Multiyear Applications of ^{14}C-Enriched Leaf Litter at Temperate Deciduous Forests Across the Eastern United States: Application to Direct Observations of Soil Carbon Transport and Storage Dynamics in Organic and Mineral Soils

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A Reality Check

Interannual dynamics of litter and soil C pools are not well defined. Data are available on CO_2 efflux from soils, but flow of C from plant sources into soil and the net effect of these fluxes on C stocks residing in soils is seldom quantified. Interannual variation in flux from the soil suggests transient changes in the soil C stocks, but the current capability to detect change in these stocks is limited.

EBIS-AmeriFlux Goal

Use unique ^{14}C-enriched materials to characterize the rate of C flux from litter sources to mineral soil sinks over a range of climatic and biological conditions.

- Leaf litter to mineral soil transfers
- Oa (humus) to mineral soil transfers
- Root litter to mineral soil transfers

The ^{14}C-enriched Materials

1. Enriched litter at ~900 ‰ applied annually, beginning in winter 2007, at 500 g m^{-2} to each 2 x 2m plot.
2. Enriched humus at ~725 ‰ applied once, in winter 2007, at 1000 g m^{-2} to each 1 x 1m plot.
3. Enriched root material at ~525 ‰ added to root decomposition bags filled with soil from 0-10 cm depth from appropriate site.

All litter materials were irradiated (sterilized) prior to being applied to each site. A side study suggests no effect on subsequent decomposition.

Hypotheses:

H1 – Carbon sources from leaf-litter, surface humus, or fine-root organic sources will exhibit distinctly different accumulation rates into distinct mineral soil C pools.

H2 -- Carbon transport from organic to mineral soil C pools will be slower in colder and/or drier environments.

H3 – The C from litter of constant composition will be apportioned differently among (1) losses via CO_2 and DOC, (2) incorporation into the microbes and microbial byproducts, and (3) persistence as undecomposed material in AmeriFlux sites with different climates and microbial community composition.

H4 – Variation in the population densities of macro-biota (esp. earthworms and millipedes) will impact the rate of surface to mineral soil incorporation across the eastern United States.

**EBIS-AmeriFlux Study Sites

Cold sites

University of Michigan Biological Station (*Peter Curtis, Knute Nadelhoffer, & Jim LeMoine*)

Bartlett Experimental Forest, New Hampshire (*Dave Hollinger, Robert Evans, & Andrew Richardson*)

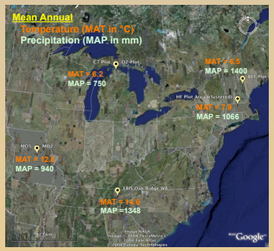
Intermediate sites

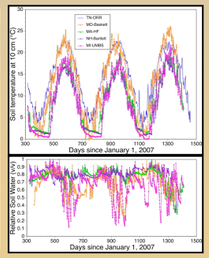
Harvard Forest, Massachusetts (*Bill Munger*)

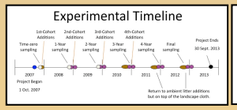
Warm sites

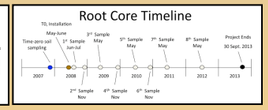
MOFlux AmeriFlux Site, Missouri (*Steve Pallardy, Kevin Hosman, & Lianhong Gu*)

EBIS-Oak Ridge project sites are being used as additional warm reference locations for climate gradient analyses (*Donald E. Todd Jr., Deanne Brice, Charles T. Garten Jr.*)





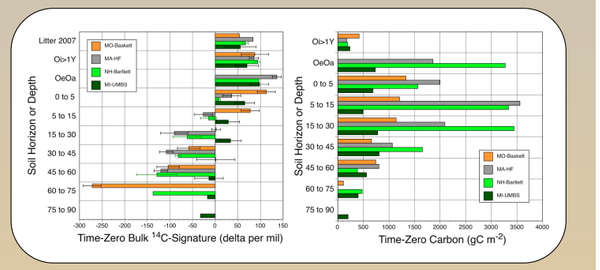




Establishment, Sampling & Monitoring

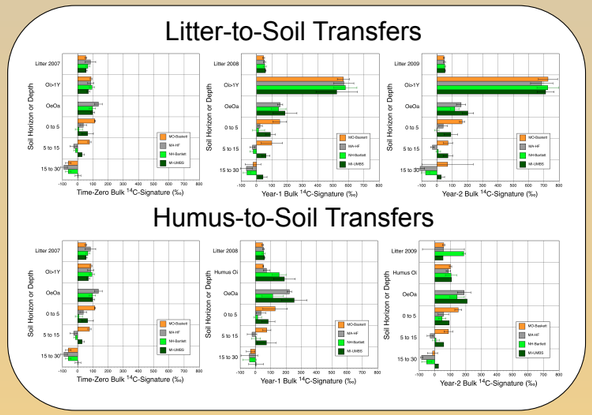
Site Characteristics

1. Carbon stocks and ^{14}C-signatures show similar depth profiles, but strong regional differences.
2. Younger carbon with depth at the Michigan site is attributed to the local coarse texture soil.
3. Carbon stocks are greatest in the colder environments.



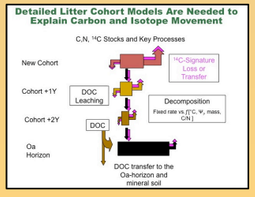
Isotopic Changes

1. Litter C is easily transferred to the organic horizons.
2. Litter to mineral soil transport takes place, but little C remains after an annual cycle due to microbial consumption of the new labile carbon forms.
3. Coarse texture soils at the UMBS site in MI may allow deeper transport and net retention of carbon than at the other sites.
4. Cold conditions enhance the accumulation of carbon within horizons, but extensive earthworm populations in MO may disrupt this pattern.
5. Humus to soil C transfer is not as obvious, but humus decomposes mores slowly than fresh leaf litter and our capacity to observed this transfer is limited by the lower level of ^{14}C enrichment of this material.



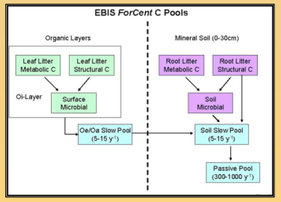
Soil Carbon Cycle Models Have Been Updated and Improved

1. Simple one-box models of soil respiration are inadequate for explaining observed carbon flows.
2. A multi-layered, cohort-based analysis will be needed to interpret the path, rate and fate of isotopically-labeled materials in soils.



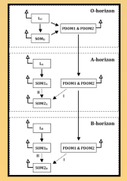
Detailed litter cohort and DOC leaching processes must be modeled to reproduce observed isotopic labeling patterns.

DayCent model was improved for Forests



Parton WJ, Hanson PJ, Swanston C, Torn M, Trumbore SE, Riley W, Kelly R (2010) ForCent Model Development and Testing using the Enriched Background Isotope Study (EBIS) experiment. *JGR-Biogeosciences* 115:G04001, doi:10.1029/2009JG001193

EBIS data allowed a DOC transport model (DyDOC) to be improved



Tipping E, Chamberlain PM, Fröberg M, Hanson PJ, Jardine PM (2011) Simulation of carbon cycling and Dissolved Organic Carbon transport in forest soil locally enriched with ^{14}C. *Biogeochemistry* (in press).