Built on bedrock, running on dust: Controls on ecosystem productivity and vulnerability in the Sierra Nevada, California

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Water and nutrients in soil and weathered rock are vital but still incompletely understood controls on ecosystem productivity and vulnerability to land use and climate change. We quantified these relationships using isotopic, bulk geochemical, and near-surface geophysical measurements at mid-elevation sites developed on granitic bedrock in the Sierra Nevada, California. Remotely sensed estimates of forest productivity correlate strongly with bedrock composition across the sites, implying strong lithologic control on the ecosystem [1]. Our analysis provides evidence for two separate bedrock-ecosystem connections: i) bedrock composition influences vegetation by moderating plant-essential nutrient supply; and ii) bedrock composition influences the degree of subsurface weathering, thereby influencing vegetation via control of subsurface water-storage capacity. This suggests that bedrock composition exerts a strong bottom-up control on ecosystem productivity through its influence on nutrient and water availability. However, neodymium isotopes in dust and vegetation indicate that dust also plays a vital role in ecosystem nutrient supply at one site developed on phosphorus-poor bedrock [2], suggesting that forest ecosystems in the region are also moderated by top-down control of nutrient supply from exogenous sources. To explore the importance of top-down and bottom-up controls on forest productivity and vulnerability to climate change, we coupled our geochemical and geophysical analyses with remotely sensed observations of mortality caused by the recent intense drought in California. Results suggest that higher nutrient inputs from bedrock and dust make forests more prone to mortality during drought. We hypothesize that, in wet years, faster forest growth, enabled by the higher nutrient supply, creates greater above-ground biomass, which in turn speeds drawdown during drought of water stored in the subsurface, leading to greater drought-induced mortality. Our work suggests that forest ecosystem vulnerability to drought is closely coupled with plant-essential nutrient cycling across our sites.

[1] Hahm et al. (2014) *PNAS* 11(9), 3338-3343.

[2] Arvin et al. (2017) *Sci. Adv.* 3(12), eaao1588, 1-10.