Landscape Indicators: Macroinvertebrates

Adapted from Nuding and Hampton 2012 TIEE

**Introduction**

Aquatic *benthic* *macroinvertebrates* are insects and other small invertebrates (like crustaceans, mollusks and aquatic worms) that live in streams and other aquatic habitats. “Benthic” refers to the lowest level of a water body, which in this case is the stream bed, and this is where these animals reside. “Macro” means that these animals are large enough to be seen with the naked eye, and “invertebrates” means that they have no spine. Many common flying insects have larval stages in streams and lakes, such as mayflies, stoneflies and dragonflies. These stream macroinvertebrates play very important roles in the stream ecosystem. For example, by shredding leaves and other detritus that falls into streams, they convert terrestrial carbon and other nutrients into forms available to other stream organisms (Vannote et al. 1980; Wallace and Webster 1996). Some macroinvertebrates eat algae, and others are predators on small invertebrates. Most macroinvertebrates eventually become an important food resource to fish and birds (Vannote et al. 1980; Wallace and Webster 1996).

Because benthic macroinvertebrates are such important members of the food web and they respond relatively quickly to ecological changes, they can be very useful to humans as indicators of the health of a stream. Accordingly, they are called “bioindicators.” Some macroinvertebrates require high levels of oxygen and low pollutant levels, and so they are useful as indicators of good water quality, while other groups of macroinvertebrates can tolerate low oxygen and high pollutant levels, thereby indicating lower water quality (EPA 2007). They are not highly mobile (especially compared with fish) and so they are susceptible to the water quality conditions around them and whatever pollutants may have accumulated in the sediment of the stream bed.

**Macroinvertebrates**

Streams often contain a large number and a wide variety of benthic macroinvertebrates. Stream ecologists often look for the pollution-sensitive insects, because they serve as bioindicators of stream health. The following taxonomic orders of pollutant-intolerant insects are collectively referred to as “EPT” because they are such a useful grouping of insects that react strongly to pollution: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). These insects begin their lives in the water, and later emerge as adults to live on the land.

Macroinvertebrates can be sampled by shuffling a net along the bottom of the stream bed and counting the number and types of insects brought up in the net. Ecologists have developed sophisticated methods of characterizing these benthic macroinvertebrate communities – rather than just counting the number of insects, we consider things like the diversity of the species present, and how many of those species are known to be pollution intolerant (e.g., EPT).

The EPA developed a method of characterization that worked best for the Wadeable Stream Assessment and called it “MMI” for “Multi Metric Index” (EPA 2007). It includes the following six categories:

* Taxonomic richness: the number of distinct taxa (e.g., species)
* Taxonomic composition: a measure of the abundance of the ecologically important taxa in the sample
* Taxonomic diversity: the distribution of the numbers of organisms in different taxa
* Feeding groups: the distribution of macroinvertebrates that have different feeding habits (e.g. leaf shredders vs. algal feeders)
* Habits: the distribution of macroinvertebrates that burrow, cling, crawl and/or swim
* Pollution tolerance: a measure of how many taxa present are pollution tolerant and intolerant

More information about these groups can be found in the WSA report (Ch 2, pgs. 27 – 29). In all cases, a higher value indicates a greater diversity of organisms and is considered to be indicative of a healthier stream. A high MMI score (max = 100) tends to indicate a healthy stream, and low score (min = 0) tends to indicate an impaired stream.

**Nitrogen and Macroinvertebrates**

Make a Prediction. If we plotted the total nitrogen values (for the entire nation) on the x-axis, and the benthic macroinvertebrate index values on the y-axis, what do you think the graph would look like? Draw a line that expresses your prediction on the graph below or write a description of what you would expect.

Total Nitrogen (ug/L)

0

50,000

MMI

100

0

MMI vs. Total Nitrogen

**Nutrients and MMI**

Using actual WSA data (Stream Nutrient Data file), create a scatter plot of MMI vs. NTL and MMI vs. PTL, with a trend line for each. When you do a linear regression of MMI with NTL, and MMI with PTL, the R2 can tell you how well the trend line fits the data (how strong is the relationship between the x and y variables). Display the R2 on each chart.

* 1. How does it appear that the macroinvertebrate community changes at low and high levels of total nitrogen and phosphorus?
  2. What are the similarities and differences between the two graphs? Is this what you expected?

1. Because the nitrogen data have such a wide range of values (over three orders of magnitude) and many data points are clustered at one end, we may want to use the logarithm (log) of the nitrogen data to plot on the x-axis instead. Create this plot with MMI on the y-axis and Log NTL on the x-axis, and add a trend line.

Comment on the results. Explain why the numbers on the x-axis changed as they did. How did the log transformation change the distribution of the points and the fit of the trend line (the R2 value)? Would you also perform this operation on the total phosphorus data? Why or why not?

1. On the Log chart you just plotted, draw circles over the areas where you would expect data from Region 7 and Region 10 to be located.
2. Construct a regional comparison of data. Create one plot of MMI vs. Log NTL for Region 7 and one for Region 10. Make sure your axes on both graphs have identical value ranges to allow for easier comparison. In a paragraph, discuss differences in the slopes of the lines, and the distribution of points between the two plots. Do these graphs demonstrate what you expected to see? Why or why not?

**Synthesis**

1. In general, what effect did land use have on both nutrient levels and macro invertebrate MMI. Refer to the land cover ( [Supplement 1](http://tiee.esa.org/vol/v8/issues/data_sets/nuding/resources/supplement1.pdf) ) and the biological condition of streams (in lecture and module 10) maps as a reminder.

2. How are nutrient concentrations and macroinvertebrate MMI useful as landscape indicators for terrestrial and aquatic systems?