1.2: Ecosystems Storyline Reading
Learning from the Work of a Ph.D. in Ecosystem Ecology

Purpose for reading: *As you read this text, work to make sense of the roles you will take on during this unit and how those roles relate to the work scientists do.*

In earlier units, you worked with your classmates as questioners, investigators, and explainers to figure out how plants or animals use matter and energy. You then used that understanding to explain what happens in other plants or animals. Now, you will be taking on the roles of questioner, investigator, and explainer to figure out how matter and energy move in ecosystems.

These activities you've performed are very similar to what I do as a scientist. My name is Dr. Bonnie McGill, and I use these tools everyday to wrestle the secrets from nature. I earned my Ph.D. in Ecosystem Ecology at Michigan State University's Kellogg Biological Station. I'm going to tell you how I went from being a student like you to being a scientist with an avid interest in what is in us and all around us: carbon.

In college, I spent a summer doing a research internship in Montana (Figure 1) where I got excited about nutrient cycling (also called *bio-geo-chemistry*). Carbon, nitrogen, and other nutrients are essential for the survival of everything from the algal slime that grows on rocks to your very self. You need carbon for everything that requires cellular respiration, which means basically everything you do. And we need nitrogen to make amino acids, which builds DNA and proteins, which make up most of our tissues. Because we all need carbon and nitrogen, how these molecules of nutrients move (or don't move) between the living and non-living parts of ecosystems can help us understand small patterns like why algal slime grows on rocks in certain parts of a river and not other parts, which is important for the river food web. Nutrient cycling can also help us understand global patterns like climate change.

Figure 1. Hiking with other student interns (I'm on the far left) in Glacier National Park, Montana in 2005. I'm on the far left. This was the summer I got hooked on nutrient cycling doing my own field experiment. Image source: Krista Heiner.

That summer in Montana was transformational: I decided I wanted to spend my career investigating and developing solutions for how humans impact nutrient cycles and the environment. So I went to graduate school. I focused on how agriculture affects (and is affected by) climate change and water quality. What could possibly bring these three topics together? You guessed it: carbon and nitrogen. Agriculture is super-important, it gets that carbon and nitrogen onto our dinner plates. But it also has a huge impact on the environment, including water quality and greenhouse gas emissions (when carbon moves from a solid form to a gas form, such as carbon dioxide, which contributes to climate change).

I was a questioner. Climate scientists predict that growing seasons in the US Midwest will get hotter and drier in coming decades. Groundwater scientists have documented the rapid increase in worldwide groundwater used for watering crops (irrigation). I wondered if this increasing use of water for irrigation affects the balance of carbon stored versus emitted from agricultural soils. Bacteria are responsible for much of the breakdown of plant matter (decomposition), carbon dioxide emissions from soil (bacteria cellular respiration), and carbon sequestration (storing organic carbon in the soil). Bacteria work harder when they have plenty of moisture and carbon, which irrigation delivers. I wondered, by increasing crop biomass (carbon input to the soil), does irrigation increase soil organic carbon sequestration? Or does irrigation increase soil decomposition of stored organic carbon and, thus, increase carbon dioxide emissions? Is irrigation increasing soil organic carbon storage ***or*** the amount of carbon dioxide in the atmosphere?

Figure 2. Collecting a soil core at the Kellogg Biological Station Long Term Ecological Research site in Michigan. I used these cores to measure the amount of soil organic carbon in fields growing corn, soy, and wheat with and without irrigation. Image source: KBS LTER.

I was an investigator. I measured soil organic carbon at the Kellogg Biological Station (KBS). It is very hard to measure changes in soil organic carbon because it changes *very* slowly. But I was in luck! KBS has a very unique project called the KBS Long Term Ecological Research, which has a special field experiment set up in 2005 to compare plots of row crops with and without irrigation from groundwater. Meaning that if I measured soil organic carbon in 2016 there was a *chance* I could measure a difference in soil organic carbon between irrigated and non-irrigated soils, *if* irrigation had an effect. Remember the questions from above: did irrigation increase soil organic carbon decomposition (carbon losses) or storage (carbon gains)? I collected soil cores from the field experiment (Figure 2) and weighed the soil into tiny foil cups the size of a pill. I combusted (burned!) these cups in a machine that measured the amount of carbon dioxide produced by combustion. This tells us how much organic carbon the soil had. I found that irrigation *significantly increased* soil organic carbon. Meaning, the bacteria in the wetter, irrigated soils stored more carbon than they did in the drier, non-irrigated plots. Cool!

As with any good experiment, you end up with more questions than answers and, thus, the cycle of scientific discovery continues. From my results, I was left wondering: Would my results be different if I irrigated with purified water (no atoms other than hydrogen and oxygen) rather than groundwater (contains other atoms and molecules like calcium and nitrate)? Does it matter if the soil is plowed or not? Also, how would the results change in other soil types and climates? These are big questions that could be part of more Ph.D. projects, maybe even yours!

During this unit, you'll be an investigator, too. You'll make predictions and then collect evidence to help answer the questions you asked earlier in the unit. Your methods will build on what you learned during earlier units. It will be important to keep notes of your predictions, your methods, and the evidence you collect on the Predictions Tool, the investigation worksheets, and the Evidence-Based Arguments Tool. Your notes will help you to remember your ideas and evidence and to share them with your peers.

I was an explainer. After several years of measurements and analyses, I was excited to share my discovery with the world! First, I shared my writing and presentations with my scientist peers at KBS. They raised questions and comments that helped me improve how I explained my evidence to new audiences. Then, I presented my research at an international conference, my written reports will soon be published in peer-reviewed journals, and now I'm sharing my story with you!

When you have enough evidence, you'll take on the role of explainer to put together the evidence and tell a scientific story. The Explanation Tools will help you figure out how to put the pieces together to tell a single story. Toward the end of the unit, you'll explain the movement of matter and energy in ecosystems. Your peers will read and critique your explanations, providing feedback to help you improve your explanations.

At the end of the unit, you'll be able to answer some of your initial questions about how ecosystems function. While your answers will be based on evidence and tell a scientific story, there will still be more to investigate and understand. Likewise, you'll be able to apply what you learn about ecosystems to other science units as you continue to ask scientific questions to deepen your understanding as well as the understanding of your peers about the world around you.