Characterizing the physical and biological environments of the lotic ecosystems of Pierce Cedar Creek Institute

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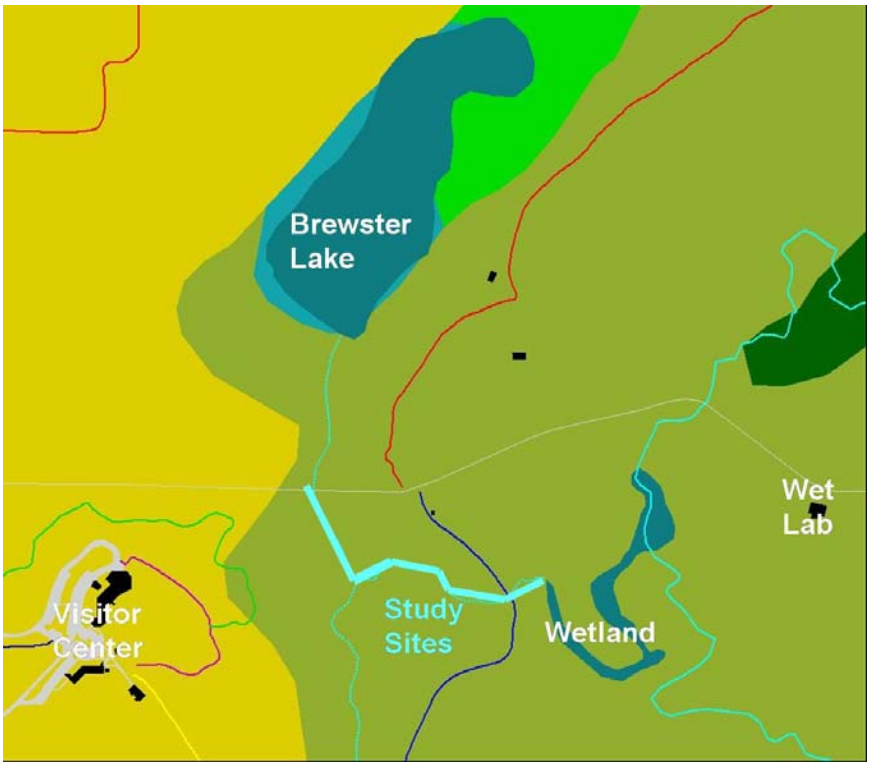
Introduction:

The purpose of this research is to study the relationship between aquatic macro-invertebrates and the physical characteristics of Brewster Creek that water. These physical characteristics include sediment composition, dissolved oxygen levels, pH levels, nitrate levels, phosphorus levels, and water temperature. These measurements were compared with the abundance and diversity of the aquatic organisms.

Map 1



Methods:

Forty-two sites were along Brewster Creek from the wetland area to Cloverdale Road (see map 1). These sites are ten meters apart, and marked by a bamboo stake with orange

biodegradable tape. Within each ten-meter site, two sampling sites were chosen. One of the sampling sites would be among woody debris while the other was a sediment area. Less than thirty minutes was spent in the site, collecting the physical characteristics and the macro-invertebrate sample. Research occurred from May 8, 2006 to July 12, 2006.

Sampling at the site consisted of collecting physical characteristics such as air temperature, weather conditions, water temperature, physical description of the stream bed, pH, and dissolved oxygen. A water sample was collected for nitrate and phosphate levels that were performed in the lab using a colorimeter. The temperatures were determined by standard Celsius thermometer. Dissolved oxygen meter that lost calibration for some of the time measured the dissolved oxygen levels. One sediment sample was taken from each site. The sample was dried in the hood in the wet lab, and then standardized sieves were used to determine percent composition by weight. The last thing to be collected on site was the macro-invertebrate sample. This was done with a Soder net being placed downstream from the area to be disturbed. The area was shuffled for thirty to forty-five seconds with the feet to stir loose the organisms. Once the water cleared, the net was removed and placed in a white pan to be taken back to the lab for analysis. Organisms were identified to the family level in most cases, using W. Patrick McCafferty's *Aquatic Entomology*.

For statistical analysis, the data was entered into Microsoft Excel. The abundance of organisms and the diversity of organisms were calculated. The number of families at each site defines diversity. Regression analysis determined significant relationships ($p \leq 0.05$) between organism abundance or diversity and physical characteristics. Analysis was done between distance from Cloverdale Road and the physical characteristics of Brewster Creek. The physical characteristics were also compared with the abundance of chironomidae, amphipoda, gastropoda, and lepidostomatidae. These four families were chosen to be analyzed because the first three are the most abundant families and lepidostomatidae is a caddisfly family and in the middle range of overall abundance. The average pH, dissolved oxygen and water temperature for the stream for sites 1-42 was determined from the sample collections and the weekly tests. The dissolved oxygen stopped working for some of the summer so there are not as many data points for this physical characteristic. The nitrate and phosphate levels are averaged from the individual site collections. Brewster Lake and the Brewster Creek north of Cloverdale Road were measured in

the weekly tests. These two locations started being measured week five. Of these five weeks, dissolve oxygen was only measured twice because the dissolved oxygen meter was broken.

Results:

The physical features of Brewster Creek from Cloverdale Road to the wetlands are listed in Table 1 (sites 1-42). The mean values for Brewster Creek sites 1-42 are pH 7.8, dissolved oxygen 7.1 ppm, phosphate 0.24 mg/L and nitrate 0.5 mg/L. We also measured the pH, dissolved oxygen, and the water temperature of the stream north of Cloverdale Road and Brewster Lake (see table 1). These were measured once a week starting the week of June 5.

Table 1

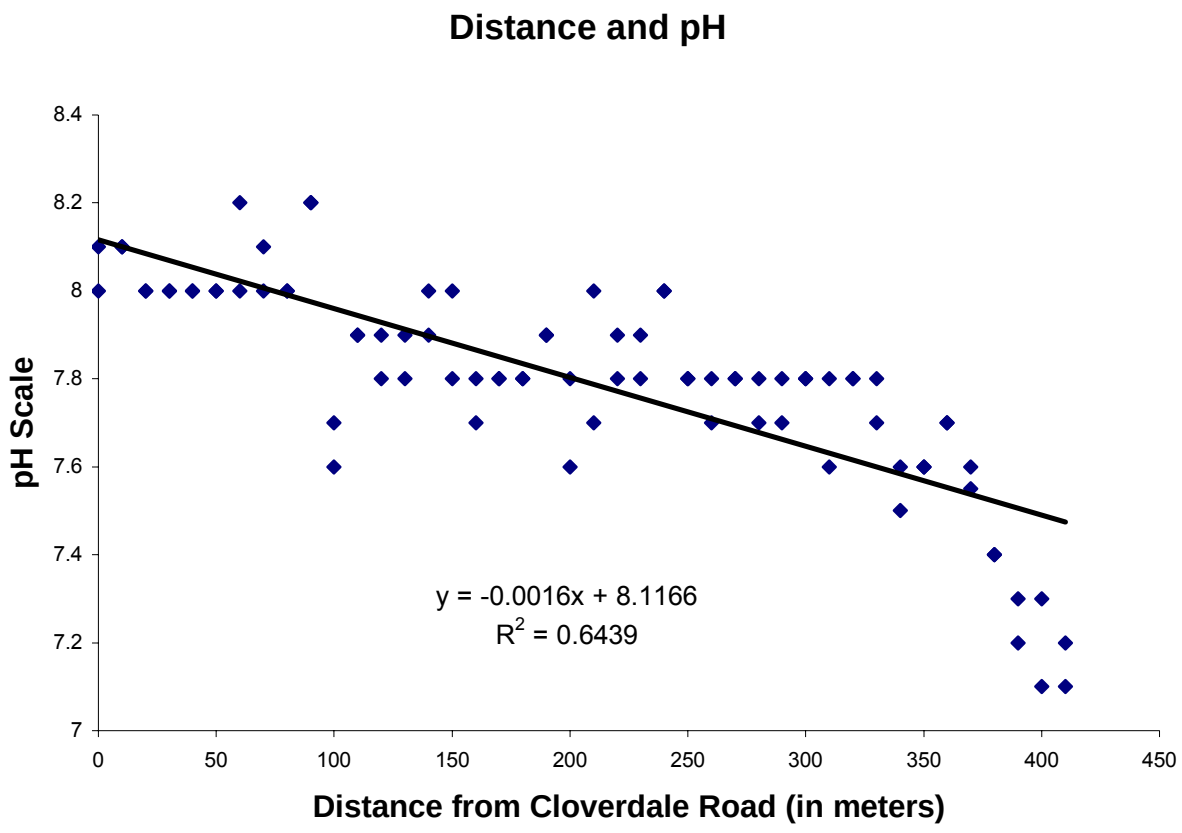
Average Readings					
Location	pH	Dissolved Oxygen (ppm)	Water Temperature (^{o}C)	Phosphate (mg/L)	Nitrate (mg/L)
Sites 1 – 42	7.8	7.1	15.5	0.24	0.5
Brewster Creek North of Cloverdale Road	7.7	6.25	21.3	not measured	not measured
Brewster Lake	8.2	8.6	22	not measured	not measured

Physical characteristics were analyzed in relation to their distance from Cloverdale Road. Site 1 was 410 meters downstream from Cloverdale Road. Site 42 was zero meters from Cloverdale Road. Table 2 shows the physical characteristics that have a significant relationship with the distance from the road. The graph of distance and pH shows the correlation between the two physical characteristics (graph 1). Table 3 shows the physical characteristics and distance from Cloverdale Road that did not show a significant relation ship. Table 4 shows the physical characteristics and organism category that have a significant relationship. Graph 2 shows the correlation of a physical aspect and an order.

Table 2

Significant Relationships			
Independent Factor	Dependent Factor	Significant Factor	Correlation
Distance from Cloverdale Road	pH	4.47E-20	Negative
Distance from Cloverdale Road	Dissolved Oxygen	0.022062	Negative
Distance from Cloverdale Road	Phosphate Level	7.65E-05	Positive
Distance from Cloverdale Road	Percent Gravel	1.78E-09	Negative
Distance from Cloverdale Road	Percent Silt	5.86E-13	Positive
Distance from Cloverdale Road	Percent Clay	4.00E-04	Positive
Distance from Cloverdale Road	Water Temperature	7.46E-18	Negative

Graph 1



Significance factor = 4.47E-20

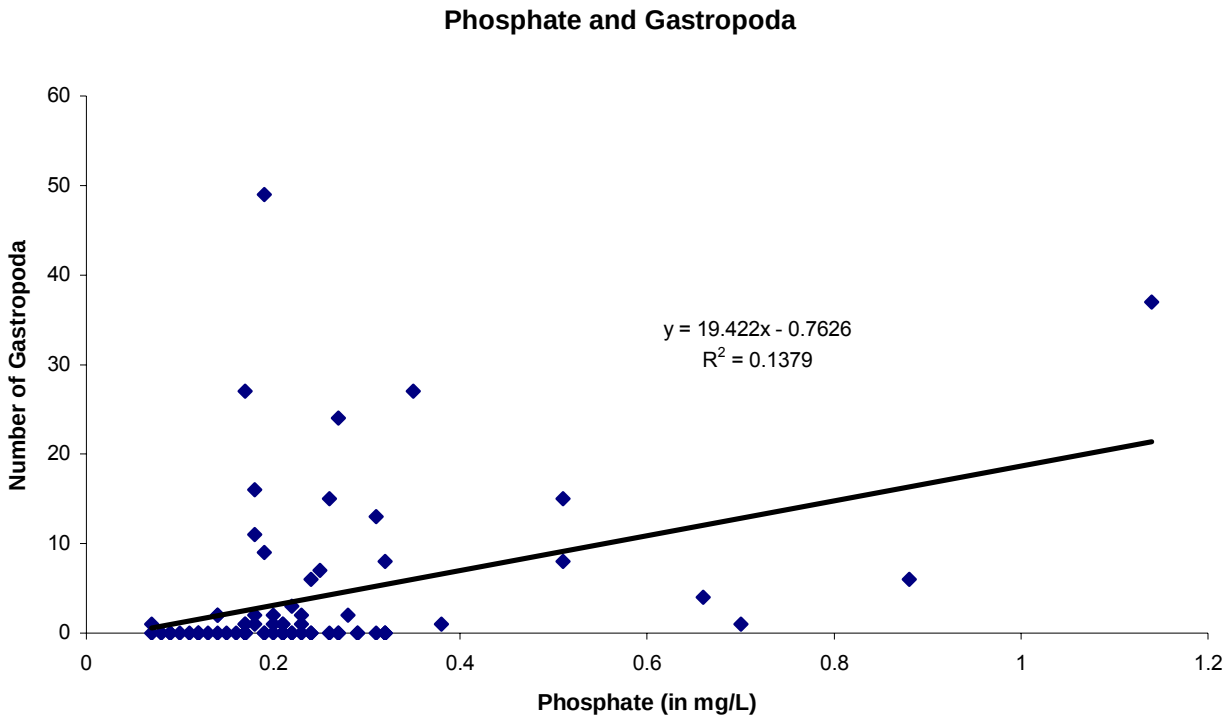
Table 3

Insignificant Relationships		
Independent Factor	Dependent Factor	Significant Factor
Distance from Cloverdale Road	Nitrate	0.507073702
Distance from Cloverdale Road	Percent Organic	0.06446945
Distance from Cloverdale Road	Percent Sand	0.169705425

Table 4

Significant Relationships			
Independent Factor	Dependent Factor	Significant Factor	Correlation
pH	Diversity	0.029298	Positive
Distance from Cloverdale Road	Diversity	0.019209	Negative
Water Temperature	Amphipoda	0.001978	Negative
Percent Gravel	Amphipoda	0.0098071	Negative
Distance from Cloverdale Road	Amphipoda	0.0091592	Positive
Phosphate Level	Gastropoda	8.84E-04	Positive
Percent Organic	Gastropoda	5.94E-03	Positive
Percent Silt	Gastropoda	7.40E-03	Positive
Percent Clay	Gastropoda	2.43E-03	Positive
Distance from Cloverdale Road	Gastropoda	4.17E-03	Positive

Graph 2



Significance factor = 8.84E-04

Table 5 shows the insignificant relations between organisms and physical characteristics. There was not a significant relationship between total abundance and any physical characteristic. Chironomidae and lepidostomatidae also did not have any significant relationship with any of the physical characteristics.

Table 5

Insignificant Relationships		
Independent Factor	Dependent Factor	Significant Factor
pH	Abundance	0.4056
Dissolved Oxygen	Abundance	0.8831
Nitrate	Abundance	0.9718
Phosphate Level	Abundance	0.3353
Water Temperature	Abundance	0.9027
Percent Gravel	Abundance	0.3471
Percent Organic	Abundance	0.6805
Percent Sand	Abundance	0.4581
Percent Silt	Abundance	0.9442
Percent Clay	Abundance	0.6630

Distance from Cloverdale Road	Abundance	0.5144
Dissolved Oxygen	Diversity	0.8904
Nitrate	Diversity	0.9334
Phosphate Level	Diversity	0.6950
Water Temperature	Diversity	0.1750
Percent Gravel	Diversity	0.2267
Percent Organic	Diversity	0.3127
Percent Sand	Diversity	0.8400
Percent Silt	Diversity	0.1515
Percent Clay	Diversity	0.7688
pH	Chironomidae	0.3838
Dissolved Oxygen	Chironomidae	0.3075
Nitrate	Chironomidae	0.8098
Phosphate Level	Chironomidae	0.8228
Water Temperature	Chironomidae	0.1508
Percent Gravel	Chironomidae	0.2506
Percent Organic	Chironomidae	0.6222
Percent Sand	Chironomidae	0.1898
Percent Silt	Chironomidae	0.9968
Percent Clay	Chironomidae	0.5283
Distance from Cloverdale Road	Chironomidae	0.4909
pH	Amphipoda	0.4056
Dissolved Oxygen	Amphipoda	0.5181
Nitrate	Amphipoda	0.7404
Phosphate Level	Amphipoda	0.2479
Percent Organic	Amphipoda	0.9348
Percent Sand	Amphipoda	0.1207
Percent Silt	Amphipoda	0.1313
Percent Clay	Amphipoda	0.3115
pH	Gastropoda	0.2053
Dissolved Oxygen	Gastropoda	0.3198
Nitrate	Gastropoda	0.6424
Water Temperature	Gastropoda	0.1900
Percent Gravel	Gastropoda	0.1393
Percent Sand	Gastropoda	0.1871
pH	Lepidostomatidae	0.6260
Dissolved Oxygen	Lepidostomatidae	0.2837
Nitrate	Lepidostomatidae	0.5484
Phosphate Level	Lepidostomatidae	0.2875
Water Temperature	Lepidostomatidae	0.6294
Percent Gravel	Lepidostomatidae	0.2250
Percent Organic	Lepidostomatidae	0.7277
Percent Sand	Lepidostomatidae	0.1154
Percent Silt	Lepidostomatidae	0.5453
Percent Clay	Lepidostomatidae	0.2997
Distance from Cloverdale Road	Lepidostomatidae	0.4600

There were 2251 total individuals collected over the ten weeks. Of those individuals, 56 families were represented. These 56 families are listed in table 6. The most abundant family is chironomidae. This is the midge family. Almost all but one of the individuals of chironomidae was in larvae form. One individual was found in the pupal stage. There were 551 individuals of chironomidae collected. The next most abundant group of organisms is amphipoda with 431 individuals.

Table 6

Name of Families					
Aeshnidae	Amphipoda	Athericidae	Baetidae	Brachycentridae	Caenidae
Calopterygidae	Capniidae	Ceratopogindae	Chironomidae	Chloroperlidae	Coenagrionidae
Conchostraca	Copepoda	Corixidae	Culicidae	Decapoda	Dryopidae
Elmidae	Empididae	Ephemerellidae	Ephemeroptera	Fingernail Clam (Order Pelecypoda)	Gastropoda
Gerridae	Gomphidae	Heptageniidae	Hirudinea	Hydracarina	Hydropsychidae
Hydroptilidae	Lepidostomatidae	Lepidoceridae	Limnephilidae	Naucoridae	Nematoda
Nemouridae	Odontoceridae	Oligochaeta (class of Annelida)	Perlidae	Perlodidae	Phryganeidae
Pleidae	Polycentropodidae	Potamanthidae	Psychodae	Ptychopteridae	Sialidae
Simuliidae	Siphlonuridae	Stratiomyidae	Tabanidae	Tipulidae	Tricorythidae
Turbellaria	Unknown	Veliidae			

Note: These are not all family names, but for this research orders such as gastropoda are referred to as family because this is the lowest name to generalize organisms found.

Discussion:

An average pH reading of 7.8 is healthy reading for a creek because it is within the neutral scale between 7.0 and 8.0. It is also within the range of highest diversity of organisms. This pH is in the range for trout, caddisflies, stoneflies and other animals to survive. The dissolved oxygen is a good reading of 7.1 ppm. It is above 3 ppm, which is needed to sustain life. Water temperature reach high temperatures during hot days because the creek is shallow so changes dramatically with the sun. The average water temperature is higher in the lake and north section of Brewster Creek than sites 1-42 due to the late start in recording weekly temperatures. Water temperature is difficult to average in the creek because it changes dramatically during the course of one day. Nitrate average reading of 0.5 mg/L is within the healthy range for a stream

system. The phosphate level on the other hand is high for a stream system. The normal range for streams is between 0.002 mg/L and 0.03 mg/L. High phosphate levels could also explain the aquatic emergent plants that are abundant in some areas of the stream.

A significant relationship between distance from the road and percent gravel, silt and clay is consistent with the dynamics of a stream. It is more dramatic because Cloverdale Road is a gravel road. The gravel would be the first thing to fall out of the water column due to its large size, so as distance from the road increases, the percent gravel decreases. The percent clay and silt have the opposite relation. As the distance from the road increases, the percent of silt and clay increase. This is because the particle size of silt and clay is small and can be carried farther downstream.

The water temperature and distance from the road significance may be skewed. The data used for this regression analysis is the organism collection data, so distance 410 meters was collected in the beginning of May and the distance zero was measured in the beginning of July. The water temperature itself is higher in July than May. But the regression analysis using the weekly tests also showed a strong significant relation between distance from the road and water temperature ($p = 3.39E-13$). Both regressions show the trend of as you move away from the road the water temperature decreases. This trend could be due to the canopy cover. Near the road, the stream is open to the sun. As you move down stream there is more tree cover that shades the stream from the sun. Also, there is tributary that enters the creek that has been following through the woods (map 1). This stream is probably cooler than Brewster Creek. Also the creek flows out of Brewster Lake, which in late spring and early summer is warm at the top. The water continues to cool as it moves away from the lake, which is also moving away from the road.

There was not a significant relationship between any of the physical characteristics and total abundance, chironomidae abundance and lepidostomatidae abundance. There are a few significant relationships between diversity, abundance of gastropoda and abundance of amphipoda and physical characteristics. Diversity and pH had a positive correlation, which means that as pH increases, diversity increases up to a point. The most common range of pH for a stream like Brewster Creek is 7.8 and 8.0. Above 8.0, the pH increase will have an opposite correlation. It will decrease as the pH, increases. This is due to that most diverse animal tolerance of pH is between 7.8 and 8.0. Diversity and distance from the road on the other hand had a negative correlation, so as distance increases, diversity decreased. This relationship could

also be due to the sediment composition becoming sandier and siltier or the time of year samples were taken. The lifecycles of the aquatic organisms would have to be analyzed to see if they would be hatched at the beginning of May or when their emergence occurs. Amphipoda abundance decreased as water temperature and percent gravel increased, but increased as distance from the road increased. These physical characteristics are similar. As the distance from the road increases, the water temperature and percent gravel decrease. Amphipoda prefer sandy sediment beds along with cooler temperatures. Gastropoda increased as phosphate levels, percent organic, silt and clay and distance from the road increased. Gastropoda are scrapers so the higher organic material the more food. Also the silt and clay provide protection for them.

This information was collected in the late spring and early summer. A change in organism composition with the different levels of physical characteristics may occur with a change in season. Also, this information should be available to future researchers of Brewster Creek to identify further changes that occur seasonally and yearly. Further research could also isolate a certain species or family and determines its limiting physical characteristics.

References:

Huron River Watershed Council. 2003. "A Quality Assurance Plan for Adopt-A-Stream." < http://www.hrwc.org/adopt/quality.htm>.

McCafferty, W.P. 1998. Aquatic Entomology. Jones and Bartlett Publishers.