Ecosystem Ecology – Part 2: Nutrient Cycles

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

1. Ecosystem Ecology: Nutrient Cycles
- **a.** In the first part of this lecture series we examined the role of energy in an ecosystem. This lecture will focus on nutrients. Recall the phrase introduced in the last lecture "Energy flows and nutrients cycle." We saw how energy takes a one way path through a food web, and once it leaves or is used by organisms in that food w web it is gone forever. For this reason, energy constantly has to be replenished. The same cannot be said about nutrients. Nutrients are easily recycled, and follow a reoccurring cycle in and out of an ecosystem.

2. Nutrients
- **a.** There are lots of different types of nutrients that any living organisms needs. There are micronutrients, those that are needed in very small amounts, and there are macronutrients, those that are needed in large quantities. Each nutrient ahs its own particular path that it takes as it cycles in and out of a food web. And each nutrient ahs its own specific processes that it goes through in order to complete a cycle. Our focus in this lecture will be on the macronutrients, particularly the top five nutrients that any organism needs: carbon, hydrogen, oxygen, nitrogen, and phosphorus.
- **b.** When these nutrients are cycled, they are cycled into a food web by producers in a food web in the form of inorganic molecules, or molecules that do not contain carbon. The producer incorporates these molecules into organic compounds, (those that contain carbon). It is in this form that most nutrients move through a food web, much like how energy moves through it. Decomposers, on the other hand are responsible for releasing these nutrients back into the ecosystem.

3. Biogeochemical Cycles
- **a.** A biogeochemical cycle is just a fancy name for a nutrient cycle. There are two main portions of any nutrient cycle. The inorganic, or non-living components of an ecosystem, and the living component, the food web.
- **b.** As you can see from this graphic, which is a there are a different paths a nutrient can take as it moves through an ecosystem and each path can cycle independently from the other. A nutrient can continually move through an environment without every entering the food web, and simply move through the inorganic reservoirs found in that system. Or, a small fraction can cycle into a food web for a brief time. Generally speaking, any given molecule is going to spend the majority of its time outside of the food web, cycling through the various reservoirs.
- **c.** As mentioned before, each nutrient has its own specific path and processes that allow that nutrient to move in and out of these 2 portions of the cycle. For each nutrient we cover, you will be required to know the main reservoir (where in the ecosystem most of that nutrient can be found at any given time), the processes that move it through the various parts of an environment, the organisms that are essential in the cycling of the nutrient, and the consequences of disrupting that cycle. We are going to explore 4 major nutrients: Carbon, phosphorus, nitrogen, and water (yes, water is a nutrient!).

4. The Carbon Cycle
- **a.** In the graphics that follow in the coming slides, you will notice that there are 2 or 3 components found in each cycle, and each is color coded: White represents inorganic reservoirs, yellow represents the trophic levels in a food web, and purple represents the processes that move the nutrient back and forth between the reservoirs and the food web. Pay attention to these, as they will help you understand how different components interact in each cycle.

- **b.** Let's start with carbon since it has already been discussed in relation to energy flow. First, draw your attention to the food web portion of the food web, represented with the yellow boxes. The most important thing to take note of here is that photosynthesis is the only way carbon can enter into a food web, and it is the sole responsibility of producers to make this happen. Recall that we already saw this fact when talking about energy.
- **c.** If there is one thing that you need to remember about the carbon cycle, it is that the only way carbon can enter a food web is through the process of photosynthesis. The next thing to notice is that although there is only one arrow directing carbon into the food web, there are several ways that carbon can enter into the atmosphere in the form of carbon dioxide.
- **d.** This inorganic reservoir by far has the most arrows pointing to it, indicating that this is the main reservoir, meaning that most of the carbon on the plant can be found here. Notice that respiration is one of those processes that releases CO_2 into the atmosphere. Remember, respiration is the reciprocal process of photosynthesis, so it makes sense that it is one of the ways that carbon dioxide can leave a food web and enter into the atmosphere.

5. Disruption of the Carbon Cycle

- **a.** As we have already discussed in various ways, disruption of the carbon cycle is one of the biggest concerns scientist have in terms of human impacts on the planet. As humans expand and exploit new habitats to support our numbers, deforestation is a huge contributor to the buildup of greenhouse gasses. A carbon sink is any natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an long period of time.
- **b.** By destroying essential carbon sinks such as rainforests to make way for urban development and agriculture, we are reducing the planet's ability to regulate the amount of carbon dioxide in the atmosphere. Human causes of CO2 production is the number one cause of buildup of green house gasses and scientists believe the biggest contributor to global warming.
- **c.** As we will learn in the video you will watch in this module, Global warming isn't just about increased atmospheric temperatures. Increases in ocean temperatures and water levels, erratic weather patterns, and decreased community stability all have significant impacts on the biosphere.

6. The Hydrologic Cycle

- **a.** Although food webs are excluded from this graphic, water is an essential nutrient for all life on this planet. In fact, the presence of water is one of the first things scientists look for on other planets in the quest for extraterrestrial life in other parts of the universe.
- **b.** Of all the nutrients organisms need to support life, the lack of water will kill any organism before the lack of any other. This is also one of the only nutrients that do not require the action of any particular organism to make it available to a food web. It can enter and leave a food web at any trophic level. The water cycle also differs from others because the ocean is its major reservoir, with its liquid phase being the most common form found on the planet.

7. Negative Effects of Irrigation

- **a.** Agriculture is one of the largest contributors to water cycle disruption, although diversion of water for urban centers has a huge impact on the water cycle as well. The biggest concern is the depletion of aquifers. An aquifer is essentially any underground accumulation of water, and this is the main source of water for both irrigation and urban water supplies.
- **b.** The overuse of aquifers can result in the lowering of the water table, or the depletion of groundwater stores. Lowering the water table can lead to things such as the buildup of minerals in the soil, intrusion of saltwater inland. Sink holes have been big in the news lately, and these can often a result of overtaxing groundwater stores in an area.

8. The Nitrogen Cycle
   a. Next cycle to explore is the nitrogen cycle. The nitrogen cycle is interesting one because it is completely dependent upon microorganisms that live in the soil. The majority of nitrogen found in the planet is found in the form of a gas in the atmosphere. Nitrogen gas is not usable to most organisms in a food web, including plants. It must first be converted to a non-gaseous form that can be absorbed by plants.
   b. This is achieved through the process of a process called nitrogen fixation. Without bacteria that live in the soil that are capable of nitrogen fixing, the nutrient would not be available to most plants, and therefore not available to organisms in higher trophic levels. We briefly visited the process of nitrogen fixing when we learned about primary succession, as this is a trait that makes an organism a likely candidate for a pioneer species. (Remember lupine that grew up in the ashes of Mt. St. Helens?)

9. Acid Deposition
   a. Human activities that interfere with the nitrogen cycle include the burning of fossil fuels and irresponsible us of manmade fertilizers used in agricultural processes. Acid rain is one of the big effects of increased nitrogen levels in and ecosystem.
   b. pH is a measure of the amount of acid present, and every living organism usually has a very narrow window on the pH scale that it can survive in. So lowering the pH of an ecosystem can have debilitating results to an ecosystem, particularly one that relies on fresh water that is easily polluted.
   c. Fortunately, the effects of acid rain were recognized several decades ago and laws were put in place to reduce the amount of nitrogen that could be released into an ecosystem, but the recovery process is slow, and in some cases it is a story of too little, too late. Sulfur also plays a significant role in acid rain, however we are not going to spend any time on that particular nutrient.

10. The Phosphorus Cycle
   a. The phosphorus cycle is the last nutrient cycle we are going to cover. Just like the carbon cycle, it relies on plants and decomposers to bring it in and out of a food web. But it is unique from all the other cycles we have talked about because if you examine this graphic you will notice that it doesn't have a reservoir in the atmosphere. The only reservoir for this nutrient outside of the food web is in the soil, rocks and sediment. And its main human source in the environment comes from sewage and the agricultural industry.

11. Eutrophication
   a. Eutrophication is the result of adding excess nutrients into an ecosystem. The most common effects of this process is the development of algae blooms and the creation of dead zones in aquatic systems. Algae blooms are often seen in lakes and streams that are close to industrial and agricultural communities and the result of releasing limiting nutrients into an ecosystem.
   b. Phosphorus is most often a limiting nutrient in any ecosystem, but particularly in aquatic ecosystems. In most aquatic systems, certain forms of photosynthetic algae are the primary producers. Their population numbers are often limited in how quickly they can grow since the have a high phosphorus requirement.
   c. By adding excess P into the water, that allows the algae population to explode. When this happens, it also means that the amount of decomposition (which is a process that uses a huge amount of oxygen) that occurs in the body of water increases dramatically. Increase the number of organism that live in the water; you increase the numbers that are dying as well, right?

12. Most decomposition that occurs in aquatic habitats is the result of decomposing bacteria that live in the system. Since decomposition uses up oxygen at a very fast rate, this means that as the amount of decomposition is taking place, the more oxygen is being removed from the water. All the organisms that live in an aquatic habitat rely on the oxygen that is dissolved in the water, so you remove the oxygen; you kill the organisms, such as fish, that live in that habitat. This is what as known as a dead zone. A body of water that has so little oxygen available that it cannot support the life that normally lives there.