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Cracking the Critical Zone: How trees grow their own pot and influence landscape evolution

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Quantifying linkages between climate, ecosystems, lithology, soil production and erosion rates is one of the grand challenges for understanding influences on the Critical Zone and landscape evolution through time. Hydrologic routing, net primary productivity, carbon storage in soils, and mineral supplies for the geochemical reactor are all linked to rates of soil production. While trees serve as soil stabilizers over short time scales, over longer time scales, trees can damage, disrupt and detach bedrock in thin to no soil settings. In this sense, trees can grow their own soil pots. The pace of tree-driven soil production may set the pace of erosion into the underlying parent material. Root growth and tree throw then prime the mobile material for downslope transport. However - do tree roots actually create fractures, expand fractures, or merely exploit existing fractures in competent bedrock or saprolite? At present, this question looms large in the earth sciences while complicated by a paucity of available data and methods to measure root forces at the bedrock-root interface. Here I present evidence suggesting that bedrock detachment is a function of the interplay among rock strength, fracture density, root and tree size, and root density with depth. I propose that depth-dependent soil production rates are controlled by both the frequency and magnitude of multiple physical mechanisms that likely weaken and detach rock including tree sway, tree throw, root growth forces, root wedging and diurnal fluctuations due to water uptake all modulated by rock properties. I present preliminary data from a novel technique that measures forces at the rock-root interface that I will use to parameterize a biomechanical soil production function.