EBIS Microbial Carbon Cycling rates and substrates

Ectomycorrhizal Fungi
Microbial biomass

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Enriched Background Isotope Study

Do ectomycorrhizal fungi use soil carbon?

What is the isotopic signature of microbial biomass and extractable C?

A field test with large-scale radiocarbon enrichment

Ectomycorrhizal fungi are often the most abundant decomposer group in forest soils

Plant ⟷ Soil

C source?

Fogel 1980; Alexander 1983

Evidence for decomposition by ectomycorrhizal fungi

- Enzyme activity
  - Protease
  - Polyphenol oxidase
  - Cellulase
  - Phosphatase
  - Lignin peroxidase
- Culture growth on organic materials
- Increased decomposition in mycorrhizal rhizospheres

e.g. Norkrans 1950; Theodorou 1971; Ho & Zak 1979; Giltrap 1982; Dighton 1983; Dighton et al. 1987; Read 1991, Durall et al. 1994; Chalot & Brun 1998

Collection of ECM root tips

Collected September 2001 and August 2003
Walker Branch and TVA

Ectomycorrhizal fungi

Definition, Source

- Culled from root tips.
- At ORR, Ecto's are found on oak trees.

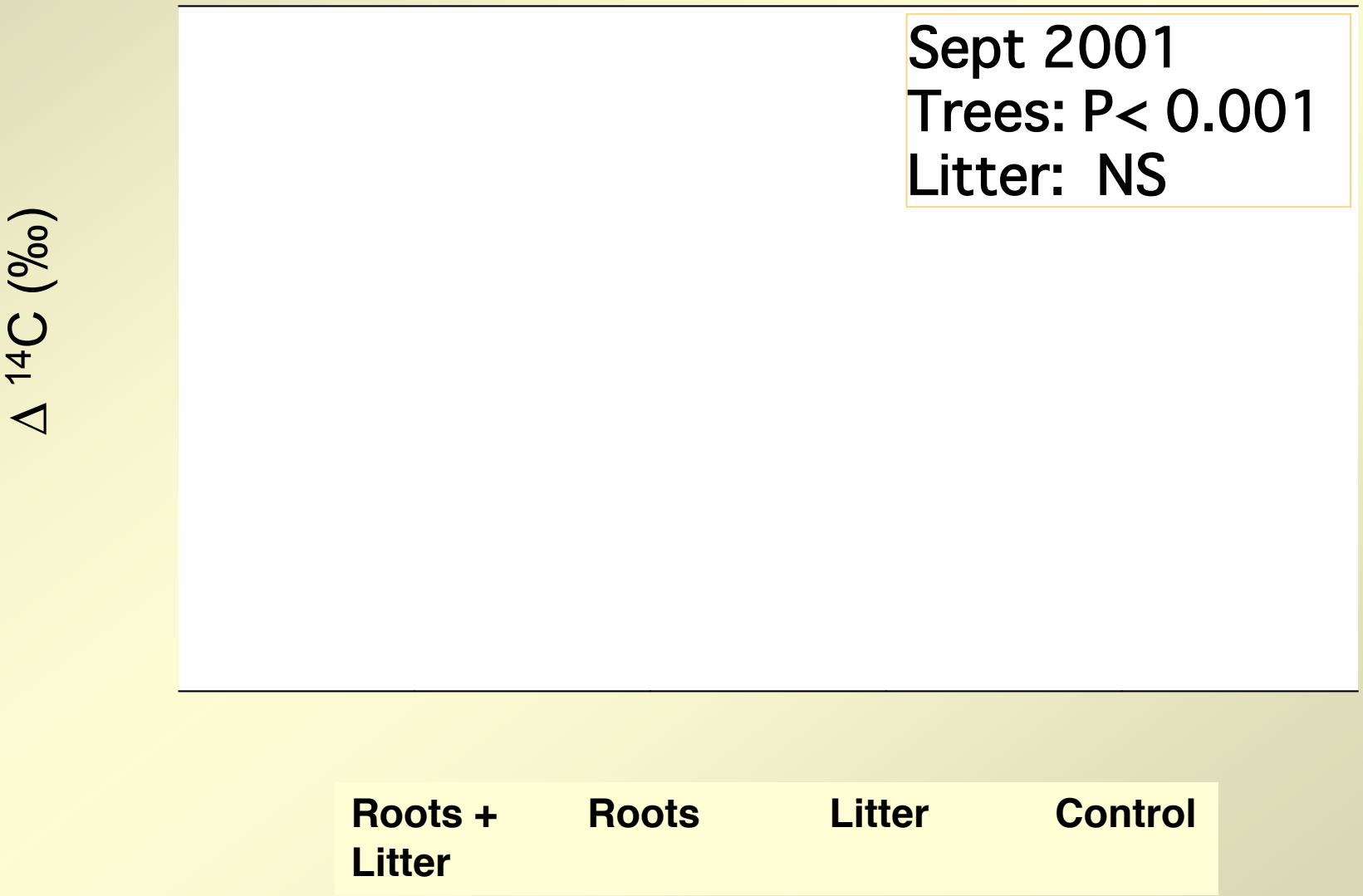
Sampling

- Sites — Walker Branch and TVA
- Depths — 0-5 cm of A horizon
- Date — September 2001
  August 2003
- Composites — 3 sub samples per plot were composited

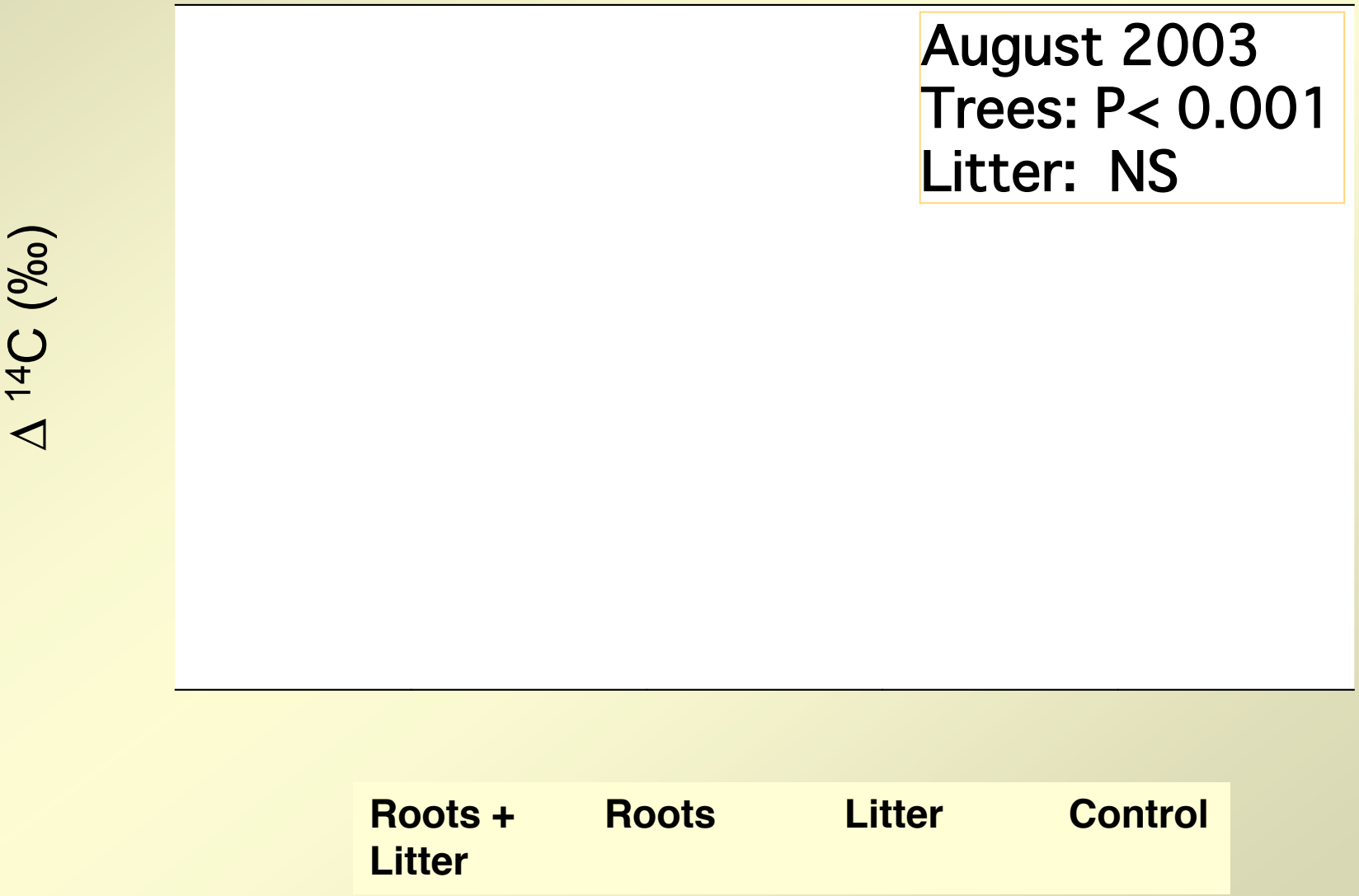
Lab Analysis

- Hand picked from root tips by Kathleen Treseder

ECM fungi didn't incorporate soil C...



ECM fungi didn't incorporate soil C ...even through 2 winters



Do ectomycorrhizal fungi use soil carbon?

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Summary: ECM Fungi

- **No switch between mycorrhizal and saprotrophic functions, even during winter**.

  Are fungi dormant in the winter, or
  Are plants transferring C to roots during winter, or
  Is organic material digested externally or carbon respired quickly?

- **Implications for regulation of decomposition by ectomycorrhizal fungi**

Extractable and Microbial Carbon

Definition, Principal of measurement

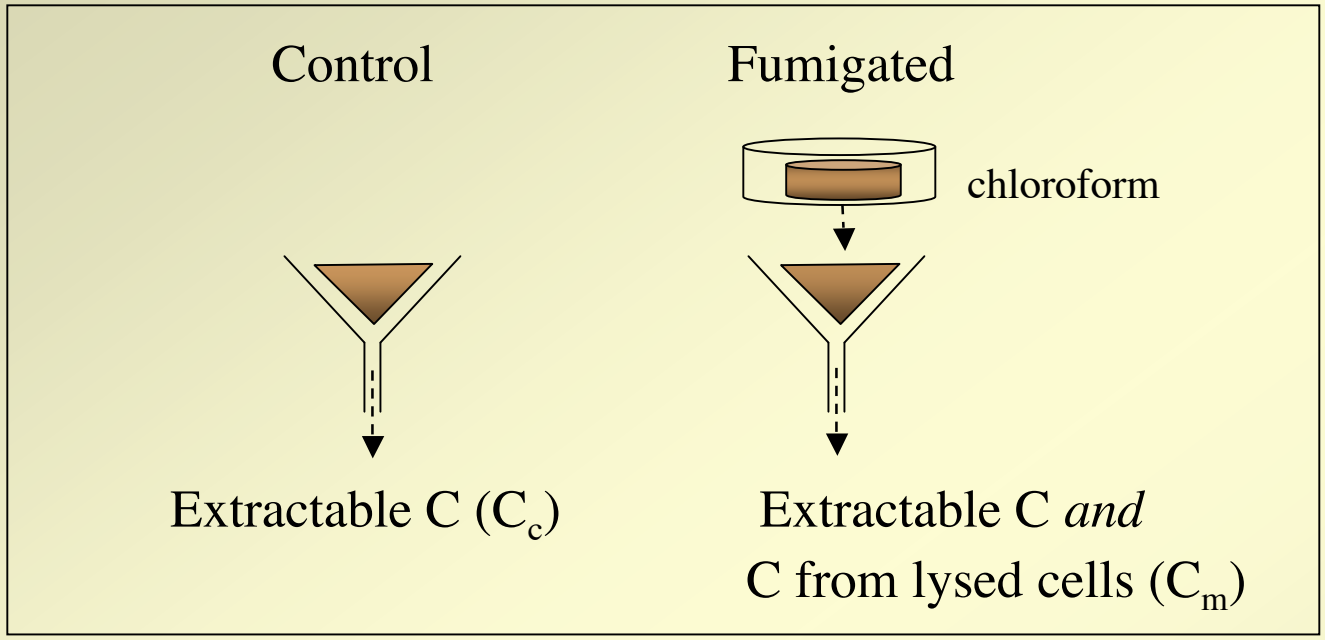
- Bulk microbial biomass, bacteria and fungi. Active and dormant.
- Assumes chloroform makes microbial C soluble without affecting solubility of other C.

Sampling

- Sites — Walker Branch and TVA
- Depths — 0-5 cm, 5-15 cm
- Date — **March 2002**, July 2002, **March 2003**, July 2003
- Composites — 3 sub samples per plot

Lab Analysis

- Control — Extracted with 0.5 M K_2SO_4
  Salt extractable carbon
- Fumigated — Fumigated in chloroform and extracted with 0.5 M K_2SO_4
  Cells lysed by chloroform and salt-extractable carbon.
- Total carbon — total organic carbon analyzer
- Isotopes — freeze-dried, combustion double-tubed with extra copper and silver



Microbial C = C_F - C_c

$$C_F \Delta_F = C_m \Delta_m + C_c \Delta_c$$

$$\Delta_F = m\Delta_m + (1-m)\Delta_c$$

$$\Delta_F = \frac{C_m \Delta_m + C_c \Delta_c}{C_m + C_c}$$

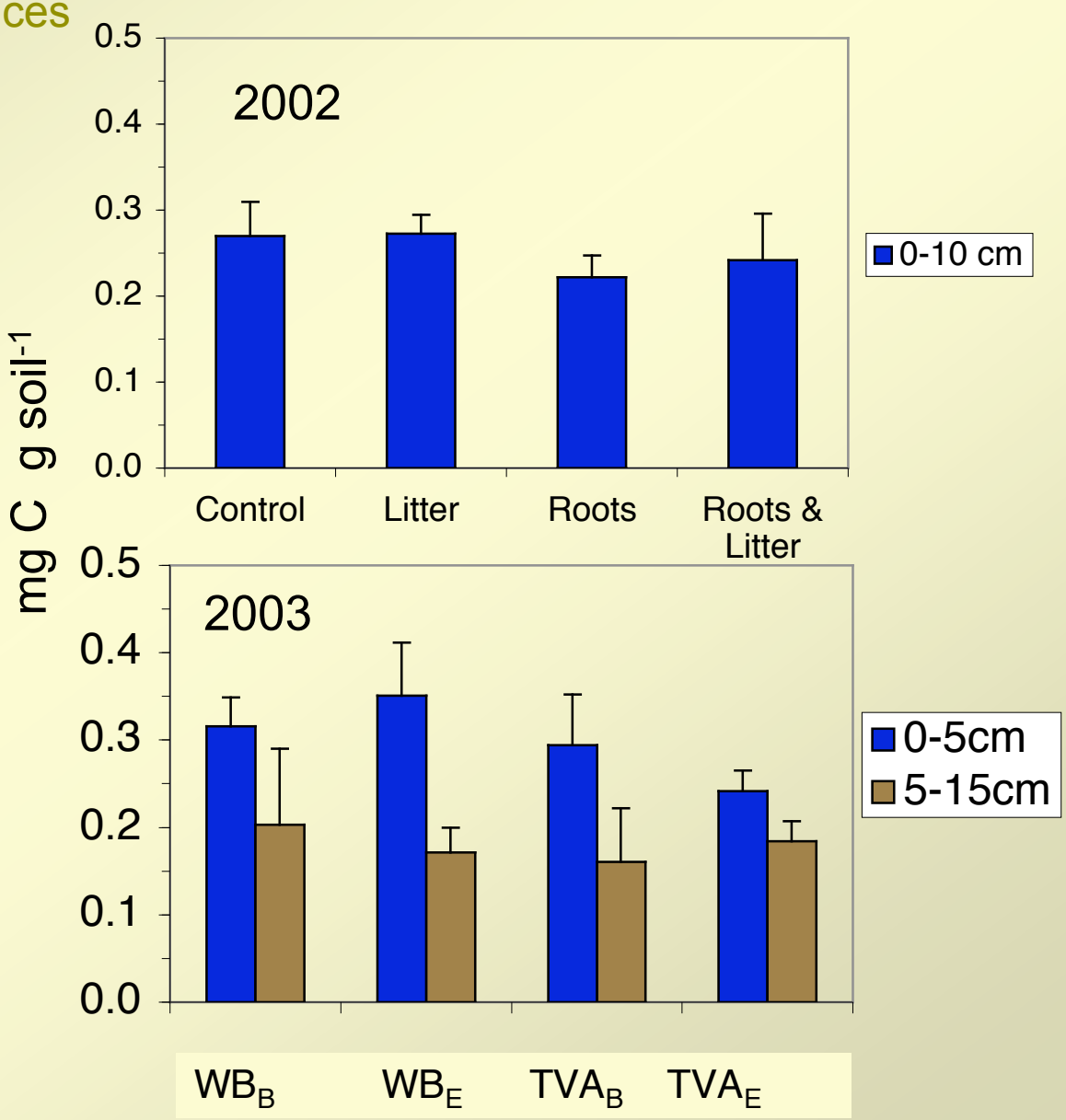
$$\Delta_m = \frac{C_F \Delta_F - C_c \Delta_c}{C_F - C_c}$$

Chloroform-Extractable C

No site or interannual differences

0-5 cm > 5-15 cm

n = 4 ±se

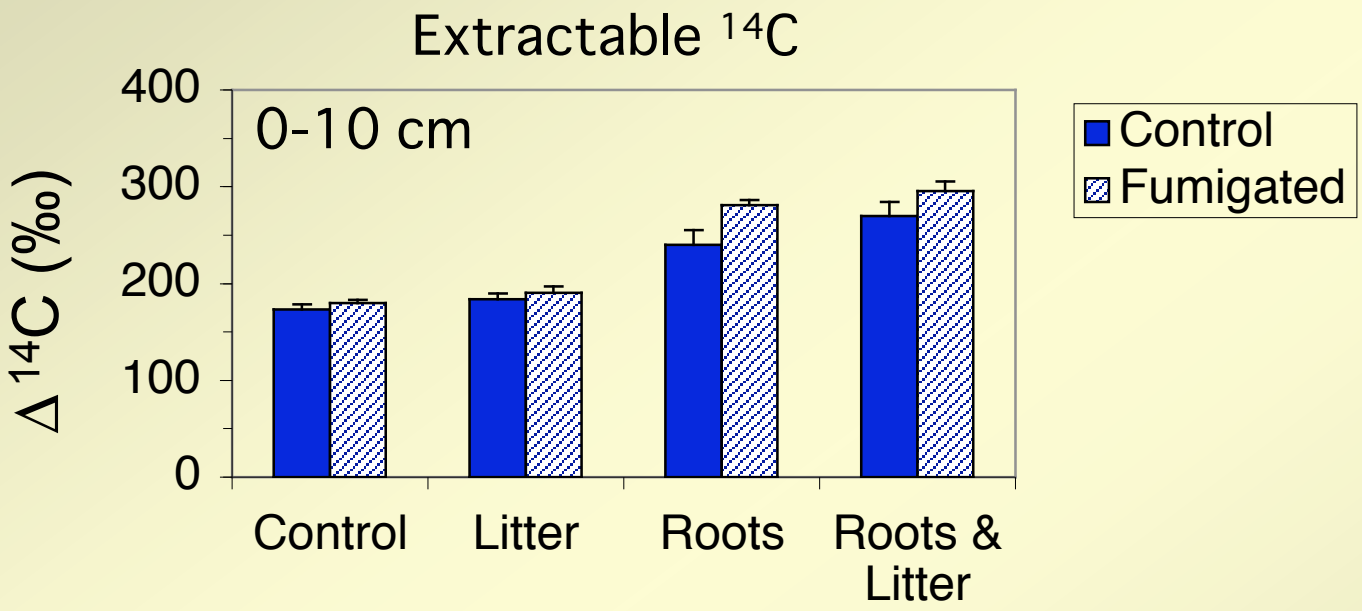


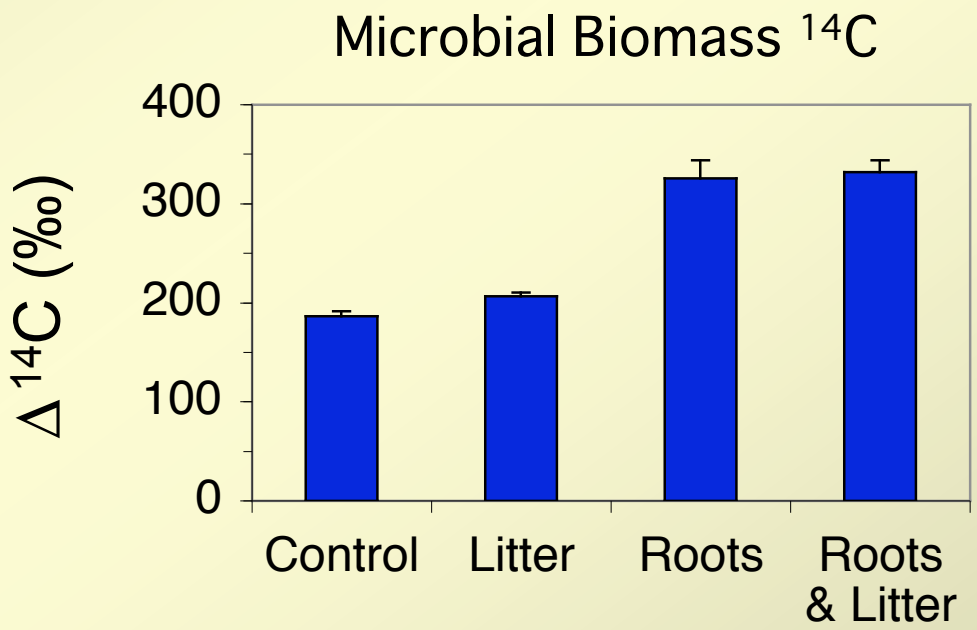
Soil Moisture

~ 25%

2003: WB > TVA

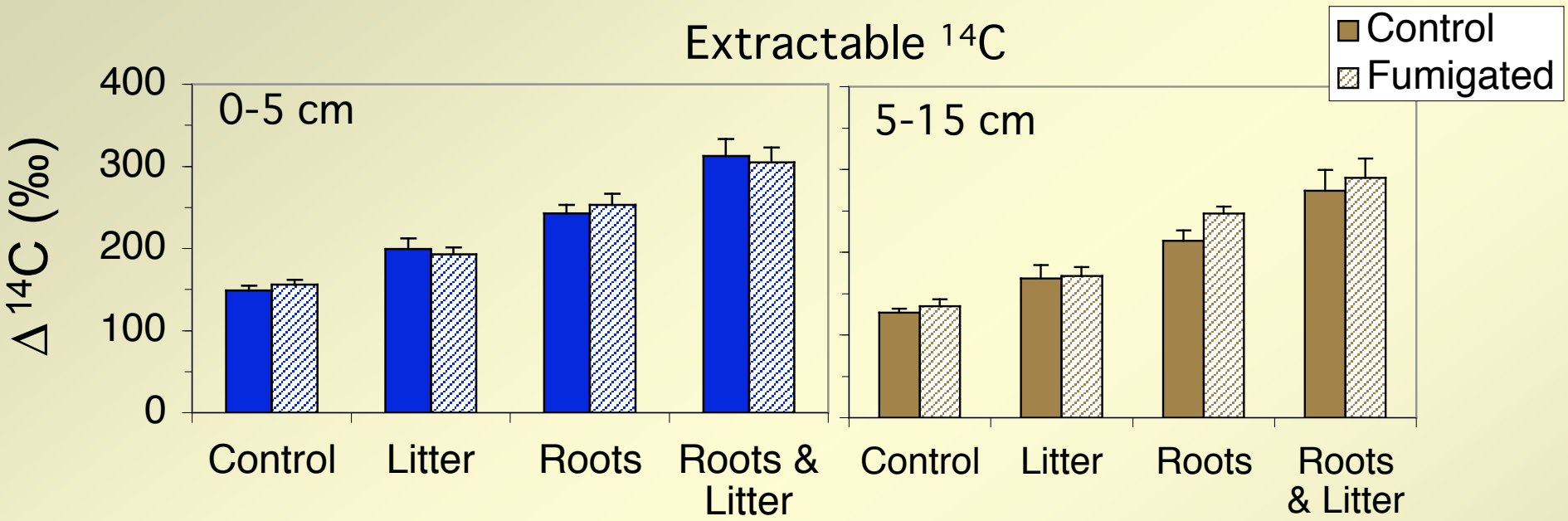
March 2002 Microbial and Extractable ^{14}C

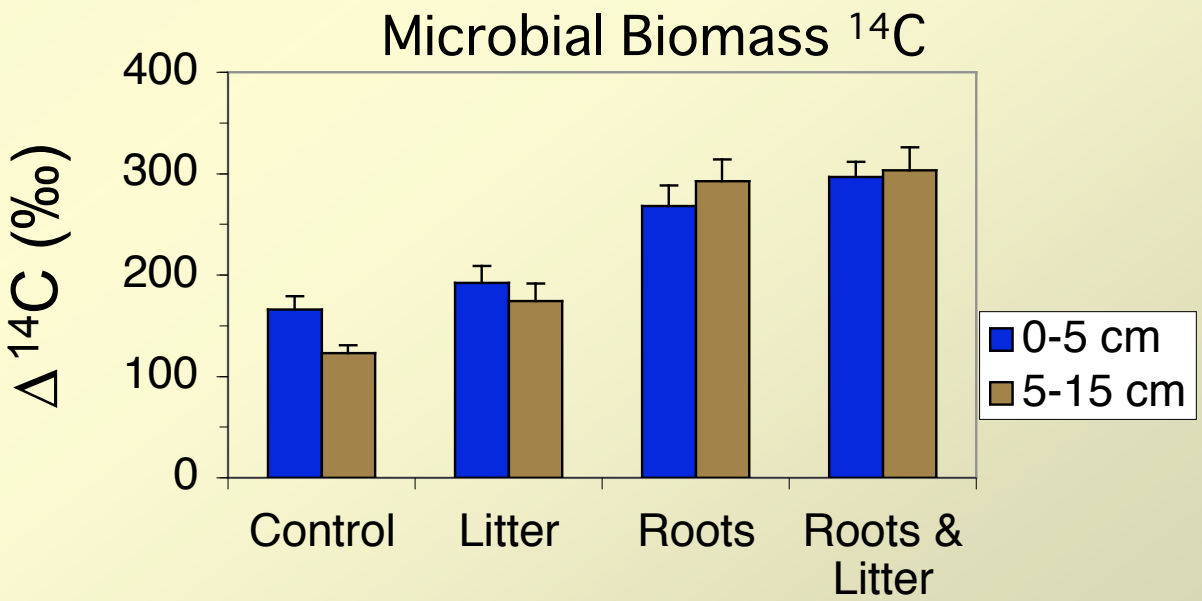




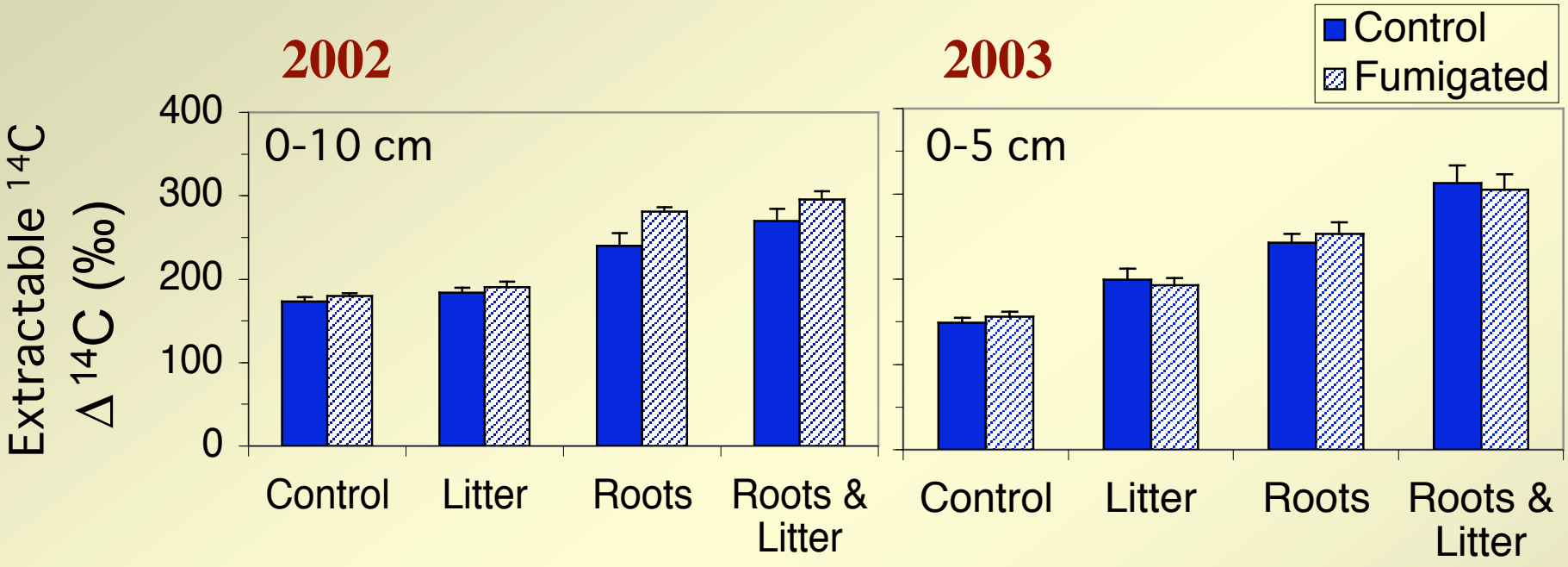
$$\Delta_m = \frac{C_F \Delta_F - C_c \Delta_c}{C_F - C_c}$$

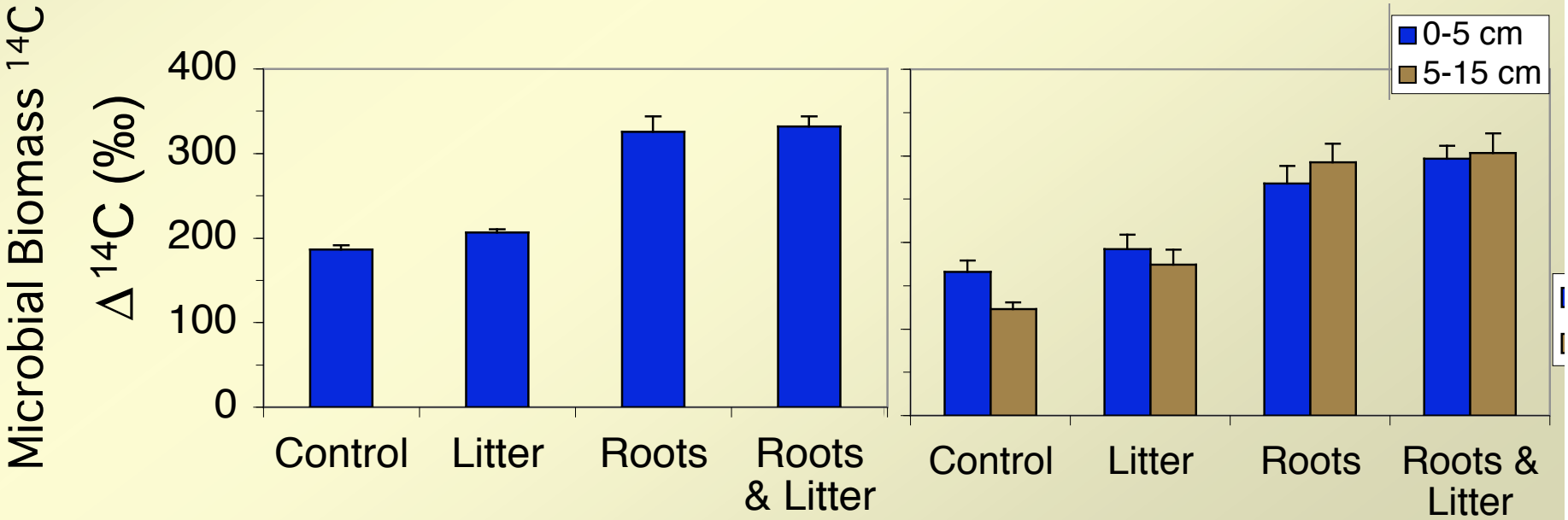
March 2003 Microbial and Extractable ^{14}C





2002 and 2003 Microbial and Extractable ^{14}C





Summary: Microbial Biomass

Microbial Biomass and extractable C are more enriched in treatments with enriched roots. No significant effect of litter source.

Heterotrophic signature = ~ 180‰ East
= ~ 320‰ West

Between depths: Extractable: 0-5cm > 5-15cm
Microbial: no depth difference

Between years: ^{14}C of extractable C increases and of microbial biomass decreases only a little bit.

July 2002 and July 2003 will be done soon.

Water-extractable C in 2004

Acknowledgments

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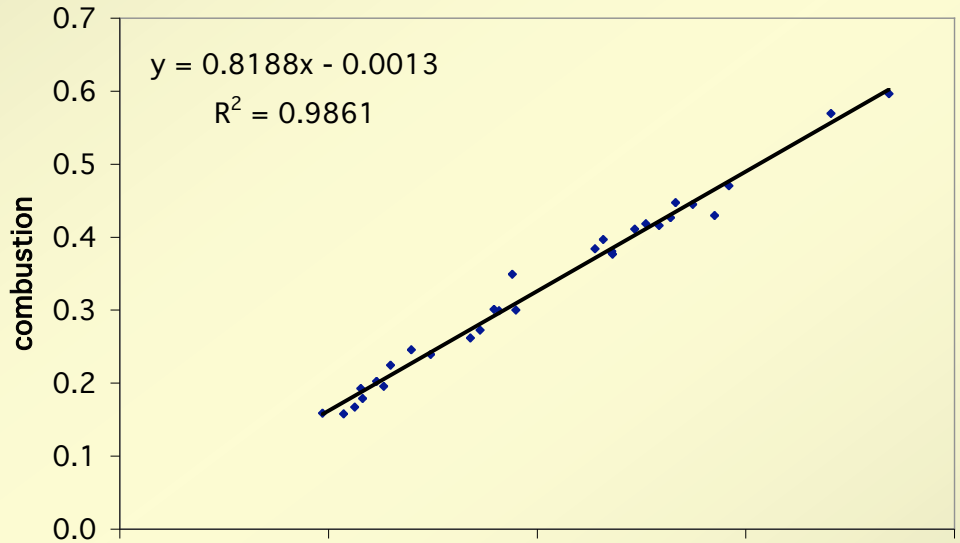
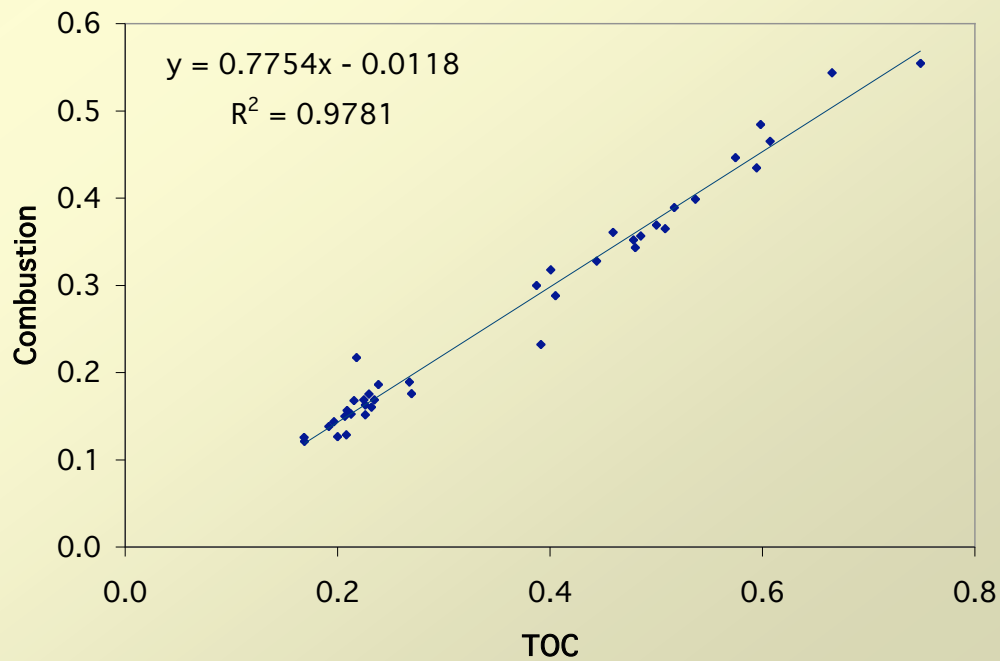
- Tara Macomber

Complete Combustion?
Carbon content for Combustion vs TOC (mg C/g soil)

March 2003 $R^2 = .99$



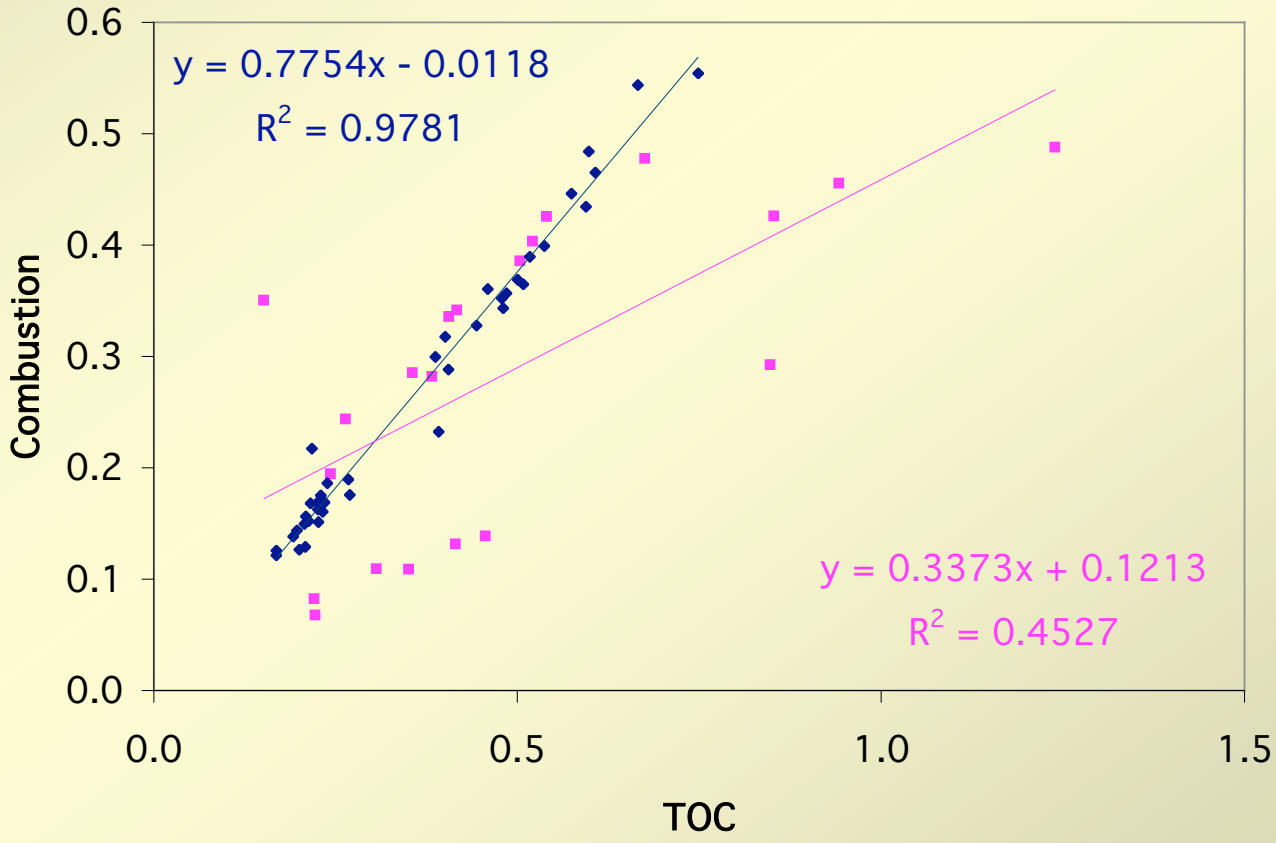
July 2002 $R^2 = .98$



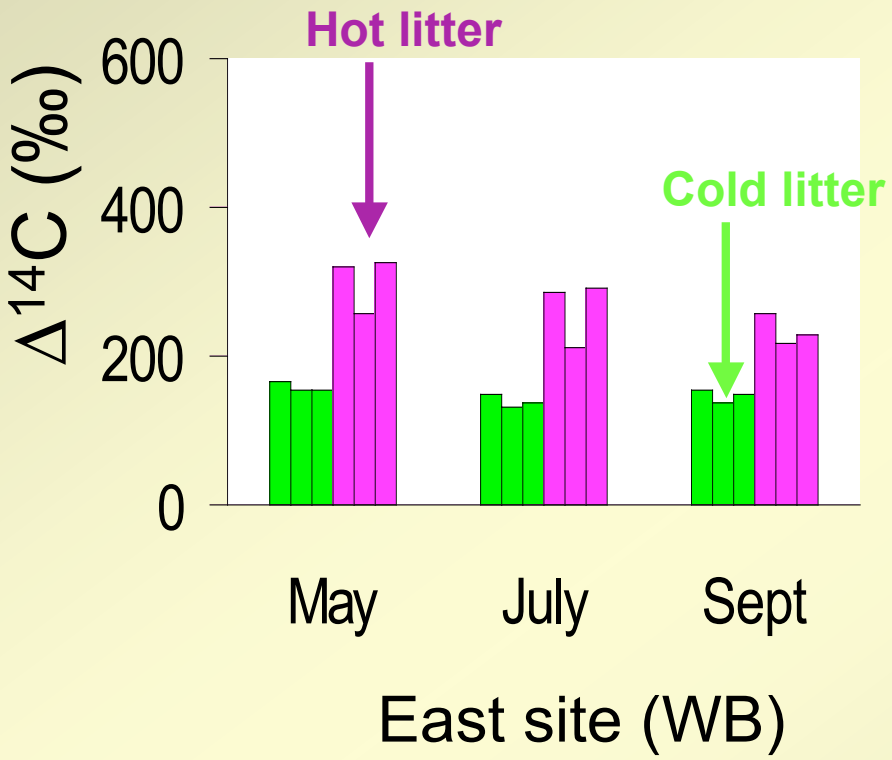
LBL and CAMS combustion
Combustion vs TOC (mg C/g soil)

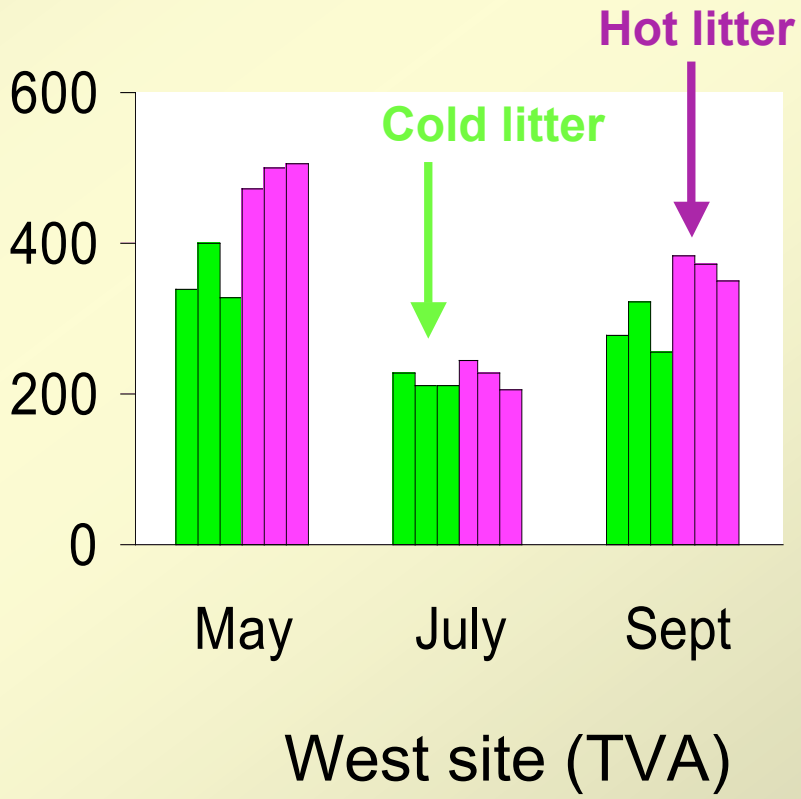
LBL R^2 = .98

CAMS R^2 = .45



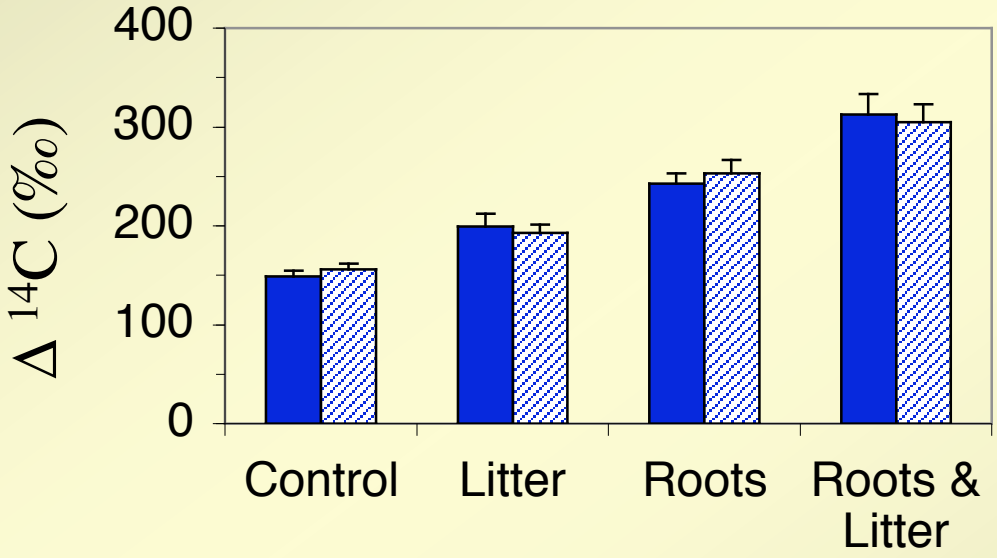
$\Delta^{14}C$ of total soil respiration in 2002





Data from Trumbore, Cisneros-Dozal, Winston

Microbial Biomass ^{14}C

- Surface is more enriched
- Litter substrate more important

$$\Delta_m = \frac{C_F \Delta_F - C_c \Delta_c}{C_F - C_c}$$