Long-term responses of a mesic grassland to manipulation of rainfall quantity and pattern

A.K. Knapp, J.M. Blair, P.A. Fay, M.D. Smith, S.L. Collins and J.M. Briggs
Department of Biology, Colorado State University, Ft. Collins, Colorado, 80523, USA, Email: aknapp@lamar.colostate.edu

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Introduction Climatic variability is an inherent feature of grassland biomes, with large fluctuations in temperatures combined with precipitation regimes characterised by floods and severe drought occurring on both an interannual and seasonal scale. Global climate models and emerging data indicate that extremes in precipitation regimes are increasing worldwide coupled with increases in temperature. Thus, variability in spatial and temporal patterns of water availability in grasslands, as directly influenced by altered precipitation patterns and indirectly by increased temperatures, will likely increase in the future. The objectives of our experiments were to experimentally manipulate rainfall amount and temporal patterns (amount and timing of individual rainfall events) to assess soil, plant, community and ecosystem responses to this projected climate change.

Materials and methods Two long-term experiments in undisturbed mesic grassland in eastern Kansas are ongoing: a 10-yr water supplementation study (Knapp *et al.,* 2001), and a 7-yr experiment in which growing season rainfall patterns (variability) have been manipulated without altering total amounts (Fay *et al*., 2000). Both experiments are fully replicated with the irrigation study designed to alleviate seasonal water limitation, and the rainfall variability experiment designed to increase rainfall event size concurrent with lengthening periods between events by 50%, but with no change in total growing season rainfall amount.

Results Water availability limited aboveground net primary production (ANPP) in 8 of 10 the years and long-term records of interannual variability in rainfall were strongly correlated with temporal variability in ANPP (r^2 = 0.62). Within-season increases in precipitation extremes characterised by fewer, larger rainfall events with longer intervening dry periods, led to a suite of responses including reduced ANPP and soil respiration (Figure 1) and shifts in plant community structure. Increased temporal variability in soil water content was strongly related to responses in these key C responses, more so than mean soil water quantity.

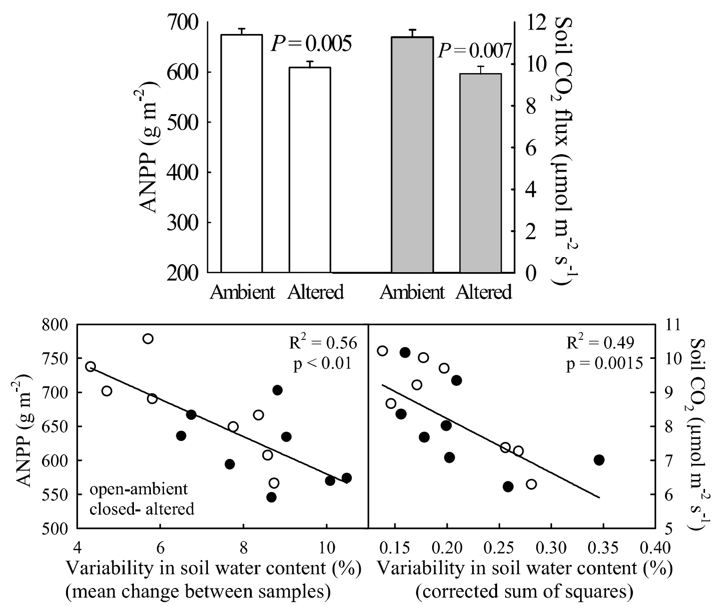

Figure 1 Top panel: Mean ANPP and mean soil CO_2 flux in grassland plots exposed to either ambient or altered rainfall patterns. Bottom panels: Negative relationship between ANPP, soil CO_2 flux, and variability in soil water content, suggesting that climate change-induced increases in the temporal variability of soil water content will have significant effects on ecosystem processes.

Conclusions Results of these two long-term studies demonstrate that even relatively mesic grasslands (annual precipitation ca. 830 mm) are quite sensitive to alterations in precipitation regime. The greater range in treatments (rainfall amount and pattern) that can be experimentally imposed permits predictions of grassland responses to climate change that extend beyond those based on past ecosystem responses to climate change constrained by the historic range of climatic divers in an ecosystem.

References

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