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Responses of desert, semi-arid grassland and scrub-oak ecosystems to elevated CO_2

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We compared observations from free air CO_2 enrichment (FACE) experiments at dry (desert, semi-arid grassland and scrub-oak) sites, to predictions from a suite of ecosystem models with differing complexity, ranging from a parsimonious forest growth model (GDAY) to a comprehensive land surface model (OCN). Dry ecosystems have often been predicted to increase in net primary productivity (NPP) and net C uptake over time in response to elevated CO_2 (eCO_2) because of increased N fixation, and alleviation of drought-stress due to reduced stomatal conductance. However, experiments at the Nevada Desert FACE (NDFF), the semi-arid prairie grassland FACE (PHACE), and the scrub-oak Kennedy Space Center open-top chamber experiment (KSCO), have revealed that dry ecosystems display a more complex biogeochemical response to eCO_2. Insights into the processes determining the responses of dry ecosystems to eCO_2 were gained by evaluating model estimates against site data, and by dissecting model responses to eCO_2. Site level findings at PHACE indicated that eCO_2 enabled more rapid C turnover, resulting in a net ecosystem C loss. Conversely, at PHACE, models such as OCN simulated a decrease in N leaching and an increase in NPP because of eCO_2, leading to increased C storage. Leaf cover and NPP at KSCO initially increased with eCO_2 before declining due to reduced N fixation and increased N leaching. At NDFF, eCO_2 only increased plant growth during one abnormally wet year; in subsequent years, soil crust cyanobacteria decreased in abundance, and gains in biomass were not sustained. In OCN simulations at NDFF, eCO_2 increased water-use efficiency and NPP in years with average to above-average precipitation. Through examination of the reasons for discrepancies between observed and modeled ecosystem responses to eCO_2, processes determining the biogeochemical responses of dry ecosystems to eCO_2 were elucidated.