Reevaluating the role of dust in mountain ecosystems: Insights from tracer isotopes, microbial genomics, and global databases

CS RIEBE[1], LJ ARVIN[1], CJ CAREY[2], SM ACIEGO[1], SM AARONS[3], MA BLAKOWSKI[4], SC HART[5], EL ARONSON[6]

[1]U. Wyoming, Laramie [2]Point Blue Conservation Science, Petaluma, Calif. [3]U. Calif., Irvine [4]U. Michigan, Ann Arbor [5]U. Calif., Merced [6]U. Calif., Riverside

Dust can be a vital nutrient source in slowly-eroding tropical ecosystems where intense weathering limits nutrient influxes from underlying bedrock. In contrast, dust is often thought to be relatively unimportant in mountain ecosystems where bedrock conversion to soil provides continuous nutrient supply. Here we challenge this assumption using observations spanning a range of scales. Sr isotopes in dust deposited across an altitudinal gradient in the Sierra Nevada, California, reveal contributions from both transoceanic and regional dust sources. They also help explain observed phylotypes in study-site soils, implying that distant dust sources influence soil microbial communities across the sites. Moreover, measured aeolian fluxes, cosmogenic ^{10}Be, and bulk geochemistry demonstrate that dust dominates over bedrock in the supply of plant-essential P to Sierra Nevada ecosystems. The ecological significance of dust is further supported by analyses of Nd isotopes in pine needles, dust, and bedrock, which demonstrate that dust contributes as much as 88% of Nd (a potential tracer of P) to vegetation at one site. To evaluate whether the large measured effects of dust are widespread, we coupled a global dust model with basin-wide erosion rates from cosmogenic nuclides. Across more than 1300 mountain sites spanning diverse climates and rock types, we found that dust deposition is often on par with bedrock conversion to soil. Moreover, erosion rates are often slow enough and soil residence times are therefore long enough that high dust fluxes during the Last Glacial Maximum have likely imparted a legacy of nutrient inputs to many modern soils. In addition, new analyses show that dust fluxes may often contribute to large overestimation in denudation rates from cosmogenic ^{10}Be, exposing potentially profound errors in previously measured landscape evolution patterns. Together, our analyses suggest that the paradigm of dust as a relatively minor contributor to mountain soils and ecosystems needs to be revised. Doing so should lead to: more accurate links between climate, tectonics, and denudation; improved understanding of the global distribution of microbial communities; and better prediction of ecosystem response to climate and land-use changes.