Chapter 8. Biodiversity Concepts – Field Trip to Albuquerque Aquarium.

Outline of activities:
1. Travel to Albuquerque BioPark
2. Walk through aquarium
3. Work on diversity calculations and questions
4. Travel back to campus

What you should get out of this trip:
You should get some practice identifying species and observing habitats. You should come away with a strong sense of niche and trophic position and what that means for the connectedness among species in nature. You should be able to use the diversity statistics presented on your own.

Handouts:

What to bring on the trip:
1. Writing utensils and notebook
2. Calculator
3. Money if you want a snack/coffee at the cafe

Today's Lab Schedule:
1. Meet at westbound Rapid Ride bus stop on the southeast corner of Yale and Central at 9:00 am sharp. We will take the first Rapid Ride (red line only) that comes along, so don't be late.
2. Arrive at BioPark and arrange tickets.
3. Head into the Aquarium.
4. After the aquarium, we will sit down at the cafe and work through the diversity indices.
5. Be at the eastbound bus stop by 11:25 am to make it back to campus at 11:50.

Introduction
One of the oldest and most vital tools in ecology is simple observation of the natural world. We may hold models, experiments, and statistics to be vital tools in ecology today, and they are, but we should always remember that the most important ecological theory ever devised, Darwin's theory of evolution by natural selection, was built by simple categorization of species and observation of patterns in nature. A good ecologist gets to know his or her system and makes observations that inform models and experiments. Today we are going to slow down and enjoy some simple observation of species, their habitats, and their trophic levels at the Albuquerque Aquarium. We are also going to learn how to calculate a variety of widely-used diversity indices. The four important topics to think about today are species identification, habitat, niche, and trophic position.

Species identification
One essential skill in ecology is the ability to identify organisms to species just by observing them. With some organisms that are hard to discern visually, you may use a dichotomous key to guide you. Today, however, you will improve your observational and identification skills by studying the fish in the aquarium tanks. It is essential in the questions below that you not just write down the names from the ID plates. You should actually try to identify the fish in the tank by observing the
shape of the fins, the colors of the scales, the shape and structure of the mouth parts. Also note that sometimes the fish and the identification information are not closely enough in line to easily make an identification, either because a particular fish looks a little different or the guide illustrations are not that great. This is a normal frustration for field ecologists and something you must work to solve on the fly, usually by looking at other individuals, or by process of elimination.

**Habitat**

Habitat is the place where an organism lives and can be described in terms of location, food resources present, refugia, and proximity to other habitats. Mobile organisms may move to different parts of their habitat to acquire different resources. Hummingbirds, for example, use flowering plants for food and trees for nesting and roosting. Both flowers and trees are essential components of hummingbird habitat. For plants, habitat is more or less fixed because plants cannot move to acquire resources (although their seeds may be blown, carried, or washed to new areas to germinate). Habitat can change around a sessile organism, as when a forest grows up around a tree. For plants, abiotic factors such as light, moisture, and soil conditions, and biotic factors such as seed dispersers and pollinators, are important parts of habitat. For marine organisms, factors such as salinity, temperature, nutrient loads, depth, light levels, substrates, and vegetation may all be habitat factors.

*Figure 8.1. A food web diagram of the tundra biome, showing typical organisms at different trophic levels. Available for educational use at http://curriculum.calstatela.edu/courses/builders/lessons/less/biomes/tundra/tundraweb.html.*
**Trophic Position**

Trophic position refers to an organism's place in a food chain or food web (Figure 8.1). There are four basic trophic levels: decomposers, primary producers, primary consumers, and secondary consumers (which may expand to tertiary or higher consumers as well).

Decomposers such as fungi, bacteria, and many types of worms and single-celled organisms break down organic matter left over from other living organisms. These species gain energy and nutrients from those tissues and both mineralize nutrients for other organisms to use and become food for consumers.

Primary producers transform solar or chemical energy into chemical energy (sugars, or more precisely the bonds holding the sugar together). They are called primary because they are the first step in the food chain, and without them no new energy would flow through the community. Primary producers include plants, algae, and some bacteria.

Primary consumers are the myriad animals, fungi, and microorganisms that eat plant tissue, algae, or other primary producers. They are grazers and parasites, diseases and herbivores, omnivores and granivores.

Secondary consumers eat primary consumers, but they may also eat a variety of organisms on different trophic levels (omnivory). Humans are a classic omnivore, eating decomposers (mushrooms), primary producers (vegetables and fruits and algae), primary consumers (cows), and secondary consumers (many fish). Above the secondary consumer level, predators add levels to a community, up to the top predators that are not eaten by other organisms (e.g., grizzly bears and sharks) until they die and consumed by scavengers and decomposers.

Figure 8.1 shows a simple version of a food web with species on four trophic levels. Most ecosystems have many more species than are shown in this diagram, and if all were shown the web would look mighty complex. The key point is that there are many components in a food web, with many linkages among species. Another key aspect of food webs is that energy is captured by the primary producers and then flows from the primary producers to other species via consumption.

**Niche**

A species’ **niche** is the array of resources it uses. A description of a niche should include habitat features and trophic position. Some species have a fairly specific niche. For example, a crossbill is a kind of bird that eats pine seeds, lives in conifer forests, and nests in the tops of trees. Occasionally, crossbills fly down to the ground to drink water or collect nest materials. Other species, such as coyotes, may have a wide niche that includes different types of food and plant communities that are acceptable. The **competitive exclusion principle** says that two species can coexist if their niches are sufficiently different. Otherwise, they cannot coexist for long because they are competing for the exact same set of resources. The competitive exclusion principle shows how subtle differences in niche, such as different preferred foraging locations, can allow otherwise similar warblers to coexist. Some of the best examples of niches come from Darwin's finches, a group of birds that evolved from one founder species into a wide variety of finch species, each with a different bill shape that allowed them to capture different resources (bugs on leaves versus bugs burrowed in the bark of trees, for example) on the Galapagos Islands.
Diversity concepts

Biodiversity is a catch-all word to describe the myriad varieties and patterns of species in nature. Because there can be so many species, and because the patterns of distribution can be so complex, ecologists have created a variety of diversity metrics. **Richness** ($S$) is simply the number of species present. This statistic is pretty easy to compute – you just count the species. A well-known index that combines the number of species with the relative abundance of the species is called the Shannon-Weaver Index and is represented by the letter $H'$.

$H' = - \sum p_i \ln(p_i)$  

where $i$ = an index for each species present in a sample, $p_i$ is the number of individuals within a species $n_i$ divided by the total number of individuals in the entire sample $N$, and $\ln$ is the natural logarithm. Basically, you calculate the proportion of that species represented in the whole community ($p_i$) and multiply that by the natural log of the proportion for that species $\ln(p_i)$, and then sum the products over all species ($\Sigma$). Lastly, multiply by -1 to reverse the sign.

Species **evenness** is how well the individuals in a community are divided up among species. A community with high evenness has about the same number of individuals in each species. A community with low evenness has one or a few dominant species, while the other species are represented by only a few individuals. Evenness is computed as follows:

$$E = \frac{e^{H'}}{s}$$  

where $e$ is base of the natural logarithm (~2.7), $H'$ is the value of the Shannon-Weaver diversity index, $s$ is the number of species. $E$ is constrained between 0 and 1. The closer $E$ is to 1, the more even it is, while the closer it is to 0, the less even.

The **Jaccard similarity index** is a measure of how much overlap there is between two diversity samples. It can be used to compare species overlap between different types of habitats, between different times at a single place, or between patches of a similar habitat that have been managed differently (such as logged versus unlogged forests). It is calculated by:

$$J = \frac{M}{M + N}$$  

where $M$ is the number of matches between the two samples and $N$ is the number of species unique to either sample. As you can see, this index is just a proportion of the total species pool that is shared.

Walking through the Aquarium

As you enter the aquarium, you will notice two tanks right up front. The first contains fish species that formerly dominated the fish community in the middle Rio Grande and the second contains fish species that are currently present. Identify all of the species in each tank. Write down the species
names (just the common names) in Table 8.1 and tally the number of individuals the species. Because this can be time consuming, divide the species up among the students and have everyone do one, or maybe two, species. We then will compile data from all of the students at the end and use the data to calculate the Shannon-Weaver index, the evenness, and the Jaccard similarity index of the fish communities in the two tanks.

Table 8.1. Shannon-Weaver diversity calculations for fish in the Rio Grande.

<table>
<thead>
<tr>
<th>Species</th>
<th>Tally ($n_i$)</th>
<th>$p_i$</th>
<th>$\ln(p_i)$</th>
<th>$p_i \times \ln(p_i)$</th>
</tr>
</thead>
</table>

Species that used to be in the Rio Grande

<table>
<thead>
<tr>
<th>Species</th>
<th>Tally ($n_i$)</th>
<th>$p_i$</th>
<th>$\ln(p_i)$</th>
<th>$p_i \times \ln(p_i)$</th>
</tr>
</thead>
</table>

Sum (number of individuals = )

Species that are currently in the Rio Grande

<table>
<thead>
<tr>
<th>Species</th>
<th>Tally ($n_i$)</th>
<th>$p_i$</th>
<th>$\ln(p_i)$</th>
<th>$p_i \times \ln(p_i)$</th>
</tr>
</thead>
</table>

Sum (number of individuals = )
(The next five questions are to be answered when we sit down at the cafe.)

- What is the Shannon-Weaver diversity of the old Rio Grande tank? ____________
- What is the Shannon-Weaver diversity of the new Rio Grande tank? ____________
- What is the species evenness of the old Rio Grande tank? ____________
- What is the species evenness of the new Rio Grande tank? ____________
- What is the Jaccard similarity index between these two fish communities? ________________

Next you come to an artificial stream tank with Rio Grande cutthroat trout.

- What is the habitat of this species?

- What is its trophic position?

As you walk up the ramp, look at the salt marsh tank on your right, but then continue on to the Gulf Coast tanks. You see one tank for what used to be in the Gulf Coast waters and one tank for what currently is in the Gulf Coast waters.

- What is the Jaccard similarity index between these two pools?

As you round the bend towards the Shallows and Shores tank on your left, you will see a surf tank in the wall.

- What marine species are here?

- How did the example human modification of the environment alter what species could occur there?

In the Shallows and Shores tank, there are two species of ray swimming around the bottom of the tank.

- What are they?

- What is their habitat?

- How can these two species coexist in the same place?
As you walk down the dark hallway, you approach the magnificent reef tank. Take a moment to take it all in, then pick two species and sketch them. Many early naturalists also were accomplished artists. It was an extremely important means of documenting and classifying species, and still is an enormously useful skill for sharpening ones powers of observation. Don't worry if you “can't draw,” just give it your best shot and try to capture the key features that helped you identify the species.

As you head into the eel tunnel, look for the three species of eels present.

- What are they?

- Why can these three eels coexist?

- What trophic position are they on?

There are several other interesting tanks in this area, but make your way to the jelly fish tank. Don't forget to check out the light refraction on the comb jellies.

- What trophic position do the jelly fish occupy?

- What predators eat jelly fish?

Now just enjoy the last room of the aquarium, as it is quite spectacular.
Homework # 7 - Tree diversity along an elevation gradient (10 points)

Calculate the Shannon-Weaver diversity index for the tree communities we sampled at the five stops we made on the field trip to the Sandia Mountains. I can send the data to you again if you need it. Answer the following questions:

1. What is the index for all the five sites?

<table>
<thead>
<tr>
<th>Site</th>
<th>Shannon-Weaver diversity index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canyon Estates TH</td>
<td></td>
</tr>
<tr>
<td>Cienega TH</td>
<td></td>
</tr>
<tr>
<td>Tree Spring TH</td>
<td></td>
</tr>
<tr>
<td>10 K TH</td>
<td></td>
</tr>
<tr>
<td>Near the crest</td>
<td></td>
</tr>
</tbody>
</table>

2. Generally state what PET/AET conditions produced the highest diversity?

3. What other conditions do you think may have influenced the diversity in these communities?