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Novel Climate Change Experiment Predicts Grasslands Future

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This ongoing, long-term study provides key insights as to how grasslands, and the services they provide, will change under more extreme future climate regimes.

Photograph Credit - Philip Fay

Figure 1. Aerial view of the Rainfall Manipulation Plots facility on the Konza Prairie in NE Kansas.

Grasslands of the Midwestern U.S. are known for their extreme weather, e.g. droughts with high temperatures and severe thunderstorms with torrential rains. Despite such climatic variation, these productive ecosystems support a multi-million dollar livestock industry that extends from Texas to North Dakota. Global change models (GCMs), driven by unremitting human alteration of the earth-atmosphere system, forecast even more extreme climate variability for this region in the future. This forecast could impact the economic and ecological services these grasslands provide.

Since 1998, a unique, long-term field experiment in northeastern Kansas has provided insight into the ways these grasslands are likely to change in response to GCM predictions. The Rainfall Manipulation Plots facility (RaMPs) in native tallgrass prairie permits the manipulation of current rainfall patterns such that individual storms are larger and the time between rainfall events longer (by 50%). This results in an intensification of within season drought, but without any change in total growing season rainfall amount. Additionally, portions of these research plots combine a warming treatment (2-3 °C) with the more extreme rainfall regime to assess the effects of changing temperature and rainfall patterns independently and interactively.

This research identified changes in soil moisture, including amount, distribution with depth, and variability through time, as a key component to understanding the ways in which these grasslands will respond to future climates. More extreme rainfall regimes will cause soil moisture at shallow depths to be more variable and drier on average during the growing season

Photograph Credit - Alan Knapp

Figure 2. The Rainfall Manipulation Plots facility, with infrared lamps in the foreground.

compared to today's patterns. Grassland productivity declined due to the plants dependence on shallow soil moisture. In contrast, the number of co-occurring species increased in plots exposed to more extreme rainfall regimes. This may be linked to increased water stress in the dominant grasses and their reduced productivity. The study has also shown that the most severe water stress in the grasses occurs when warmer temperatures co-occur with more extreme rainfall regimes. Increased loss of plant species from warmed plots suggests coupled climate change factors will greatly impact grassland productivity, but the exact outcome will be difficult to predict.

Future more extreme climate regimes will likely alter the carbon balance of these grasslands. RaMPs experiment results indicate that both more variable soil moisture regimes and warmer temperatures decrease the amount of CO_2 that is released from the soil to the atmosphere. The primary source of this carbon is from soil microbial and root respiration. Decomposition rates of soil organic matter are predicted to decrease in response to reduced soil moisture. Depending on the magnitude of carbon inputs via roots, the carbon sequestration capacity of these grasslands will be impacted. Ongoing measurements of the carbon budget of these plots are underway to assess the net effect of these projected changes in climate on ecosystem carbon storage.

Results to date indicate that larger rainfall events coupled with longer periods between storms can also lead to pulses of high soil nitrogen availability. Nitrogen is typically a limiting nutrient in a grassland ecosystem and periods of high resource availability have been linked to the invasion of exotic plant species. Research in the RaMPs facility has expanded to include invasibility studies in which seeds of potentially invasive exotic species are added to small plots and their establishment success measured. The long-term continuation of this study will enable the forecast of alterations in the susceptibility of these grasslands to exotic species invasion under future climate regimes.

IMPACT

The complexity of the ecosystem responses, including plant species loss and changes in variability as well as reduction in plant productivity above ground and altered carbon sequestration below ground, highlight the need for an integrative systems approach to provide the fundamental knowledge required to manage our nation's grassland resources. Researchers have long realized that long-term experiments are vital for providing critical understanding into the behavior of complex ecosystems. Consistent with this, many of the impacts identified in this research were manifest only after experimental treatments had been imposed for several years. Thus, experiments are continuing as it is clear that the impact of this research will only increase with time, particularly with continued climatic changes looming.

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