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Managing for soil carbon sequestration: a modeling framework for decision-making

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In order to plan for responsible soil carbon (C) management, it is important to know how site factors will affect C stabilization. For example, is mineral-associated C vulnerable to climate change, and how do management practices that modify plant inputs affect mineral-associated C? We applied a soil organic carbon (SOC) decomposition model that represents microbial physiology and mineral sorption. The model was able to reproduce large spatial gradients in SOC stocks; model predictions of SOC were highly correlated with SOC observations across an 4000 km transect ($R2 > 0.9$). We also used a Random Forest algorithm to compare our model predictions with transect data. We applied this model to explore expected changes to SOC across a range of mineral surface properties, mean annual temperature (MAT), and plant input rates. We found that SOC generally increased after plant amendments. Furthermore, the type of amendment (i.e. high vs. low lignin content), soil mineralogy, and climate all affected the sign and magnitude of SOC change over time. In particular, cold sites with low mineral surface availability were most vulnerable to SOC loss, and may benefit most from plant amendments. At all sites, mineral surface saturation reduced the SOC pool's sensitivity to changes in plant inputs. Saturated soils lost a smaller fraction of initial mineral-associated C following warming. We encourage the use of soil carbon models as frameworks to evaluate how particular sites may respond to changes in management and/or climate.