Carbon and Soils:
How to improve soil carbon sequestration

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Soil functions

Soils deliver ecosystem services that enable life on Earth

2015 International Year of Soils

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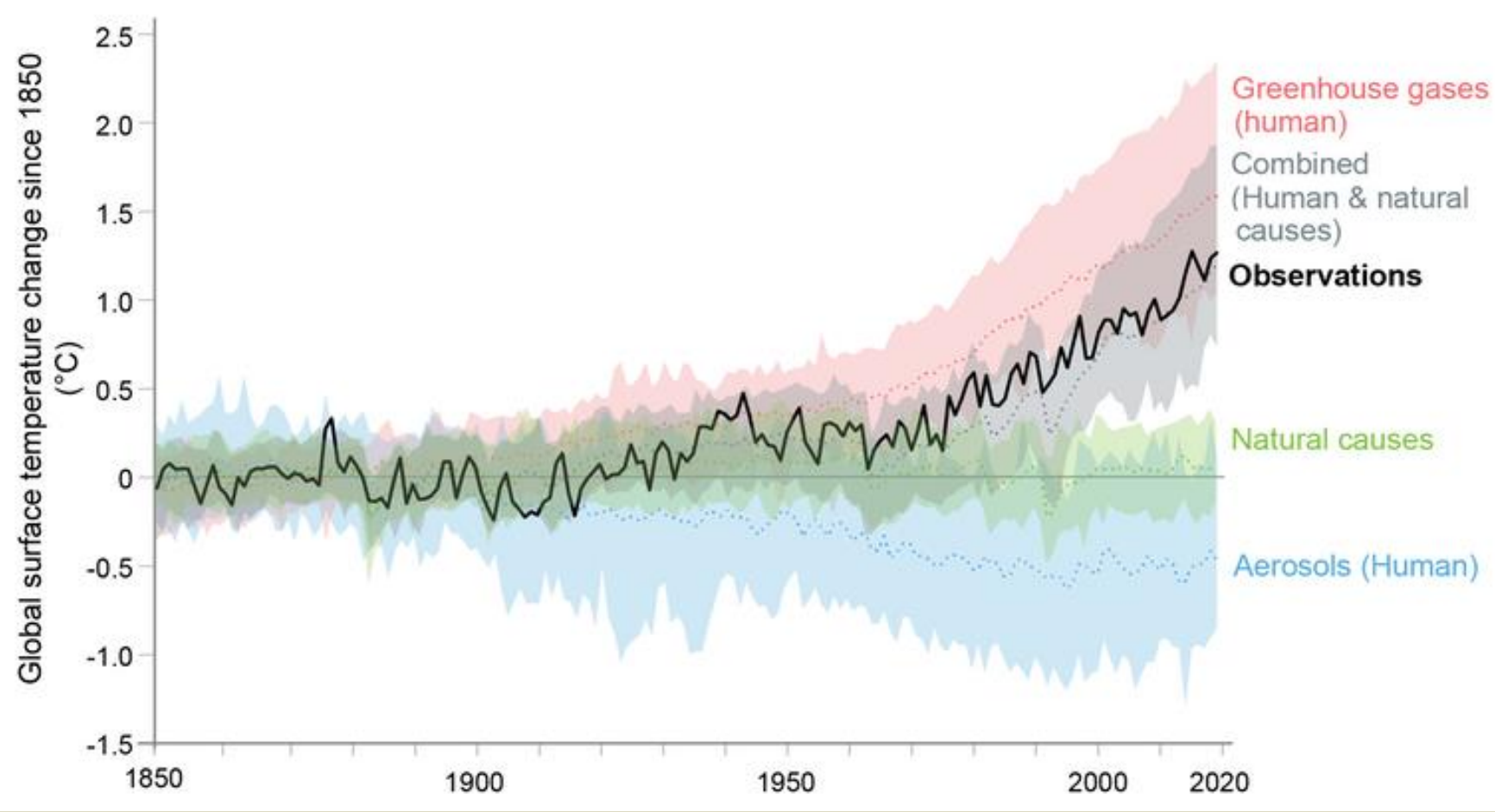
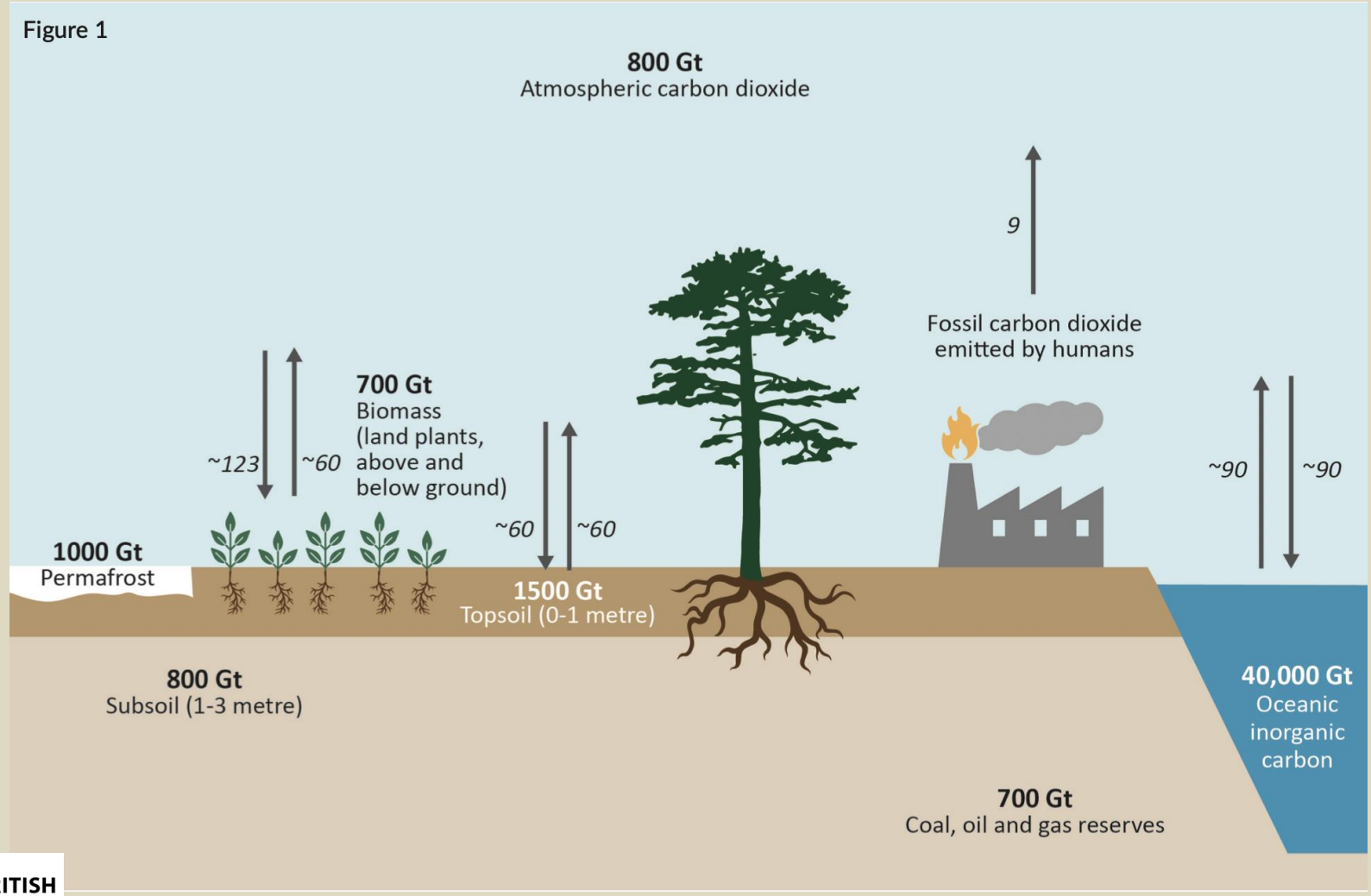
To tackle climate change, we must not only reduce fossil fuel emissions to near zero, but also support natural systems to sequester and store carbon.



From: IPCC Sixth Assessment Report

Carbon stocks and flows



BRITISH SOCIETY OF SOIL SCIENCE

Some terminology

Carbon Sequestration

A net transfer of carbon (C) from the atmosphere to land (either into soil or vegetation).

Carbon Sink

Any reservoir that over time accumulates and stores more C than it loses.

Carbon Store

A medium that stores C. Over a given period of time, the amount of C in the store may go up, down or stay the same.

Carbon Source

Any reservoir that over a given period of time loses more C than it accumulates**.**

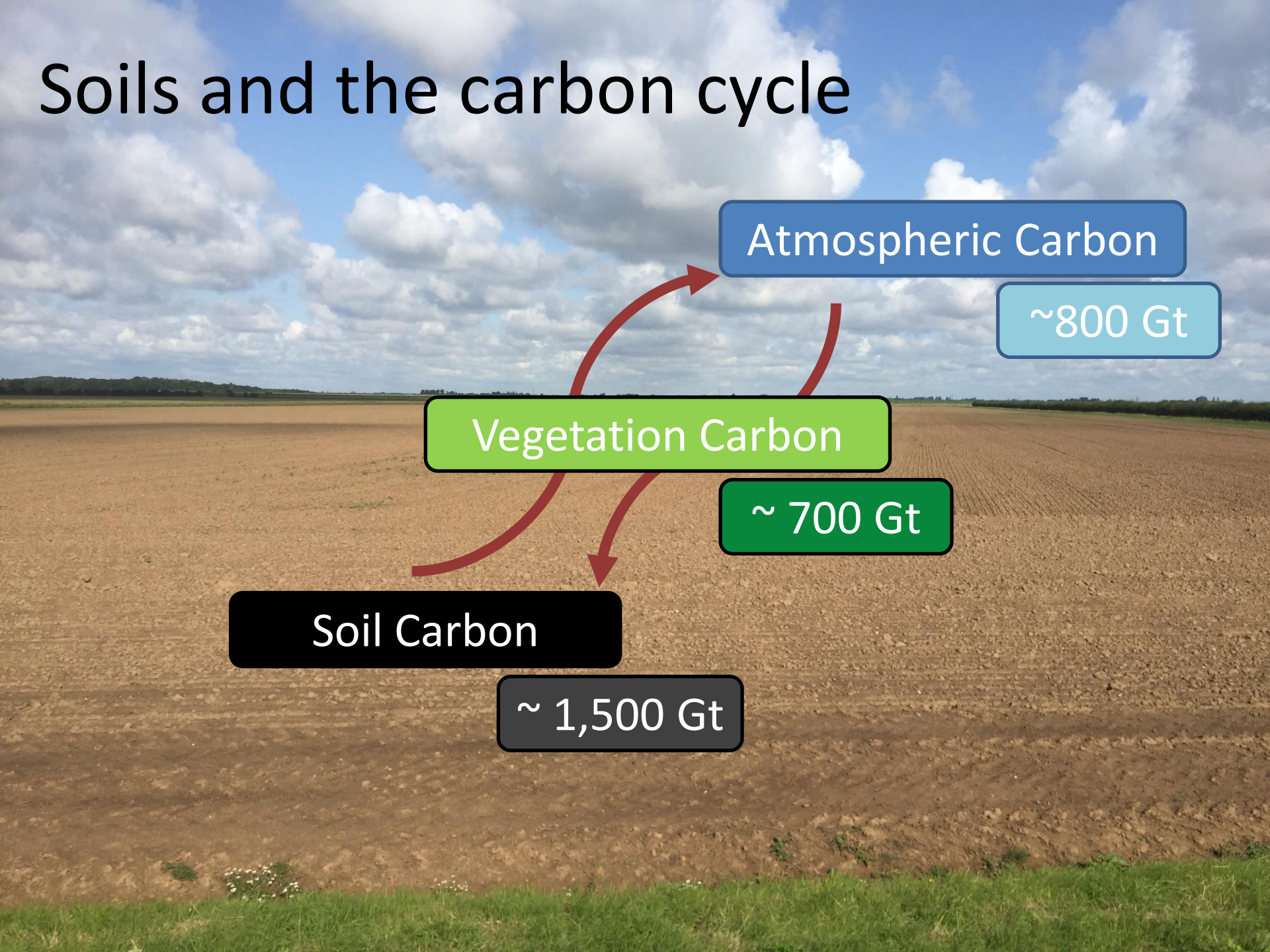
Carbon budgets: beware the units!

1 Gigatonne (Gt) = 1 billion tonnes = 1 x 10^{15} g = 1 Petagram (Pg)

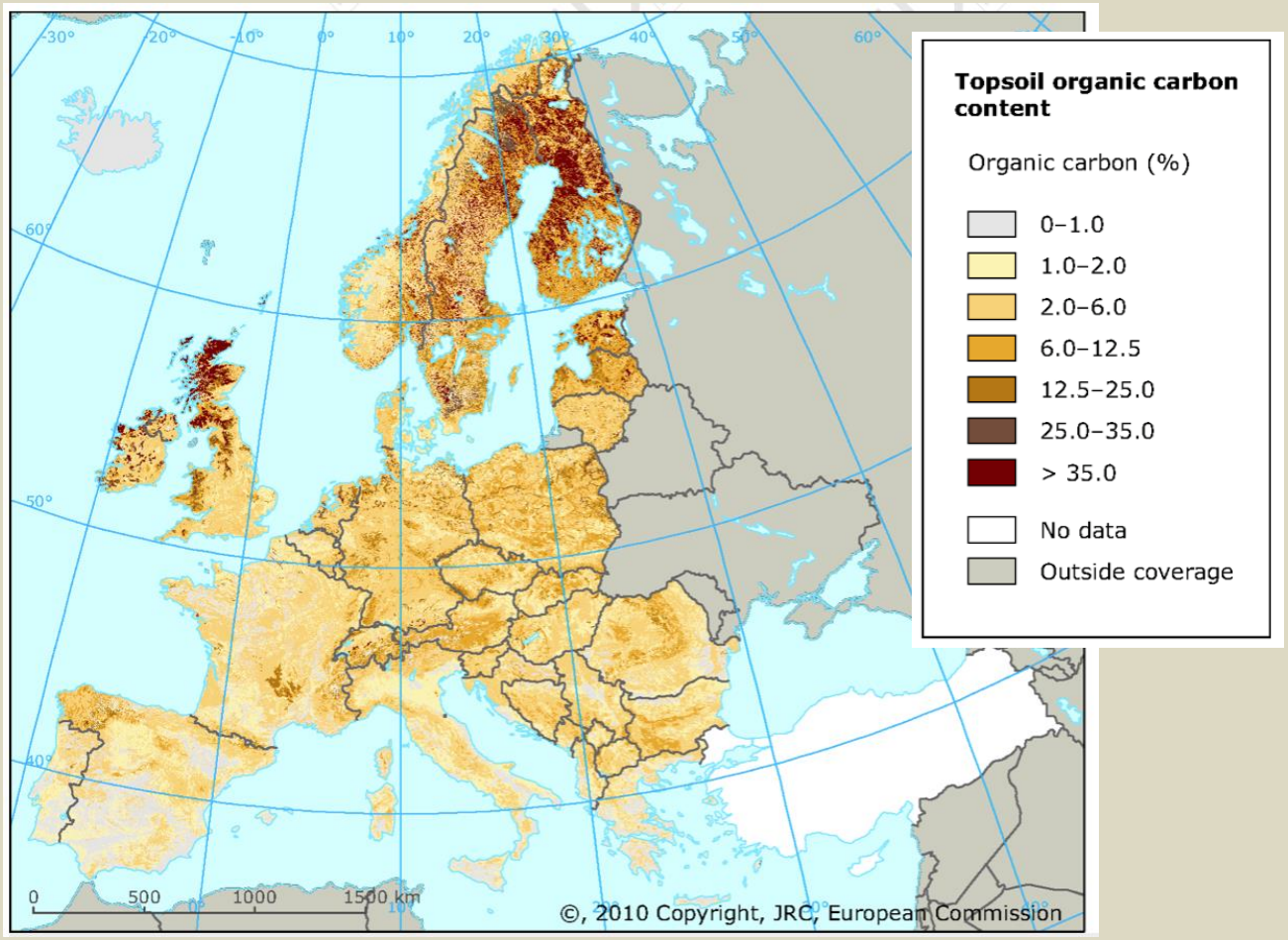
1 Kg carbon = 3.67 Kg of CO_2

1 GtC = 3.67 billion tonnes of CO_2 = 3.67 $GtCO_2$

Soils and the carbon cycle



In the EU-27, ~50% of soil C stocks are located in Ireland, Finland, Sweden and the UK.



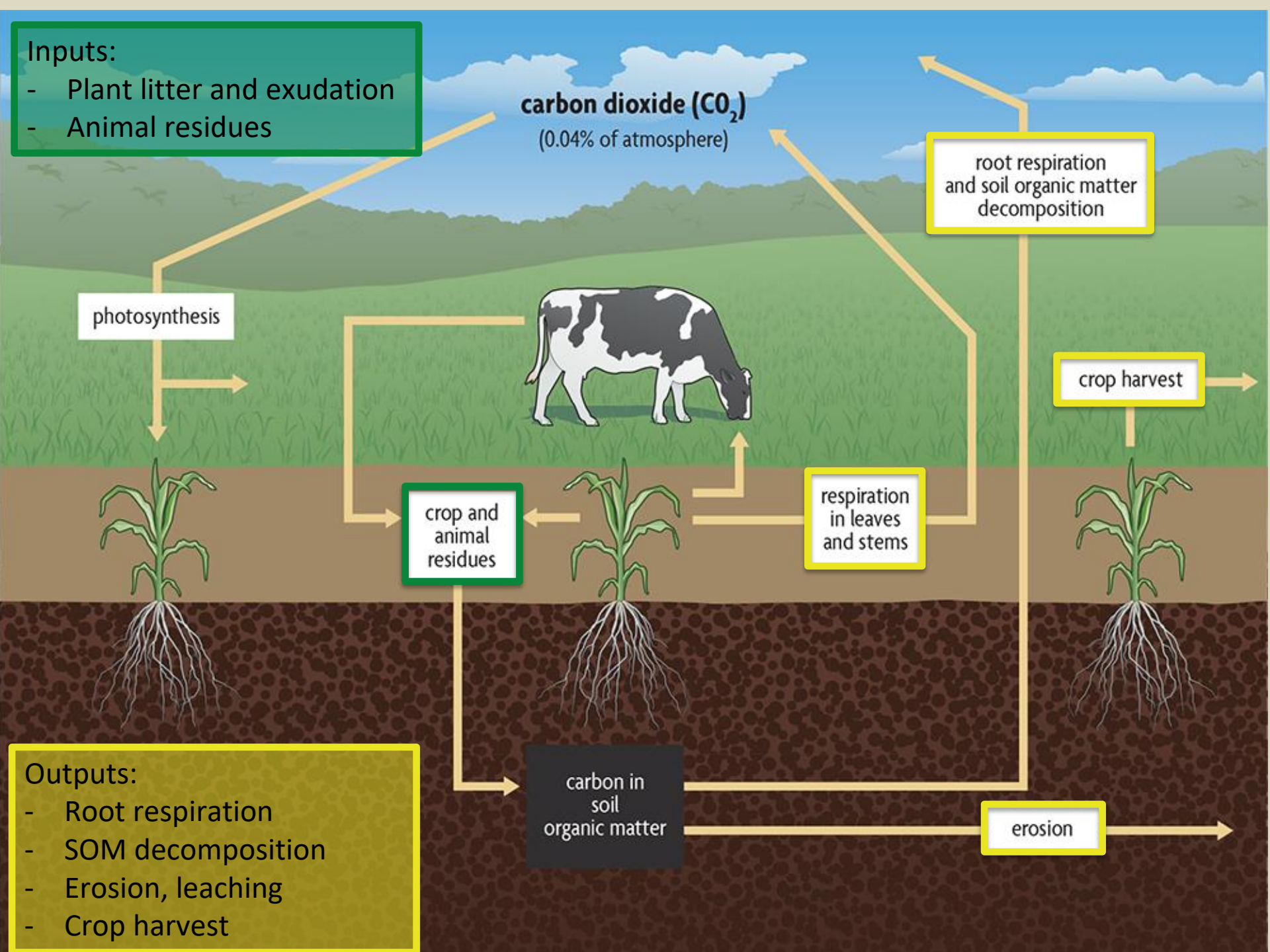
From: European Soil Database (2003)

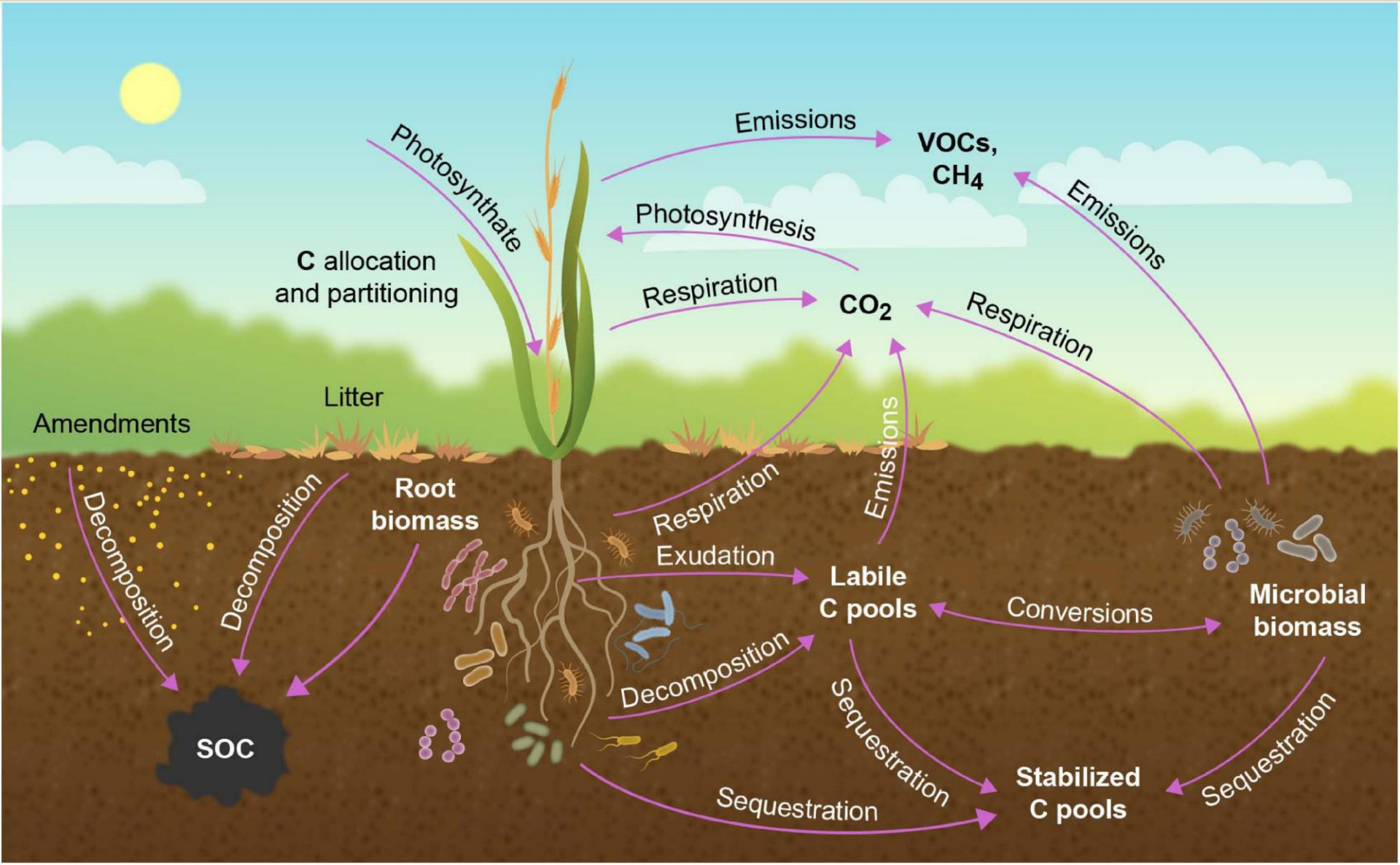
Types of soil carbon

Soil Inorganic Carbon (SIC)
Derived from mineral composition of soils (e.g. chalk, calcium carbonate).

Soil Organic Carbon (SOC)
Organically derived from plant or animal material breakdown.

How is soil organic matter built up/lost in soils?


Inputs:
- Plant litter and exudation
- Animal residues
carbon dioxide (CO_2)
(0.04% of atmosphere)
root respiration and soil organic matter decomposition
photosynthesis
crop harvest
crop and animal residues
respiration in leaves and stems
carbon in soil organic matter
erosion
Outputs:
- Root respiration
- SOM decomposition
- Erosion, leaching
- Crop harvest

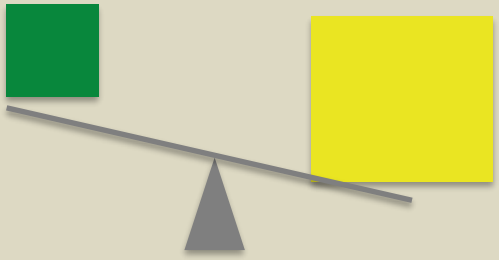


From: Jansson et al. (2021)

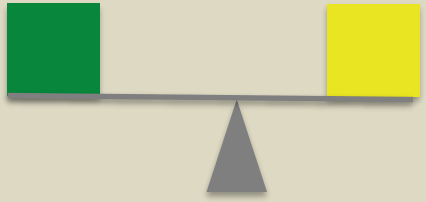
How is SOM built up/lost in soils?

Balance between **inputs** and **outputs**:

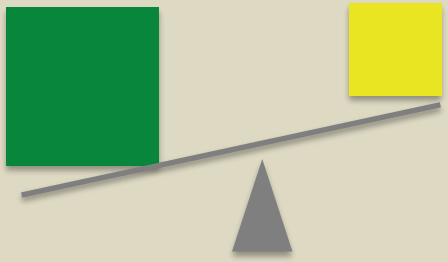
Loss in SOM



No change in SOM



Sequestration in SOM



How is SOM built up/lost in soils?

Each input and output will be influenced by **environmental** (natural) and man made factors (management).

Environmental factors:

- Moisture and aeration
- Warm temperatures
- pH

UK peat soils -> wet, cold = C accumulation

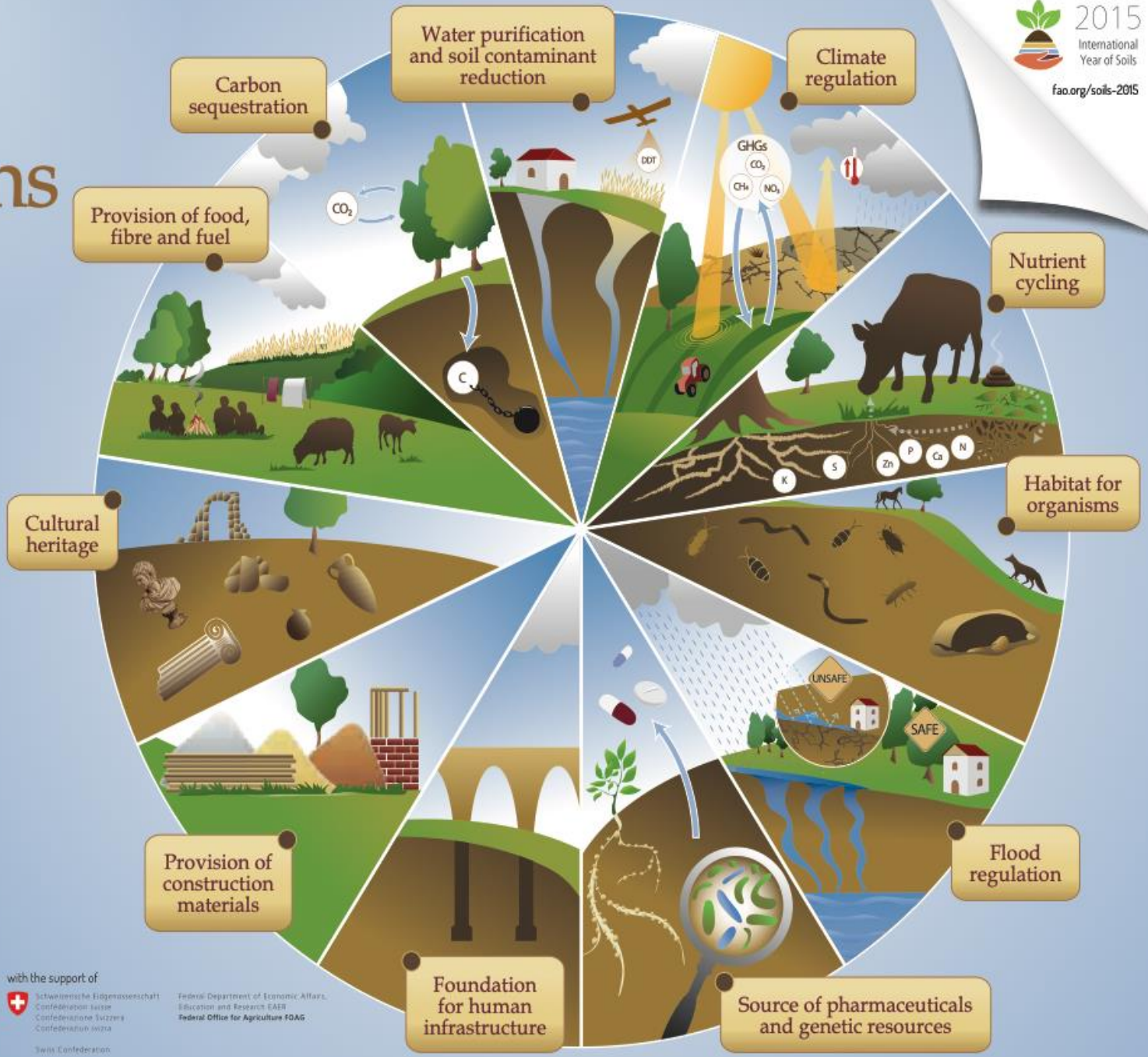
How is SOM built up/lost in soils?

Each input and output will be influenced by environmental (natural) and man made factors (**management**).

Management factors influencing organic matter levels in soil

Soil functions

Soils deliver ecosystem services that enable life on Earth



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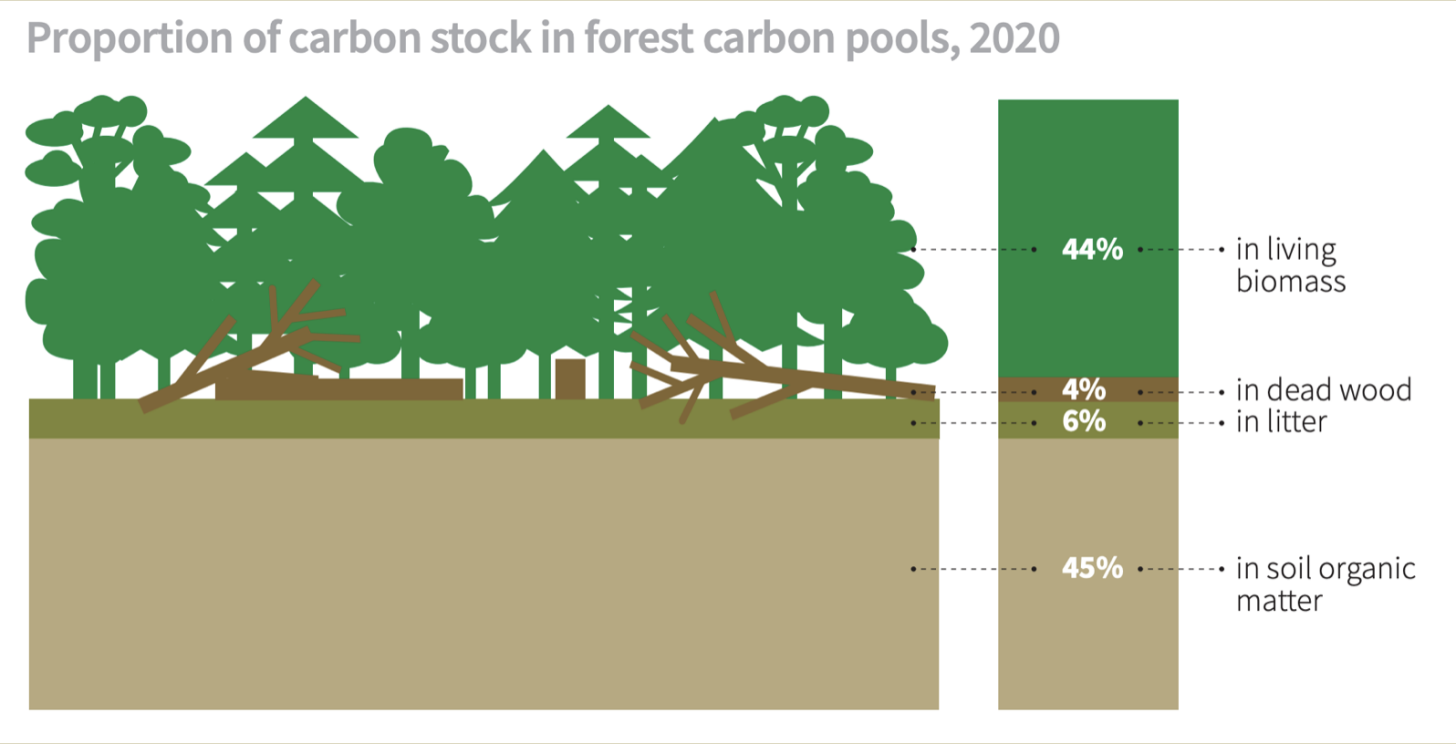
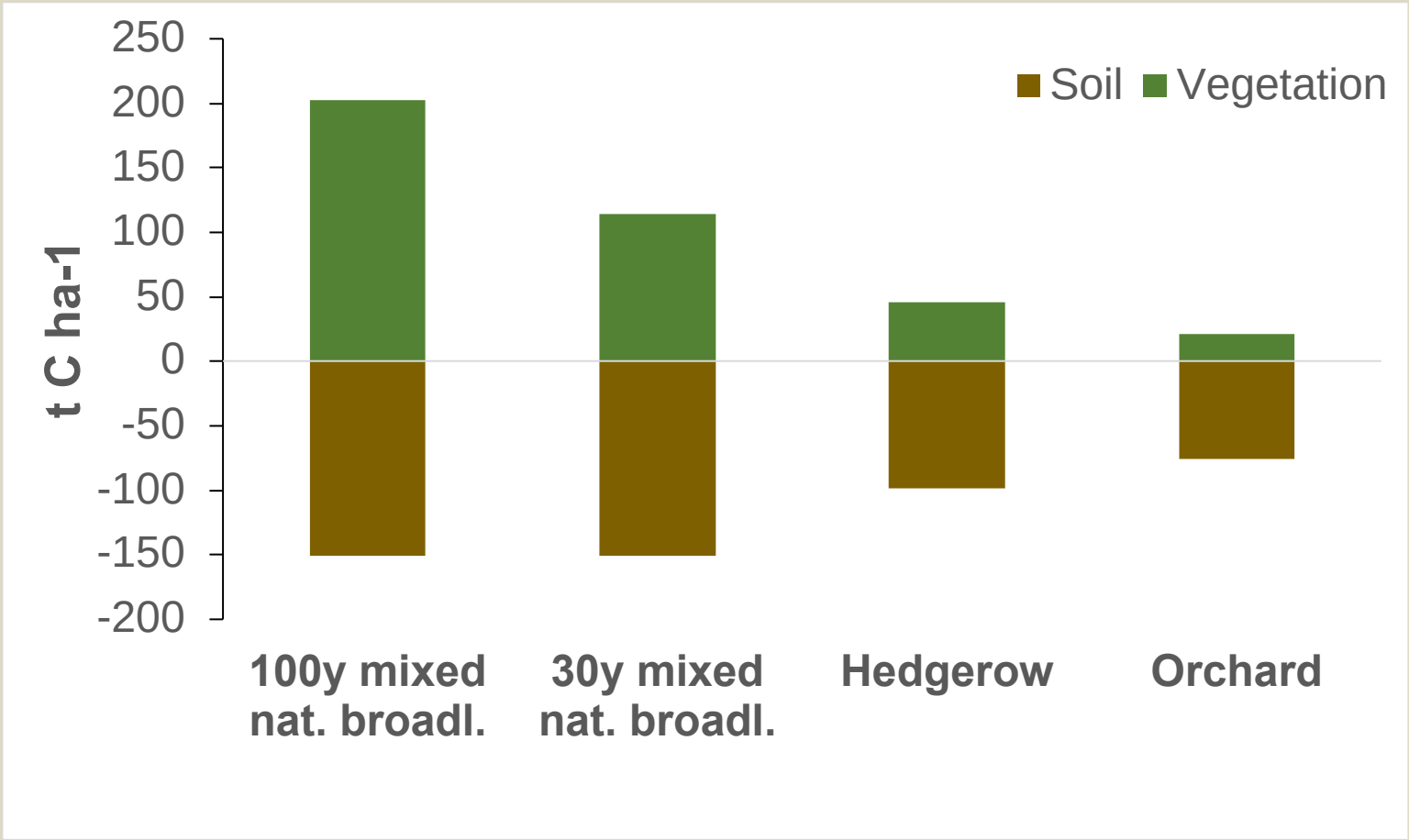
Woodlands

Woodland cover = ~13% UK's land

Total global C stock: ~4000 Mt CO_2e



From: FAO

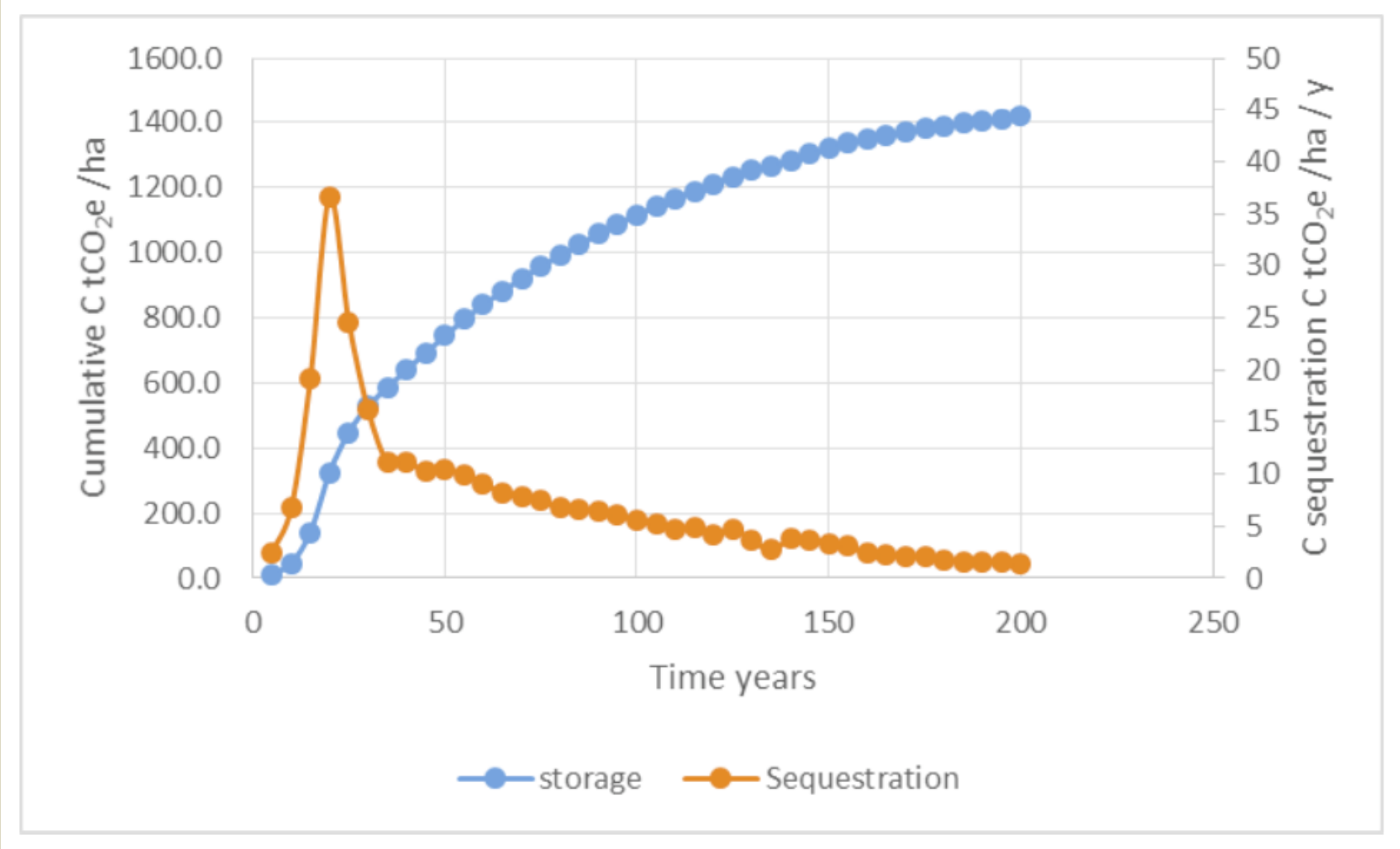


From: Natural England report (2021)

Practices and Impacts

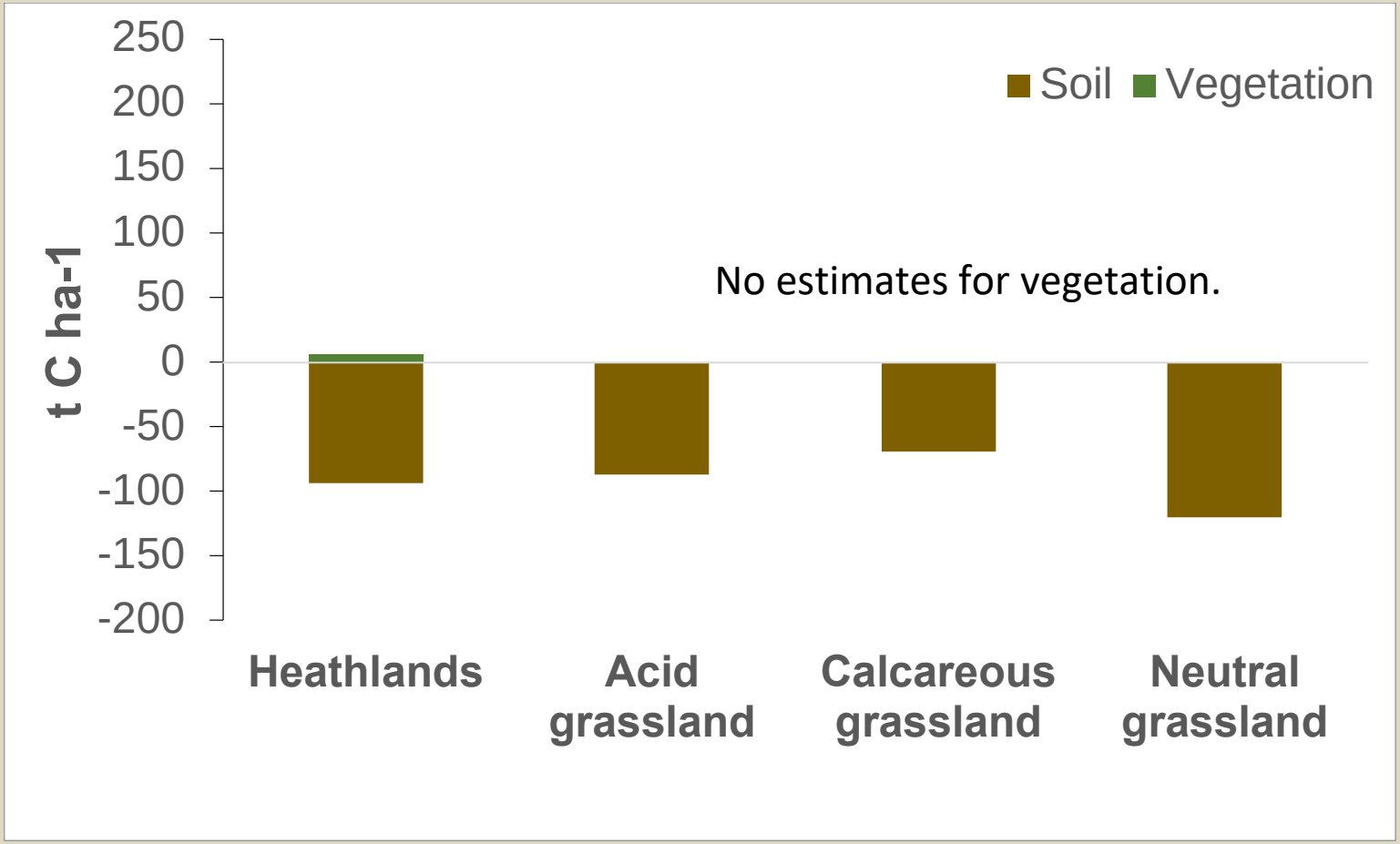
- Reducing deforestation
- Controlling disturbances (fires and pests)
- Reducing slash and burn agriculture
- Afforestation/reforestation
- Sustainable forest management

C sequestration of new woodlands peaks after a few decades, whereas C storage increases towards an equilibrium



From: Alonso et al. (2021) Natural England Research Report

Open habitats and farmland



From: Alonso et al. (2021) Natural England Research Report

Practices and Impacts

Practice	Increased C inputs	Reduced C losses
Improved crop rotations and crop residues	✓	
Cover crops	✓	
Conversion to perennial grasses and legumes	✓	✓
Manure and compost addition	✓	
No-tillage		✓
Rewetting organic (i.e. peat) soils		✓
Improving grazing land management	✓	

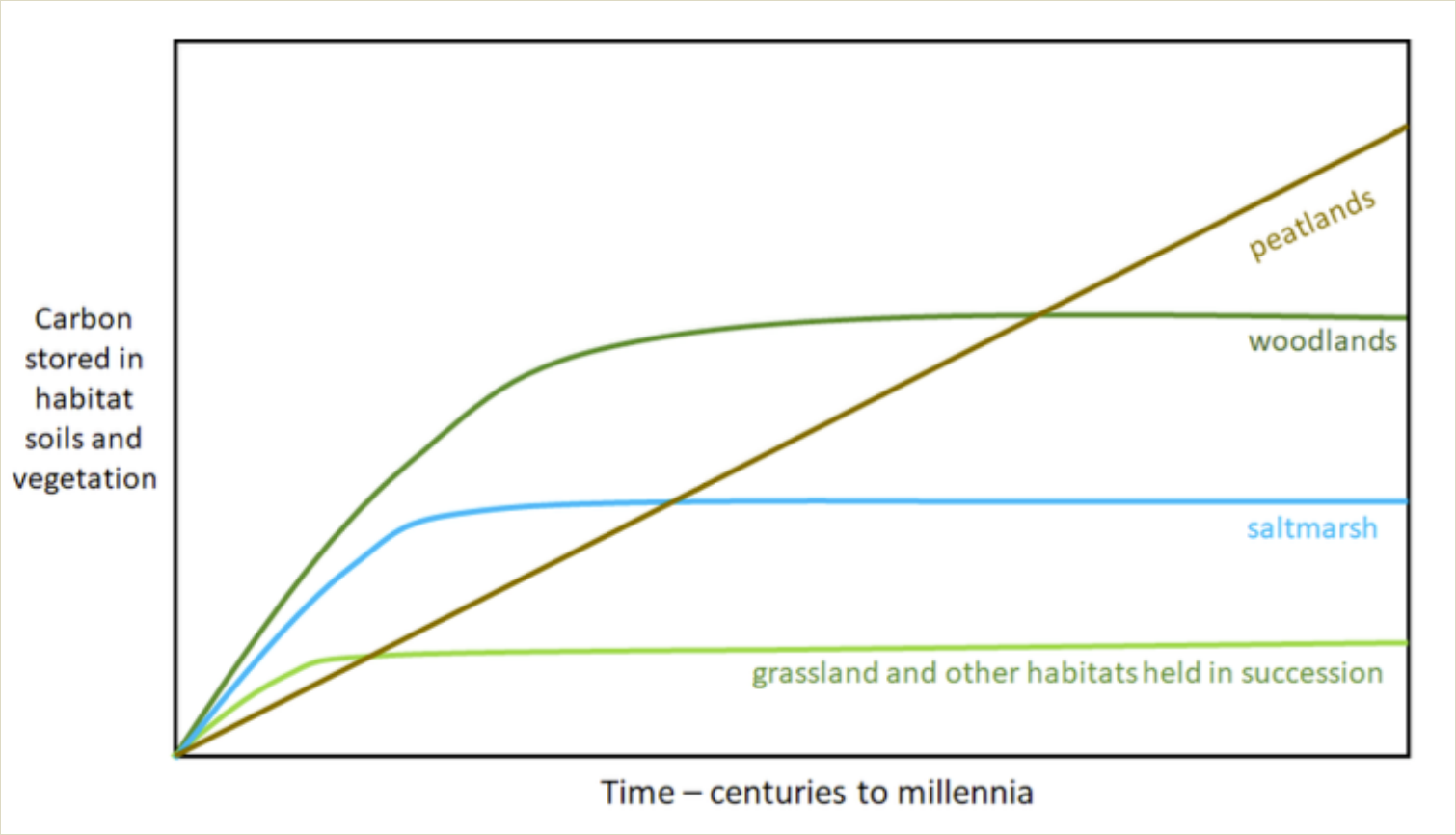
Non-conventional practices

- Biochar (C-rich solid produced from biomass) addition: highly resistant to microbial decay.
- Breeding to develop cereal grains with a perennial growth habit: reduce the need for tillage.
- Selective breeding to develop annual crops with more, deeper roots.

https://en.wikipedia.org/wiki/Biochar#/media/File:Biochar.jpg

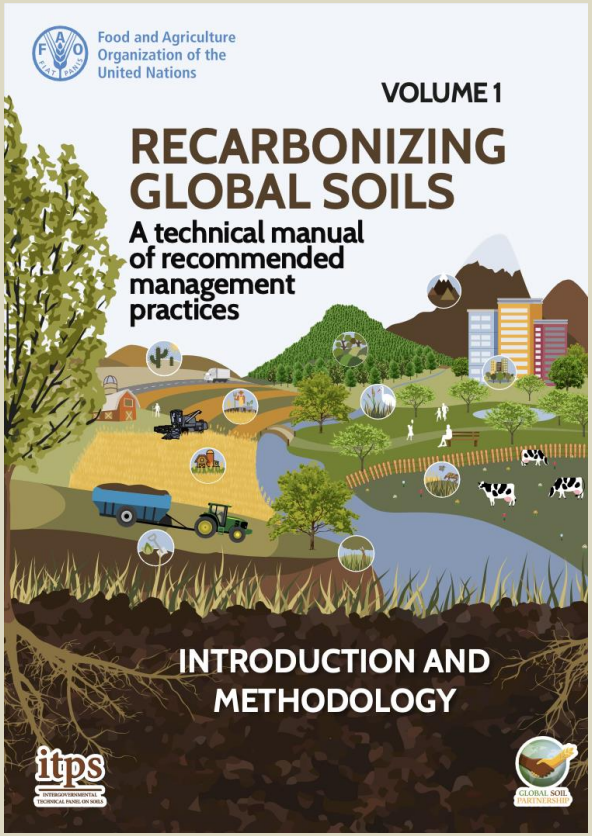
How much carbon can be sequestered?

C sequestration and is different for different habitats, with every site having an equilibrium specific to its management, climate and soils.



From: Alonso et al. (2021) Natural England Research Report

To know more…



Vol. 1 – Introduction and methodology
Vol. 2 – Hot spots and bright spots of SOC
Vol. 3 – Cropland, grassland, integrated systems and farming approaches – Practices overview.
Vol. 4 - Cropland, grassland, integrated systems and farming approaches – Case studies.
Vol. 5 – Forestry, wetlands, urban soils - Practices overviews.
Vol. 6 – Forestry, wetlands, urban soils – Case studies.

From: https://www.fao.org

Carbon and Soils:

How to improve carbon sequestration

Any questions?

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