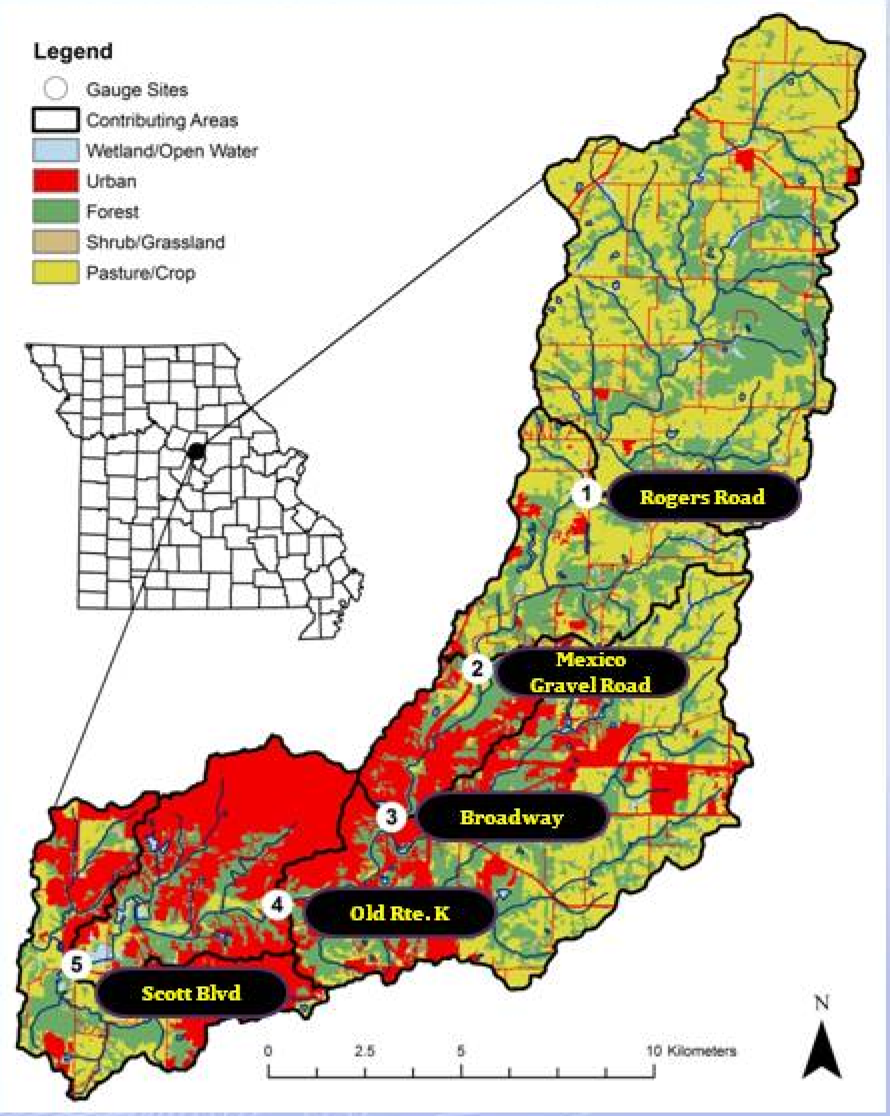
- "What is wrong with Hinkson Creek?"
- Classic black box problem. Start by asking simple questions…
  - Why?
    - The law of Parsimony, or Occam's razor
    - Among competing hypotheses, the one that makes the fewest assumptions and therefore offers the simplest explanation is often correct.
    - And… often simpler solution = less expensive to mitigate.

My Research Approach to Watershed Management: Ask Simple Questions

- How does the watershed function?
  - E.g. Pollutant <u>transport</u>
- How does the watershed respond to variable climates?
  - E.g. Pollutant <u>transport</u> regime
- How does the watershed respond to perturbation(s)?
  - E.g. Altered pollutant <u>transport</u> regimes
  - *Key: understand the transport mechanism

Regime = Quantity and Timing

Hinkson Creek Experimental Watershed



- **Nested-Scale Experimental Watershed Study Design**
  - Installation began 11/08
  - Took 6 months to complete

Needs for Long-Term Data Sets

- Many of the Big questions require multiple years (i.e. >6yrs) of data to deal with stochastic events (e.g. Climate):
  - Precipitation regime
  - Water flow
  - Peak flow

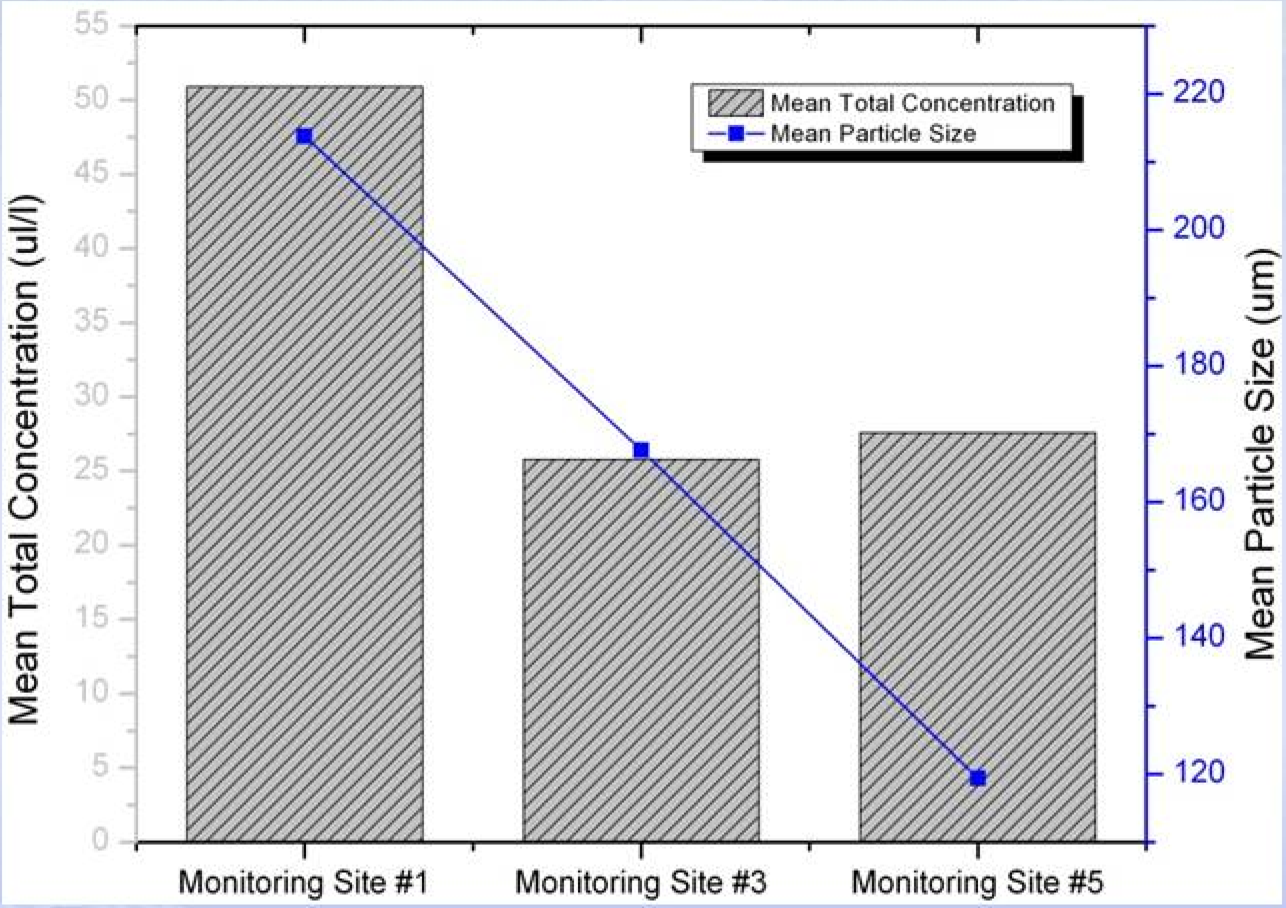
Key Drivers of Transport!

- We are in year 4 (annual year), and year 3 (water year, WY).
  - WY? Hydrologic replenishment generally begins in the northern hemisphere around October 1.

Interim Results and Ongoing Investigations

- Suspended Sediment
- Bank Erosion
- Nutrients, Chloride
- Floodplain Management
- Precipitation Regime
- Streamflow Regime
- Macro Invertebrates

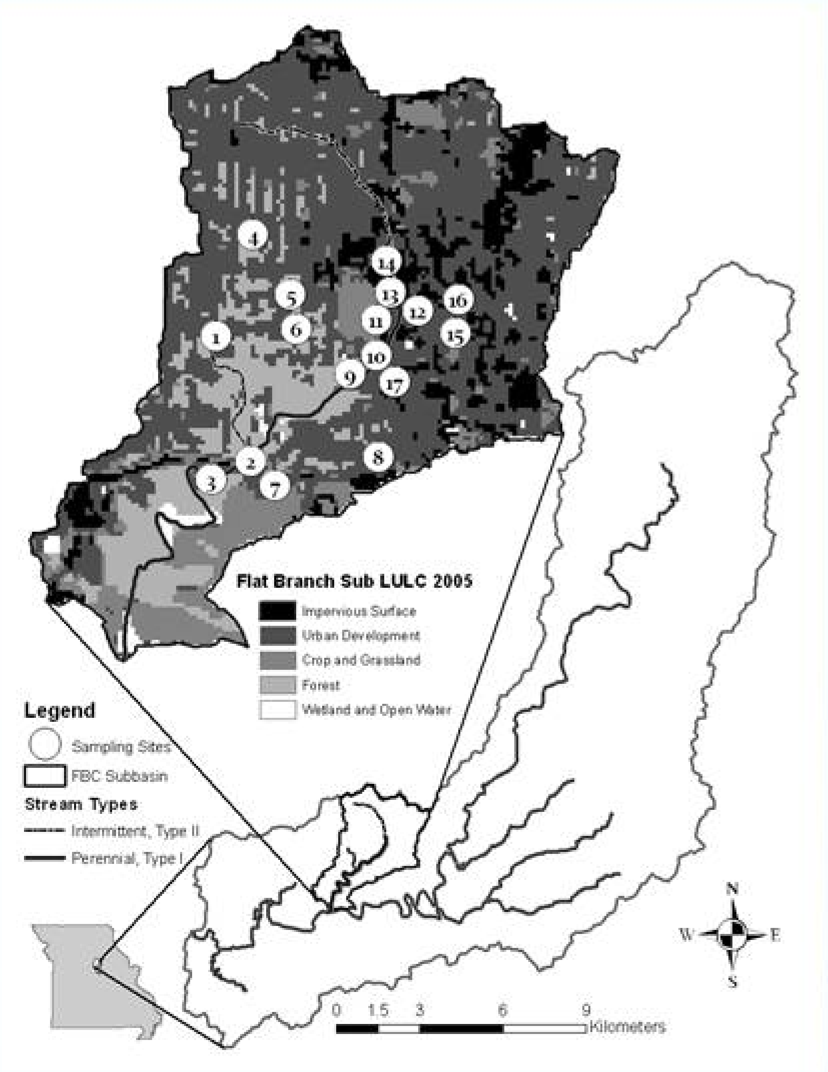
Suspended Sediment: March, 2010 (sites 1, 3, 5)



Hubbart, J.A., and G. Freeman. 2010. Sediment Laser Diffraction: A New Approach to an Old Problem in the Central U.S. Stormwater Journal, 11(7):36-44.

Hubbart, J.A., and N.A. Gebo. 2010. Quantifying the Effects of Land-Use and Erosion by Particle Size Class Analysis in the Central U.S. Erosion Control Journal, 17(7):24-36.

Columbia: Stormwater Sediment



Focus:

- Flat Branch Creek (FBC) subbasin
  - ~60% Urbanized
- 17 Sampling sites
- 16 Runoff causing rainfall events
  - N=272

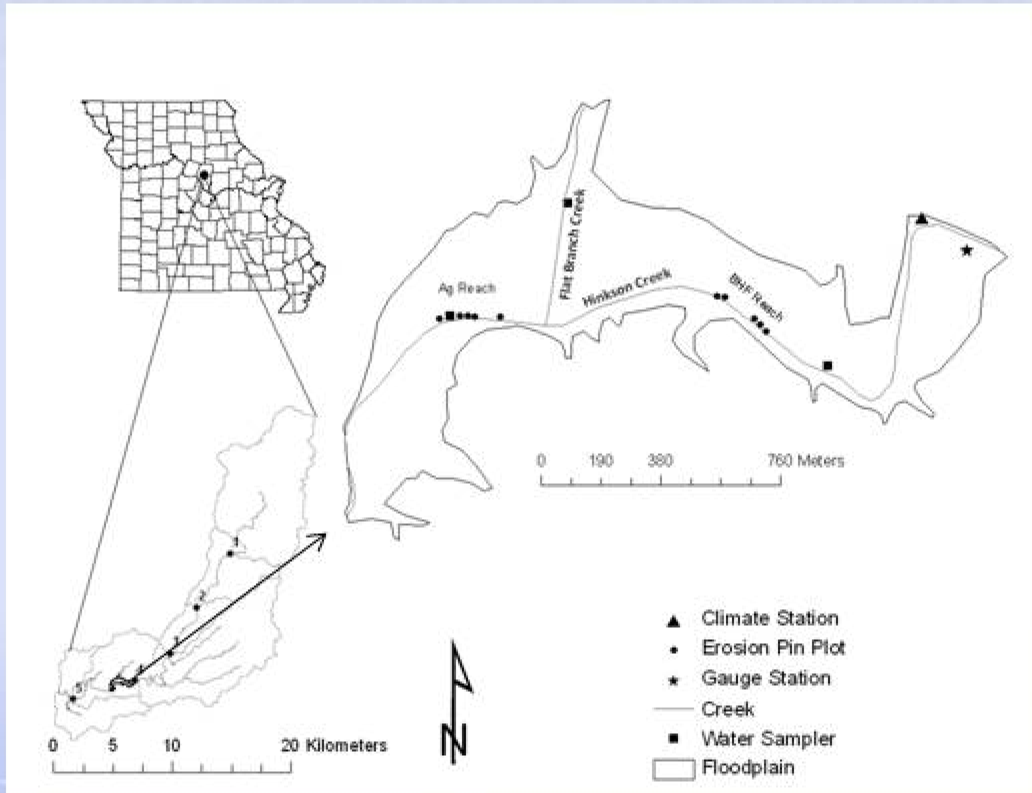
Kellner et al. *in preparation*. An Analysis of Urban Stormwater Suspended Sediment Particle Size Class Distribution. JAWRA.

Columbia: Stormwater Sediment

	Total Concentration (ul/l)	Mean Size (um)	Silt Volume (ul/l)
SW Mean	205.11	58.94	124.08
SW Min	64.61	27.53	33.42
SW Max	375.74	143.57	304.03
SW Std. Dev	100.91	34.94	75.30
FB Mean	318.77	167.48	147.98
FB Min	15.35	19.28	0.79
FB Max	1924.53	291.89	1461.49
FB Std. Dev	510.17	94.52	361.09
HC Mean	323.26	131.13	172.82
HC Min	36.39	9.94	4.17
HC Max	1317.43	312.98	1293.09
HC Std. Dev	381.16	91.31	340.06
SW = Stormwater Samples (n=272)			
FB = Flatbranch Creek			
HC = Hinkson Creek			

- % silt volume to total sediment volume
  - Urban stormwater = 60%
  - Flat Branch Creek = 46%
  - Hinkson Creek = 53%

In-Stream Contributions to Suspended Sediment: Bank Erosion WY 2011



Huang, D. 2012. Quantifying stream bank erosion and deposition rates in a central U.S. urban watershed. Master's thesis, University of Missouri, USA.

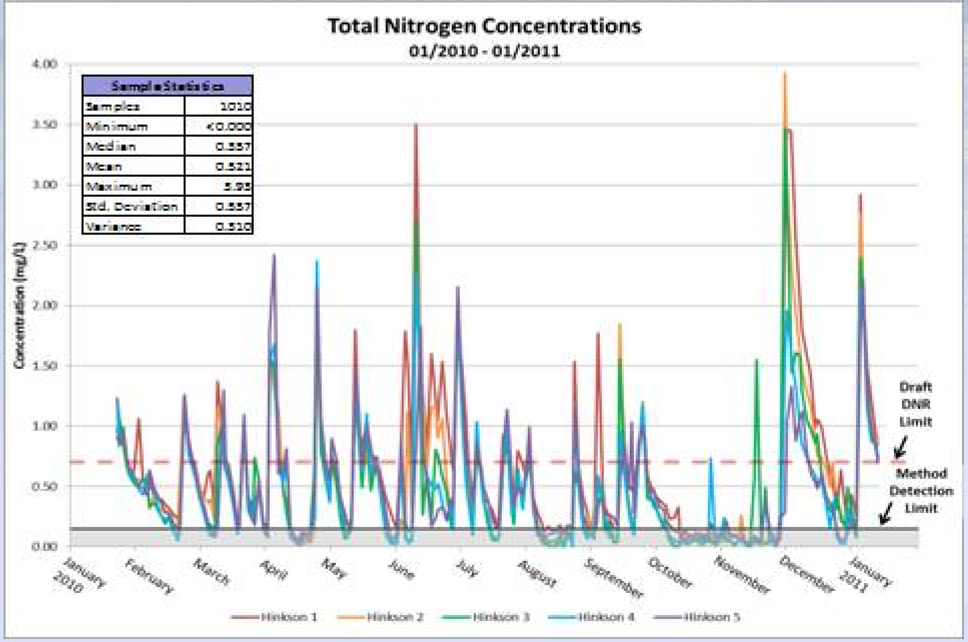
- Bank Erosion:
  - BHF: ~16 tonnes
  - Ag: ~178 tonnes
- ~67% of in-stream suspended sediment load from bank erosion
- Causative Mechanisms:
  - Bank slope & height
  - Forested banks: woody root systems

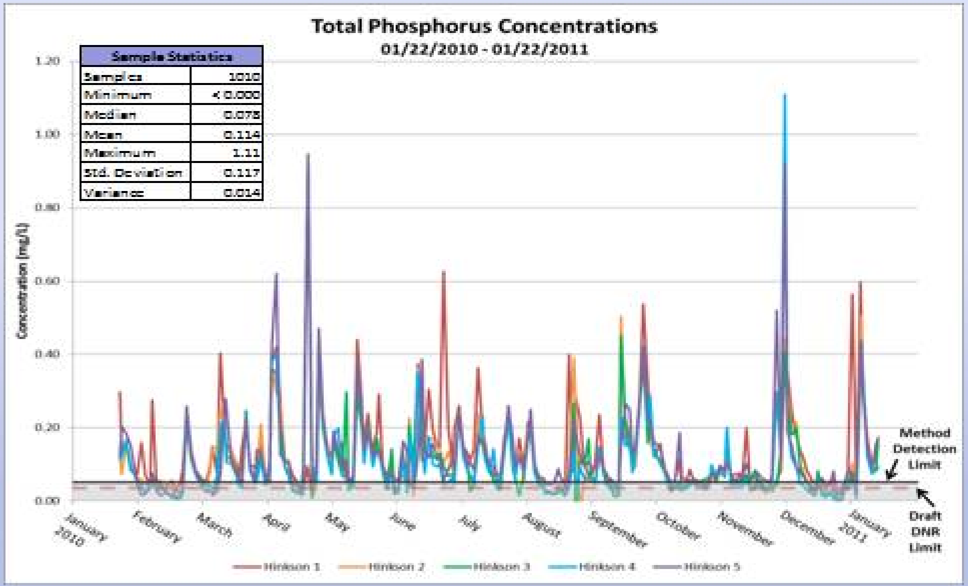
Sediment: Key Findings To Date

- HCW at large:
  - Mean particle sizes decrease as percent urban area increases
    - Also likely a function of stream distance
- Urban stormwater suspended sediment
  - Disproportionate contribution of finer sediment
- Bank erosion is a significant player in suspended sediment loading
  - ~67% of suspended sediment is from in-stream processes
    - Further work and additional years of data collection required to validate this interim result.
- Some Solutions: Trees, restored FP's, Riparian Zones, and Woody Bank Vegetation:
  - Need research to quantitatively validate!

Nutrients:

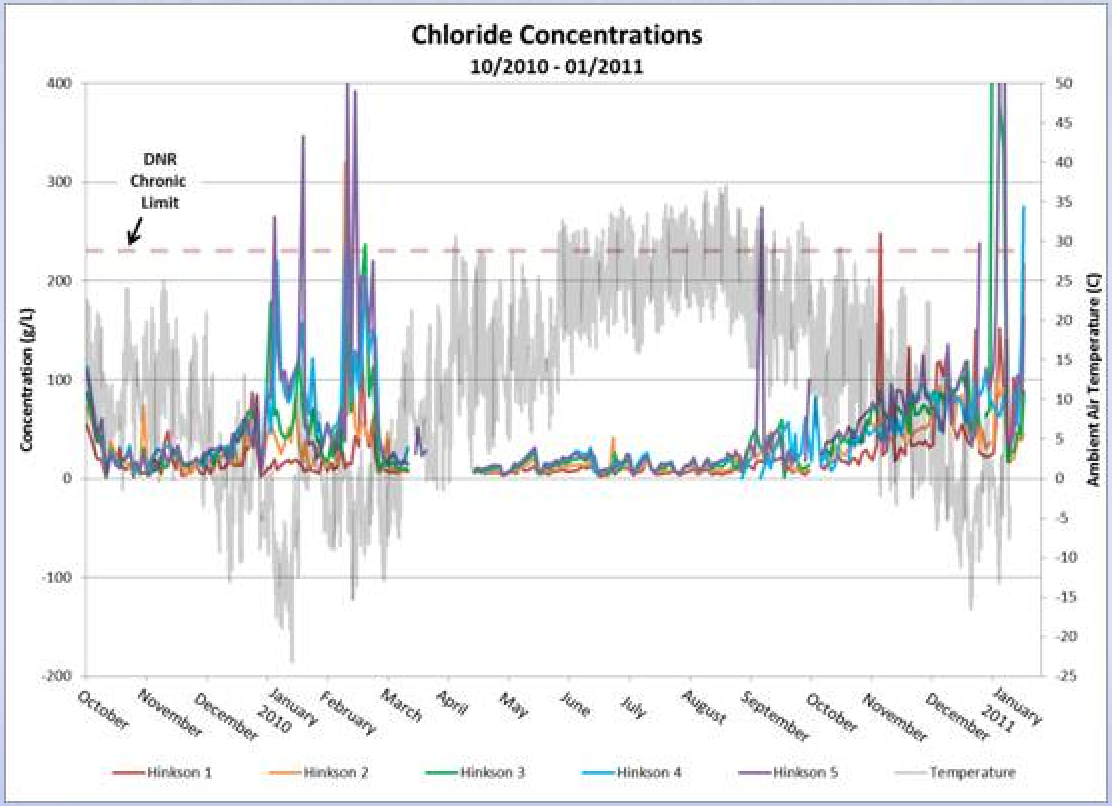
- Why Nutrients?
  - Supplies the base of the aquatic food chain.
- Jan 2009-Oct 2011
  - Avg Nitrate (NO_3^-)
    - 0.47-0.38 mg/l
  - Avg Nitrite (NO_2^-)
    - 0.03 mg/l
  - Avg Ammonia (NH_3)
    - 0.08-0.07mg/l
  - Avg Phosphorus (P)
    - 0.34-0.33 mg/l





Currently 2.5 years of data: Analysis after 1.5 more years.

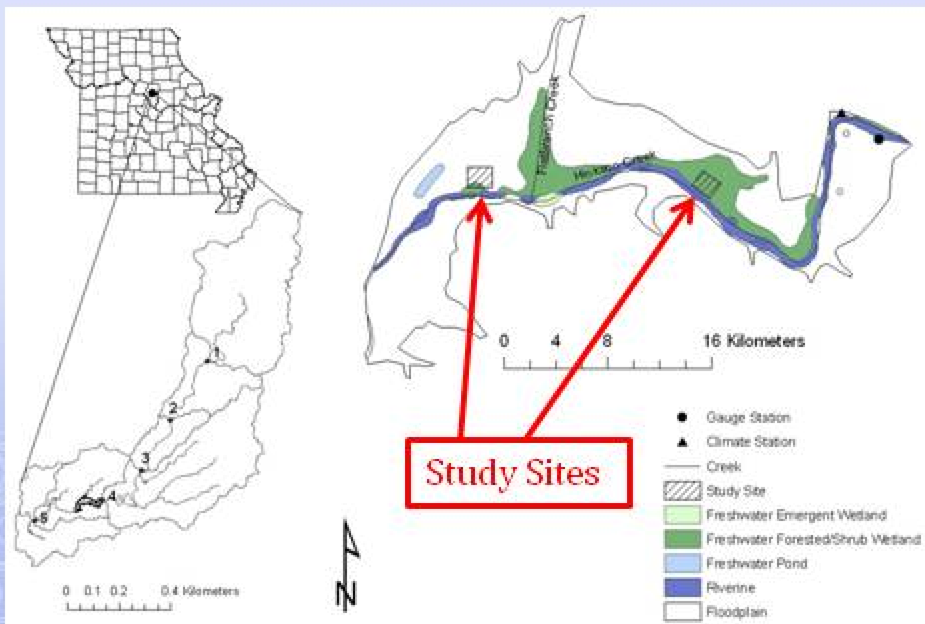
Chloride

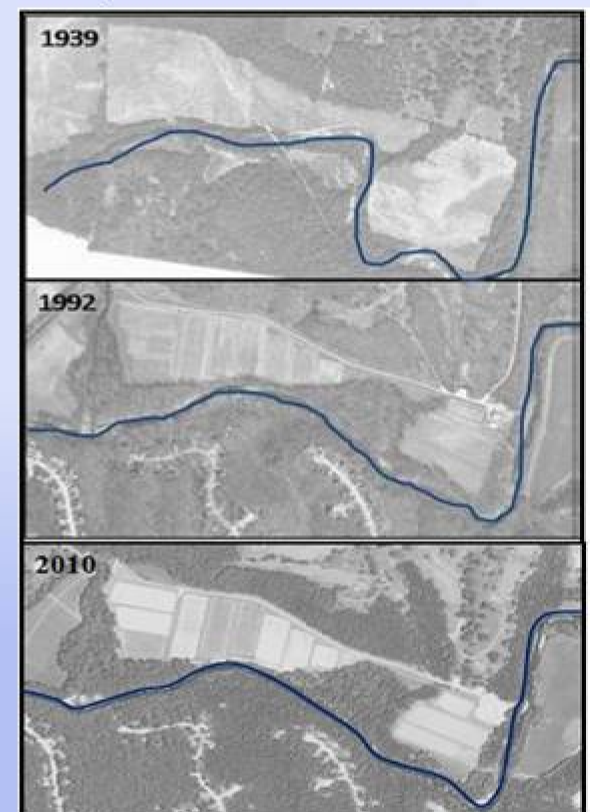


Currently 2.5 years of data: Analysis after 1.5 more years.

Stormwater Runoff Mitigation: Floodplain Management

- Approach:
  - Case study: Study the Hydroecology of two "bookended" floodplain sites.
    - Bottomland Hardwood Forest (BHF)
    - Agricultural Field





Infiltration Capacity

Hubbart, J.A., R-M. Muzika, D. Huang, and A. Robinson. 2011. Improving Quantitative Understanding of Bottomland Hardwood Forest Influence on Soil Water Consumption in an Urban Floodplain. The Watershed Science Bulletin, 3:34-43.

Descriptive Statistic	Agriculture IC (cm/hr)	BHF IC (cm/hr)
Average	22.7	37.7
Std Dev (±)	20.8	29.0
Min	0.1	3.0
Max	69.0	126.0
BHF = Bottomland Hardwood Forest		
IC = Infiltration Capacity		

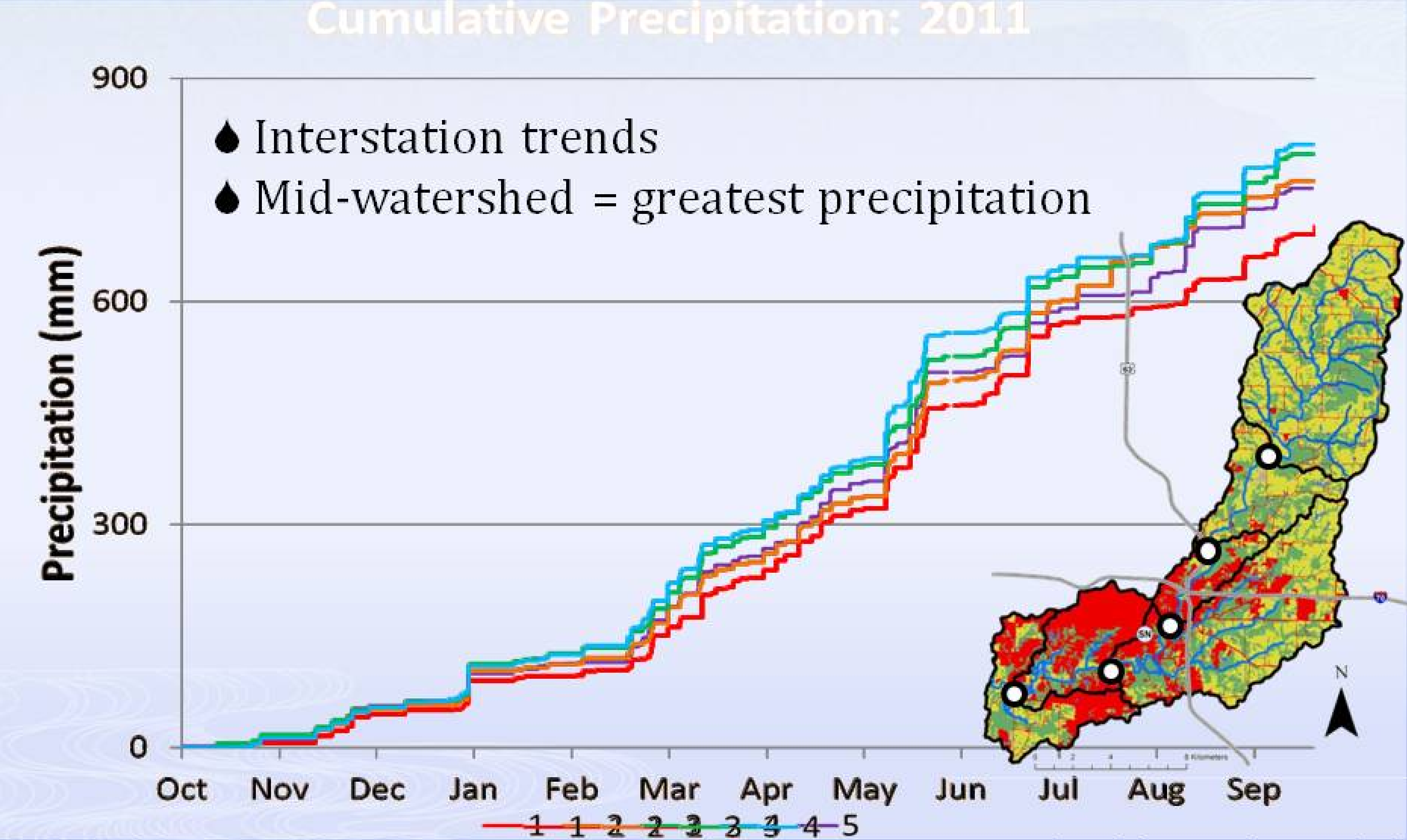
Implications: Stormwater & Flooding

- Differences between BHF and Ag sites in VWC: A nearly 11% difference in soil water over a100-cm profile.
  - Top 30cm ($P < 0.05$), 5%, or 57.6 mm more water in BHF!
- Potential consumptive water use:
  - Transpiration > 720 mm of water per equivalent forested floodplain area, over only a six-month growing period.
  - This could be substantial in urban watersheds like the HCW, where 700 mm is approximately two-thirds the long-term average annual precipitation (1,032 mm/year).
- Tree roots create pore spaces and preferential flow paths.
  - Enhances Floodplain Attenuation Capacity for water!!!...
  - Woody roots also stabilize the streambank!

Precipitation Variability

- Spatial variability of precipitation means spatial variability of transport of diffuse pollutants.
- What if…
  - It rains more in Columbia, where there may also be more pollutants to transport?

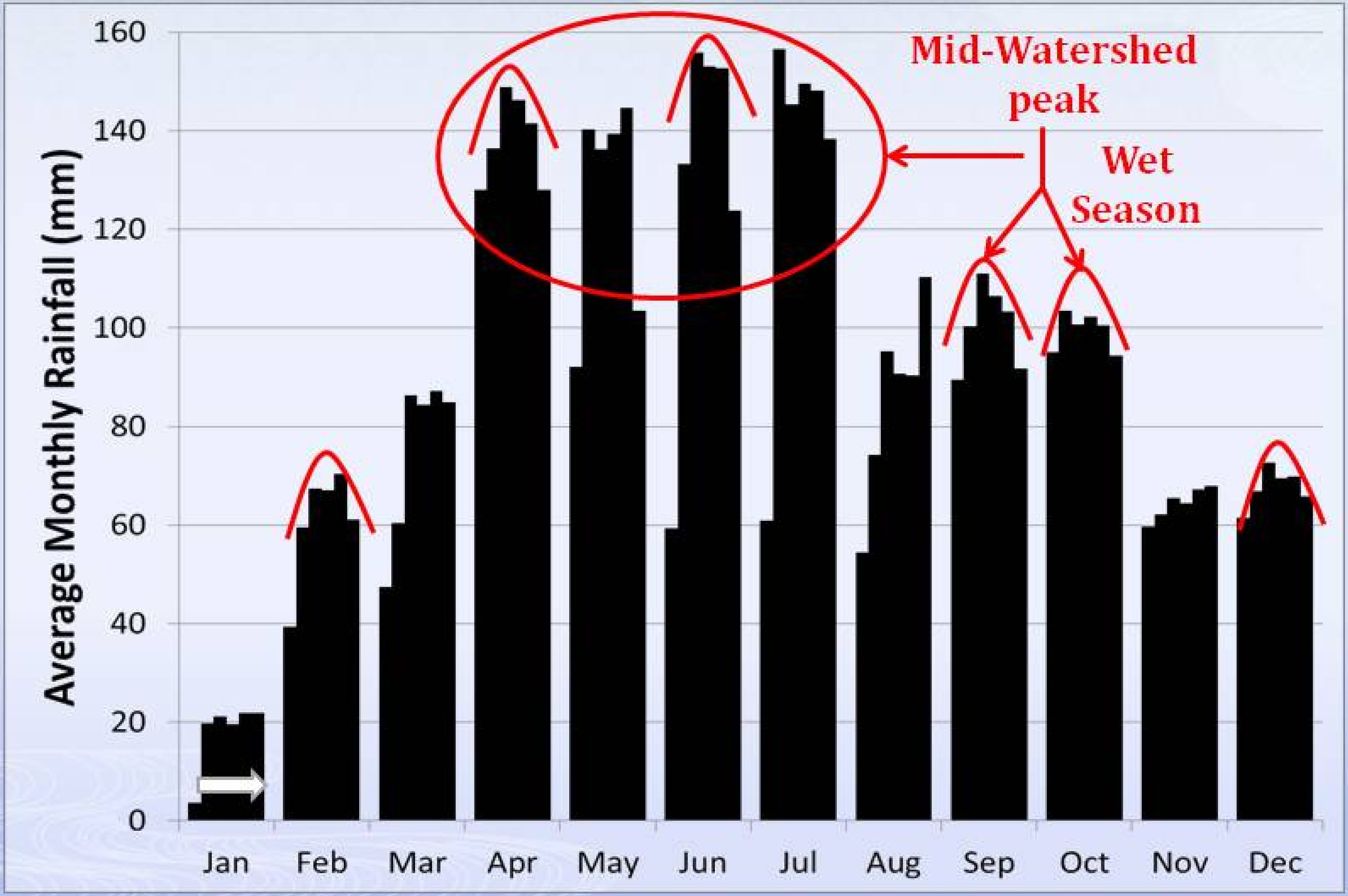
Precipitation Variability Results



- Interstation trends
- Mid-watershed = greatest precipitation

Acknowledgement: Shannon Bobryk

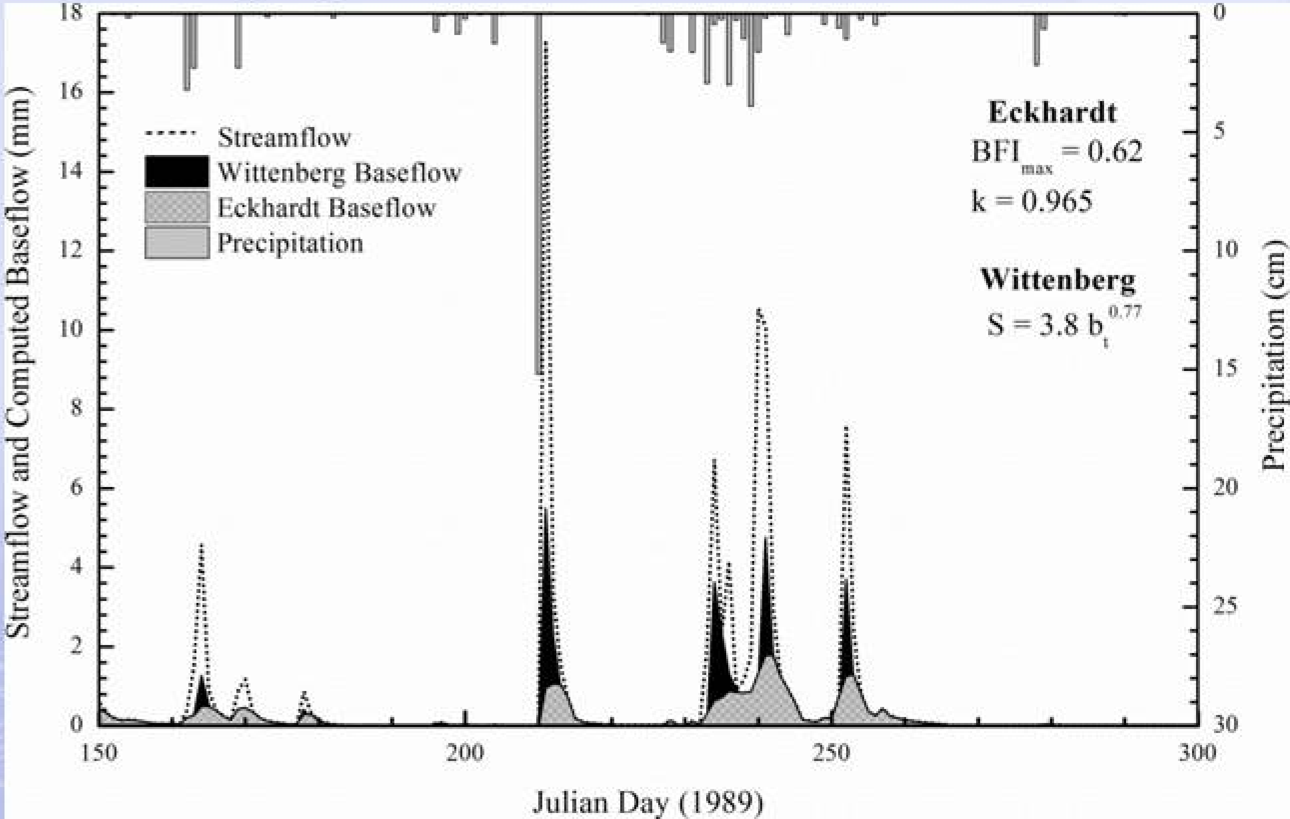
Precipitation Variability



WY 2011

Streamflow Regime

- No significant change in streamflow regime (P≤ 0.05) from 1967-2010.
- Runoff Volume & Baseflow Index (BFI) shallow (yet insignificant) (P>0.05) trends in urban setting.
  - Harbinger of hydrologic changes yet to come…



Hubbart, J.A., and C. Zell. (In Submission). Considering Streamflow Trend Analyses Uncertainty in Urbanizing Watersheds: A Case Study in the Central U.S. Water Resources Management.

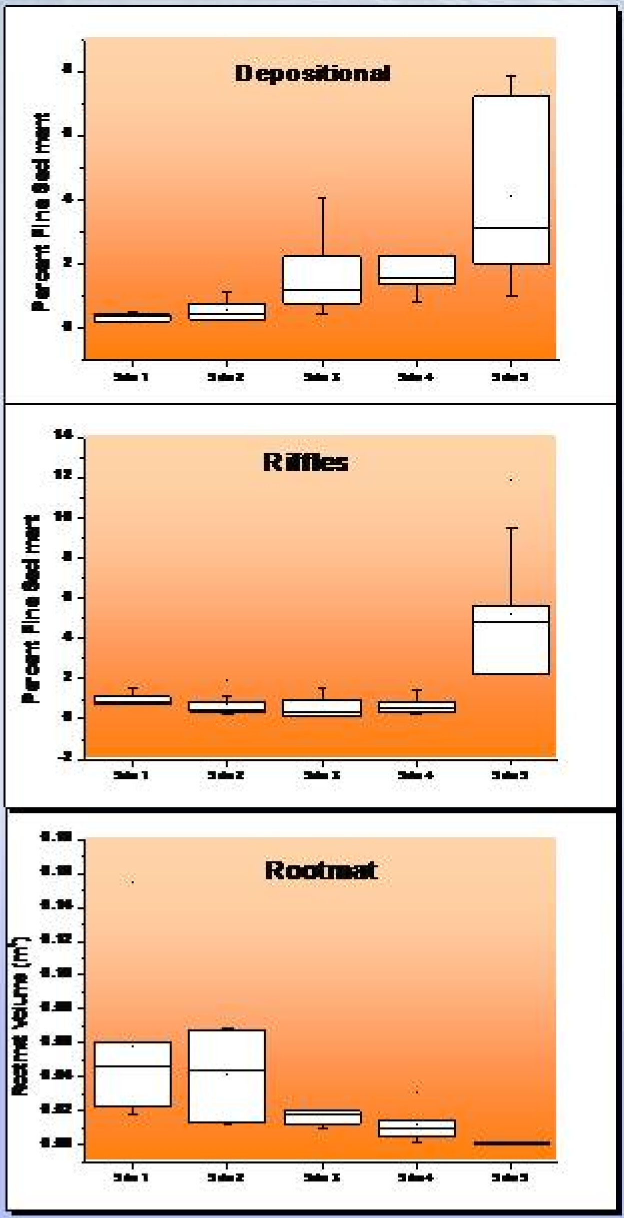
Macroinvertebrates: 2011
An Environmental Biophysical Assessment

- 199 taxa identified
- Lower Taxa and EPT richness in urban sites
- S1 to S5: Increasing Traits: Fast development, tendency to drift, habitat generalists, burrowers
- S1 to S5: Decreasing Traits: Sprawlers, stationary location

Site	Taxa Richness		EPT Richness		Biotic Index		Shannon Diversity		Stream Condition Index	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
1	80	89	20	12	6.20	6.87	3.35	3.00	20	16
2	80	91	16	25	6.32	6.53	3.37	3.45	18	20
3	83	87	18	18	6.34	7.09	3.35	3.60	20	18
4	73	68	13	12	6.99	6.97	3.27	3.03	14	14
5	74	79	10	13	6.99	7.58	3.43	3.48	14	16

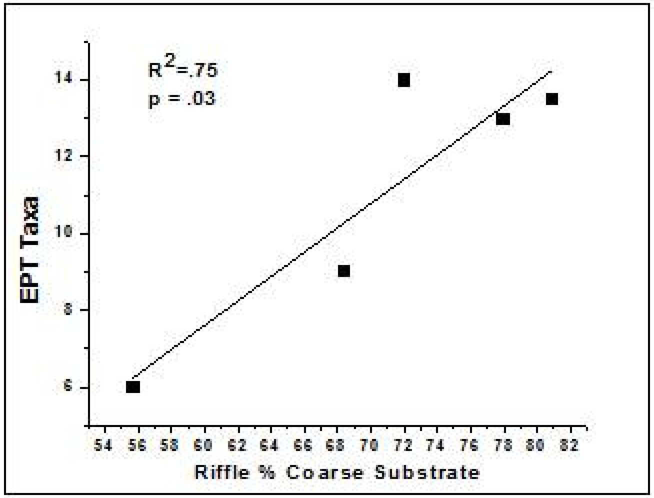
Habitat Characteristics

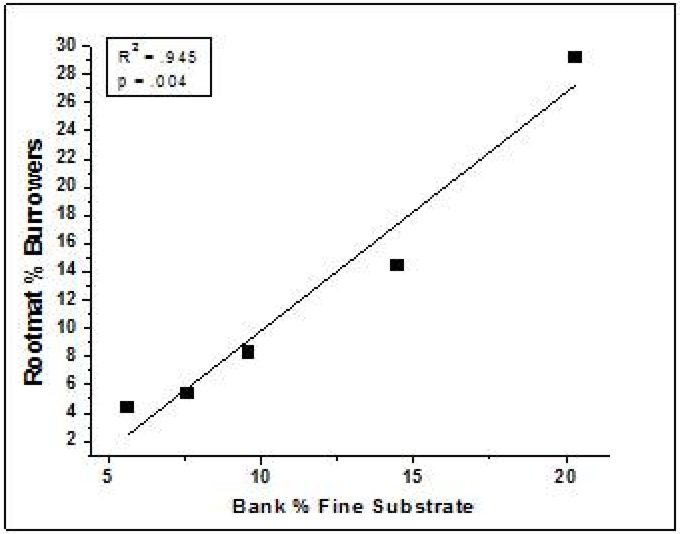
- Substrate:
  - Urban sites have higher % Fine sediment
- Less Rootmat volume and biomass

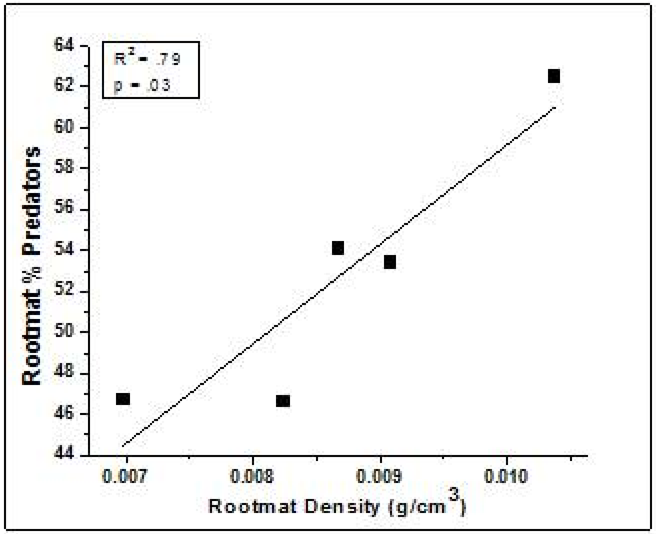


Habitat/Mac-Invert Relationships

- Habitat specific trends
  - Riffles: fewer obligate riffle dwellers, more burrowers
  - Depositional: fewer depositional obligates, fewer sprawlers
  - Rootmat: increase in predators, and burrowers







Mac-inverts: Emerging Story

- Urbanization does impact stream environment
- Macroinvertebrate communities in urban sites are different from rural sites
- Trends in functional trait composition suggest more frequent disturbance, less stable environment
  - Fast development
  - More generalists and opportunists
- Addressing flow regime, hydrogeomorphology, sediment, and reestablishing a consistent forested riparian corridor could be key

HCW: Needed Work

Disclaimer: I don't claim to have the answers to the "need" question. These may or may not be related to current activities

- Ongoing analyses: Sediment , Chloride, Nutrients, Modeling
- Bedload study. Hydrogeomorphology and aquatic habitat.
- Riparian forest and streambank restoration (woody veg)
- Shallow groundwater study (antecedent conditions): Baseflow
  - Isotopes, tracers, etc.
- Broad investigation of metals, chemicals, etc.
  - Nested-Scale experimental design
- Landscape/terrestrial landuse processes
  - Urban non-point source pollutants
- Ongoing macroinvertebrate research
- Fish surveys
- Citizen perceptions work
  - What is water quality?
  - What is acceptable water quality in urban ecosystems?

- Closing Comment:
- Remember Law of Maximum Parsimony:
  - Example:
    - If, forest harvest = altered surface runoff regime
    - Then, to restore surface runoff regime, replant forests.
    - If we are not going to reforest the HCW, we may wish to reassess urban water quality criteria.

Thank You

Acknowledgments:

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