Introduction to the Shortgrass Steppe Long Term Ecological Research Project

The Shortgrass Steppe occupies the middle of the productivity gradient along which the LTER grasslands lie. It is unique among North American grasslands for its long evolutionary history of intense selection by both drought and herbivory, leading to an ecosystem that is very well adapted to withstand grazing by domestic livestock (Mack and Thompson 1982, Milchunas et al. 1988).

Our research focus on the Shortgrass Steppe Long Term Ecological Research Project (SGS-LTER) over the past 17 years has been to understand the processes that account for the origin and maintenance of structure and function in shortgrass steppe ecosystems. The key questions that continue to organize and guide our research are:

1. *How are the distribution and abundance of biotic components of the shortgrass steppe maintained through time and over space?*
2. *To what factors are the distribution and abundance of biotic components vulnerable?*
3. *How do changes brought about by these factors influence biological interactions and ecosystem structure and function?*

We have made significant progress toward answering these questions through research efforts that include long- and short-term experiments, monitoring, survey, simulation analyses, and spatial analyses. Our research addresses 5 key areas, populations and processes, biogeochemical dynamics, paleoecology, water and energy dynamics, and disturbances (http://sgs.cnr.colostate.edu/proposal/section2.html#conceptual). We currently have 46 long-term experiments and over 30 short-term experiments, all supported by the LTER (see our web page, http://sgs.cnr.colostate.edu/proposal/figures/table1-1.html, for a list of long-term experiments). Below, we summarize the SGS-LTER research in each of our 5 main areas, and finally, briefly describe research on related research projects that rely on our long term experiments and the SGS-LTER Field Station.

Populations and Processes: Work in this area is organized by the idea that two kinds of populations are most important in the long-term dynamics and sustainability of the SGS. The first are dominant species, such as the shortgrass blue grama (Bouteloua gracilis), which overwhelmingly dominates the SGS. The second kind of important population is those that have a large effect on the ecosystem because of their unique traits; these are keystone species and we consider that prairie *dogs (Cynomys ludovicianus*) and prickly pear cactus (*Opuntia polycantha*) are keystone species in the SGS. SGS-LTER past and continuing work has focused a great deal on the population dynamics of blue grama and the factors that influence its role in the system. In addition, population dynamics of other species across the tropic structure are also studied. Most recently, we have begun intensive work on the biology of prairie dogs and prickly pear cactus as keystone species, and on the population genetics of blue grama as they influence its resistance to grazing.

Biogeochemical Dynamics: Our research in this area focuses on elucidating the key abiotic and biotic variables that control biogeochemical dynamics. Continuing long-term experiments are designed to assess how precipitation, temperature, topography, and soil texture interact to control spatial and temporal patterns of primary productivity, nutrient cycling, and trace gas loss.

Paleoecology and Paleopedology: Over evolutionary time scales, climatic variation has been the major force influencing the structure and function of SGS ecosystems. Our work in this area involves sampling the extensive paleosols across the SGS site, and evaluating their long-term vegetative and physiographic history by analyzing the stable C isotope signatures of soil organic matter, phytoliths, and $CaCO_3$. These studies provide information on the distribution of C3 and C4 plants during the Holocene soil-forming intervals.

Water and Energy Dynamics: The SGSLTER project identifies this area as important because water availability is the key variable driving SGS ecosystem structure and function. Measurements of precipitation, temperature, microclimate, and soil water are part of the long-term program. A weighing lysimeter measures daily evapotranspiration. We have recently initiated new studies to quantify the potential impact of current land use on the SGS by coupling a mesoscale atmospheric model with an ecosystem dynamics model.