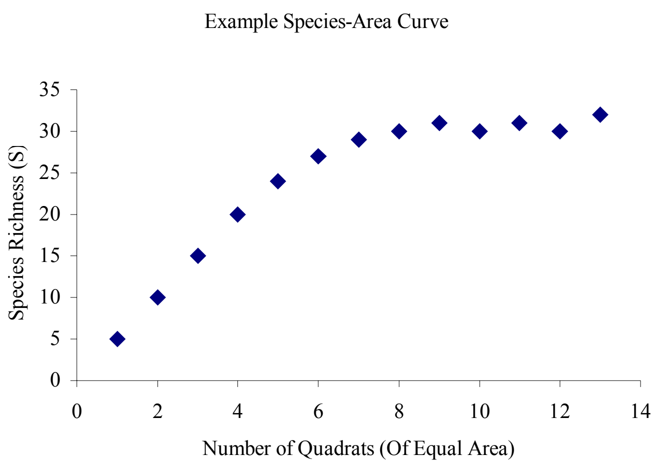
Assessment of Macro-Invertebrate Communities:

Macro-invertebrate surveys can be used in several ways to assess the structure and health of an aquatic system. The simplest approach to assessing the invertebrate community structure is to compile a list of species present in that system. Species Richness (S) is the number of species observed during this survey, and can be used as a preliminary estimate of diversity for a given community. This strategy has some inherent problems in that more intensive surveys will often produce a higher number of observed species, or a higher S value. This problem can be solved by constructing a Species-Area Curve. We can estimate the true value of S by graphing S against the number of quadrats used.



In the above Species-Area Curve, we can see that this community should be sampled using about 10 quadrats to obtain the most accurate Species Richness value. This relationship can also be carried out with increasing quadrat area as opposed to replicate quadrats of the same area (replace the x-axis with quadrat area and repeat survey using different area quadrats). However, for invertebrate surveys, it becomes difficult to capture all the invertebrates when the quadrat area becomes too large. Therefore, replicate surveys using equal area quadrats within the community can be used to obtain an estimate of the "true" Species Richness. If this method is carried out on two communities, Species Richness can be compared for a simple analysis of differences in community structure between the two communities.

In general, higher Species Richness (or biodiversity) indicates good community quality or integrity. Communities with relatively low biodiversity are usually impaired in some way, or are engaged in primary settling (e.g., a new channel formed by a river). However, the Species Richness approach has some inherent flaws. The primary problem with using Species Richness is that it fails to account for relative abundances, or in other words is non-weighted. For example, a strict Species Richness survey might reveal the following results for two communities:

	Abundance			
	Species 1	**Species 2**	**Species 3**	**Species 4**
Community #1	90	2	2	6
Community #2	20	24	26	30

In the above example, we can see that Species Richness would not be a good descriptive value for comparing these two communities. While a survey of both communities would yield a Species Richness value of 4 (S = 4), we can see that the relative abundances of these species are much more evenly distributed in Community #2 whereas Community #1's invertebrate community is primarily represented by one species. In other words, Community #1 has lower biodiversity than Community #2. These differences tell significantly different things about these two communities. To account for relative abundances, a species diversity index can be used to gain more information, and hence a better descriptive variable, about the systems in which you wish to analyze.

While there are many different diversity indexes currently used, we will focus on the Simpson Index. This index is said to be a dominance index because it weights the result towards the most common species. Calculating a Simpson index for your survey will yield the probability that any two individuals that are randomly removed from the sampled community would belong to the same species. The Simpson's Index is calculated as follows:

$$D_S = \sum \frac{(n_i\,(n_i - 1\,)}{(N_i\,(N_i - 1\,)}$$

In the above equation, n_i is the number of individuals observed for species i, N_i is the total number of individuals observed for all species. By summing the weighted abundances of each species, the Simpson's diversity Index is obtained. Typically, the reciprocal of D_s is taken so that as diversity increases, so does the diversity index. To try this out, we can compare Community #1 and #2 as listed in the previous table. The calculation would be carried out as follows:

Community #1:

$D_S = (90(90–1))/(100(100–1)) + (2(2–1))/(100(100–1)) + (2(2–1))/(100(100–1)) + (6(6–1))/(100(100–1))$

$D_S = 0.8091 + 0.0002 + 0.0002 + 0.003$

$D_S = 0.8125$

$\mathbf{1/D_S = 1.231}$

Community #2:

$D_S = (20(20–1))/(100(100–1)) + (24(24–1))/(100(100–1)) + (26(26–1))/(100(100–1)) + (30(30–1))/(100(100–1))$

$D_S = 0.0384 + 0.0558 + 0.0657 + 0.0879$

$D_S = 0.2478$

$\mathbf{1/D_S = 4.036}$

By utilizing a species diversity index, such as above, we can see that Communities #1 and #2 are indeed more different than a simple Species Richness survey would yield. By weighting the abundance of each species using a simple biodiversity index (such as the Simpson Index), a better picture of these two ecosystems can be obtained from our survey. In fact, the results show that Community #2 has a significantly higher biodiversity index than that of Community #1.

While a biodiversity index can provide a useful descriptive variable for the systems being studied, the actual composition of species within the system can tell a lot about the community as well. For example, some species may be more tolerant to certain environmental conditions, e.g., pollution or high sediment loading. Therefore, an assessment of the species present, in addition to the biodiversity of species in a system can provide a lot of useful information on both the health and structure of the system being surveyed. Generally, Ephemeropterans, Plecopterans, and Trichopterans are intolerant to pollution, although there are some species within each order that are extremely pollution tolerant. Chironomids, Oligochaetes, and Simulids are pollution tolerant. As a result, more Ephemeroptera, Plecoptera, and Trichoptera taxa would be expected in a community that has good water quality. Likewise, communities dominated by Chironomidae, Oligochaete, and Simulidae taxa with very few Ephemeroptera, Plecoptera, and Trichoptera taxa would be expected in a community that has poor water quality.

One common approach to assessing quality of aquatic systems based on taxa-level pollution involves the direct assessment EPT richness (number of Ephemeroptera, Plecoptera, and Trichoptera taxa). In general, EPT richness declines as the aquatic community is degraded, as mentioned above. Typically, 8-12 EPT taxa are considered good. Another useful way to modify this approach incorporates the use of taxa that are known to be pollution tolerant. By determining the EPT/C ratio (the total number of Ephemeroptera, Plecoptera, and Trichoptera individuals divided by the number of Chironomidae individuals), a good assessment of the aquatic system's health can be obtained. In general, good water quality is represented by a EPT/C ratio of 0.75 or greater.

While the above discussed macro-invertebrate survey strategies represent some effective and simple ways to assess the structure and health of an aquatic system, there are many more ways to examine the health of an aquatic system than are mentioned here. Logically, the strategy required by a survey is extremely dependent on the conditions being surveyed, desired detail of the survey, and the desired output of the survey. To learn more about macro-invertebrate surveys, please see the sources listed below.

For More Reading:

EPA. 2003. Biological Indicators of Watershed Health. http://www.epa.gov/bioindicators/html/publications.html

Murdoch, T., M. Cheo, and K. O'Laughlin. 2001. Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods. Adopt-A-Stream Foundation, Everett, WA. 297 pp. (See Chapter 6)