Panarchy in Soil Systems: Towards Evaluating Resilience Across Multiple Spatial Scales

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Many soils posses an inherent capacity to recover functional and structural integrity after perturbation. While the resilience of soils is generally appreciated amongst pedologists, the dynamic and heterogeneous nature of soil systems has made efforts to characterize resilience operationally challenging. Adding to this complexity, soils function at a continuum of spatial and temporal scales regulated by scale distinct physical, chemical, and biological interactions. In the effort to decrease the negative consequences inflicted upon soil regulated ecosystem services from increased and variable perturbations due to climate change, additional efforts to understand resilience in soil systems are needed if we wish to decrease climate risk through soil management.

Herein we propose a conceptual framework that can be used to characterize soil resilience at distinct spatial and temporal scales ranging from the microaggregate (in seconds) to the landscape (in centuries) as organized by a Holling Panarchy of individually nested adaptive systems. Acknowledging the nested, dynamic and adaptive nature of soil systems allows for a more thorough characterization of cross-scale communication and feedbacks resulting in a more comprehensive understanding of broad system resilience. Such an approach may lend itself to better identifying dynamic thresholds and stable states in soil systems with implications to targeted management across scales.