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Plant composition and the effects of temperature, soil moisture, and aboveground biomass on soil respiration in grassland

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Future changes in climate are likely to cause shifts in plant species composition. In grasslands, the growth form composition (i.e., grass/forb) and species diversity of vegetation are important controls on ecosystem carbon cycling because species and growth forms vary in their capacities for carbon uptake, productivity, and allocation belowground. The dominant grasses determine many aspects of ecosystem function, but few studies have examined the relationship of growth form composition and diversity to soil respiration (J_{CO2}; root + microbial respiration), and how this relationship may influence the response of J_{CO2} to soil temperature and moisture. We studied effects of plant growth form and species diversity on J_{CO2} by measuring the 2007 annual course of J_{CO2}, soil temperature (Tsoil, 0-15 cm), soil moisture (SWC, % volumetric, 0-10 cm), and aboveground biomass in plots of varying composition and diversity. The plots contained a total of 8 C4 grasses, 1 C3 grass, and 4 C3 forbs grown in equal-density monocultures or in mixtures of 2, 4, or 8 species planted in either even or geometric rank abundance distributions. There was strong seasonality in J_{CO2} associated with soil temperature (R^2 =0.41, $p < 0.0001$), with less seasonal variation in the geometric than even species distribution plots (p = 0.017). The temperature sensitivity of J_{CO2} (the slope of J_{CO2} vs. Tsoil) differed strongly with the composition of the plots ($p < 0.0001$), with weaker temperature sensitivity in forb monocultures compared to grass monocultures or species mixtures. J_{CO2} also correlated with SWC although less so than with Tsoil (R^2 = 0.04, $p < 0.0001$), and the SWC sensitivity of J_{CO2} was lower in forb monocultures than in either grass monocultures or mixtures.

These results suggest that the growth form composition of vegetation mediates the effects of Tsoil and SWC on J_{CO2}. Aboveground biomass did not correlate with J_{CO2}. However, the ratio of J_{CO2} to biomass was 3 to 4-times greater in 2-species mixtures compared to 4 or 8-species mixtures ($p = 0.007$). This ratio is an index of the net carbon balance in the plots, therefore this result suggests that lower species number is associated with reduced net carbon uptake. Overall, these results indicate that plant growth form composition and diversity may play an important role in soil respiration responses to abiotic drivers and ultimately the net carbon balance of grasslands.