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Response of grassland ecosystems to prolonged soil moisture deficit

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Soil moisture is commonly used for predictions of plant response and productivity. Climate change is predicted to cause an increase in the frequency and duration of droughts over the next century, which will result in prolonged periods of below-normal soil moisture. This, in turn, is expected to impact regional plant production, erosion and air quality. In fact, the number of consecutive months of soil moisture content below the drought-period mean has recently been linked to regional tree and shrub mortality in the southwest United States.

This study investigated the effects of extended periods of below average soil moisture on the response of grassland ANPP to precipitation. Grassland ecosystems were selected for this study because of their ecological sensitivity to precipitation patterns. It has been postulated that the quick ecological response of grasslands to droughts can provide insight to large scale functional responses of regions to predicted climate change.

The study sites included 21 grassland biomes throughout arid-to-humid climates in the United States with continuous surface soil moisture records for 2-13 years during the drought period from 2000-2013. Annual net primary production (ANPP) was estimated from the 13-year record of NASA MODIS Enhanced Vegetation Index extracted for each site. Prolonged soil moisture deficit was defined as a period of at least 10 consecutive months during which soil moisture was below the drought-period mean. ANPP was monitored before, during and after prolonged soil moisture deficit to quantify shifts in the functional response of grasslands to precipitation, and in some cases, new species assemblages that included invasive species.

Preliminary results indicated that when altered climatic conditions on grasslands led to an increase in the duration of soil water deficit, then the precipitation-to-ANPP relation became non-linear. Non-linearity was associated with extreme grassland dieback and changes in the historic species assemblage. The magnitude of change was related to the precipitation regime, where grasslands in hyper-arid and humid regimes were least likely to be affected by prolonged soil moisture deficit, and semiarid and mesic grasslands were most likely to be impacted, depending on the duration of the deficit. These results were applied to a large grassland region in Australia with soil moisture estimates from the European Space Agency (ESA) Soil Moisture Ocean Salinity (SMOS) sensor to demonstrate the continental-scale potential of this application with satellite measurements. These results are even more relevant for application with the higher-resolution NASA Soil Moisture Active Passive (SMAP) products to be available in 2015.