

Using EBIS to partition sources of soil respiration

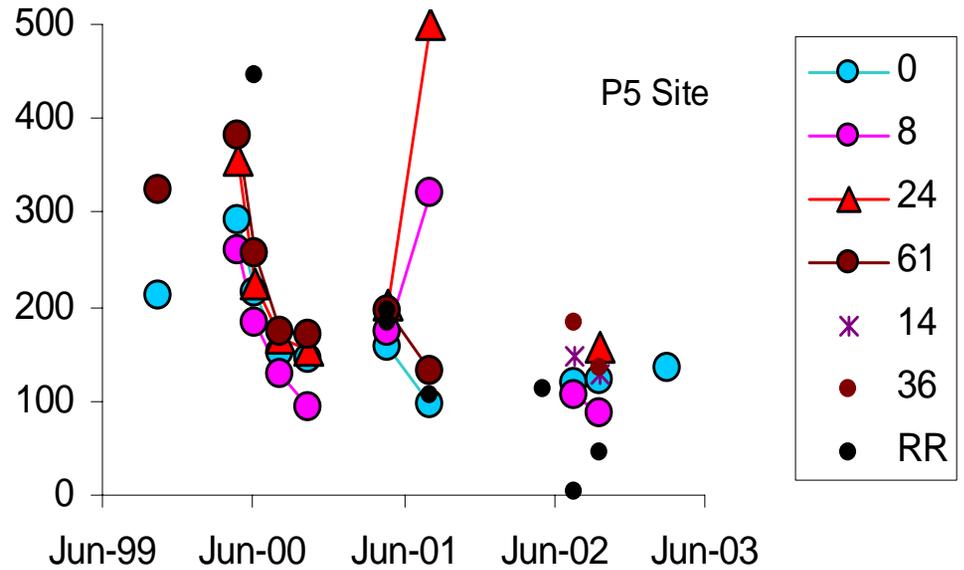
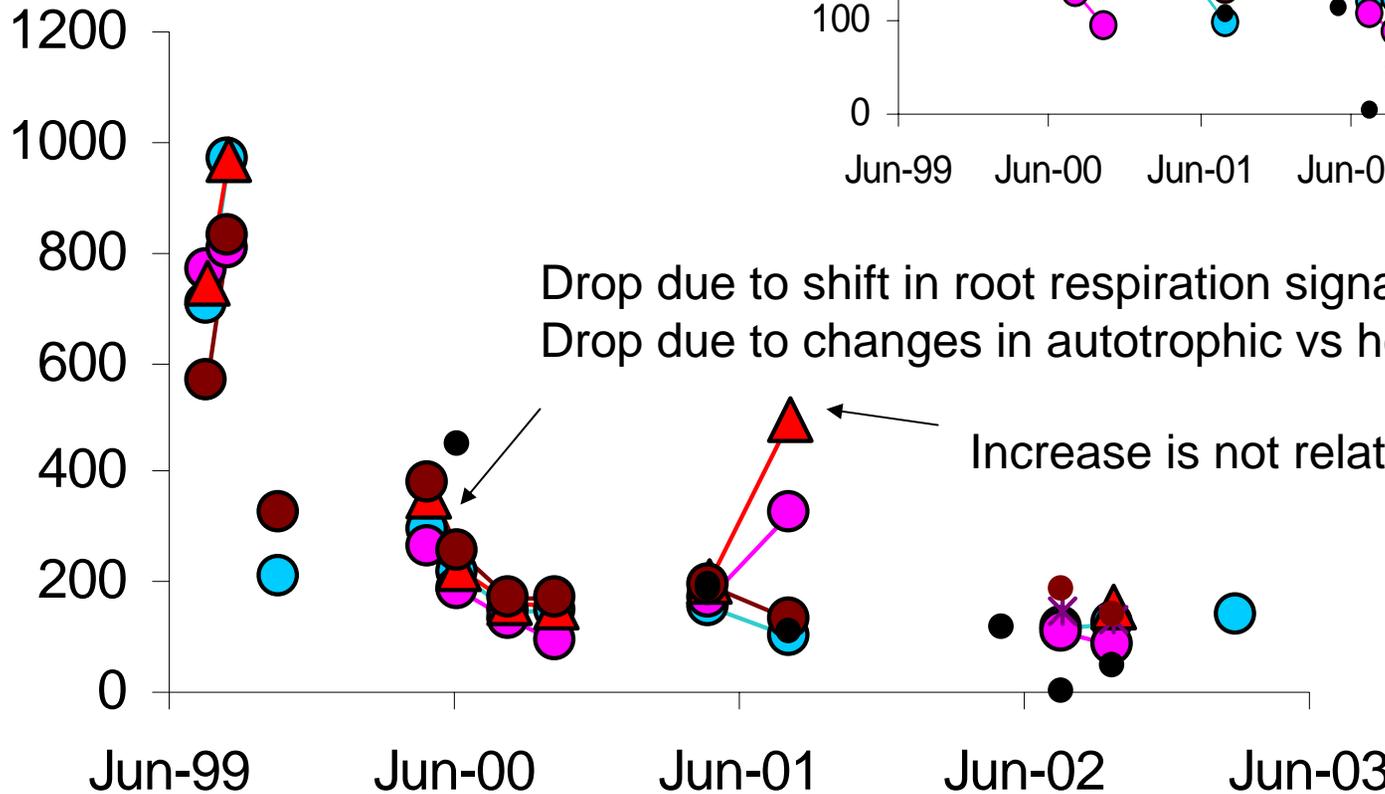
UC Irvine

Cisneros Dozal, Trumbore,
Winston

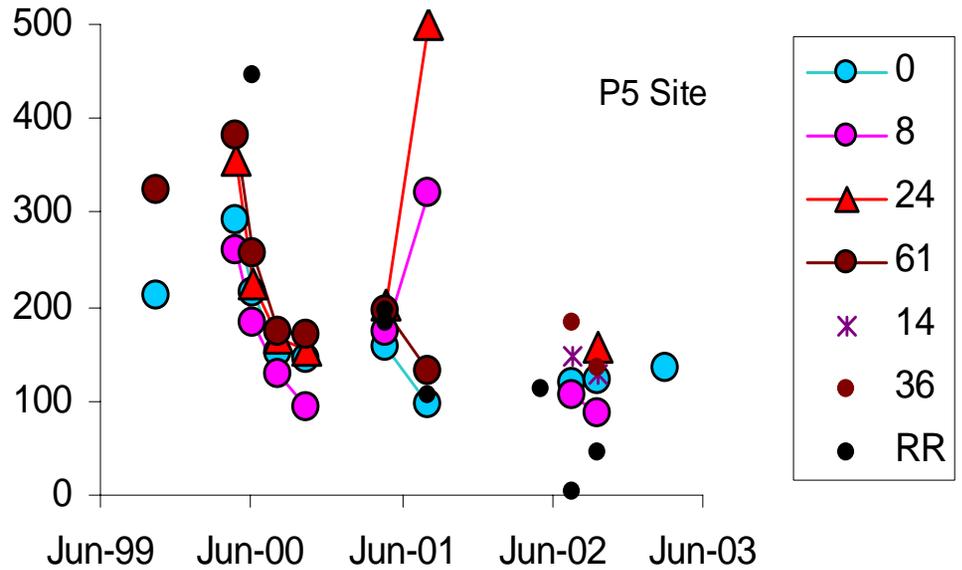
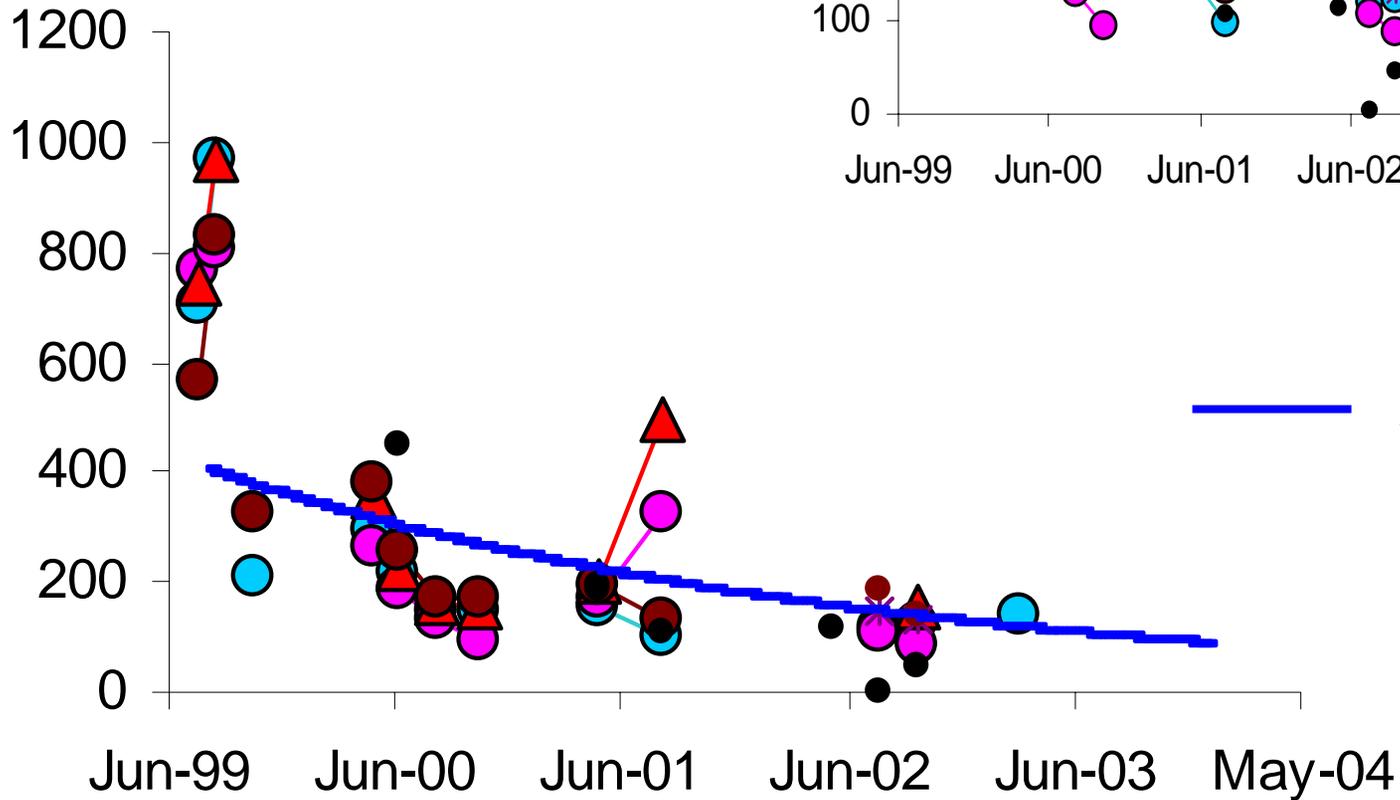
Goals

- Partition C respired by soils into autotrophic (root respiration) and heterotrophic (microbial decomposition) sources
- Further determine how much of the microbial decomposition source comes from leaf versus root litter
- Determine how these sources vary with season (phenology, soil temperature, moisture, substrate availability)
- Test models of soil respiration that separate controls of autotrophic and heterotrophic sources.

Walker Branch Watershed
 Not an experimental plot
 (How fast is C moving through
 the undisturbed ecosystem?)



Walker Branch Watershed
 Not an experimental plot
 (How fast is C moving through
 the undisturbed ecosystem?)



Approach:

Estimate respiration sources using radiocarbon mass balance

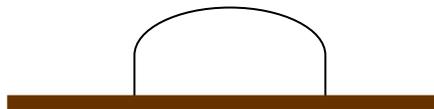
Total = root respiration (autotrophic; A) + microbial decomposition (heterotrophic)

$$\Delta^{14}\text{C}_{\text{Total}} = (A)\Delta^{14}\text{C}_{\text{Autotrophic}} + (1-A)\Delta^{14}\text{C}_{\text{Heterotrophic}}$$

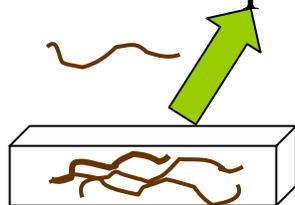
Total



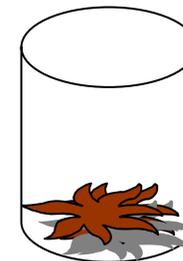
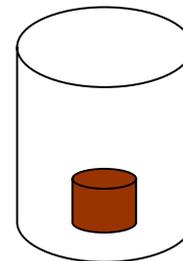
Chamber
measurement



Root
respiration



Decomposition of
soil organic matter
and leaf litter



Methods: Isotopes in total soil respiration

(1) Manual – chamber is placed on a preinstalled collar and flux is measured by concentration increase over time. 3x chamber volume of air is passed over soda lime to remove CO₂ initially in air, then CO₂ from soil respiration is trapped by circulating over molecular sieve. No need to correct for air in the chamber. Analyses reported are mean and standard deviation of 3 plots



(2) Autochambers

Chambers close and flux is measured. After 10 minutes, air stream is passed over molecular sieve. An ambient air sample is collected before the chamber closes and the ¹³C is used to estimate the fraction of air in the final sample. ¹⁴C of the soil respiration source is calculated by mass balance. Chambers were deployed at two of the WB plots.

Root respiration isotopes are measured on freshly excavated roots that are sealed in an air-tight container from which initial CO₂ is scrubbed. The CO₂ that accumulated (over ~40 min to 1 hour) is trapped and measured for C isotopes.

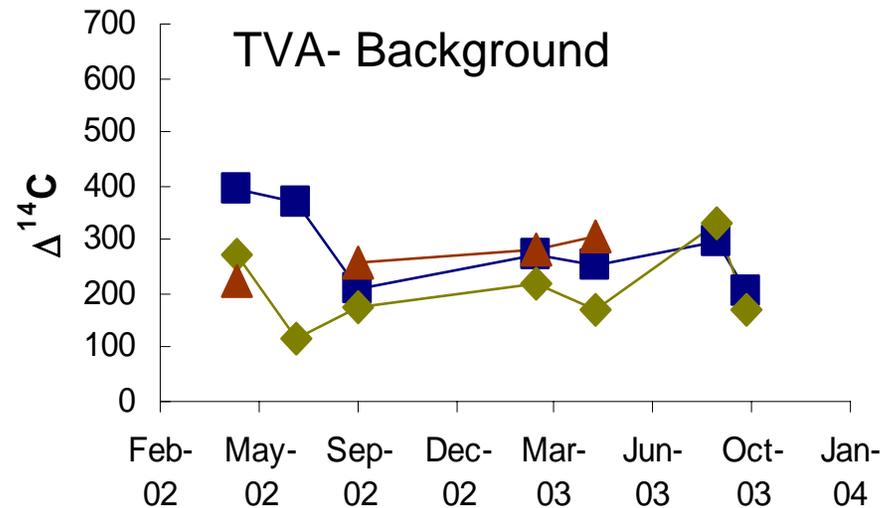
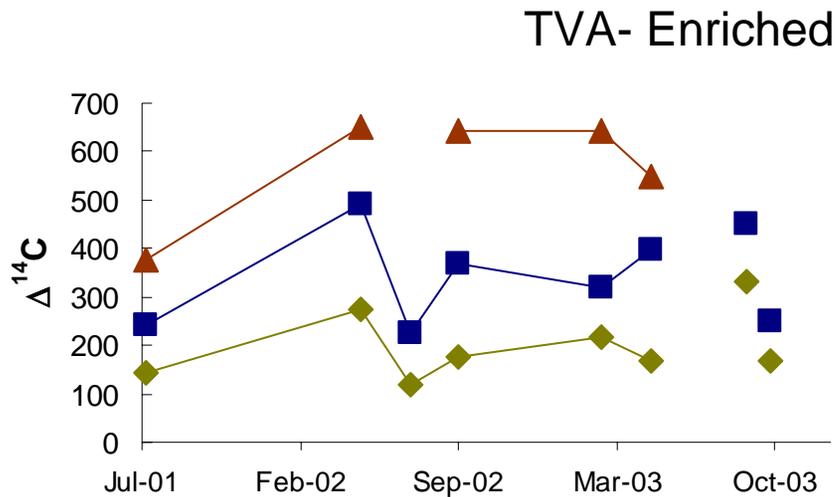
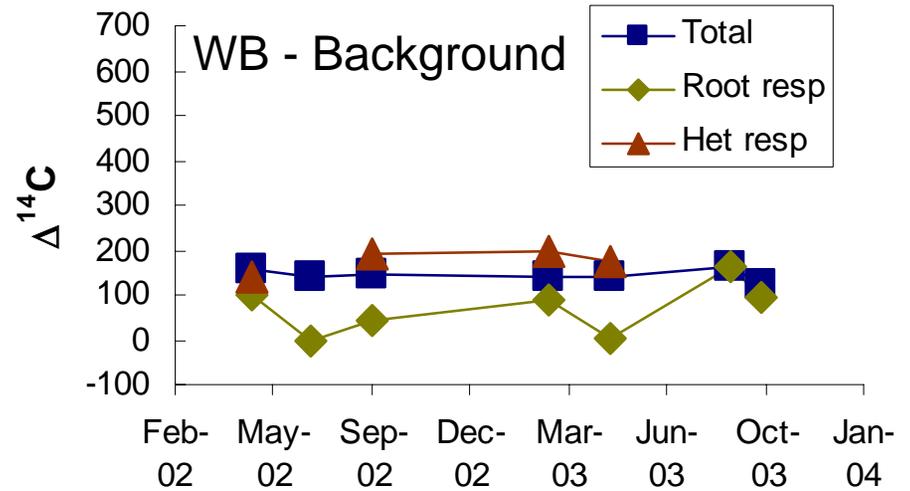
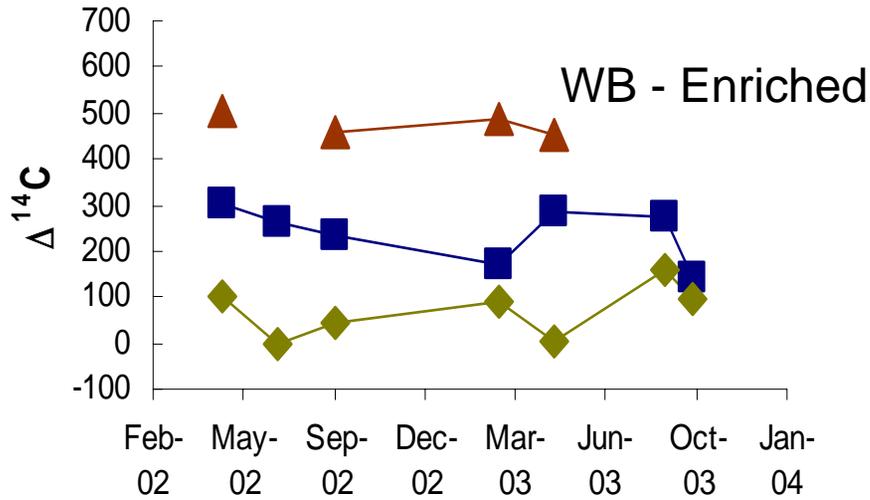


Heterotrophic Respiration is measured by putting litter and 0-5 cm soil cores in sealed jars, then measuring the rate of CO₂ evolution and the isotopic signature of evolved CO₂.



Radiocarbon Signatures of Soil, Root and Microbial Respiration

- Temporal variability dominated by root respiration (TVA)
- Differences among sources is largest in Enriched plots

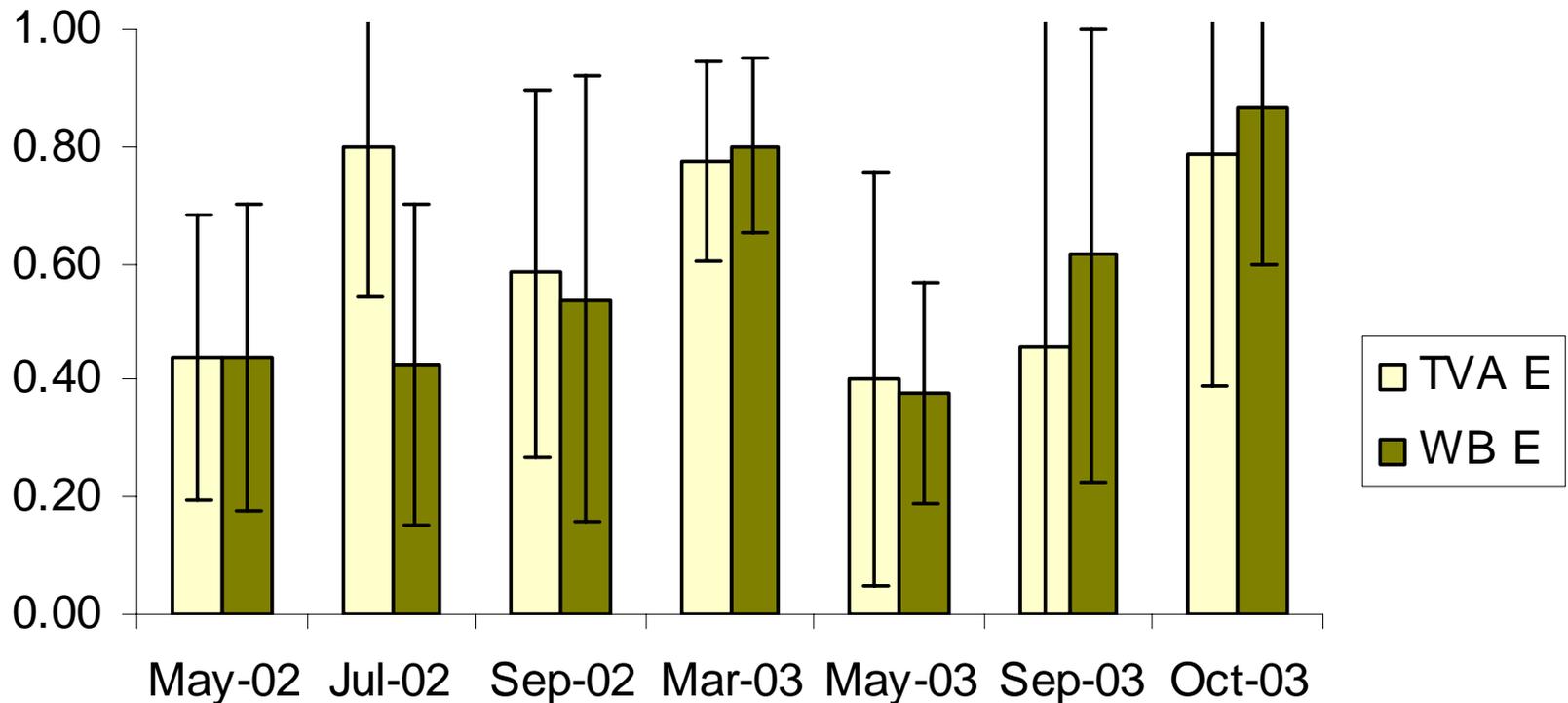


Fraction of total soil respiration coming from root respiration

Varies from 40-80%

High values in spring (before leaf-out) and fall (after senescence), or when soil is dry (TVA July 02)

Lower values in mid-growing season when moisture is not limiting

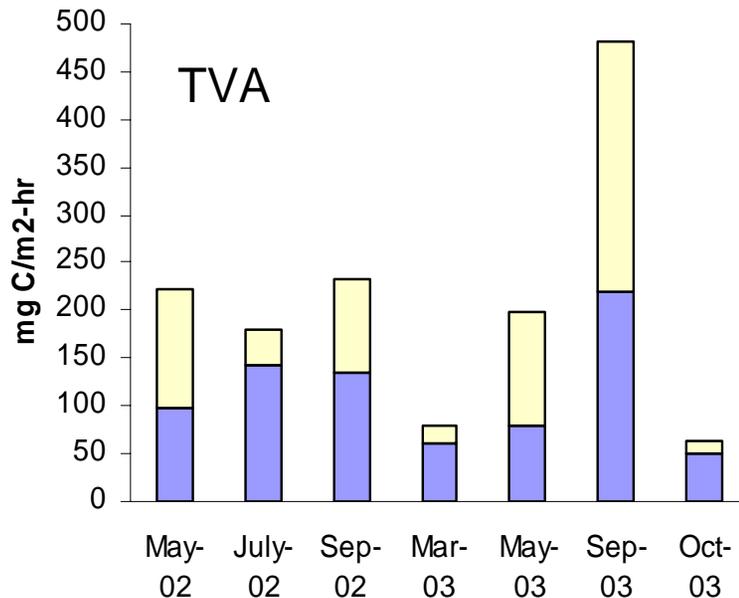
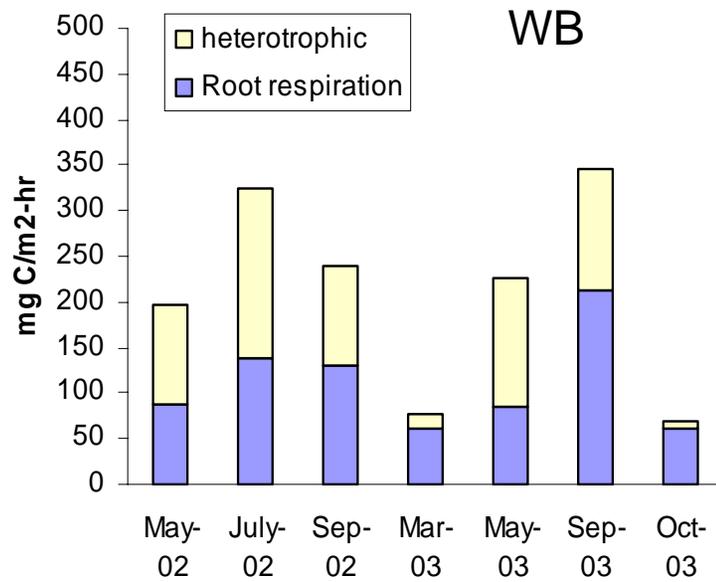


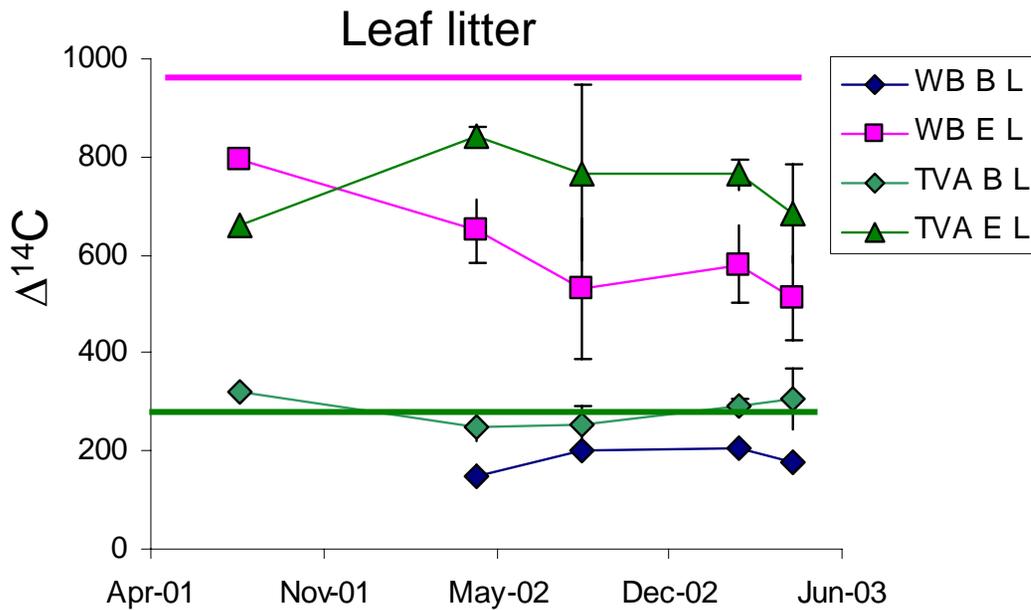
Partitioning respiration into root and microbial respiration

Seasonal cycle

Greatest spatial heterogeneity from root respiration

To be completed: comparisons with data on root phenology, soil temperature and moisture

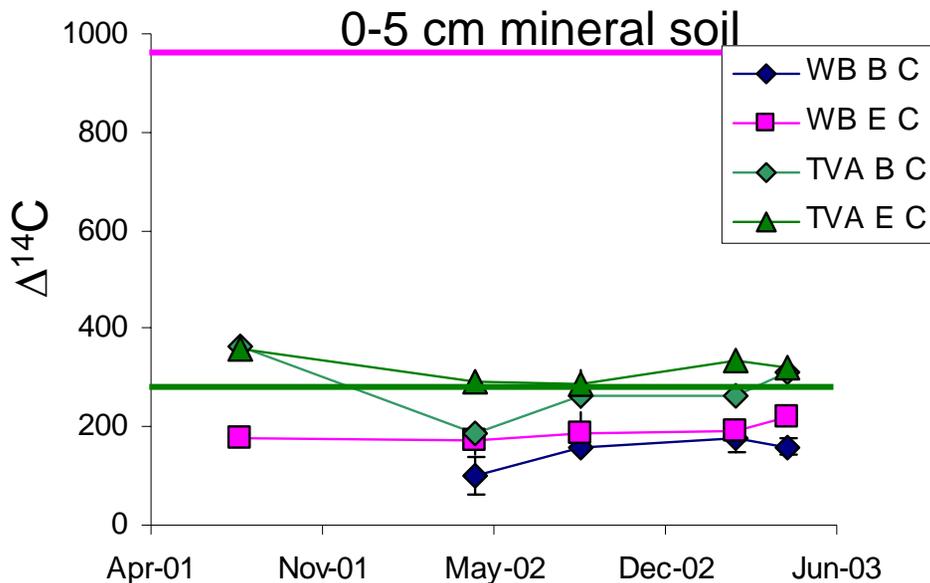




Heterotrophic respiration sources

CO_2 respired from litter is below labeled litter values and decreases during 2003

Elevated > Background (site)
TVA > WB (treatment)



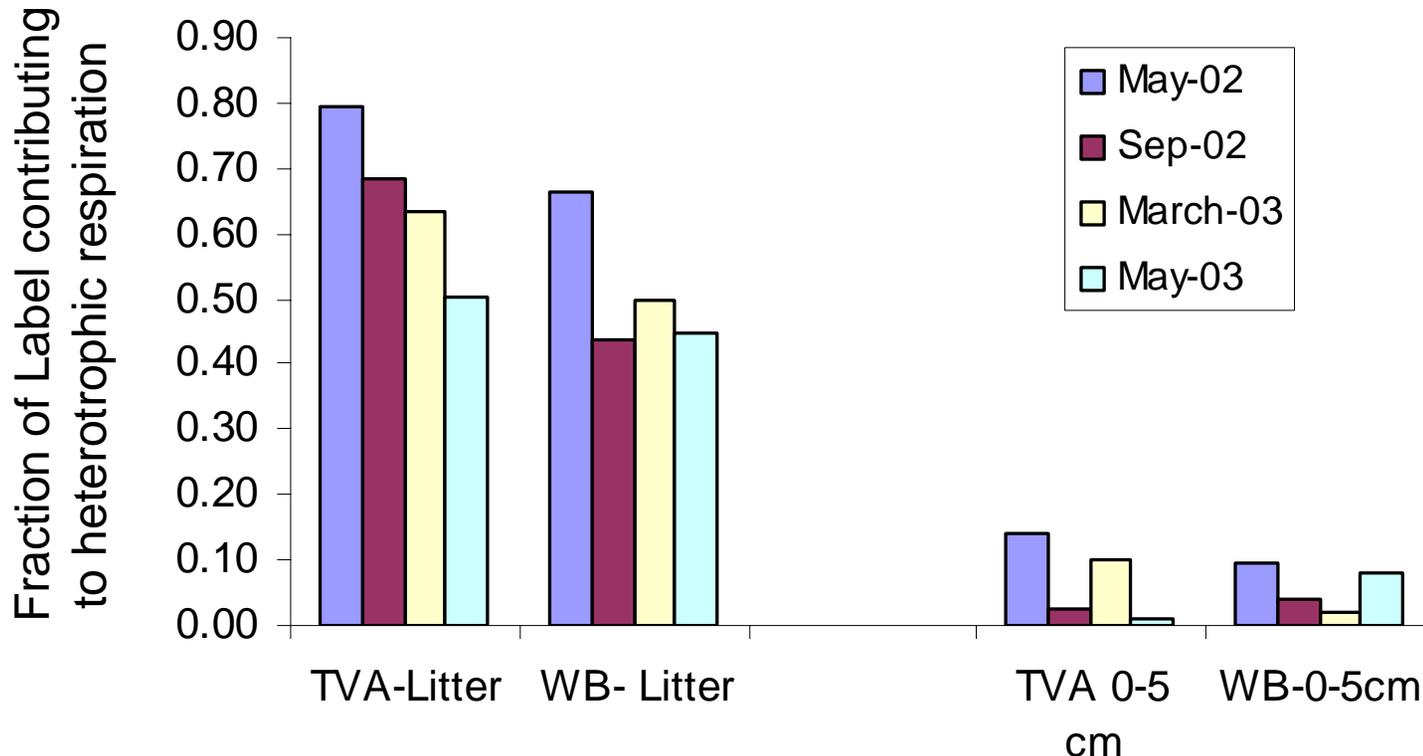
^{14}C in CO_2 respired by mineral soils is increasing with time – argues for incorporation/ decomposition of label derived from leaf litter added to the surface

Fraction of labeled litter contributing to heterotrophically respired CO₂

(obtained from the difference in microbially respired CO₂ between Enriched and Background plots)

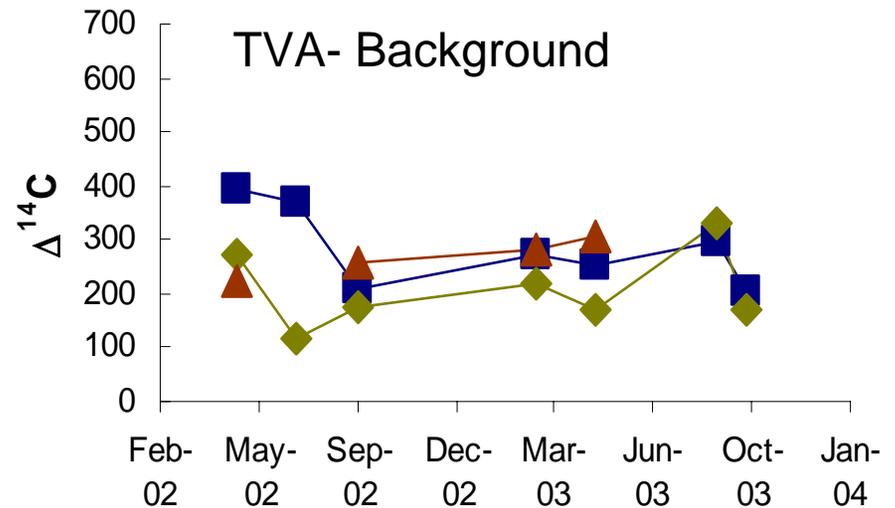
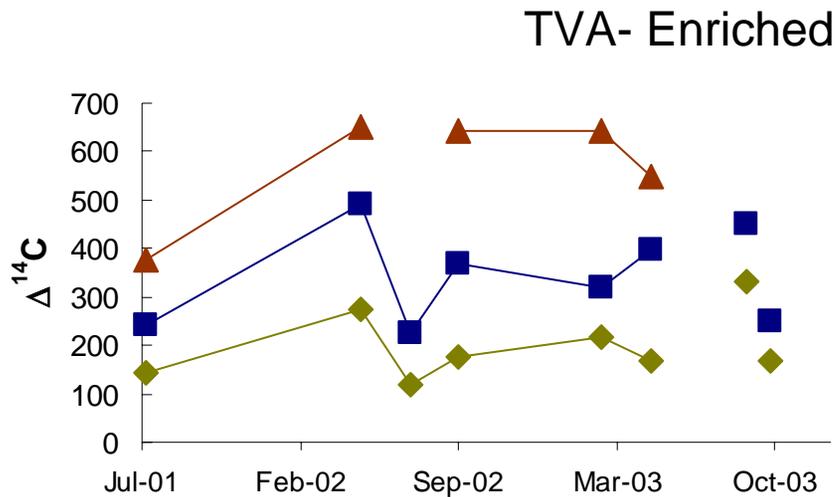
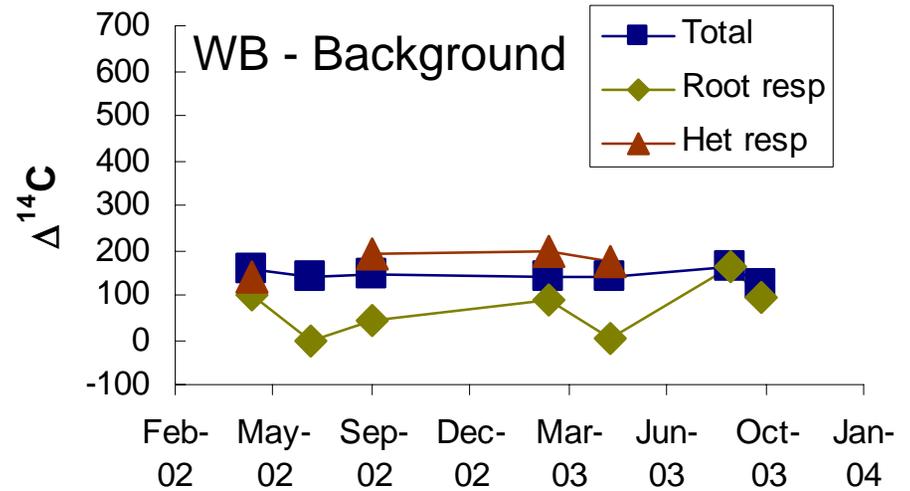
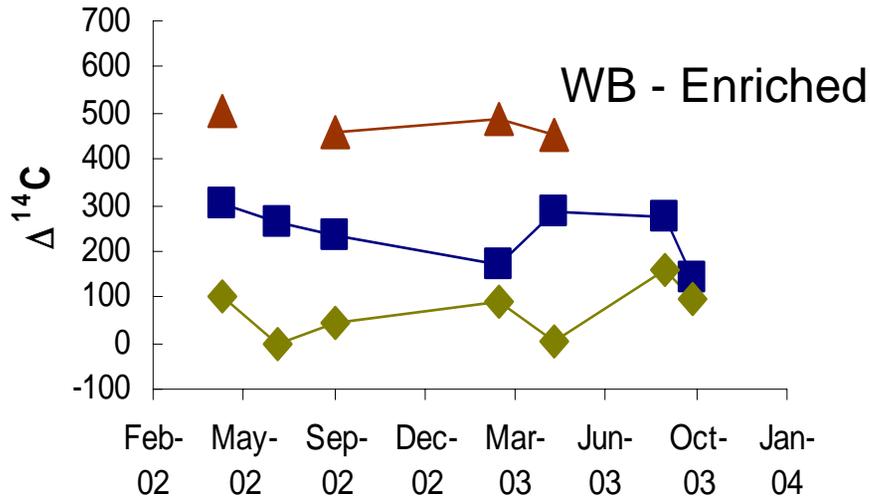
Labeled litter makes up 40-70% of the C respired from leaf litter decomposition and 3-10% of the C respired from the 0-10 cm layer of mineral soil

Label-C respired from the mineral soil must have been transported there by leaching from leaf litter above

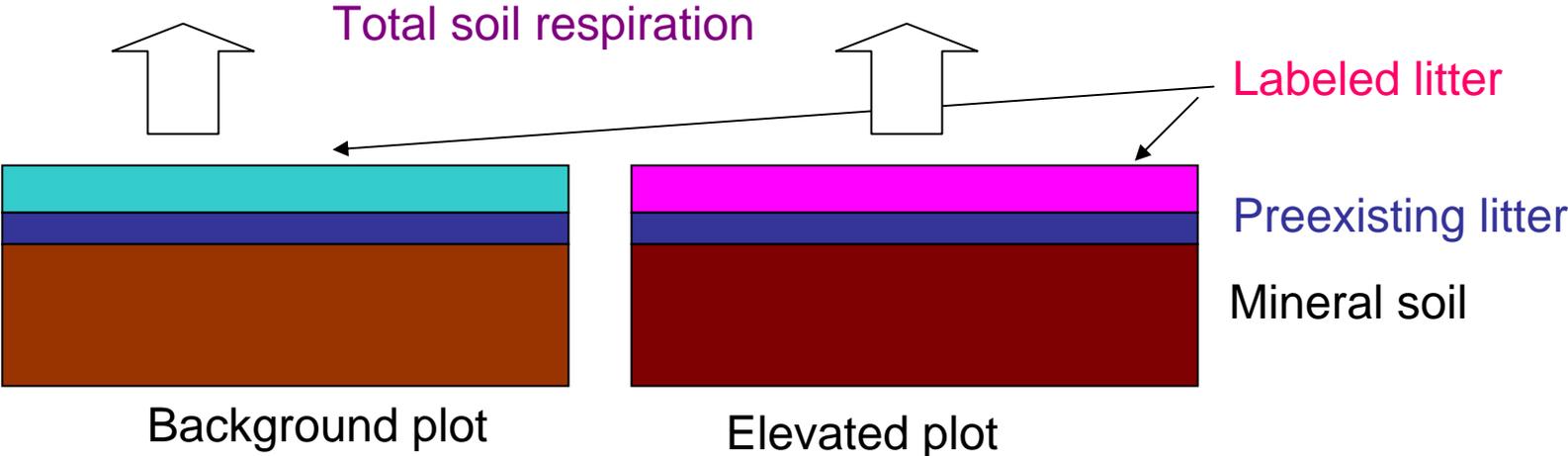
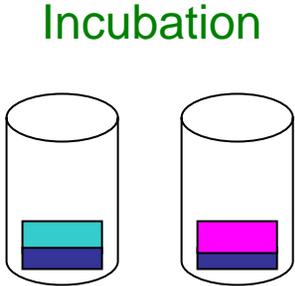
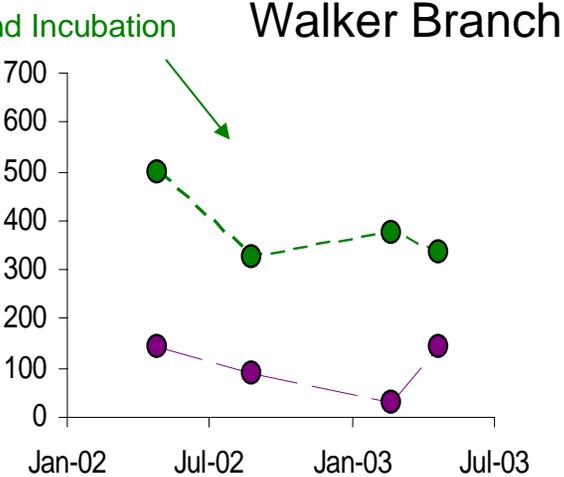
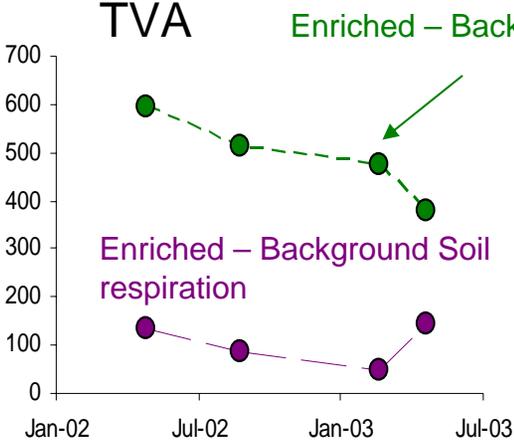


Radiocarbon Signatures of Soil, Root and Microbial Respiration

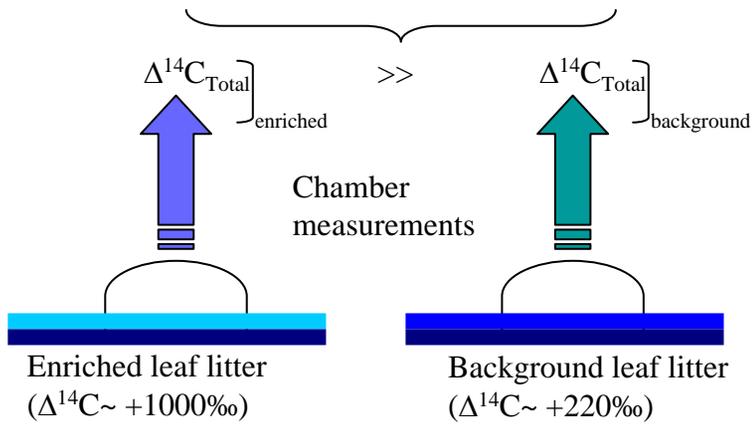
- Temporal variability dominated by root respiration (TVA)
- Differences among sources is largest in Enriched plots



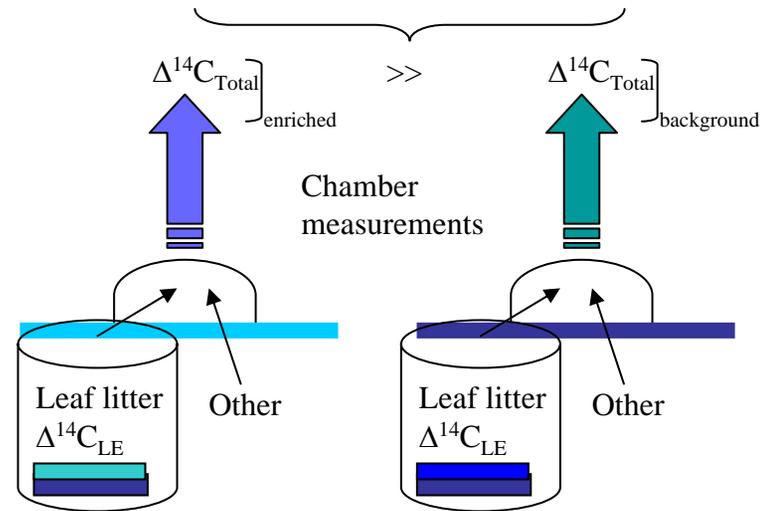
Differences between Elevated and Background Plots enables us to determine the fraction of respired C coming from labeled leaf litter added to the plots in the last 3 years



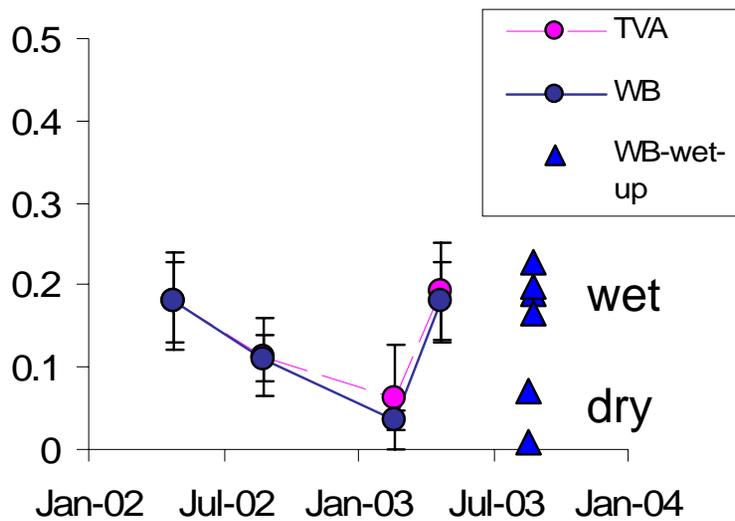
Difference between treatment plots ~ FLD



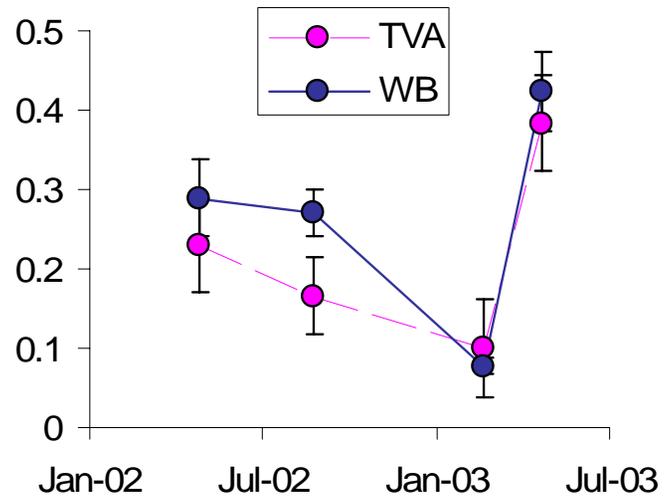
Difference between treatment plots ~ FLD



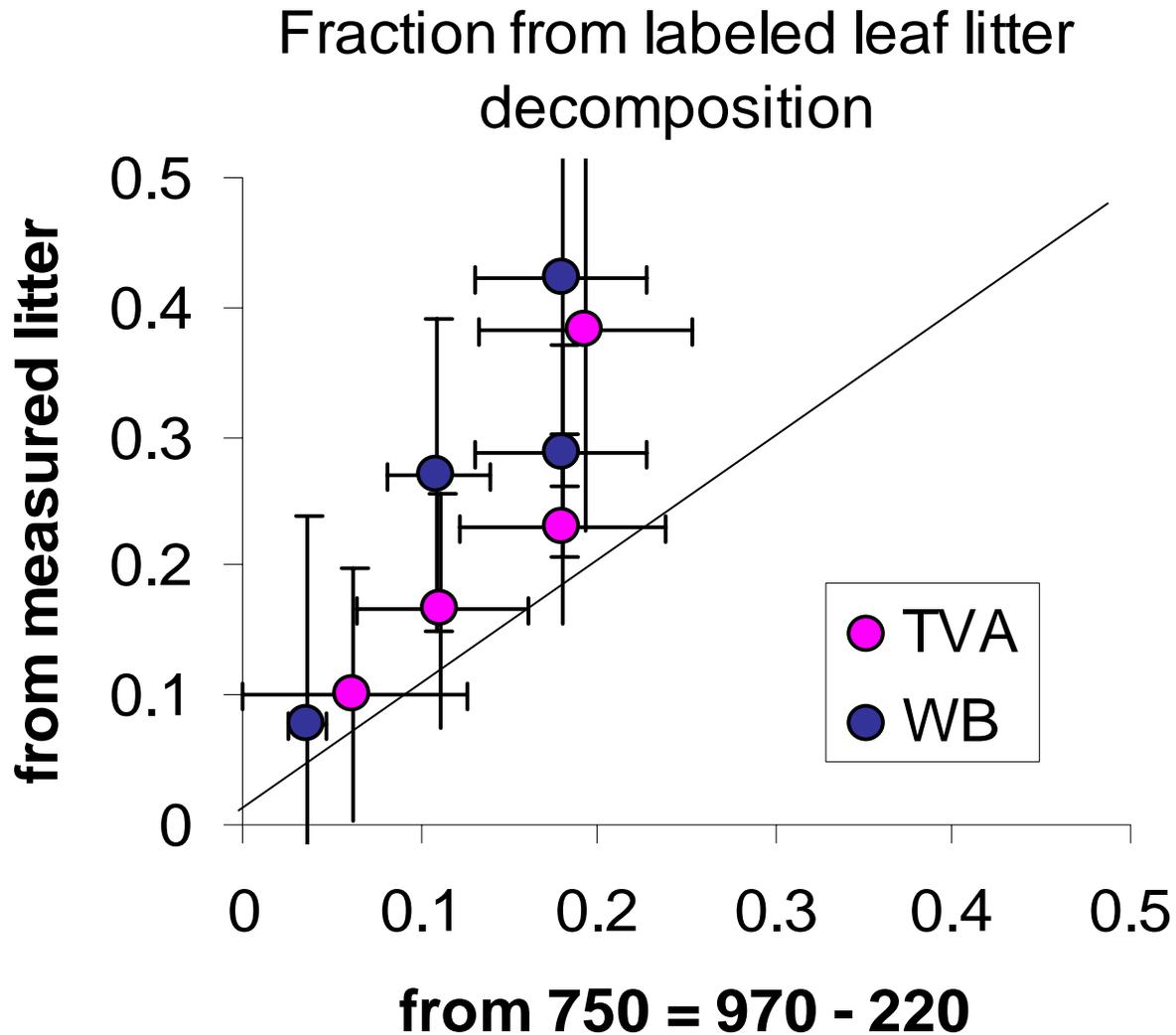
Fraction from label decomposition



Fraction from leaf litter decomposition



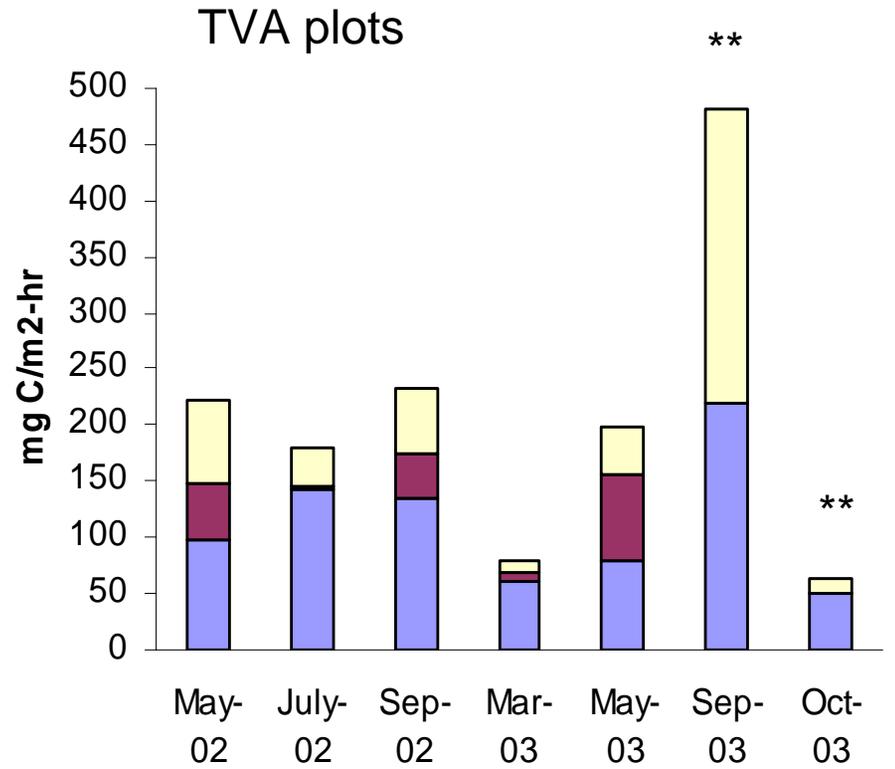
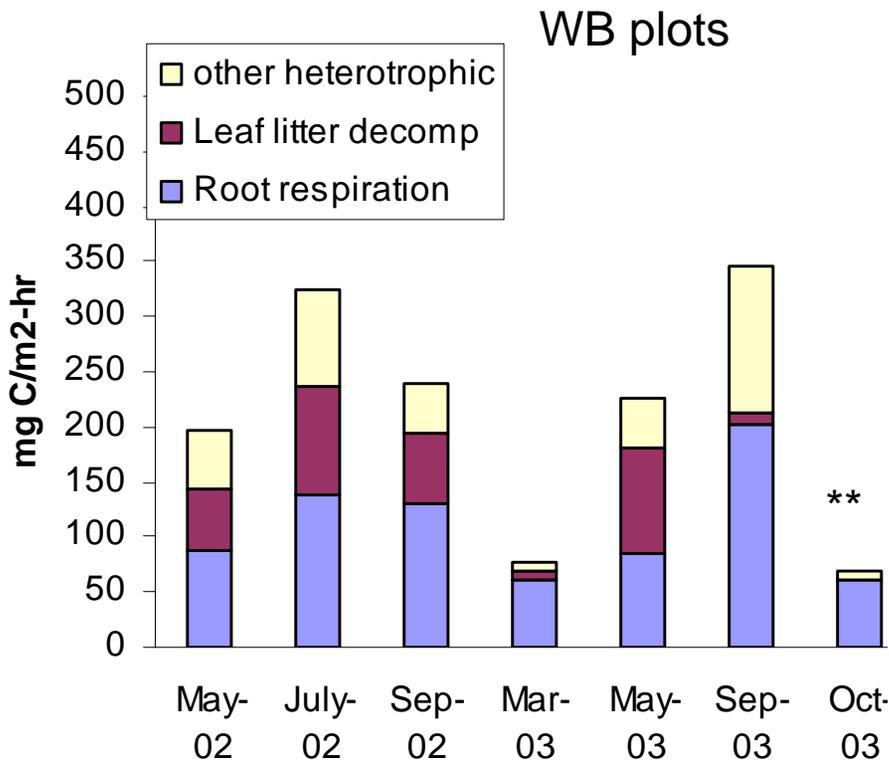
Disagreement between the two methods may be the result of (1) use of the wrong values for labeled and background litter (2) leaching losses observed in elevated leaf litter, or (3) differences in sampling of horizons? We use the measured litter values for subsequent slides.



Partitioning of soil respiration sources using radiocarbon.

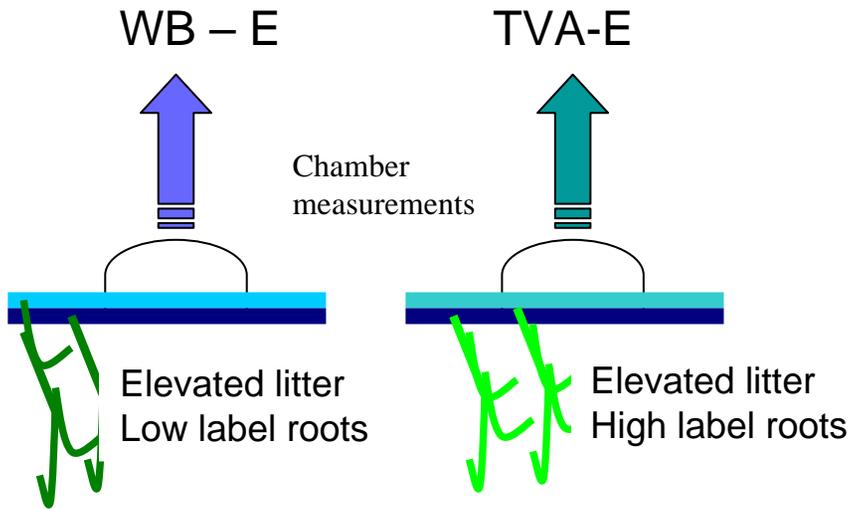
-Seasonality in root

-Remaining tasks: Relate variations to soil temperature, moisture conditions.



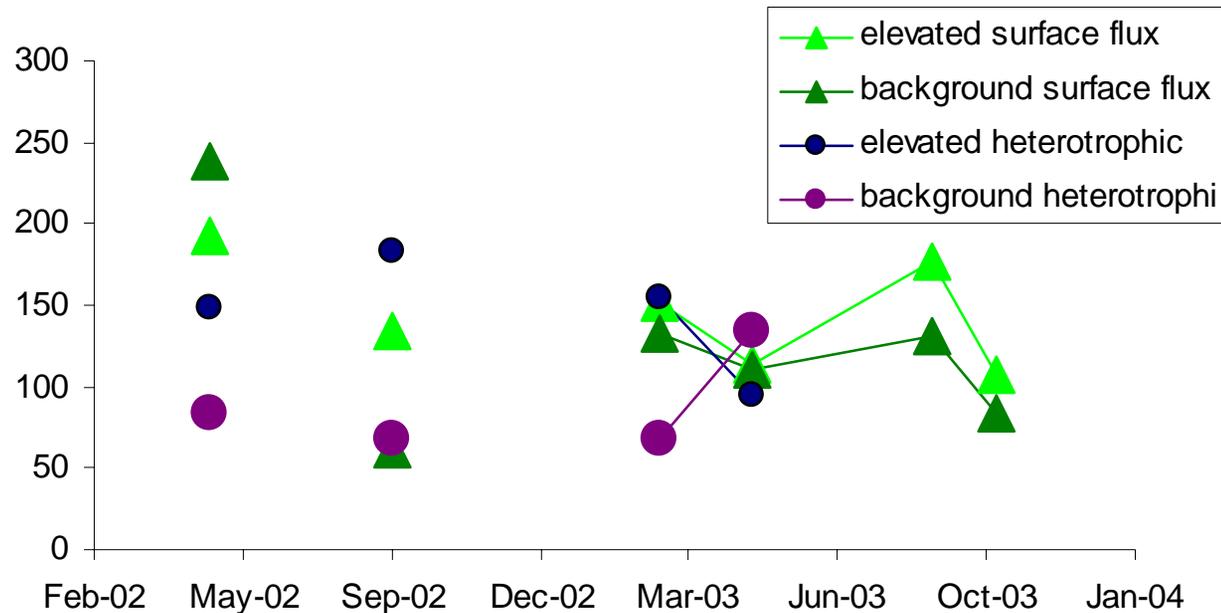
**** awaiting incubation results to calculate labeled leaf litter contribution**

Difference between locations – Root (*and prelabel litter*) contribution



Decrease from 2002-2003 likely due to decrease in ^{14}C of dead roots;

Differences in surface fluxes similar to differences in microbial respiration (expected)

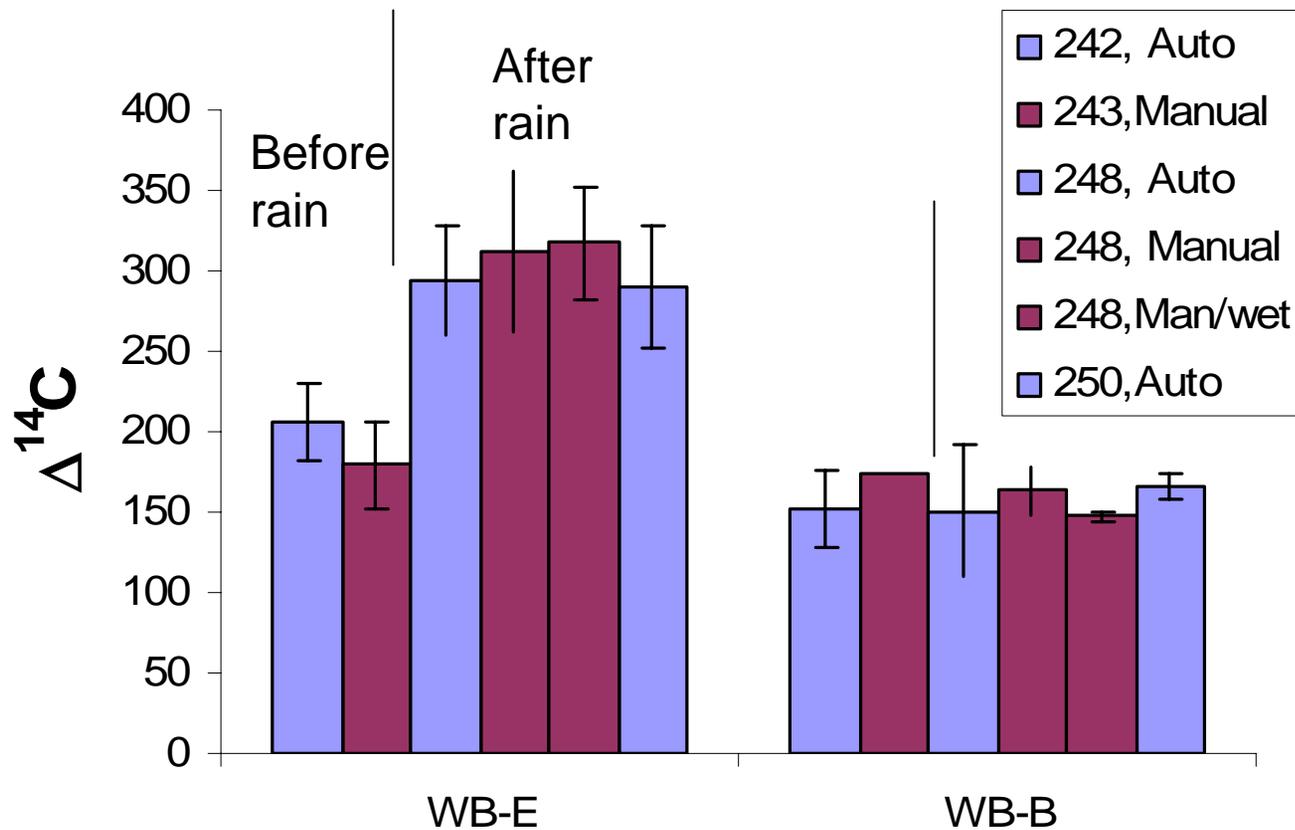


Test of UCI autochambers (built with NSF Carbon Cycle grant)

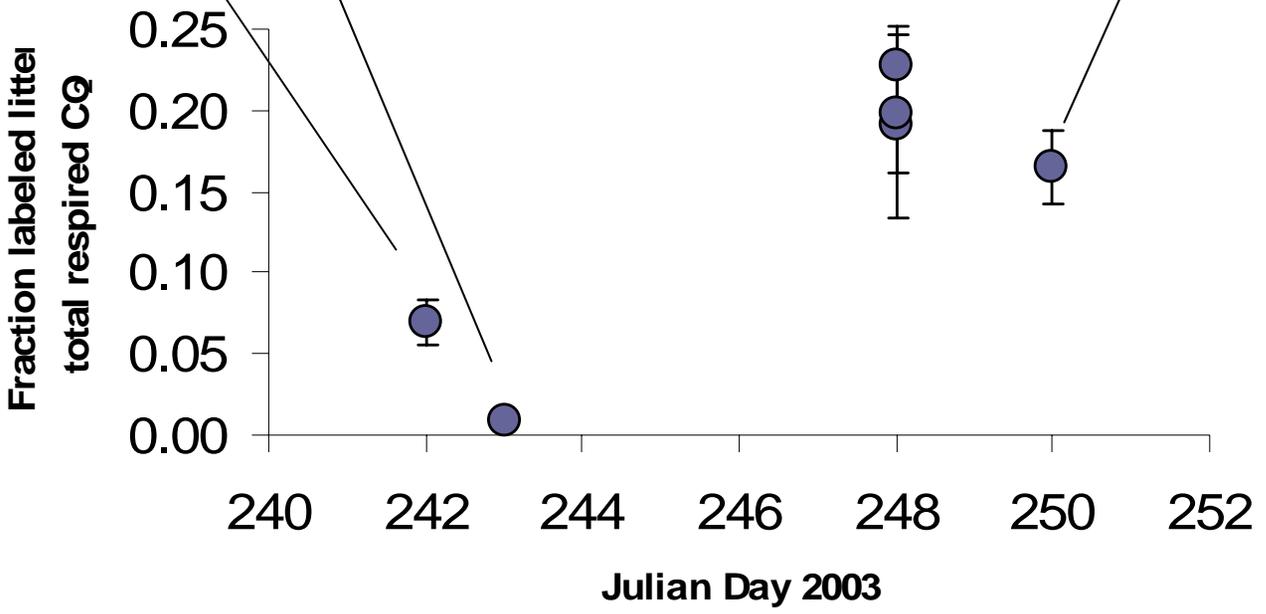
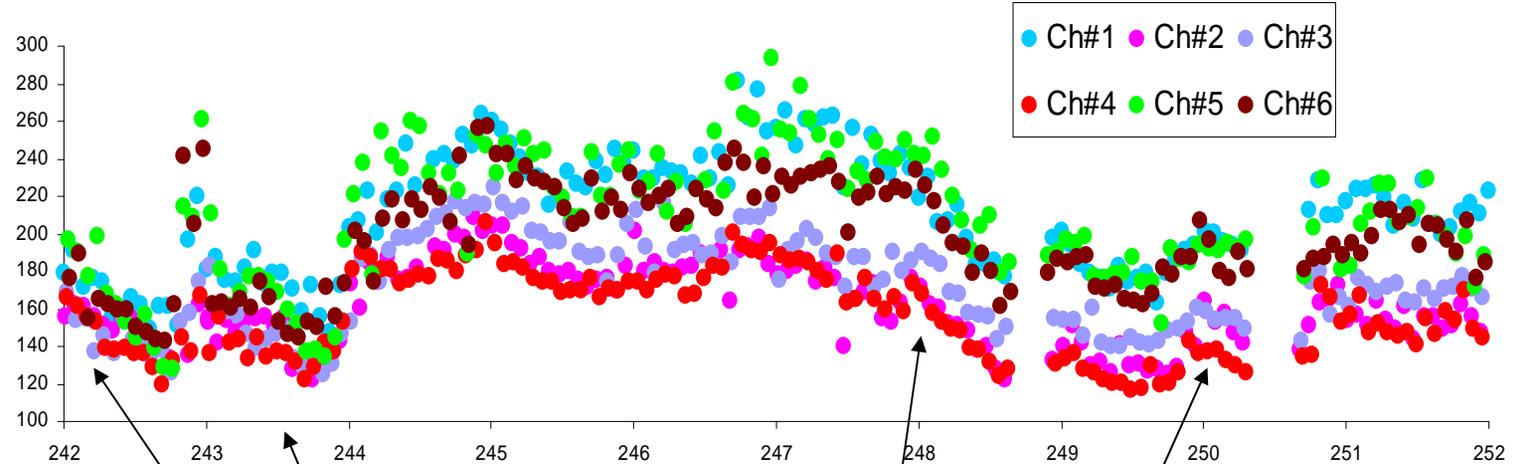




Autochamber and manual chamber isotope collection methods compare well



Surface flux ($\text{mg m}^{-2} \text{ hr}^{-1}$)



NB – autochamber fluxes generally lower than manual chamber fluxes

What we have learned

Seasonal cycle in soil respiration is due to both root and microbial respiration changes

Root respiration ranges from 40-80% of total soil respiration; highest values in the spring (cool soil temperatures and pulse of root growth)

The labeled litter is contributing 40-80% of the microbially respired C in the O horizon

and 1-10% of the microbially respired C from the 0-5 cm of mineral soil

We see a trend from 2002-2003 in microbially respired C that reflects the bulk O horizon data – why?