LAB #10: SOIL ECOLOGY

Soil is one of the earth's most important resources. For a community of plants and animals to become established on land, soil must first be present. Further, soil quality is often a limiting factor for growth many systems. Soil is a complex mixture of inorganic and organic materials, microorganisms, water and air. The weathering of bedrock produces small grains of rock that accumulate as a layer on the surface of the earth. There they are altered by biology, becoming mixed with organic matter, which results from the decomposition of the waste products and dead tissue of living organisms to form humus. The soil formation process is very slow (hundreds to thousands of years), so it can be very detrimental to a community if the soil is lost through erosion or its quality degraded by pollution or misuse.

Soil Sampling

As a class, we will identify interesting soil ecosystems on campus that we would like to examine further. Your small group will be assigned to collect one of those samples. Using a trowel, you will scoop the top 5 cm (this is where most of the biological "action" happens) into a ziplock bag. Also, take notes to record the environmental surroundings. What is the land usage? What plants are growing here? What is the soil moisture? These environmental characteristics will influence many aspects of the soil.

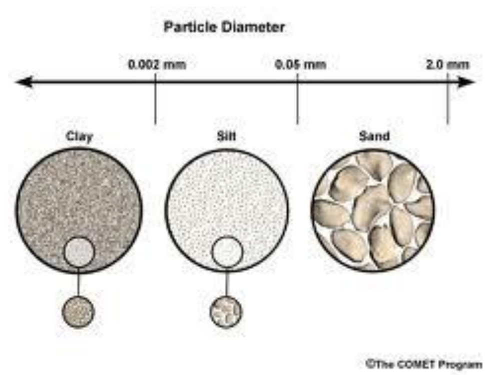
Questions

- Describe the environment from which you took your soil sample. Include all of the information from your notes.
- How do these conditions relate to the soil characteristics measured during the lab exercise (texture, nutrients, pH, and biota)?

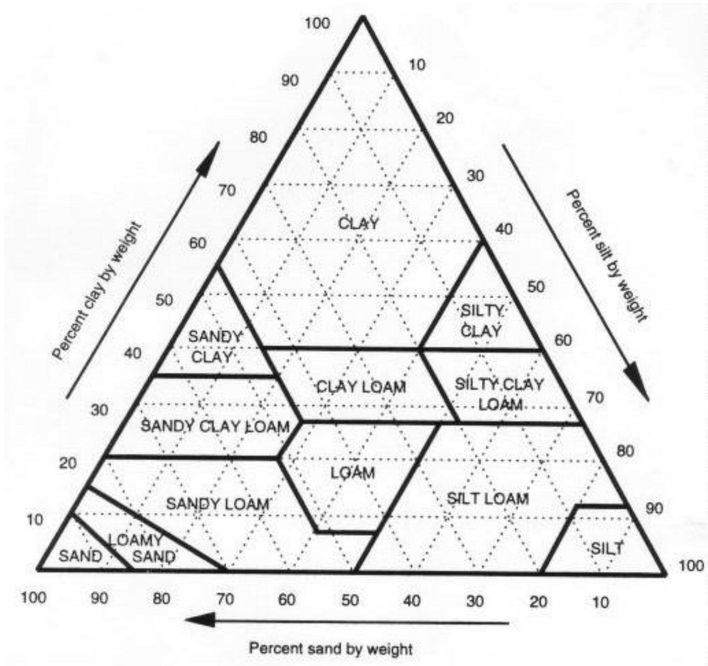
After samples are collected, we will return to the lab and measure the following characteristics:

Soil Texture

Soil texture refers to the proportion of sand, silt, and clay present in a soil, which differ in their particle size. The differences in particle size (and therefore surface area) influence water tension and pore space in the soil. Water and air are trapped in pore spaces, both of which are necessary ingredients for plant growth. Thus, texture is an important physical property of soils that influences water percolation, aeration, and therefore animal habitat and plant growth.



Most soils are mixtures containing a range of particle size classes. There are 12 soil texture classes ranging from sand to silt to heavy clay, with intermediate classes containing different amounts of sand, silt and clay. These can be seen on the soil textural triangle.



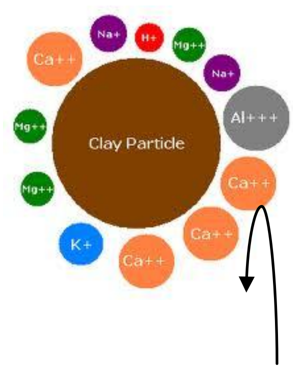
In lab, we will use a tactile method to determine the % sand, silt and clay fractions in your soil sample for use on the textural triangle to identify the texture type of your soil sample. Once you have done this, locate your soil type on the soil triangle: The right side of the triangle indicates percent silt, the bottom of the triangle indicates percent sand, and the left side of the triangle indicates percent clay. This represents the range of percents that are contained in your soil sample.

Questions:

- Looking at the soil texture triangle, which soil type has the greatest:
    - a. water retention ability?
    - b. water percolation rate?
- What is the soil texture of your sample?
- How will this influence plant growth in your soil compared to the other soils sampled?
- One influence humans have on soil is with our feet. What will happen when an area of soil is heavily trodden by humans?

Soil pH

Soil reaction, or soil pH, is a measure of a soil's health. Soil pH affects availability of nutrients, toxicity of certain elements in soil, and functioning of soil organisms. The optimum soil pH range for most plants is 6.0 to 7.0.



In lab, we will measure soil pH. To do so, you will make an aqueous solution of the soil. We then add an indicator that reacts with the H^+ cations to change color in relation to H^+ concentration.

Questions:

- Why is pH such an important aspect of soil fertility?
- What is the pH of your soil sample? How will this influence organisms living in the soil (plant, animal, and microbial).
- Nitrogen pollution in the atmosphere causes excess N deposition to soils, usually in the form of HNO_3 formed in the atmosphere. What do you think will happen when HNO_3 falls on the soil?

Soil Nutrients

Soil contains important primary plant nutrients such as nitrogen, potassium and phosphorus. Nutrients tend to exist as ions that may be dissolved in water or attached to soil particles. Soils are also a hot-spot for nutrient cycling, where these nutrients are then taken up by plants, to eventually be returned to the soil via decomposition. The amount of available nutrients in the soil will be a product of the decomposer community and will influence plant growth. It is the cosmic loop of nutrient cycling!

In lab, we will compare the availability of nitrogen among our soil samples. Nitrogen (N) is one of the main essential nutrients for all life. Similar to pH, we will make an aqueous solution. However, the nutrient ions may be floating in the water, or they may still be attached to soil particles. Therefore, we must remove ions chemically to place them in solution. This is done by using another soluble ion (e.g., K^+) in very large numbers so that the excess K^+ "bumps" practically all nutrients off of the soil. In the second step, we add an indicator to change the color of the soil solution in relation to nitrogen concentration.

Questions:

- Given the nutrient status of your soil sample, how much and what kind of plant and animal life would you expect to find living here?
- Evaluate the fertility of the soil used in this lab activity based upon your results.
- Throughout lab, we've discussed many leguminous plants, which are able to create symbiotic associations with N-fixing bacteria. How will soils beneath these plants differ from the surrounding soil, and why?

Soil Biology

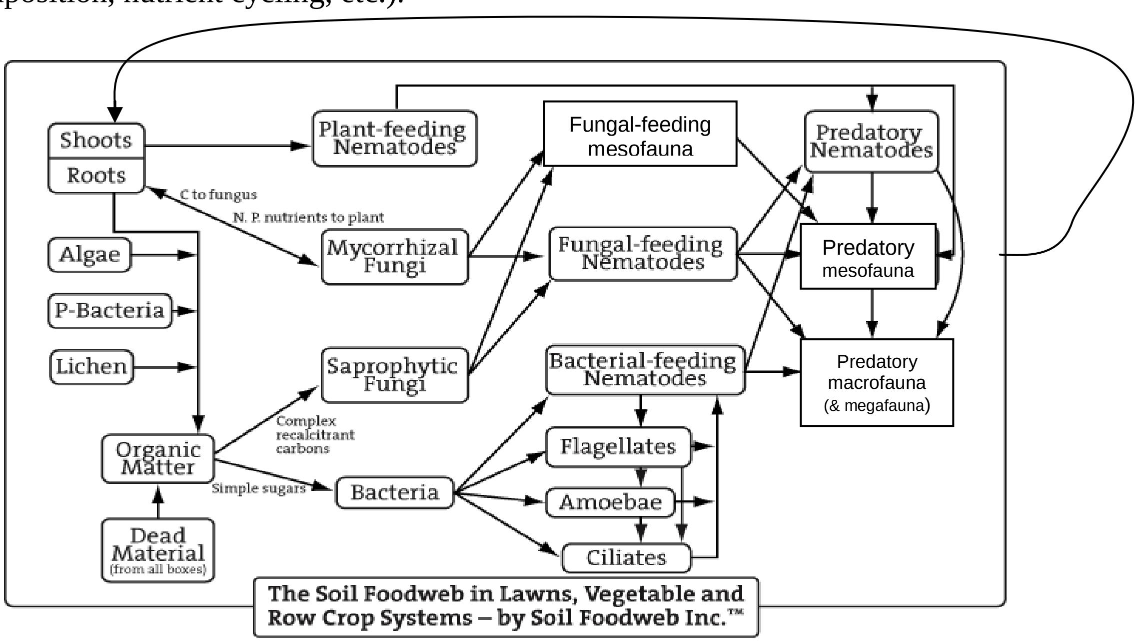
The soil is inhabited by a complex community of organisms that are incredibly numerous. There's millions of minute microbes, strange arthropods you've never heard of before, insects and worms, even small mammals. Every step you take, you're stepping on hundreds of thousands of lives, many of which you'd never recognize even though you contact them every single day.

Through their activity, biota influence important soil processes that are key for soil fertility. We will review soil biota according to their functional role in the soil:

- Herbivores (eat plant roots and shoots, e.g. nematodes, protozoa)
- Bacterivores (specifically eat bacteria, e.g. nematodes)
- Fungivores (specifically eat fungi, e.g. mites, nematodes, collembola, tardigrades)
- Detritivores (eat detritus and whatever is on it, e.g. earthworms, millipedes)
- Predators (eat other animals, e.g. pseudoscorpions, centipedes, nematodes, mites)

Microfauna are the very small, microscopic organisms that live in water films of soil and litter. They include nematodes, rotifers, and tardigrades. They are primarily microbivorous (but not always!) and incredibly numerous (nematodes are one of the most numerous multicellular organisms on Earth!). The mesofauna are the slightly larger (but for the most part still microscopic) organisms that live in the air-filled pore spaces in soil and litter. Mesofauna mostly include the microarthropods, but also enchytraeids (segmented worms), large nematodes, immature macrofauna, and other soft-bodied fauna. There are mesofauna represented in every functional role in the soil. There's a mesofauna to do everything! The macrofauna are what most people think of when they hear "soil biota". They're the guys big enough to see without the aid of a microscope. Common macrofauna include earthworms, beetles, crickets, ants, termites, and larger or adult forms of the microarthropods (collembola, centipedes and millipedes, e.g.). They tend to be much more mobile than the mesofauna. Most macrofauna are not exclusively soil-dwellers, and have either partial stages of their life cycle in the soil, or are active on the soil surface.

In lab, there will be mesofauna samples from several different locations around campus. We will investigate the mesofauna extracted to compare the communities living in these different habitats and discuss how this relates to what's going on in the different locations (relative rates of decomposition, nutrient cycling, etc.).



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<u>*Questions*</u>:

- Compare the mesofauna community of the different types of soil. How do they differ in abundance and diversity? What can we guess about the nutrient status of the soils, based on the biota living in them?
- Compare litter to soil. Which has a more abundant/diverse community? Why?
- One way of increasing soil fertility is to add commercial fertilizers. What are some other, longer-lasting ways that you could suggest to increase soil fertility?