Teacher Background Knowledge: Biodiversity

Center for Urban Resilience

Teacher Background Knowledge: Module 6 – Biodiversity

What is biodiversity?

Biodiversity is the science of biological variation. We know that living systems are complex, but they also vary considerably among geographic locations and across size scales. *Evolutionary Theory* tells us that random mutations in the genes of organisms provide the genetic variation within populations. From there, natural selection favors the most effective combinations of genes and they are represented at higher frequency in the succeeding generations of organisms. This is where the often misunderstood phrase, "survival of the fittest" comes from. Natural selection is not just *survival*. Natural selection is actually about *reproduction*. The most successful combinations of genes give organisms a reproductive advantage. Hence, the most reproductively successful combinations are found in increasing frequency over time. Other forces influence evolution as well, such as climate change natural disasters.

Here's where the biodiversity part fits in. Organisms avoid extinction by maintaining enough genetic variation within their populations so that they can adapt to changing environmental conditions. What is the fittest combination of genes now may not be so in 1000 or 10,000 years. Especially at the scale of ecological communities, variation is critical . Healthy ecosystems have many different species that buffer the community against changes. Abiotic (nonliving) factors such as flood, fire and drought can stress an ecosystem. So can biotic (living) factors such a competition, invasive species and predator/prey relationships. The more varied an ecological community is, the more likely is to survive these challenges.

Biodiversity is also the measure of biological variation across all of the scales of life. So, at the smallest scale, biodiversity includes the genetic diversity in a single population of organisms. At the level of the community, biodiversity measures include the number of different species within that community. At an even larger scale, communities can be compared to each other.

Why do we care about biodiversity?

Biodiversity matters to everyone because of the need for humans to live in healthy ecosystems. Healthy ecosystems provide clean air and water, modulate our climate extremes and provide us with the supplies for food and shelter. When ecosystems degrade, human health suffers and the cost of replacing those lost ecosystem services places an enormous strain on the local economy. The science of biodiversity has consistently revealed that the healthiest ecosystems have relatively high levels of biological diversity at all possible scales. It is imperative that the ecosystems in which we live maintain their natural functions. Therefore, we must monitor the health of ecosystems and have ways to compare them to each other.

How do we measure biodiversity?

The imperative to monitor ecosystem health is the driving force behind the study of biodiversity. Scientists who study biodiversity at the community level gather two fundamental categories of data, **species richness** and **relative abundance**. Species richness is gathered by counting each species that is encountered during the survey. For species richness analysis, once a species is noted, no further data are gathered about that species. Species richness data are presence-absence analysis, the species in question are either found at the site, or not. These data are critical for initial ecosystem analysis.

Often, relative abundance data will be gathered for groups of species. Here, not only are the individual species noted, but so are the numbers of organisms of each species that were observed. These data are more informative as scientists can now compare the numbers of individuals observed from each species and gauge the relative composition of the community. The challenge of accurately counting the number of individuals can be daunting. This leads to errors in sampling. For this reason, species richness data are still quite valuable and are often more dependable.

These biodiversity data are often used to create an index of biological variation for any given site. Scientists might create an index of biodiversity for birds, plants or soil organisms. The index from one site can then be compared to other indices that were calculated. In this way, ecosystems can be monitored and signs of trouble can be interpreted before the system is in danger of collapse.

Two biodiversity indices are typically used for community-level studies of biodiversity. One of the more commonly used is the Simpson Index. It varies between 0 and 1. The Shannon-Weaver index is also used and can be as high as 4.5 in very diverse communities. The two indices tend to favor different aspects of species distribution. For instance, if you are measuring disturbance from a fire or flood, the Simpson's Index will be most sensitive to a new species becoming dominant. Shannon-Weaver is more sensitive to changes in rare species and is therefore more sensitive to the presence, or absence of endangered species.

However, in our spreadsheet, the maximum number of species that you can measure is ten. In real communities, the number of species can exceed 100. So, you are likely to see both indices behave in very similar ways

Simpson Index

Remember that the Simpson's index is given by the following formula:

$$D = \frac{\Sigma\, n(n-1)}{N(N-1)}$$

With the diversity index being **1- D.**

Have the students put their data in a table similar to the one below. Let's assume your students have collected the following tree data:

Species	**Number (n)**
Green Ash	2
Oak	8
Norway Maple	1
Littleleaf Lindon	1
Elm	3
Total (**N**)	**15**

You have the following 5 different species and 15 birds in total (abundance). Now let's calculate what n(n-1) is for each species.

Species	**Number (n)**	**n(n-1)**
Green Ash	2	2
Oak	8	56
Norway Maple	1	0
Littleleaf Lindon	1	0
Elm	3	6
Total (**N**)	**15**	**64**

Now let's use that data to calculate Simpson's biodiversity index (D). Now we just simply add and divide using the numbers from the table.

$$D = \frac{\Sigma\, n(n-1)}{N(N-1)}$$

$$D = \frac{64}{15(14)}$$

$$D = \frac{64}{210}$$

So **Simpson's index of diversity**

$$S = 1 - D = 0.3$$

What impacts biodiversity?

On a worldwide scale, habitat destruction and fragmentation are the most important threats to the earth's biodiversity. The second biggest negative impact is the introduction of non-native species, also called invasive species. Pollution, soil degradation and over-harvesting of land and aquatic natural resources are also important sources of biodiversity decline.

Habitat loss occurs when natural ecosystems are converted to farmlands or cities in order to provide additional space for humans. Habitat fragmentation results from the cutting up of ecosystems with roads and areas of development. Fragmentation leaves habitats isolated, smaller and more vulnerable. One of the ecosystems hit hardest by the forces of habitat destruction is that of the world's tropical rainforests. According to research conducted by the United Nations, over 40 million acres of the world's rainforest habitat is being lost each year to agriculture conversion and logging. This represents nearly 2% of the word's rainforest ecosystems. At this rate, all the earth's rainforests will be gone in fifty years! This kind of massive change to the forest ecosystem damages the chemical composition of the soil, increases pollution and leads to extinction of native species. In addition, the loss of trees increases the rate of climate change, itself a cause for biodiversity loss.

Habitat fragmentation and destruction impacts birds as well. In 1620, just as the Pilgrims were arriving from England, the natural forest systems of the United States covered nearly 420 million acres. Now, only about 25 million acres remain. They have been replaced with farmlands, suburbia and cities. According to scientists, 30% of the 1100 species of birds that are found in North America have shown significant population declines in the last forty years. Despite the increased awareness and laws such as the Endangered Species Act, the loss of bird populations continues. The challenge of biodiversity loss is very complicated and the factors interact in a positive feedback loop that acts to increase the rate of biodiversity loss.