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Impacts of Dynamic Soil Redox on Biogeochemical Transformations and Soil Microbiomes

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Wet upland soils, particularly in the tropics, naturally oscillate between oxic and anoxic conditions, constraining both microbial metabolism and mineral-organic matter relationships that regulate soil C, Fe and P cycling. In the coming decades, many neotropical sites will see an increase in temperature, changes in rainfall patterns, and higher hurricane frequency. All these factors affect soil moisture, soil O_2 and solute diffusion, mineral availability of terminal electron acceptors, and thus aerobic versus anaerobic respiratory processes. But unlike temperature, moisture, or atmospheric [CO_2], Eh is inherently a nonlinear controlling variable—i.e. while organismal response may be well-defined at either end of a redox gradient, a mean level of response will not necessarily occur in a system that rapidly fluctuates between anoxic and oxic extremes. This may be because environmental stochasticity creates increased niche space through spatial and temporal heterogeneity, and also because entirely new microorganisms become thermodynamically favored as physiologically important redox thresholds are crossed. In addition, reactive Fe-oxide phases and aromatic OM preservation under anoxic conditions may affect OM turnover via co-precipitation or chelation.

In the past two decades, many studies have examined biogeochemical processes in upland redox-ocillating soils and described responses to changes in redox oscillation: dissolution/reprecipitation of Fe surfaces and P release, rapid N cycling, microbial community composition, and evolution of Fe mineralogy. I will describe new insights that cutting edge technologies--stable isotope probing, STXM-NanoSIMS imaging, Mössbauer spectroscopy and next generation sequencing—have contributed to our understanding microbial and viral community structure, organic matter turnover and fate, Fe speciation, and P utilization in dynamic redox soils. The mechanistic understanding obtained from these studies is critical to improve the predictive capacity of mathematical models that forecast future tropical soil carbon and nutrient balance.