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ABSTRACT TITLE: The role of stomatal signaling on plant water and carbon balance

ABSTRACT: Stomata respond to environmental stimuli through physical and biochemical signaling mechanisms that regulate ecosystem water and carbon fluxes. In particular, species have been observed to fall along a spectrum of stomatal sensitivity to drought. At one end of this spectrum, stomata close rapidly under drought conditions such that leaf water potential is regulated within a narrow range and xylem cavitation is limited, but carbon uptake is reduced (i.e. isohydric behavior). At the other end, stomata remain open during drought, which promotes carbon uptake at the expense of decreased leaf water potential and extensive xylem cavitation (i.e. anisohydric behavior). One hypothesis suggests that these strategies emerge from a combination of a biochemical signal indicating drying soil and a physical signal indicating drying of the canopy or upstream xylem. In this framework, isohydric plants are more sensitive to the soil signal.

A simplified model for the soil-plant-atmosphere system that incorporates these two signaling mechanisms is proposed to delineate their relative importance in water and carbon fluxes. In a first-order analysis, it is assumed that stomatal conductance and canopy gas exchange respond to soil moisture, a slowly varying external environmental state, and plant water potential, a rapidly varying internal state. The relative strengths of these two feedback mechanisms lead to a range of dynamics in the coupled soil-plant system consistent with the spectrum of stomatal control strategies and the trade-off between gas exchange and hydraulic safety. These preliminary model results suggest soil moisture feedback is an efficient mechanism for controlling plant water potential and xylem cavitation. Further, we deduce relations between soil, climate, and stomatal control that can be linked to the geographic distribution of these stomatal control strategies thereby allowing, for the first time, the spectrum of stomatal control strategies to be incorporated into large-scale land-surface modeling schemes.