THE EFFECTS OF LOG WEIRS ON THE AQUATIC MACROINVERTEBRATE COMMUNITY OF A CHANNELIZED STREAM

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The Effects of Log Weirs on the Aquatic Macroinvertebrate Community of a Channelized Stream

A Thesis

Presented for the

Master of Science

Degree

Austin Peay State University

Kevin L. Buchanan

May 1995

Abstract

The effects of log weirs on the aquatic macroinvertebrate community of Brushy Branch Creek, a channelized stream in West Tennessee, were investigated. Aquatic macroinvertebrates were sampled using artificial substrate samplers placed upstream and downstream from the weirs. The upstream macroinvertebrate community was compared to the downstream macroinvertebrate community utilizing the Jaccard community similarity index as well as the following community metrics: abundance, taxa richness, Shannon-Weiner diversity, biotic index, the percentage of Ephemeroptera, Plecoptera, and Trichoptera, and the ratio of Ephemeroptera, Plecoptera, and Trichoptera to Chironomidae. The two communities were found to be very dissimilar with the downstream community having significantly higher abundance, percentage of Ephemeroptera, Plecoptera, and Trichoptera, and ratio of Ephemeroptera, Plecoptera, and Trichoptera to Chironomidae. The downstream community had a significantly lower biotic index. These results suggest that the downstream community was significantly less tolerant of pollution and therefore more healthy than the upstream community. It was concluded that the log weirs are improving the habitat quality of Brushy Branch Creek, both by removimg sediments from the water as well as providing an increase in available habitat.

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Introduction

The water quality of the West Sandy Creek (WSC) embayment of Kentucky Lake in Henry County, Tennessee is characterized as poor (Finley and Hamilton, 1991). Water quality problems are attributed in part to nonpoint source (NPS) pollutants. NPS pollutants include excessive sediments, fecal bacteria, organic nutrients, and certain metals, particularly manganese. In 1992, the Austin Peay State University Center for Field Biology began a five-year research project to monitor and reduce NPS pollution to improve water quality in the WSC watershed. A number of best management practices (BMPs) for improving water quality in the WSC watershed were proposed and implemented (Finley et al., 1992). One such BMP was the use of instream structures for the mitigation of the effects of stream channelization.

Stream channelization is a common practice for flood control and the draining of wetlands throughout the United States (Simpson et al., 1982) including West Tennessee (Hupp, 1992). Most of the streams in West Tennessee were channelized by 1926 (Hupp, 1992), and were rechannelized from the 1950s through the 1970s. Channelization involves dredging, straightening, and clearing of streams. While channelization is an effective means for flood control in the upper and midreaches of the watershed, this practice can be quite detrimental to the water quality and biota, not only in the channelized reaches, but to downstream reaches and other water bodies as well (Simpson et al., 1982). Stream channelization can cause loss of habitat diversity, increased water velocities especially during rain events, increased degradation of stream banks due to scouring, and increased transport of sediments (Carline and Klosiewski, 1985; Hupp, 1992; Simpson et al., 1982).

The adverse effects of stream channelization on fish and invertebrate populations are well documented (Arner et al., 1976; Moyle, 1976; Edwards et al., 1984; Carline and Klosiewski, 1985). These studies report that channelized streams or channelized stretches of streams contain fauna with decreased abundances, biomass, and diversities. These fauna generally consist of organisms with adaptations to conditions such as high sediment loads and/or extreme fluctuations in flow velocities. Although the effects of channelization can be extreme, artificial instream structures, such as artificial riffles and deflectors, can have significant mitigating effects on the fauna of these streams (Carline and Klosiewski, 1985; Edwards et al., 1984).

In October 1992, a series of three 3-log weirs were installed in a channelized reach of Brushy Branch Creek, a third order tributary of Holly Fork Creek in the upper drainage of the WSC watershed. It was theorized by Finley et al. (1992) that these weirs would act to slow down the stream flow and increase the retention time of the stream, thereby reducing the amounts of pollutants transported downstream. Such weirs could also act to return the aquatic community in the channelized reach to a more natural state by increasing habitat diversity and by giving the stream a more natural flow regime. This would enhance the stream's "natural cleansing" ability and thereby improve the water quality downstream.

The goal of this project was to determine the effects of log weirs on the aquatic macroinvertebrate community of Brushy Branch Creek. Aquatic macroinvertebrates are defined by Klemm et al. (1990) as "invertebrates that are large enough to be seen by the unaided eye and which can be retained by a U.S. Standard No. 30 sieve and live at least part of their life cycles within or upon available substrates in a body of water." Aquatic macroinvertebrates are excellent indicators of water quality (Lenat et al., 1990). They are ubiquitous in aquatic environments, there are large numbers of species and individuals, they are sedentary in nature, and they have relatively long life cycles (Rosenberg and Resh, 1993). Other advantages of using aquatic macroinvertebrates for determining water quality include the fact that they are easily collected, their taxonomy is well known, and the responses of many species to different forms of pollution are well documented (Resh and Rosenberg, 1984). It was hypothesized that if the series of weirs on Brushy Branch act to improve water and habitat quality, then this improved state should be indicated by the aquatic macroinvertebrate community downstream from the weirs. It was expected that the upstream and downstream communities would differ in their species compositions, and that the downstream community would be a more abundant and diverse community composed of more species that are intolerant to environmental stresses than the upstream community. To test this hypothesis the downstream macroinvertebrate community was compared to the upstream macroinvertebrate community utilizing the Jaccard community similarity index as well as the following community metrics: abundance (N), taxa richness (S), Shannon-Weiner diversity (H'), biotic index (B.I.), the percentage of Ephemeroptera, Plecoptera, and Trichoptera (% EPT), and the ratio of Ephemeroptera, Plecoptera, and Trichoptera to Chironomidae (EPT:CHIRO).

Macroinvertebrates were sampled using artificial substrate samplers. Artificial substrates, due to lower variabilities among samples, allow for more accurate quantitative sampling than many other methods and allow for better sampling in streams where there are little or no natural substrates conducive to sampling (Cairns, 1982). A very important advantage of artificial substrates is that they provide standardization among samples and allow sites with differing microhabitats to be quantitatively compared (Cairns, 1982).

Study Site

Brushy Branch is a third order tributary of Holly Fork Creek located in the northern portion of the WSC watershed (Fig. 1) in northeastern Henry County, Tennessee. Henry County is located within the East Gulf Coastal Plain physiographic province whose geological formations consist of loose unconsolidated sand, clay, and gravel (Wildermuth, 1958). The predominant soil types through which Brushy Branch flows are Hymon and Beechy silt loams and fine sandy loams.

Land usage in the Brushy Branch watershed is primarily agricultural, consisting mostly of no-till row cropping with some cattle grazing and at least one hog lot operation. Brushy Branch flows through mostly cleared land with occasional woodlots throughout. The stream banks typically include a riparian zone of woody vegetation approximately 3-5 meters wide consisting of multiflora rose, hackberry, river birch, box elder, silver maple, and sycamore.

Brushy Branch is channelized for approximately 2 kilometers before reaching its confluence with Holly Fork Creek. The stream is nearly straight except for occasional slight bends. The stream channel is deeply incised with the banks of the stream being nearly vertical and approximately 3 meters high. The stream bed is nearly flat and ranges from 3 to 6 meters wide. The normal run-riffle-pool sequence of a stream is lacking in Brushy Branch. Riffles are uncommon and when they do exist are usually unstable

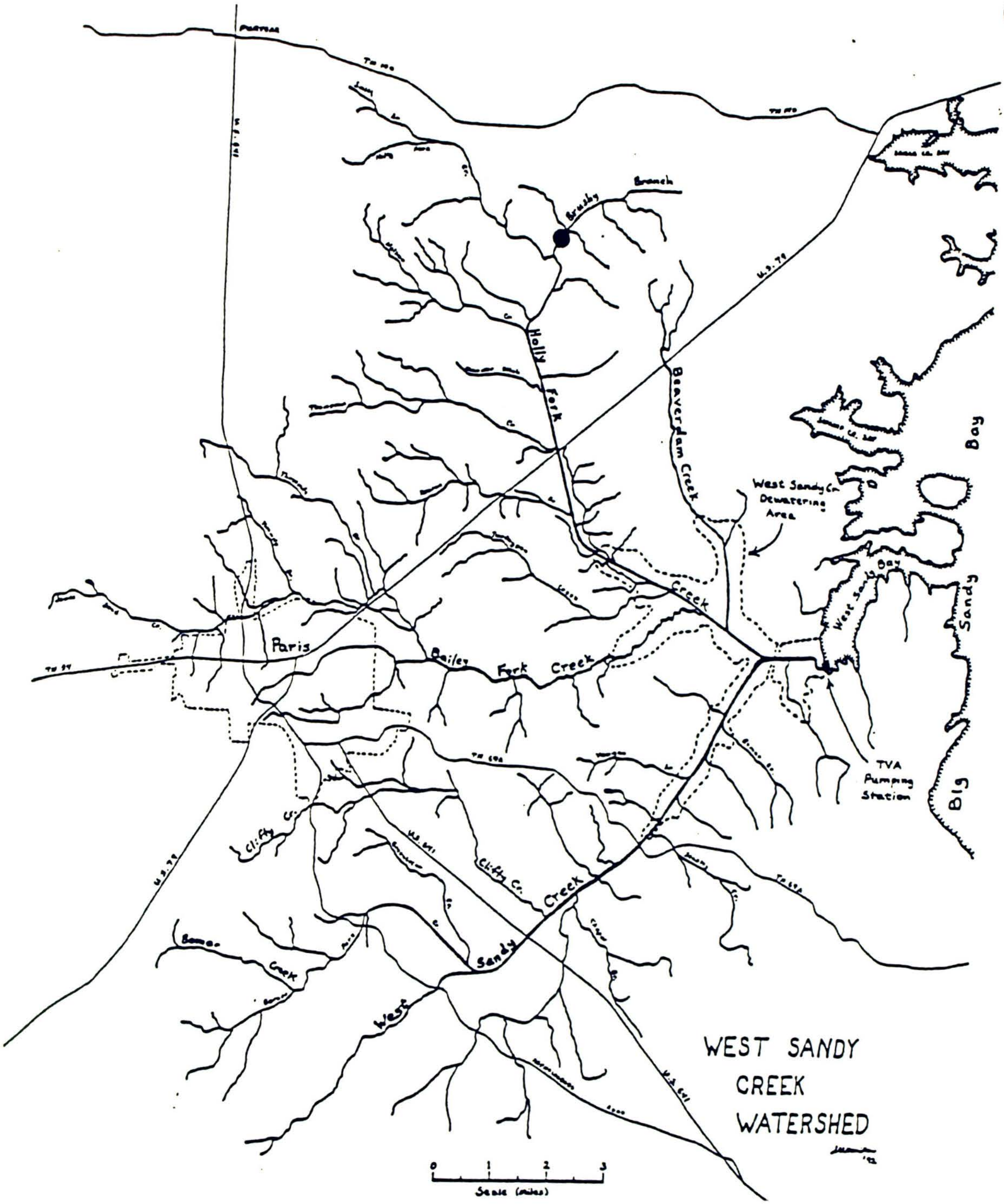
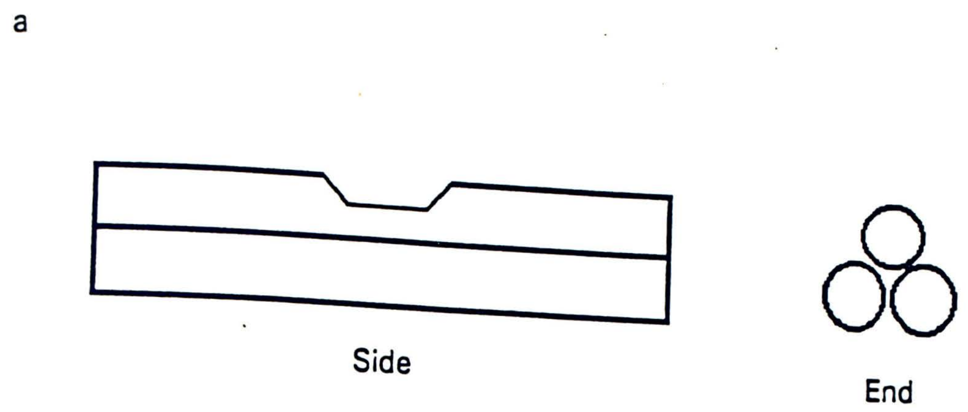


Figure 1. Map of the West Sandy Creek watershed showing the location of the Brushy Branch Creek study site (●).

and composed of sand or fine gravel. Most of the stream bottom is fine sand providing little stable substrate. Occasional tree root masses and snags provide the most significant stable substrates.

In October of 1992, a series of three 3-log weirs were installed approximately 50 meters apart in a channelized section of Brushy Branch. Each weir consisted of three logs, two on the bottom and one on the top (Fig. 2a). Logs were 30-40 cm in diameter and 8 meters in length. The ends of the logs were buried into the banks and covered with riprap. A notch was cut into the center of the top log to allow flow. An apron of riprap was placed on the downstream side of the notch to prevent scouring of the stream bottom and to create an artificial riffle.



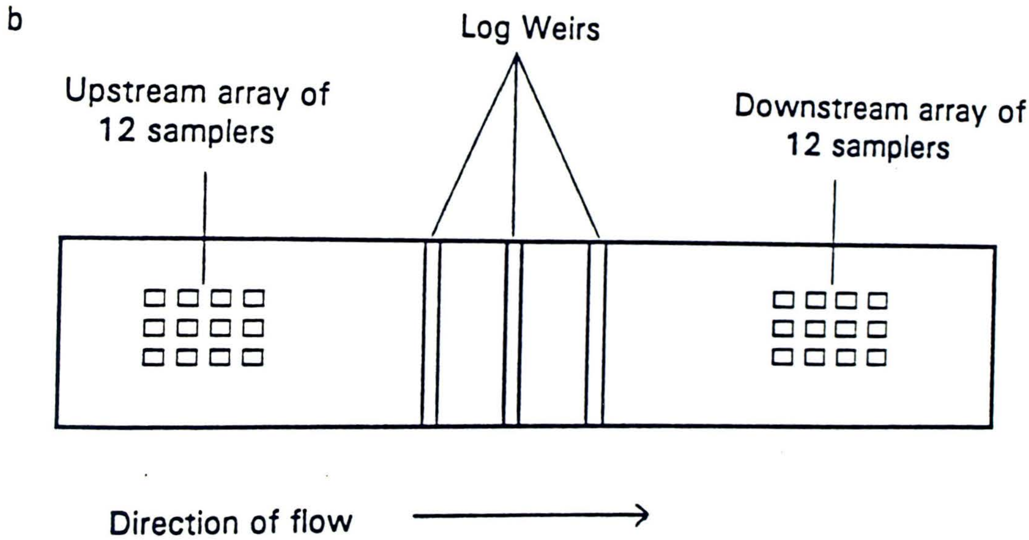


Figure 2. a) Diagram of a three log weir; b) diagram showing arrangement of sampler arrays and log weirs.

Methods

Field Methods

Quantitative sampling of macroinvertebrates above and below the weirs on Brushy Branch Creek began on September 3, 1993. An array of 12 artificial substrate samplers was placed 45 meters above the uppermost weir in a riffle area. A second array of 12 artificial substrate samplers was placed in a riffle 15 meters below the lowermost weir. Each array was comprised of 3 rows of 4 samplers (Fig. 2b). Each sampler consisted of an 18x20 cm plastic mesh pouch filled with rocks. The pouch was made from 3/4 in. plastic aquaculture mesh. The pouches were filled with natural stream rocks that were approximately 5 cm in diameter. Care was taken to be as consistent as possible in the size and number of rocks placed into each pouch. Rocks were scrubbed in detergent, rinsed, and air dried before placing them in the pouches. Samplers were anchored to the stream bottom with steel rods driven into the substrate. Three samplers (one chosen randomly from each row) were removed from each array at intervals of 1, 2, 4, and 6 weeks. Samplers were removed by gently sliding them into one gallon size plastic bags and then detaching them from the anchor rod. Care was taken to dislodge as few macroinvertebrates as possible. The bags were sealed, placed on ice, and transported to the laboratory. Beginning on April 8, 1994, the same sampling scheme was repeated. As before, 1 array of 12 samplers was placed above and below the weirs with three samplers being removed from each array at intervals of 1, 2, 4, and 6 weeks.

In addition to macroinvertebrate sampling, a number of physicochemical measurements were taken above and below the weirs upon each site visit. Temperature, pH, dissolved oxygen, conductivity, and total dissolved solids were measured with a Hydrolab H20 multiparameter water quality data transmitter and Surveyor 3 display unit. Turbidity was determined with a Nephlometric turbiditimeter (HF Scientific Instruments, Model DRT15C).

Laboratory Methods

The samples were washed from the samplers by scrubbing the mesh bags and rocks with a brush. The samples were collected in a no. 40 sieve (0.38 mm opening) and preserved in 80% isopropanol. In most cases, the samples were later allutriated to remove the organisms from the gravel, sand, and other debris which had collected in the sampler.

Using dissecting microscopes all organisms were sorted, identified to the lowest practical taxon (usually genus) and counted. Chironomid larvae were subsampled by randomly choosing 25% of the individuals from each sample. The chironomids from these subsamples were then permanently mounted on glass slides with CMCP-10 mountant and identified to genus by the use of a compound light microscope. Identifications of organisms were made according to Merrit and Cummins (1984) as well as Brigham et al. (1982), Wiederholm (1983), and Pennak (1989).

As a part of the overall monitoring scheme for the WSC project water samples were collected from various sites throughout the WSC watershed. Two of these sites were located on Brushy Branch, one upstream and one downstream from the weirs. Water samples were analyzed for nitrate-nitrite nitrogen, ortho-phosphate, total phosphate, sulfate, total organic carbon, dissolved organic carbon, hardness, and calcium. Chemical sampling of the two sites on Brushy Branch took place for one year prior to and during the current study.

Data Manipulation

For each sample from the fall sampling period the following community metrics were calculated : abundance (N); richness (S); Shannon-Wiener diversity (H'); biotic index (B.I.); percent Ephemeroptera, Plecoptera, and Trichoptera (% EPT); and the ratio of Ephemeroptera, Plecoptera, and Trichoptera to Chironomidae (EPT:CHIRO). Abundance was calculated as the total number of individuals per sample. Richness was calculated as the total number of taxa per sample. Both the abundance and richness of a community are very sensitive to environmental stress with higher richness values being associated with better water quality (Klemm et al., 1990).

Diversity was calculated using the Ecological Analysis Vol. 3-PC computer program (Ekblad, 1989). The formula used to calculate diversity was as follows:

$$H' = -\sum_{i=1}^{s} (p_i \ln p_i)$$

where s is the number of taxa in the sample and p_i is the ratio of the number of individuals in the i^{th} taxa to the total number of individuals in the sample (Ludwig and Reynolds, 1988). Diversity is a measure of species composition which is affected by the number of taxa in a sample and by the distribution of individuals within those taxa (Klemm et al., 1990). Higher diversity values are generally associated with more healthy communities.

The biotic index was calculated according to the following formula:

$$B.I. = \text{Sum } TV_i N_i / \text{Total } N$$

where TV_i is the tolerance value of the i^{th} taxa, N_i is the abundance of the i^{th} taxa, and Total N is the number of individuals in the sample (Lenat, 1993). A lower B.I. indicates the presence of a community with an overall lower tolerance to pollution which is indicative of better water quality.

Percent EPT was calculated as the combined number of individuals belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera divided by the total number of individuals in the sample. EPT:CHIRO was calculated as the number of individuals belonging to EPT taxa in the sample divided by the total number of individuals belonging to the dipteran family Chironomidae in the sample. EPT are generally less tolerant to pollution than other groups, particularly chironomids, and communities with high percentages of EPT are usually indicative of good water quality (Klemm et al., 1990).

Differences between the upstream and downstream site with regard to the above listed six community metrics were analyzed statistically. Differences between sites for individual sampling dates (i.e. 1, 2, 4, or 6 weeks) were examined utilizing a T-test of means calculated with the Keystat-PC software program (Eckblad, 1986). The differences between the upstream and downstream sites for all four sampling dates combined were analyzed as a split plot design with site as the whole plot and sample date as the subplot using the General Linear Models Procedure of the SAS statistical software package (SAS Institute, 1988). All data was log transformed prior to running statistical tests.

The fall 1993 data was further analyzed by calculating a Jaccard Community Similarity Index value between the upstream and downstream sites for each of the four sampling dates. The Jaccard Community Similarity Index measures the similarity between communities based on the presence or absence of taxa. Jaccard Index values range from 0 (no similarity) to 1 (complete similarity). Jaccard Index values were calculated using the Ecological Analysis Vol. 3-PC software package (Eckblad, 1989) by the following formula:

$$\text{Jaccard Index} = C/s1+s2-C$$

where s1 is the number of taxa in community 1, s2 is the number of taxa in community 2, and C is the number of taxa in both communities.

For the spring 1994 samples only abundance and richness were calculated. The upstream and downstream sites differed so greatly in their abundance and richness values that comparisons between the two sites with regard to diversity, B.I., %EPT, and EPT:CHIRO were deemed infeasible. Differences between the upstream and downstream sites for each fall sample date were determined using a T-test.

Differences between the two sites with regard to temperature, pH, dissolved oxygen (D.O.), conductivity, total dissolved solids (TDS), and turbidity were determined by the use of T-tests. T-tests were also used to determine differences between the two sites with regard to nitrate-nitrite nitrogen, ortho-phosphate, total phosphate, sulfate, total organic carbon (TOC), dissolved organic carbon (DOC), hardness, and calcium. In all statistical tests a probability of $p<0.05$ was considered significant.

Results

Fall 1993

A total of 3,542 individuals representing 72 taxa were collected during the fall sampling period. The number of individuals per taxa for each sample are listed in Table 1. Table 2 shows the mean values (3 replicates/site/sampling date) for abundance, taxa richness, diversity, Biotic Index, % EPT, and EPT:CHIRO ratio.

A T-test of means indicated that for the week 6 samples the downstream site had significantly higher abundance relative to the upstream site. The mean abundances for the weeks 1, 2, and 4 samples, although not statistically different, were generally higher downstream. A split plot analysis indicated that the upstream site had a significantly higher abundance for all four sampling dates combined.

The mean value for Biotic Index for the week 6 samples was significantly lower for the downstream site. Means were also lower downstream for the weeks 1, 2, and 4 samples, but did not reach significance. The means for Biotic Index for all four sampling dates combined were significantly lower downstream.

The values for % EPT and EPT:CHIRO ratio were significantly higher downstream for samples from weeks 4 and 6 according to the T-test. The means for these two metrics were somewhat higher for the samples from

Table 1. The number of individuals per taxa for each sampler collected during the fall of 1993 both upstream and downstream from the weirs on Brushy Branch Creek.

	Wk 1						Wk 2						Wk 4						Wk 6					
	UP			DN			UP			DN			UP			DN			UP			DN		
Taxa	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Ephemeroptera																								
Acerpenna		1				3										2		3					1	
Baetisca											1													
Caenis							1													1				1
Eurylophella				1	1		1			2	5	2	6			2		1				5	6	4
Hexagenia									1				7	5										
Paracloeodes					2	1				1	3	1					2		1					
Paraleptophlebia		1	1	4	12	2	1		3	11	4	10				30	13	15				26	36	27
Stenacron								2		8	8	6				33	27	7				26	42	26
Stenonema						3	1			1	3	2				14	2					4		
Baetidae							1							1										
Ephemeropt(undet)											2	10				10	3							
Trichoptera																								
Cheumatopsyche		1	2					3	1															
Hydropsyche								1		1					1									
Hydroptila											1							1						
Lepidostoma																			1					
Oecetis								1			1					1		1				5	1	
Oxyethira		2		5	3	3	2			5	3	1						1				5	4	
Polycentropus				1						3	3	5				9	6	5				5	2	9
Ptilostomis								1		1			3											
Trichopt(undet)																7			1					

Table 1. Continued.

Taxa	Wk 1						Wk 2						Wk 4						Wk 6					
	UP			DN			UP			DN			UP			DN			UP			DN		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Diptera(Chironomid)																								
Ablabesmyia	2	3		3	11	3				7	4	36	**	4		8		4				12	8	8
Brillia			1				4									8					1			
Chironomus			1											12					7					
Cladopelma																			2					
Clinotanypus							4																	
Constempellina																							4	
Corynoneura	1							1							1	15		4		2	2			4
Cricotopus	1	4	1	3	15	2	4	1			4	4	**		4	37	8	17	2	4	4	23	4	11
Cryptochironomus		2					4	2												4				
Cryptotendipes	3						4						**	27										
Dicrotendipes				3	11					3	8	12						4					4	
Labrundinia		1		3	4	3		1	2		12	4	4				4							
Microtendipes							4				4	4				8	4					4	8	
Nanocladius					4			1			12	12	4	4					5					4
Nilotanypus	2	2		3			4	2	2															
Paracladopelma								2	2												3			
Paralauterborniella										3														
Paramerina	2	2		3		7				7	12	12		4			4						4	
Parametriocnemus	1						7		2												1	12		
Paratendipes	1						29		8				4	8					2					
Polypedilum		6	2	3			4	8	5					8	3	8		8	12	27	7	19	4	
Procladius																			2					

Table 1. Continued.

Taxa	Wk 1 UP a	Wk 1 UP b	Wk 1 UP c	Wk 1 DN a	Wk 1 DN b	Wk 1 DN c	Wk 2 UP a	Wk 2 UP b	Wk 2 UP c	Wk 2 DN a	Wk 2 DN b	Wk 2 DN c	Wk 4 UP a	Wk 4 UP b	Wk 4 UP c	Wk 4 DN a	Wk 4 DN b	Wk 4 DN c	Wk 6 UP a	Wk 6 UP b	Wk 6 UP c	Wk 6 DN a	Wk 6 DN b	Wk 6 DN c
Rheotanytarsus	2	1	2	3	4	2		6			8	4				11	16	34	2		4		8	4
Stenochironomus																				2				
Tanytarsus	3	3	5	27	29	4	37	11	10	24	124	103	**	42	3	112	72	85	11	2	6	70	67	61
Thienemannimyia	2	3	1	11	22	20	4	4	7	14	20	67		8	1	19	24	8				39	16	42
Tribelos									2						1									
Zavrelia	2	4	3	3			4			10	12		**	15		8	4		5			12	8	
pupae	2	1		6	4	3	1	3	2	1	12	6	6	6		3	7	8	1	2		19	20	7
Diptera(other)																								
Bezzia									1				7						5	4	2			
Chrysops			1						1	1			2	1	1				2	1	2			
Hemerodromia			1					4						1		1		2			1			
Prosimulium																1								
Tipula									1				3							1	2			
Hexatoma								1							2									
Pseudolimnophila																			1					
Odonata																								
Calopteryx	14	10	3	4	3	3	3	2		2		4	4	3		3	1	1		2		2		1
Dromogomphus							1						4	1						1				
Enallagma										1														
Progomphus	4	5					1	3	7										1		1			

Table 1. Continued.

	Wk 1						Wk 2						Wk 4						Wk 6					
	UP			DN			UP			DN			UP			DN			UP			DN		
Taxa	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Other																								
Ancyronyx																		1						
Ferrissia				1	3					2	1													
Helichus	1																							
Hyalella																			1					
Microvelia	4																							
Nigronia																								1
Orconectes	1												2											1
Physella				1								20						1	1					
Pisidium	1	6					5	1	2				••	3				3	8	1				
Sialis																				1				
Oligochaeta	4	7	3		1		18	4	9	1	2	3	••	8	12	2		1	19	12	18		7	
Plecoptera	1	1	1				1	1							1		1	3		1	2			

Table 2. Mean values (3 replicates/site/exposure time) for abundance, richness, diversity, Biotic Index, % EPT, and EPT:CHIRO ratio for samples collected from Sept. 10 through Oct. 15, 1993, at Brushy Branch Creek. An asterisk (*) indicates that means were significantly different ($p<0.05$) for all four exposure times combined. Two asterisks (**) indicate that the two means were significantly different for that exposure period.

	Exposure Time			
	1 Week	2 Weeks	4 Weeks	6 Weeks
Abundance*				
Up	49.3	94.7	148.3	72.0**
Down	92.0	235.3	256.0	251.0**
Richness				
Up	19.0	23.0	16.7	18.0
Down	16.3	23.0	21.7	17.3
Diversity				
Up	2.67	2.69	2.28	2.34
Down	2.38	2.38	2.29	2.30
Biotic Index*				
Up	6.88	6.92	6.90	7.87**
Down	6.49	6.29	6.37	6.12**
% EPT*				
Up	8.41	8.77	5.63**	3.26*
Down	15.60	18.07	24.97**	31.45**
EPT/CHIRO*				
Up	0.160	0.133	0.097**	0.059**
Down	0.200	0.255	0.350**	0.477**

weeks 1 and 2, though not significant. Both indices were significantly higher downstream for the four sampling dates combined.

There were no significant differences between the upstream and downstream sites with regard to richness or diversity for the four sampling dates combined or for any individual week.

Jaccard Community Similarity Index values between the upstream and downstream sites for the four sampling dates were 0.400, 0.364, 0.320, and 0.235 for weeks 1, 2, 4, and 6, respectively.

Spring 1994

Table 3 shows the total number (3 replicates/site/sampling date combined) of individuals per taxa for the spring sampling period. A total of 1,680 individuals representing 28 taxa (individuals belonging to the family Chironomidae were not identified beyond family for the spring sampling period) were encountered. Table 4 shows the mean values for abundance and richness for each sample date. T-tests showed that the abundances and richness values were significantly higher for the downstream site for each of the four sample dates.

Water Chemistry

T-tests indicated that there were no differences between the upstream and downstream sites for temperature, pH, dissolved oxygen,

Table 3. The combined number of individuals (3 replicates/site/ sampling date) per taxa for samples collected during the Spring of 1994 both upstream and downstream from the weirs on Brushy Branch Creek.

Taxa	Week 1		Week 2		Week 4		Week 6	
	Up	Dn	Up	Dn	Up	Dn	Up	Dn
Acerpenna								6
Amphinemura				3		5		2
Baetis		4		1		2		1
Bezzia			3	5		1	1	3
Baetidae						1		1
Boyeria								1
Caecidotea								1
Dineutus						1		1
Helichus						1		4
Hydroporus				3		3		1
Hydropsyche						2		4
Isonychia								1
Orconectes						1		
Paraleptophlebia				6		4		1
Paracloeodes								1
Perithemis						1		
Physella								1
Pisidium				2				1
Pycnopsyche						1		
Sialis						2	1	1
Simulium						1		
Stenelmis				1				
Tabanus						1		
Tipula		1						1
Hexatoma			1					
Chironomidae		8	4	136	10	461	34	873
Oligochaeta	1			13	8	12	6	19
Plecoptera			1	2	1			

Table 4. Mean values (3 replicates/site/exposure time) for Abundance and Richness for samples collected upstream and downstream from the weirs on Brushy Branch Creek during the Spring, 1994 sampling period. All differences were significant at $p<0.05$.

	Abundance		Richness	
Exposure Time	UP	DOWN	UP	DOWN
1 WEEK	0.3	4.3	0.3	2.0
2 WEEKS	3.0	57.3	2.3	6.3
4 WEEKS	6.3	167.0	2.0	8.7
6 WEEKS	14.0	310.0	2.3	10.0

conductivity, total dissolved solids, or turbidity for either sampling period. There were also no statistical differences between the two sites for nitrate-nitrite nitrogen, ortho-phosphate, total phosphate, sulfate, total organic carbon (TOC), dissolved organic carbon (DOC), hardness, or calcium.

Discussion

The upstream and downstream macroinvertebrate communities differed considerably in the fall 1993 samples as indicated by the Jaccard Community Similarity Index values. In fact they became increasingly dissimilar as the weeks progressed. Macroinvertebrate data also indicate a much healthier community at the downstream site. The downstream site supported significantly more individuals than the upstream site as demonstrated by abundance data. The Biotic Index data indicate that the downstream community was significantly less tolerant to environmental stresses. A lower Biotic Index is generally indicative of better water or habitat quality or both (Lenat, 1993). The idea that the downstream site was of higher quality is further supported by the fact that the downstream site contained significantly more EPT with respect to the total population and with respect to the number of individuals belonging to the family Chironomidae. Organisms belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) are generally considered to be less tolerant to environmental stress and are usually found in streams having cleaner water than most other groups of organisms, especially chironomids (Barton and Metcalfe-Smith, 1992; Lenat, 1993).

The fact that the upstream and downstream sites had distinctly different communities yet did not differ with regard to any physicochemical parameter measured (e.g., pH, D.O., temperature, TDS, TOC, DOC, etc.)

indicates that community differences were probably due to physical differences in the two sites. The two sites differed in their quality of habitats rather than water qualities.

One factor which pertains to habitat quality is simply the amount of habitat available. A computer model of the three weirs in Brushy Branch calculates that they increase the habitat (weighted usable area) up to four-fold. Most of this habitat is associated with the weirs and the downstream rock aprons (J. A. Gore, pers. comm.).

Another major factor influencing habitat quality in channelized streams is the large amounts of sediments/organics transported from upstream (Simpson et al., 1982). Sedimentation fills in the interstitial spaces between natural substrates turning an otherwise heterogeneous habitat into a more homogeneous one. Excessive sedimentation can be harmful to macroinvertebrates either directly due to smothering or interfering with feeding, or indirectly by decreasing light and interfering with the overall food chain processes (Resh and Rosenberg, 1984).

Sedimentation was quite evident at the upstream site during the fall sampling period. By the second week of exposure, the upstream samplers were beginning to show signs of sedimentation. By the fourth week the upstream samplers were approximately 50% covered by fine sand. By the sixth and final week only small portions of the remaining upstream samplers were visible. The samplers at the downstream site remained clear of sedimentation throughout the 6 week sampling period.

This trend of heavy sedimentation at the upstream site was more pronounced during the spring sampling period. This period was characterized by heavy weekly rains. By the end of the first week of exposure, the upstream samplers were completely covered with sediments. The samplers continued to become covered during each exposure period even though the overlying material was removed by hand at each visit to the site. The downstream samplers remained mostly clear of sediments during spring sampling although there was some accumulation of small gravel in and around the samplers. This extreme difference between the two sites with regard to the ratio of sedimentation is reflected by the macroinvertebrate communities. In fact the macroinvertebrate communities were so greatly different that only abundance and richness values were calculated. Macroinvertebrates in the downstream site were much more abundant and diverse compared with those in the upstream site.

The efficacy of the weirs on Brushy Branch Creek to remove sediments from the stream and to prevent those sediments from being transported downstream was obvious. By the end of the spring of 1994, after only one and a half years, the pool created by the upper weir was filled with sediments. The pool above the second weir was nearly half full and the third weir was beginning to show signs of filling.

In conclusion, macroinvertebrate data clearly indicate that the weirs are improving habitat quality of Brushy Branch Creek, both by providing an increase in available habitat and by removing sediments from the water. In addition, the weirs are effective sediment traps which are preventing large amounts of sediments from being transported downstream to Holly Fork Creek and the West Sandy Creek embayment.

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List of References

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