Ecosystem Ecology – Part 1: Food Webs

Written by Miranda Dudzik, for LBCC iLearn BI 101

*Number in outline corresponds to slide number the PowerPoint presentation.

1. Ecosystem Ecology – Food Webs

2. Ecosystem s
- **a.** Recall that earlier in the term, we defined an ecosystem to encompass all the living and non-living components of a habitat, including the organisms that share the habitat, the interactions they have and the resources that they obtain. We have spent the last 3 weeks on the living components, biotic factors. Now we will turn our focus to the abiotic parts of an ecosystem: Energy and nutrients.

3. Energy Flows and Nutrients Cycle
- **a.** If there is one sentence that will help you understand how each of these abiotic factors, energy and nutrients, move through an ecosystem, it is this: Energy flows and nutrients cycle. As demonstrated in this graphic, what this sentence essentially means is that energy flows through an ecosystem in one direction. As the sun being the origin of all energy, once it enters a food web, it is either used by the organisms in that web, or lost as heat, but once it is gone it is gone for good. This means that energy always needs to be replenished.
- **b.** Nutrients on the other hand, continuously are recycled. When they are consumed by organisms they can be incorporated into the body of that organism or excreted as waste. But either way, they will eventually be returned to the environment and available once again for another organism to take in. Can you think of how a nutrient that is incorporated into the body of an organism can once again enter back into the environment?

4. Photosynthesis vs. Respiration
- **a.** Photosynthesis is an important process both in the flow of energy and in nutrient cycling. For now, let's focus on its role in energy flow.
- **b.** Organisms that are capable of photosynthesis are known as autotrophs (AKA primary producers). The most obvious example of an autotroph would be the entire plant kingdom. But other types of organism, many species of algae and bacteria are capable of photosynthesis. In marine habitats, microorganism known as phytoplankton are the primary producers where plants cannot live.
- **c.** Photosynthesis essentially captures energy from the sun and converts into a form that is usable by living organisms. In nearly all organisms, energy is stored as sugar. All cells have the ability to use energy that is stored in the bonds of a glucose molecule. That energy is released through the process of cellular respiration.
- **d.** Notice that these chemical equations are the exact reciprocal of each other? All energy that enters into a food web comes from producers. Without photosynthesis, there would be no energy available for the heterotrophs in an ecosystem.

5. Ecological Models
- **a.** Now that we understand where energy comes from, let's look at the various ways it can be evaluated in an ecosystem and the organisms that need it. Because the natural environment is so complex, there are a variety of different types of models that attempt to describe the relationship between energy and the organisms that need it.
- **b.** We will briefly look at these types of models, but our main focus will be that of the food web. A food web looks at the hierarchal relationships that occur between organisms as they transfer energy through an ecosystem.

6. Trophic Levels
   a. The trophic levels found in any given ecosystem are basically the steps that energy takes as it moves though different organisms in that ecosystem. Trophic levels identify how close a particular organism is to where energy enters a food web. There are typically 4 – 5 trophic levels found in any given habitat, the higher the trophic level, the farther away from the energy input that organism is.
   b. Autotrophs will always occupy the first trophic level, whereas top predators will occupy the last trophic level being the farthest away from energy input. The trophic levels above the first are all going to be occupied by heterotrophs, or organisms that must consume others to obtain energy.
   c. There are different types of heterotrophs (AKA consumers). The type of consumer identifies the trophic level that it occupies. Primary consumers are considered herbivores, or plant eaters. Primary consumers occupy the 2nd trophic level.
   d. Secondary consumers are carnivores. Specifically, they are carnivores that eat carnivores, and they occupy the third trophic level. Tertiary consumers, as you might expect, are those carnivores that consume other carnivores. They occupy the 4th trophic level in an ecosystem, and typically speaking, are usually considered top predators.

7. Energy Flow
   a. What is the difference between a food chain and a food web? The answer to that question really boils down to simplicity. A food chain is a straight line, following one possible route that energy can take through an ecosystem. It always starts with a producer, where energy enters an ecosystem, and it always ends with a top predator, the last level energy can reach before being completely exhausted.

8. Tall-Grass Prairie Food Web
   a. A food web is the complex, inter-connected chains that make up an ecosystem as a whole. One thing to notice is the direction of arrows in this food web. When constructing and evaluating a food web, it is important to note that the arrow always points in the direction that energy is flowing. It is a common mistake to those who are new to this to want to draw the arrows in terms who is getting eaten. A frog eats a spider, therefore is a way it makes sense to draw the arrow pointing towards the spider. But that is not the purpose of the arrow to identify who's getting eaten; it is identifying the direction that energy is moving, or who the eater is.
   b. As we view this simplified prairie food web, this is a good time to bring into the picture one type of consumer we have not discussed yet. Any guesses to what that might be? How about an animal that eats both plants and animals? AKA the omnivore. In an earlier slide we discussed trophic levels and how they relate to herbivores and carnivores.
   c. The omnivore is an interesting case because they can occupy multiple levels, depending on what they happen to be eating at any given time. In this web, an example of an omnivore would the Coyote. When eating a ground squirrel, the coyote is occupying the 3rd trophic level. But when consuming the fruits, such as raspberries, it is occupying the 2nd level. Can you identify any other organisms that occupy multiple trophic levels?

9. Food Webs
   a. Typically speaking, every ecosystem has two different food chains present. There is the grazing food chain in which energy flows towards consumers. And there's what are known as detrital food chains, where energy flows to organisms that break down dead and decaying materials within the environment.
   b. Detrital food chains are responsible for releasing nutrients from a food web back in to the environment, as well as utilizing some of the energy that was not passed up the food web through consumption.

10. Recycling

- **a.** The detrital food chain can be thought of as the recycling center of any habitat. There are two types of recyclers that are present in an ecosystem: The Detritivores and the Decomposers. There are important nuances between these two types of organisms. They both feed on dead and decaying materials in the ecosystem, but it is the digestive strategies that differ. Detritivores consume small particles, such as leaf litter and dead animals. Scavengers such as vultures would be considered a detritivore because they don't feed on animals that died by the direct actions of that vulture. Decomposers secrete digestive enzymes into their surroundings and essentially break down food particles before absorbing them into their cells.

11. Biomass Pyramids vs. Biomass Pyramids Pyramids

- **a.** Now let's briefly talk about two ecological models briefly mentioned at the beginning of this lecture: Energy pyramids and biomass pyramids. Biomass pyramids are a measurement of how much space a particular trophic level takes up in an ecosystem. Depending on the habitat, that pyramid can look like a typical pyramid, with the majority of the organisms occupying the habitat are producers. A rainforest or wetlands for example are going to exhibit an upright pyramid. But in an aquatic habitat, most producers are microscopic, and the consumers are much, much larger. This type of pyramid would be inverted.

12. Energy Pyramids

- **a.** An energy pyramid on the other hand, is always going to be upright. This is because the transfer of energy is an extremely inefficient process. At any given trophic level, only 10-15% of all of the energy in that level is transferred to the next. This also demonstrated the idea that there is a limited number of trophic levels that can be found in any given habitat. It was mentioned before that there are usually 4 or 5 trophic levels in an ecosystem. Because so much energy is lost at each transfer, there is just not enough energy at the top to sustain anymore levels. And because energy is lost at each level, the higher the level an organism occupies, the more that individual has to eat to obtain all the energy it needs.

13. Biological Magnification

- **a.** And this brings up to the concept of biomagnification. There are certain types of pollutants and toxins that can become increasingly concentrated as you move up a food chain. These molecules are typically fat soluble (meaning that they build up in the fat tissues and are not excreted easily through urine).
- **b.** So the more you consume, the more that builds up in your tissues. Since predators at the top of a food chain have to consume a lot of prey items in order to obtain all the energy they need, these types of toxins are found in very high concentrations in top predators.

14. Toxins that Biomagnify

- **a.** The issue arises when these molecules are toxic to the animals that consume them. Examples include mercury, lead, and arsenic, all of which cause serious birth defects and other health issues. The concept of biomagnifications is why pregnant women are warned against eating certain types of sushi. Tuna, shark, bass and certain species of mackerel, are all fish commonly found in sushi, and all are examples of top predators. On the other hand, trout, salmon, herring, and shellfish are all relatively low on the food chain and usually are not ones that should be avoided.
- **b.** DDT is a particularly interesting case. DDT is a pesticide that was used very heavily after WW2 in areas that had a high incidence of malaria, such as Africa and South America. In the years that followed, ecologist started to notice a dramatic decline in predatory bird species, many of which were essential to the overall health of an ecosystem. Although the connection was not made for several years, it was discovered that the buildup of DDT in predatory birds such as the bald eagle was the main contributing factor to their decline. DDT was found to seriously inhibit the proper formation of egg shell, which led to a significant decrease in the reproductive success of these types of birds. By 1984, DDT was banned worldwide, but the unfortunate aspect of DDT is that it can take decades for it to drop below toxic levels in an environment.