Soil: Our Natural Capital

The role of soil and soil management in decarbonising agriculture

Professor R Jane Rickson, FIAgrE
Cranfield Soil and AgriFood Institute
Cranfield University

Institution of Agricultural Engineers Annual Conference
October 11th, 2017

www.cranfield.ac.uk

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Soil: Our Natural Capital
The role of soil and soil management in (de)carbonising agriculture

Outline of the presentation

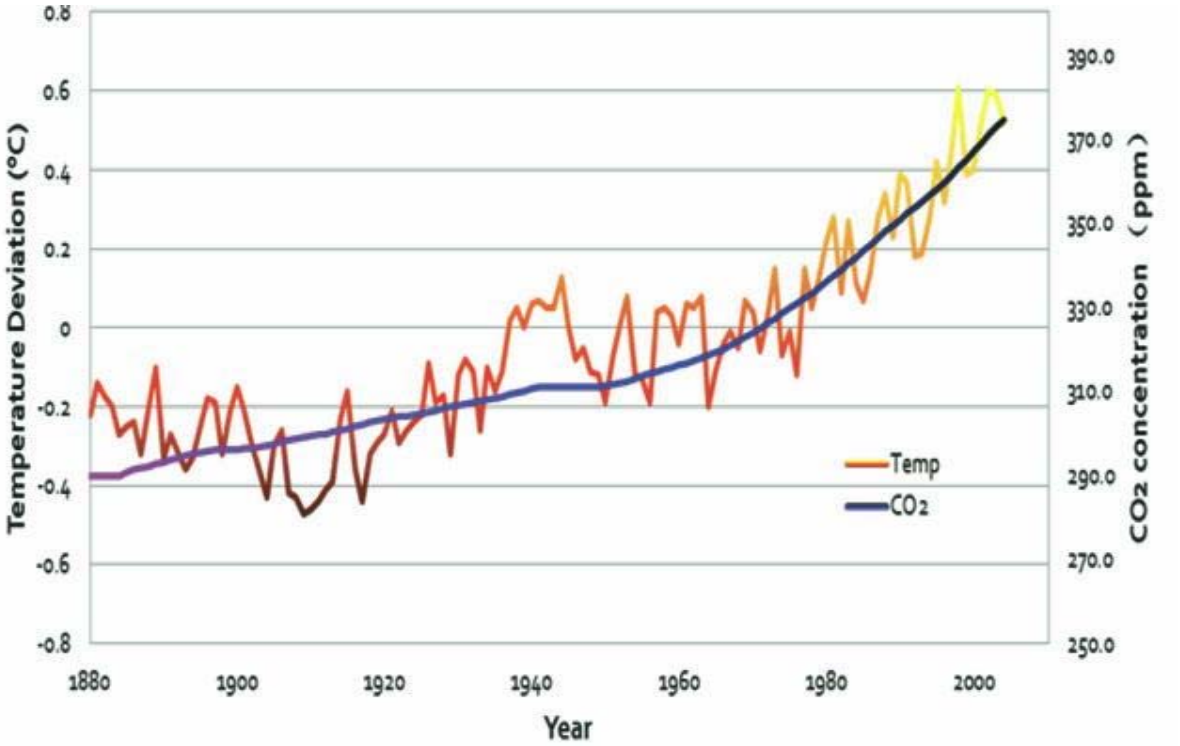
1. The issue of carbon and climate change
2. The role of soil in the carbon cycle
3. How much soil carbon do we have?
4. How can we increase soil carbon?
5. Take home message

Acknowledgement: K. Ritz

1. The issue of CO_2 and climate change

Increased CO_2 in the atmosphere associated with:

- temperature rises (global warming)
- climate change
- extreme weather events
  - sea temperatures and hurricanes?



http://www.coalnews.net/papers/November2013/HTML/files/assets/seo/page16.html

Cumbria flooding, Carlisle, NW England, December 2015

2. The role of soil in carbon cycle

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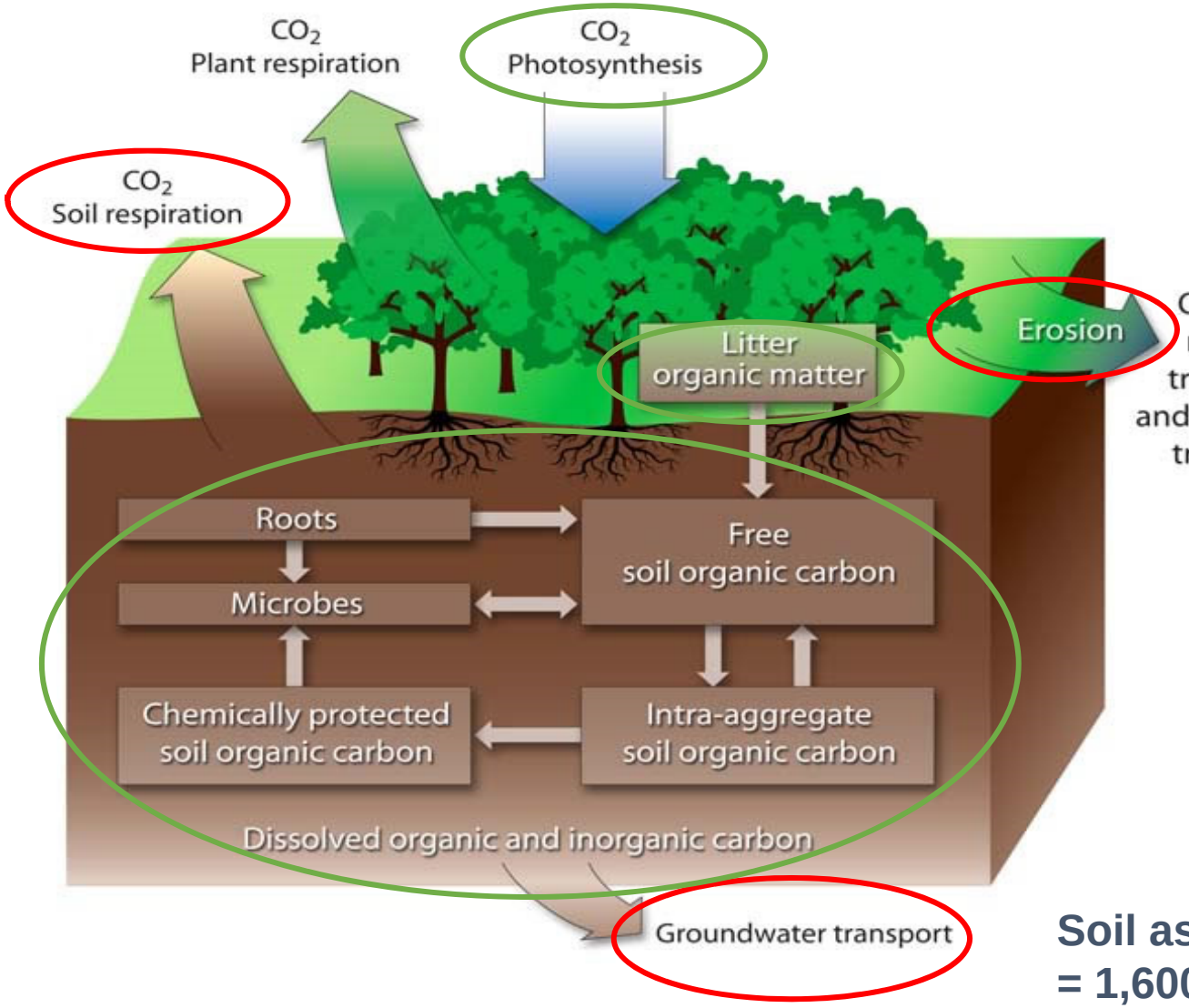
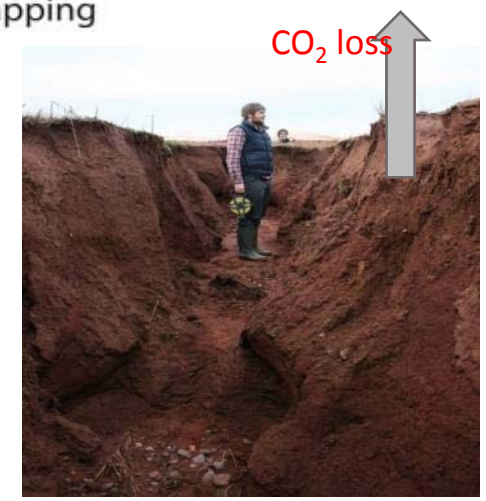
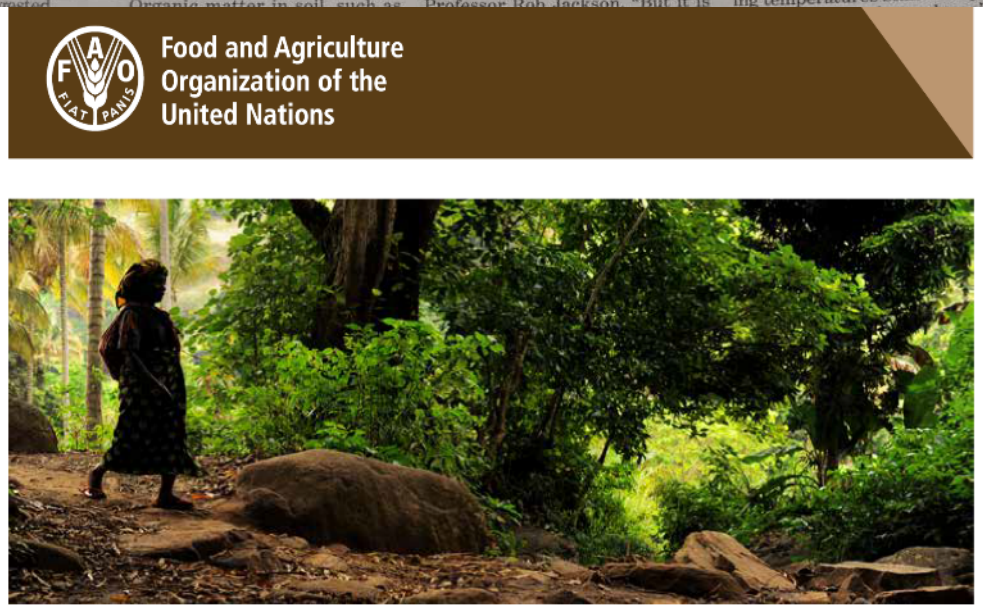




Soil as a global store of carbon
= 1,600 Gigatonnes C
= 1,600,000,000,000 tonnes C
(*N.B.* Vegetation = 610 Gt C)

https://public.ornl.gov/site/gallery/originals/Carbon_Transformation_.jpg

2.



store of carbon

– 1,600 Gigatonnes C

= 1,600,000,000,000 tonnes C

(*N.B.* Vegetation = 610 Gt C)

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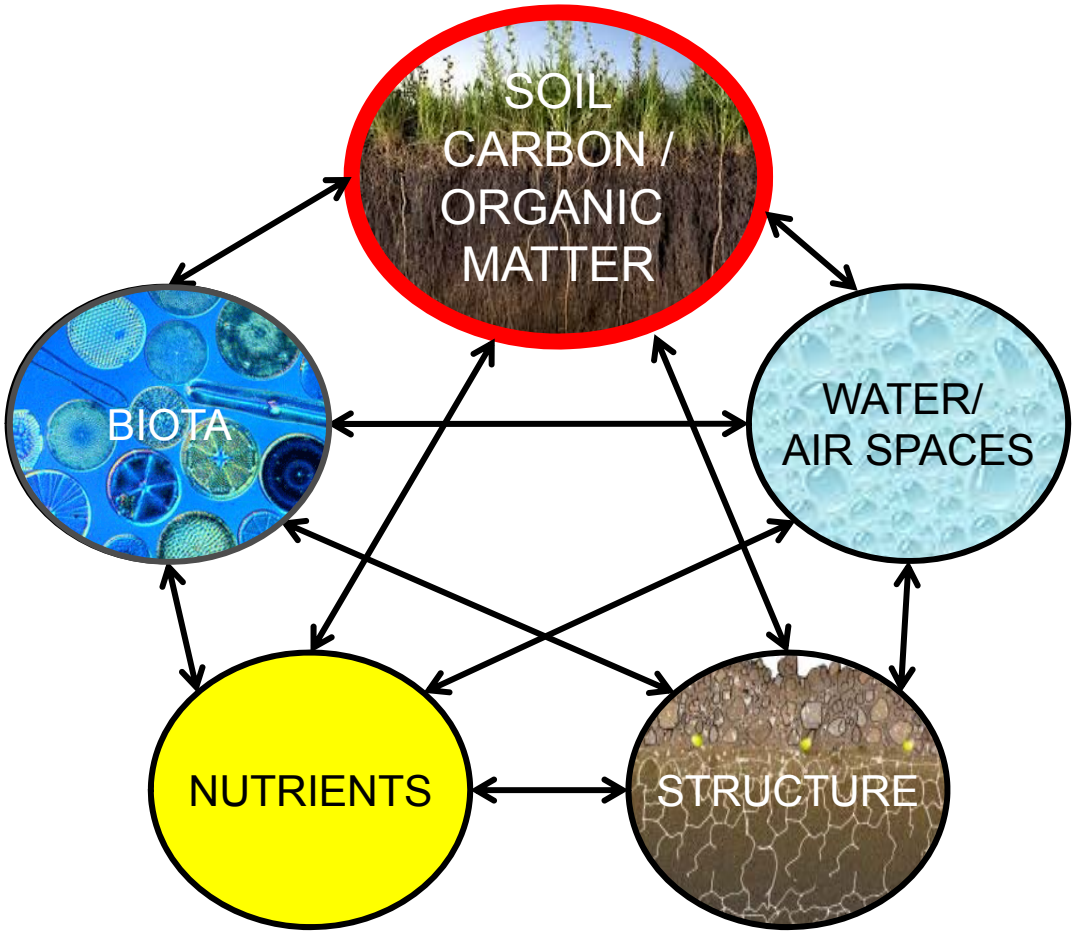
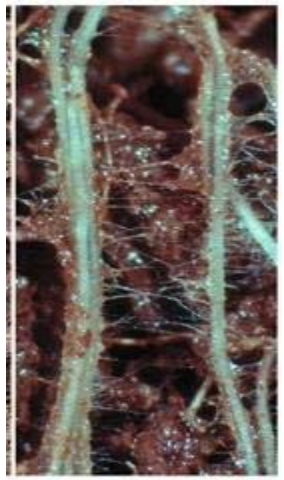
2. The role of soil in the carbon cycle

Soil carbon plays many other roles too….

Soil health and delivery of essential ecosystem goods and services



Soil health: the “pivotal 5” and their interrelationships
(after K Ritz, pers. comm)



3. How much soil carbon do we have?

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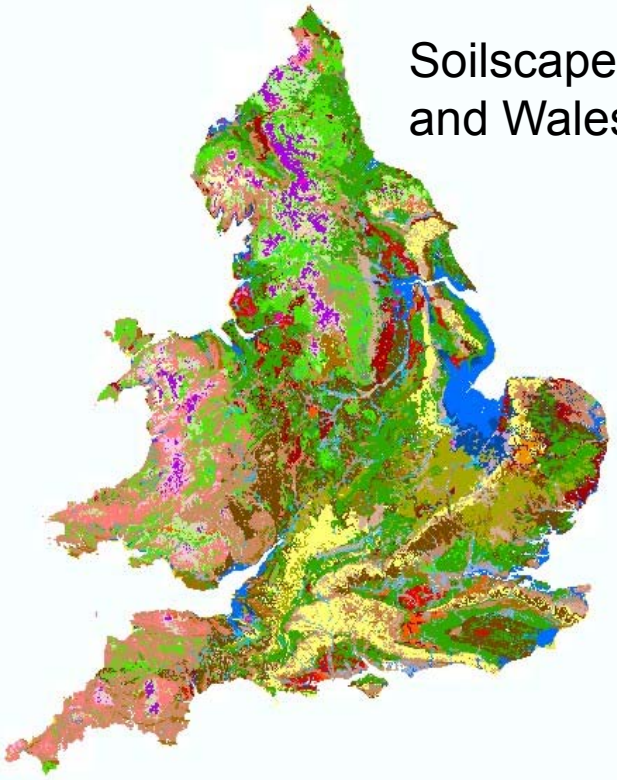
Soilscapes of England and Wales



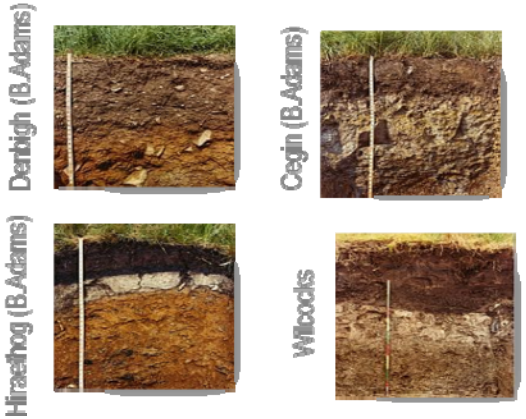
The National Soil Inventory, Soil Survey of England and Wales, 1979 – 1983

5 km grid, 0 – 15 cm depth

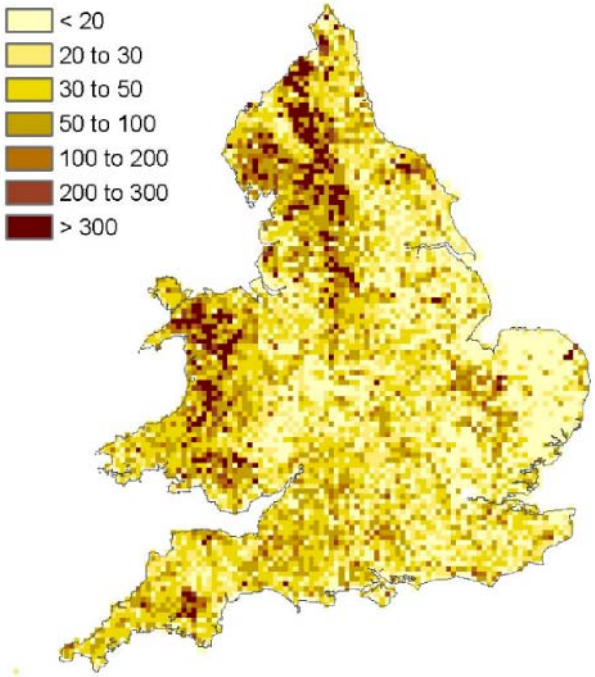
Organic carbon, pH, metal concentrations, nutrients

747 Soil Series

306 Soil Associations



Carbon g kg^{-1} (c. 1980)



3. How much soil carbon do we have?

- Some sites resurveyed 1994 – 2003
- Mean annual rate of loss = 0.6 g of organic carbon per kg of soil
- For soils with >100 g carbon per kg, annual rate of loss = > 2 g per kg

Estimated annual soil C loss:

England & Wales alone

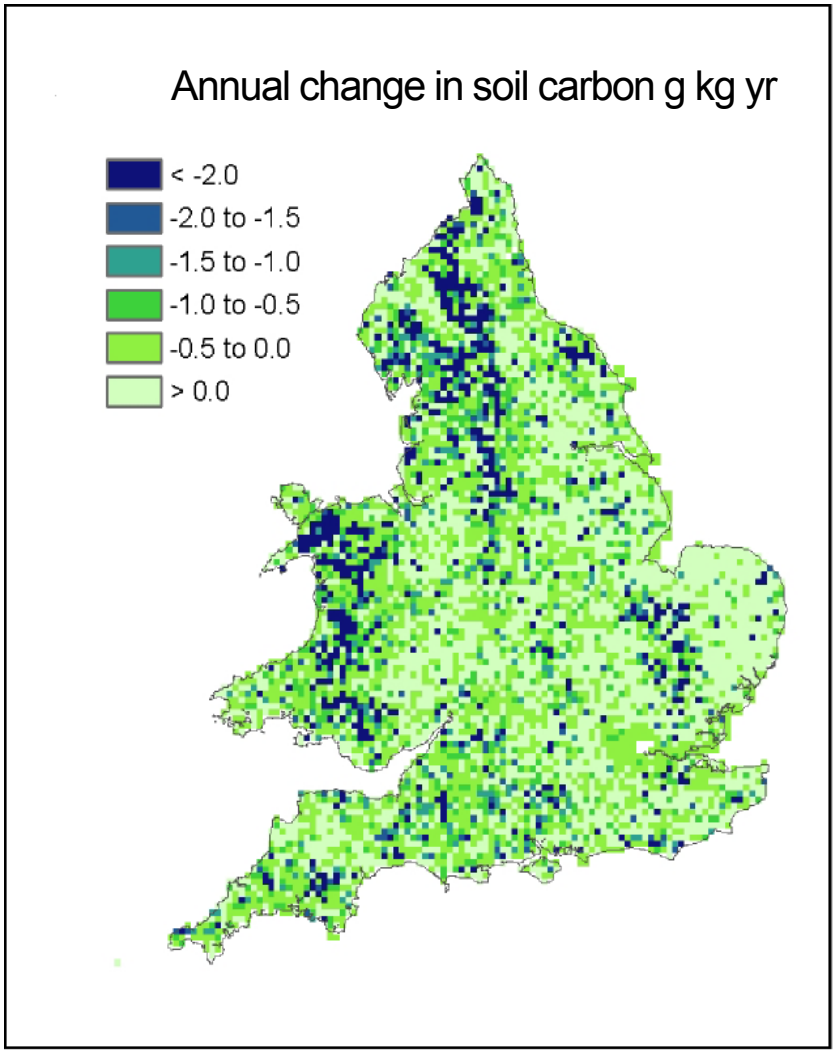
≈ 4.4 million tonnes

(costs c. £558 million/ yr (Graves et al., 2015))

For UK ≈ 4.4 x UK / E&W C stock

≈ 13 million tonnes

???How can this be replaced?



Carbon losses from all soils across England and Wales 1978-2003 (2005) Pat H. Bellamy, Peter J. Loveland, R. Ian Bradley, R. Murray Lark & Guy J.D. Kirk, *Nature* 437 pp 245 – 248.

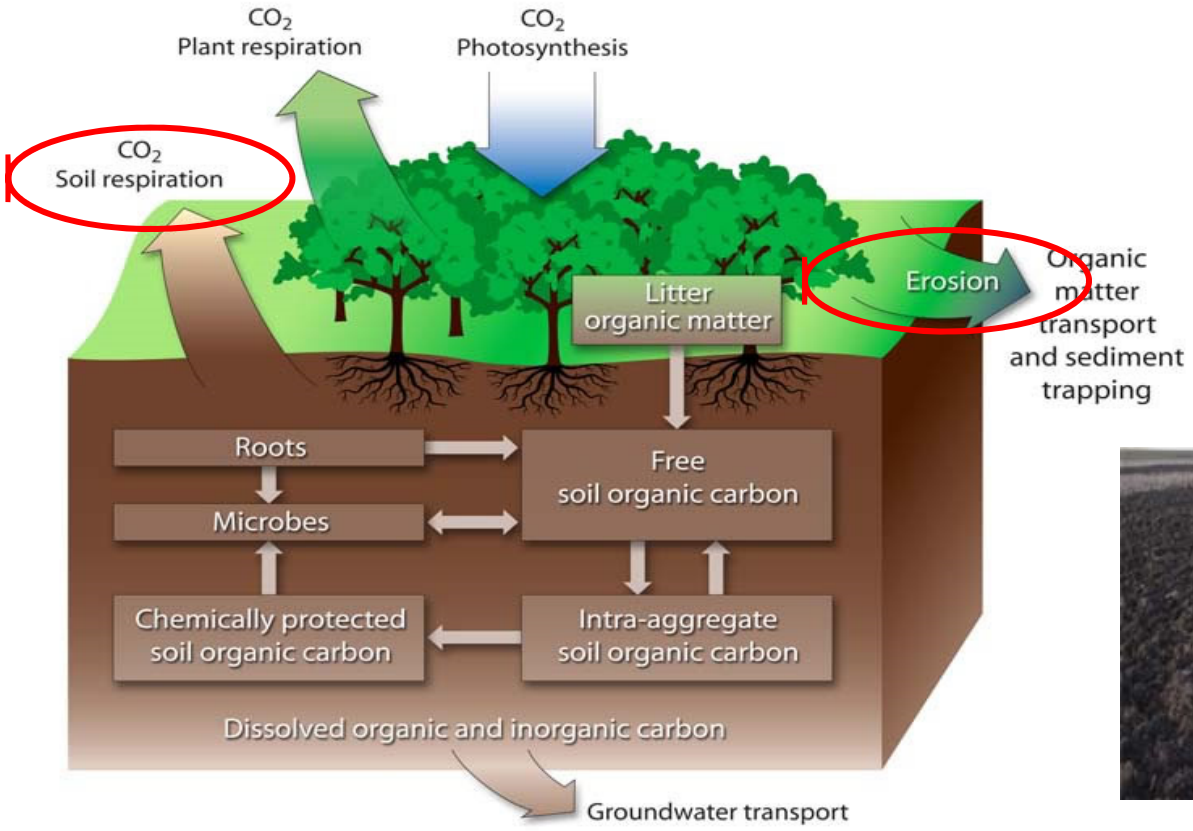
4. How can we increase soil carbon?

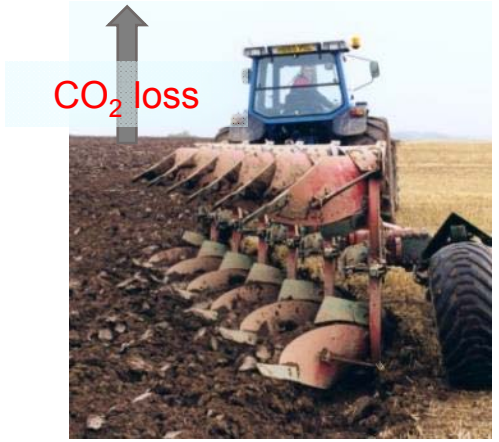
4. How can we increase soil carbon?

A. Reduce CO_2 losses from soils

Avoid exposing soil carbon (C) to the atmosphere (oxygen; O_2) = CO_2

- **less inversion tillage; more non-inversion, reduced tillage system**





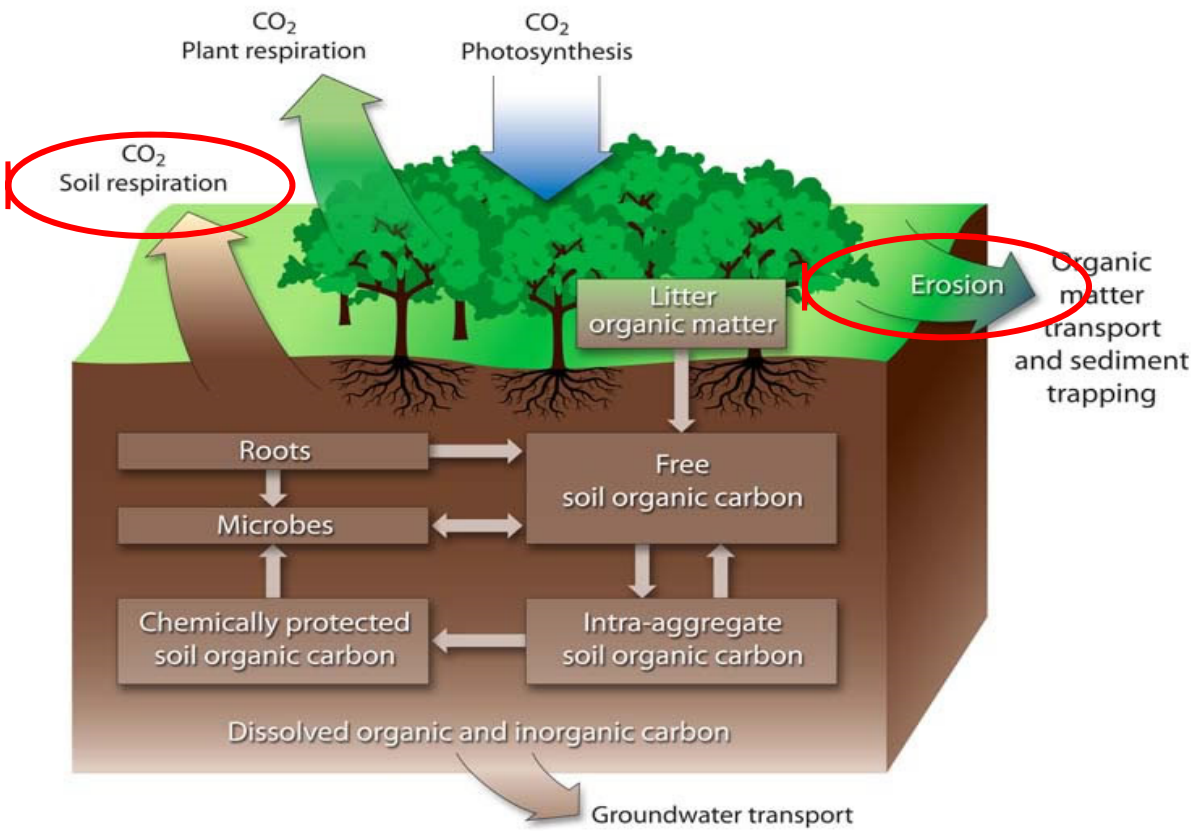
Acknowledgement: Iain Dummett

4. How can we increase soil carbon?

A. Reduce CO_2 losses from soils

Avoid exposing soil carbon (C) to the atmosphere (oxygen; O_2) = CO_2

- less inversion tillage; more non-inversion, reduced tillage system
- **less soil erosion**



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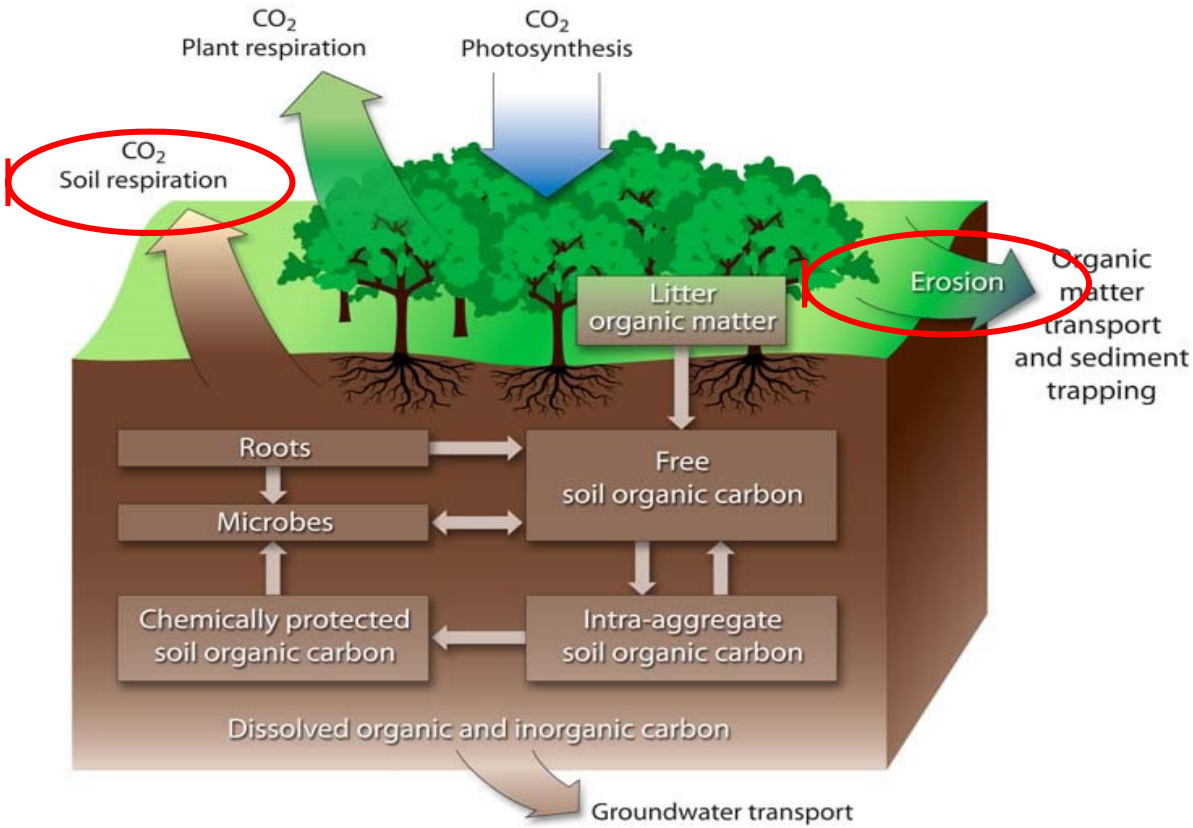
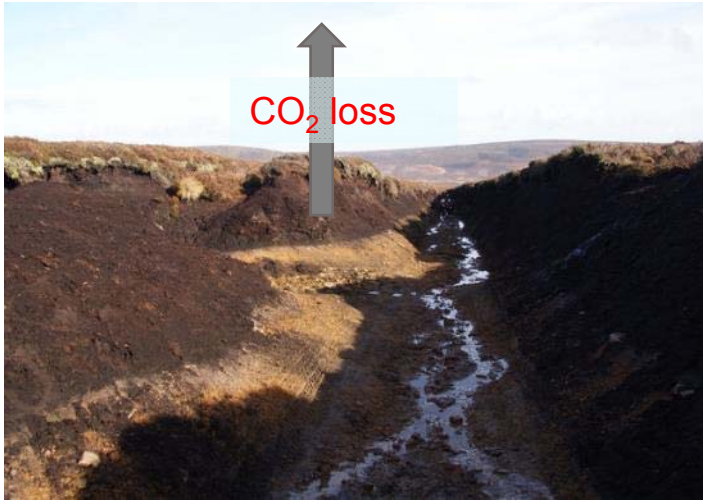
A. Reduce CO_2 losses from soils

Avoid exposing soil carbon (C) to the atmosphere (oxygen; O_2) = CO_2

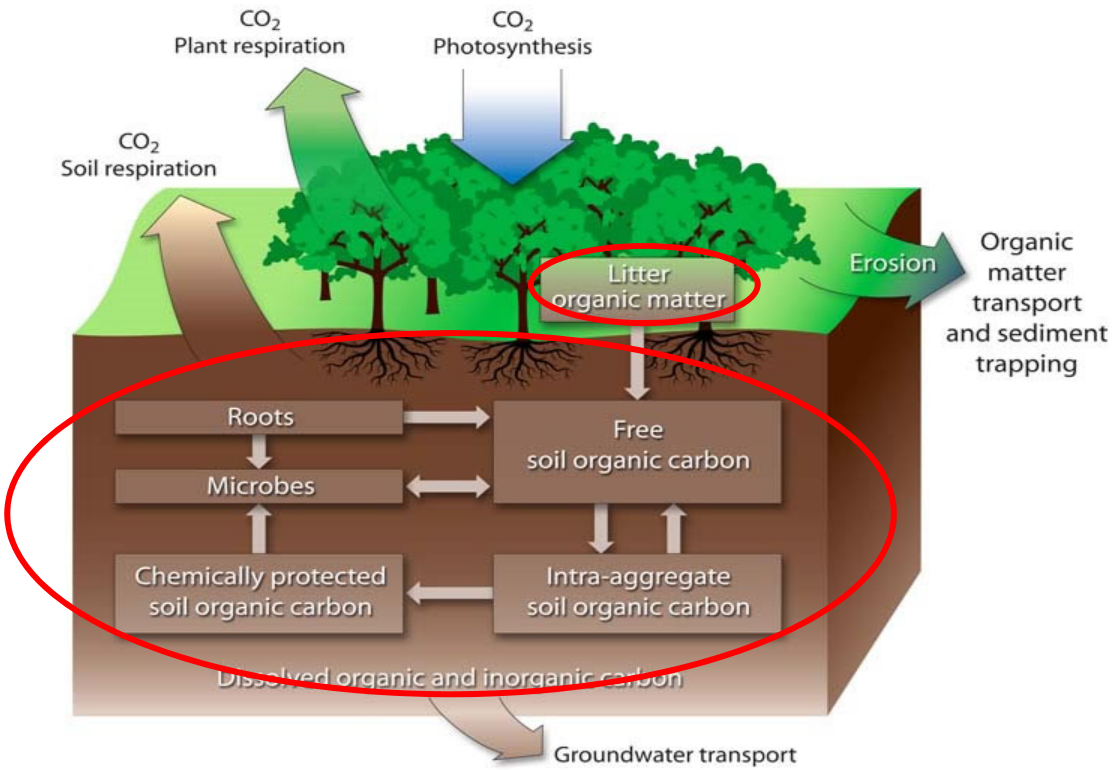
- less inversion tillage; more non-inversion, reduced tillage system
- less soil erosion
- **avoid draining wetlands**





4. How can we increase soil carbon?

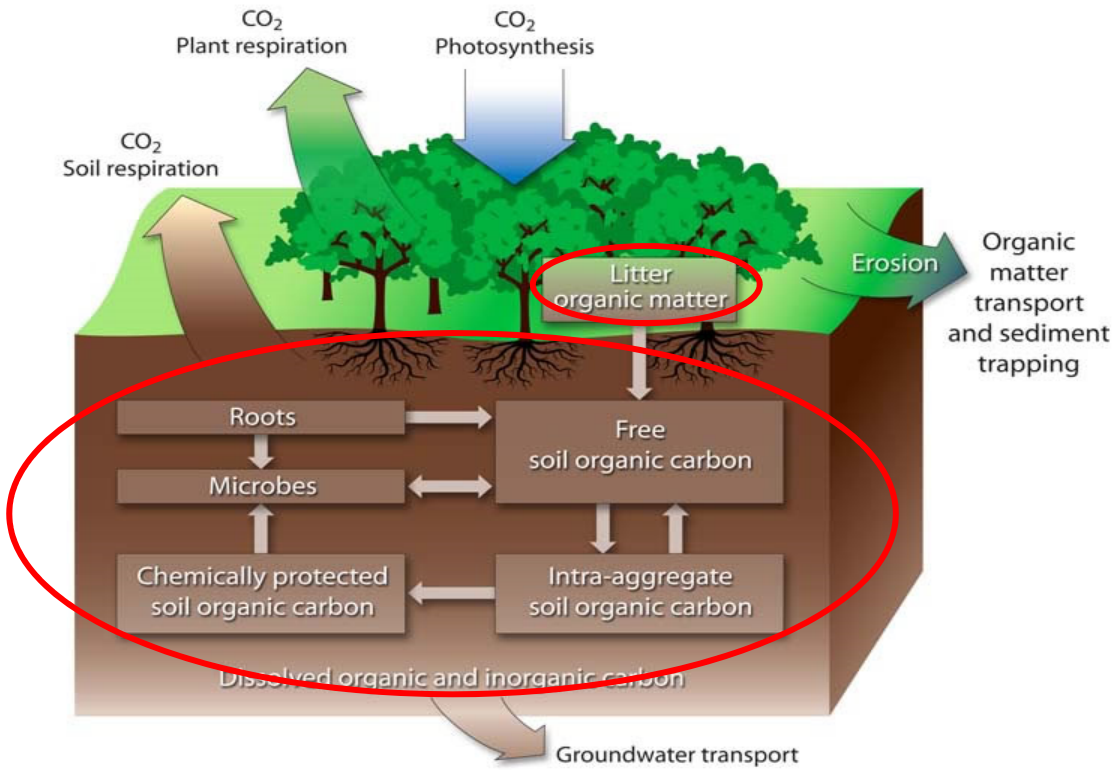
B. Increase soil carbon storage (sequestration)



4. How can we increase soil carbon?

B. Increase soil carbon storage (sequestration)

- **Change land use (e.g. arable to forestry or agroforestry)**
  - e.g. Scottish Government: 16,000 ha per year of new forest planting (March 2016)



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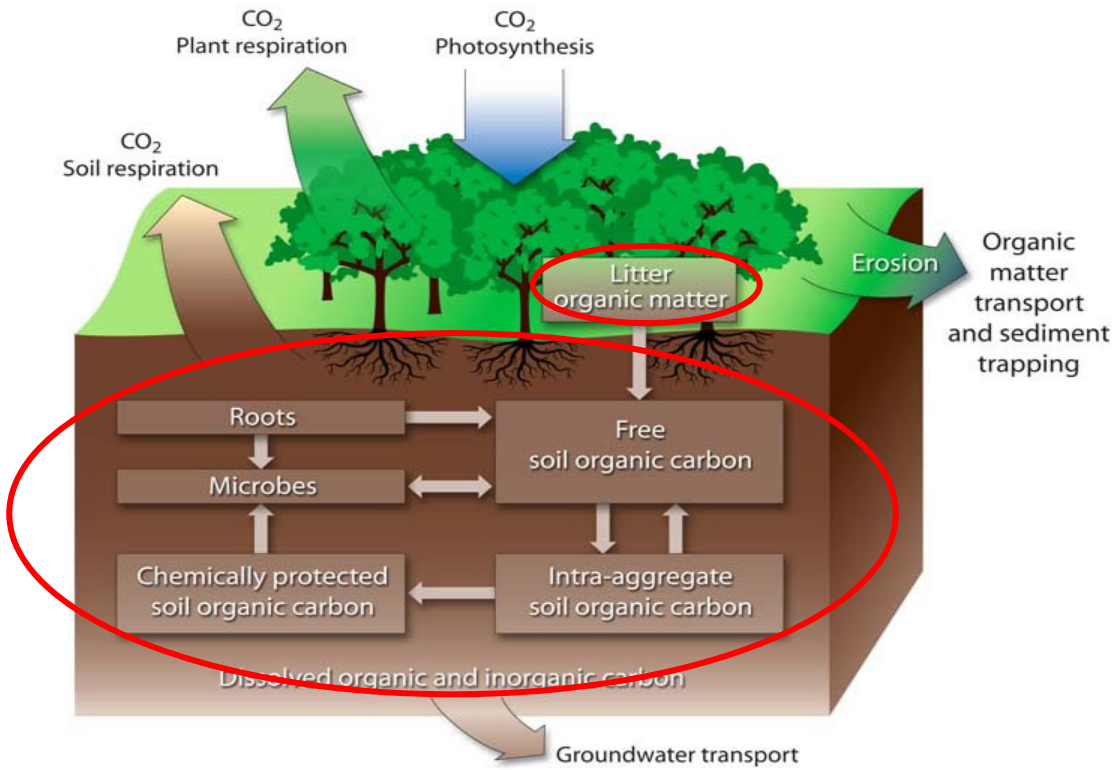
- Change land use (e.g. arable to forestry or agroforestry)
- **Reduced tillage systems (retain residues [and reduce CO_2 emissions])**



Reduced tillage systems and carbon storage (Dr Mikhail Giannitsopoulos)


Control Treatment: Two Pass

Claydon Hybrid

Sumo DTS

Mzuri Pro-Til 3

Vaderstad Seed Hawk

Vaderstad Rapid A

Results: How tillage affects soil quality e.g. soil carbon

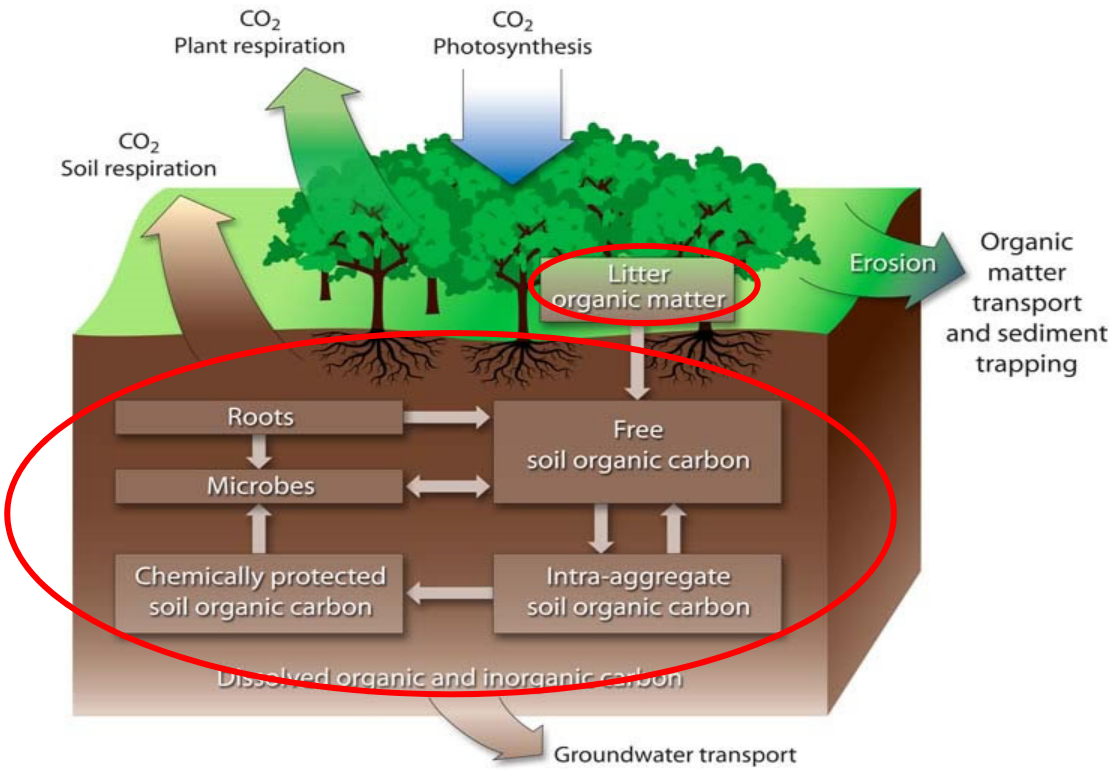
Different letters show statistically significant differences

	Penetration resistance MPa	Organic carbon (%)	Microbial biomass carbon (µg C g soil^{-1})	Earthworms / m^2
1	0.50 ^{c}	2.710 ^{b}	339.1 ^{b}	75.0 ^{c}
2	0.60 ^{bc}	2.789 ^{ab}	321.8 ^{b}	118.8 ^{b}
3	0.70 ^{ab}	2.829 ^{ab}	380.2 ^{ab}	137.5 ^{b}
4	0.61 ^{abc}	2.714 ^{b}	379.8 ^{ab}	103.1 ^{bc}
5	0.76 ^{a}	2.985 ^{a}	443.8 ^{a}	187.5 ^{a}

4. How can we increase soil carbon?

B. Increase soil carbon storage (sequestration)

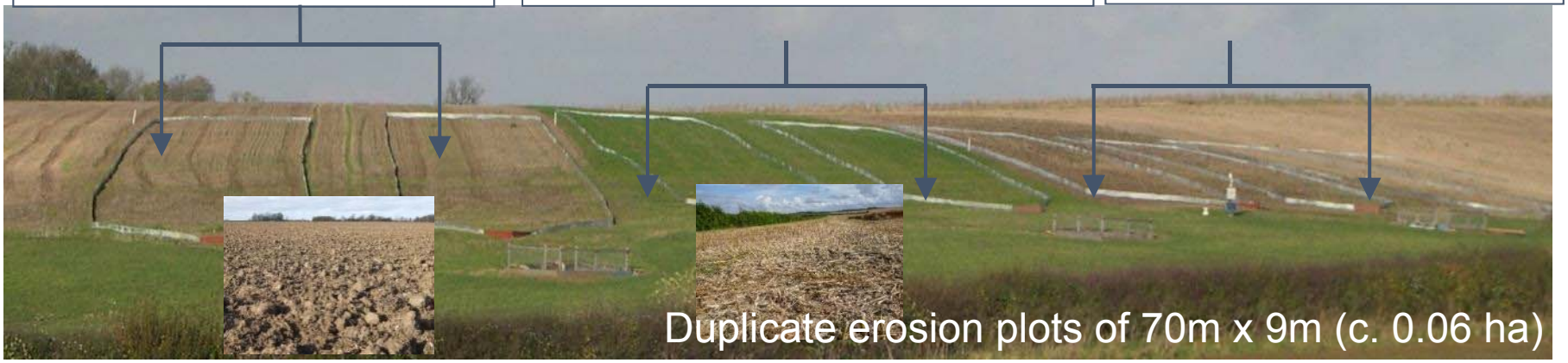
- Change land use (e.g. arable to forestry or agroforestry)
- Reduced tillage systems (retain residues [and reduce CO_2 emissions])
- **Control erosion (C losses in sediment and runoff)**

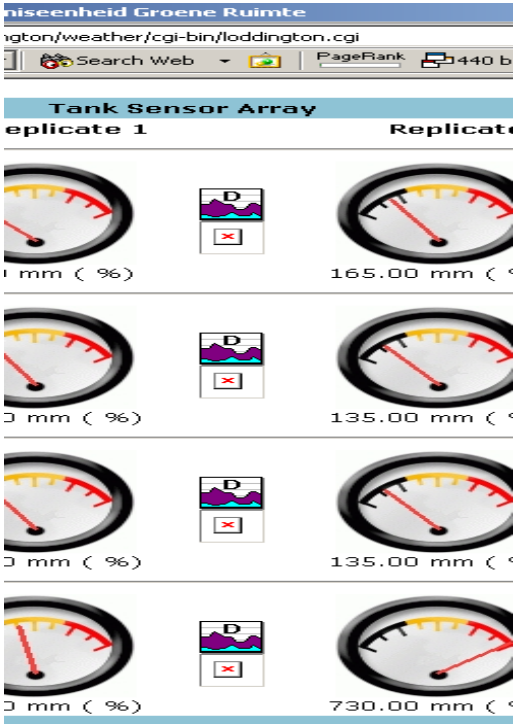


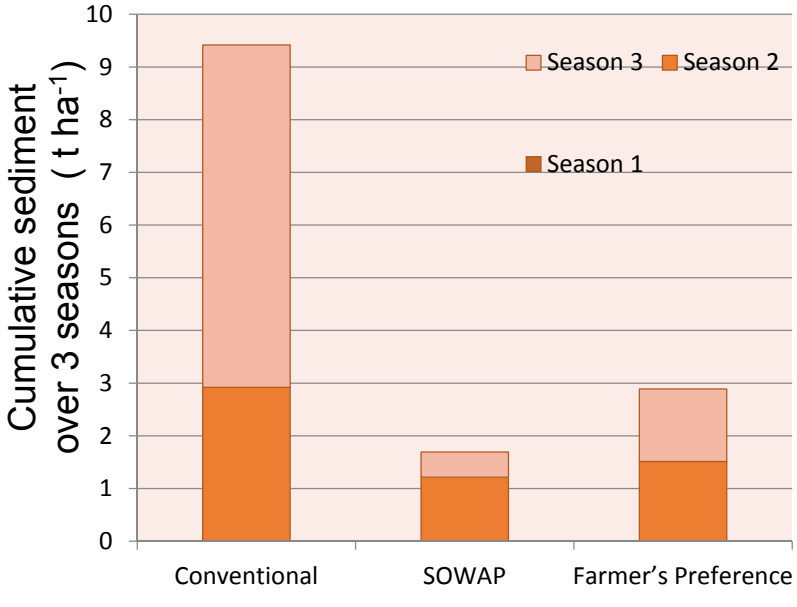
B. Increase soil carbon storage: Reduce soil erosion

Soil and Water Protection in Northern Europe (SOWAP)

Conventional practice | SOWAP (Minimum tillage) | Farmer's Preference







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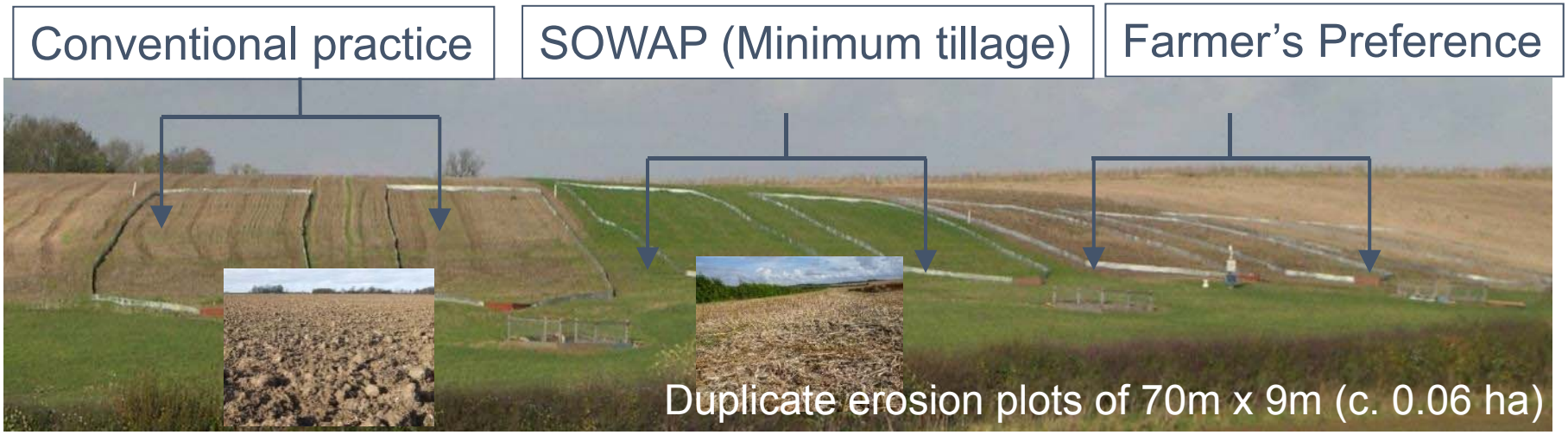
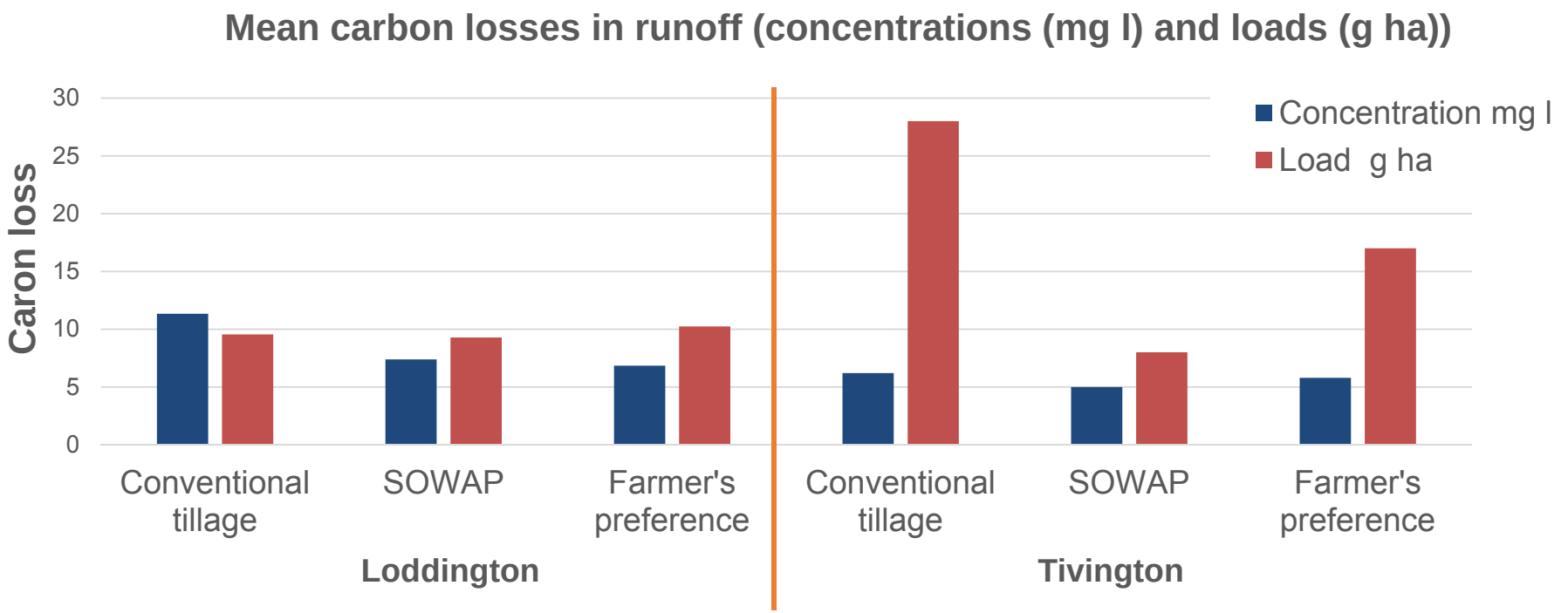
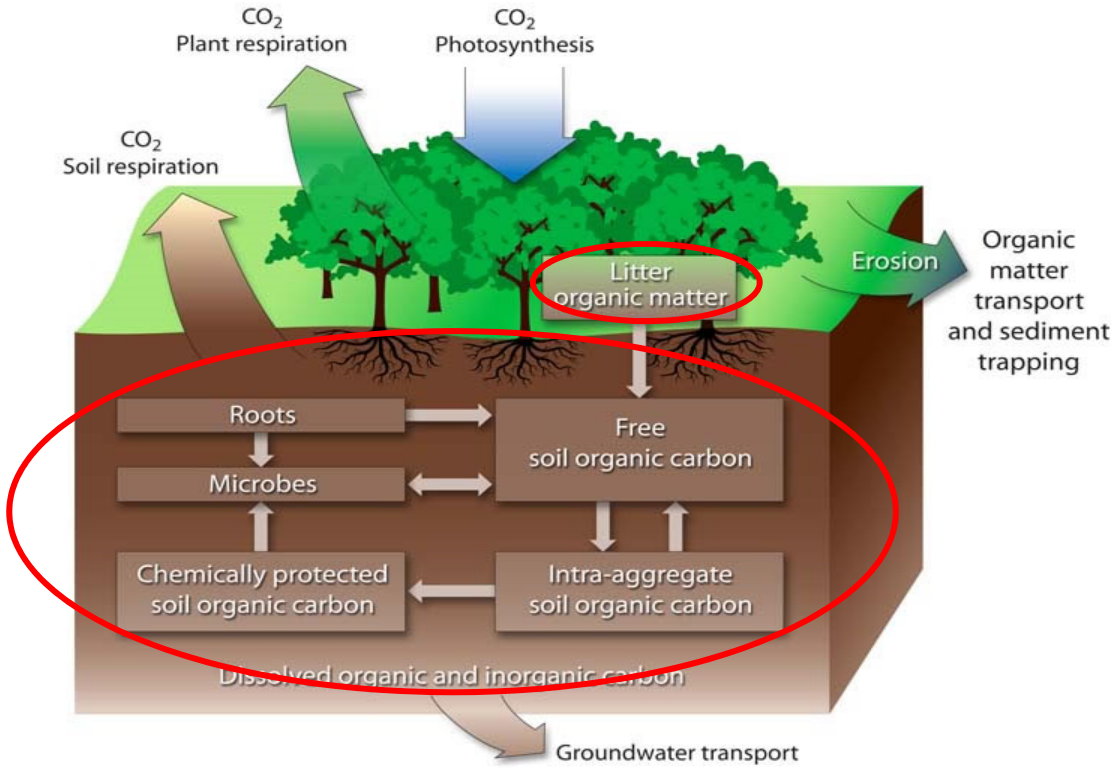




4. How can we increase soil carbon?

B. Increase soil carbon storage (sequestration)

- Change land use (e.g. arable to forestry or agroforestry)
- Reduced tillage systems (retain residues [and reduce CO_2 emissions])
- Control erosion (C losses in sediment and runoff)
- **Add soil organic amendments**



B. Increase soil carbon storage

Application of organic waste to restore soil health and productivity of a degraded soil (Benedict Unagwu, PhD student)

Improve Soil Quality Indicators (SQIs, including soil carbon)?

Mushroom compost

Poultry manure

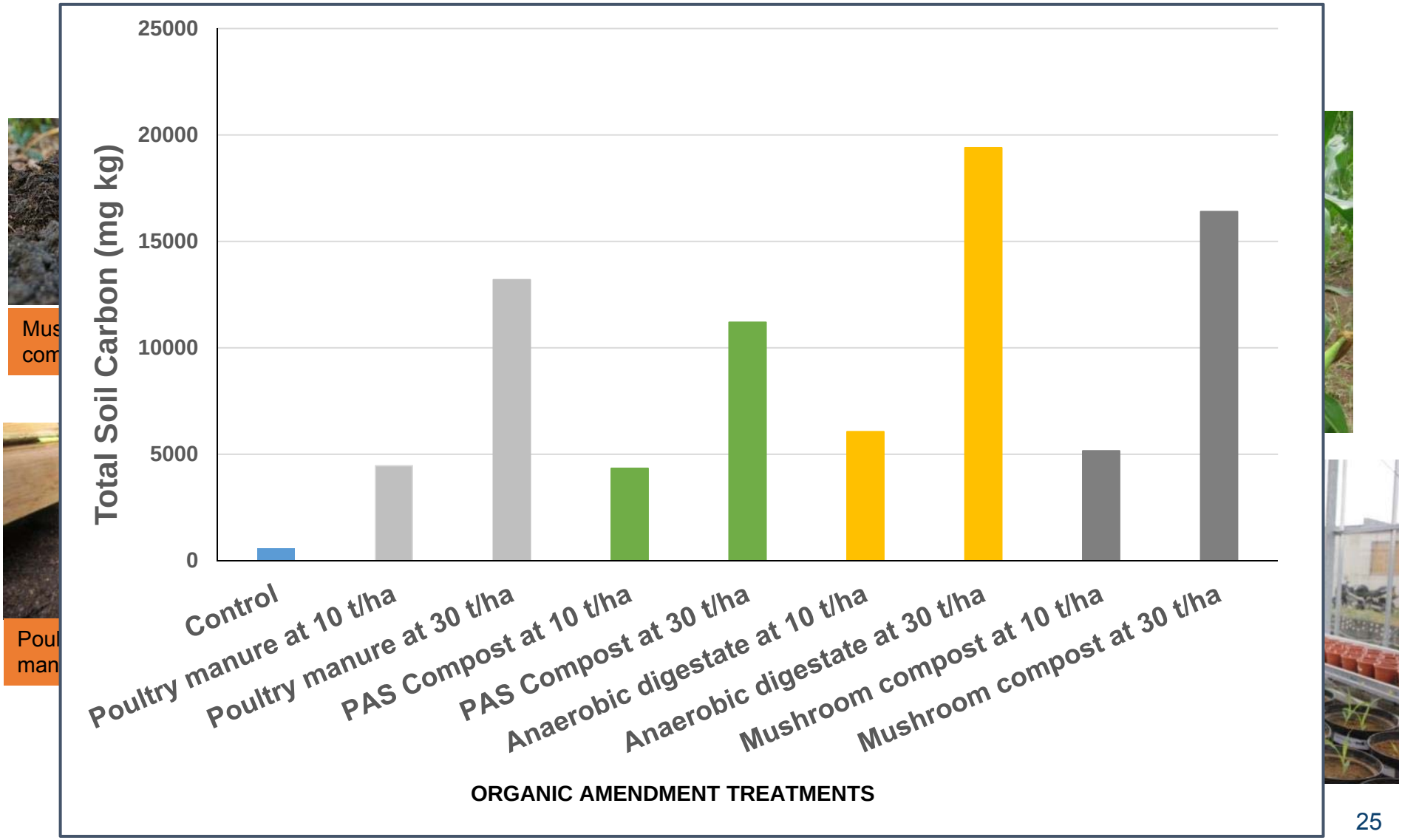
PAS compost (green waste)

Anaerobic digestate

Increase crop yield?

B. Increase soil carbon storage

Application of organic waste to restore soil health and productivity of a degraded soil (Benedict Unagwu, PhD student)



5. Take home messages

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4 PER 1000
CARBON SEQUESTRATION IN SOILS
FOR FOOD SECURITY AND THE CLIMATE

Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt

http://4p1000.org/understand

4 PER 1000
SOILS FOR FOOD SECURITY AND CLIMATE

Soil carbon 4 per mille

Budiman Minasny [a,*], Brendan P. Malone [a], Alex B. McBratney [a], Denis A. Angers [b], Dominique Arrouays [c], Adam Chambers [d], Vincent Chaplot [e], Zueng-Sang Chen [f], Kun Cheng [g], Bhabani S. Das [h], Damien J. Field [a], Alessandro Gimona [i], Carolyn B. Hedley [j], Suk Young Hong [k], Biswapati Mandal [l], Ben P. Marchant [m], Manuel Martin [e], Brian G. McConkey [b], Vera Leatitia Mulder [n], Sharon O'Rourke [o], Anne C. Richer-de-Forges [c], Inakwu Odeh [a], José Padarian [a], Keith Paustian [p], Genxing Pan [g], Laura Poggio [i], Igor Savin [q], Vladimir Stolbovoy [r], Uta Stockmann [a], Yiyi Sulaeman [s], Chun-Chih Tsui [f], Tor-Gunnar Vågen [t], Bas van Wesemael [u], Leigh Winowiecki [t]

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If we increase by 4‰ (0.4%) a year the quantity of carbon contained in soils, **we can halt the annual increase in CO_2 in the atmosphere,** which is a major contributor to the greenhouse effect and climate change

increased absorption of CO_2 by plants :

farmlands, meadows, forests…

+4‰ carbon storage in the world's soils

= more fertile soils
= soils better able to cope with the effects of climate change


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