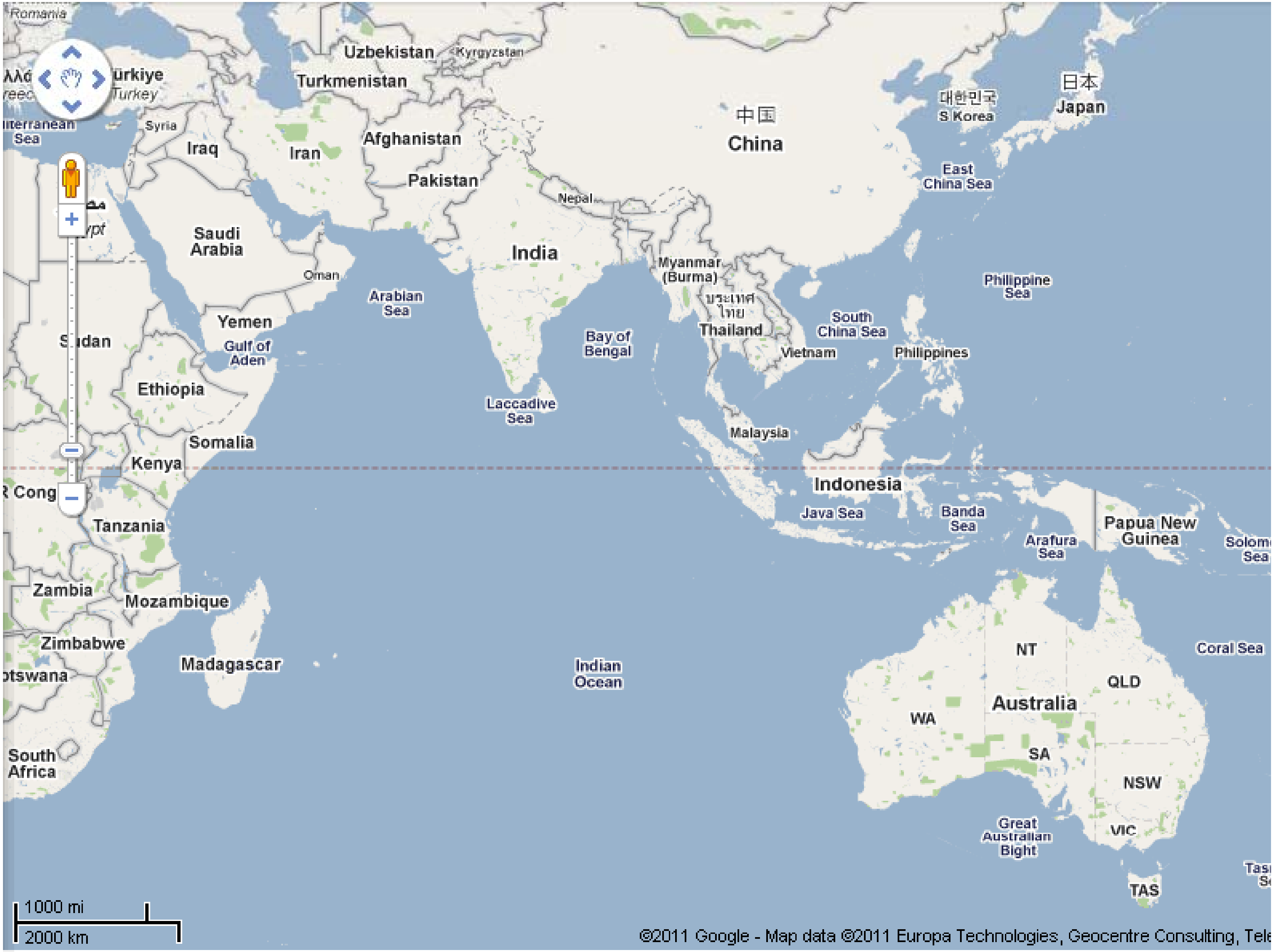
Measuring and Modelling CO_2 Emissions From Indonesian Peat Soils

Jenny Farmer

Presentation outline

- Introduction to sites
- Sampling CO_2 emissions
- Partitioning respiration
- Soil C
- Additional fieldwork
- Modelling



Romania
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Kyrgyzstan
Türkiye
Turkey
Turkmenistan
Syria
Iraq
Iran
Afghanistan
Pakistan
中国
China
대한민국
S Korea
日本
Japan
East China Sea
Nepal
Saudi Arabia
Oman
India
Myanmar (Burma)
Arabian Sea
Yemen
Gulf of Aden
Bay of Bengal
ประเทศไทย
Thailand
South China Sea
Philippine Sea
Vietnam
Philippines
Ethiopia
Laccadive Sea
Malaysia
Somalia
Kenya
Indonesia
Tanzania
Java Sea
Banda Sea
Arafura Sea
Papua New Guinea
Zambia
Mozambique
Zimbabwe
Madagascar
Indian Ocean
Coral Sea
NT
QLD
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NSW
South Africa
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VIC
TAS
1000 mi
2000 km
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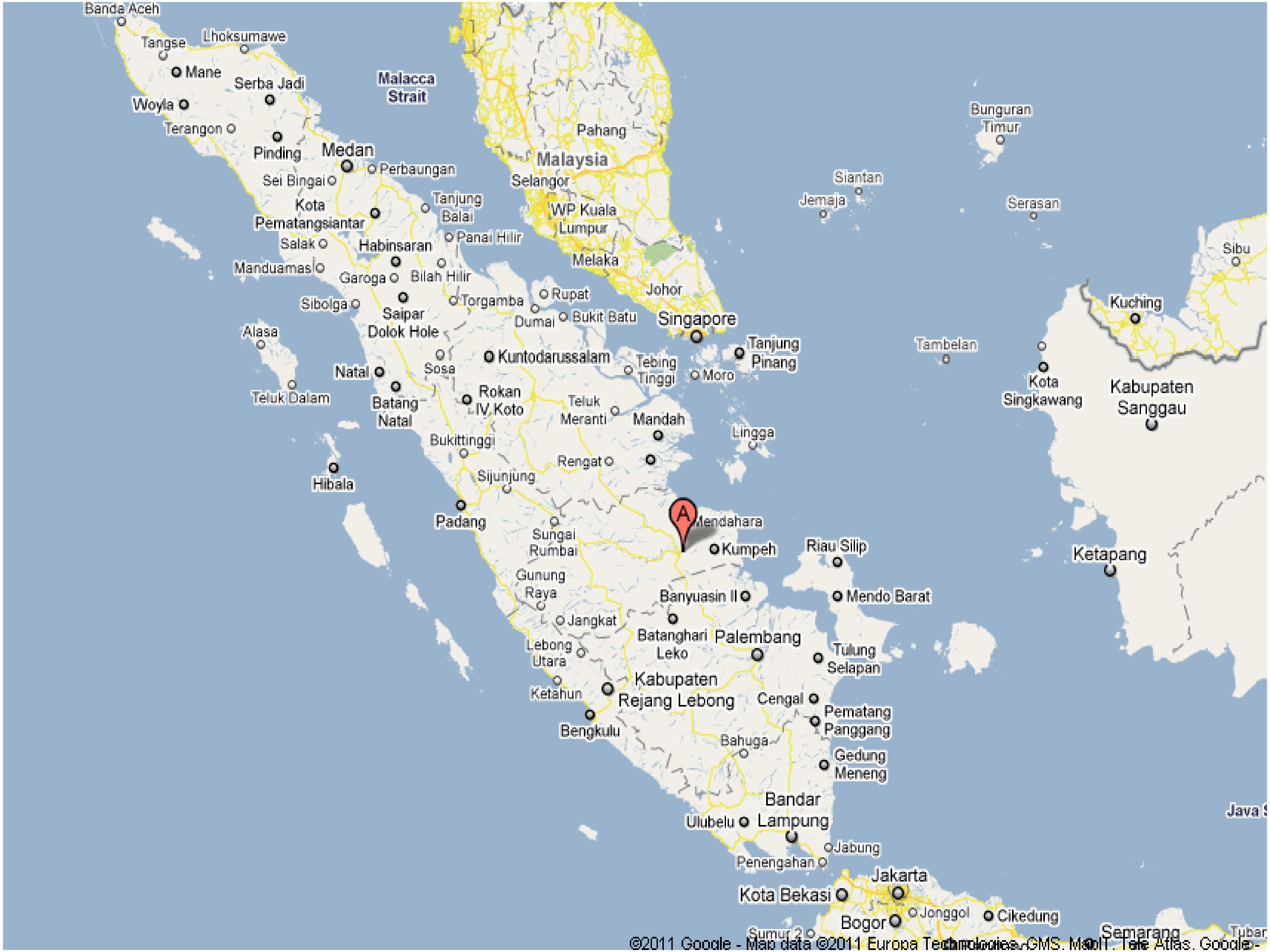
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Singkawang
Kabupaten
Sanggau
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Sites

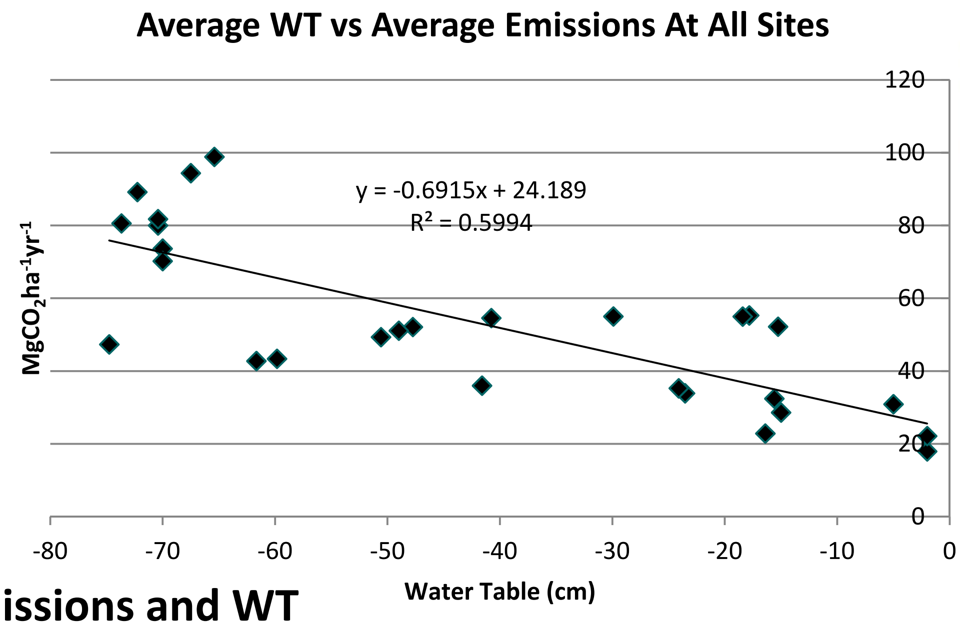
- Deep peats:
  - Intact forest , drained and logged forest, 3 year oil palm, 5 year oil palm (commercial)

Measuring CO_2 Emissions

- 30 collars per land use
- Using a PP Systems EGM-4
  - Uses a gas analyser, the same as an IRGA but much more compact


EGM-4

CO_2 Emissions Results



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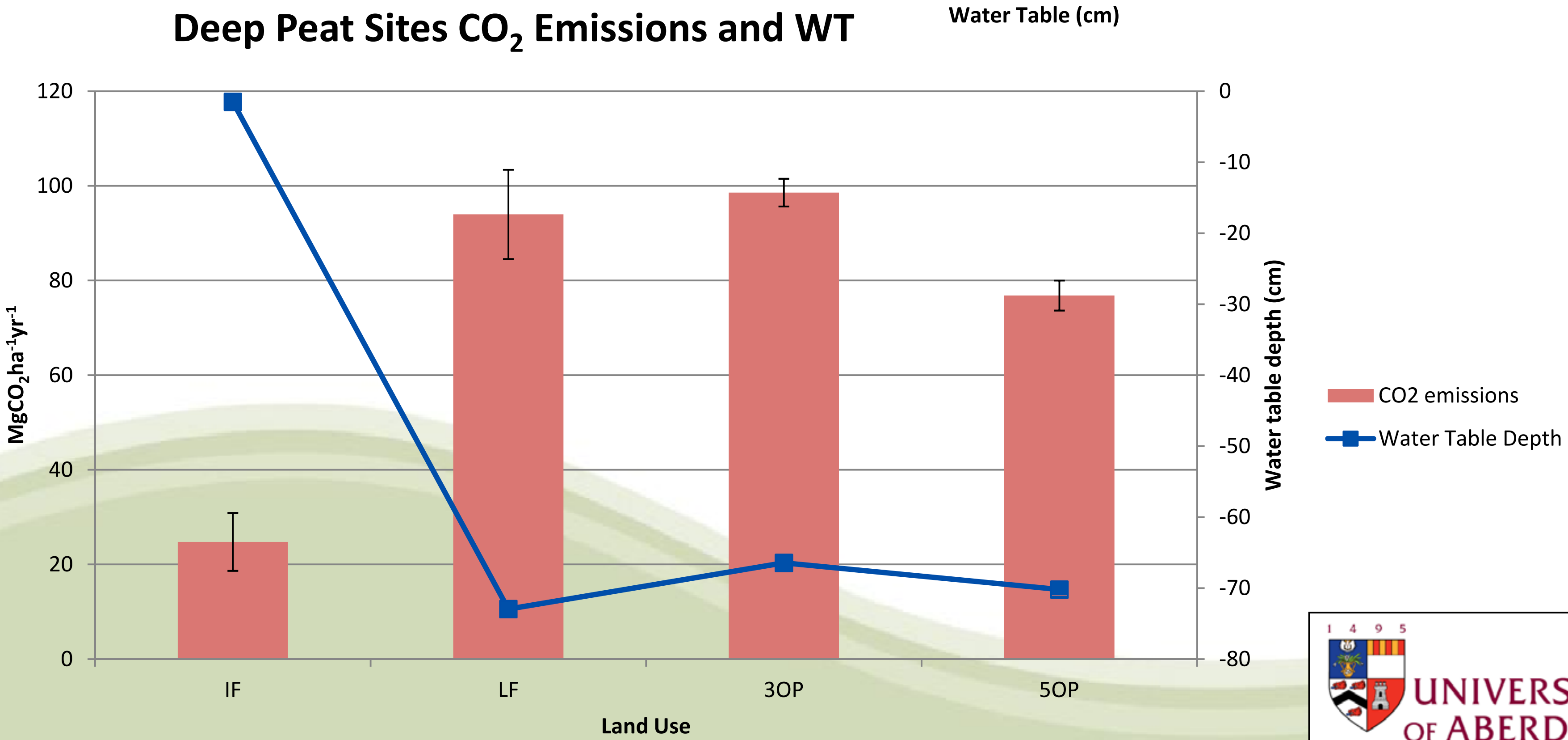

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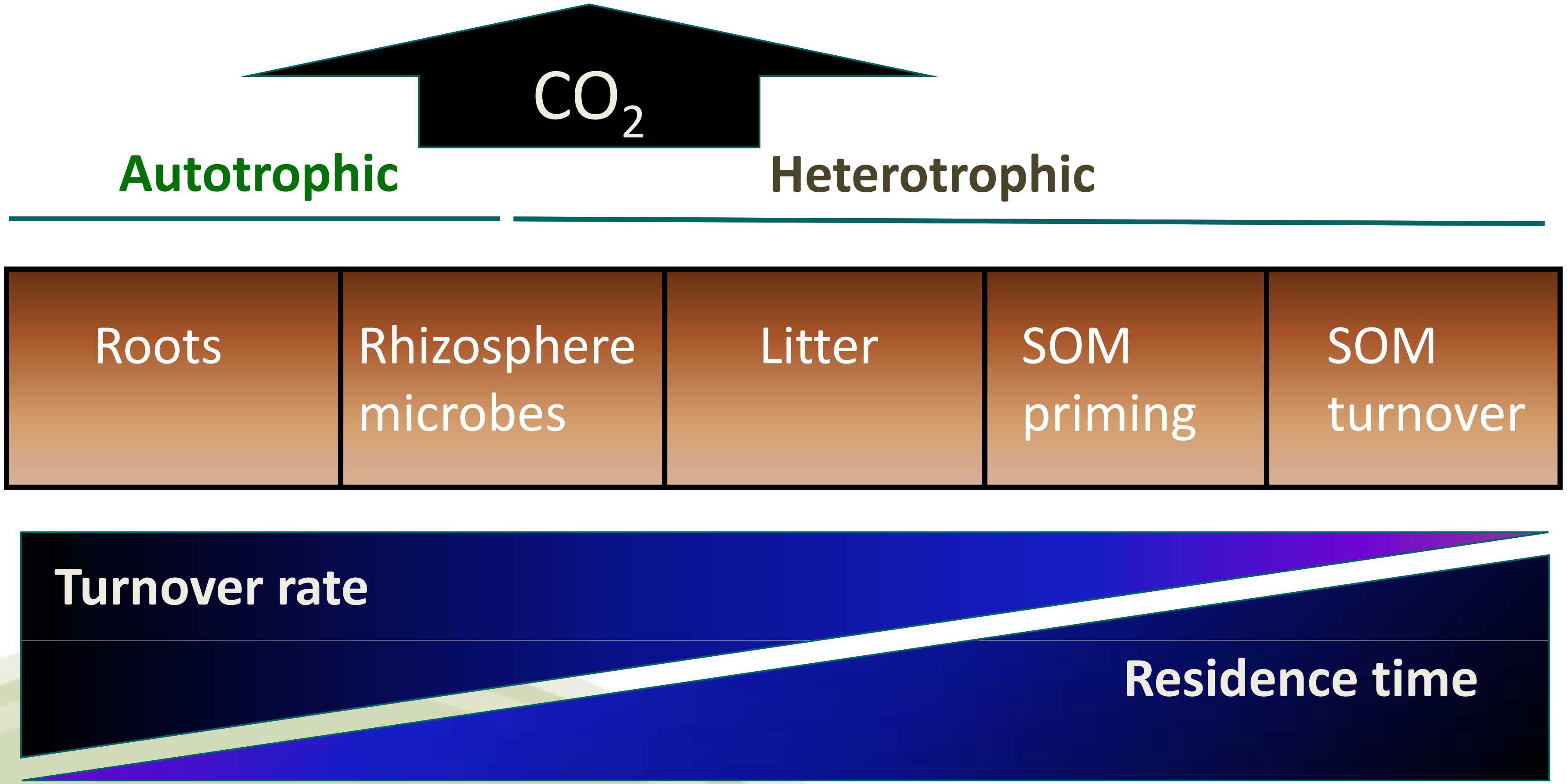
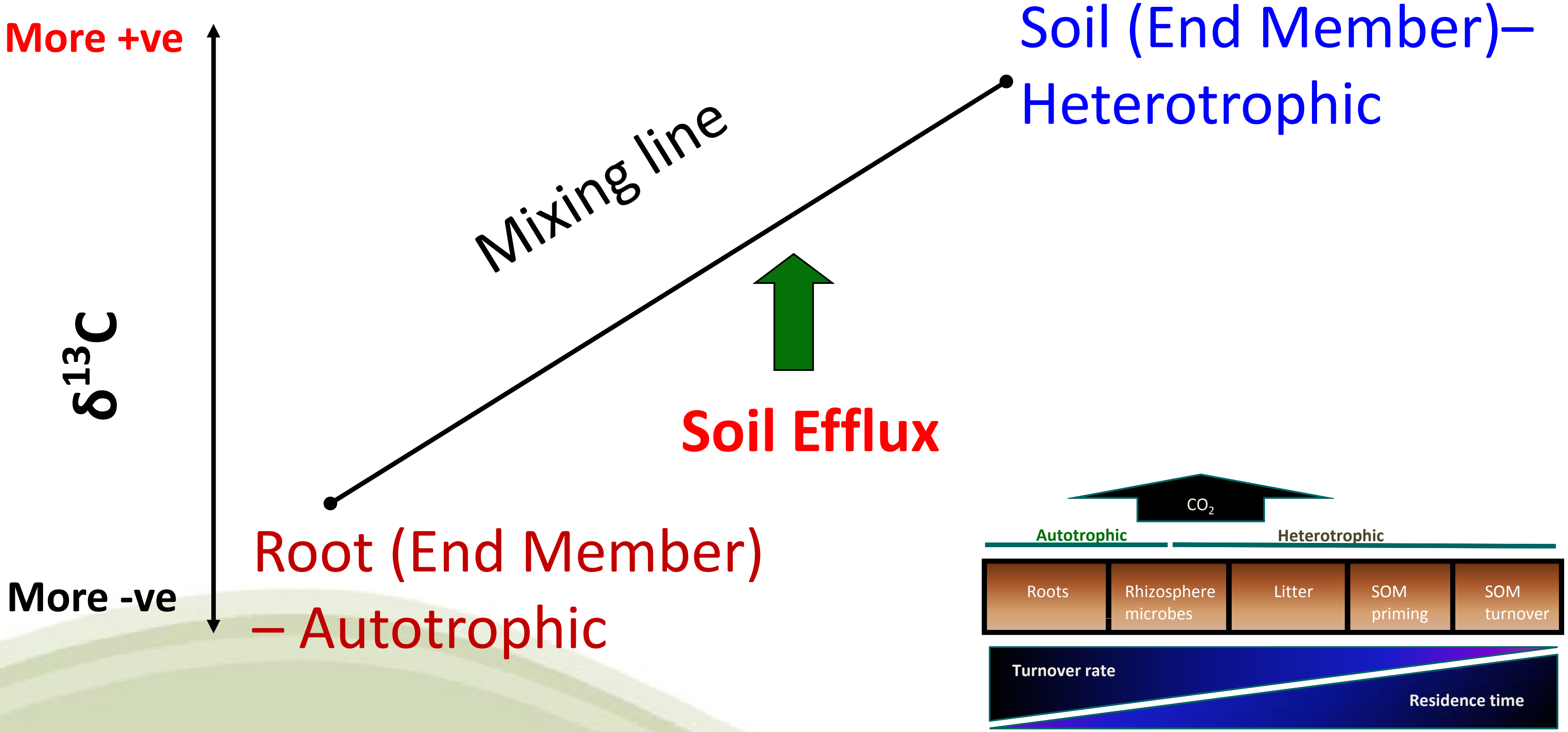
Partitioning CO_2 Using Stable Isotopes

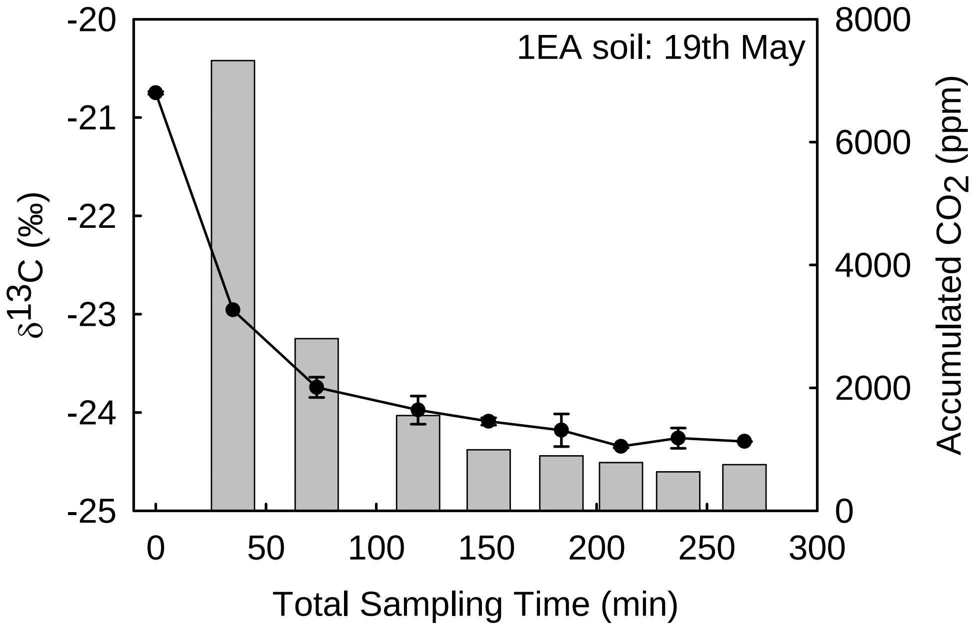
Sources of Soil CO_2 Efflux

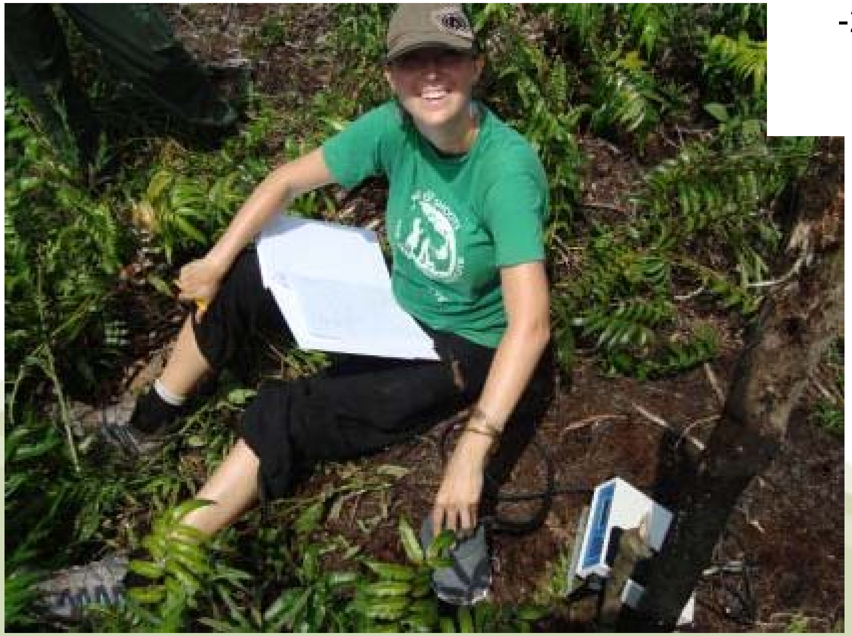


Isotopic End Members of Mixing Model



Low Tech Approach – Efflux Measurements





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Root and Soil End Members

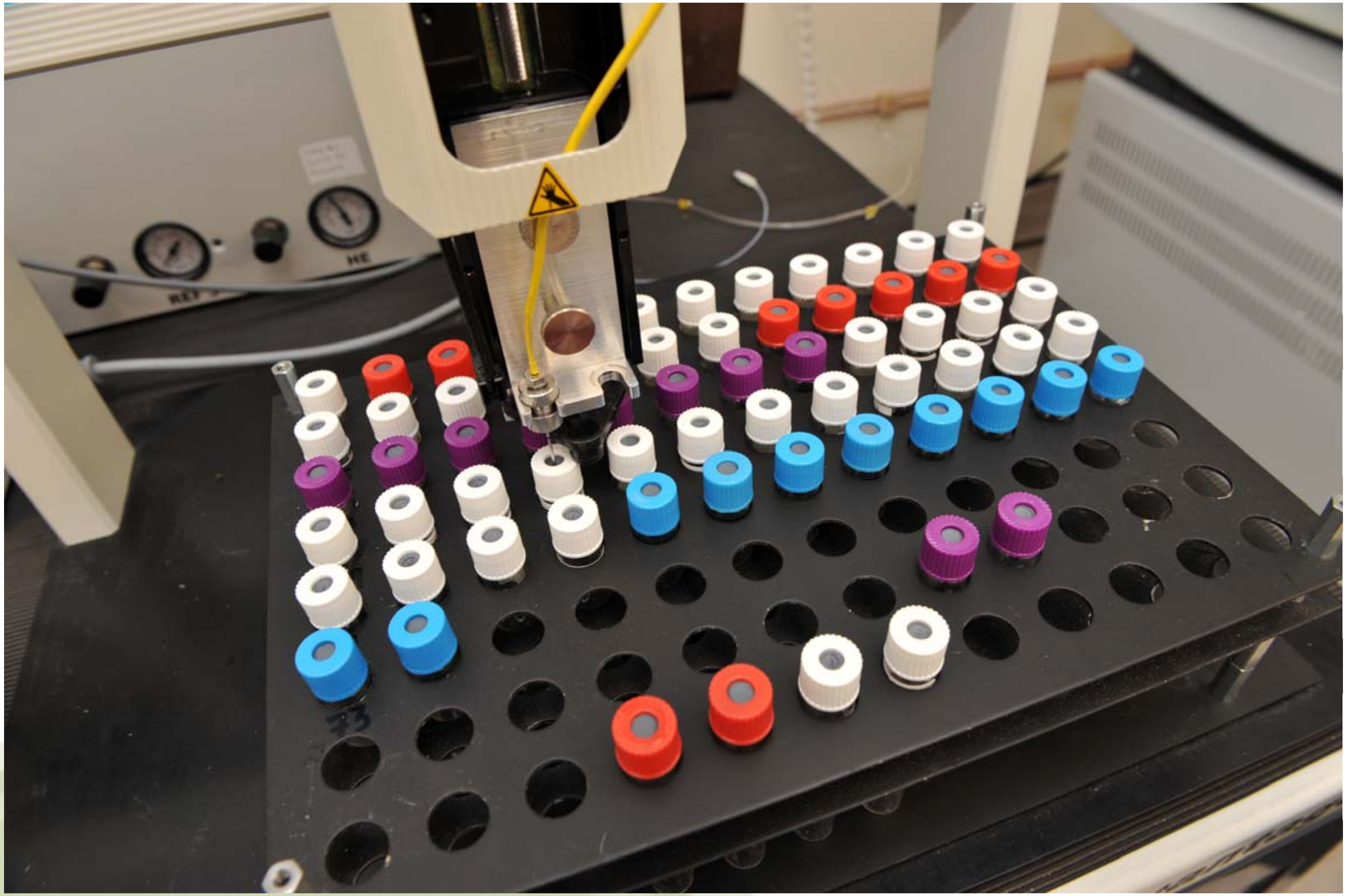
Collect roots and root free soil.

Place in Tedlar bag and remove air.

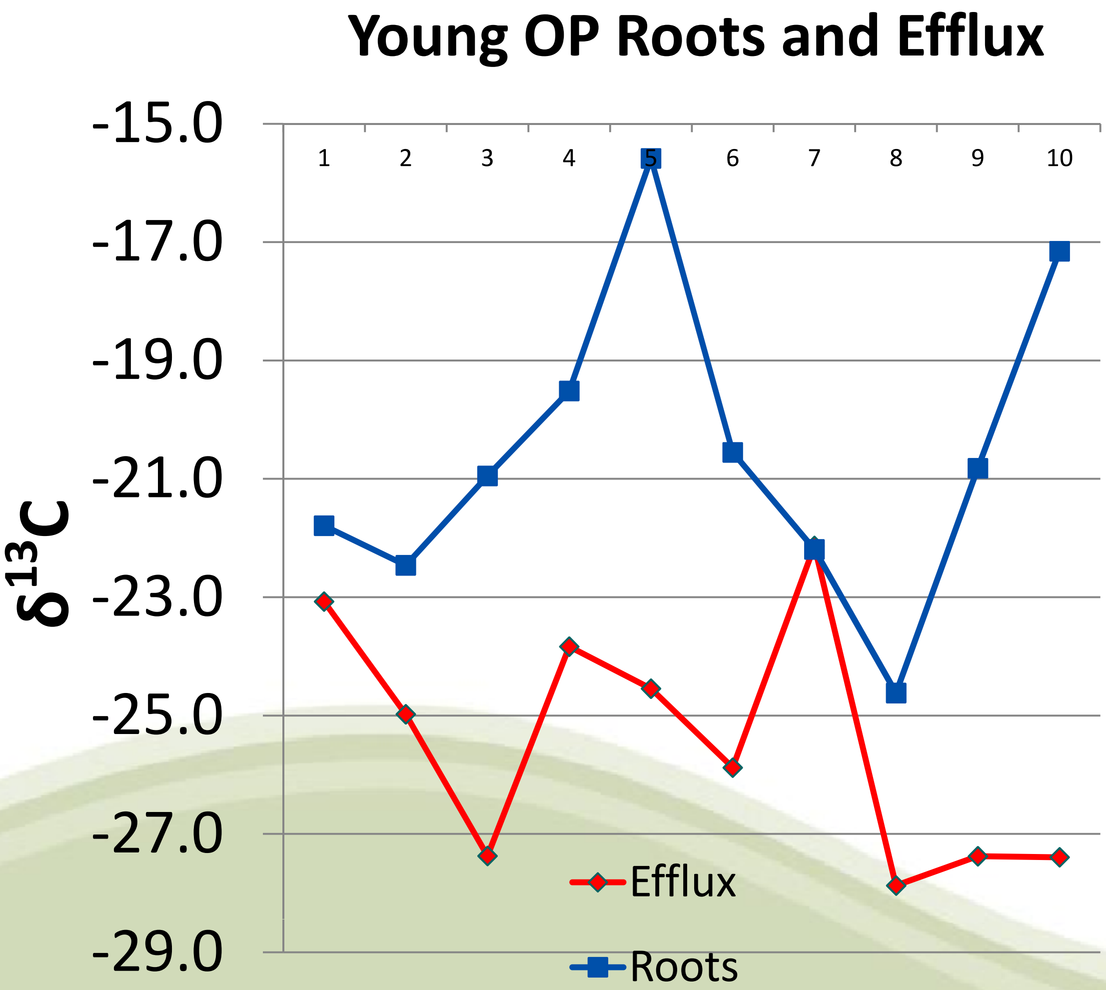
Add CO_2-free air and incubate.

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

Analysis in Scotland...



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

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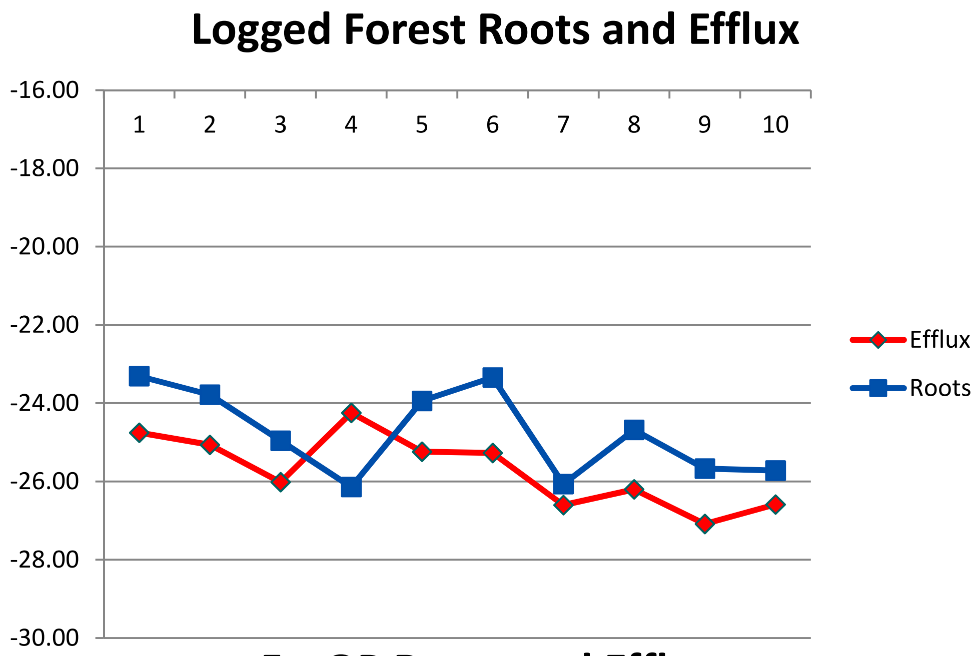

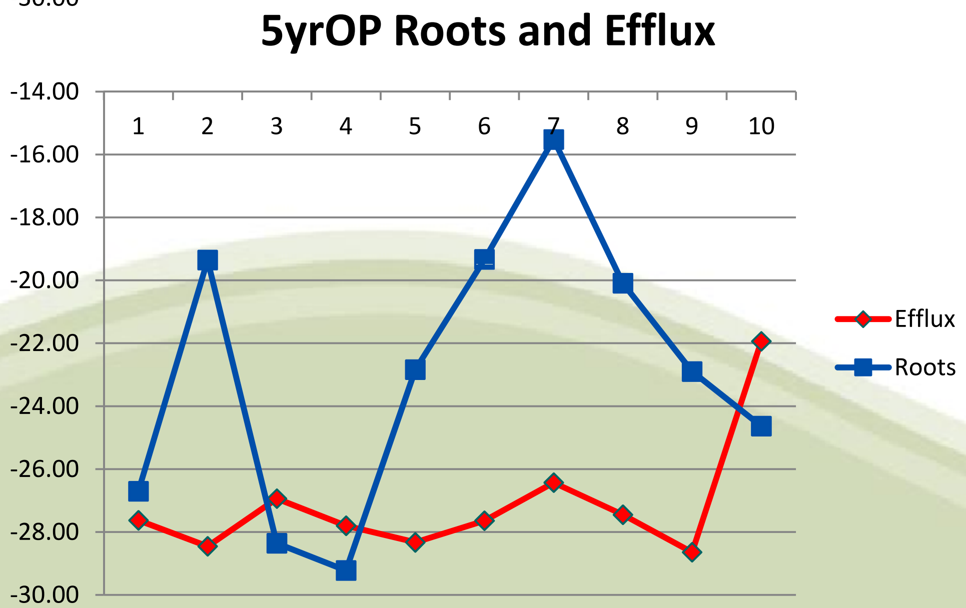

- Why is the efflux so depleted?
- Methane is known to be very depleted in ^{13}C (-50 ‰) but does not interfere with isotope analysis of CO_2
- Methane Oxidation?
- 3rd End Member on Mixing Model

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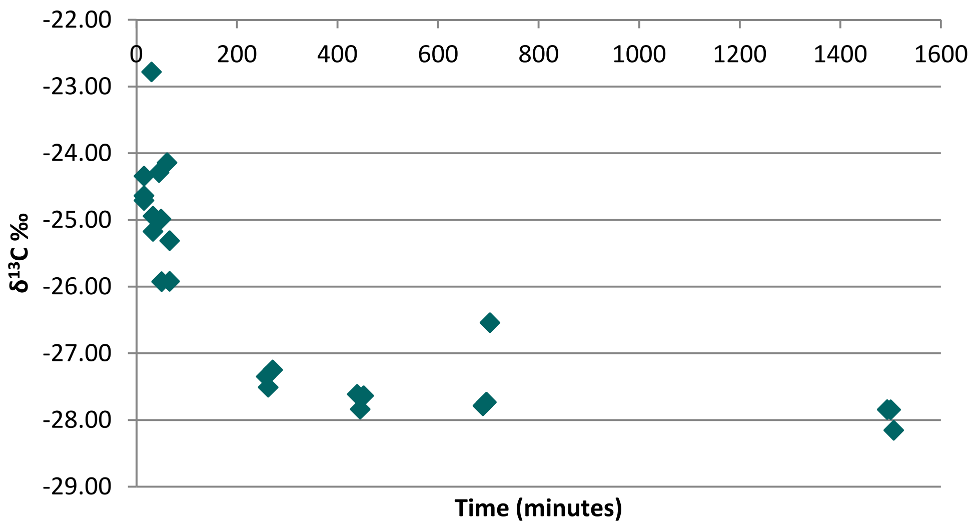
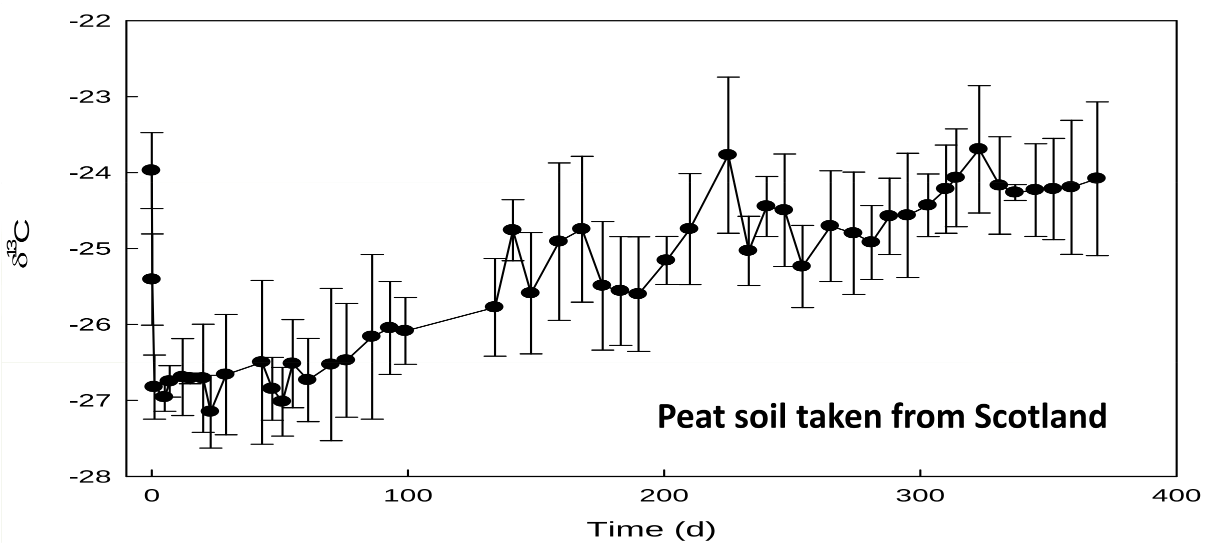
SOM Values

SOM δ13C Values for SP LF

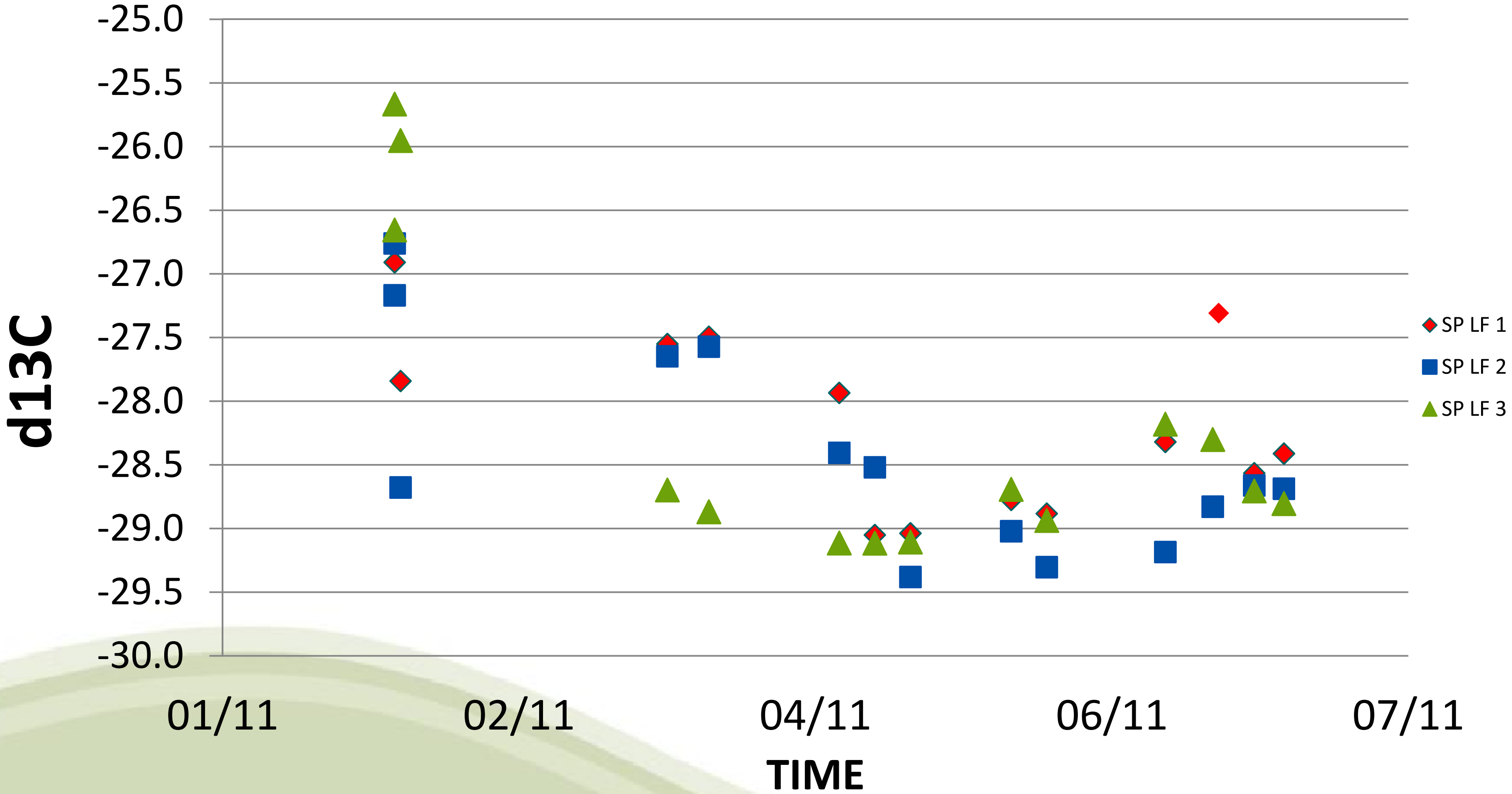


Efflux and bag incubations



- SOM values should look like this, but in some sites the trend isn't as clear.
- Soil will 'recover' from disturbance with prolonged incubation.
- Can use this to try to pin down the SOM value.

Indonesian Peat Incubations... Ongoing



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
DOI 10.1007/s004420000578

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.

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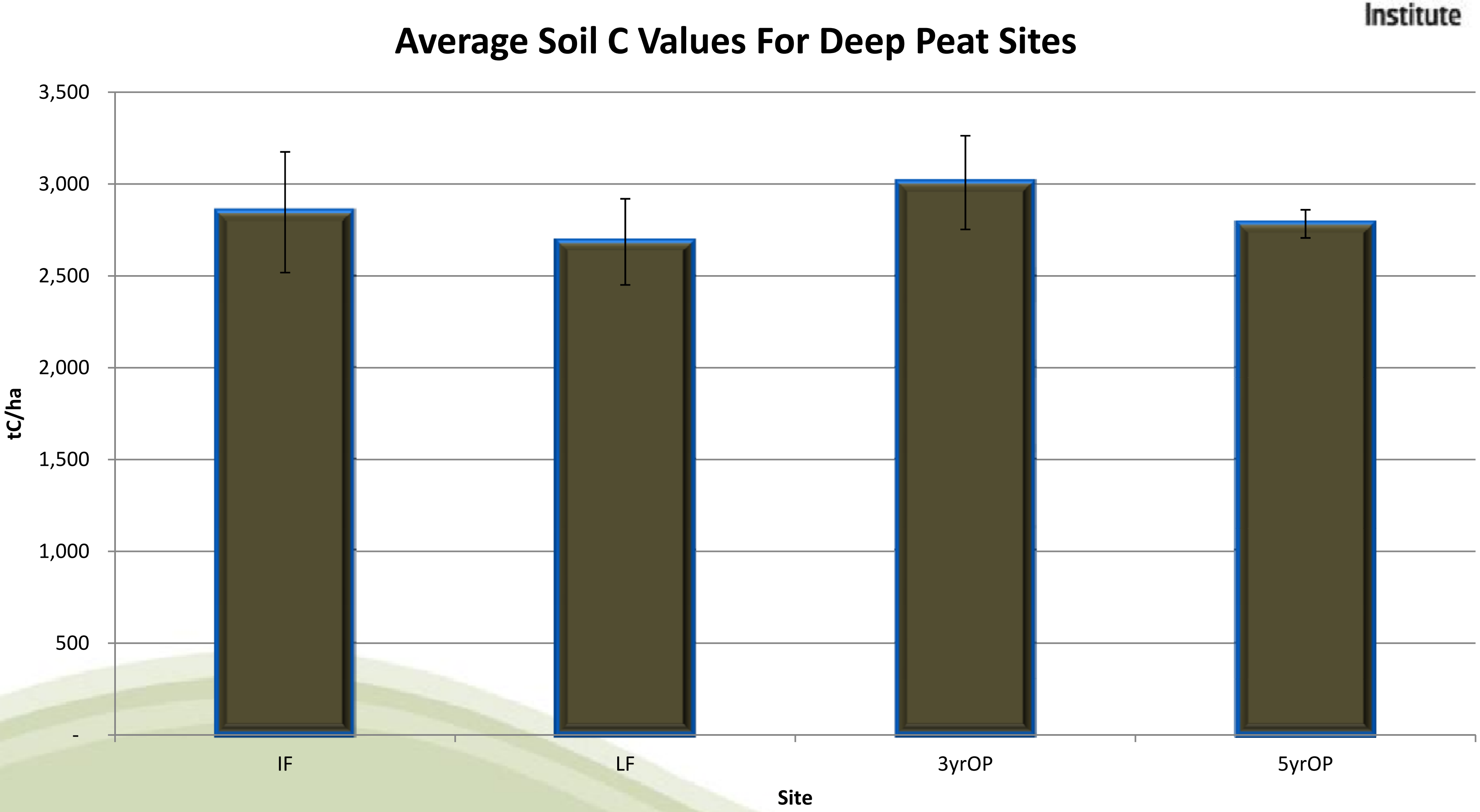
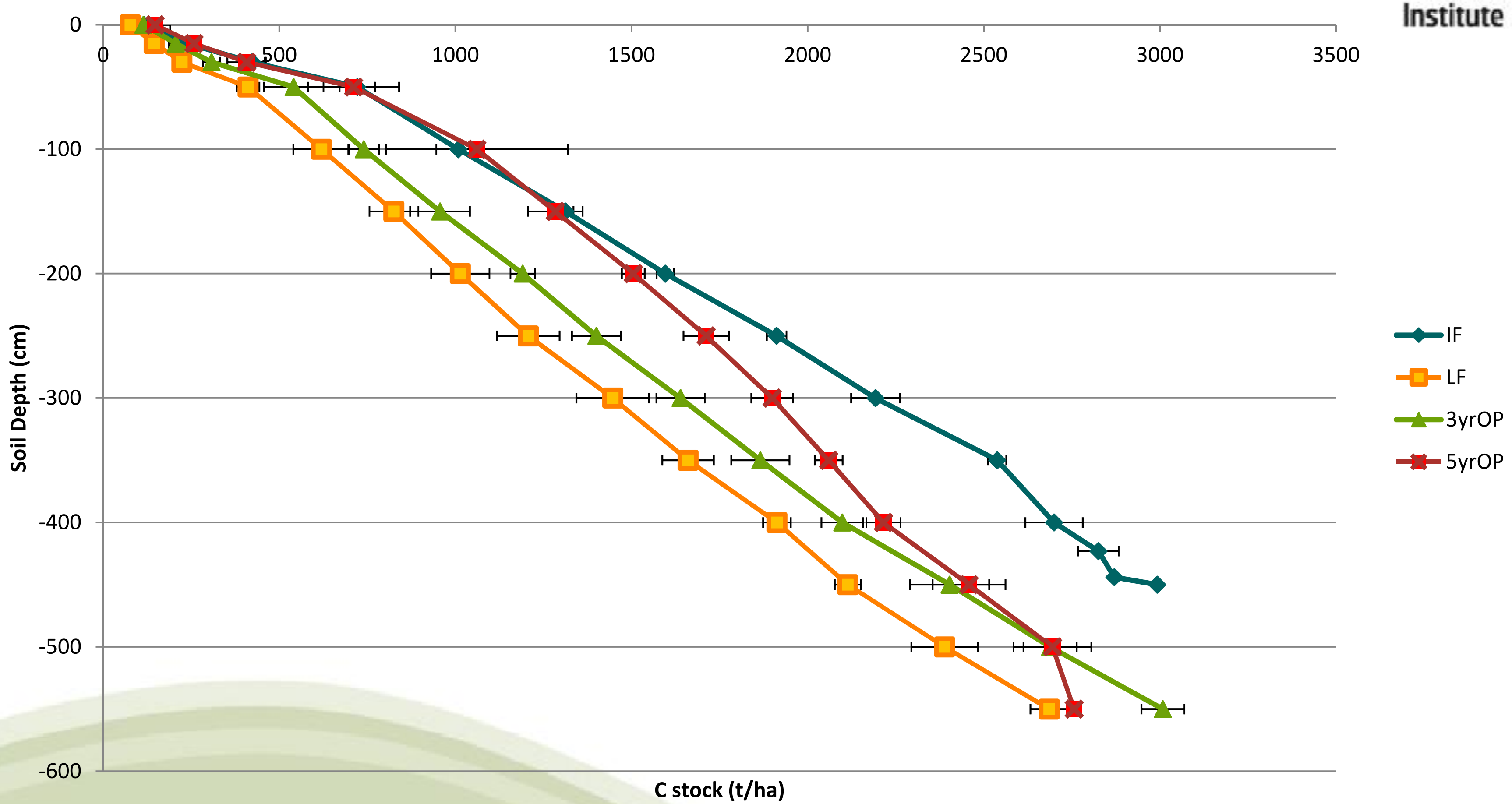
Sampling Soil Carbon

Soil Carbon Results



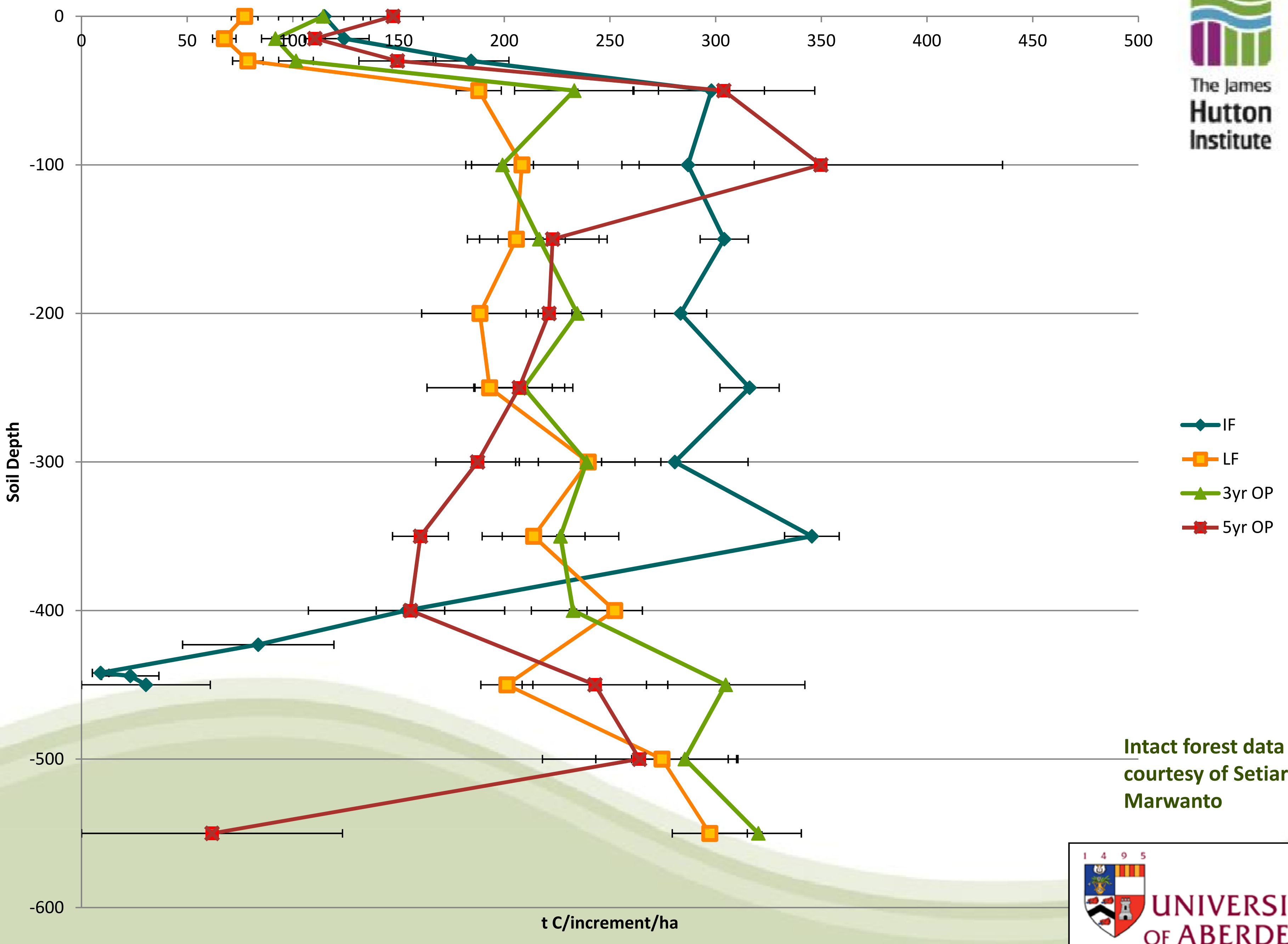
Intact forest data courtesy of Setiari Marwanto

Cumulative Soil C Stocks In Deep Peat Sites



Intact forest data courtesy of Setiari Marwanto

Soil C Per Land Use At Each Depth Increment



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Intact forest data courtesy of Setiari Marwanto

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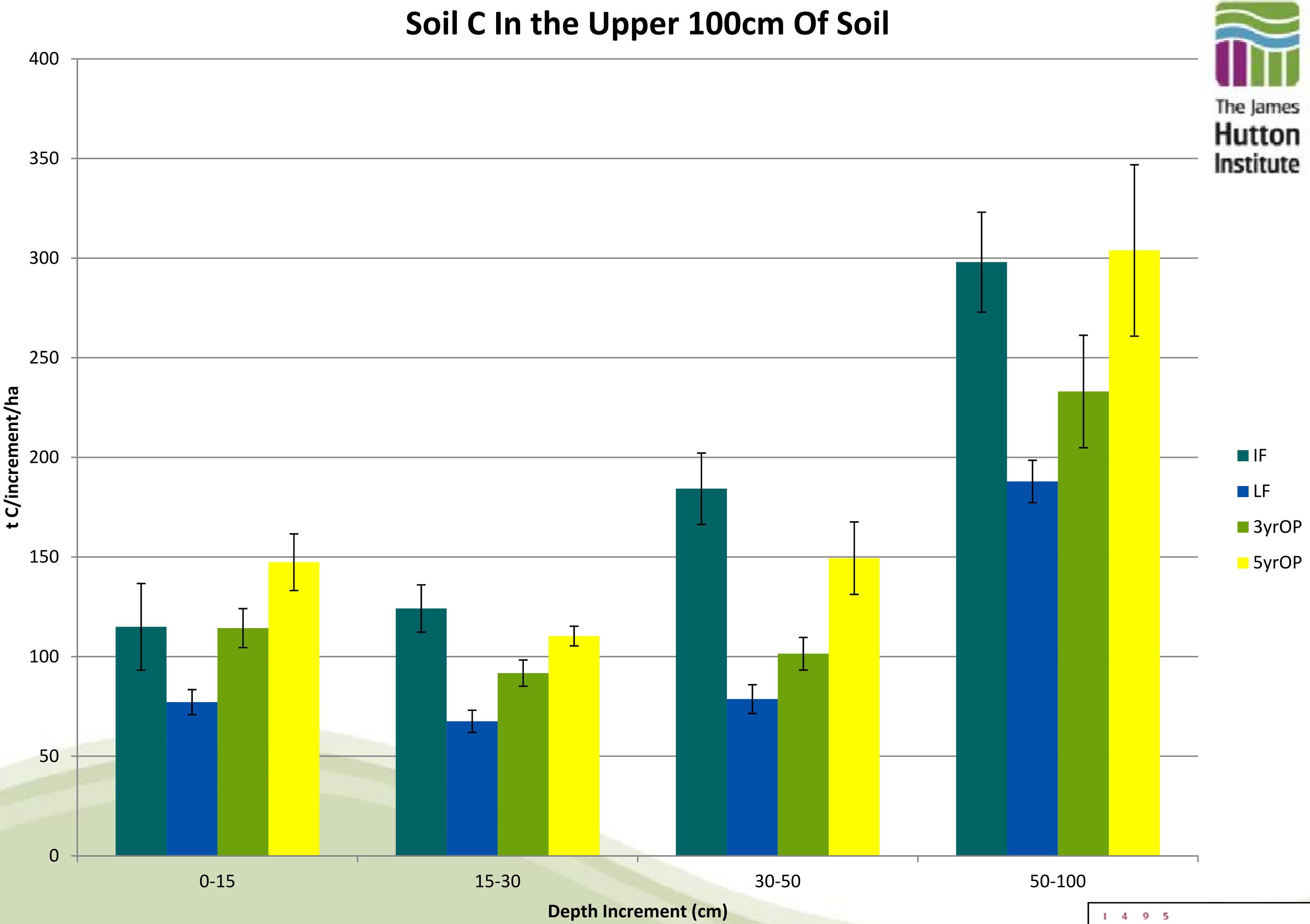


Intact forest data courtesy of Setiari Marwanto

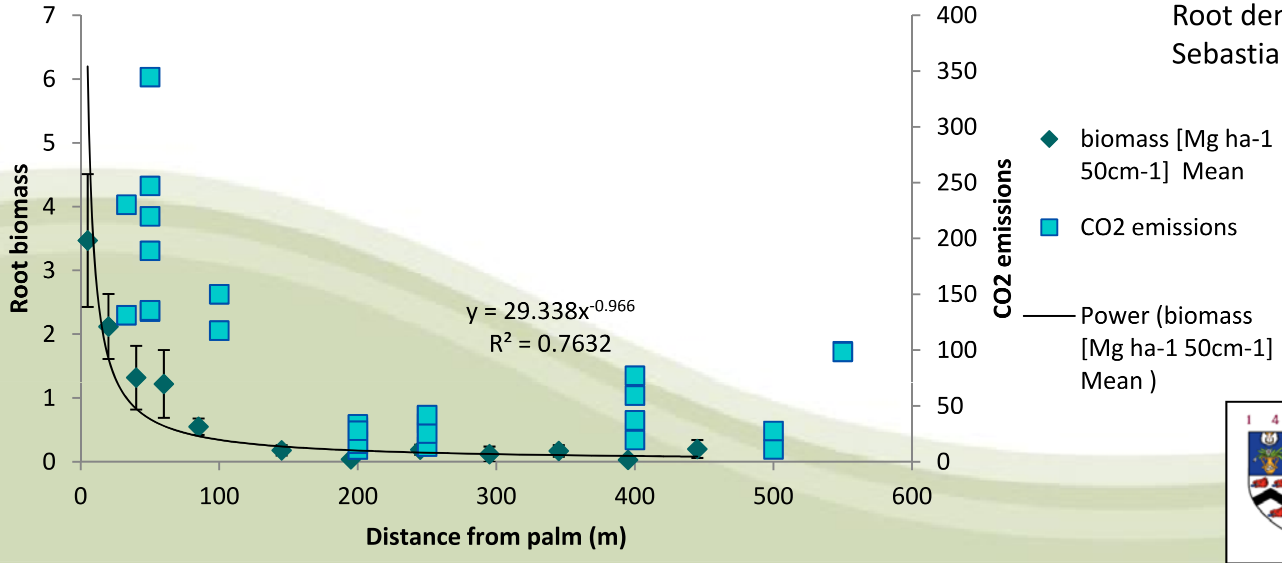
Upcoming fieldwork

- Additional sites in intact forest, logged forest and oil palm.
  - Including 7 year oil palm
  - CO_2, soil C
- Fractionation of soil C pools, in particular the inert organic matter
- Soil moisture retention values
  - Wilting point and field capacity

Upcoming 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.

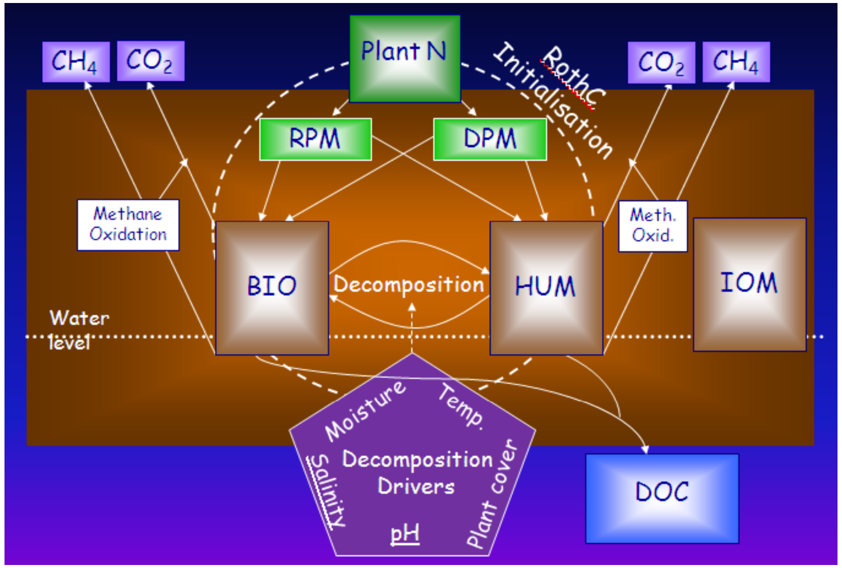
Lateral Root Distribution With CO_2 Emissions



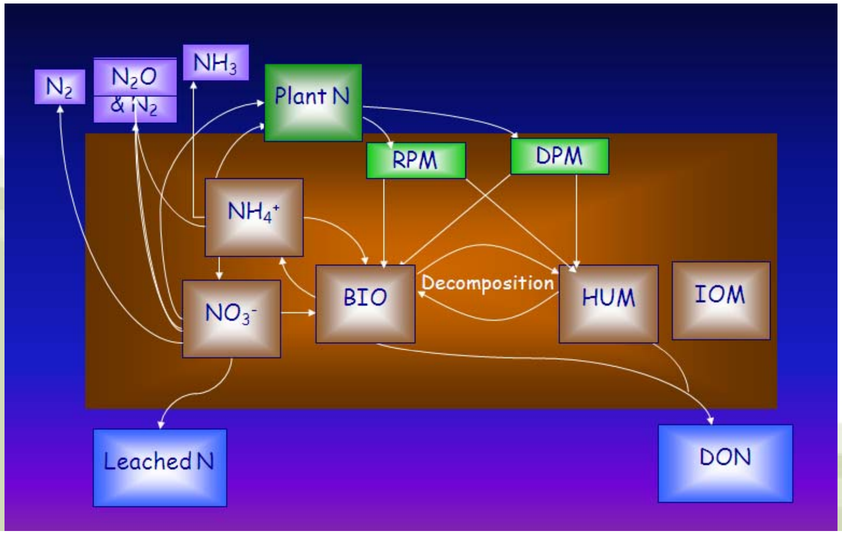
Root density data courtesy of Sebastian Persch

Modelling Using ECOSSE

Made up of a modified existing soil C model (Roth C)....



... And a modified existing soil N model (SUNDIAL).



Modelling with ECOSSE

- Uses commonly available data.
- Predicts impacts of land use change and climate change.
- Mineral and organic soils.
- National and field scale.

```
025e        ! Output file name. Format = 4 characters (extension '.OUT' added by programme)
wet3        ! Site name Format = 4 characters (extension '.DAT19:07 08/03/2010' added by programme)
3           ! Mode of run (1=short-term; 2=equilibrium run using known plant inputs; 3=equilibrium run using measured TOC to get plant inputs and SOM pools; 4=short
2538        ! Total soil C (t C / ha) (only used in mode 3 - but always put value line)
369.75      ! IOM (t C / ha) (only used in mode 3 - but always put value on line)
2           ! Bomb effect: Atm C14 with  1) Suess effect only, 2) Bomb effect
0           ! C in DPM (t C / ha) (only used in mode 1 or 2)
0           ! C in RPM (t C / ha) (only used in mode 1 or 2)
0           ! C in BIO (t C / ha) (only used in mode 1 or 2)
0           ! C in HUM (t C / ha) (only used in mode 1 or 2)
0           ! C in IOM (t C / ha) (only used in mode 1 or 2)
0           ! Radiocarbon age of DPM (yrs)
0           ! Radiocarbon age of RPM (yrs)
0           ! Radiocarbon age of BIO (yrs)
0           ! Radiocarbon age of HUM (yrs)
0           ! Radiocarbon age of IOM (yrs)
0.25        ! DPM:RPM ratio - Agric.crops & improved grass = 1.44;Unimproved grass & scrub = 0.67;Deciduous & tropical woodland = 0.25
lm01        ! Land management file Format = 4 characters (extension '.DAT' added by programme)
2010        ! Start year
100         ! Number of years to run simulation for (used in modes 1 and 4 only)
1           ! Start month (1=Jan, 2=Feb, ...12=Dec) (used in modes 1 and 4 only)
1           ! Output produced (1) every year or (2) final year only (used in modes 1 and 4 only)
1           ! Years needing monthly output (>0) (used in modes 1 and 4 only)21:16 13/03/2010
```

Sources of Modelling Data

- Fieldwork of other REDD-ALERT team members e.g. Setiari Marwanto of ISRI
  - Soil C, BD, soil profile
- My own research
  - CO_2, temp, pH, water table
  - Soil C, BD, soil profile
- New research as it comes in i.e. from new REDD-ALERT researchers
  - CH_4, N_2O

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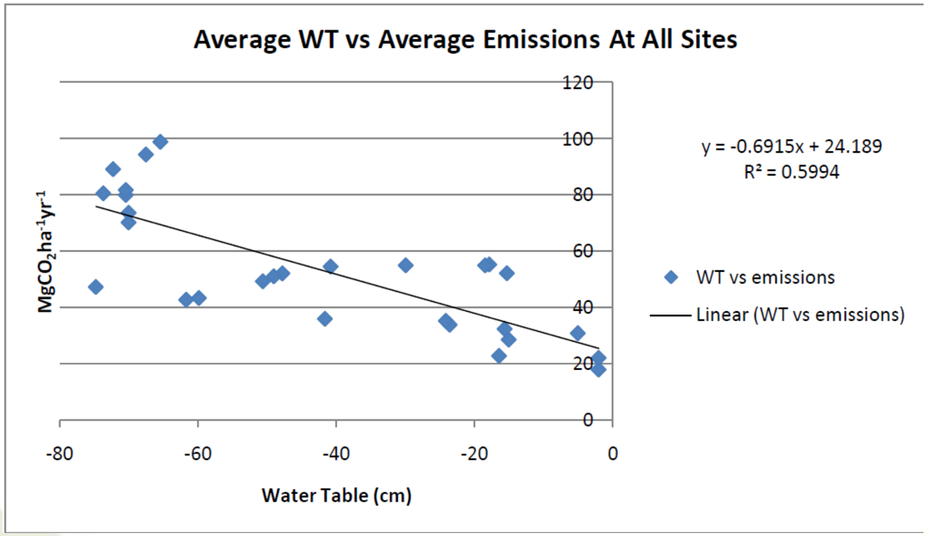
Starting with Roth C

- Only CO_2 emissions, no field values for CH_4 and N_2O.
- Trends in field results (e.g. between temperature and CO_2 emissions and water table and CO_2 emissions) indicated the potential for Roth C application.

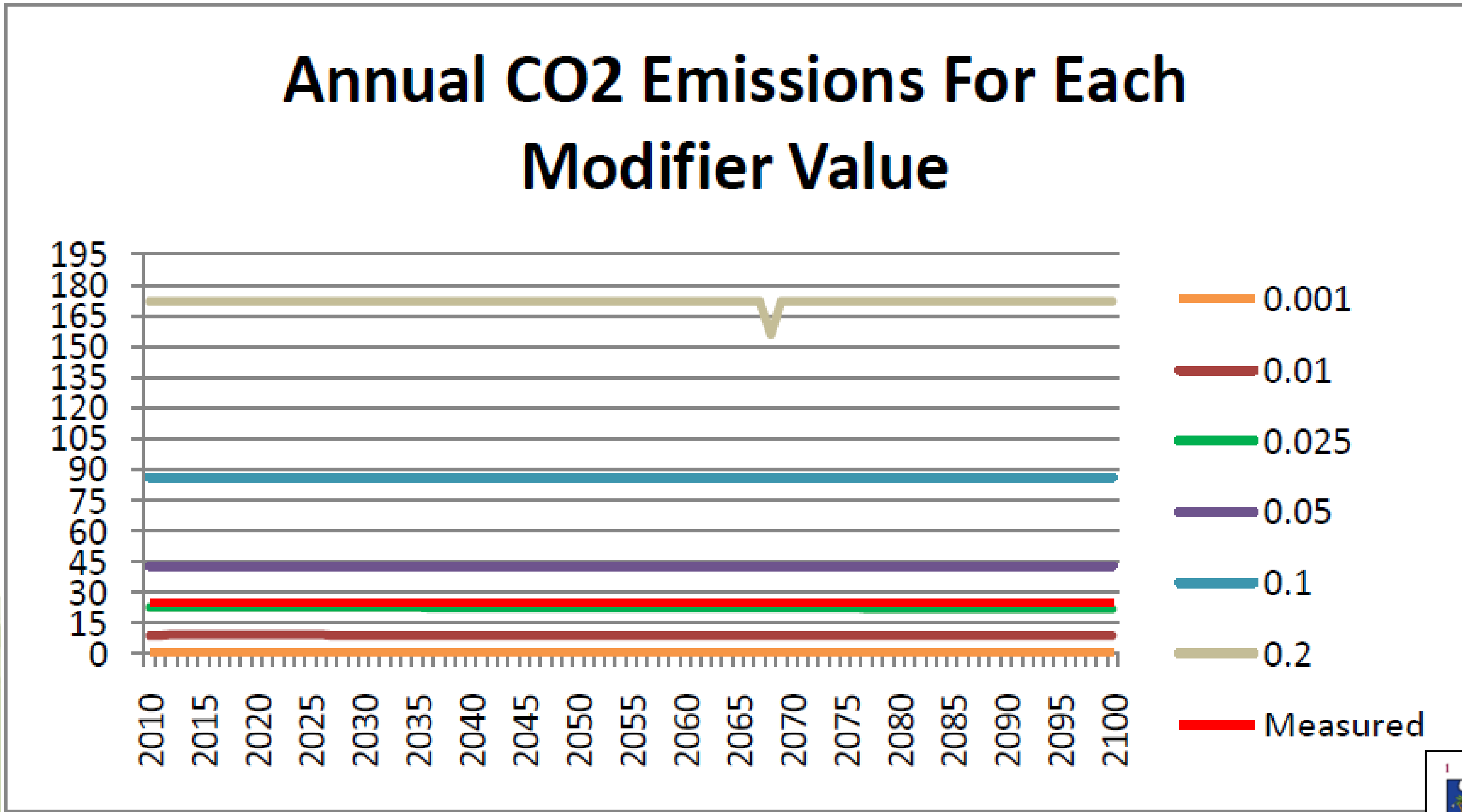


Adding Modifications...

E.g. For submerged soils.

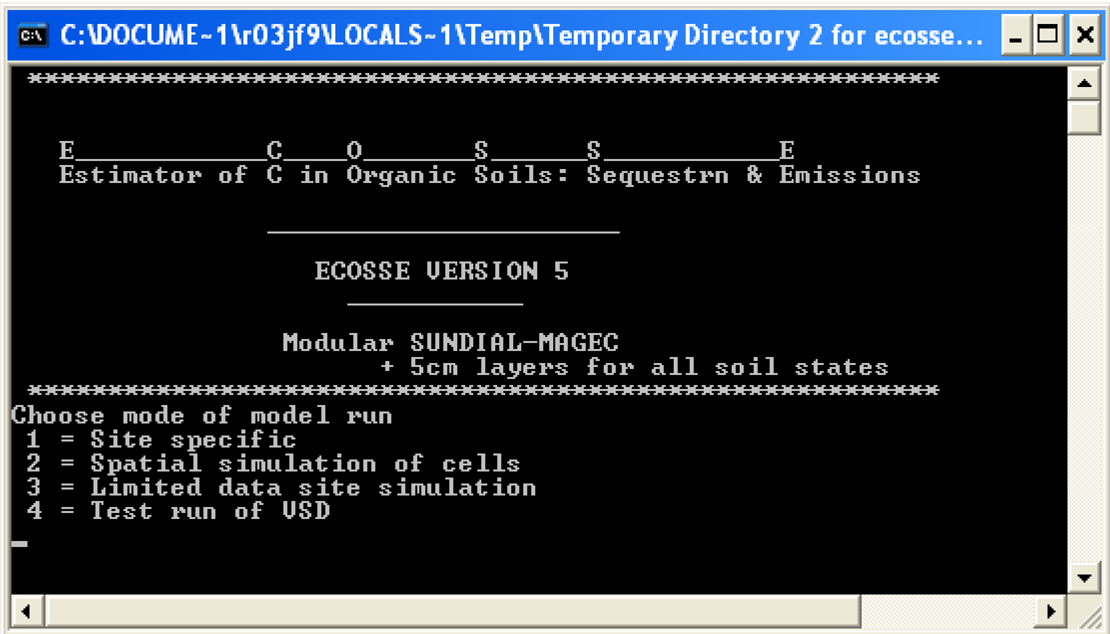
```
C
C ** Combining rate modifiers
C
      DO 160 M=1,12
         RMSMD(M)=0.2
         RATEM(M)=RMTEMP(M)*RMSMD(M)*RMCROP(M)*RMPH*EXTRARM*RMSAL(M)
  160 CONTINUE
C
```

Used on the intact forest:



Using ECOSSE...

- Will start using ECOSSE once we have further field data (March/April 2012).
- Aim to initialise ECOSSE for these sites.
- Scaling up of site specific to national level.



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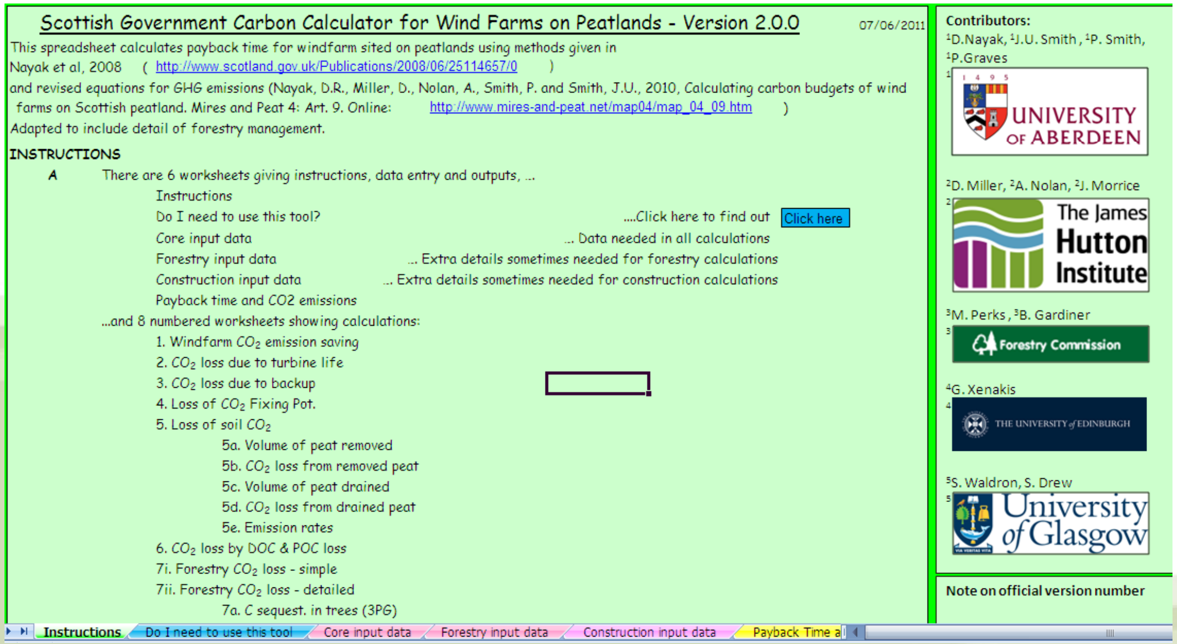
Carbon Calculator

- Based on the idea of a windfarm peatland calculator.
- Being developed to assess the impacts of oil palm plantations on peatlands.
- Aims to be user friendly i.e. for plantation managers, policy makers.
- Using elements of Roth C to calculate emissions.



Available online at www.sciencedirect.com

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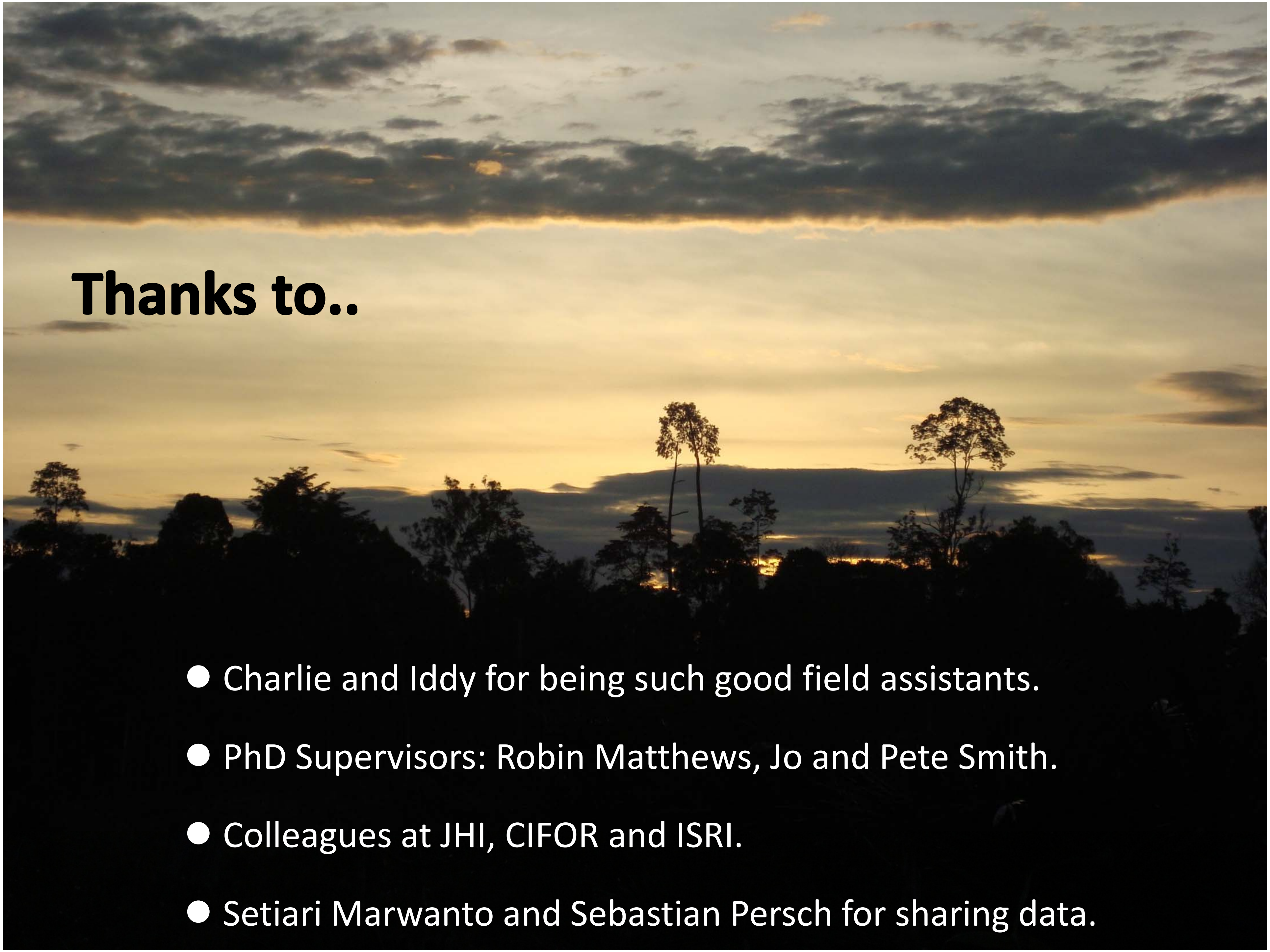
Current Opinion in
Environmental
Sustainability

Assessing existing peatland models for their applicability for modelling greenhouse gas emissions from tropical peat soils

Jenny Farmer[1,2], Robin Matthews[2], Jo U Smith[1], Pete Smith[1] and Brajesh K Singh[3]

Modelling greenhouse gas (GHG) emissions from tropical peatlands is of crucial importance in determining GHG emission rates under global change. Modelling efforts to date have been restricted by the lack of available data for parameterisation, input and validation of simulation models, due to the complex and often inaccessible nature of tropical peatland ecosystems. There have been very limited experimental or modelling studies to predict GHG fluxes from tropical peatlands. However, our understanding of temperate and boreal peatlands is much more advanced. In this paper we consider the processes that would need to be taken into account in modelling tropical peatlands subject to land use change, and discuss how progress in modelling on temperate peatlands could be applied to these systems.

ranging from open areas with low lying vegetation to dense tall interior forest [4,5]. Carbon dioxide (CO_2) emissions from peatlands of the same peat depth and groundwater level in temperate and boreal zones are far lower than those in the tropical regions (found between latitudes 35° North and South [2]), for example of South-East Asia, due to the lower rate of aerobic decomposition in temperate and boreal peats [6,7]. Even within areas experiencing similar climatic conditions, there can be dramatic variation in the peat itself; peat in Sumatra, for example, ranges from 0.75 to 10 m [3]. This variation makes it difficult to generalise about peatlands in national and global peatland assessments, necessitating more localised research and management strategies.


Thanks to..
Charlie and Iddy for being such good field assistants.
PhD Supervisors: Robin Matthews, Jo and Pete Smith.
Colleagues at JHI, CIFOR and ISRI.
Setiari Marwanto and Sebastian Persch for sharing data.