Shortgrass Steppe Long Term Ecological Research (SGS)

Decades of research by SGS-LTER scientists have revealed an ecosystem governed by climate, natural disturbance, physiography, and human use. Our research focuses on large-scale variation in these factors, how they influence communities of plants and animals, how they drive cycling and storage of carbon, nitrogen, and methane, and ultimately how the shortgrass steppe ecosystem responds.

Located on the western edge of the central Great Plains, the shortgrass steppe is unique among North American grasslands for its long history of grazing by large herbivores and periodic drought. Over time, intense selection by grazing and drought has created an ecosystem that is well adapted to both, with low-standing vegetation and below ground concentration of biological activity and organic matter. Currently, grazing by domestic livestock is the primary land use of native grassland, which occupies about 60% of the land area of the shortgrass steppe.

We work closely with the USDA Agricultural Research Service (ARS) Great Plains Rangeland Resources Research Unit, the US Forest Service Pawnee National Grassland (PNG) Ranger District, and the Colorado Agricultural Experiment Station (AES). These formalized relationships allow for easy transfer of ideas, data and technology.

Site characteristics. The SGS-LTER site encompasses a large portion of the Colorado Piedmont Section of the western Great Plains. It is defined by the boundaries of the 6820 ha Central Plains Experimental Range (CPER), managed by the USDA ARS, and the 78,100 ha PNG, managed by the US Forest Service. The SGS-LTER site headquarters lies approximately 61 km northeast of Fort Collins, Colorado, at an elevation of 1650 m. The topography is typically gently rolling, with broad valleys and ephemeral streams. Soils of the SGS-LTER are principally derived from alluvium and wind-reworked sediments eroded from local sedimentary rock formations and Rocky Mountain sources. The climate of the SGS-LTER is typical of mid-continental semiarid temperate zones, but is somewhat drier because of a strong rain shadow effect of the Rocky Mountains to the west. Annual precipitation has averaged 322 mm over the past six decades; average monthly temperatures range from -4 to 22 ^{o}C in winter and summer. Approximately 70 % of the precipitation occurs during the April-September growing season.

The main natural plant communities are shortgrass steppe, floodplain shrubland, and salt meadow. The ecosystem is dominated by short grasses (64%), succulents (21%) and dwarf shrubs (8%). Blue grama (*Bouteloua gracilis*) predominates and contributes 60 to 80% percent of plant cover, biomass, and net primary productivity. Other important plants include buffalo grass (*Buchloe dactyloides*), prickly pear cactus (*Opuntia polyacantha*), rabbitbrush (*Chrysothamnus nauseosa*) and saltbush (*Atriplex canescens*). Pronghorn (*Antilocapra americana*) are among the most common wildlife species seen on shortgrass steppe. Black-tailed prairie dogs (*Cynomys ludovicianus*), through their clipping and burrowing activities, are also conspicuous, and create habitat for a number of other invertebrate and vertebrate animals, including horned larks (*Eremophila alpestris*), mountain plovers (*Charadrius montanus*), and burrowing owls (*Athene cunicularia*). Other species of special conservation interest or concern

include the swift fox (*Vulpes velox*) and the lark bunting (*Calamospiza melanocorys*), the state bird of Colorado.

Research focus. The SGS-LTER, through Colorado State University and in collaboration with the USDA ARS Great Plains Rangeland Resources Research Unit, the US Forest Service PNG Ranger District, and the Colorado AES, investigates the inter-relationships among climate, natural disturbance, biota and physiography, and human use through three core areas. Research on Populations and Processes examines two kinds of populations most important to long-term dynamics and sustainability of the shortgrass steppe. The first are spatially dominant species like blue grama, domestic livestock, and other grazers like grasshoppers and bison. The second are species that have large effects on the ecosystem because of their unique traits, such as black-tailed prairie dogs and prickly pear cactus. Our studies have lead to comparisons between the SGS-LTER site and LTER grassland projects at Konza (eastern Kansas tall grass prairie), Sevilleta (central New Mexico shortgrass prairie at the desert boundary) and Jornada (southern New Mexico desert grasslands). Research on Land-Atmosphere Interactions focuses on how water determines the ecological structure and function of shortgrass steppe. Biotic response to inter-annual and seasonal variations in precipitation is large, and is mediated by disturbances such as farming, domestic livestock grazing, urbanization, and environmental change. We use the Regional Atmospheric Modeling System (RAMS) to investigate the influences of land use change on precipitation, evaporation, transpiration and other climatic variables. Studies involving the analysis of fossil plant cells and ancient, buried soils allow us to reconstruct the effect of paleoclimate change on ecosystem structure in order to enhance our predictive capabilities regarding future climate change.

Research on Biogeochemistry studies factors controlling primary productivity, nutrient cycling, nutrient input and export, and trace gas fluxes. The key abiotic factors are water availability and temperature, and their variation across soil types, landscapes and regions. The key biotic factors are the dominance of below-ground biomass, the presence and distribution of individual plants and the composition of plant communities. Our site is a member of the National Atmospheric Deposition Program and, as such, we have long-term measurements of elemental inputs to the ecosystem. Further, we measure trace gas fluxes on many of our long-term plots in order to understand key areas of element balance relating to the nitrogen budget, including total N inputs, volatile NH_3 losses from plants and NO_2 and NH_3 absorption by plants.

Outreach and Education are important aspects of the SGS-LTER and include activities associated with several NSF programs: Schoolyard LTER, Research Assistantships for Minority High School Students, GK-12, Teacher Enhancement, Research Experience for Undergraduate Students and Research Experience for Teachers.

Our active Information Management group maintains data from over 60 years of research as well as the SGS-LTER website. The latter is the window to an extensive, searchable database of short- and long-term experiments dating back to 1939 (including the years of the International Biome Project), related publications and metadata.