Effects of Iron to Stream Communities

Prepared for:

Chesapeake Bay Trust: Pooled Monitoring Initiative's Restoration Research Forum

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Research Objectives

Research Objectives in simplistic terms

1. Do Iron concentrations change in streams over time?

2. Does Iron impact the stream community?

3. Do either of the above questions appear to be related to Regenerative Stormwater Conveyance (RSC)?

Stream Characterization

- **Step-pool or Regenerative Stormwater Conveyance (RSC)**

Materials can include a mix of granite or iron boulder to create the step-pools

Within pools is a mixture of woodchips/sand and microbial community that typically leads to 'reducing' conditions - potential for dissolved iron (Fe^{2+})

Water leaving pools and mixing with oxygen may create 'oxidizing' conditions – potential for particulate iron (Fe^{3+})

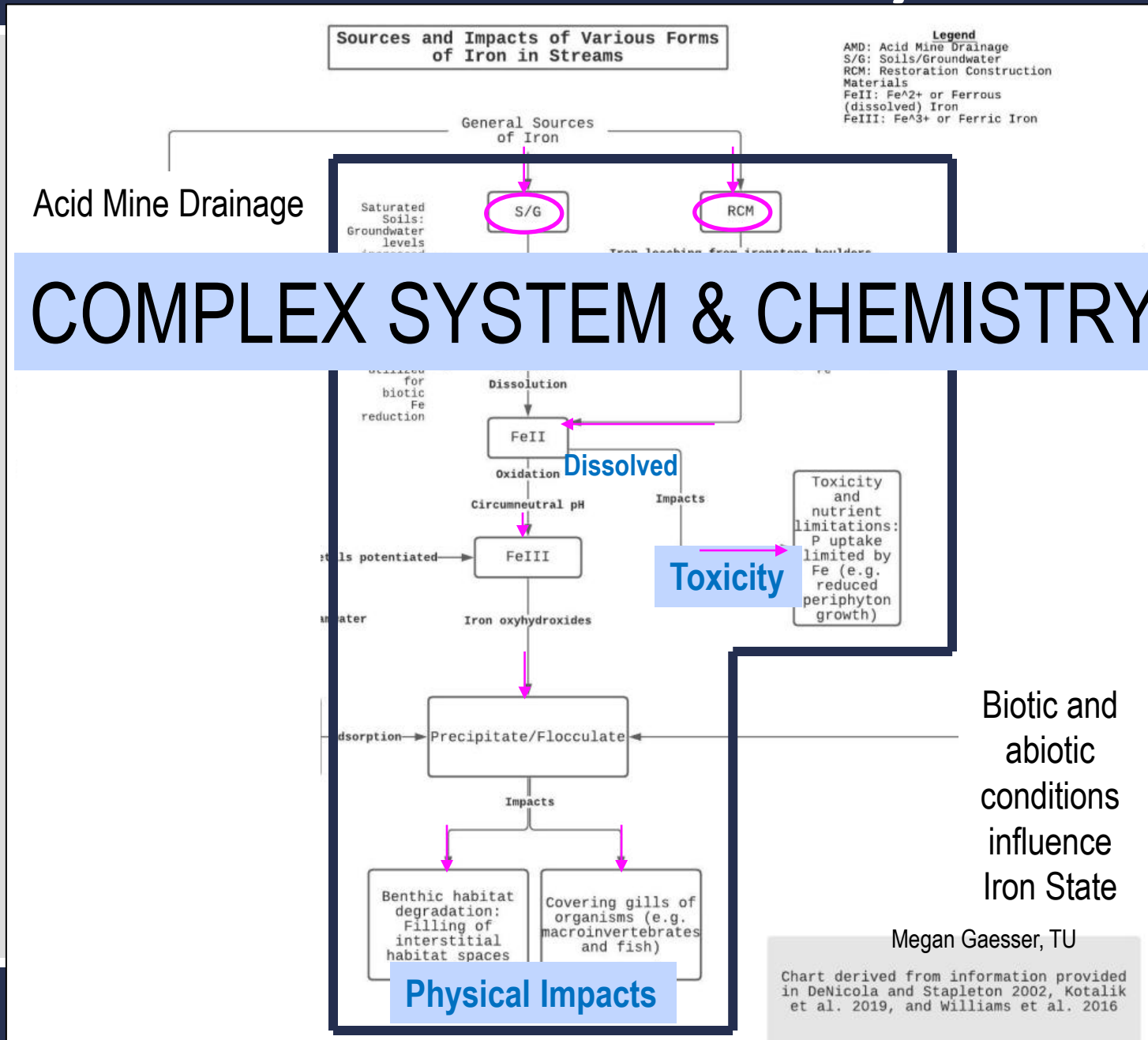
Stream Characterization

- **No Restoration**

Low iron stream system

High iron stream system

Iron in Freshwater Steam Systems



COMPLEX SYSTEM & CHEMISTRY

Objectives

Multiple lines of evidence approach to address project objectives

1. Laboratory Experiment – Mesocosms

Objective: Determine effects of dissolved iron and iron flocculate to a representative benthic community

2. Field Experiment and Monitoring

Objective: Determine potential temporal fluctuations in iron chemistry and in-situ effects of iron to macroinvertebrates

Mesocosm Experiment

Brief Methods

Setup

- 15 - gallon HDPE plastic tubs
- 30.25L - dechlorinated tap water
- 5.5L – triple washed playground sand
- 1L – cobble/sediment substrate (field collected)
- 3 large rocks
- 20 aged leaves (mixed deciduous)
- 1- 12” air stone

Organism	Source	Approximate Age	Number Loaded per Tank
Mayfly (Hexagenia)	ARO	~ 6 months	10
Amphipod (*Hyalella azteca*)	ARO	~15 days	10
Diptera (*Chironomous dilutus*)	ARO	10 days	10
Caddisfly (Hydropsychidae)	Field	--	5
Mayfly (Isonychiiadae)	Field	--	10
Mayfly (Heptageniidae)	Field	--	8

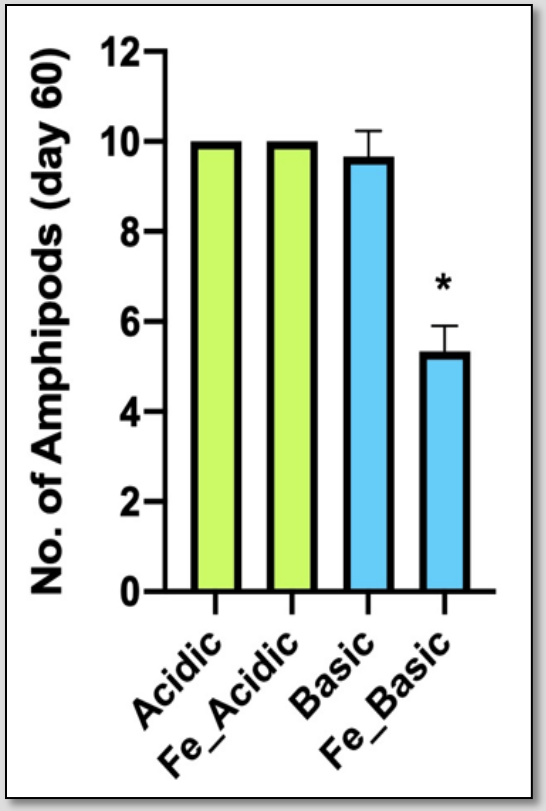
Mesocosm Experiment

- **Brief Methods**

Treatments	Total No. of Tanks	pH	Iron (mg/L)	Termination Days	Number of tanks per termination day
Acidic	9	5.5-7	0	• 21 • 42 • 60	3
Basic	9	7.5-9	0		
Acidic + Iron	9	5.5-7	0.6		
Basic + Iron	9	7.5-9	0.6		

Mesocosm Experiment

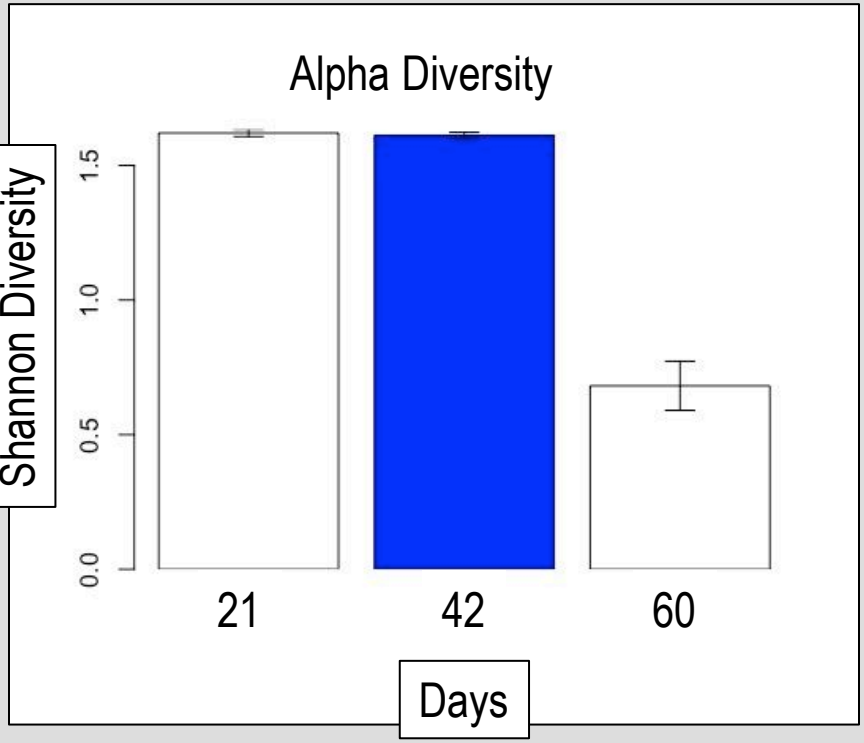
- **Results - Survival**

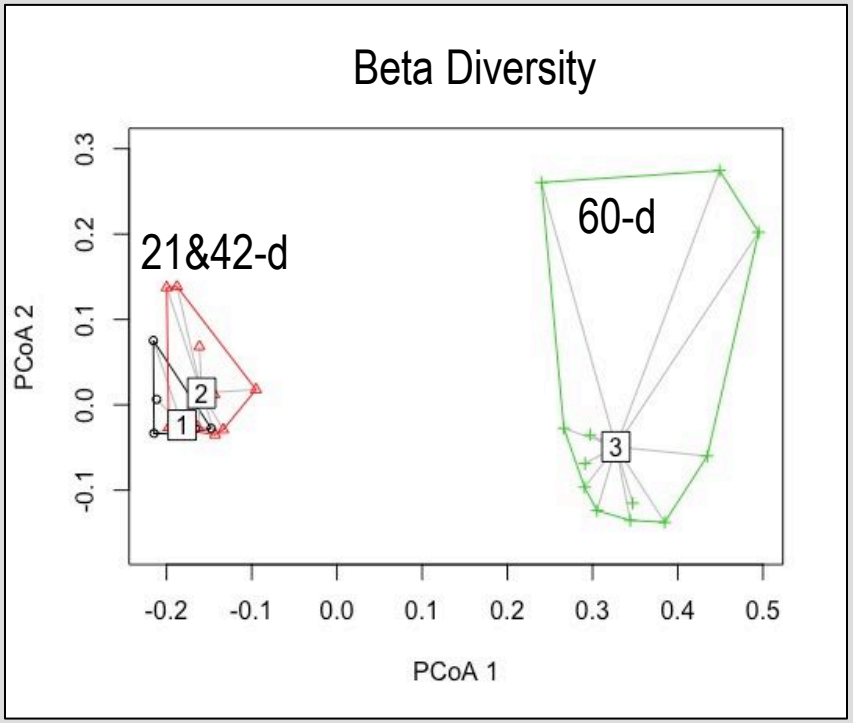


Reduced Survival in tanks with Fe_Basic treatment: Iron precipitate

Mesocosm Experiment

- **Biodiversity Metrics: Time**





There was a *significant effect* of time on diversity indices: Tanks taken down on Day 60 had little survival compared to tanks removed at days 21 and 42

Mesocosm Experiment

Take home message

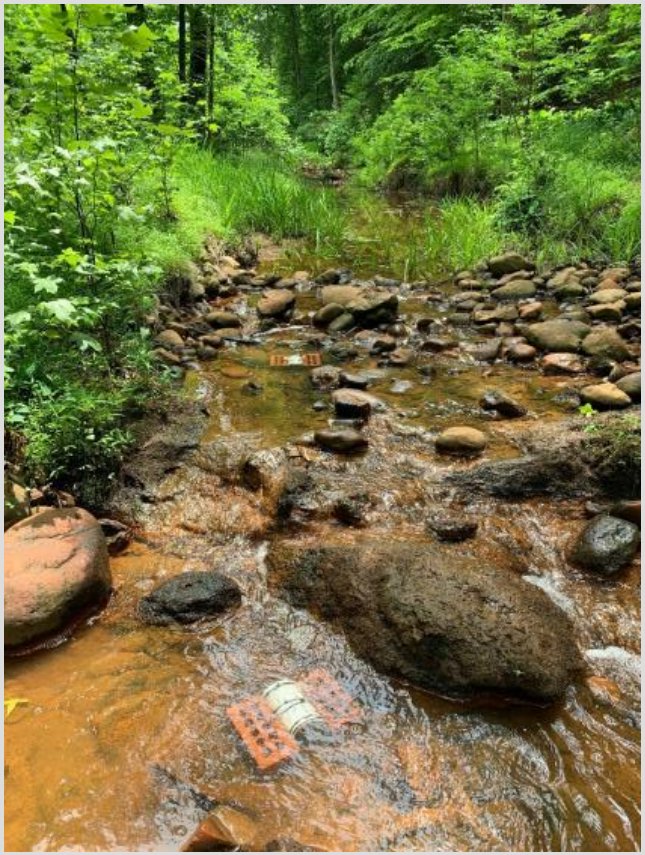
- **Reduced survival in amphipods was noted at 0.6 mg/L Iron under basic conditions.**
  - **EPA Ecological Screening Criteria for chronic exposure to Iron in surface water is 1mg/L (US EPA 2015*).**

- **Future laboratory efforts using macro-invertebrate communities should be terminated prior to 60-days.**

*US EPA. 2015 Region 4 Ecological Risk Assessment Supplemental Guidance Interim Draft

Field Investigations

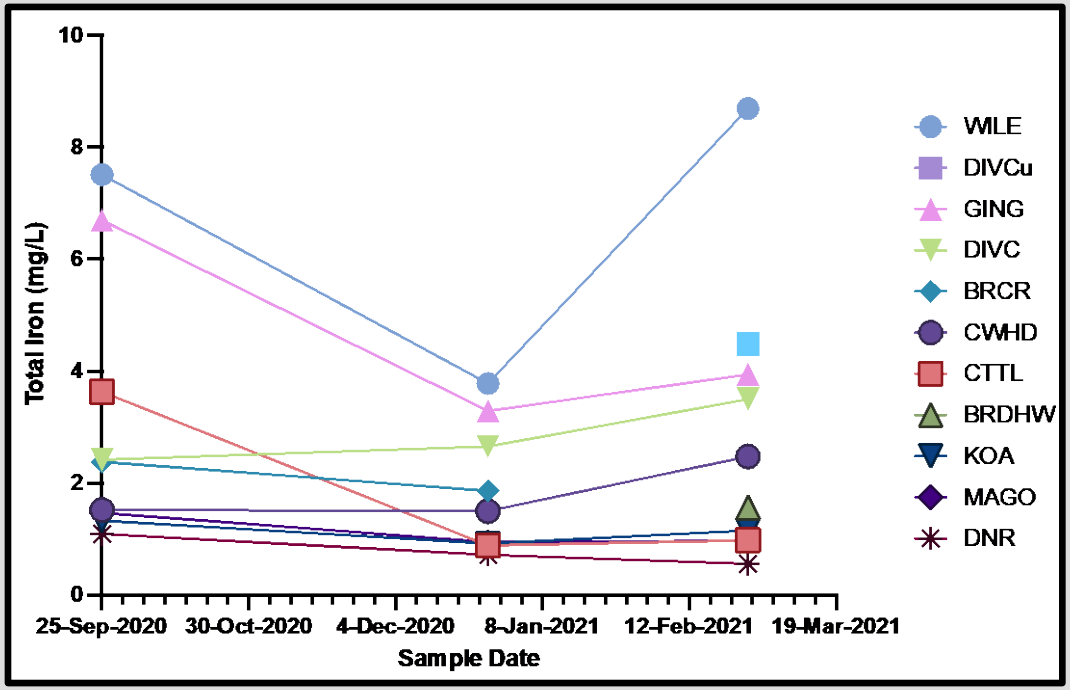
- **Methods: Iron and water chemistry field sampling every 8 weeks**



- Iron measured in the field with Hach strips and in the laboratory on Flame Atomic Absorption Spectrometry (FAAS)
- Standard water quality measurements also collected with a YSI
- Collecting water for chloride analysis (new)

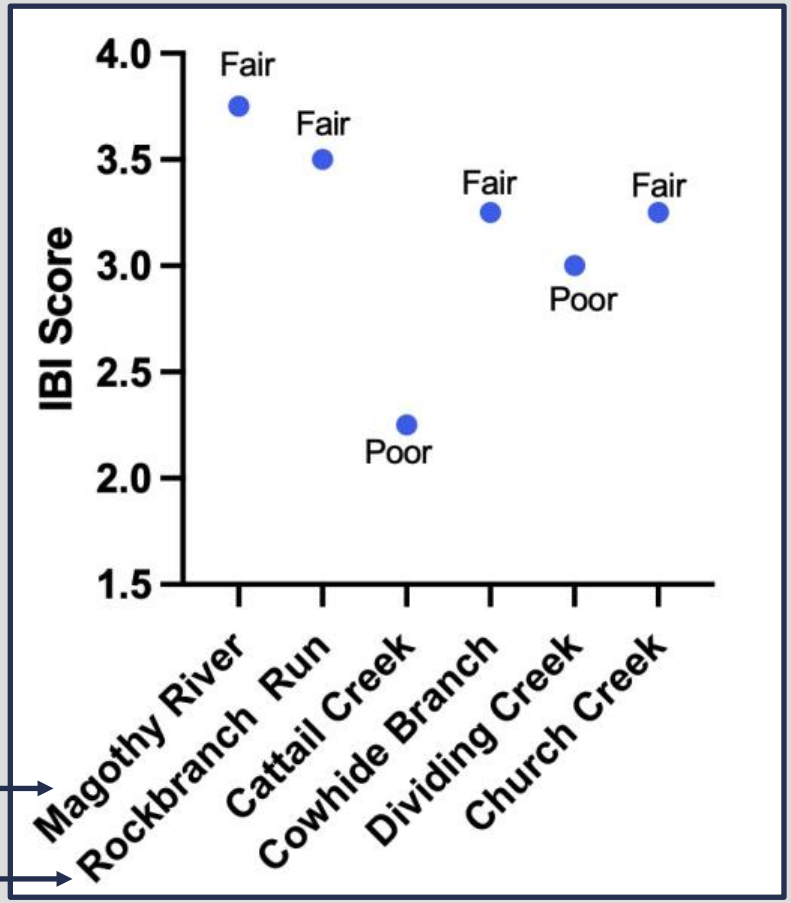
Field Investigations – Temporal

- Total iron as measured by FAAS
  - High Iron sites tend to be high through time
  - Confirmation of previous samples ongoing (change in personnel)
  - To strengthen dataset, an additional year of sampling and analysis is ongoing



Field Investigations – Fish Diversity

- **Fish diversity: Spring 2020**

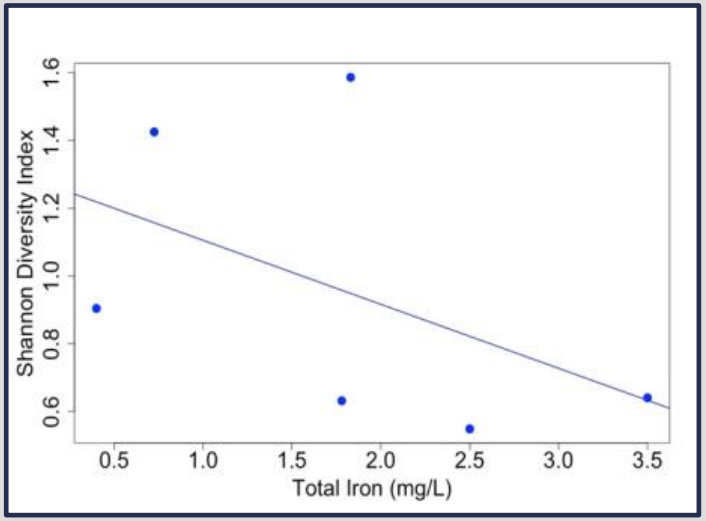


No Restoration

Increasing Iron Concentrations

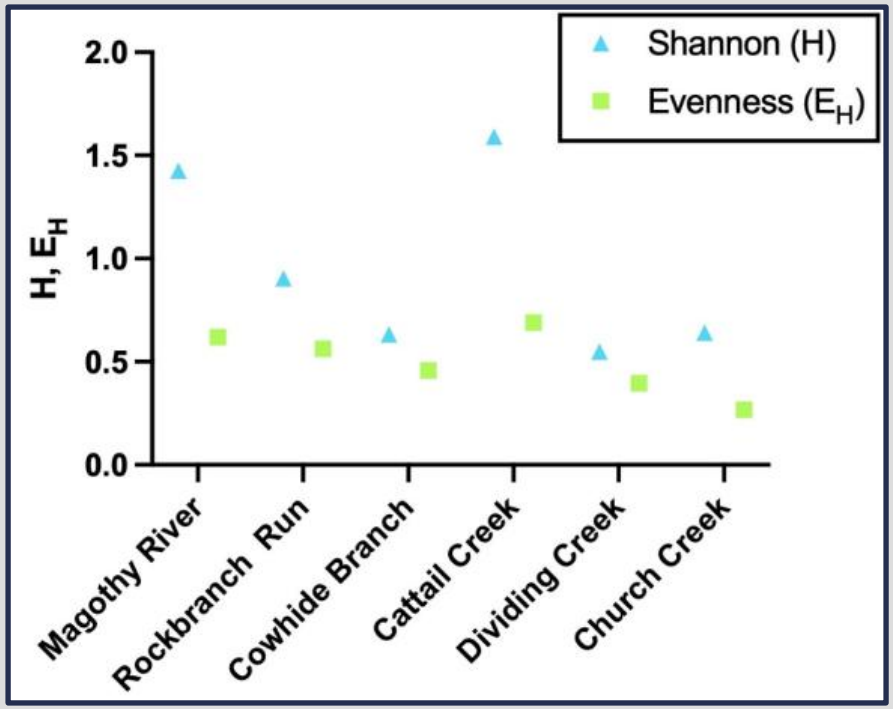
Still an unclear picture

Shannon Diversity- Iron Regression



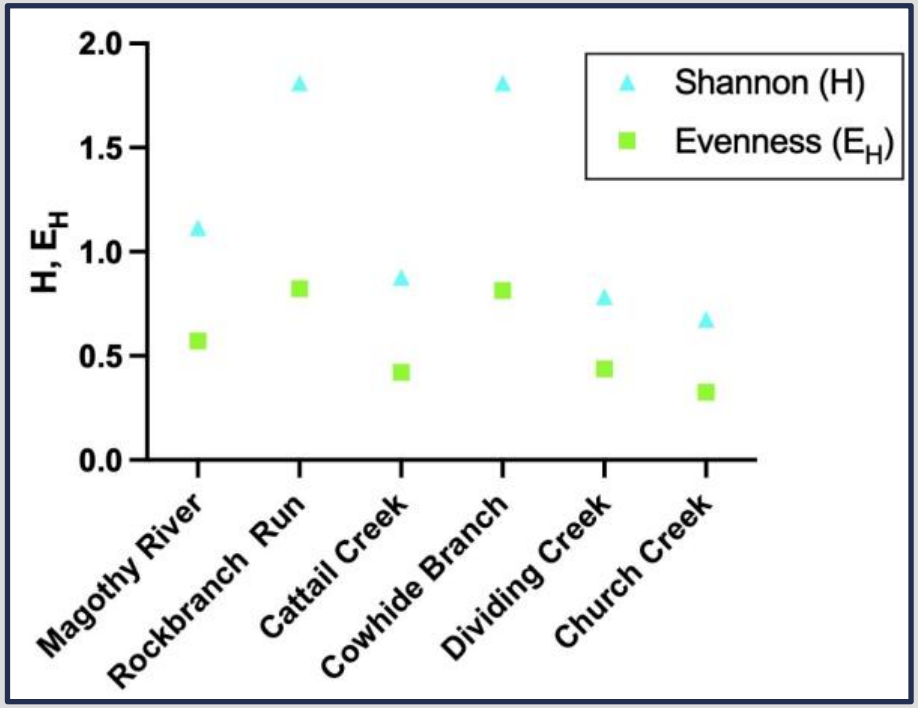
Field Investigation – Local Diversity

Fish



Increasing Iron Concentrations

Macroinvertebrates



Increasing Iron Concentrations

Field Experiment

- **In situ Pilot Study**
  - **Overall Objective – determine the effects of iron to stream macroinvertebrates under in-field conditions**
  - **Pilot Objective – determine most appropriate cage design and duration**

8-12 macroinvertebrates placed in each enclosure

Survivorship following 6-days in the 4” PVC pipe = 80%

Survivorship following 12-days in the 3” PVC pipe = 77%

Successful Design

Noticeable accumulation of algae, detritus and sediment accumulated on the enclosures at day 12

Preliminary Conclusions

- Iron concentrations in streams appear to show minimal temporal variation
- Iron flocculate appears to impact macroinvertebrates more than dissolved iron
- Iron may impact stream communities
- Definitive caged field experiments are ongoing

Acknowledgements

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What does this mean for me?

- ✓ Iron is one factor in a complex system where there are many other stressors (urban streams).
- ✓ Even without restoration, there are a range of iron conditions; interventions such as RSC can influence the amount of iron floc.
- ✓ What role does iron play if the practitioner aims to take a system from, say, fair to good condition, and is that even a realistic possibility in many cases?
- ✓ How can we assess impacts to the restoration reach (e.g., from iron) vs. downstream benefits?

What does this mean for me?

What do I take from this if I am a practitioner:

- ✓ **Condition assessment as part of design, e.g., iron levels in soil, groundwater.**
- ✓ **Reconnecting to floodplain is great objective, but may have other consequences; good communication needed through the process with regulators, community.**

What do I take from this if I am a regulator:

- ✓ **Consider reach vs. downstream impacts, benefits.**
- ✓ **Reducing sediment transport and energy downstream may be the more important thing to consider.**

You are done!

Thank you for your hard work to do the research, communicate it clearly to the audience, and translate this into something the audience can do with the information in their work tasks.