Experimental and modeling study of interactive effects of warming and altered precipitation on function and structure of a tallgrass prairie in the Great Plains

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The objectives of the proposed project are (1) to quantify main vs. interactive effects of experimental warming, added and reduced precipitation on ecosystem processes and community structure and (2) to integrate experimental results into models to improve our ability of predicting ecosystem responses to warming and altered precipitation.

We will quantify main vs. interactive effects of warming, increased and reduced precipitation on (1) carbon processes, (2) nitrogen processes, (3) water processes, and (4) phenology and plant community structure. We proposed three hypotheses for each of the four aspects of ecosystem attributes, two on main effects of temperature and precipitation respectively, and one on their interactive effects, totaling 12 hypotheses. Examples of the hypotheses are:

Warming stimulates decomposition and nitrogen mineralization, resulting in increased nitrogen availability and plant uptake. Although plant nitrogen content increases, nitrogen concentration in plant tissues decreases due to warming-stimulated plant growth, leading to decreased litter quality and negative feedback to the warming effects on nitrogen cycling over time.

Effects of warming and altered precipitation are additive for soil respiration and soil carbon content but are interactive for biomass production and root/shoot ratio.

Warming stimulates evapotranspiration, causes soil surface drying, and reduces runoff. The combination of reduced runoff and increased biomass growth leads to an increase in rain use efficiency under warming.

To test those hypotheses, we propose to initiate a new experiment in a tallgrass prairie in central Oklahoma to manipulate temperature and precipitation.

We will first construct a warming and precipitation facility in central Oklahoma that will warm the ecosystem by 1.5/3.0 ^{o}C day/night temperature, and add or reduce precipitation by 50% in the treatment plots from their respective ambient levels. We will measure aboveground biomass; belowground biomass; carbon and water fluxes at leaf, canopy, and ecosystem levels; nitrogen mineralization and availability; plant nitrogen uptake and use efficiency, runoff; evapotranspiraiton; phenology, and plant community structure to detect warming and precipitation effects. To understand mechanisms underlying complex interactive effects of warming and altered precipitation on various ecosystem and community processes, we will use advanced statistical, modeling, and inversion approaches.

This proposed project has the potential to fundamentally improve our understanding of main and interactive effects of climate warming and altered precipitation on ecosystem processes and to improve models for their capability of projecting ecosystem responses to climate change.