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Interannual responses of net ecosystem CO_2 exchange and NEP of intact tallgrass prairie ecosystems to an anomalously warm year under elevated atmospheric CO_2

John Arnone, Richard Jasoni, William Coulombe, and Paul Verburg
Desert Research Institute, Earth and Ecosystem Sciences, Reno, Nevada, United States (jarnone@dri.edu)

Increases in anthropogenic greenhouse gas (GHG) levels in the atmosphere continue to warm the troposphere and cause a higher frequency and intensity of extremely warm climatic events. Because the terrestrial biosphere strongly influences the fluxes of CO_2, the most important GHG, to and from the atmosphere globally, quantification of the responses of these ecosystems to extremely warm years is essential to project how ecosystem process such as net ecosystem CO_2 exchange (NEE) and net ecosystem productivity (NEP) will be affected, and to predict how these responses will impact atmospheric CO_2 levels.

Our earlier research with intact grassland ecosystems using the EcoCELL large-scale controlled environment facility under present day atmospheric CO_2 concentrations demonstrated a 1-2 year lagged recovery time of NEE and NEP (with NEP= net primary productivity [NPP] minus heterotrophic respiration [R_h]) in response to exposure to an anomalously (+4˚C) warm year (Arnone et al. 2008—*Nature* 455:383-386). This lagged effect was attributed to large reductions in NPP during the warm year and then a 1-year delayed increase in R_h followed in the next year by a recovery. Responses of NPP resulted primarily from decreases in leaf stomatal conductance and photosynthesis caused by warming-induced high vapor pressure deficits (VPDs) and drying soil in the rooting zone. Lagged responses in R_h resulted from dry surface soils occurring during the anomalously warm year followed by a recovery in soil moisture in the following year, with carbon fixed and deposited in the rhizosphere during warm year—in addition to carbon fixed and deposited in the rhizosphere during the year following—able to be decomposed in the year after the temperature extreme.

Given the large modulating role that these hydrologic factors (VPD, soil moisture) played in defining responses of NEE and NEP to an extremely warm year, and the fact that elevated atmospheric CO_2 concentrations can alleviate these hydrologic limitations, we repeated the earlier experiment with these tallgrass prarie grassland ecosystems but under artificially atmospheric CO_2 concentrations expected in less than 30 years from now (600 μmol CO_2 l^{-1}) and for 3 years. We hypothesized that exposure to an extremely warm year might still reduce NEP during that year, but that this reduction might be caused more by increases in R_h (because soils should remain moist from CO_2-induced reductions in transpiration) than by decreases in NPP. We also hypothesized that stimulated R_h in the warm year could stimulate nitrogen mineralization that would promote NPP and NEP in the post-warm year. Thus, the main objective of this study was to quantify NEE and NEP responses to an anomalously warm year under future atmospheric CO_2 concentrations. We present these findings here.