If you build it, do they come?

Biological Monitoring Pre- and Post-Restoration

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Study Objectives

- Initiated in 2017, RES funded an internal research project for biological sampling at stream restoration sites
- Goals include:
  - Provide data for the discussion on ecological uplift in stream restoration
  - Determine achievable ecological uplift in stream restoration projects
  - Improve design process to produce better habitat
  - Show clients and the public the charismatic side of stream restoration, the critters!

Flyer

Crane fly larvae

Setting Expectations Based on Context

Mud Minnow

Hellgrammite

- **What are your watershed conditions?**
  - Poor water quality, heavy sediment load, and high water temperatures impacts what can live in your stream
- **What is the existing assemblage?**
  - Pre-restoration sampling is vital to understanding potential and achieved uplift
- **Do aquatic organisms have access to your stream?**
  - Upstream and downstream connectivity is key to recruitment
- **Does the designed restoration improve habitat diversity and quality?**
  - What habitat was lacking pre-restoration?

Determining Ecological Uplift Goals

- Expect at minimum to see return of the pre-restoration assemblage – this may take time
- Determine if additional recruitment is possible based on site conditions
- Look beyond Indices of Biological Integrity (IBIs) for success criteria
  - Habitat requirements
  - Spawning substrate needs
  - Functional feeding groups

Pirate Perch

Shorthead Redhorse

Little Westham Creek
Proctors Creek
Pikes Branch

Project Examples

Little Westham Creek, University of Richmond - TMDL

Pre-construction

- 3 mi^2 suburban watershed, 13% impervious
- Reach begins downstream of a large dam
- Limited habitat diversity, no floodplain access

Post-construction

- Smaller baseflow channel
- Frequent floodplain access
- Increased riffle habitat
- Native vegetation

Little Westham Creek - Fish

Little Westham Creek Fish Species Caught By Year - Restorations Reach

Species		2017- Pre-construction	2019	2020	2021
Bluegill	*Lepomis macrochirus*	60	9	29	11
Largemouth Bass	*Micropterus salmoides*	4	5	7	15
Eastern Mosquitofish	*Gambusia holbrooki*		5	2	1
Green Sunfish	*Lepomis cyanellus*	1		4	11
Tessellated Darter	*Etheostoma olmstedi*	3		1	4
Pumpkinseed	*Lepomis gibbosus*	2		4	
Pirate Perch	*Aphredoderus sayanus*	3			1
Yellow Bullhead	*Ameiurus natalis*	5			1
Warmouth	*Lepomis gulosus*				
American Eel	*Anguilla rostrata*	1			
Central Stoneroller	*Campostoma anomalum*		1	1	8
Spotfin Shiner	*Cyprinella spiloptera*		75	4	2
Bluntnose Minnow	*Pimephales notatus*		110	4	
Creek Chub	*Semotilus atromaculatus*				3
Channel Catfish	*Ictalurus punctatus*			2	
Gizzard Shad	*Dorosoma cepedianum*			1	
Redbreast Sunfish	*Lepomis auritus*			1	
Total species captured					
		8	*6*	12	10
Total individuals captured					
		79	205	60	57

Spotfin Shiner

Bluntnose Minnow

Little Westham Creek – Benthic Macroinvertebrates

Order	Family	Common Name	Tolerance Value	Habitat Preference	Functional Feeding Group	Pre-Restoration 2019 Count	Year 1 2020 Count	Year 2 2021 Count
Amphipoda	Gammaridae	Scuds	6	Sw	Collector	20	43	46
Annelida-Hirudinea-unknown	Unknown	Leech	NA	NA	NA	1	3	
Annelida-Oligochaeta-unknown	Unknown	Aquatic worm	NA	Bu	Collector	3	3	
Coleoptera	Elmidae	Riffle beetle	4	Cn	Scraper		5	6
Diptera	Chironomidae	Non-biting midge	5	Sp, Bu, Cb	Collector	4	2	13
Diptera	Simuliidae	Black fly	6	Cn	Filterer	1		
Diptera	Tipulidae	Cranefly	3	Bu	Shredder	1	4	2
Ephemeroptera	Baetidae	Small minnow mayfly	4	Sw	Collector	23	9	2
Odonata-Anisoptera	Aeshnidae	Darner Dragonfly	3	Cb	Predator			2
Odonata-Anisoptera	Libellulidae	Skimmer Dragonfly	9	Sp	Predator			2
Odonata-Zygoptera	Calopterygidae	Broadwinged damselfly	5	Cb	Predator		2	2
Odonata-Zygoptera	Coenagrionidae	Narrowwinged damselfly	9	Cb	Predator	1	3	17
Pelecypoda	Corbiculidae	Asian Clam	8	Sp	Filterer		1	
Trichoptera	Hydropsychidae	Common net-spinning caddisfly	6	Cn	Filterer	59	24	23
Trichoptera	Philopotamidae	Fingernet caddisfly	3	Cn	Collector	2		
Tricladida	Unknown	Flatworm	8	NA	Collector	5	11	

Habitat abbreviations: bu=burrower, cb=climber, cn=clinger, sp= sprawler, dv=diver, sk=skater, sw= swimmer

*HBI is Hilsenhoff Biotic Index-uses tolerance levels to weight abundance in an estimate of overall pollution. HBI increases in response to increased pertubation.

Identifies metrics that are expected to decrease in response to increased pertubation

Identifies metrics that are expected to increase in response to increased pertubation

The Virginia Stream Condition Index (VSCI)				Difference
# Taxa	11	12	10	+ , -
# EPT Taxa	3	2	2	- , =
# intolerant of urban stress (TV = 0-3)	2	1	2	- , +
% Ephemeroptera	19	8	2	- , -
%Plecopter+Trichoptera-Hydropsychidae	2	0	0	- , =
% Scraper Taxa	0	5	5	+ , =
% Chironomidae	3	2	11	- , +
%Top 2 Dominant	68	71	60	+ , -
HBI	5.6	5.7	6.3	+ , +
VSCI Score	39.43	36.15	34.18	- , -

Proctors Creek, Chesterfield VA - TMDL

Pre-Restoration

- 6.2 mi^2 suburban watershed, 14% impervious
- Highly acidic soils in reach, limiting bank vegetation
- Lack of habitat diversity and complexity

Post-Restoration

- Buried acidic soils under vegetated floodplain bench
- More diverse riffle and pool habitat with wood toe treatment

Proctors Creek - Fish

Proctors Fish Species Caught By Year

Species		Restoration Reach 2018 - Pre-construction	Reference Reach 2018	Restoration Reach 2021- Post-construction	Reference Reach 2021	Restoration Reach 2022 - Year 1	Reference Reach 2022
Chain Pickerel	*Esox niger*	1		1			
Largemouth Bass	*Micropterus salmoides*	3		2		2	2
American Eel	*Anguilla rostrata*	3	5	8	16	2	17
Mud Minnow	*Umbra pygmaea*			4		1	3
Pirate Perch	*Aphredoderus sayanus*	2	1	5	1	1	1
Yellow Bulllhead	*Ameiurus natalis*		1	1	2	6	6
Bluehead Chub	*Nocomis leptocephalus*			8	3	2	18
Creek Chub	*Semotilus atromaculatus*		1	2	4	1	25
Shorthead Redhorse	*Moxostoma erythrurum*			1			
Creek Chubsucker	*Erimyzon oblongus*					5	1
Tessellated Darter	*Etheostoma olmstedi*					1	
Redbreast Sunfish	*Lepomis auritus*		16	2	12	9	26
Green Sunfish	*Lepomis cyanellus*				3		1
Bluegill	*Lepomis macrochirus*		4	2	4	2	
Easetern Mosquitofish	*Gambusia holbrooki*			1			5
Total Species Captured							
		4	6	12	8	11	11
Total Individuals Captured							
		9	28	37	45	32	105

Bluehead Chub

Bluehead Chub Nest

Proctors Creek – Benthic Macroinvertebrates

Order	Family	Common Name	Habitat Preference	Functional Feeding Group	Year 1 (2021)		Year 2 (2022)	
					Reference	Reach 3	Reference	Reach 3
Amphipoda	*Gammaridae*	Scuds	Sw	Collector			5	
Ephemeroptera	*Baetidae*	Small minnow mayfly	Sw	Collector			14	8
Ephemeroptera	*Heptageniidae* [C]	Flatheaded mayfly	Cn	Scraper	5	7	7	10
Odonata - Zygoptera	*Calopterygidae*	Broad-winged damslefly	Cb	Predator			3	
Odonata - Zygoptera	*Coenagrionidae*	Narrow-winged damslefly	Cb	Predator		11	7	3
Odonata - Anisoptera	*Aeshnidae*	Darner dragonfly	Cb	Predator	3		2	2
Odonata - Anisoptera	*Libellulidae*	Skimmer dragonfly	Sp	Predator				1
Trichoptera	*Glossosomatidae* [C]	Saddle case-maker caddisfly	Cn	Scraper			1	
Trichoptera	*Hydropsychidae*	Common net-spinning caddisfly	Cn	Filterer	50	20	7	5
Trichoptera	*Philopotamidae* [C]	Fingernet caddisfly	Cn	Collector	6	6	8	7
Trichoptera	*Phryganeidae*	Giant case-maker caddisfly	Cb	Shredder	2			
Trichoptera	*Uenoidae* [C]	Uenoid case-maker caddisfly	Cn	Scraper			1	2
Coleoptera	*Elmidae* [C]	Riffle beetle larva	Cn	Scraper	20	10	17	28
Coleoptera	*Psephenidae* [C]	Water-penny	Cn	Scraper	3	2	11	8
Diptera	*Chironomidae*	Non-biting midge	Sp, Bu, Cb	Collector	14	37	16	34
Diptera	*Empididae*	Dance fly larva	Sp	Predator	1			1
Diptera	*Simuliidae*	Blackfly larva	Cn	Filterer	14	19	13	7
Diptera	*Tipulidae*	Cranefly larva	Bu	Shredder	1			

*HBI is Hilsenhoff Biotic Index-uses tolerance levels to weight abundance in an estimate of overall pollution. HBI increases in response to increased pertubation.

[C] denotes *Clinger* habitat species

Habitat abbreviations: bu=burrower, cb=climber, cn=clinger, sp= sprawler, dv=diver, sk=skater, sw= swimmer

Identifies metrics that are expected to decrease in response to increased pertubation

Identifies metrics that are expected to increase in response to increased pertubation

The Coastal Plain Macroinvertebrate Index (CPMI)					Difference
Total Taxa (Diversity)	12	9	14	13	+
EPT Taxa	5	4	6	5	+
% Ephemeroptera	4	6	9	9	+
HBI	5.2	5.7	4.9	4.9	-
% Clingers	28	21	40	47	+
Score (Total Possible Score = 30)	20	14	22	22	+
Assessment Rating	Good	Stress	Good	Good	+

Pikes Branch, Fairfax VA - TMDL

Pre-construction

- 6.2 mi^2 suburban watershed, 35% impervious
- Reach initiates at outfall, ends at culvert with a fish blockage
- Limited habitat diversity and complexity
- 25+ stormwater outfalls onsite

Post-construction

- Floodplain valley restored
- Frequent floodplain access
- Increased instream habitat diversity and complexity
- Wetlands, vernal pools, pollinator habitat

Pikes Branch - Fish

Pikes Branch Fish Species Caught By Year

Species		2017- Pre-construction	2020 - Post Construction	2021 - Year 1
Blacknose Dace	*Rhinichthys atratulus*	313	521	487
Total species captured				
		1	1	1
Total individuals captured				
		313	521	487

Blacknose Dace

Pikes Branch – Benthic Macroinvertebrates

Order	Family	Common Name	Tolerance Value	Habitat Preference	Functional Feeding Group	Pre-Restoration 2017 Count	Year 1 2020 Count	Year 2 2021 Count
Diptera	*Antocha*	Cranefly	3	Bu	Shredder	1	4	2
Diptera	*Chironomidae*	Non-biting midge	5	Sp, Bu, Cb	Collector	10	17	12
Diptera	*Simuliidae*	Black fly larva	6	Cn	Filterer	12	5	2
Diptera	*Empididae*	Dance fly larvae	6	Sp	Predator	2		
Ephemeroptera	*Baetidae*	Small minnow mayfly	4	Sw, Cn	Collector	1	2	21
Gastropoda	*Physidae*	Freshwater snail	8	NA	Scraper	5		
Odonata-Zygoptera	*Coenagrionidae*	Narrowwinged damselfly	9	Cb	Predator	3	3	7
Trichoptera	*Hydropsychidae*	Common net-spinning caddisfly	6	Cn	Filterer	22	52	49
Trichoptera	*Philopotamidae*	Fingernet caddisfly	3	Cn	Collector	54	27	21

	The Virginia Stream Condition Index (VSCI)			Difference
Habitat abbreviations: bu=burrower, cb=climber, cn=clinger, sp= sprawler, dv=diver, sk=skater, sw= swimmer	**# Taxa**	9	7	7	- , =
	# EPT Taxa	3	3	3	= , =
*HBI is Hilsenhoff Biotic Index-uses tolerance levels to weight abundance in an estimate of overall pollution. HBI increases in response to increased pertubation.	**# intolerant of urban stress (TV = 0-3)**	2	2	2	= , =
	% Ephemeroptera	1	2	18	+ , +
Identifies metrics that are expected to decrease in response to increased pertubation	**%Plecopter+Trichoptera-Hydropsychidae**	49	26	18	- , -
	% Scraper Taxa	5	0	0	- , =
Identifies metrics that are expected to increase in response to increased pertubation	**% Chironomidae**	9	16	11	+ , -
	%Top 2 Dominant	68	75	61	+ , -
	HBI	4.5	5.2	5.2	+ , =
	VSCI Score (Total Possible Score = 100)	49	40	45	- , +

Pikes Branch – Floodplain

- **Limited biological uplift <u>in the channel</u> in the near term**
- **BUT look outside of channel!**
  - Wetland Habitat for amphibians
  - Floodplain forest instead of upland forest with invasives
  - Pollinator habitat throughout floodplain
- **Stream Restoration is really valley restoration**
  - We need to value floodplains, wetlands, pools and early successional habitat as much as we do the streams
- **Future Removal of Fish Blockage** should allow fish movement from downstream

Conclusions

- Every site has different potential for uplift, dependent on context
- Repopulation post-construction can happen quickly if there is a robust upstream and downstream community
- Some species require several years to repopulate a site
- Uplift considerations should include both stream and valley
- Value of biological monitoring – benefit much greater than cost

Questions

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