Comparison of Forest Soil Carbon Dynamics at Five AmeriFlux Sites Along a Latitudinal Gradient

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INTRODUCTION

Carbon and nitrogen stocks, and C:N ratios, were measured in the forest floor, mineral soil, and two mineral soil fractions (particulate organic matter and mineral-associated organic matter, POM and MOM, respectively) at five, mature, AmeriFlux forest sites along a latitudinal gradient in the eastern United States for the purpose of calculating turnover times of labile soil organic carbon and modeling differences in soil carbon dynamics.

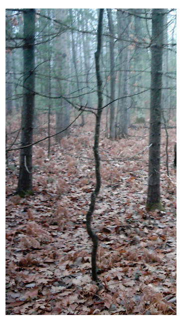
Soils were sampled at five AmeriFlux forest sites over two consecutive years (2007-2008 and 2008-2009)

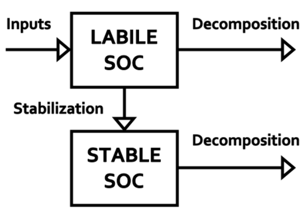
Site code	AmeriFlux Site Location	Mean Annual Temperature (°C)	Annual Precipitation (mm)
UMB	University of Michigan Biological Station, MI	6.2	750
BEF	Bartlett Experimental Forest, NH	6.5	1300
HAR	Harvard Forest, MA	7.9	1066
MOZ	University of Missouri (MOFLUX), MO	13.9	940
ORR	Oak Ridge Reservation, TN	14.6	1348

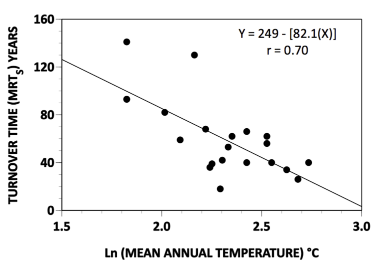
MODELING

Data were summarized using a two-compartment model that included "labile" and "stable" soil carbon stocks to a 20-cm soil depth. Labile soil carbon was based on carbon in the forest floor and POM from the mineral soil. Stable soil carbon was calculated from carbon in soil silt and clay.

Turnover times of labile and stable pools of soil organic carbon (SOC) were calculated from an assumption that soil carbon was near steady-state. Annual soil carbon inputs ranged from 310 to 470 g C m⁻². A stochastic modeling approach was used to estimate the turnover time of labile soil carbon.

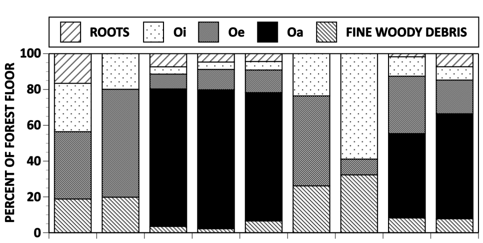






RESULTS

1. Partitioning of forest floor dry matter (and carbon) varied markedly among the five sites. Some northern sites (BEF, HAR) had significant forest floor carbon in the humus layer (Oa horizon). Other sites (UMB, MOZ) lacked a humus layer.



2. Forest floor and mineral soil carbon stocks increased from warm, southern sites (MOZ, ORR) to cool, northern sites (BEF, HAR).

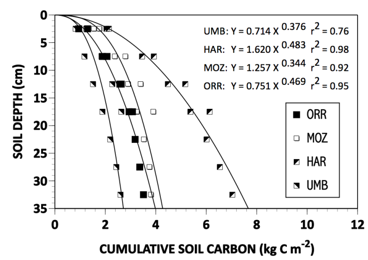
However, southern and northern sites differed in soil texture. Southern sites (MOZ, ORR) had fine-textured soils (>70% silt-clay) while northern sites (UMB, BEF, HAR) had more sandy soils. The one exception to the latitudinal pattern was a northern site (UMB) with <10% silt-clay content that had a SOC stock similar to stocks measured in the south.

3. Moving from south to north, the turnover time of labile SOC increased from about 5 to 14 years and the turnover time of stable SOC increased from about 30 to 100 years.

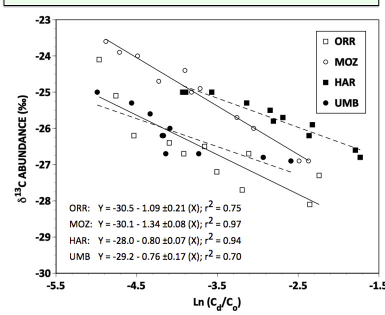
Mean labile and stable soil organic carbon (SOC) stocks and calculated turnover times of labile and stable SOC (20 cm soil depth) at the five sites over two study years

	Labile SOC (kg C m⁻²)		Stable SOC (kg C m⁻²)		Turnover Time Labile SOC (years)		Turnover Time Stable SOC (years)	
Site	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
UMB	1.24	1.55	1.01	1.40	4.1 ±0.1	4.9 ±0.2	104 ±1.3	100 ±1.3
BEF	nd	4.03	nd	3.06	nd	13.6 ±0.4	nd	96 ±1.1
HAR	3.86	4.28	3.78	4.55	12.3 ±0.3	14.1 ±0.4	79 ±0.8	80 ±0.7
MOZ	1.67	1.50	2.04	2.66	5.1 ±0.2	4.2 ±0.1	33 ±0.5	33 ±0.5
ORR	1.82	2.49	1.96	2.22	4.0 ±0.1	5.4 ±0.1	29 ±0.5	30 ±0.5

4. Changes in cumulative whole mineral soil C stocks with depth were best described by a power function.



5. Carbon-13 enrichment factors (ε) from the Rayleigh Equation that described the rate of change in δ¹³C through the soil profile were associated with SOC turnover. Southern sites (ORR, MOZ) had steeper rates of change in carbon-13 abundance.



6. The rate of SOC stabilization in the model was positively correlated (r = 0.91; P < 0.001) with silt-clay content.

CONCLUSIONS

This relatively simple approach to modeling soil carbon dynamics indicated that temperature was strongly associated with latitudinal differences in the storage and turnover of SOC, but soil texture superseded temperature when there was too little silt and clay to stabilize labile carbon and protect it from decomposition. All sites had a high proportion of labile SOC (about 50% to a depth of 20 cm). Depending on temperature sensitivities, large labile pools of forest soil carbon are at risk of decomposition in a warming climate, and losses could be disproportionately higher from coarse textured forest soils, even in cool climates.

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