# Using stable isotopes in peat soils: some of the challenges

Jenny Farmer and Andy Midwood

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# So why stable isotopes?

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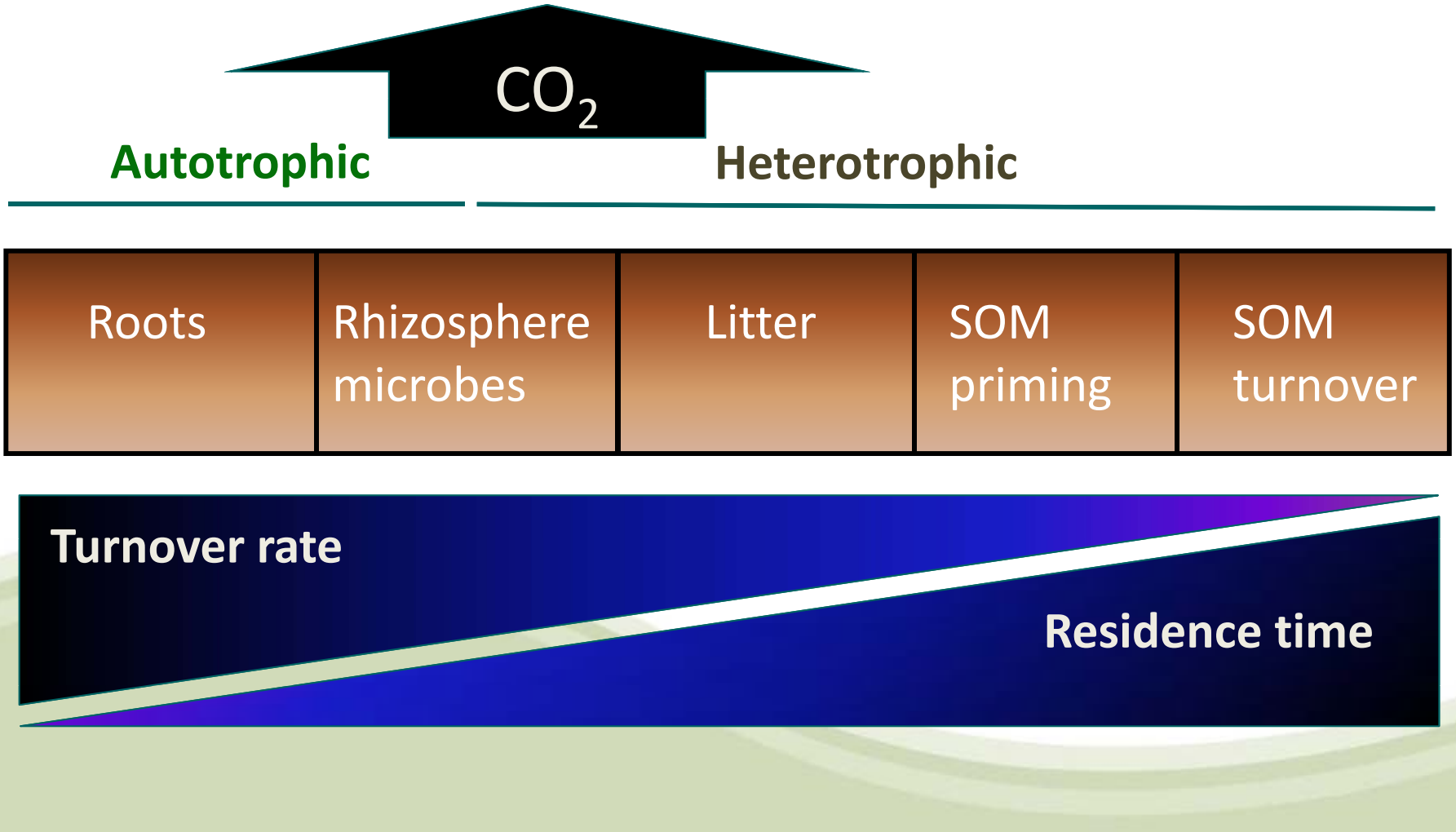
## Sources of Soil $CO_2$ Efflux



# Methods to Partition Soil Surface Efflux

- Root exclusion from soil (trenching)
- Shading, clipping or girdling trees
- *In situ* measurement of root respiration (root chambers)

All give a major disturbance

- Isotopes

Högberg et al 2001

# Isotope Methods

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Duke Forest, Loblolly Pine

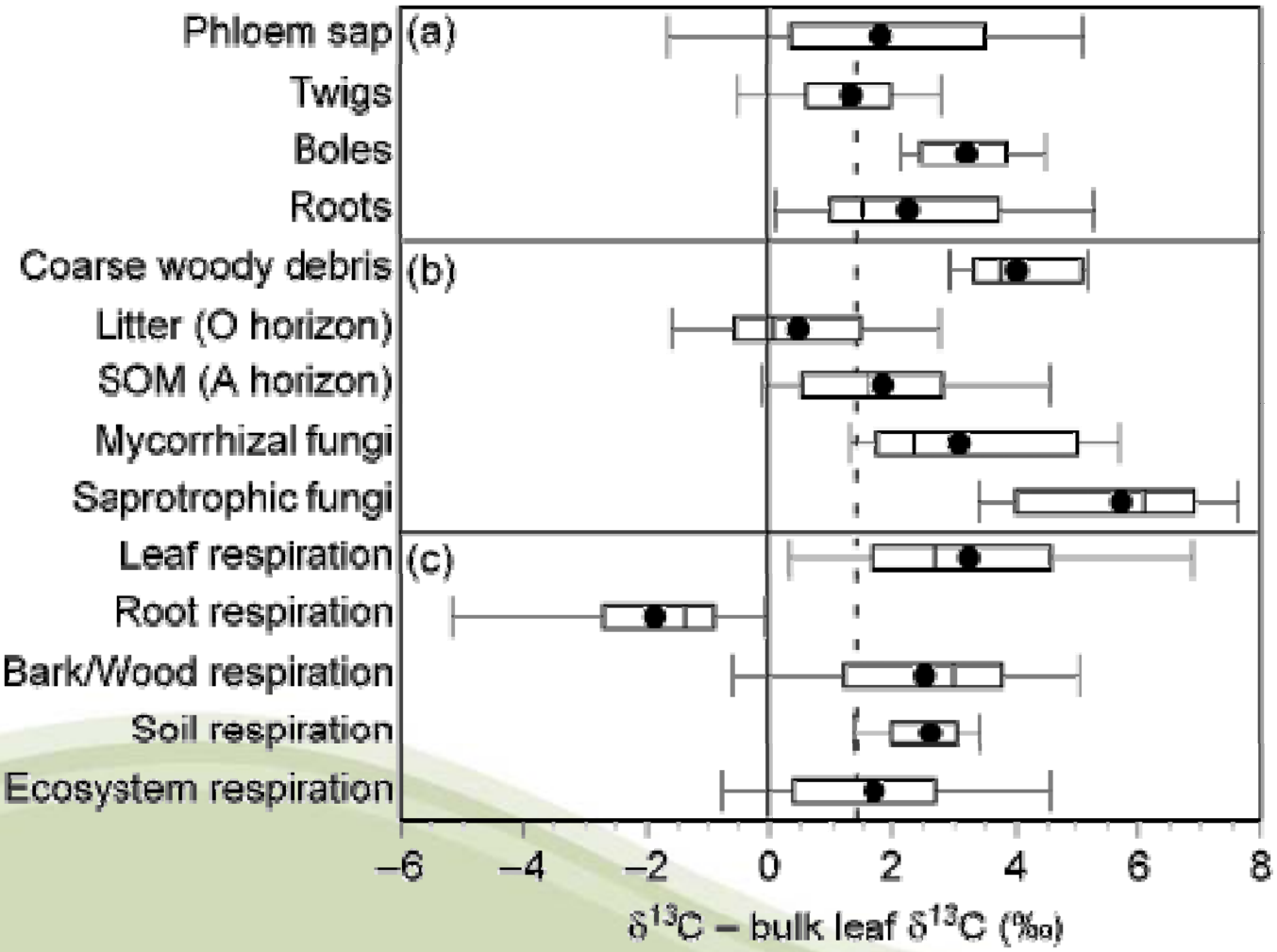
- Bomb Carbon ($^{14}C$)
- Labelling: Pulse or continuous labelling
  FACE approach with elevated $^{13}CO_2$
- $\delta^{13}C$ natural abundance discrimination

# $\delta^{13}C$ Natural Abundance $C_3$ in Plants

- $\delta^{13}CO_2$ signature of air is -8‰

- $C_3$ discrimination
  - by Rubisco -19‰
  - by water status/ shade ≈ - 4‰

# Natural Abundance Variation *within* $C_3$ Plants




Bowling et al 2008

# Isotopic End Members of Mixing Model

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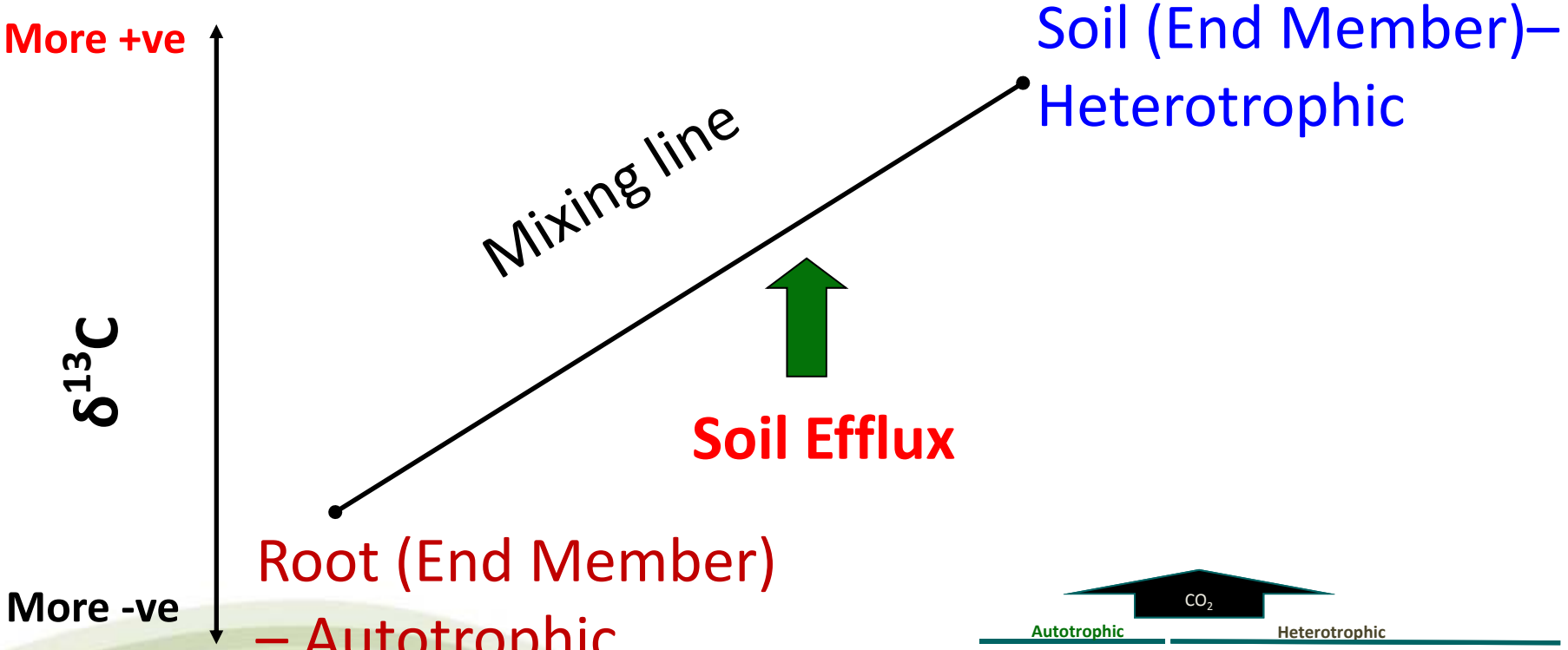
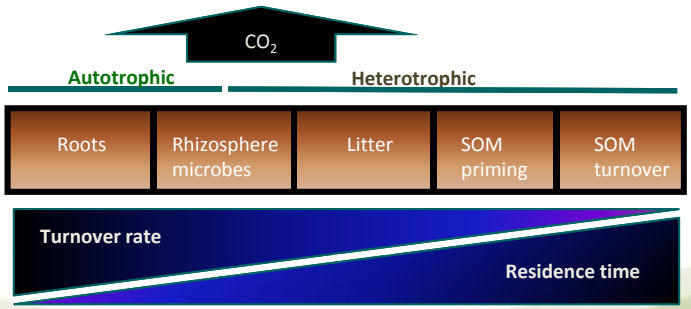
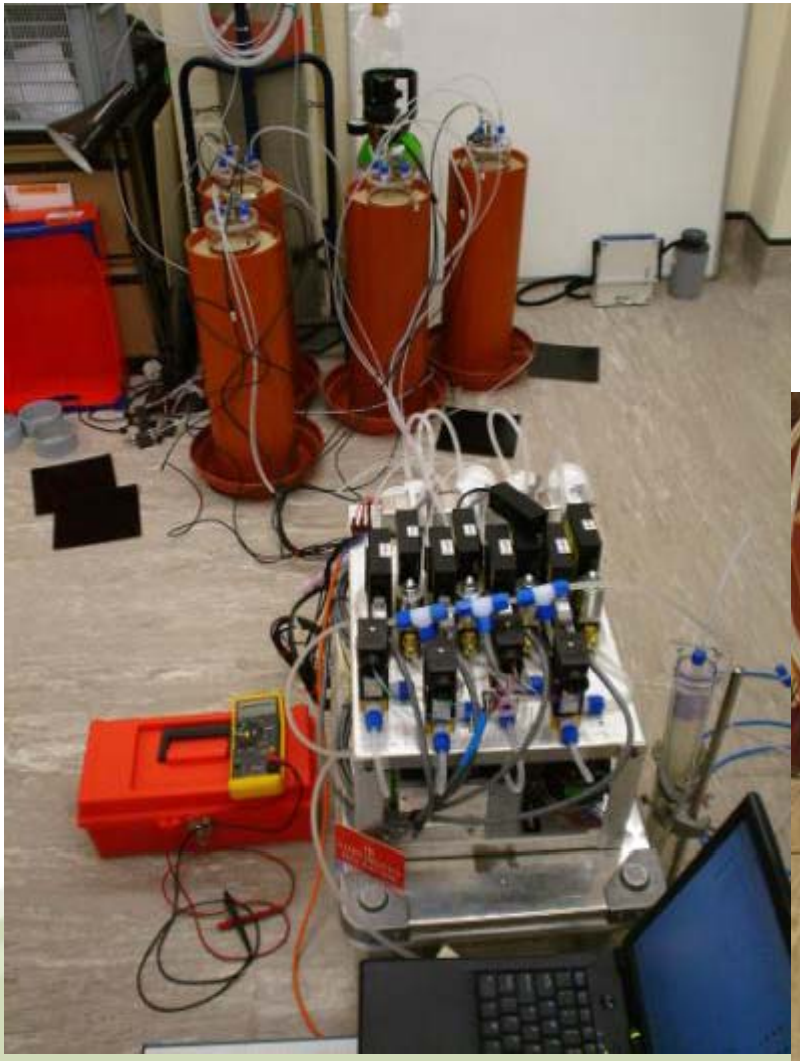
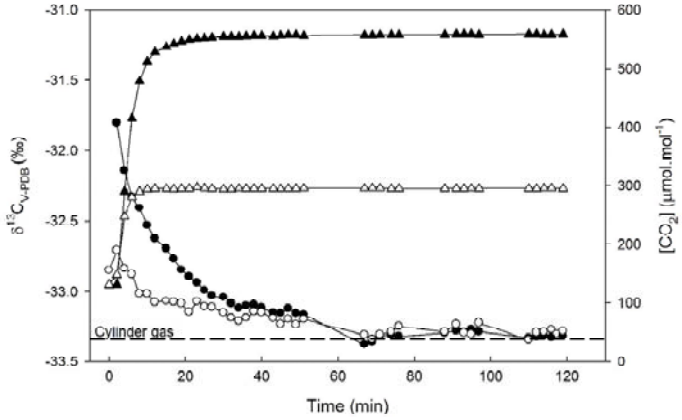


# Measuring and Analysing the Efflux






# Partitioning Efflux in the Field

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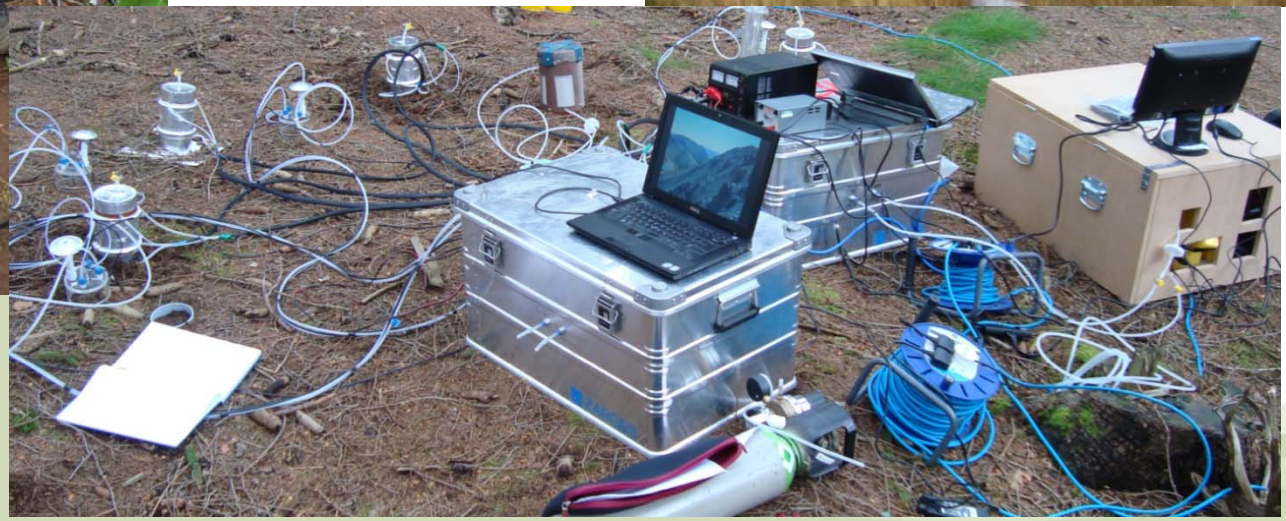
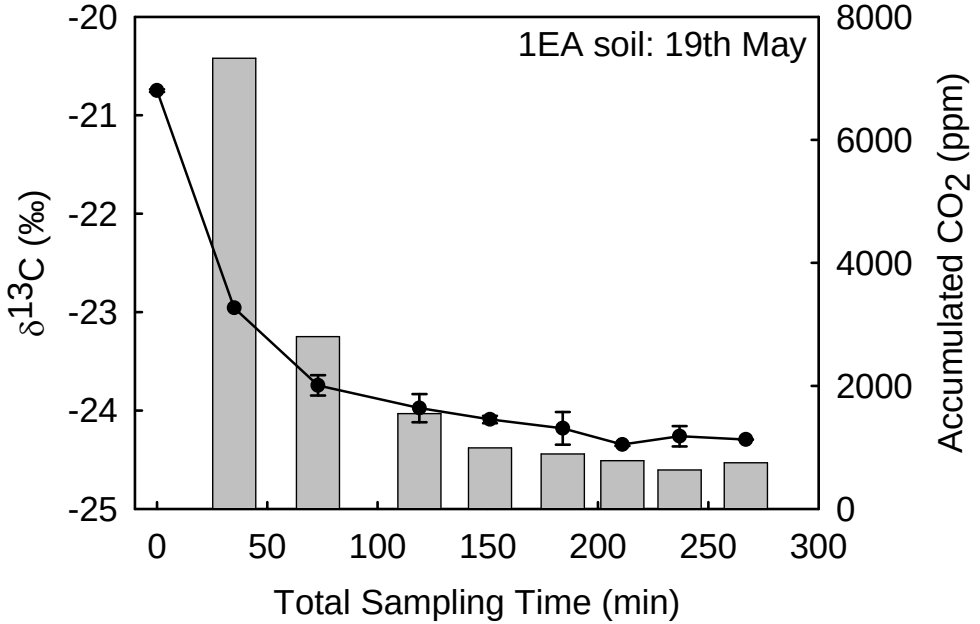
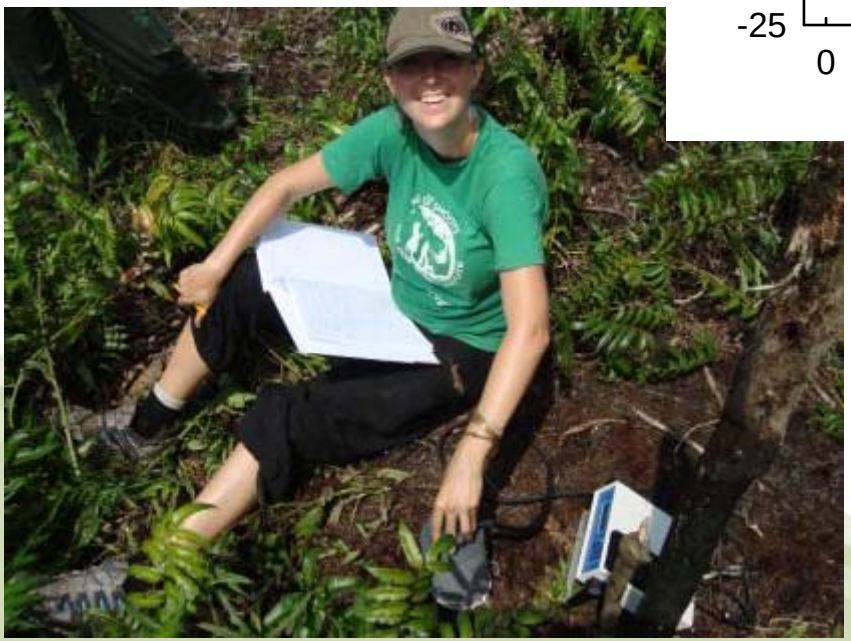


# Low Tech Approach – Efflux Measurements



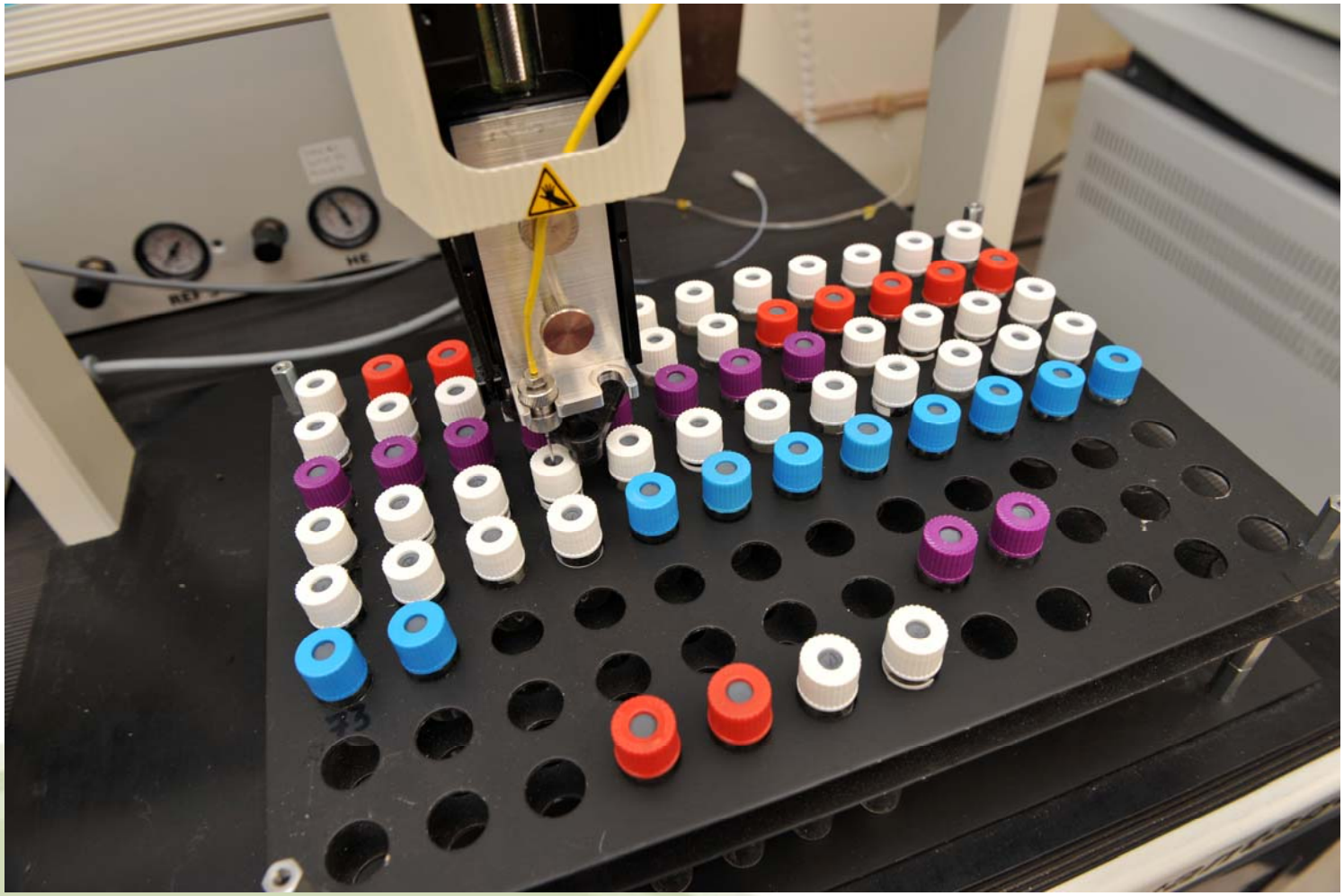
# Root and Soil End Members

Collect roots and root free soil

Place in Tedlar bag and remove air
Add $CO_2$-free air and incubate

Sampled in Executainers and shipped to Scotland for analysis with a mass spectrometer

# Analysis in Scotland...



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# Low tech approach – Now the Application to Peat Soils in Indonesia

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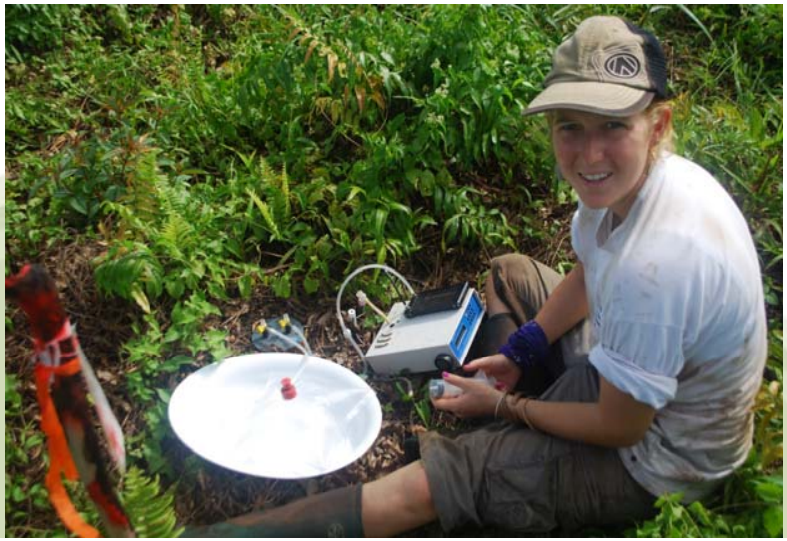
- Major land use changes due to oil palm plantations
- Clearing of native forest and drainage of peatlands
- How does this impact the rates of organic matter turnover, and can we measure this using isotopes?

# Experimental Plan

- Shallow peats:
  - Drained and logged forest, 1 year oil palm, 5 year oil palm (smallholders)
- Deep peats:
  - Intact forest , drained and logged forest, 3 year oil palm, 5 year oil palm (commercial)

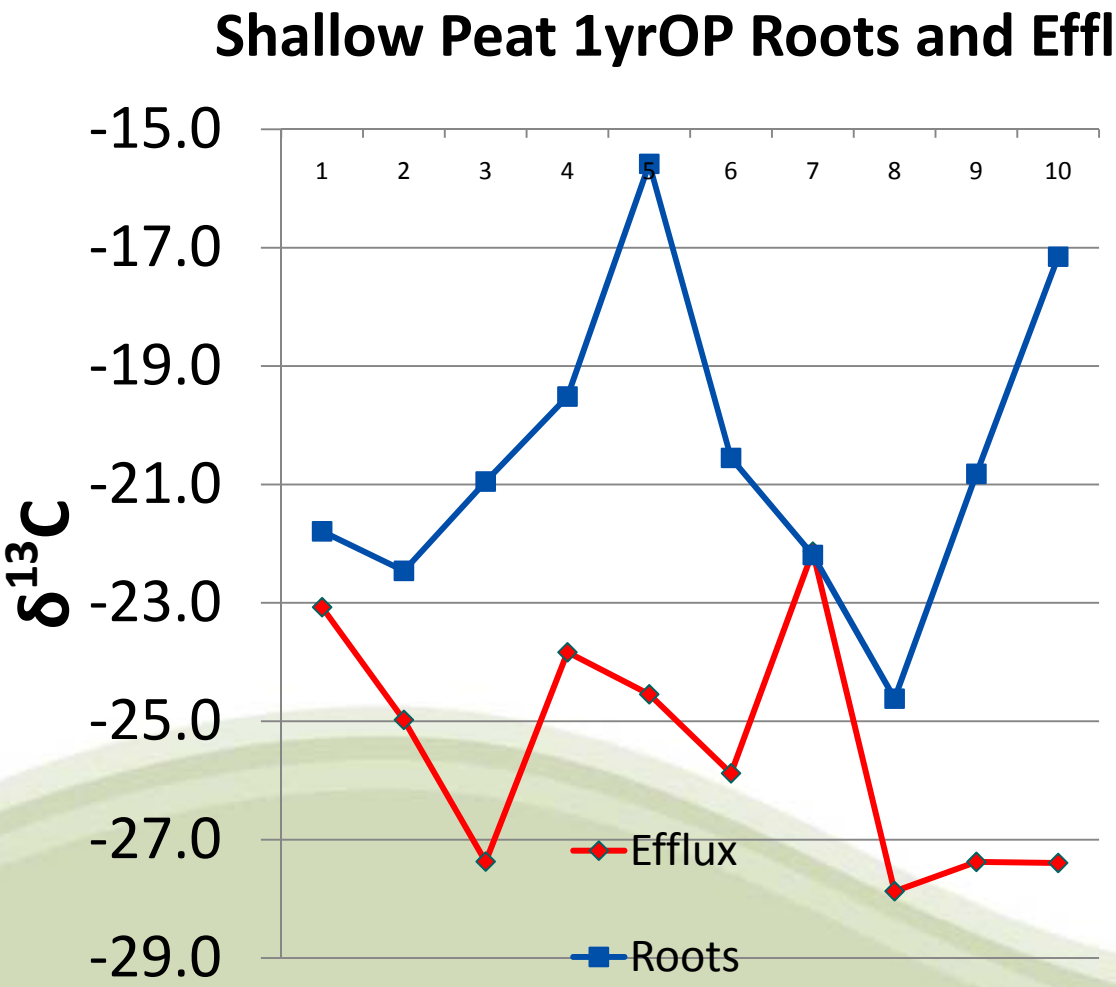
# Experimental Plan

- Initial tests on chamber flushes
- 10 chambers per land use
  - Efflux and root samples



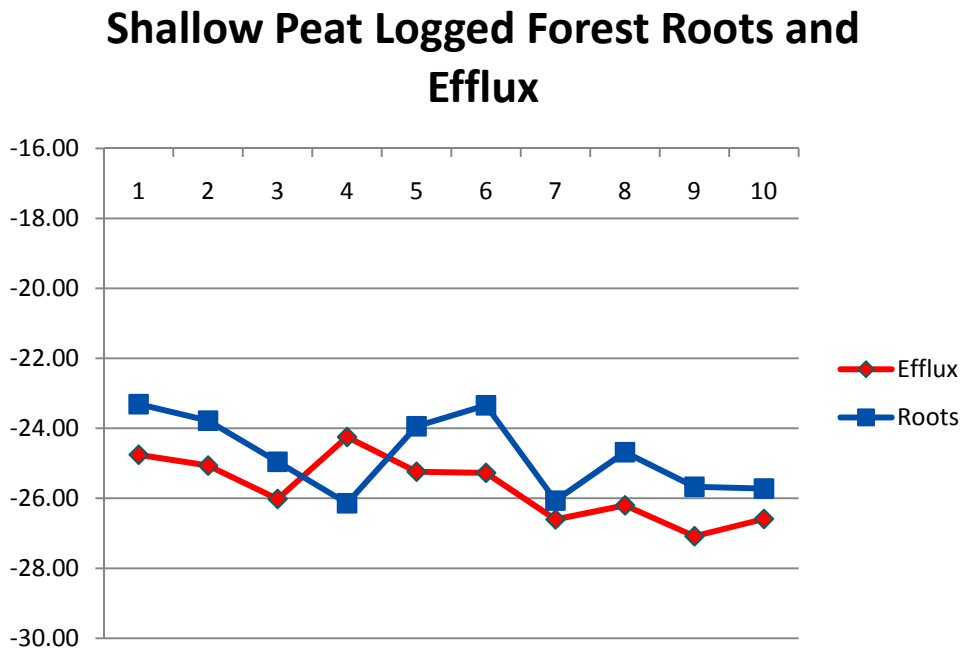
- SOM incubations
  - Incubated and sampled up to 5 times in 18 hours

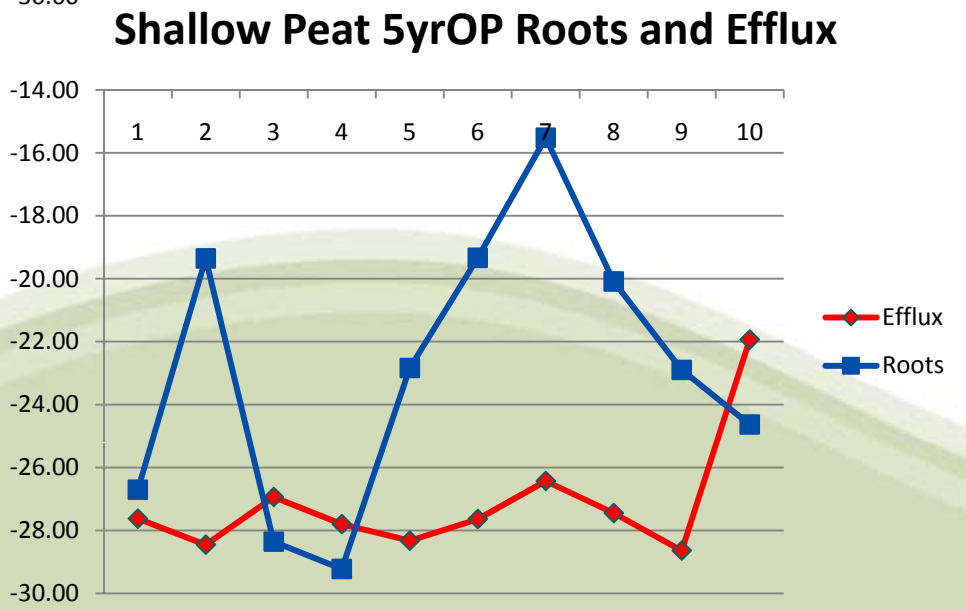
# Snapshot of some of the data….
# Efflux measurements




- Marked difference between efflux and roots – heterotrophic respiration
- Variable across landscape
- BUT data is the wrong way around!!

# Repeated at other sites




- Why is the efflux so depleted?
- Methane is known to be very depleted in $^{13}C$ (-50 ‰) but does not interfere with isotope analysis of $CO_2$
- Methane Oxidation?
- 3rd End Member on Mixing Model

# Can we still work with the Data?

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- Phillips and Gregg 2001 proposed a model for solving multiple isotope source scenarios – used for diet analysis
- Doesn't provide absolute proportions but does provide a range of possible solutions and associated errors
- Requires End Members to be well defined (Soil, Roots and Methane Oxidation) and the mix (Efflux)

Oecologia (2001) 127:171–179
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Donald L. Phillips · Jillian W. Gregg

**Uncertainty in source partitioning using stable isotopes**

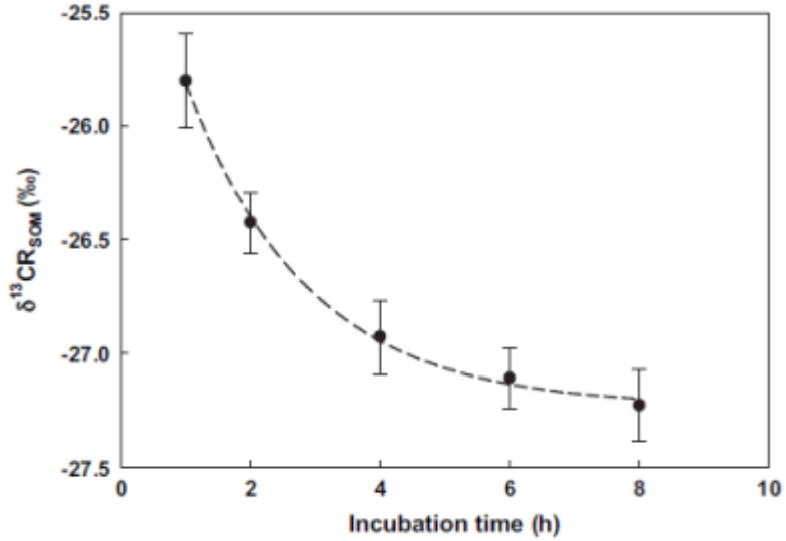
Received: 14 April 2000 / Accepted: 10 October 2000 / Published online: 21 February 2001


**Abstract** Stable isotope analyses are often used to quantify the contribution of multiple sources to a mixture, such as proportions of food sources in an animal's diet, or $C_3$ and $C_4$ plant inputs to soil organic carbon. Linear mixing models can be used to partition two sources with a single isotopic signature (e.g., $\delta^{13}C$) or three sources with a second isotopic signature (e.g., $\delta^{15}N$). Although variability of source and mixture signatures is often reported, confidence interval calculations for source proportions typically use only the mixture variability. We provide examples showing that omission of source variability can lead to underestimation of the variability of source proportion estimates. For both two- and three- than the population SDs. Proportion SEs were minimized when sources were evenly divided, but increased only slightly as the proportions varied. The variance formulas provided will enable quantification of the precision of source proportion estimates. Graphs are provided to allow rapid assessment of possible combinations of source differences and source and mixture population SDs that will allow source proportion estimates with desired precision. In addition, an Excel spreadsheet to perform the calculations for the source proportions and their variances, SEs, and 95% confidence intervals for the two-source and three-source mixing models can be accessed at http://www.epa.gov/wed/pages/models.htm.

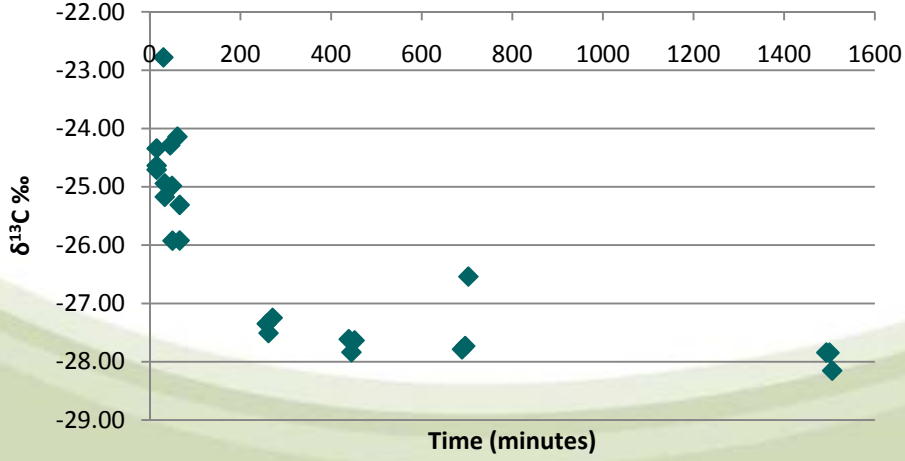
# Soil End Members

- Isotopic content of respired $CO_2$ from soil is sensitive to disturbance
- Increasing in $O_2$ and breaking up of soil structure exposes 'new' C for oxidation
- So measuring the soil end member value is not straight forward

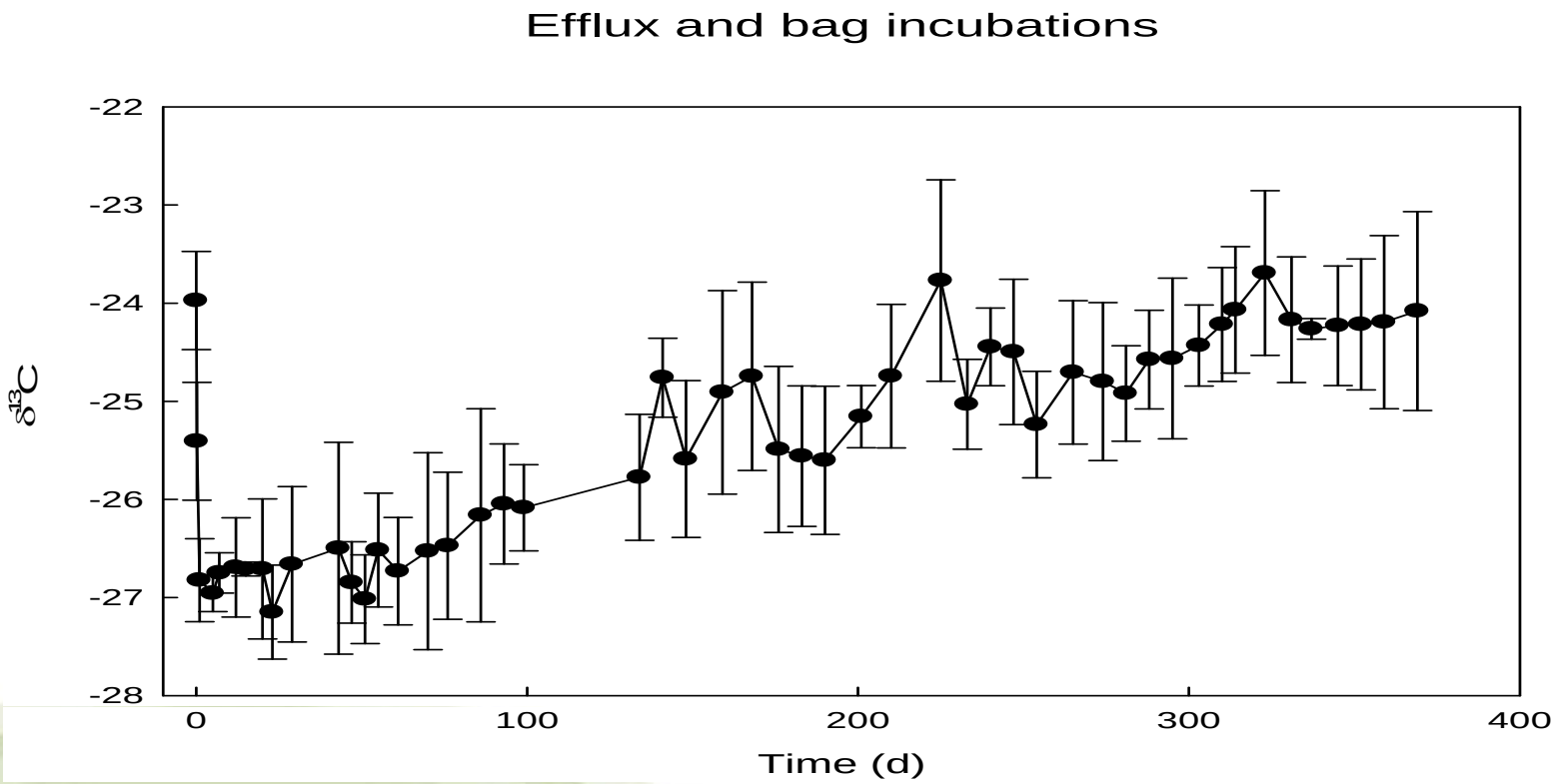
**Millard et al 2010**




**SOM $\delta^{13}C$ Values for SP LF**

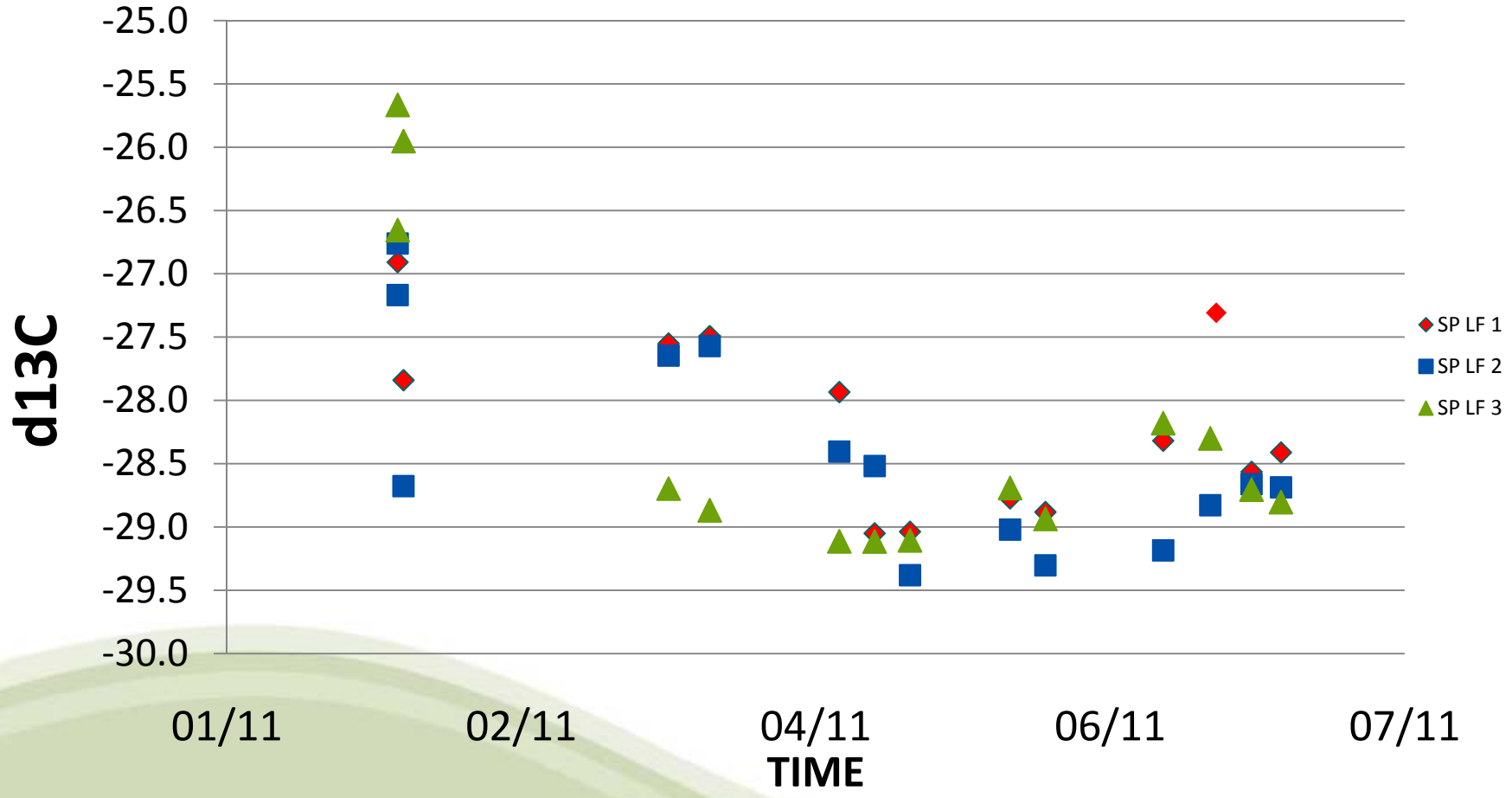


# Soil will ‘recover’ for disturbance with prolonged incubation



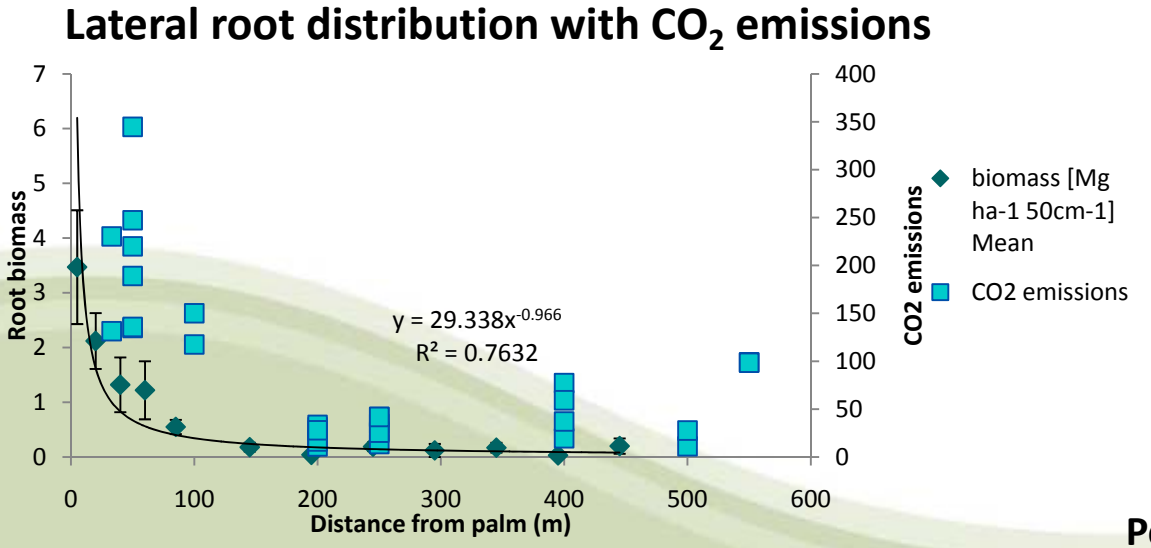

**Peat soil taken from Middlemuir**

# Indonesian Peat Incubations..ongoing



# Future fieldwork

- Efflux rates are correlated with distance from oil palm plants
- Aim to sample soil surface efflux and root density to determine a regression between the two
- Attempt to predict heterotrophic  efflux rate
- Will allow comparison with isotopic results




**Persch and Farmer unpubished**

# Thanks to..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- PhD Supervisors: Robin Matthews, Jo and Pete Smith.
- Barry, Maureen and Gillian for isotope analysis.
- Andy for bringing isotopes into my life.