ASSESSMENT OF BENTHIC MACROINVERTEBRATE COMMUNITIES IN RELATION TO REGULATED FLOWS IN THE DEERFIELD RIVER, MASSACHUSETTS

Michael B. Cole

ABR, Inc.—Environmental Research & Services

Greenfield, MA

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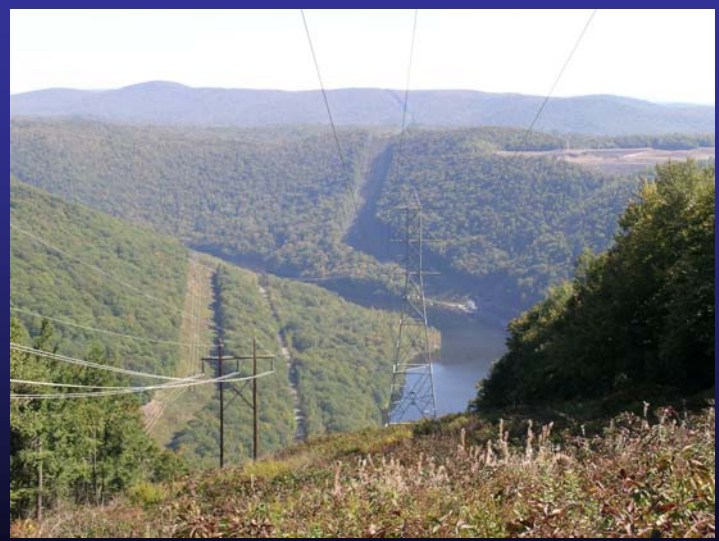
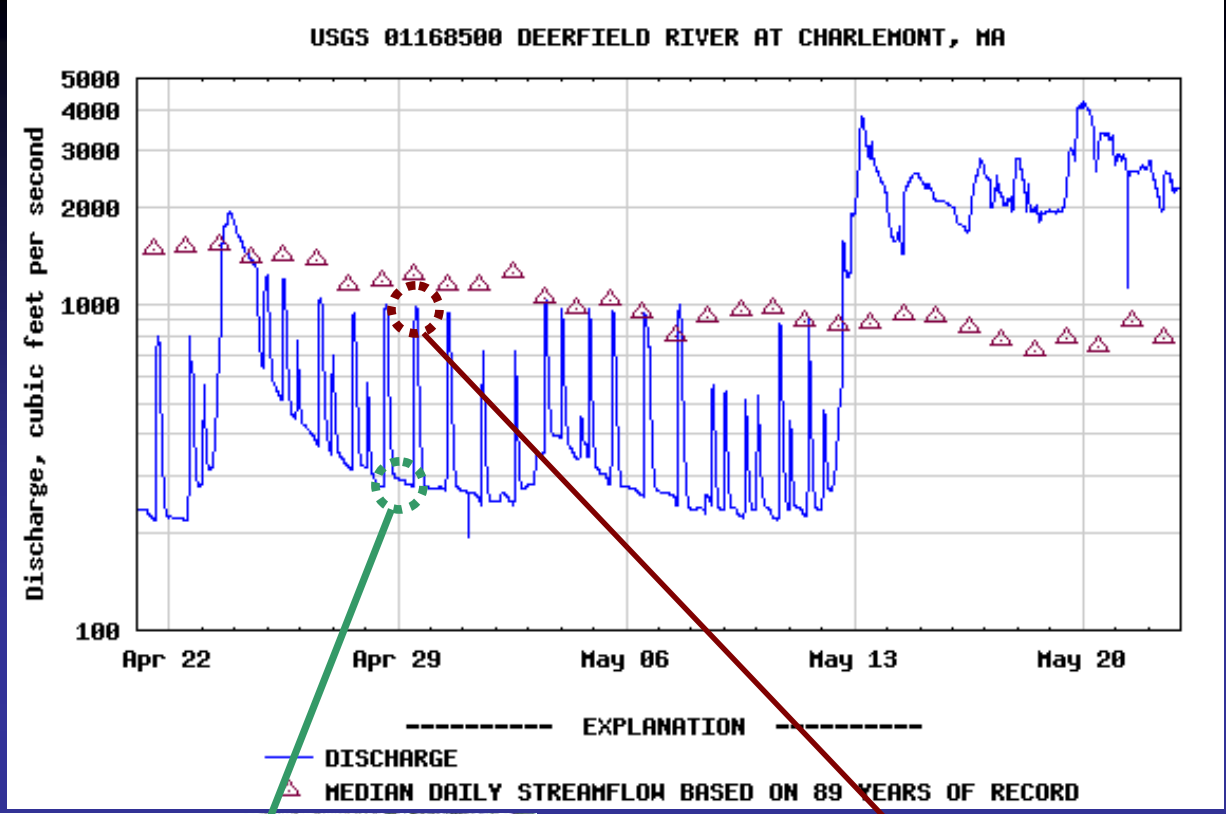
THE DEERFIELD RIVER

- Watershed drains 665 square miles in VT and MA
- Supports multiple and diverse uses: rafting, boating, fishing, swimming, power production, and flood control
- One of the cleanest and least disturbed watersheds in MA
- Supports nine dams used for hydropower generation

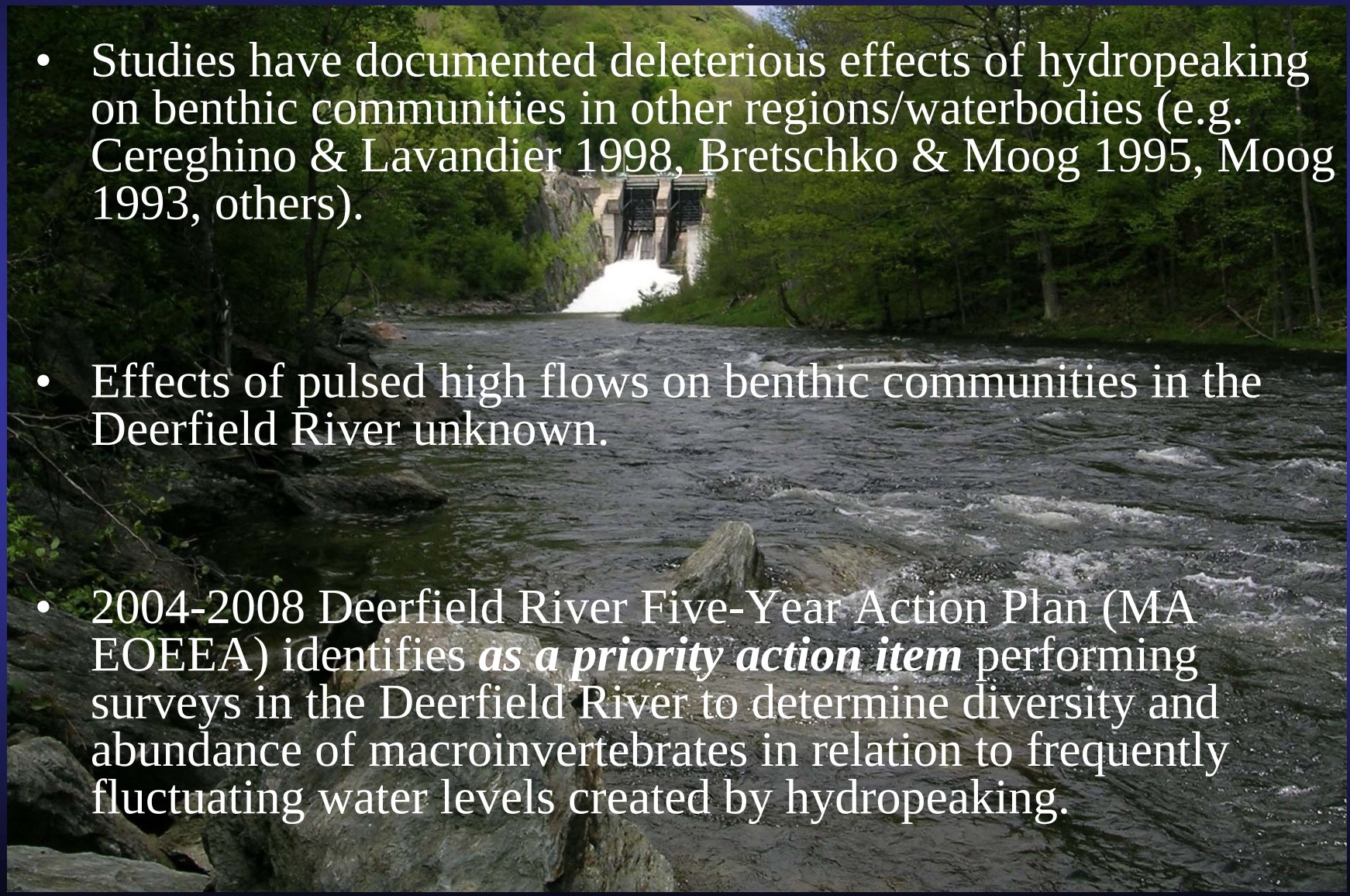


DEERFIELD HYDROELECTRIC SYSTEM

- Historically, extreme low flows had significant effects on aquatic communities (e.g. Bain studies on fish and habitat)
- 1997 FERC hydro relicensing settlement agreement established minimum flows in 12 miles of previously bypassed river
- Agreement guarantees minimum flows, but does not consider potential effects of regular pulses of high flows used to generate power and support boating recreation.
- Current operations result in flows that can vary as much as tenfold on a daily basis.


USGS 01168500 DEERFIELD RIVER AT CHARLEMONT, MA
Discharge, cubic feet per second
5000
4000
3000
2000
1000
100
Apr 22
Apr 29
May 06
May 13
May 20
---------- EXPLANATION ----------
DISCHARGE
MEDIAN DAILY STREAMFLOW BASED ON 89 YEARS OF RECORD

WHAT'S THE ISSUE?



- Studies have documented deleterious effects of hydropeaking on benthic communities in other regions/waterbodies (e.g. Cereghino & Lavandier 1998, Bretschko & Moog 1995, Moog 1993, others).

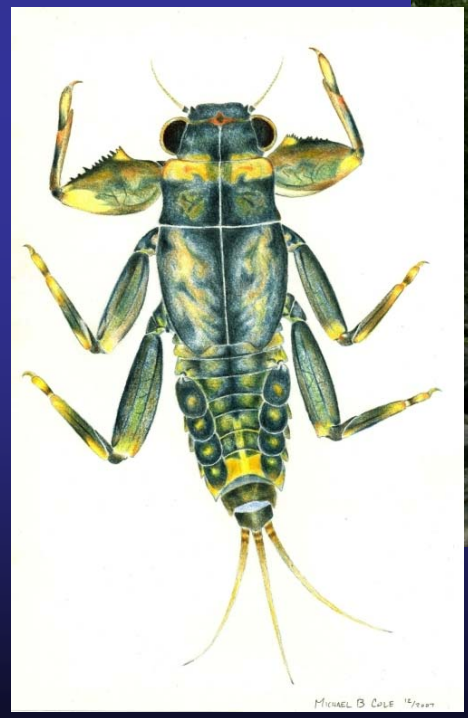
- Effects of pulsed high flows on benthic communities in the Deerfield River unknown.

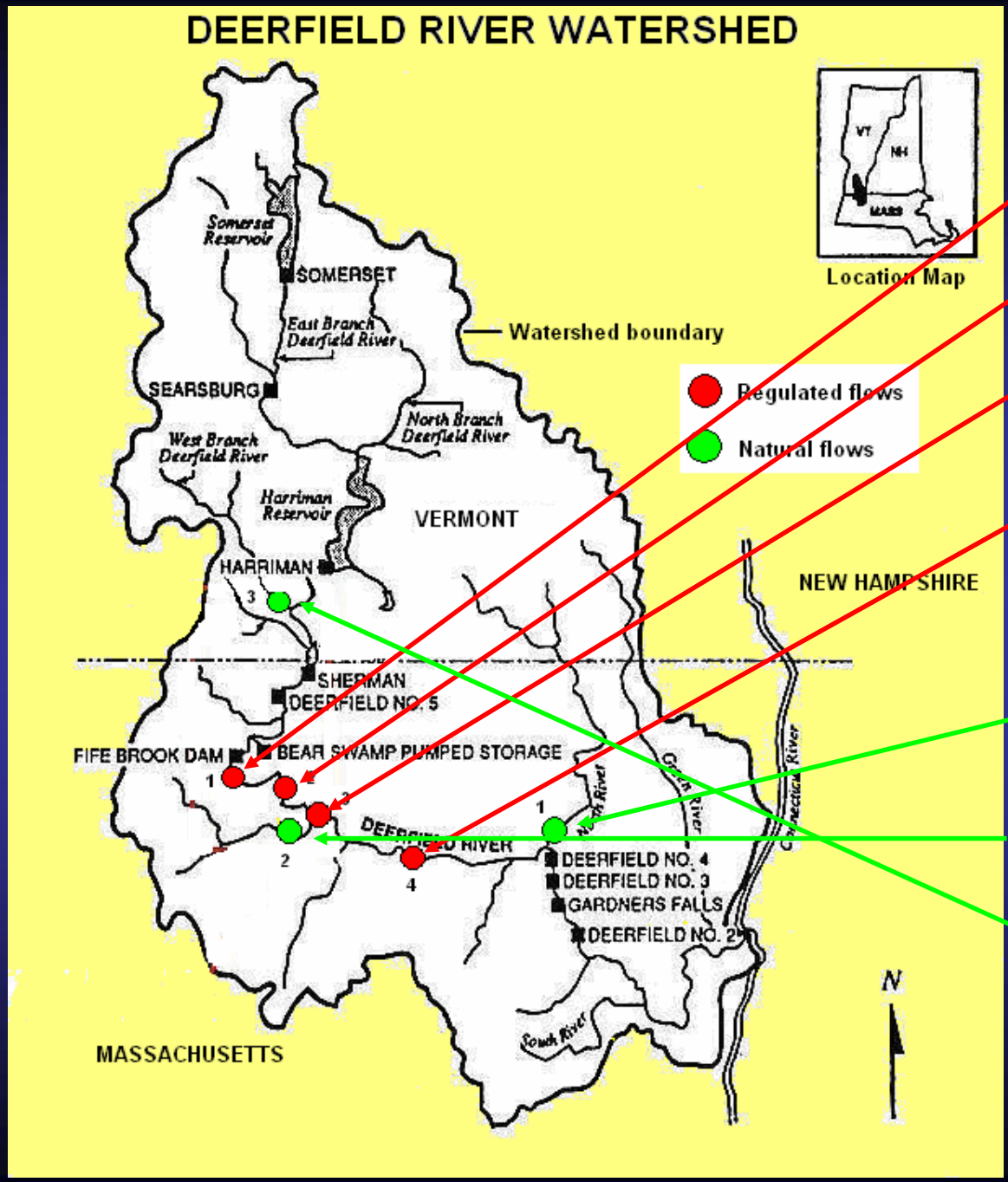
- 2004-2008 Deerfield River Five-Year Action Plan (MA EOEEA) identifies ***as a priority action item*** performing surveys in the Deerfield River to determine diversity and abundance of macroinvertebrates in relation to frequently fluctuating water levels created by hydropeaking.

OBJECTIVES

- Determine whether macroinvertebrate communities differ between flow-regulated and unregulated reaches with respect to:

- Abundance
- Taxonomic Richness
- Functional Composition
- Taxonomic Composition





REGULATED FLOW REACHES

1. Deerfield River below Fife Brook Dam (RM 37)
2. Deerfield River abv Bridge to Nowhere (RM 34.5)
3. Deerfield River abv Cold R confl (RM 30)
4. Deerfield River below Charlemont (RM 25)

NATURAL FLOW REACHES

1. North River (confluence @ RM 19.5)
2. Cold River (confluence @ RM 30)
3. West Br Deerfield River (confluence @ RM~50)

SAMPLING DESIGN

Samples – collected in triplicate from each reach in each of two seasons:

Reach	Number of benthic samples collected during 2006 Season		
	Summer 2006 (July)	Fall 2006 (Sept)	Total
Regulated – Hydropeaking			
1 Deerfield River below Fife Brook Dam (RM 37)	**3**	**3**	**6**
2 Deerfield River above Bridge to Nowhere (RM 34.5)	**3**	**3**	**6**
3 Deerfield River above Cold River confluence (RM 30)	**3**	**3**	**6**
4 Deerfield River below Charlemont (RM 25)	**3**	**3**	**6**
Reference – No Hydropeaking			
1 North River (confluence at RM 19.5)	**3**	**3**	**6**
2 Cold River (confluence at RM 30)	**3**	**3**	**6**
3 West Branch Deerfield River	**3**	**3**	**6**
Total	**21**	**21**	**42**

FIELD METHODS – MACROINVERTEBRATE SAMPLING

- 10-kick composite samples collected using MA DEP protocols (3 replicates per reach)
- Rectangular-frame kick net
- Used sampling frame to standardize area sampled to .22 m^2
- Samples preserved in ethanol in field for later sorting and identification
- Microhabitat assessment at each sample location (water depth, velocity, substrate composition)

REACH HABITAT ASSESSMENTS

- Wolman Pebble Counts
- Bankfull Channel Width
- Water Temperature Monitoring: deployment of temperature loggers in late July – retrieved in late September

SAMPLE PROCESSING

- 300-organism subsample
- Taxonomy to lowest practical level (genus or species for most insects)

Variable	Non-Flow-Regulated Reaches			Flow-Regulated Deerfield River			
	North R	Cold R	West B	Charl-emont	Abv Cold	Abv Br NoWh	Below Fife
Bankfull Width	32	23	18	69	46	49	43
Substrate:							
D50 (mm)	180	256	512	180	256	180	256
Percent Fines	3.4	0.9	0	2.7	0.8	0.8	0.9
Aug. Water Temp:							
Avg Daily Max	22.2	21.0	19.7		21.0		**18.8**
Avg Daily Min	18.4	16.3	16.9		17.1		18.2
Avg Daily Mean	20.3	18.2	18.3		18.7		18.5
Avg Max-Min	3.8	4.7	2.8		3.9		**0.7**
Sept. Water Temp:							
Avg Daily Max	17.3	15.7	15.3		18.5		17.5
Avg Daily Min	14.6	12.6	13.2		15.3		**16.9**
Avg Daily Mean	15.9	13.9	14.3		16.7		17.1
Avg Max-Min	2.7	3.2	2.2		3.2		**0.7**
Hydropeaking	N	N	N	Y	Y	Y	Y

Substrate conditions similar among reaches

Avg Daily Max Temp in August – lowest in below-Fife reach

Avg Max-Min Diff lowest in below-Fife Reach

Sept Daily Max Temps similar, but Daily Min warmer below Fife Brook Dam

Avg Max-Min Diff again lowest in below-Fife Reach

Temperature data suggest a different thermal regime in the reach below Fife Brook Dam than in other reaches

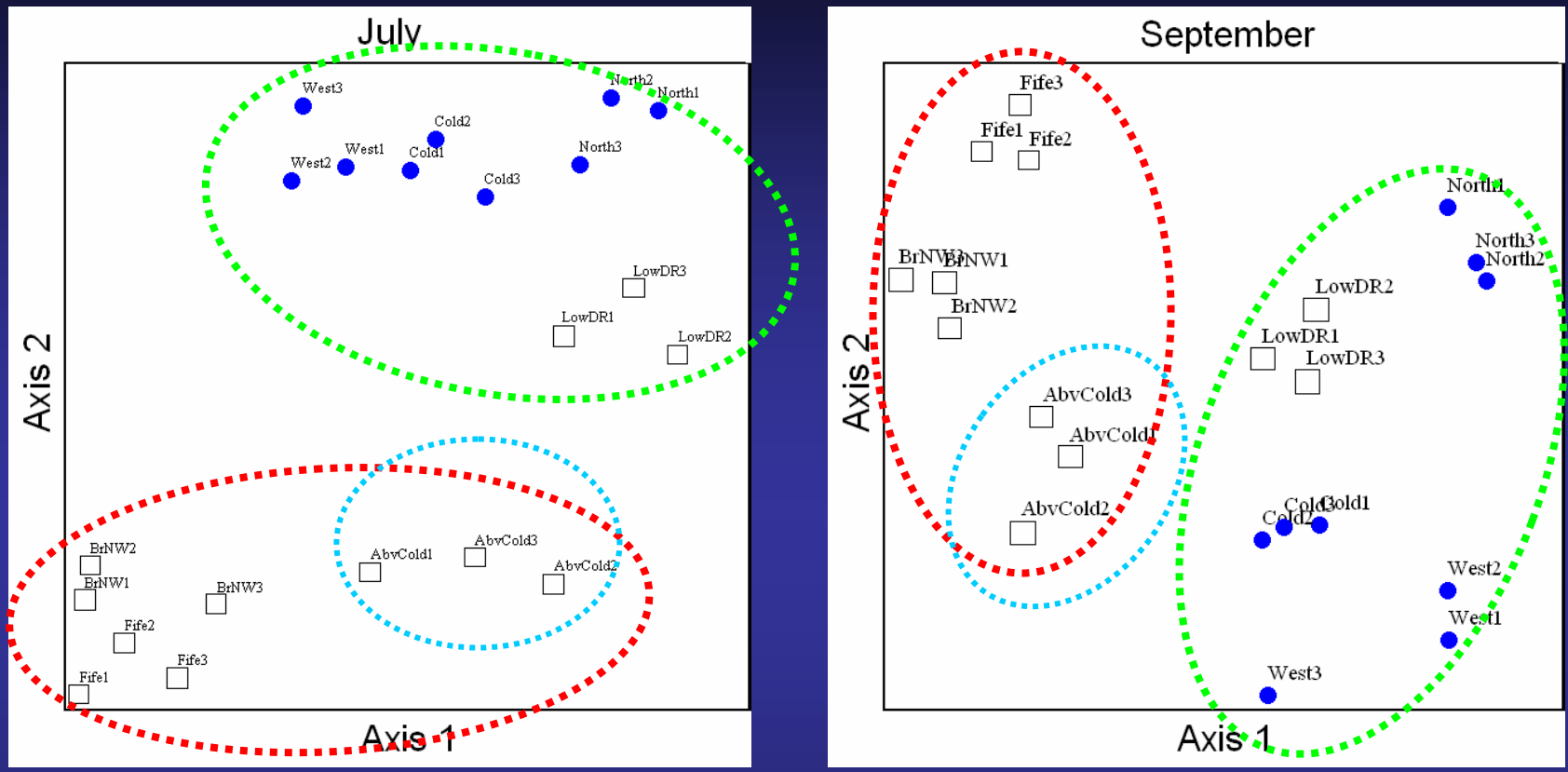
MICROHABITAT CONDITIONS

Site	July Sampling				September Sampling			
	Avg Veloc (mps)	SD	Avg Depth (cm)	SD	Avg Veloc (mps)	SD	Avg Depth (cm)	SD
North River	0.39	0.14	20.4	3.3	0.38	0.15	20.9	4.4
Cold River	0.43	0.12	24.7	3.7	0.38	0.14	18.7	3.7
West Branch	0.32	0.18	23.1	7.3	0.34	0.10	20.9	4.2
DR Charlemont	0.47	0.13	24.6	4.7	0.41	0.10	23.1	3.3
DR abv Cold	0.45	0.14	26.2	6.5	0.43	0.11	26.3	4.5
DR abv Br to NoWh	0.49	0.12	27.3	3.3	0.49	0.12	22.5	2.7
DR below Fife	0.48	0.10	29.2	5.3	0.42	0.12	21.9	3.9

Water velocity and depth of sampled locations were similar among all reaches – sample locations were selected to minimize the influence of microhabitat variation on benthic communities

MACROINVERTERBRATE COMMUNITIES

Similarity in composition as determined by NMS



- Reaches fell into two distinct groups: mainstem reaches in closer proximity to Fife Brook dam and lowermost flow-regulated reach grouping with the unregulated tributary reaches

- The abovc-Cold-River Deerfield River reach – intermediate compositional characteristics - suggesting that a gradient in macroinvertebrate community conditions occurs in the mainstem, with reaches in closer proximity to hydro-operations more dissimilar to unregulated tributaries than are more distant reaches

JULY TAXONOMIC COMPOSITION & ABUNDANCE

	NO ORGANISMS PER SQ M						
	Non-flow-regulated Tributaries			Flow-regulated Deerfield River Reaches			
Taxonomic Group	North R	West Br	Cold R	Charlemont	abv Cold River	Abv Br to Nowh	below Fife
			JULY				
Oligochaeta	92	20	106	409	726	171	82
Chironomidae	661	3024	2246	2026	2913	3042	1767
Other Diptera	165	46	120	93	50	93	27
Freshwater Clams	**0**	**0**	**0**	**0**	**79**	**149**	**483**
Coleoptera	140	52	57	79	274	207	22
Ephemeroptera	**1707**	**992**	**1434**	**1615**	**640**	**163**	**66**
Plecoptera	58	212	127	52	50	37	106
Trichoptera	370	211	461	996	205	664	745
Other Taxa	159	42	149	110	356	196	125

- Filter-feeding freshwater clams increased in abundance with closer proximity to Fife Brook Dam
- Mayflies decreased in abundance with closer proximity

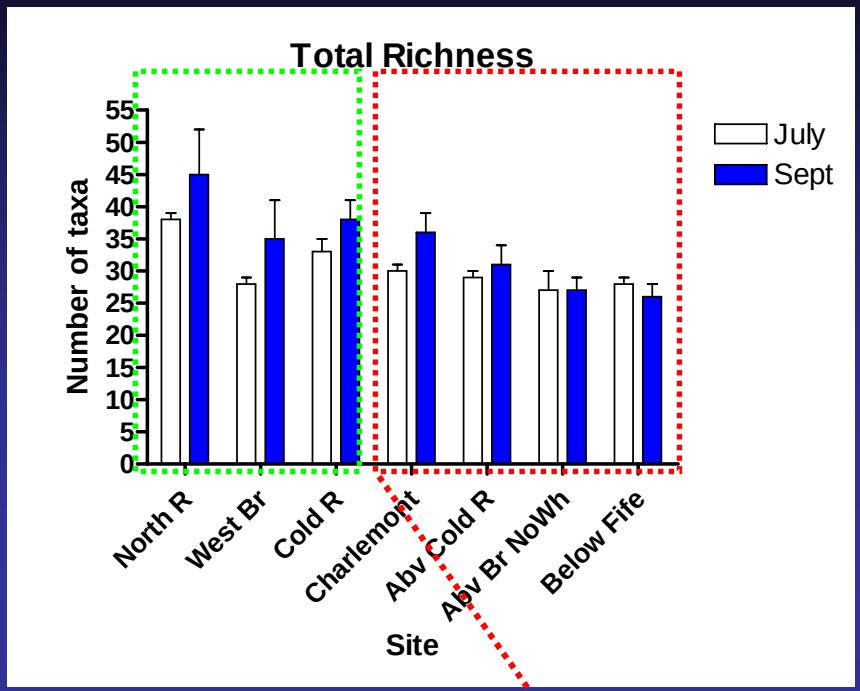
SEPTEMBER TAXONOMIC COMPOSITION & ABUNDANCE

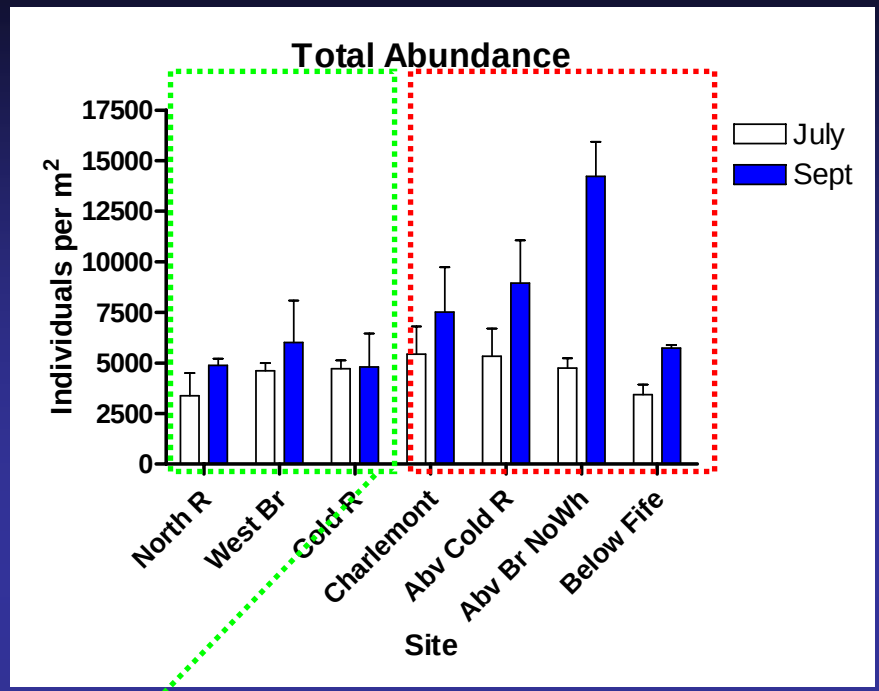
	NO ORGANISMS PER SQ M						
	Non-flow-regulated Tributaries			Flow-regulated Deerfield River Reaches			
Taxonomic Group	North R	West Br	Cold R	Charlemont	abv Cold River	Abv Br to Nowh	below Fife
			SEPTEMBER				
Oligochaeta	136	86	268	1153	1144	519	49
Chironomidae	537	3078	1354	3140	5624	9893	1527
Other Diptera	201	43	76	76	43	191	49
Freshwater Clams	0	0	0	**0**	**41**	**509**	**1937**
Coleoptera	174	78	44	94	203	93	25
Ephemeroptera	1028	1704	1603	**979**	**880**	**447**	**282**
Plecoptera	84	555	284	**117**	**89**	**<10**	**24**
Trichoptera	2496	417	1048	1741	664	1852	1695
Other Taxa	198	58	125	175	221	624	135

Spatial patterns similar to July:

- Filter-feeding freshwater clams increased in abundance with closer proximity to Fife Brook Dam
- Mayflies decreased in abundance with closer proximity
- Stoneflies also decrease in abundance

COMMUNITY ATTRIBUTES



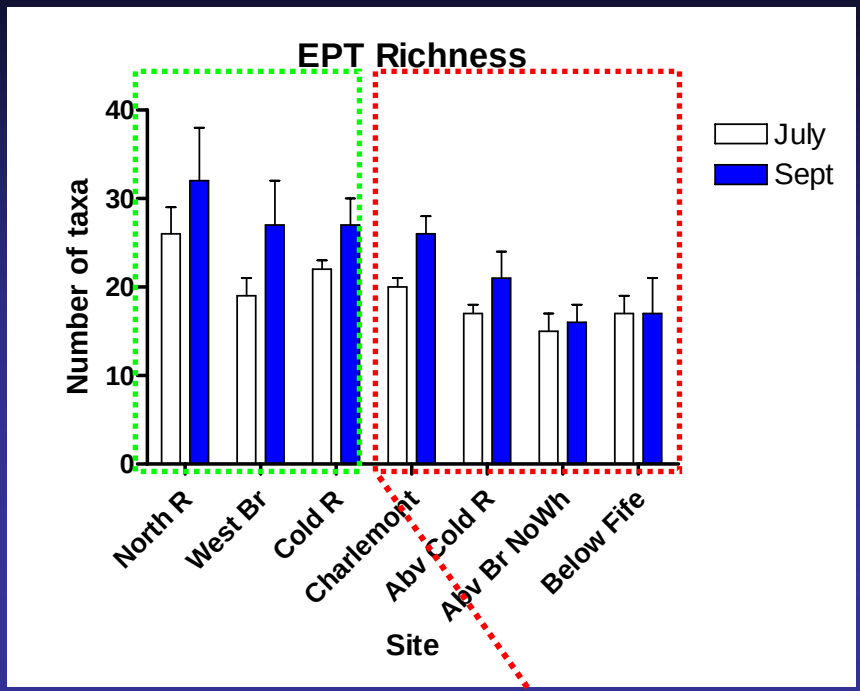


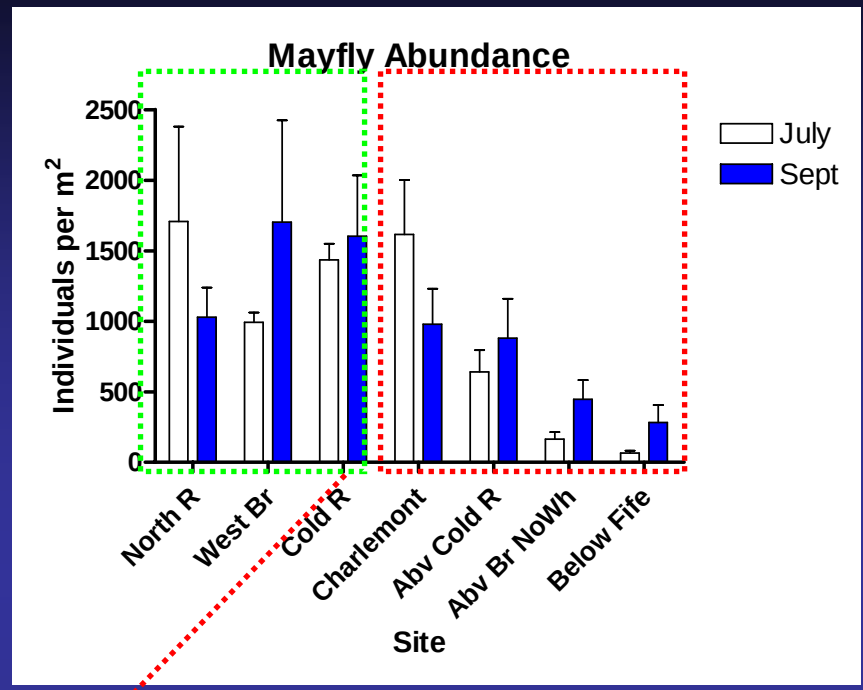
	p-values		
Attribute	Treatment Effect	Sampling Period Effect	Interaction
Total Richness	**0.011**	0.109	0.303
Total Abundance	0.085	**0.040**	0.169

Two-way ANOVA results suggest that unregulated reaches support a larger number of taxa

Total abundance not significantly different between reach types – wide variation among regulated reaches

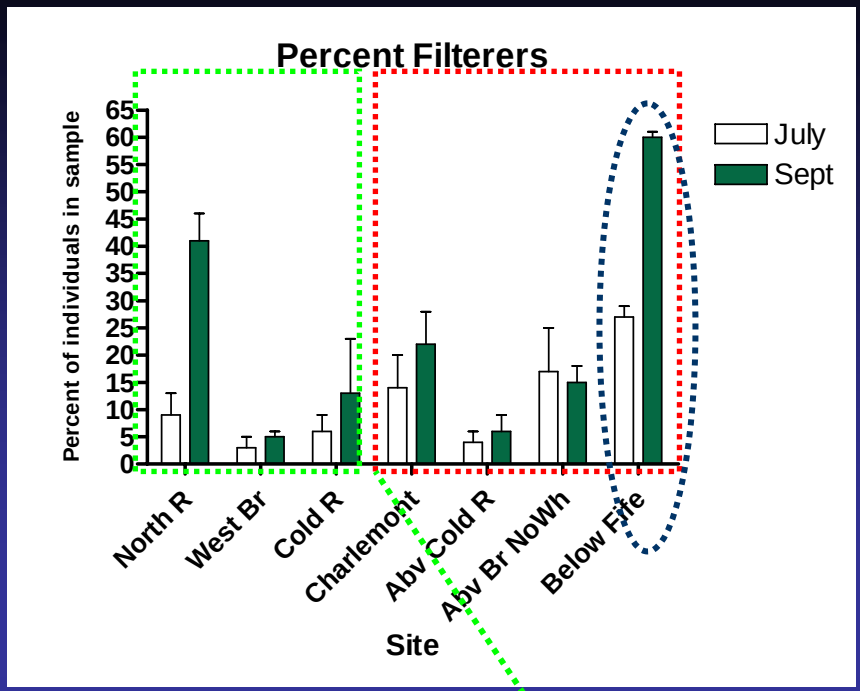
COMMUNITY ATTRIBUTES

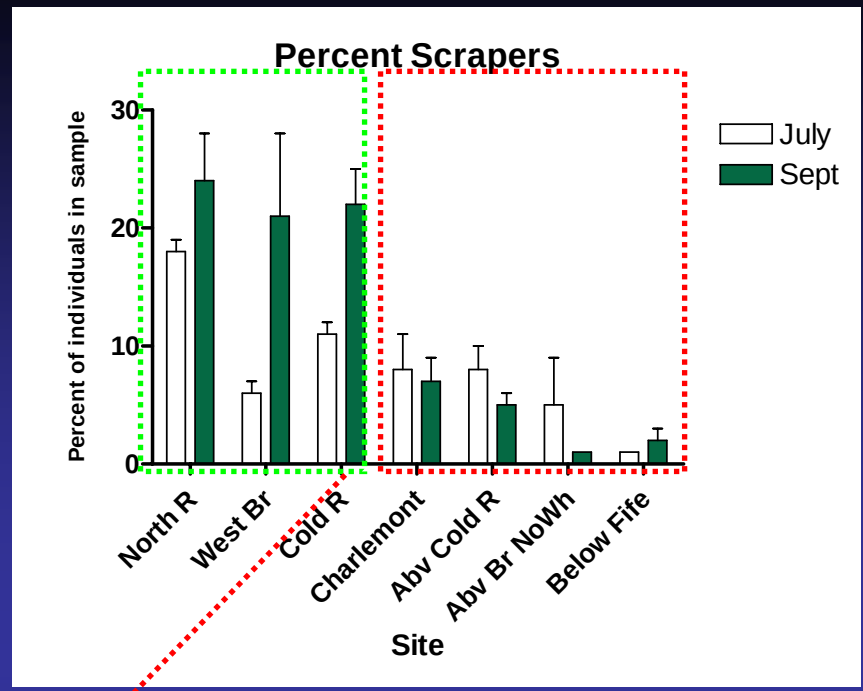




	p-values		
Attribute	Treatment Effect	Sampling Period Effect	Interaction
EPT Richness	**0.004**	0.033	0.353
Mayfly Abundance	**0.014**	0.863	0.939

Two-way ANOVA results suggest that unregulated reaches support a larger number of EPT taxa and higher densities of mayflies





	p-values		
Attribute	Treatment Effect	Sampling Period Effect	Interaction
Percent Filterers	0.400	0.207	0.851
Percent Scrapers	**<0.001**	**0.047**	**0.010**

Two-way ANOVA results suggest that flow-regulated reaches supported a larger proportion of scrapers than did unregulated reaches.

Although not significantly different between the reach types, the below-Fife-Brook-Dam reach supported the largest proportion of filterers in both July and September

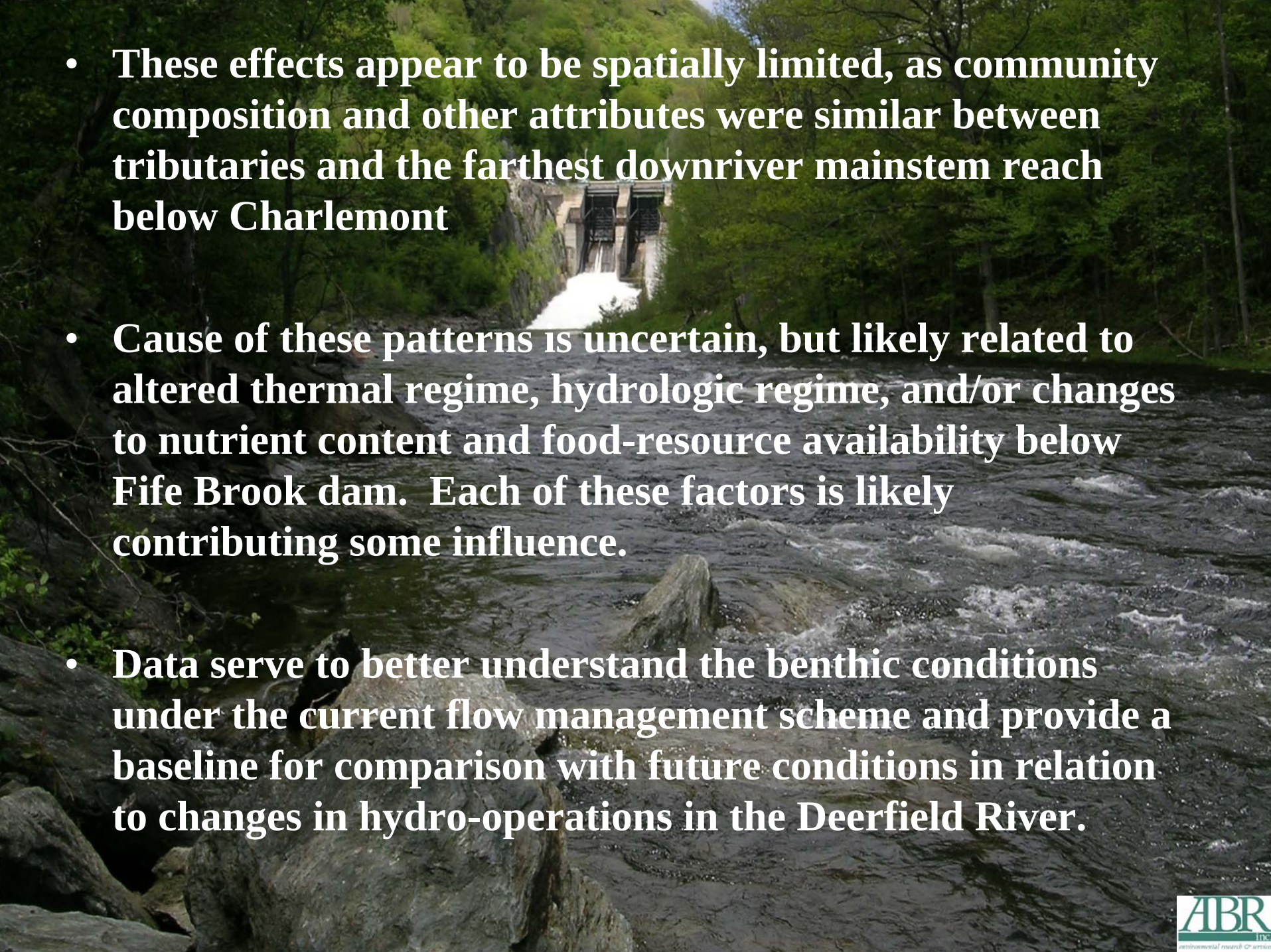
CONCLUSIONS

- **Relative to macroinvertebrate communities in river reaches with natural flow regimes, communities in the mainstem Deerfield River show an increasing divergence in community condition with closer proximity to the Fife Brook Dam.**

- **Communities in reaches nearer Fife Brook Dam are more heavily dominated by filter-feeding organisms, and support a lower abundance of mayflies and stoneflies.**

  - increased dominance by filterers likely caused by plankton and other particulates carried into the river via reservoir releases

  - Altered thermal or hydrologic regime potentially responsible for lower richness and abundance of mayflies and stoneflies



- **These effects appear to be spatially limited, as community composition and other attributes were similar between tributaries and the farthest downriver mainstem reach below Charlemont**

- **Cause of these patterns is uncertain, but likely related to altered thermal regime, hydrologic regime, and/or changes to nutrient content and food-resource availability below Fife Brook dam. Each of these factors is likely contributing some influence.**

- **Data serve to better understand the benthic conditions under the current flow management scheme and provide a baseline for comparison with future conditions in relation to changes in hydro-operations in the Deerfield River.**

ACKNOWLEDGMENTS

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- Kelly Nolan of Watershed Assessment Associates provided external laboratory quality control on macroinvertebrate taxonomy

- ABR technician Robin Creamer assisted with sample sorting

Thank you

View of the Deerfield River valley from the High Ledges, Shelburne, MA