Enriched Background Isotope Study (EBIS): Application of an Ecosystem-scale $^{14}$C Tracer to Soil-Carbon-Cycle Studies


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A Unique Opportunity

- Local emissions produced a significant source of $^{14}$C at Oak Ridge.
- Sampling of unusual nature of the 1999 event, the C-enrichment event was a permitted emission and not a safety hazard.
- Sufficient enrichment (near background) and near background initial conditions with respect to $^{14}$C in litter, roots, and mineral soils.

The Experiment

Eight experimental plots were established in 2000 at each of the four sites shown above. Time-zero sampling of organic and mineral horizons was done in Jan/Feb 2001. All plots received either enriched litter (4 plots/site) or background litter (4 plots/site) in March of 2001 from the 2001 collection. The second litter addition was made in February 2002 following 1-year sampling. Final litter additions will be made in February 2003. Ambient litterfall was excluded from all plots starting in the fall of 2001 (see photo below).

Research Objectives and Bulk C Pool Analyses

Objectives

- Identify pathways and rates of bulk C transfer from carbon sources (litter and root litter) to respiratory losses, leaching or accumulation in stable forms or in the mineral soil.
- Partition soil respiration into autotrophic and heterotrophic sources.
- Quantify differences between mineral soil and forest C sources for heterotrophic and autotrophic respiration.
- Measure the rate of C accumulation in soils having different chemical and physical protection from degradation.
- Evaluate the role of observed organic carbon (OC) in vertical transport.
- Measure increases (decreases) in vertical transport of C from the litter layer to the mineral horizons.
- Identify the longevity and turnover time of the roots.

Bulk $^{14}$C Analyses by Horizon

- For each horizon, $^{14}$C signatures were compared to their respective background ($^{14}$C - 100‰) and to the initial litterfall ($^{14}$C - 0‰).
- Surprisingly, $^{14}$C signatures did not continue to increase in the 'enriched' treatment plots. Differential decomposition of individual litter cohorts and/or differential labeling of soluble/labile C components are being investigated as reasons for this dilution.

Soil Carbon Modeling (see next)

A. Rothamsted model carbon pools and processes. Their approximate equivalents for the EBIS sample processing scheme: C = DPM+PRT of RPM, Da/Da = BOD-20% of RPM, A = HUM+HCI.
B. A 55-year spin-up of the Rothamsted model for the ultisol soils showing the influence of two annual enriched litter additions starting in 2001.
C. An expanded view of the model simulations for the experimental period (2001 and beyond). Observed $^{14}$C-signatures of the Oi-Y layer, the Oa/Da layers, and the A soil horizon show that model improvements need to be made to capture observed soil carbon cycling and transport processes.

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