Soil organic matter persistence as an ecosystem property

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Globally, soil organic matter (SOM) contains more than three times as much carbon as either the atmosphere or terrestrial vegetation. Yet, it remains largely unknown why some soil organic matter (SOM) persists for millenia while other SOM decomposes readily—and this limits our ability to predict how soils will respond to climate change. Recent analytical and experimental advances have demonstrated that molecular structure alone does not control SOM stability: in fact, environmental and biological controls predominate. We propose ways to include this understanding in a new generation of experiments and soil carbon models, thereby improving predictions of the SOM response to global warming.

Understanding soil biogeochemistry is essential to stewardship of ecosystem services provided by soils, such as soil fertility (for food, fiber, and fuel production), water quality, resistance to erosion and climate mitigation through reduced feedbacks to climate change. Soils store at least three times as much carbon (in SOM) in organic matter as is found in either living plants or the atmosphere 1. This major pool of organic carbon is sensitive to changes in climate or local environment, but how and on what time scale will it respond? The feedbacks between soil organic carbon and climate are not fully understood, so we are not fully able to answer this question 2-7. We can explore them, however, using numerical models of soil-organic-carbon cycling, not only to simulate feedbacks between climate change and ecosystems, but also to evaluate management options and analyze carbon sequestration and biofuel strategies. These models, however, rest on some assumptions that have been challenged and even disproved by recent research arising from new isotopic, spectroscopic, and molecular-marker techniques in long-term field experiments. Here, we describe how recent evidence has led to a framework for understanding soil organic matter (SOM) cycling, and we highlight new approaches that could lead us to a new generation of soil carbon models to better reflect observations and inform predictions and policies.