EBIS-AmeriFlux: Tracking Carbon Flux into Soil Sinks in Temperate Broadleaf Forests in the Eastern US with Radiocarbon

K. J. McFarlane[1], P. J. Hanson[2], M. S. Torn[3], R. C. Porras[3], R. Matamala[4], J. D. Jastrow[4], and T. P. Guilderson[1]

[1]Center for AMS, Lawrence Livermore National Laboratory, Livermore, CA; [2]Oak Ridge National Laboratory, Oak Ridge, TN; [3]Earth Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA; [4]Argonne National Laboratory, Argonne, IL

Introduction:

Forests and forest soils are a significant reservoir of carbon, component of the terrestrial carbon sink, and source of biospheric CO_2 to the atmosphere. Extensive data exist on aboveground carbon cycling, soil carbon stocks, and soil respiration rates, but transfer rates for plant carbon into soil sinks are not well quantified.

We used ^{14}C-enriched plant litter (leaves and roots) to track plant C from litter sources to soil sinks in four deciduous broadleaf forests in the eastern U.S.

Methods:

Figure 1. Map of study sites (red pins).

Table 1. Description of study sites.

Site Abbr.	MAT (° C)	Earth-worms?	Soil Texture/ Great Group
UMBS	7	Yes	Sandy Spodosol
BEF	7	No	Coarse Loam Spodosol
HAF	8	No	Coarse Loam Inceptisol
MOZ	13	YES	Silt Loam Alfisol/Mollisol

1. Leaf Litter Transplant Experiment:

- ^{14}C-enriched leaves (~ 1000 ‰) from Oak Ridge, TN replaced native autumn litterfall
- 4 years beginning in 2007
- Annual sampling of soil 2007-2011

2. Humus Experiment:

- ^{14}C-enriched Oe material (~ 725 ‰) from Oak Ridge, TN
- Single application in 2007
- Annual sampling of soil 2007-2011

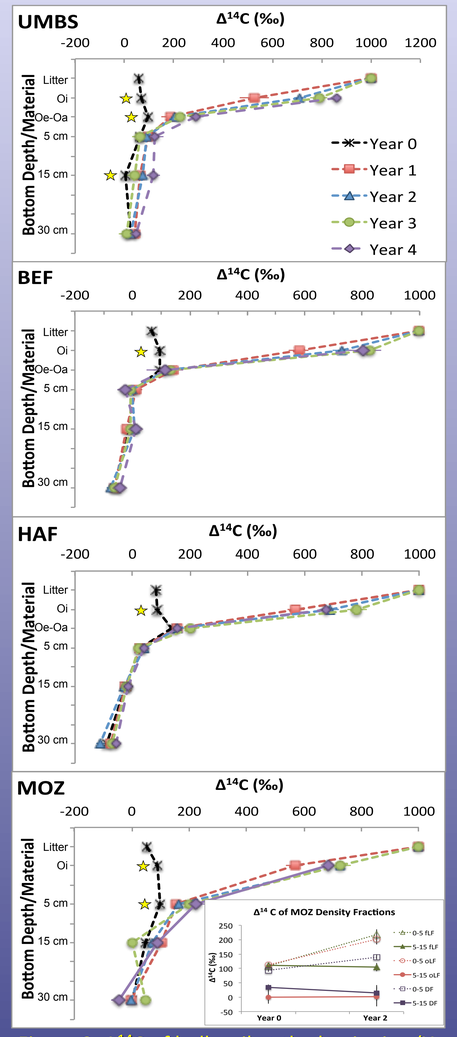
3. Root Decomposition Experiment:

- 14C-enriched roots (~ 470 ‰) from Oak Ridge, TN
- Litterbags with enriched roots and native soil (0-10 cm)
- Buried at study sites May 2008
- Bags harvested sequentially every 6 mo for 4 yrs.

4. Soil ^{14}C measurements were used to track litter-C as it moved into soil sinks
   - Leaf and humus experiment included O horizons and mineral soil to 30 cm.
   - Mineral soil fractionation allowed for identification of which SOM pools incorporate new litter-C.
   - The portion of new litter-C in samples determined using an isotopic mixing model.

Results:

Leaf Litter



Humus

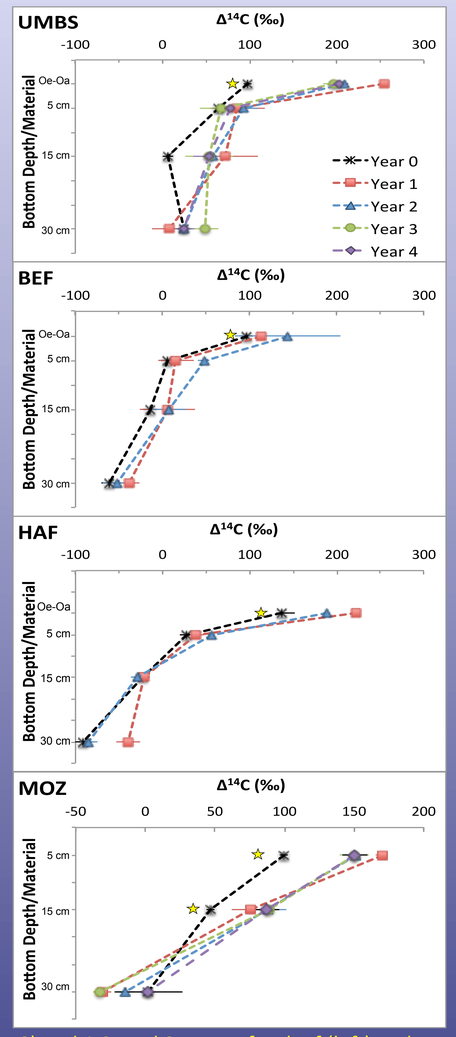


Figure 2. $\Delta^{14}C$ of bulk soil at the beginning (Year 0) and 1,2, and 2 years after leaf (left) and humus (right) experiments began. Note that Oe-Oa is absent at MOZ as a result of high levels of earthworm activity. Stars indicate statistically significant increases in $\Delta^{14}C$ after application of labeled materials ($\alpha = 0.05$). Insert: $\Delta^{14}C$ of density fractions at MOZ in Year 0 and Year 2 with significant increases in $\Delta^{14}C$ in all 0-5 cm density fractions..

Table 2. Portion of total C from labeled litter for horizons, soil depths, and fractions with increases in $\Delta^{14}C$.

Site	Horizon	Year 1	Year 2	Year 3	Year 4
UMBS	Oi	49±6%	69±3%	77±4%	85±3%
BEF	Oi	54±4%	70±4%	81±1%	78±3%
HAF	Oi	53±4%	66±4%	76±4%	64±2%
MOZ	Oi	53±2%	70±3%	70±4%	66±3%
UMBS	Oe-Oa	10±4%	12±2%	27±13%	35±14%
MOZ	0-5 cm	5±2%	6±1%	10±2%	12±2%
	fLF	---	12%		
	oLF	---	10%		
	DF	---	5%		
UMBS	5-15 cm	6±2%	7±2%	2±1%	11±2%

Roots

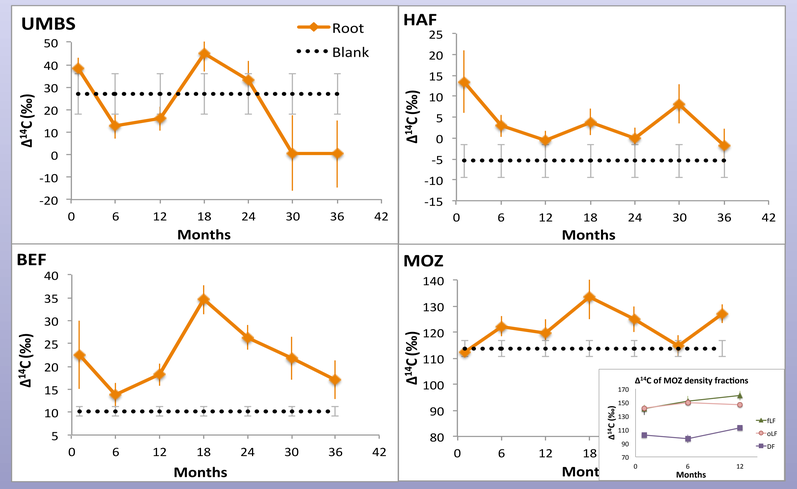


Figure 3. Difference in Δ14C of bulk soil in root decomposition bags with (root) and without (blank) enriched roots collected 1-36 months after bags were buried in May 2008.

Enriched root-C was detected in:

- Bulk soil at BEF and HAF 1 month after bags were buried (and for several months after)!
- Bulk soil at MOZ after 24 months, even through it was incorporated into fLF and DF during first year.

Summary and On-Going Work:

1. Carbon from enriched materials was incorporated into soil pools with faster turnover times (see McFarlane et al., in press)
2. Carbon from ^{14}C-enriched leaf litter was:
   - ≥ 50% of Oi-C at all sites in 1 year and ≥ 70% by Year 3.
   - Up to 15% of C in Oe-Oa at UMBS, but not detected at BEF and HF where Oe-Oa horizons are large.
   - 7% of C in 0-5 cm bulk soil carbon at MOZ by Year 2, where it was detected in all soil fractions. Warm temperatures and bioturbation may result in high decomposition and C transfer rates at MOZ.
   - Detected in small amounts in 5-15 cm bulk soil at UMBS, where small C stocks and sandy soil may result in faster and easier to detect C transfer rates.
3. Enriched humus-C was detected in Oe-Oa all sites except MOZ where worms incorporated it into surface mineral soil.
4. With these data, we will calculate flux rates of new litter-C into soil sinks, infer the relative contribution of leaf versus root litter to C pools at each site, and compare transfer rates across sites with different climate and soil types.

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