April 2021

Reading - The Challenge of Measuring Biodiversity

Center for Urban Resilience

The Challenge of Measuring Biodiversity

Scientists measure biodiversity by collecting data on the number of species and the number of individuals of that species that are found in a given location. Well, that sounds pretty general and is not very precise. We need to add a bit more explanation. You see, deciding which species to monitor and where to monitor them is the trick behind the science of biodiversity. On the smallest scale, scientists might choose to monitor the single-celled organisms in a soil sample from a park, or from a water sample from the local river. On the other end of the scale, they might count the total number of mature tree species in a park. The choice of what to count depends on the questions the scientists are trying to answer. Like so many issues in ecology, the scale of the question is sometimes the most complex part of the process.

In urban neighborhoods, the biodiversity that is most often measured is the composition of parks and green spaces. Usually, scientists are measuring plants, birds, amphibians or insect communities. For example, plants can't get up and leave and their health is dependent upon local conditions. If the soil, air or water quality is poor, the distribution of plants that can be found will reflect those conditions. Only the species that can tolerate the conditions survive to be counted. On the other hand, birds are highly mobile and very sensitive to local changes. If the ecosystem becomes unhealthy, they will just fly away and leave. As such, they are good indicators of environmental stress in any given area. Amphibians, such as salamanders and toads, rely both on healthy ponds and healthy forests. Their eggs develop in the local temporary ponds that form in the spring. These temporary ponds are a critical link in the life cycle of these animals. Spotted salamander eggs are pictured below. You can see the developing embryos in the egg.

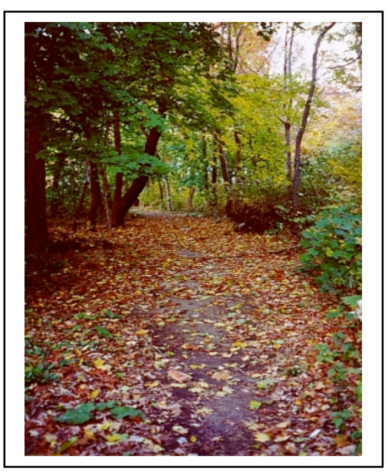
Any reduction in quality of the standing water will result in local population decline. Insects are also very sensitive to local changes in the environment. The bottom line is that the choice of the organisms being counted is dependent on the question being asked.

Once the scientists decide which organisms to measure, they can collect two kinds of data about biodiversity. The first is **species richness**. Species richness is defined as the total number of different species of a certain group of organisms that can be found in a given patch of habitat. This measure is straightforward in that every species encountered, no matter how many individuals from each species are observed, is just recorded one time. For example, if a team is counting bird species and they observe robins (*Turdus migratorius*), no matter how many individual robins they encounter, the score is still one. The same will be true for each species of bird they encounter on their survey. Some particularly diverse habitats in cities can be full of birds. Mount Auburn Cemetery in the City of Cambridge, MA hosts more that 200 species of birds.

Species richness is the fundamental measure of biodiversity. Species richness can be astounding, especially in tropical ecosystems such as rainforests. In 1982, tropical insect biologist Terry Erwin investigated rainforest trees in previously unreported regions of the jungle. From a single species of tree, he discovered 1100 species of beetles! Most of those species were being discovered for the first time.

As good as they are, species richness data are limited in their value. They lack the ability to tell the differences between common and rare species. Every species is counted once, no matter how many individuals there are. Another way to measure biodiversity is **species evenness**. Evenness refers to the similarity of the numbers of individuals of each species. To account for evenness, not only is the number of species counted, but also the number of individuals of each species. This measurement is formally called **relative abundance.**

In most healthy ecosystems, no particular species should dominate the community. Each species is represented by a similar number of individuals. If the data reveal such a trend, we say that the distribution is even. Testing the hypothesis of evenness is tricky. While it is easy to imagine, evenness is much harder to measure and evaluate. Some urban parks, like this one shown below in Boston, have many species represented.



Scientists use two different methods to assess the relative abundance, or evenness of species. One test is called the **Simpson's Index**, which measures both species richness and evenness. The index value ranges between 1 and 0. Perfect evenness would receive a 1 and no diversity at all would yield a 0. In reality, the measure of the system falls somewhere in-between. With respect to evenness, Simpson's Index gives more weight to the more abundant species. This means if a rare species is encountered, it does not impact the index value very much. The second index used by scientists is called the **Shannon-Weaver Index**. This index also accounts for both richness and evenness. However, it favors either high evenness or many rare species. In disrupted habitats such as urban areas, the Shannon-Weaver Index is typically used. You will be using both indexes to measure the biodiversity of your neighborhood.

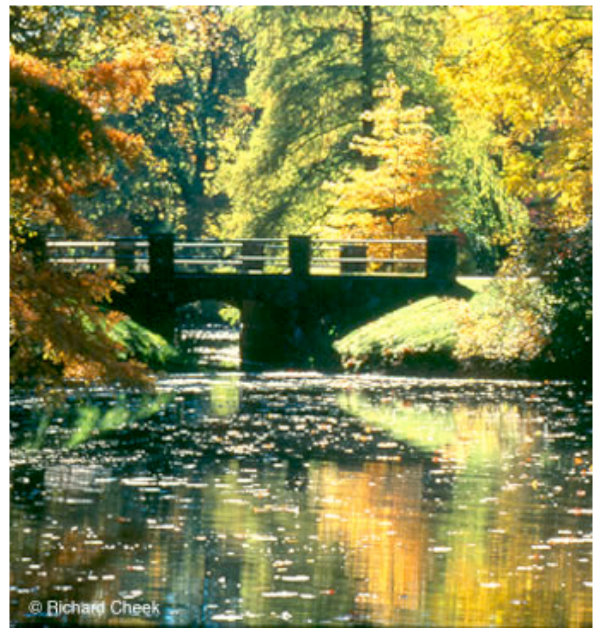
The greatest value in measuring biodiversity is revealed when it is used in the **comparative method**. Scientists use the comparative method to analyze data from multiple sites or even data from different cities. The comparative method looks for trends or patterns that might help reveal why some urban areas remain healthy and diverse while others show declines in biodiversity. In this activity, you are comparing biodiversity data from three sites in Boston, all located along the Orange line. Each site has unique characteristics that impact the local bird biodiversity. You will be able to analyze the data and suggest reasons for the different biodiversity patterns you have observed.

Closer to Home – Boston Metropolitan Area: Mount Auburn Cemetery, a Biodiversity Hot-Spot

Mount Auburn Cemetery is located in the heart of the Boston urban landscape, in the neighboring city of Cambridge. The Charles River runs through the center of the urban community with Boston on one side and Cambridge on the other. From an ecological perspective, they are really one large city. Started in 1831 as a cemetery garden, the 174 acre (70 hectare) park is famous for its biodiversity. The wildlife value of Mount Auburn Cemetery is important to the animals and plants that live there because the surrounding habitat is highly urbanized.

Below is an aerial view of the park. It can be seen as a green oasis at the left of the picture on the west side of the Charles River. Note how city the surrounds the landscape of the cemetery.

Despite the fact that over 80,000 people are buried there, the site has over 5000 trees of 700 different species and varieties. With lots of hills covered by trees and shrubs, Mount Auburn has become home to thousands of local and migratory birds that use this urban area. Birders have counted over 175 species of birds while walking along the 10 miles of trails inside the boundaries of the cemetery. This island of green in an urban community provides a valuable resource for local birds and they flock to the site for food, water and shelter. As you can see below, the site is filled with trees and water.



Scientists and birdwatchers flock to Mount Auburn each year to count, study and enjoy the extraordinary biodiversity of this site. It is easily accessible by public transportation and is free and open to the public.