OOS 33-5 - Rising atmospheric CO2 effects on productivity and plant composition differs among soils in Southern Plains tallgrass prairie

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Background/Question/Methods

Rising atmospheric CO2 concentrations are expected to alter grassland ecosystem structure and function, and may have contributed to the current level of woody encroachment. But critical questions remain regarding 1) how much change in productivity or species composition may occur with near-future increases in CO2, compared to changes caused by past CO2 increases; and 2) how ecosystem responses might vary among soils across the landscape. Soils differ in water holding capacity, organic matter, and other properties crucial to primary productivity, and plant species differ in physiological efficiency and drought tolerance. These differences should have important consequences for species change and soil water balance as CO2 increases. We conducted a five year experiment in which we imposed a subambient to enriched gradient in CO2 concentration on a tallgrass prairie. Plots were established in weighing lysimeters containing an upland clay, a lowland clay, or a sandy alluvial soil representative of those in Southern Plains tallgrass prairie. We hypothesized that elevated CO2 would cause varying degrees of increase in aboveground net primary productivity (ANPP) among the soils, favor more mesic species, and increase soil water availability, especially on coarser soils with lower water holding capacity.

Results/Conclusions

The response of ANPP to increased CO2 differed among the soils, with little to no response on the lowland clay, a diminishing increase on the upland clay, and a linear increase on the sandy alluvial soil. Structural equation models indicated that ANPP was limited by plant access to N on the lowland clay, by soil N supply, soil water content, and plant water status on the upland clay, and by soil water content/plant water status on the sandy alluvial soil. CO2 enrichment reduced evapotranspiration and increased soil moisture accumulation. Dramatic differences in plant species composition developed along the CO2 gradient, with more drought tolerant C4 mid-grasses assuming dominance at subambient CO2 and the mesic C4 tallgrass *Sorghastrum nutans* assuming dominance at enriched CO2 on the alluvial and upland clay soils. Composition changes at higher CO2 were associated with changes in leaf carbon assimilation and greater water use efficiency and canopy light attenuation. Thus, rising atmospheric CO2 concentrations, acting mainly through changes in water balance, will likely drive differential changes in ANPP and species composition among soils in the Southern Plains tallgrass prairie. Such changes with CO2 enrichment may also influence woody encroachment on some soils.