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Using climatological transects to understand the relationship between soil C lability-temperature sensitivity

R. Conant
Colorado State University, NREL, Fort Collins, CO, United States (conant@nrel.colostate.edu)

The question of how temperature sensitivity of soil organic matter (OM) decomposition varies with its lability is likely to be a main determinant of whether soils act as a sink or source for atmospheric CO2 under the climate of the future. This question is unaddressed in leading climate-carbon models, masking a potentially large source of uncertainty with substantial implications for changes in soil carbon stocks. Kinetic theory suggests that biochemically complex OM substrates that normally resist decomposition should be more sensitive to temperature than labile substrates that decompose quickly. If decomposition of resistant soil OM is more sensitive to temperature than is labile soil OM, then warmer sites should be depleted of resistant soil OM relative to cooler sites and measures of soil quality should be greater at warmer sites. This should be true regardless of differences in OM input amounts or quality for comparison of compounds within a decay cascade (e.g., whole soil C:N ratio or lignin:lignitic aldehydes:lignitic acids) for sites at steady state (i.e., sites with a long-term history under a given land use regime). Some anecdotal data on tropical soil fertility support this prediction as do data from incubations of soils from across the Great Plains and Canadian forests, though shorter-term data from temperate forest soil incubations do not. Soil C:N data newly synthesized to test this prediction are consistent with the expectation that whole soil and silt-associated C:N ratios will increase with site mean annual temperature and that the MAT-C:N relationship for clay-associated soil OM will be weaker or non-existent. Data collected along a climosequence arrayed across the Great Plains show that soils at warmer sites are enriched in labile lignin decay products and depleted in resistant products, which are more biochemically resistant to decomposition than lignin itself. All of these results support the prediction of kinetic theory – that the temperature sensitivity of decomposition of resistant soil OM is greater than that of labile soil OM.