Carbon sequestration – A question of scale

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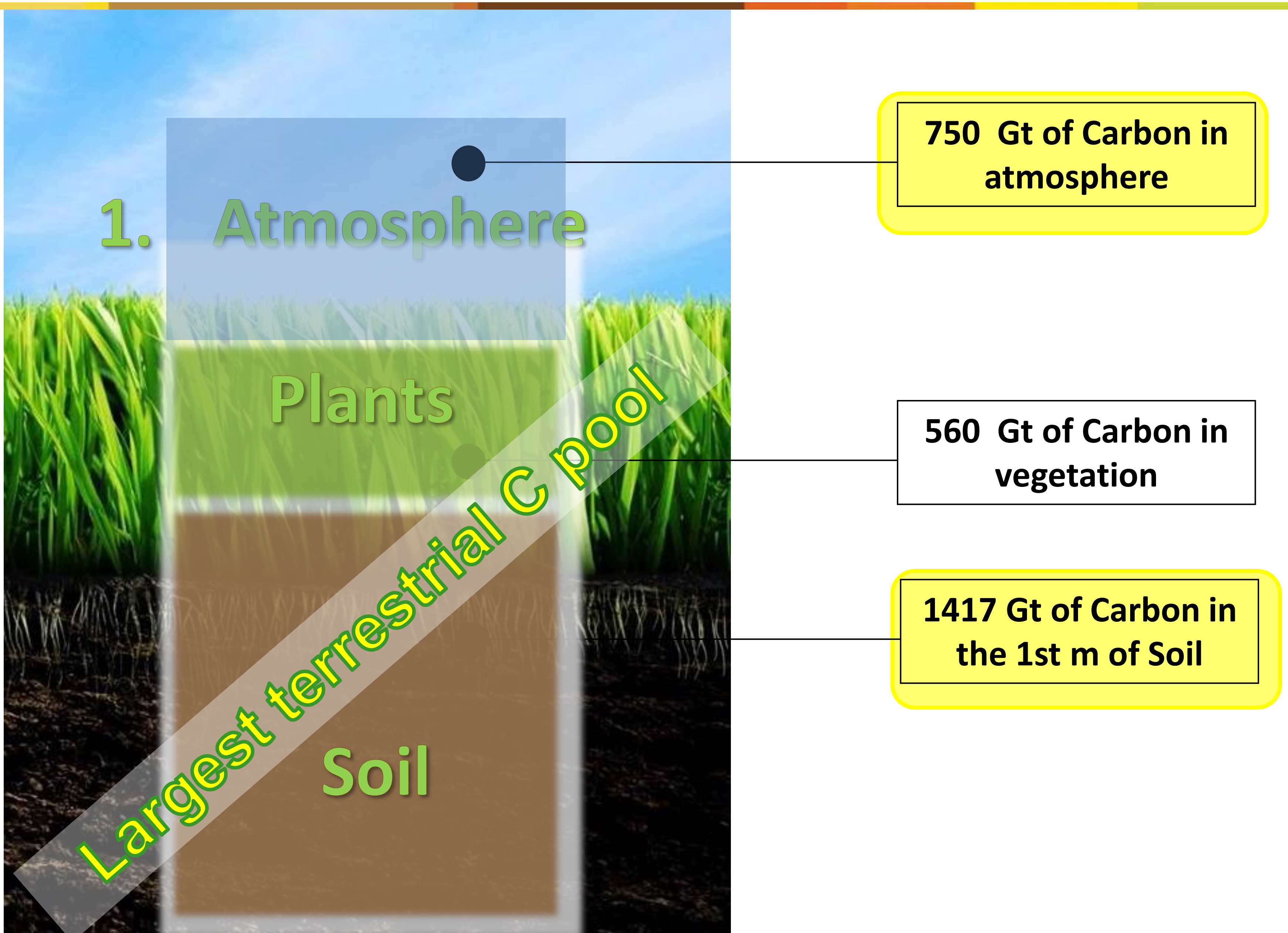
How Carbon is distributed in our soils?

Soil carbon
plays a crucial role
mitigating climate change,
enhancing soil fertility, and
supporting overall ecosystem
health.



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The Irish scenario

Soil is a net source of carbon loss in Ireland

Peat soil source +3.9 Mt CO_2e yr^{-1} **Mineral soil** sink -1.4 Mt CO_2e yr^{-1}

LULUCF inventory highly uncertain!

- EU LULUCF Target -0.626 Mt CO_2e yr^{-1}
- Agricultural emissions target +17.25 Mt CO_2 e yr^{-1}

Framework for climate-smart land management

Maintain

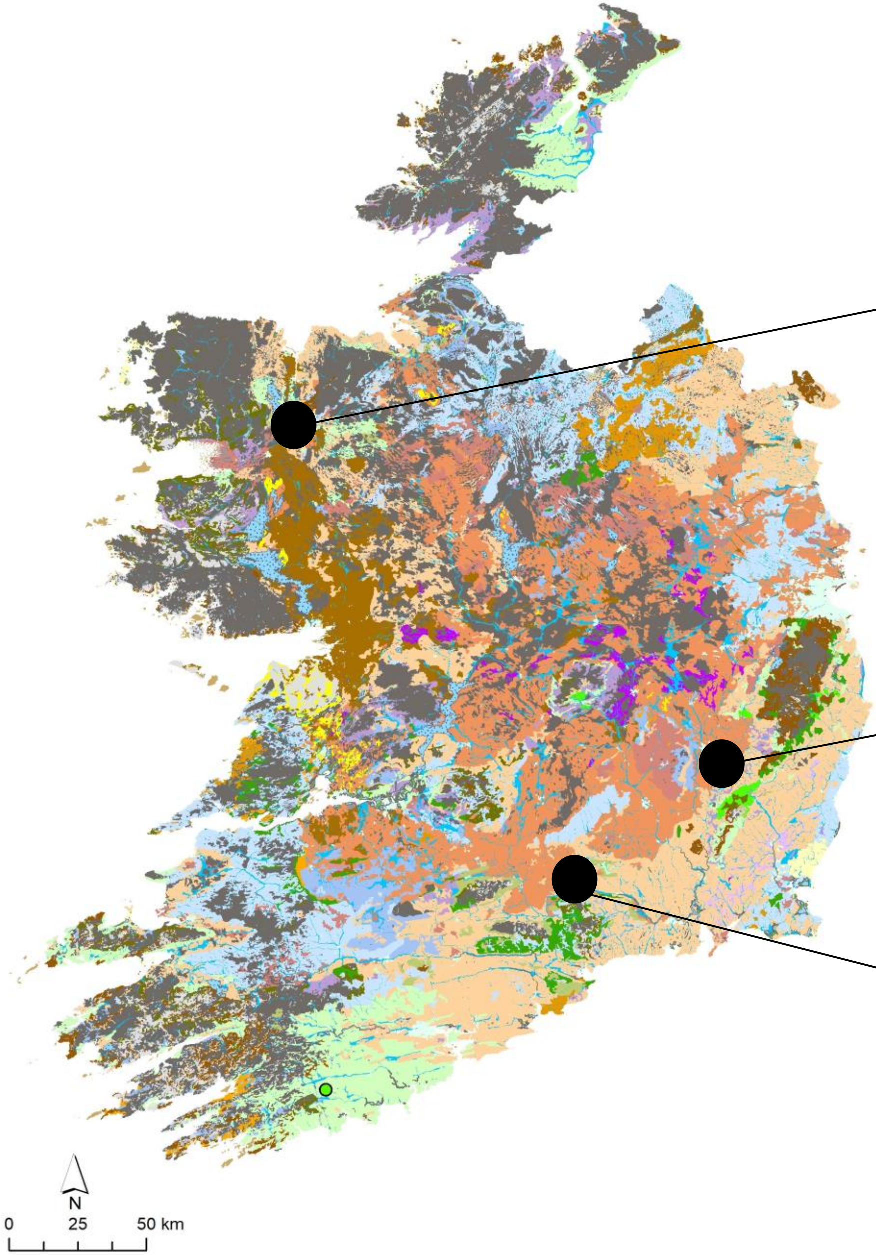
- **Where is the C?**
  - **Identify hotspots in organic soils and incentivise maintenance**

Prevent

- **Sensitive soils!**
  - **Avoiding drainage on organic soils**
  - **Land use change**

Enhance

- **Enhance sequestration!**
  - **Identify new Forest areas and hedgerow**
  - **Improved grassland management**
  - **Organic inputs**



Schulte et al., 2016

How can we manage agricultural soils to optimise C?

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C Cycle – Inputs 1

C Cycle – Inputs - 2

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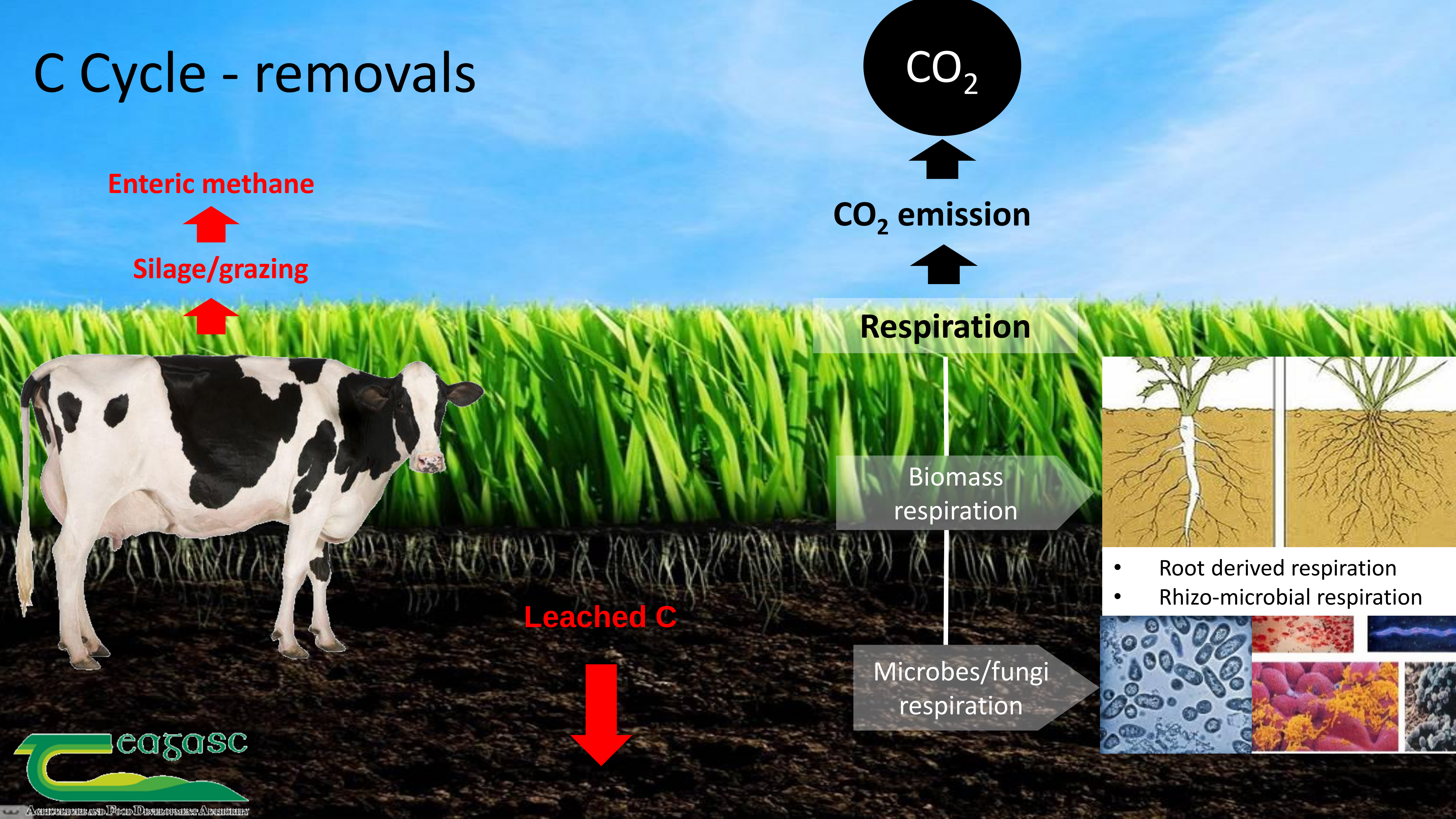
The turnover rate and the residence time of all these sources is different!

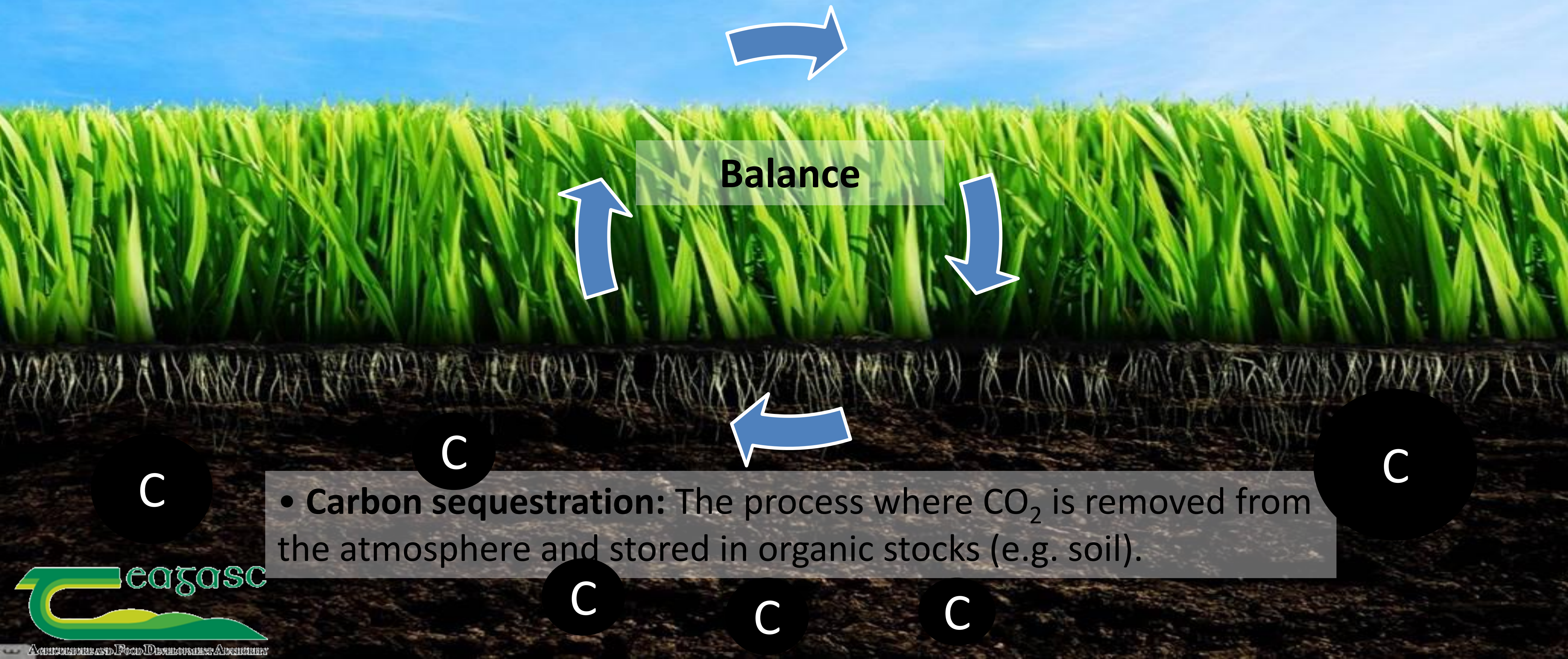
C Cycle - removals



C balance

The typical carbon balance for an improved Irish grassland

0.1 to 1.1 t C ha^{-1} yr^{-1} or 0.4 to 4 t CO_2 ha^{-1} yr^{-1}



- **Carbon sequestration:** The process where CO_2 is removed from the atmosphere and stored in organic stocks (e.g. soil).

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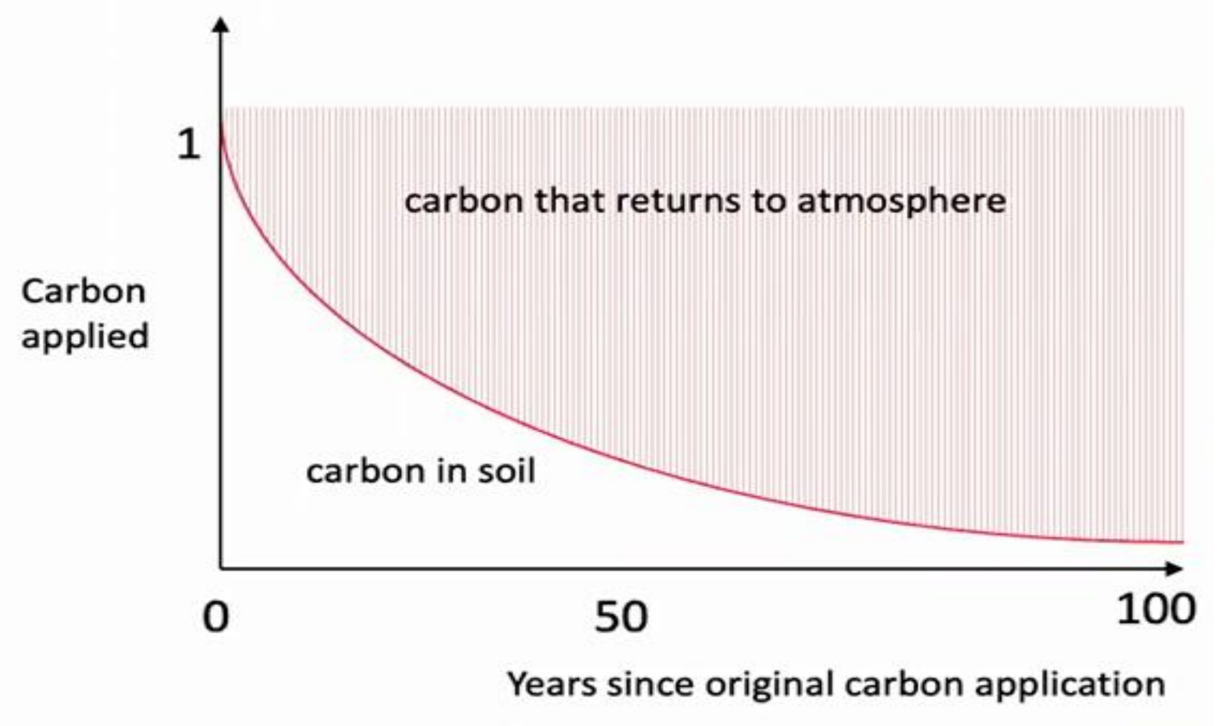
What is climate relevant when applying C to soil? - 1

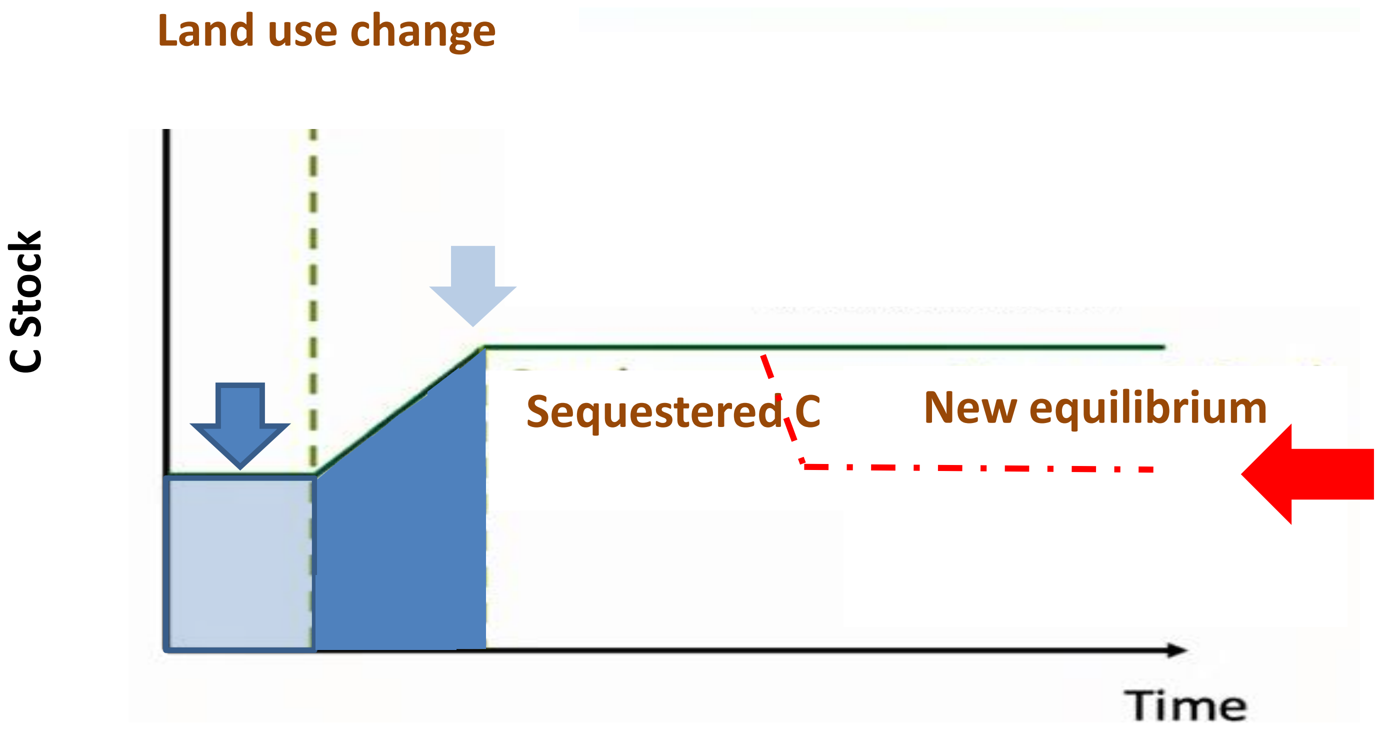
The majority of **C** applied to soil **is released back to the atmosphere** at some point in the near future.

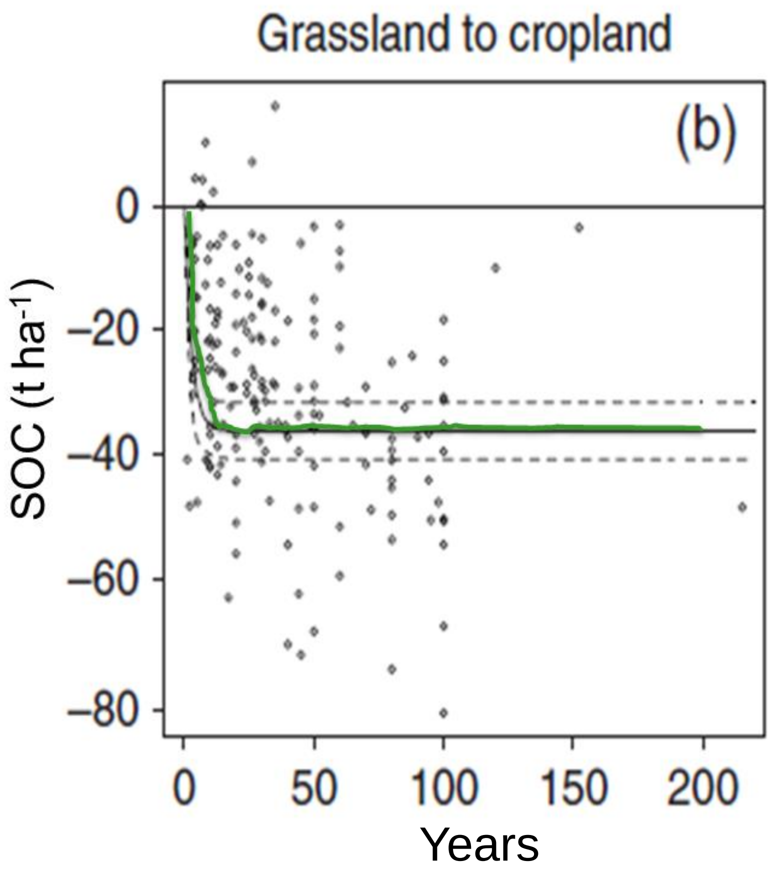


Carbon that stays out of the atmosphere over a period of time has a **climate benefit**

What is climate relevant when applying C to soil? - 2

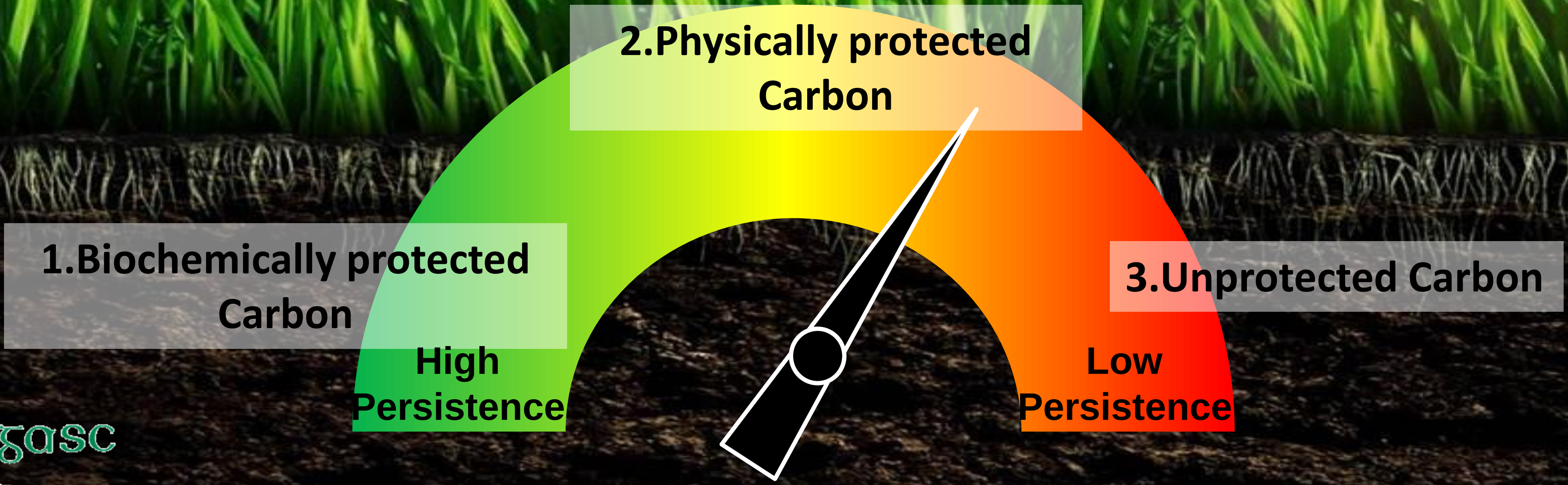
Why it's so difficult to measure C seq:
i. very small quantity C; **ii.** it take a long time to build up





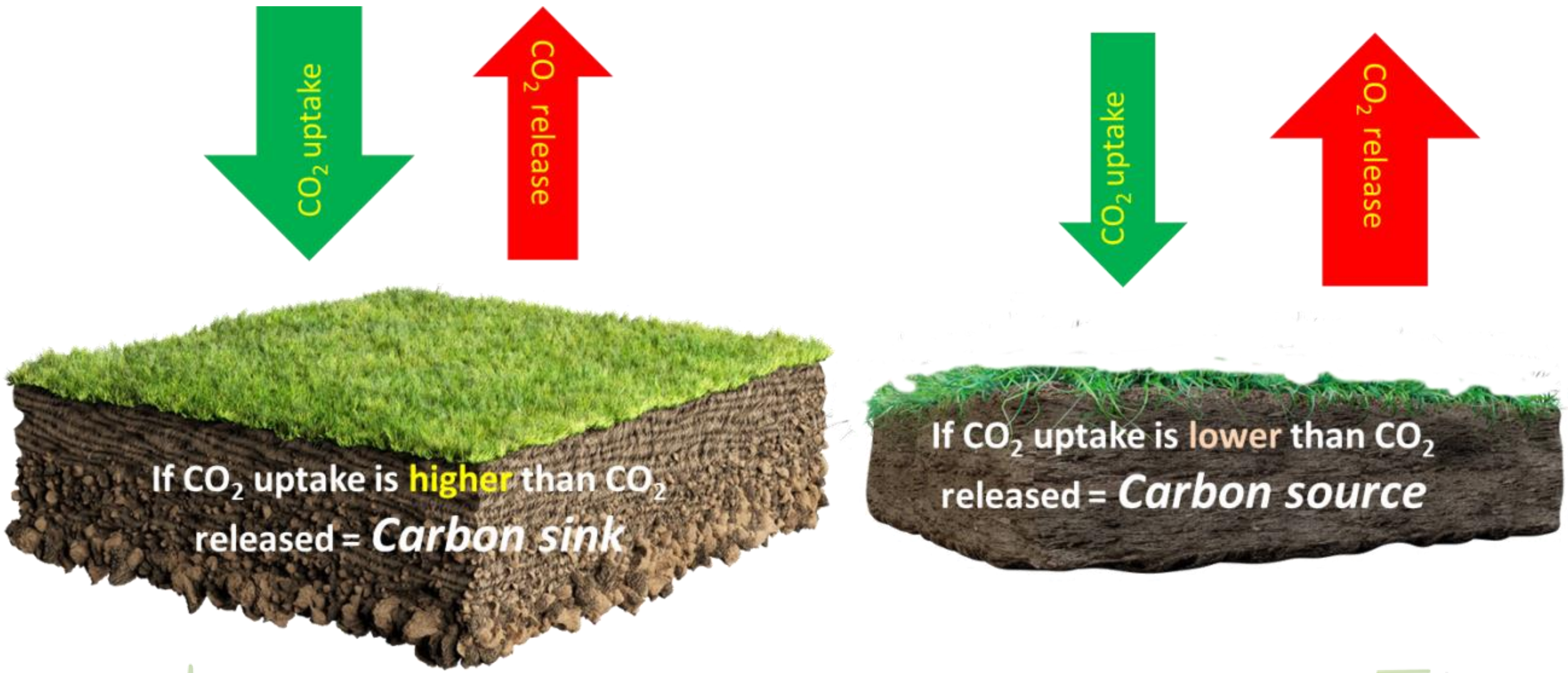
Carbon sequestered is considered **reversible**

Type of Carbon



C stocks vs C sequestration

- **Soil carbon stocks** represent the total amount of C stored in an area (t C/ha).
- **Carbon sequestration** refers to the net change in soil carbon stocks over time.

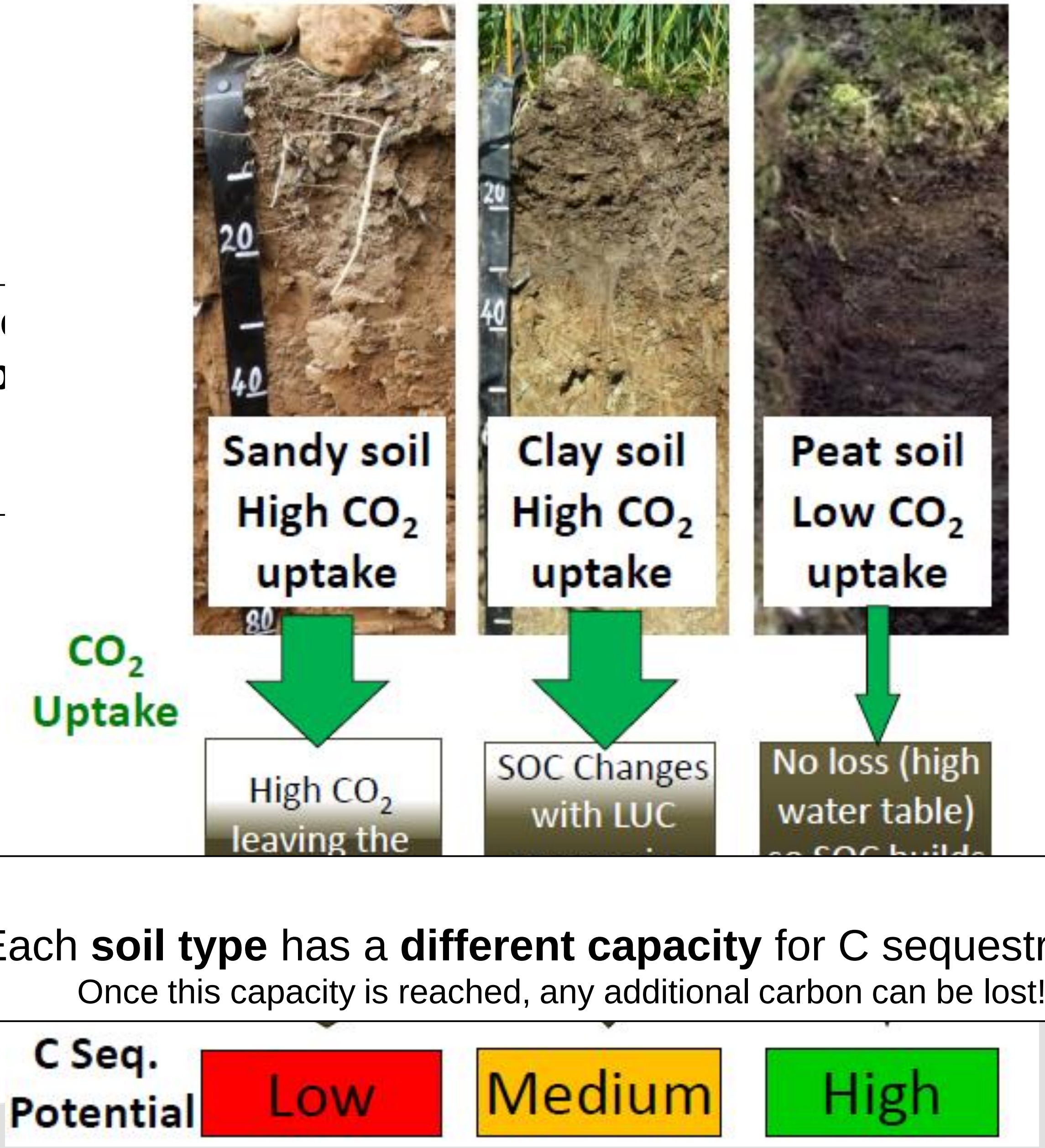


Are we increasing or decreasing C stocks?

What are the challenges measuring C stocks and sequestration potential?

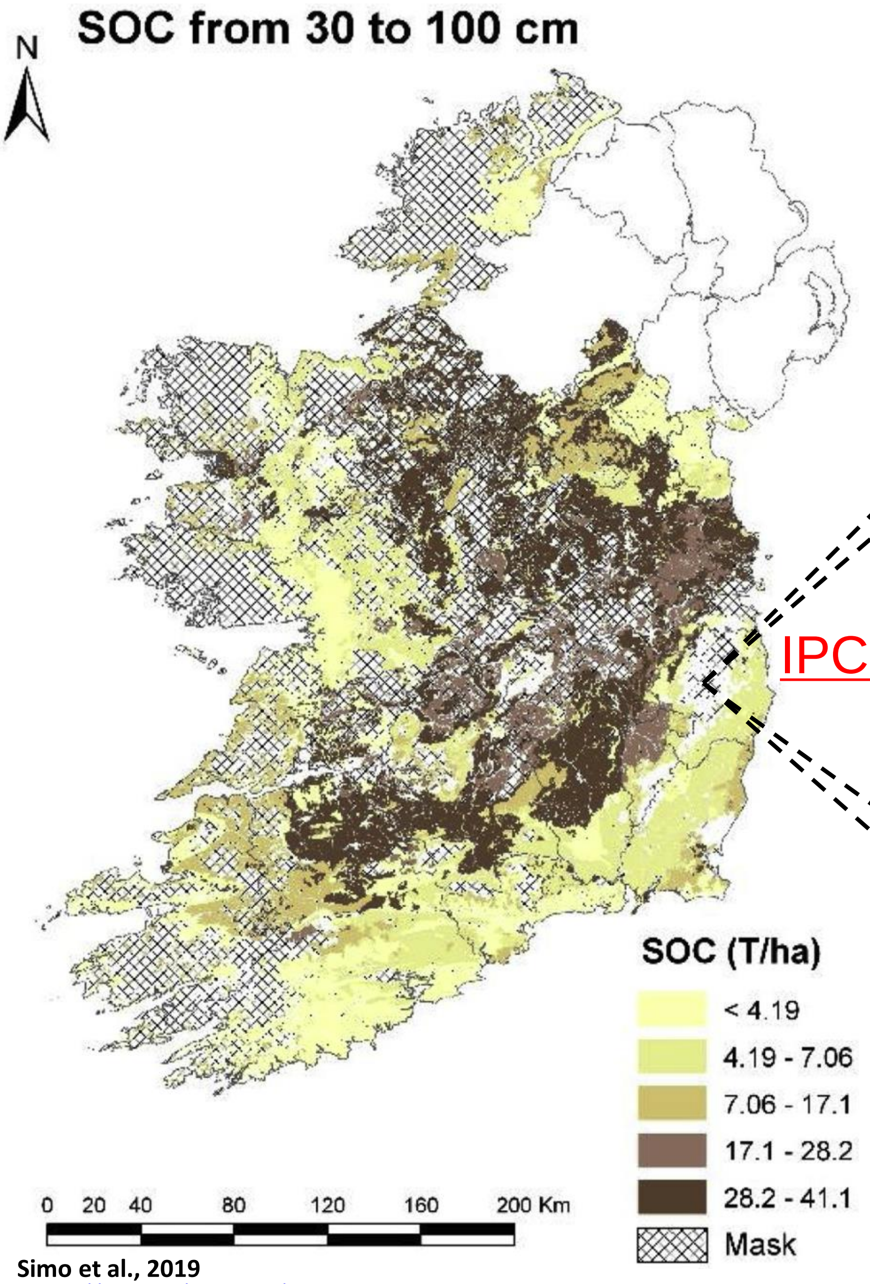
Challenge of Measuring C -Soil type influence

Different soils can stor
different amounts of carb
affecting their ability to act
carbon sinks



Each **soil type** has a **different capacity** for C sequestration
Once this capacity is reached, any additional carbon can be lost!

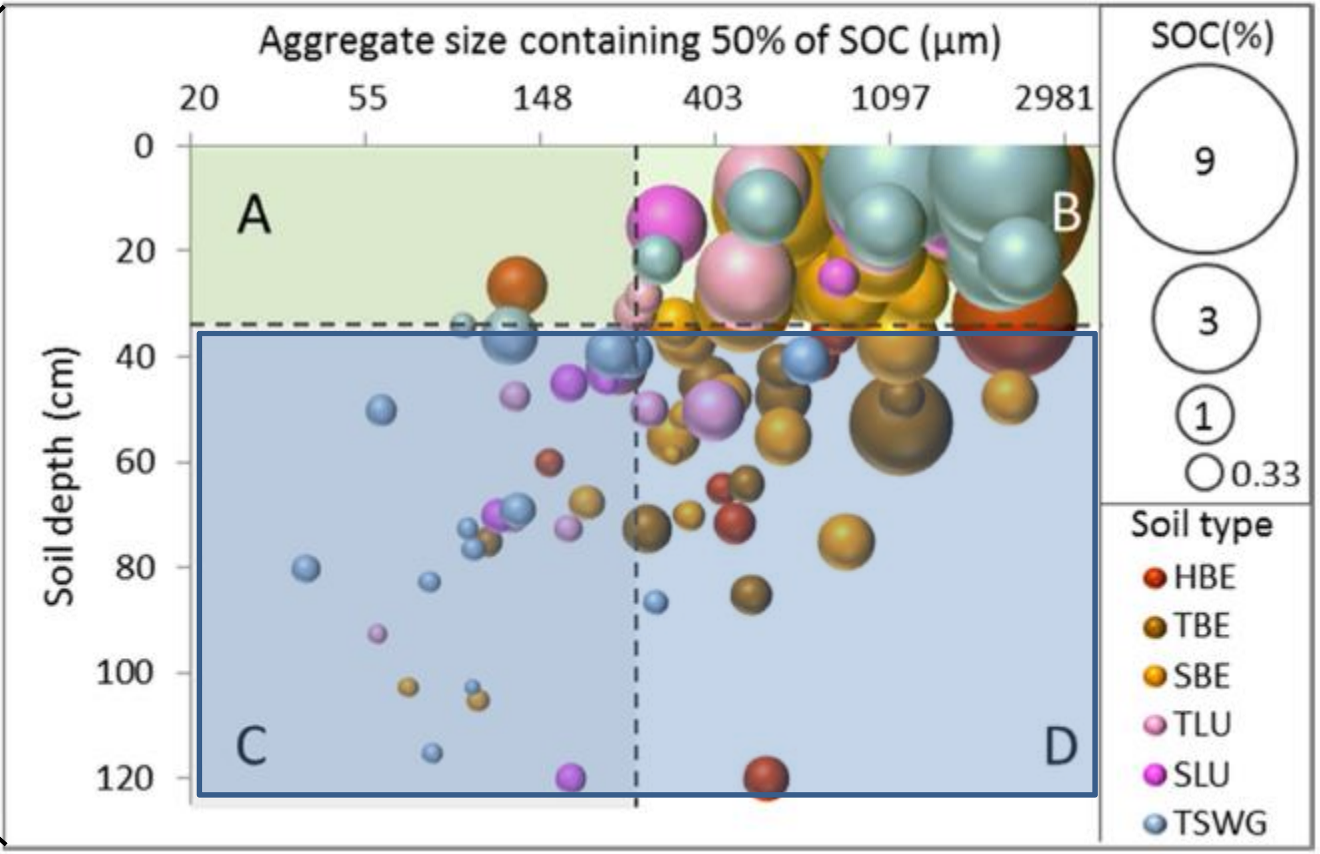
Challenge of Measuring C -Deep Soil Sampling



Simo et al., 2019
https://doi.org/10.1016/j.envsci.2019.05.004

IPCC Depth

A larger proportion of the SOC is associated with microaggregates and S+C fractions **in clay illuviated soils**



Torres-Sallan et al., 2017
https://doi.org/10.1038/srep45635

Photos: Alex Castellon

Challenge of Measuring C – Method Accuracy - 1

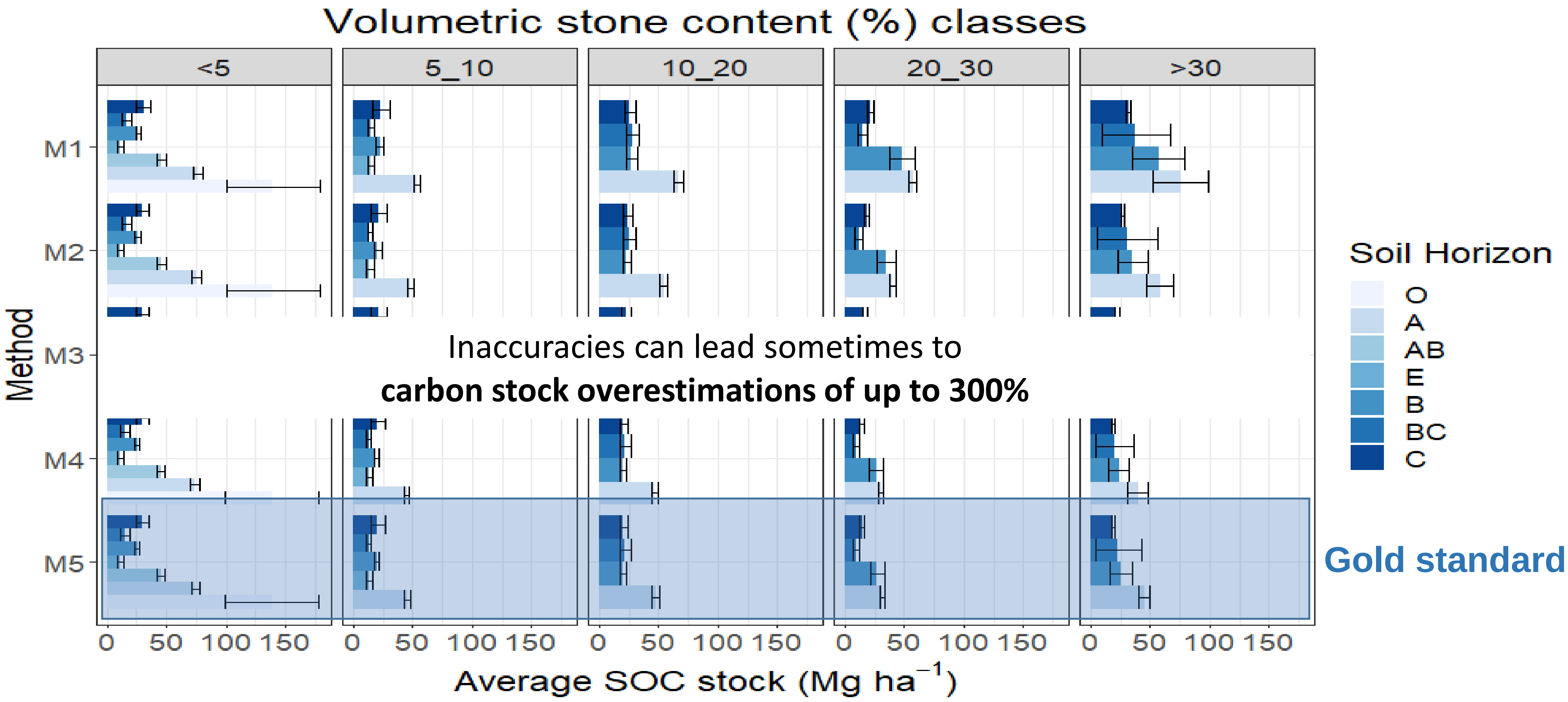
Challenge of Measuring C – Method Accuracy - 2

Challenge of Measuring C – Method Accuracy - 3

Adjust for rock fragments is key!

Photos: Luis Lopez-Sangil

Challenge of Measuring C – Method Accuracy - 4



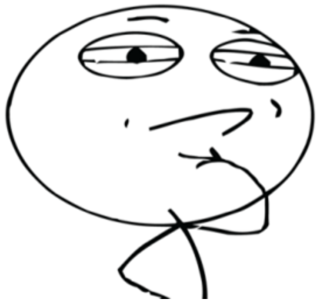
Inaccuracies can lead sometimes to
carbon stock overestimations of up to 300%

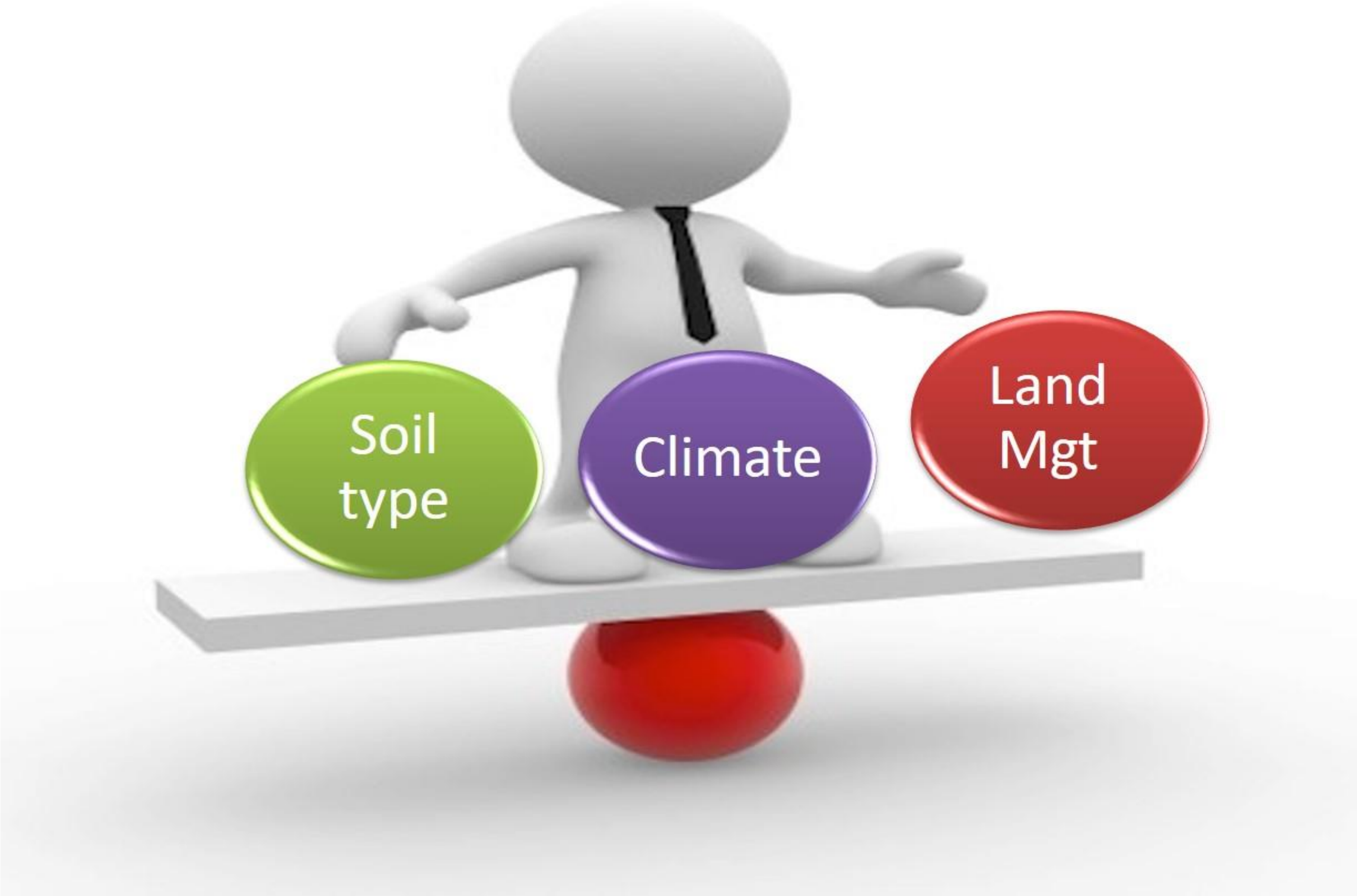
Gold standard!

Average soil organic carbon stocks (Mg ha^{-1}) for different horizon types using five different calculation methods found in the literature to account for SOC stocks.

Fenton et al. 2024 (Geoderma Regional)

Research Mission





Are we able to develop a **baseline for C stocks** at national level?
Can we develop **sequestration factors** based on farming scenarios in Ireland?

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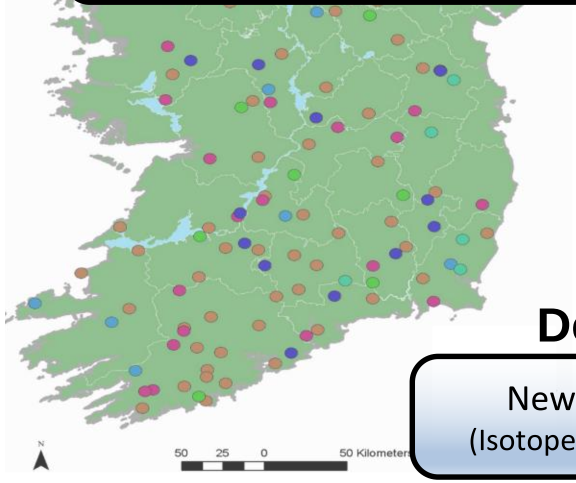
A three pronged approach for an MRV platform

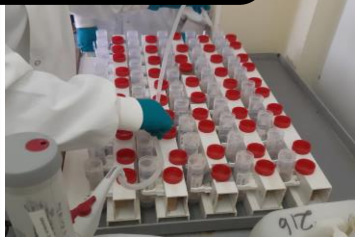
Measure soil C …& wait

Long term C Measurements
(Deep Soil Sampling an soil Nutrient tests)

Harmonise existing data

Climate, Soil & Land-use and activity data
(NMP Online, pasture based)



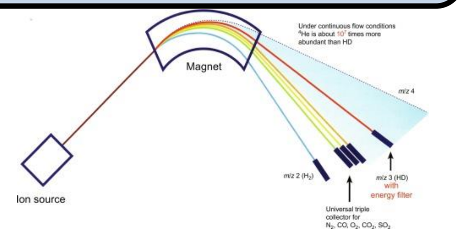


Measure fluxes

Short term C Measurement
(Remote sensing, Flux, Eddy Covariance Tower)

Develop new data

New tools and technologies
(Isotope experiments, C fractionation)



Modelling

Grass/crop growth and soil modelling (M/R/V)

C change over time

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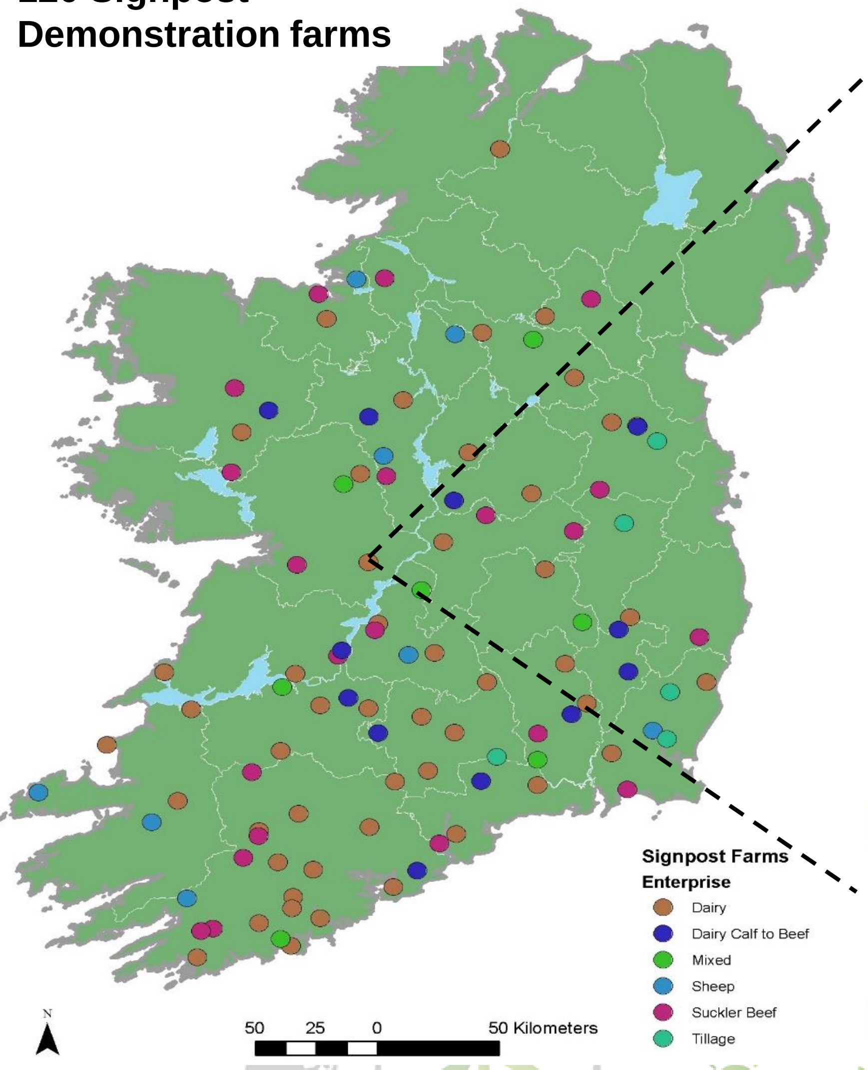
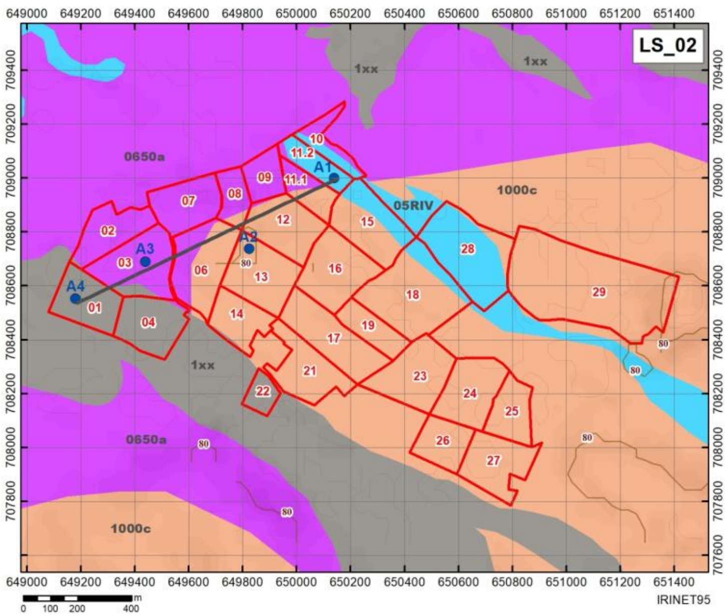
Signpost Farms – Long term Soil C Stocks changes

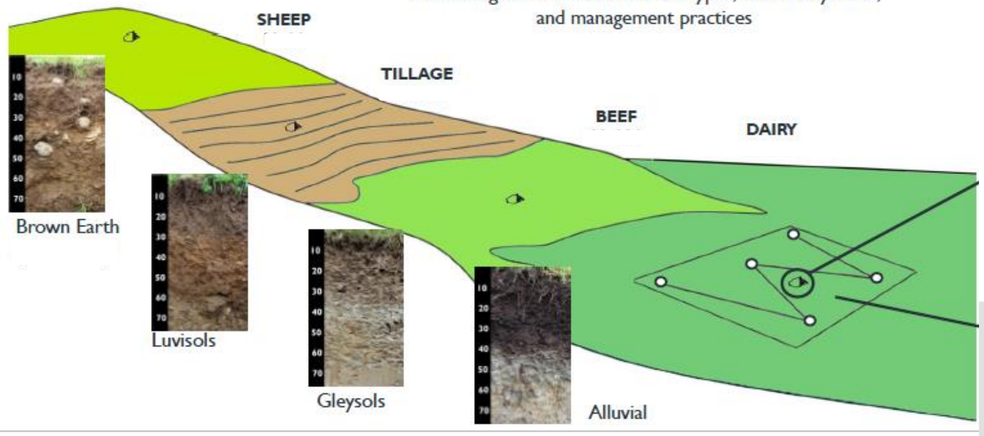
120 Signpost Demonstration farms



Spatial & Activity Data



Landscape distribution



Soil Data

Topsoil

IPCC Depth

Subsoil

SIGNPOST

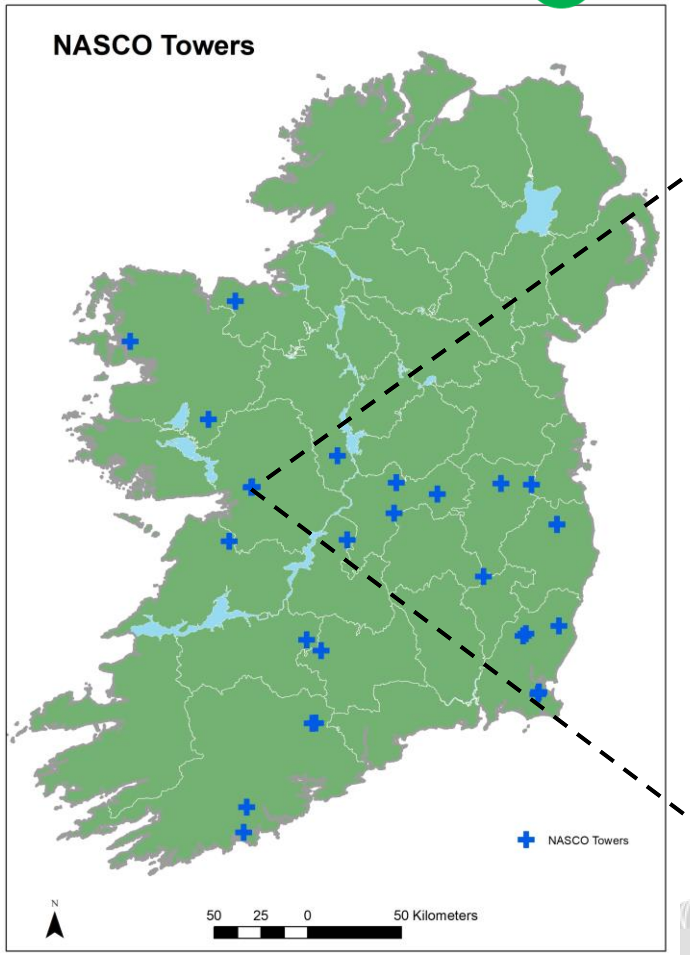
Farmers for Climate Action

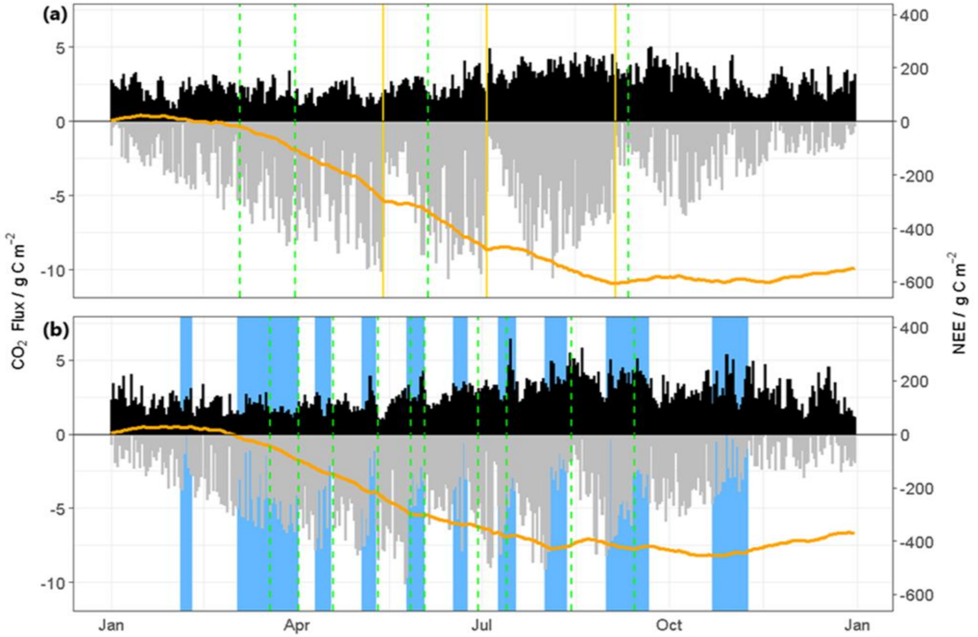
Flux Measurement - Eddy covariance towers

28 eddy covariance towers
- 8 peat soils
- 20 mineral soils

All towers measure CO_2 and H_2O fluxes
- 8 towers measure CH_4
- 2 towers measure N_2O

Located on different land-uses, managements and soil types





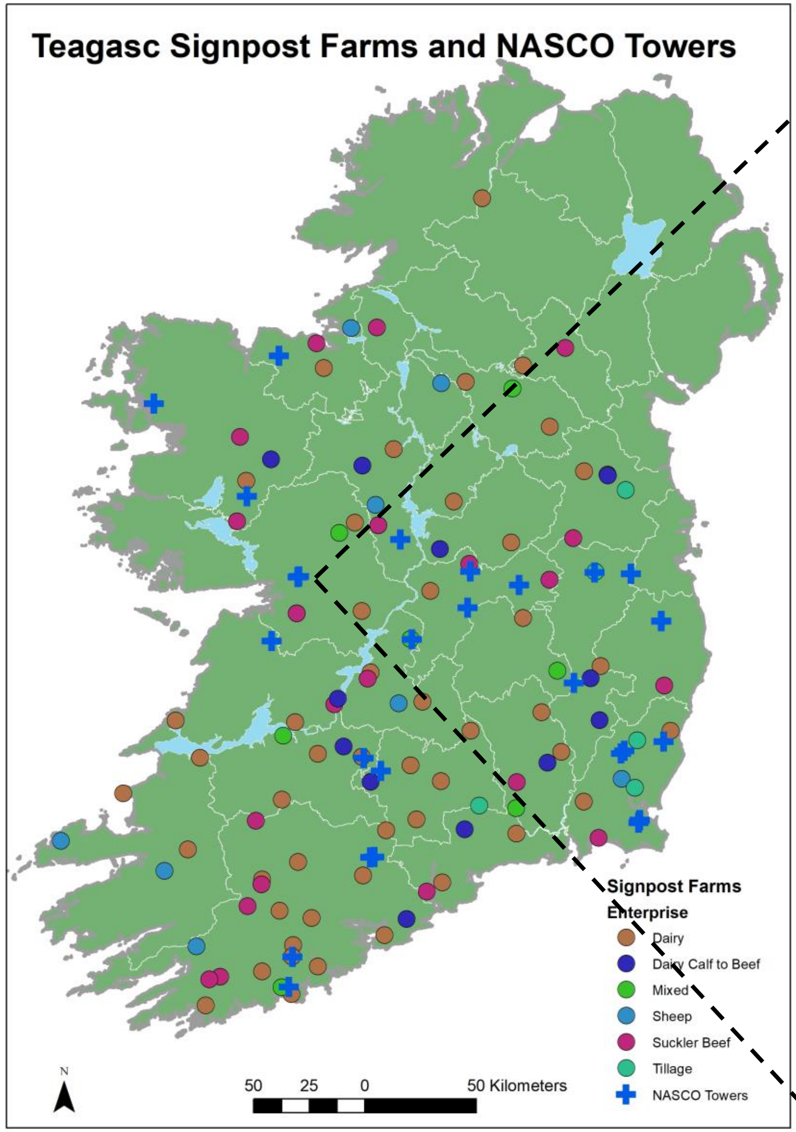
Photos: James Rambaud

How do we use this data to refine the Inventory?

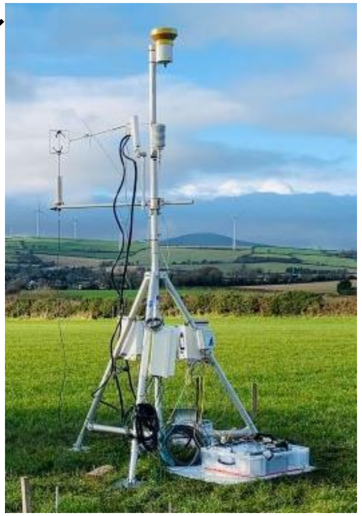
Soil C and EC Data used for Tier 2-3 model development

These models can:

- Quantify management impacts on soil C
- Quantify long term climate impacts



High resolution GHGs measures



Soil Data

Spatial & Activity Data

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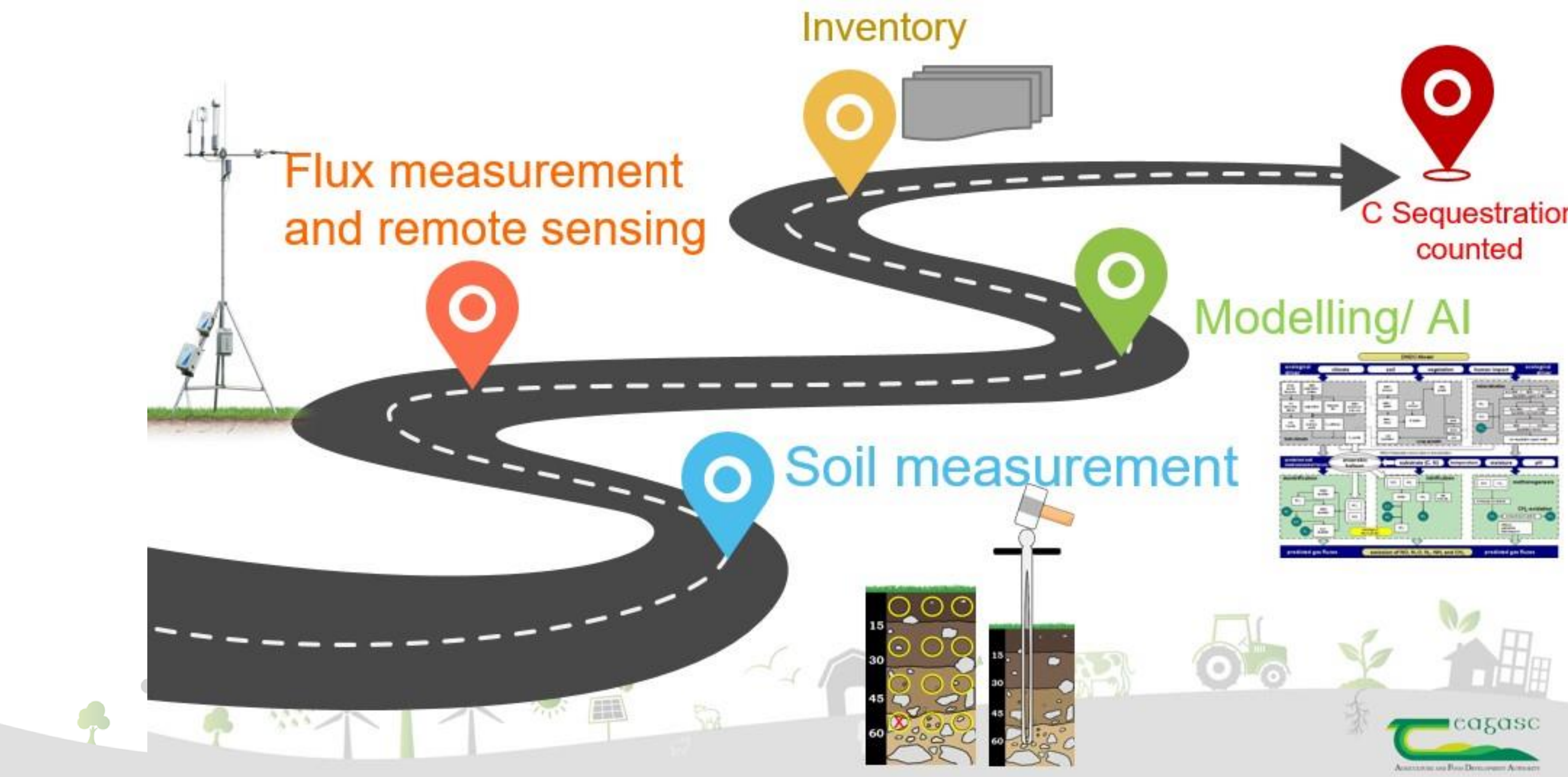
Teagasc roadmap to C sequestration accounting



Take Home Messages

- Inventory still uncertain!
- Soil Type (Clay) set the potential size of the sink
- Land Use and Management help to switch to higher or lower factors rate of C sequestration
- Soil sampling and C calculation methods are important!

Refine the national inventory for carbon emissions from land-use and management (Tier 2 and 3)
combined modelling support by soil sampling and EC measurements

Thanks for the attention

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