The Pros and Cons of Soil Carbon Sequestration

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Soil carbon sequestration: Problems, possibilities and practices.
A workshop organised by the FCRN, London, 21 January 2010
Outline

• The challenge
• How can carbon be sequestered in agricultural soils
• Global mitigation potential for soil C sequestration
• Comparison with other GHG mitigation measures
• Limitations of soil C sequestration
• Conclusions
What are our emission reduction targets?

- UK Climate Change Act (2008)
  - Targets of 34% (or 42%) reduction in UK emissions by 2020, and 80% by 2050

- Climate Change (Scotland) Act (2009)
  - The Act places a duty on the Scottish Ministers to reduce the net Scottish emissions account by 42% by 2020, and 80% by 2050.
UK emissions now and in 2050

Source: UK Committee on Climate Change
What will it cost?

• 80% cut in GHG emission by 2050 relative to 1990: all GHGs, aviation and shipping included

• 42% cut in GHGs by 2020 relative to 1990 (31% relative to 2005)

• 2020 cost less than 1% of GDP
How does soil C sequestration work?

Increase C inputs......or reduce C losses

Organic carbon source

Add to soil

CO₂

Some C is stabilised in the soil

Soil C cycle

e.g. residue management, organic amendments, increased plant C input...

e.g. restore & rewet farmed organic soils

Soil

C in soil
How does soil C sequestration work? – reduced disturbance

No-till

Tillage breaks open aggregates

Organic material (C) more exposed to microbial attack and weathering

Key:
○ = microbe
= C inside aggregate
= weathering
## Mechanisms for soil C sequestration in agriculture

<table>
<thead>
<tr>
<th>Activity</th>
<th>Practice</th>
<th>Specific management change</th>
<th>Increase</th>
<th>Decrease</th>
<th>Reduce disturbance</th>
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<td>Cropland management</td>
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<td>Increased productivity</td>
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<td>Degraded lands</td>
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Smith et al. (2008)
Manure – large & long-lasting effects

Organic C in Soil (t ha\(^{-1}\))

Farmyard manure annually

Farmyard manure 1852-1871
nothing thereafter

Unmanured

Rothamsted Hoosfield – Jenkinson 1998
Global mitigation potential in agriculture

Global biophysical mitigation potential (Mt CO$_2$-eq. yr$^{-1}$)

Mitigation measure

- Cropland management
- Water management
- Rice management
- Seaside, LUC & agroforestry
- Grazing land management
- Restore cultivated organic soils
- Restore degraded lands
- Bioenergy (soils component)
- Livestock
- Manure management

$^*$N2O
$^*$CH4
$^*$CO2

Smith et al. (2008)
High and low estimates of the mitigation potential in each region

Smith et al. (2007)
Effect of C price on implementation

Smith et al. (2007)
Global mitigation potential in agriculture (Mt CO$_2$-eq. yr$^{-1}$)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>0-20</th>
<th>0-50</th>
<th>0-100</th>
<th>0-&gt;&gt;100 (technical potential)</th>
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<td>2384</td>
<td>3149</td>
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<td>2549</td>
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</table>

Smith et al. (2007)
Global economic mitigation potential for different sectors at different carbon prices

IPCC WGIII (2007)
How do we cut GHG emissions and how much will it cost?

**Global GHG abatement cost curve beyond 2030 BAU**

Cost of abatement below €60 per tCO₂e

How do we cut GHG emissions and how much will it cost?

Global GHG abatement cost curve for the Agriculture sector
2030 curve in a societal perspective including levers up to € 60 per tCO₂e


• “There are a number of well rehearsed arguments against reliance on carbon sequestration for tackling climate change, involving saturation of the carbon sink (the carbon is only removed from the atmosphere while the tree is growing or until the soil reaches a new equilibrium soil carbon level; Smith, 2005), permanence (carbon sinks can be reversed at any stage by deforestation or poor soil management; Smith, 2005), leakage/displacement (e.g. planting trees in one area leads to deforestation in another; Intergovernmental Panel on Climate Change (IPCC), 2000), verification issues (can the sinks be measured; Smith, 2004), and total effectiveness relative to emission reduction targets (only a fraction of the reduction can be achieved through sinks; IPCC, 2007)”.
Saturation – the time course of C sequestration

- Sink saturation ~ 20-100 years
- Sink strength declines towards new equilibrium

Smith (2004a)
Permanence

Year

Total SOC to 23 cm (t C ha\(^{-1}\))

Conversion to low-input cropland

Management change

Manure treatment in red, Woodland in blue

Smith (2005)
Leakage / displacement: are we actually sequestering carbon or just moving it about?

More manure here….but……..less manure here

Effect over the whole cropland area = zero
Verification

Value of C sequestered

No. of samples required to demonstrate increase in soil C

Cost

Zero return

Value of C sequestered

Smith (2004b)
“Trying to sequester the geosphere in the biosphere”

- The C we release through fossil fuel burning has been locked up for ~300 Million years and was accumulated over many millions of years – we are trying to lock that up over years / decades – it does not add up!
- “It is easier to leave the marbles in the jar than to tip them out and try to pick them all up again” W.H. (Bill) Schlesinger
- Soil C sequestration is time limited, non-permanent, difficult to verify and is no substitute for GHG emission reduction
- Soil C sequestration may have a role in reducing the short term atmospheric CO₂ concentration, and buying us time to develop longer term solutions, largely in the energy sector
Conclusions

• Soil C sequestration globally has a large, cost-competitive mitigation potential
• Useful to meet short / medium term targets – especially if these are high (e.g. in UK)
• Many co-benefits – soil fertility, workability, water-holding capacity etc. (see other talk)
• Don’t forget the limitations: time limited, not permanent, doesn’t replace genuine emission reduction
Thank you for your attention