**Introduction**

Globally, soils hold more carbon than the atmosphere and total terrestrial biomass combined. The bulk of soil carbon is soil organic carbon (SOC), a dynamic pool which receives inputs from plants and releases carbon mainly via microbial respiration. Imbalances between these SOC inputs and outputs can cause soil to become a carbon source or sink to the atmosphere, thereby exacerbating or mitigating the problem of greenhouse gas-induced global warming. Therefore, many recent land management efforts have focused on maintaining and increasing SOC stocks.

To effectively manage SOC, land managers need to track both the size and the trajectory of the SOC pool. However, detecting landscape-scale changes in SOC is difficult - it may take years for a measurable change in SOC to occur, and extensive sampling may be required to produce confident estimates of SOC stocks (Wiesmeier et al., 2019). Therefore, direct measurement of SOC stocks may not be feasible for many farmers, ranchers, and ecologists. Furthermore, implementing and adapting SOC management strategies often occurs faster than SOC stocks can be reliably assessed. This makes it difficult for land managers to evaluate the effectiveness of their actions in time to change course. However, if reliable indicators of the size and trajectory of SOC stocks were available, land managers would be able to make more informed decisions. Therefore, identifying reliable indicators of SOC change is a crucial step toward the development of effect soil management strategies.

Living organisms drive key processes in the carbon cycle. Plants are the original source of SOC, capturing carbon via photosynthesis, which can become stored as SOC. Plant traits such as net primary productivity, litter quality, relative allocation to aboveground and belowground biomass, or root exudation rate could all affect the overall rate of SOC formation. Because all of these traits vary between species, the composition of species in the plant community may affect the overall rate of SOC formation at a site. If this is the case, then land managers may be able to use observations of plant community composition to predict future changes in the SOC stock.

However, plant community composition might also reflect the recent of the SOC stock, particularly in ecosystems dominated by annuals. Soil with more organic carbon tend to have higher water holding capacity, which could affect the viability of different species. Similarly, decomposition of organic matter can mobilize nutrients, which could affect the competitive balance between species. Therefore, plant community composition could indicate the current status or recent changes in SOC stocks.

Similarly, microbial communities may be useful as SOC indicators. Microbes can control SOC by influencing the rate of decomposition processes and the fate of carbon during decomposition. When microbes decompose organic carbon, some carbon is used to build microbial biomass, and some is respired as CO2. Because microbial biomass can become stabilized in the soil, the partitioning of organic C between these two fates can affect the size of SOC stocks. Different taxa of microorganisms may be adapted to different life history strategies that affect the rate of decomposition, or the partitioning of C during decomposition. For instance, some species produce extracellular enzymes to break down polymers while others do not. Some species invest more C in growth, while others invest more in stress tolerance. Therefore, the taxonomic composition of the soil microbiome could indicate subsequent changes in the SOC stock.

Like plants, the composition of the soil microbiome can respond to the current status of the SOC stock as well. Carbon rich soils may harbor faster-growing microbes that thrive in the abundance of resources, while soils with less SOC might harbor microbes with more conservative survival strategies.

Plant and soil microbial communities can shift in response to underlying processes that control SOC. Additionally, these biological communities influence rates of primary production and decomposition, processes that directly affect SOC stocks. Because both plant and microbial communities in annual grasslands can exhibit significant interannual variation, measurements of these communities may indicate the status of SOC-controlling processes in the recent past. Furthermore, because both plants and soil microbes directly influence SOC stocks, measurements of these communities may help predict the future trajectory of SOC stocks in the soils they inhabit.

**What regional scale is appropriate for what indicator**

* **Are indicators good for states or rates?**

**Methods**

*Site*

*Soil Sampling*

*SOC Measurements*

*Bacterial Community*

*Plant Community*

*Statistics*