CARBON CYCLES

Carbon is constantly cycling between different global carbon pools as it changes molecular forms. Photosynthesis and the subsequent use of its byproducts by other organisms cycles carbon between the atmosphere into forests, soils, and oceans, while human energy consumption cycles carbon from fossil fuel pools to the atmosphere. As carbon flows between them, each of these different pools has the capacity to be either a source or a sink. Carbon sinks are pools that accumulate more carbon than they release, while carbon sources release more carbon than they accumulate. Understanding source/sink dynamics and how to optimize the capacity of sinks to draw and keep carbon out of the atmosphere is crucial to reversing anthropogenic climate change. Currently the atmosphere and ocean have too much carbon while soils have lost carbon at an alarming rate due to development, conversion of native grasslands and forests to cropland, and agricultural practices that decrease soil organic matter.

WHAT IS SOIL CARBON?

Although some soil carbon comes from mineral sources, the vast majority of it is derived from plants. As plants grow and die, they leave behind organic, carbon-based compounds in the soil of varying size and chemical composition. Under the right conditions, soil fauna metabolize these compounds, incorporating some of the carbon in them into new chemical compounds within their own biomass, while respiring the rest to the atmosphere as CO_2 or excreting it back into the soil. This continuous movement of carbon through the soil food web means that carbon is constantly changing forms in the soil as it is incorporated into new organisms or converted into different compounds. Soil scientists classify carbon into general categories or pools based on how long the carbon remains in the soil, a figure often referred to as "mean residence time." The most commonly used model of these pools includes three different groupings: the fast or labile pool, the slow pool, and the stable pool.

The **fast pool** is soil carbon that turns over and returns to the atmosphere sometime within a few days to a few years. Carbon in this pool is typically composed of recently incorporated plant residues and simple carbon compounds that are exuded by roots. This **labile pool** is the one most readily used by soil microbes, meaning it generates a great deal of CO_2.

The **slow pool** is composed of more processed plant residues, microbial byproducts of the fast pool, and carbon molecules that are protected from microbes by physical or biochemical soil processes. Mean residence time of the slow pool is generally considered to be in the range of years to decades, but this range can be heavily influenced by soil texture, management, and climate.

In contrast, the **stable pool** is more resistant to disturbances and is extremely slow to change, with mean residence times ranging from centuries to millennia. This pool is comprised of what is often called humus, a loose term for a group of carbon compounds that are extremely resistant to decomposition, and soil carbon that is very well protected from microbial decomposition.

HOW IS CARBON SEQUESTERED IN SOILS?

Since the size of the stable pool is generally static, soil carbon is effectively increased in the labile and slow pools by increasing the net balance of carbon that enters the soil every year relative to what is lost. Agricultural managers can strongly influence this dynamic in four ways:

1.) Decreasing the level of soil disturbance (i.e. tillage) to enhance the physical protection of soil carbon in aggregates.

2.) Increasing the mass and quality of plant and animal inputs to soils.

3.) Improving soil microbial diversity and abundance.

4.) Maintaining continuous living plant cover on soils year-round.