The Effect of Stream Width on Stream Quality at the Confluence of Flat Creek and Line Creek in Fayette County, Georgia.

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Abstract: As urban planners and ecologists work to restore the natural hydraulic parameters of riparian environments along the flood plains of urban streams, they have flexibility in deciding the level of structural complexity in channel reconfiguration and re-alignment in order to restore the ecological integrity, and natural structures and functions of streams.

Introduction

The quality and overall health of a stream is measured by the diversity and abundance of the flora and fauna that the stream is able to support. The quality of streams is affected by many factors, but in general larger streams in terms of width, depth, and flow rates are able to support a variety of vertebrate and invertebrate species due to the presence of more diverse microhabitats, stable water chemistry, and the increased organic contribution of wider vegetated riparian zones (Allan 1995). In addition, forested reaches of streams typically have greater diversity of invertebrates due to cooler temperatures, wider channels, and fewer sediments (Allan 2004). Historically, rivers and streams have been one of the ecosystems most impacted by human activity. Currently, extinction rates are higher in the aquatic environments of North America than anywhere in the world. Estimates place the rates equal to those in tropical rainforests where extinction rates are the highest. (Ricciardi 1999).

Increasingly stakeholders in urban areas are realizing the benefits that healthy and viable streams bring to the urban landscape. The quality of life of the human population is improved and property values are enhanced. Supported by federal funding and strict stormwater/non-point source pollution rules, local governments have been looking for ways to restore the natural cleansing resources that streams provide in the natural environment. In a comprehensive stormwater plan, reconfigured and partially restored streams and the associated riparian buffers offer many benefits associated with livable communities and sustainable development in addition to the pollution abatement services (Groffman 2003).

Within the reconfiguration and realignment process, stream width is a common factor in most aspects of stream design, such as meanders, pools, and drops. Stream width and depth are determined by site constraints along with water and sediment discharge. The slope of the bed, size of the sediment, and the extent of vegetative margins are also key design elements to ensure stream stability (FISRWG 1998). The objective of this study is to assess the relation of stream width to stream quality as measured by chemical characteristics of the water and measures of the makeup of the aquatic macroinvertebrate populations. By comparing these stream quality parameters within three streams closely associated spatially, we hypothesize that stream width is a determinant of stream quality and may serve to inform stream restoration efforts.

Methods

Study area and design

The study site is in the upper most drainage areas of the Upper Flint River Watershed in southwest Fayette County, Georgia at the confluence of Flat Creek and Line Creek (33.336040°N, −84.537321°W). The climate of the study site has a mean annual minimum temperature of 10.0°C and a mean annual maximum temperature of 22.8°C. Mean annual temperature is 16.4°C. Mean annual precipitation is 129.2 cm (NOAA 2004).

Line Creek comprises the boundary of Coweta and Fayette Counties and is the drainage area for eastern Coweta County to the west and high-density residential areas of Peachtree City to the east. Two municipal sewage treatment plants and a large field sports complex are situated within two kilometers upstream of the Line Creek sample sites. Flat Creek, a tributary of Line Creek, drains high-density residential development of Peachtree City. Residential development is clustered around two lakes, three golf courses and an industrial park straddles the ridgeline separating the Flat Creek and Line Creek catchments. The streams in our study have heavily wooded and wide riparian zones that cover their respective flood plains. The sample sites lie within a 500-meter radius of the Flat Creek and Line Creek confluence easily accessed from a bridge crossing along Rockaway Road along the lower city limits of Peachtree City in south

Fayette County. The characteristics of the area and the associated land use draining to the study site are characterized as "urban" for the purpose of this study (Paul 2001).

Three sample sites each were selected along Line Creek, Flat Creek, and the combined Flat/Line Creek confluence with consideration for easy access to diverse microhabitats. Sample sites were separated along the respective streams by at least 50 meters. Biological samples were collected with a D-frame dip net approximately 30 cm wide. Eleven samples 30 cm in length were collected from each site: Six samples from vegetated margins; three from stream areas with woody debris or other organic matter; and two from the sand and gravel streambed. The total area from the each composite sample is approximately 1-square meter (30 cm x 30 cm x 11 samples = 9900 cm^2 = 0.99 m^2). Each composite sample was placed in a 5-gallon bucket to be examined for macroinvertebrates off-site.

Measurements of water temperature, pH, dissolved oxygen, and conductivity were taken directly in the stream using a Vernier LabPro® interface with probes manufactured by Vernier Software & Technology (Beaverton, Oregon, USA). Dissolved oxygen, conductivity, and pH probes were calibrated before each day of stream chemical measurement using solutions traceable to national standards.

Statistical Analysis

One-way ANOVA statistical tests of differences in means were conducted comparing three stream widths. Flat Creek, Line Creek, and the Flat/Line Creek confluence were the three treatments in our experiment as small, medium and large streams. Dependent variables were direct measurement values of dissolved oxygen (mg/l), pH, conductivity (µS/cm), and water temperature (°C). Calculated dependent variables were species diversity as measured by the Shannon Index (Hs), and (S), species abundance (Stiling 2002). The water quality index used in the Georgia Adopt-a-Stream program was also calculated and evaluated statistically. This index takes into account the relative tolerance of different species of aquatic macroinvertebrates to the stresses of pollution (GAAS 2008).

Results

Measurements of the width of the streams at the sample sites from Flat Creek, Line Creek and the Flat/Line Creek confluence averaged 5, 7 and 12 meters respectively. Samples were collected during a five-week period in October and November and the period was characterized by falling ambient and water temperatures. There were also significant rain events that resulted in the rivers overflowing their banks on three occasions during the period.

Overall, there were no significant differences on average between the different stream widths in terms of the chemical characteristic dependent variables measured (Table 1).

The effect of stream width between the sites were not significant species diversity, species abundance, or AAS index .

Discussion

The finding of no significance in the sample data among the three stream widths indicate that other influences may be a factor in overall stream quality. The influence of similar land uses and extensive riparian buffers in the catchments of Line creek and Flat Creek and the associated anthropomorphic effects may act upon the streams equally and minimize its effect as a major determinant in macroinvertebrate abundance and diversity.

Studies suggest that land use activities are important factors affecting native mussel species, and aquatic insects by affecting the habitat of aquatic species primarily by the increase in impervious surface area especially when this activity diminishes the integrity of the riparian zone (Diamond 2002). According to the official web-site, Peachtree City, is among the few communities in the United States that was totally planned from its origins in 1959 from rural crossroad communities in western Fayette County. This advanced planning and strict buffer codes conserved generous greenbelts that are typically located along main drainage areas. Larger corridors protect feeder streams and neighborhood design codes are based on ecological parameters that sustain contiguous habitat for native wildlife. Studies indicate that the influence of impervious surfaces are mitigated if the flows drain through pervious land rather than directly to streams through pipes (Walsh 2005).

In a similar study of mussel diversity, richness, and abundance in the Lower Flint River Watershed, riparian wetland cover was found to be the best predictor of these three parameters at the microhabitat level (Gagnon 2006). There is no doubt among ecologist that extensive urban development has a negative impact on stream ecology, but it is difficult to quantify. Flat Creek and Line Creeks are impacted by the extent of impervious surfaces and are sensitive to current and future land use, but are able to retain quality and stability by the retention of much of their native riparian buffer (Niezgoda 2005). In a longitudinal study of Line Creek and the associated rapid residential development, historical mussel data were compared with recent samples and correlated with GIS measurements of increases in impervious surface area. The results indicate that sites below the Flat/Line Creek confluence lost more than 50% of their mussel species. The study could not claim that urbanization caused loss of mussel species, but that based on many factors, they were “associated” (Gillies 2003).

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Figure 1. Effect of stream width on average (+/- 1 S.E.) water temperature. No significant differences observed.

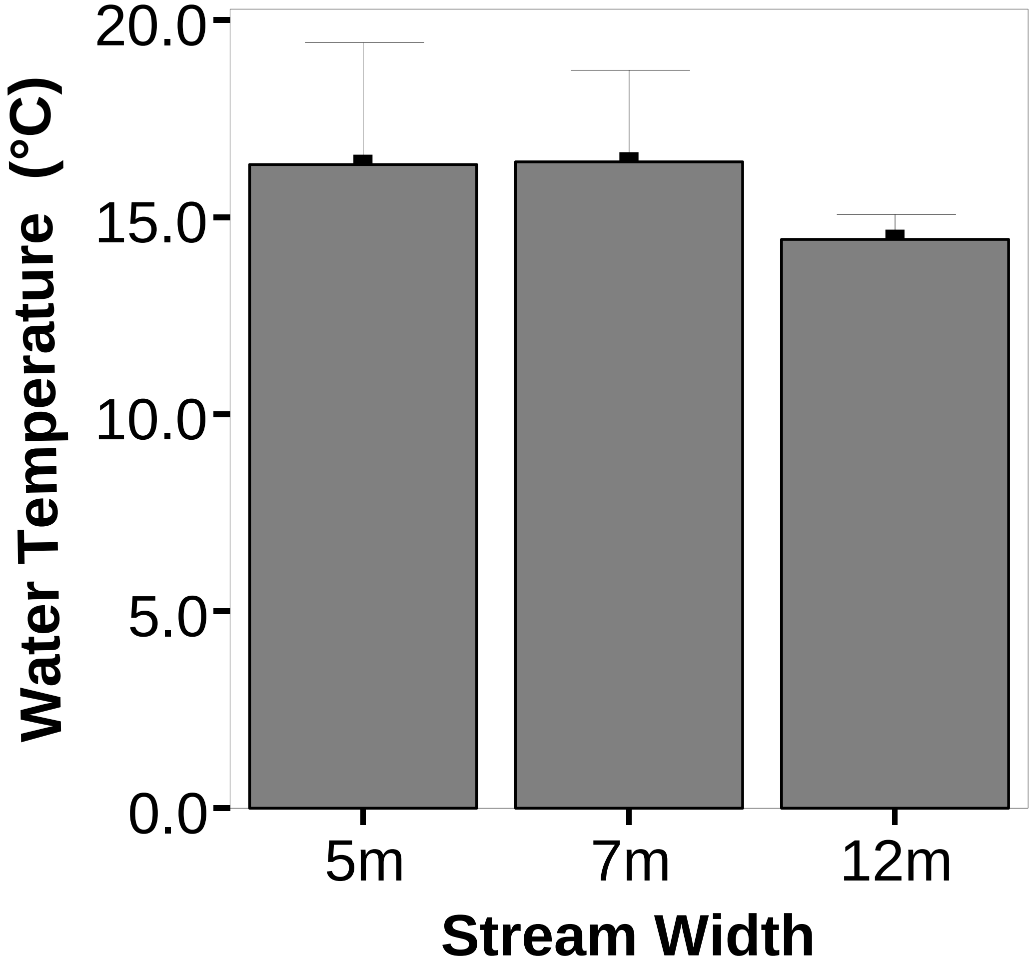

Figure 2. Effect of stream width on average (+/- 1 S.E.) pH. No significant differences observed.

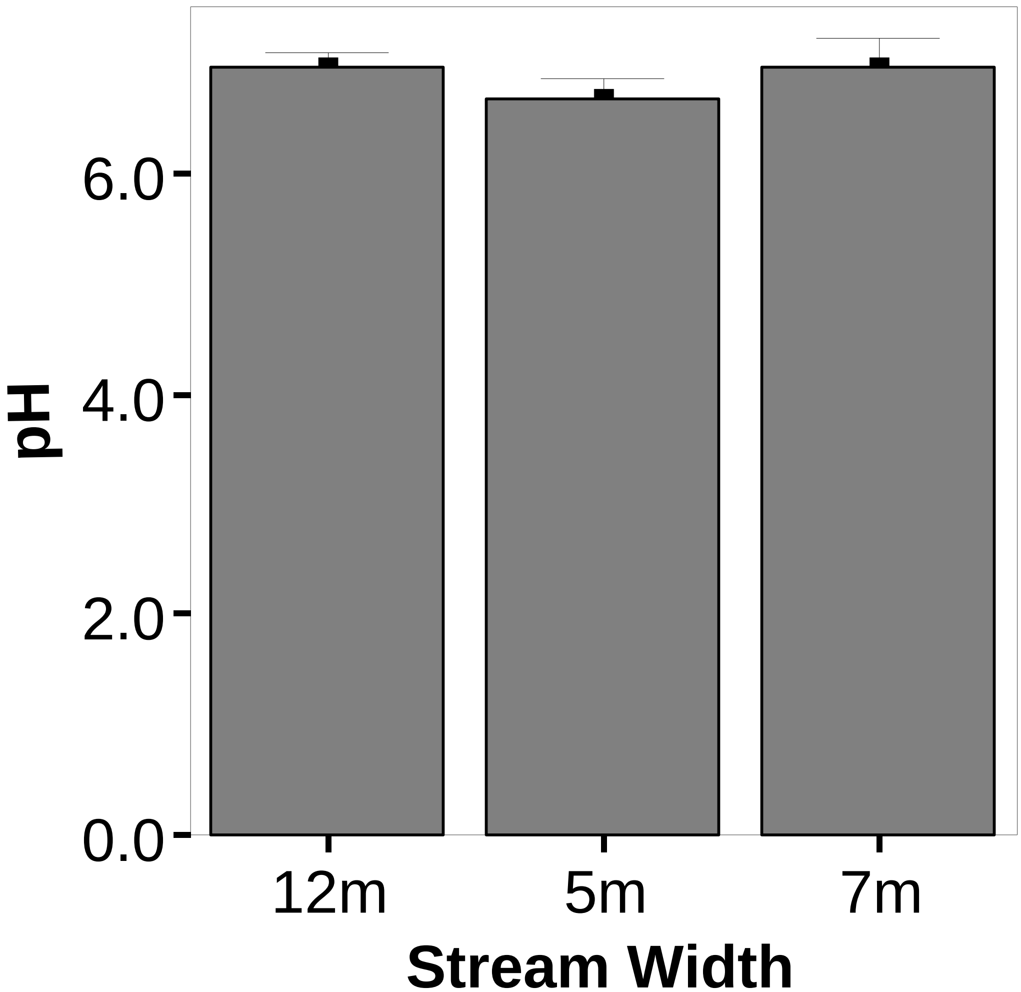

Figure 3. Effect of stream width on average (+/- 1 S.E.) dissolved oxygen. No significant differences observed.

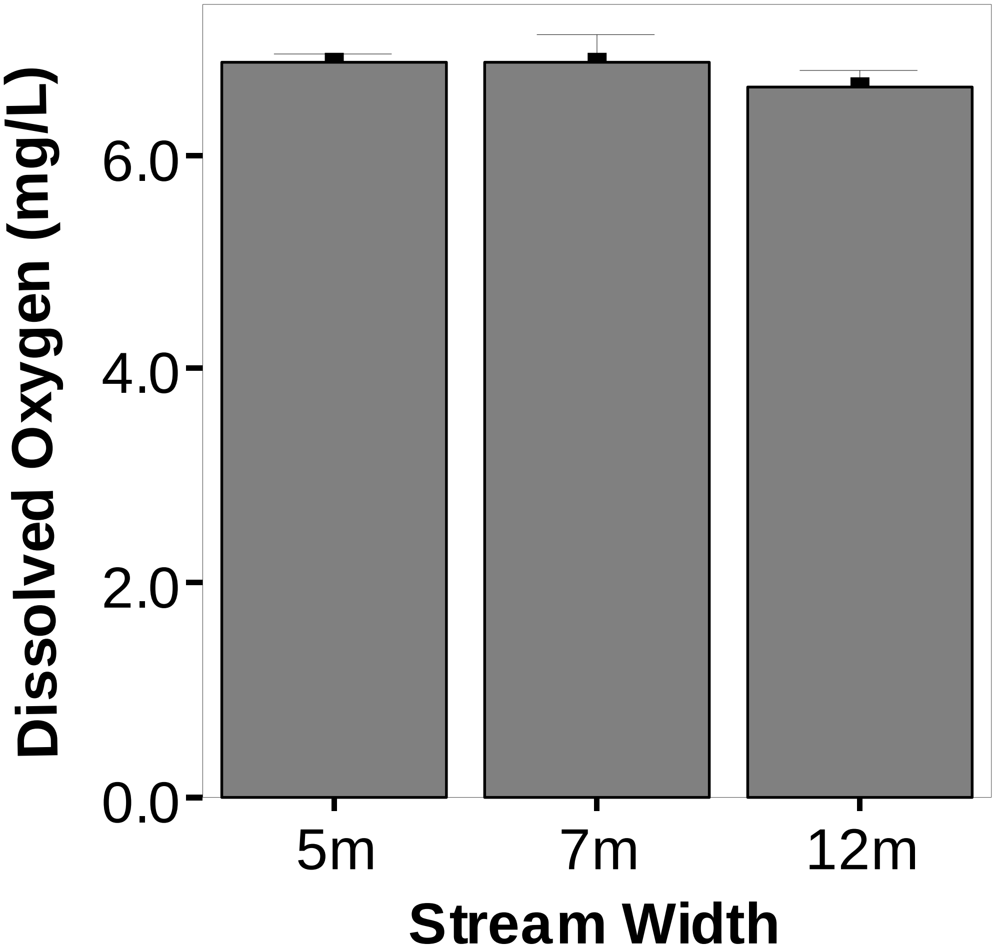

Figure 4. Effect of stream width on average (+/- 1 S.E.) conductivity. No significant differences observed.

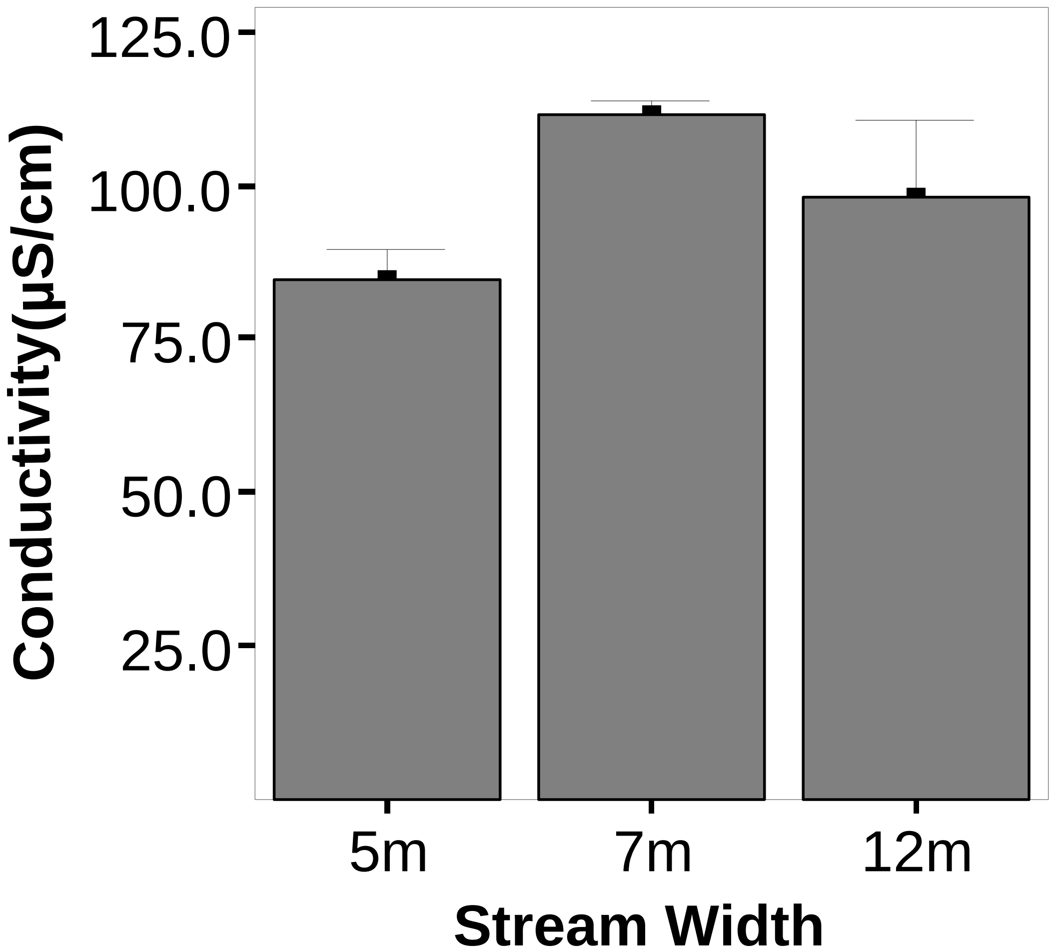

Figure 5. Effect of stream width on average (+/- 1 S.E.) Shannon diversity index. No significant differences observed.

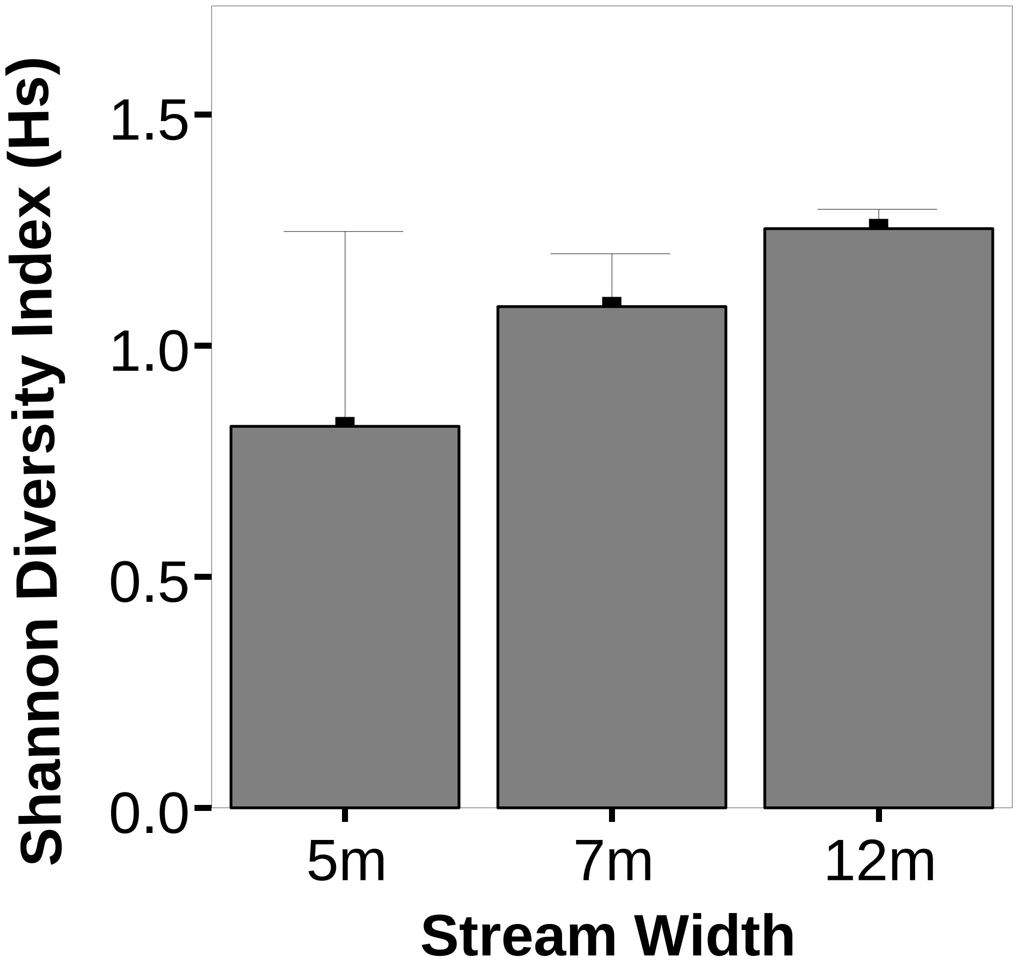

Figure 6. Effect of stream width on average (+/- 1 S.E.) species abundance. No significant differences observed.

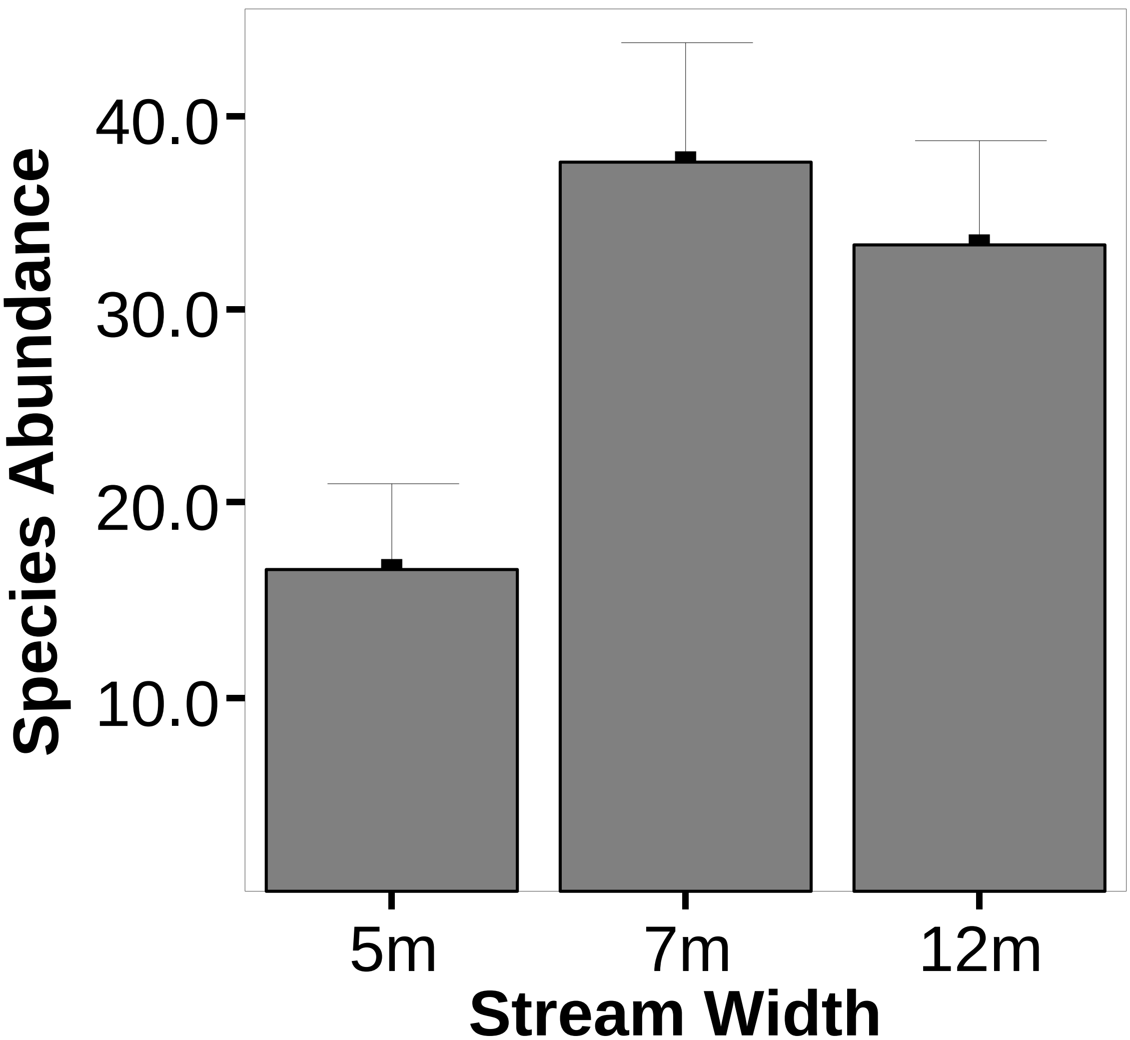

Figure 7. Effect of stream width on average (+/- 1 S.E.) AAS stream quality index. No significant differences observed.

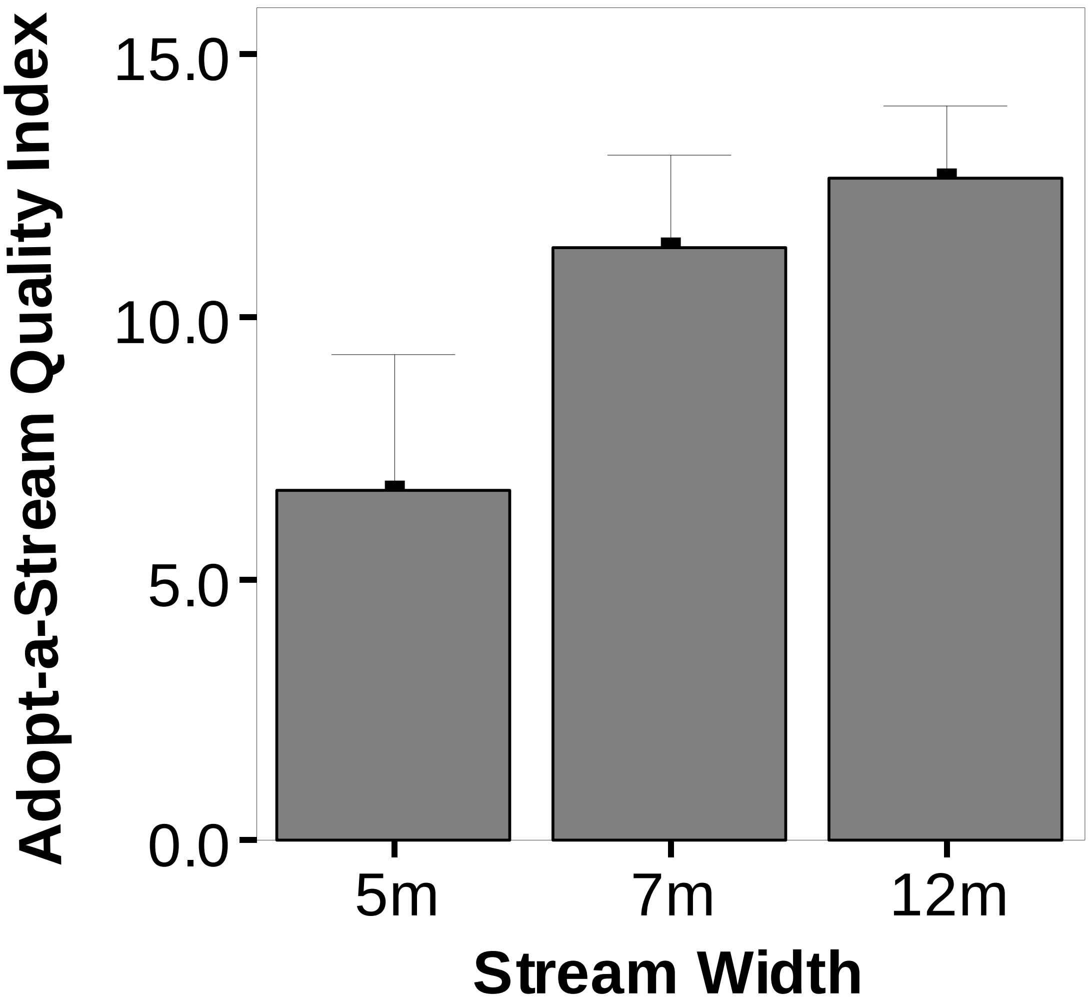

Table 1. Chemical and Biological measurements of three stream treatments at Flat Creek and Line Creek Confluence, Fayette County, GA. Three samples each from Flat Creek, Line Creek and Flat/Line Confluence were tested for water temperature, pH, dissolved oxygen, and conductivity. Biological parameters measured the diversity, abundance, and Adopt-a-Stream quality index for macroinvertebrates in the three stream treatments. Air Temperature measurements were taken at the sample site for reference purposes only.

Samples	Stream Width (m)	Air Temp (°C)	Water Temp (°C)	pH	DO (mg/L)	Conduc-tivity (µS/cm)	Shannon Diversity Index (Hs)	Species Abundance (S)	AAS Index
Flat Creek 1	5.9	24.1	22.5	6.3	6.9	75.2	1.12	24	7
Flat Creek 2	5.0	17.3	13.1	6.9	6.7	89.0	0	9	2
Flat Creek 3	5.0	16.9	13.3	6.8	7.0	90.0	1.36	17	11
Line Creek 1	7.6	19.1	21.0	6.5	7.4	108.6	0.97	36	12
Line Creek 2	7.4	19.1	14.1	7.3	6.6	110.7	1.31	49	14
Line Creek 3	7.3	19.3	14.1	7.1	6.6	115.6	0.97	28	8
Line/Flat Creeks 1	13.4	19.5	13.2	6.8	6.9	123.1	1.21	44	14
Line/Flat Creeks 2	12.1	16.0	15.1	6.9	6.6	85.9	1.21	30	10
Line/Flat Creeks 3	12.0	16.5	15.1	7.2	6.4	84.6	1.34	26	14

Table 2. Results of 1-way ANOVA tests.

Samples	F	Degrees of Freedom	P-Value
Air Temp (°C)	0.589	2,6	0.584
Water Temp (°C)	0.232	2,6	0.800
pH	0.844	2,6	0.475
DO (mg/L)	0.544	2,6	0.606
Conductivity (µS/cm)	2.912	2,6	0.131
Shannon Diversity Index	0.727	2,6	0.522
Species Abundance	4.288	2,6	0.070
AAS Index	2.552	2,6	0.158

Note: The following data tables were not part of the report. Data was presented in summary form in tables 1 and 2.

Macroinvertibrate Data

Sample Macroinvertibrates	Order	Flat Creek 1	Flat Creek 2	Flat Creek 3	Line Creek 1	Line Creek 2	Line Creek 3	Line Flat Conf.1	Line Flat Confl.2	Line Flat Confl.3
Clams	Bivalvia	11	9	3	25	26	17	27	3	16
Crayfish	Decapoda	3		7	4	11	8	8	8	2
Mayfly Larva	Ephemeroptera			1	3	8		2		
Dragonfly Nymph	Odonata				5	2	2	2		1
Damselfly Nymph	Odonata	9		5		2	1	3	1	2
Mussels	Bivalvia									2
Water Boatman	Hemipotera	1								2
Gilled Snail	Gastropoda				1			2		
Aquatic Sowbug	Isopoda			1						
Aquatic Worms	Oligochaeta					1			2	
Cadisfly Larva	Trichoptera								16	
Dobsonfly Larva	Megaloptera									1

Diversity Data Calculations

Des	Variety	# of Indiv.	Pi	ln(pi)	H'
FC1	Clams	11	0.458	-0.78016	-0.357573
FC1	Crayfish	3	0.125	-2.07944	-0.259930
FC1	Damselfly Nymph	9	0.375	-0.98083	-0.367811
FC1	Water Bug	1	0.042	-3.17805	-0.132419
		24			1.12
FC2	Clams	9	1.000	0	0
FC2		9			
FC2					
FC2					
FC3	Clams	3	0.176	-1.7346	-0.306106
FC3	Crayfish	7	0.412	-0.8873	-0.365360

FC3	Damselfly Nymph	5	0.294	- 1.22378	-0.359934
FC3	Mayfly Nymph	1	0.059	- 2.83321	-0.166660
FC3	Aquatic Sowbug	1	0.059	- 2.83321	-0.166660
		17			1.36

LC1	Clams	25	0.694	- 0.36464	-0.253224384
LC1	Crayfish	4	0.111	- 2.19722	-0.244136064
LC1	Damselfly Nymph	1	0.028	- 3.58352	-0.099542193
LC1	Dragonfly Nymph	5	0.139	- 1.97408	-0.27417792
LC1	Gilled Snail	1	0.028	- 3.58352	-0.099542193
		36			0.97

LC2	Clams	26	0.531	- 0.63372	-0.336261587
LC2	Crayfish	11	0.224	- 1.49393	-0.335370924
LC2	Damselfly Nymph	2	0.041	- 3.19867	-0.130558086
LC2	Dragonfly Nymph	2	0.041	- 3.19867	-0.130558086
LC2	Aquatic Worm	1	0.020	- 3.89182	-0.079424904
LC2	Mayfly Nymph	8	0.163	- 1.81238	-0.295898572
LC2		49			1.31

LC3	Clams	17	0.607	- 0.49899	-0.302958922
LC3	Crayfish	8	0.286	- 1.25276	-0.357932277
LC3	Damselfly Nymph	1	0.036	-3.3322	-0.119007304
LC3	Dragonfly Nymph	2	0.071	- 2.63906	-0.188504095
		28			0.97

LF1	Clams	27	0.614	- 0.48835	-0.299671017
LF1	Crayfish	8	0.182	-	-0.309954199

				1.70475	
LF1	Damselfly Nymph	3	0.068	-2.68558	-0.183107546
LF1	Dragonfly Nymph	2	0.045	-3.09104	-0.14050193
LF1	Gilled Snail	2	0.045	-3.09104	-0.14050193
LF1	Mayfly Nymph	2	0.045	-3.09104	-0.14050193
		44			1.21

LF2	Clams	3	0.100	-2.30259	-0.230258509
LF2	Crayfish	8	0.267	-1.32176	-0.352468224
LF2	Damselfly Nymph	1	0.033	-3.4012	-0.113373246
LF2	Aquatic Worms	2	0.067	-2.70805	-0.18053668
LF2	Caddis Fly Nymph	16	0.533	-0.62861	-0.335257952

LF3	Clams	16	0.615	-0.48551	-0.29877404
LF3	Crayfish	2	0.077	-2.56495	-0.197303797
LF3	Damselfly Nymph	2	0.077	-2.56495	-0.197303797
LF3	Mussel	2	0.077	-2.56495	-0.197303797
LF3	Waterbug	2	0.077	-2.56495	-0.197303797
LF3	Dobsonfly Larva	1	0.038	-3.2581	-0.125311405
LF3	Dragonfly Nymph	1	0.038462	-3.2581	-0.125311405
		26			1.34

SPSS[DataSet1] C:\Program Files (x86)\SPSS Student\Stream.sav

Between-Subjects Factors

		N
Width	5.00	3
	7.00	3
	12.00	3

Tests of Between-Subjects Effects

Dependent Variable: AirTemp

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.842[a]	2	3.921	.589	.584
Intercept	3128.538	1	3128.538	469.986	.000
Width	7.842	2	3.921	.589	.584
Error	39.940	6	6.657		
Total	3176.320	9			
Corrected Total	47.782	8			

a. R Squared = .164 (Adjusted R Squared = -.115)

Tests of Between-Subjects Effects

Dependent Variable: WaterTemp

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.109[a]	2	3.554	.232	.800
Intercept	2224.694	1	2224.694	145.363	.000
Width	7.109	2	3.554	.232	.800
Error	91.827	6	15.304		
Total	2323.630	9			
Corrected Total	98.936	8			

a. R Squared = .072 (Adjusted R Squared = -.238)

Tests of Between-Subjects Effects

Dependent Variable: pH

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.180[a]	2	.090	.844	.475
Intercept	424.360	1	424.360	3978.375	.000
Width	.180	2	.090	.844	.475
Error	.640	6	.107		
Total	425.180	9			
Corrected Total	.820	8			

a. R Squared = .220 (Adjusted R Squared = -.041)

Tests of Between-Subjects Effects

Dependent Variable: DO

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.109[a]	2	.054	.544	.606
Intercept	414.801	1	414.801	4148.011	.000
Width	.109	2	.054	.544	.606
Error	.600	6	.100		
Total	415.510	9			
Corrected Total	.709	8			

a. R Squared = .154 (Adjusted R Squared = -.129)

Tests of Between-Subjects Effects

Dependent Variable: Conduc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1085.616[a]	2	542.808	2.912	.131
Intercept	86573.254	1	86573.254	464.382	.000
Width	1085.616	2	542.808	2.912	.131
Error	1118.560	6	186.427		
Total	88777.430	9			
Corrected Total	2204.176	8			

a. R Squared = .493 (Adjusted R Squared = .323)

Tests of Between-Subjects Effects

Dependent Variable: H

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.277[a]	2	.138	.727	.522
Intercept	10.007	1	10.007	52.565	.000
Width	.277	2	.138	.727	.522
Error	1.142	6	.190		
Total	11.426	9			
Corrected Total	1.419	8			

a. R Squared = .195 (Adjusted R Squared = -.073)

Tests of Between-Subjects Effects

Dependent Variable: S

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	737.556[a]	2	368.778	4.288	.070
Intercept	7685.444	1	7685.444	89.366	.000
Width	737.556	2	368.778	4.288	.070
Error	516.000	6	86.000		
Total	8939.000	9			
Corrected Total	1253.556	8			

a. R Squared = .588 (Adjusted R Squared = .451)

Tests of Between-Subjects Effects

Dependent Variable: AAS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	59.556[a]	2	29.778	2.552	.158
Intercept	940.444	1	940.444	80.610	.000
Width	59.556	2	29.778	2.552	.158
Error	70.000	6	11.667		
Total	1070.000	9			
Corrected Total	129.556	8			

a. R Squared = .460 (Adjusted R Squared = .280)

Between-Subjects Factors

		N
Width	5.00	3
	7.00	3
	12.00	3

Tests of Between-Subjects Effects

Dependent Variable: AirTemp

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.842(a)	2	3.921	.589	.584
Intercept	3128.538	1	3128.538	469.986	.000
Width	7.842	2	3.921	.589	.584
Error	39.940	6	6.657		
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Width	7.109	2	3.554	.232	.800
Error	91.827	6	15.304		
Total	2323.630	9			
Corrected Total	98.936	8			

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Source	Type III Sum of Squares	df	Mean Square	F	Sig.
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Intercept	424.360	1	424.360	3978.375	.000
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a R Squared = .154 (Adjusted R Squared = -.129)

Tests of Between-Subjects Effects

Dependent Variable: Conduc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1085.616(a)	2	542.808	2.912	.131
Intercept	86573.254	1	86573.254	464.382	.000
Width	1085.616	2	542.808	2.912	.131
Error	1118.560	6	186.427		
Total	88777.430	9			
Corrected Total	2204.176	8			

a R Squared = .493 (Adjusted R Squared = .323)

Tests of Between-Subjects Effects

Dependent Variable: H

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.277(a)	2	.138	.727	.522
Intercept	10.007	1	10.007	52.565	.000
Width	.277	2	.138	.727	.522
Error	1.142	6	.190		
Total	11.426	9			
Corrected Total	1.419	8			

a R Squared = .195 (Adjusted R Squared = -.073)

Tests of Between-Subjects Effects

Dependent Variable: S

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	737.556(a)	2	368.778	4.288	.070
Intercept	7685.444	1	7685.444	89.366	.000
Width	737.556	2	368.778	4.288	.070
Error	516.000	6	86.000		
Total	8939.000	9			
Corrected Total	1253.556	8			

a R Squared = .588 (Adjusted R Squared = .451)

Tests of Between-Subjects Effects

Dependent Variable: AAS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	59.556(a)	2	29.778	2.552	.158
Intercept	940.444	1	940.444	80.610	.000
Width	59.556	2	29.778	2.552	.158
Error	70.000	6	11.667		
Total	1070.000	9			
Corrected Total	129.556	8			

a R Squared = .460 (Adjusted R Squared = .280)