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Assessing Small Streams in the Upper Ocmulgee Watershed Using the Georgia Adopt-a-Stream Macroinvertebrate Monitoring Protocols

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ASSESSING SMALL STREAMS IN THE UPPER OCMULGEE WATERSHED USING THE GEORGIA ADOPT-A-STREAM MACROINVERTEBRATE MONITORING PROTOCOLS

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ABSTRACT

Using Georgia Adopt-A-Stream's (AAS) volunteer macroinvertebrate monitoring protocol, we examined how several streams' macroinvertebrate communities differed with the land usage surrounding each stream reach. Our study sites included various headwater streams and larger tributaries of the South River within the upper Ocmulgee watershed. We sampled at different locations from January 2007 through June 2007 in a parking lot, in a wetland, several forests, and suburban parks within Clayton, Henry, and Rockdale counties, including *Panther Creek, Big Cotton Indian Creek, Bush Creek, Martin Creek*, and an unnamed tributary of *Alexander's Lake* at Panola Mountain State Park. Sites in parking lots and suburban parks had macroinvertebrate communities which scored in the poor range on the AAS scale, whereas sites in forests and wetlands scored in the range considered fair or good.

Key Words: Stream Ecology, Macroinvertebrate, Impervious Surface, Georgia Adopt-A-Stream, Volunteer Monitoring, Ocmulgee, land use, disturbance

INTRODUCTION

Both professional stream ecologists and volunteer stream monitors are interested in knowing what makes a stream suitable for an aquatic macroinvertebrate community. Many published studies suggest the watershed surrounding a stream is a key impacting factor, and in fact, deforestation and impervious surface can degrade a stream. Removing forest vegetation surrounding a stream decreases woody debris input, and thus reduces habitat and food available for macroinvertebrates (1). Any form of land development that involves the removal of forested areas increases the amount of impervious surface which increases runoff, peak discharge, and pollutants into streams (2). Beyond these well-established principles, there is some debate as to how much an entire watershed affects a particular stream reach, and recent studies are focusing and whether local land use makes any difference at all. Burcher and Benfield (3) sampled 3rd and 4th order streams from agricultural and recently suburbanizing watersheds, but found only very subtle differences between them for macroinvertebrate assemblages. Roy *et al*. (4) reported that the presence or absence of forest canopy cover at the stream reach scale had no effect upon habitat quality or macroinvertebrate richness in study sites within urban catchments. On the other hand, Schiff and Benoit found that amount of impervious surface within the 100 m buffer area within the 5 km^2 surrounding a stream, negatively influenced the stream's water quality and macroinvertebrate indices more than entire upstream watershed (5). Because some studies show that the immediate land use adjacent to a stream reach is important, whereas others suggest that that the land use over an entire watershed is more important, the importance of local land usage is under debate. Thus, in our investigation, we asked the question, "does the type of local land usage immediately adjacent to the stream affect the macroinvertebrate community?"

We examined several different streams in sites differing in levels of suburban development ranging from nearly pristine forest preserves and wetlands to suburban parks, and a site surrounded by 100% impervious surface (a parking lot). Small streams and their headwaters were chosen for this project because 80% of the stream network in North America consists of this stream order, and are generally overlooked for protection, despite their importance (6, 7). Usually, small headwater streams depend upon vegetative input such as leaves, branches, and logs that are deposited from the surrounding watershed, and these inputs are influenced by stream order (8).

Being quick and relatively inexpensive, Georgia Adopt-a-Stream's volunteer monitoring protocols were ideal for this two-semester research project (2, 9, 10). The biological protocol, for instance, requires volunteers to identify macroinvertebrates to taxonomic order, thus eliminating the daunting task of identification to species. Several published studies have investigated this simple, but reliable approach. Engel and Voshell (11) confirmed that volunteers in Virginia's Save Our Streams program could correctly categorize an acceptable stream using coarser taxonomic levels such as order, but found that unacceptable streams are sometimes overrated, due to the way that the scores are calculated. Winn et al. (7) found that the Georgia Adopt-a-Stream (AAS) protocol was valid as an indicator of stream macroinvertebrate quality, and the use of coarse taxonomic levels involved less ecological noise. Muenz *et al*. (12) verified that the AAS water quality index corresponded well to professional metrics, and showed that the volunteer protocol correctly identified streams as either protected or impaired based upon the macroinvertebrates present.

MATERIALS AND METHODS

Locations of study sites

All of our study sites were within 45 minutes driving distance of Clayton State University in the city of Morrow, a suburb to the south of Atlanta, Georgia (see inset of Figure 1). We specifically selected nine study sites that had safe and easy stream access (2), and were located in the upper Ocmulgee watershed, Hydrologic Unit Code 03070103, in Clayton, Henry, and Rockdale counties. We registered all of these sites with Georgia Adopt-A-Stream, so that their locations and all data we collected could be available in the future for public use on the Internet. We classified study sites by land use type; one study site was adjacent to a parking lot, two were in suburban parks, one was downstream from a wetland, and the remaining five were in forest. As shown in Figure 1, our parking lot site (CSU) was an unnamed tributary that we considered to be the headwaters of *Panther Creek*, between a parking lot and a busy road on Clayton State University's campus in Morrow. Sites in suburban parks included a small unnamed tributary of *Panther Creek* at Indian Springs/Duffey Park in Morrow (IS) and part of *Bush Creek* in Gardner Park (GP), a suburban day-use park in Stockbridge. Our wetland study site (MR) was just downstream of a wetland near Maddox Road on *Panther Creek* in Rex. Our forest study sites included *Panther Creek* behind Liberty Baptist Tabernacle in Stockbridge (LB), two reaches on *Big Cotton Indian Creek* located on a floodplain on the grounds of Stockbridge High School (SHS) and farther downstream in at the northern most edge of J.P. Mosely Park (JP), *Martin Creek* located in Hidden Valley Park (HV), and a portion of Panola Mountain State Park (PM) on an unnamed tributary of *Alexander's Lake*, which was the only rocky-bottom stream in the study.

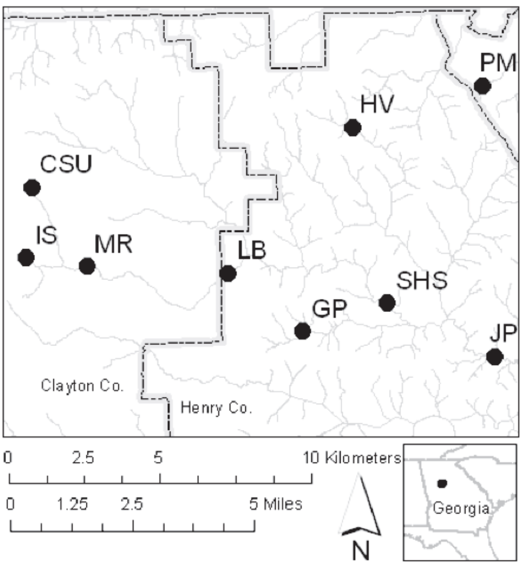

Figure 1. Study sites in Clayton, Henry, and Rockdale Counties, all tributaries of the South River, Upper Ocmulgee Watershed. The following were on Panther Creek: CSU = Clayton State University (CSU) , Indian Springs Park (IS), Maddox Road (MR). The following were on Big Cotton Indian Creek: Liberty Baptist Church (LB), Stockbridge High School (SHS), JP Mosely Park (JP). Gardner Park (GP) was on Bush Creek, and Panola Mountain State Park (PM) was on an unnamed tributary of Alexander's Pond.

Stream monitoring

Macroinvertebrates include the larval stages of aquatic insects, crustaceans, mollusks, and aquatic worms, and are important to study because they serve as good indicators of the long-term physical, chemical, and biological conditions within a stream whereas the physical and chemical characteristics of a stream reach can change daily (9). Studying stream physics and chemistry properly would take many more site visits over several years, so in this paper we chose to focus mainly on our macroinvertebrate data, but we included stream flow and chemistry data in our results because the local macroinvertebrate community depends upon the abiotic conditions. As shown in Table I, we were able to visit each site from one to three times during the Spring and Summer semesters of 2007.

Table I. Study Site Visit Schedule

Site Name	Site Type	Dates Visited in 2007
Clayton State University	Parking Lot	Jan. 16, Mar. 24, Mar. 26
Gardner Park	Suburban Park	Jun. 14
Hidden Valley Park	Forest	Jun. 12
Indian Springs	Suburban Park	Jun. 8
JP Mosely Park	Forest	Feb. 20, Mar. 27
Liberty Baptist Church	Forest	Jan. 30, Mar. 13
Maddox Road	Wetlands	Jan. 23, Mar. 6
Panola Mountain Park	Forest	Jun. 28
Stockbridge High School	Forest	Feb. 6, Mar. 20

Under the Georgia Adopt-A-Stream protocol, which is based on sensitivities to dissolved oxygen, sensitive macroinvertebrates receive 3 points, moderately-tolerant taxa receive 2 points, and tolerant taxa receive 1 point. Thus, streams with a diverse group of sensitive macroinvertebrates score higher than streams having only a few tolerant macroinvertebrates. Equipment used for biological assessment included collapsible D-frame nets, sorting pans, forceps, and pipettes (9). All of the study sites except Panola Mountain State Park were muddy-bottom streams, therefore sampling primarily involved sampling near vegetated margins, woody debris with organic matter, and the middle of the streambed where sand, rock, and gravel accumulate. Because it was categorized as a rocky-bottom stream, sampling at Panola Mountain State Park required the use of a kick seine, which samples a 2x2 foot area. Following the AAS methodolgies, each D-frame sample covered one foot of area, sampling only those habitats that were submerged. We sorted macroinvertebrates in the field to the AAS taxonomic order and preserved them in 70% ethyl alcohol as voucher specimens. We consulted Voshell's "A Guide to Common Freshwater Invertebrates of North America" where necessary (13). A water quality rating for each of the nine sites was calculated using GA Adopt-A-Stream's Macroinvertebrate Count Form (9).

Statistical Analysis

We used chi-square to test (α = 0.05) for difference in distributions was calculated, to test for a significant difference between the number of individual macroinvertebrates found across each of the four study site land use types. All assumptions and conditions were met in order to do this type of statistical test (*i.e.* data are independent of each other, data are nominal and discrete, no more than 20% of the expected values are less than five, and no expected value is less than 1 *etc.*).

RESULTS

Our data showed no clear relationship between average water quality score and average water temperature at each site (Figure 2). Sites with low average flow had poor, fair, and good water quality scores, whereas the two sites with the highest flows both scored in the good range. On the other hand, average score seemed to correlate positively with both pH and dissolved oxygen.

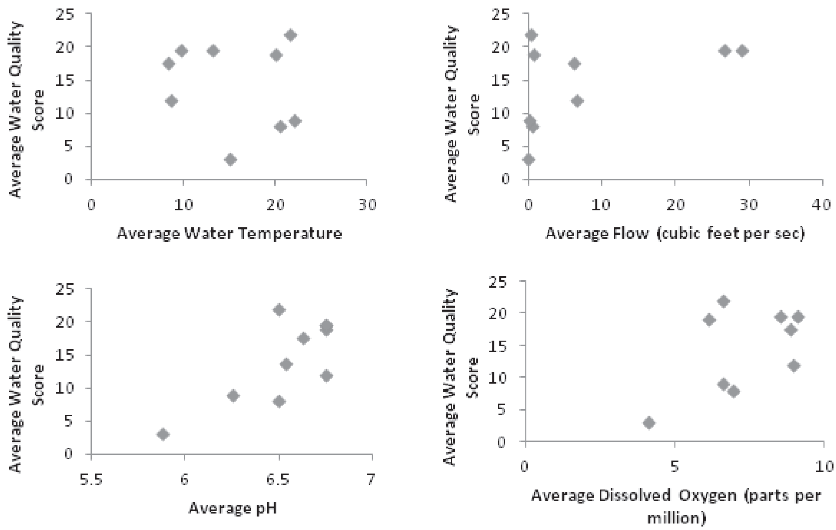

Figure 2. The Georgia Adopt-A-Stream water quality index as a function of water temperature, flow, pH, and dissolved oxygen.

Interestingly, the site at Clayton State University stood out from the rest, as it had the lowest average pH, dissolved oxygen, and water quality score in the entire study (Table II).

Table II. Average water quality score, dissolved oxygen, pH, flow, and water temperature.

Site	Water Quality Score	Dissolved Oxygen	pH	Flow cm^3/sec	Water Temperature °C
Panola Mtn State Park	22.0	6.6	6.5	0.3	21.5
JP Mosely Park	19.5	8.5	6.8	29.1	13.1
Stockbridge HS	19.5	9.1	6.8	26.7	9.8
Hidden Valley Park	19.0	6.1	6.8	0.6	20.0
Maddox Road	17.5	8.9	6.6	6.1	8.3
Liberty Baptist Church	12.0	8.9	6.8	6.5	8.6
Indian Springs	9.0	6.6	6.3	0.1	22.0
Gardner Park	8.0	6.9	6.5	0.5	20.5
Clayton State University	3.0	4.1	5.9	0.0	15.0
Average	13.6	7.5	6.5	7.0	13.8

Figure 3 shows the average Georgia Adopt-A-Stream (AAS) water quality index scores from our study sites. Streams with scores less than 11 indicate poor water quality; scores ranging from 11-16 are rated fair; and scores ranging from 17-22 are rated as good, while scores greater than 22 indicate excellent water quality (9).

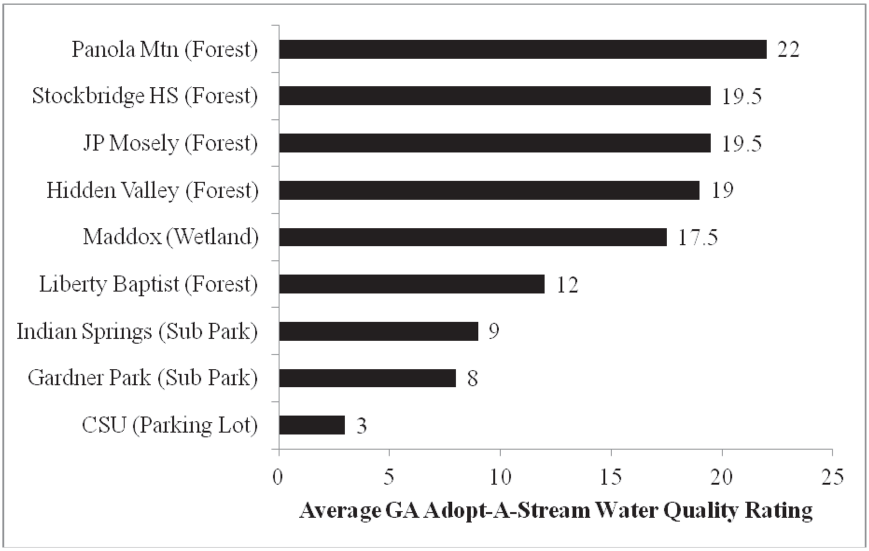

Figure 3. Water Quality scores for all study sites based on surrounding land use type (forest, wetland, suburban park, parking lot).

The parking lot and suburban parks have poor water quality scores, but the wetlands and all of the forested study sites range from fair to good water quality.

Tables III and IV show the observed and expected frequencies from the chi-square test of difference between distributions.

Table III. Observed chi-square values of macroinvertebrates in sites with different land usage.

Observed Values	Parking lot	Wetlands	Suburban park	Forest	Row Totals
Sensitive	0	14	3	308	325
Moderate	7	70	14	80	171
Tolerant	15	19	22	183	239
Column totals	22	103	39	571	735

Table IV. Expected chi-square values of macroinvertebrates in sites with different land usage.

Expected values	Parking lot	Wetlands	Suburban park	Forest	
Sensitive	9.7	45.5	17.2	252.5	
Moderate	5.1	23.9	9.07	132.9	
Tolerant	7.2	33.5	12.7	185.7	
				Total =	735

Since there are six degrees of freedom, the critical X^2 value is 12.6 and the calculated X^2 value is 190.71, yielding a probability < 0.001, so based on the data from our samples there is a significant difference between the amounts of macroinvertebrates found across all four types of land use categories.

DISCUSSION

We conclude that there is indeed a significant difference in the groups of macroinvertebrates found at sites having different types of land usage. The site near the parking lot had the lowest score. On the day that we monitored it, there was no observed flow, yet the banks at this particular site were steep and had a lot of exposed roots, suggesting erosion. During rainfall events subsequent to our monitoring, we noticed that rain greatly swelled this small creek, and its flow rapidly decreased when the rain stopped. The sudden flow changes, combined with a ready supply of silt would explain the poor macroinvertebrate community at this study site. Unfortunately, any vehicles leaking oil, antifreeze, and other automotive chemicals could also have negatively affected the health of the stream (2).

Interestingly, the streams that were located in suburban parks also possessed depauperate macroinvertebrate communities, as evidenced by low scores. Streams in these areas lacked natural vegetation, and the adjacent areas were constantly mowed. These areas often had patchy vegetation cover (grasses) and steep banks.

The site near the wetlands and sites within forested areas had water quality scores that ranged from good to excellent. Wetlands are known for filtering pollutants so streams that flow through these areas tend to have good water quality (6). Streams that are located in forested areas with little anthropogenic disturbance also have good water quality, because forested banks with plenty of shade cover add to the amount of diverse habitats for the macroinvertebrates to live within. We observed woody debris and leaf packs in the forest streams which would presumably serve as a food source and good refugia for macroinvertebrates.

Even though the results of our study are clear, further investigation is needed to confirm our conclusions. Although there were plenty of forested sites that had good water quality, more sites are needed in disturbed areas that have poorer water quality in order to accurately assess the affects of impervious land cover on smaller streams. A larger sample size could also lead to correlation studies to find out which variables are more likely to affect stream health.

Additionally, the occurrence of an elevated AAS score just downstream of our one wetland site raises the question of whether this was due to effects of the wetland, or simply an artifact from small sample size. Lastly, although it is clear that parking lot streams are poor habitats for macroinvertebrates, a larger dataset could even address the question of how much impervious land cover near headwaters or smaller streams that an area can undergo before the health of a stream declines. A single research team would have a hard time addressing such a large question--perhaps the answer lies in a confluence of volunteer data.

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