Carbon Sequestration on Rangelands: *The Role of Plants*

Xuejun Dong, Ecophysiologist, CGREC

In terrestrial ecosystems, carbon sequestration is defined as the uptake of carbon through photosynthesis followed by storage in plants and soil. Photosynthesis is the process by which plants create their own food using water, sunlight and carbon dioxide (CO_2). This type of carbon storage plays an important role in reducing the rise of atmospheric CO_2.

In past decades, more ecological studies on carbon sequestration were carried out in forests and croplands than in rangelands. Because rangelands occupy about one-half of the world's land area, more scientists are studying the potential of rangeland carbon sequestration.

Xuejun Dong places root-filled nylon net bags in the soil to study carbon sequestration.

Xuejun Dong takes soil moisture readings using a neutron moisture meter.

However, the high variability in floristics, soil types and topography pose many challenges to this research. Current studies are focused on soil organic carbon dynamics or the overall balance of carbon exchange (carbon sink or sequestration vs. source or net release of CO_2 from the soil) on rangelands through time and under different management regimes. However, a scarcity of data on key ecophysiological mechanisms is hindering further understanding on this topic important for both the general public and rangeland managers.

At the CGREC, we have developed a field plot-scale study linking plant photosynthesis to rangeland carbon sequestration. After two years of field-plot preparation and pilot measurements, full-scale measurements started in 2008 and will continue for five years. The main objective is to document plant photosynthetic activity and the components of soil respiration on pastures subjected to both grazing and drought treatments. This will provide site-specific data that account for the vegetation's contribution to rangeland carbon sequestration. In particular, this study considers the following issues:

- Identification of the origins of the rangeland carbon flux, such as photosynthetic input, live root respiration, dead root decay or soil mineral respiration, along with the phenology (different stages of plant growth) of vegetation. This provides opportunities for improving management of rangelands both as an agricultural production system and as a carbon sink.
- Some carbon release from soil to the atmosphere is necessary in a healthy ecosystem. Respiration during the growth of plant roots, for instance, releases CO_2.
- The formation of below-ground plant biomass (roots) increases the life-time of newly sequestered carbon, but also releases nutrients back to the soils for plant use.

This study provides opportunities for observing the behavior of the rangelands in terms of water use and carbon flux as a function of grazing intensity and drought. Three types of manipulations are used:

- Simulated grazing at two grazing intensities: moderate and heavy. Grazing is the most common type of range management in this area.
- Simulated drought using rain-out shelters. The range ecosystem in this area is highly altered due to the widespread introduction of species such as smooth brome and Kentucky bluegrass. Thus, the ecosystem could be vulnerable under prolonged climatic drought, which is not uncommon in this semiarid area.
- Soil trenching around each plot to exclude live root growth. This is required to separate live root respiration from mineral soil respiration.

Results from 2008

- Differences in water use and photosynthetic capacity between western wheatgrass (a native species) and Kentucky bluegrass (an introduced species): Kentucky bluegrass needs more water to survive and creates more biomass when adequate water is available. Grazing increases Kentucky bluegrass's photosynthetic potential, but also makes it more susceptible to drought. Western wheatgrass is tolerant to both grazing and drought in terms of leaf physiology.
- The calibration of a stomatal conductance model for use in range plants (see report by Jinzhi Wang), which is a key to calculate both photosynthesis and transpiration in range plants.
- The observation that even in a drought year, about 75 percent of the total plant biomass production is below-ground on rangelands of the mixed-grass prairie.
- The observation that the decomposition of fine roots takes about four years in the mixed-grass prairie and that the root decomposition rate (and therefore the nutrient release rate) in the winter months (October to April) is about 50 percent of that in the summer months (May to September).

The outcome of this study will:

- Provide more accurate accounting of the contribution of plants to carbon sequestration on the mixed-grass prairie rangelands. This will be useful for updating the current reward system for proper range management that sequesters carbon.
- Update and elaborate our current understanding of the inter-dependencies of photosynthesis and soil respiration in rangelands.

For more information, visit the CGREC Web site at www.ag.ndsu.edu/streeter.