Vertebrate Community Trajectory in Regenerative Stream Conveyances

Mark Southerland, Bob Murphy, and Nancy Roth

Tetra Tech

Ryan Woodland and Solange Filoso

UMCES-CBL

mark.southerland@tetratech.com

Pooled Monitoring Forum
June 16, 2022

Key Research Questions

B. Effectiveness of restoration practices at the project scale

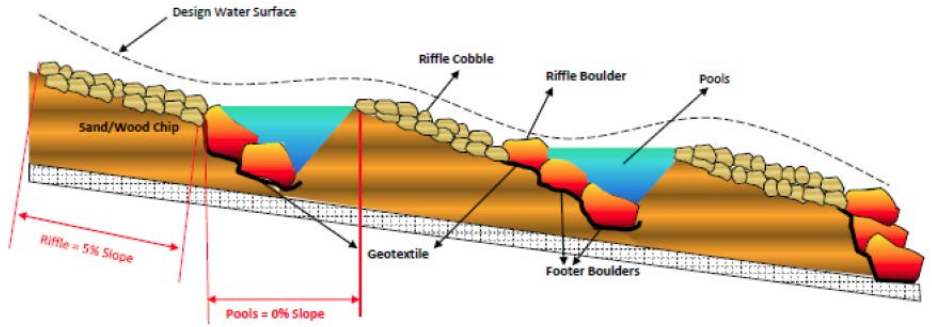
B.4. Biological Community Restoration: Recent research has shown that in many situations, especially in watersheds with relatively high impervious cover, stream restoration may result in improved physical habitats but not restored biological communities (macroinvertebrates, fishes, etc.). …

D. Trade-offs in resource improvements incurred by restoration practices and the resulting net ecological change as measured by a common "currency"

D.10. Resource trade-offs in different types of restoration projects. The decision to install a restoration project at any given site implies that an existing condition at that site will be modified, replaced, and/or improved. The hypothesis of the restoration practitioner is that the net condition will be improved. However, a value judgment is placed on the existing condition, (e.g., deeming the existing condition to be inferior to the desired "restored" condition) that is often not based on quantification. …

Outline

- What are RSCs?
- Study Questions and Approach
- Conceptual Model
  - References
- Methods
  - Site Selection
  - Field Sampling
- Results
  - Fish
  - Herpetofauna (amphibians and reptiles)
- Conclusions



What are RSCs?

- **Regenerative stream conveyances (RSCs) typically**
  - *transform* degraded, single-channel, lower-order streams (some with wetlands)
  - *into* stream-wetland complexes designed to provide more opportunity for sediment retention and nutrient removal
- **RSCs result in channel widening and partial impoundments that**
  - slow flow rates
  - typically reduce shading
  - create periodic anoxia
  - increase diel dissolved oxygen variation and ecosystem gross primary production (GPP)

What are RSCs?

Immediate post-construction

16 and 10 years post-construction

Wilelinor 2004 and 2020

North Cypress Branch 2010 and 2020

Specific Study Questions

- **What trajectory should we expect vertebrate communities to follow in Regenerative Stream Conveyances (RSCs)?**

- **How can practitioners and regulators more appropriately**
  - *quantify* the biotic resource changes that occur when defined-channel stream systems are transformed into less-defined stream-wetland complexes
  - *consider* those changes in the context of nutrient reduction benefits expected from restoration

Conceptual Model

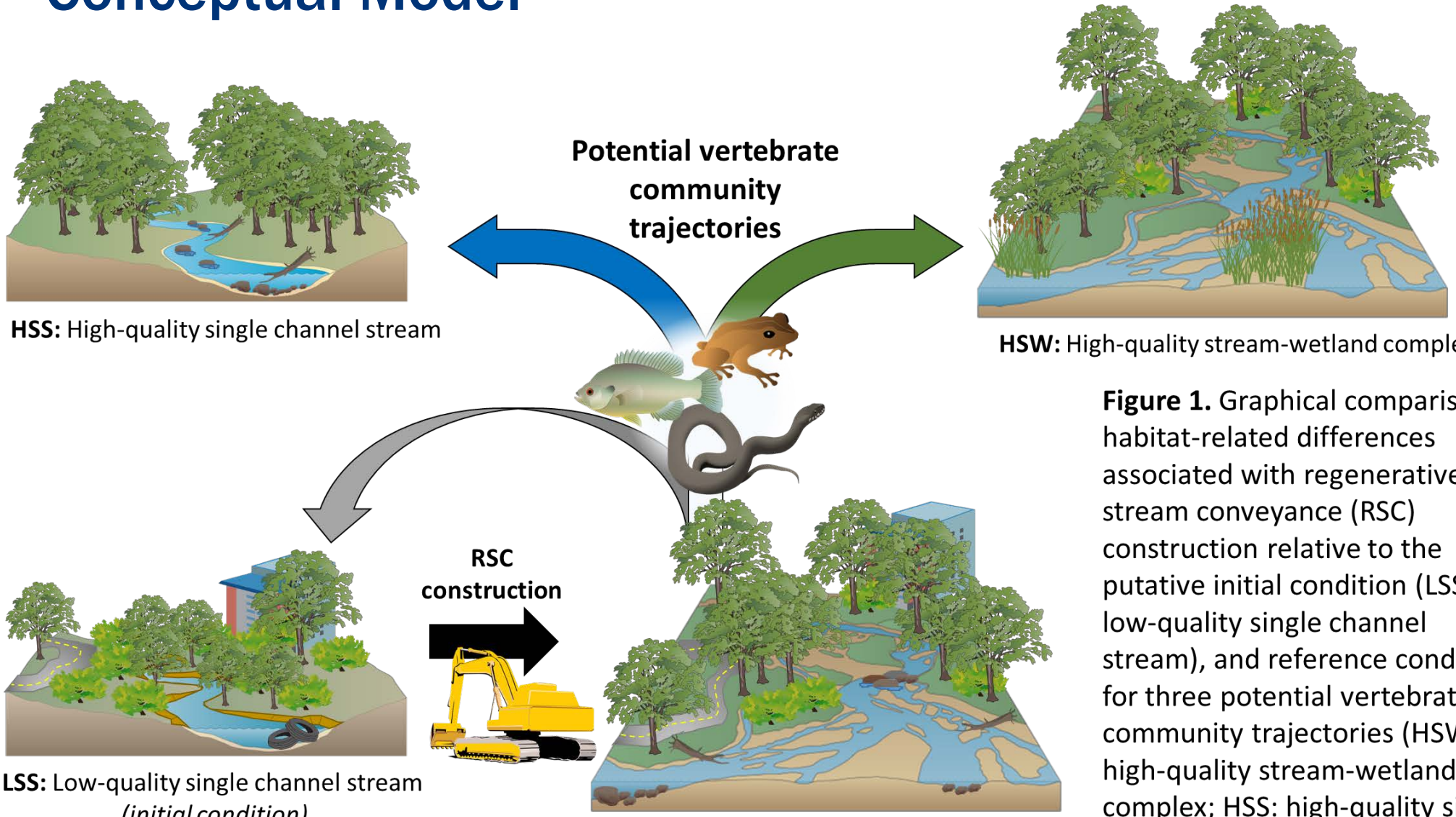
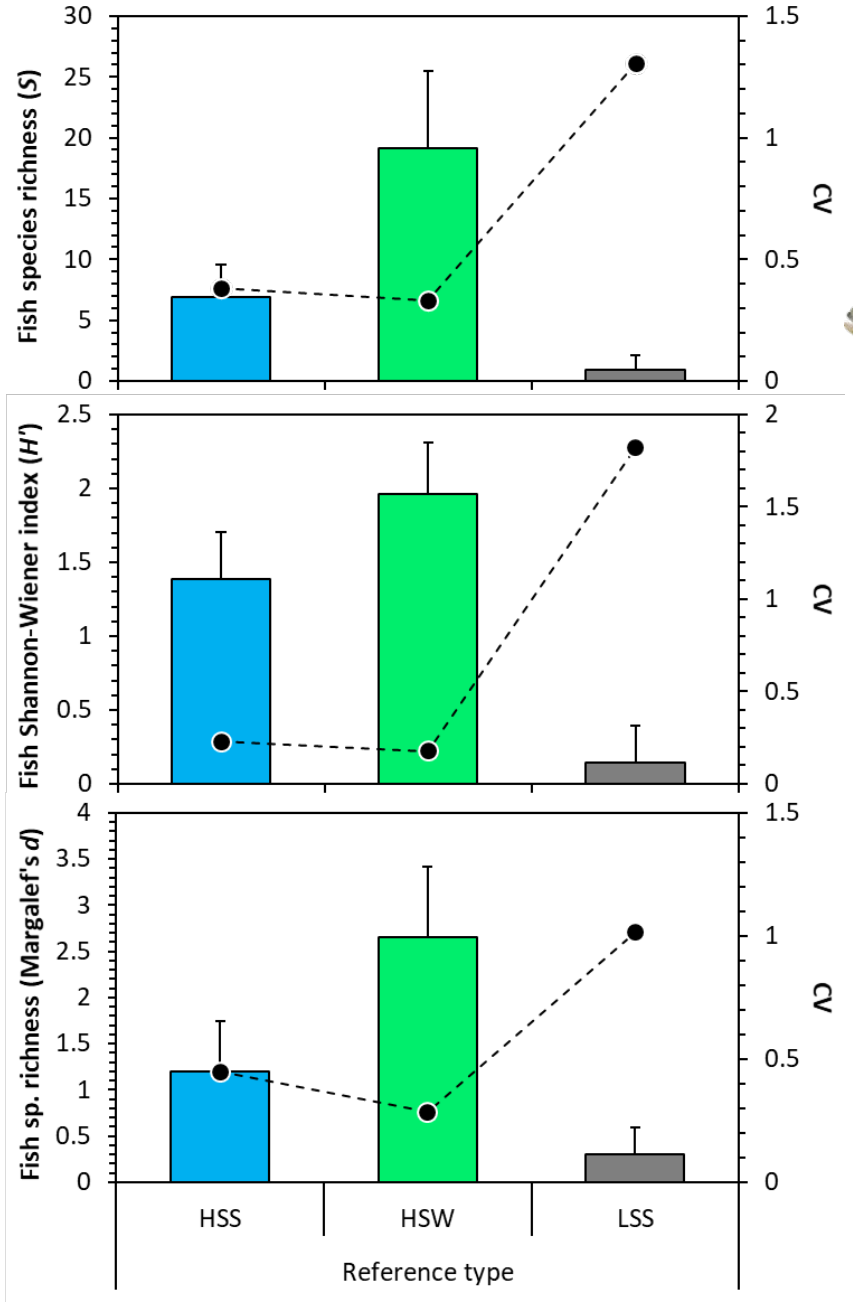
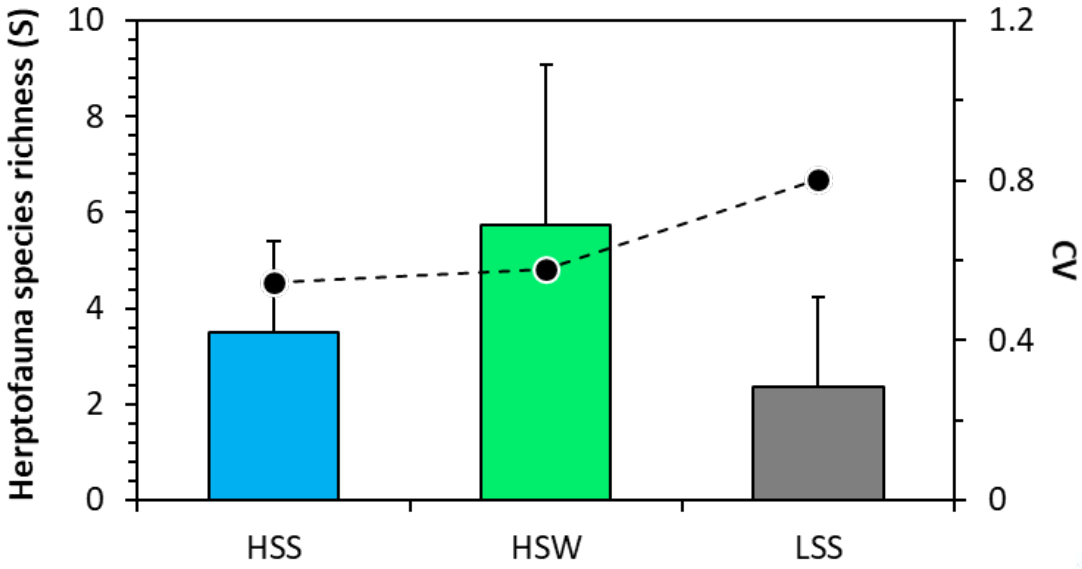


Figure 1. Graphical comparison of habitat-related differences associated with regenerative stream conveyance (RSC) construction relative to the putative initial condition (LSS: low-quality single channel stream), and reference conditions for three potential vertebrate community trajectories (HSW: high-quality stream-wetland complex; HSS: high-quality single channel stream; LSS).

Conceptual Model

HSS – High-quality Single Stream
HSW – High-quality Stream Wetland
LSS – Low-quality Single Stream





Site Selection for Field Study

- Natural factors were similar among stream types, except for larger catchment sizes that are inherent to HSWs

- 8 HSS *High-quality Single Streams* = 453–664 acre catchments
- 8 HSW *High-quality Stream Wetlands* = 552–52,936 acres
- 8 LSS *Low-quality Single Streams* = 134–669 acres
- 11 RSC *Regenerative Stream Conveyances* = 30–4550 acres

- Total of 35 sites sampled during August-September 2020

TETRA TECH

HSS-10

HSW-17

LSS-4

RSC-2

RSCs with Age and Catchment Areas

	RSC Site Name	Date constructed	Age (years)	Catchment (acres)
RSC-1	Bacon Ridge	2018	2	1757
RSC-2	N Branch Cypress Creek	2010	10	461
RSC-3	Crofton Tributary	2011	9	211
RSC-4	Dividing Creek	2016	4	220
RSC-5	Howard's Branch	2003	17	237
RSC-6	Cabin Branch Saltworks Creek	2013	7	121
RSC-8	Wilelinor	2004	16	262
RSC-9	Church Creek at Allen Apartments	2017	3	30
RSC-10	Cowhide Branch to Weems Creek	2013	7	4550
RSC-11	Church Creek at Bywater	2015	5	67
RSC-12	Church Creek at Annapolis Harbour Center	2014	6	151

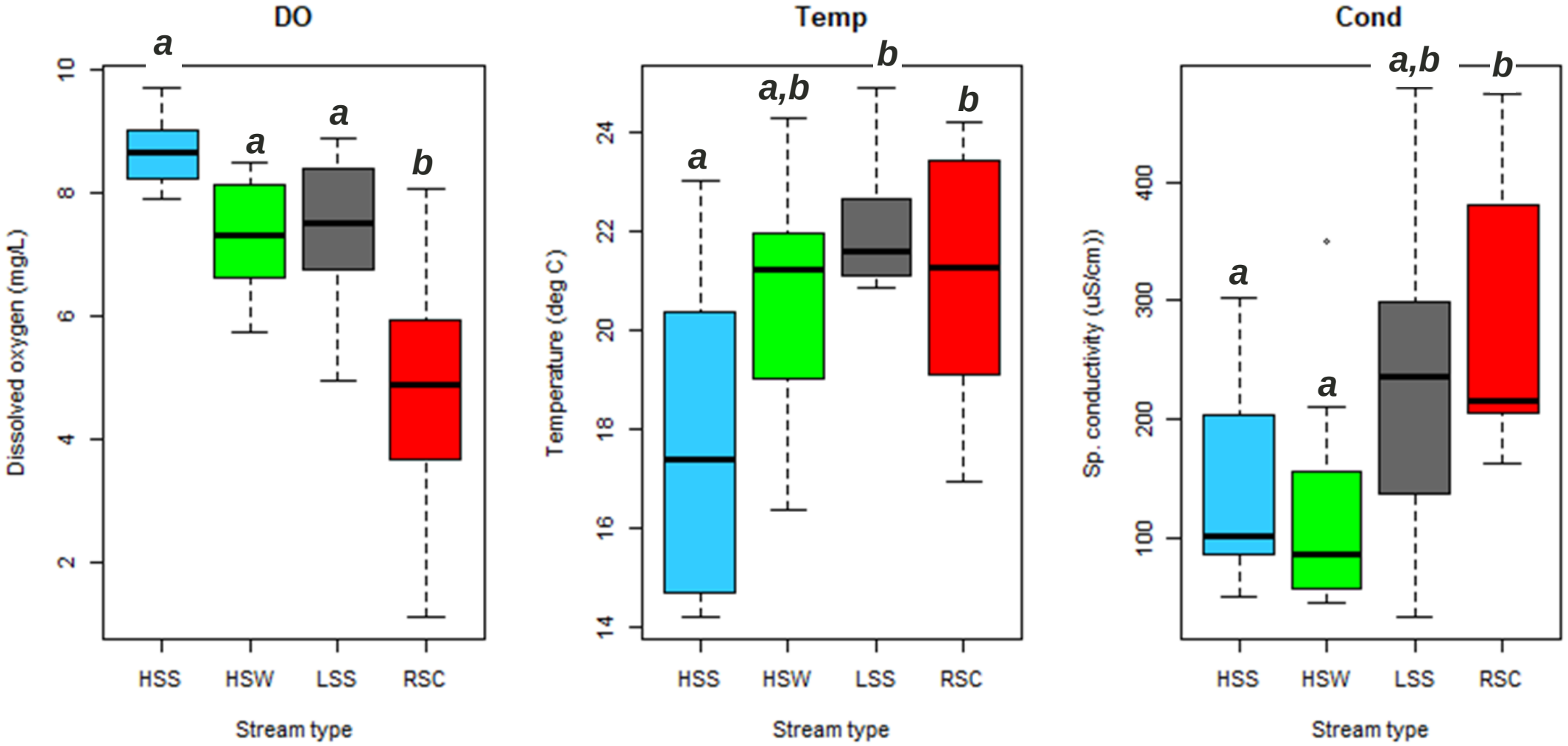
Field Sampling Methods

Sampling Protocols

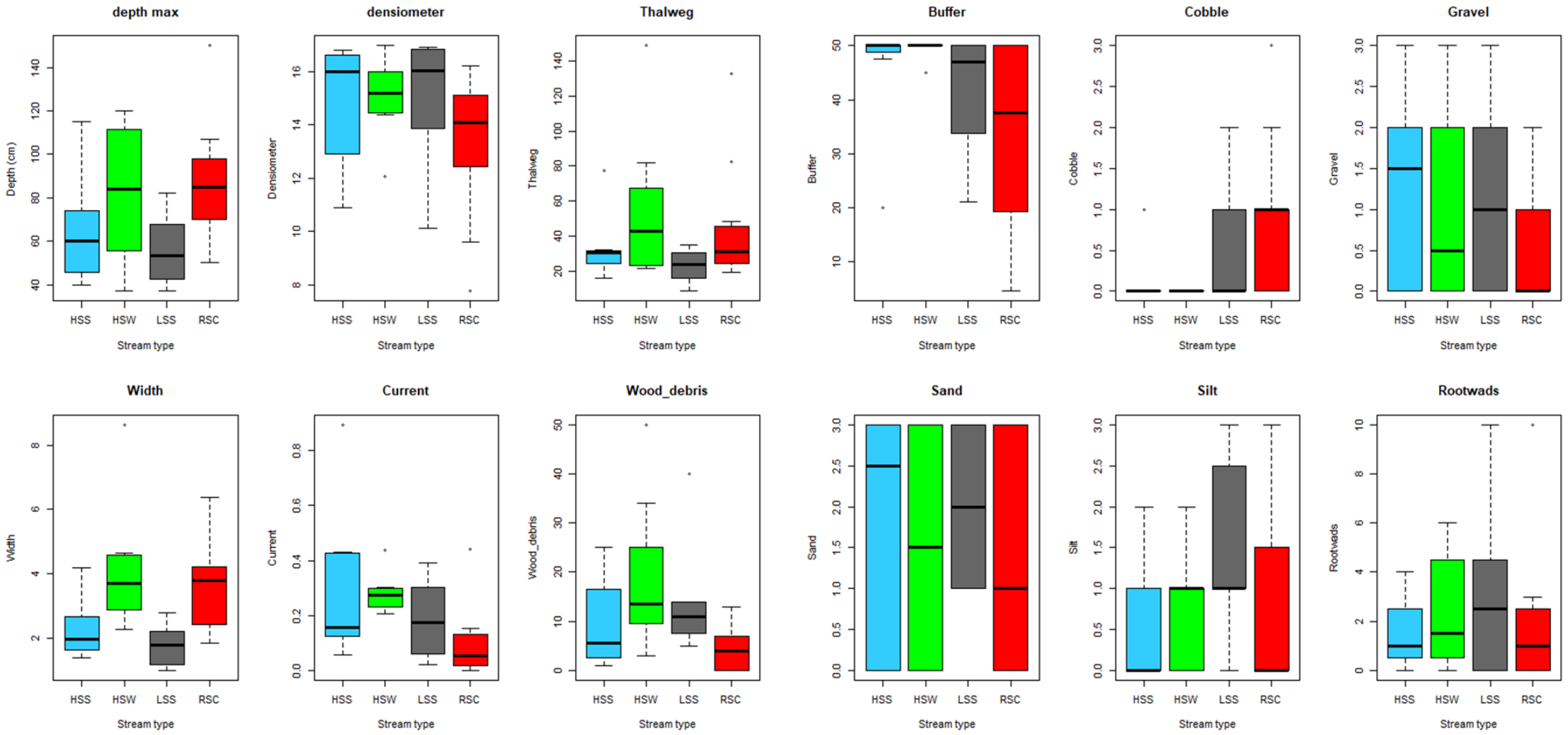
- MBSS for Fish, Herps, Habitat
- Basic Water Quality of Dissolved Oxygen, Temperature, Conductivity
- Stream Metabolism

- High flow days after rain were not sampled
- All sites were sampled in August-September 2020 with sampling of each stream type spread across the calendar

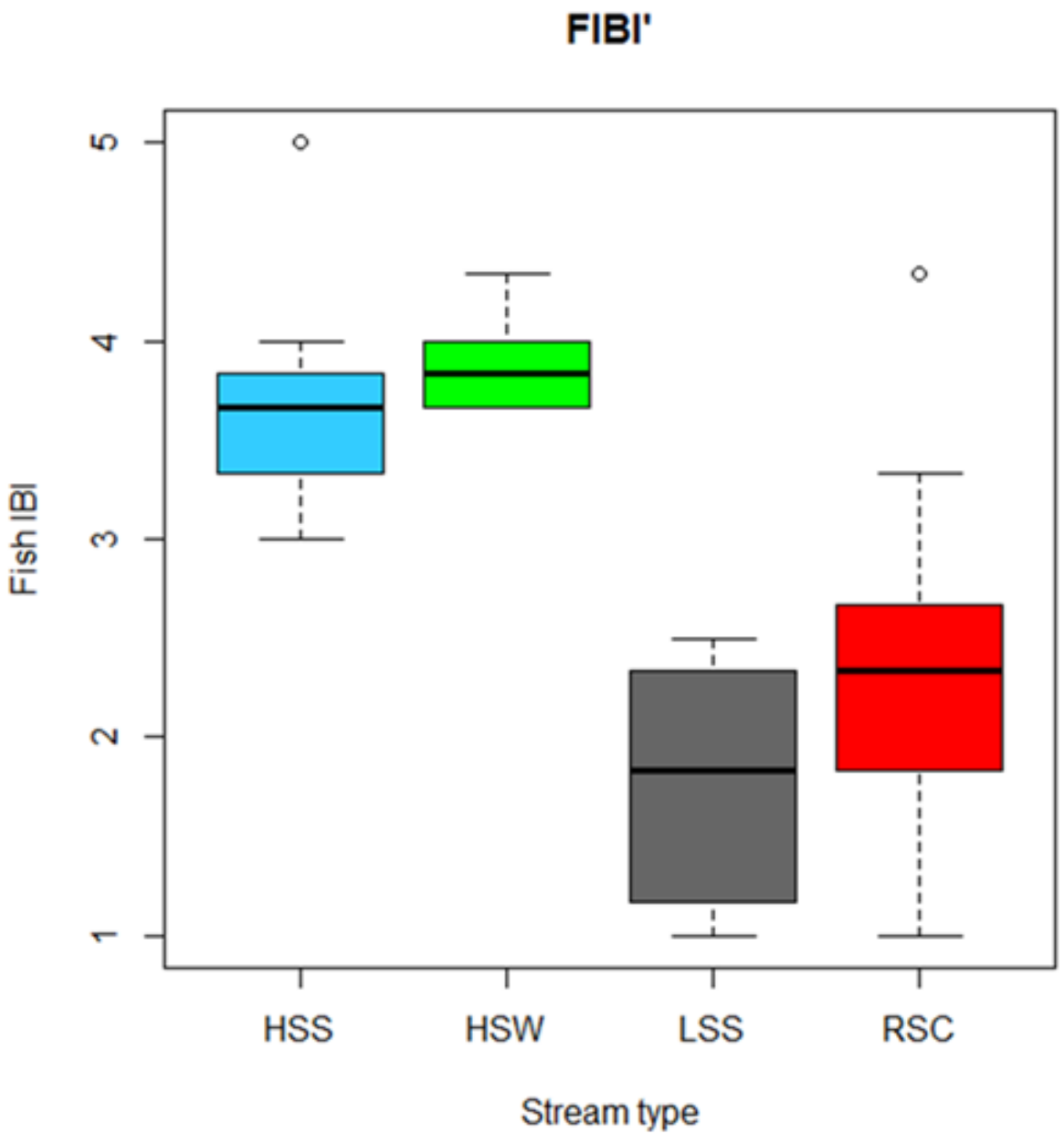
Water Quality is Different in RSCs



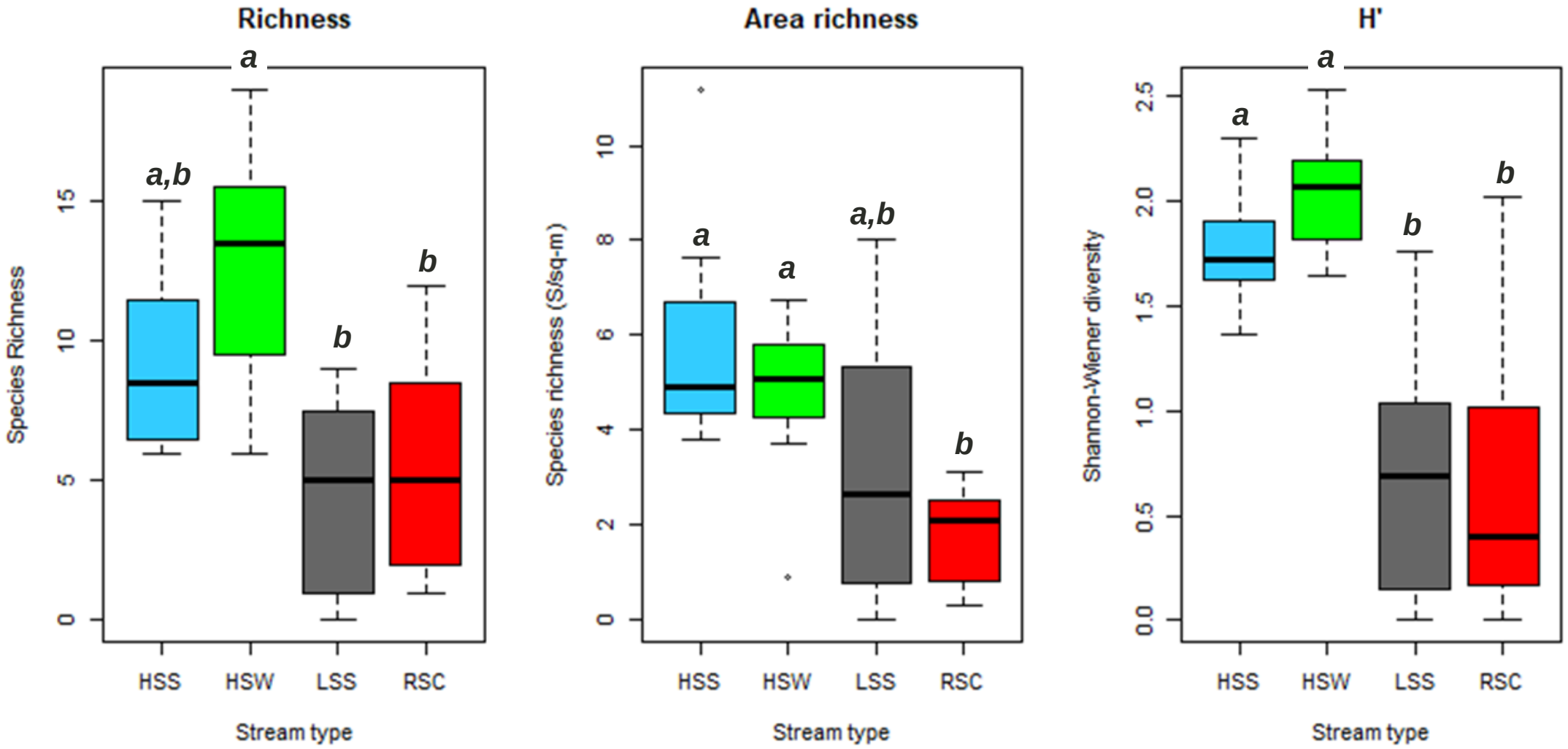
Habitat is Similar in RSCs (except for Buffers and Cobble)



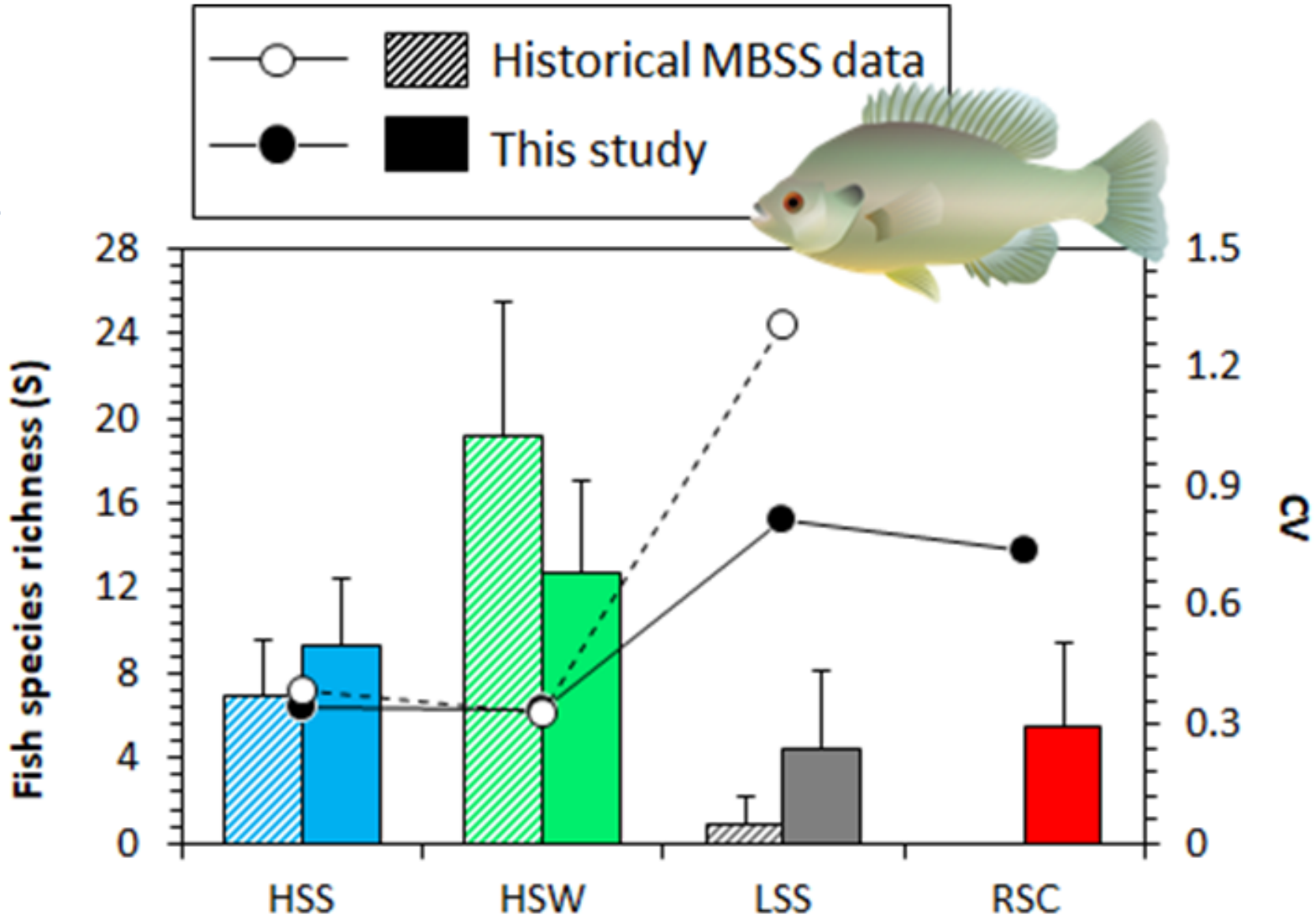
RSC FIBI is Low



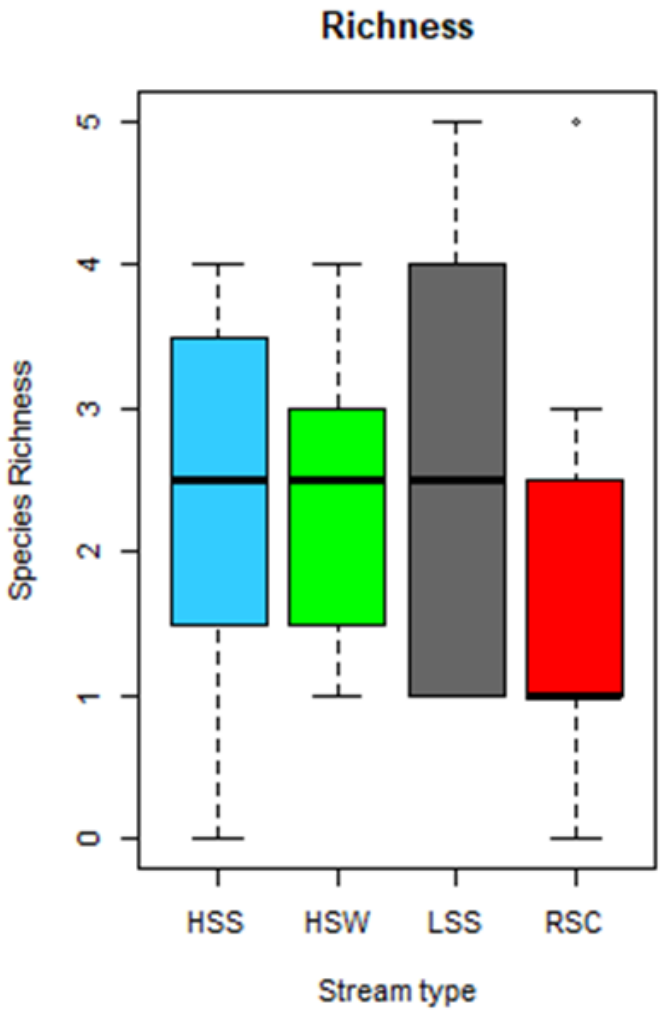
RSC Fish Diversity is Low

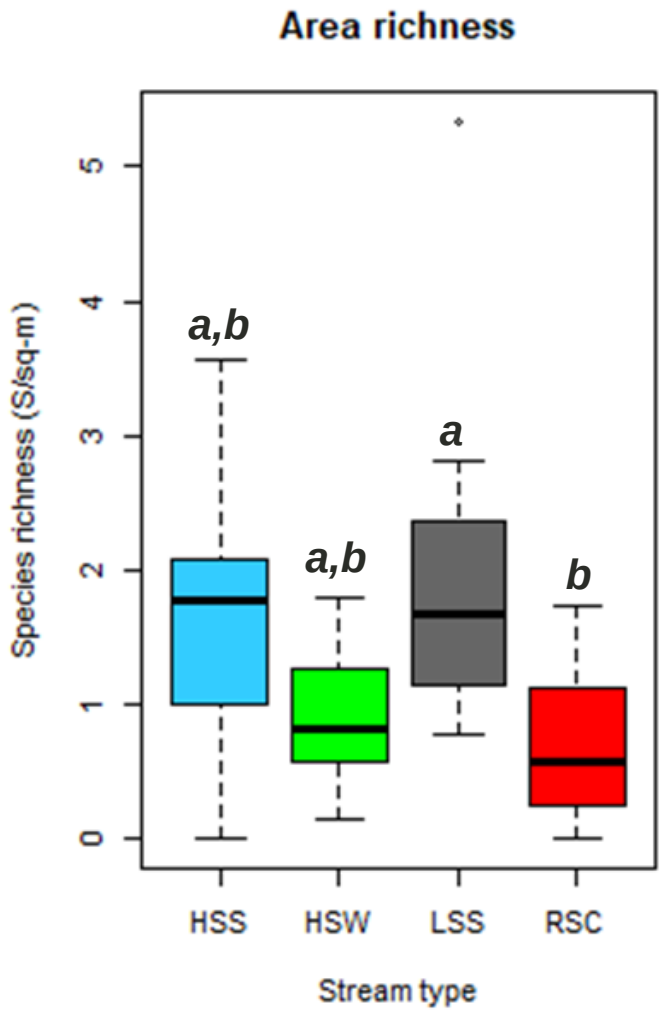


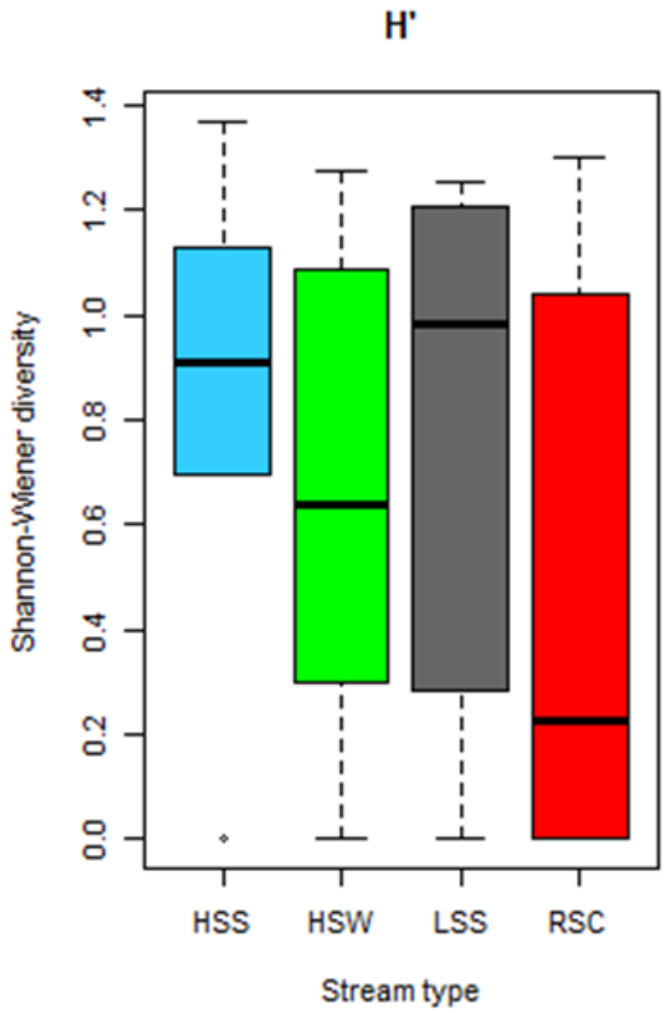
Fish Field Matches Model



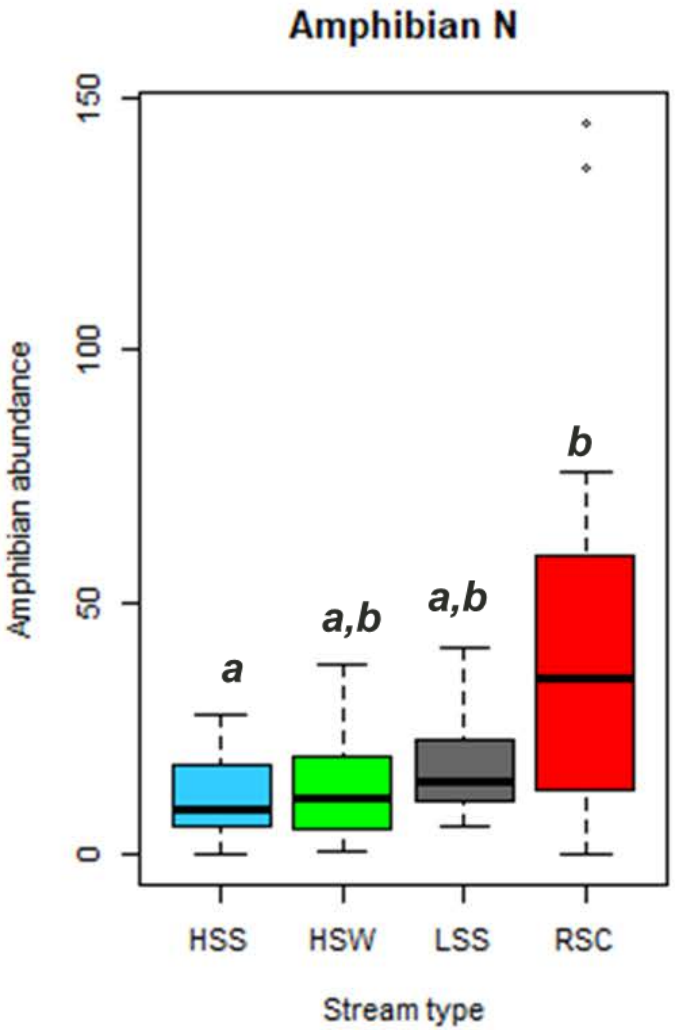
Herpetofauna Diversity is Similar

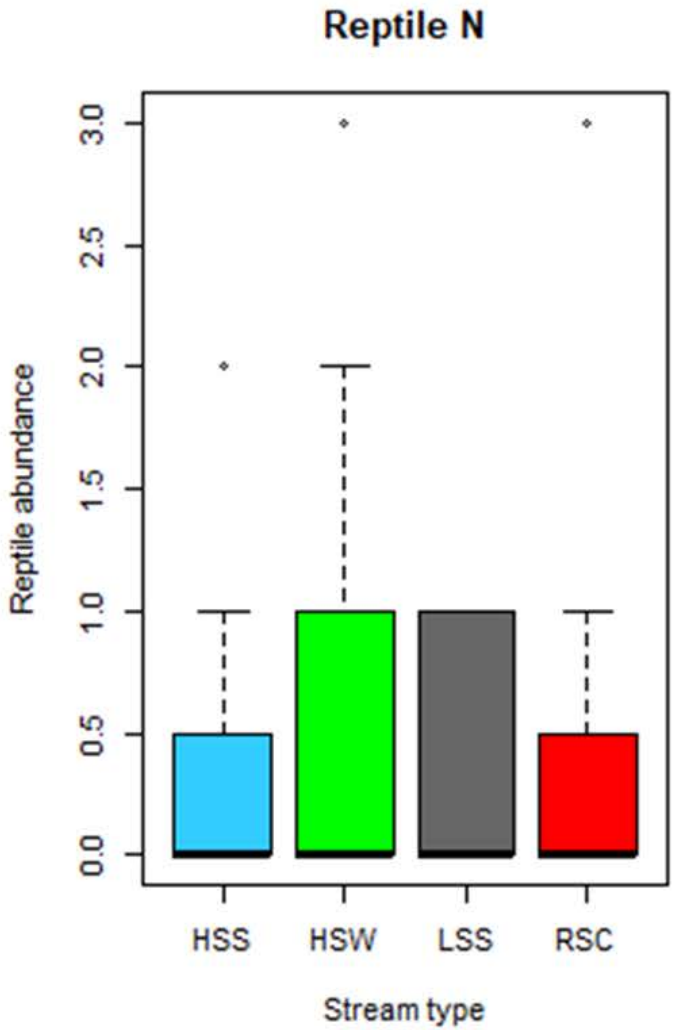


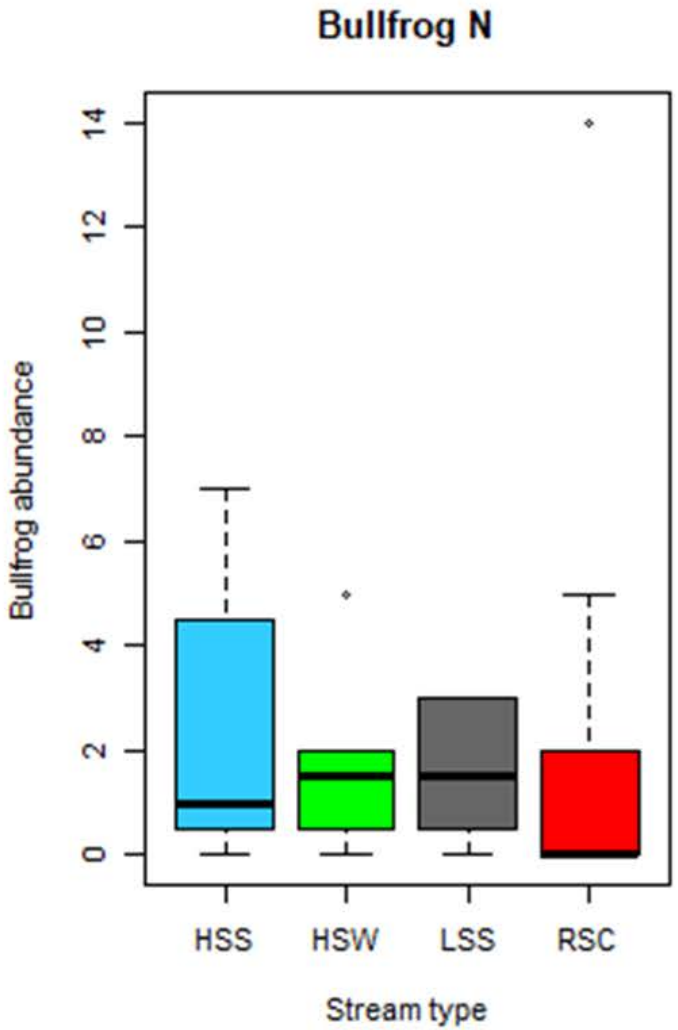




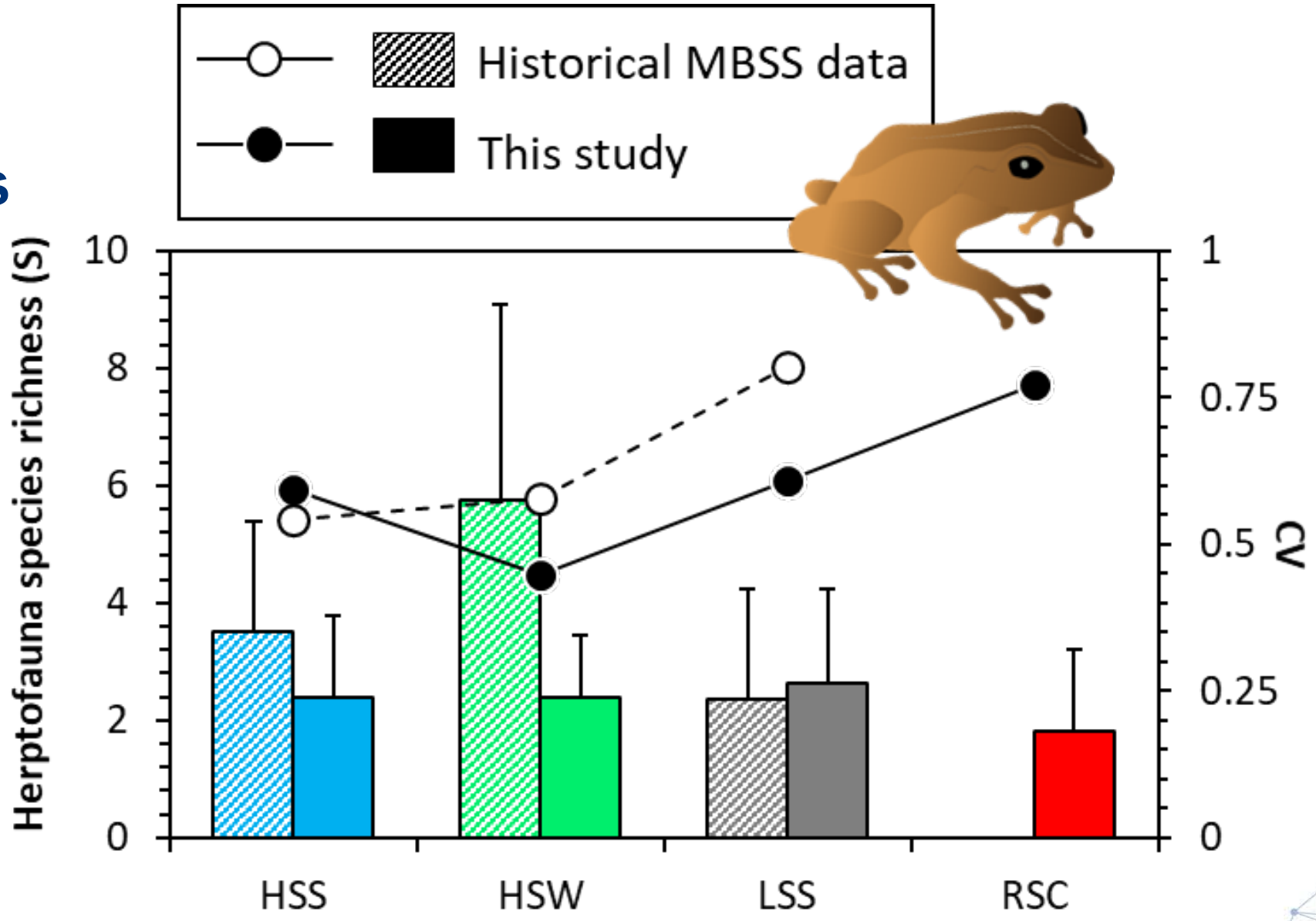
Frog Abundance in High in RSCs



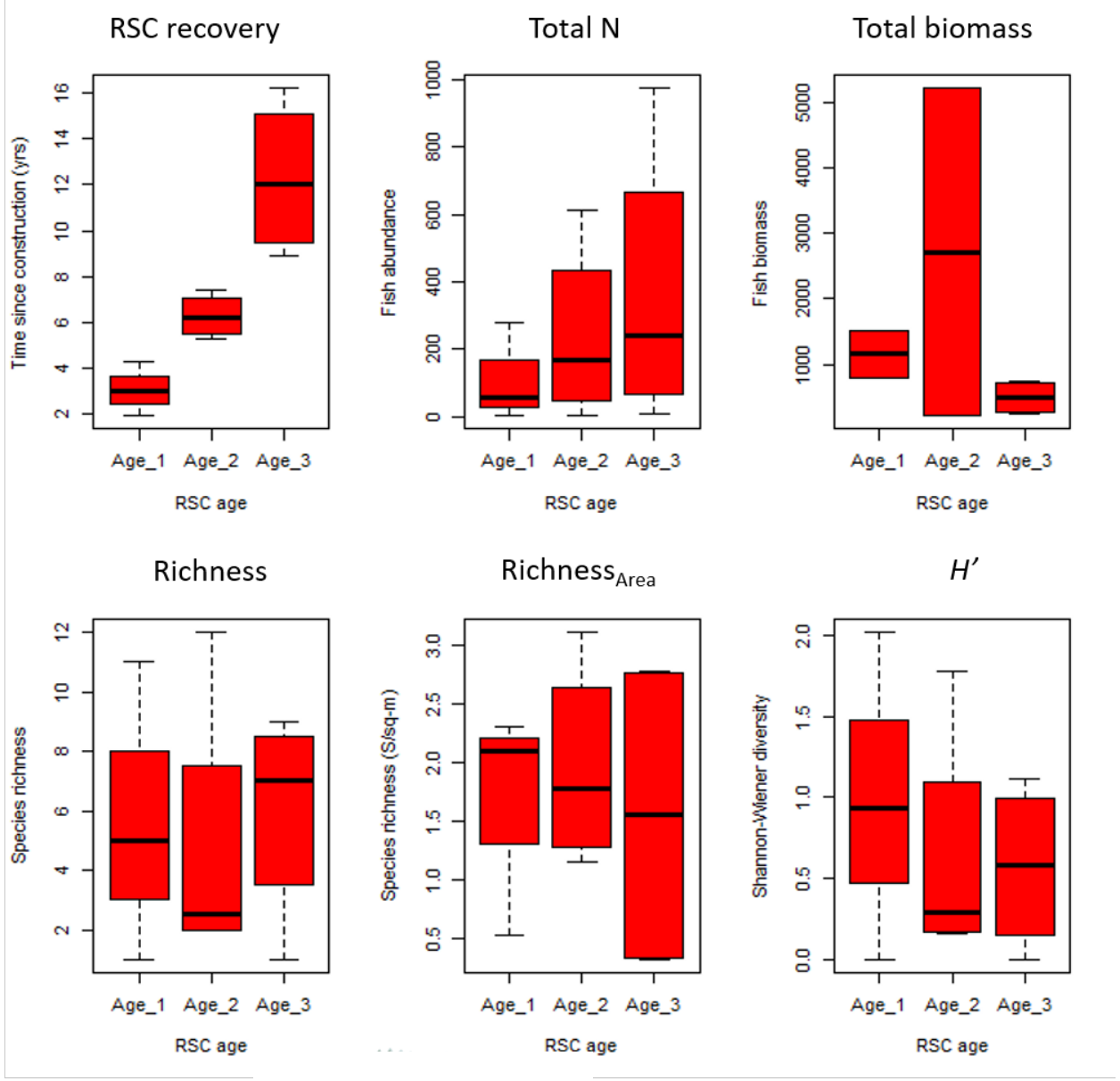




Herp Field Matches Model

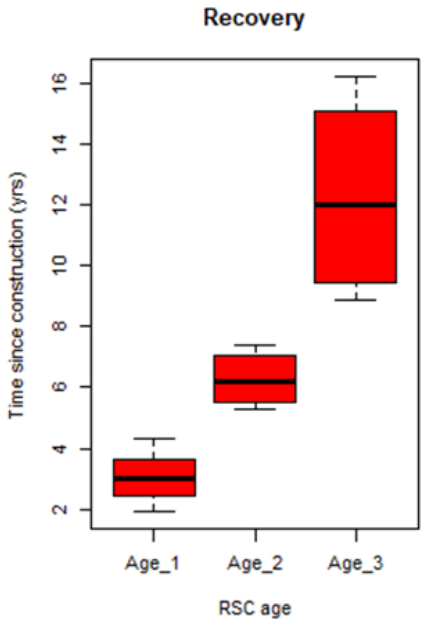


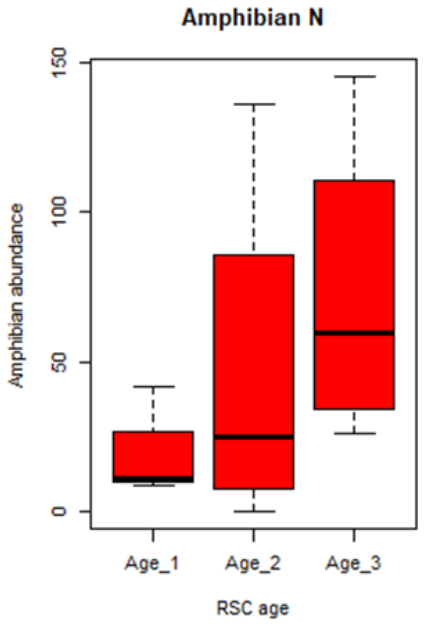
Fish Abundance but not Diversity Increases with Time since RSC Construction

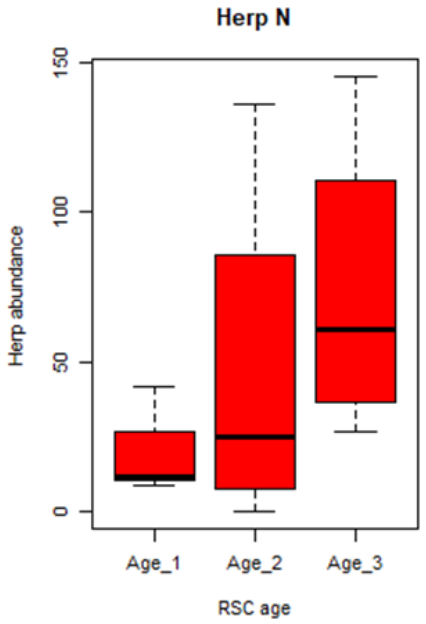


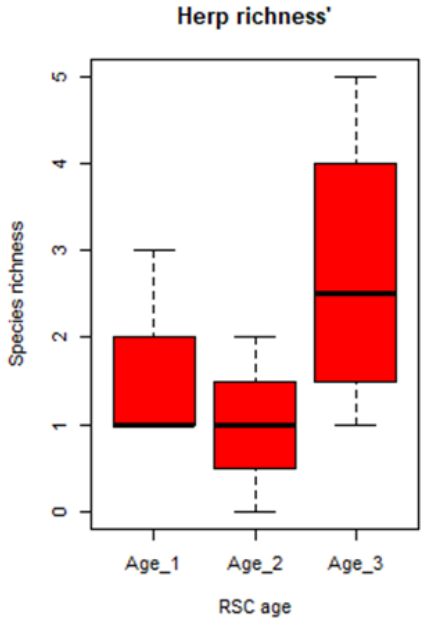
Age_1 = 1.9–4.3 yrs
Age_2 = 5.3–7.4 yrs
Age_3 = 8.9–16.2 yrs

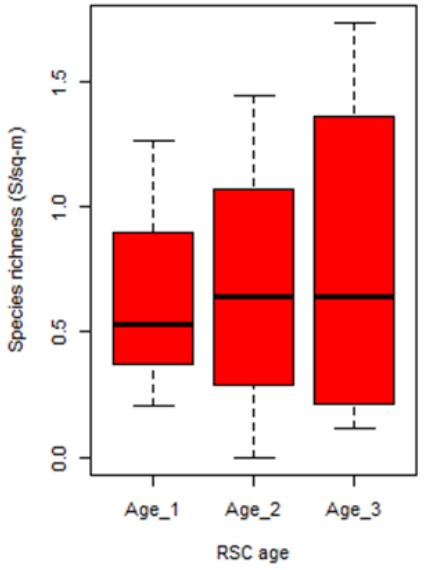
Herp Abundance and Diversity Increases with Time since RSC construction

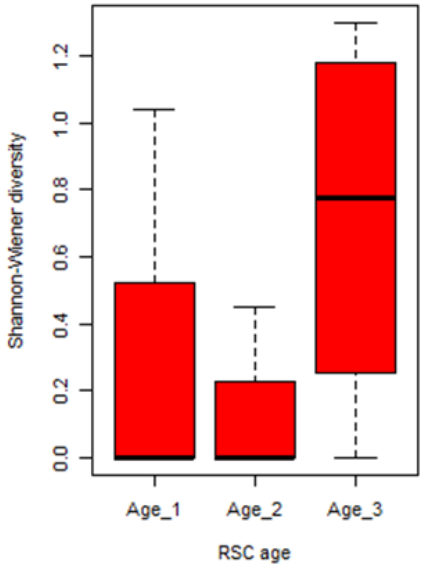




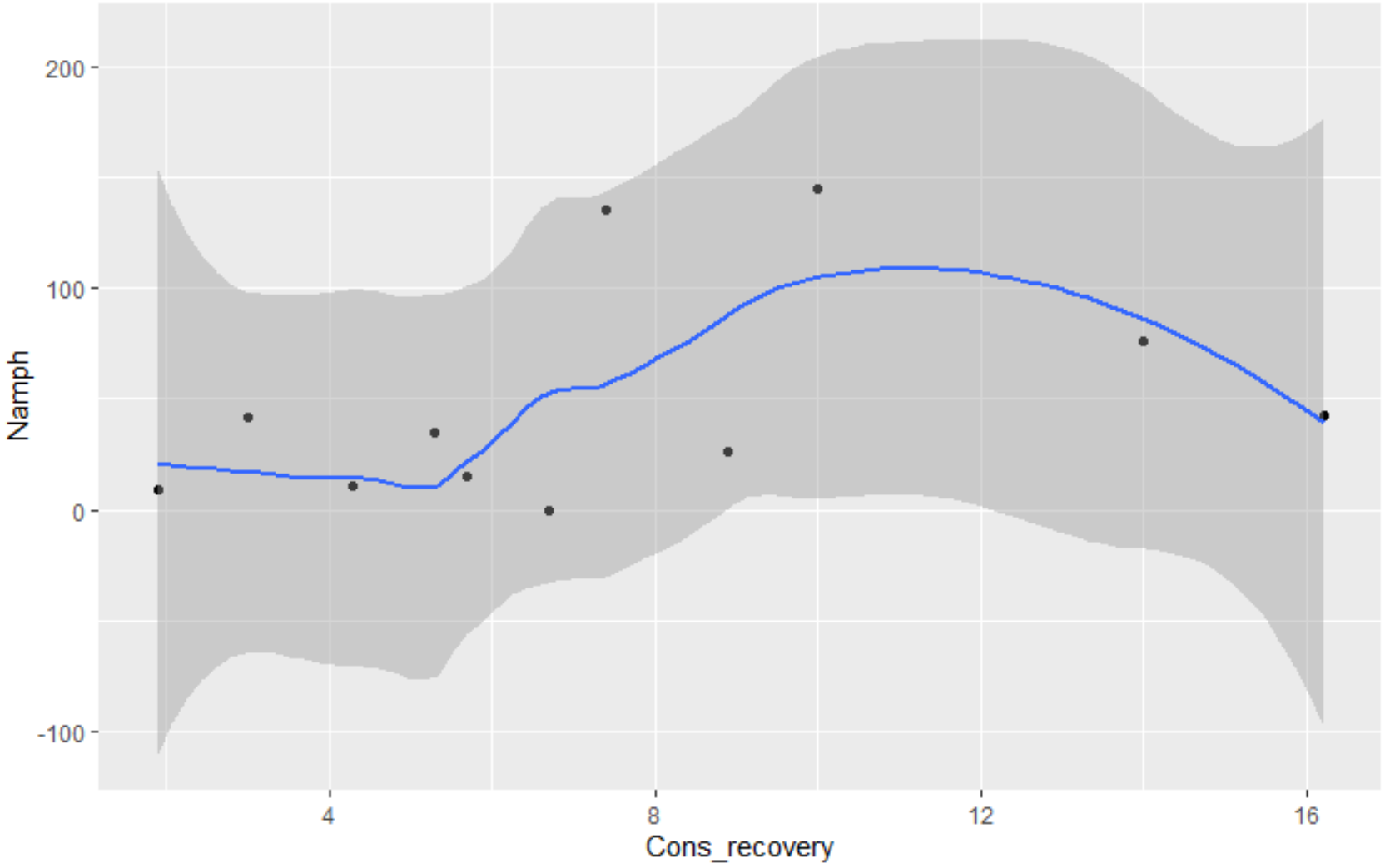




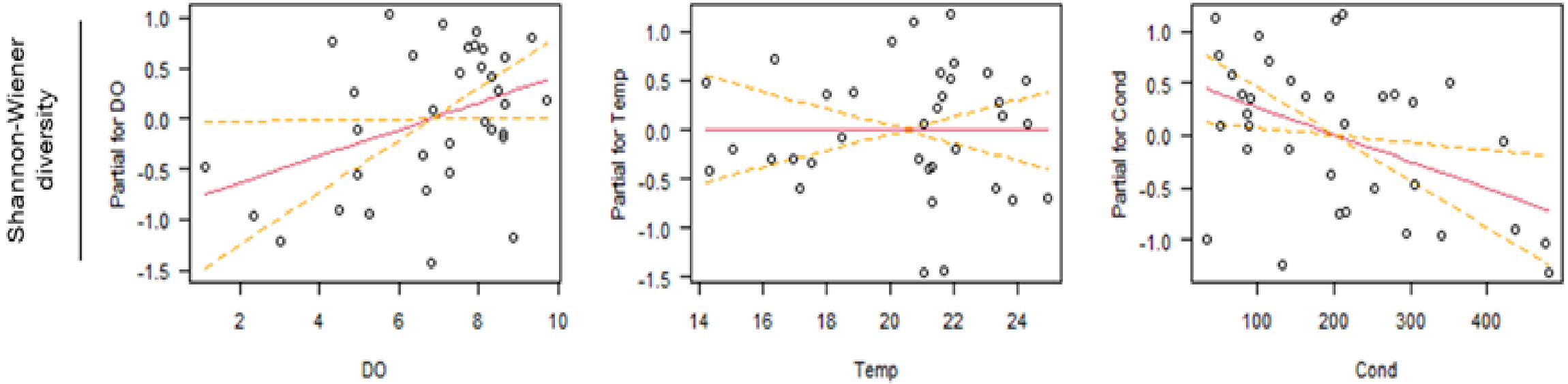




Herp Abundance takes 8 years to Increase after RSC construction

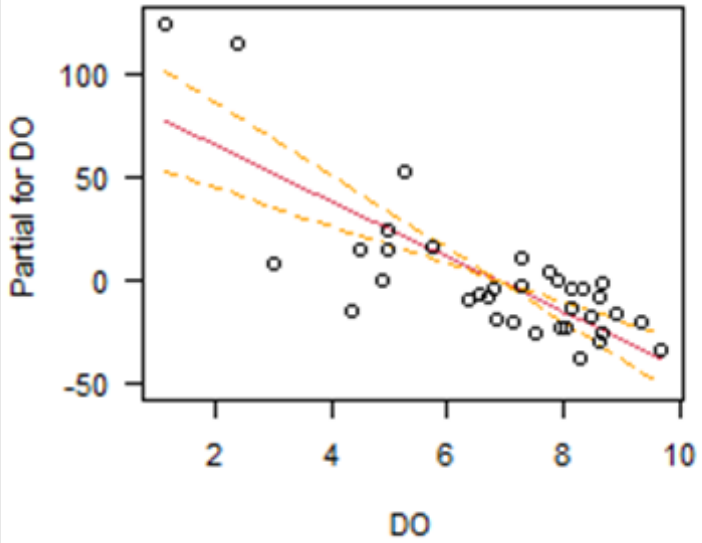


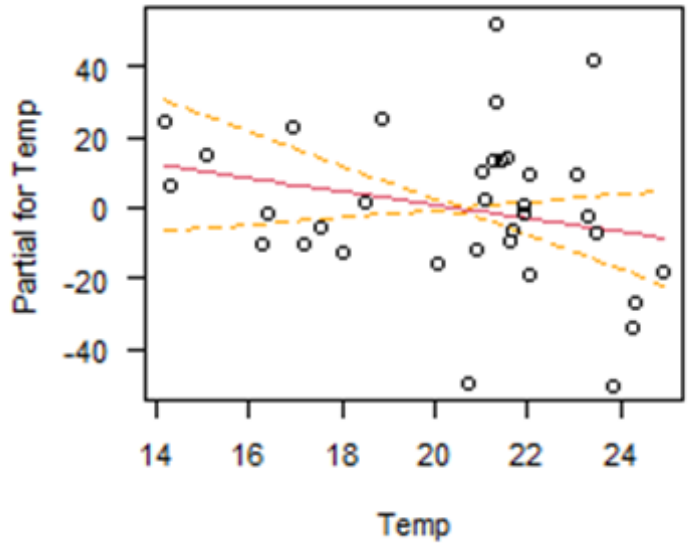
Fish Diversity Increases with DO and Decreases with Conductivity

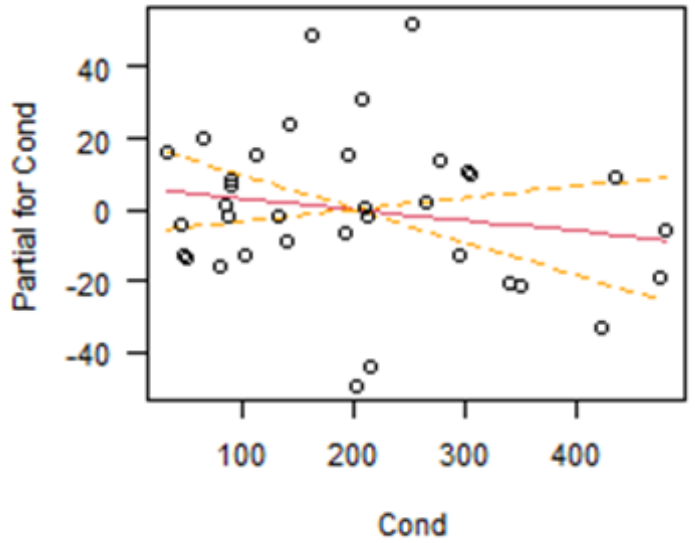


Herpetofauna is Not Reduced by Water Quality

Amphibian abundance



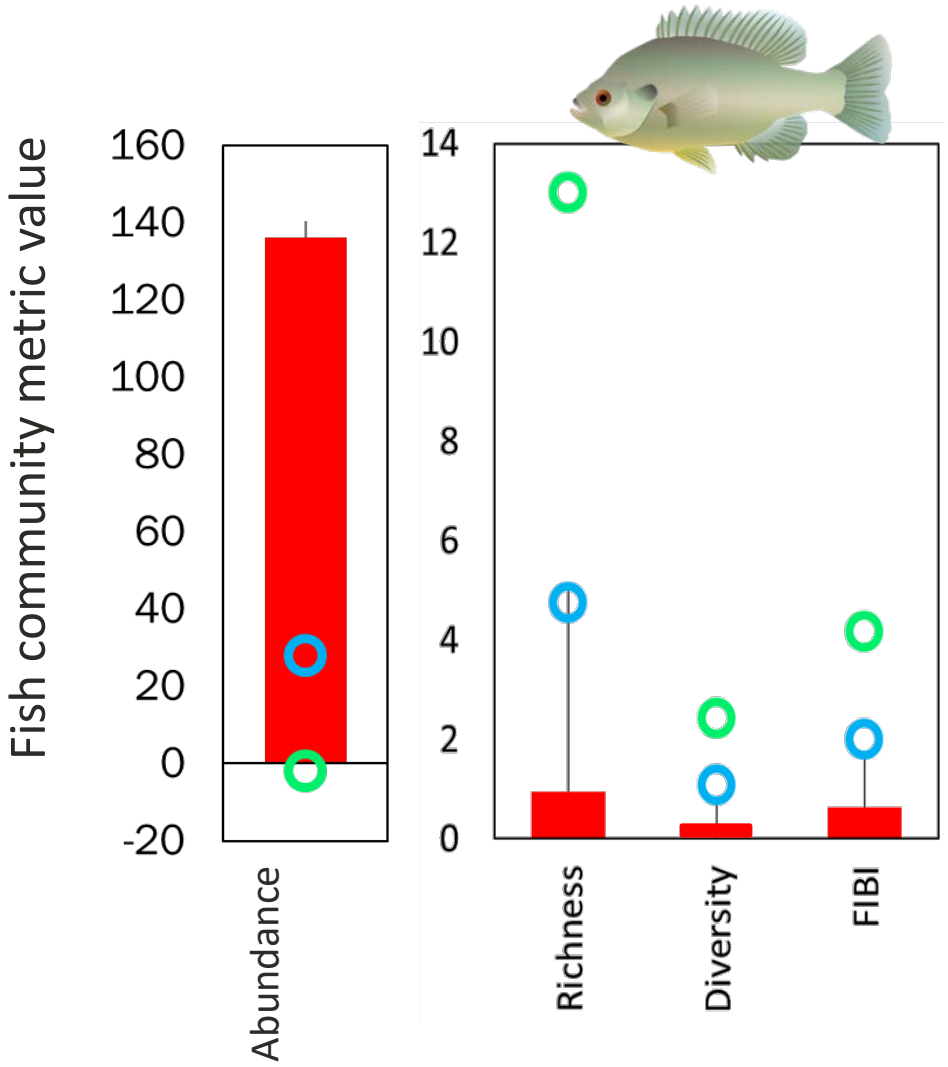


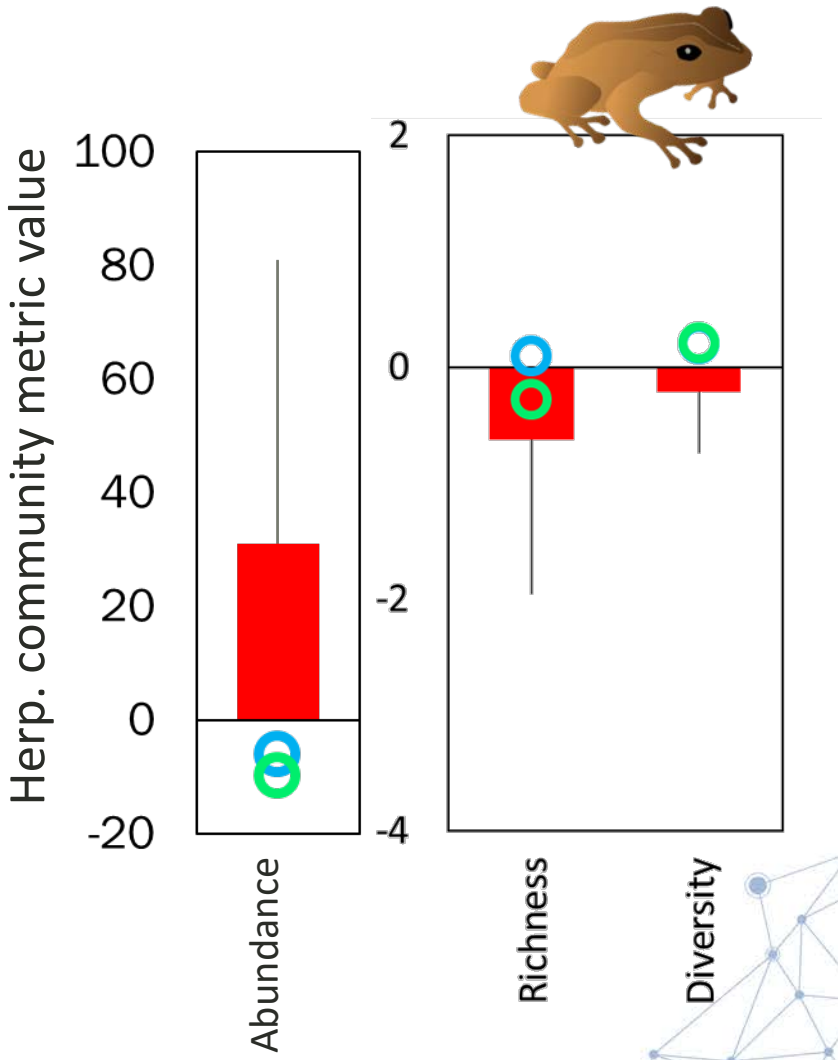


RSC Fish Communities Only Partially Approach High Quality

LSS reference (baseline condition)

- RSC
- HSS
- HSW





Conclusions

1. Overall, fish and herp communities in RSCs are similar to low-quality streams, not to high-quality streams
2. Fish Index of Biotic Integrity (IBI) was lower in RSCs than high-quality streams, with RSCs non-significantly higher than low-quality streams
3. Fish and frog abundance in RSCs are higher than both low- and high-quality streams
4. RSCs recreate stream-wetland structure (such as width and depth) typical of high-order streams in reaches that are low-order, but reference DO, conductivity, and flow levels are not attained
5. Vertebrate uplift in RSCs appears constrained by continuing poor water quality, but may improve as RSCs mature
6. Refinements to RSC designs (and stream restoration in general) may improve vertebrate trajectories, but our understanding of ecological states may also limit uplift

Translation Slides:

Vertebrate Community Trajectories in Regenerative Stream Conveyances (RSCs)

Study by: Mark Southerland et al.

Translation by PMAC member: Chris Ruck, Ecologist
Watershed Assessment Branch
Stormwater Planning Division

Department of Public Works and Environmental Services
Working for You!

A Fairfax County, VA, publication
June 2022

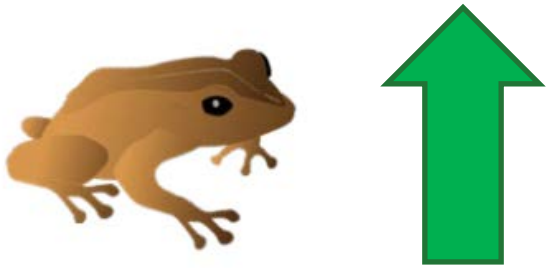
What are the key take-home points?

Two questions: B.4. Biological community restoration

D.10. Resource trade-offs based upon the type of restoration

- Fish assemblage in RSCs
  - Low diversity & low FIBI scores
  - Affected by water quality (DO and Conductance)
  - Fish abundance increases over time (not diversity or FIBI)

- Herp community in RSCs
  - Herp abundance and diversity increase over time
  - Not affected by water quality (DO, Temp, or Conductance)
  - Take 8-10 years post construction to show community maturation



What does this mean for me?

- As a practitioner
  - Increase pool size for increased numbers of fishes, but maintain sediment transport
  - Increase the amount and diversity of habitat, for biological lift
  - Look to high-quality stream-wetland complexes for designs and biological trajectories
- As a regulator
  - Acknowledge there may be urban/suburban thresholds that limit restorative improvements
  - Fundamentally, RSCs create different habitat/geomorphology from single thread channels
  - Would want to ensure 10+ years of monitoring to see changes to Herp community
- As a PMAC member
  - We may want to fund additional research comparing perennial RSCs with stream-wetland complexes and not single thread channels
  - Does landscape composition / water quality affect the assemblages more that the type of restoration?

Questions

Cartoon with permission: Seppo Leinonen, www.seppo.net

Variation in RSCs

	RSC Site Name	Date constructed	Age (years)	Catchment (acres)
RSC-1	Bacon Ridge	2018	2	1757
RSC-2	N Branch Cypress Creek	2010	10	461
RSC-3	Crofton Tributary	2011	9	211
RSC-4	Dividing Creek	2016	4	220
RSC-5	Howard's Branch	2003	17	237
RSC-6	Cabin Branch Saltworks Creek	2013	7	121
RSC-8	Wilelinor	2004	16	262
RSC-9	Church Creek at Allen Apartments	2017	3	30
RSC-10	Cowhide Branch to Weems Creek	2013	7	4550
RSC-11	Church Creek at Bywater	2015	5	67
RSC-12	Church Creek at Annapolis Harbour Center	2014	6	151

Variation in RSCs

RSC site	Herpetofauna		Amphibians			Reptiles	Fish fauna			Fish area metrics			FIBI
	S	Total *N*	Total *N*	Anuran *N*	Larval *N*	*N*	*S*	*N*	*B*	*S* m^{-2}	*N* m^{-2}	*B* m^{-2}	
1	1	9	9	8	0	0	11	57	796	0.023	0.12	1.66	3.33
2	1	145	145	143	99	0	9	974	709	0.028	2.99	2.17	2.67
3	3	27	26	22	15	1	1	10	266	0.003	0.03	0.87	1.00
4*	3	12	11	8	0	1	5	278	1509	0.021	1.17	6.34	2.67
5	2	76	76	66	58	0	6	362	244	0.004	0.21	0.14	2.33
6	2	136	136	130	0	0	3	254	208	0.022	1.83	1.5	2.33
8	5	46	43	17	0	3	8	122	743	0.028	0.42	2.57	2.33
9†	1	42	42	40	0	0	1	5		0.005	0.03		1.00
10*	0	0	0	0	0	0	12	614	5208	0.031	1.59	13.48	4.33
11†	1	35	35	35	0	0	1	9		0.007	0.06		1.67
12†	1	15	15	15	0	0	1	86		0.006	0.50		2.00

- RSC 10 (Cowhide Branch to Weems Creek) is most taxonomically diverse with predators (pickerel), several functional groups, and salt tolerants (eel, killifish, stickleback, silverside, mummichog)
- RSC 1 (Bacon Ridge) is next most diverse with lentic character and centrarchids (bluegill, bluespotted sunfish, green sunfish, pumpkinseed)

PCA Clusters of RSCs

- Larger RSCs (1 and 10)
- RSCs more tree canopy and lower temperature (2, 3, 8, 6, and 4)
- RSCs with higher conductivity (9, 12, and 11)
- Variation in design, such as more of less pools and faster or slower flow