

Effectiveness of urban stream restorations for improving habitat and benthic invertebrates

Q1: What is the impact on habitat and biological factors of different restoration techniques?

Q2: Do different design types result in net ecological benefit relative to pre-project conditions?

Q3: What is the impact of land use on habitat and biological factors

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Acknowledgments



Key Research Questions

- How much ecological uplift can be achieved by urban stream restorations?
- What are the influences of Impervious Surfaces, Restoration Length, and Restoration Age?
- Are there differences between NCD and RSC approaches?
- Do any restoration-specific activities promote ecological uplift?

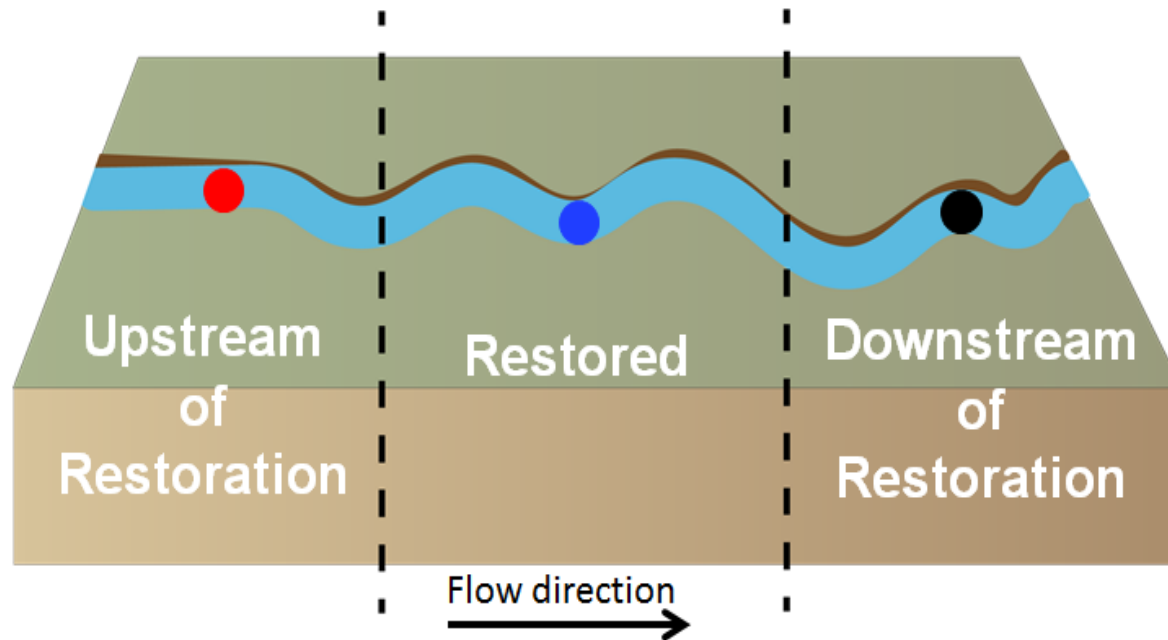
Restoration effectiveness questionable in urban streams

- Physical attributes sometimes (often?) repaired or stabilized
- Ecological attributes rarely improved

Conclusion: Good news and Bad

- Physical habitat generally improved
 - Fewer fine sediments
 - Greater bank and channel stability
- Very limited evidence for ecological improvements
 - No differences in community structure, diversity, or stream health
 - Restoration activities may destabilize ecological recovery and make the system more vulnerable

Triplet sampling design



- Physical attributes using EPA rapid assessment
- Ecological attributes using benthic macroinvertebrates

Sampling locations

- 22 Piedmont NCD (Natural Channel Design) sites
- 18 Coastal Plain
 - 9 NCD
 - 9 RSC (Regenerative Stormwater Conveyance)

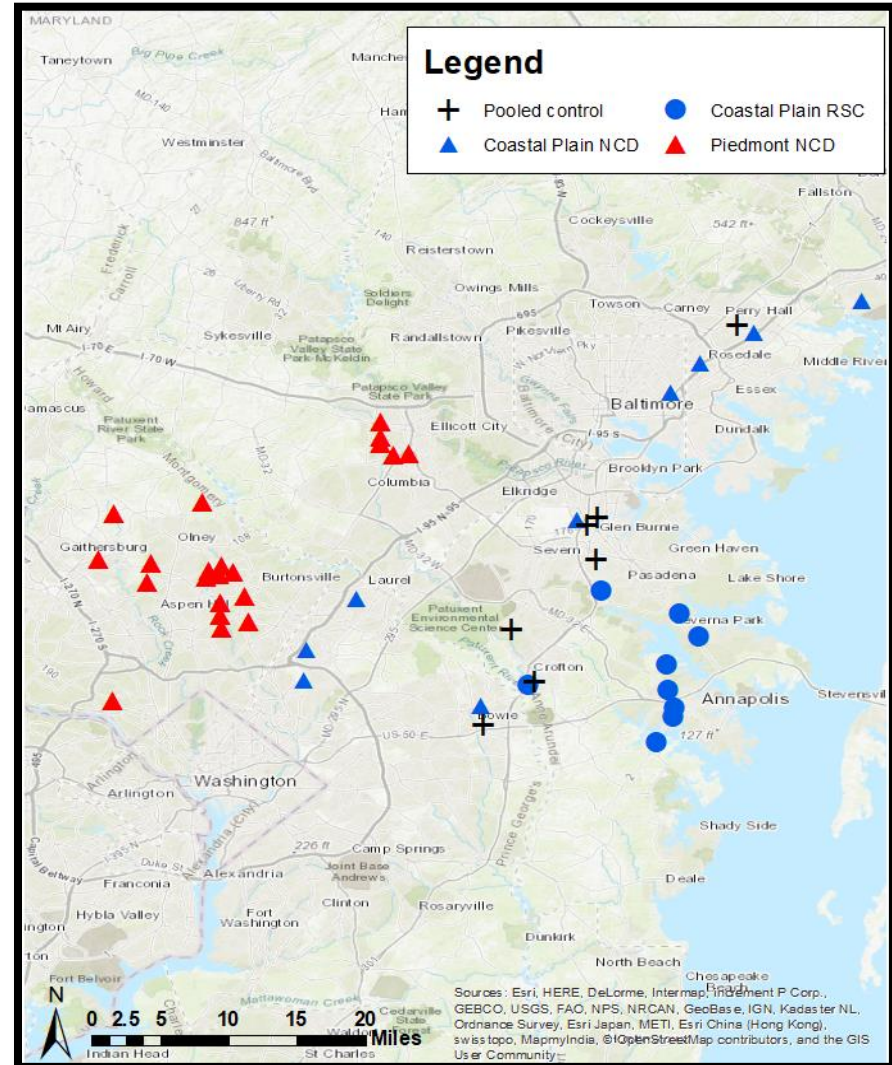
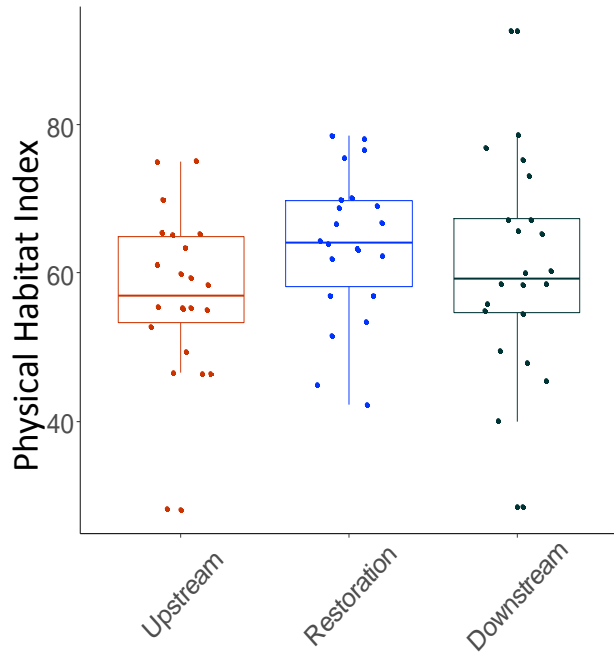


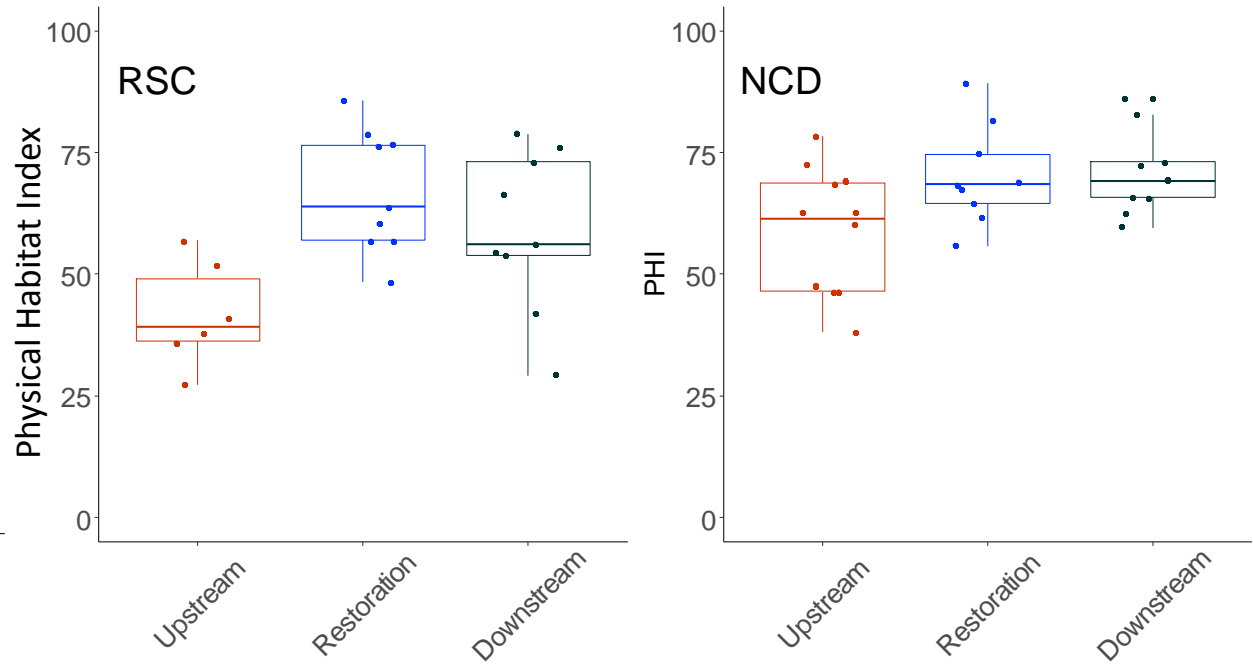
Figure 1. All 40 restoration sites separated by physiographic province and restoration type

Overall habitat improvement in Coastal Plain, but not in Piedmont

Piedmont



Coastal Plain



Some Piedmont habitat improvements

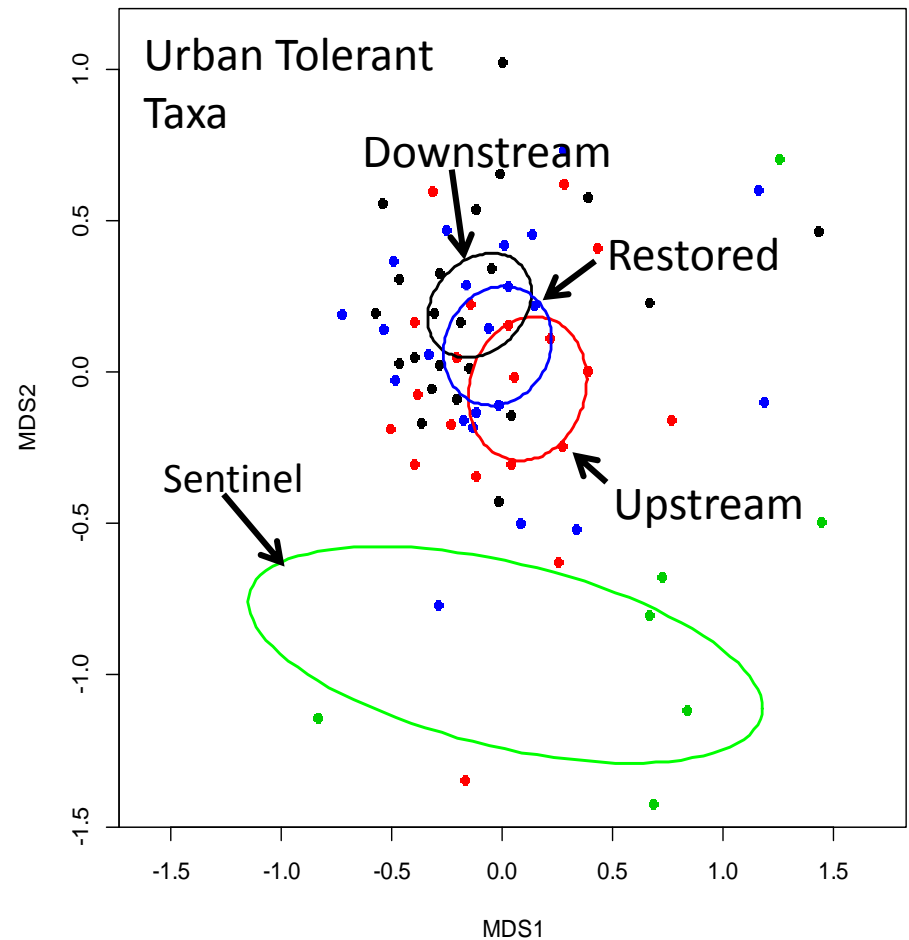
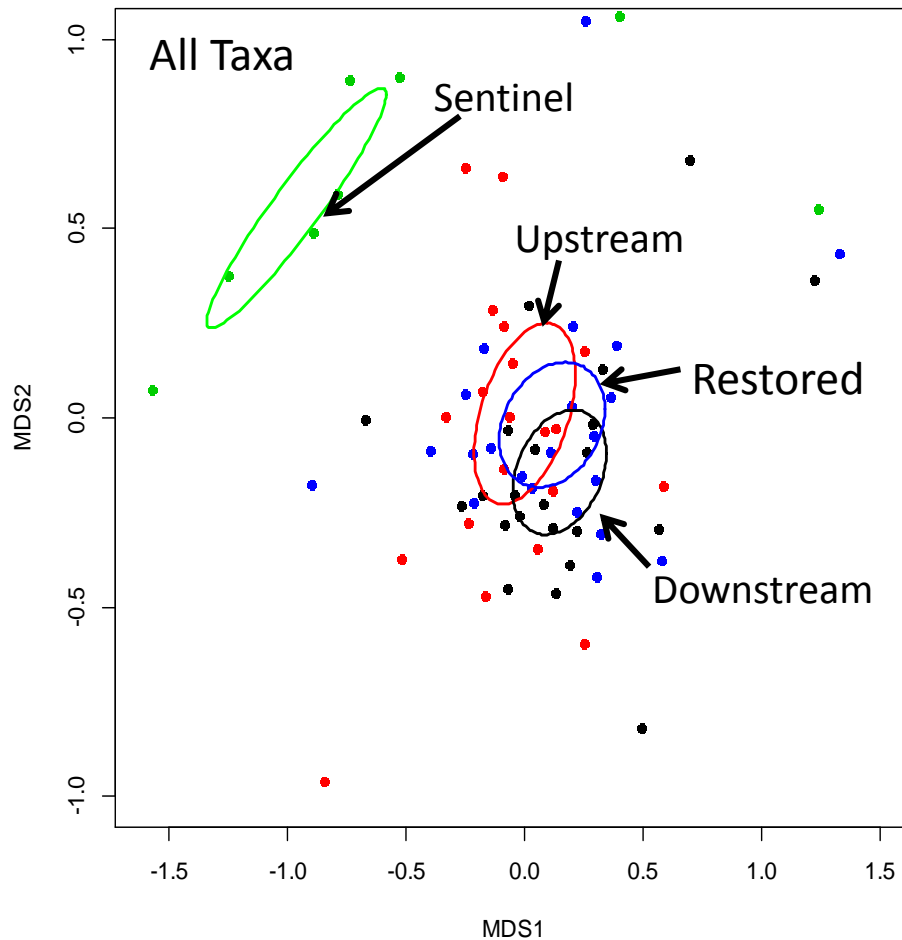
Habitat Attribute	Restored vs Upstream	Restored vs Downstream	Downstream vs Upstream
Epifaunal Substrate	NS	NS	NS
Embeddedness	NS	NS	NS
Velocity Depth Pool Variability	NS	NS	NS
Channel Alteration	-	-	NS
Sediment Deposition	+	+	NS
Riffle Frequency Channel Sinuosity	+	NS	+
Total Bank Stability	+	+	+
Total Bank Vegetative Protection	+	+	NS
Total Width Undisturbed Vegetative Zone	NS	NS	NS
Pool Substrate Characterization	NS	NS	NS
Pool Variability	NS	NS	NS
Sinuosity	NS	NS	NS
% Fines	NS	NS	NS
% Sand	-	-	NS
% Sand and Silt	-	-	NS
% Gravel	NS	NS	NS
% Cobble	NS	NS	NS
% Boulder	NS	NS	NS
D50	+	+	NS
D84	NS	NS	NS

Coastal Plain habitat improved

Habitat Attribute	Restored vs Upstream	Restored vs Downstream	Downstream vs Upstream	NCD vs RSC
Epifaunal Substrate	+	+	NS	+
Embeddedness	+	NS	+	+
Velocity Depth Pool Variability	+	NS	+	+
Channel Alteration	NS	NS	NS	NS
Sediment Deposition	+	NS	+	NS
Riffle Frequency Channel Sinuosity	+	NS	+	+
Total Bank Stability	+	+	+	NS
Total Bank Vegetative Protection	+	NS	NS	+
Total Width Undisturbed Vegetative Zone	+	NS	+	NS
Pool Substrate Characterization	NS	NS	NS	NS
Pool Variability	+	+	+	+
Sinuosity	NS	NS	NS	NS
% Fines	-	NS	-	-
% Sand	-	NS	-	NS
% Sand and Silt	-	NS	-	-
% Gravel	NS	NS	NS	+
% Cobble	+	NS	+	NS
% Boulder	+	NS	+	NS
D50	+	NS	+	NS
D84	+	NS	+	NS

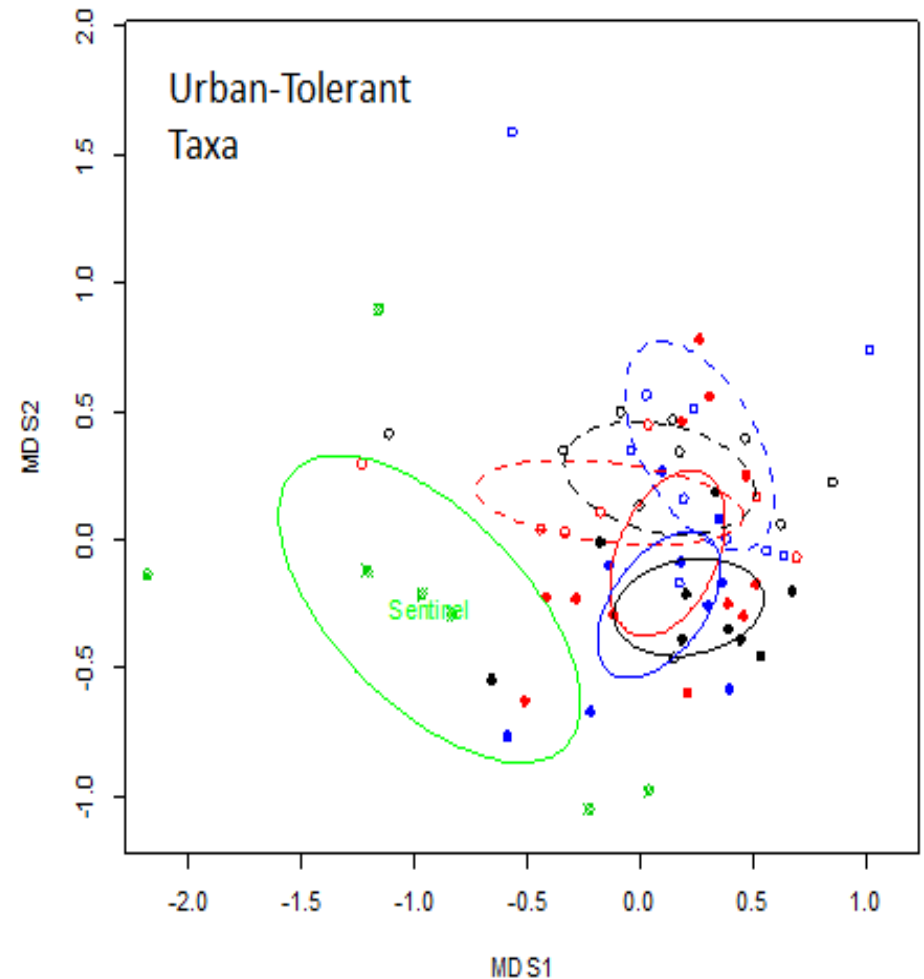
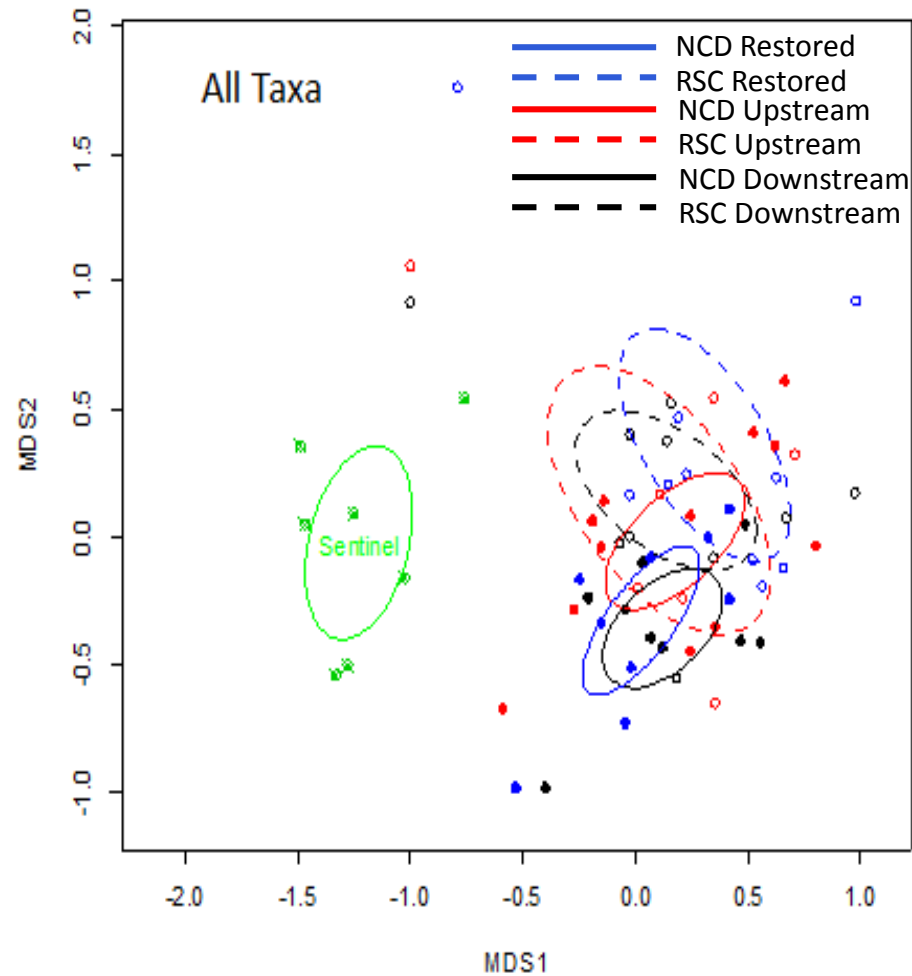
Big differences between lesser disturbed stream communities and restored Piedmont streams.

No differences between restored and unrestored



Big differences between lesser disturbed stream communities and the rest in Coastal Plain streams

No differences between restored and unrestored



Not much Index of Biotic Integrity (IBI) improvement in Piedmont restorations

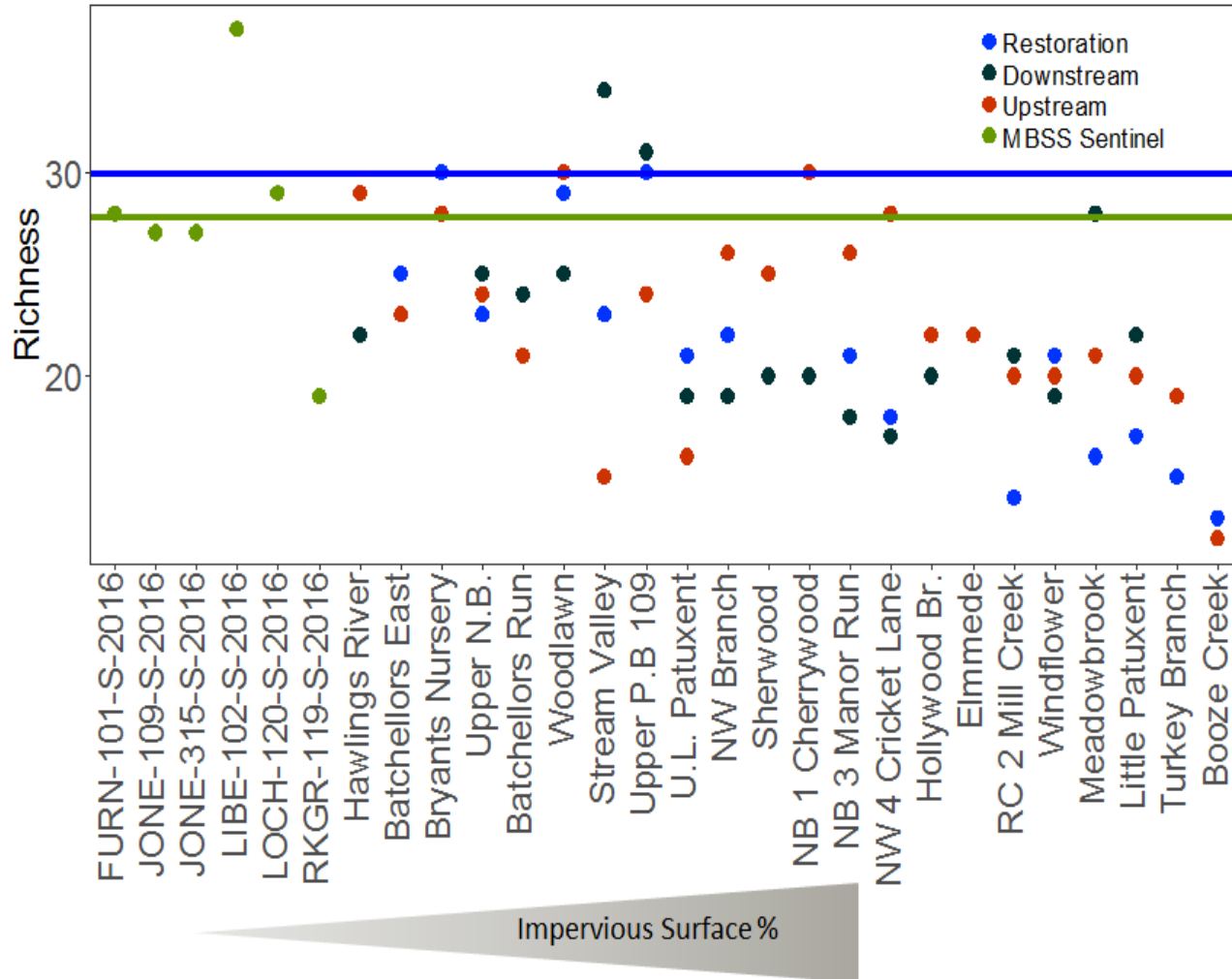
Project	Upstream	Restoration	Downstream	Realized uplift	Restoration Uplift?	Downstream Uplift?
Batchellors East	2.04	2.46	1.79	0.42	✓	×
Bryants Nursery	3.31	3.45	2.49	0.14	✓	×
Turkey Branch	1.58	1.36	1.38	-0.22	×	×
Upper N.B.	2.03	2.27	2.02	0.24	✓	×
Batchellors Run	1.88	2.28	1.75	0.4	✓	×
NW Branch	1.8	1.91	1.67	0.11	✓	×
Sherwood	2.71	1.89	1.58	-0.82	×	×
Hawlings River	3.02	2.92	1.71	-0.1	×	×
Booze Creek	1.24	1.28	1.67	0.04	×	✓
Stream Valley	2.89	3.11	3.72	0.22	✓	✓
Hollywood Br.	2	2.03	1.99	0.03	✓	×
NB 1	1.66	1.34	1.33	-0.32	×	×
NB 3	1.93	1.67	1.38	-0.26	×	×
RC 2	1.33	1.1	1.62	-0.23	×	✓
PB 109	2.23	2.34	2.3	0.11	✓	×
NW 4	1.99	1.9	1.36	-0.09	×	×
Elmmede	1.74	1.96	1.68	0.22	✓	×
Little Patuxent	2.74	1.95	1.92	-0.79	×	×
Meadowbrook	2.02	2.08	2.31	0.06	✓	✓
U.L. Patuxent	1.97	1.55	2.5	-0.42	×	✓
Windflower	2.42	1.73	1.46	-0.69	×	×
Woodlawn	2.51	2.32	2.46	-0.19	×	×

Very Poor

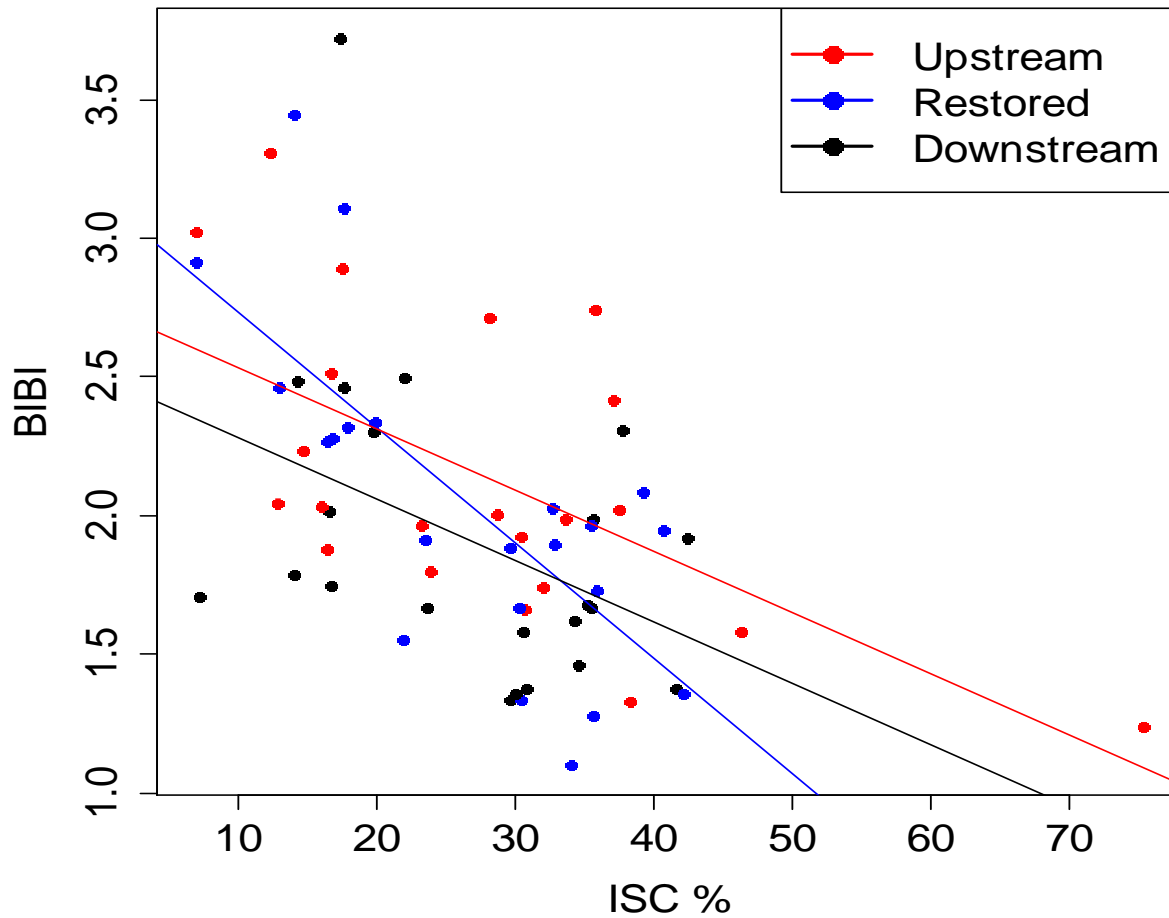
Poor

Fair

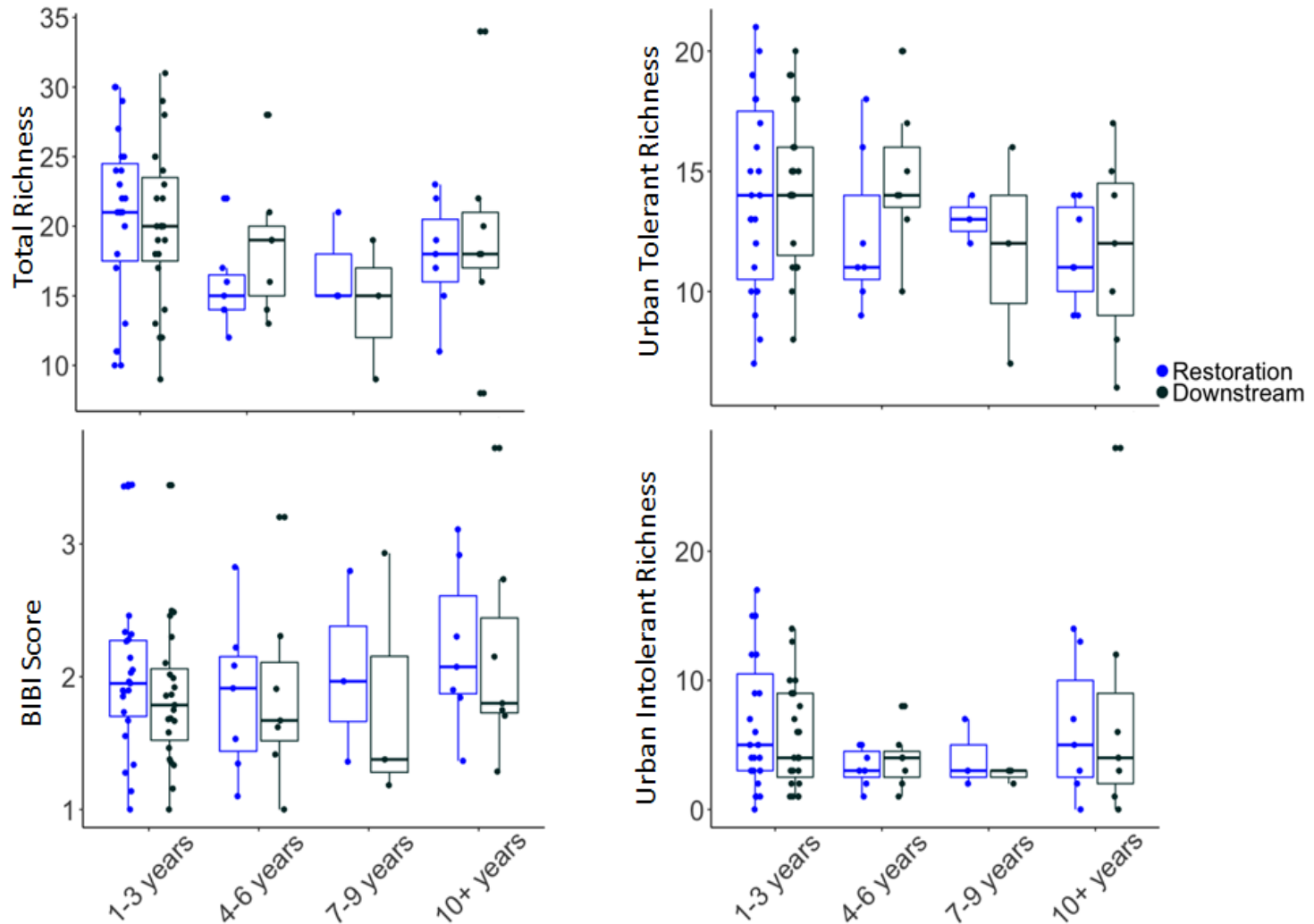
Condition and lack of improvements in Piedmont restorations associated with Impervious Surface Cover (ISC)



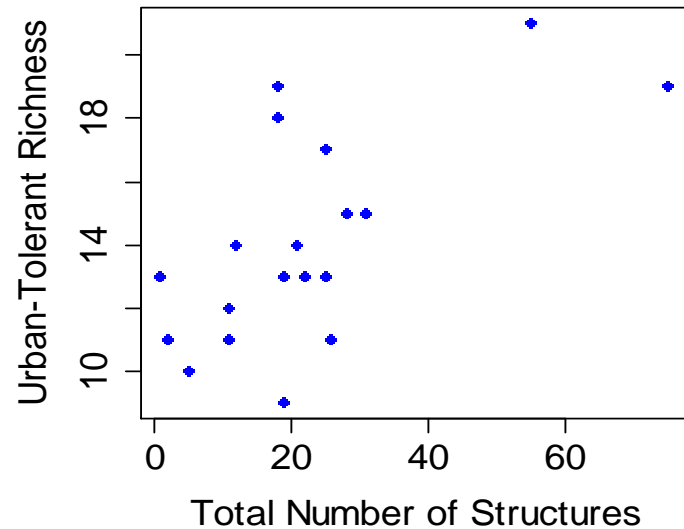
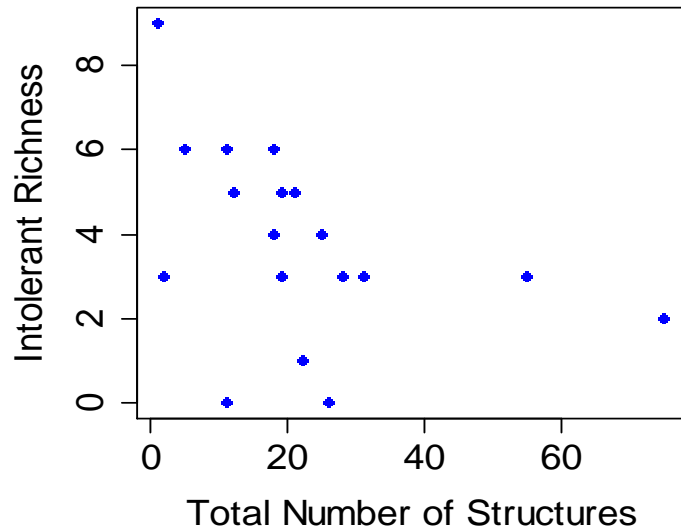
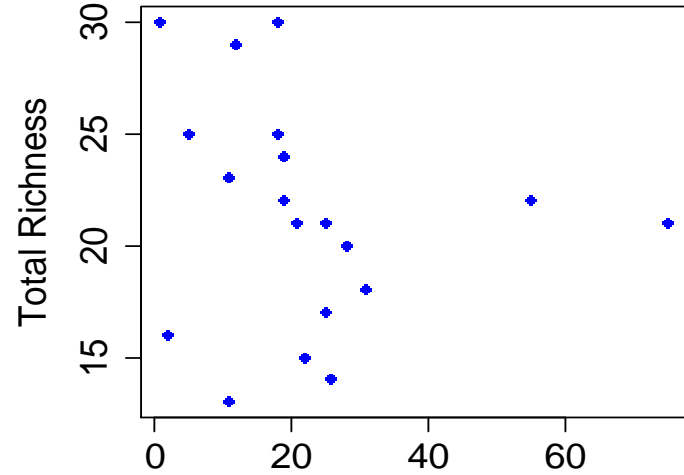
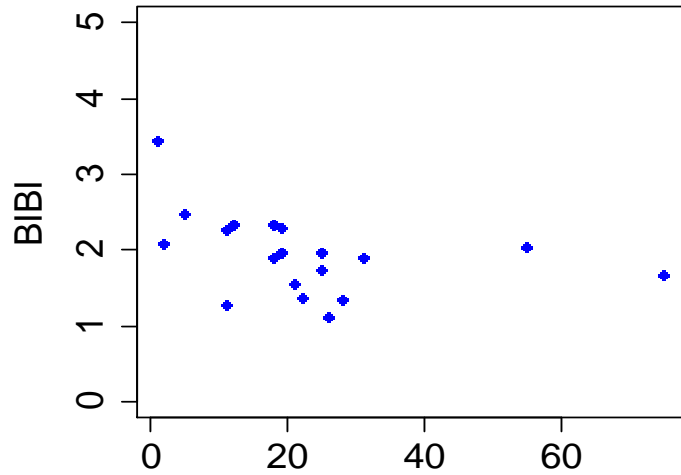
Piedmont restored streams less resilient to increasing ISC



Ecological recovery not improved with time since restoration

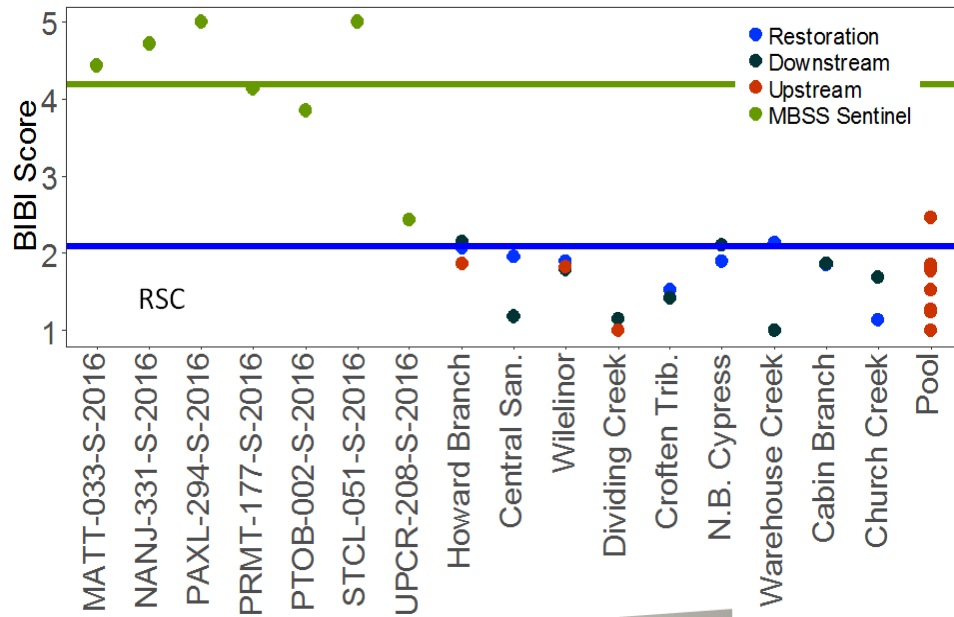


More installed structures associated with declines in ecological health

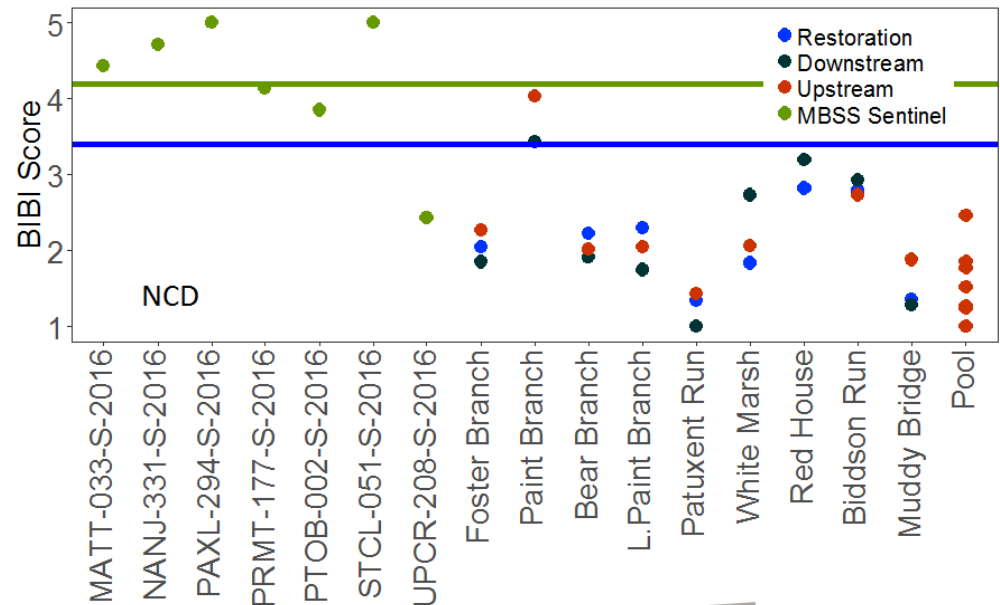


Not much improvement in Coastal Plain restorations

Approach	Project	Upstream	Restoration	Downstream	Realized Uplift	Restoration Uplift?	Downstream Uplift?	
NCD	Bear Branch	2.01	2.22	1.91	0.21	✓	×	
	Biddson Run	2.74	2.8	2.93	0.06	✓	✓	
	Foster Branch	2.27	2.05	1.86	-0.22	×	×	
	L.Paint Branch	2.05	2.3	1.75	0.25	✓	×	
	Muddy Bridge	1.88	1.37	1.29	-0.51	×	×	
	Paint Branch	4.04	3.43	3.44	-0.61	×	×	
	Patuxent Run	1.44	1.35	1	-0.09	×	×	
	Red House	1.58*	2.83	3.2	1.25	✓	✓	
	White Marsh	2.06	1.84	2.73	-0.22	×	✓	
RSC	Cabin Branch	1.58*	1.85	1.87	0.27	✓	✓	Very Poor
	Church Creek	1.58*	1.14	1.69	-0.44	×	✓	Poor
	Central San.	1.58*	1.97	1.18	0.39	✓	×	
	Croften Trib.	1.58*	1.53	1.41	-0.05	×	×	
	Dividing Creek	1	1	1.16	0	×	✓	Fair
	Howard Branch	1.86	2.07	2.15	0.21	✓	✓	
	N.B. Cypress	1.58*	1.9	2.1	0.32	✓	✓	Good
	Warehouse Creek	1.58*	2.14	1	0.56	✓	×	
	Wilelinor	1.82	1.9	1.8	0.08	✓	×	



Lack of improvements
in Coastal Plain
restorations not
associated with ISC



Impervious Surface %

Impervious Surface %

Summary Q1: How much ecological uplift can be achieved by urban stream restorations?

- Very little evidence for uplift.
- Positive responses rare and not easily explained

Summary Q2: What are the influences of Impervious Surfaces, Restoration Length, and Restoration Age?

- ISC has an overwhelming influence in Piedmont streams and probably limits any potential for ecological uplift
- Coastal Plain streams not as influenced by ISC
 - Most are high ISC and so no gradient to examine
- Length of the restoration project negatively associated with ecological uplift
- Time since restoration largely unrelated to ecological uplift

Summary Q3: Are there differences between NCD and RSC approaches?

- Can only compare for Coastal Plain
- NCD approaches generally produced better habitat responses
- RSC approaches had relatively better ecological responses
 - Absolute scores were really low
 - RSC typically in streams with substantially lower unrestored condition

Summary Q4: Do any restoration-specific activities promote ecological uplift?

- Remember that restorations not improved over unrestored.....
- Vanes and J-Hooks beneficial in Coastal Plain
- Step pools beneficial in Piedmont
- Total number of installed structures NOT beneficial in Piedmont nor root wads in Coastal Plain
- Larger, more invasive restorations NOT beneficial to ecological recovery

Translation by Scott Stranko (MD DNR)

-Stream physical habitat improved after restoration (in most cases).

-Benthic macroinvertebrates did not improve at most sites.

- Considerations regarding stream benthic macroinvertebrates:

- Time since restoration (not related to benthics in this study)
- Recolonization potential (not examined)
- More/longer restoration not necessarily better
- Factors that may be difficult to address with stream restoration alone, but that could be limiting (not examined)
- Watershed condition (likely important – especially Piedmont)