Abstract Title:

From volcanic ash to abundant earth: Understanding Andisol soil health and organic matter dynamics across an environmental gradient on Hawai‘i Island

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Abstract:

While research on the mechanisms of carbon stabilization in Andisols is ongoing, the role of soil organic matter (SOM) dynamics in (sub)tropical Andisol soil health, and its variation across landscapes, has largely been unexplored. High concentrations of poorly and noncrystalline minerals favor greater organic matter accumulation in Andisols than phyllosilicate-dominant soils. Nevertheless, SOM quantity and quality vary greatly across volcanic natural and working lands. Therefore, a systems-level understanding of SOM composition and function is critical for climate change mitigation and adaptation, especially for vulnerable tropical and subtropical islands. Soil health, a soil's capacity to sustain biological productivity and maintain environmental quality, connects management practices to social-ecological vitality and resilience. In this study, we measured the effects of moisture regime and current land use on SOM fractions and soil health in Andisols. We collected soil samples from 24 sites across two moisture regimes (Udands and Ustands) and three land uses (cropland, pasture, forest) on Hawai‘i Island. We quantified the carbon (C) and nitrogen (N) concentrations of three SOM components, including mineral-associated organic matter (MAOM), heavy particulate organic matter (HPOM), and light particulate organic matter (LPOM), separated by size and density. Additionally, we measured ten dynamic soil properties which were integrated into a soil health score. We used multiple linear regression to determine which SOM pools best predicted the soil health score and semi-partial analysis to understand the amount of model variability uniquely accounted for by each predictor. We found that land use influenced SOM fraction mass proportion ($p < 0.05$), but its effect on mineral-associated (MAOM) and heavy particulate organic matter (HPOM) proportions depended on the moisture regime ($p < 0.01$). Further, pastures had greater HPOM-C and N concentrations than forests and croplands ($p < 0.01$). Soil health scores ranged from 0.05 to 0.91. The highest scoring systems included Udand forests, Udand pastures, and Ustand pastures. Multiple linear regression revealed that MAOM-C ($sr^2 = 0.41$), HPOM-N ($sr^2 = 0.05$), and LPOM-N ($sr^2 = 0.07$) best predicted the soil health score ($R^2 = 0.82$), indicating that N mobilization from particulate fractions may be an important process to overcome the high mineral sorption potential of poorly and noncrystalline minerals and maintain N bioavailability in Andisols.