



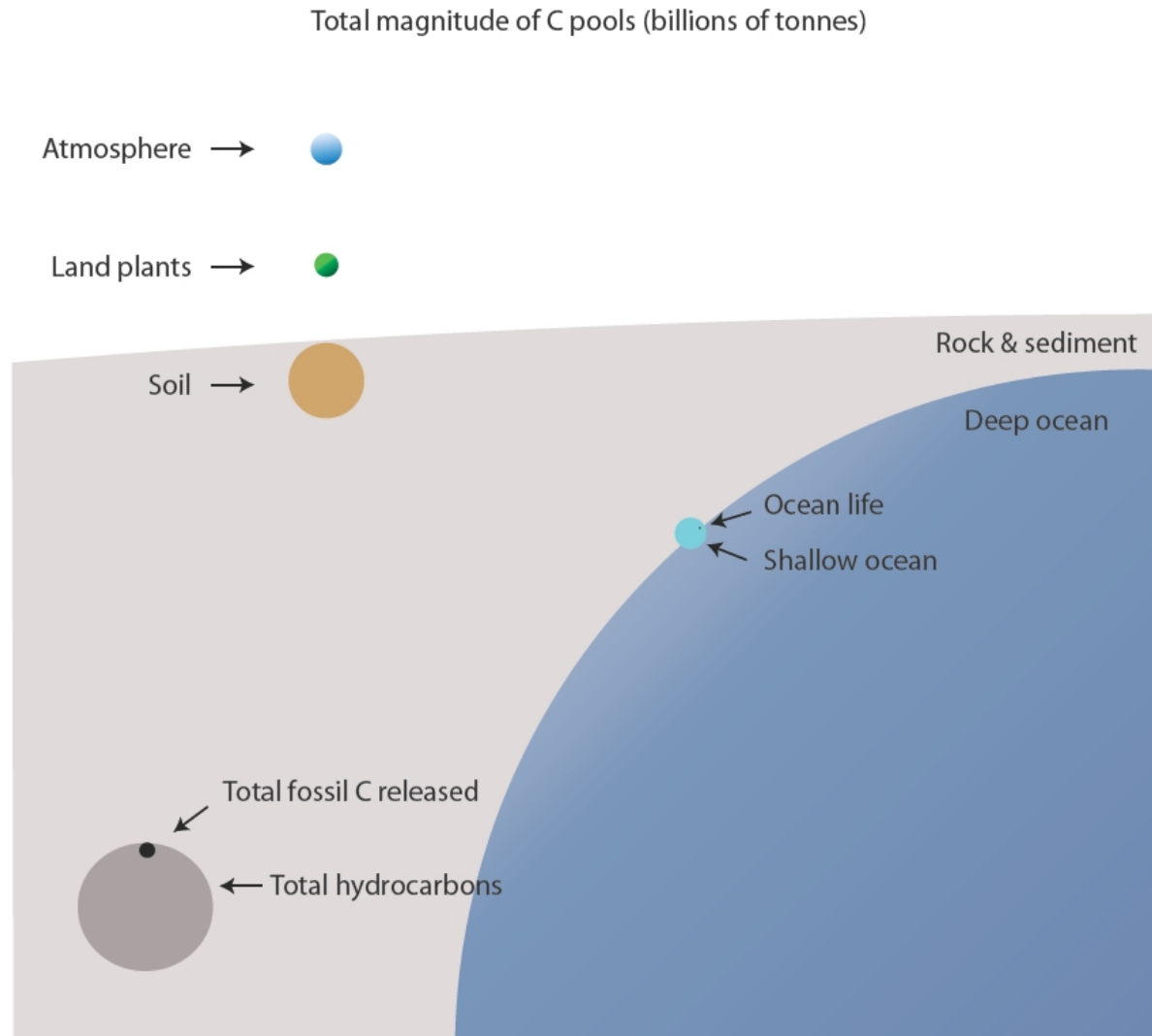
Soil Carbon Modelling

Budiman Minasny
Alex McBratney
Jose Padarian



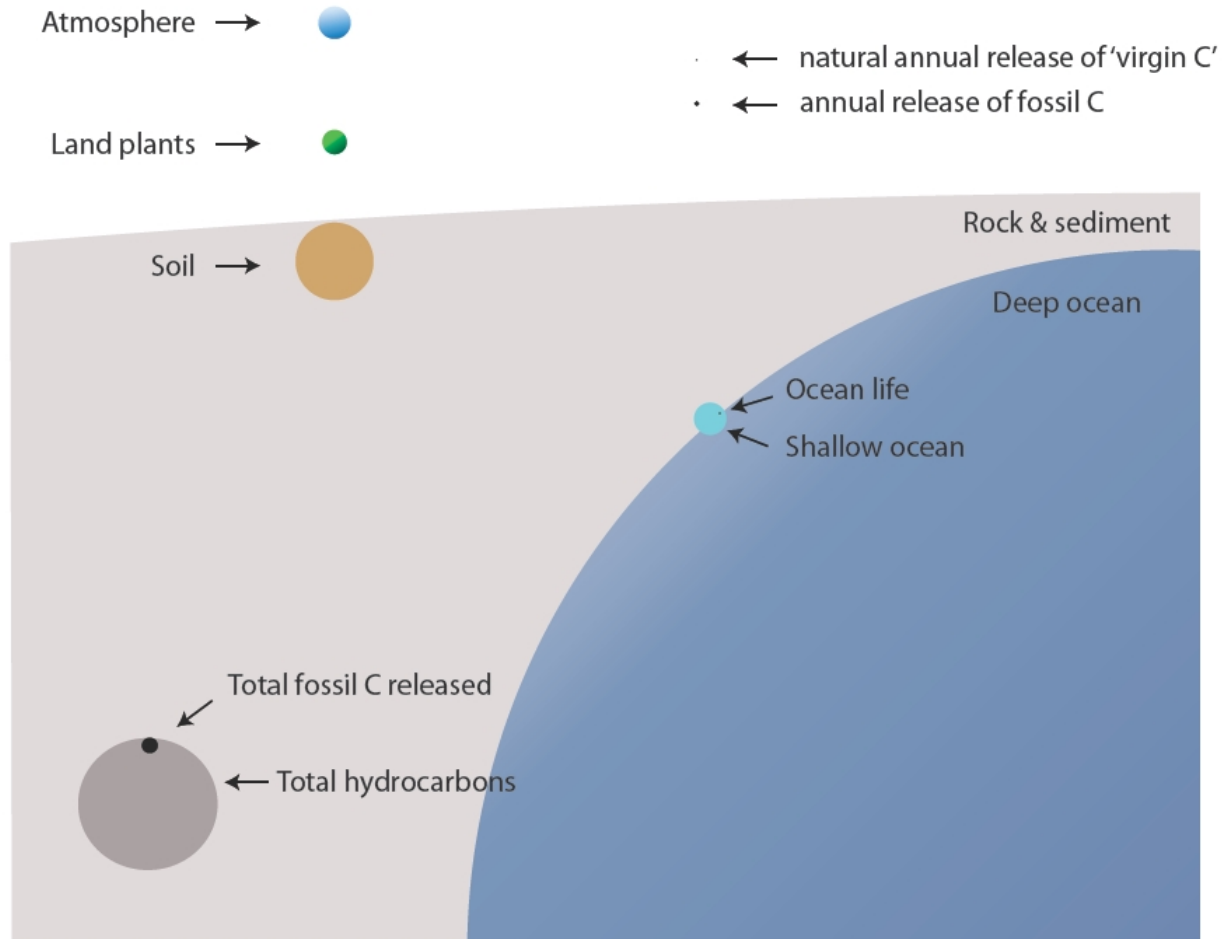
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SYDNEY

Background – Why the interest in soil carbon?

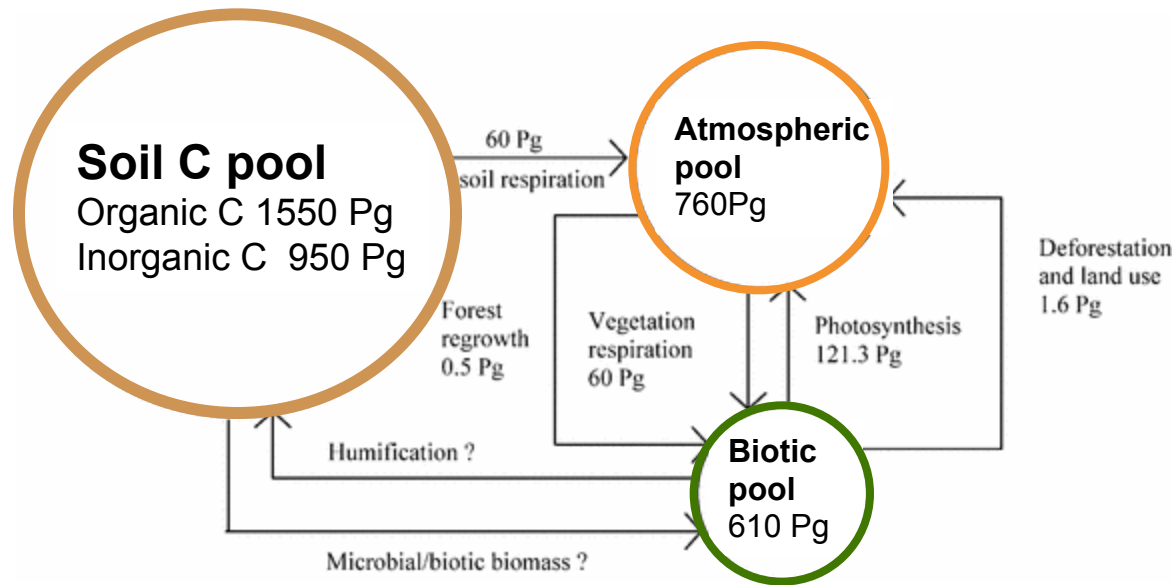


Soil carbon

Total magnitude of C pools (billions of tonnes)



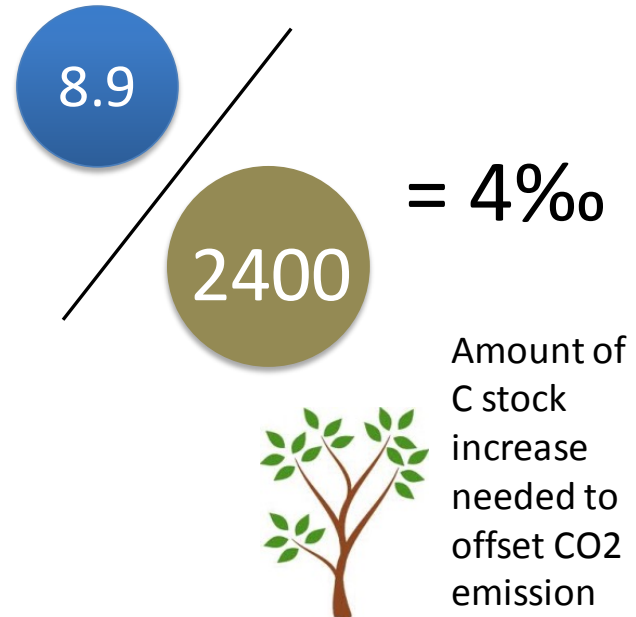
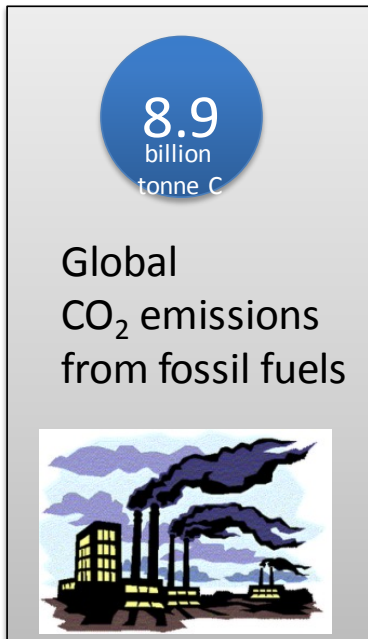
Why Soil Carbon 'Gold Rush'?



1 Pg = 10^{15} g = 1 billion ton

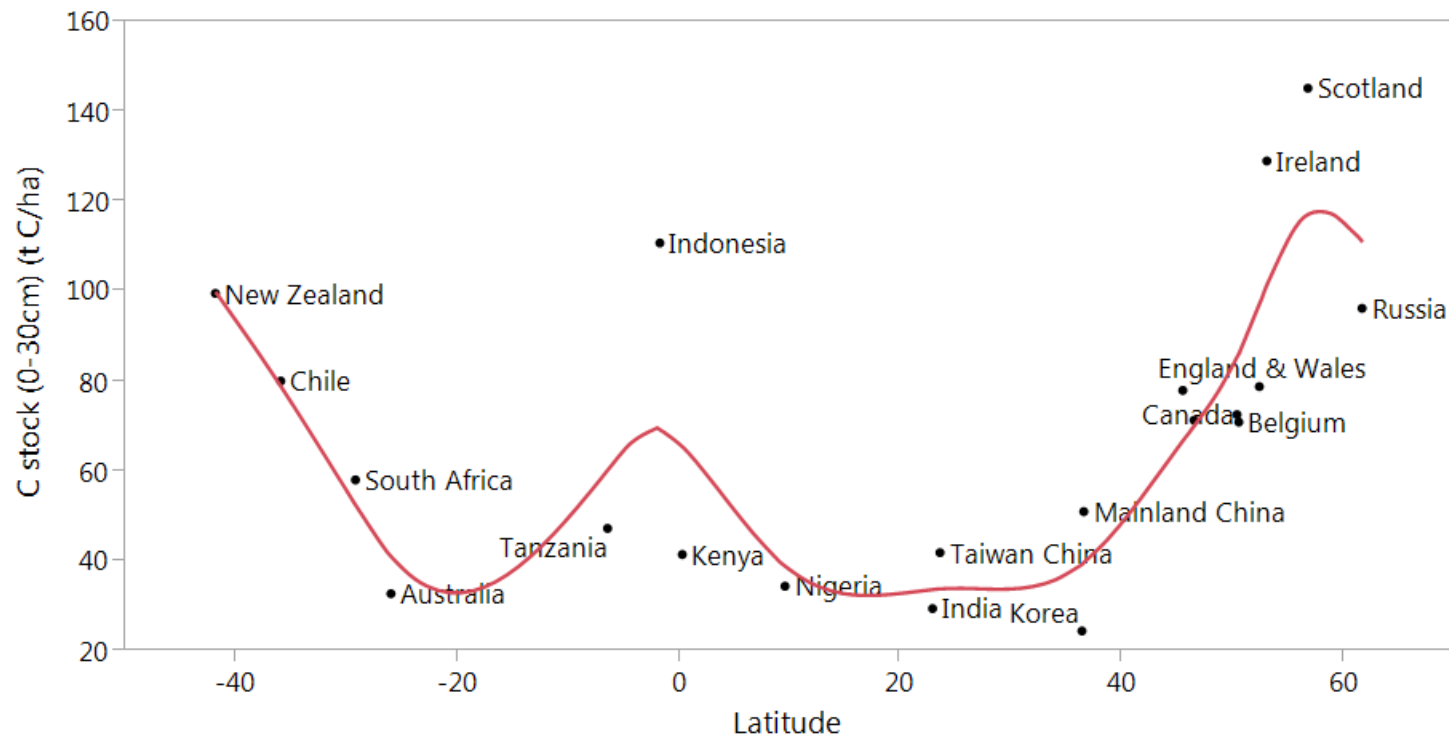
Paris Climate Change Conference

- Soil Carbon 4 per mille

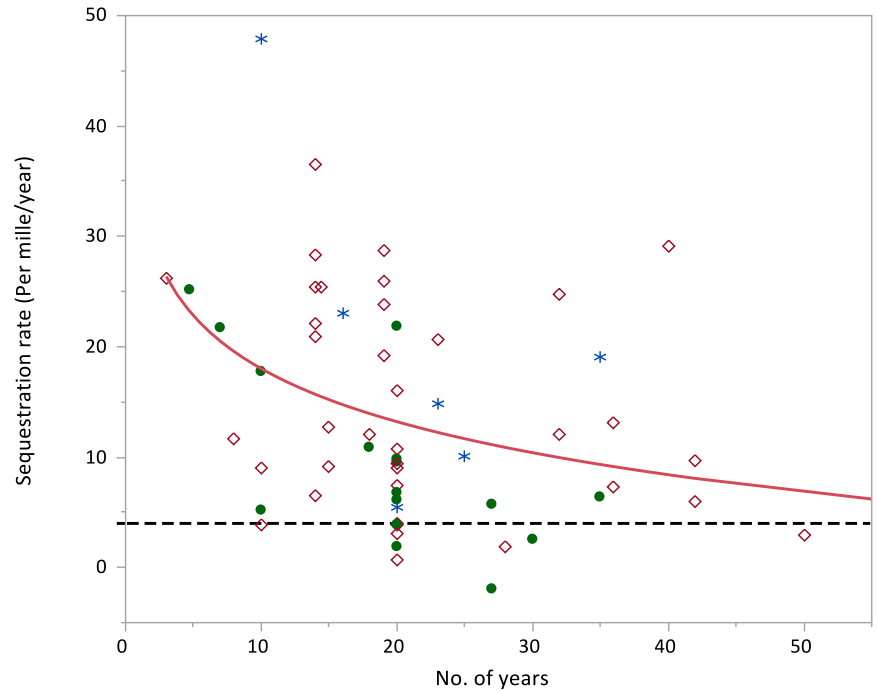
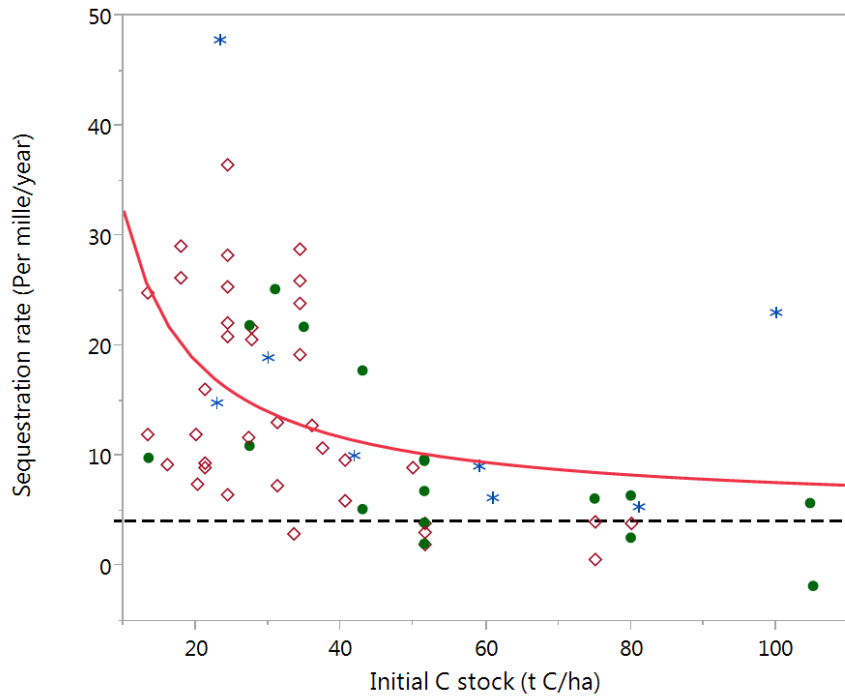


Soil C 4 per mille

Agricultural practices that can sequester soil carbon

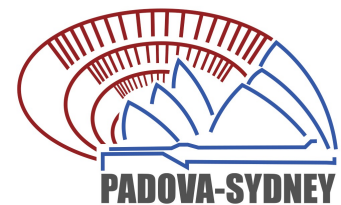


Soil C 4 per mille



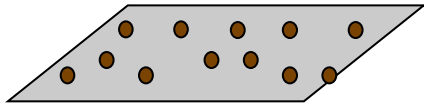
- The need for better and more cost effective measurement of soil C
- Auditing SOC
- Modelling SOC
- Monitoring SOC

Empirical models

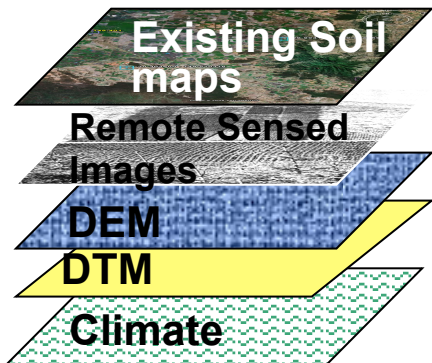


Digital soil mapping

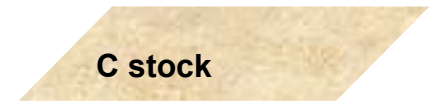
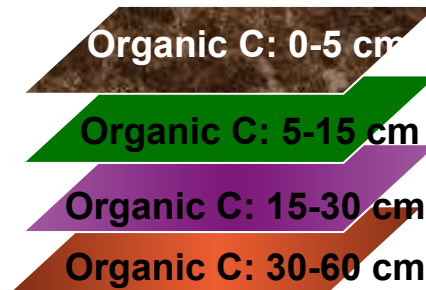
Soil observations



scorpan layers

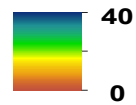
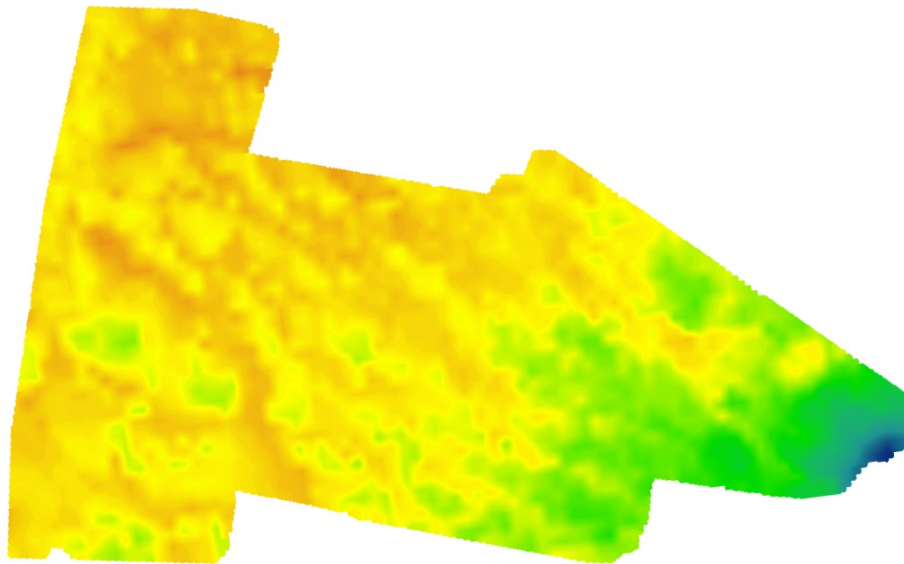


$C = f(s, c, o, r, p, a, n)$
Spatial Soil
Prediction Functions

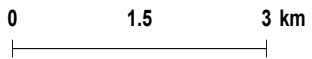
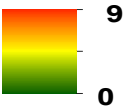
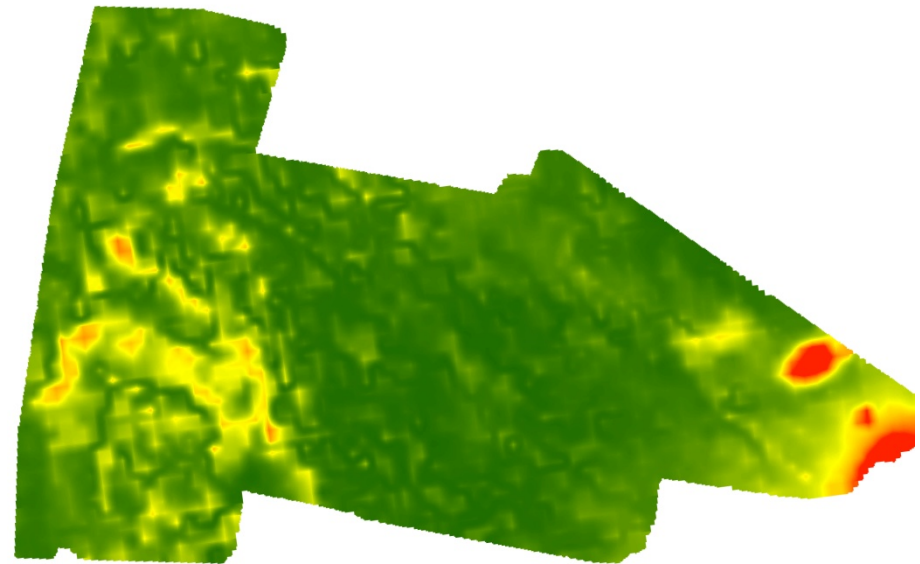


Digital soil mapping

Prediction

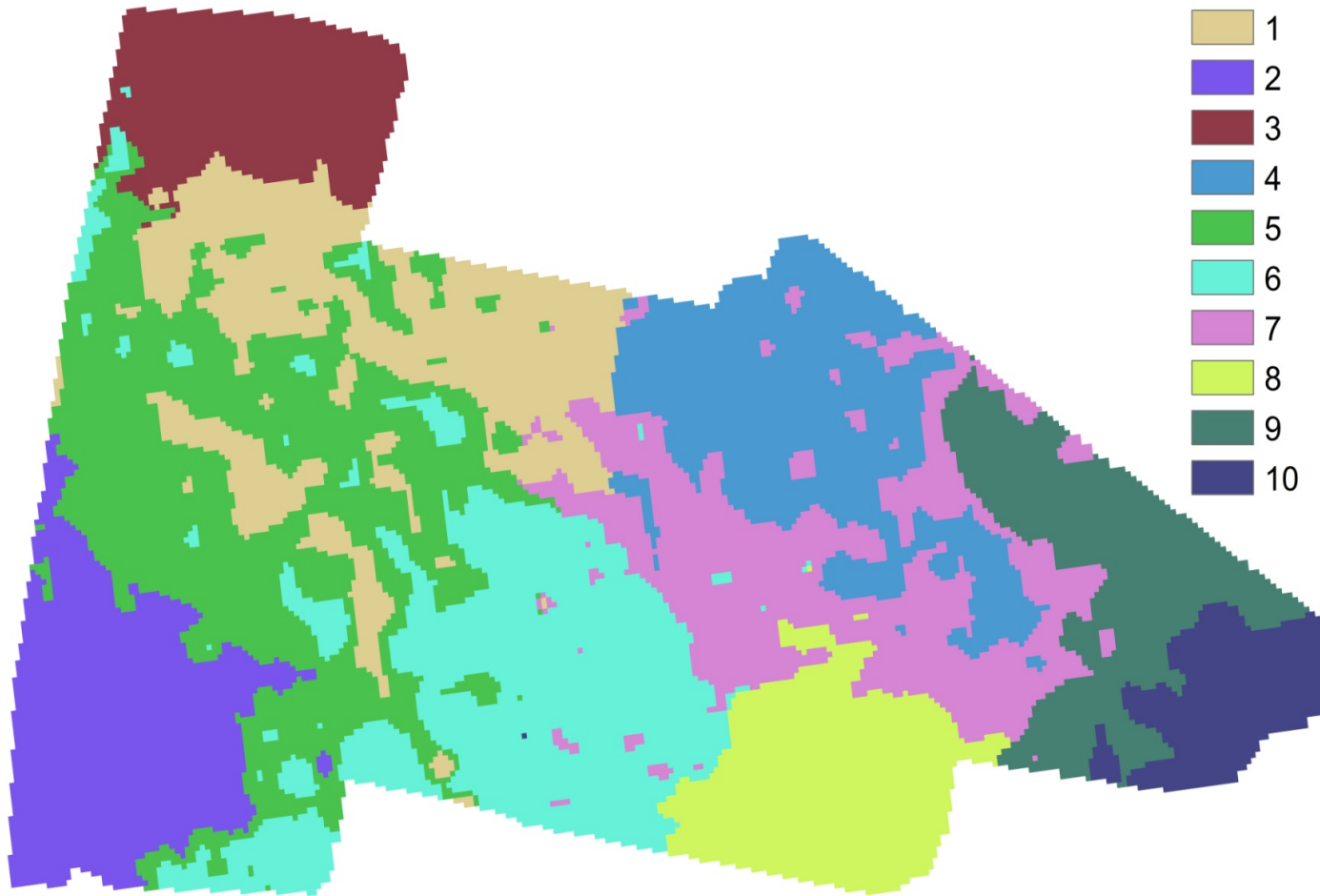


Prediction variance



C stock

Sampling Design for Soil C Auditing



De Gruijter et al., 2016. Farm Scale Soil C Auditing. Geoderma.

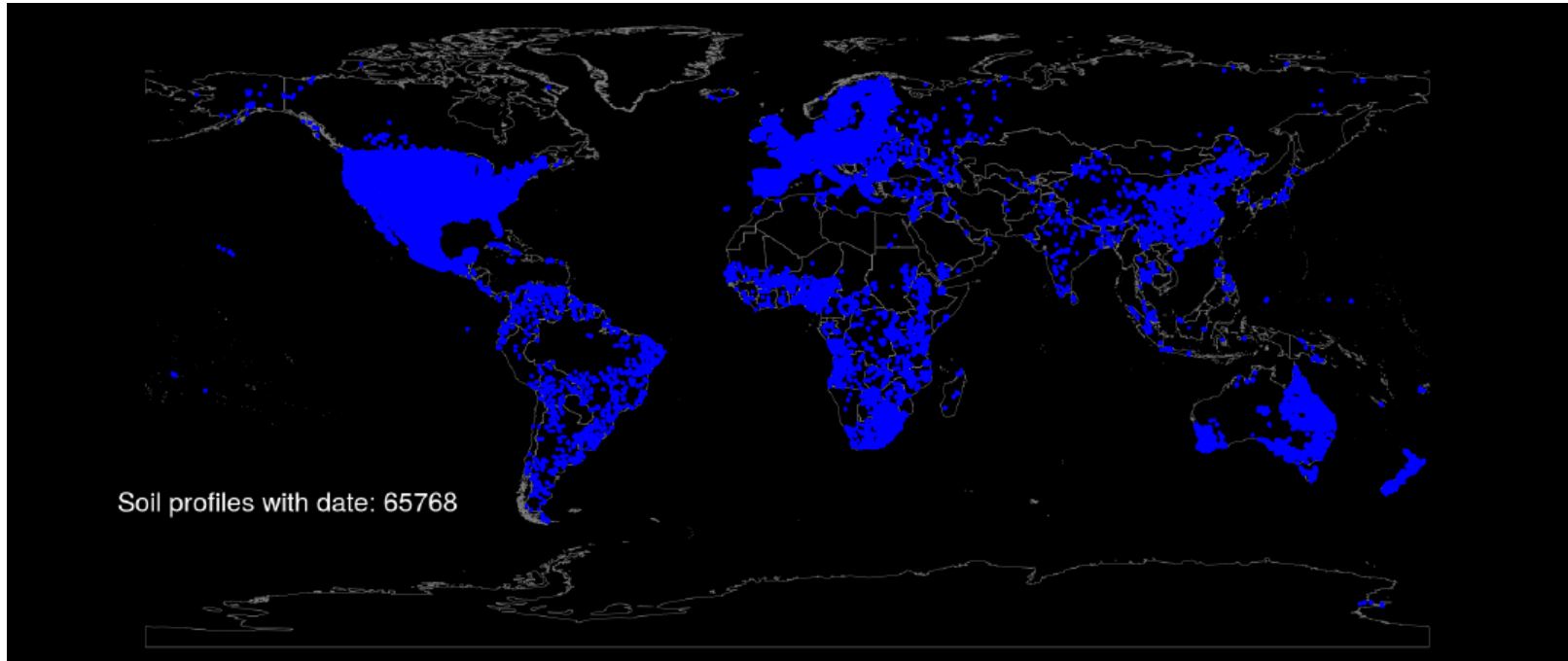
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Semi Empirical/Mechanistic models



Global Soil C Assessment

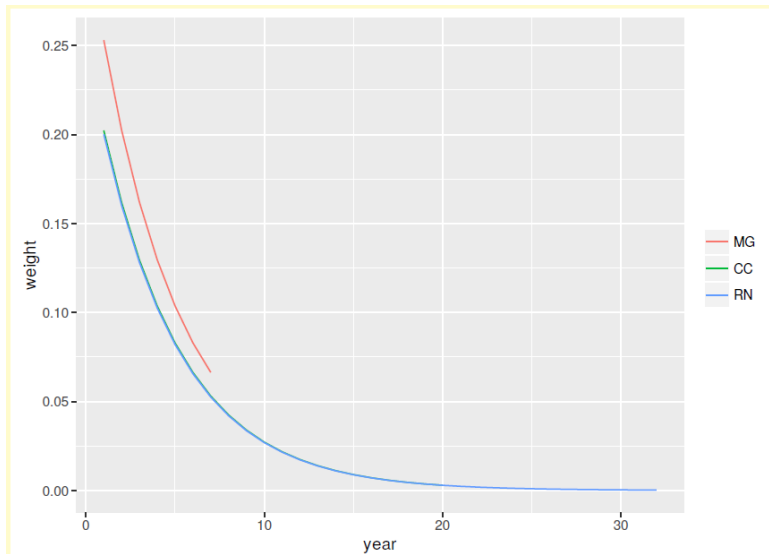


Model

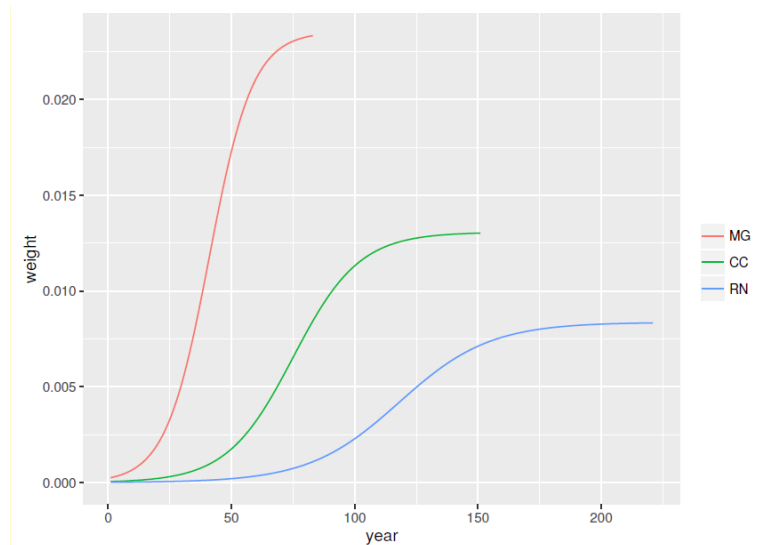
$$SOC_{xyt} = f(elev_{xy}, slope_{xy}, tap_{xy}, mat_{xy}, lc_{xyt})$$

Global Soil C Assessment

- Models based on land cover change
- $dC/dt = A - k \cdot C$

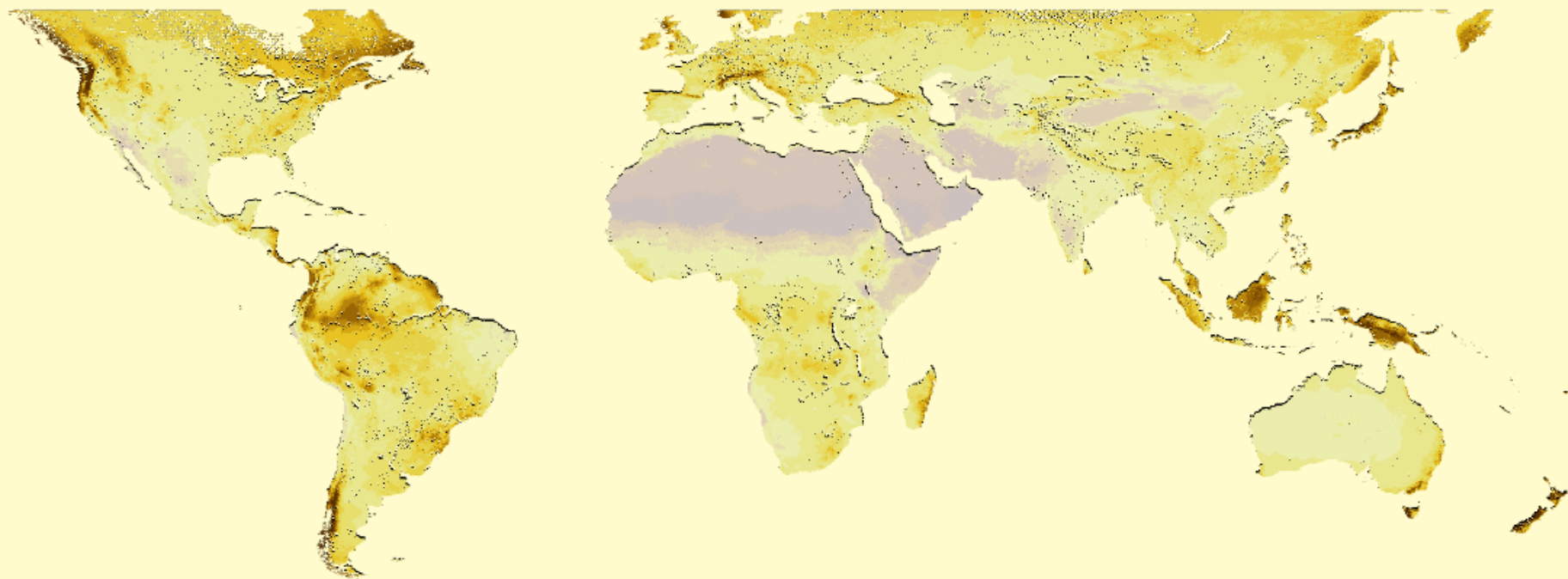


MG (MAT: 24 °C, TAP: 1900 mm), CC (MAT: 14 °C, TAP: 500 mm), and RN (MAT: 9 °C, TAP: 200 mm)

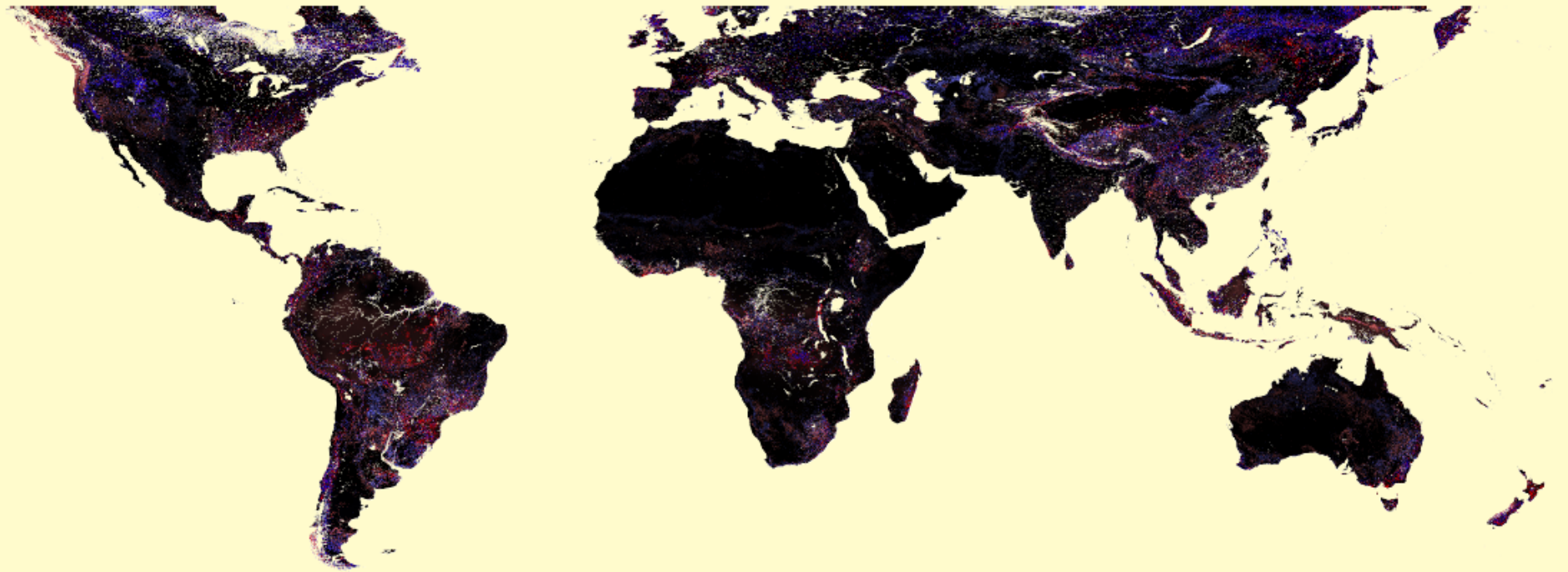


MG (MAT: 24 °C, TAP: 1900 mm), CC (MAT: 14 °C, TAP: 500 mm), and RN (MAT: 9 °C, TAP: 200 mm)

Baseline



Change 2001-2009



Process-based models

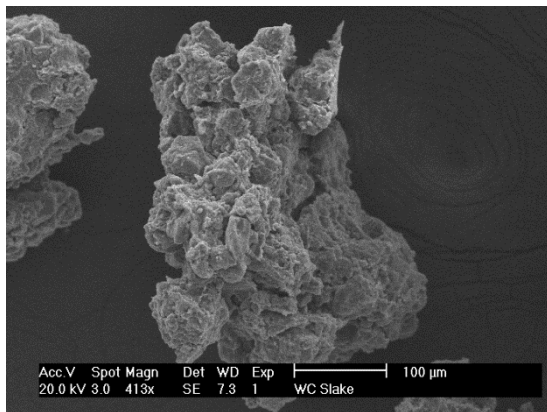


Modelling how carbon affects soil structure

Geoderma

Karim Malamoud *, Alex. B. McBratney, Budiman Minasny, Damien J. Field

Faculty of Agriculture Food & Natural Resources, McMillan Building A05, The University of Sydney, NSW 2006, Australia



- There are influences and feedbacks between Soil Organic Carbon and soil structure (e.g. Edwards and Bremner, 1967; Field, 2000; Kleber et al, 2007; Six et al., 2004)
- Soil structure is rarely considered in soil carbon models

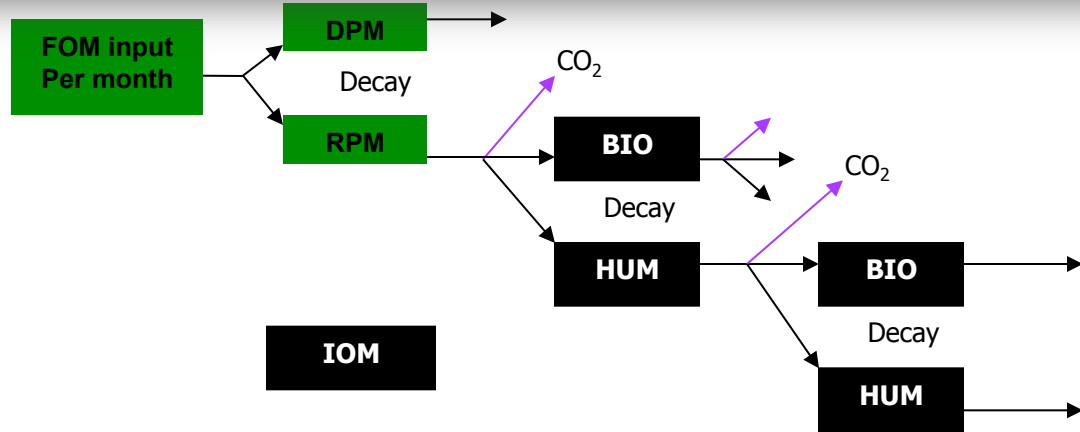
- ◇ How does SOC influence the soil aggregation?
- ◇ Building a better structure (model)

Modelling how carbon affects soil structure

Karim Malamoud*, Alex. B. McBratney, Budiman Minasny, Damien J. Field

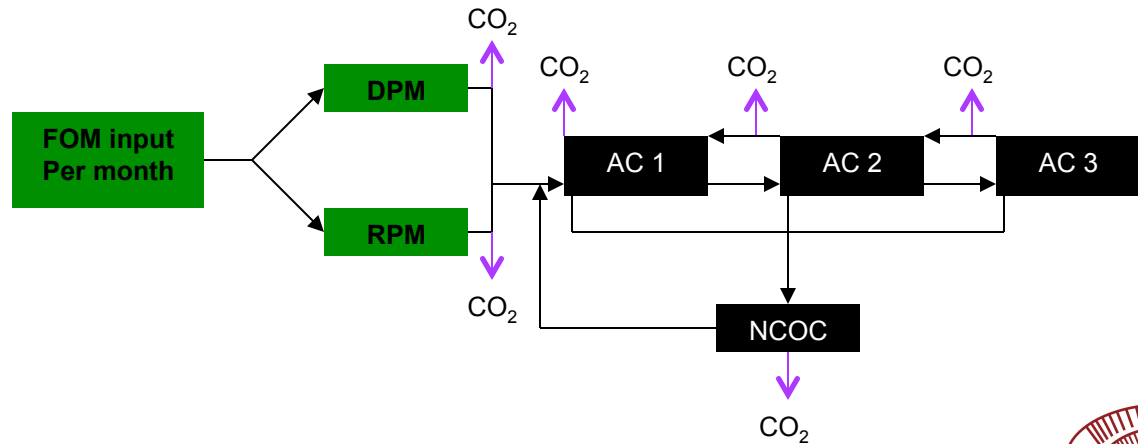
Faculty of Agriculture Food & Natural Resources, McMillan Building A05, The University of Sydney, NSW 2006, Australia

RothC



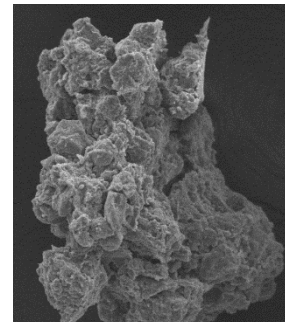
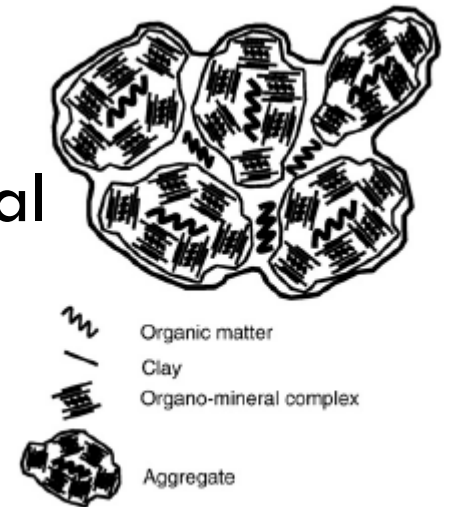
Coleman and Jenkinson, 1999

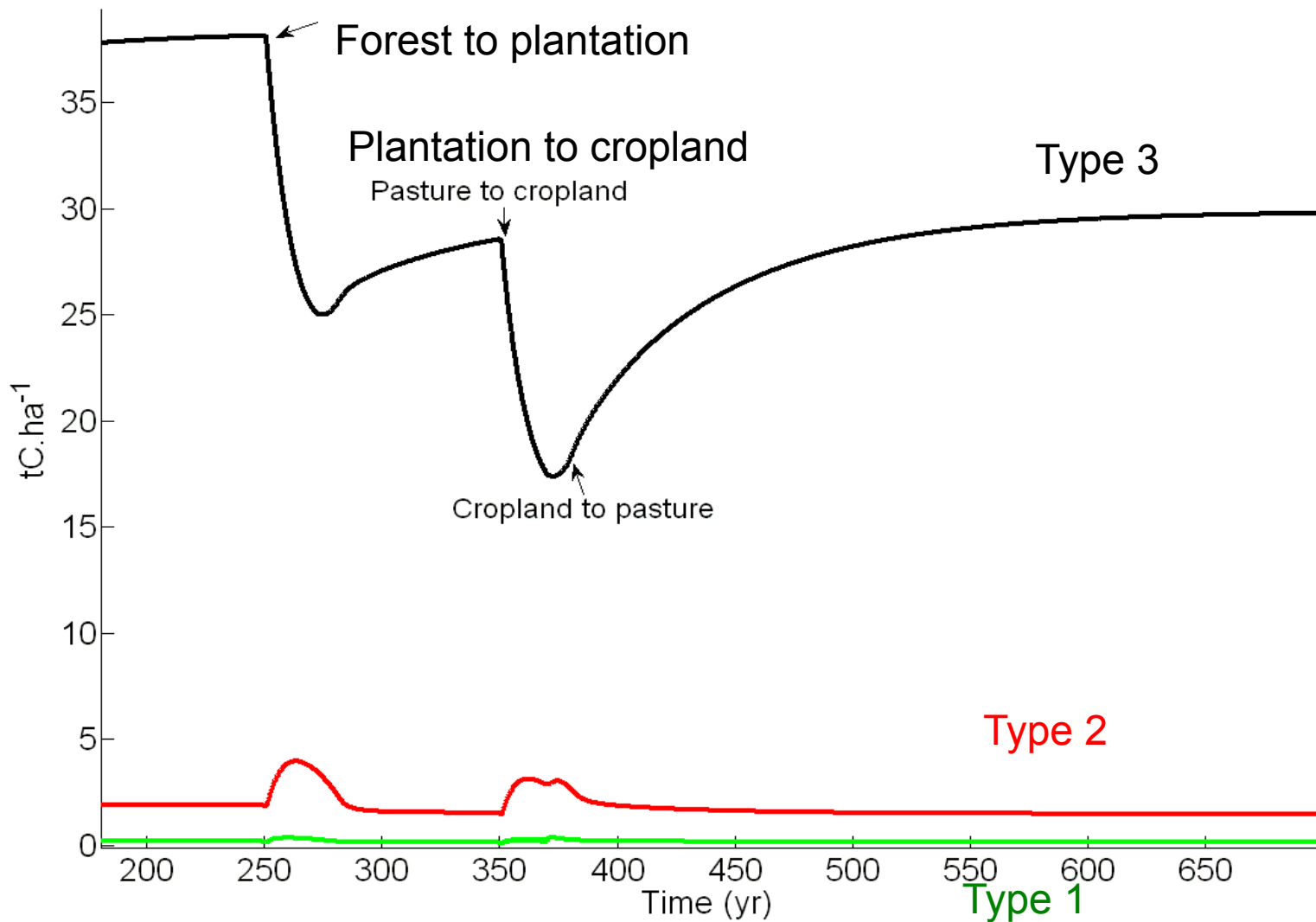
Struc-C



Aggregation

- The smallest aggregates are composed of organo-mineral associations. Strong clay to SOC bonds
- The clustering of these smaller aggregates forms larger aggregates, which in turn provides physical protection of the SOC between these aggregates from microbial attack.



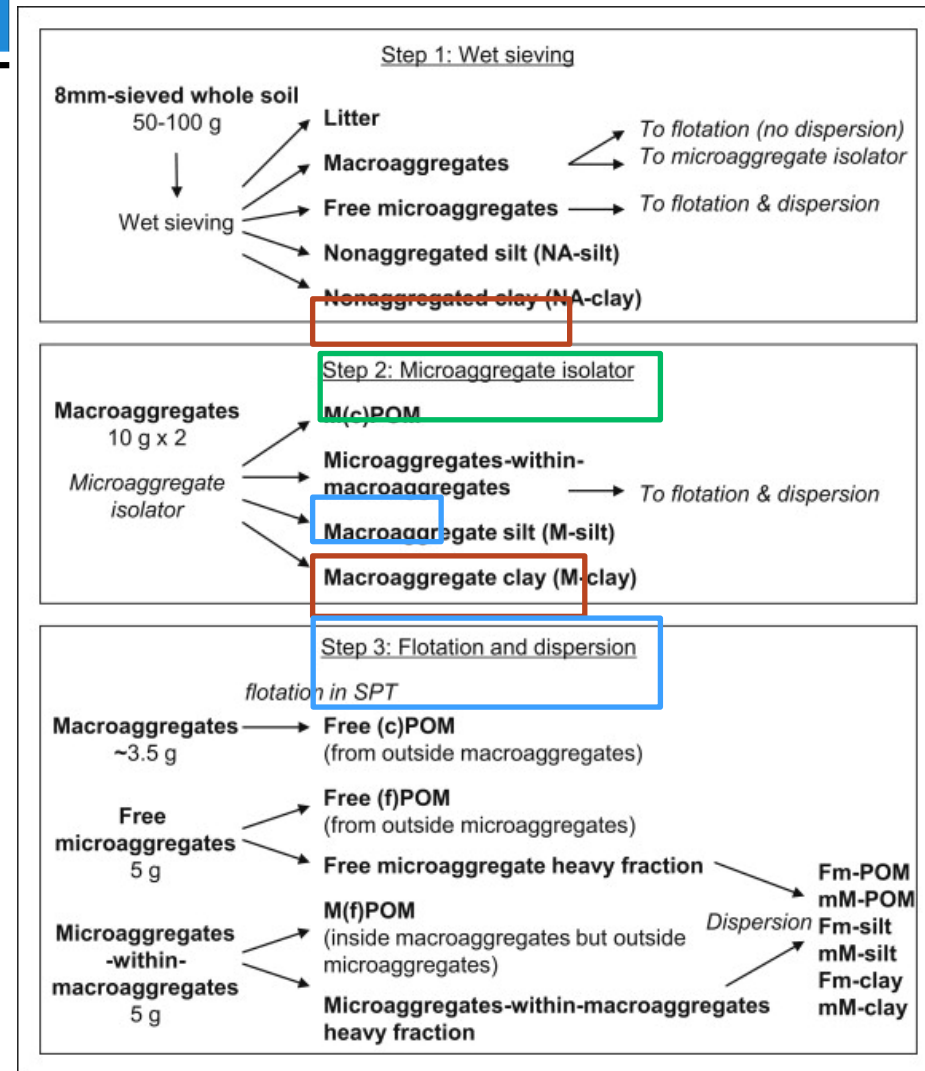


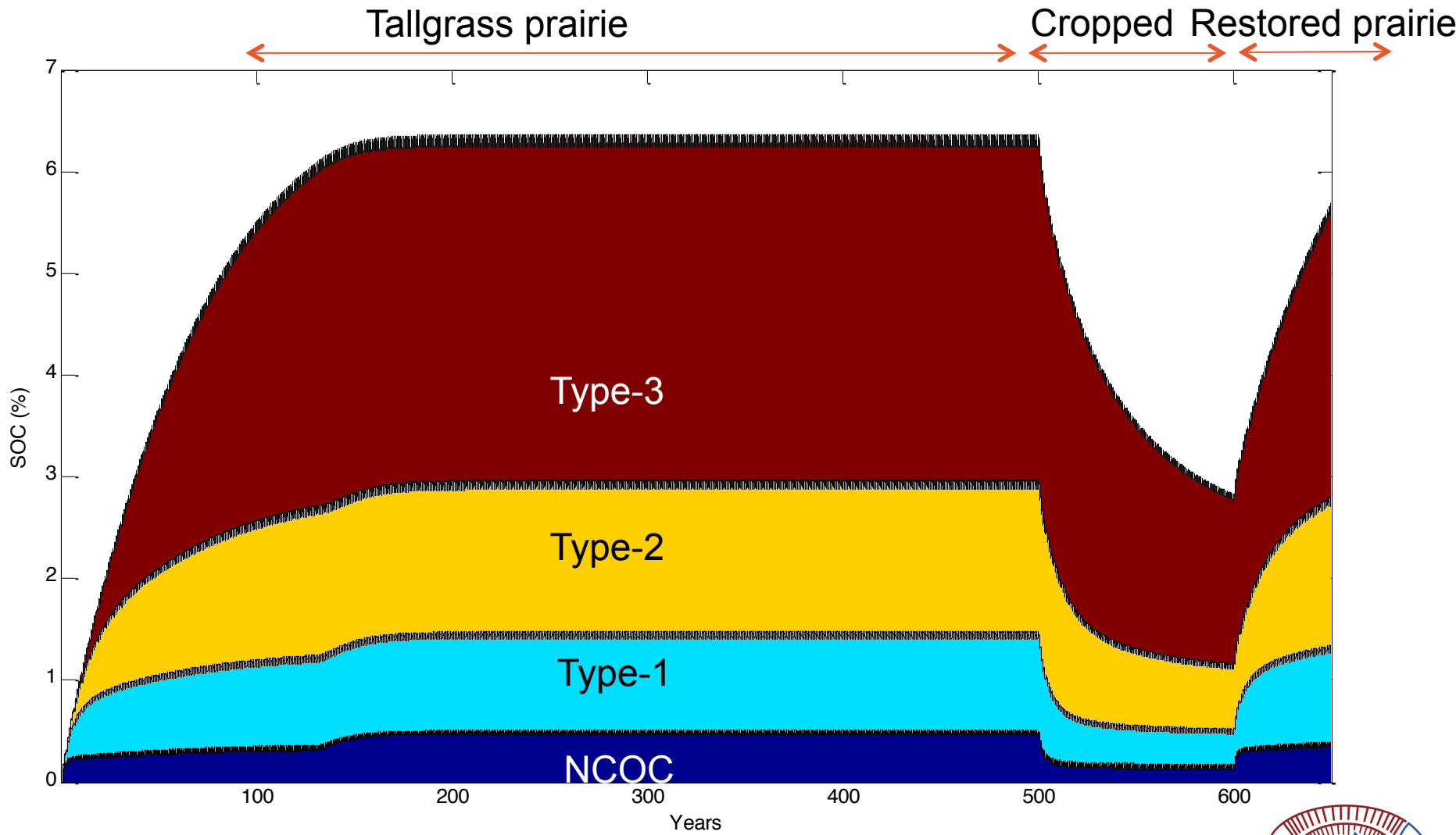
Physical and chemical protection in hierarchical soil aggregates regulates soil carbon and nitrogen recovery in restored perennial grasslands

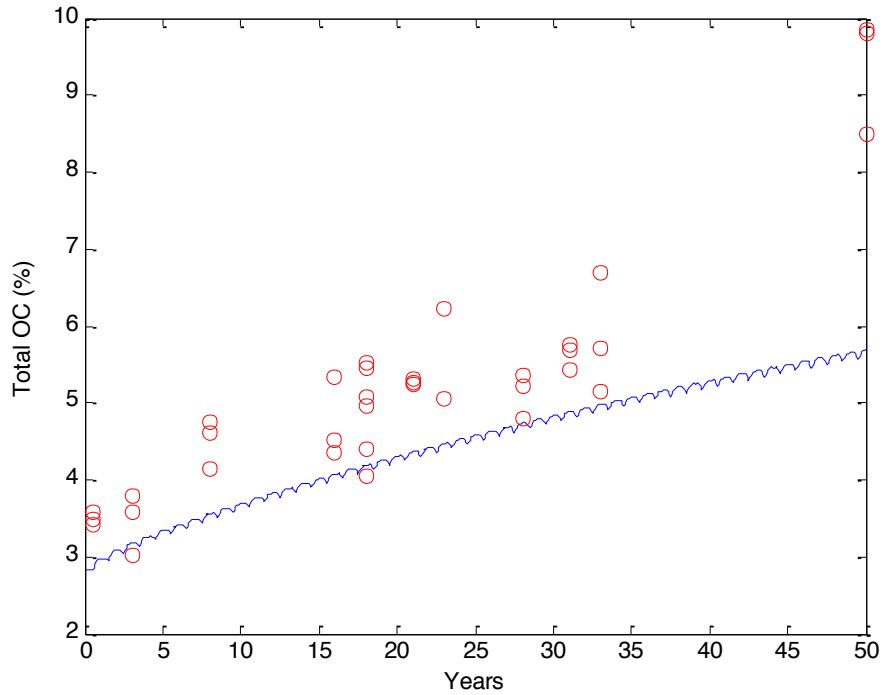
Sarah L. O'Brien^{a,b,*}, Julie D. Jastrow^b

^aDepartment of Biological Sciences, M/C 066, University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL 60607, USA

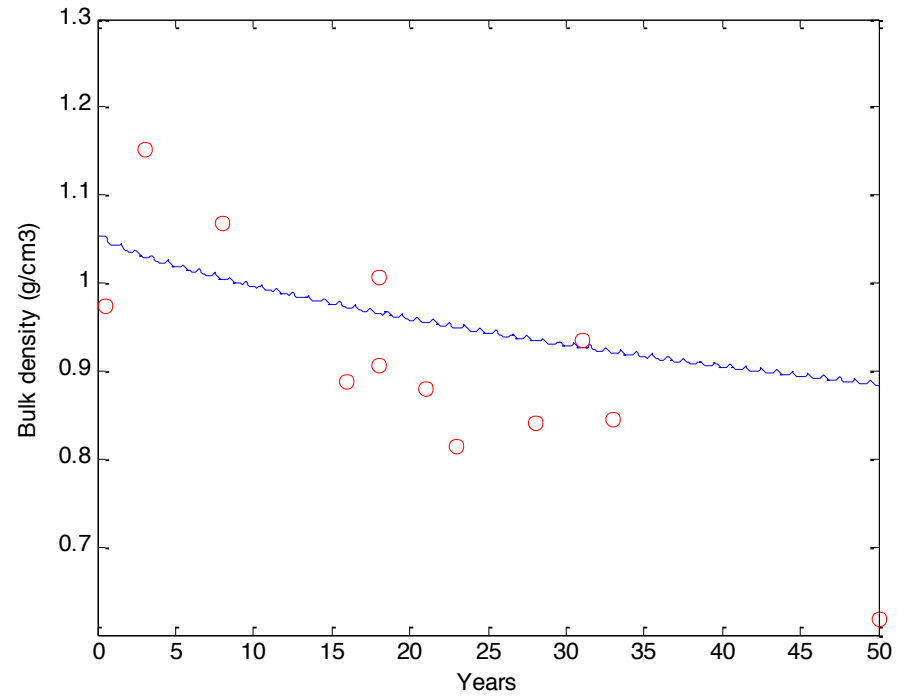
^bBiosciences Division, Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439, USA

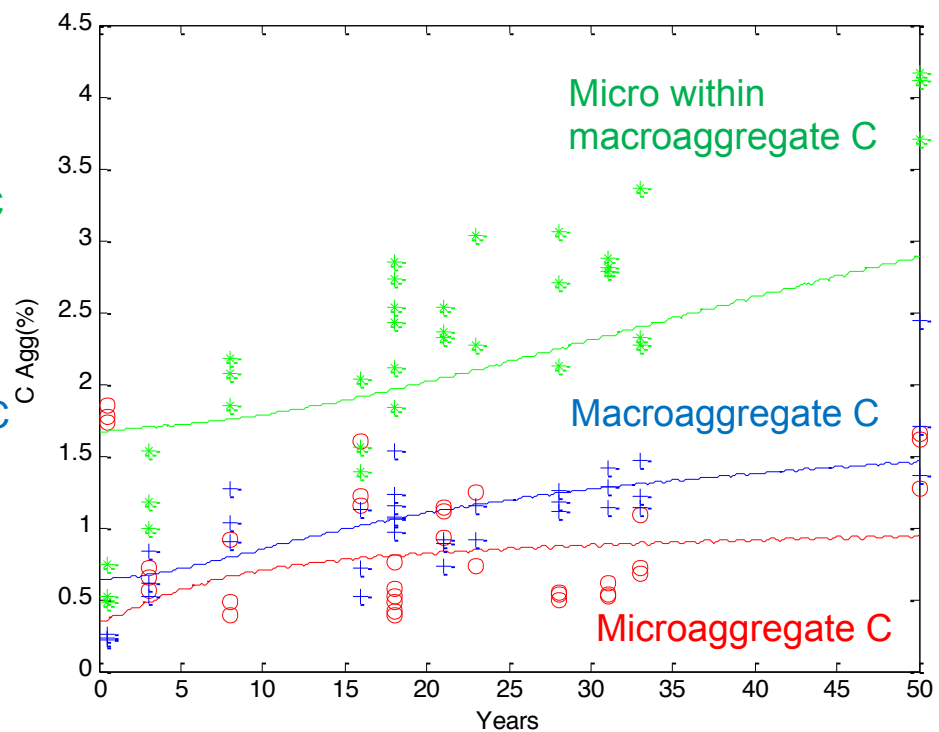
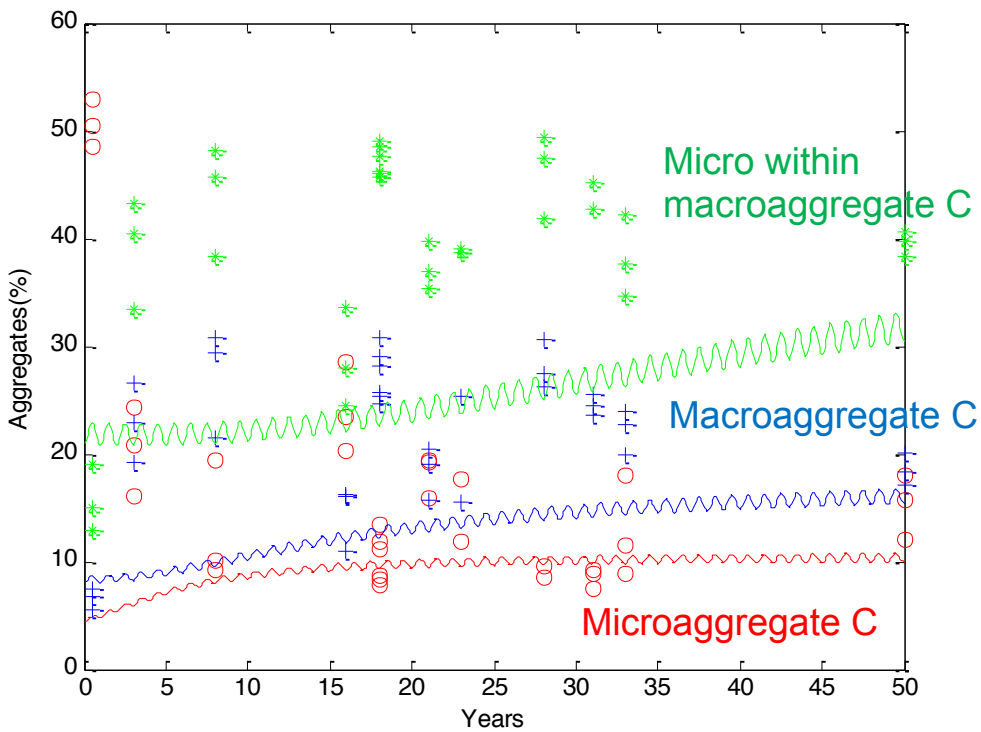






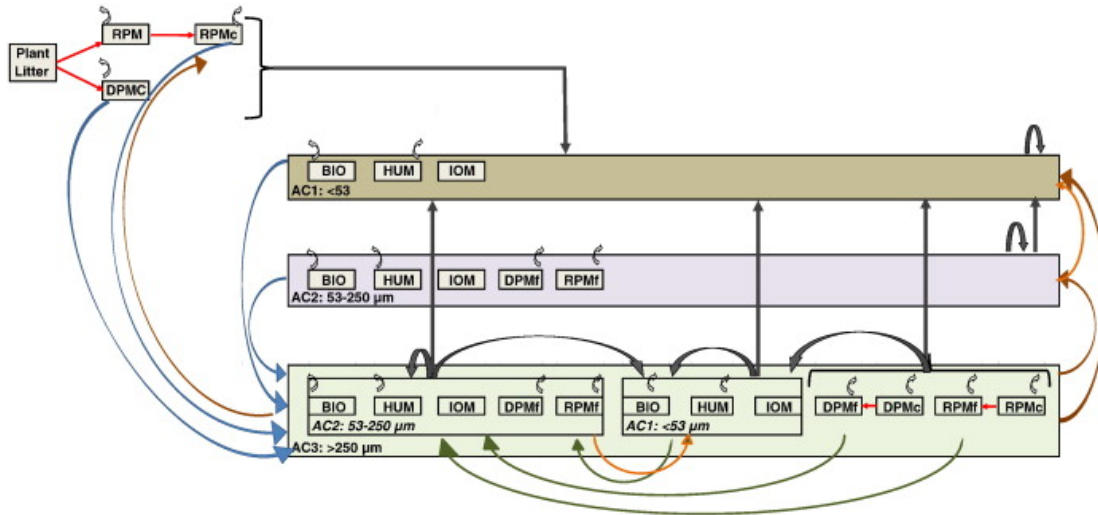
Years since restoration





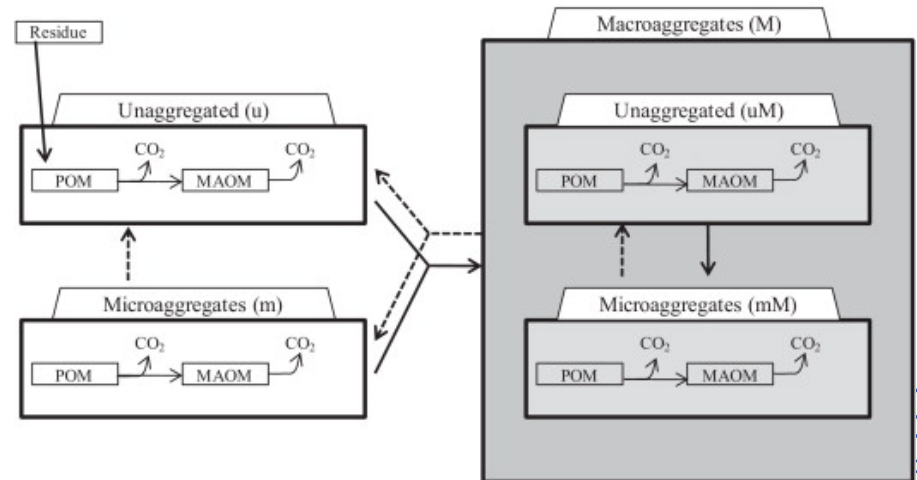
Other models

- Carbon, aggregation, and structure turnover (CAST) , Stamati et al. 2013



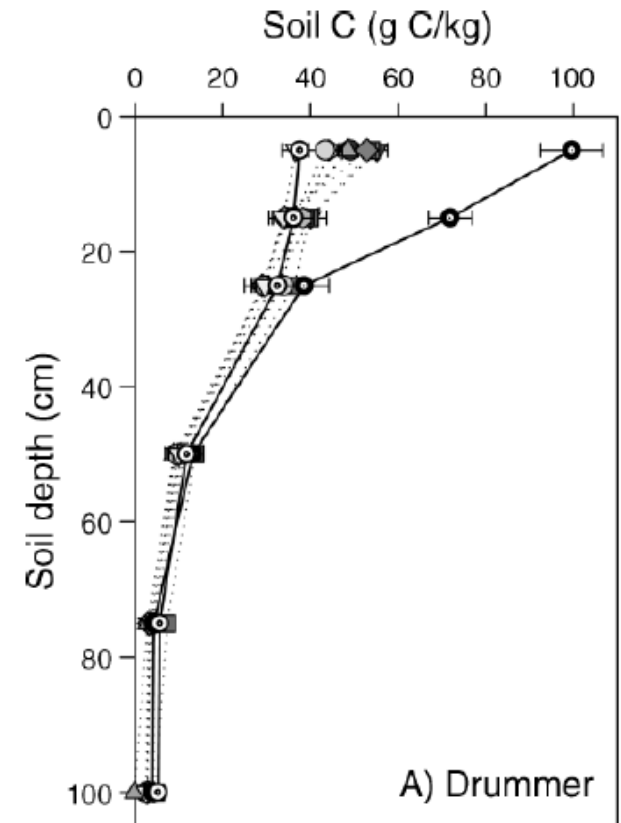
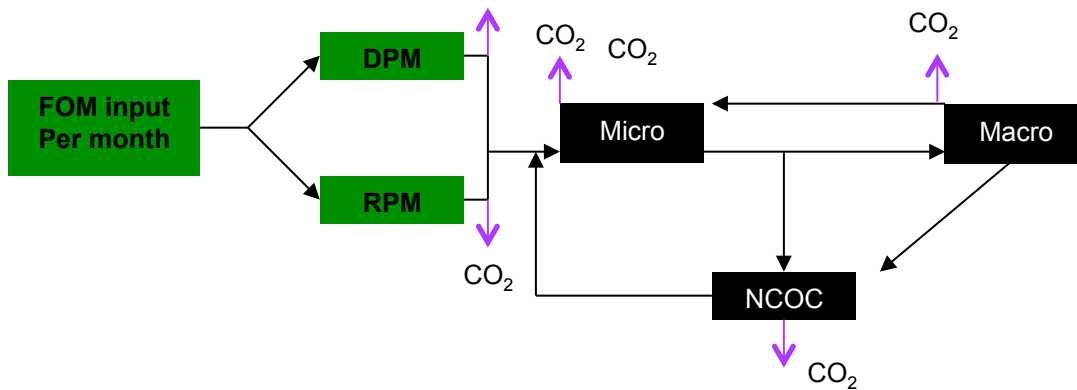
- Fluxes of plant litter and fragmentation of plant material
- MACROAGGREGATION
- MICROAGGREGATION
- MACROAGGREGATE DISRUPTION
- MICROAGGREGATE DISRUPTION
- ↻ Production of Emissions due to decomposition
- Fluxes of decomposition products (BIO and HUM)

AggModel, Segoli et al. 2013



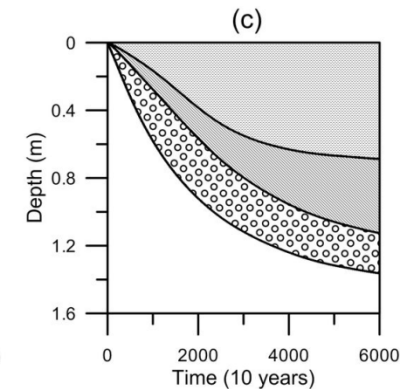
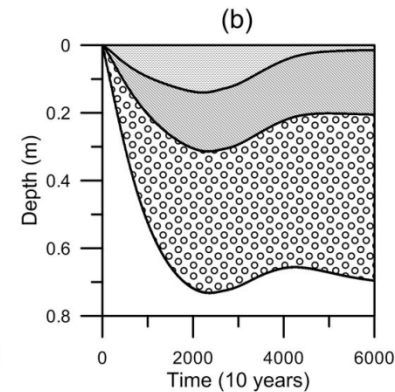
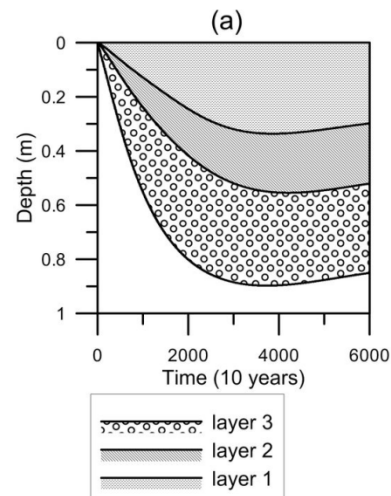
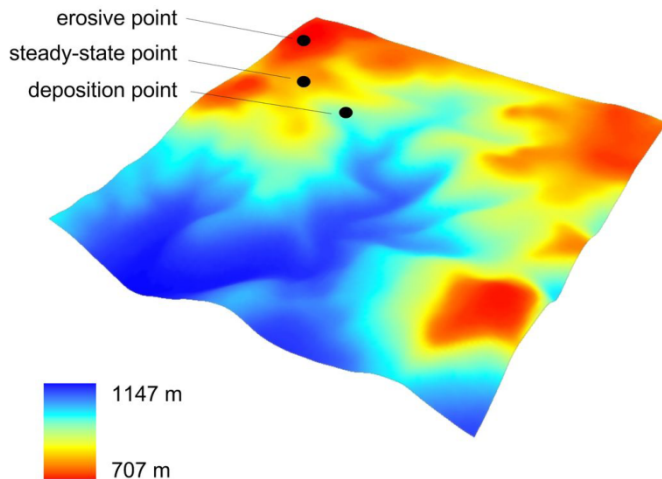
Struc-C Improvement

- A better definition of Aggregate pools
- Reconciling measured & modelled aggregates
- Distribution with depth

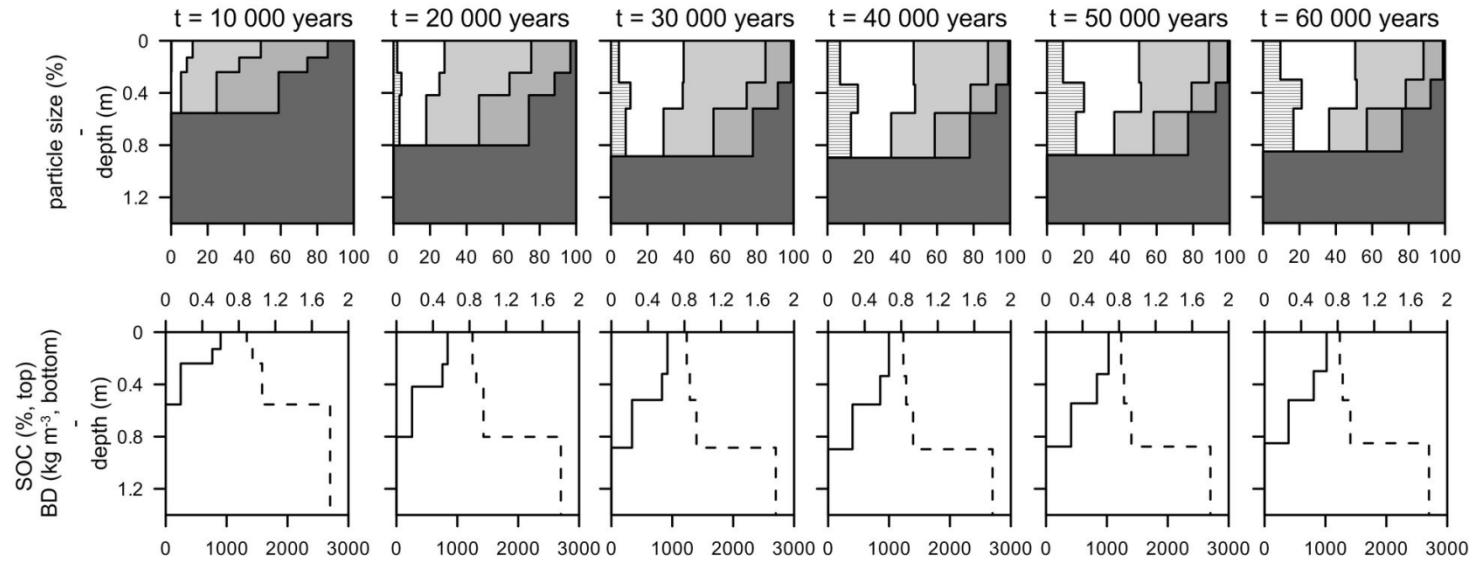
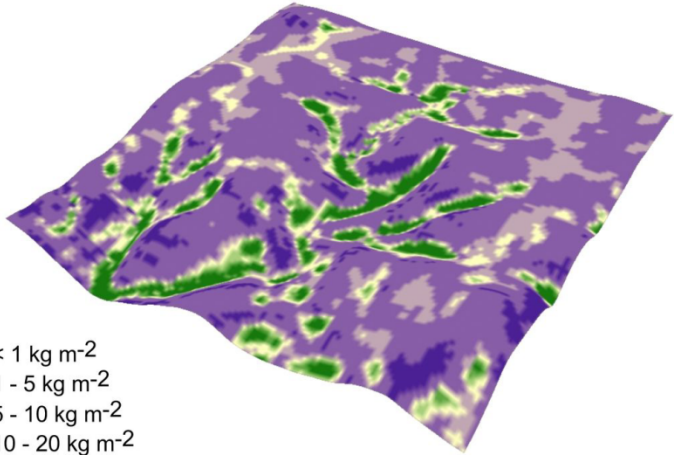


Soil C Landscape model

- 3D Soil genesis model, millennial time scale
- C -> Simple 2 Compartment model, NPP production, erosion, vertical mixing, productivity feedback



Soil-landscape model



Conclusions

- 4 per 1000: Soil C is relevant for mitigation of climate change
- To achieve 4 per mille Soil C initiative, we need to be able to measure it with confidence, model the C change & monitor it.
- Soil C & structure still lacks a quantitative model.
- Opportunities for greater collaboration