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Hydrologic control of rooting depth at the catchment and global scales: implications for ecosystem resilience

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Ecosystem productivity and resilience to environmental stress are tightly linked to soil water availability and plant rooting depth. We explore here the controls on plant root uptake, imposed by climate and groundwater accessibility, underlying the spatial and temporal patterns of rain-fed and groundwater-fed ecosystems at the large and catchment scale. We estimate root water-uptake depths with an inverse model, based on observed productivity and atmosphere, at 30$''$ ($\sim$1-km) global grids to capture the topography critical to soil hydrology. Results reveal strong sensitivities of rooting depth to local soil water profiles determined by precipitation infiltration depth from the top (reflecting climate and soil), and groundwater table depth from below (reflecting topography-driven land drainage). They indicate highly variable uptake-depth across seasonal and local hydrologic gradients, and a far more common occurrence of deep (>5m) uptake than previously thought. The resulting patterns of plant rooting depth bear a strong topographic and hydrologic signature at catchment to global scales and explain the contrasting rooting depths observed under the same climate for the same species but at distinct topographic positions. These results highlight the role of groundwater accesibility as one of the main organizing principles shaping ecosystem patterns and stress response at the catchment scale.