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ABSTRACT TITLE: Soil Carbon and Nitrogen Responses throughout Twelve Years of Atmospheric CO2 Enrichment in Deciduous Forest

ABSTRACT: The impact of atmospheric CO_2 enrichment on soil organic matter (SOM) dynamics and stocks depends on the interplay between plant responses, the soil's capability to protect and stabilize SOM against decomposition, and nutrient availability. Information on C and N allocation to functionally meaningful SOM pools and their dynamics can improve our understanding of soil responses and facilitate predictions of the potential for long-term stabilization. At the sweetgum free-air CO_2 enrichment (FACE) experiment in Oak Ridge, Tennessee, we used (1) repeated sampling over time, (2) the ^{13}C tracer provided by the fossil fuel source of fumigation CO_2, and (3) physical fractionation to determine the fate and dynamics of FACE-derived detritus inputs to SOM. Samples collected in years 0, 3, 5, 8, 10, and 12 of the experiment were fractionated to separate particulate organic matter (POM) and silt- and clay-associated organic matter protected by occlusion in stable microaggregates from their more readily dispersible counterparts. In this aggrading system, significant linear increases in bulk soil C and N occurred in the surface 5 cm of both ambient and elevated CO_2 treatments during the 12 years of the experiment, but accrual rates doubled in response to CO_2 enrichment – with no treatment effect on C:N ratio. "New" FACE-derived C accounted for the 12-year increase in bulk soil C and also replaced 30% of the "old" pretreatment C. Below the surface 5 cm, bulk soil C tended to increase to a depth of 45 cm, but these trends were not significant and did not differ between ambient and elevated CO_2 treatments. The difference in SOM accrual between elevated- and ambient-CO_2 treatments in the surface 5 cm occurred mostly in silt-sized and fine POM fractions. Initially, occlusion within microaggregates facilitated much of this accrual. But in years 8 and 10 during a prolonged drought, microaggregate-occluded C and N were transferred to non-aggregated pools. In year 12, after the drought ended, the quantities of silt-associated SOM occluded in microaggregates recovered to pre-drought levels. However, microaggregate-occluded POM continued to decline. This finding, coupled with an observed lagged/phased cycling of "old" pretreatment C through some SOM pools, suggests that continued SOM accrual might not be sustained for an extended time period – given that net primary production has declined at the site over time. The sensitivity of physical protection mechanisms to climate has implications for the potential long-term stability of accrued SOM in this system and those with similar soil characteristics. Beyond the CO_2 treatment responses, the isotopic tracer and observed dynamic changes contribute to understanding of SOM cycling and stabilization processes and provide data for model calibration and validation.