Water relations in grassland and desert ecosystems exposed to elevated atmospheric CO2

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Author(s) Morgan, J. A.; Pataki, D. E.; Körner, Christian; Clark, H.; Del Grosso, S. J.; Grünzweig, J. M.; Knapp, A. K.; Mosier, A. R.; Newton, P. C. D.; Niklaus, P. A.; Nippert, R. S.; Parton, W. J.; Polley, H. W.; Shaw, M. R.
Author(s) at UniBasel Körner, Christian ;
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Atmospheric CO2 enrichment may stimulate plant growth directly through enhanced photosynthesis or indirectly, through reduced plant water consumption and hence slower soil moisture depletion, or the combination of both. Herein we describe gas exchange, plant biomass and species responses of five native or semi-native temperate and Mediterranean grasslands and three semi-arid systems to CO2 enrichment, with an emphasis on water relations. Increasing CO2 led to decreased leaf conductance for water vapor, improved plant water status, altered seasonal evapotranspiration dynamics, and in most cases, periodic increases in soil water content. The extent, timing and duration of these responses varied among ecosystems, species and years. Across the grasslands of the Kansas tallgrass prairie, Colorado shortgrass steppe and Swiss calcareous grassland, increases in aboveground biomass from CO2 enrichment were relatively greater in dry years. In contrast, CO2-induced aboveground biomass increases in the Texas C-3/C-4 grassland and the New Zealand pasture seemed little or only marginally influenced by yearly variation in soil water, while plant growth in the Mojave Desert was stimulated by CO2 in a relatively wet year. Mediterranean grasslands sometimes failed to respond to CO2-related increased late-season water, whereas semiarid Negev grassland assemblages profited. Vegetative and reproductive responses to CO2 were highly varied among species and ecosystems, and did not generally follow any predictable pattern in regard to functional groups. Results suggest that the indirect effects of CO2 on plant and soil water relations may contribute substantially to experimentally induced CO2-effects, and also reflect local humidity conditions. For landscape scale predictions, this analysis calls for a clear distinction between biomass responses due to direct CO2 effects on photosynthesis and those indirect CO2 effects via soil moisture as documented here.
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