DO INTRINSIC ISOTOPIC SIGNATURES REVEAL REACTIVE NITROGEN AND CARBON PRIMING OF SOIL ORGANIC MATTER?

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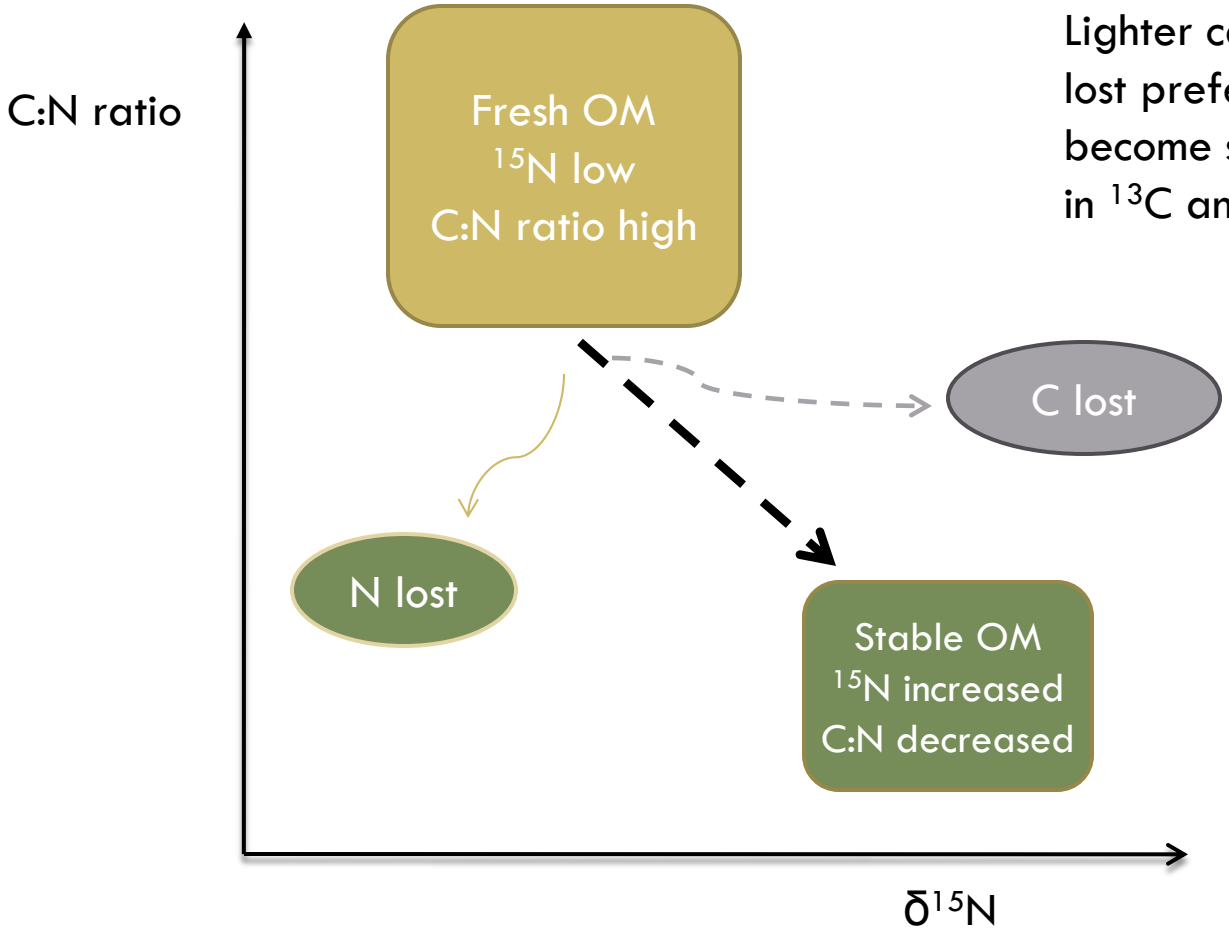
Priming.

- The priming effect is classically termed the increase in soil organic matter (SOM) decomposition rate, after the addition of fresh organic matter.
- Both inorganic nitrogen and soluble carbon additions are also thought to lead to priming.
- Priming is thought to result from a general increase in microbial activity (Fontain 2003).

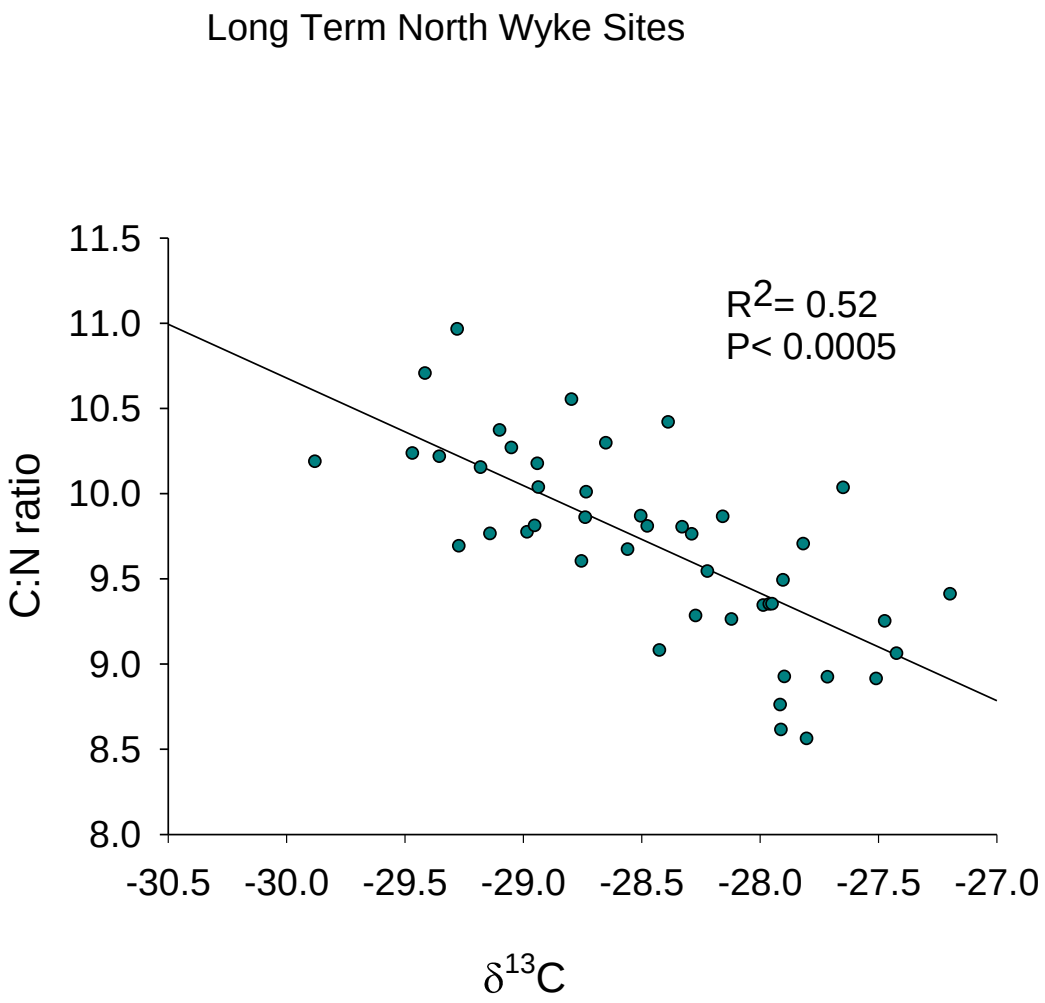
How does this effect the isotopes



Lighter carbon and nitrogen will be lost preferentially so OM will become sequentially more enriched in ^{13}C and ^{15}N, as it breaks down.

Based on Conen et al., 2008, Biogeosciences

Initial impetus for research.



Rowden Moor drainage experiment.

(Kevin McTiernan, Tyson et al. 1992).

Mack *et al.*, (2004) Nature Nitrogen additions stimulated NPP but accelerated decomposition leading to net loss in carbon from Arctic tundra systems.

Hypothesis

- If there is significant priming of the SOM, due to the addition of reactive nitrogen and carbon, it should be evident in the ^{15}N and ^{13}C of the SOM.
- Primed plots should see increases in $\delta^{13}C$ and $\delta^{15}N$ compared to the control plots.
- Increases in production due to N fertilization could cloud issues, due to increased production of fresh OM in grasslands, due to fertilizer input, but probably not in forest soils on such short time scales.

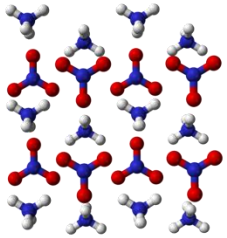
Experimental sites.

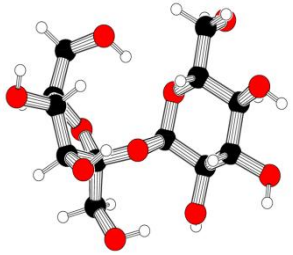
- Randomized block design, forest or grassland sites.

Grasslands

Forests

Experiment treatments.



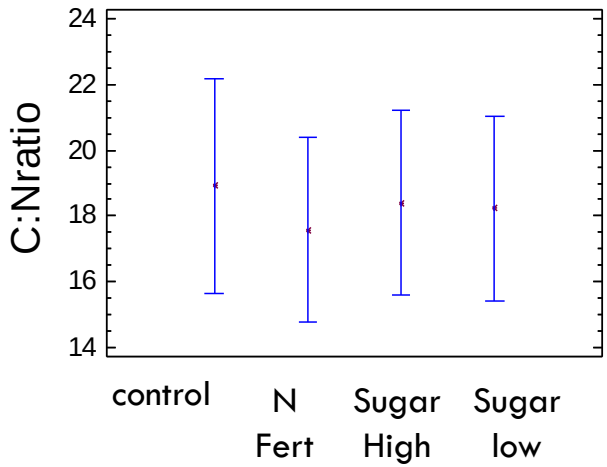


- C-Unfertilized plot (control; de-ionized water only)
- N-(NH_4NO_3) -fertilized plot (80-100 kg N ha-1)
- SH (Sucrose)-fertilized plot – *high*; started in 2010 (36 t sugar ha^{-1}, 15 t C ha^{-1})
- S (Sucrose)-fertilization plot – *low*; started in 2011(3.6 t sugar ha^{-1}, 15 t C ha^{-1})

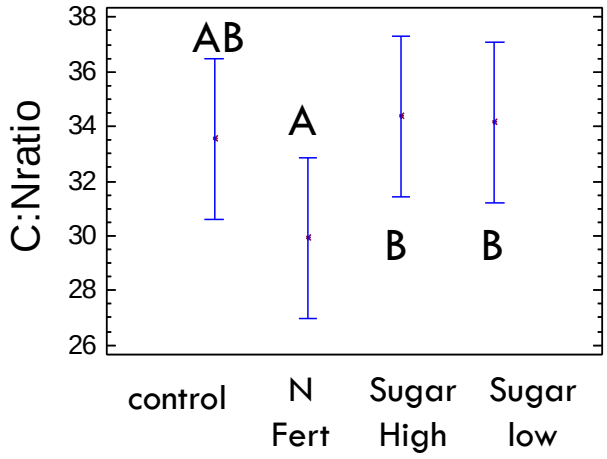
Sample preparation.

- Four replicate plots
- Sampled soil from 0-5 cm layer, below vegetation/litter layer.
- From each replicate we took three random spatulas from same depth combined and homogenized.
- Sieved to 2mm, removed visible roots
- Homogenized a 1-2 g fresh sub-sample
- Samples dried at 60°C and ground
- Analysed with EA-IRMS, for %N, %C, ^{15}N & ^{13}C.

Overall results



Grassland
DE 3



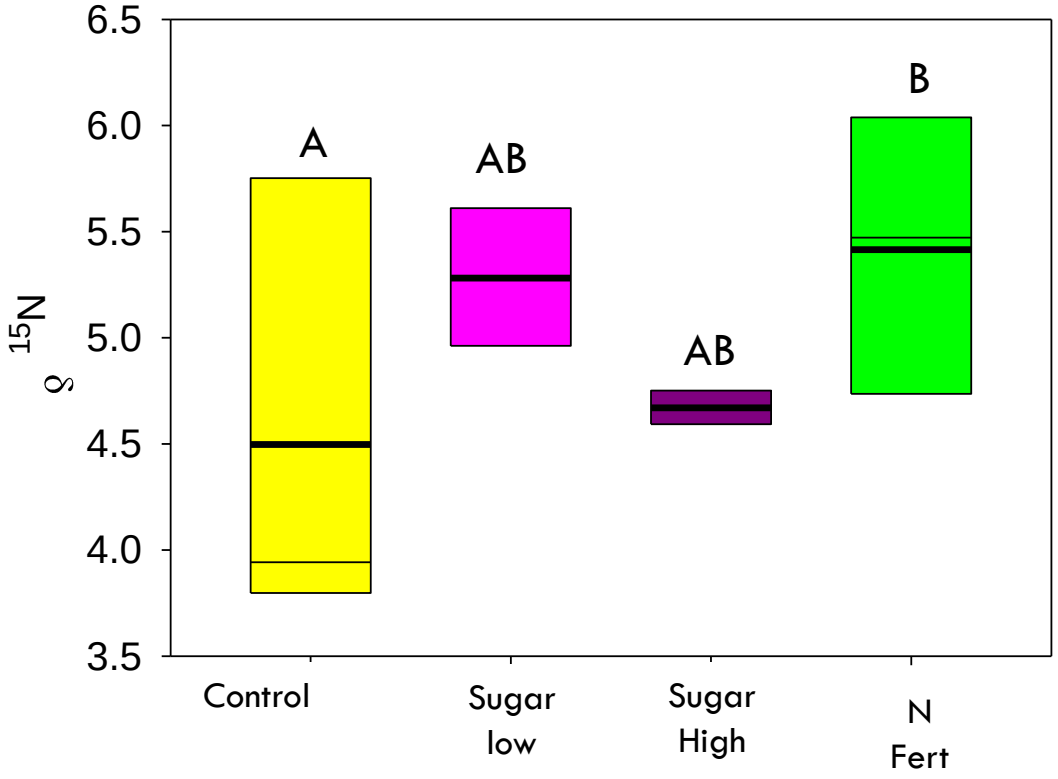
Forest
FR 14

TWO-WAY ANOVA
No significant effect on
% N bulk soil
% C bulk soil
^{15}N bulk soil
^{13}C bulk soil at both sites

At Forest site:
Multiple range suggest C:N ratio in N significantly different from SH and SL as expected

Site 3, grassland Frankfurt, Germany

- Hainich Lindig Grass land (Bernhardt-Römerman)

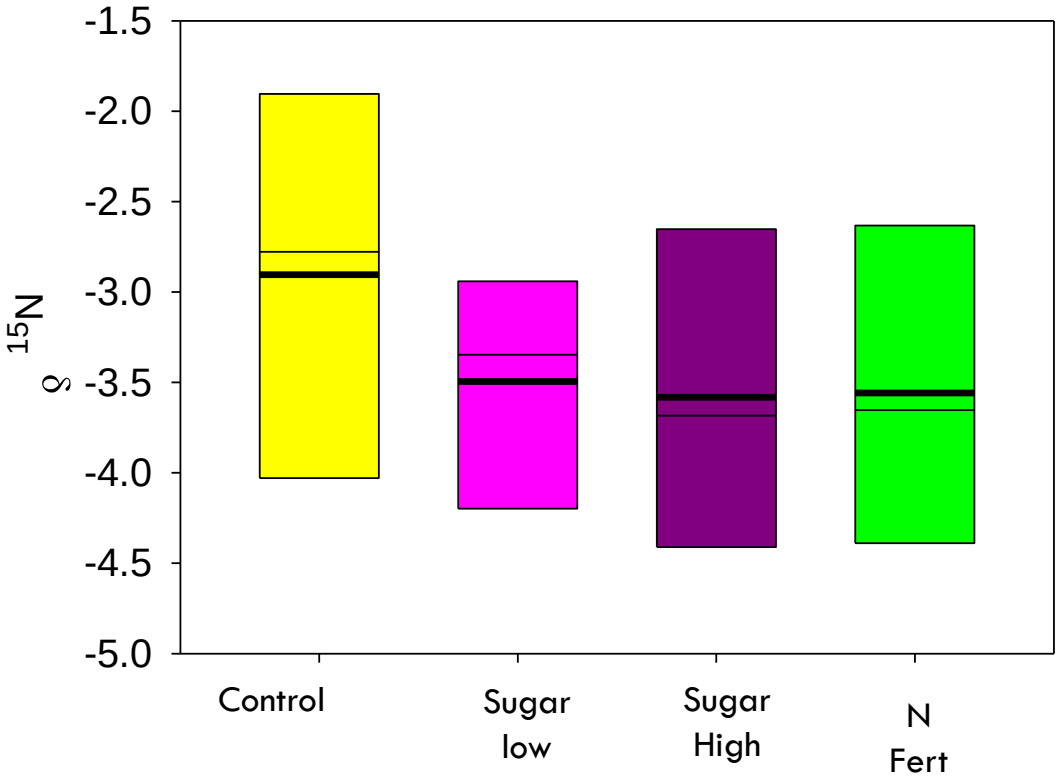


No significant change (P=0.089) Two way ANOVA taking account of block effects.

95 percentile and thick black line mean n=4.

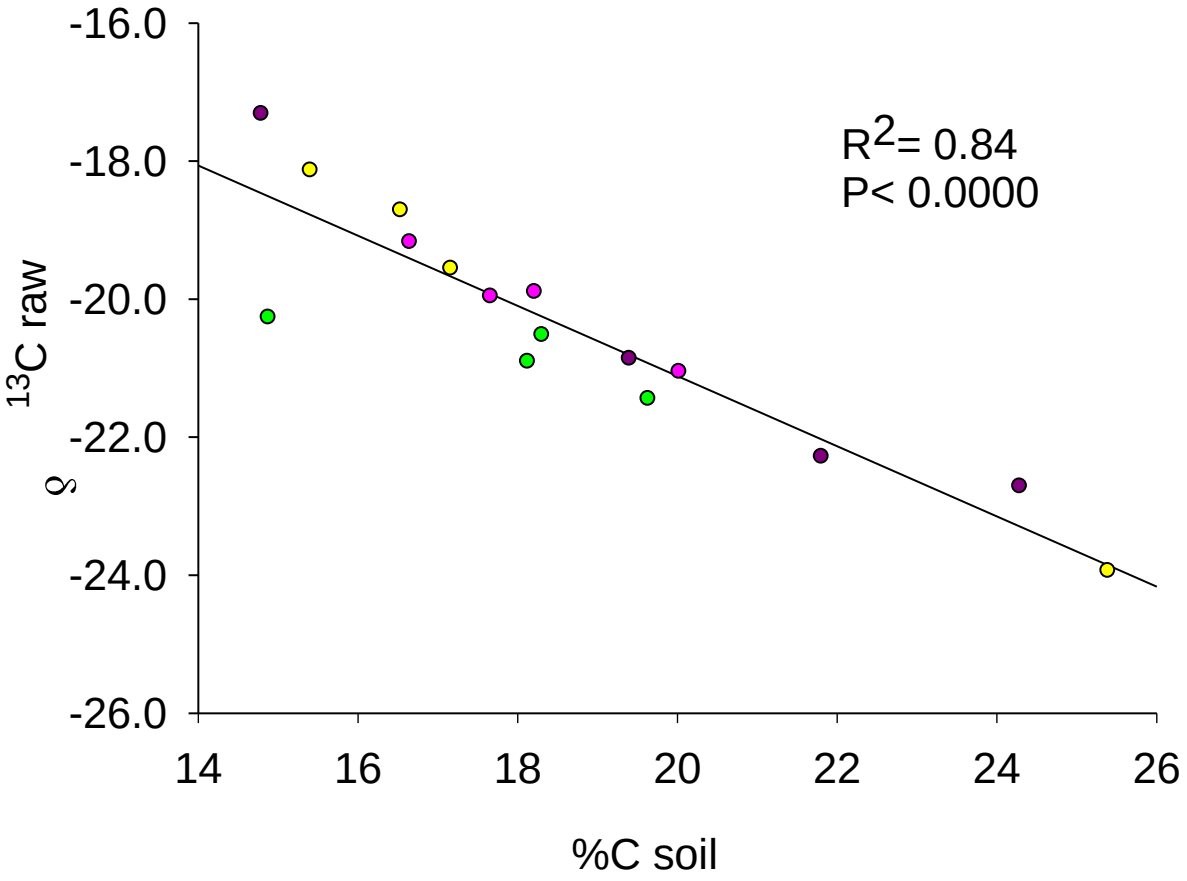
Site 14, Forest Aix-en-Provence, France

- Venelles Forest France (Bernard Prevosto).
- Calcisol



No significant change, even after taking account of block effects

Site 14, Forest Aix-en-Provence, Forest France.



Raw $\delta^{13}C$ values carbonate in the samples.

Theory 1.
If more mineral soil in the sample there will be a greater contribution of carbonate and less OM contribution to the $\delta^{13}C$.

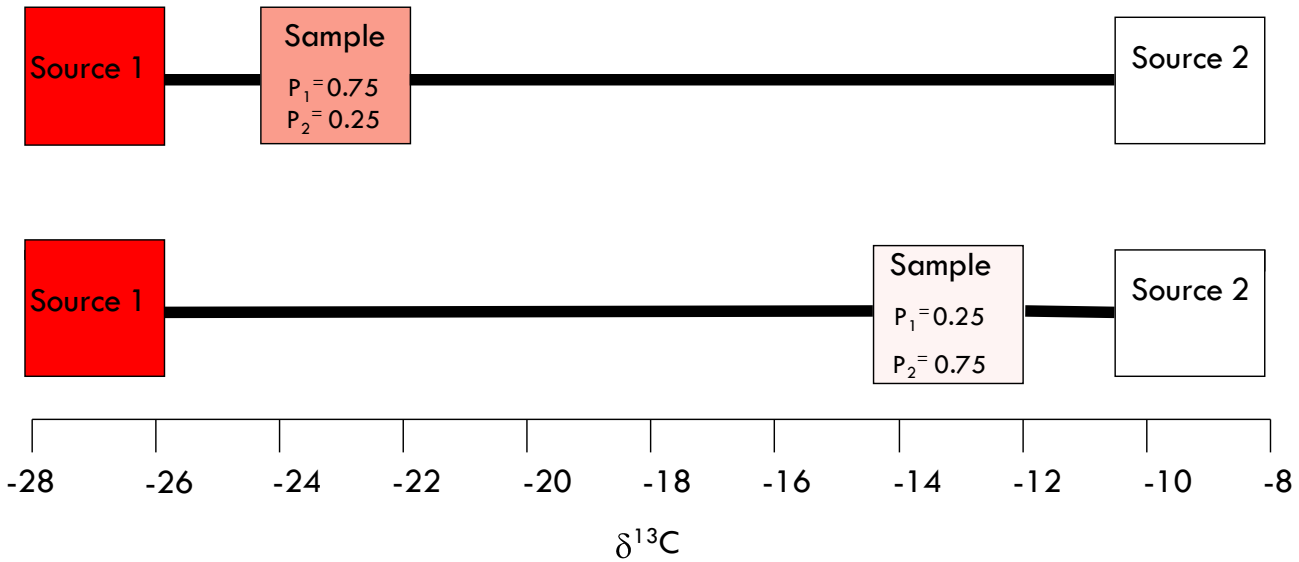
Theory 2.
The more carbonate, the higher the pH the greater the mineralisation of OM. So lower % C in soil.

How do we tease out the two effects?

Source of carbon in soils

- Organic carbon, $\delta^{13}C \approx$ same as input OM, C_3 -28‰
- Inorganic carbon in the form of carbonate
- $\delta^{13}C \approx$ -9 to-6 in southern France
- Soils with significant carbonate pH ≈ 6.5

$$2Na^+ + CO_3^{2-} + 2H^+ + 2OH^- \Rightarrow 2Na^+ + 2OH^- + H_2CO_3$$



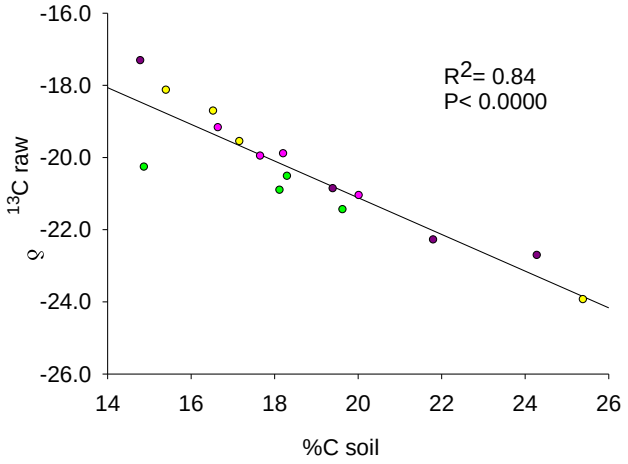
Theory 1.

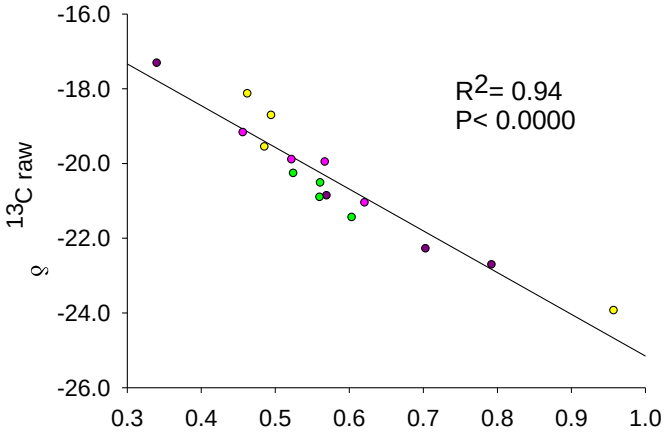
Theory 1.

If more mineral soil in the sample there will be a greater contribution of carbonate and less OM contribution to the $\delta^{13}C$.

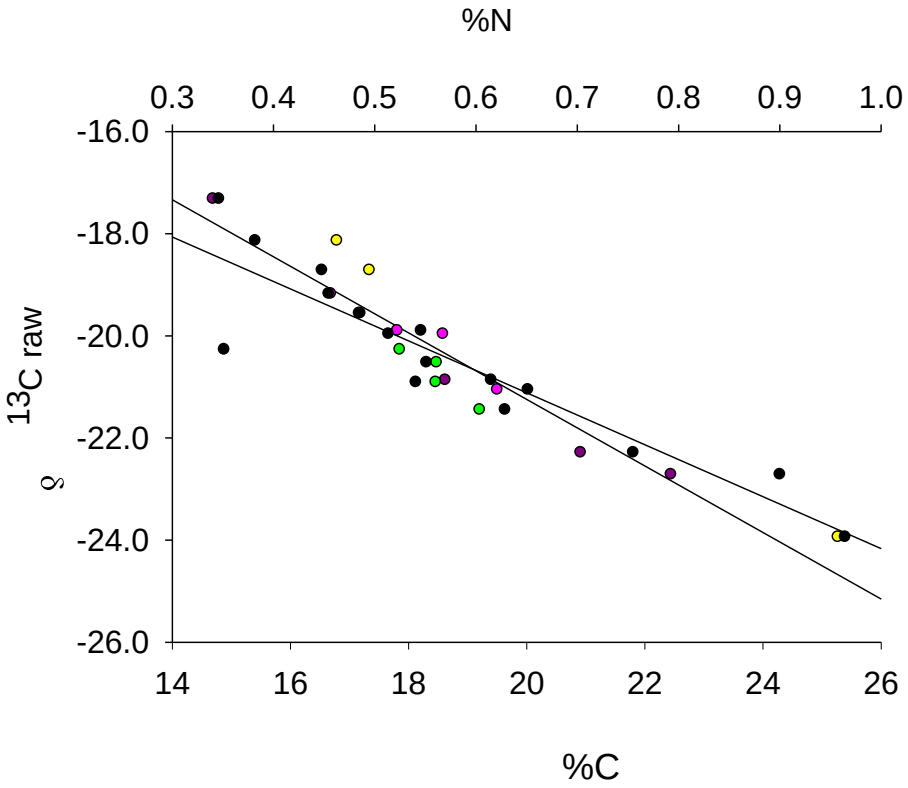
If it is only the carbonate concetration pushing up the %C of the soil we should see higher not lower % C with increased carbonate concentrations or $\delta^{13}C$ values .

Conclusion small change in carbonate leads to big change in %OM.





Theory 1.

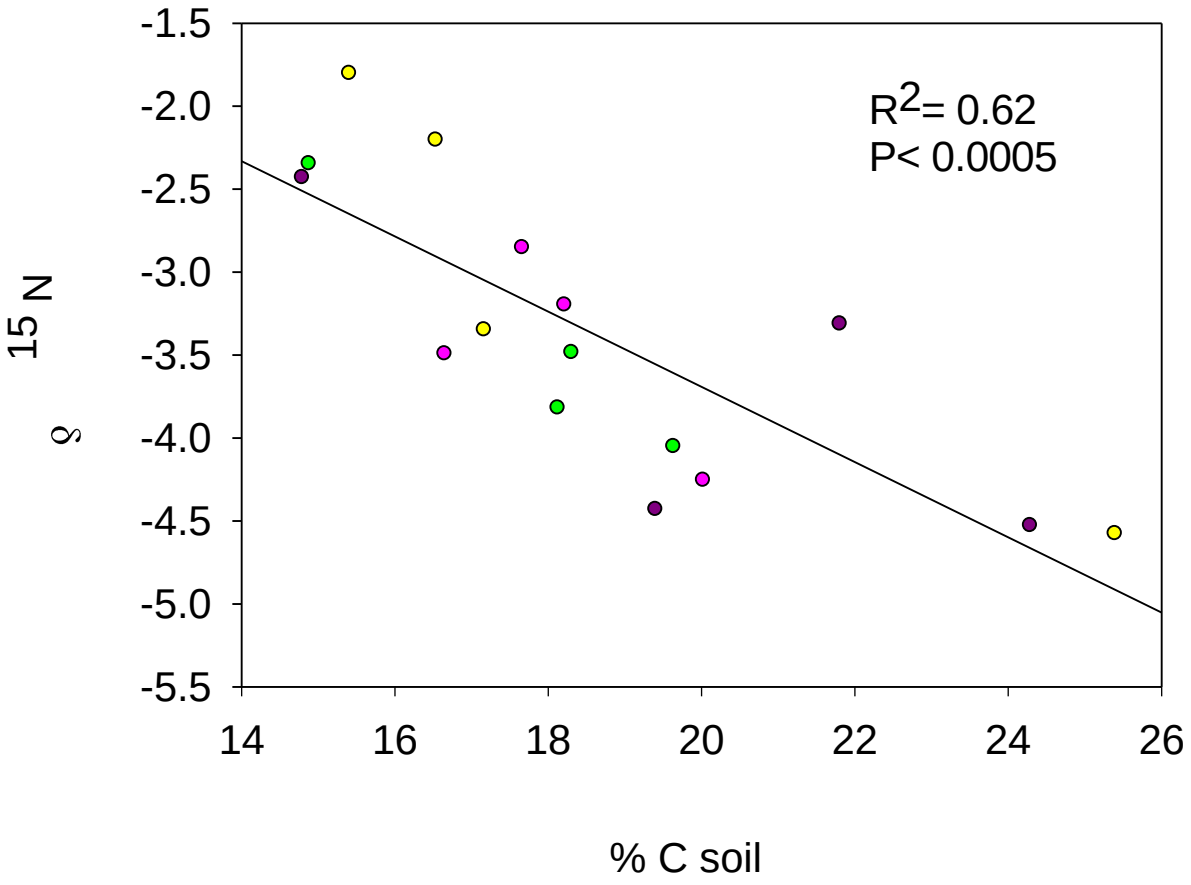


Theory 1.

There is some influence of carbonate on the % C of soil but not much.

Other wise we would see a big divergence of two lines.

Theory 1.



Theory 1.

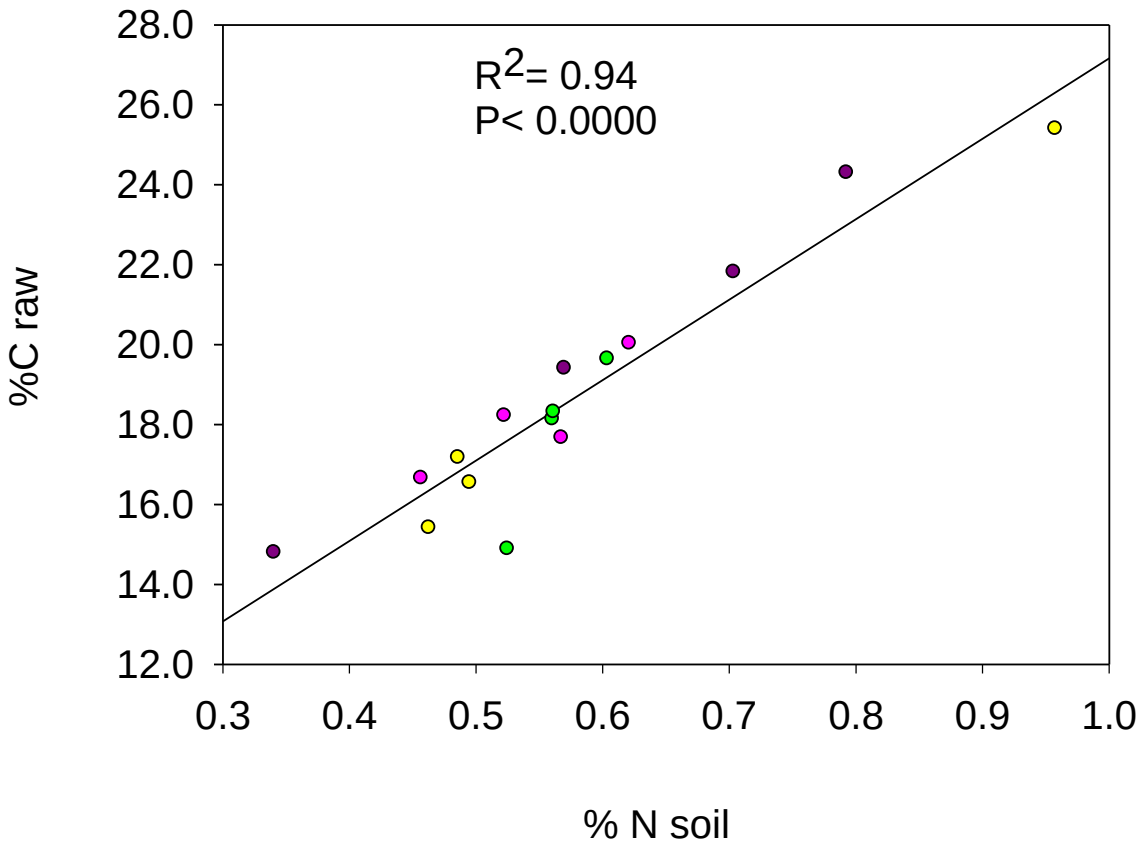
If it is only a soil mixing effect and not a mineralisation effect there should be no effect of soil mixing on the $\delta^{15}N$ of OM.

There is an significant trans-treatment difference of ^{15}N values across a range of %C values.

$\delta^{15}N$ increases with decreasing %C as our model would suggest.

REJECT THEORY ONE AS SOLE EXPLANATION.

Theory 2.



Theory 2.

The more carbonate, the higher the pH the greater the mineralisation of OM. So lower % C in soil.

C:N ratio ≈ 33:1

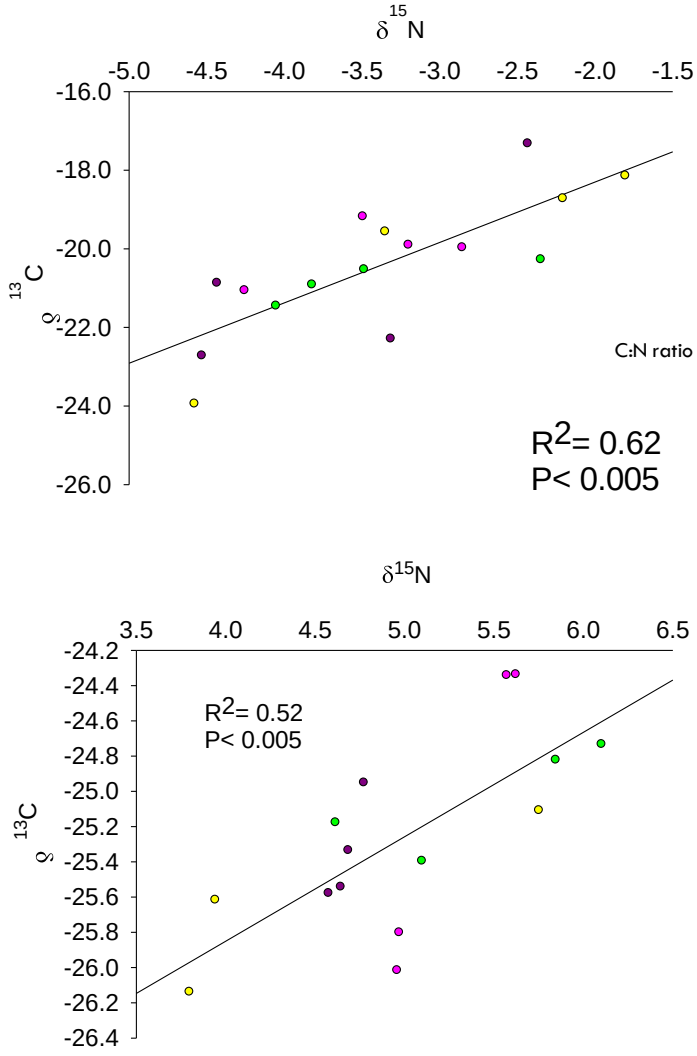
Carbon OM associated.

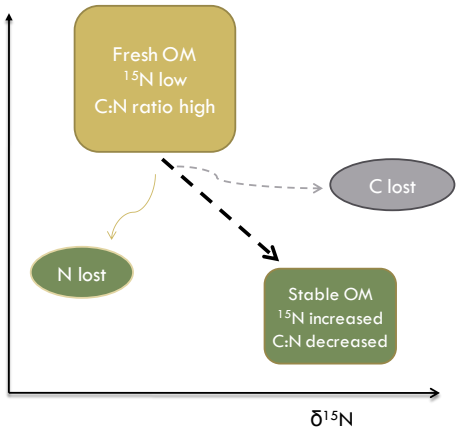
No significant correlation of C:N ratio with $\delta^{15}N$.

Ammonium loss?

Also in site 3 there was no significant correlation of C:N ratio with $\delta^{15}N$.

Theory 2.





Theory 2.

Model?

Original Conen model developed for POM and MOM.

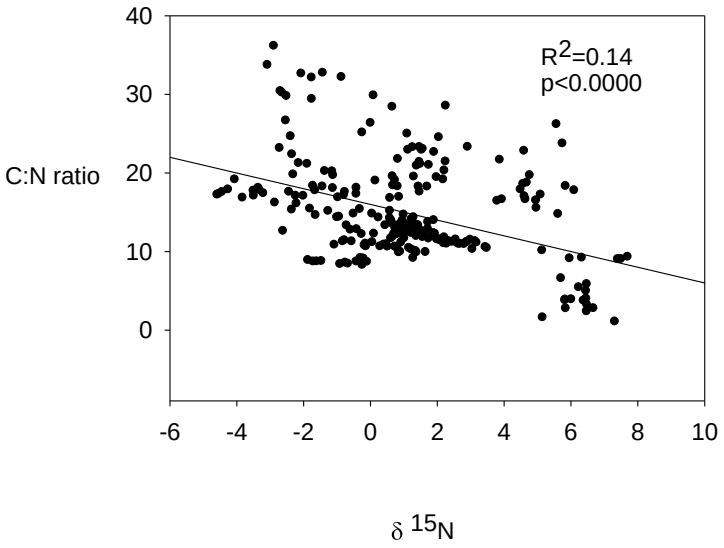
In site3 fresh OM input and treatment maybe problematic.

In site 14 carbonate confusing the picture.

But ^{15}N and ^{13}C in both sites appear to be following model.

Err with theory 2.

Model?

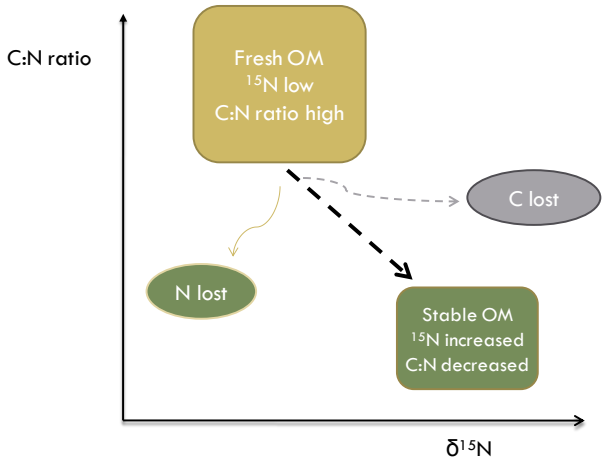


Model?

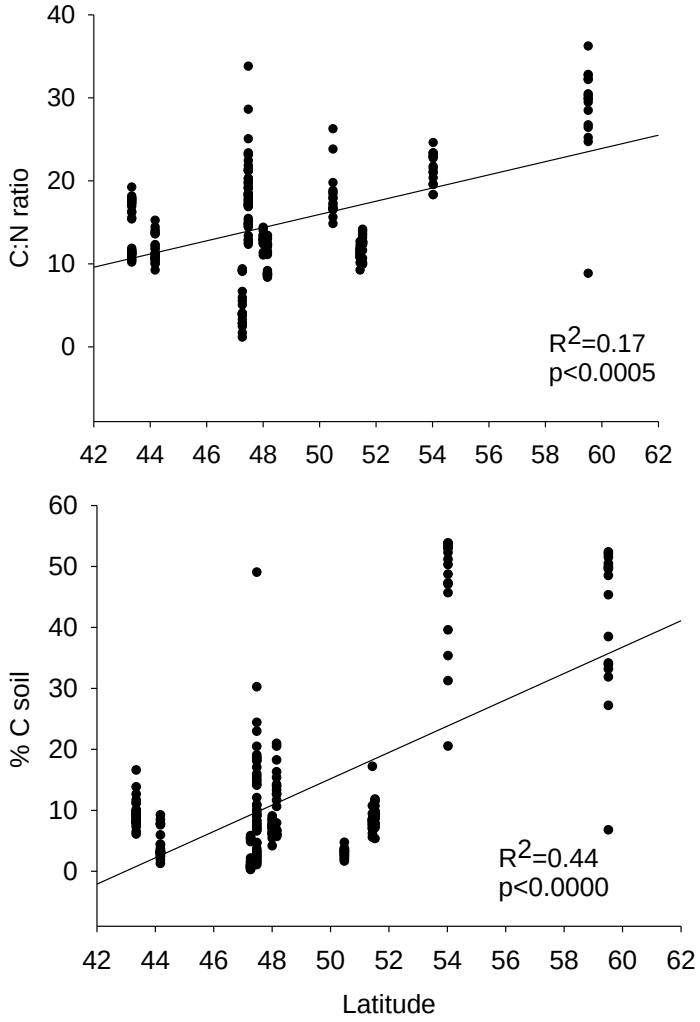
Globally we see a a significant trend.

But very week correlation.

This also held if forest and grasslands were analysed sepparately.



Global data



No signifcant and obvious effects of treatments $\delta^{13}C$ and $\delta^{15}N$, % N or % C

Latitude sigificant but week correlation with both C:N ratio

Slightly stronger correlation with % C of soil

These trends also consitent when forest and grassland analysed sepparately.

Conclusions

- pH has bigger influence than priming on OM breakdown.
- Isotopes can be used to untangle processes

- Isotopes could be early indicators of OM changes
- Wait longer to see effect?
- Look at soil fractions such as POM only
- Further analysis of whole data set required