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Stimulation of Mojave Desert net ecosystem CO_2 uptake after winter precipitation with the opposite effect after summer rains based on 7 years of flux data

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Eddy covariance measurements of net ecosystem CO_2 exchange (NEE) in the Mojave Desert (Jasoni et al. 2005—*Global Change Biology* 11:749-756; Wohlfahrt et al. 2008—*Global Change Biology* 14:1475-1487), and in other deserts of the world (e.g., Hastings et al. 2005— *Global Change Biology* 14:927-939, indicate greater rates of net CO_2 uptake (more negative NEE values) and net ecosystem productivity (NEP) than would have been expected for deserts (as high as -120 g C m^{-2} $year^{-1}$). We continue to observe high rates of NEE and NEP and seek explanations for these findings at interannual, seasonal, and sub-seasonal time scales. Because moisture availability most strongly constrains biological activity in deserts, responses to rains probably play a significant role in defining components of NEE—namely net primary productivity (NPP, or roughly net photosynthesis by vascular and non-vascular plants) and heterotrophic respiration (R_h, mainly by soil microorganisms). Most precipitation in the Mojave Desert falls from October through April and periodically in the summer as convective storms.

The main objective of this study was to quantify the extent to which NEE and the net flux of CO_2 from/to biological soil crust (BSC) covered soil surfaces respond to rain pulses occurring during cool/cold and warm/hot times of the year. Flux data from 7 years (2005-2011) of measurements at our shub land desert site (average 150 mm rain per year) located 120 km northwest of Las Vegas showed a range in NEP from -111 ± 34 to -47 ± 28 g C m^{-2} $year^{-1}$. Cool season rains usually stimulated NEE (more negative NEE values or net CO_2 uptake) while warm season rains reversed this effect and led to positive NEE values (net ecosystem CO_2 efflux. Cool season stimulation of NEE often occurred in the absence of green leaves on vascular plants, suggesting that photosynthesis of BSCs (up to 70% of soil surface covered by cyanobacteria, mosses, and lichens) were responsible for this net uptake. At other times during the cool season, herbaceous vascular plants also contributed to increases in NEE. Parallel experiments in which we simulated rain pulses (10 mm) in the cool (February) and warm (May) seasons and measured net CO_2 fluxes from BSC covered soil surfaces showed responses similar to those observed at the level of the ecosystem. Earlier continuous measurements of soil air relative humidity (RH; 2001-2006) showed that soil moisture increases occurring after rains in the cool season persist up to 3 weeks after events (a total of 48-108 day equivalent per year at >98% RH) indicating conditions favorable for photosynthetic activity. Thus, net CO_2 uptake by BSCs during cool months may largely determine large NEEs measured under moist conditions during this time of year and, together with NPP of herbaceous vascular plants, help explain overall consistently high annual NEP in these ecosystems.