Land Cover and Climate Impacts on Water Availability and Drought Susceptibility in Central Asia Drylands

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The extensive arid and semiarid rangelands in Central Asia (Mongolia, Northern China, Kazakhstan, and Turkmenistan) have been subjected to rapid socioeconomic changes since the collapse of the Soviet Union in 1990. As a result, there have been extensive land cover changes with increasing rangeland productivity throughout the semiarid regions of Central Asia, however little is known regarding vegetation-climate equilibria and the interactions of land cover dynamics with precipitation patterns and variability. This region is experiencing spatially-extensive land cover changes over precipitation gradients resulting in significant interannual shifts in above ground net primary production (ANPP) and precipitation use efficiency (PUE). There is an urgent need to understand how shifting land cover conditions in central Asia respond to precipitation and other external drivers to permit the forecasting of potential biosphere feedback to natural and anthropogenic changes in the climate system. In this study we utilize time series satellite data to analyze dryland ecosystem behavior and land cover modifications, including drought severity and land degradation. We mapped the spatial and temporal patterns of ANPP sensitivity to precipitation across the Central Asia drylands using MODIS and AVHRR datasets and we evaluated the relationships between PUE with remotely-sensed drought indices in order to improve the prediction of vegetation health in response to climate change and human land cover modifications. Precipitation use efficiency (PUE), which describes the ANPP achieved per unit amount of precipitation, is an important and crucial measure of water-vegetation dynamics and was found to vary across land cover types, due to differences in vegetation physiognomy soil, temperature, and biogeochemical constraints. We successfully applied thermal- and shortwave infrared-based satellite products to measurements of ANPP anomalies, indicative of above- or below-normal rainfall conditions and found large differential sensitivities of ANPP to inter-annual variability in precipitation across the land cover types. Life history, land use, land cover changes (e.g. degradation, invasives), soils, and biogeochemical mechanisms were very influential in determining the production response of all the ecosystems to precipitation. Our results yielded improved methods of assessing vegetation stress in response to climate and land use forcings.