The Signpost Programme

Soils, Nutrients and Fertiliser Campaign

Giulia Bondi – Carbon Sequestration Research Officer

Teagasc
Agriculture and Food Development Authority

Carbon storage and cycling

Soil Organic Matter contains approximately 50% of C and it's a crucial source of life in earth!

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How Carbon is distributed in our soils?

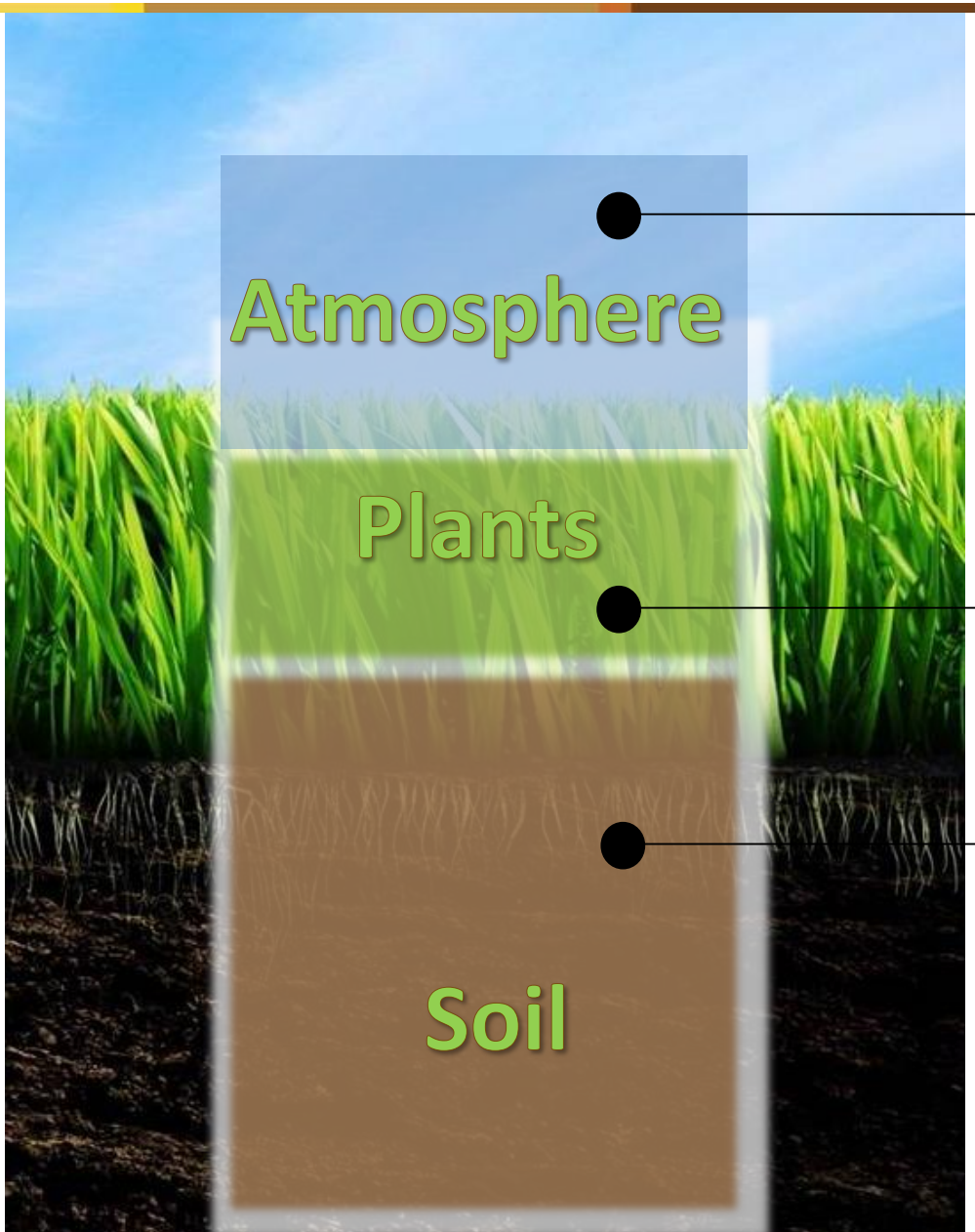
In Ireland, overall emissions
62.70 Mt CO_2 eq.

↓

about 35.3% of GHG emissions are coming from agriculture

↓

Responsibility!



750 Gt of Carbon in atmosphere

560 Gt of Carbon in vegetation

1417 Gt of Carbon in the 1st m of Soil

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How can we manage agricultural land use to optimise C in the soil?

C Cycle

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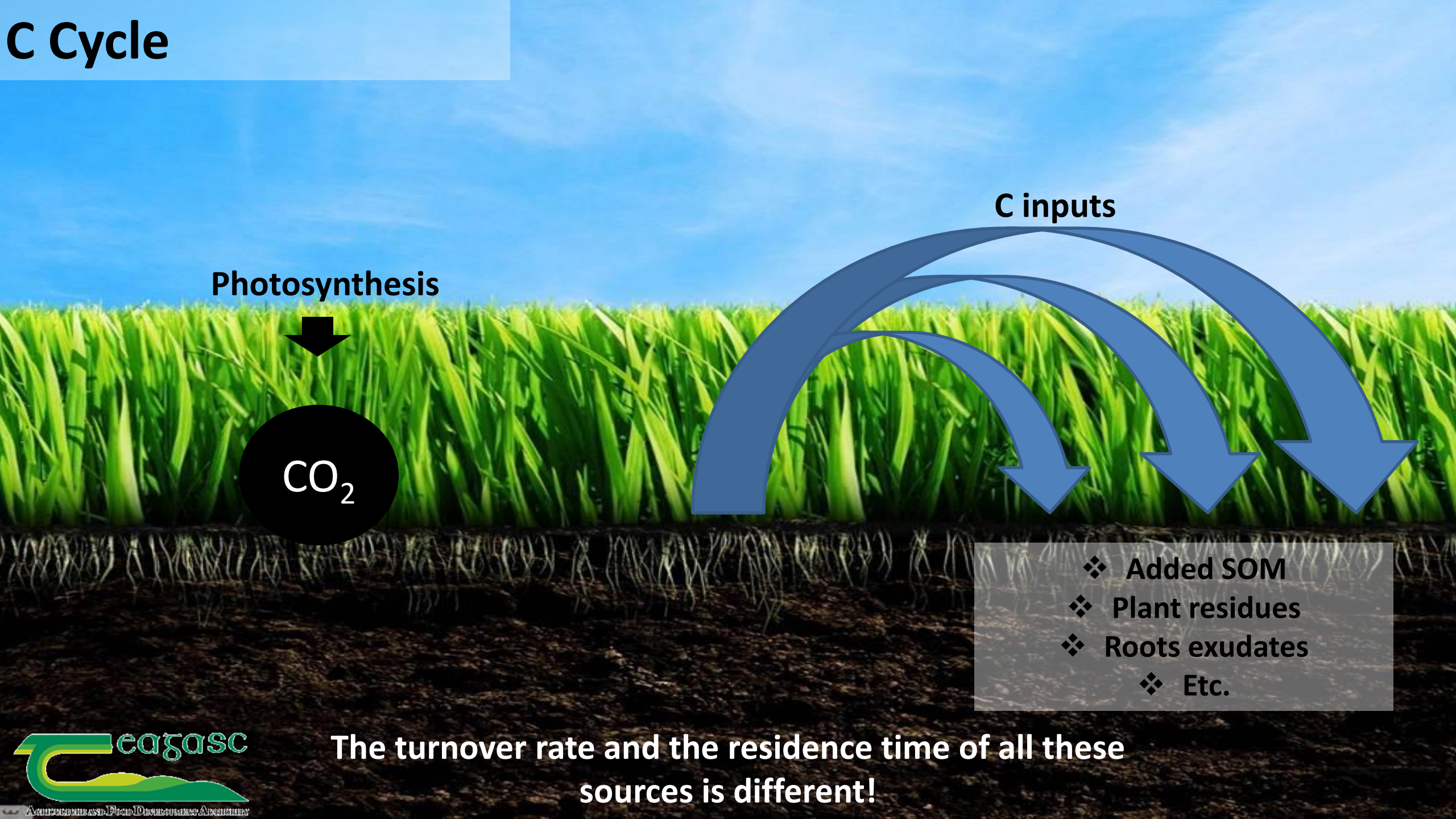
C Cycle



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

C Cycle

CO_2

CO_2 emission

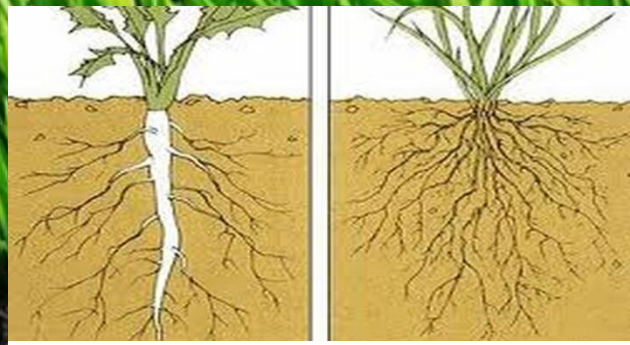
Photosynthesis

CO_2

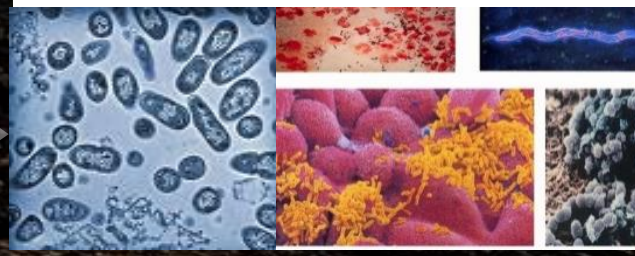
Respiration

Biomass respiration

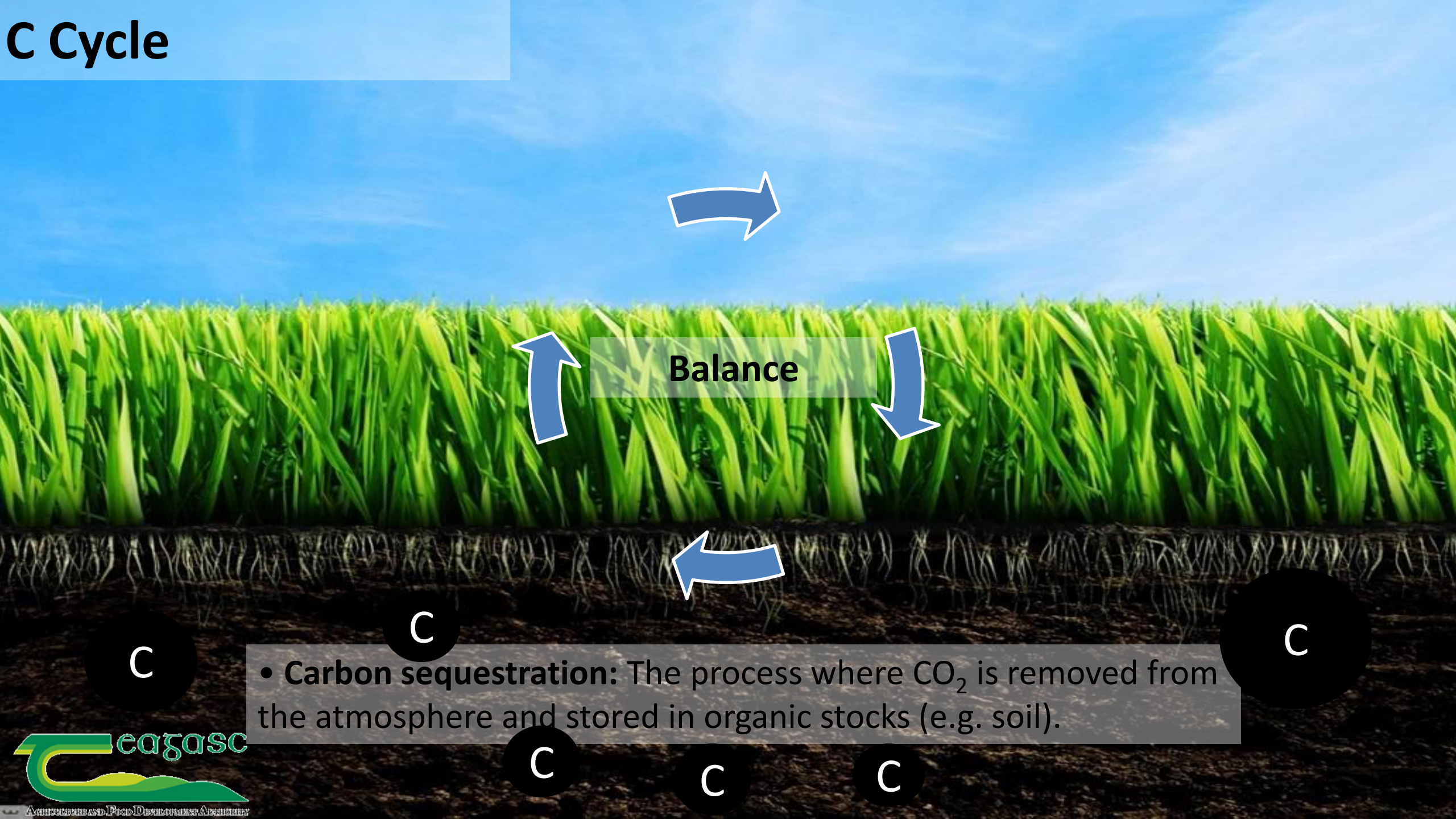
Microbes/fungi respiration



- Root derived respiration
- Rhizo-microbial respiration



C Cycle

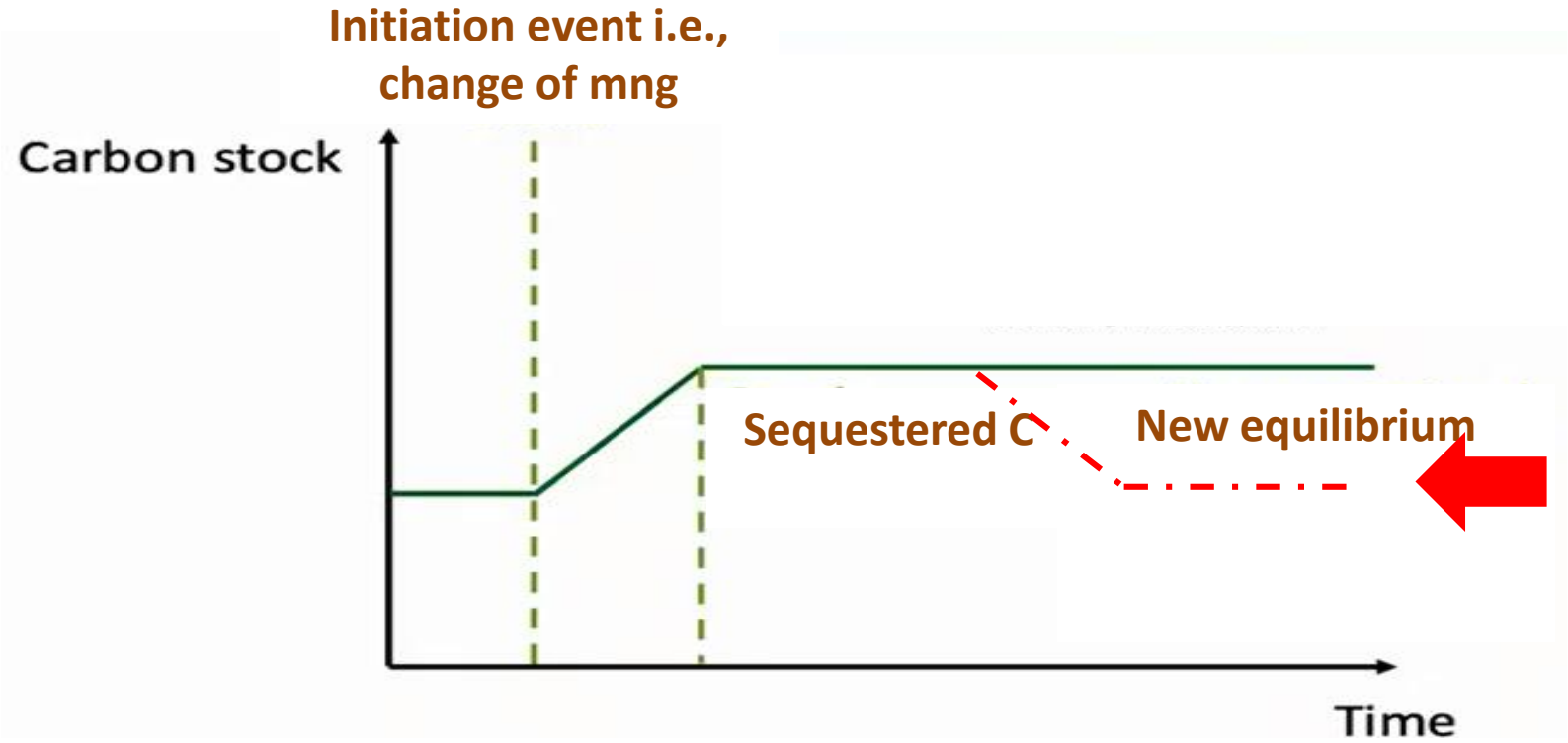


• **Carbon sequestration:** The process where CO_2 is removed from the atmosphere and stored in organic stocks (e.g. soil).

What is climate relevant when applying C to soil?

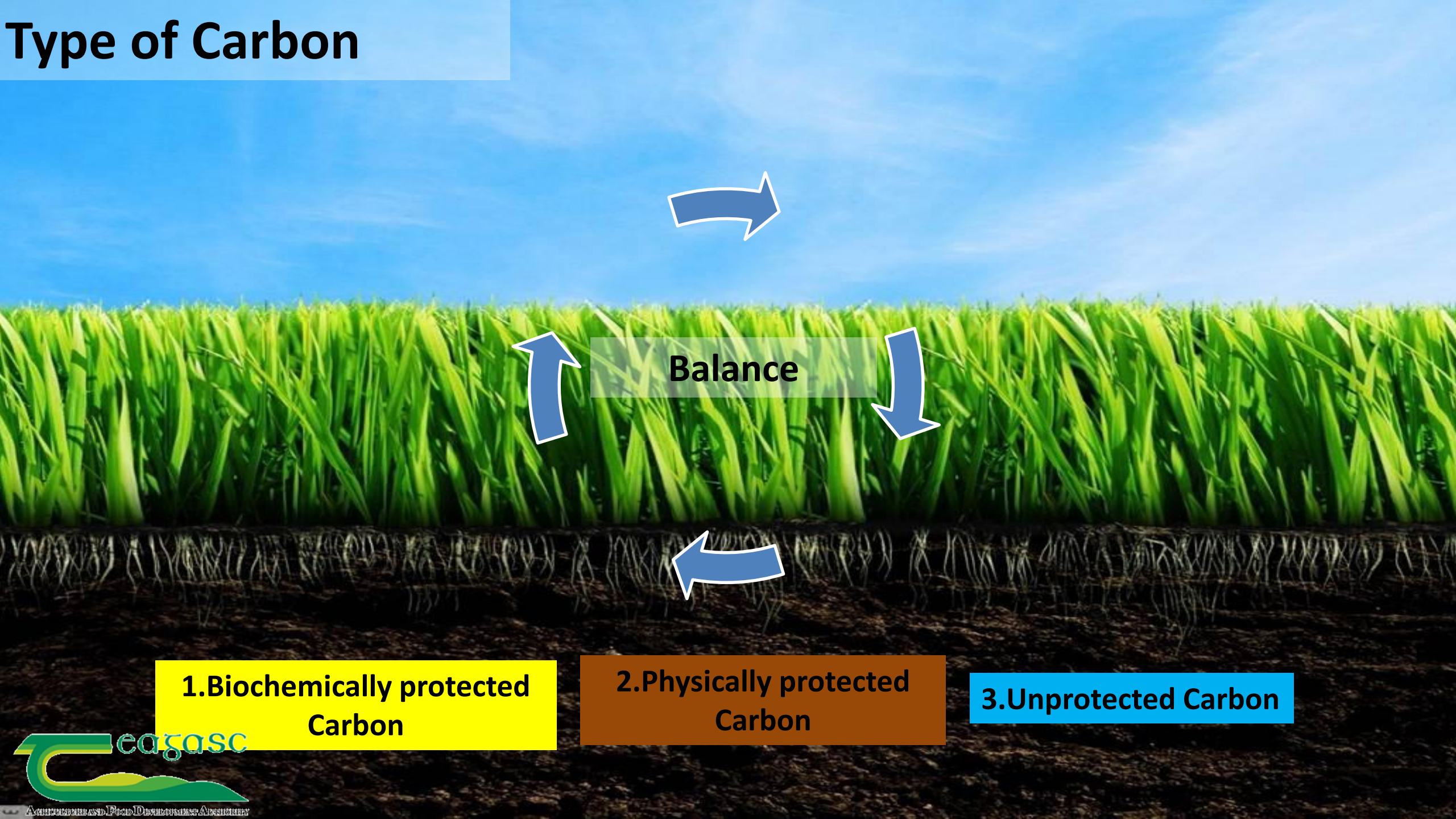
Why it's so difficult to measure C seq:

i. It is a small build up, very small quantity; **ii.** it take a long time to build up



Gains in sequestered carbon are considered **reversible out of precaution**

Type of Carbon



1.Biochemically protected Carbon

2.Physically protected Carbon

3.Unprotected Carbon

The Signpost Programme

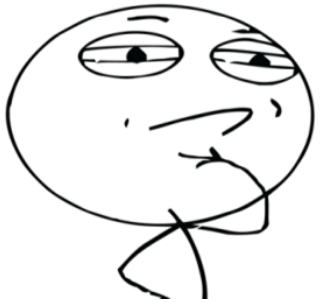
- A national multi-annual campaign to lead climate action by all Irish farmers:

✓ A whole of industry approach to reducing GHG emissions

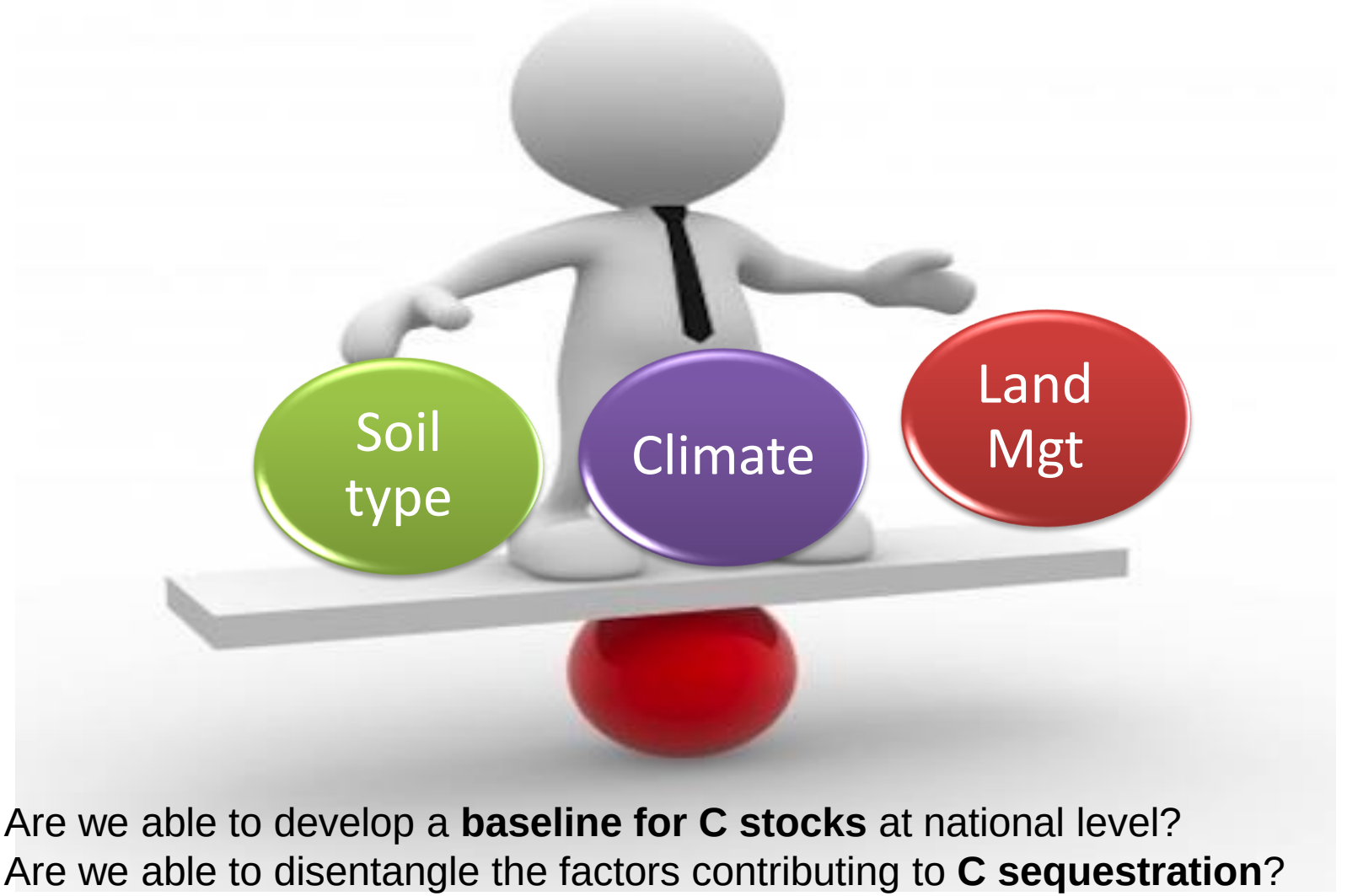
- There are two elements to the programme:

✓ A network of ***Signpost Farms***, which act as demonstration farms for the programme and sites for carbon sequestration measurements.

✓ ***The Signpost Advisory campaign***, this will engage with all farmers and support them to move towards more sustainable farming systems.



What's the challenge?



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

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Signpost Carbon Sampling Campaign

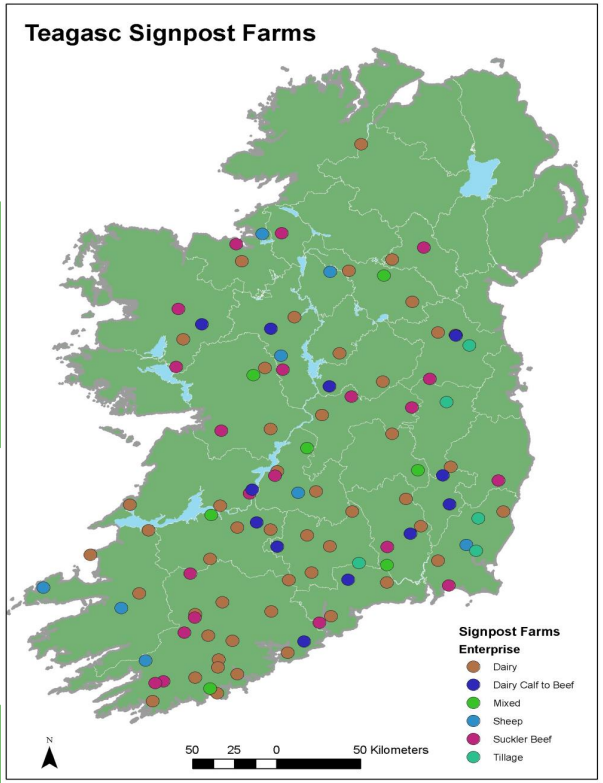
Some Signpost farms are part of NASCO (*National Agricultural Soil Carbon Observatory*) *Use a combined approach of Gas measurements and Soil C measurements*

Objectives

- Understand which scenario represent a sink or a source of carbon in Irish agriculture
- Monitoring long-term changes in soil carbon stocks in response to management, land-use, soil type and climate
- Refine the national inventory for carbon emissions from land-use and management (Tier 2 and 3)

Objectives of the Soil sampling Campaign:

- ❑ Provide information in terms of Nutrient status across Irish farms (Sampling Phase1)
- ❑ Quantify carbon stored in soil in depth (Sampling Phase 2)



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Site Selection

Clear effect of <u>Soil Type X Climate/Land use X Management</u>

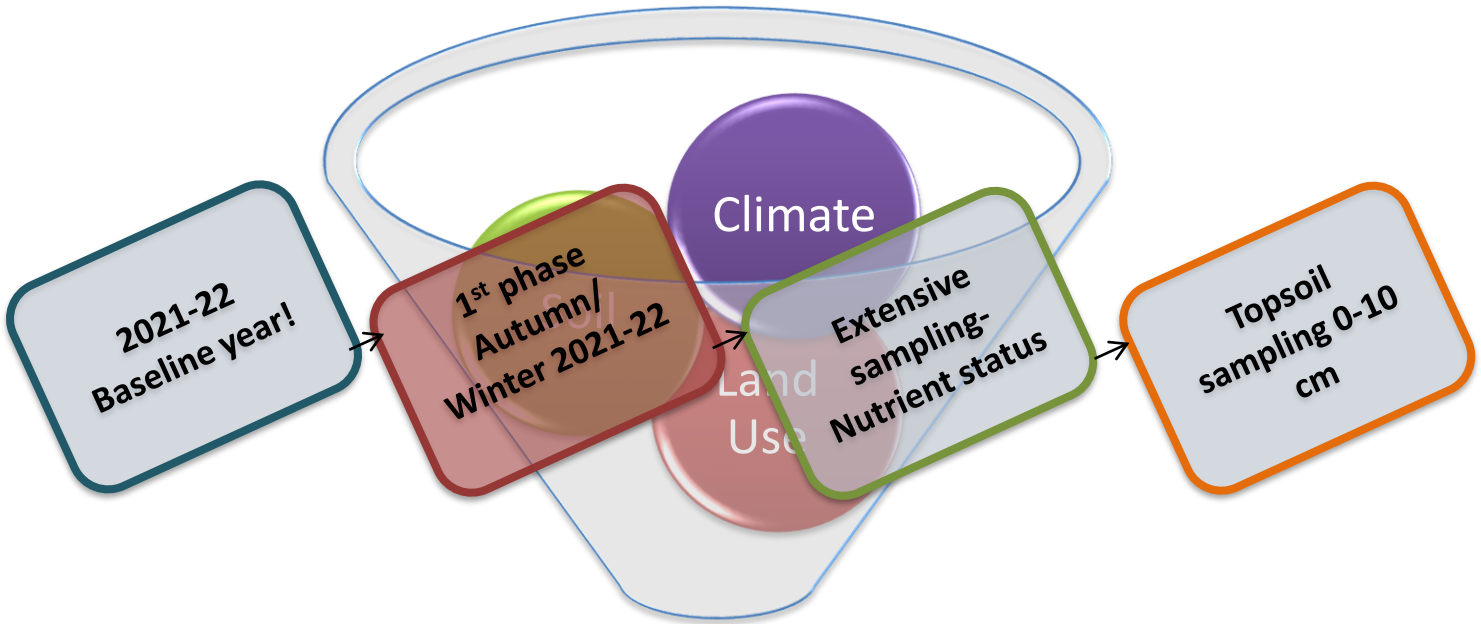
- *How the sites have been selected?*

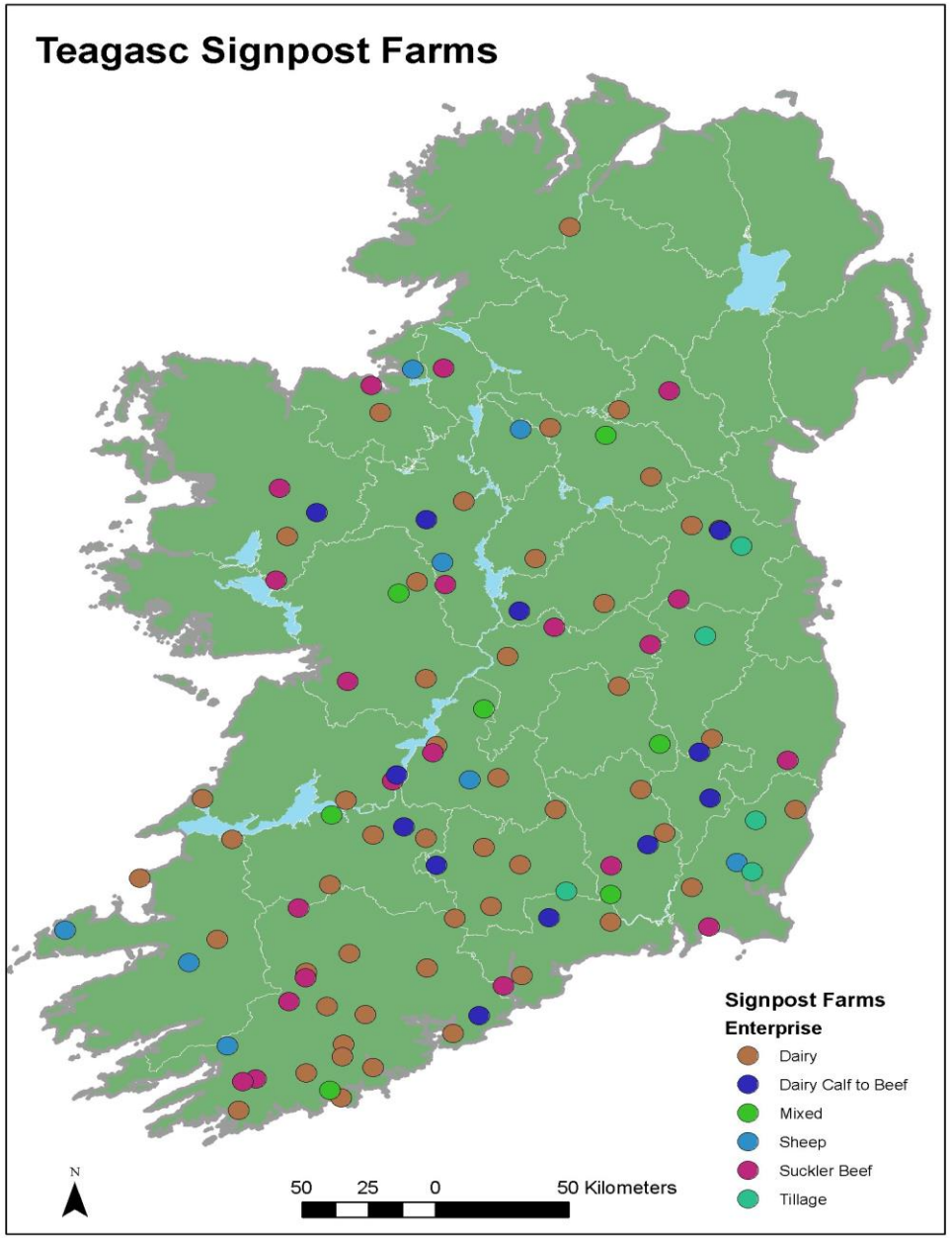
✓ **<u>Geographical spreading</u>**:
sites distributed in the five major agro-climatic regions of Ireland

✓ **<u>Land Use:</u>**
sites classified into different land uses

✓ **<u>Soil type:</u>**
sites classified according to the Irish Soil Information System

✓ **<u>Management:</u>**
In farm Management regimes

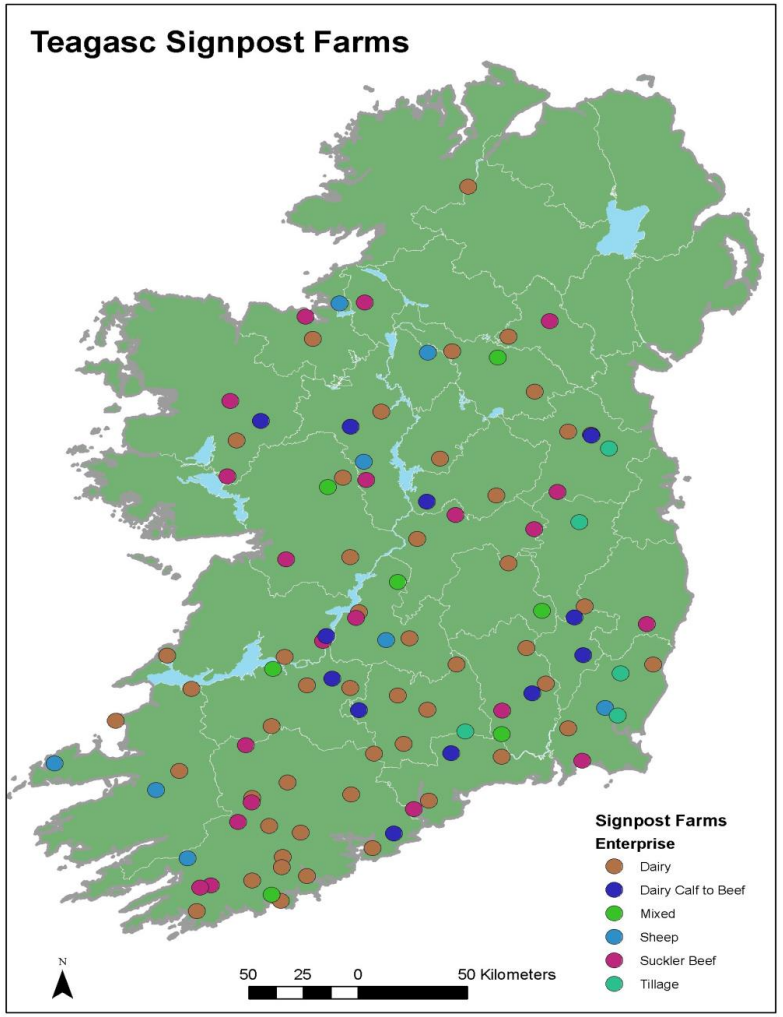




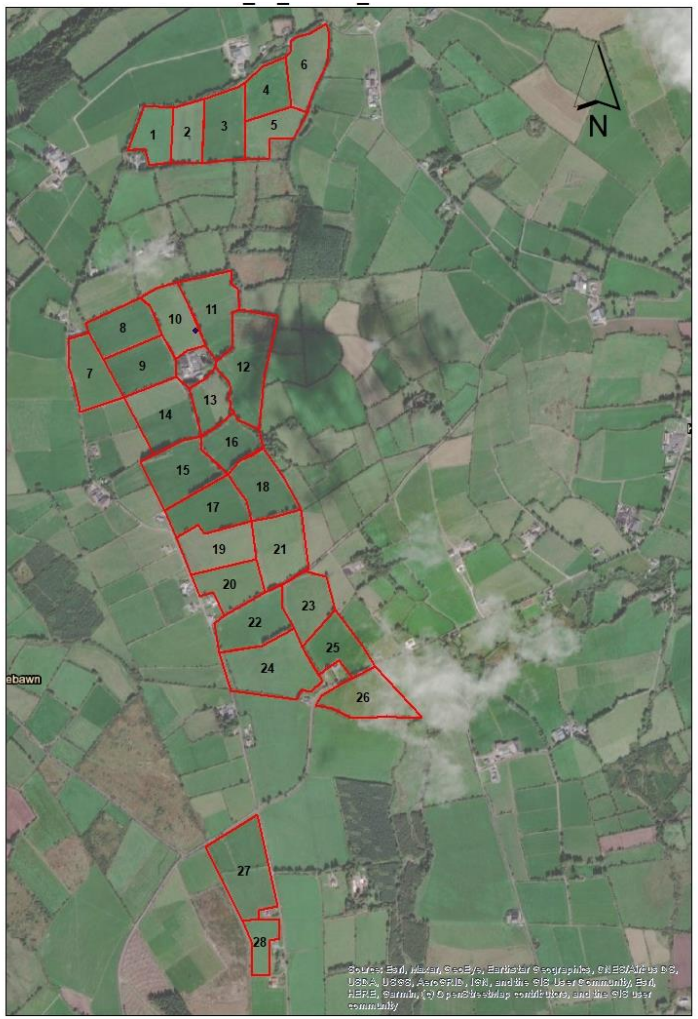
Soil Sampling – Assessing Nutrient status Phase 1

1 Climate (and Land Use) → sites geographically spread around the main agro-climatic regions. **Tillage, grasslands, mixed systems**

Selected farms



Updated farm maps



103 farms

Extensive agronomic soil sampling!

- **30 fields in each farm (field<5Ha)**

1. Beef →35 farms → 911 fields
2. Sheep →7 farms → 176 fields
3. Dairy→49 farms → 1410 fields

4. Tillage→6 farms → 176 fields
5. Mixed→6 farms → 403 fields

Total: 3076

Soil Sampling – Assessing Nutrient status Phase 1

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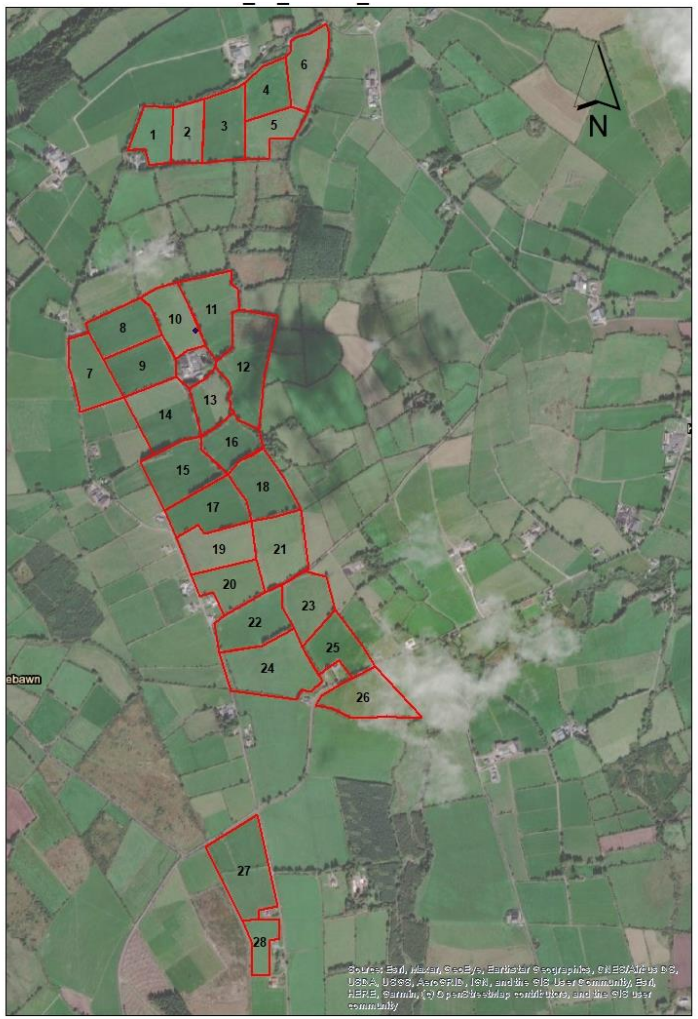
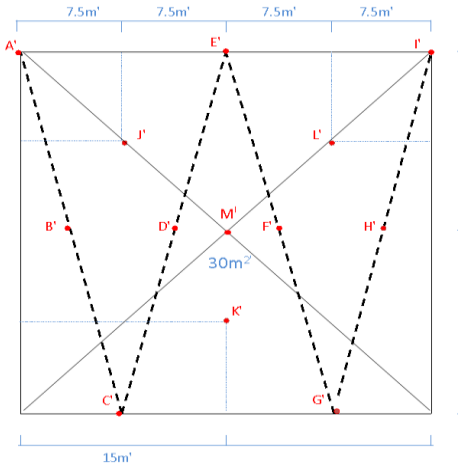


Topsoil Sampling:
Composite sample for each chosen sampling unit



physico-chemical characteristics
pH, LR, Mehlich 3, SOC, TC, TN, P and K. Spectroscopy

Soil analysis and archive:
All results and updated maps are back to advisors/farmers

Preliminary Results– Soil fertility

Soil Fertility Report https://www.teagasc.ie/media/website/environment/climate-change/signpost-programme/Teagasc-Signpost-Programme-Soil-Fertility-Report-2021.pdf

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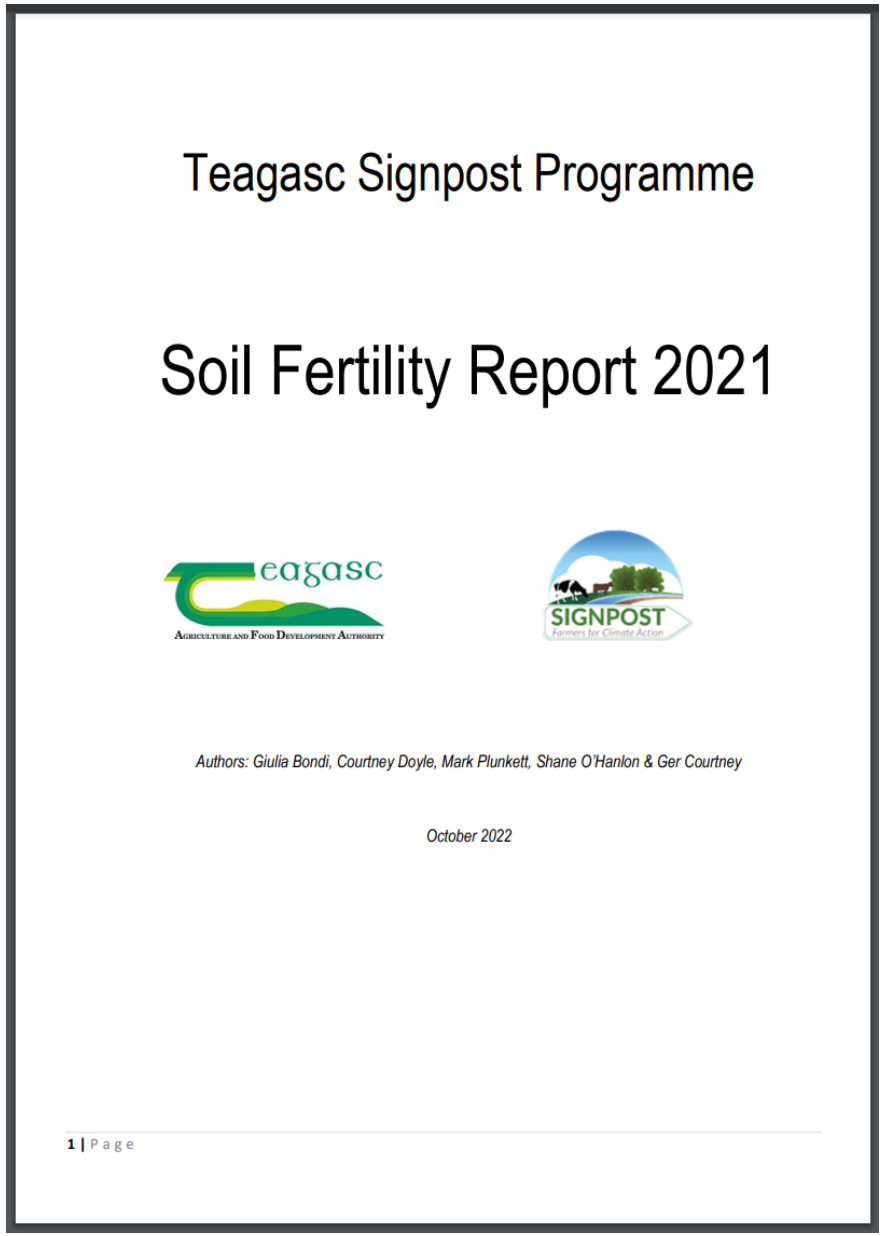


Teagasc Signpost Programme

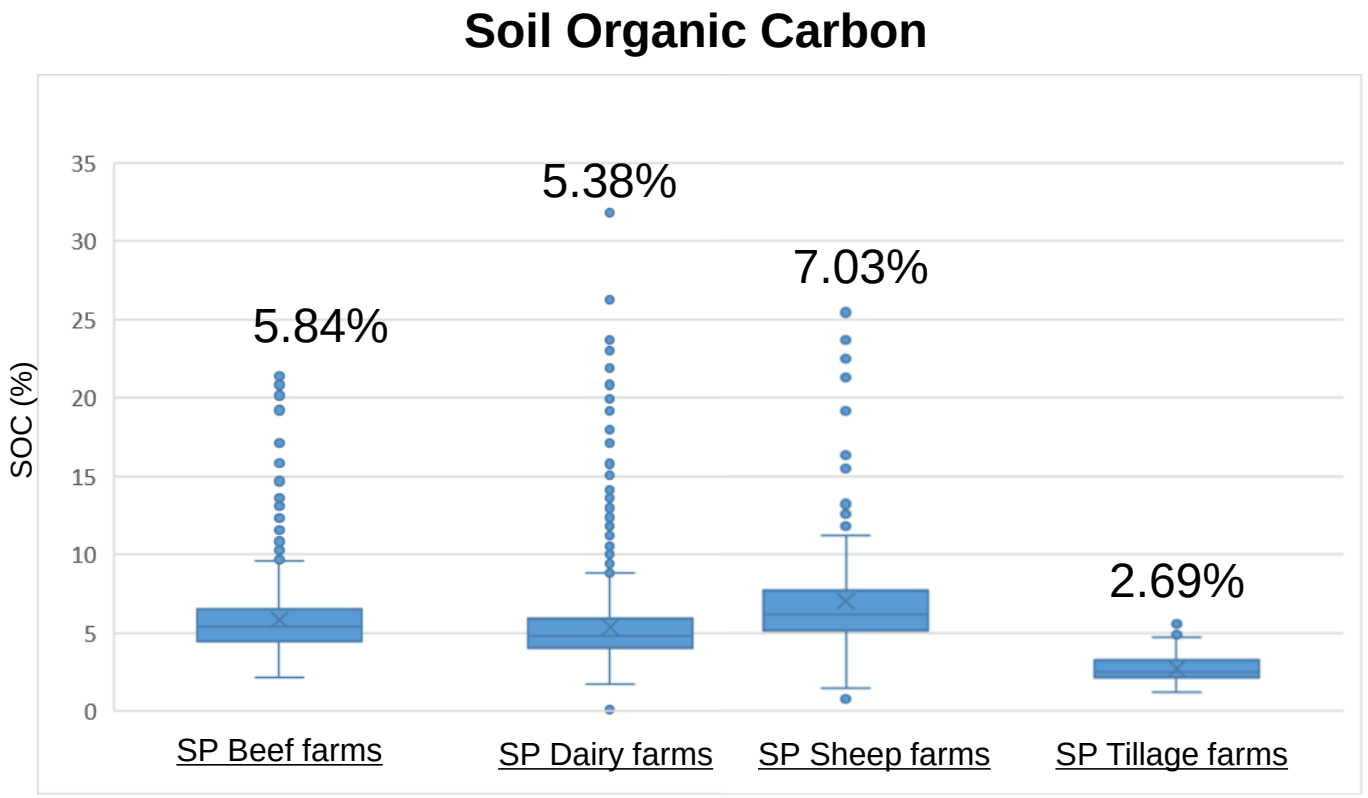
Soil Fertility Report 2021

Authors: Giulia Bondi, Courtney Doyle, Mark Plunkett, Shane O'Hanlon & Ger Courtney

October 2022

1 | Page

Preliminary Results– Soil fertility

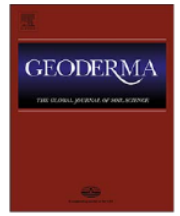


Preliminary Results– All farms

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma



Optimal organic carbon values for soil structure quality of arable soils. Does clay content matter?

Alice Johannes[a,b,*], Adrien Matter[a], Rainer Schulin[b], Peter Weisskopf[c], Philippe C. Baveye[d], Pascal Boivin[a]

SOC : Clay

index of soil quality gives us an understanding of the C that is bounded into minerals, specifically finer minerals such as Clay

>1/8 v. good
1/8 good

Optimum for soil quality

1/10 moderate

Reasonable - goal for farmers

1/13 degraded

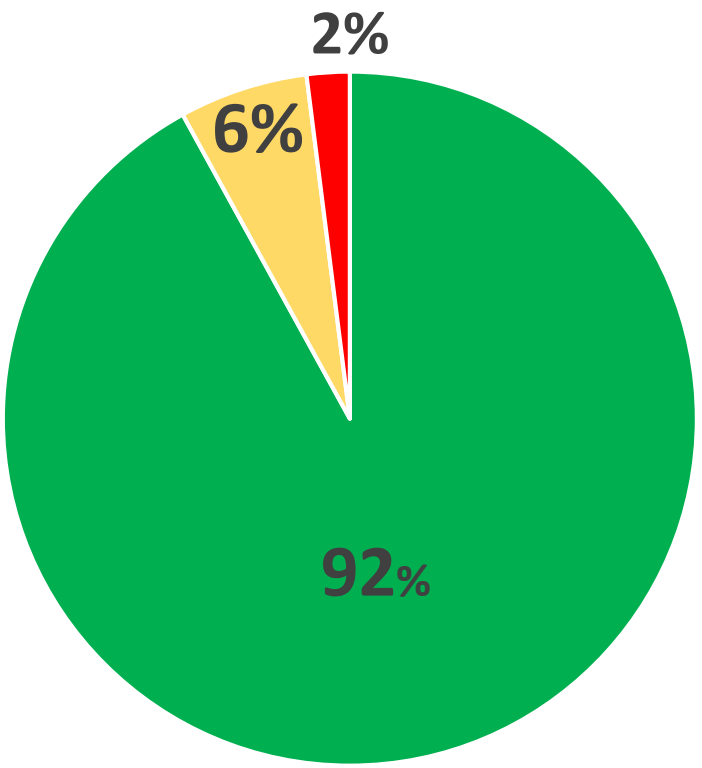
Low soil quality- In need of improvement

Preliminary Results– All farms

SOC : Clay

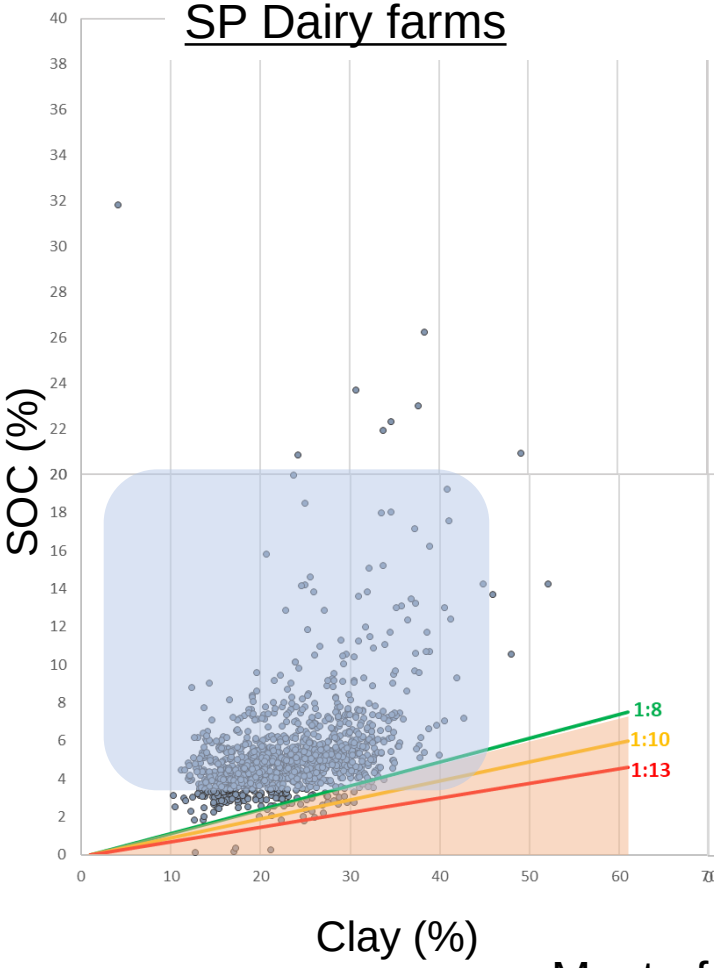
is an overall index of soil quality gives us an understanding of the C that is bounded into minerals, specifically finer minerals such as Clay

High Quality	Moderate	Poor
1927/2080	135/2080	18/2080



Preliminary Results– SOC:Clay by Systems

>1/8 v. good 1/8 good 1/10 moderate 1/13 degraded



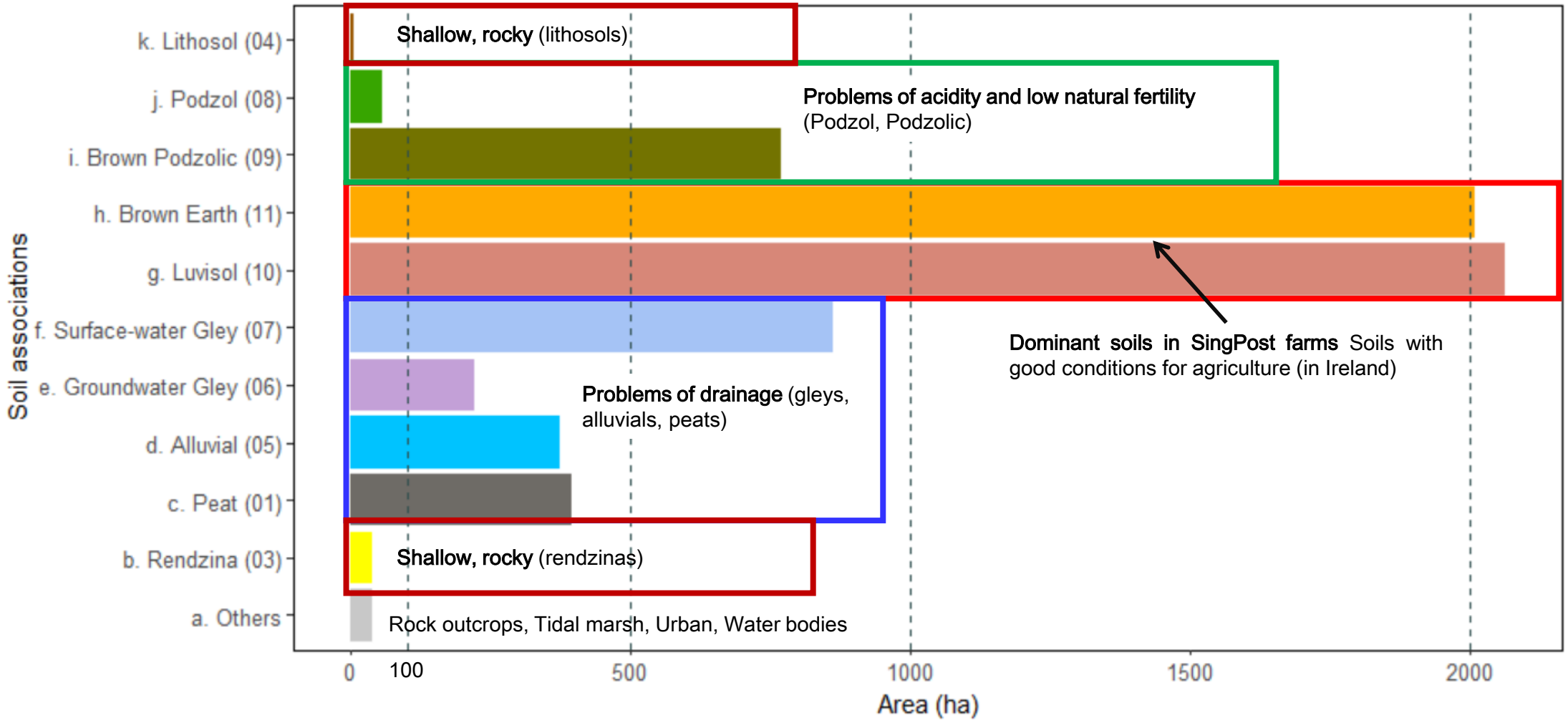
Most of the moderate and poor are associated to tillage activities.

- moderate 55%
- poor 39%

Preliminary Results– All farms

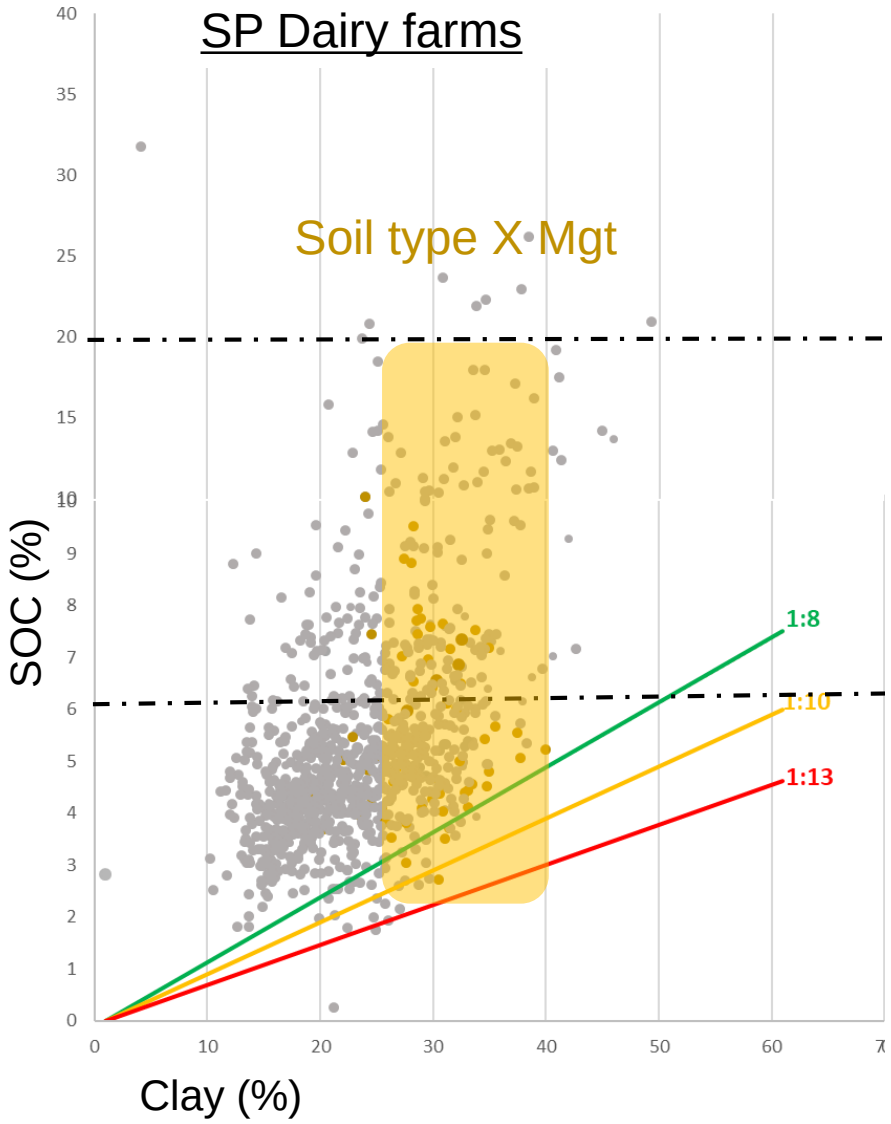
Step 2 **2 Soil Type**→Identification of main soil types using mapping resources or/and technical knowledge.

SOILS WITHIN THE SIGNPOST FARMS AND THEIR NATURAL LIMITATIONS FOR AGRICULTURE



Preliminary Results– SOC:Clay by Soil

>1/8 v. good 1/8 good 1/10 moderate 1/13 degraded



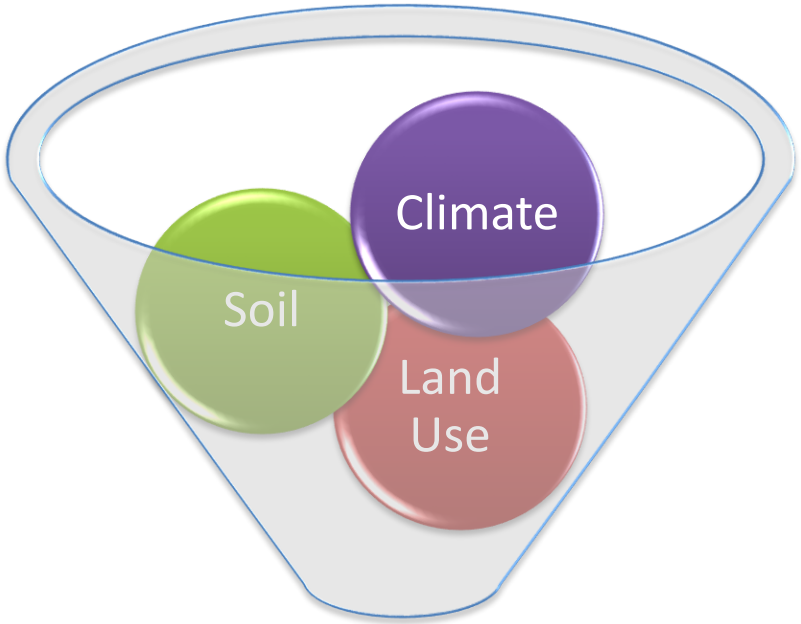
Climate

Land Use

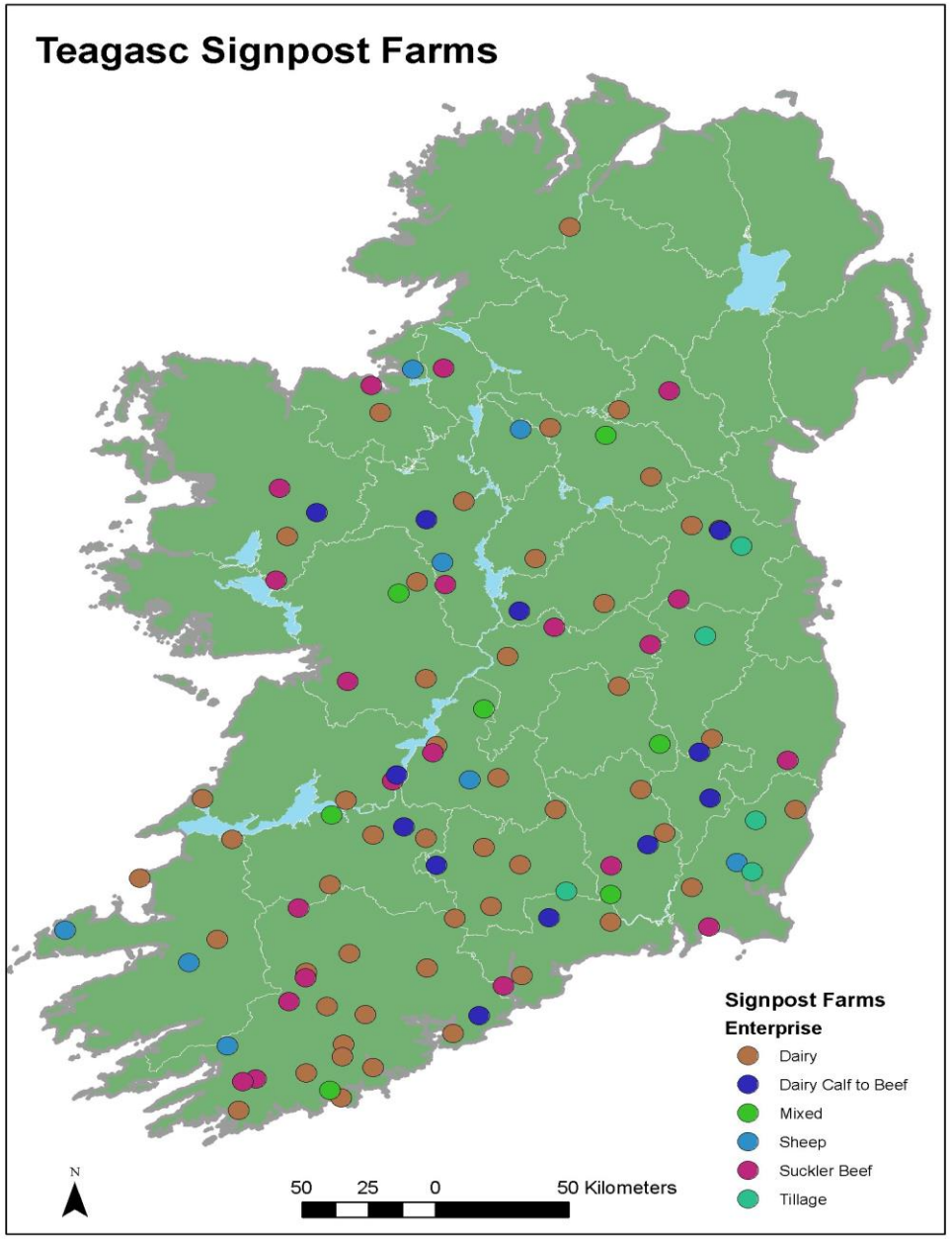
Site Selection

- ❑ **Provide information in terms of Nutrient status across Irish farms**
- ❑ **Quantify carbon stored in soil in depth- soil specifc seq factors**

Clear effect of <u>Soil Type X Climate/Land use X Management</u>



2021-22 Baseline year! → 2st phase Summer 2023 STARTED! → Target sampling- Carbon stocks → Deep sampling≈1m



Soil Sampling – Site targeting for Deep Soil Sampling

In farm site targeting

1. BASELINE NUTRIENT CONTENT
2. SOIL TYPE: Identification of extremes **gleysols and cambisols**
3. MGT: Identification of extremes **mgt regimes**

Deep sampling for C stocks
from ~30 fields to 4 target fields

Phase 2:
34 farms over 10 counties

1. Beef →9 farms → 36 fields
1. Sheep →1 farms → 4 fields
2. Dairy→13 farms → 52 fields

3. Tillage→10 farms → 40 fields
4. Mixed→1 farms → 4 fields

Work on adding more sites especially **Tillage sites**!

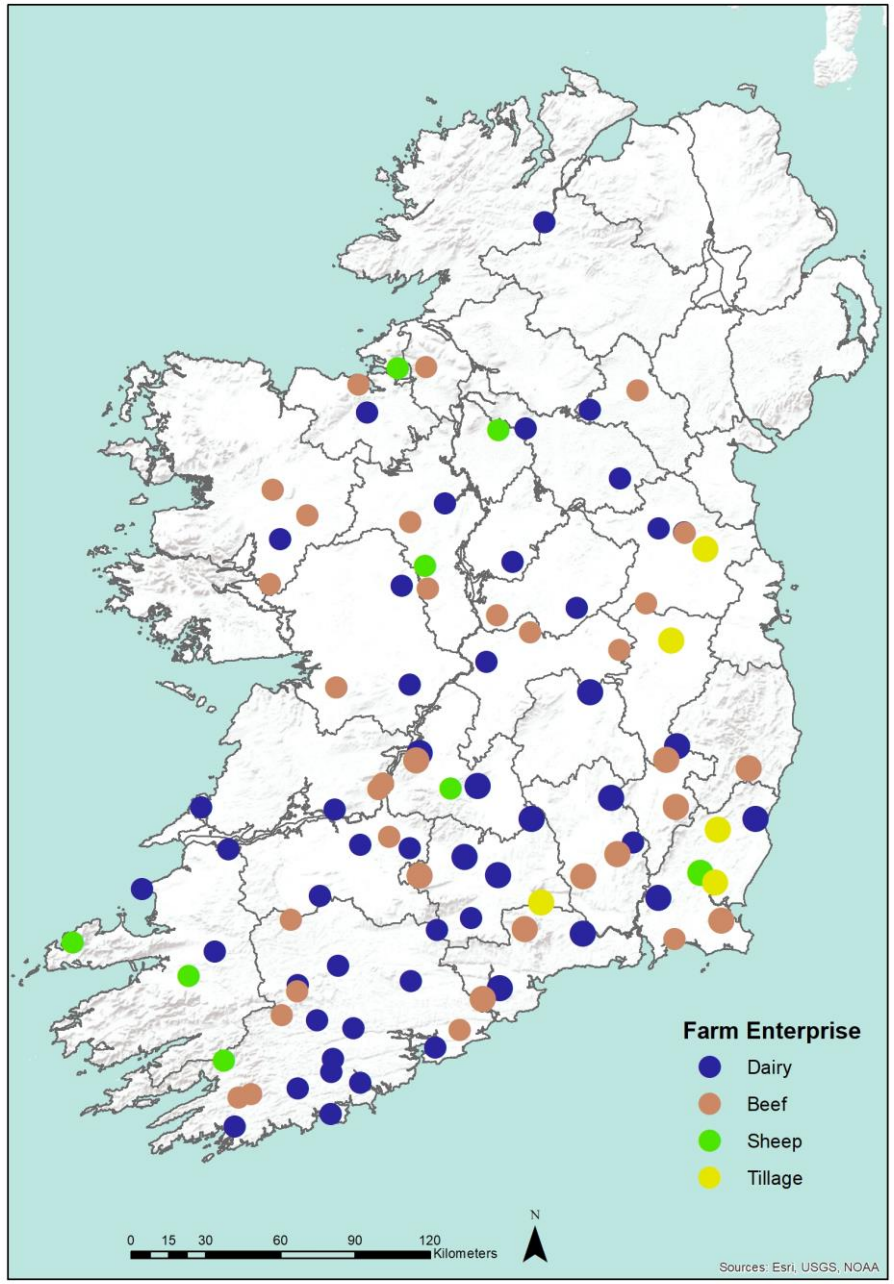
Soil Sampling – Site targeting for Deep Soil Sampling

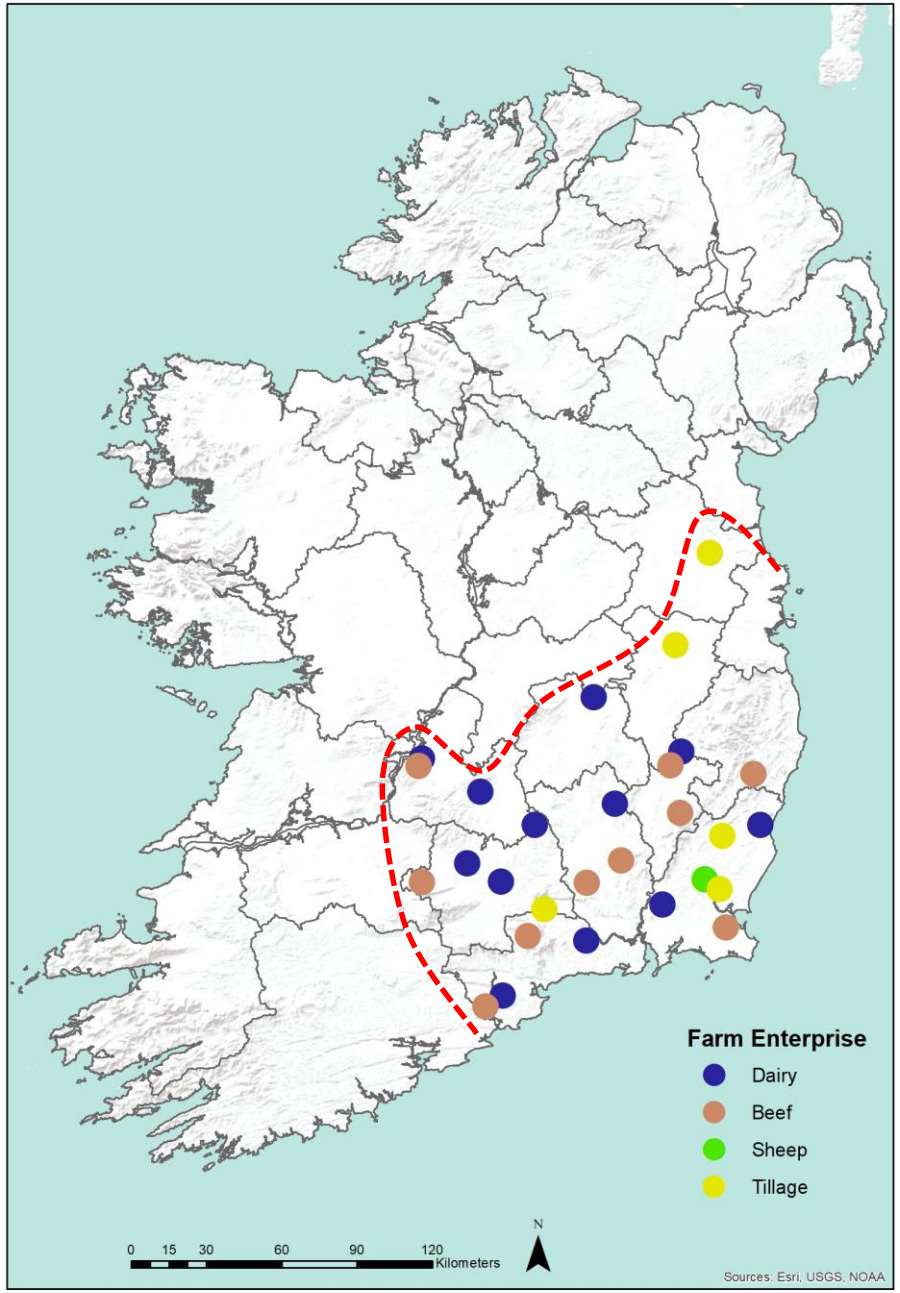
All:

Wexford, Wicklow, Waterford, Carlow, Laois, all Kildare.

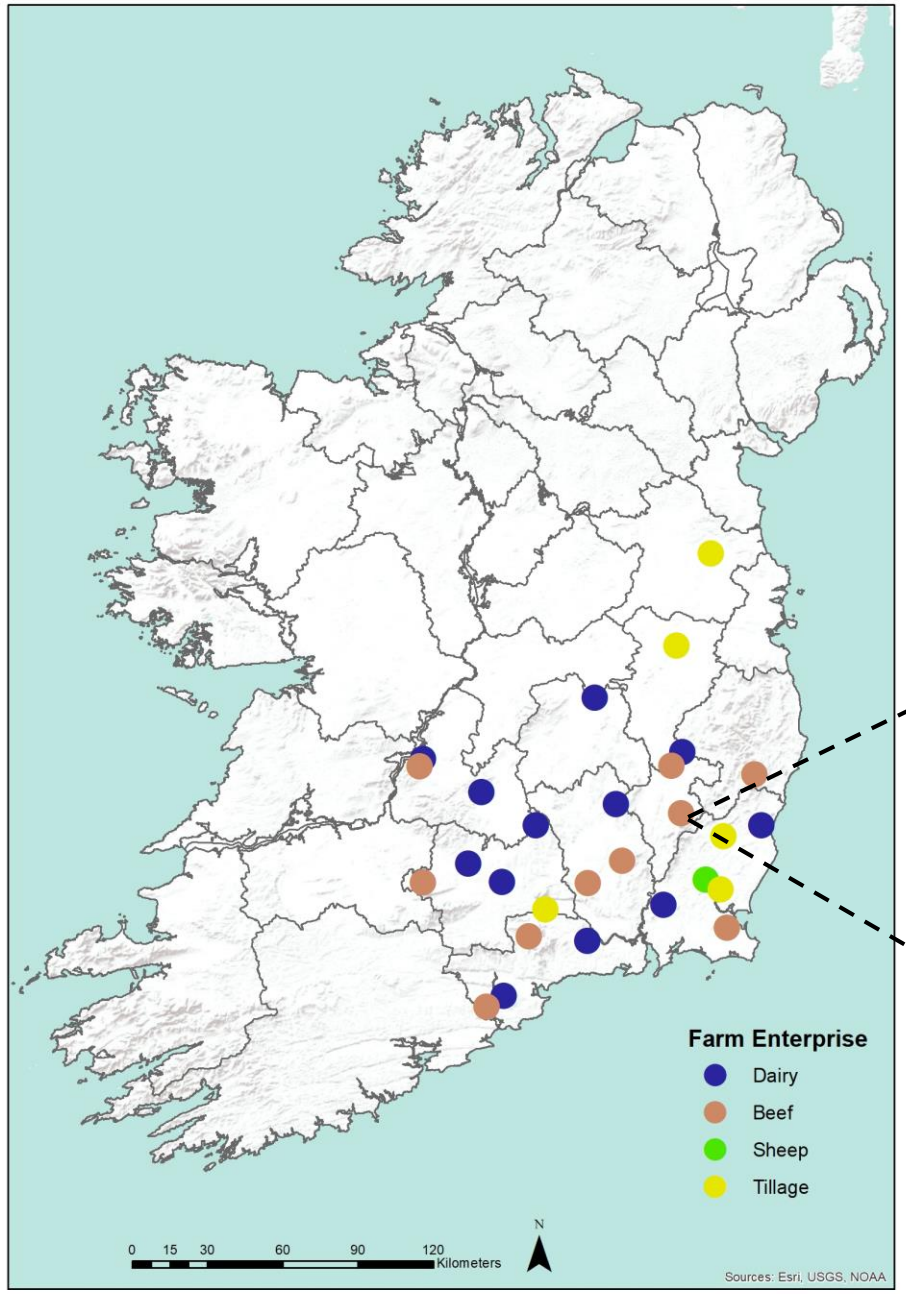
Part:

Tipperary, Kilkenny, Offaly and Meath



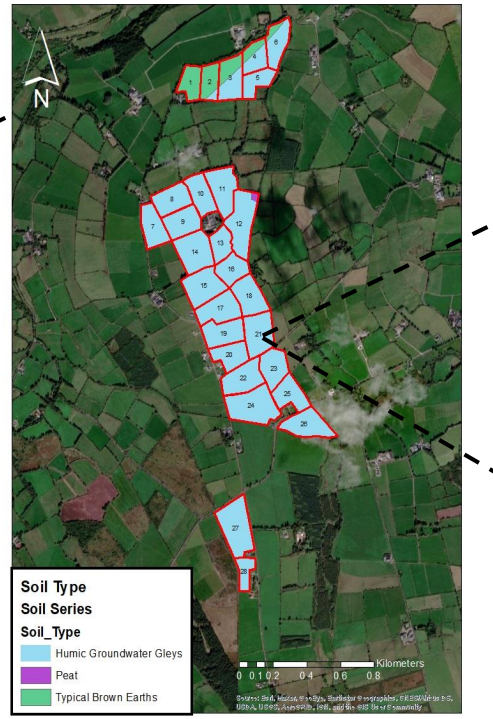


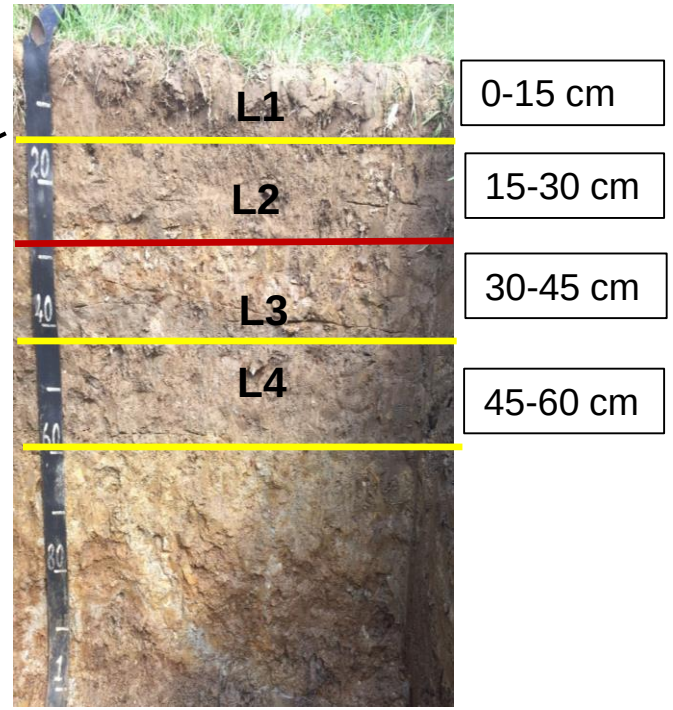
Soil Sampling – Site targeting for Deep Soil Sampling



34 farms over 10 counties → 4 fields for farm → 1 profile pit for field → 136 profile pits

4 depths for pit → 544 samples

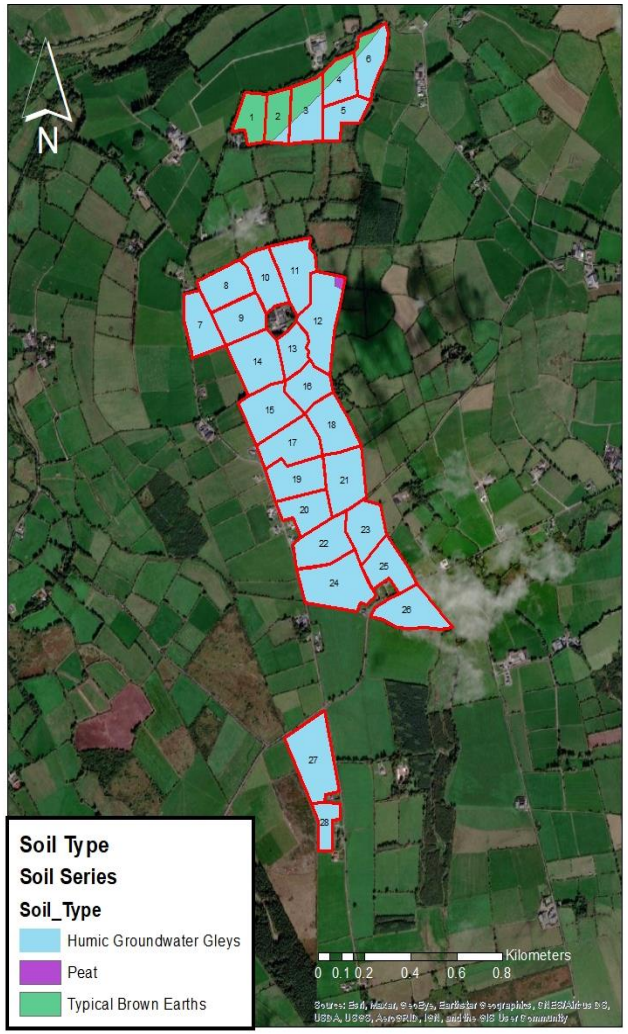


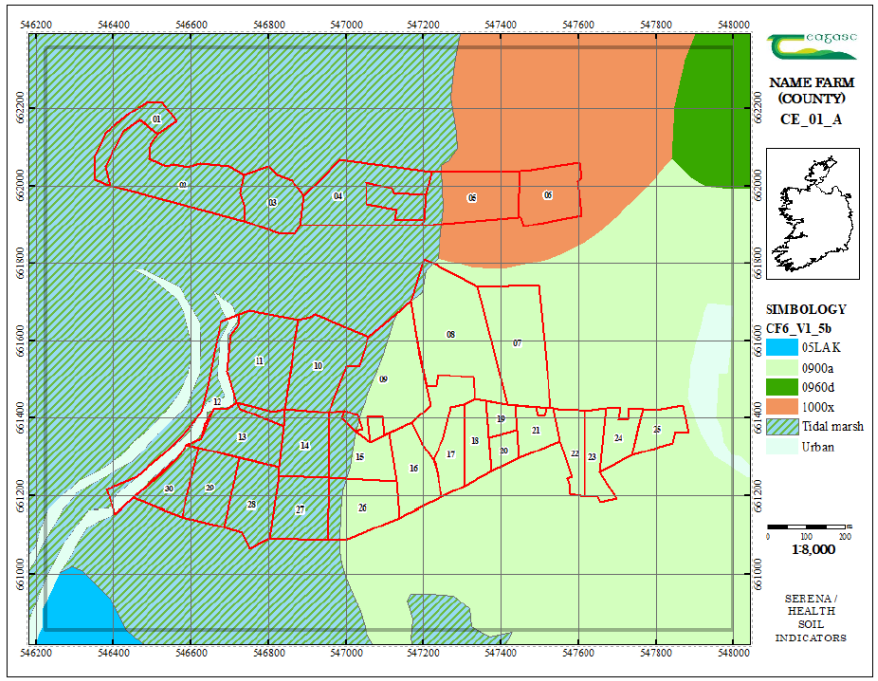


Soil Sampling – Site targeting for Deep Soil Sampling

Step 2 **2 Soil Type**→Identification of main soil types using mapping resources or/and technical knowledge.

Soil maps



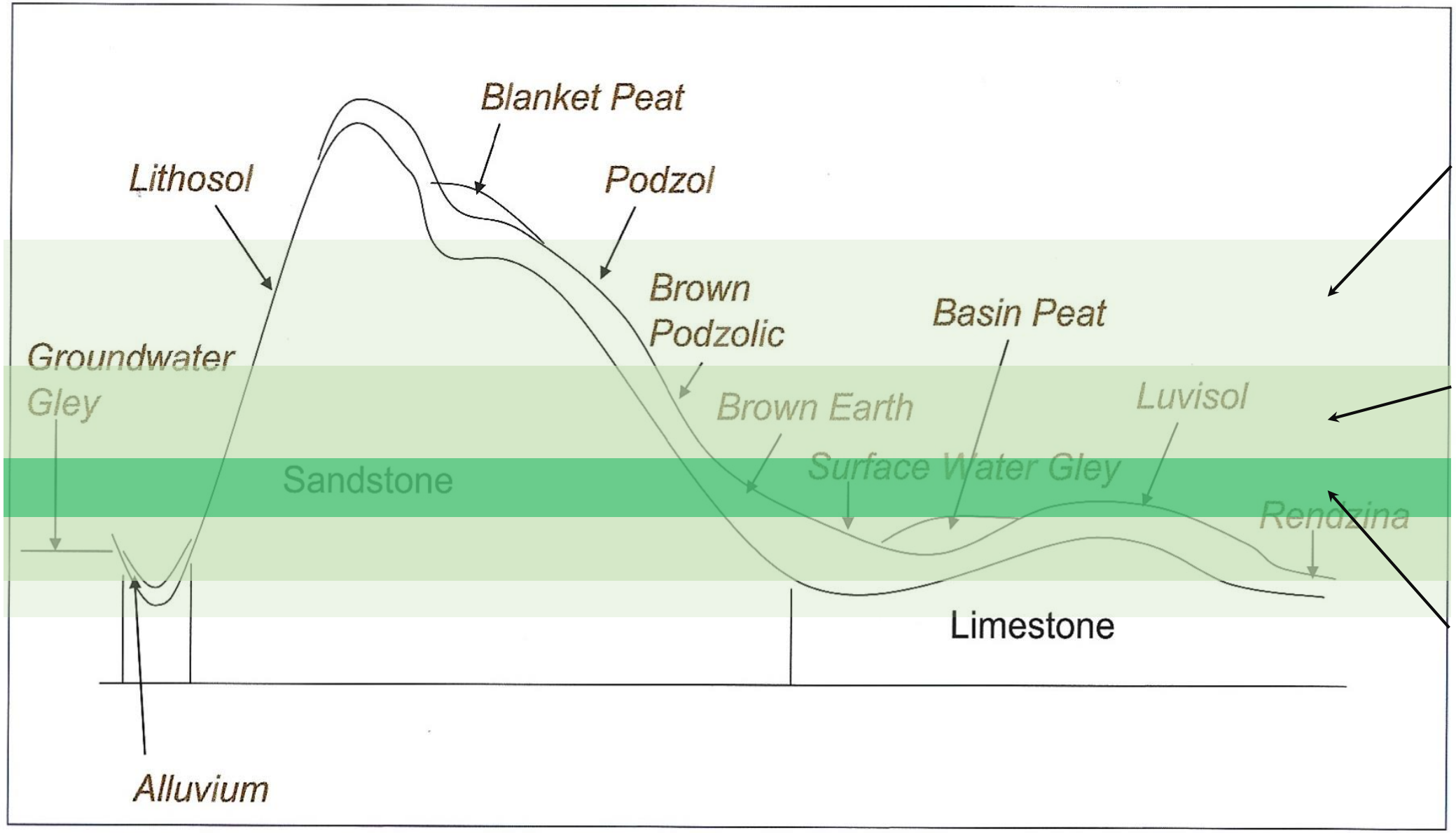


Extraction of environmental attributes TO OPTIMISE SOIL MAP AT FIELD LEVEL!

- Digital elevation model (DEM) (www.usgs.gov)
- Landsat-8 operational land imager (OLI) (www.usgs.gov)
- Geology map (www.gsi.ie)
- Soil map (www.epa.ie)
- Pip map (www.catchments.ie)
- Slope map

Terrain attributes, i.e. elevation, topographic wetness index (TWI), **slope-length (LSF**), aspect (Asp)), soil adjusted vegetation index (SAVI), ratio vegetation index (RVI) etc.

DISTRIBUTION OF SIGNPOST FARMS IN DIFFERENT SOILSCAPES POSITIONS



Soils in SignPost farms
Whole spectrum

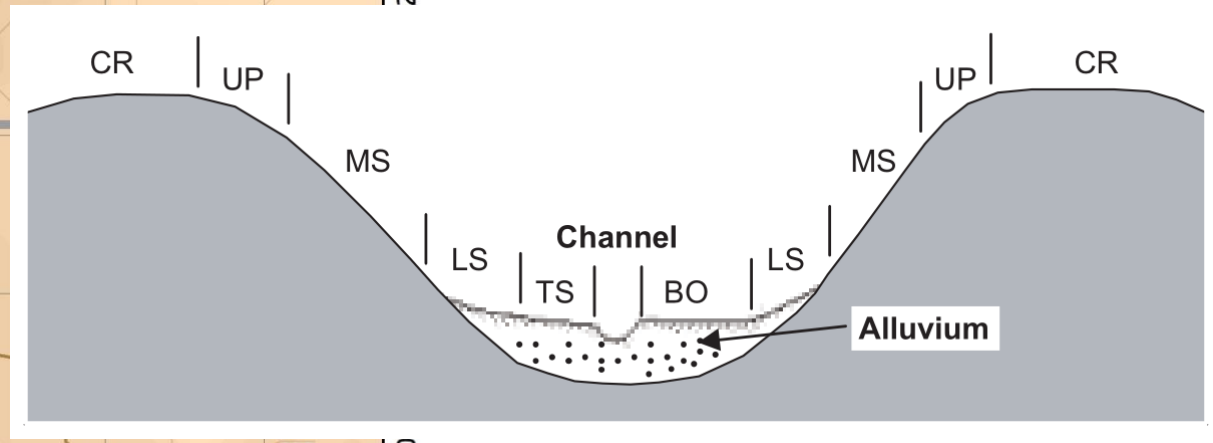
100-1000 ha
% of total area
From Brown Podzolic to Groundwater Gleys

>1000 ha
?% of total area
From Brown Earths to Luvisols

Catena Approach

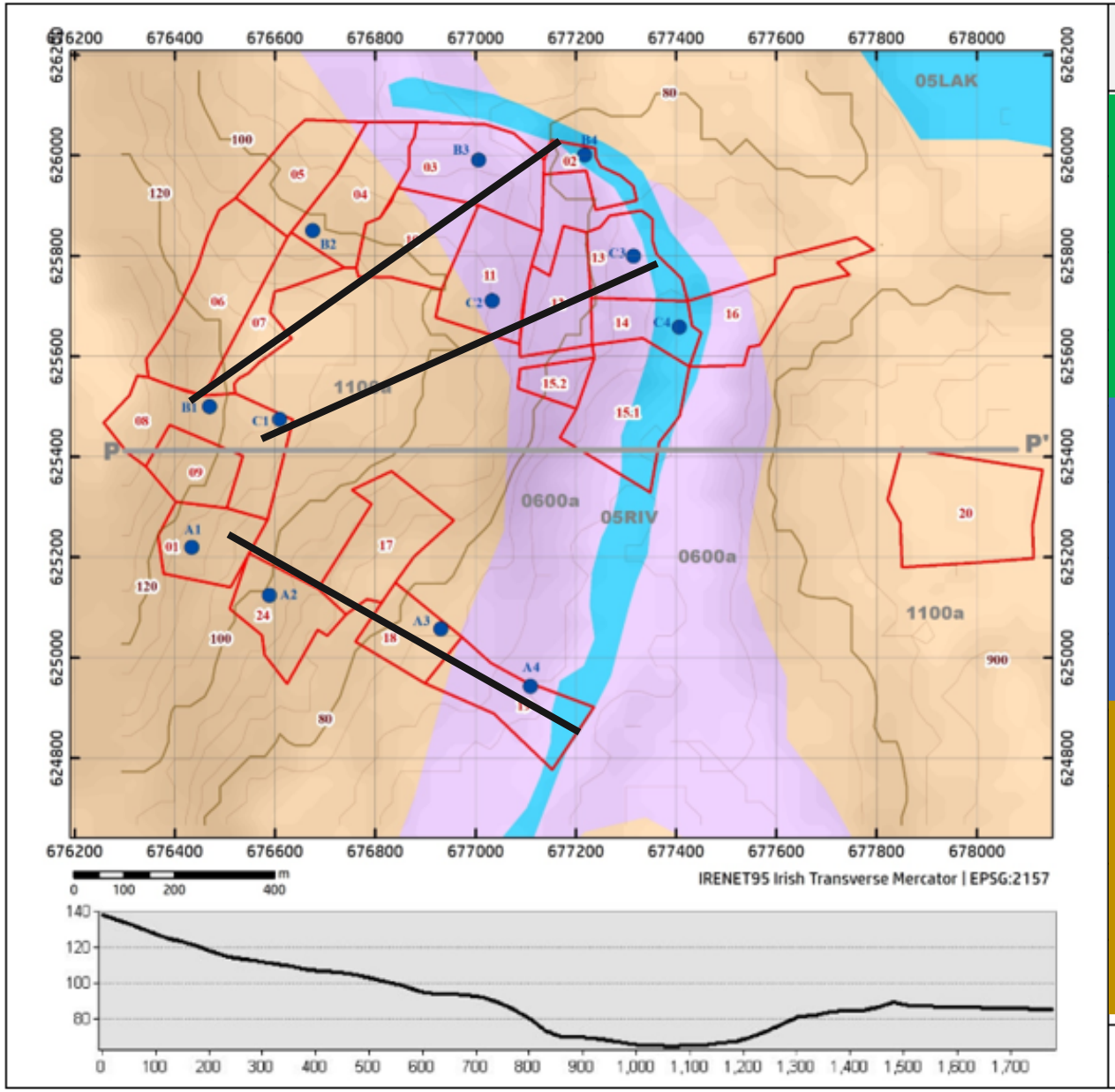
Seems to be an efficient way to distribute the pits, capturing:

- The variability of soils inside the farms
- The natural variability of the dominant soils as well



IRENET95 Irish Transverse Mercator | EPSG:2157

SOIL SAMPLES DISTRIBUTION



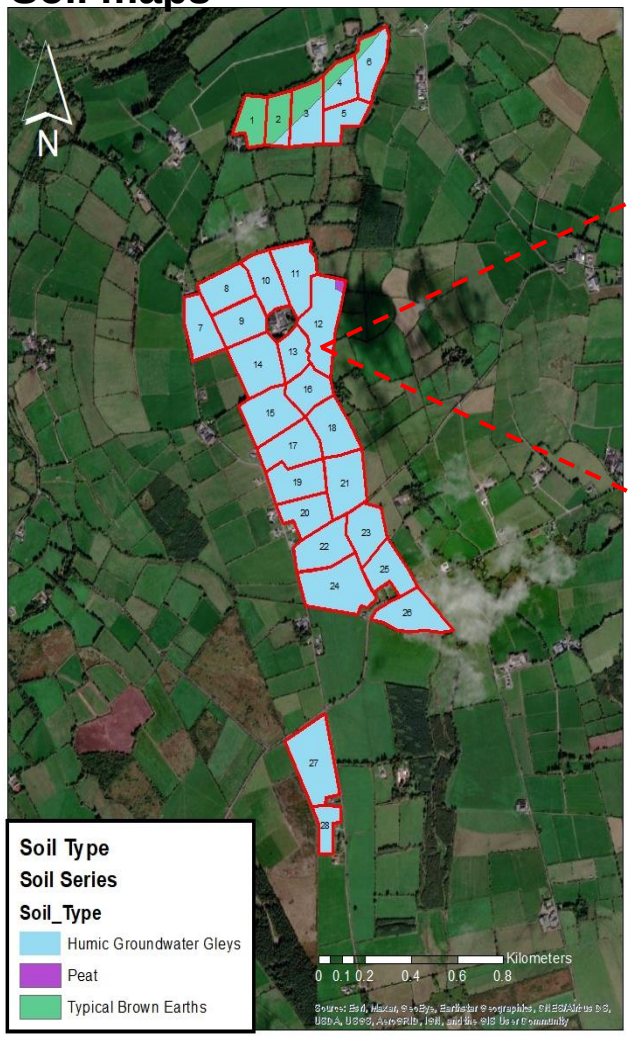
OBS ID	PLOT	COORD.	SLOPE POSITION	SLOPE (%)	SOIL ASSOC.	LAND MANAGEMENT	INTEN-SITY
A1	01	X: 676435 Y: 625220	Upper slope 113 masl	9	1100 Typical Brown Earth	Permanent Grassland	Low
A2	24	X: 676589 Y: 625124	Middle slope 98 masl	5	1100 Typical Brown Earth	Improved Grassland	Mod
A3	18	X: 676931 Y: 625057	Lower slope 74 masl	2	1100 Typical Brown Earth	Tillage	Hgh
A4	19	X: 677110 Y: 624943	Toe slope 63 masl	8	0600 Typical Groundwater Gleys	Tillage	Hgh
B1	08	X: 676470 Y: 625500	Upper slope 119 masl	17	1100 Typical Brown Earth	Permanent Grassland	Low
B2	04	X: 676675 Y: 625850	Middle slope 105 masl	6	0600 Typical Groundwater Gleys	Improved Grassland	Mod
B3	03	X: 677006 Y: 625991	Lower slope 92 masl	6	0600 Typical Groundwater Gleys	Tillage	Hgh
B4	02	X: 677218 Y: 626001	Toe slope 80 masl	3	0500 Typical Alluvial Soils (River)	Tillage	Hgh
C1	08	X: 676610 Y: 625474	Upper slope 109 masl	8	1100 Typical Brown Earth	Permanent Grassland	Low
C2	11	X: 677034 Y: 625710	Middle slope 95 masl	14	1100 Typical Brown Earth	Improved Grassland	Mod
C3	13	X: 677315 Y: 625800	Lower slope 71 masl	3	0600 Typical Groundwater Gleys	Tillage	Hgh
C4	14	X: 677408 Y: 625658	Bottom 67 masl	1	0500 Typical Alluvial Soils (River)	Tillage	Hgh

Soil Sampling – Site targeting for Deep Soil Sampling

Step 3

3.Management→Within the main soil types for each farm different mgt practices can be identified.

Soil maps



Work on historical management data at farm and field level to develop a range of management practice regimes

MGT DATA COLLECTION FORM at field level! Collected 67/103 farms at field scale

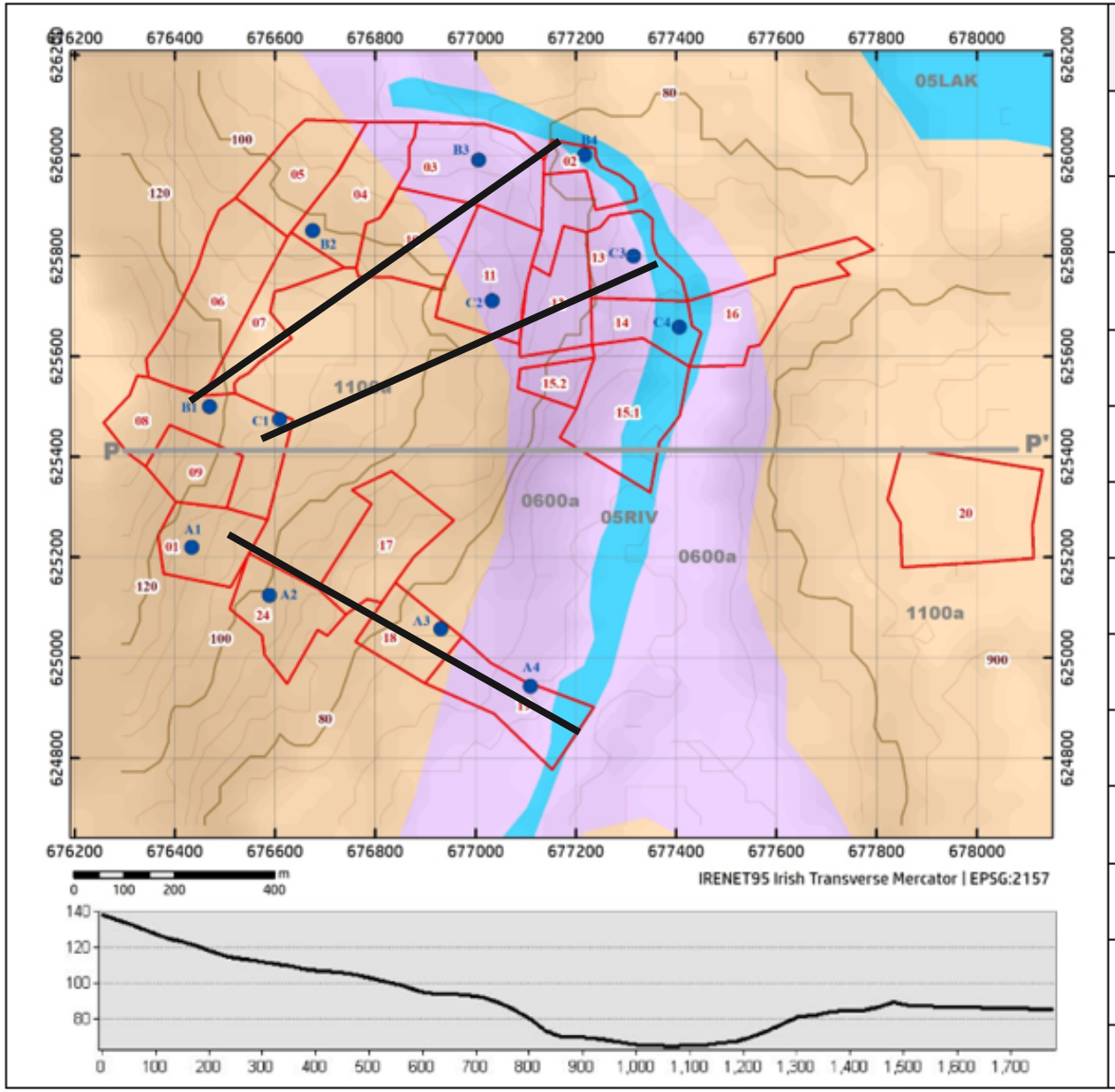
Farmer Name	Address/ Location/ County	Field/Soil Sample Area No.	Farm Level : Main farming system Classification	Farm level: Whole Farm Org N loading (kg ON/ha)	Farm Level: Grassland Org N loading (kg ON/ha)	Field level: Land Use	Field Level: Soil drainage (soil type) *(best estimate)*	Field level: Crop/Use *(year of sampling)*	Field level: Grazing Livestock type	Field level: Grazing Stocking rate (kg ON/ha) *(av. Annual)*	Field level: Soil tillage method Reseeding / crop planting	Field level: Annual N rate (kg/ha/yr)	Field level: Organic manure application
Joe Bloggs	Carlow	1001	Dairy	≤ 100	≤ 100	Grassland (permanent)	Mineral- Wet (poorly drained)	Grass: Grazing only	None	0	None	0	Yes
John Doe	Cork	1002	Beef	101-130	101-130	Grassland (improved)	Mineral - Moderately drained	Grass: 1 Cut + Grazing	Dairy	≤ 100	Plough based	≤ 50	No
....	Claire	1003	Sheep	131-150	131-150	Arable	Mineral - Dry (well drained)	Grass: 2 Cut + Grazing	Beef	101-130	Minimum Tillage (~5 cm)	51-75	
	Donegal	1004	Tillage	151-170	151-170	Other	Mineral-Organic Soil	Grass: Silage only (1 cut)	Sheep	131-150	Direct Drill/No Till	76-100	
	Dublin	1005	Dairy & Beef	171-190	171-190		Peat Soil (≥40cm organic layer)	Grass: Silage only (2 cut)	Dairy & Beef	151-170		101-125	
	....	1006	Beef & Sheep	191-210	191-210			Grass: Silage only (3 cut)	Beef & Sheep	171-190		126-150	
		1007	Dairy & Tillage	211-230	211-230			Grass: Zero grazing	Dairy, Beef, Sheep	191-210		151-175	
		1008	Beef & Tillage	231-205	231-250			Winter Wheat (Feed)		211-230		176-200	
		1009	Sheep & Tillage	>250	>250			Winter Wheat (Milling)		231-205		201-225	
		1010	Dairy, Beef, Sheep					Spring Wheat (Feed)		>250		226-250	
		1011	Dairy, Beef & Tillage					Spring Wheat (Milling)				251-275	
		1012	Beef, Sheep & Tillage					Winter Barley				276-300	
		....						Spring Barley				> 300	
								Winter Oats					
								Spring Oats					
								Beet					
								Potatoes (Maincrop)					
								Potatoes (Early)					
								Potatoes (Seed)					
								Maize					
								Field Peas					
								Field Beans					
								Oilseed Rape					
								Linseed					
								Swedes/Turnips					
								Kale					
								Forage Rape					
								Setaside					
								Grazing (2/3 Fert)					
								Grazing (1/3 Fert)					
								Grazing (No Fert)					
								Non-Fertilised Area					
								Non-Fertilised Area - Organic					
								Non-Fertilised Area - Chemical					
								Lucerne					
								Vacant/Unlet					

Farm level information

Basic field level information

- Land use/Crop use
- Soil drainage status
- Stocking rate
- Annual N rate
- ..

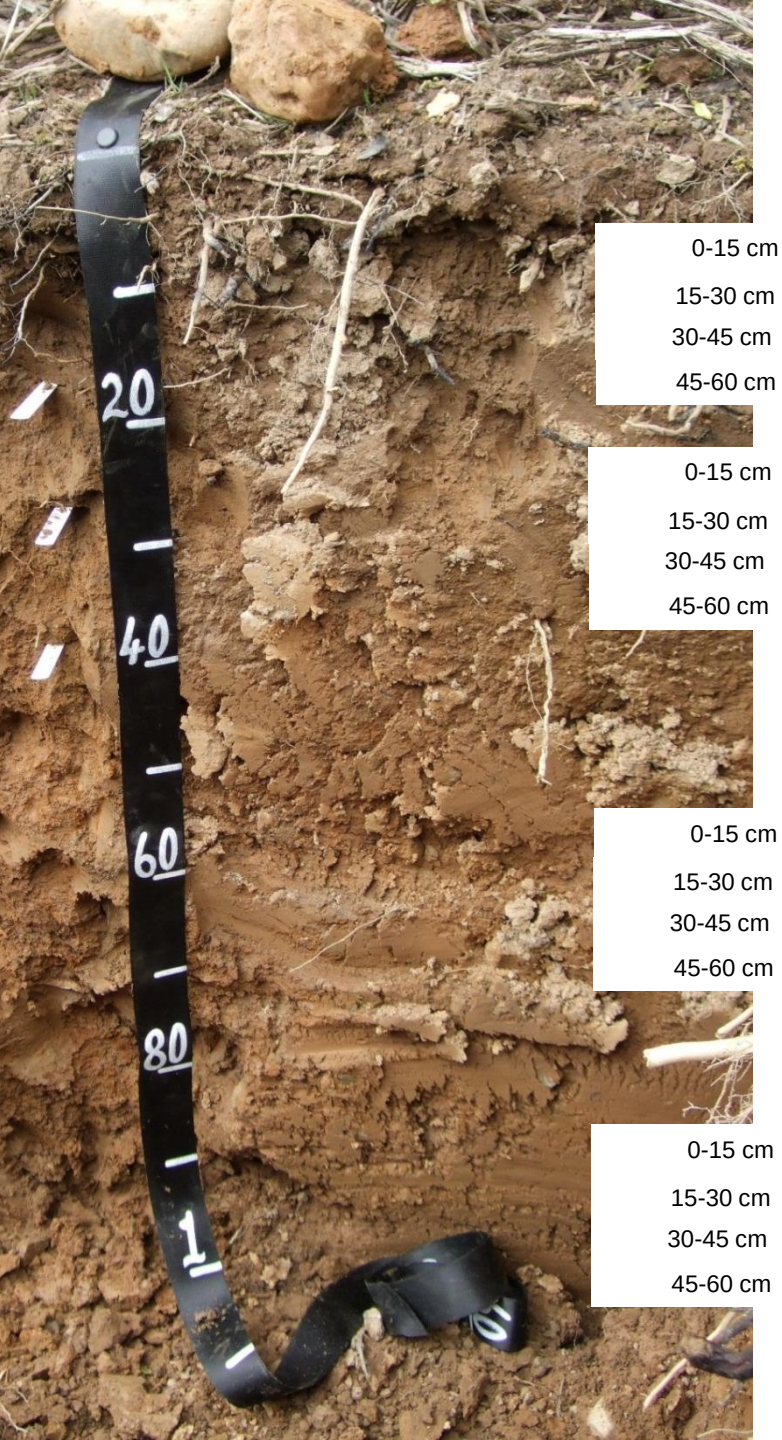
SOIL SAMPLES DISTRIBUTION



OBS ID	PLOT	COORD.	SLOPE POSITION	SLOPE (%)	SOIL ASSOC.	LAND MANAGEMENT	INTEN-SITY
A1	01	X: 676435 Y: 625220	Upper slope 113 masl	9	1100 Typical Brown Earth	Permanent Grassland	Low
A2	24	X: 676589 Y: 625124	Middle slope 98 masl	5	1100 Typical Brown Earth	Improved Grassland	Mod
A3	18	X: 676931 Y: 625057	Lower slope 74 masl	2	1100 Typical Brown Earth	Tillage	Hgh
A4	19	X: 677110 Y: 624943	Toe slope 63 masl	8	0600 Typical Groundwater Gleys	Tillage	Hgh
B1	08	X: 676470 Y: 625500	Upper slope 119 masl	17	1100 Typical Brown Earth	Permanent Grassland	Low
B2	04	X: 676675 Y: 625850	Middle slope 105 masl	6	0600 Typical Groundwater Gleys	Improved Grassland	Mod
B3	03	X: 677006 Y: 625991	Lower slope 92 masl	6	0600 Typical Groundwater Gleys	Tillage	Hgh
B4	02	X: 677218 Y: 626001	Toe slope 80 masl	3	0500 Typical Alluvial Soils (River)	Tillage	Hgh
C1	08	X: 676610 Y: 625474	Upper slope 109 masl	8	1100 Typical Brown Earth	Permanent Grassland	Low
C2	11	X: 677034 Y: 625710	Middle slope 95 masl	14	1100 Typical Brown Earth	Improved Grassland	Mod
C3	13	X: 677315 Y: 625800	Lower slope 71 masl	3	0600 Typical Groundwater Gleys	Tillage	Hgh
C4	14	X: 677408 Y: 625658	Bottom 67 masl	1	0500 Typical Alluvial Soils (River)	Tillage	Hgh

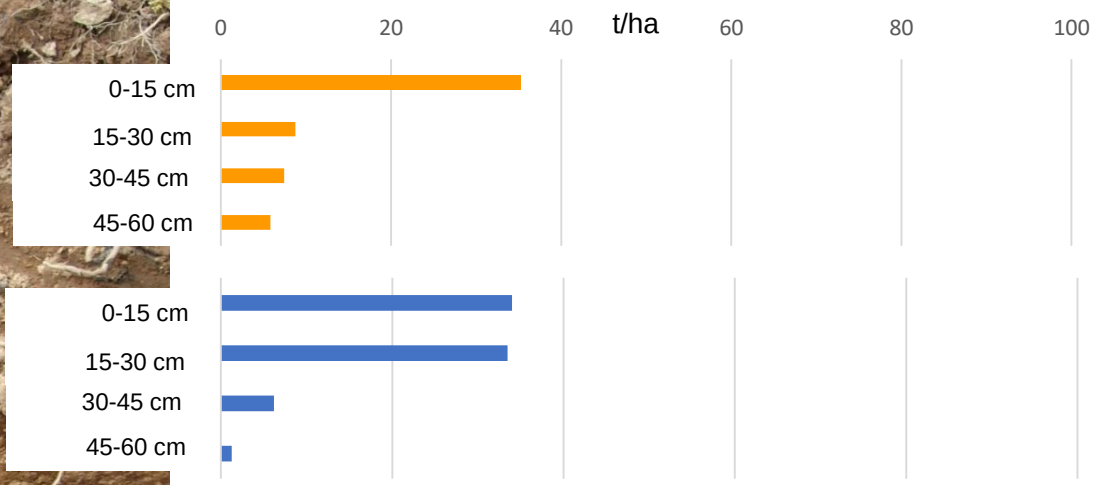
Preliminary Results

High Quality	Moderate	Poor
1927/2080	135/2080	18/2080
92%	6%	>2%

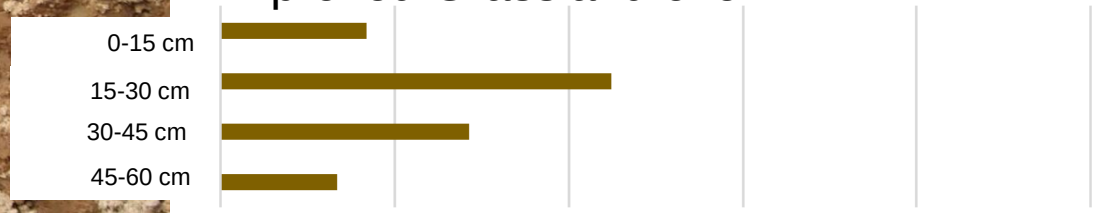


Preliminary Results

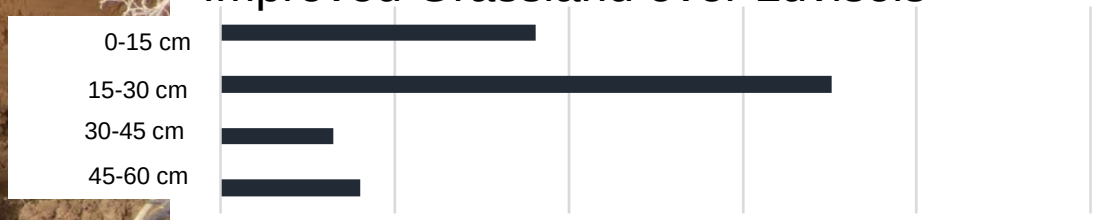
Permanent Grassland



Improved Grassland over BE



Improved Grassland over Luvisols



Take Home Messages

- Overall the levels of C are high and the soil quality status is good

- Soil Type (Clay) set the potential size of the sink
- Land Use has an overriding effect on the permanence of C
- Management help to switch to higher or lower factors rate of C sequestration

This work will help to understand where the potential to store C is and generate a new revenue stream for C farming.

Thanks for the attention

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