Soil carbon: part of the journey to net zero?

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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 m²

Stocks require us to know the density of the soil
Carbon Dioxide Equivalent (CO2e) 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 CO2 needed to create the same effect, and presented in this report as CO2e.
Soil Carbon cycle
Global terrestrial carbon cycle

Soil 2400

Vegetation 760

Atmosphere 760

60

50

110

62

1 Petagram (Pg) = $1 \times 10^{15}$ g

Adapted from Brady and Weil (2008)
Ready cash versus savings

0 – 2 yrs

10– 1000 yrs
Where is the soil carbon?
Soil carbon with depth

Soil pit: deep ploughed

Soil pit: margin

Carbon stock (Kg)

Depth (cm)

Carbon stock assessment near Appleby

20.5 kg
Total stock
17.8 kg
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 potential of soil carbon to contribute to net zero

Land area of UK = 243,610 km²

UK soil carbon stock = $1 \times 10^{13}$ kg

If you could increase this by 0.02% per year, this would equal $2 \times 10^9$ kg per year or 2 million tonnes or

7.3 million tonnes CO₂e

From Bradley et al (2005)
**UK carbon emissions**

Figure 1.1 UK estimated GHG emissions for agriculture, 1990 and 2020 (million tonnes carbon dioxide equivalent, MtCO2e)

- **UK Agriculture: total GHG emissions**
  - 1990: 53.6
  - 2020: 44.8

- **Nitrous oxide emissions**
  - 1990: 18.1
  - 2020: 14.5

- **Methane emissions**
  - 1990: 29.0
  - 2020: 24.8

- **Carbon dioxide emissions**
  - 1990: 6.5
  - 2020: 5.5

**Soil sequestration potential**: 7.3

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

- Vegetation: 760 Pg
- Atmosphere: 760 Pg
- Soil: 2400 Pg

Flows: 60 Pg yr\(^{-1}\)

Adapted from Brady and Weil (2008)

1 Petagram (Pg) = 1 \times 10^{15} g
1. Maintain a permanent plant cover

Ostle et al (2009) Soil C content for broad habitat types
2. Don’t disturb grassland or woodland

SOC changes following land use change, Rothamsted

Movement towards new equilibrium SOC content

2. Do add animal manures, compost, or leaf litter.
Adapted from Johnston et al. (2009) photo David Powlson.
Long-lasting effects of management on soil C & N

Hoosfield spring barley experiment,
Started 1852

Fig. 1. Hoosfield Barley Experiment, Rothamsted, UK. Total N, g kg⁻¹, 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.

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).

3. Support biodiversity restoration especially including legumes

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 over 150 years at the Holme Post, correlated with water table levels that declined in response to the successive stages of pumped drainage.

The Holme Fen post
Which soils have the largest carbon densities in the AONB?
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.
What about the soils of the AONB

Where limestone 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)

Malham-Lonsdale complex
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