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EFFECTS OF NON-POINT SOURCE POLLUTION ON THE MACROINVERTEBRATE COMMUNITY OF STANDING STONE CREEK

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ABSTRACT

The effects of streamside agriculture and urbanization on water nitrate content and macroinvertebrate taxic richness were examined at four sites along Standing Stone Creek (Huntingdon County, Pennsylvania). No significant differences in taxic richness (χ^2 = 1.575; *df* = 3; *P* = 0.665) or EPT index (number of taxa of Ephemeroptera, Plecoptera and Trichoptera: χ^2 = 1.394; *df* = 3; *P* = 0.707) were observed among the sampling sites, despite significantly different nitrate concentrations (*H* = 9.75, *df* = 3, *P* = 0.021). Further research is needed to draw meaningful conclusions from these data.

Keywords: non-point source pollution, macroinvertebrates,, Standing Stone Creek, taxic richness

INTRODUCTION

Standing Stone Creek is a sparsely populated watershed in Huntingdon County, Pennsylvania, running from the Alan Seeger State Park into the Juniata River east of Huntingdon. Generally, this creek is characterized by pockets of shallow to medium-depth water moving over a predominantly rocky streambed, and thus should provide a well-oxygenated environment favorable to a variety of aquatic invertebrate life (Fritz et al, 1999). However, the land in this watershed has historically been used for forestry, crop and animal agriculture, all of which have the potential to contribute to non-point source pollution (Wilson et al 2001). The combination of years of runoff from agricultural fields, as well as increased urbanization along Stone Creek may be impacting the health of the stream. Additional possible effects include soil deposition caused by storm water runoff and nutrient loading by excessive nitrates and phosphates. This concern not only relates to environmental health, but also to the maintenance of the stream as Huntingdon's water supply (Wilson et al. 2001) Studies previously done on Spruce Creek indicate that "poor water quality or degraded habitat are stressing the invertebrate communities" (Blattenberger et al, 2000).

One way of looking at stream health is through macroinvertebrate diversity, a well-known indicator of water quality. Some families of macroinvertebrates such as Ephemeroptera, Plecoptera and Trichoptera are especially sensitive to pollutants and are commonly used as bio-indicators (the number of these taxa = EPT index). Less sensitive organisms include crayfish, dragonflies, isopods, and damselflies (Wilson, et al. 2001). Other organisms such as aquatic worms and leeches are especially tolerant of low oxygen levels, their presence being an indicator of high levels of pollution. In addition to changing chemical properties of the water such as pH, hardness, alkalinity, and dissolved solids, leaching from crop fields can cause elevated levels of nitrates and phosphates. These additional nutrients cause algal blooms, which use up large amounts of oxygen in decomposition, and can cause eutrophication of streams (Painter, 1999).

To determine whether or not such factors were influencing Standing Stone Creek, we estimated macroinvertebrate taxic richness and the EPT index at different sites along the creek. We predicted that upstream forested sites should have higher taxic richness, EPT indices and water quality than downstream sites affected by agriculture and urbanization. We also predicted that stream sites near pastureland or towns would have less macroinvertebrate richness due to higher temperatures, and the possible presence of higher nitrates, herbicides, pesticides and other pollutants.

FIELD SITE

The sites sampled were located on four different sections of Standing Stone Creek in Huntingdon County, Pennsylvania. The first site, (indicated by the uppermost red dot in Fig. 1), is located in Alan Seeger State Park, within Rothrock Forest. The width of this section was 41 ft and the average depth was 18.75 inches. The second site (indicated by the upper middle red dot in Figure 1) is located near a bridge on Standing Stone Road downstream from cropland and is near lightly urbanized areas. The width of this section was 36 ft and the average depth was 12.00 inches. The third site (indicated by the lower middle red dot in Fig. 1) is located within an area used heavily for cattle farming. The width of this section was 32 ft and the average depth was 14.63in. The fourth site (indicated by the lowest red dot in Figure 1) is located in Detweiler Park in a partially forested area. The width of this section was 49 ft and the average depth was 18.87 inches. The four sites were very similar in substrate composition (mostly gravel and cobbles).

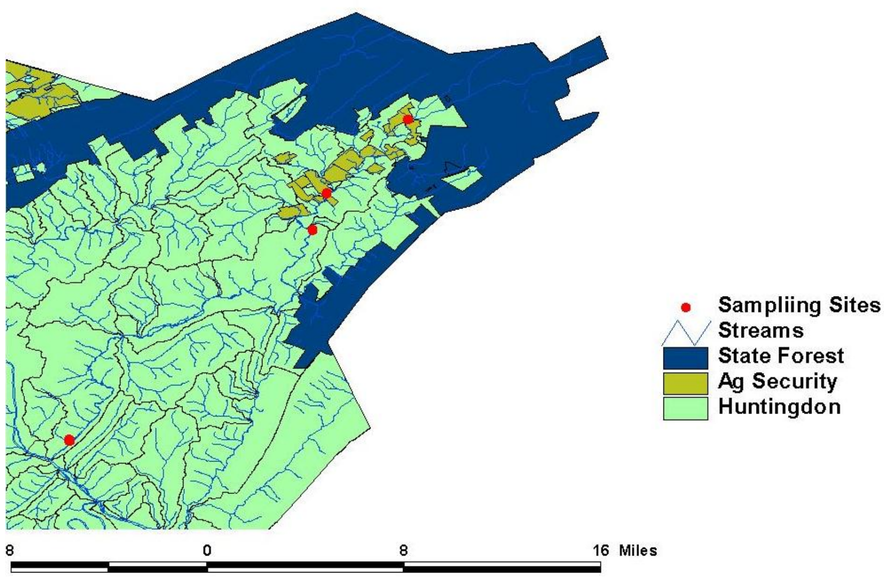


Figure 1. The location of sampling sites along Standing Stone Creek and the corresponding land use

METHODS AND MATERIALS

The location of our four sampling sites was determined by using GIS information from the Huntingdon County Planning Commission. The first site was selected as a pristine site presumably uninfluenced by agricultural and urban pollution. The second site was located at the beginning of the urban and agricultural pollution. The third site was located downstream from a major agricultural area. And the fourth site was located far downstream from the agricultural areas, at which point the pollution should have either been absorbed by the stream system or compounded. We used D nets (0.5 mm mesh) to collect 12 samples of macroinvertebrates at each study site. Each sample was obtained by kicking the substrate for approximately thirty seconds upstream from a D net. The invertebrates were placed in sampling buckets and taken back to the laboratory for sorting and identification. This procedure was repeated a second time one week after the first sample (April 4 and 15, 2003). The pH, dissolved oxygen (mg l^{-1}), and temperature (°C) were also recorded at each site on the first day of sampling. Water samples were also obtained on two separate days (April 24 and 25, 2003) and analyzed within 48 hours of collection for nitrate content using a modified cadmium reduction method using a Hach® DR2000 spectrophotometer. To ensure accuracy, two tests were run on each of the water samples from the first day's collection. One test was run on each of the samples from the second day to determine if there were any differences in nitrate concentrations between sampling days.

The macroinvertebrates were identified to the genus level and assigned to one of five functional groups (shredder, scraper, collector-gatherer, collector-filterer, or predator). We used the following biotic indices to characterize macroinvertebrate communities at each site: taxic richnes (total number of genera present); EPT Index (total number of genera of pollution sensitive Ephemeroptera, Plecoptera, and Trichoptera present), and the percentage of genera belonging to each of the five functional guilds.

RESULTS

The four sites sampled had relatively similar physical and chemical characteristics: pH close to neutral, temperatures averaging 7.86 ºC, and high levels of dissolved oxygen (Table 1). Therefore, these factors probably played little role in causing any observed among-site differences in taxic richness.

Table 1. Seelcted environmental features of four study sites along Standing Stone Creek

	Site 1	**Site 2**	**Site 3**	**Site 4**
pH	6.66	7.44	7.905	6.705
D.O. (mg/L)	13.24	13.95	14.645	13.29
Temperature (ºC)	6.4	8.9	8.3	7.85
Nitrate (day1)	0	0.4	0.5	0.4
	0	0.4	0.5	0.4
Nitrate (day2)	0.3	0.5	0.6	0.4

However, nitrate levels increased significantly from site 1 to sites 2-4 (Kruskall Wallis test: $H = 9.75$, $df = 3$, $P = 0.021$). However, although the kinds of taxa varied among sites (Table 2), neither taxic richness ($\chi^2 = 1.575$; $df = 3$; $P = 0.665$; Table 3) or the EPT Index ($\chi^2 = 1.394$; $df = 3$; $P = 0.707$; Table 4) differed significantly among sites. Functional guild composition did not vary much among sites either (Fig. 2).

Table 2. Macroinvertebrate taxa found at each of four study sites along Standing Stone Creek

Site 1	**Site 2**
Ephemeroptera Heptageniidae Macdunnoa	Ephemeroptera Heptageniidae Macdunnoa
Ephemeroptera Ephemerellidae Attenella	Ephermeroptera Potamanthidae Potamanthus
Ephemeroptera Baetiscidae Baetisca	Ephemeroptera Leptophlebiidae Paraleptophlebia
Ephemeroptera Polymytardidae Ephoron	Ephemeroptera Leptophlebiidae Habrophlebiodes
Ephemeroptera Ephemerellidae Ephemerella	Ephemeroptera Ephemerellidae Ephemera
Ephemeroptera Heptageniidae Heptagenia	Ephemeroptera Heptageniidae Stenacron
Ephemeroptera Leptophlebiidae Paraleptophlebia	Ephemeroptera Ephemerellidae Drunella
Trichoptera Lepidostomatidae Lepidostoma	Ephemeroptera Heptageniidae Heptagenia
Trichoptera Leptoceridae Mystacides	Trichoptera Glossosomatidae Glossoma
Trichoptera Limnephilidae Lenarchus	Trichoptera Lepidostomatidae Thellopsyche
Plecoptera Perlidae Acroneuria	Trichoptera Hydropsychidae Hydropsyche
Plecoptera Perlidae Eccoptera	Trichoptera Limnephilidae Neophylax
Plecoptera Perlodidae Arcynaptryx	Trichoptera Hydropsychidae Potamyia

Plecoptera Peltoperlidae Peltoperla Tallaperla	Trichoptera Philopotamidae Chimarra
EPT = 14	Trichoptera Philopotamidae Wormaldia
Megaloptera Corydalidae Corydalus	Trichoptera Limnephilidae Goera
Megaloptera Coryalidae Nigrana Serricarnis	Plecoptera Perlidae Acroneuria
Megaloptera Sialidae Sialus	Plecoptera Perlidae Eccoptera
Crustacea Decapoda Cambaridae Obscurus	Plecoptera Leuctridae Paraleuctra
Odonata Anisoptera Gomphidae	Plecoptera Pteronarcyidae Pteronarcys
Odonata Libellidae Ladona	Plecoptera Perlidae Paragnetina
Mollusca Bivalvia Sphaeracea Sphaeriidae Psidium	**EPT = 21**
Coleoptera Psephinidae Psephenus	Megaloptera Corydalidae Corydalus
richness = 22	Crustacea Decapoda Cambaridae Obscurus
	Mollusca Bivalvia Sphaeracea Sphaeriidae Psidium
	Mollusca Bivalvia Sphaeracea Corbiculidae Corbicula fluminea
	Coleoptera Psephinidae Psephenus
	Coleoptera Elmidae Optioservus
	Diptera Simulidae Simulium
	Diptera Athericidae Atherix
	Tipulidae Lepidosarsus
	richness = 31
Site 3	**Site 4**
Ephermeroptera Potamanthidae Potamanthus	Ephemeroptera Heptageniidae Macdunnoa
Ephemeroptera Baetiscidae Baetisca	Ephermeroptera Potamanthidae Potamanthus
Ephemeroptera Leptophlebiidae Habrophlebiodes	Ephemeroptera Baetiscidae Baetisca
Ephemeroptera Ephemerellidae Ephemerella	Ephemeroptera Siphlonuridae Isonychia
Ephemeroptera Heptageniidae Stenacron	Ephemeroptera Ephemerellidae Ephemera
Ephemeroptera Ephemerellidae Drunella	Ephemeroptera Heptageniidae Stenacron
Ephemeroptera Heptageniidae Stenonema	Ephemeroptera Heptageniidae Stenonema
Trichoptera Hydropsychidae Hydropsyche	Ephemeroptera Ephemerellidae Ephemerella
Trichoptera Limnephilidae Neophylax	Trichoptera Hydropsychidae Hydropsyche
Plecoptera Perlidae Acroneuria	Trichoptera Lepidostomatidae Lepidostoma
Plecoptera Perlidae Eccoptera	Trichoptera Leptoceridae Mystacides
Plecoptera Pteronarcyidae Pteronarcys	Plecoptera Perlidae Acroneuria
EPT = 12	Plecoptera Perlidae Eccoptera
Megaloptera Corydalidae Corydalus	Plecoptera Leuctridae Paraleuctra
Crustacea Decapoda Cambaridae Obscurus	**EPT = 14**
Odonata Coenagrionidae Enallagma	Megaloptera Coryalidae Neothermes
Onondata Anisoptera Libellulidae Leucorrhinia	Crustacea Decapoda Cambaridae Obscurus
Coleoptera Psephinidae Psephenus	Odonata Coenagrionidae Enallagma
Coleoptera Elmidae Optioservus	Odonata Aeshnidae Coryphaeschna
Coleoptera Elmidae Stenelmis	Mullusca Gastropoda Bithyniidae Bithynia tentaculata
Coleoptera Dytiscidae Matus	richness = 19
Circulanidae	
Diptera Simulidae Simulium	
Diptera Chironomidae Ablabesymia	
Diptera Brachycera Orthorrhapha Empididae Hemerodromia	
Turbellaria Planariidae Phagocota	
richness = 25	

Table 3. Observed taxic richness at each of four study sites in Standing Stone Creek. Expected taxic richness according to a null hypothesis are also indicated

Taxa/Genus Richness:	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Observed Richness	22	31	25	19
Expected Richness	24	24	24	24

Table 4. . Observed frequency of EPT taxa at each of four study sites in Standing Stone Creek. Expected frequencies according to a null hypothesis are also indicated

EPT Index for:	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Observed # EPT	14	21	12	14
Expected # EPT	15	15	15	15

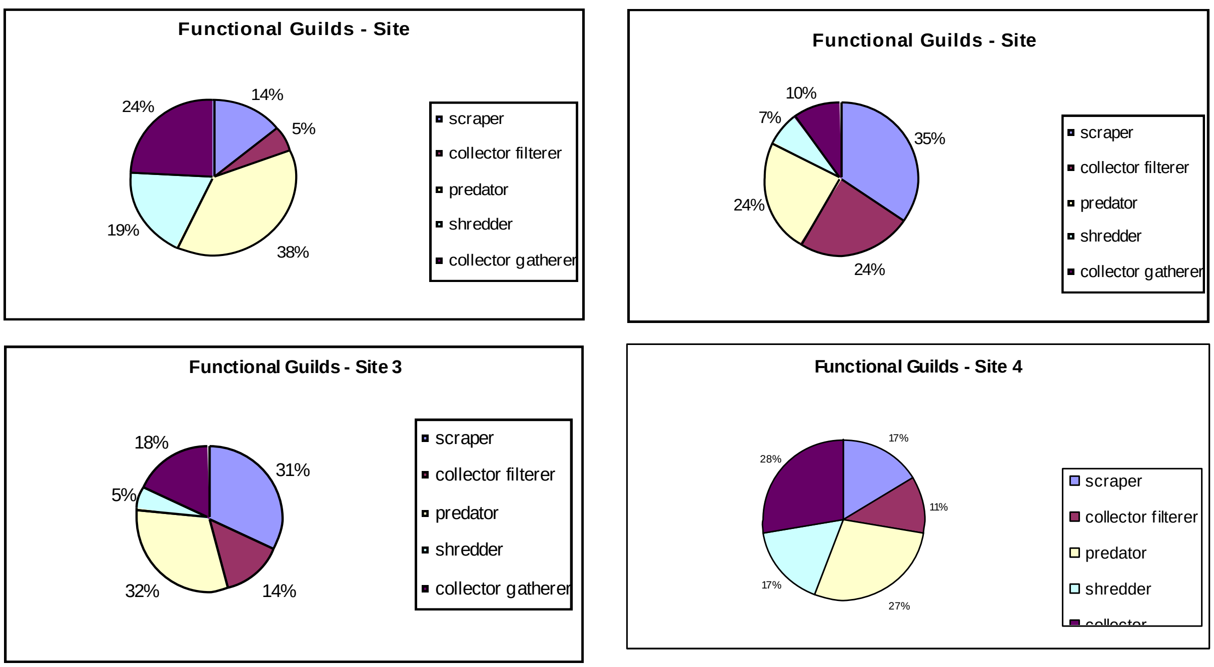
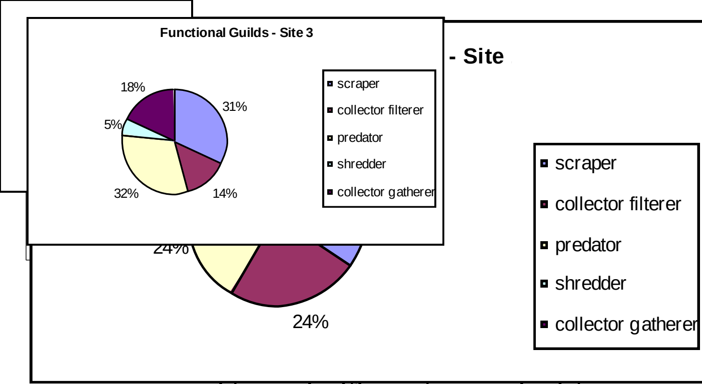


Figure 2. Percentage of macroinvertebrate genera belonging to different functional (feeding) guilds at each of four study sites along Standing Stone Creek

DISCUSSION

We hypothesized that macroinvertebrate richness should be highest at the first "pristine" forested site, and then decrease as Standing Stone Creek passes through agricultural and urban areas. Instead, we found no significant



...mong EPT taxa, despite a significant increase in nitrate content from ... either that the macroinvertebrate populations are not affected by ... or that the concentrations were not large enough to elicit a response. ...nctional guild composition along the creek suggested that the habitat ...m. This can be interpreted to mean that the observed influence of ...l enough to change community structure. Therefore, having found neither a significant decrease in richness, nor a significant difference in guild composition, we cannot deduce that macroinvertebrate richness is negatively affected by agricultural land use or urbanization. Because this was a qualitative preliminary study focused on finding as many different species as possible, we collected data from a few large samples rather than many small ones. Because of this, degrees of freedom were small and statistical tests were not very powerful. However, with further qualitative and quantitative data collection, a more definitive conclusion may be obtained.

Although not significantly different, the relatively low taxic richness at sites 1 and 4 relative to site 2 (Table 3) could be due to the fact that these sites had relatively low pH values (Table 1). Another consideration is that site 2 was more urbanized than other sites, located under a bridge near a church, a gas station, and a pizza shop. This could have increased the amount and diversity of food available, creating niches that could be occupied by generalist species. The relatively high taxic richness of site 2 may also be an indication that this area was a disturbed habitat, giving rise to a succession of different species as change occurred. Another way to interpret these data is to assume that the creek is representative of a healthy system, and that the species numbers and types observed are only indicative of a normal stream succession. For example, if the normal pattern of this stream was to have relatively constant macroinvertebrate richness along the stream, peaking towards the upper middle, we could conclude that our data demonstrated this pattern and indicated a healthy stream.

Some sources of error in this study included possible inconsistencies in sampling technique and of taxic identification. Because this study is only a preliminary, qualitative examination of Standing Stone Creek macroinvertebrate communities, our data are inconclusive. Future research should involve sampling throughout the year at more sites than were used in this study. Better resolution of habitat effects may be possible by sampling multiple sites within each habitat type. Comparisons with other less polluted streams may also be useful.

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