Quantifying and Understanding the Earth System

soil C:N:P stoichiometry as a means to constrain decomposition

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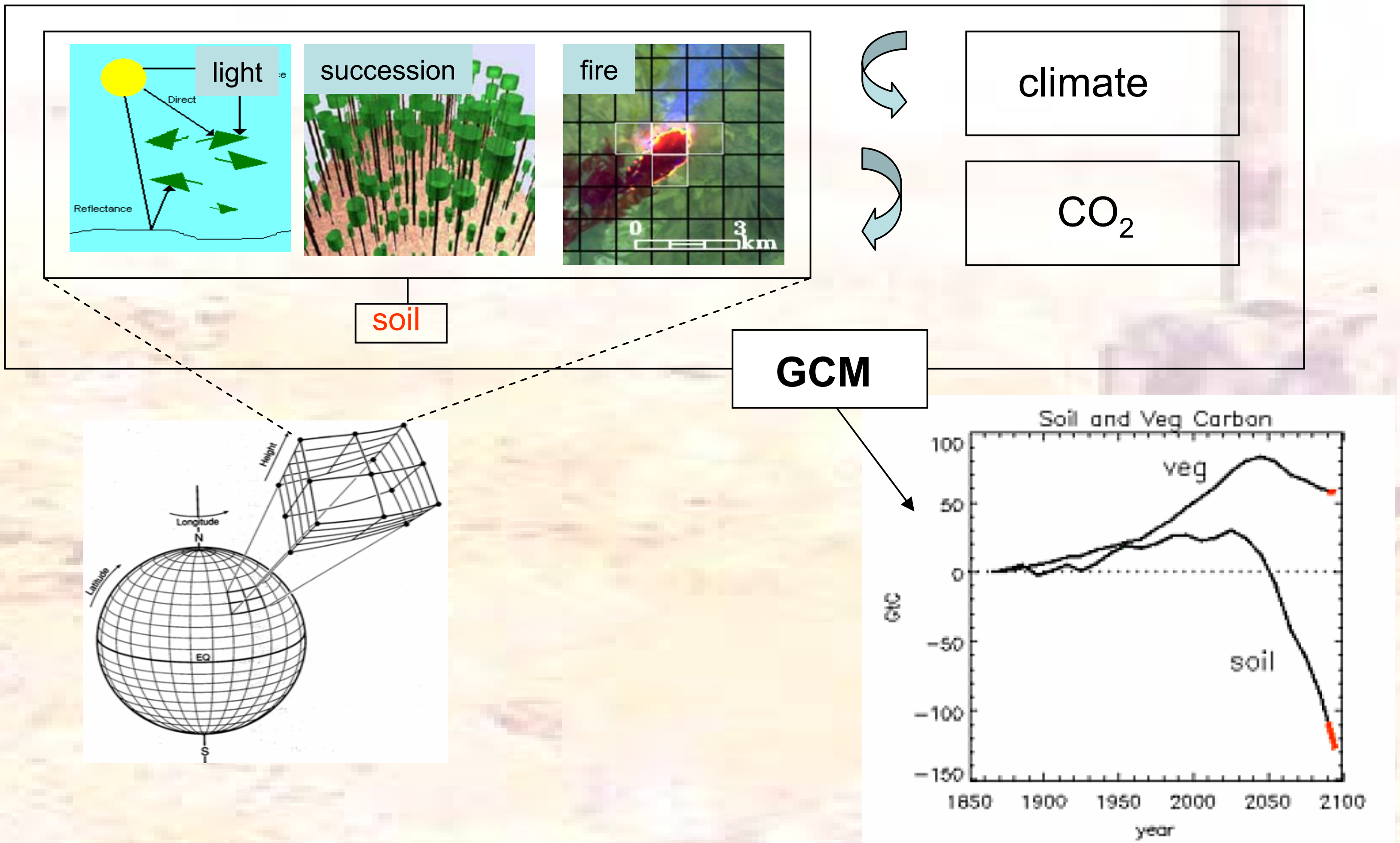
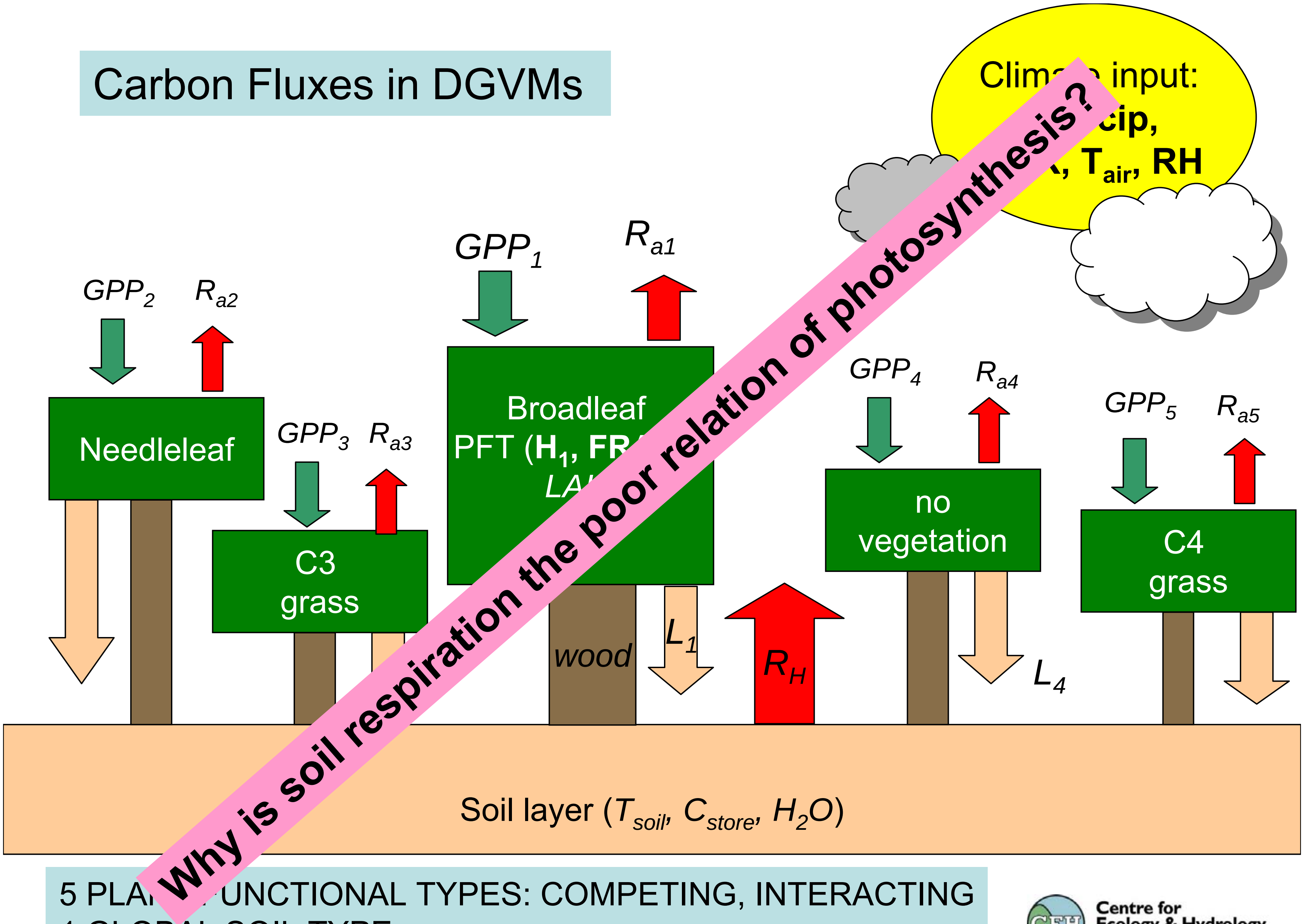
Dynamic Global Vegetation Models (DGVMs)

Simulate fluxes of carbon, water and nitrogen along with changes in the vegetation dynamics, within an integrated system.



Cox et al. 2000 (Nature)

Carbon Fluxes in DGVMs



5 PLA UNCTIONAL TYPES: COMPETING, INTERACTING
1 GLOBAL SOIL TYPE

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Process studies

Ra

Table 2

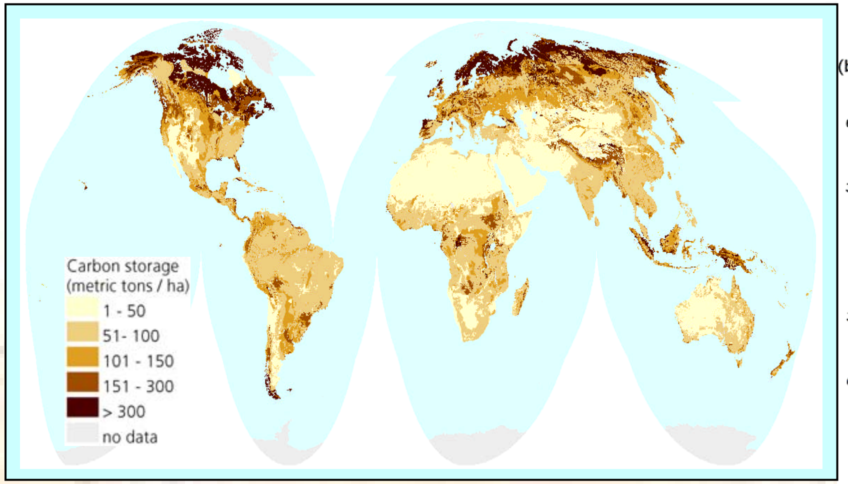
Q_{10} values derived from different fitted relationships with Eq. (5). Q_{10} value at 10°C for forest soil with linear equation is not available because of a negative efflux was estimated with the fitted relationship

Equation	Q_{10} at 10°C		Q_{10} at 30°C	
	Farmland	Forest	Farmland	Forest
Linear	8.8	NA	1.5	1.5
Quadratic	4.0	4.0	1.8	1.8
Kucera and Kirkham	3.1	4.9	1.9	2.4
Eq. (4)	2.8	4.7	2.0	2.5
First-order exponential	2.3	3.1	2.3	3.1
O'Connel	2.2	2.6	2.4	3.7
Arrhenius	2.4	3.4	2.2	2.9
Lloyd and Taylor	2.4	3.3	2.2	2.9
Jenkinson	2.2	2.6	2.6	5.8
Schlentner and Cleve	2.5	3.5	2.8	8.1

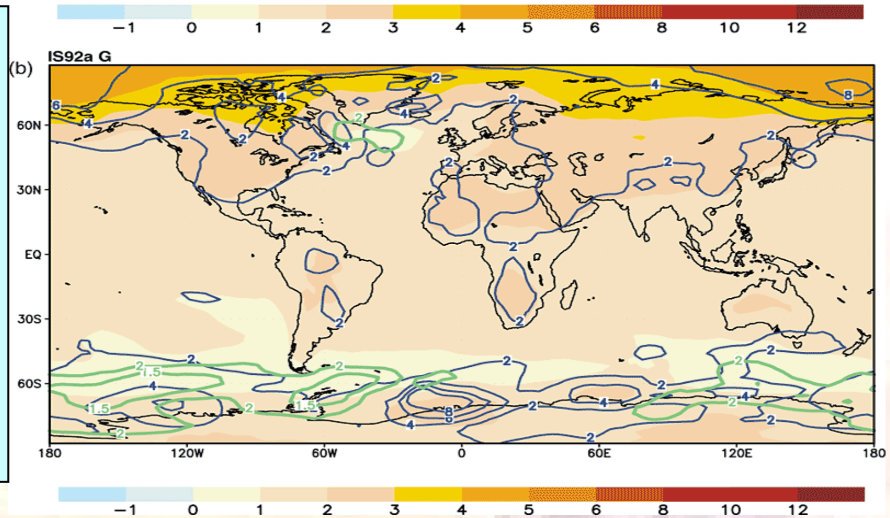
C. Fang, J.B. Moncrieff / Soil Biology & Biochemistry 33 (2001) 155–165

Case for soil function types (SFTs)

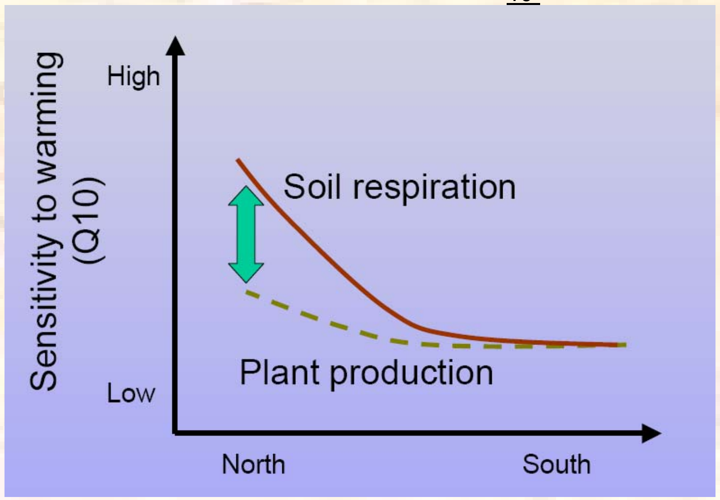
Large stocks of C in high latitude soils

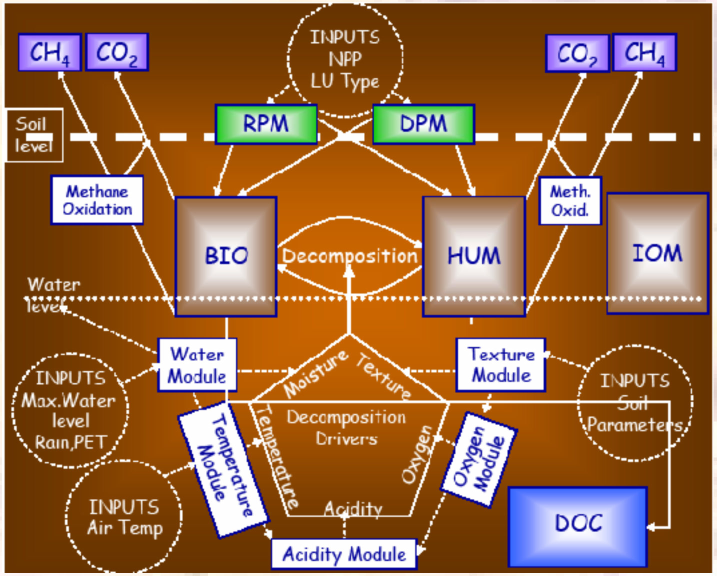


High latitude soils will warm the most



Experimental evidence on Q_{10} variability



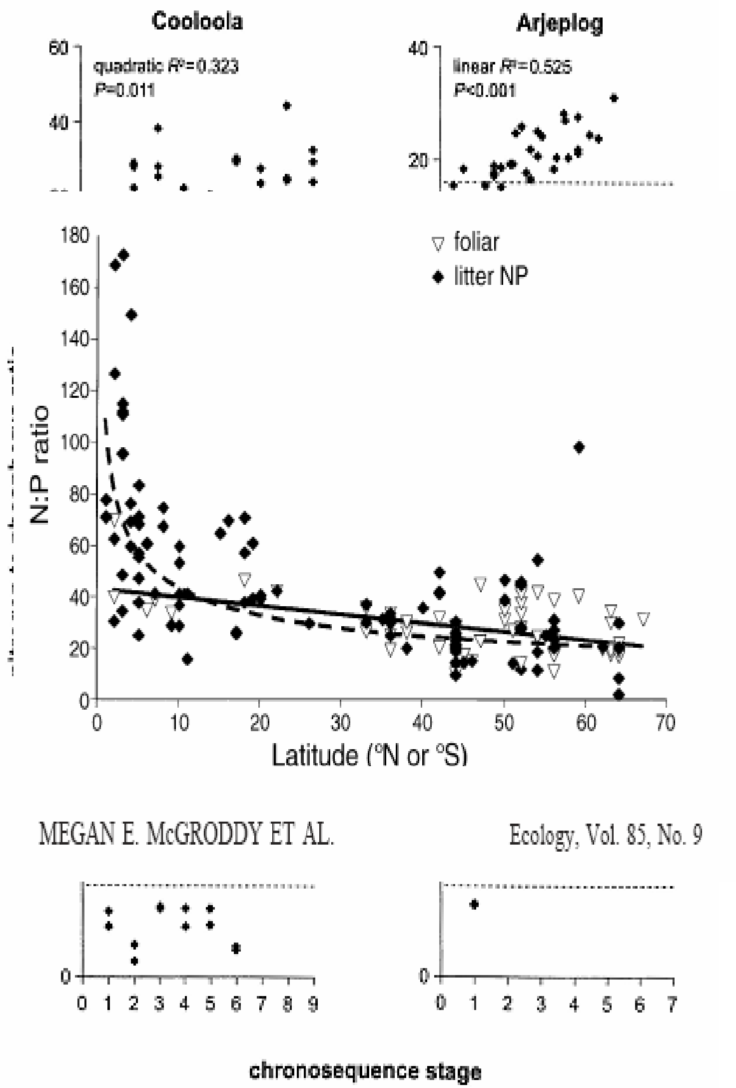


QUERCC: focus on organic soils.

ECOSSE

Evidence of P limitation during forest decline phase

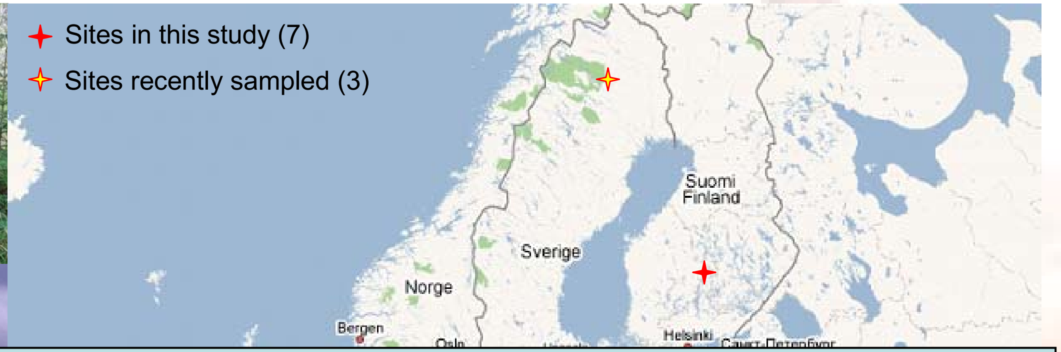
Significant increase in humus N:P and C:P with increasing age at all sites



Wardle, Walker and Bardgett (2004) *Science.*

Peat respiration experiment

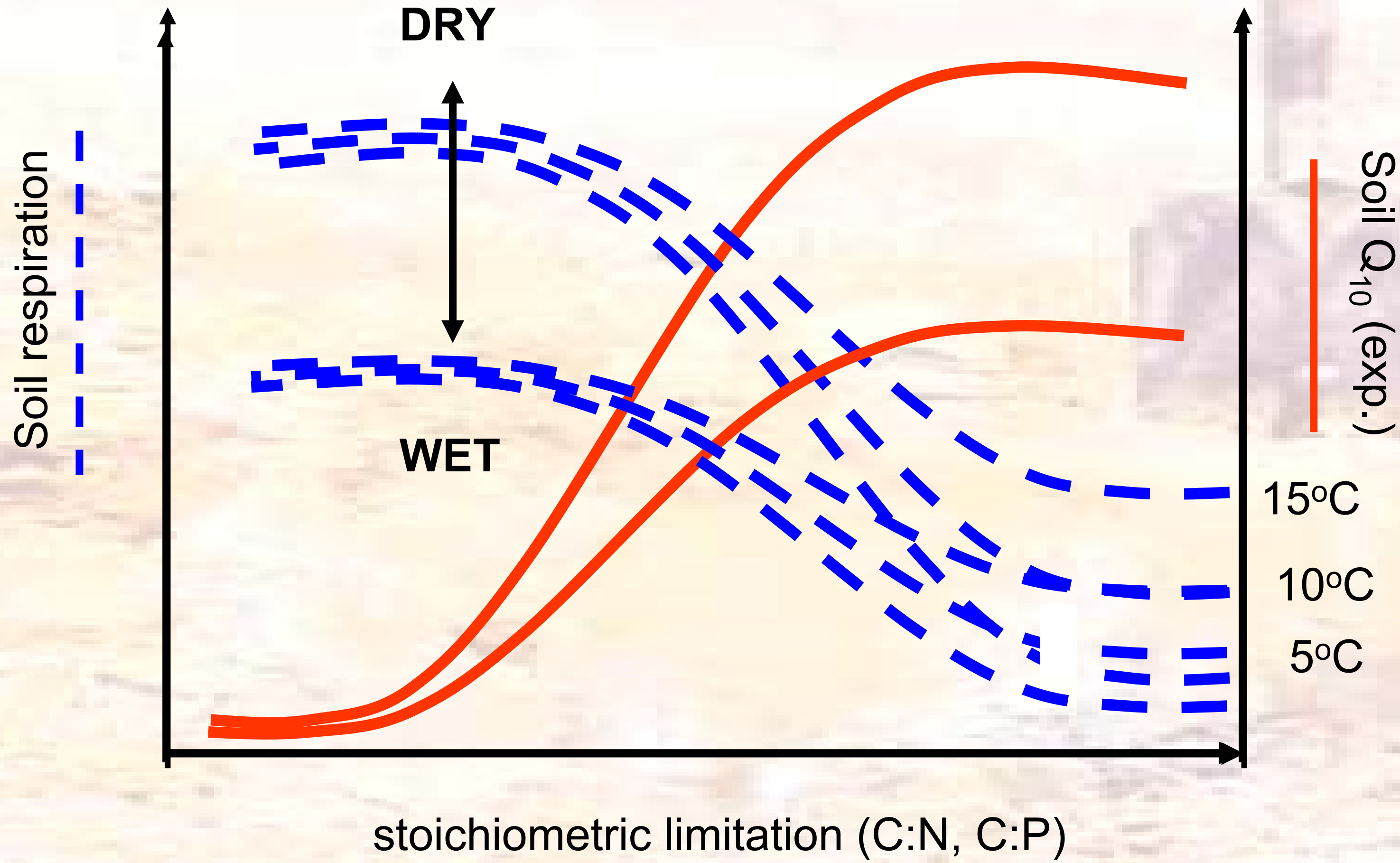
Objective: To compare respiration rates in peat soils from UK and European sites in relation to C:P, N:P, C:N stoichiometry and abiotic conditions.



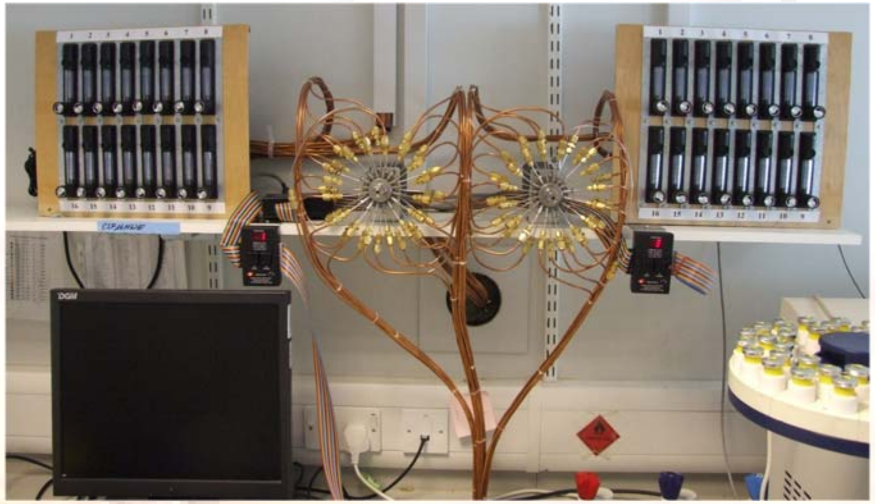
SITE	C:P	N:P	C:N
Moor House Bog	984	32	31
Moor House	641	24	26
Auchencorth Moss	442	21	21
Finland	427	13	32
Great Dun Fell	361	19	19
Plynlimon	351	18	19
Xistral, Spain	275	13	21

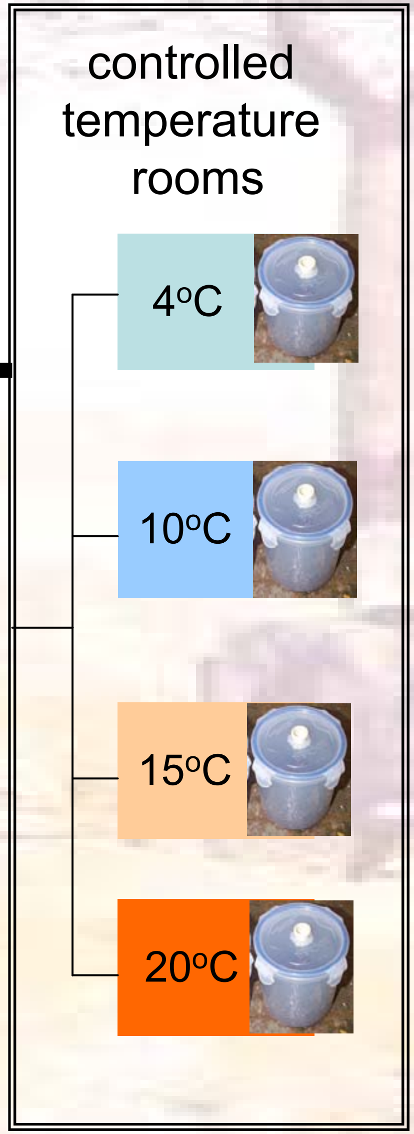
Mere Bleu Canada, Bonanza Creek Alaska, Caithness, Gallway

Eco-stoichiometric framework
: to explain peat C temperature sensitivity

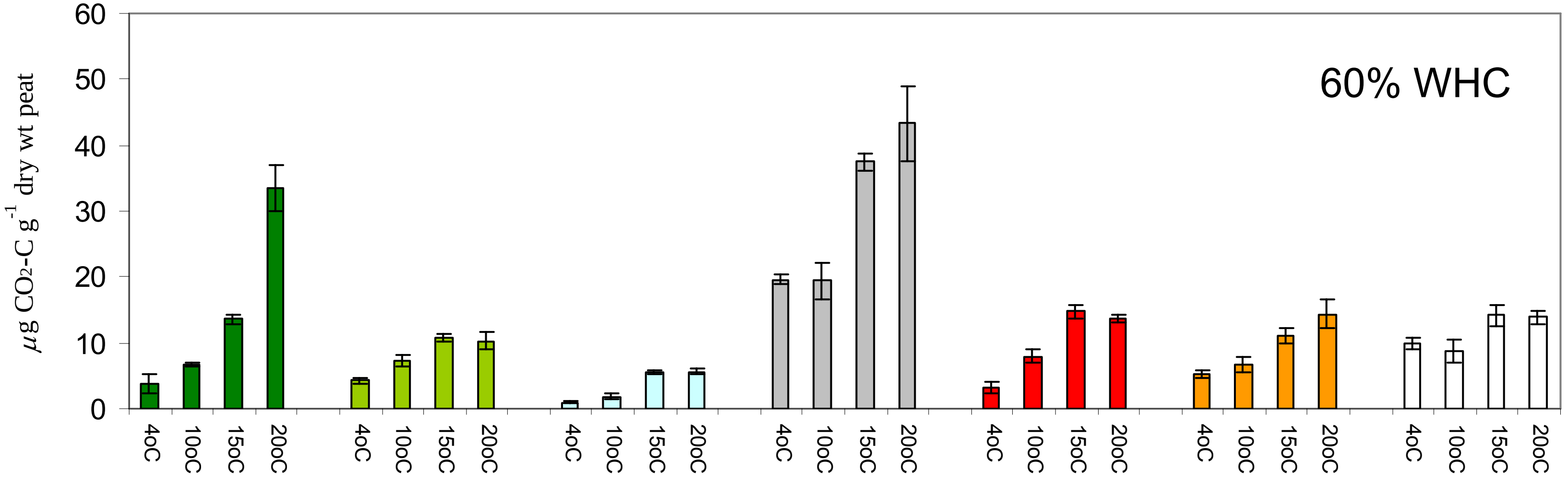


Earth Respiration System

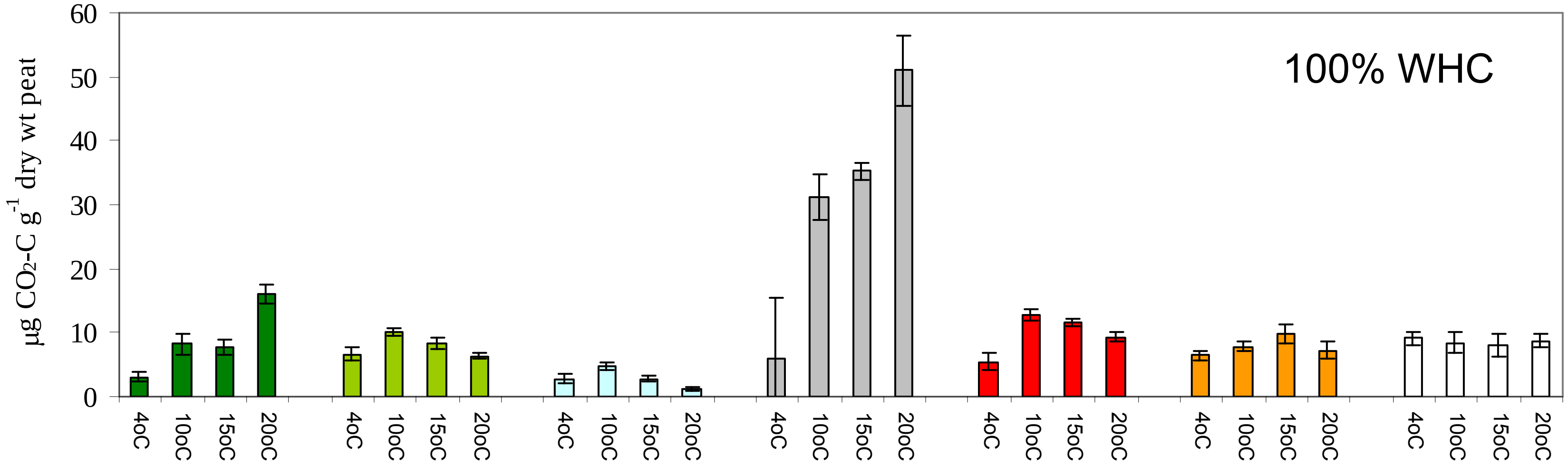




- Automated CO_2, CH_4 and N_2O measurements
- Measure 32 soils simultaneously
- Can make repeated measurements over time
- Constant or variable temperature

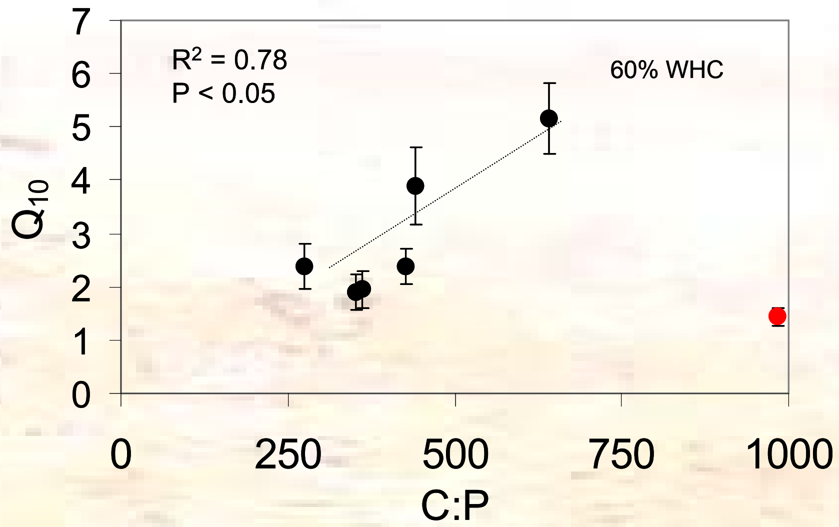


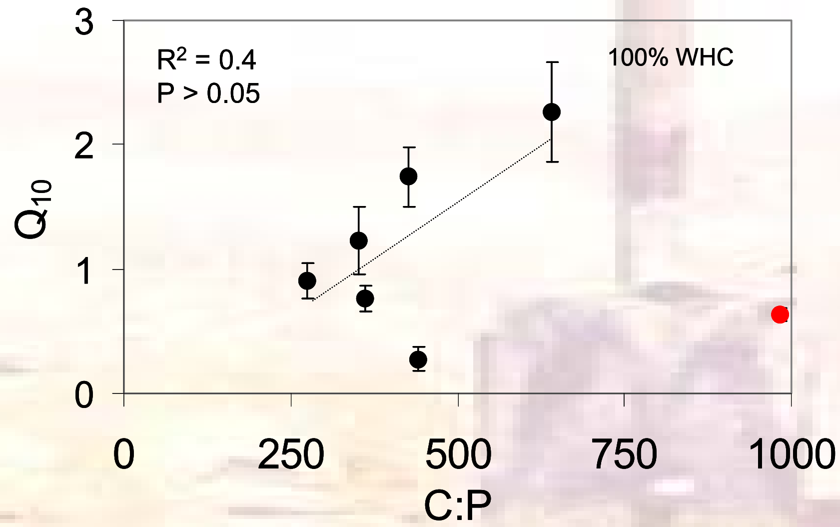
60% WHC
μg CO_2-C g^{-1} dry wt peat
0
10
20
30
40
50
60
4oC
10oC
15oC
20oC



100% WHC
μg CO_2-C g^{-1} dry wt peat
0
10
20
30
40
50
60
4oC
10oC
15oC
20oC

peat C:P and respiration Q_{10} values



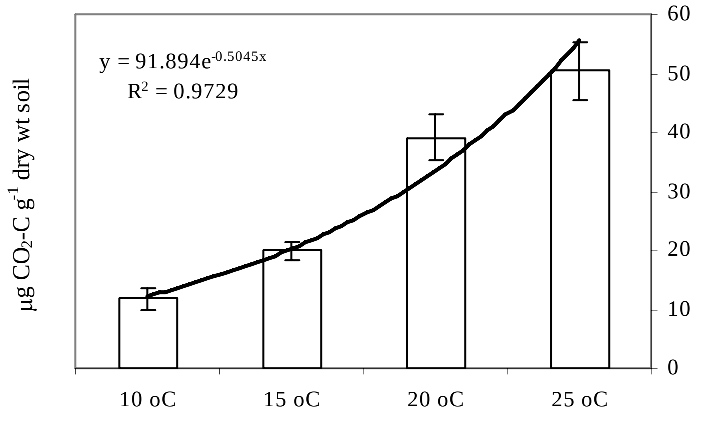


"The temperature sensitivity of peat SOM to decomposition increases with increasing C:P"

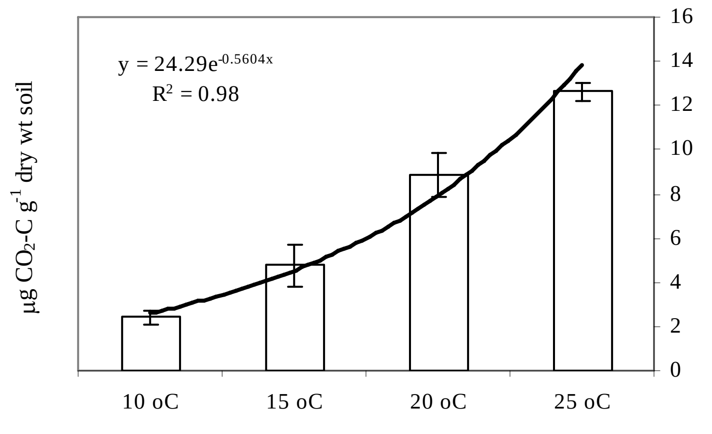
PERU ANDES 2007

Soil cores collected along 3 (so far of 14) altitudinal gradients with variable C:P and N:P

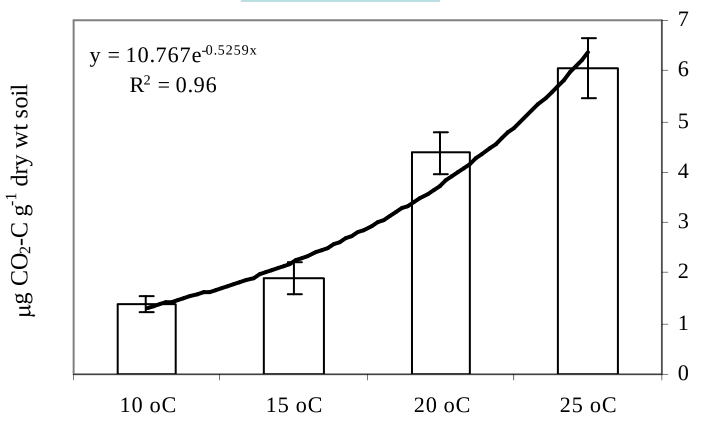
3000 m



1500 m



1000 m

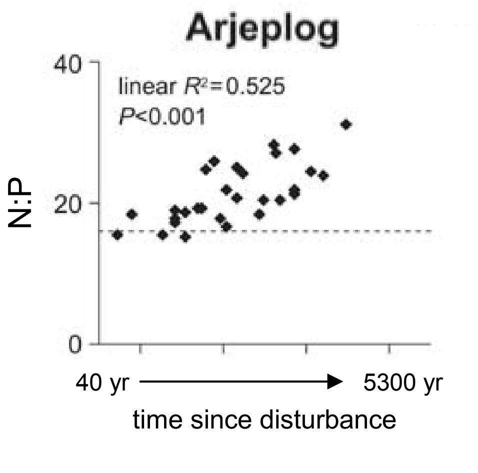


In collaboration with: Patrick Meir & Yadvinder Malhi

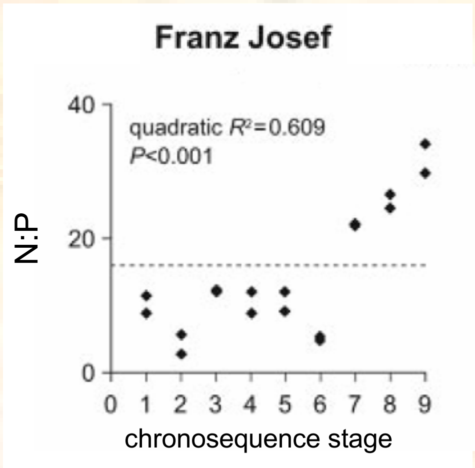
SWEDEN

● CO_2 & CH_4 flux measurements *in-situ* on 30 islands with variable C:P and N:P.

● Laboratory incubations under different temperature ranges.



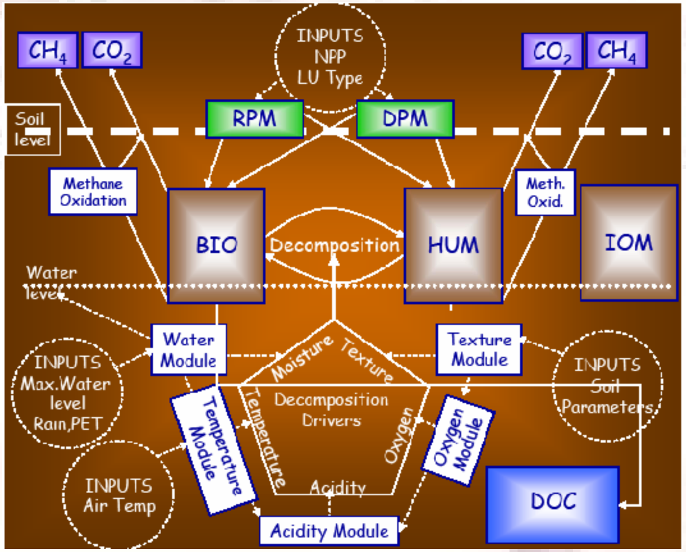
NEW ZEALAND



● Laboratory incubations under different temperature ranges.

● Nutrient assays on soils under incubation with different temperature ranges.

Examining the temperature sensitivity of different soil carbon pools



→ Developing methods to parameterise 3 pool organic soil models

- Size fractionation
- Density fractionation
- Chemical fractionation

European Journal of Soil Science, 2006 doi: 10.1111/j.1365-2389.2006.00855.x

Measured soil organic matter fractions can be related to pools in the RothC model

M. Zimmermann[a], J. Leifeld[a], M. W. I. Schmidt[b], P. Smith[c] & J. Fuhrer[a]
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Summary

Understanding the response of soil organic carbon (SOC) to environmental and management factors is necessary for estimating the potential of soils to sequester atmospheric carbon. Changes over time in the amount and distribution of SOC fractions with different turnover rates can be estimated by means of soil SOC models such as RothC, which typically consider two to five SOC pools. Ideally, these pools should correspond to measurable SOC fractions. The aim of this study was to test the relationship between SOC pools used in RothC and fractions separated through a fractionation procedure. A total of 123 topsoil samples from agricultural sites (arable land, grassland and alpine pasture) across Switzerland were used. A combination of physical and chemical methods resulted in two sensitive (particulate organic matter and dissolved organic carbon), two slow (carbon associated to clay and silt or stabilized in aggregates) and one passive (oxidation-resistant carbon) SOM fractions. These fractions were compared with the estimated equilibrium model pools when the corresponding soils were modelled with RothC. Analysis revealed strong correlations between SOC in measured fractions and modelled pools. Spearman's rank correlation coefficients varied between 0.82 for decomposable plant materials (DPM), 0.76 for resistant plant materials (RPM), 0.99 for humified organic matter (HUM) and biomass (BIO), and 0.73 for inert organic matter (IOM). The results show that the proposed fractionation procedure can be used with minor adaptations to identify measurable SOC fractions, which can be used to initialize and evaluate RothC for a wide range of site conditions.

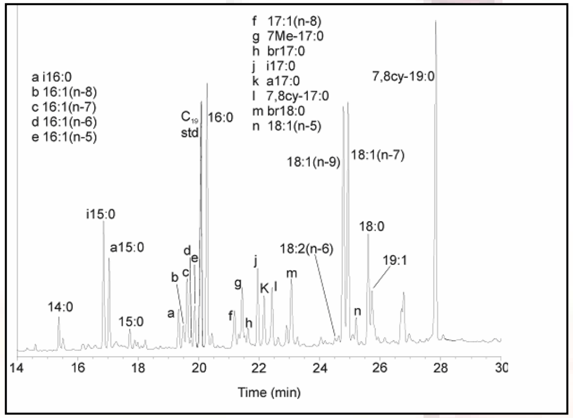
Eva Tregidgo PhD **"Organic Soil Carbon Fractions"**

altered CO_2 exchange between terrestrial ecosystems and the
Most models are based on several conceptual SOM pools with

Examination of soil microbial and C pools at experimental end point

4°C
10°C
15°C
20°C

All treatments → 10 °C

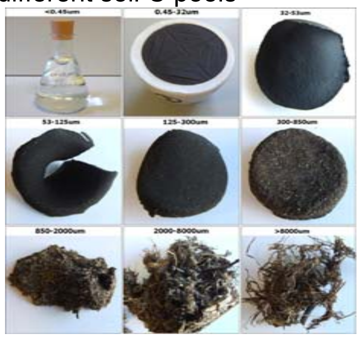


PLFA microbial biomass

Respiration function

microbial communities

"Examining the temperature sensitivity of different soil C pools

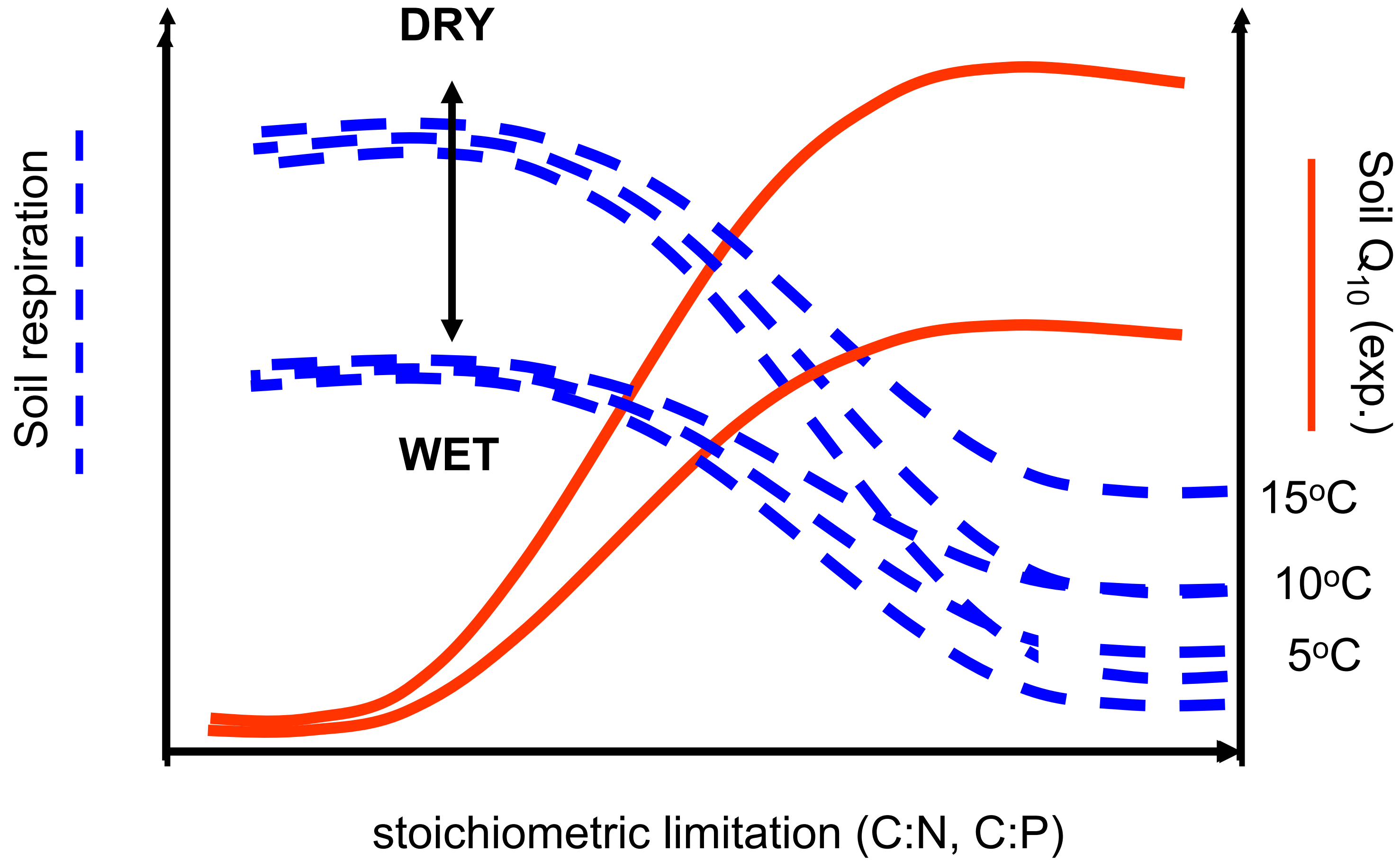


"soil fractions (Eva Tregidgo)"

Nutrients (C, N, P)

carbon quality

Eco-stoichiometric framework
: to explain peat C temperature sensitivity



SO,

Organic soil stoichiometry experiments on-going and extended to other soil types e.g. tropical soils.

Development of meaningful measures of organic soil C pools for modelling
Looking to expand capability for soil Q_{10} studies with our Earth Resp System

Continued contribution of benchmark data for ECOSSE and Roth-C for JULES development.