Water flow from moist to dry soil through plant roots affects microbial activity and ecosystem productivity

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Water flow upward or downward through plant root systems, from moist to drier soil, occurs worldwide in seasonally-dry ecosystems. How strongly this "hydraulic redistribution" (HR) affects soil microbial activities remains largely unknown. We combine modeling with measurements to explore the magnitude of HR's effects on carbon and nutrient cycling at ecosystem scales in four seasonally-dry, well-instrumented ecosystems. These systems were arrayed from Washington State to the Amazon, with annual rainfall from ~400 to 2000 mm, soil textures ranging from clay to sandy loam and loamy sand, and diverse vegetation types. AmeriFlux towers provided multi-year measurements of water, energy, and net ecosystem carbon exchange: US-Wrc (Pacific Northwest douglas fir/hemlock forest); US-SCf (Southern California oak-pine forest); US-SRM (Santa Rita semi-desert grassland with mesquite); and BR-Sa1 (evergreen broadleaf primary tropical forest). For modeling, we incorporated a representation of HR developed by Ryel *et al.* [1] into the Community Land Model Version 4.5 (CLM4.5).

Including HR in CLM4.5 improved model predictions of measured water, energy, and carbon fluxes at the four Ameriflux sites. Modeled plant and microbial activities were strongly and differentially stimulated by upward HR, and diminished by downward HR, at times exacerbating nutrient limitation of ecosystem productivity. Results demonstrate that the ecological significance of HR in seasonally-dry ecosystems extends beyond the direct effects of HR on plants (through stomatal conductance, evapotranspiration, and photosynthesis). Both upward and downward HR can affect the system-scale balance of nutrient supply and demand, and CO_2 fixation and respiration (plant and microbial), all of which interact as major determinants of system productivity and exchange of CO_2 with the atmosphere.

Ryel et al. (2002) *Oecologia* **130**, 173–184.