Monitoring and Modeling Soil Water Dynamics on Shortgrass Steppe

Justification: We are requesting funds to install soil moisture probes at five sites across our research site. In the past we used neutron probes for this effort. These were removed from use due to changes in hazardous materials rules and have not been replaced. With water as the limiting resource on the shortgrass steppe, monitoring soil moisture again will provide essential data for our long term studies. Over the past decade, we have been working to elucidate the proximal controls over primary production and nutrient dynamics.

Background: Our long term data sets have clearly demonstrated that above ground net primary production of native grasslands of the western Great Plains is primarily limited by water availability (Dregne and Willis 1983, Hagan et al 1967, Sala et al. 1988, Lauenroth et al. 2000). A widely published relationship between aboveground net primary production and annual precipitation (a proxy of water availability) emphasizes the importance of water as a control on NPP (Lauenroth 1979, Rutherford 1980).

The distribution of water at the land surface is related to landscape position and appears to be linked to processes that control water balance of the grassland system, namely, precipitation, evaporation, transpiration, leaching, overland and sub-lateral flow. Long-term experiments have shown a strong correlation between landscape position and biogeochemical pools and processes (Schimel et al. 1985, Milchunas et al. 1989, Burke et al. 1999, Hook and Burke 2000). We have conducted a detailed analysis of soils in a three-dimensional, pedological context (Yonker et al. 1988), which suggests that soil water varies in a more complex fashion across the landscape. Parent material, landscape age and soil development all influenced soil distribution/content. While we recognize that landscape position is considerably more complex than the 2-dimensional catenas outlined by Ruhe and Walker (1968), our long term data on primary productivity and nutrient pools and turnover have continued to show a strong pattern with simple catena landscape positions. This pattern is generally correlated with soil texture. Lauenroth et al (submitted) reviewed the long term primary productivity data sets and found that if one separates texture from topography, ANPP is highest in swale or low lying landscape positions, and is higher on coarse textured than fine-textured soils, supporting the inverse texture hypothesis (Noy-Meir 1973). Similarly, Burke et al. (1999) and Hook and Burke (2000) found that soil C and N pools and N turnover dynamics have strong correlation with both landscape position and soil texture.

The most likely causes of higher production in the swales is increased soil water availability. Currently data from the SGS site do not allow us to evaluate the relative importance of enhanced nutrient cycling versus water additions in controlling increased ANPP in lower landscape positions. Data suggest that N mineralization in swales is higher because of greater N retention in fine textured soils (Delgado et al. 1996) and deposition of soil organic matter (SOM). The only explanation for higher water availability in swales would be down slope movement, but to date, data in this critical area is lacking. Although evaporation probably accounts for a very large fraction of the total water loss from the soil its distribution across the landscape is poorly understood. Similarly, our understanding of other vectors of soil water loss have yet to be quantified.

Filling Critical Data Gaps: We propose to establish a more intensive monitoring of soil water content by augmenting one of our new experiments designed to separate the effects of soil texture and topography on net primary productivity and nutrient turnover dynamics. Our key questions are: How do texture, topography, and landform influence water dynamics and nutrient input and outputs, and how important are lateral vs. vertical flows? We will examine three different level topographic highs (summits) with varying soil textures due to different parent material (thus separating texture from topography). Second, we will examine three different, lithologically diverse toposequences; within each toposequence, we will sample at least three different landscape positions. In each location, we will estimate *in situ* soil water content, net primary production, trace gas flux (N_2O and NO), soil respiration, decomposition, and N mineralization. To accomplish this we are requesting funds to purchase soil moisture sensors and data loggers, and to support installation of, and data collection from the sensors by Caroline Yonker, our soils technician.

(Literature Cited is included as a Supplementary Document.)

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