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Timescales, a soil carbon conundrum, and actuating the benefits of accumulating carbon in landscapes

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Carbon is the currency of climate change; but the value of it as such varies, and not always predictably, because of a wide range in timescales for the persistence of carbon within systems. Uncertainty in the longevity of carbon in natural and managed ecosystems contributes directly to lack of progress on policies that might otherwise promote land use and management practices that accumulate carbon in landscapes as part of climate action planning. The apparent age of carbon in mineral soils is highly dependent on time (or substrate age), climate legacy, and anthropogenic influences, in addition to ecosystem properties such as mineralogy. Partitioning carbon into various quantifiable pools and making radiocarbon, or other, measurements assists in the discernment among the predominant drivers of ecosystem carbon persistence. However, the ability to consistently project potential soil carbon balance across scales and in the face of change remains elusive. Yet, the capacity to make these projections with some degree of certainty is critical to science-based implementation of climate policy in the land use sector. Deriving carbon indices that 1) respond to changing environment or inputs, represent substrate for thriving microbial communities, and reflect potential persistence across various timescales and 2) honor the complexity of soil ecosystems while simplifying projection and verification requirements is tantamount. Sound science-based policies require science-based decision support and planning tools for fair and equitable implementation and enforcement. With carbon sequestration, comes a multitude of benefits associated with soil organic matter including fertility, improved water relations, and porosity. To attain all the benefits associated with soil organic matter, decomposition and stabilization must simultaneously occur. Not all carbon that enters the soil system is sequestered, but some is. Answering basic questions about how much and for how long, as accurately as possible within reason, is critical to engaging broad support and actuating natural and working lands as a climate mitigation tool with important co-benefits of improved soil health and function.