Analysis and Results

Because we found some significant differences in habitat, water quality and macroinvertebrate metrics between sub-basins and sites, we wanted to examine the relationships between macroinvertebrates and environmental parameters.

Land-use

On the sub-basin level, we tested the correlation of percent EPT and percent Diptera to percent agriculture and percent forest using standard Pearson correlation methods (Mathsoft 1999). Although the correlations were not significant to the p=0.05 level, we did observe trends among the data. There is a negative relationship between percent agriculture and percent EPT taxa (r = -0.578). So as percent agricultural land increases, percent EPT taxa decreases. There is a positive relationship between percent agriculture and percent diptera (r = 0.470) and a negative relationship between percent forest and percent diptera (r = -0.444). Figures 16 and 17 illustrate these trends.

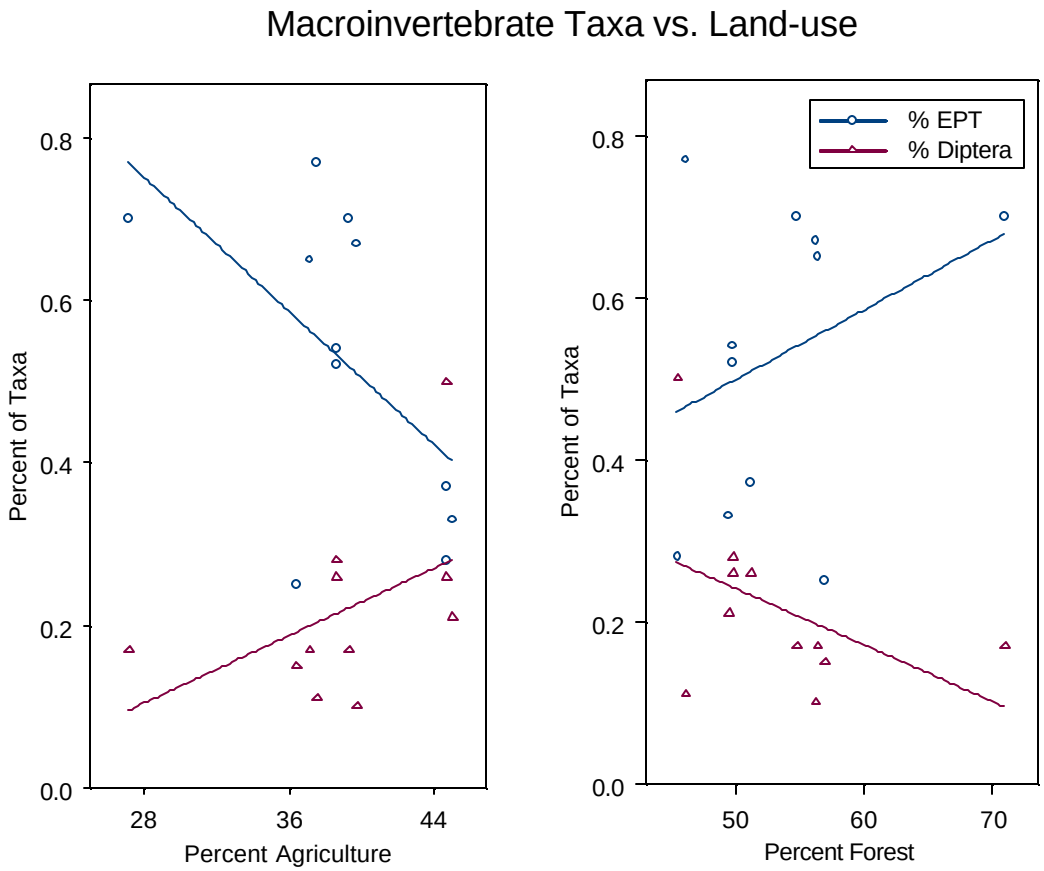
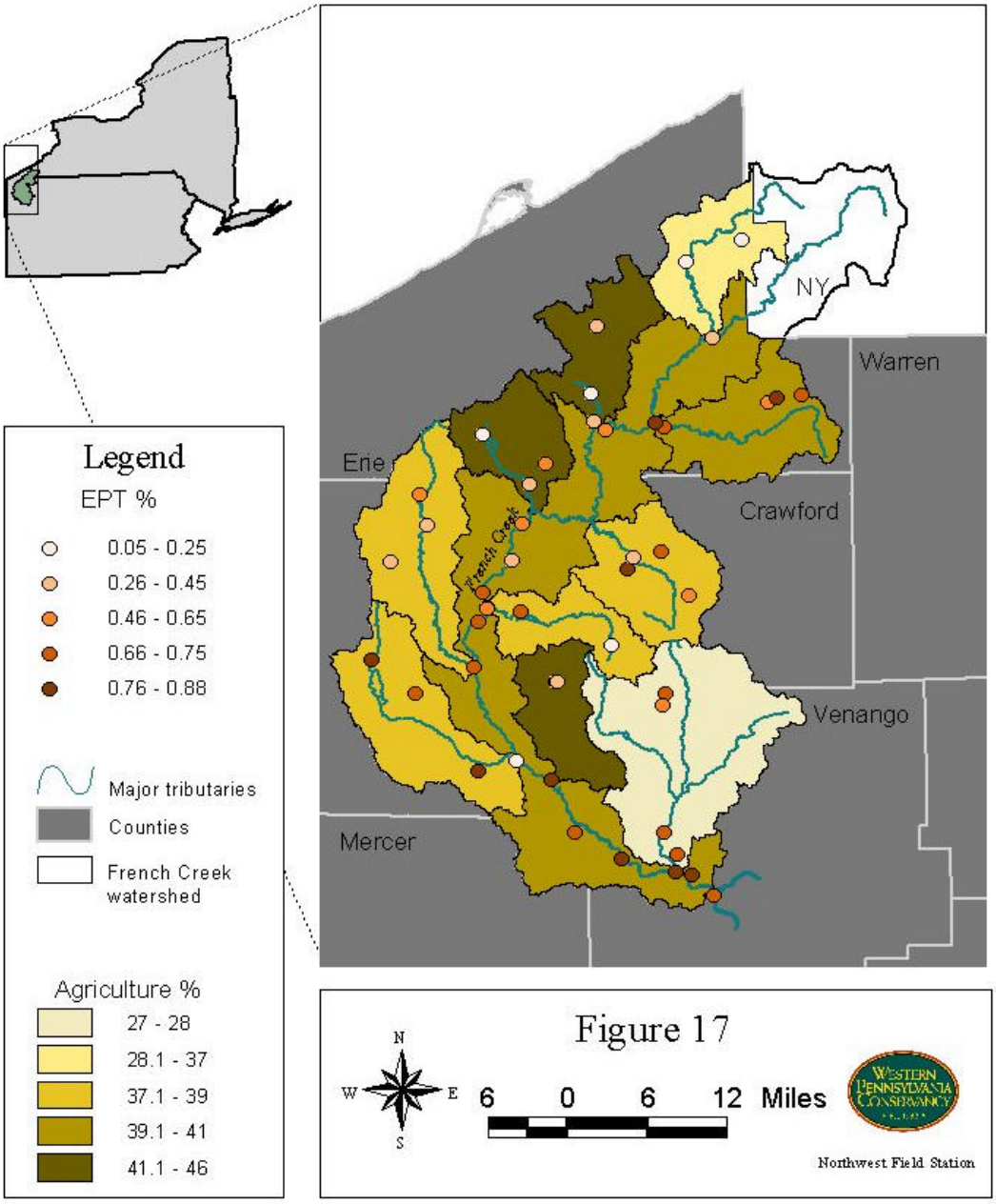


Figure 16: Percent EPT taxa and percent Diptera vs. percent agriculture and percent forest.

Figure 17: Percent EPT versus percent agriculture in the French Creek watershed



We tested the correlation of taxa richness and macroinvertebrate composition measures to water quality or habitat parameters using Kendall's rank-based correlation methods. For each test, we used two-sided alternative hypothesis that ? ? 0, where ? is the (population) correlation coefficient parameter. Significance was assessed at the a = 0.05 level. If ? > 0, then there is a positive correlation, if ? < 0, there is a negative correlation. Kendall's method is based on ranks, and therefore not so sensitive to outliers and non-normality as the standard Pearson estimate (Mathsoft 1999). Kendall's rank correlation measures whether the macroinvertebrate metric increases or decreases with a given water quality or habitat parameter even when the relationship between the two is not necessarily linear (Ott 1993). Significant (p-value<0.05) responses of taxa richness or composition measures to increasing water quality or habitat parameter are given in Table 13. Discussion of each significant parameter follows.

Habitat/Riparian

Habitat/riparian score 1 was positively correlated with percent EPT taxa, number of Ephemeroptera, number of Plecoptera and total number of EPT taxa. Habitat/riparian score 2 was positively correlated with taxa richness, number of Plecoptera and total number of EPT taxa. Total habitat/riparian score was positively correlated with number of Plecoptera and total number of EPT taxa. Habitat/riparian score 2 and total riparian score were both negatively correlated with HBI scores. As total habitat/riparian score increases, HBI score decreases. This strong relationship is partly due to the habitat/riparian score 2; HBI decreased with increasing habitat/riparian 2 score.

Total Phosphorus

We found a significant relationship between total phosphorus in the spring rain and base flow events and percent Diptera. As total phosphorus increases, percent Diptera increases.

Organic Nitrogen

We found a significant relationship between organic nitrogen and percent Diptera. During the spring rain event, percent Diptera showed increasing trends with increased organic nitrogen.

Kjeldahl nitrogen

There is a significant relationship between kjeldahl nitrogen and number of Ephemeroptera during base flow, Ephemeroptera decreasing with increased kjeldahl nitrogen concentrations.

Total Dissolved Solids (TDS)

There was a significant relationship between spring rain TDS concentrations and taxa richness, number of Plecoptera, and number of EPT taxa. All of these metrics decreased with increased TDS concentrations. During the base flow percent EPT decreased with increasing TDS. Number of Ephemeroptera showed decreasing trends with increasing TDS concentrations during the summer rain event. HBI score showed increasing trends with increasing TDS during the spring rain and base flow.

Table 13: Significant ($p<0.05$) response of taxa richness or composition measures to increasing water quality or habitat parameter. Correlations for %EPT and % Diptera were made using all data. Kendall's rank correlation methods were used for the remaining macroinvertebrate metrics using the data from the 19 sub-sampled sites.

		% EPT	% Diptera	HBI	Taxa Richness (Genus Level)	% Chironomidae	No. Ephemeroptera Taxa (Genus Level)	No. Plecoptera Taxa (Genus Level)	No. Tricoptera Taxa (Genus Level)	No. EPT Taxa (Genus Level)
Habitat/ Riparian Scores	Score1	Increase					Increase	Increase		Increase
	Score2			Decrease	Increase			Increase		Increase
	Total			Decrease				Increase		Increase
P, total (mg/L)	Spring		Increase							
	Base		Increase							
	Summer									
N, organic (mg/L)	Spring		Increase							
	Base									
	Summer									
N, kjeldahl (mg/L)	Spring									
	Base									
	Summer						Decrease			
TDS (mg/L)	Spring			Increase	Decrease			Decrease		Decrease
	Base	Decrease		Increase						
	Summer						Decrease			
Conductivity (mS/cm)	Spring		Increase							
	Base									
	Summer									
Salinity (ppt)	Spring									
	Base							Decrease		
	Summer									
DO (%)	Spring									
	Base	Decrease							Decrease	
	Summer									
DO (mg/L)	Spring									
	Base	Decrease							Decrease	
	Summer									
pH	Spring									
	Base	Increase								
	Summer		Decrease							

Conductivity

We found a significant correlation between % Diptera and conductivity during the spring rain event. As conductivity increased, we saw an increase of % Diptera.

Salinity

We found a significant correlation between number of Plecoptera taxa and base flow salinity levels. As salinity increases, the number of Plecoptera taxa decreases.

Dissolved Oxygen

We found significant correlation between %EPT and DO % during base flow. As DO saturation increases, %EPT increases. We found a similar relationship between number of Tricoptera and DO % during base flow. We found significant correlations between dissolved oxygen concentrations and the same metrics as above.

pH

We found a significant correlation between percent EPT and pH, which showed an increase with increasing pH. We found a significant correlation between percent Diptera and pH. Percent Diptera showed a decreasing trend with increasing pH during the summer rain event.

Discussion of Results

Several studies have recognized relationships between land use and water quality with macroinvertebrate communities (Barbour et al. 1994, Barbour et al. 1996, DeShon 1995, Fore et al. 1996, Smith and Voshell 1997). These studies show that total number of taxa, EPT taxa, Ephemeroptera, Plecoptera, and Tricoptera are all expected to decrease with increased perturbation. Similarly, percent EPT taxa, Ephemeroptera, Plecoptera, and Tricoptera are expected to decrease with increasing disturbance. Percent Diptera and percent Chironomidae increase with increasing disturbance. Additionally, HBI is expected to increase with increasing disturbance (organic pollution) (Barbour et al. 1992, Kerans and Karr 1994).

Our study concurs with other studies, trends in our data show that as habitat/riparian and water quality was more degraded, number and percentage of EPT taxa decreased, while percentages of diptera and chironomids increased. Our study made the assumption that water quality was identical throughout the sampled reach. Although we found no significant correlations between macroinvertebrates and nitrogen (nitrate + nitrite), BOD, suspended solids, ammonia, or temperature, we did see trends in our data that indicate some of these and other parameters may need to be studied in finer detail on a microhabitat level.

Macroinvertebrates can readily drift to new acceptable microhabitats. On the other hand other aquatic organisms, such as freshwater mussels, cannot as easily choose their immediate environment.