**Soil Carbon Sequestration in Grazing land Ecosystems**

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The term 'climate change' refers to the long-term changes in the average weather patterns (temperature, precipitation, wind patterns) that occur over several decades or longer. These shifts are driven mainly by human activities, particularly fossil fuel burning; however, natural processes (e.g., cycling ocean patterns such as El Niño and La Niña) can also contribute to climate change. Climate change continues to be a topic of debate and societal and scientific interest. There is substantial evidence that increased atmospheric concentrations of greenhouse gases (mainly carbon dioxide, methane, and nitrous oxide) is affecting global climate. Although the impacts of these increased levels of greenhouse gas concentrations on local, regional, and global scales are still uncertain, there is a general consensus that extreme weather events such as heat waves and strong storms will likely to become more frequent and more intense in the future. Approaches to mitigate climate change often involve either reducing or preventing emission of greenhouse gases to the atmosphere.

## What is soil carbon sequestration and why is it important?

In simple terms, soil carbon sequestration refers to the process of transferring $CO_2$ from the atmosphere into the soil. This process is mediated primarily by plants through photosynthesis. Soil carbon represents the largest pool in the Earth's terrestrial system, accounting for nearly five times that of the atmospheric carbon pool. Carbon stored in soils is stable for decades or longer and can help offset emissions from combustion of fossil fuels and other human-induced activities.

Soils can also act as a source of carbon and other greenhouse gas to the atmosphere. Whether a soil acts as a source or sink of carbon is determined by the balance between the amount of carbon added to the soil (mainly from plant residues) and the rate of carbon losses (decomposition, soil erosion, etc). The extent that carbon can be sequestered in soils vary by climate, topography, and soil type; however, there is strong evidence that adoption of conservation management practices can increase soil carbon sequestration. Despite the uncertainties about whether soil carbon sequestration can achieve large-scale emissions reductions, there is compelling evidence for continuing to promote soil carbon sequestration. Increasing carbon storage in agricultural soils, for instance, offers significant accompanying benefits such as improved soil and water quality, reduced soil erosion, increased water conservation and crop productivity.

## Potential for soil carbon sequestration in grazing lands

Native and improved pastures are two types of land use that retain substantial amounts of carbon in the soil. These land uses usually cause little soil disturbance, which reduces the carbon loss from organic matter decomposition and allows fresh plant materials from the grasses to become part of the soil organic matter over time.

Pasture management has a major role on soil carbon sequestration potential. Management practices that increase plant production (e.g., nitrogen fertilization, proper grazing management, use of legumes) often result in greater carbon inputs to the soil and, consequently, an increase in soil carbon sequestration. These conservation practices can also have other beneficial environmental and economic effects such as increased productivity and resilience. However, our understanding of the complex factors affecting soil carbon responses to pasture management is limited, particularly within subtropical and tropical climates. One of the main constraints is the lack of long-term studies to inform management strategies that can potentially increase soil carbon sequestration in these regions. Most of the cultivated pastures in Southeastern US that receive adequate rainfall and, consequently, have greater potential to respond to management than arid regions. However, the warm and moist conditions can also favor carbon decomposition.

**Measuring soil carbon sequestration**

From a practical perspective, direct measurement of the rate of carbon accumulation is often difficult and, in many circumstances, unrealistic. The effect of management on soil carbon sequestration is the subject of much current research but there is still a major gap in our knowledge. One of the reasons for that is management-induced changes in soil carbon typically take many decades to occur, making actual measurements of changes in soil carbon stocks difficult. In addition, the high spatial variability of soil and vegetation, extensive land area, and heterogeneous distribution of nutrients by grazing animals also complicate accurate quantification of soil carbon sequestration in grazing lands. Development of reliable measurement tools and models are critical to design and validate the benefits of adopting conservation practices at different spatial scales and to inform land managers and policy makers. Although voluntary markets are paying farmers or ranchers for carbon sequestration, the prices are often too low to cover the cost of adoption. Other social and political factors also represent major barriers to adoption of carbon conservation practices. Another important consideration is the potential impacts of management on greenhouse gas emissions. A life cycle analysis approach is required to understand the net benefit of management practices on the carbon cycle.

There is no doubt that the soil carbon sequestration and the role of grazinglands in climate change mitigation should and will continue to be relevant topic of research in years to come, particularly in subtropical and tropical regions. Furthermore, carbon trading-related markets and the growing interest in carbon sequestration as mechanisms for environmental protection are also expected to enhance the economic value of carbon sequestered in grazing land soils.

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