Soil C Dynamics in Unprotected and Protected Pools
Task 4a. Process/Mechanistic-Based Fractionations

Results (to date) for Year-0 and Year-1 Samples
Mineral Soil; 0 – 15 cm depth

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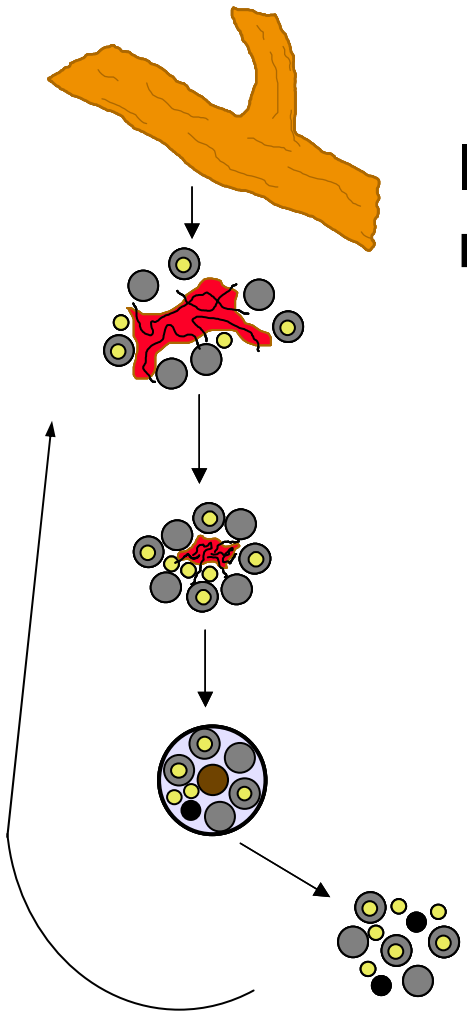
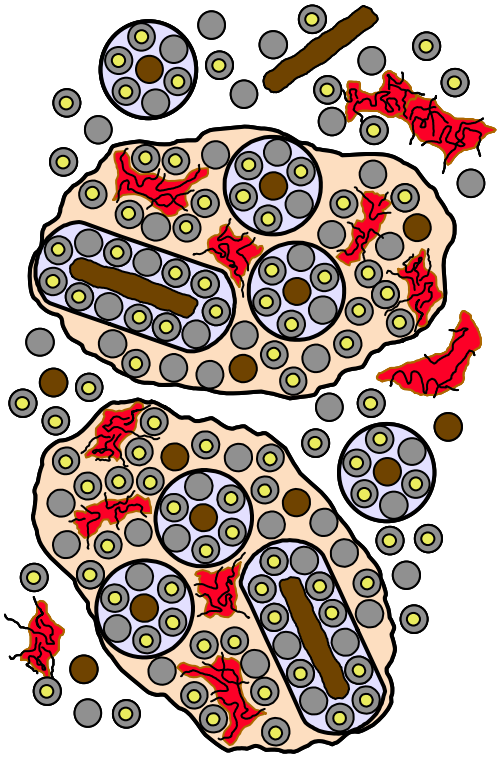
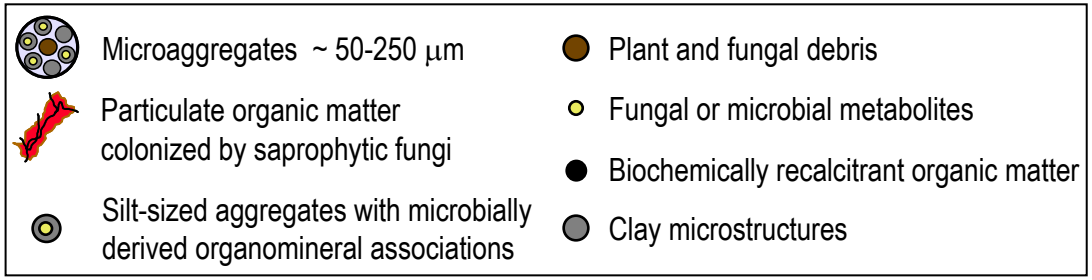
Conceptual models of soil C cycling and protection mechanisms used to develop new soil fractionations



Incorporation into microaggregates:

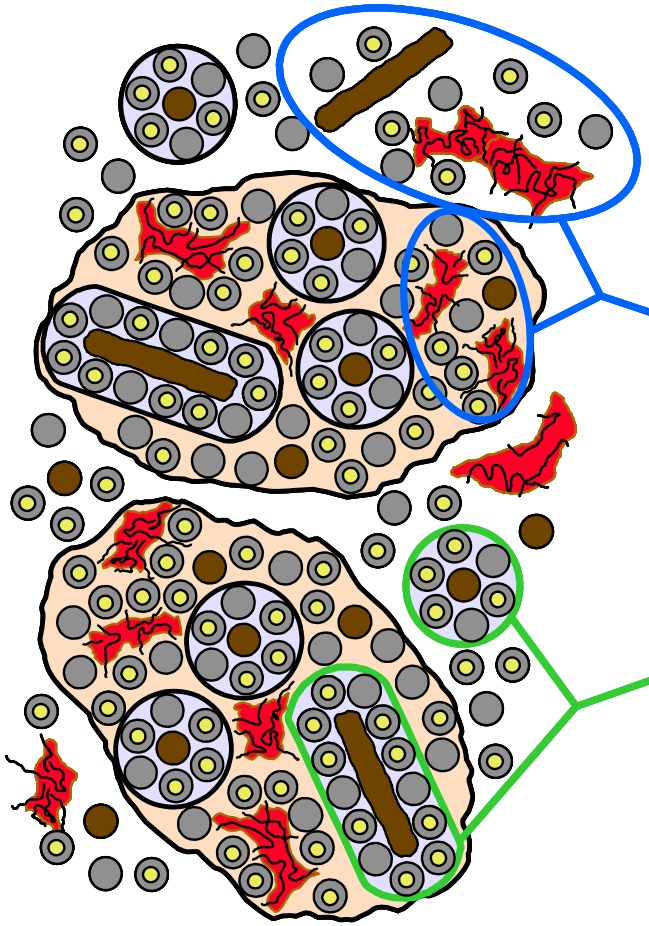
- ⇨ Physically protects organic inputs from decomposition
- ⇨ Enables organic matter to be humified or chemically protected by association with the mineral fraction





EBIS Fractionation of Soil Organic Matter

(Investigating the protective function of microaggregates)



Physical fractionation

Chemical fractionation

Non-Microaggregated

Microaggregate isolator
⇒ POM, silt & clay

Acid hydrolysis
silt & clay

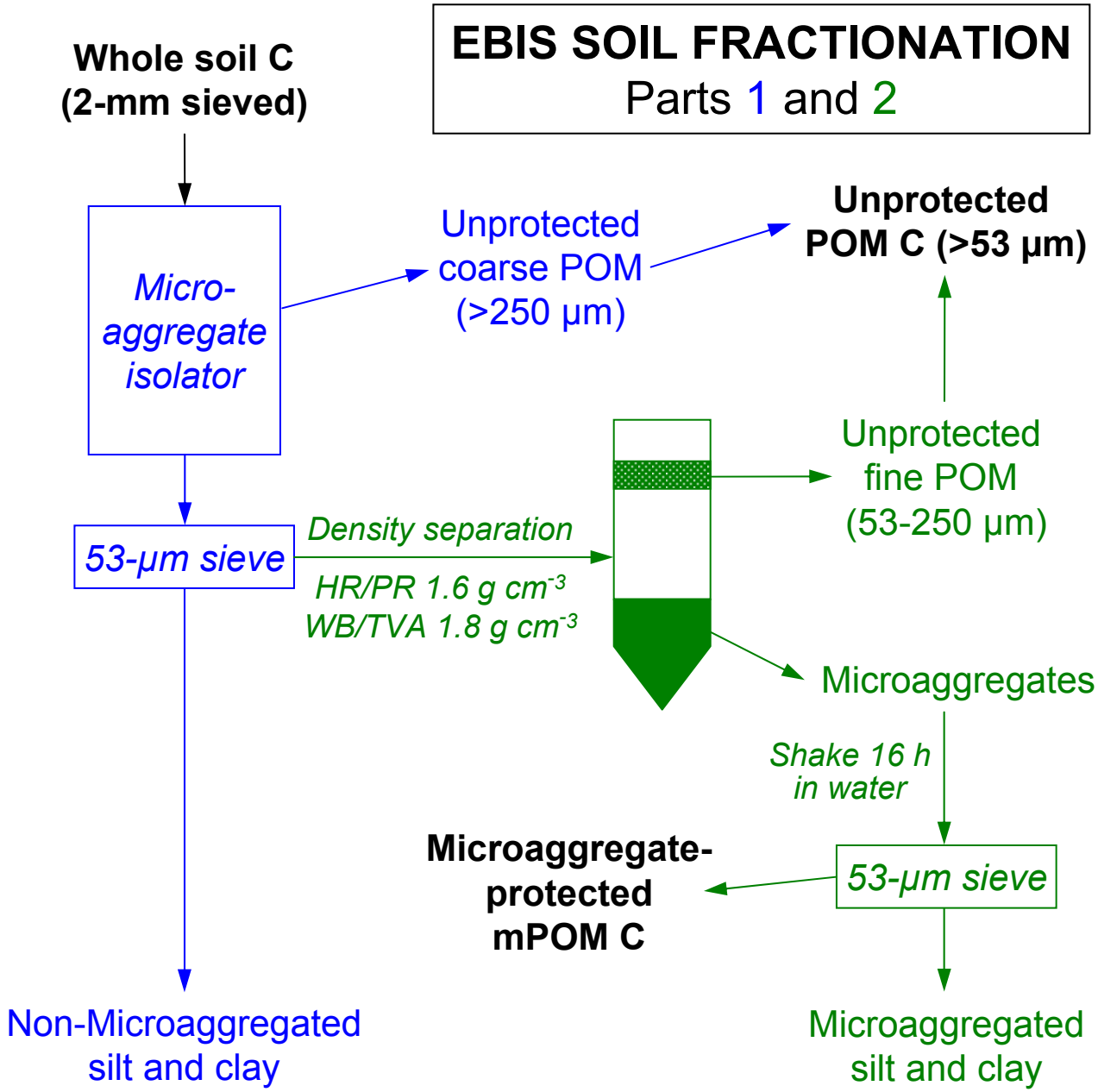
Microaggregated

Dispersion
⇒ POM, silt & clay

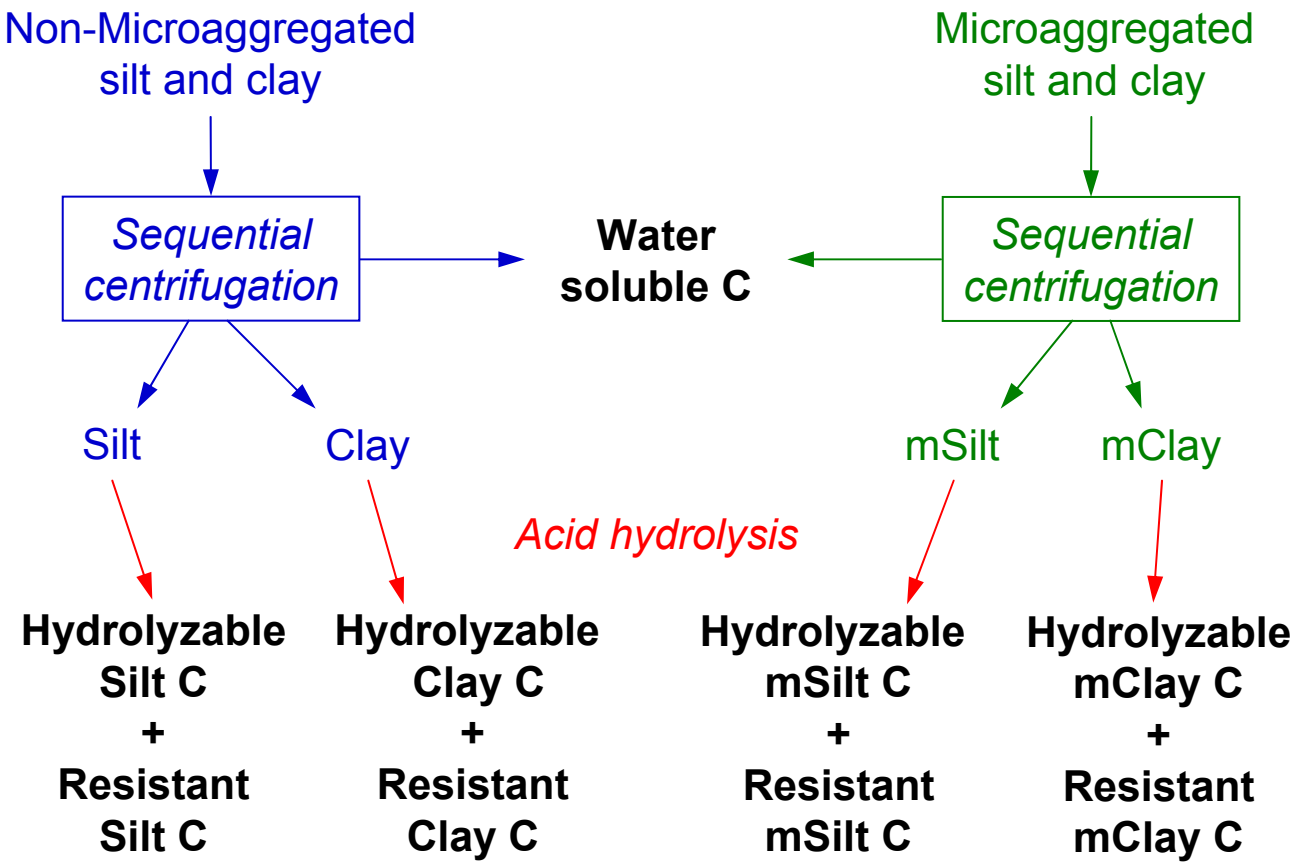
Acid hydrolysis
silt & clay

Based on increasing disruptive energies

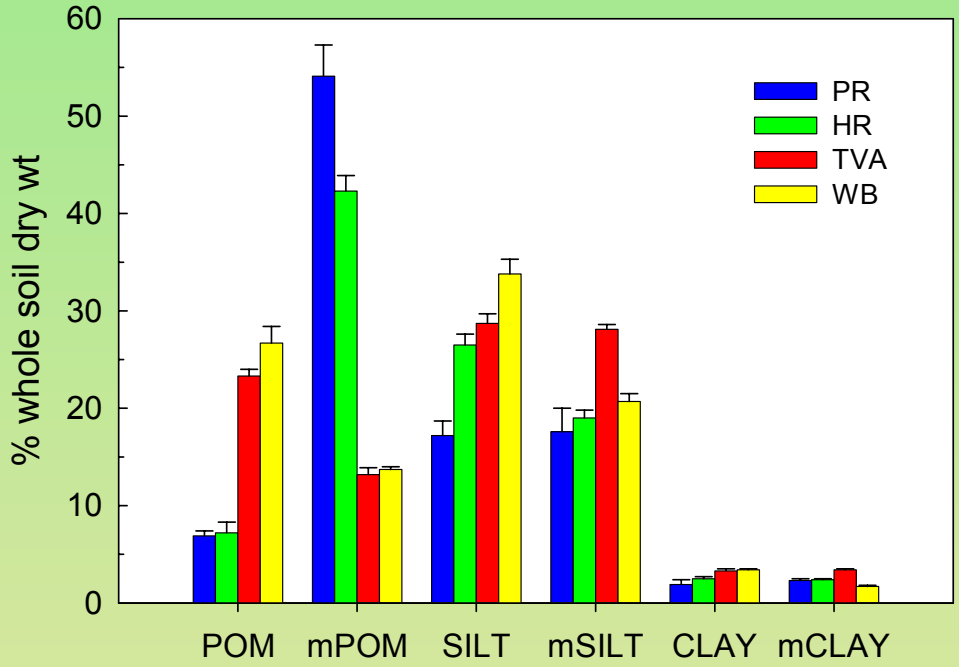
Yields resistant and more labile fractions


EBIS SOIL FRACTIONATION
Parts 1 and 2
Whole soil C
(2-mm sieved)
Micro-
aggregate
isolator
Unprotected
coarse POM
(>250 µm)
Unprotected
POM C (>53 µm)
Unprotected
fine POM
(53-250 µm)
53-µm sieve
Density separation
HR/PR 1.6 g cm-3
WB/TVA 1.8 g cm-3
Microaggregates
Shake 16 h
in water
53-µm sieve
Microaggregate-
protected
mPOM C
Non-Microaggregated
silt and clay
Microaggregated
silt and clay

EBIS SOIL FRACTIONATION
(continued)
Parts 1, 2, and 3



Distribution of Fraction Weights (% of Whole Soil)
0 – 15 cm depth; Year-0



- POM fractions are sand-sized:
  - POM is mostly >250 µm
  - mPOM is 50-250 µm
- Silt fraction may include some aggregated clay particles

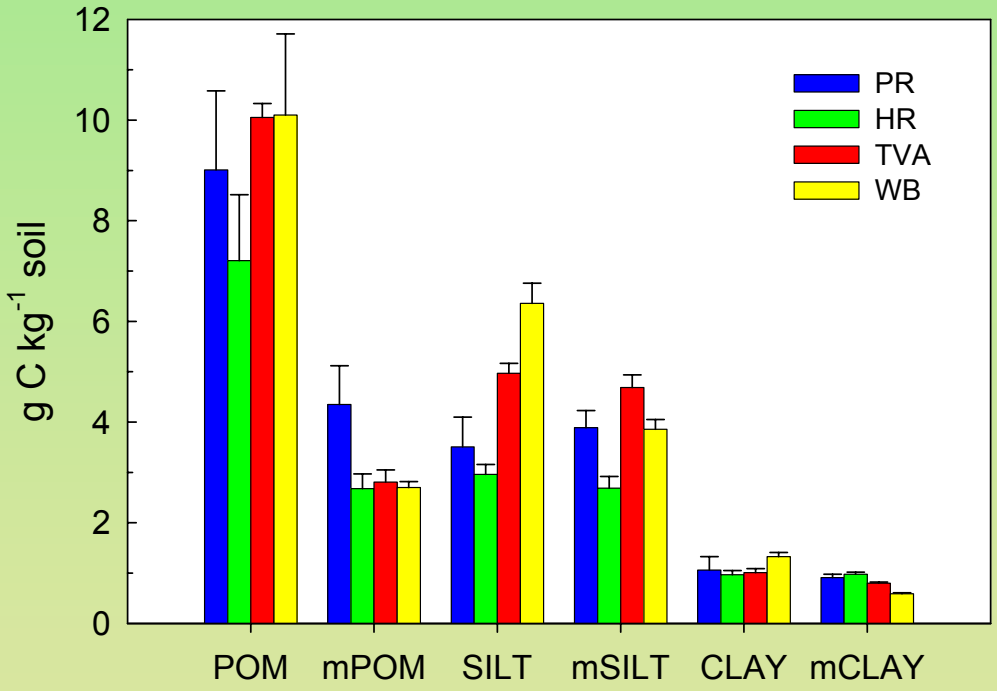
Fractionation recovery efficiencies

Part 1 = 98.3 ± 0.2 %

Part 2 = 99.3 ± 0.2 %

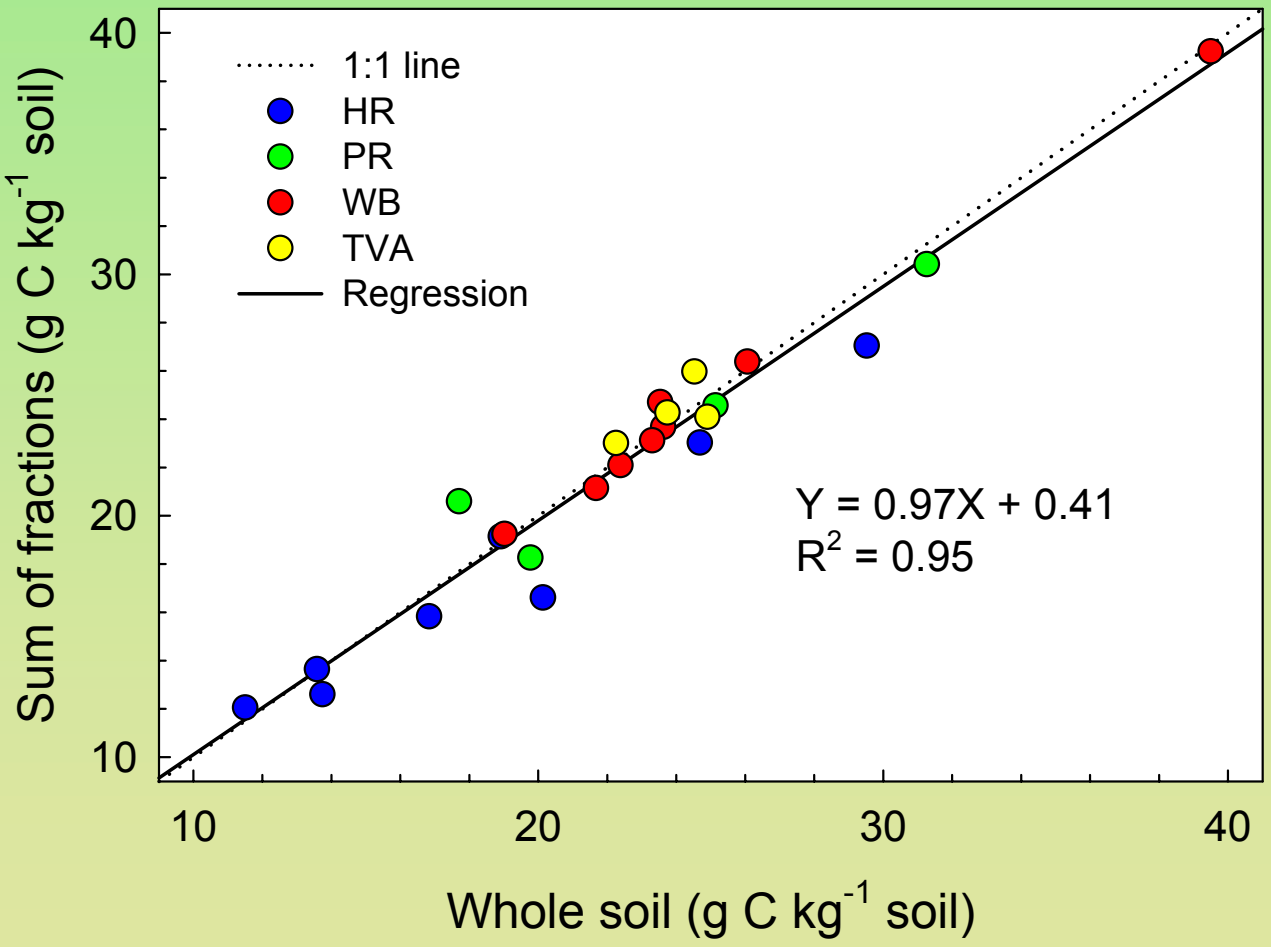
Overall = 97.6 ± 0.2 %

Distribution of Soil Organic Carbon Across Fractions 0-15 cm depth; Year-0



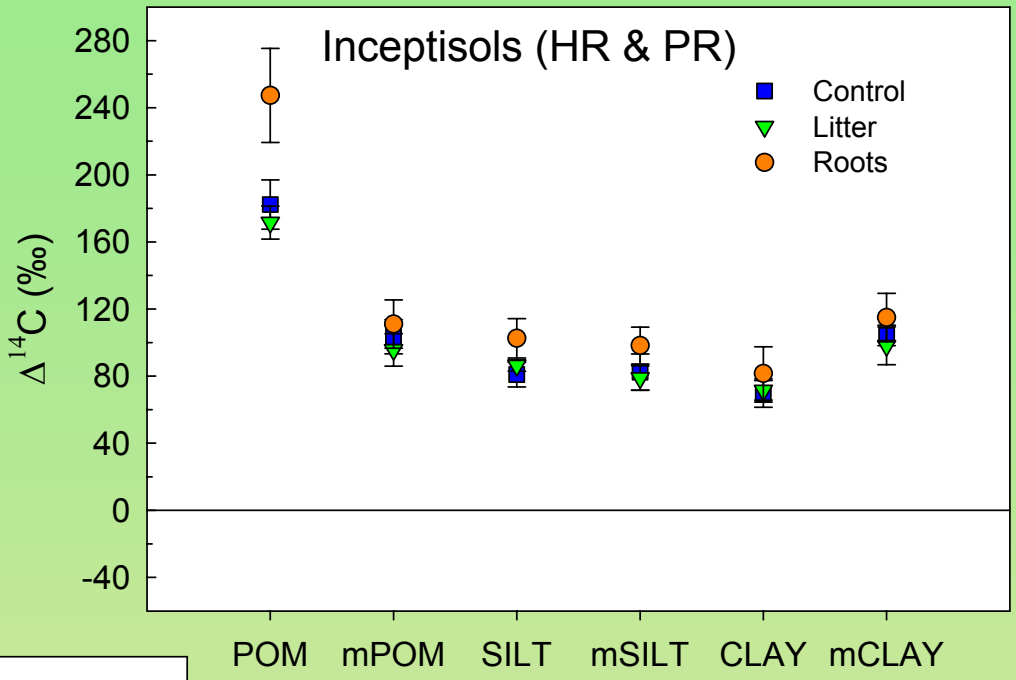
- 50-60% of SOC in POM fractions
- 30-40% of SOC in SILT fractions
- ~10% in CLAY fractions

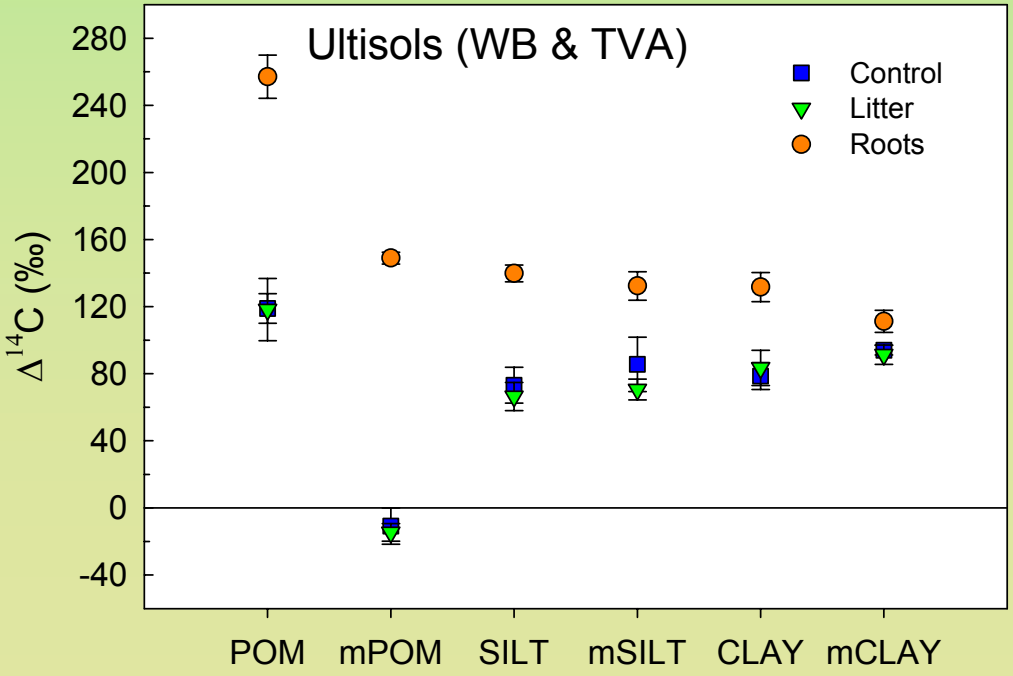
Sum of Fractions C vs. Measured Whole Soil C
0-15 cm depth; Year-0



Fraction $\Delta^{14}C$ at Year-0

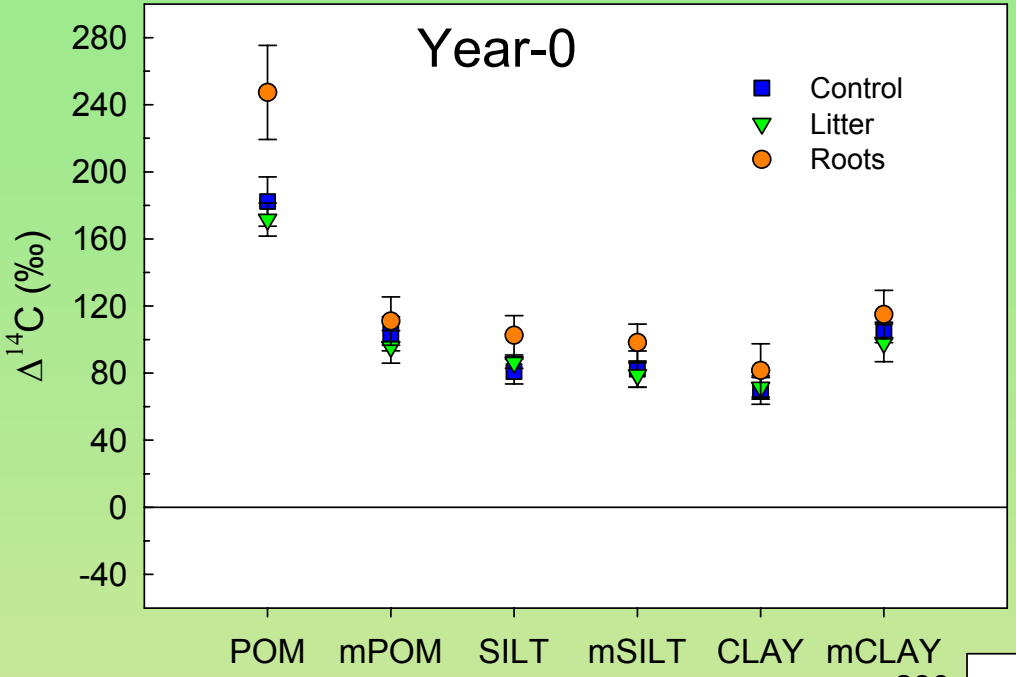
- ROOTS ^{14}C enrichment greatest in POM
- Large mPOM difference for Ultisols due to charcoal in this fraction at WB (negative signatures)





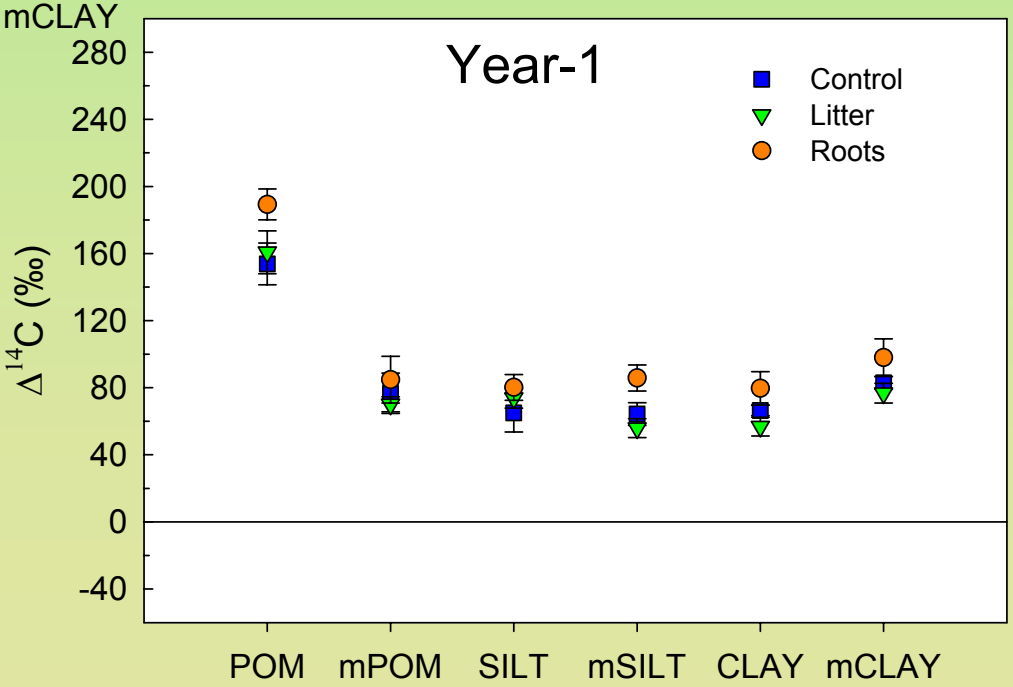
- Significant ROOTS ^{14}C enrichment for mineral fractions in Ultisols

Inceptisols (HR & PR) Fraction $\Delta^{14}C$

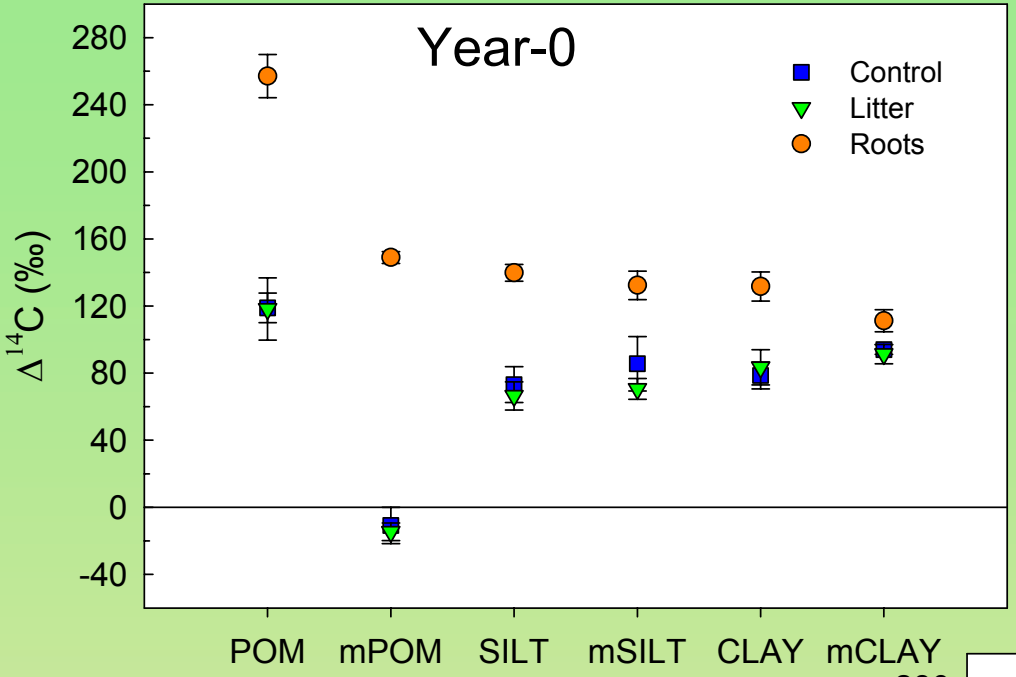


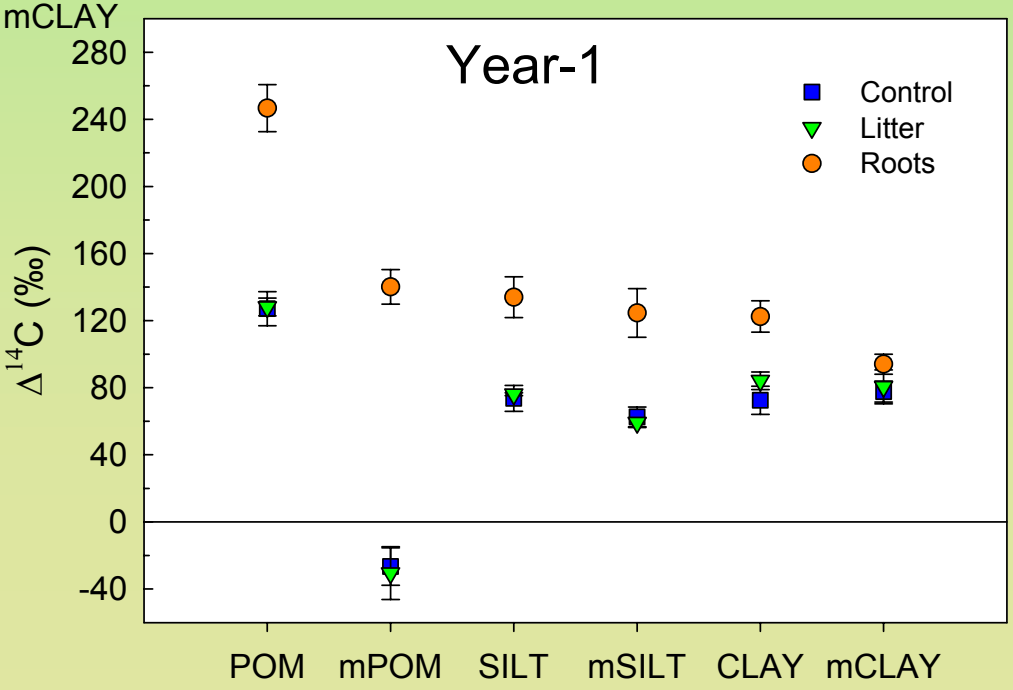
- $\Delta^{14}C$ decreased in all fractions in all plots

- Most obvious change is rapid loss of POM ^{14}C in ROOTS plots
- For Year-1 mSILT, significant separation between ROOTS and other plots indicates less loss and possible movement into this fraction



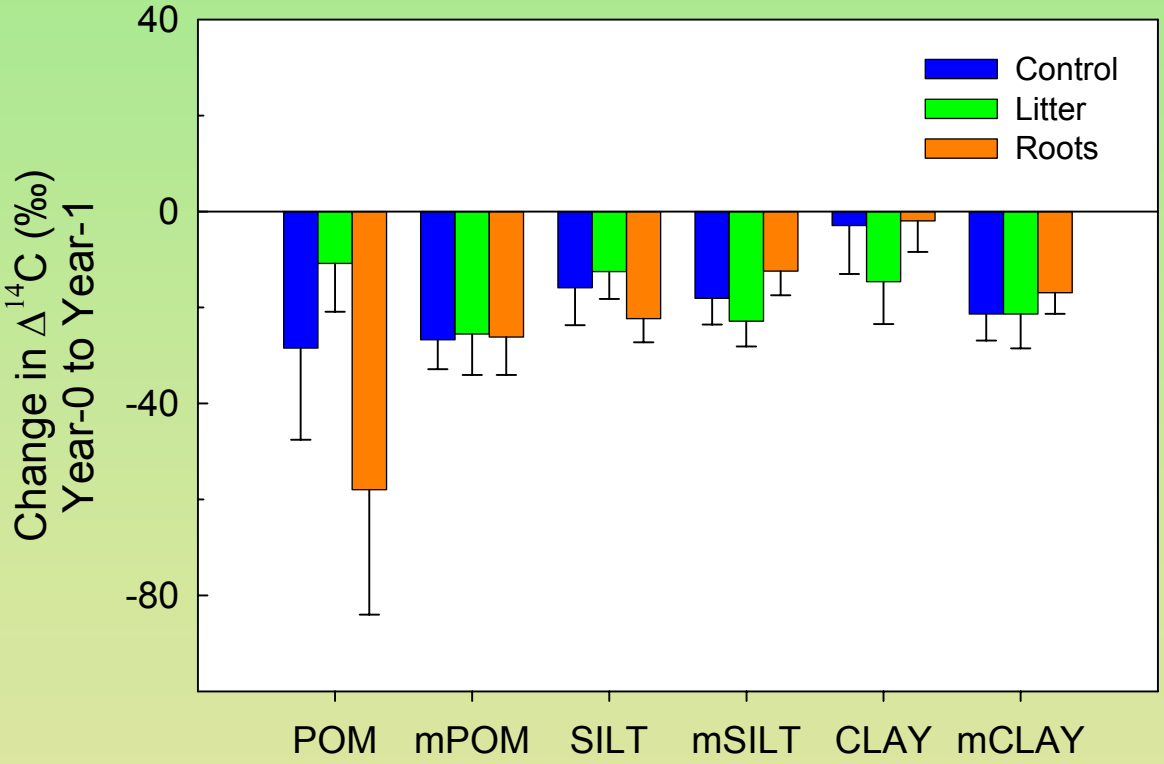
Ultisols (WB & TVA) Fraction $\Delta^{14}C$





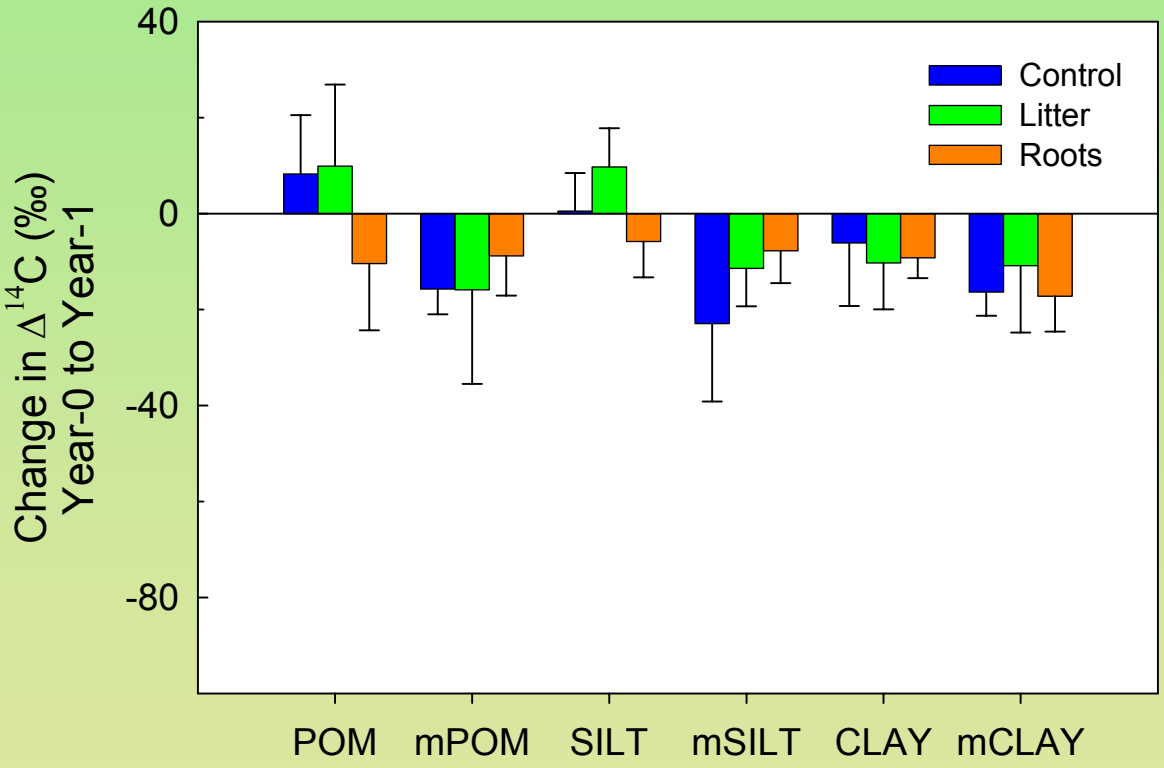
- Changes generally smaller and more variable than in Inceptisols

Change in Fraction $\Delta^{14}C$ from Year-0 to Year-1 Inceptisols (HR & PR)



- Loss of POM ^{14}C greatest in ROOTS plot
- Smallest decline in POM ^{14}C in LITTER plot (could new inputs from labeled litter be reducing rate of loss??)
- Similar but less obvious pattern in SILT
- Opposite pattern in mSILT and mCLAY

Change in Fraction $\Delta^{14}C$ from Year-0 to Year-1
Ultisols (WB & TVA)



- High degree of variability, with few significant changes
- Does charcoal affect results??
- Is spatial heterogeneity associated with each year's sample locations affecting results??

Weighting of Radiocarbon Signatures Based on Carbon Distribution Across Fractions

$\Delta^{14}C$ x (mg fraction C g^{-1} soil) / (mg bulk C g^{-1} soil)

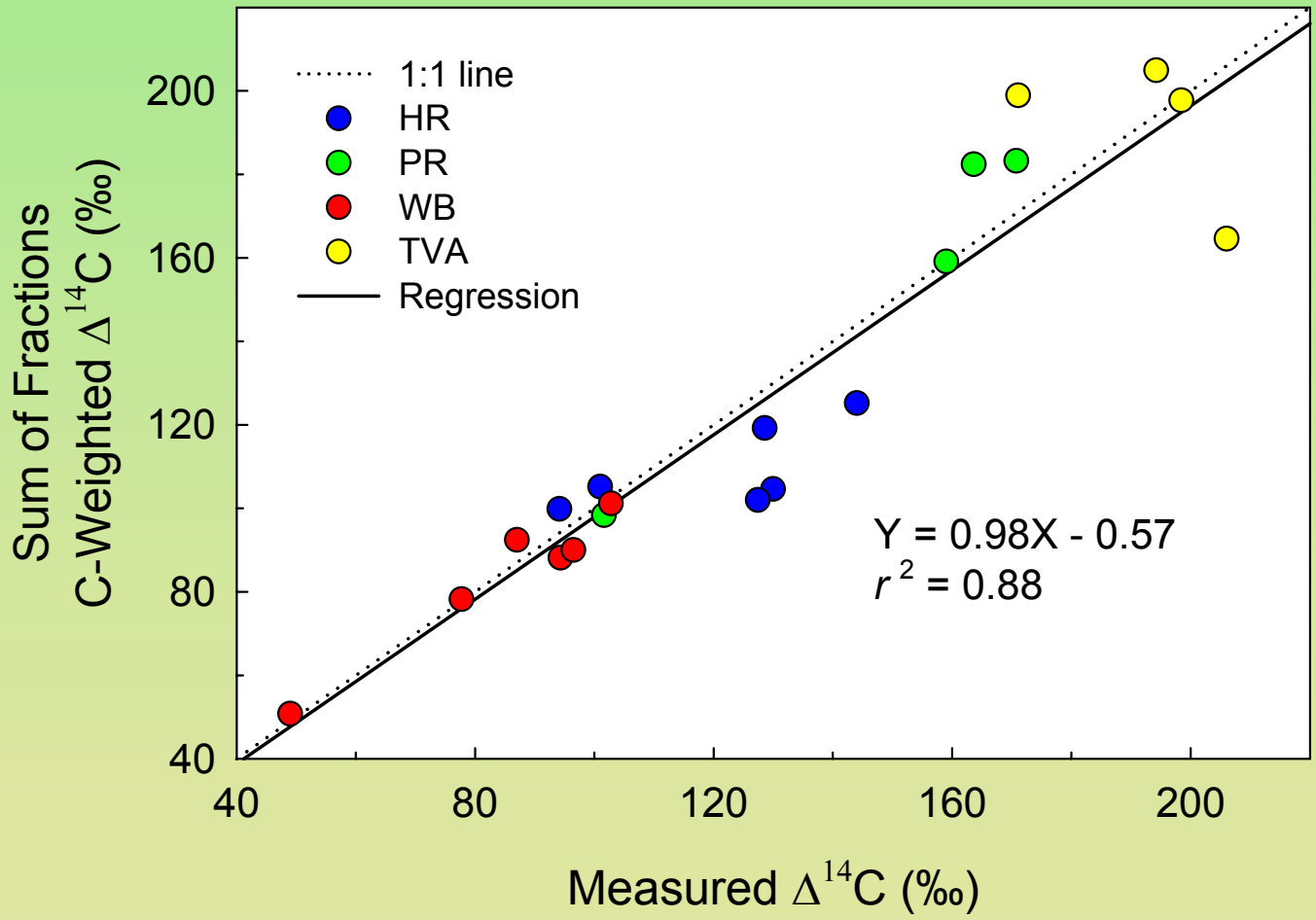
- Sum of C-weighted ^{14}C signatures for all fractions should approximate bulk soil signatures
- May facilitate tracking of changes across fractions based on their relative contributions to the whole

Also allows pooling of fractions:

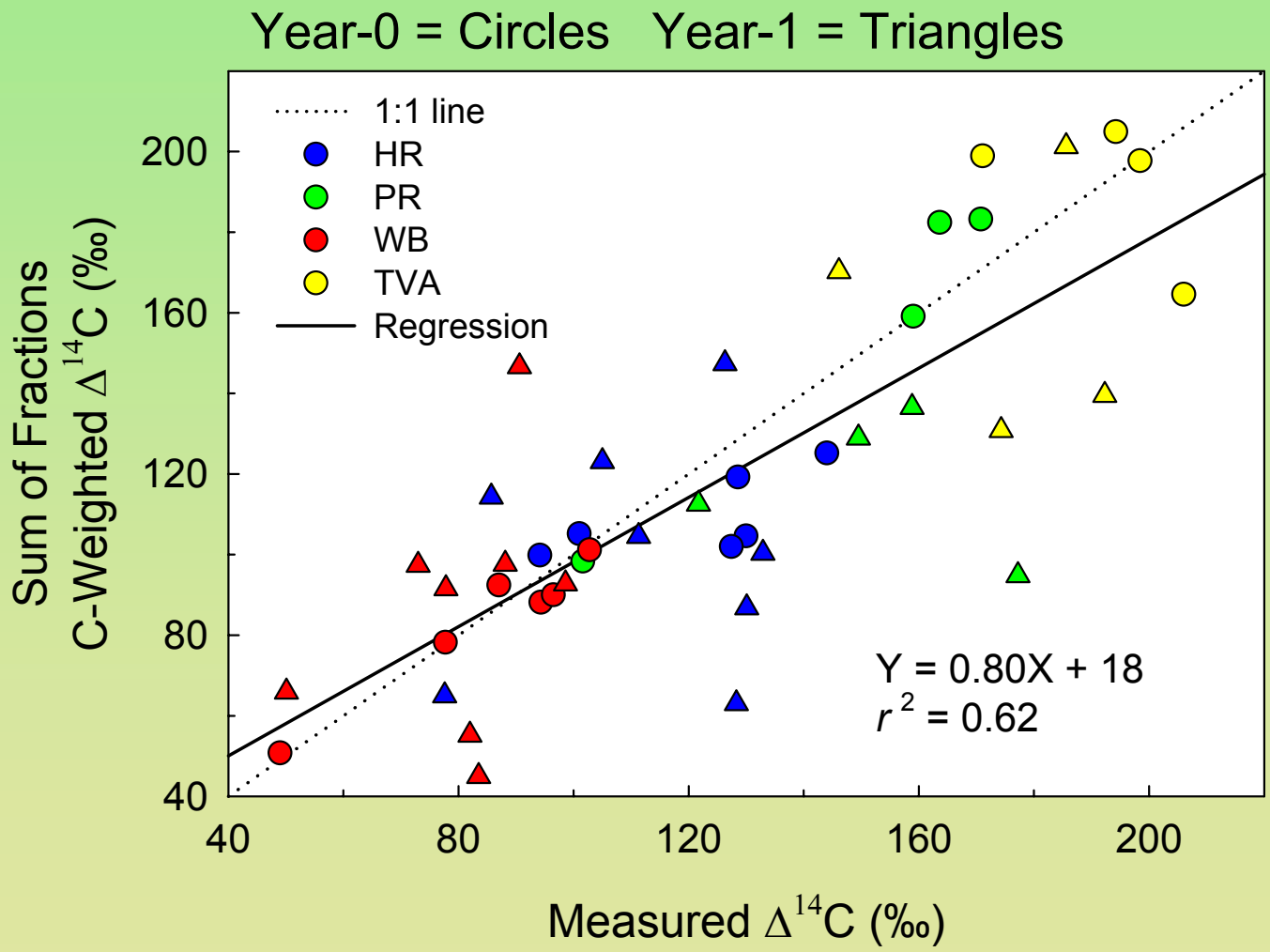
Sum C-weighted signatures for fractions being pooled; then reverse calculation to give $\Delta^{14}C$ for pooled fraction

- Reduce variability
- Ease interpretation (until trends can be tracked over multiple years)
- Allow comparisons to density fractionation

Sum of Fractions vs. Measured Whole Soil -- Year-0 (2001)
C-Weighted ^{14}C Signatures

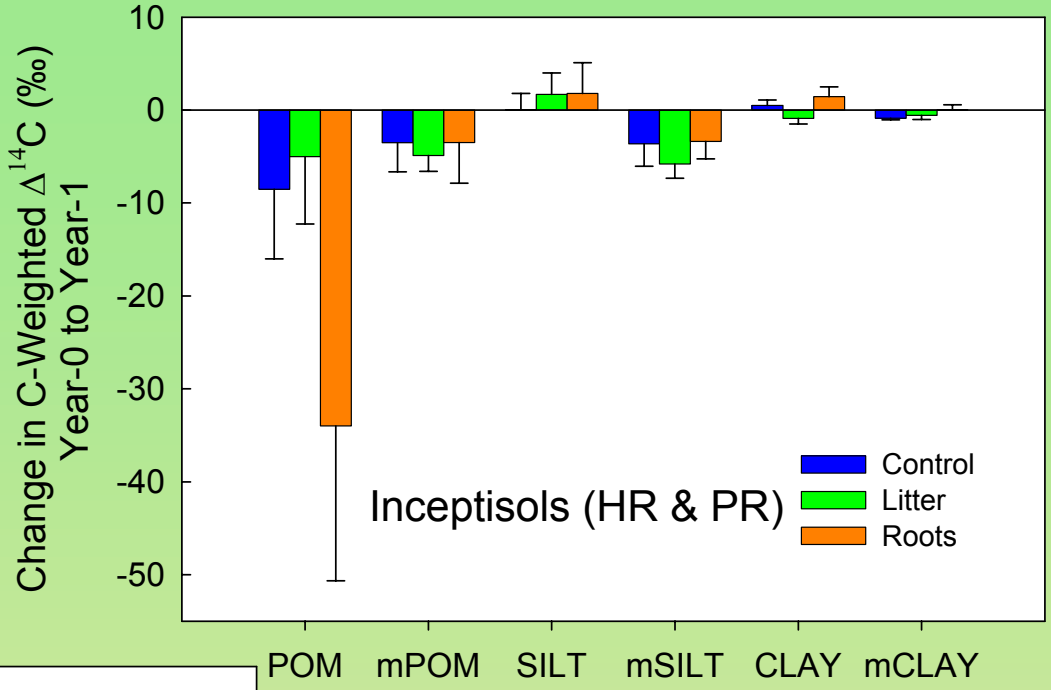


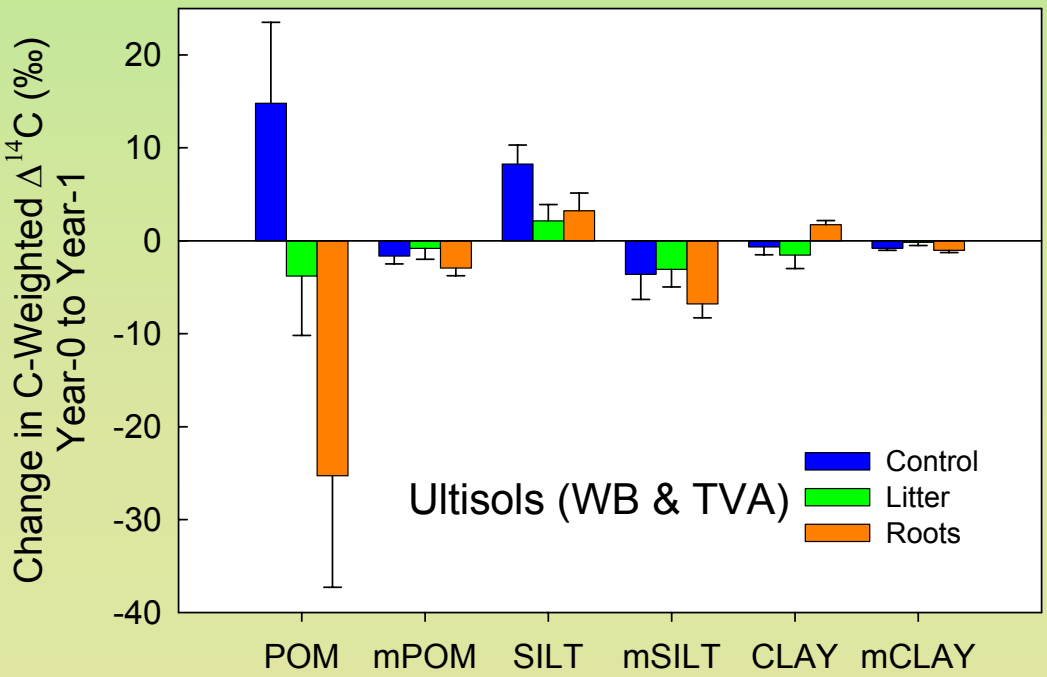
Sum of Fractions vs. Measured Whole Soil -- Year-0 & Year-1 *C-Weighted* ^{14}C Signatures



Change in *C-Weighted* $\Delta^{14}C$ (Year-0 to Year-1)

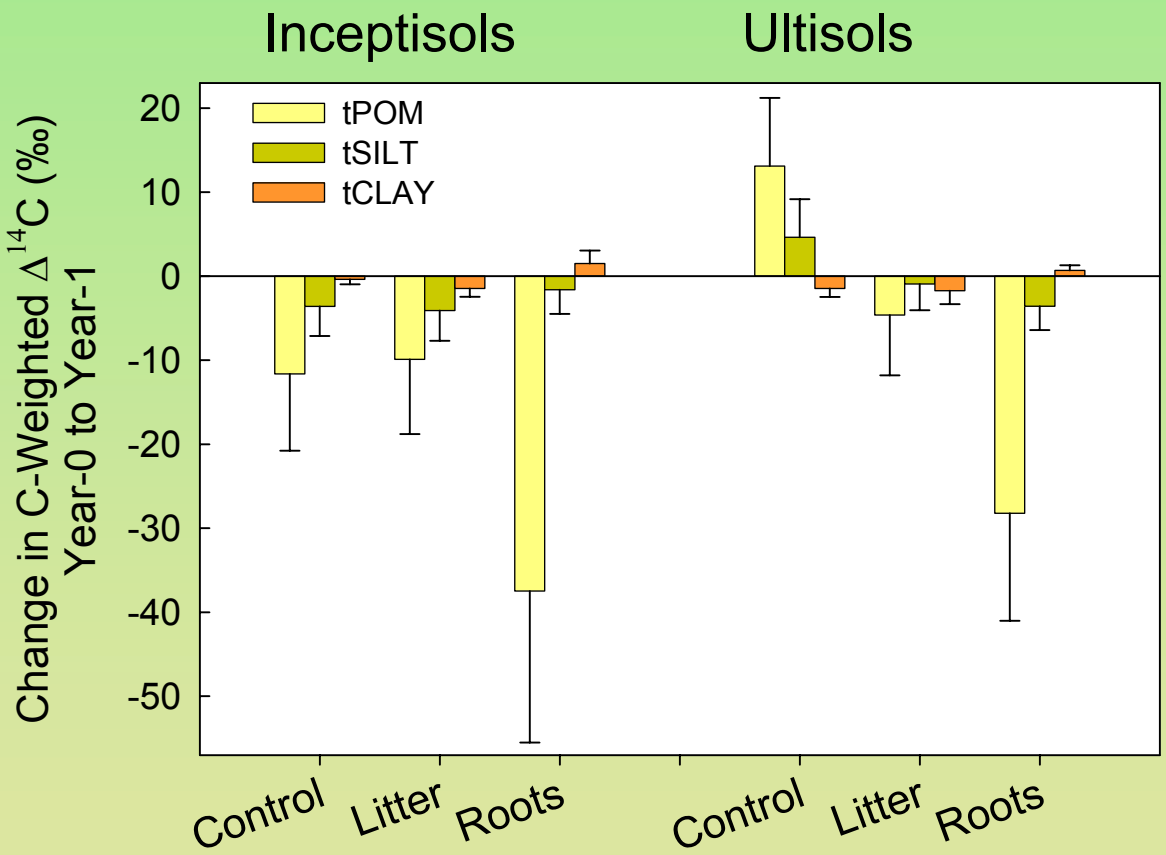
- Trends for increase in SILT and loss of mSILT due to less microaggregates in Year-1 than Year-0 (possible effect of differing yearly climatic conditions?)





- Need more years to track changes (amounts of microaggregates in Year-2 similar to Year-0)

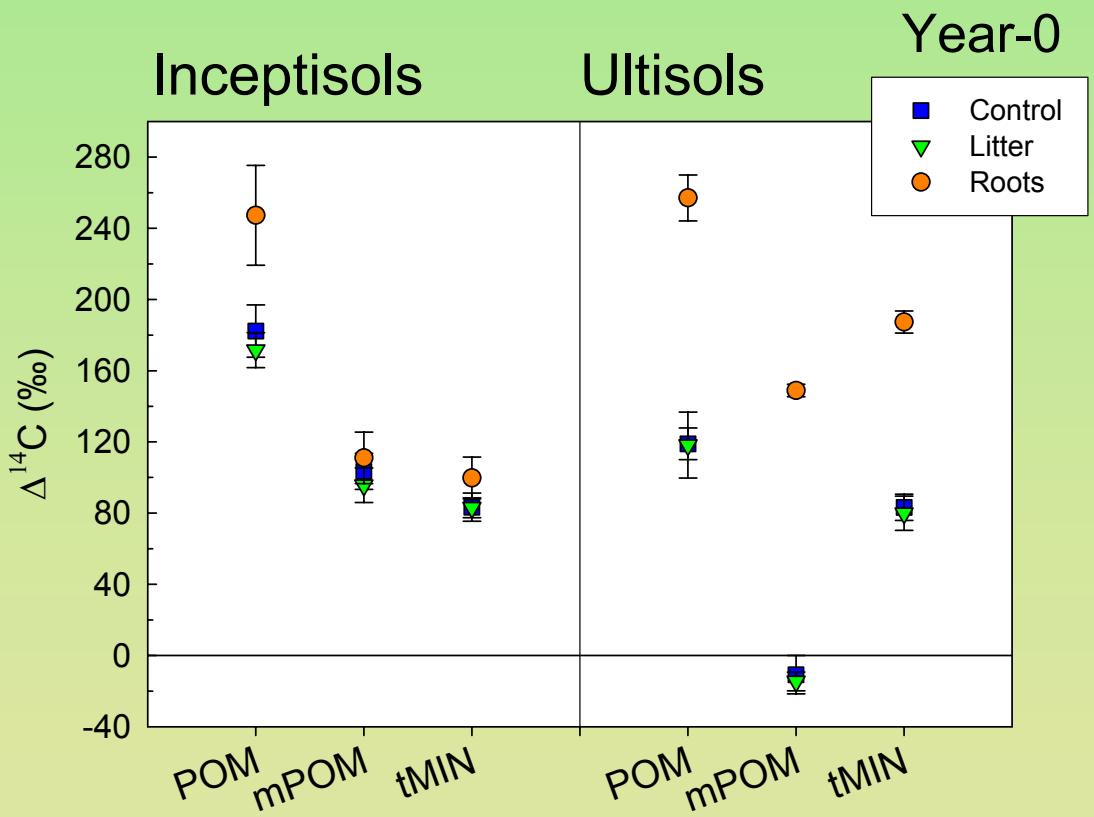
Change in *C-Weighted* ^{14}C Signatures (Year-0 to Year-1) for Pooled (total) POM, SILT and CLAY Fractions



- Removes effects of inter-year changes in microaggregate mass
- Gain in tPOM for Ultisol CONTROL probably due to spatial heterogeneity
- "Possible" transfer to clay for ROOTS

Mathematical Pooling of Fractions Allow Comparisons to Density Fractionation

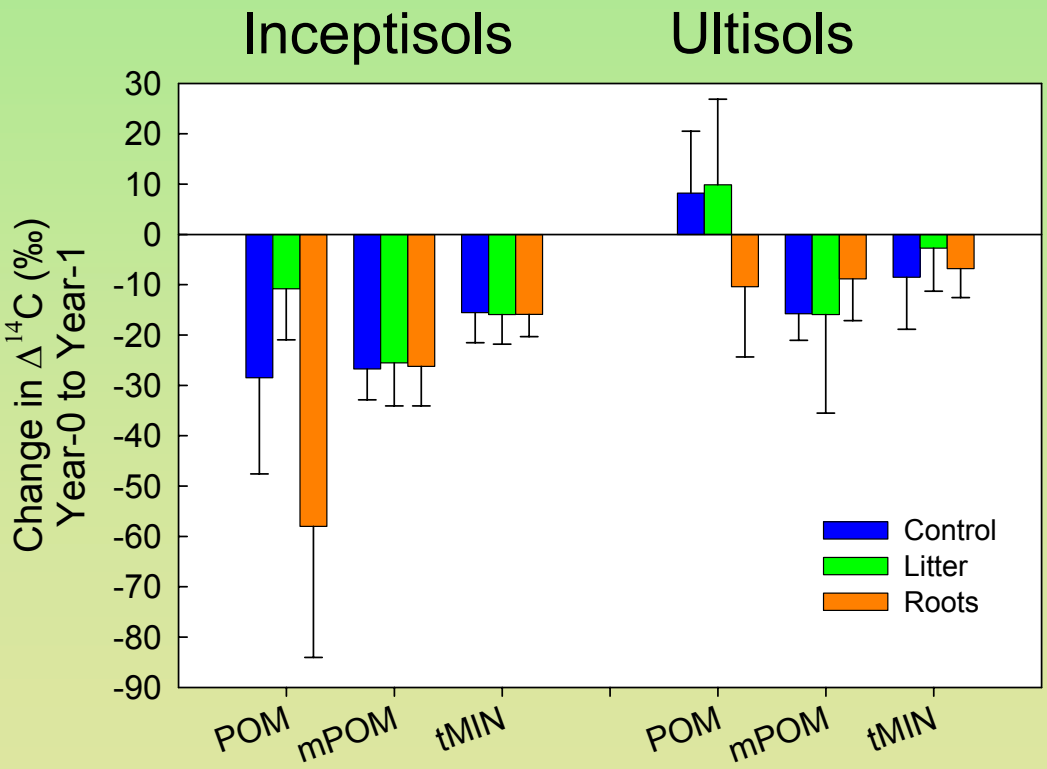
(POM ≈ fLF, mPOM ≈ oLF, tMIN ≈ HF)



- Comparable patterns to density fractionation, especially for TVA
- BUT, for WB charcoal clearly lowers mPOM compared to oLF and increases signature of tMIN relative to HF

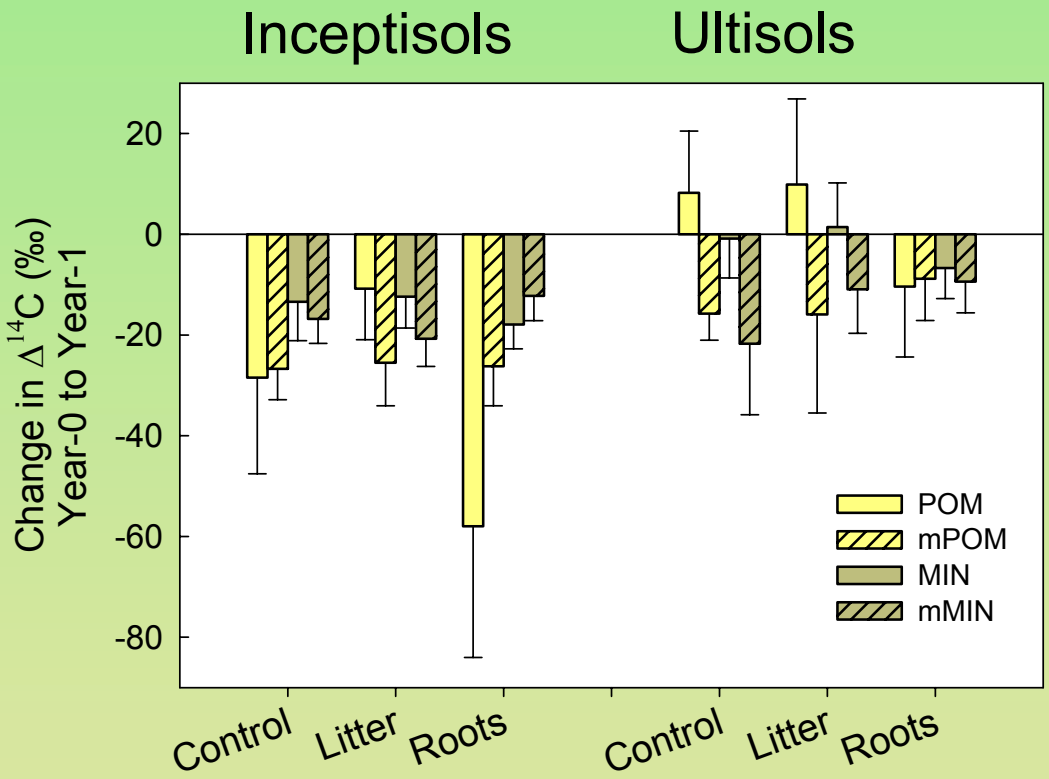
Change in $\Delta^{14}C$ for Pooled Fractions (Year-0 to Year-1)

(POM ≈ fLF, mPOM ≈ oLF, tMIN ≈ HF)



- For Inceptisols, clearly no treatment effect on mPOM or tMIN; any potential treatment differences confined to POM fraction
- For Ultisols, no clear trends as yet; charcoal and spatial heterogeneity may be affecting results

Change in $\Delta^{14}C$ for Unprotected and Microaggregate-Protected Fractions (Year-0 to Year-1)

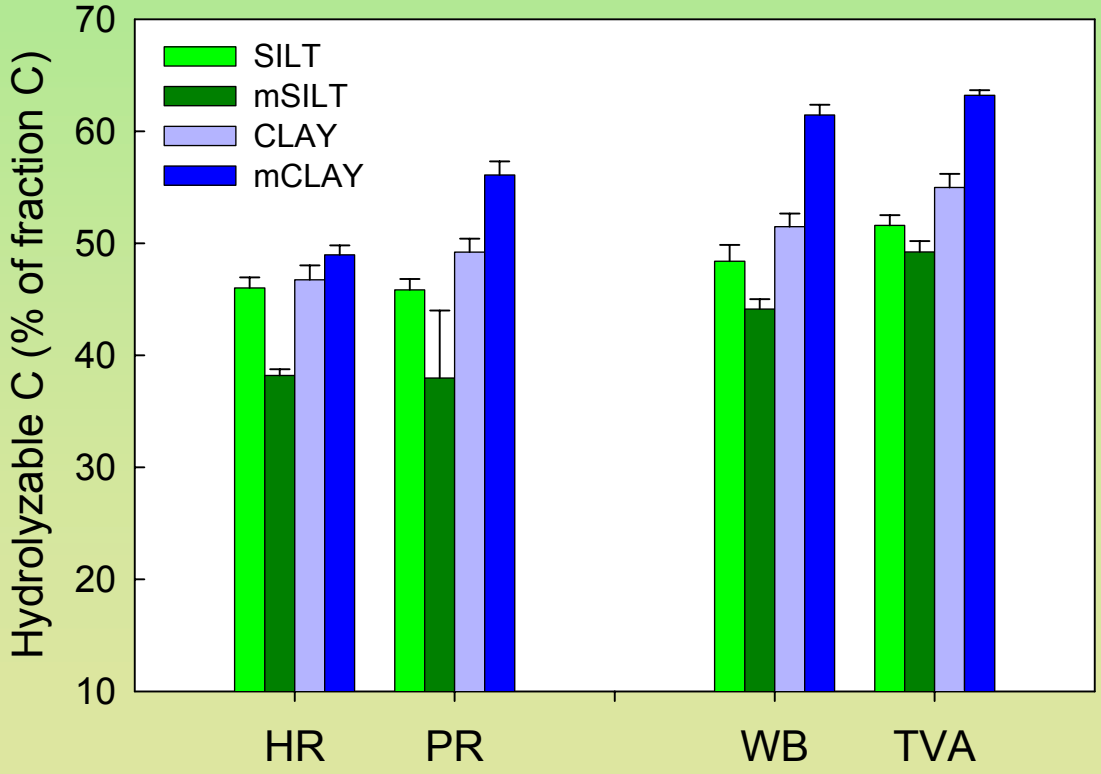


- For Inceptisols, ROOTS unprotected POM and MIN show greater loss than microaggregate-protected fractions – opposite trend for LITTER
- For Ultisols, no clear trends for ROOTS as yet; LITTER and CONTROL lose more from microaggregated fractions (but charcoal and spatial heterogeneity may be affecting results)

Separation of tMIN into MIN and mMIN appears to increase sensitivity and should lead to better mechanistic understanding

Hydrolyzable C in Mineral Fractions -- Year-0 (2001)

- Expect most of labeled C in mineral fractions (especially clay) to be hydrolyzable (at least initially)
- Likely derived from exudation, microbial activity, leached DOC



Interesting trends:

- More hydrolyzable-C in mCLAY than CLAY suggests greater protection of this pool by microaggregates
- More hydrolyzable-C in SILT than mSILT could result from DOC or decomposition of unprotected POM

CONCLUSIONS

- At least 3 years will be needed to observe trends over time
- Unprotected vs. microaggregate-protected fractions appear to be showing some differences
- Chemical fractionation (acid hydrolysis) may increase sensitivity in mineral fractions

WHAT'S NEXT?

- Analyze Year-0 hydrolyzed fractions at CAMS
- Year-2 samples fractionated and ready for analysis at CAMS
- Acid hydrolysis of for selected Year-1 and Year-2 mineral fraction samples to verify no change in resistant fractions over time
- Analyze fractions for C and N concentrations and ^{13}C (for ^{14}C correction)

LONG TERM GOALS

- Follow dynamics of ^{14}C signatures in fractions over time
- Modeling