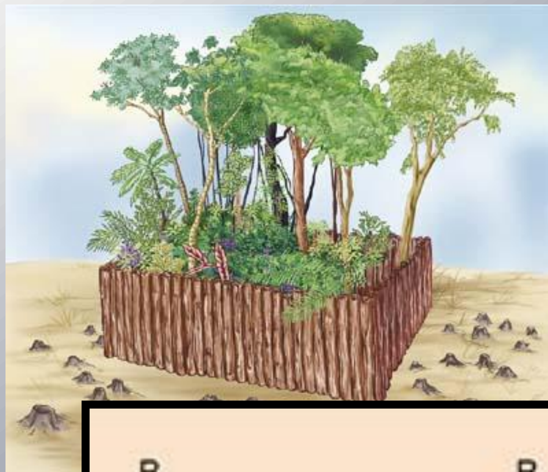
NPP: Chamber approaches

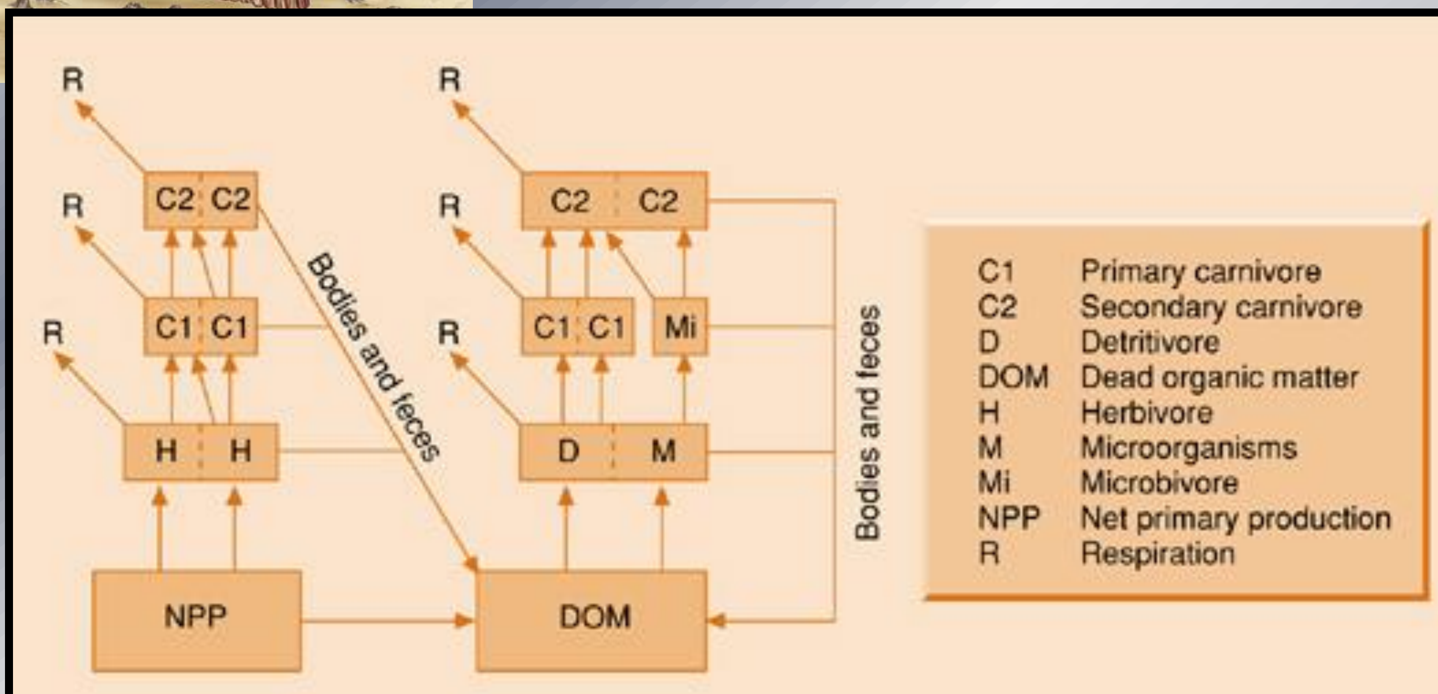
Phil Ineson
University of York

Picture: Moor House; Pennines



Ecosystem energy flow

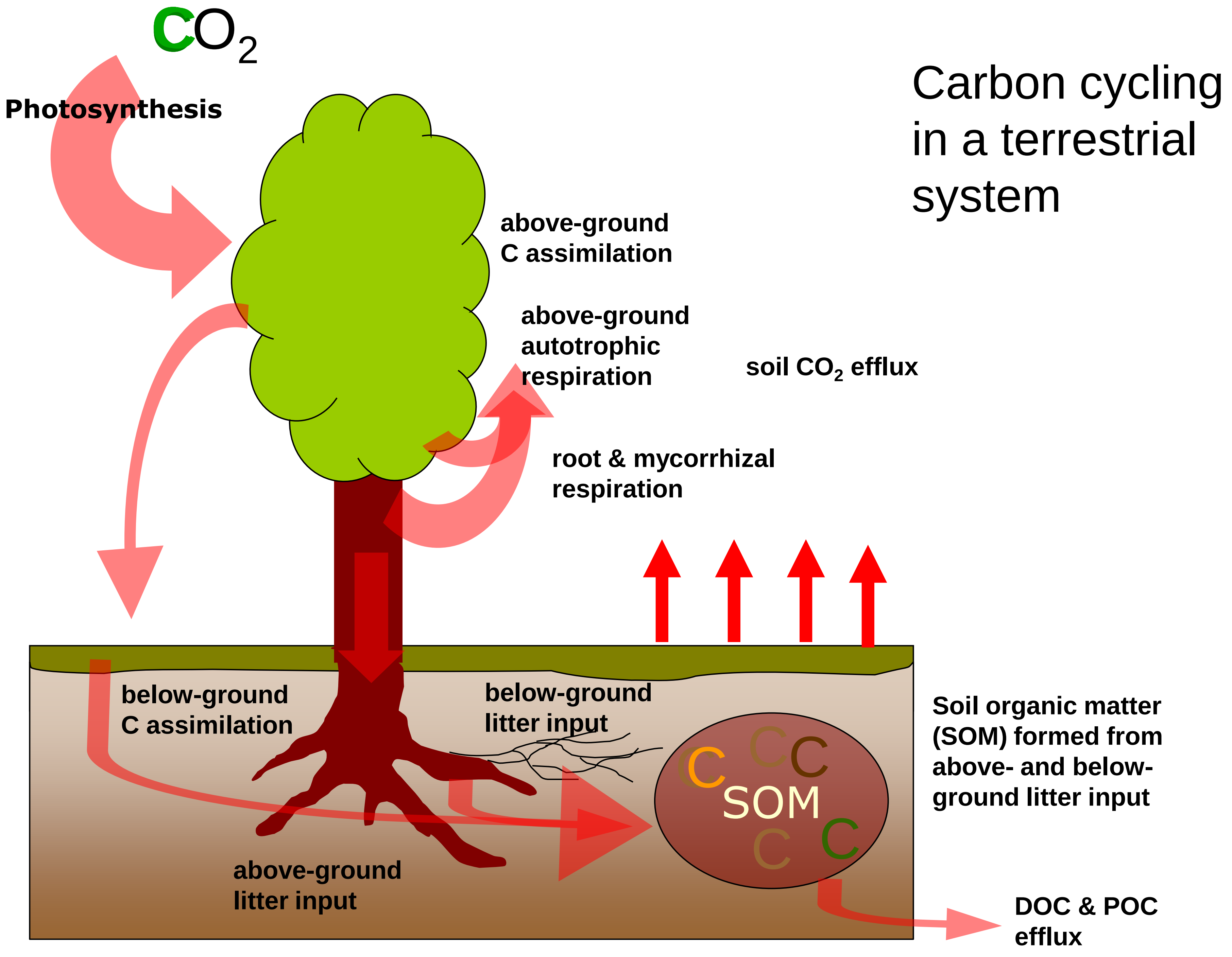
Generalized model of energy flow through a food web (Heal & MacLean, 1975 - developed during the IBP)

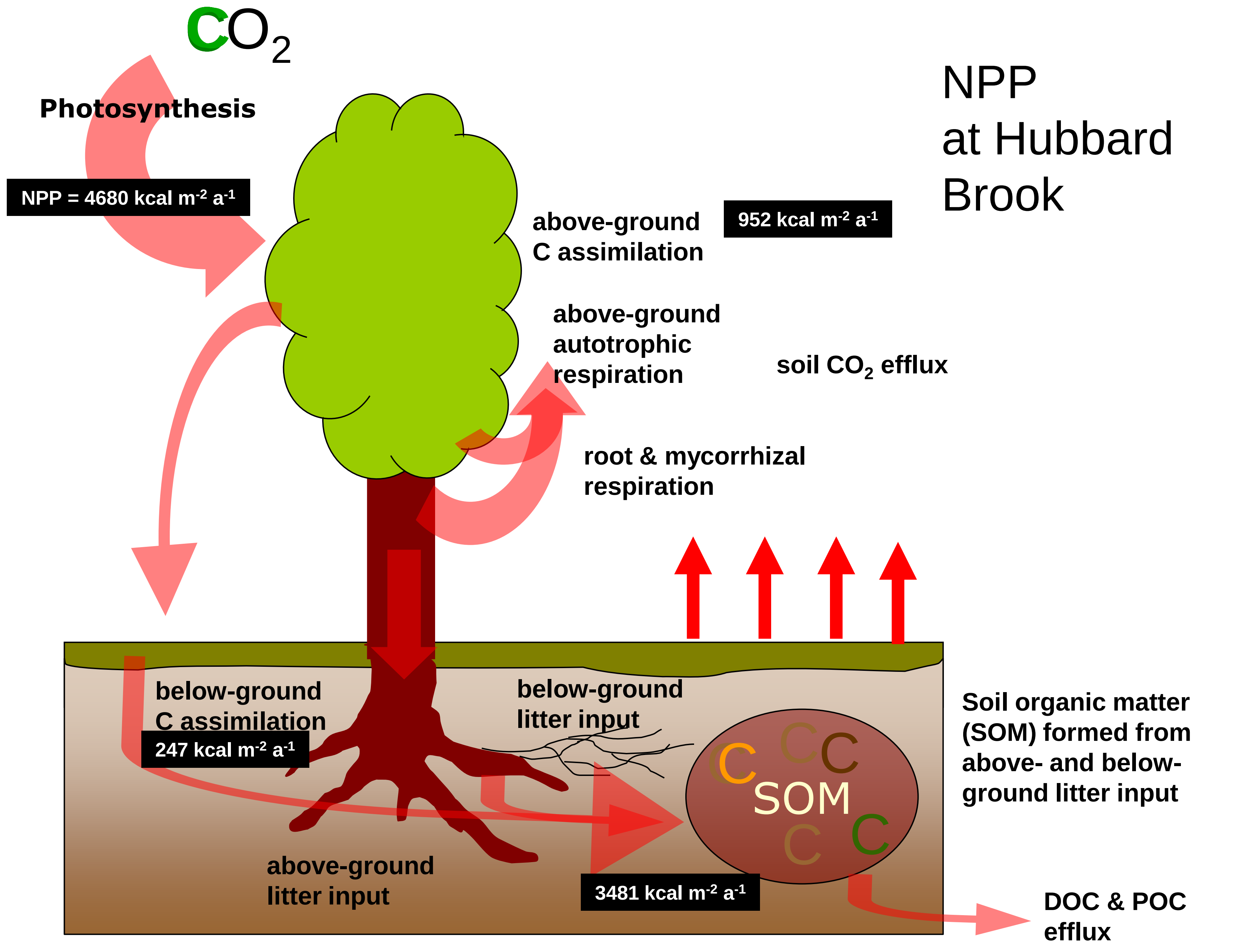


R

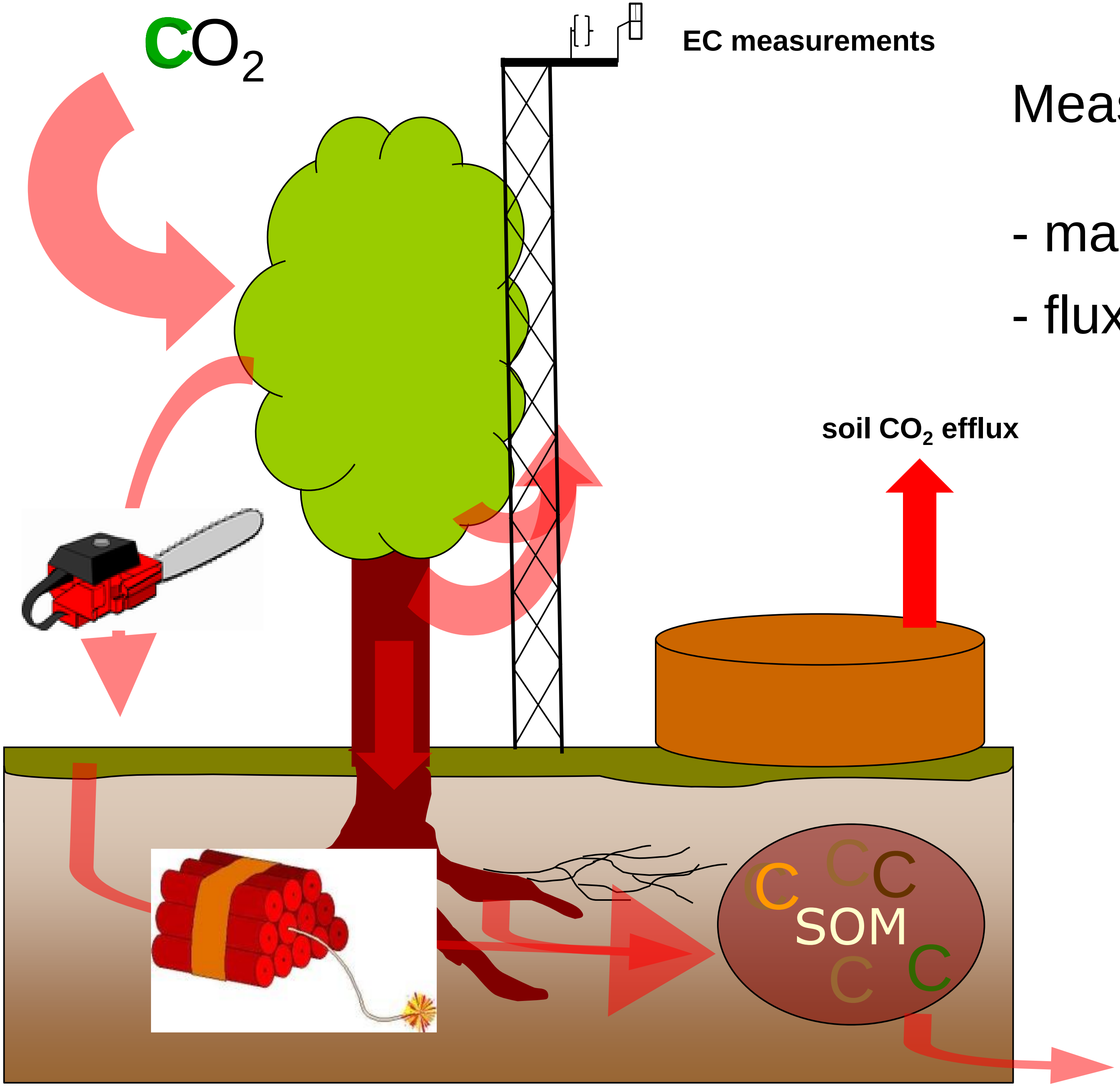
GPP

Solar energy input


CO2
Photosynthesis
Carbon cycling in a terrestrial system
above-ground C assimilation
above-ground autotrophic respiration
soil CO2 efflux
root & mycorrhizal respiration
below-ground C assimilation
below-ground litter input
SOM
Soil organic matter (SOM) formed from above- and below-ground litter input
above-ground litter input
DOC & POC efflux



CO_2
Photosynthesis
NPP = 4680 kcal m-2 a-1
NPP
at Hubbard
Brook
above-ground
C assimilation
952 kcal m-2 a-1
above-ground
autotrophic
respiration
soil CO_2 efflux
root & mycorrhizal
respiration
below-ground
C assimilation
247 kcal m-2 a-1
below-ground
litter input
C C C
SOM
C C
Soil organic matter
(SOM) formed from
above- and below-
ground litter input
above-ground
litter input
3481 kcal m-2 a-1
DOC & POC
efflux



Measurements:

- mass balance
- fluxes

NPP: Difficult/impossible to measure?

- **Has anybody ever really accurately measured net primary productivity?**
- **Mass balance approaches - a small change in a large number**
- **Fluxes – assumptions and errors in measurement**

$^{13}CO_2$ pulse labelling with Peter Högberg at Vindeln

- N-fertilisation vs control
- Deep soil collars vs surface collars
- Atmospheric $^{13}CO_2$ label in excess of 17000 ‰


YH02 JUF

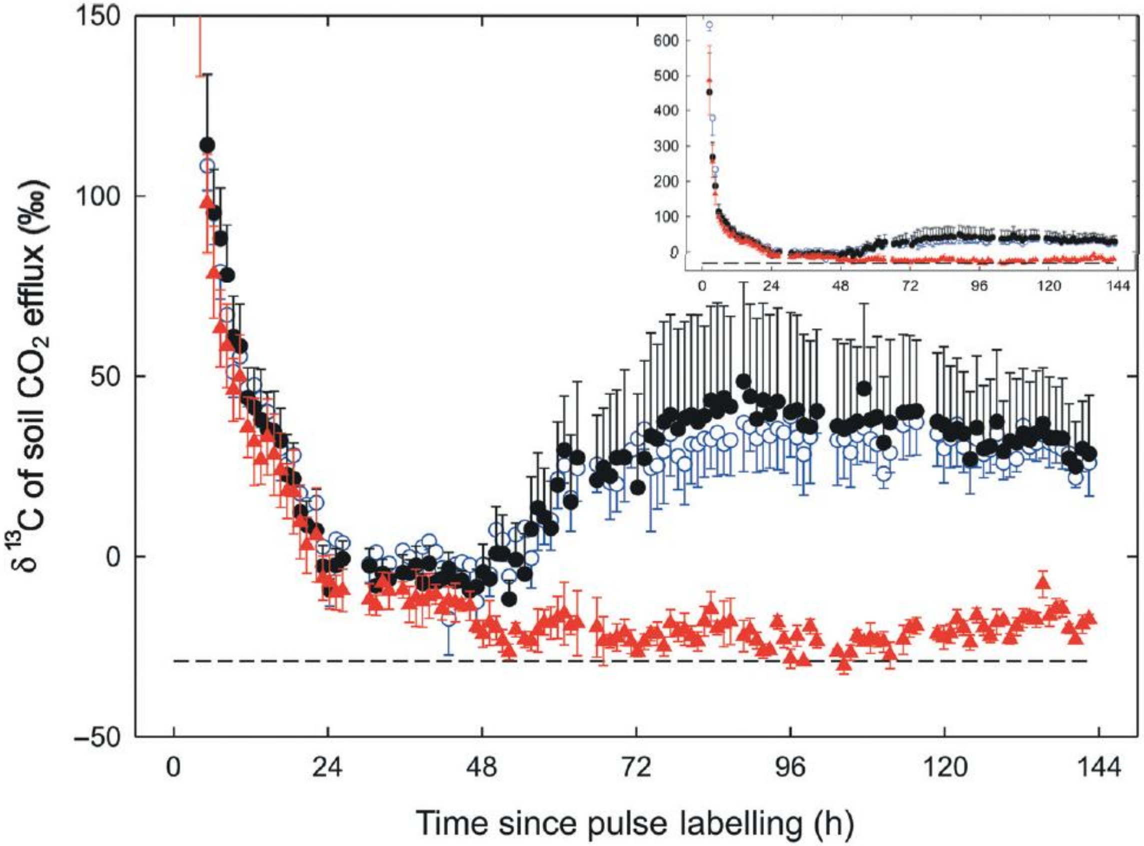
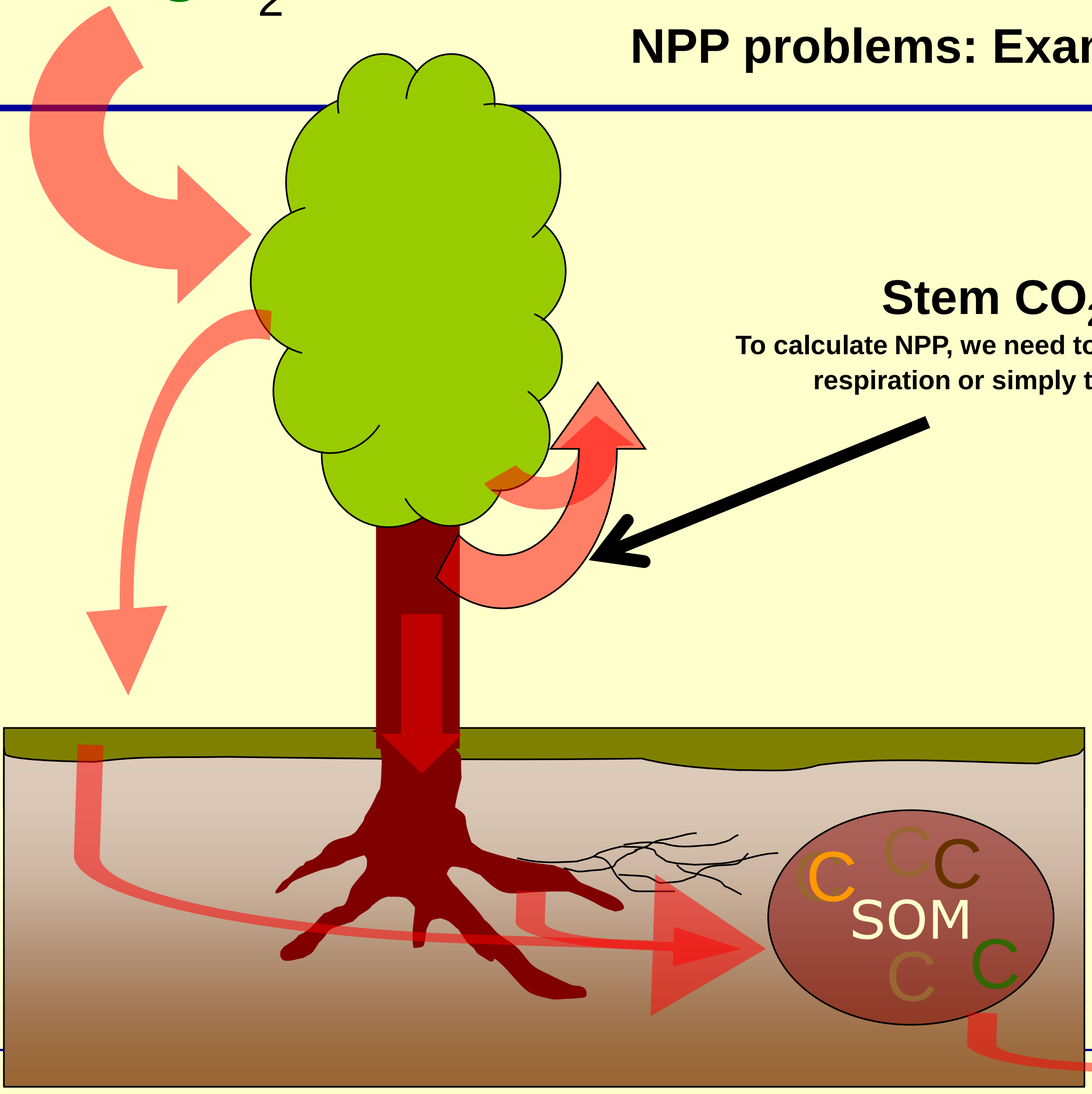


Fig. 1 δ^{13}C of soil CO_2 efflux following stand-level $^{13}CO_2$ pulse labelling. Symbols mean values of surface collars in plot 1 (bl circles) and plot 2 (open blue circles), and deep collars in plot 1 (red triangles). Error b are standard errors, and for the two surfa flux means are indicated in one direction c to aid clarity. The dashed line represents m isotopic composition of natural abundanc soil CO_2 efflux (mean of collars before pu labelling). The *y*-axis is scaled to a maxim of 150‰ for δ^{13}C, but isotopic values following the pulse reached values of up t 644‰ (see in-set graph; axis labels are th same as in the main graph).

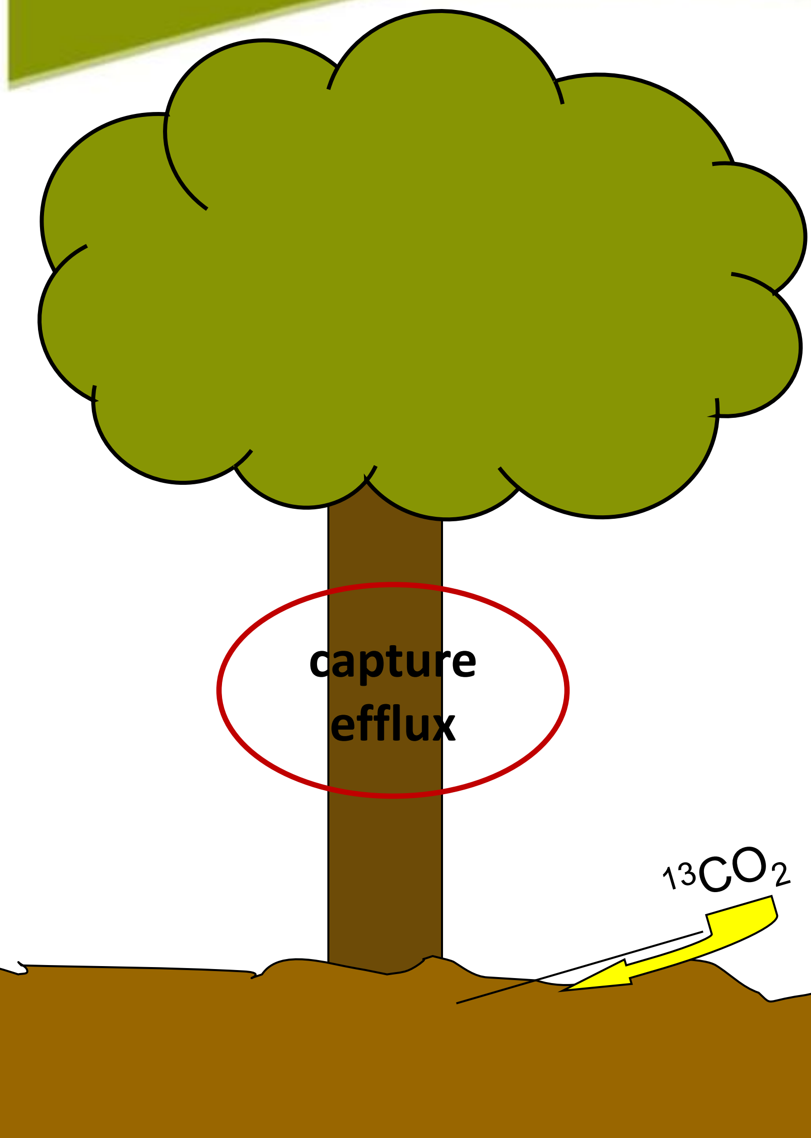
NPP problems: Example 1



Stem CO_2 efflux –

To calculate NPP, we need to know if is this autotrophic respiration or simply transported soil CO_2?

Objectives and Method

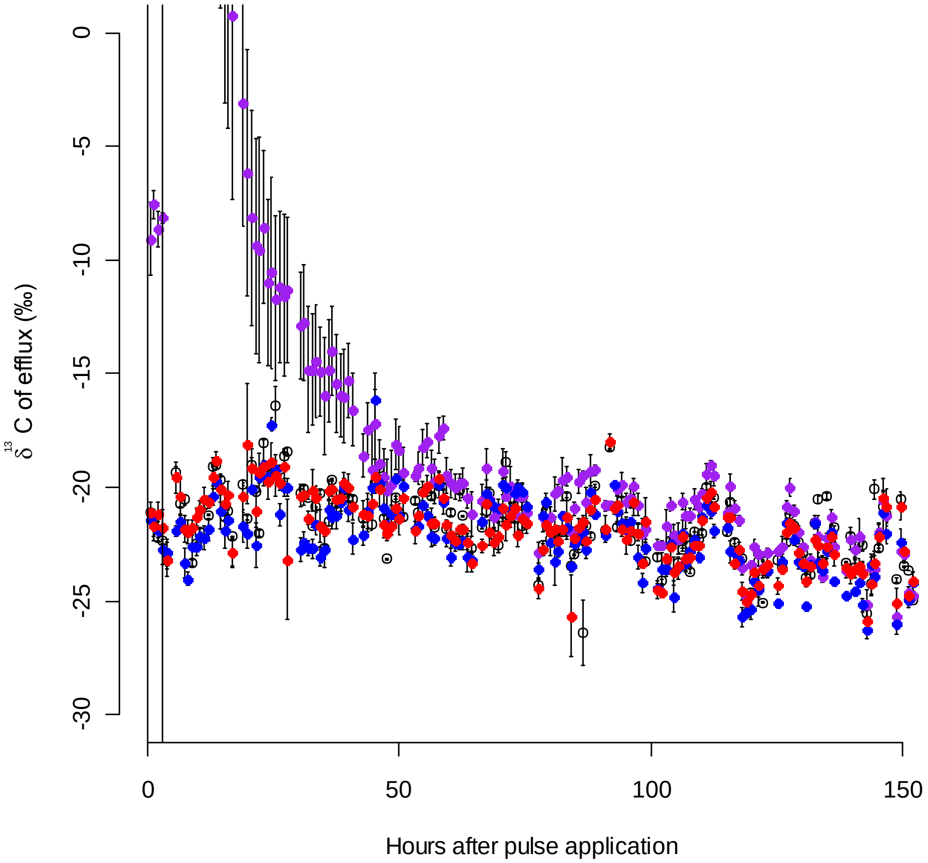


- Gaseous CO_2 label pumped into the soil to strongly label soil airspace
- Chamber for capturing stem CO_2 efflux

- Measure abundances of $^{12}CO_2$ and $^{13}CO_2$
- Measure $[CO_2]$ and $\delta^{13}C$

No evidence for soil CO_2 in stem efflux

- Clear return of pulse label from soil over 2.5 days after labelling
- No difference between **control** and **treated stems,** no $\delta^{13}C$ spike visible, no significant treatment effect
- No evidence for uptake of $^{13}CO_2$ tracer across the roots

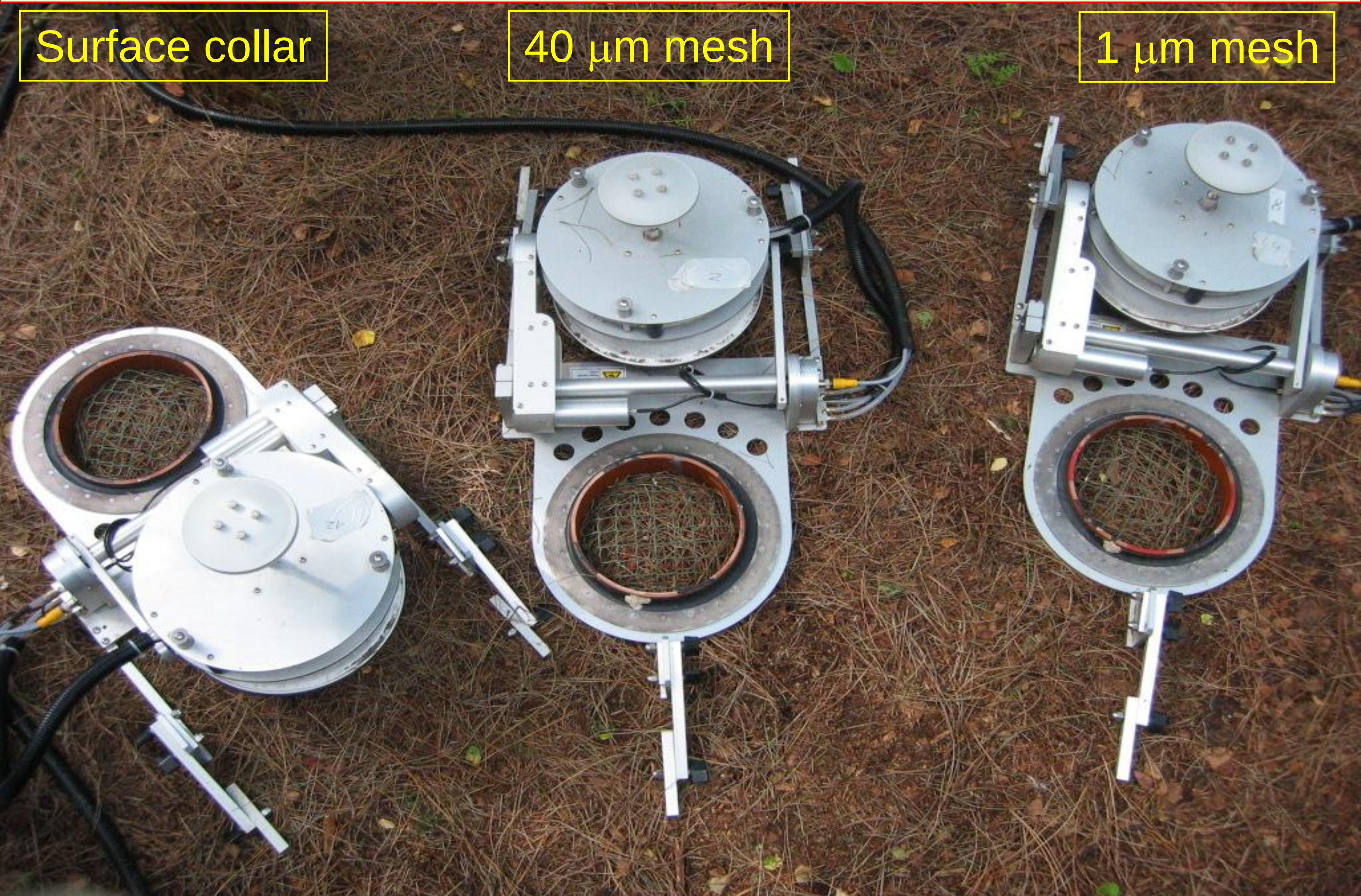


NPP problems: Example 2

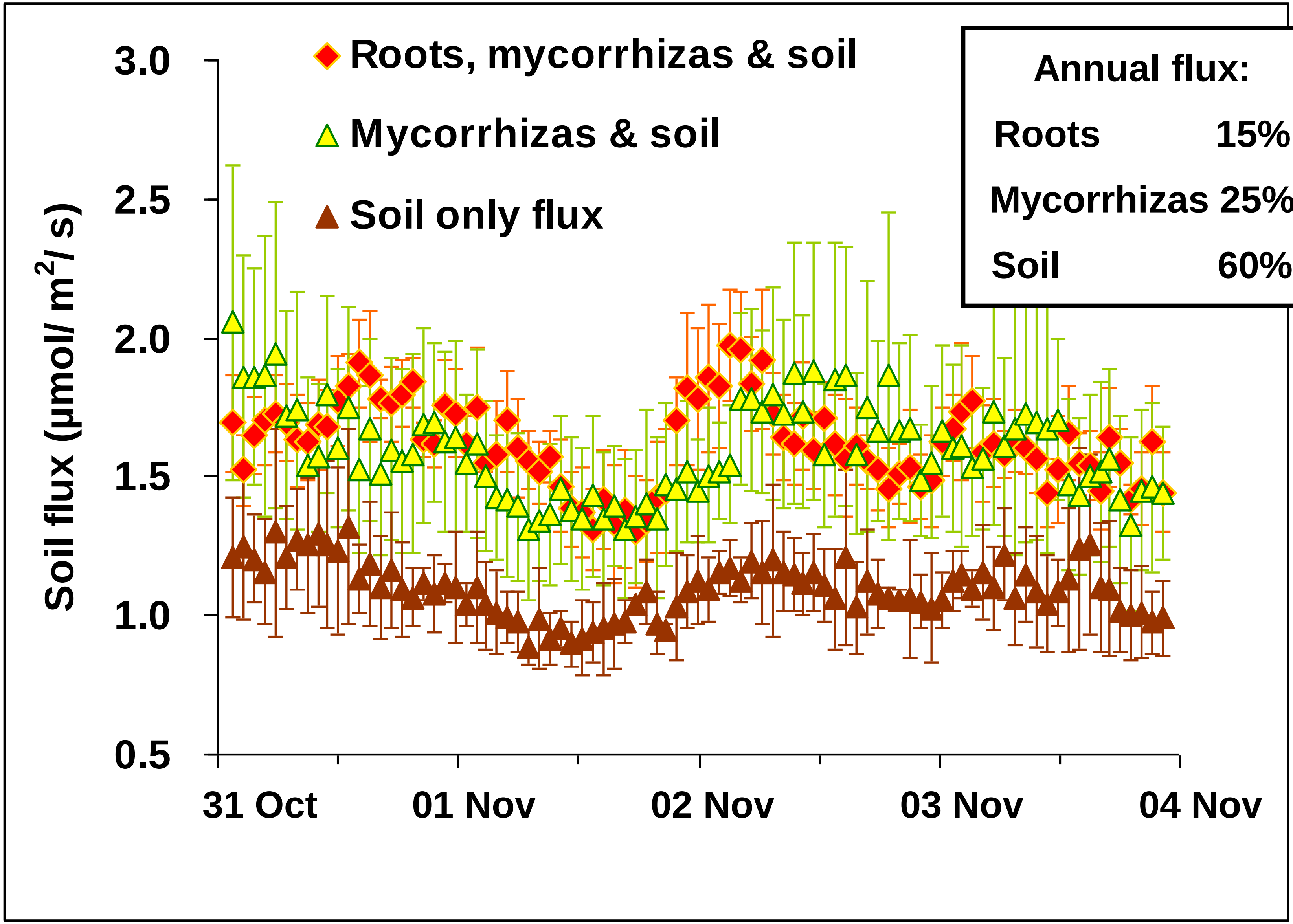
Is mycorrhizal C flux part of NPP or detrivore system?

Photo courtesy of Paula Flynn, Iowa State University Extension

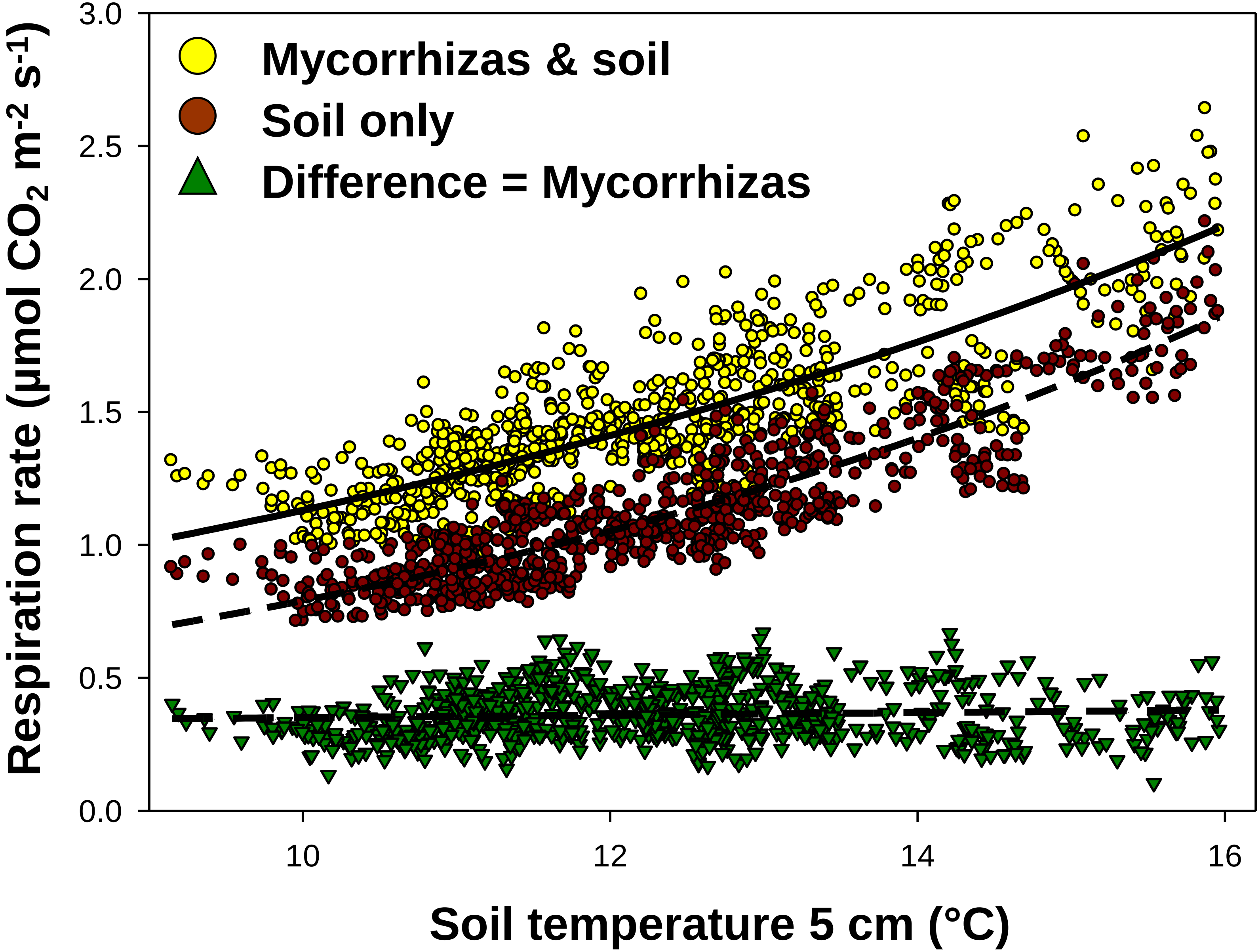
Forests: component fluxes

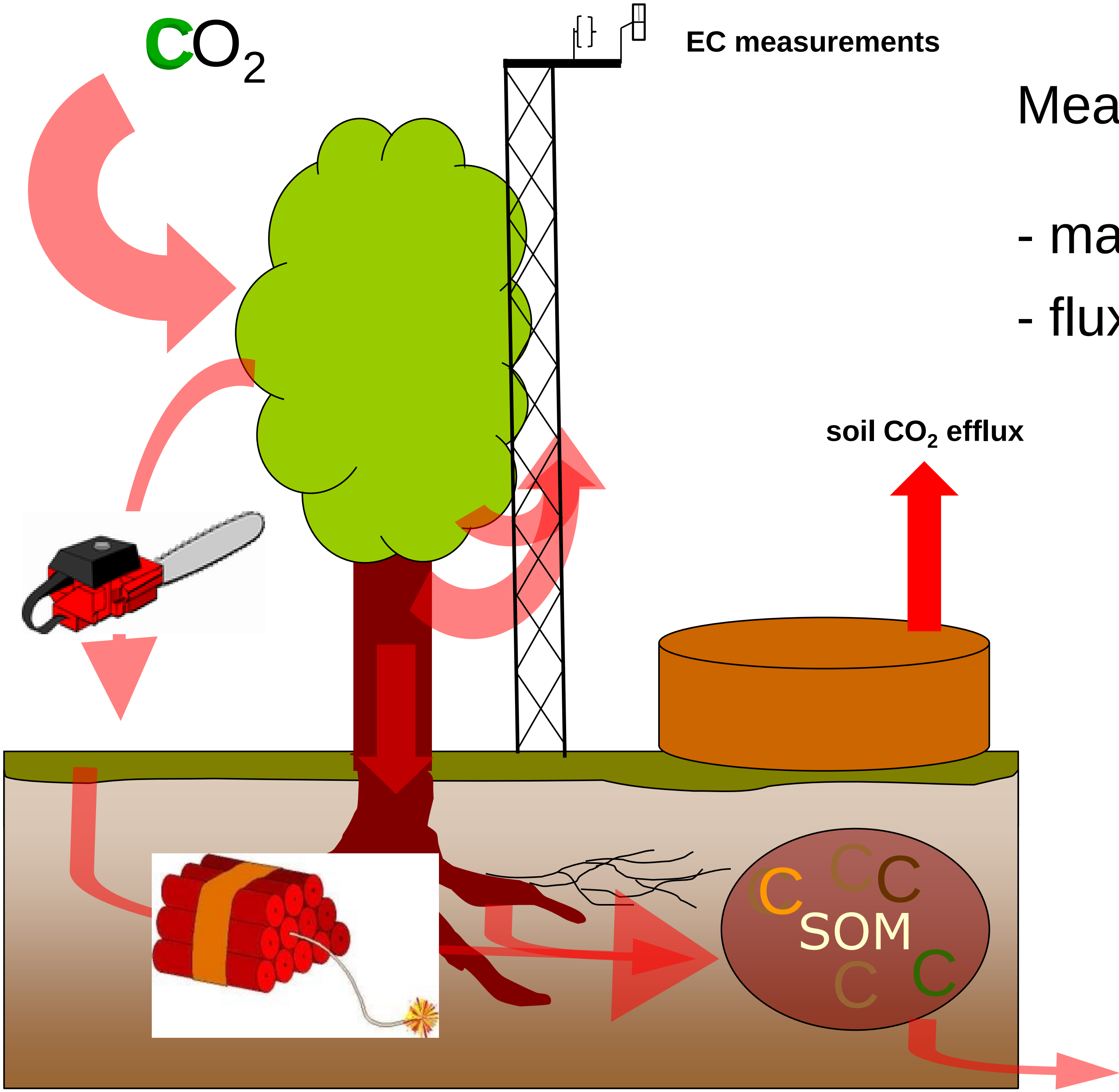


Coniferous system: forest soil CO_2 output



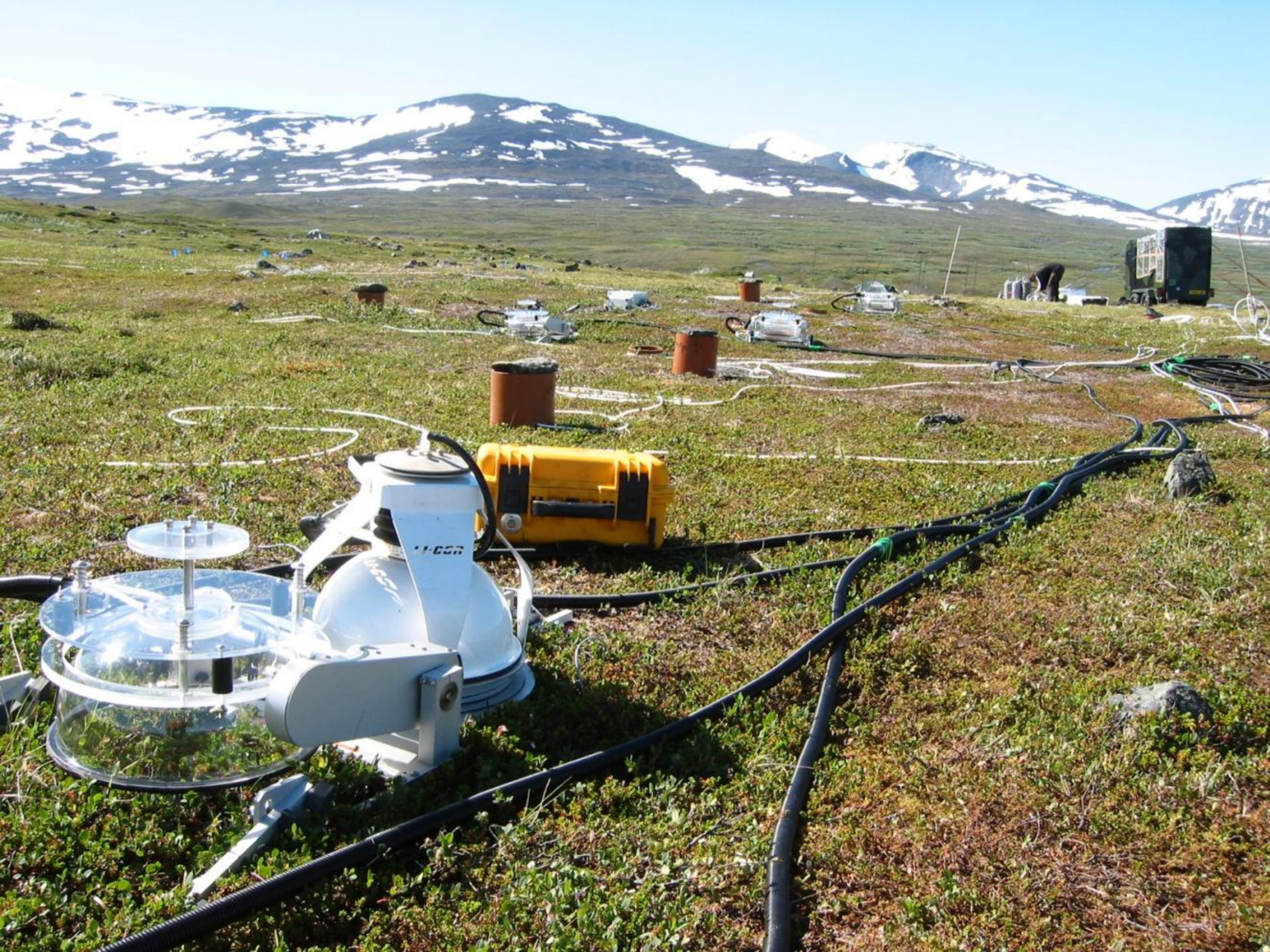
Temperature sensitivity





Measurements:

- mass balance
- fluxes



NEE: Comparison of C mass balance and flux methods

Absolute fluxes derived from chamber measurements have frequently been questioned :

- chamber pressure, humidity and temperature artifacts
- a need for dynamic mixing of air in the chambers during measurements
- debate about which regressions to use for flux calculations

Objective
Test the hypothesis that chambers give the same results as mass balance approaches

Method
Established 12 replicated grass mesocosms for which all carbon inputs (e.g. seeds) and outputs (e.g. in drainage water) were measured and accounted over a 4 month period. This is normally not possible to assess because of measuring small changes in large C pools.

NEE: Comparison of C mass balance and flux methods

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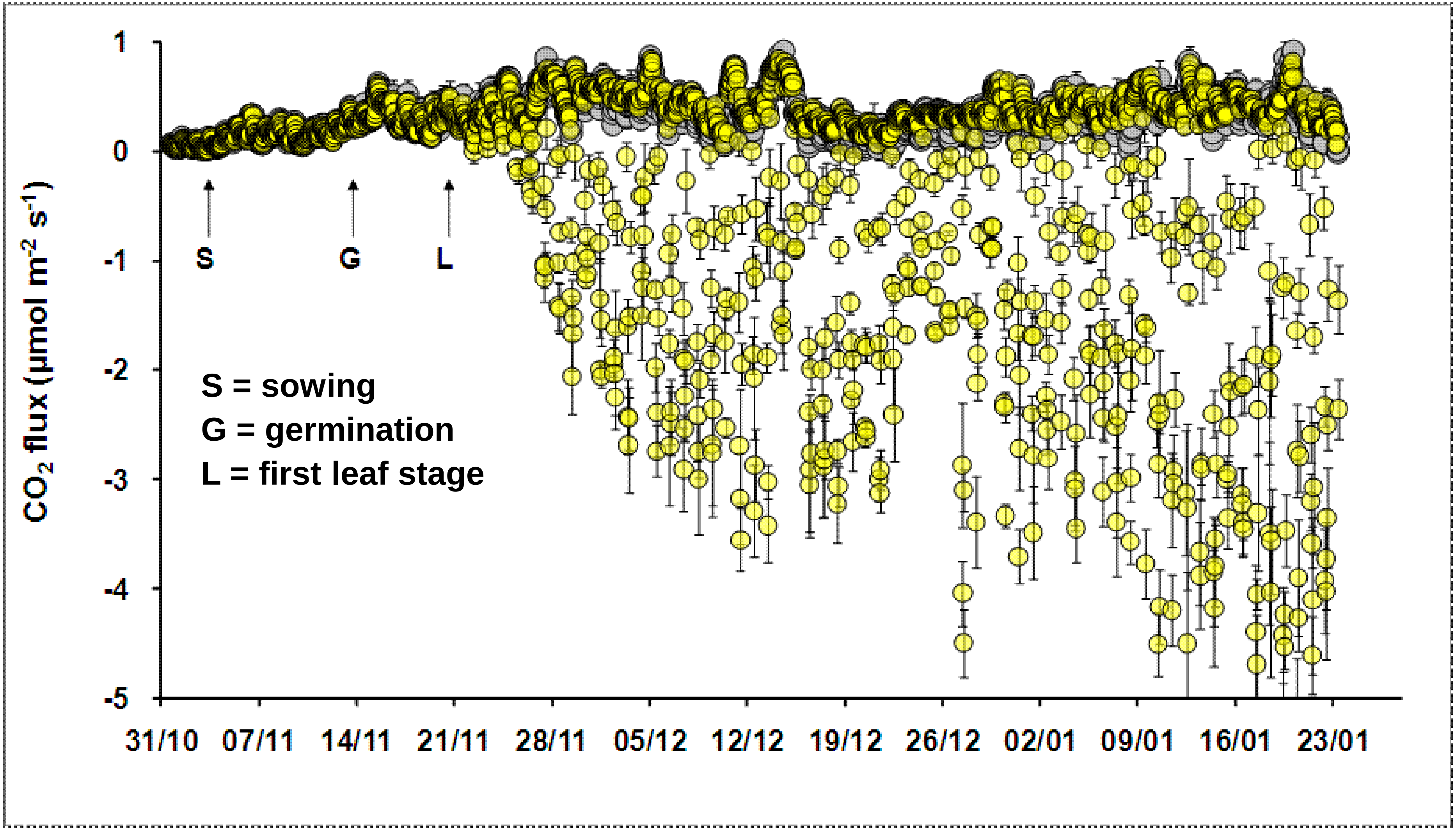
CO_2 flux under dark ○ and transparent ○ chambers?



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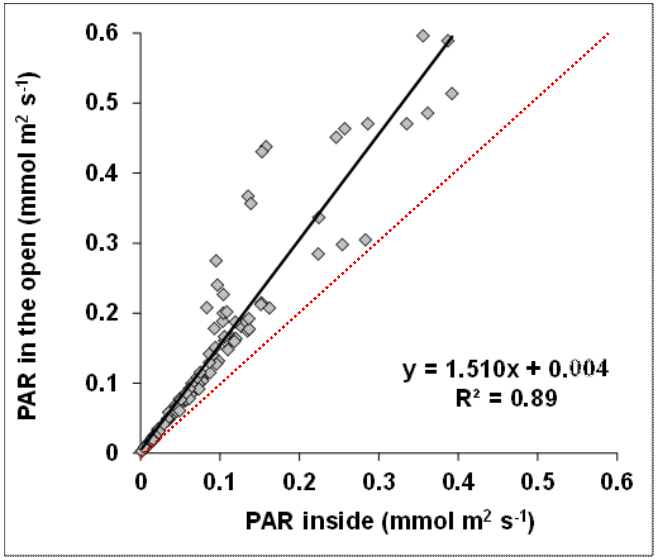
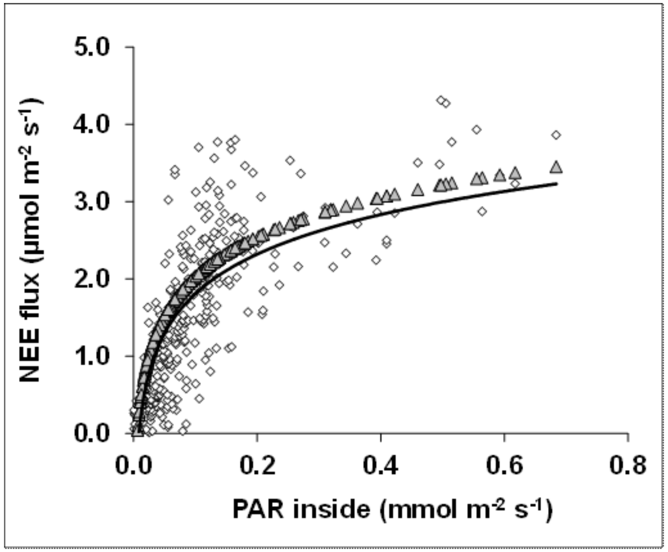
Allowing for chamber PAR interception



a) Comparison of PAR outside and inside the transparent chambers



b) Essential to create a PAR/NEE curve to correct for chamber

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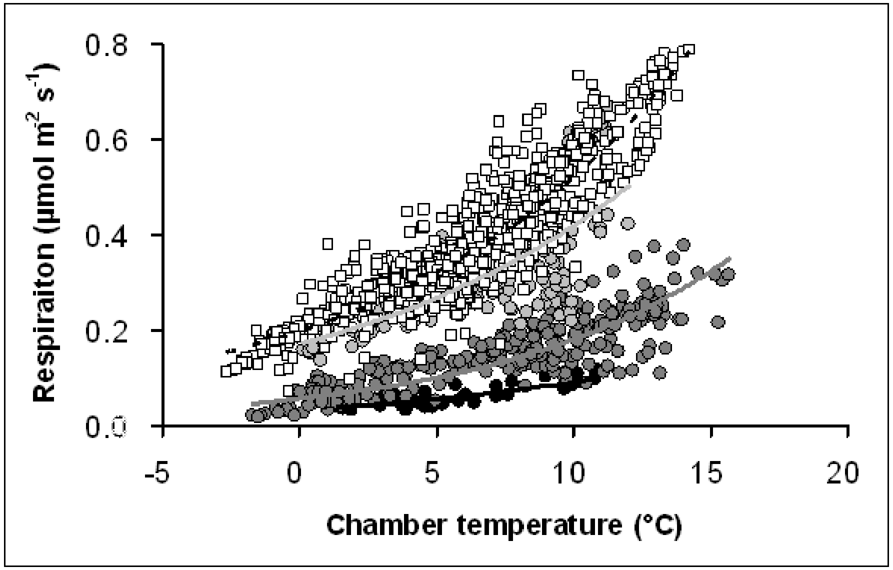
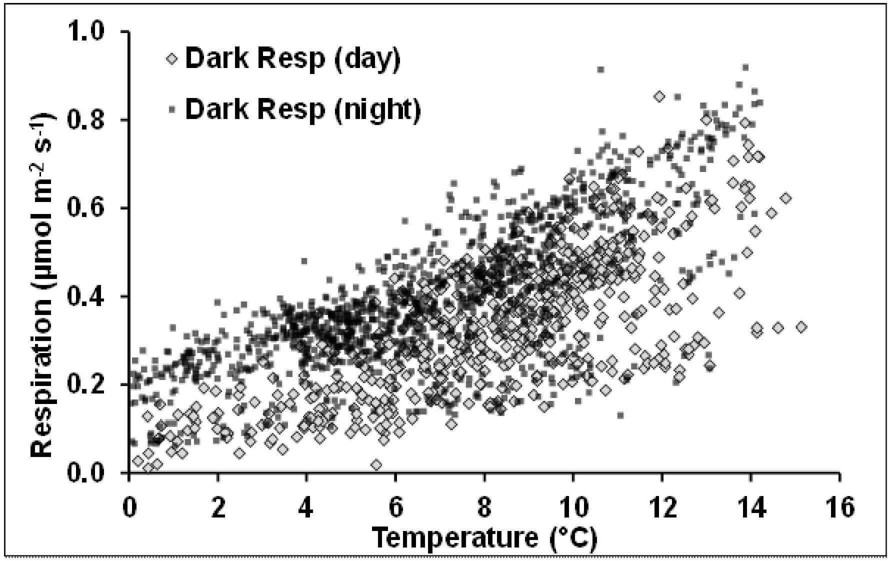
Impact of temperature on respiration



a) Opaque chamber dark respiration fluxes

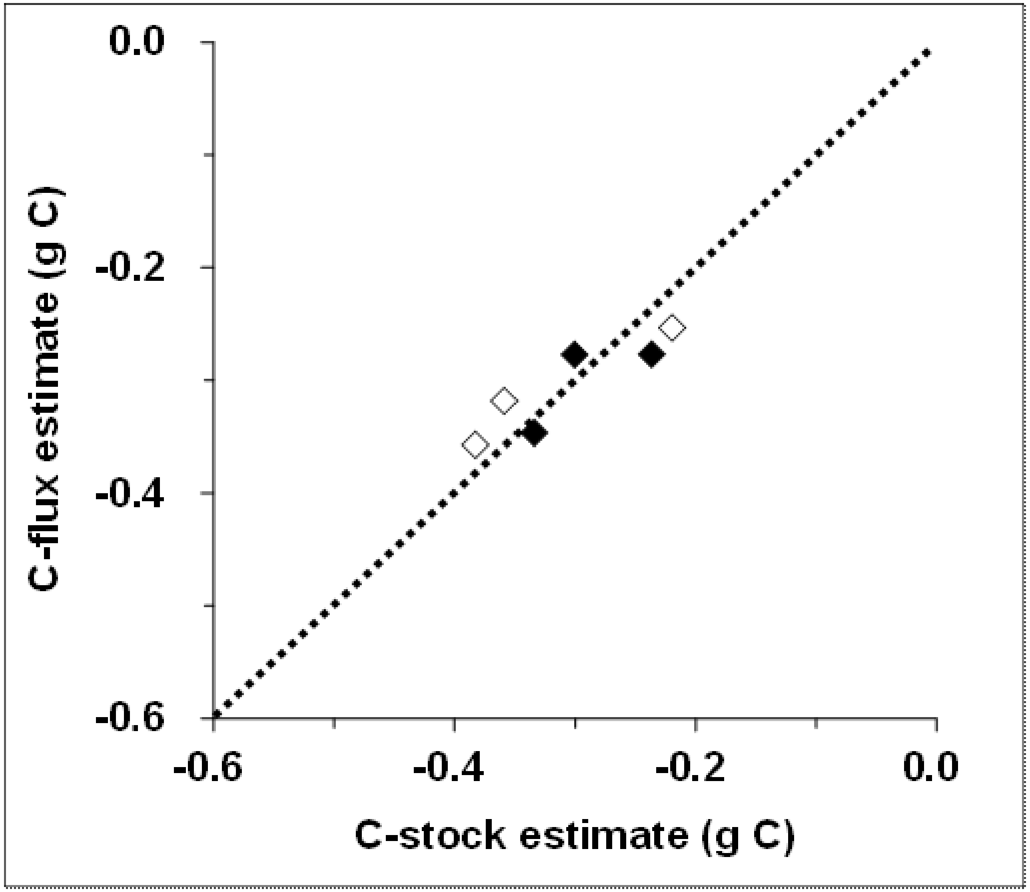
- Soil-only stage
- Germination stage
- Seedlings
- Full sward stage



b) Opaque chamber; day vs night

- plant respiration during the day is reduced

The bottom line



NEE: Comparison of C mass balance and chamber methods

CONCLUSIONS

1. Flux chambers provide a very useful tool in partitioning and investigating C fluxes in intact ecosystems.

2. Automated NEE flux chambers provide accurate C balances in these systems.

3. A combination of transparent and opaque chambers can produce reliable ecosystem NEE and respiration data useful for modelling, e.g. day vs night plant respiration.

4. It is imperative to correct for chamber impacts on PAR.

5. In these short-vegetation, short-closure chambers, corrections for other micro-climate aspects were not necessary

5. There was no significant differences in C balances in systems with or without chambers.

Acknowledgements:

Peter Högberg team + Harry Vallack & Jens Subke: Vindeln fluxes
Richard Nair & Forestry Research: Tree stem pulse
Andreas Heinemeyer: Wheldrake Forest and grass mesocosm study

NERC SCIENCE OF THE ENVIRONMENT (formerly known as NATURAL ENVIRONMENT RESEARCH COUNCIL) for funding

Picture: Moor House; Pennines