The age of C respired from tropical forest

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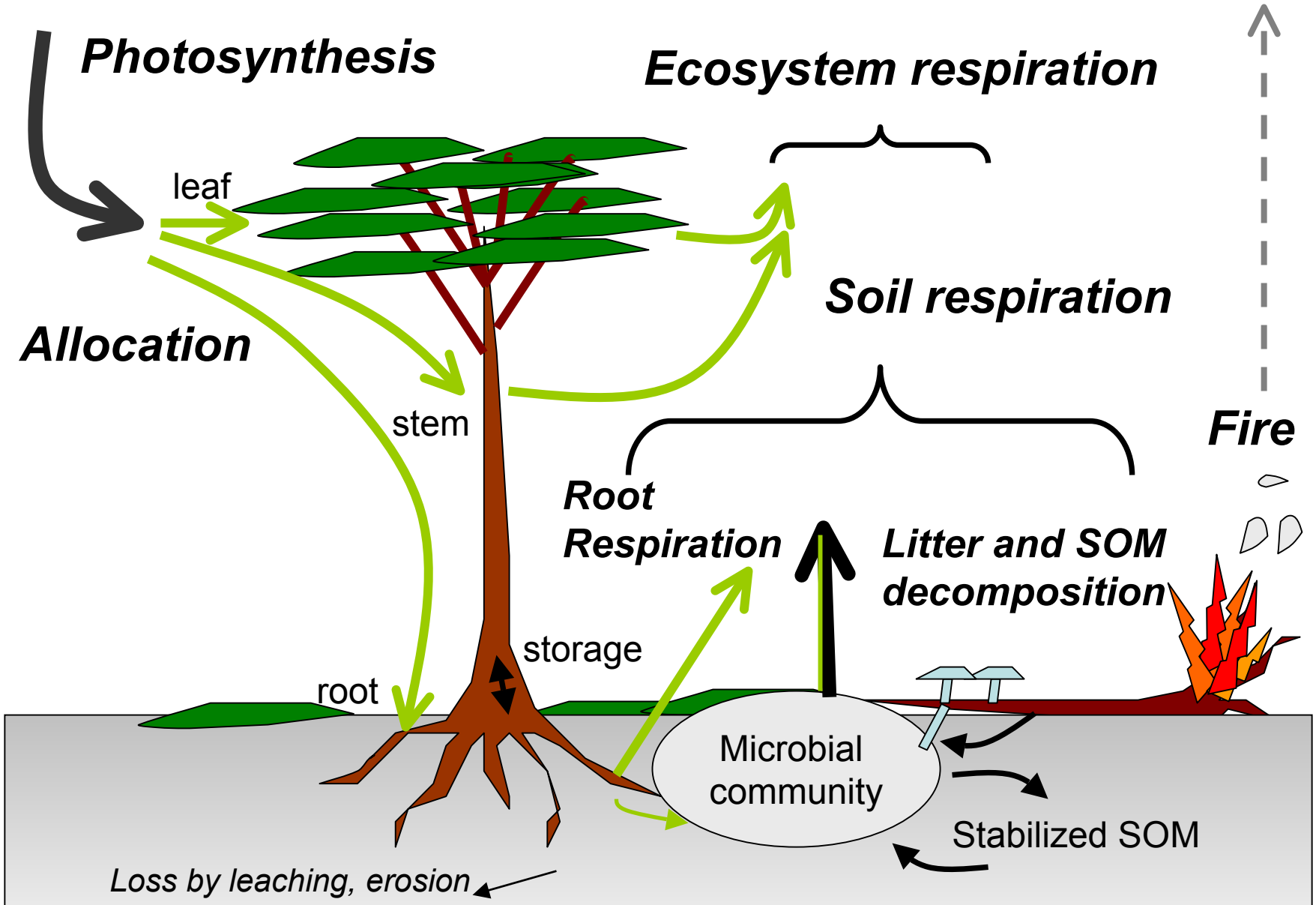
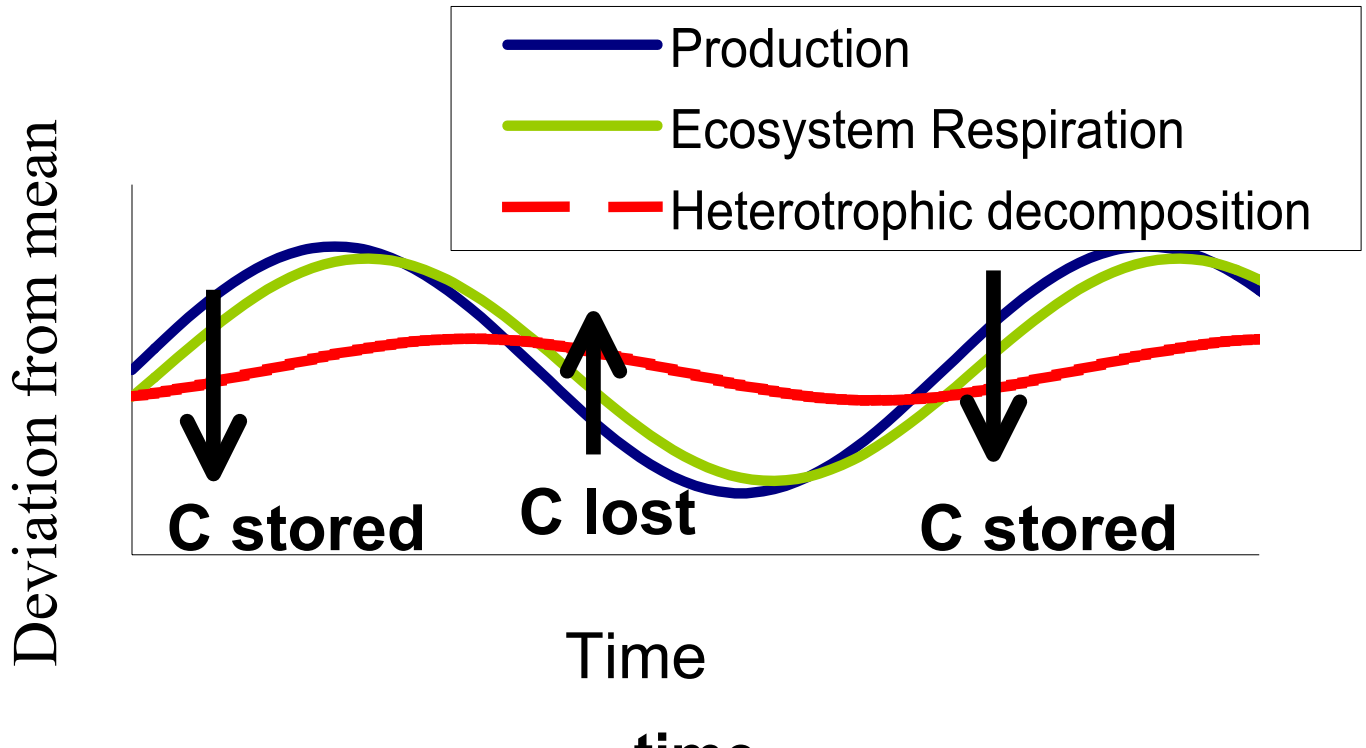
The age of C respired from forest

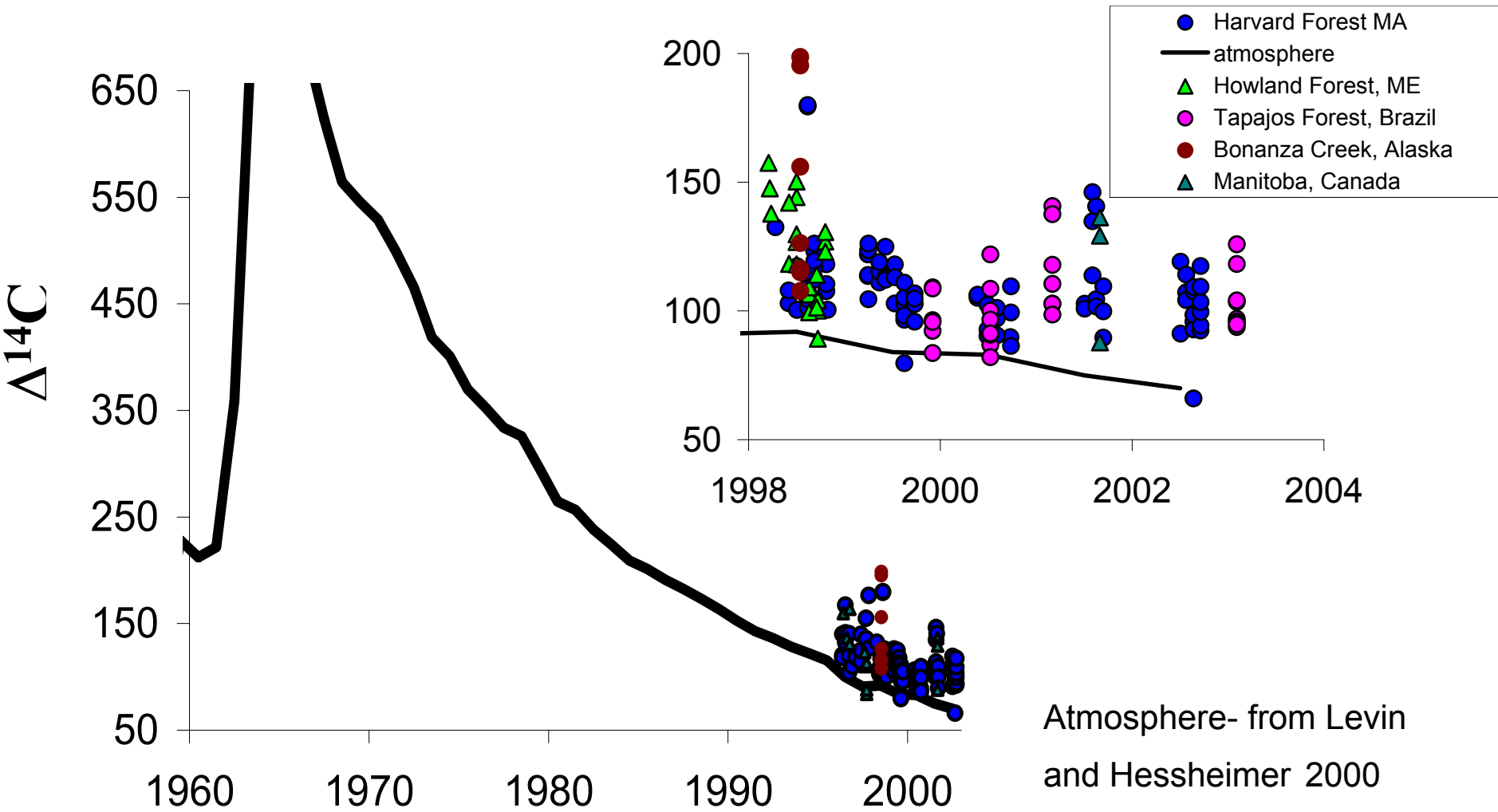


Why this might be interesting

- Measure of the capacity for storage of C and interannual variability in C balance
- Potential for direct comparison of data with models

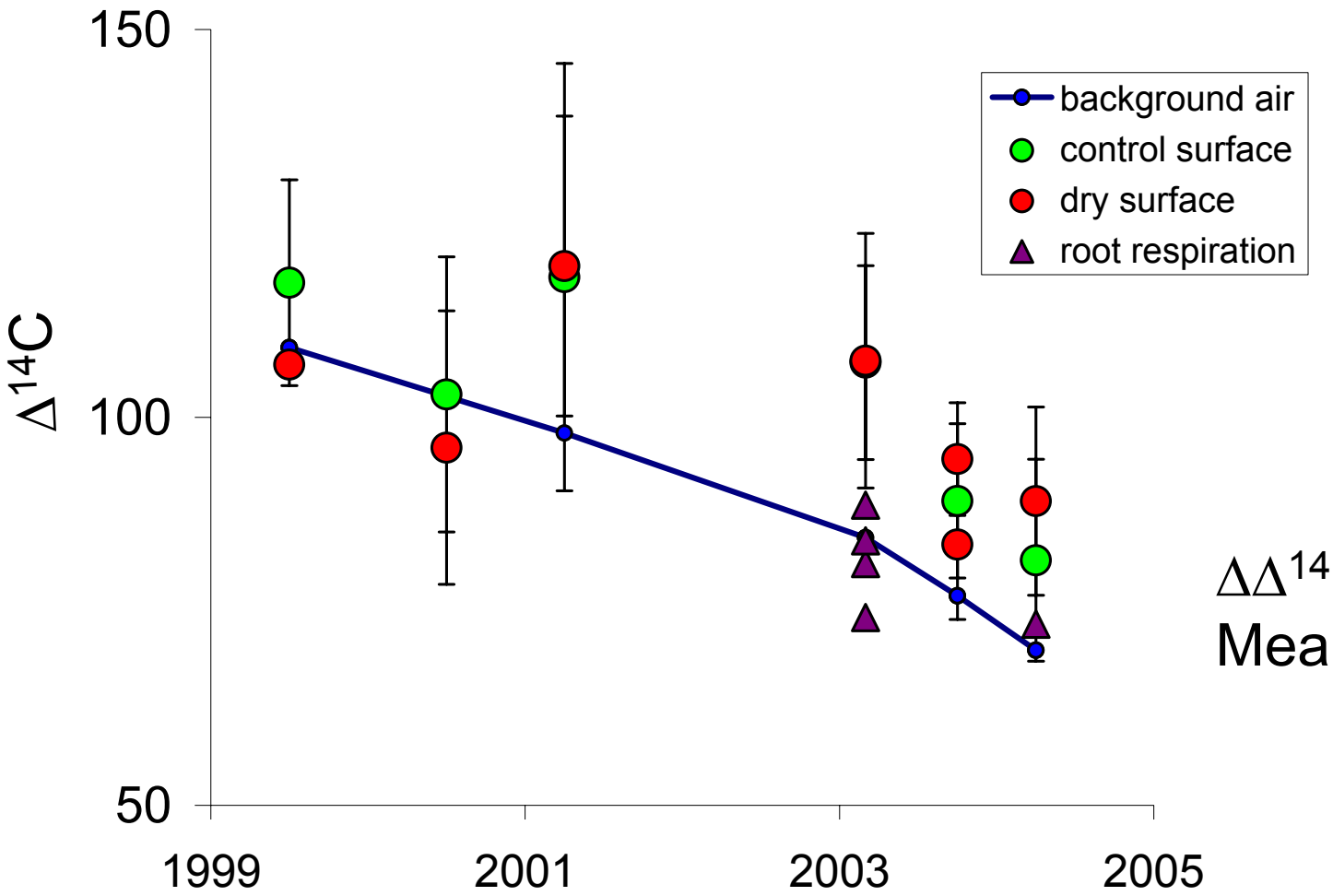


Radiocarbon of soil-respired CO_2 provides a direct measure of isodisequilibrium "mean age" of several years up to a decade



Atmosphere- from Levin and Hessheimer 2000

Soil respired CO_2 is a mix of heterotrophic and autotrophic sources

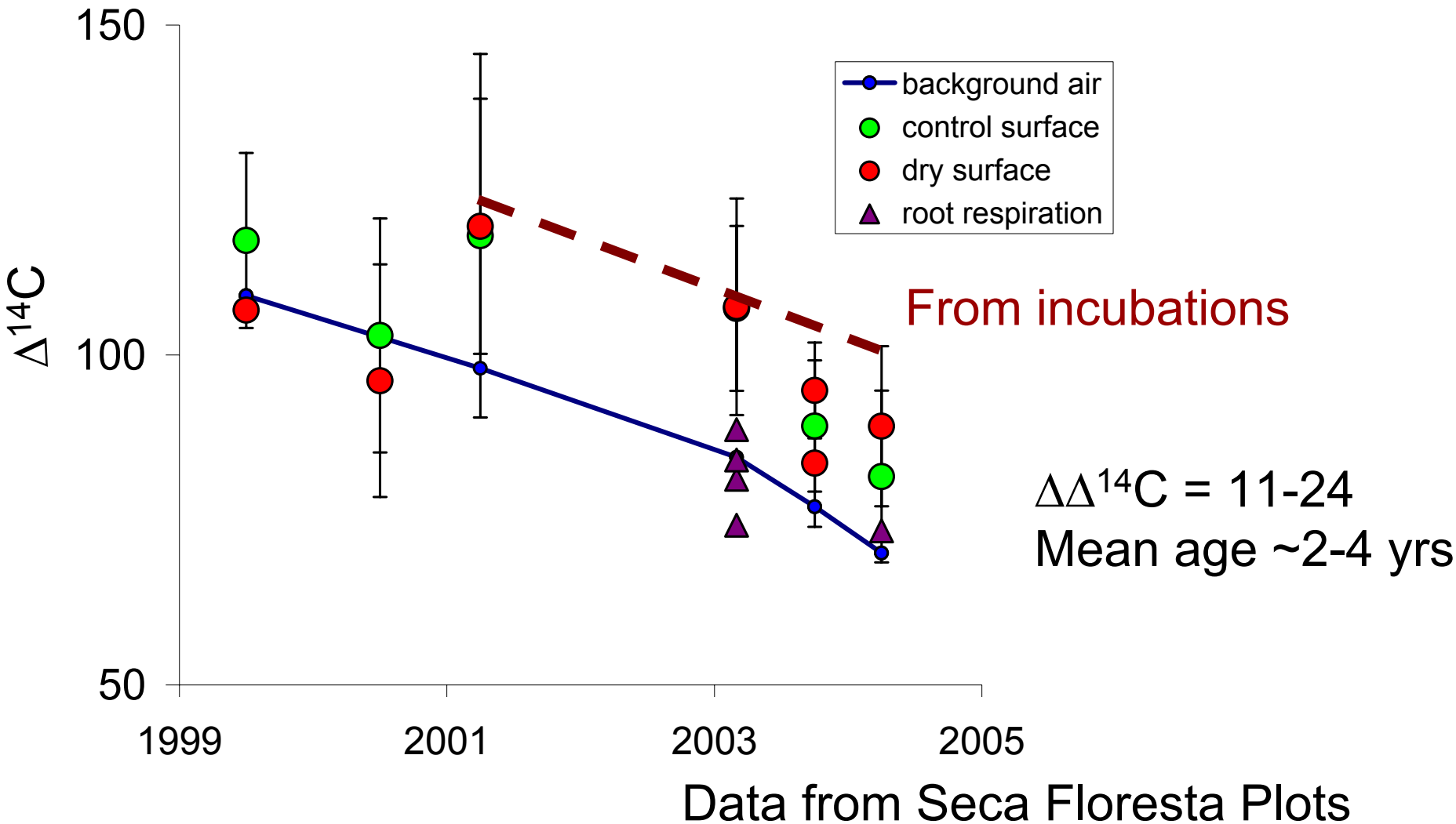


$\Delta\Delta^{14}C$ = 11-24
Mean age ~2-4 yrs

Data from Seca Floresta Plots

Heterotrophic Respiration can be **measured** by putting litter and 0-5 cm soil cores in sealed jars, then measuring the rate of CO_2 evolution and the isotopic signature of evolved CO_2.

Soil respired CO_2 is a mix of heterotrophic and autotrophic sources

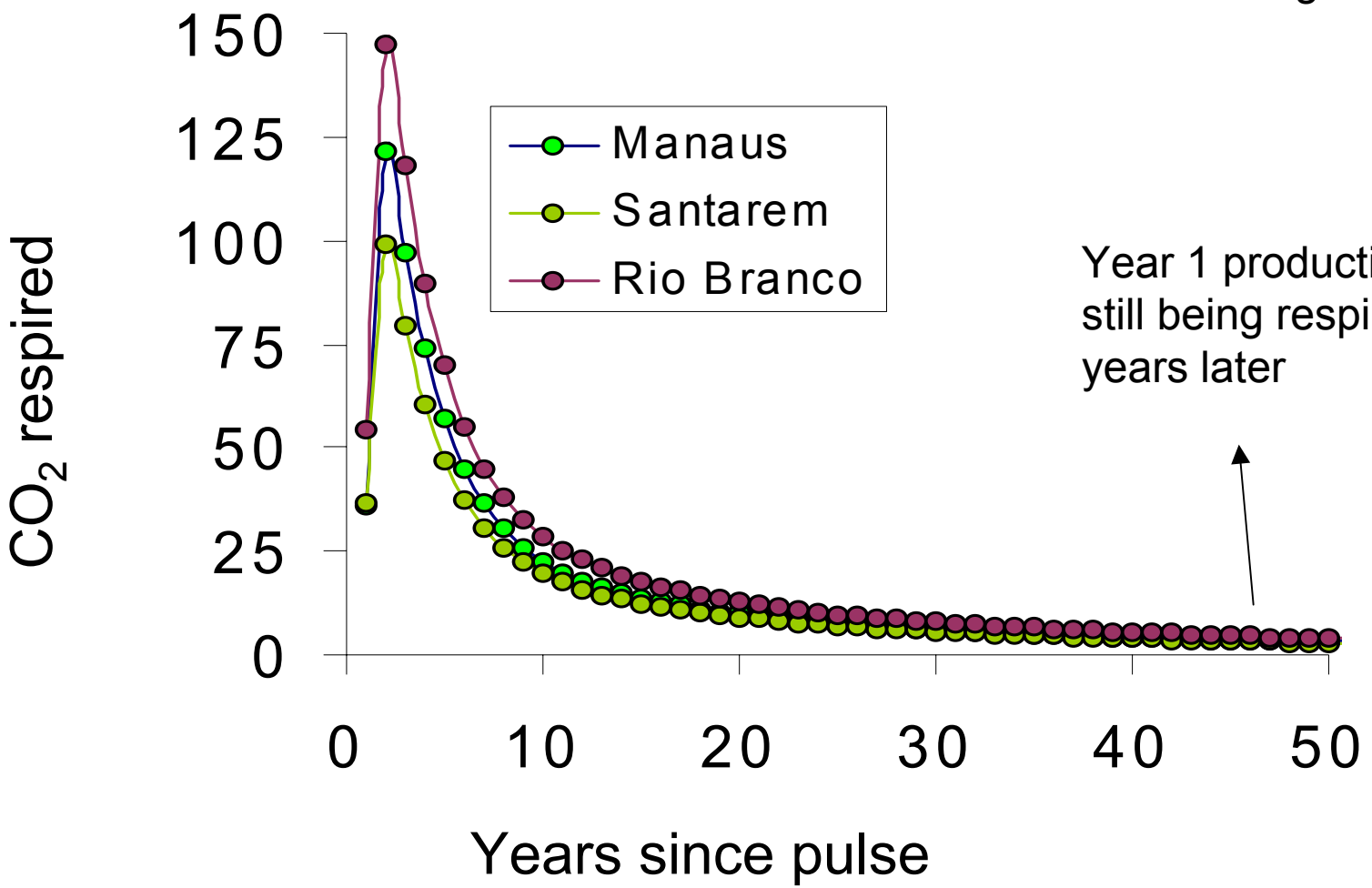


Why is heterotrophic respiration so old?

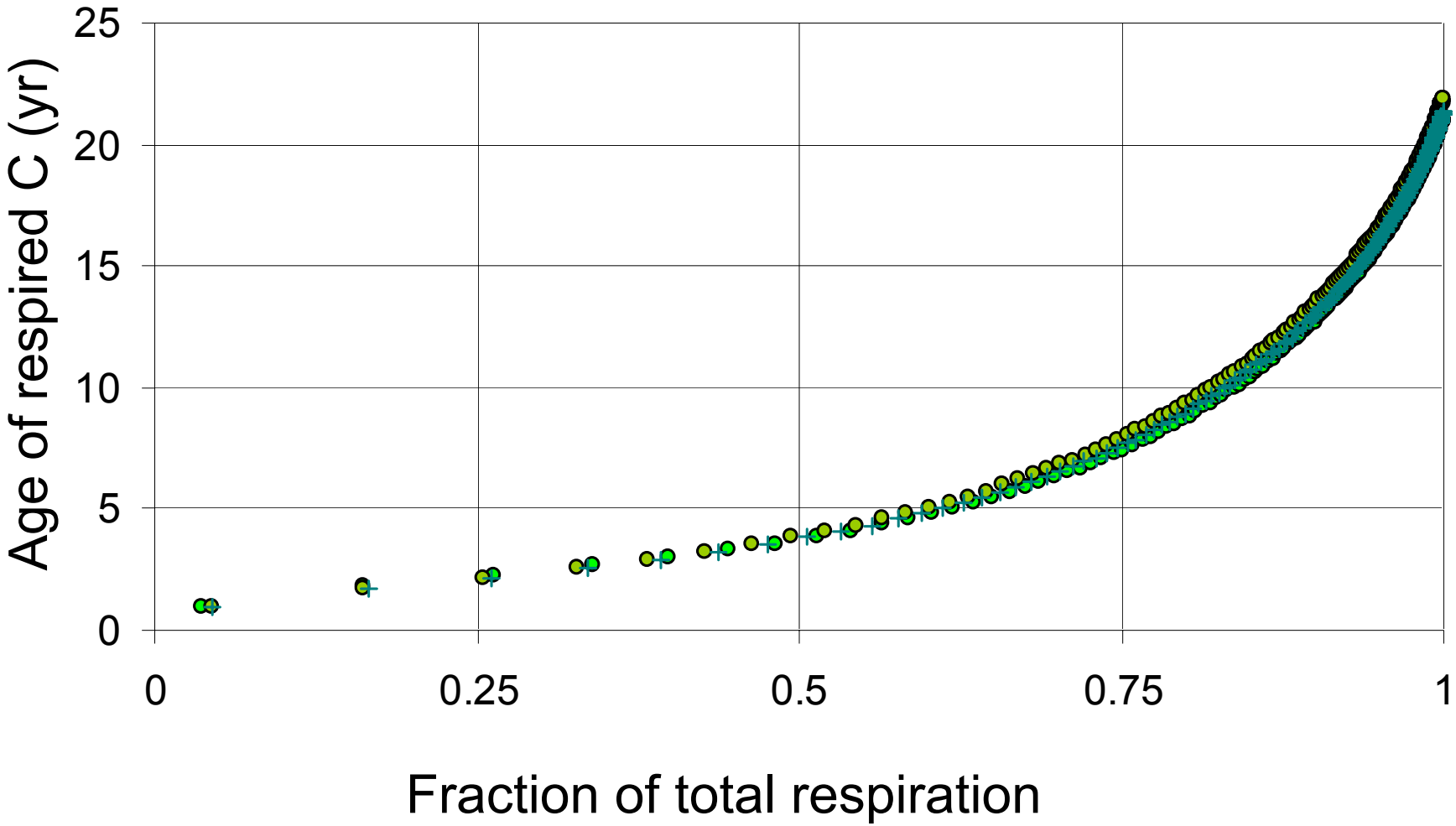
- Leaves are 2-3 years old on average before they fall to the forest floor (Telles et al. 2003); branches and woody debris will be older
- Fine roots – those that do not die and decompose rapidly live for several years to decades (Trumbore et al. 2005)
- Soil organic matter – 'Fast' turnover pools have turnover times of several years to a decade (Telles et al. 2003)

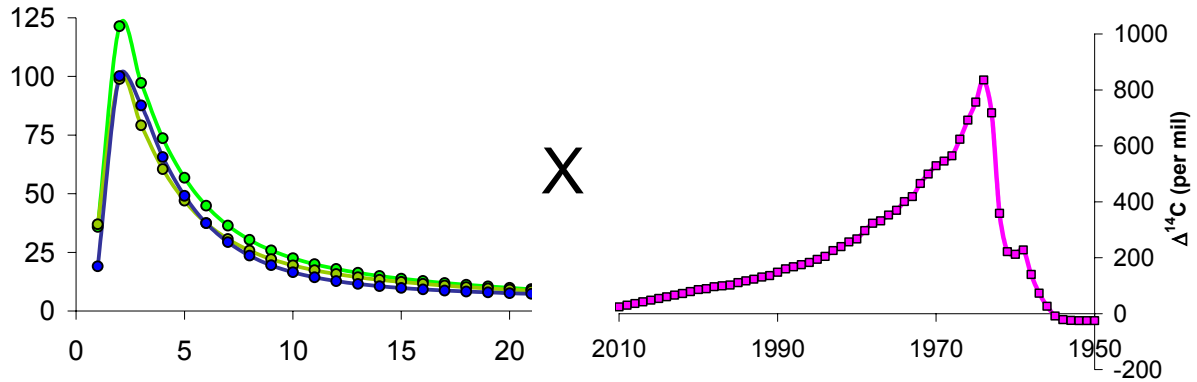
Determine age of respired CO_2 using pulse-response function for CASA

Thompson,and Randerson, Global ChangeBiol., 1999.

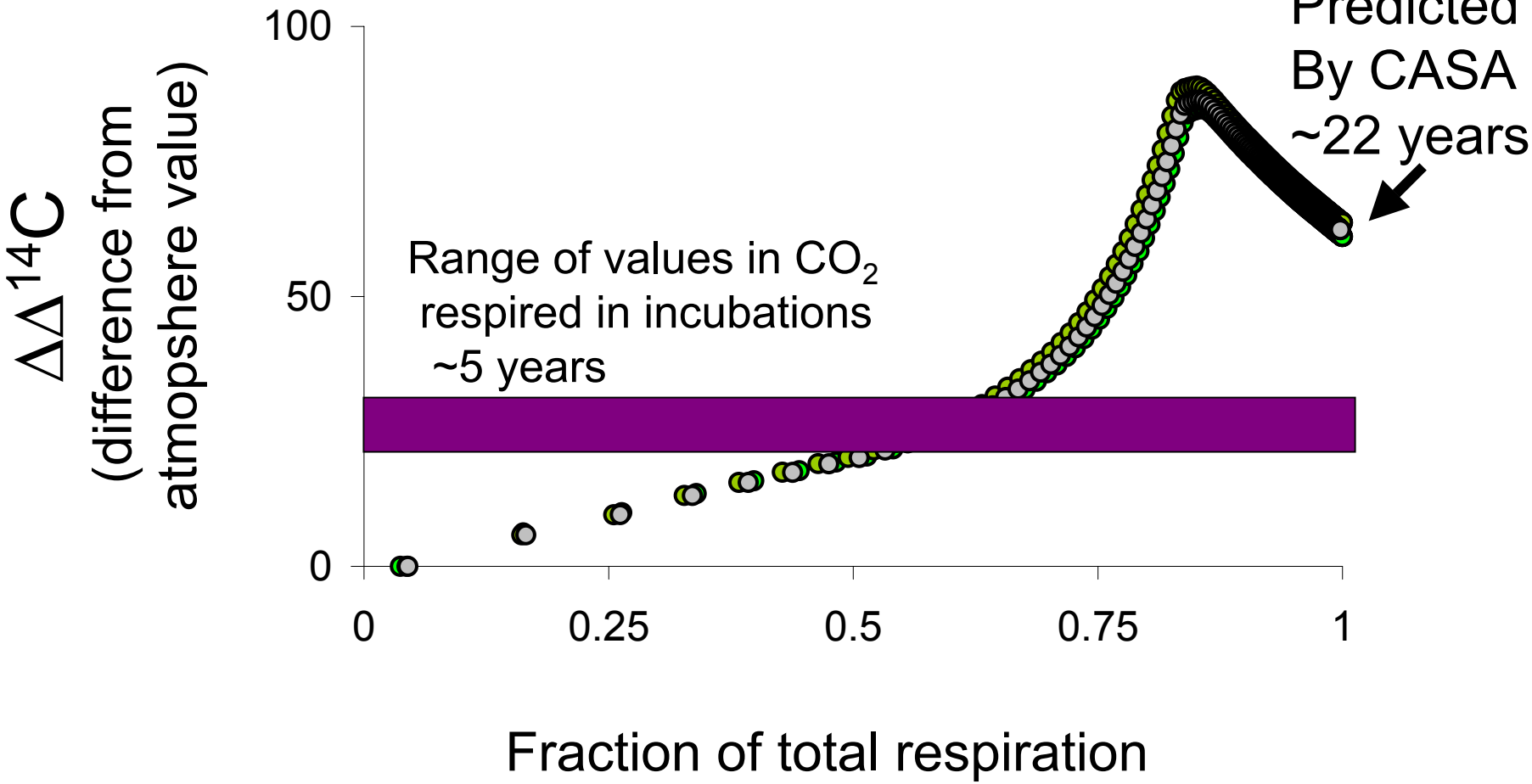


Mean age of heterotrophically respired C from CASA is 22 years but 50% is <4 years old

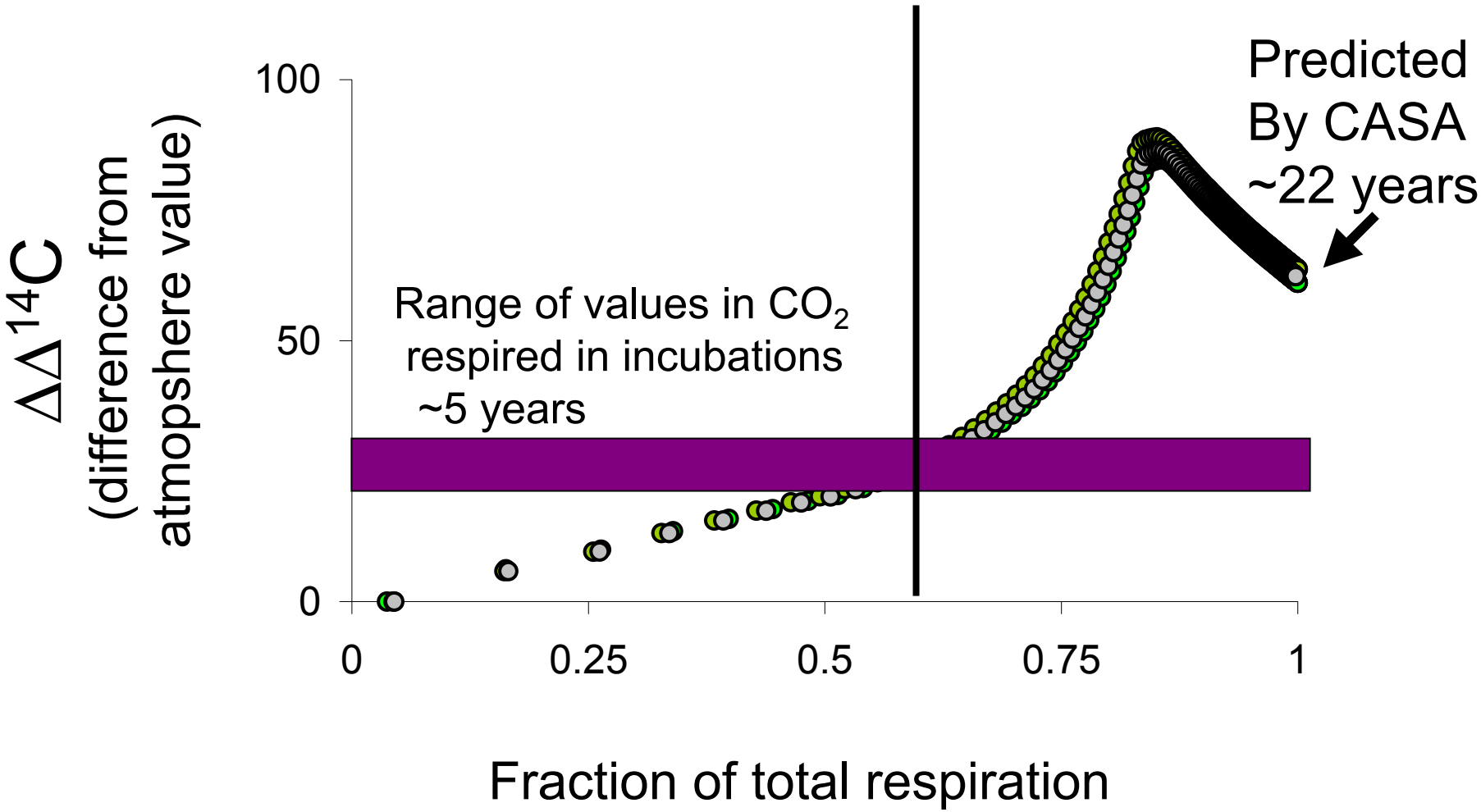




^{14}C from CASA



Model and measurements agree only for the fastest ~60% of respired CO_2 - the difference is in that long tail distribution



Problems with incubations

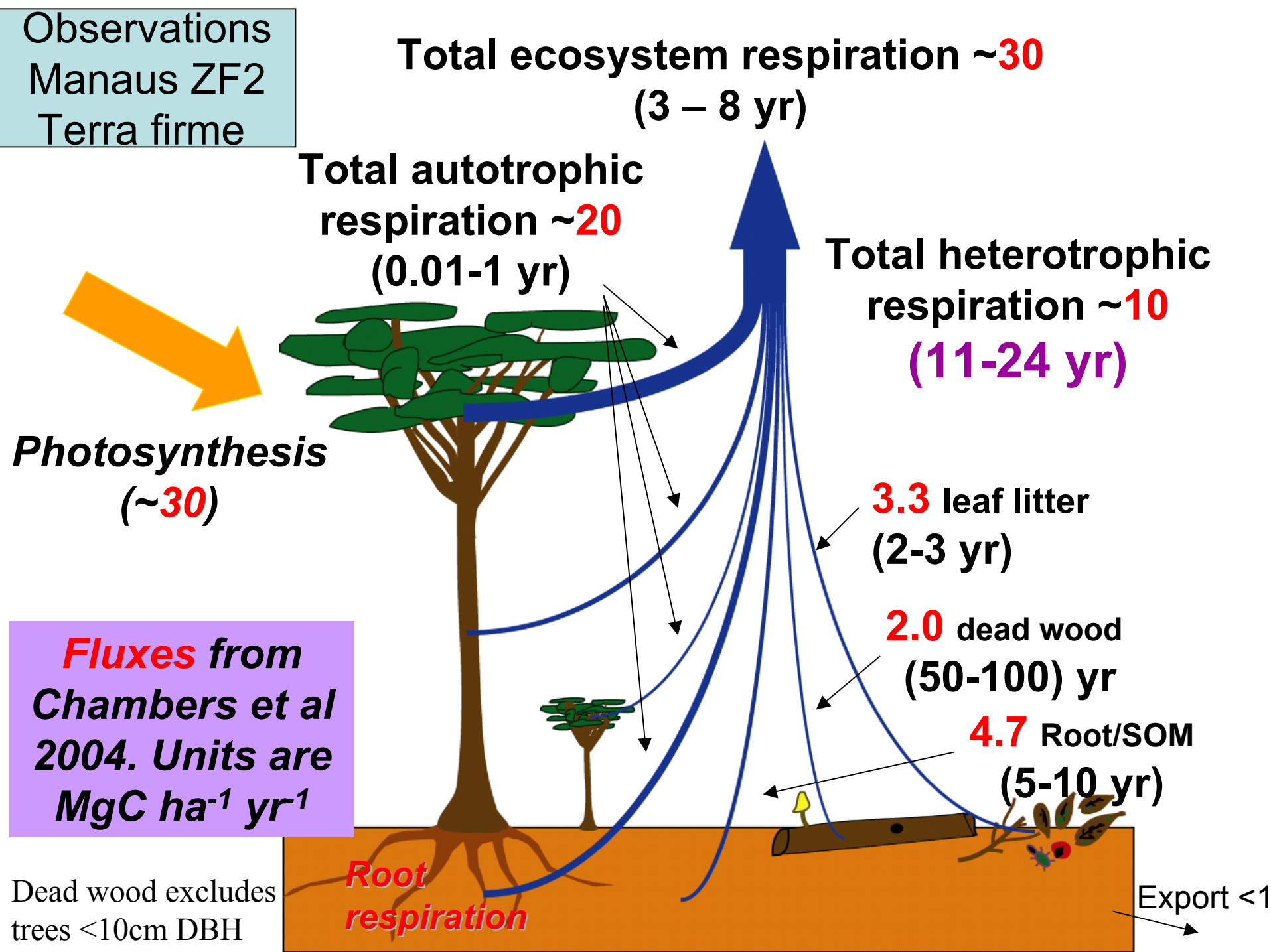
- Overemphasis of ‘young’ part of the respiration distribution
  - Exclusion of woody debris from soil sampling will bias against the longer ‘tail’
  - Artifacts with incubations in general
  - Inclusion of roots in incubations emphasizes ‘young’ pools

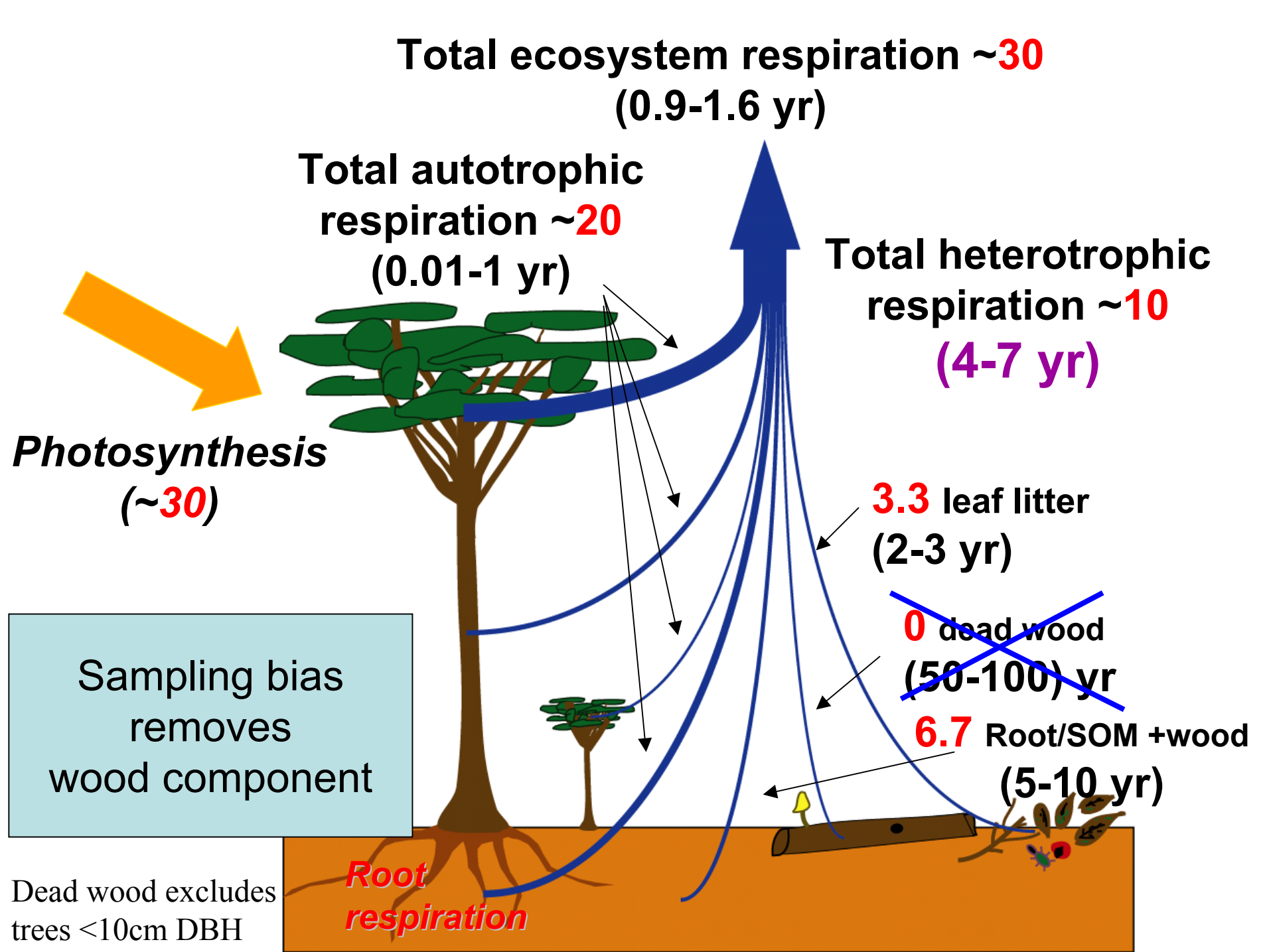
Potential issues with CASA

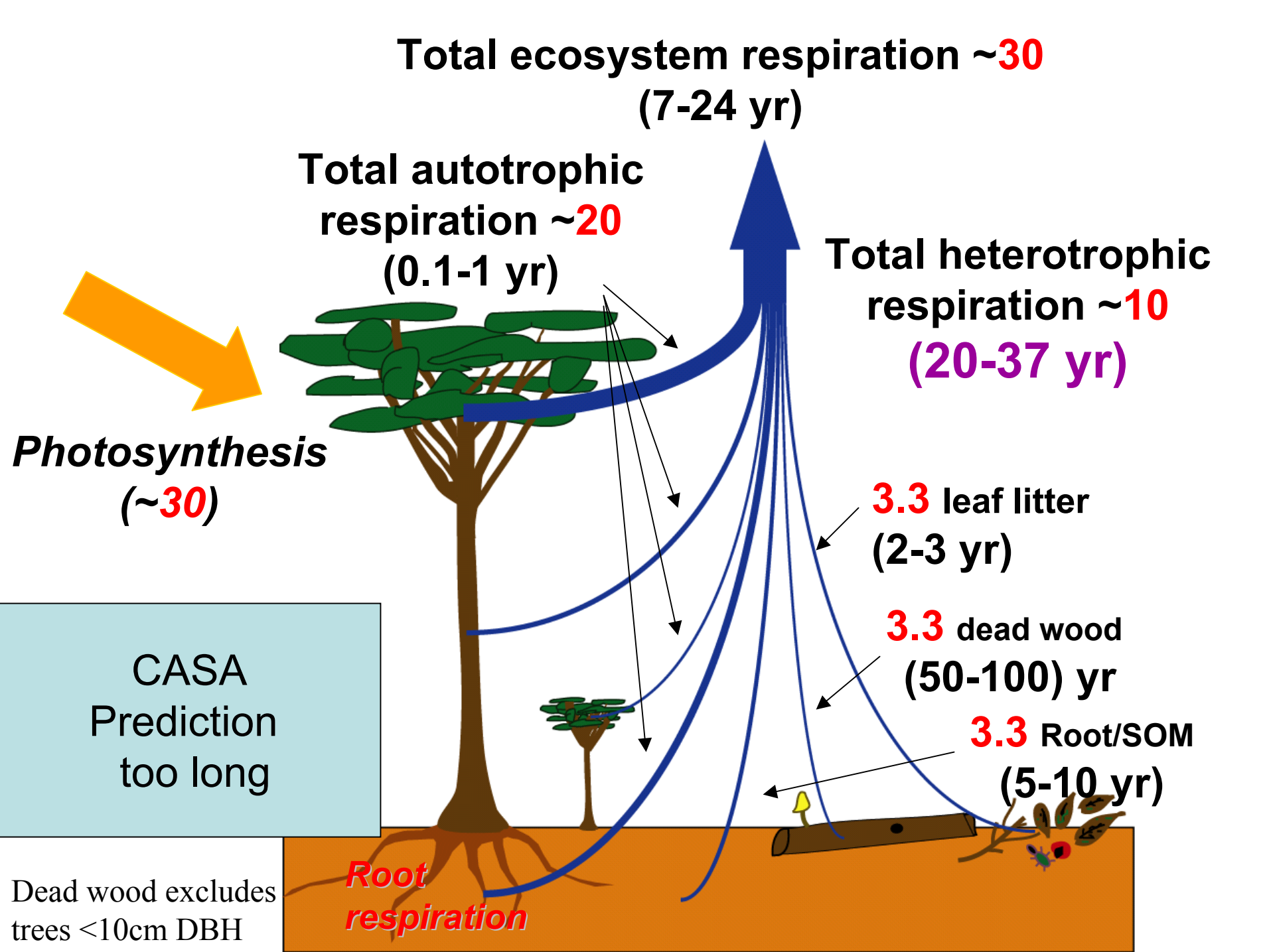
Too long of a ‘tail’

- treatment of the wood pool – wrong turnover time (certainly true in Manaus, maybe not for Santarem) Vieira et al. in revision PNAS)

- model may allocate too much NPP to stem growth in tropical forests (stem allocation <1/3 of NPP)


Observations
Manaus ZF2
Terra firme
Total ecosystem respiration ~30
(3 – 8 yr)
Total autotrophic
respiration ~20
(0.01-1 yr)
Total heterotrophic
respiration ~10
(11-24 yr)
Photosynthesis
(~30)
3.3 leaf litter
(2-3 yr)
2.0 dead wood
(50-100) yr
4.7 Root/SOM
(5-10 yr)
Fluxes from
Chambers et al
2004. Units are
MgC ha-1 yr-1
Root
respiration
Export <1
Dead wood excludes
trees <10cm DBH


Total ecosystem respiration ~30
(0.9-1.6 yr)
Total autotrophic respiration ~20
(0.01-1 yr)
Total heterotrophic respiration ~10
(4-7 yr)
Photosynthesis
(~30)
3.3 leaf litter
(2-3 yr)
0 dead wood
(50-100) yr
6.7 Root/SOM +wood
(5-10 yr)
Sampling bias removes wood component
Root respiration
Dead wood excludes trees <10cm DBH


Total ecosystem respiration ~30
(7-24 yr)
Total autotrophic respiration ~20
(0.1-1 yr)
Total heterotrophic respiration ~10
(20-37 yr)
Photosynthesis
(~30)
3.3 leaf litter
(2-3 yr)
3.3 dead wood
(50-100) yr
3.3 Root/SOM
(5-10 yr)
CASA Prediction too long
Root respiration
Dead wood excludes trees <10cm DBH

Interannual variability in C fluxes

- Wood increment ~ 0.7 MgC ha^{-1} yr^{-1} (15 - 20%)
  (Vieira et al 2004)
- Litterfall ~ 0.7 MgC ha^{-1} yr^{-1} (10 - 16%)
- Mortality can vary 3-fold from one year to the next (at least equal to wood increment variations)
- If coherent over large areas of the basin, these are globally significant
- Are we likely to see a forest at steady state? Time lags of ~5-20 years between production and decomposition mean that periodic changes in GPP will lead to periodic changes in NEP

Conclusion

The longer term components (SOM, wood) make up 25-30% of the respiration on an annual basis but are critical for understanding time lags - hence C storage or interannual variability