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Rising atmospheric CO_2 decreases the rate of deep soil water use in a water-limited mature woodland

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Elevated atmospheric [CO_2] (eCa) may affect ecosystem water use. Elevated Ca reduces leaf-level transpiration (Es) in trees via reduced plant stomatal conductance (gs) and also enhances photosynthesis and productivity. Subsequently, it is hypothesized that eCa increases vegetation water use efficiency, reduces ecosystem water use and increases soil water content (θs) and ground water recharge. However, enhanced productivity in eCa could increase leaf area index (L), offsetting net vegetation water savings despite reduced water use per unit leaf area, as well as increasing canopy interception (I). Alternatively, in water-limited ecosystems, increased soil water from reduced Es would be lost via forest floor evapotranspiration (Efloor). Here, we tested for the effects of eCa on the partitioning of the hydrological components in a mature Eucalyptus woodland exposed to Free Air CO_2 Enrichment (the 'EucFACE' experiment). EucFACE is the first native forest eCa experiment and it is established in a seasonally water-limited climate. We hypothesized that in the short term (< 1 year), eCa would reduce canopy Es per unit of leaf area, while L would remain unaffected, leading to increased θs. Alternatively, in the longer term (> 1 year) increased L would offset reduced Es under eCa. Over two years, we measured shallow (30 cm) θs with 48 time domain reflectomers (TDR) and deep (up to 450 cm) θs on 15 locations with a neutron probe, we estimated Es from measurement of sapflow velocity (Js) on 24 trees, and calculated L and Efloor from measurements of the understory radiative environment, soil temperature and θs. Under eCa, gs decreased to some extent during certain periods. We found that shallow soil θs was not significantly affected by eCa, whereas deep (300-450 cm) θs decreased more rapidly under ambient Ca than under eCa, which could imply that deep-rooted vegetation (trees) underlie this trend. We found that Js under eCa was lower only while the ecosystem was energy-limited, but we did not find a significant effect of eCa on total Esap. Finally, to date, eCa did not significantly affect L or I, thus leaf-scale effects were not offset at the canopy level. These results suggest that in the longer term, under sustained periods of water scarcity ('el Niño' conditions for eastern Australia), rising atmospheric CO_2 could significantly affect deep soil water storage and eventually ground water recharge in water-limited Eucalyptus woodlands.