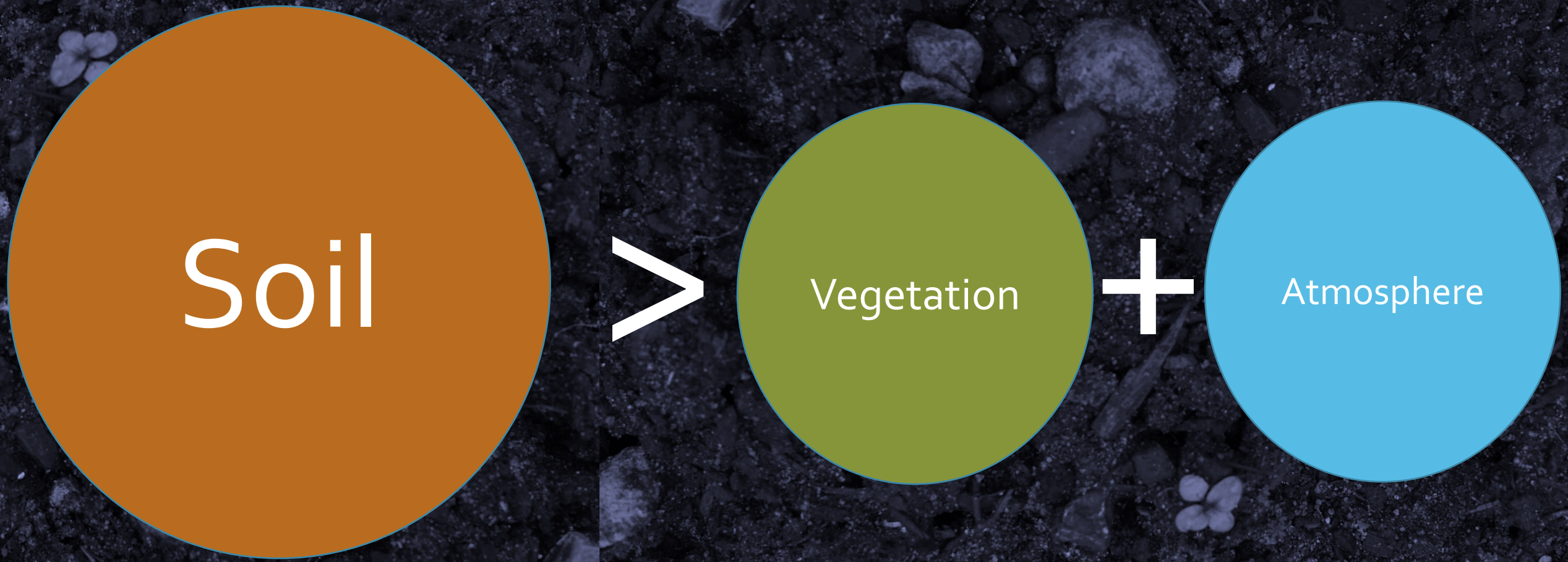
Soil carbon: part of the journey to net zero?

Professor John Quinton
Lancaster Environment Centre

Outline

- Why should we be interested in soil carbon?
- A few definitions
- How carbon behaves in the soil
- How we might increase soil carbon
- Which soils in the AONB store the most carbon?

Why soil carbon?



Definitions 1

Soil organic matter: the fraction of soil made up of plant or animal tissue, including microbial biomass that is in varied stages of decomposition

Soil Carbon: the element carbon. It makes up a significant fraction of soil organic matter, but not all.

Definitions 2

- Soil carbon concentrations : mass per unit of mass

e.g. 10g per kg or 10%

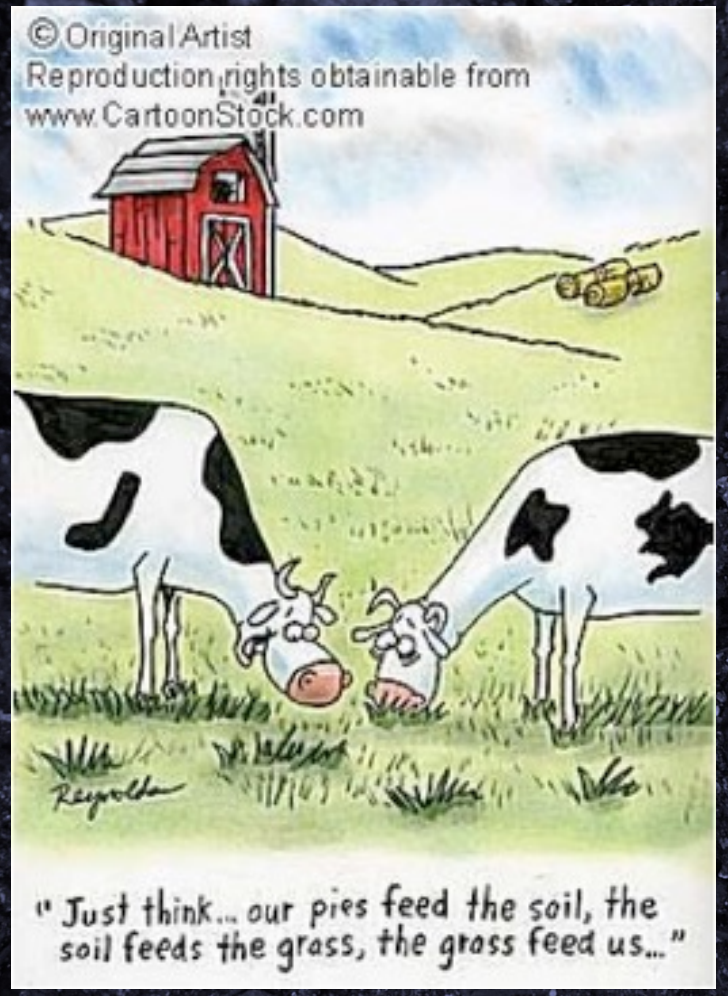
Soil carbon stocks : as mass sometime mass per unit area

e.g. kg per m^2

Stocks require us to know the density of the soil

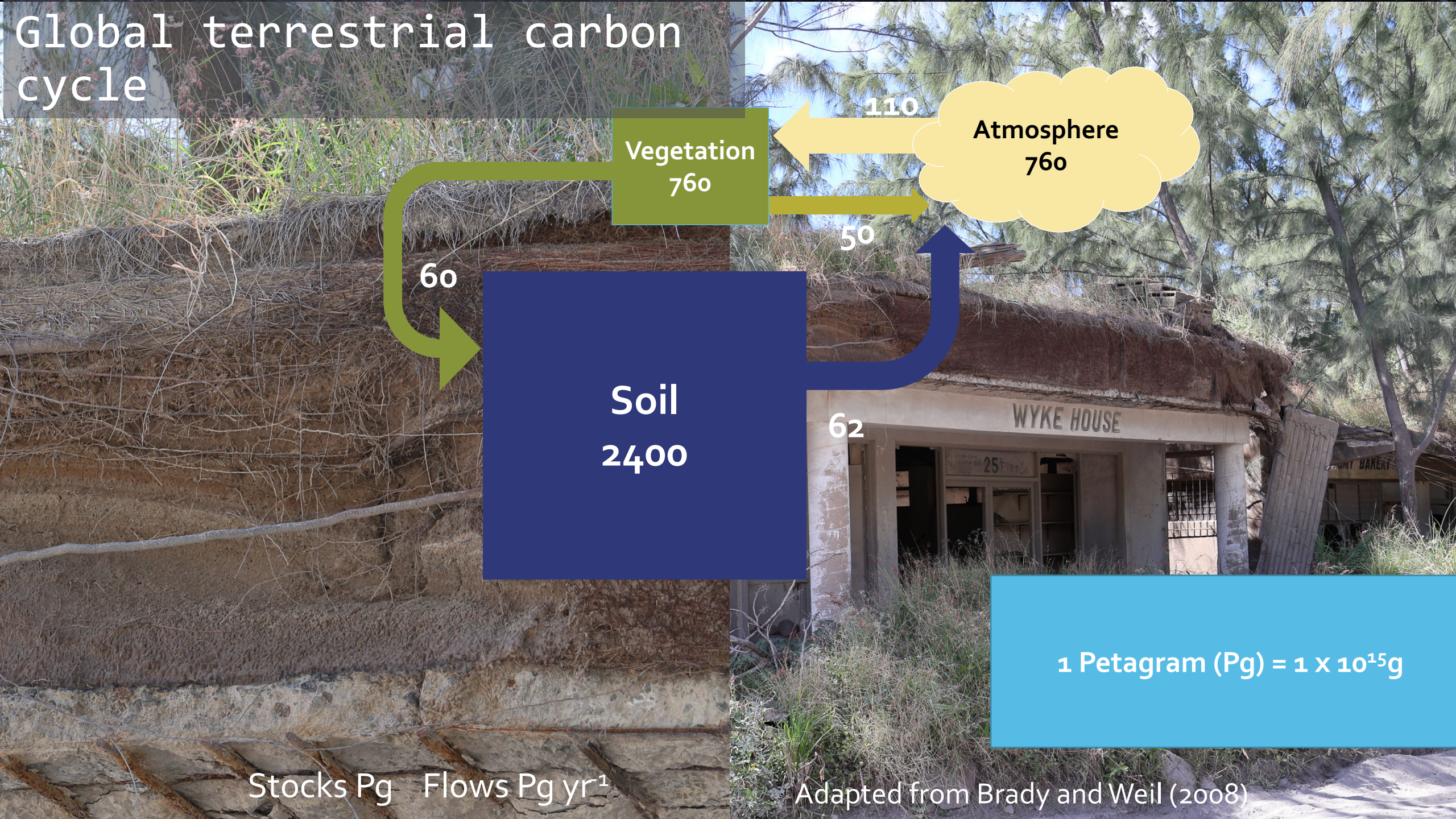
Definitions 3

- Carbon Dioxide Equivalent (CO_2e) Different greenhouse gases, such as methane and nitrogen oxides, have different impacts on the greenhouse gas effect. All gaseous emissions are converted to the amount of CO_2 needed to create the same effect, and presented in this report as CO_2e



Soil Carbon cycle

Global terrestrial carbon cycle



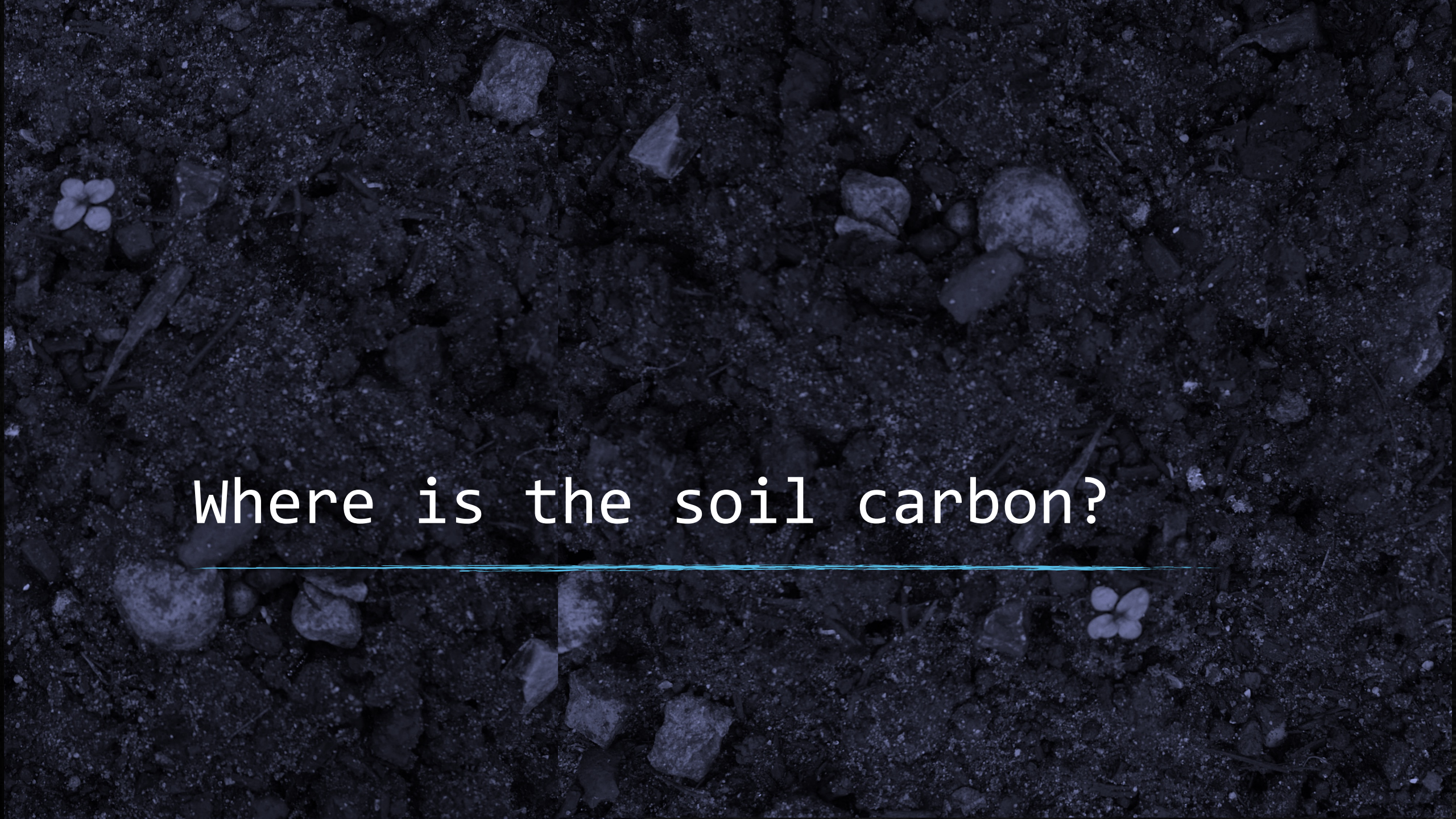
Ready cash versus savings

Image from UK Finance

0 – 2 yrs

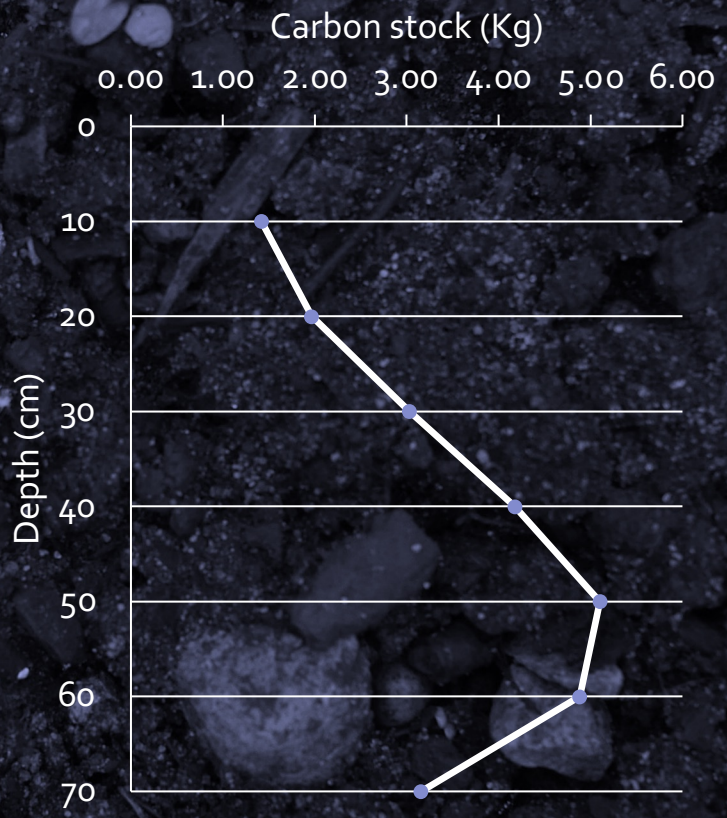
Image from Sky News

10– 1000 yrs

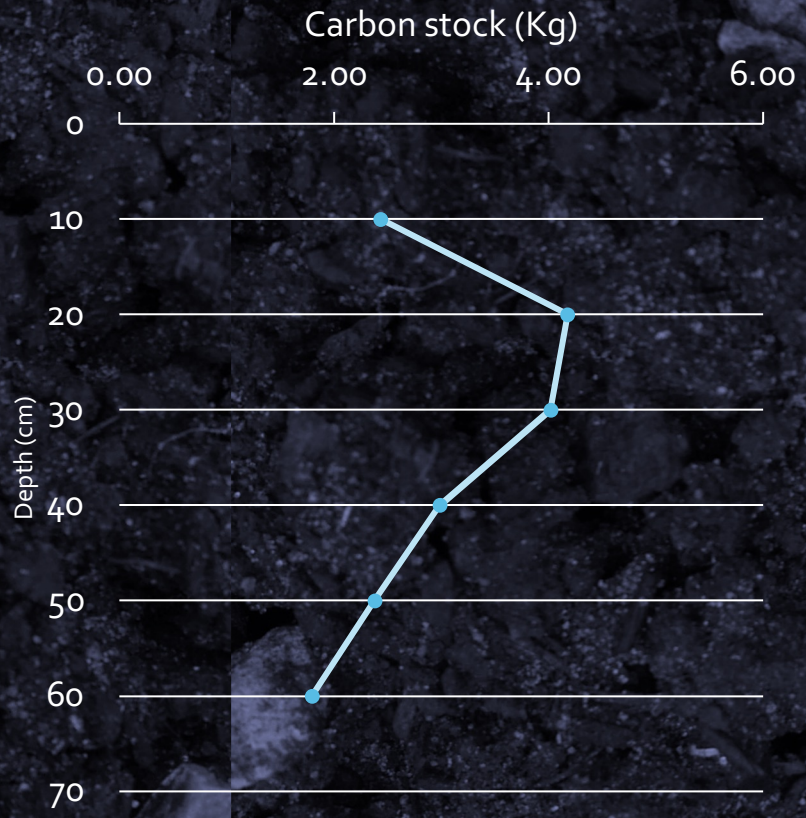

Where is the soil carbon?

Soil carbon with depth

Soil pit: deep ploughed



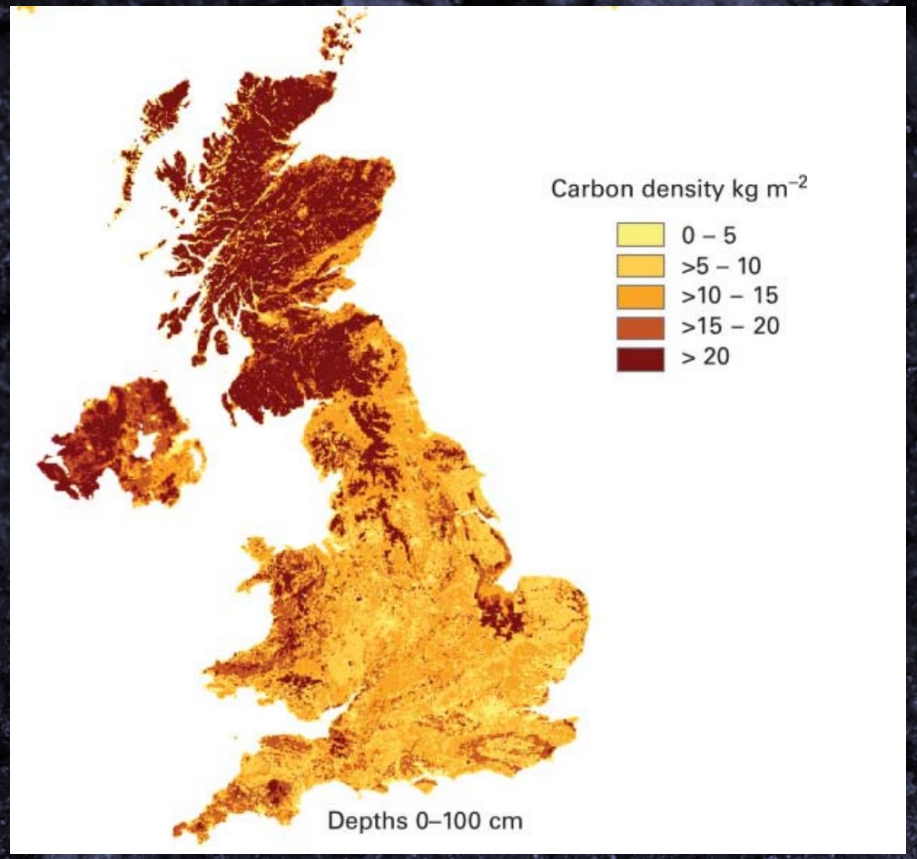
Soil pit: margin



20.5 kg	Total stock	17.8 kg

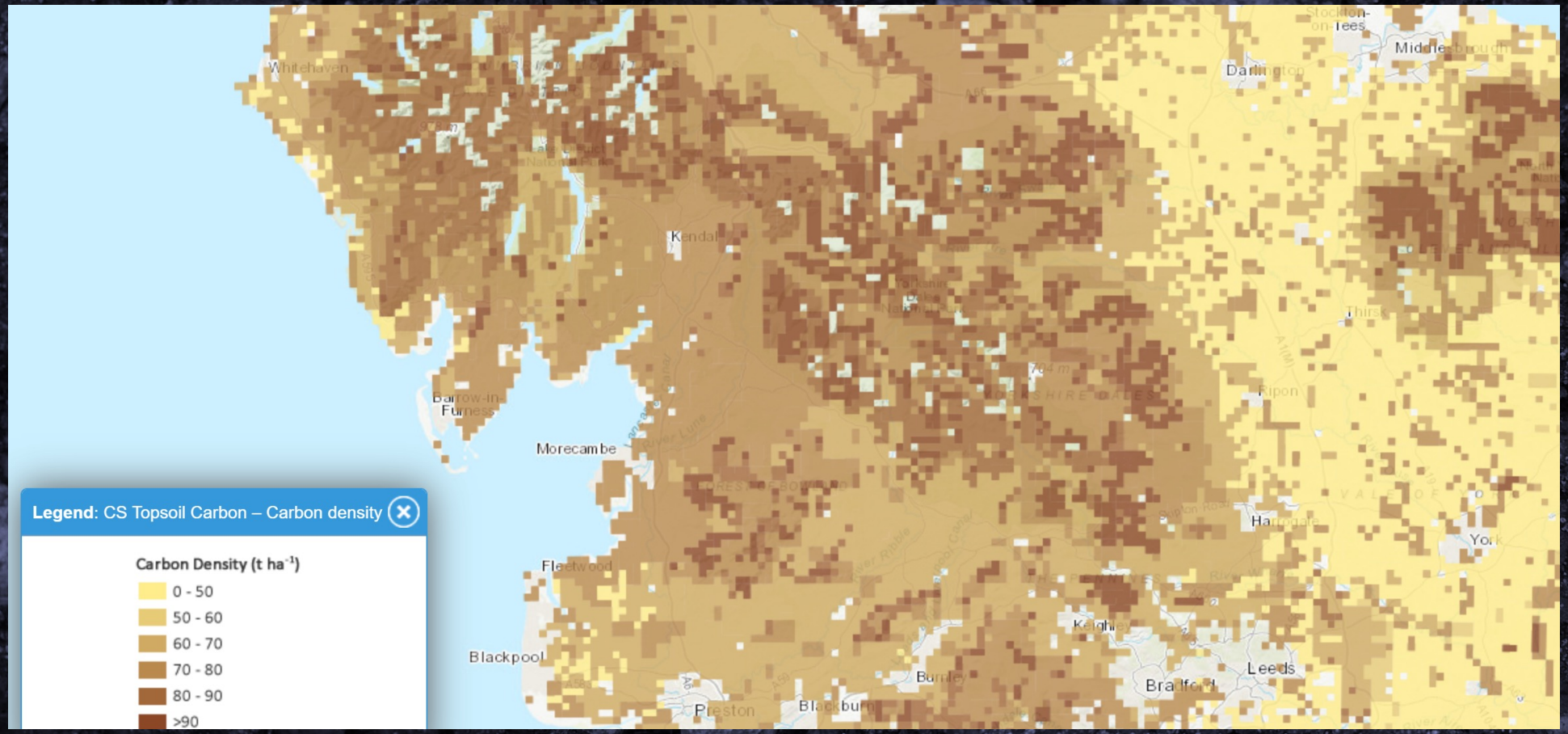
Carbon stock assessment near Appleby

UK soil carbon distribution



From Bradley et al (2005)

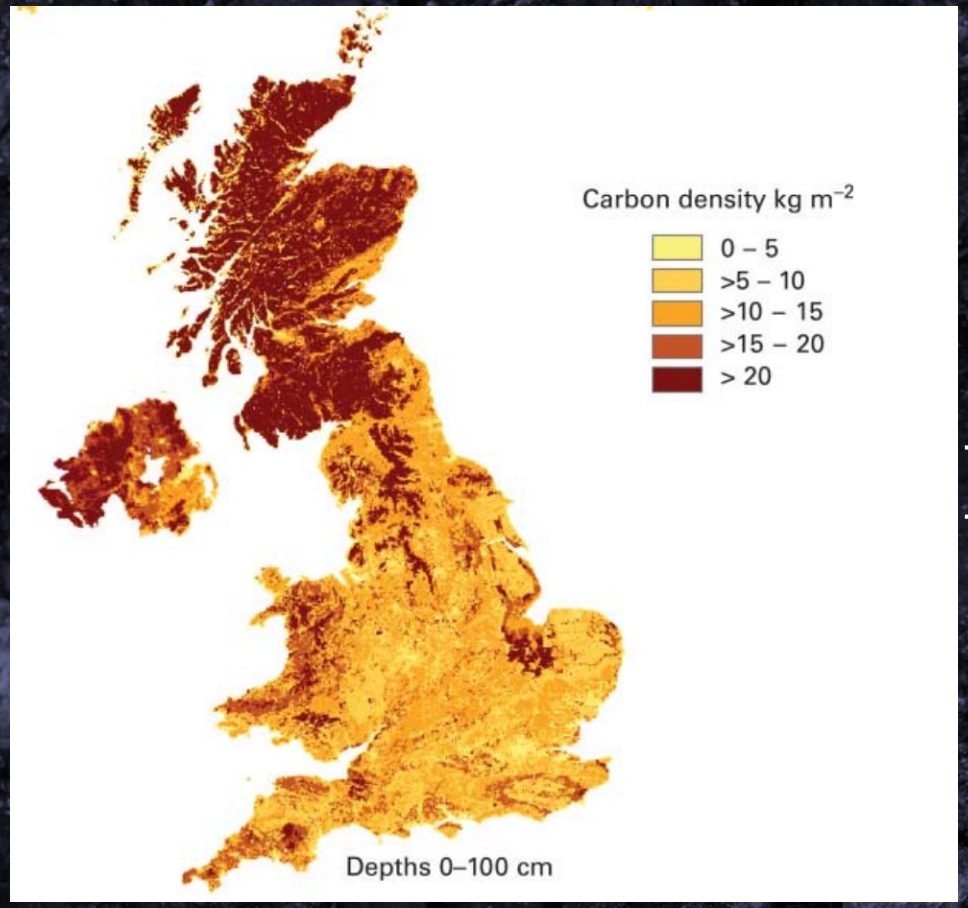
Carbon density from UK Soil observatory



UK soil carbon store

- 10 billion tonnes
- 15 tonnes for every person in UK
- Half in peat

The potrntial of soil carbon to contribute to net zero



From Bradley et al (2005)

Land are of UK = 243,610 km^2

UK soil carbon stock = 1 x 10^{13} kg

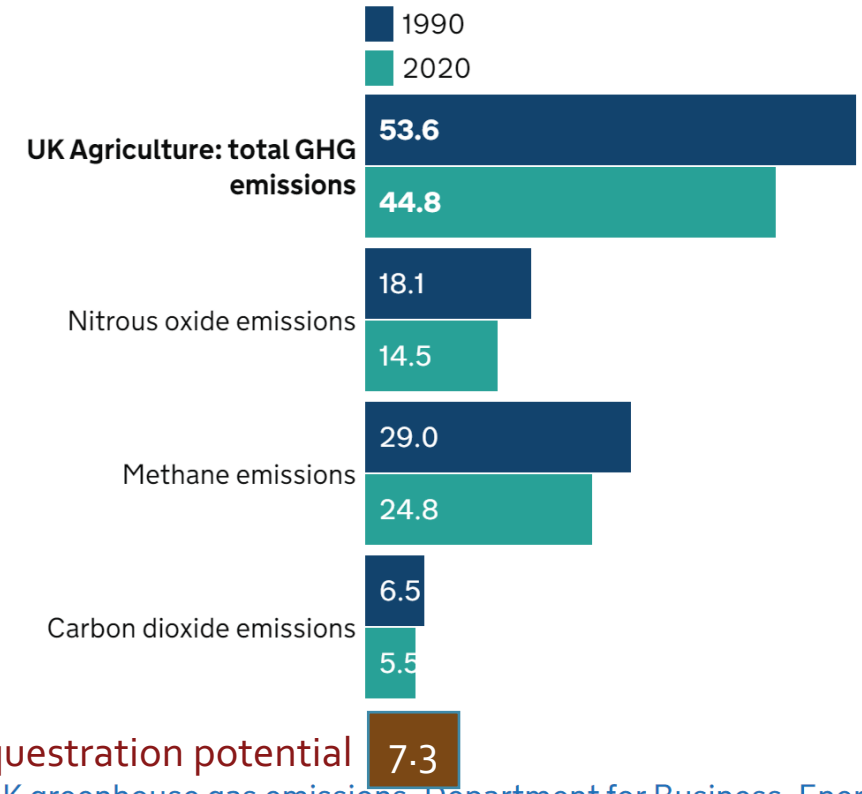
If you could increase this by 0.02% per year this would equal 2 x 10^{9}kg per year or 2 million tonnes or

7.3 million tonnes CO_2e

UK carbon emissions

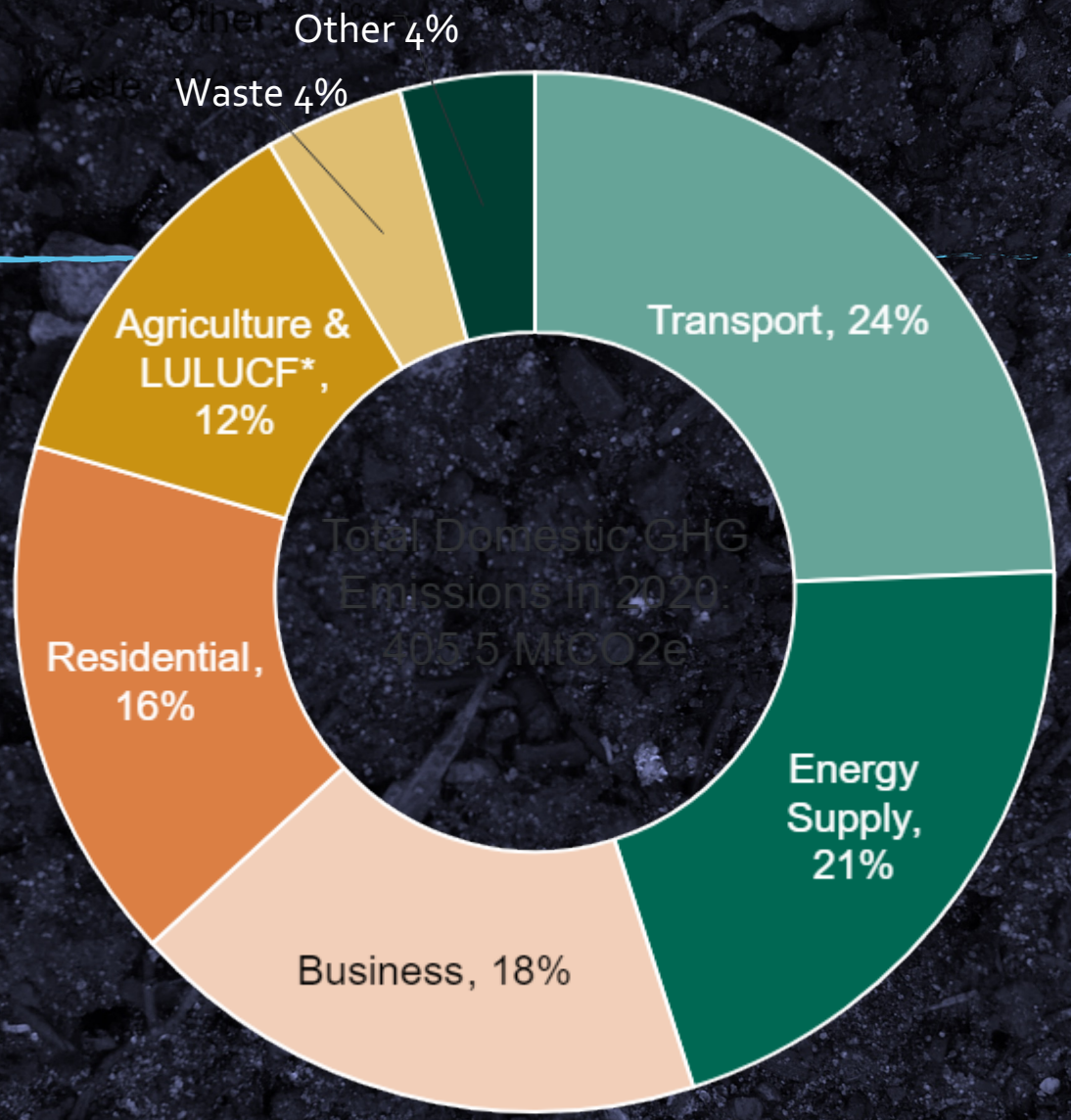
Figure 1.1 UK estimated GHG emissions for agriculture, 1990 and 2020 (million tonnes carbon dioxide equivalent, $MtCO_2e$)

Change to table and accessible view



Soil sequestration potential 7.3

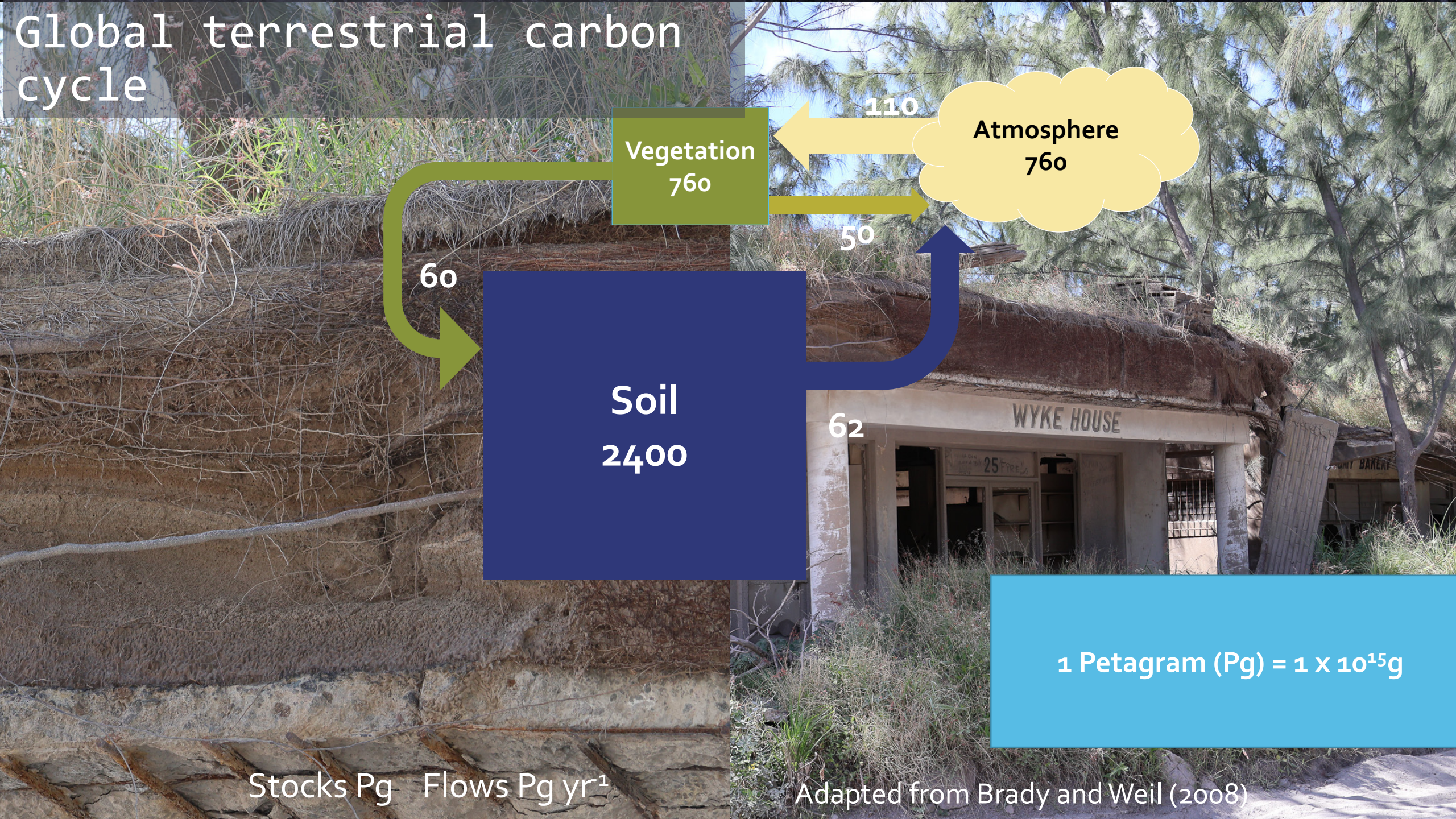
Source: UK greenhouse gas emissions, Department for Business, Energy and Industrial Strategy



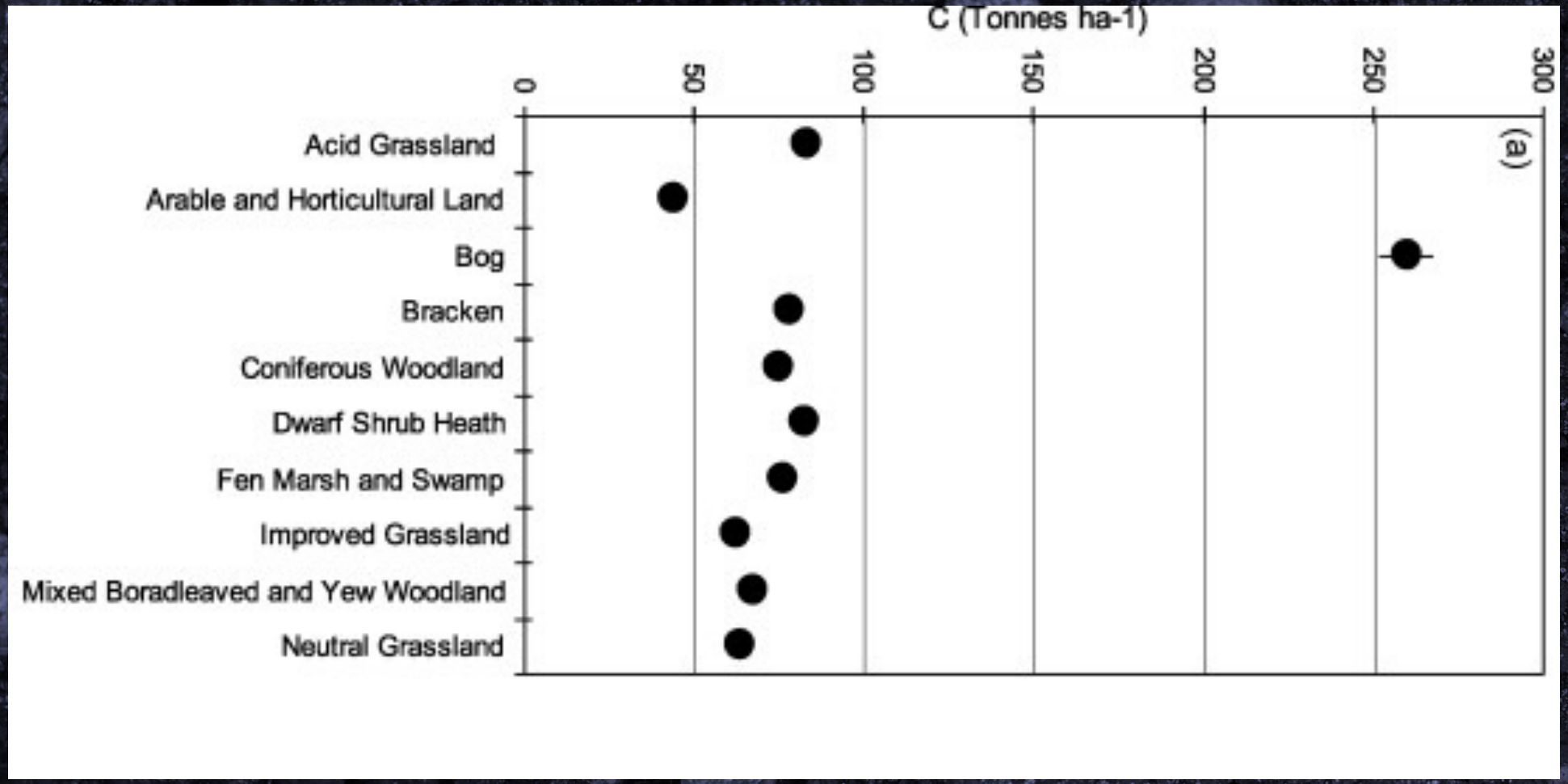
Official Statistics
Transport and environment statistics 2022
Published 20 October 2022

What can we (you) do to sequester more soil carbon?

Global terrestrial carbon cycle



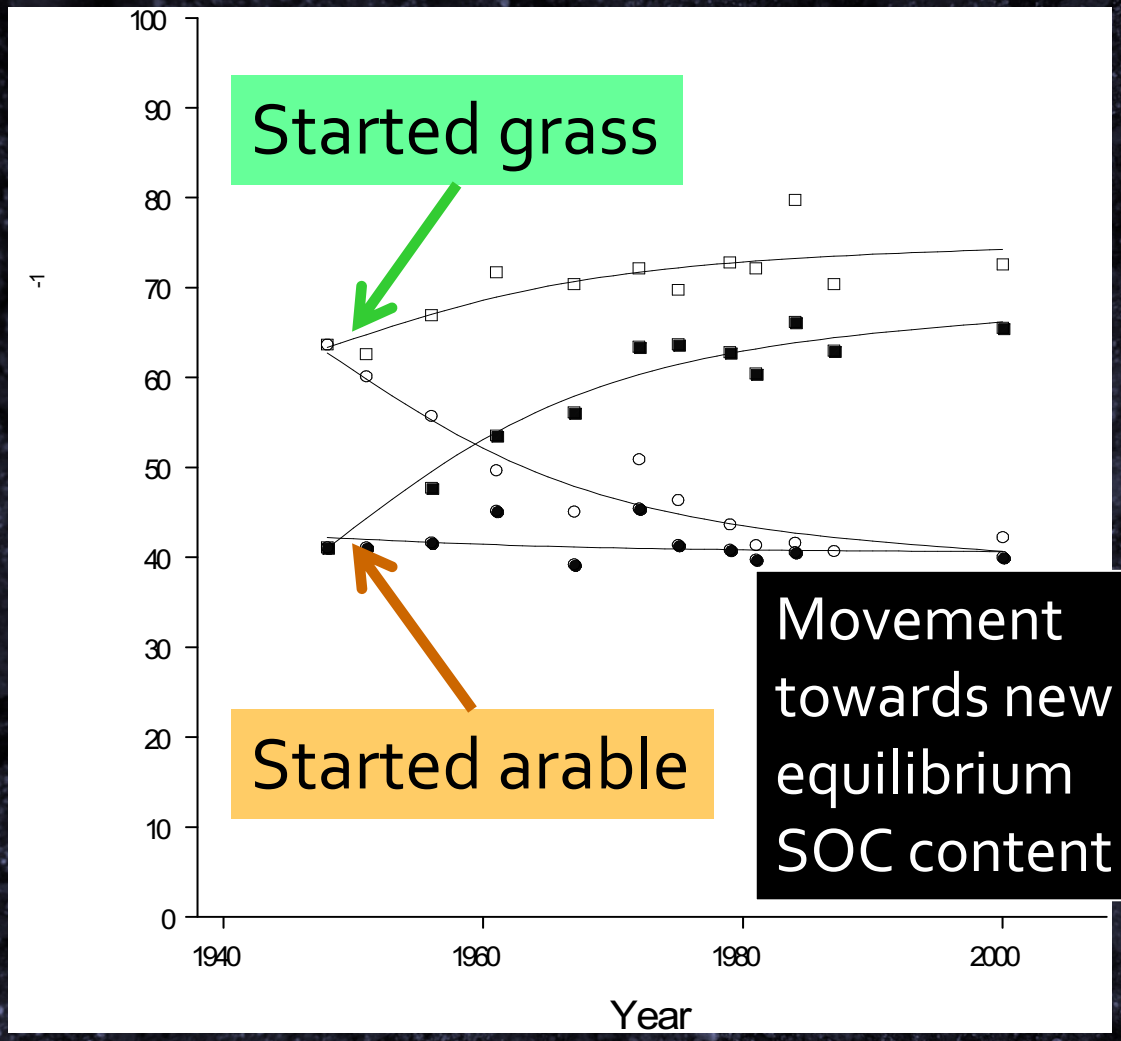
1. Maintain a permanent plant cover



Ostle et al (2009) Soi C content for broad habitat types

2. Don’t disturb grassland or woodland

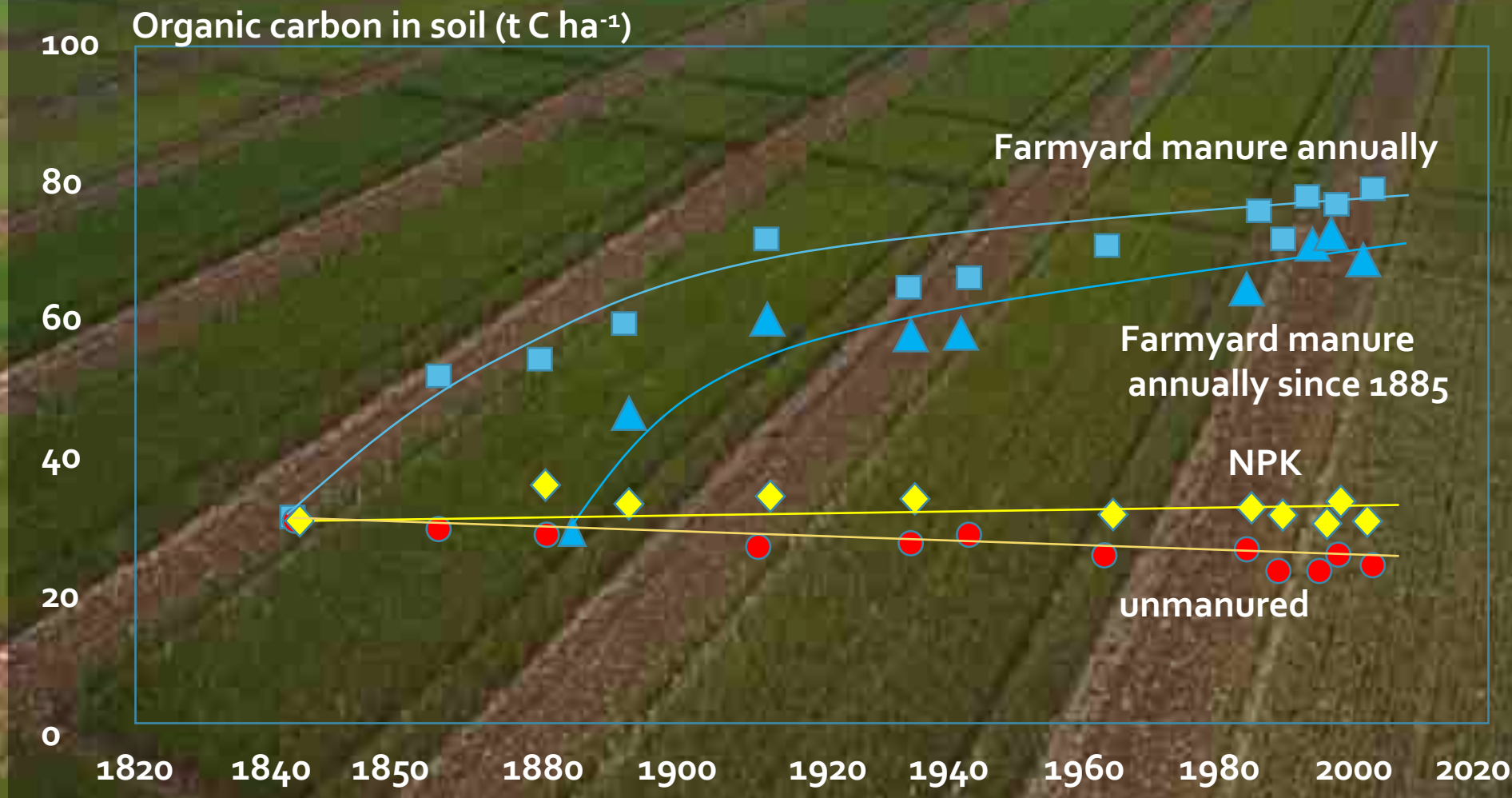
SOC changes following land use change, Rothamsted



Johnston *et al* (2009) *Advances in Agronomy* **101**, 1-57

2. Do add animal manures, compostor leaf litter

Broadbalk continuous wheat experiment



Adapted from Johnston *et al* (2009) photo David Powlson

Long-lasting effects of management on soil C & N

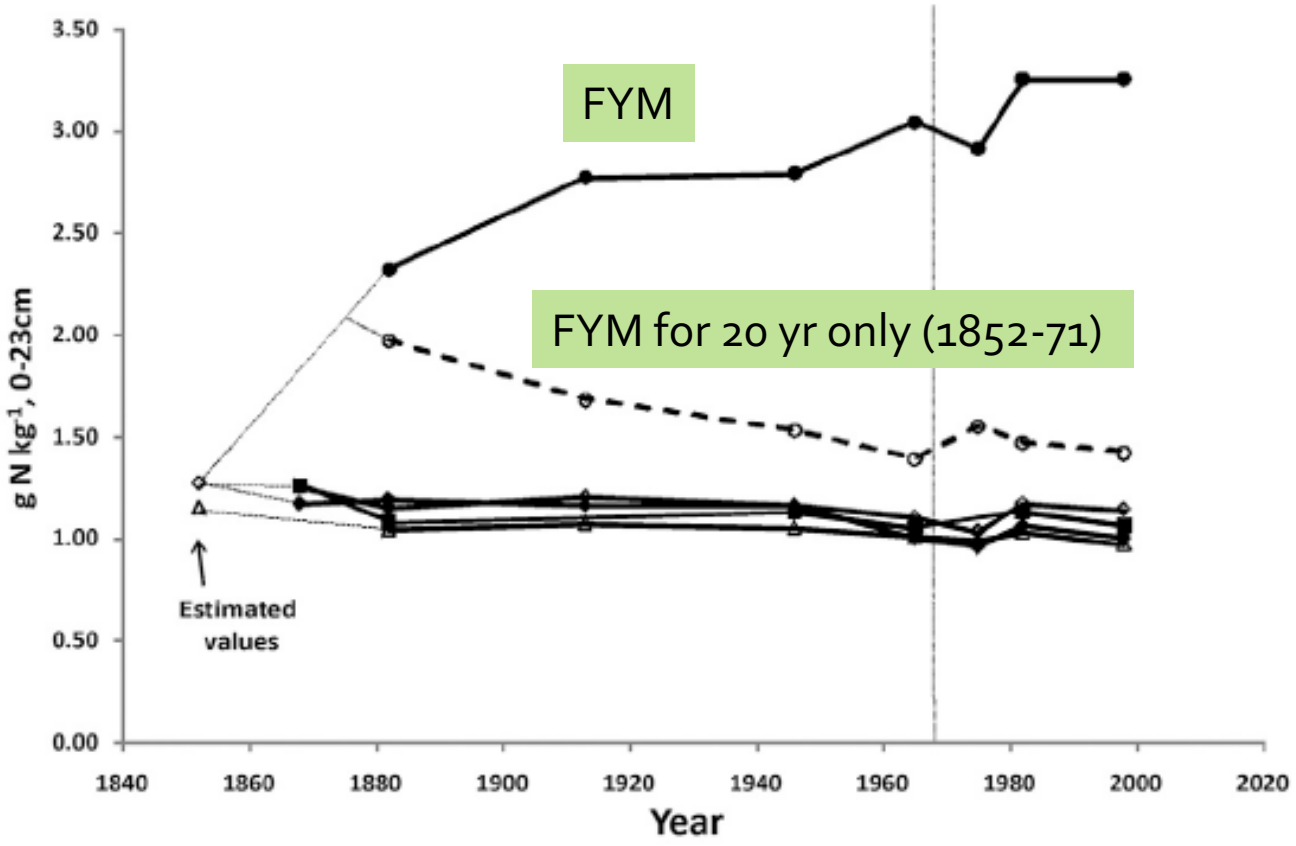


Fig. 1. Hoosfield Barley Experiment, Rothamsted, UK. Total N, g kg^{-1}, in topsoil, 0–23 cm. The treatments (ha^{-1} yr^{-1}) are (△) nil; (◇) PKMg since 1852; (♦) PKMg + 48 kg N as ammonium sulfate since 1852; (■)PKMg + 48 kg N as sodium nitrate since 1852; (●) farmyard manure, 35 t, since 1852; and (O) farmyard manure residues, 35 t, 1852–1871 only, none since. Since 1968 (indicated by vertical line) all treatments have received, on average, 72 kg N ha^{-1} yr^{-1}.

750

Hoosfield spring barley experiment,
Started 1852

Powlson *et al* (2010) *Journal of Environmental Quality* **39**, 749-752

But you need to add a lot of C to change Soil C

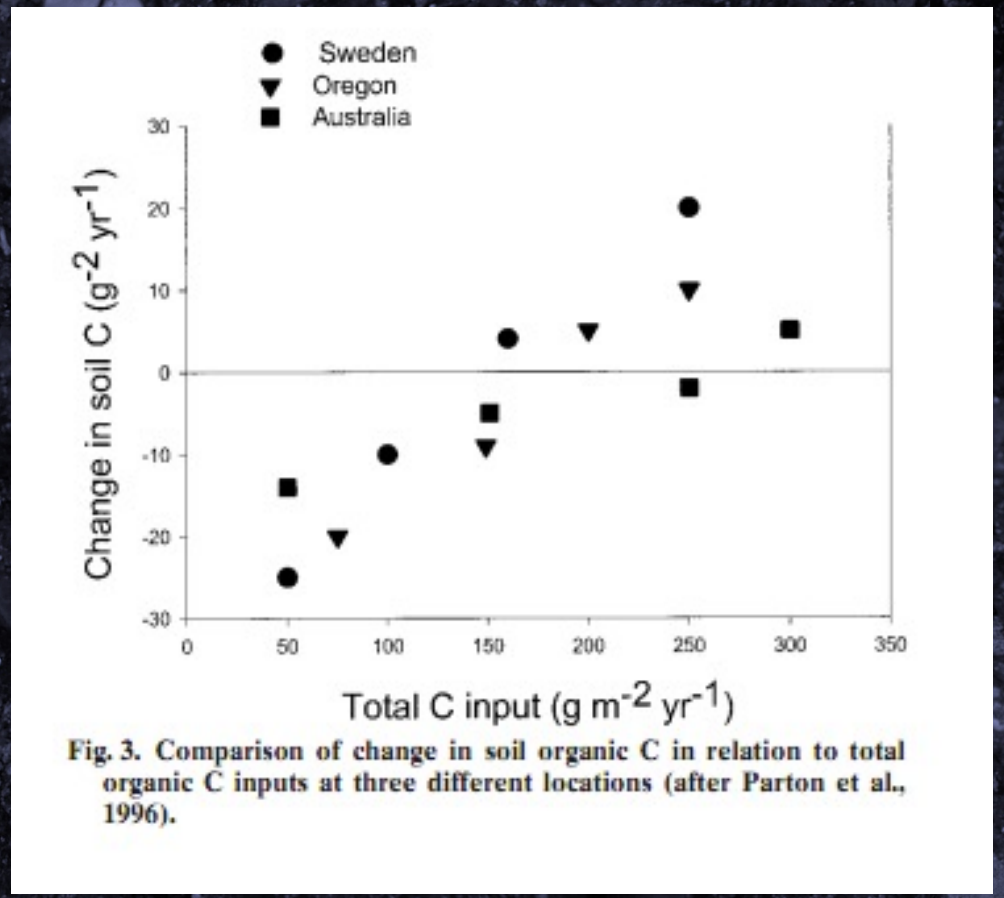
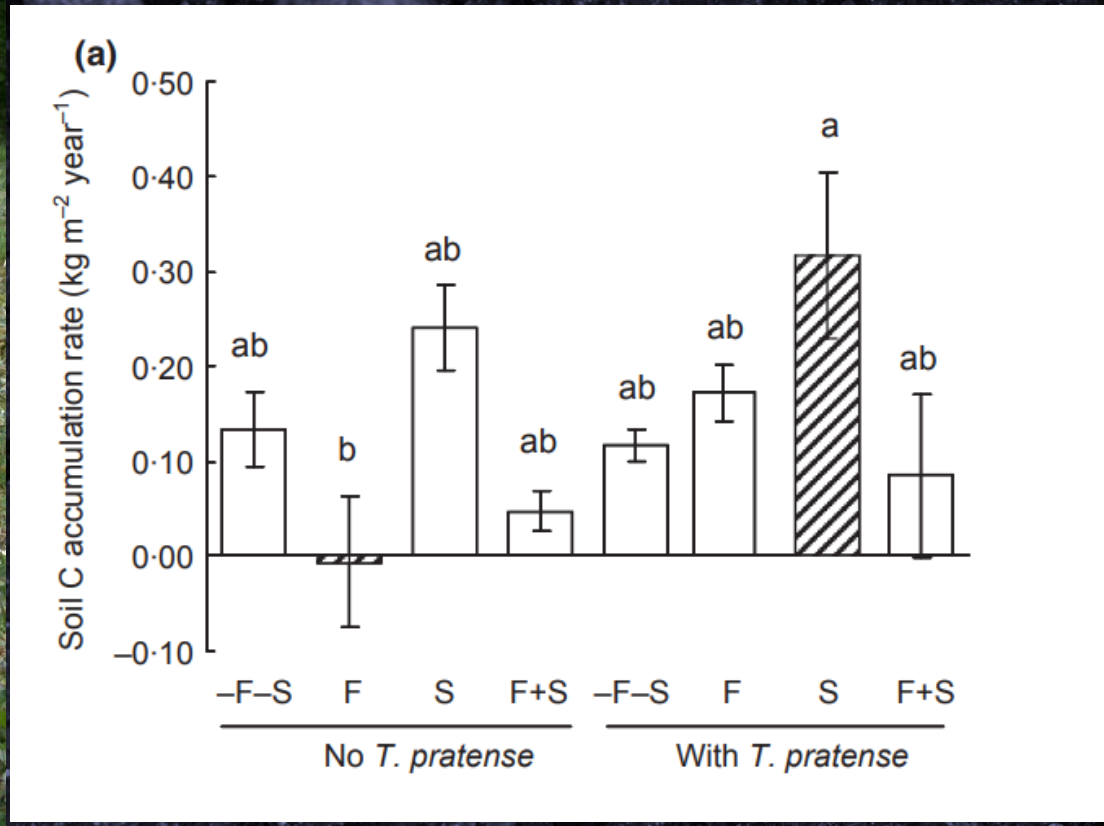


Fig. 3. Comparison of change in soil organic C in relation to total organic C inputs at three different locations (after Parton et al., 1996).

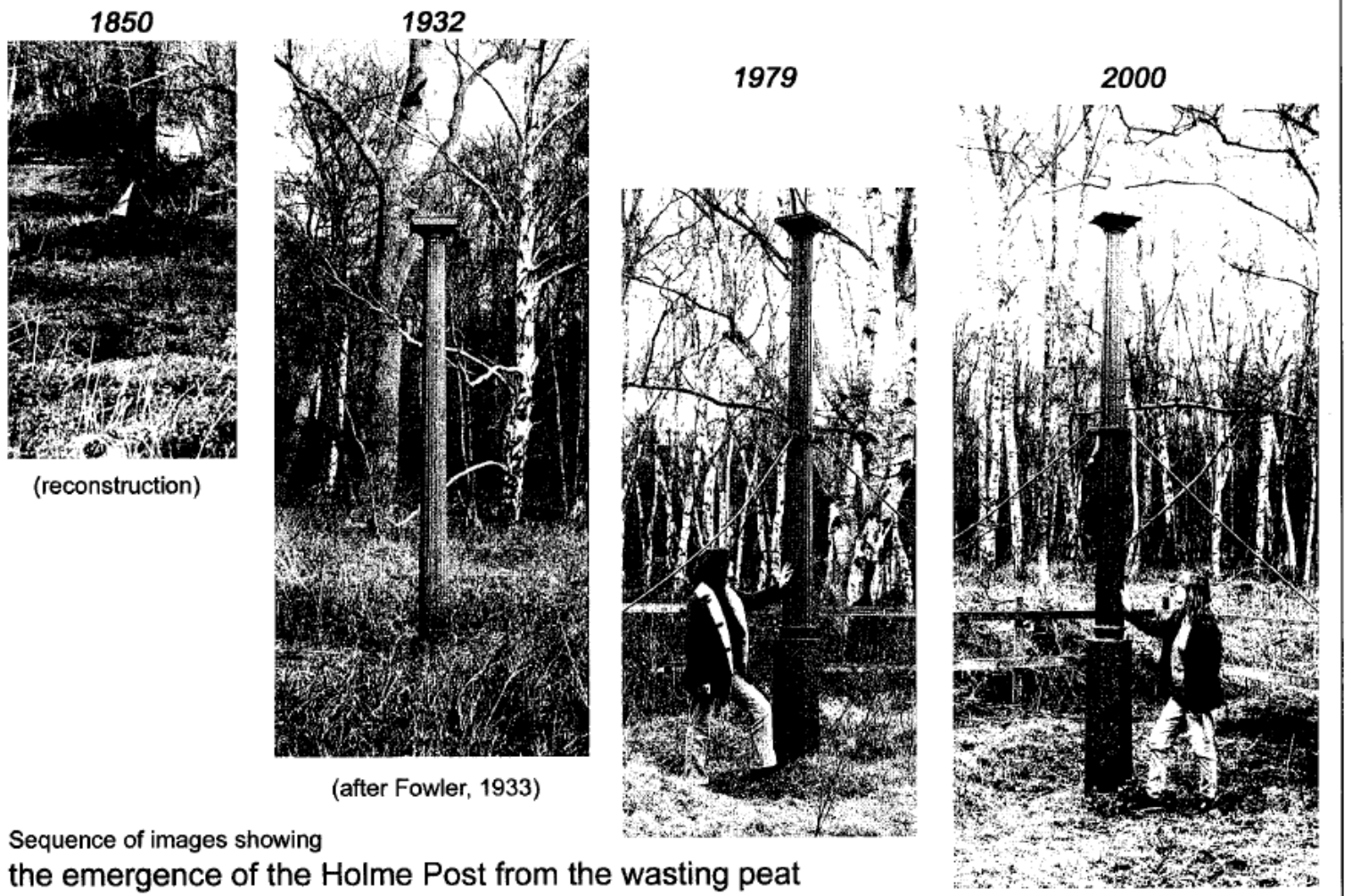
From Carter (2002) Agron. J. 94:38–47 (2002

3. Support biodiversity restoration especially including legumes



De Dyn et al (2010)

4. Keep organic soils wet



Sequence of images showing
the emergence of the Holme Post from the wasting peat

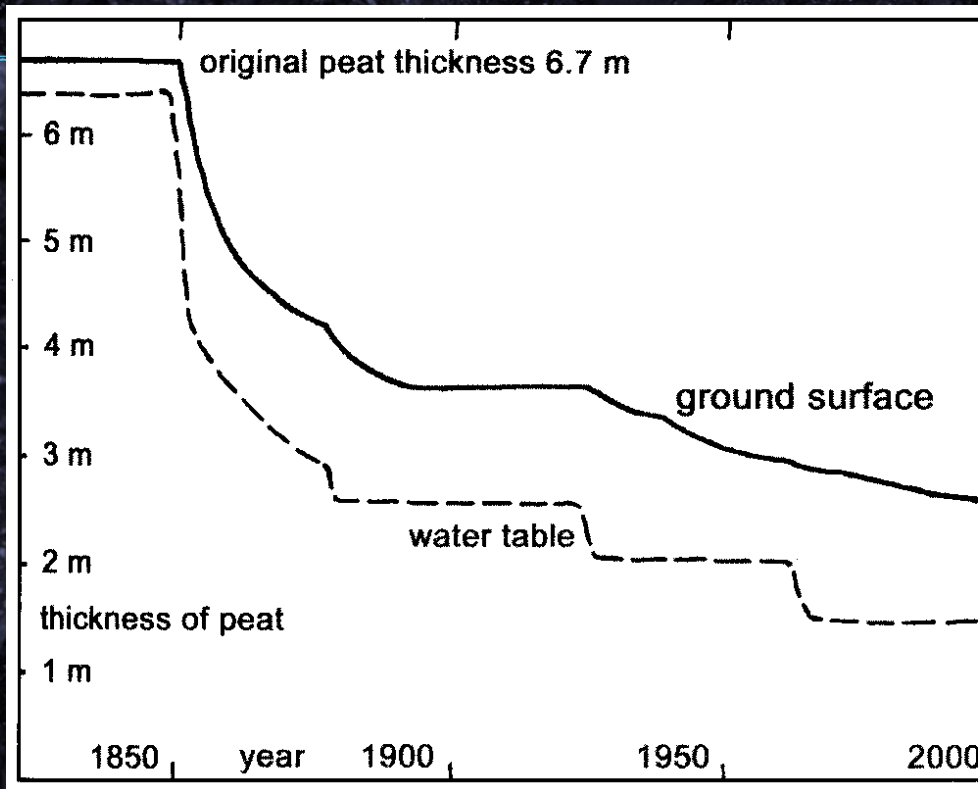


Figure 3. The record of ground subsidence on the peat ove
150 years at the Holme Post, correlated with water tabl
levels that declined in response to the successive stages o
pumped drainage.

The Holme Fen post


Which soils have the largest carbon densities in the AONB?

1st

Down Holland association
Soils formed in valleys, floodplains, tidal flat
marshes and raised beaches
Extremely variable

Gleyed soils common
In hollows peaty gley soils predominate.

2nd

Malham-Lonsdale complex

Where limestome pavement interspersed with small level areas and hollows containing soils formed on stoneless silt loam (drift)
Acid brown earths :deeper (50 cm),
Shallow calcareous soils (Rendzinas)

3rd

Marian-rock complex
Scree and limestone crags covered in places by a dark brown or black fibrous calcareous soil
Shallow (3-30 cm) and free draining
pH 6.9 at surface

Take homes

- Soils store a lot of carbon and there is potential to protect or increase this
- Remember:
  - Plant cover,
  - Organic additions,
  - promote biodiversity (esp legumes),
  - don't disturb grass and woodland soils,
  - and keep organic soils wet
- We have rich diversity of soils in the AONB