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Using BioSim2 to identify statistically-valid sectors of indicator taxa

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Outline

- Introduction
  - Index of Biotic Similarity – Brief Review
  - What is a Sector?
- VTDEC Ambient Biomonitoring Program
  - Small, Moderate Gradient (Wadable) Streams
  - Macroinvertebrate sampling
- Results
  - Macroinvertebrate % Composition Data
  - Environmentally Reasonable Sectors
  - Statistically Valid Sectors
- Conclusions

Index of Biotic Similarity

(Pinkham-Pearson Index)

$$B = \frac{1}{k} \sum_{i=1}^{k} \frac{\text{Min } (X_{ia}, X_{ib})}{\text{Max } (X_{ia}, X_{ib})}$$

Barbour *et al.* (1992) in a systematic comparison of the metrics proposed in EPA's rapid bioassessment protocol (Pfalkin *et al.,* 1989), concluded that *B* "may be the most appropriate metric to serve as a measure of community similarity."

Index of Biotic Similarity

(Pinkham-Pearson Index)

$$B = \frac{1}{k} \sum_{i=1}^{k} \frac{\text{Min}\ (X_{ia}, X_{ib})}{\text{Max}\ (X_{ia}, X_{ib})}$$

	Taxon 1	Taxon 2	Taxon 3	Taxon 4	Taxon 5	Taxon 6
Site 1	10	0	0	5	30	2
Site 2	10	0	0	5	30	2
Site 3	0	10	20	0	0	0
Site 4	1	50	2	3	15	12

Site1w Site 2

$$\frac{\frac{10}{10} + \frac{0}{0} + \frac{0}{0} + \frac{5}{5} + \frac{30}{30} + \frac{2}{2}}{6} = 1$$

$$\frac{1 + 1 + 1 + 1 + 1 + 1}{6} = 1$$

Site1w Site 3

$$\frac{\frac{0}{10} + \frac{0}{10} + \frac{0}{0} + \frac{0}{5} + \frac{0}{30} + \frac{0}{2}}{6} = 0$$

$$\frac{0 + 0 + 0 + 0 + 0 + 0}{6} = 0$$

Site1w Site 4

$$\frac{\frac{1}{10} + \frac{0}{50} + \frac{0}{2} + \frac{3}{5} + \frac{15}{30} + \frac{2}{12}}{6} = 0.23$$

$$\frac{0.1 + 0 + 0 + 0.6 + 0.5 + 0.17}{6} = 0.23$$

Matrix of B's Between 11 Habitat Parameters

	SiltRating	PcBoulder%	PcCobble%	PcCoarseGravel%	PcGravel%	PcSilt%	PcClay%	Embeddedness	Canopy%	Width	FilamentousGreen%
SiltRating	1	0.4531	0.5797	0.5264	0.4447	0.1188	0.1122	0.568	0.5953	0.3926	0.2854
PcBoulder%	0.4531	1	0.5296	0.4035	0.4725	0.0701	0.1184	0.444	0.3985	0.4775	0.3455
PcCobble%	0.5797	0.5296	1	0.6305	0.4283	0.0661	0.0198	0.7029	0.5629	0.4591	0.3132
PcCoarseGravel%	0.5264	0.4035	0.6305	1	0.4844	0.0868	0.0521	0.6775	0.6	0.5009	0.2734
PcGravel%	0.4447	0.4725	0.4283	0.4844	1	0.1437	0.0397	0.5284	0.4558	0.5761	0.3737
PcSilt%	0.1188	0.0701	0.0661	0.0868	0.1437	1	0.7736	0.1345	0.0905	0.0832	0.3793
PcClay%	0.1122	0.1184	0.0198	0.0521	0.0397	0.7736	1	0.0305	0.0483	0.0411	0.3153
Embeddedness	0.568	0.444	0.7029	0.6775	0.5284	0.1345	0.0305	1	0.653	0.459	0.2853
Canopy%	0.5953	0.3985	0.5629	0.6	0.4558	0.0905	0.0483	0.653	1	0.4149	0.2304
Width	0.3926	0.4775	0.4591	0.5009	0.5761	0.0832	0.0411	0.459	0.4149	1	0.3314
FilamentousGreen%	0.2854	0.3455	0.3132	0.2734	0.3737	0.3793	0.3153	0.2853	0.2304	0.3314	1

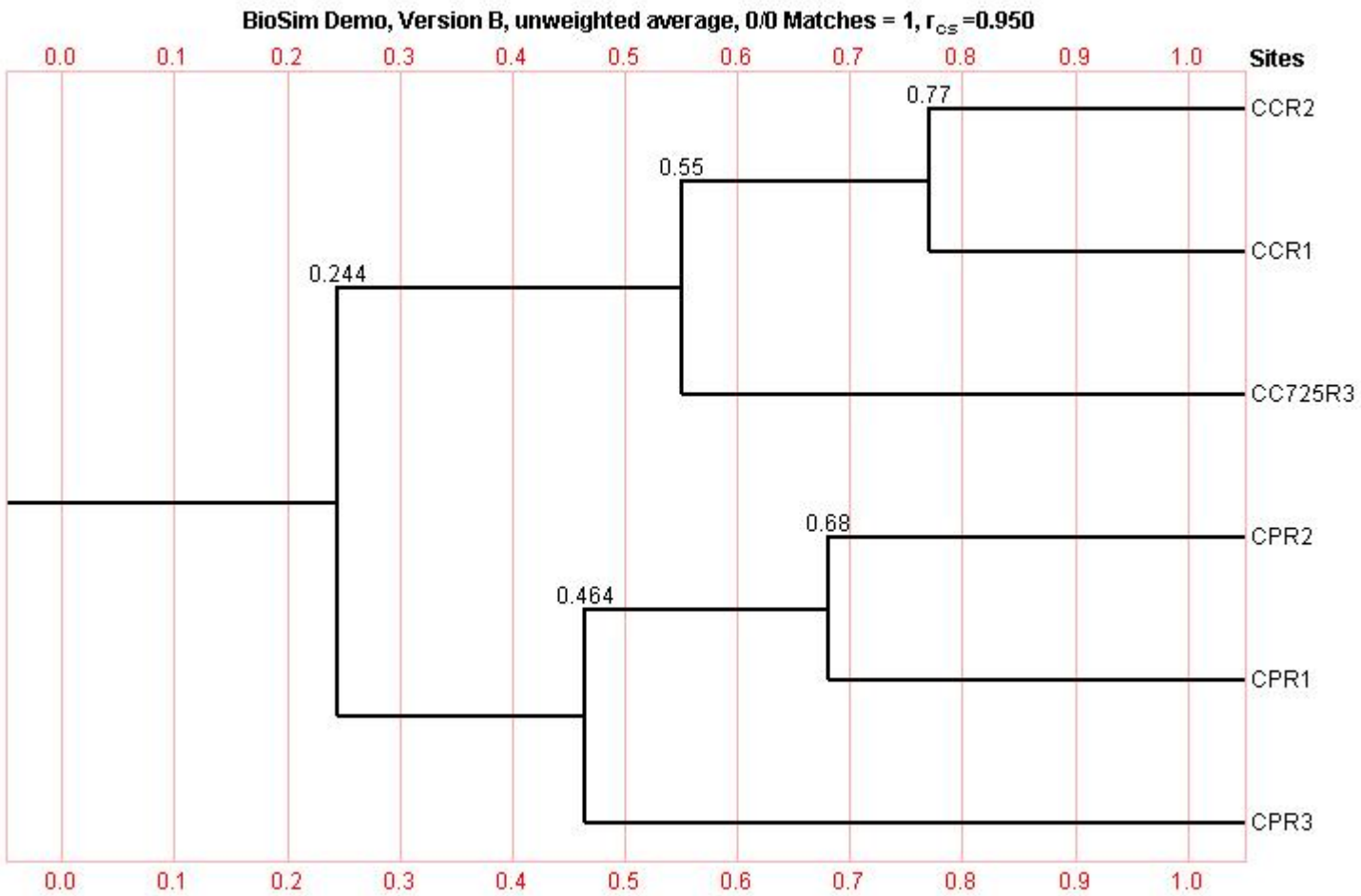
What is a Sector?

original data matrix, rows coded

sites/taxa	A	B	C	D	E	F	G
CPR1	3.8	0.2	0.9	15.7	0.7	6.9	0
CPR2	3.8	0.7	0.7	12.5	6.4	8.7	0
CPR3	8.4	0.5	2	22	3.8	9.6	1.5
CCR1	5.7	3.2	0	0	1.8	0	0
CCR2	7.7	2.1	0	1.1	1.8	0	0
CCR3	9.5	4.7	0	0.5	5	0	0.2

What is a Sector?

Row Dendrogram



What is a Sector?

original data matrix

sites/taxa	A	B	C	D	E	F	G
CPR1	3.8	0.2	0.9	15.7	0.7	6.9	0
CPR2	3.8	0.7	0.7	12.5	6.4	8.7	0
CPR3	8.4	0.5	2	22	3.8	9.6	1.5
CCR1	5.7	3.2	0	0	1.8	0	0
CCR2	7.7	2.1	0	1.1	1.8	0	0
CCR3	9.5	4.7	0	0.5	5	0	0.2

Original data matrix rearranged in order of the row dendrogram

sites/taxa	A	B	C	D	E	F	G
CCR2	7.7	2.1	0	1.1	1.8	0	0
CCR1	5.7	3.2	0	0	1.8	0	0
CCR3	9.5	4.7	0	0.5	5	0	0.2
CPR2	3.8	0.7	0.7	12.5	6.4	8.7	0
CPR1	3.8	0.2	0.9	15.7	0.7	6.9	0
CPR3	8.4	0.5	2	22	3.8	9.6	1.5

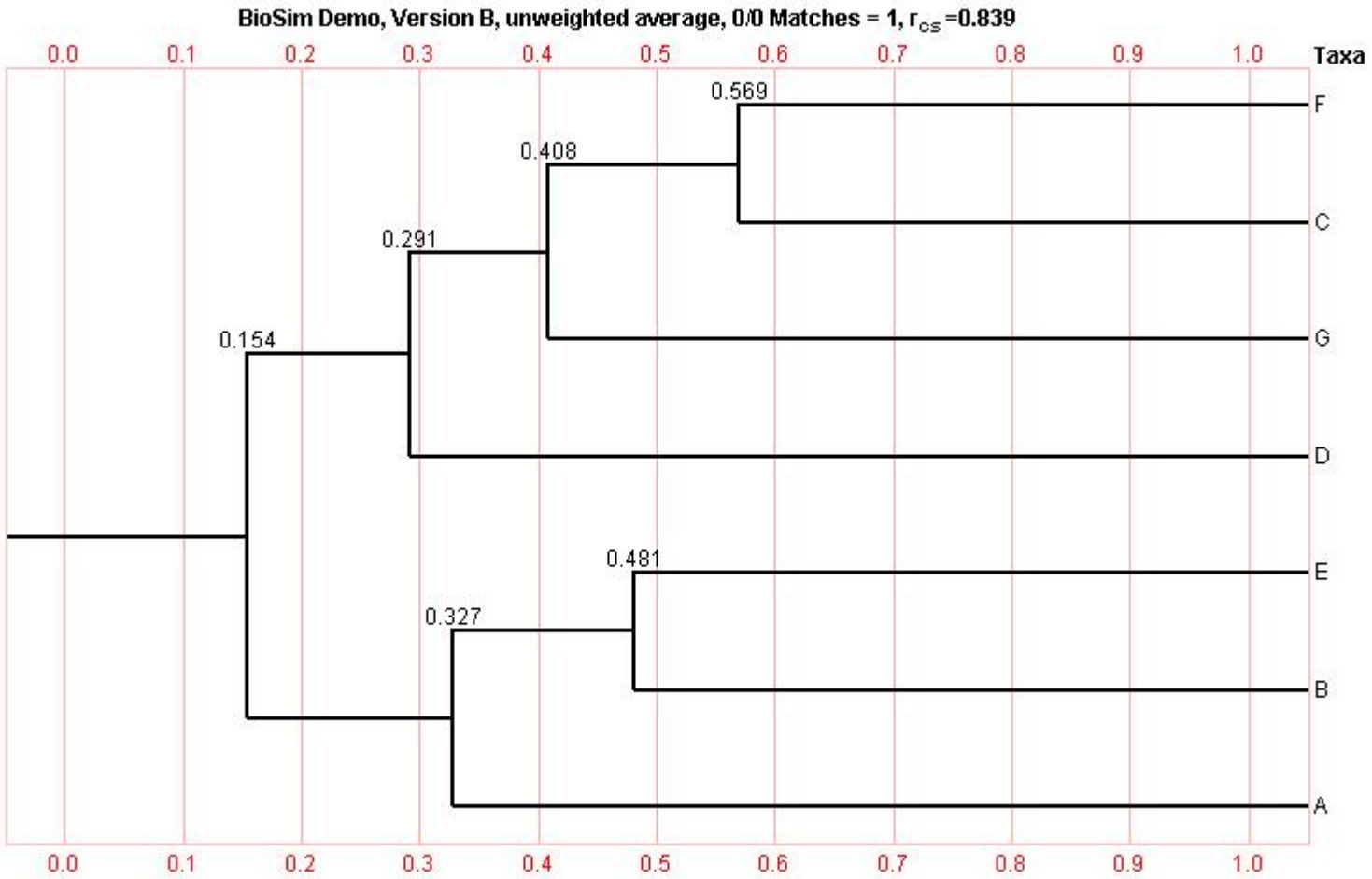
What is a Sector?

Original data matrix rearranged in order of the row dendrogram, taxa coded

sites/taxa	A	B	C	D	E	F	G
CCR2	7.7	2.1	0	1.1	1.8	0	0
CCR1	5.7	3.2	0	0	1.8	0	0
CCR3	9.5	4.7	0	0.5	5	0	0.2
CPR2	3.8	0.7	0.7	12.5	6.4	8.7	0
CPR1	3.8	0.2	0.9	15.7	0.7	6.9	0
CPR3	8.4	0.5	2	22	3.8	9.6	1.5

What is a Sector?

Taxa Dendrogram



What is a Sector?

Original data matrix rearranged in order of the row dendrogram, taxa coded

sites/taxa	A	B	C	D	E	F	G
CCR2	7.7	2.1	0	1.1	1.8	0	0
CCR1	5.7	3.2	0	0	1.8	0	0
CCR3	9.5	4.7	0	0.5	5	0	0.2
CPR2	3.8	0.7	0.7	12.5	6.4	8.7	0
CPR1	3.8	0.2	0.9	15.7	0.7	6.9	0
CPR3	8.4	0.5	2	22	3.8	9.6	1.5

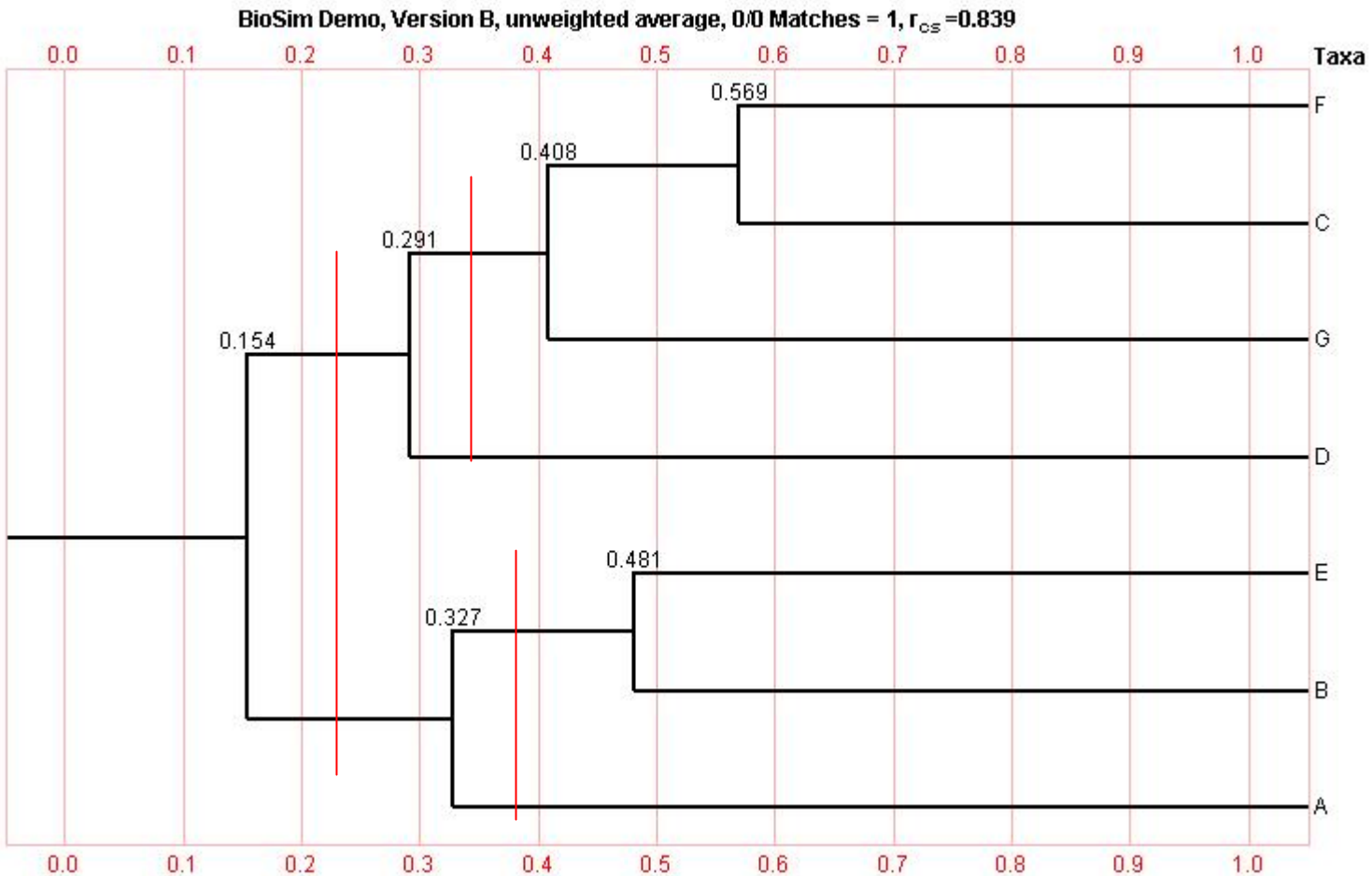
Rearranging original data matrix in double-dendrogram order

	F	C	G	D	E	B	A
CCR2	0	0	0	1.1	1.8	2.1	7.7
CCR1	0	0	0	0	1.8	3.2	5.7
CCR3	0	0	0.2	0.5	5	4.7	9.5
CPR2	8.7	0.7	0	12.5	6.4	0.7	3.8
CPR1	6.9	0.9	0	15.7	0.7	0.2	3.8
CPR3	9.6	2	1.5	22	3.8	0.5	8.4

What is a Sector?

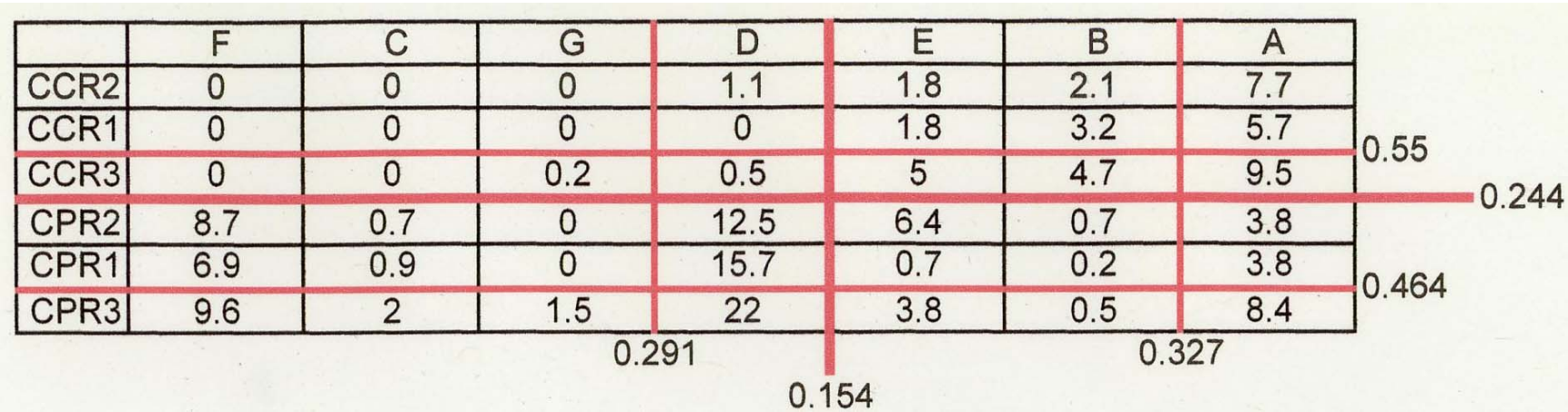
Taxa Dendrogram

Identifying environmentally reasonable sectors



What is a Sector?

Establishing environmentally reasonable sectors



	F	C	G	D	E	B	A
CCR2	0	0	0	1.1	1.8	2.1	7.7
CCR1	0	0	0	0	1.8	3.2	5.7
CCR3	0	0	0.2	0.5	5	4.7	9.5
CPR2	8.7	0.7	0	12.5	6.4	0.7	3.8
CPR1	6.9	0.9	0	15.7	0.7	0.2	3.8
CPR3	9.6	2	1.5	22	3.8	0.5	8.4

VTDEC Ambient Biomonitoring Program

- The Vermont Department of Environmental Conservation (VTDEC) is charged with assessing the biological integrity of wadable stream sites throughout Vermont.

- Specific data are being collected to better refine the biological expectation of very small (<1-15 km^2), low elevation (118-550 ft), eurythermal, wadable streams of moderate gradient in Vermont.

- These data will be used to evaluate the response of these streams to current agricultural and storm-water management practices, within their watersheds.

Small, Moderate Gradient (Wadable) Streams

- From this Program 27 streams were selected, 26 in the Champlain Valley, One in the Connecticut Valley
- One stream was sampled in 2 successive years to provide a reference for the technique.
- One stream was sampled at two points
- Thus data from 29 streams were used in this study.

Deer Creek

Engelsby Brook

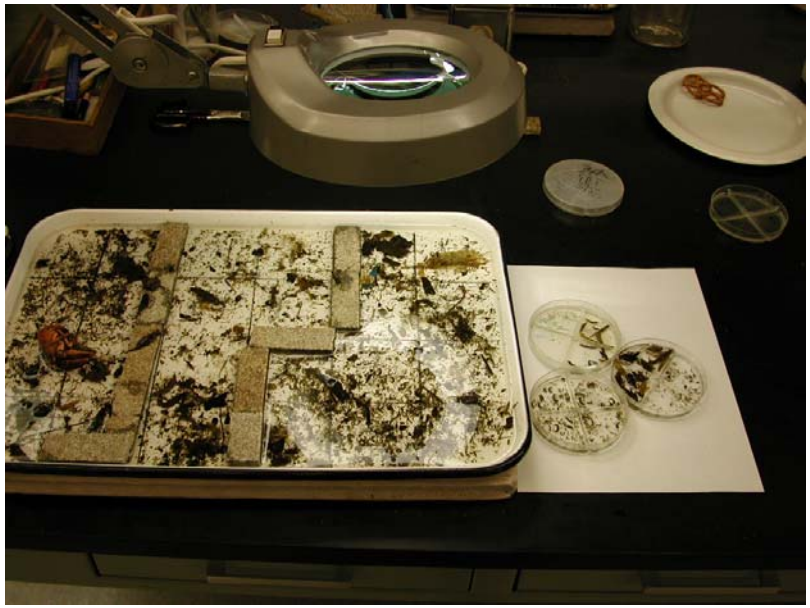
Moorehouse Brook

Reference

Macroinvertebrate Sampling

- Collected in late summer-early Fall index period of Sept to Mid Oct
- Collected from representative locations in a riffle in the stream.
- Substrate in an area about 1 square meter upstream of a 500 micron mesh, D net is thoroughly disturbed by hand.
- Four composite samples collected each sample lasting about 30 seconds
- Two replicates done per stream; preserved in 75% alcohol.

Macroinvertebrate Processing



1) Sample washed and spread evenly over a white, gridded tray with 24 squares
2) Starting with random grid, it and the next 5 consecutive squares are picked clean of macroinvertebrates using a 3 diopter magnifying light.
3) Process is continued if necessary until 300 organisms are picked.
4) Total Number of squares picked is recorded.
5) Picked macroinvertebrates are preserved in 75% alcohol
6) Macroinvertebrates are identified to species or genus, except Oligochaetes (Family)

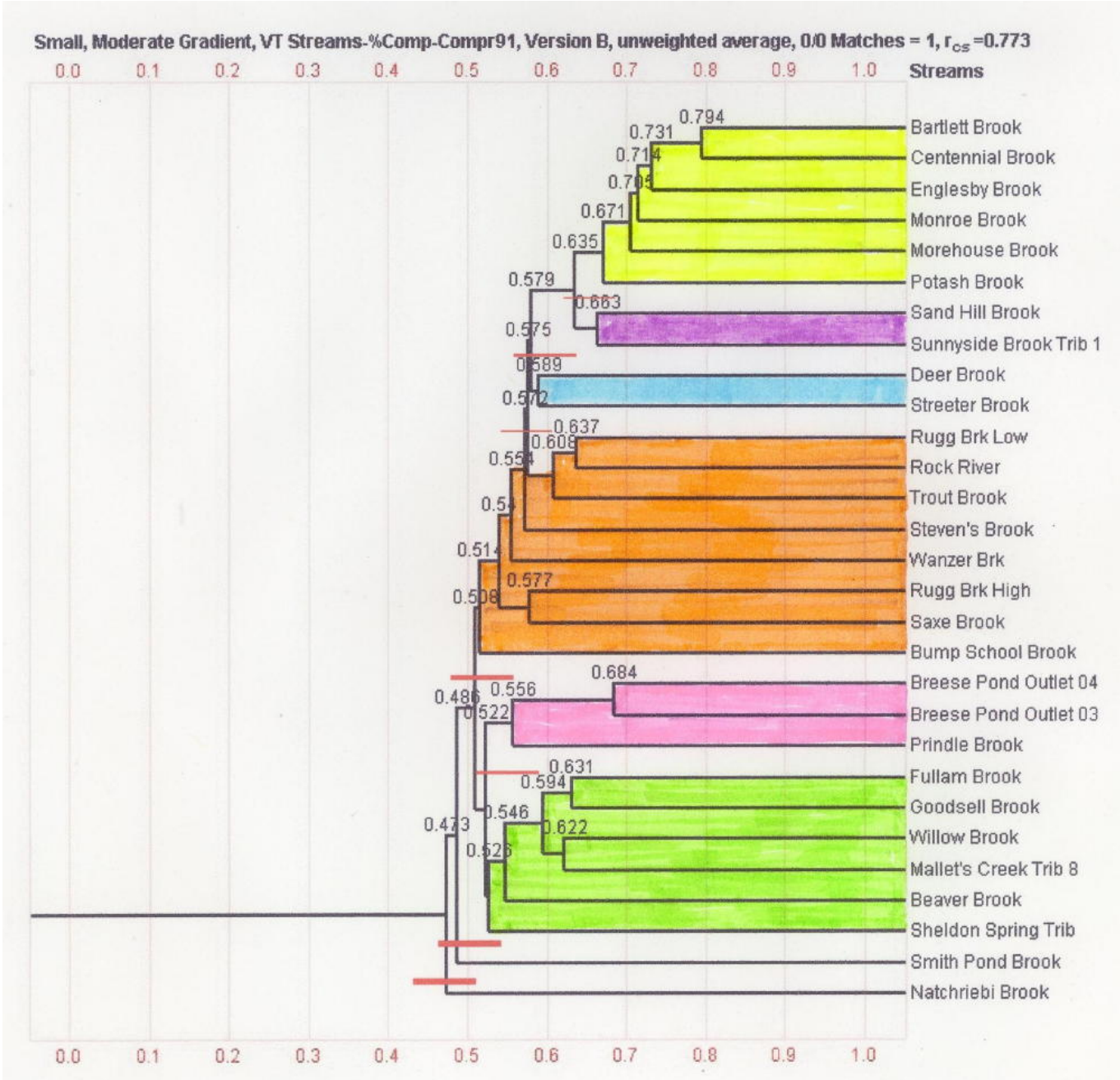
Macroinvertebrate Results

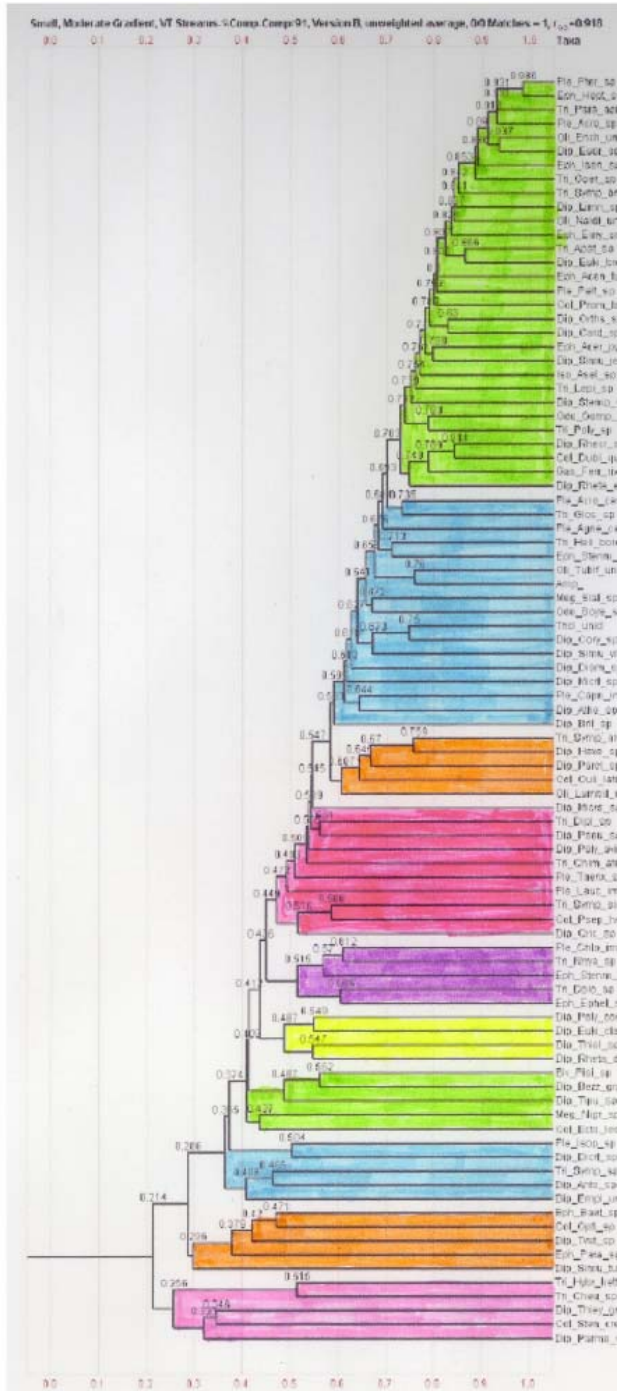
- 170 taxa collected at 29 “Sites”
- Compressed to 91 taxa at 29 Sites by eliminating
  - taxa which appeared in only one site with a % composition < 1.25% (38)
  - taxa which appeared in only two sites with a maximum % comp < 1.2% (23)
  - taxa which appeared in only three sites with a maximum % comp < 1.1% (11)
  - taxa which appeared in only four sites with a maximum % comp < 1% (7)

RESULTS

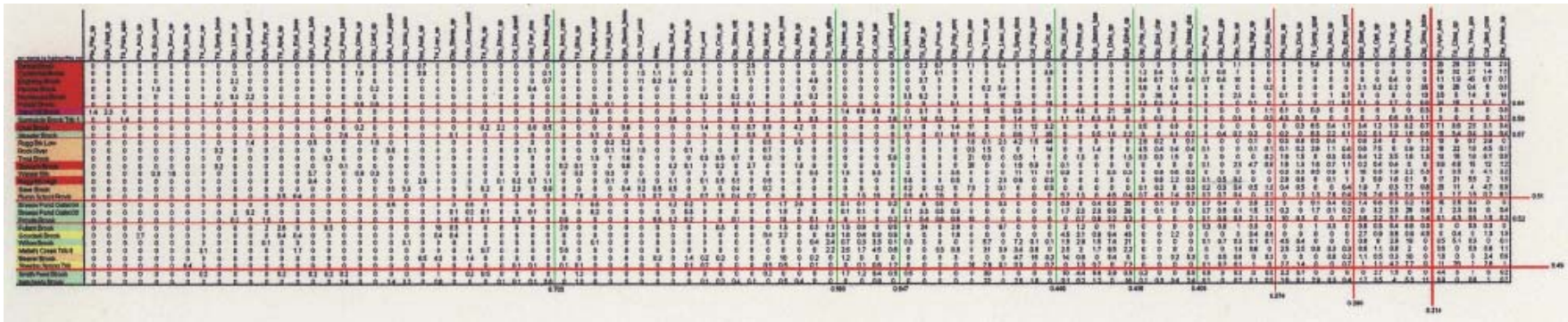
MACROINVERTEBRATE DATA

- Why % Composition
- Stream Dendrogram
- Taxa Dendrogram
- Reordered Data Matrix – 0's Included
- Reordered Data Matrix – 0's Removed
- Reordered Data Matrix - Coded
- Synthesis

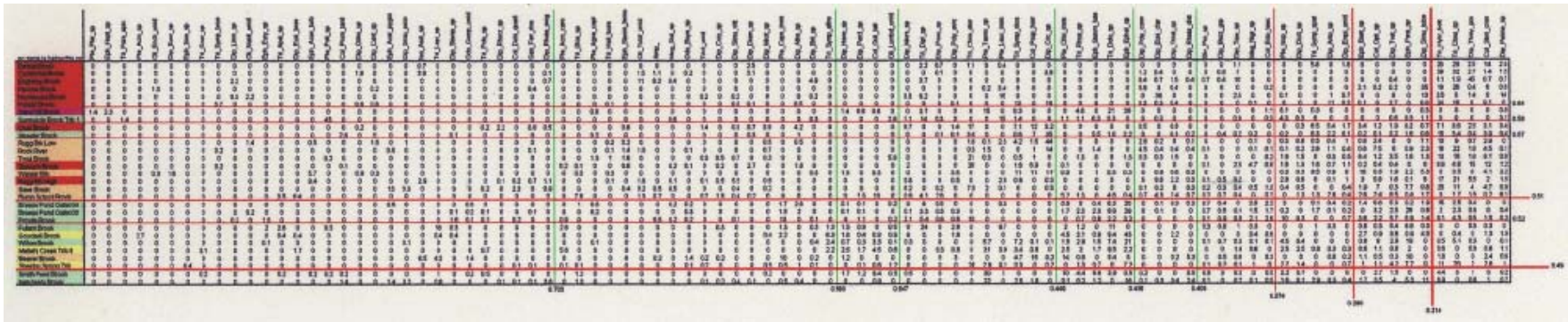

Small, Moderate Gradient, VT Streams-%Comp-Compr91, Version B, unweighted average, 0/0 Matches = 1, r_cs =0.773
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Streams
0.794
0.731
0.714
0.705
0.671
0.635
0.579
0.663
0.575
0.589
0.572
0.637
0.608
0.554
0.54
0.514
0.577
0.508
0.684
0.556
0.486
0.522
0.631
0.594
0.546
0.622
0.473
0.526
Bartlett Brook
Centennial Brook
Englesby Brook
Monroe Brook
Morehouse Brook
Potash Brook
Sand Hill Brook
Sunnyside Brook Trib 1
Deer Brook
Streeter Brook
Rugg Brk Low
Rock River
Trout Brook
Steven's Brook
Wanzer Brk
Rugg Brk High
Saxe Brook
Bump School Brook
Breese Pond Outlet 04
Breese Pond Outlet 03
Prindle Brook
Fullam Brook
Goodsell Brook
Willow Brook
Mallet's Creek Trib 8
Beaver Brook
Sheldon Spring Trib
Smith Pond Brook
Natchriebi Brook


Small, Moderate Gradient, MT Streams, %Comp Comp>91, Version B, unweighted average, 00 Matches = 1, r_cc = 0.915
Taxa

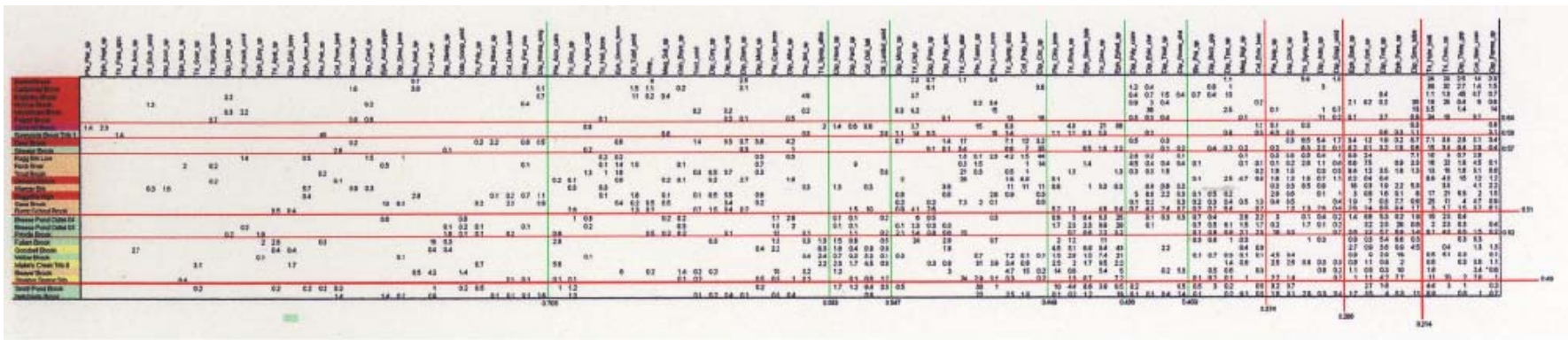
Zero’s Present



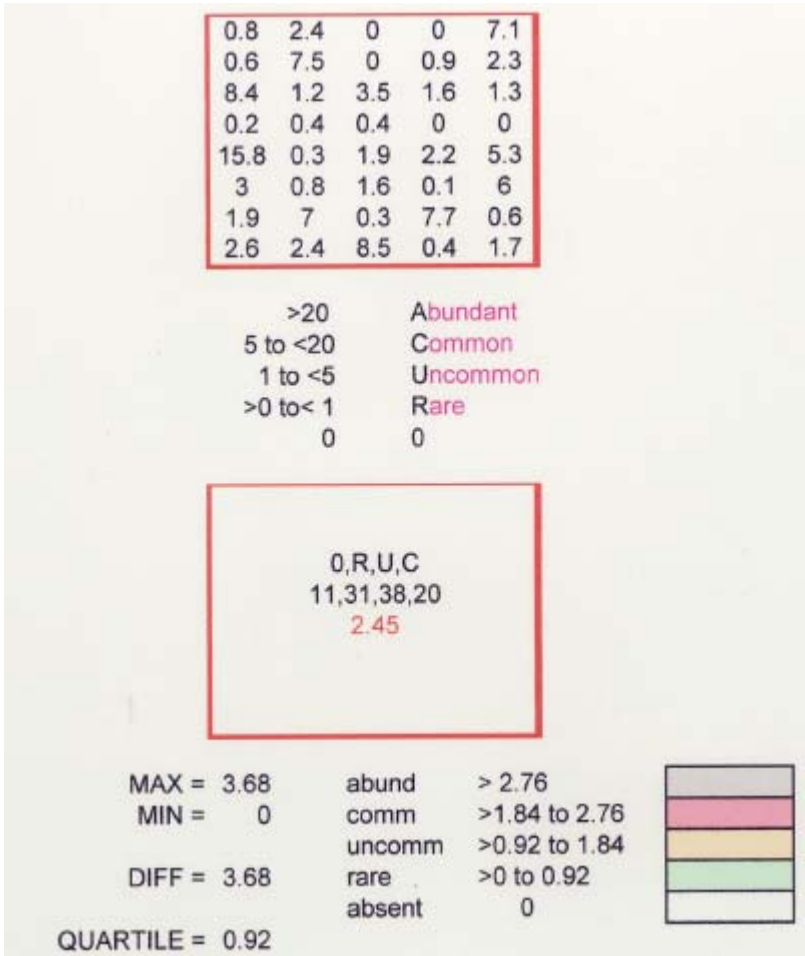
Zero’s Present

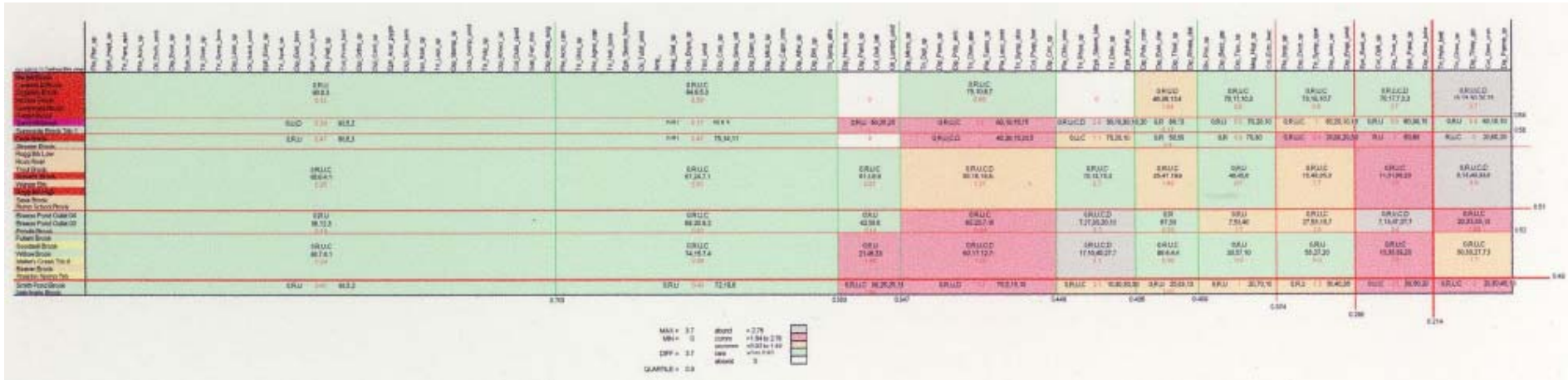


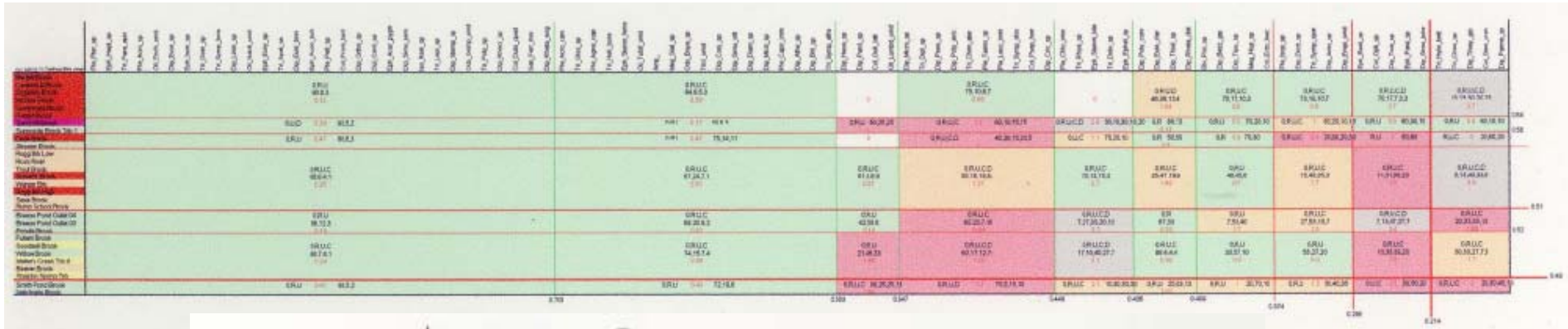
Zero’s Removed



Coding The Reordered Data Matrix



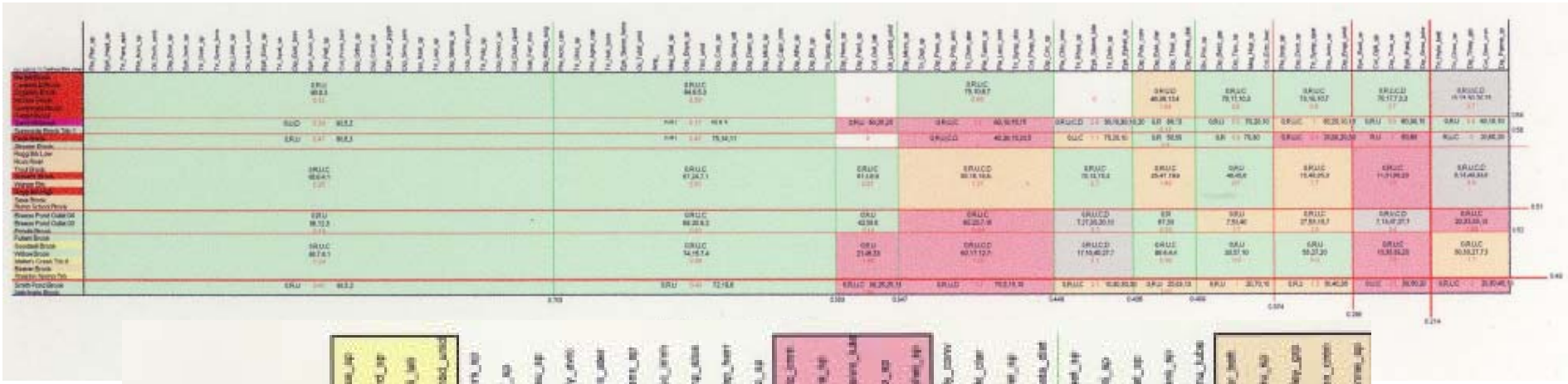




no zeros is below this one	Ple_Pter_sp	Eph_Hept_sp	Tri_Para_apic	Ple_Acro_sp	Oli_Ench_unid
Bartlett Brook					
Centennial Brook					
Englesby Brook					
Monroe Brook					
Morehouse Brook					
Potash Brook					
Sand Hill Brook					
Sunnyside Brook Trib 1					
Deer Brook					
Streeter Brook					
Rugg Brk Low					
Rock River					
Trout Brook					
Steven's Brook					
Wanzer Brk					
Rugg Brk High					
Saxe Brook					
Bump School Brook					
Breese Pond Outlet 04					
Breese Pond Outlet 03					
Prindle Brook					
Fullam Brook					
Goodsell Brook					
Willow Brook					
Mallet's Creek Trib 8					
Beaver Brook					
Sheldon Spring Trib					
Smith Pond Brook					
Natchriebi Brook					

Monroe Brook	Stream in Urban Setting
Sand Hill Brook	Stream in Suburban Setting
Trout Brook	Stream in Agricultural Setting
Breese Pond Outlet 03	Reference Stream
Goodsell Brook	Presumed Reference Stream

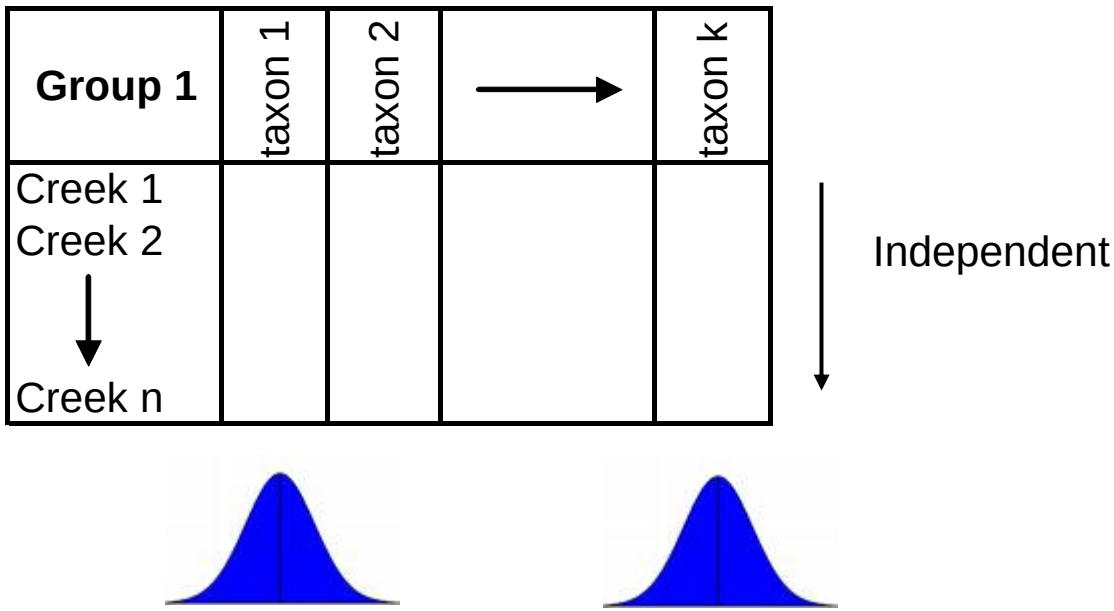
Synthesis




Urban
Agricultural
Reference
abund > 2.76
comm >1.84 to 2.76
uncom >0.92 to 1.84
rare >0 to 0.92
absent 0

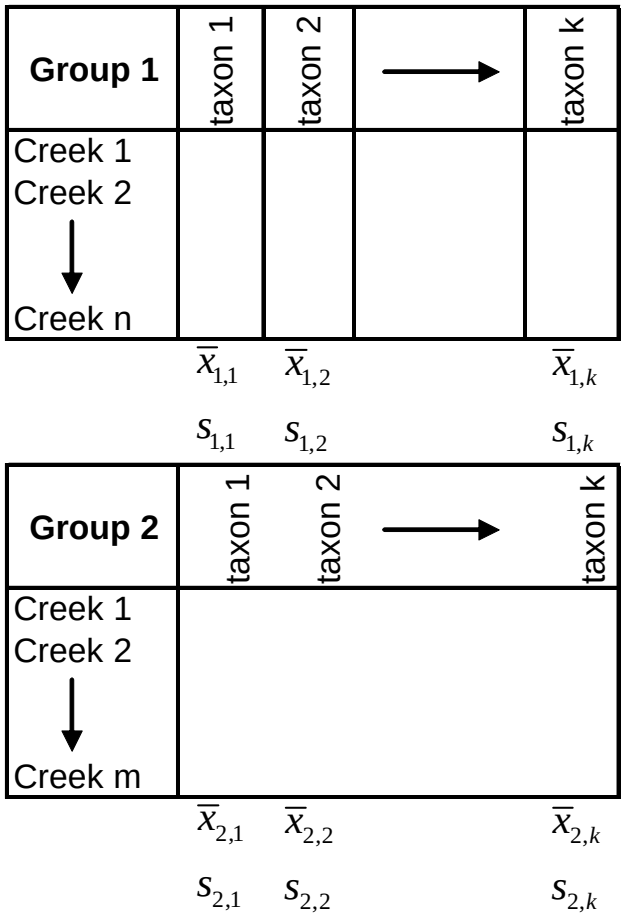
Statistical Analysis

- Assumptions
  - The measurements in each creek are independent
  - The relative abundance of taxa follow a normal distribution



Statistical Analysis

- Calculations



$$d_i = \frac{\overline{x}_{1,i} - \overline{x}_{2,i}}{\sqrt{\frac{s_{1,i}^2}{n} + \frac{s_{2,i}^2}{m}}}$$

Statistical Analysis

- Calculations

  H_o: There is a not a significant difference between the percent composition of taxa in Group 1 and Group 2 creeks.

  H_a: There is a significant difference between the percent composition of taxa in Group 1 and Group 2 creeks.

  Given H_o is true then

$$d_i : N(0,1)$$

$$\text{so} \quad \sum_{i=1}^{k} d_i^2 : \chi^2(k).$$

  The *p*-value is calculated using the chi-square distribution.

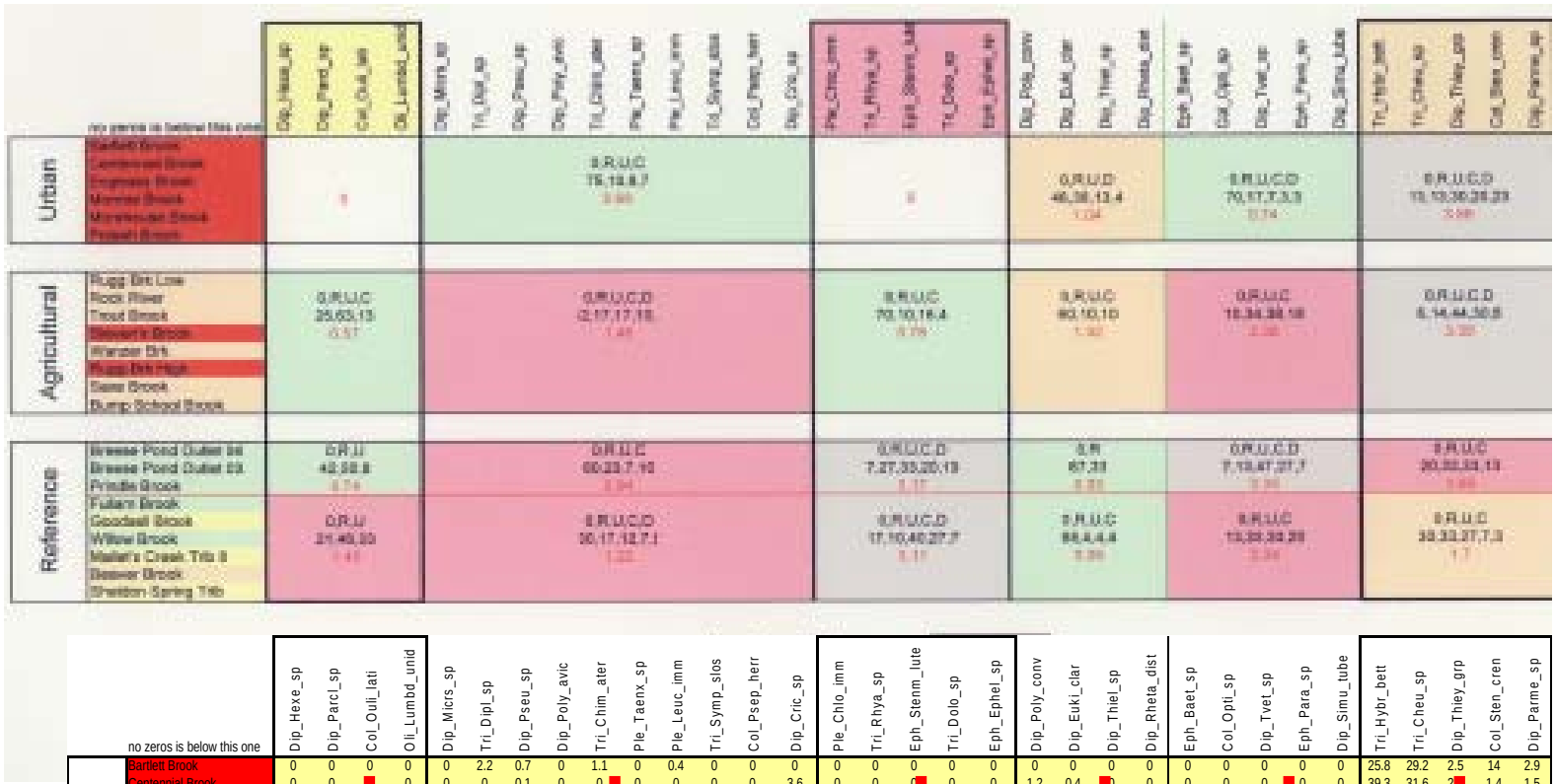
	no zeros is below this one	Dip_Hexe_sp	Dip_Parcl_sp	Col_Ouli_lati	Oli_Lumbd_unid	Dip_Micrs_sp	Tri_Dipl_sp	Dip_Pseu_sp	Dip_Poly_avic	Tri_Chim_ater	Ple_Taenx_sp	Ple_Leuc_imm	Tri_Symp_slos	Col_Psep_herr	Dip_Cric_sp	Ple_Chlo_imm	Tri_Rhya_sp	Eph_Stenm_lute	Tri_Dolo_sp	Eph_Ephel_sp	Dip_Poly_conv	Dip_Euki_clar	Dip_Thiel_sp	Dip_Rheta_dist	Eph_Baet_sp	Col_Opti_sp	Dip_Tvet_sp	Eph_Para_sp	Dip_Simu_tube	Tri_Hybr_bett	Tri_Cheu_sp	Dip_Thiey_grp	Col_Sten_cren	Dip_Parme_sp
Urban	Bartlett Brook	0	0	0	0	0	2.2	0.7	0	1.1	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25.8	29.2	2.5	14	2.9
	Centennial Brook	0	0		0	0	0	0.1	0	0	0	0	0	0	3.6	0	0	0	0	0	1.2	0.4	0	0	0	0	0	0	0	39.3	31.6	2	1.4	1.5
	Englesby Brook	0	0		0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.7	.5	0.4	0	0	0.4	0	0	1.1	1.9	44.3	0.7	0.7
	Monroe Brook	0	0		0	0	0	0	0	0	0.2	3.4	0	0	0	0	0	0	0	0	0.9	3	.4	0	2.1	0.2	0.2	0	34.9	18.9	25.7	0	6	0.6
	Morehouse Brook	0	0		0	0.3	9.2	0	0	0	0	14.9	0	0	0	0	0	0	0	0	0	35.5	0	0	0	0	0	0	12.5	3.5	0	1	0	13.9
	Potash Brook	0	0		0	0	0	0	0.1	0	0	0	12.6	0	15.9	0	0	0	0	0	0.2	0.9	.4	0	0.1	0	2.7	0	0.9	23.9	1	0	9.1	0
Agricultural	Rugg Brk Low	0	0		0	0	0	0	0	1.8	0.1	2.3	4.2	1.5	44.3	0	0	0	0	0	2	0.2	0	0.1	0.8	.4	0	0	7.1	10.2	9	0	2.9	0
	Rock River	0	9		0	0	0	0	0	0.3	1.5	0	0	1	14.2	0	0	1.4	0	0	4	0.4	.4	0.4	0.6	.6	0	0.9	2.3	15.7	22	1	4.5	0.1
	Trout Brook	0	0		.8	0	0	0	0	21.4	.3	0	0.5	1	0	0	1.3	0	0	1.3	0.3	0.3	.3	0	8.4	1.2	3.5	1	1.3	12.7	16.1	1	0.1	0.8
	Steven's Brook	0	0		0	2	0	0	0	25.9	.3	0	1.6	6.9	0	0.1	0	0	0	0	0	0	0	0	0.2	0.4	0.4	0	0	8.9	4.8	14.7	12.2	1.2
	Wanzer Brk	1.3	0	.3	0	0	0	0	3.5	0	0	0	11	10.7	10.7	0.9	0	1	0.3	0.3	0	0.9	.6	0.3	15.8	0.3	1.9	2.2	5.3	0	3.5	0	4.1	2.2
	Rugg Brk High	0	0		0	0.8	0	0	0.5	0	0	2.8	0.9	0	0.3	0	0	0	0	0	5	8.6	.2	0.3	3	0.8	1.6	0.1	6	16.5	21.2	5	2	1.5
	Saxe Brook	0	0		0	0.2	0	0.2	0	7.3	2	0.1	0	0	0.5	0	0	0	0	0	0	0.2	0	0.3	1.9	7	0.3	7.7	0.6	25	11.4	4	4.7	0.9
	Bump School Brook	0	.5	.0	0	0.9	4.1	2.6	0	.0	0	0	0	0	0	5.2	1	0	4.6	0.4	0	4.3	.4	8.7	2.6	.4	8.5	0.4	1.7	3	1	1	0.2	6.1
Reference	Breese Pond Outlet 04	0.1	0.1		0.2	0	6	0.5	0	0	0	0.3	0	0	0	0.9	5	0.4	6.3	24.9	0	0.1	.3	0.3	1.4	.6	5.3	0.2	1.9	15.3	2.5	0	0	0
	Breese Pond Outlet 03	0.1	0.1		0	0.1	3.3	0.3	0.3	0	0	0	0	0	0	1.7	2.3	2.3	9.9	28.7	0	0.1	0	0	0	.2	2.5	26	0.6	2	2.3	0	0	0.4
	Prindle Brook	0	1.1		0.2	2.1	5.4	0.8	0.6	10.1	0	0	0	0	0	0	0.7	0	2.2	3.2	0	0	0	0	3.6	2.2	5.7	6.9	1.4	9.1	4.3	0	1.5	0.2
	Fullam Brook	1.5	0.8		0.5	0	24.3	0	2.8	0	0	9.7	0	0	0	2	1.2	0	11	0	0	0	0	0	0.8	0.3	5.4	6.6	0.3	0	0	0.3	0.3	0
	Goodsell Brook	1.8	0.4	0.9	0.9	0	0	0	1.8	0	0	0	0	0	0	4.5	3.1	0.9	9.4	42.9	0	0	2.2	0	2.7	0.9	3.6	0.9	4.5	0	0.4	0	1.3	1.3
	Willow Brook	0.7	0.3	3.3	0.1	0.3	0	0	0	0	5.7	0	7.2	0.1	0.1	1.5	2.9	1.5	7.4	20.6	0	0	0	0	0.8	9	2.9	19.3	0	0.5	5.1	0.3	0	0.1
	Mallet's Creek Trib 8	2.5	1.7	4.5	0.6	0	0	0.3	0.8	0	31.3	3.9	3.4	0.8	0	2.5	2	1.7	9.5	2.2	0	0	0	0	0.8	1.1	0.8	2	0	0.6	0	0.3	0.6	1.1
	Beaver Brook	1.2	0	0	0	0	0	0	3	0	0	0	4.7	14.7	0.2	13.6	0.6	0	5.4	5	0	0	0.2	5.3	1.1	0.5	0.3	10	0	1.8	0	0	2.4	0.6
	Sheldon Spring Trib	0	0.1	0.6	1.2	0	0	0	0	23.7	2.9	0.1	0.3	0	0.2	0	1.3	0.7	0	7.2	0	0	0	0	1	1.1	4.2	7.7	0	10.7	20.2	2	2.8	1

	p-value	p-value	p-value	p-value	p-value	p-value
Urban vs Agricultural	0.11	0.03	0.02	0.06	0.00	0.36
Urban vs Reference	0.00	0.07	0.00	0.02	0.00	0.00
Agricultural vs Reference	0.08	0.37	0.00	0.01	0.01	0.00

S: There is a not a significant difference between the relative abundance of this group of taxa within each classification of creeks

D: There is a significant difference between the relative abundance of this group of taxa within each classification of creeks

Conclusion



	no zeros is below this one	Dip_Hexe_sp	Dip_Parcl_sp	Col_Ouli_lati	Oli_Lumbd_unid	Dip_Micrs_sp	Tri_Dipl_sp	Dip_Pseu_sp	Dip_Poly_avic	Tri_Chim_ater	Ple_Taenx_sp	Ple_Leuc_imm	Tri_Symp_slos	Col_Psep_herr	Dip_Cric_sp	Ple_Chlo_imm	Tri_Rhya_sp	Eph_Stenm_lute	Tri_Dolo_sp	Eph_Ephel_sp	Dip_Poly_conv	Dip_Euki_clar	Dip_Thiel_sp	Dip_Rheta_dist	Eph_Baet_sp	Col_Opti_sp	Dip_Tvet_sp	Eph_Para_sp	Dip_Simu_tube	Tri_Hybr_bett	Tri_Cheu_sp	Dip_Thiey_grp	Col_Sten_cren	Dip_Parme_sp
Urban	Bartlett Brook	0	0	0	0	0	2.2	0.7	0	1.1	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25.8	29.2	2.5	14	2.9
	Centennial Brook	0	0		0	0	0	0.1	0	0	0	0	0	0	3.6	0	0	0	0	0	1.2	0.4	0	0	0	0	0	0	0	39.3	31.6	2	1.4	1.5
	Englesby Brook	0	0		0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.7	1.5	0.4	0	0	0.4	0	0	1.1	1.9	44	0.7	0.7
	Monroe Brook	0	0		0	0	0	0	0	0	0.2	3.4	0	0	0	0	0	0	0	0	0.9	3	1.4	0	2.1	0.2	0.2	0	34.9	18.9	25.7	0	6	0.6
	Morehouse Brook	0	0		0	0.3	9.2	0	0	0	0	14.9	0	0	0	0	0	0	0	0	0	35.5	0	0	0	0	0	0	12.5	3.5	0	1	0	13.9
	Potash Brook	0	0		0	0	0	0	0.1	0	0	0	12.6	0	15.9	0	0	0	0	0	0	0.2	1.4	0	0.1	0.7	0	0	0.9	23.9	16	1	9.1	0
Agricultural	Rugg Brk Low	0	0		0	0	0	0	0	1.8	0.1	2.3	4.2	1.5	44.3	0	0	0	0	0	0	0.2	0	0.1	0.8	0	0	0	7.1	10	9	0	2.9	0
	Rock River	0	9		0	0	0	0	0	0.3	1.5	0	0	1	14.2	0	0	1.1	0	0	4	0.4	1.4	0.4	0.6	1.5	0	0.9	2.3	15.7	22	1	4.5	0.1
	Trout Brook	0	0		5.8	0	0	0	0	21.4	0.3	0	0.5	1	0	0	1.3	0	0	1.3	0.3	0.3	1.5	0	8.4	1.2	3.5	1.6	1.3	12.7	16.1	1	8.1	0.8
	Steven's Brook	0	0		0	2	0	0	0	25.9	0	1.6	6.9	0	0.1	0	0	0	0	0	0	0	0	0	0.2	0.4	0.4	0	0	8.9	4.8	14	12.2	1.2
	Wanzer Brk	1.3	0		0	0	0	0	3.5	0	0	0	11	10.7	10.7	0.9	0	1	0.3	0.3	0	0.9	1.6	0	15.8	0.3	1.9	2	3	0	3.5	0	4	2.2
	Rugg Brk High	0	0		0	0.8	0	0	0.5	0	0	2.8	0.9	0	0.3	0	0	0	0	0	5	8.6	2	0.3	3	0.8	1.6	0.1	6	16.5	21.2	5	2	1.5
	Saxe Brook	0	0		0	0.2	0	0.2	0	7.3	2	0.1	0	0	0.5	0	0	0	0	0	0	0.2	0	0.3	1.9	0	0.3	7.7	0.6	25	11.4	4	4.7	0.9
	Bump School Brook	0	1.5		0	0.9	4.1	2.6	0	0	0	0	0	0	0	5.2	1.6	0	4.6	0.4	0	0.4	1.4	8.7	2.6	4	4.5	0.4	1.7	3	1.5	1	0.2	6.1
Reference	Breese Pond Outlet 04	0	0.1		0.2	0	6	0.5	0	0	0	0.3	0	0	0	0.9	5	0	6.3	24.9	0	0.2	1.3	0.3	1.4	0	5.8	0.2	1.9	15	2.5	0	0	0
	Breese Pond Outlet 03	0.1	0.1		0	0.1	3.3	0.3	0.3	0	0	0	0	0	0	1.7	2.3	2	9.9	28.7	0	0.1	0	0	0	2	2.5	26	0.6	2	2.3	0	0	0.4
	Prindle Brook	0	1.1		0.2	2.1	5.4	0.8	0.6	10	0	0	0	0	0	0	0.7	0	2.2	3.2	0	0	0	0	3.6	2.2	5.7	7.9	1.4	9.1	4.3	0	1.5	0.2
	Fullam Brook	1.5	0.8		0.5	0	24.3	0	2.8	0	0	9.7	0	0	0	2	1.2	0	11	0	0	0	0	0	0.8	0.3	5.4	6.6	0.3	0	0	0.3	0.3	0
	Goodsell Brook	1.8	0.4	0.9	0.9	0	0	0	1.8	0	0	0	0	0	0	4.5	3.1	0.9	9.4	42.9	0	0	2.2	0	2.7	0.9	3.6	0.9	4.5	0	0.4	0	1.3	1.3
	Willow Brook	0.7	0.3	3.3	0.1	0.3	0	0	0	0	5.7	0	7.2	0.1	0.1	1.5	2.9	1.5	7.4	20.6	0	0	0	0	0.8	9	2.9	19.3	0	0.5	5.1	0.3	0	0.1
	Mallet's Creek Trib 8	2.5	1.7	4.5	0.6	0	0	0.3	0.8	0	31.3	3.9	3.4	0.8	0	2.5	2	1.7	9.5	2.2	0	0	0	0	0.8	1.1	0.8	2	0	0.6	0	0.3	0.6	1.1
	Beaver Brook	1.2	0	0	0	0	0	0	3	0	0	0	4.7	14.7	0.2	13.6	0.6	0	5.4	5	0	0	0.2	5.3	1.1	0.5	0.3	10	0	1.8	0	0	2.4	0.6
	Sheldon Spring Trib	0	0.1	0.6	1.2	0	0	0	0	23.7	2.9	0.1	0.3	0	0.2	0	1.3	0.7	0	7.2	0	0	0	0	1	1.1	4.2	7.7	0	10.7	20.2	2	2.8	1

	p-value	p-value	p-value	p-value	p-value	p-value
Urban vs Agricultural	0.11	0.03	0.02	0.06	0.00	0.36
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Questions?

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