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Carbon sequestration in agricultural soils – a global perspective

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climate change

Connecting climate science and policy in Scotland

Carbon Credits for Sustainable Land Use Systems (CaLas). Scientific basis and practical implications – reality and visions. Frick, Switzerland, 15 December 2010

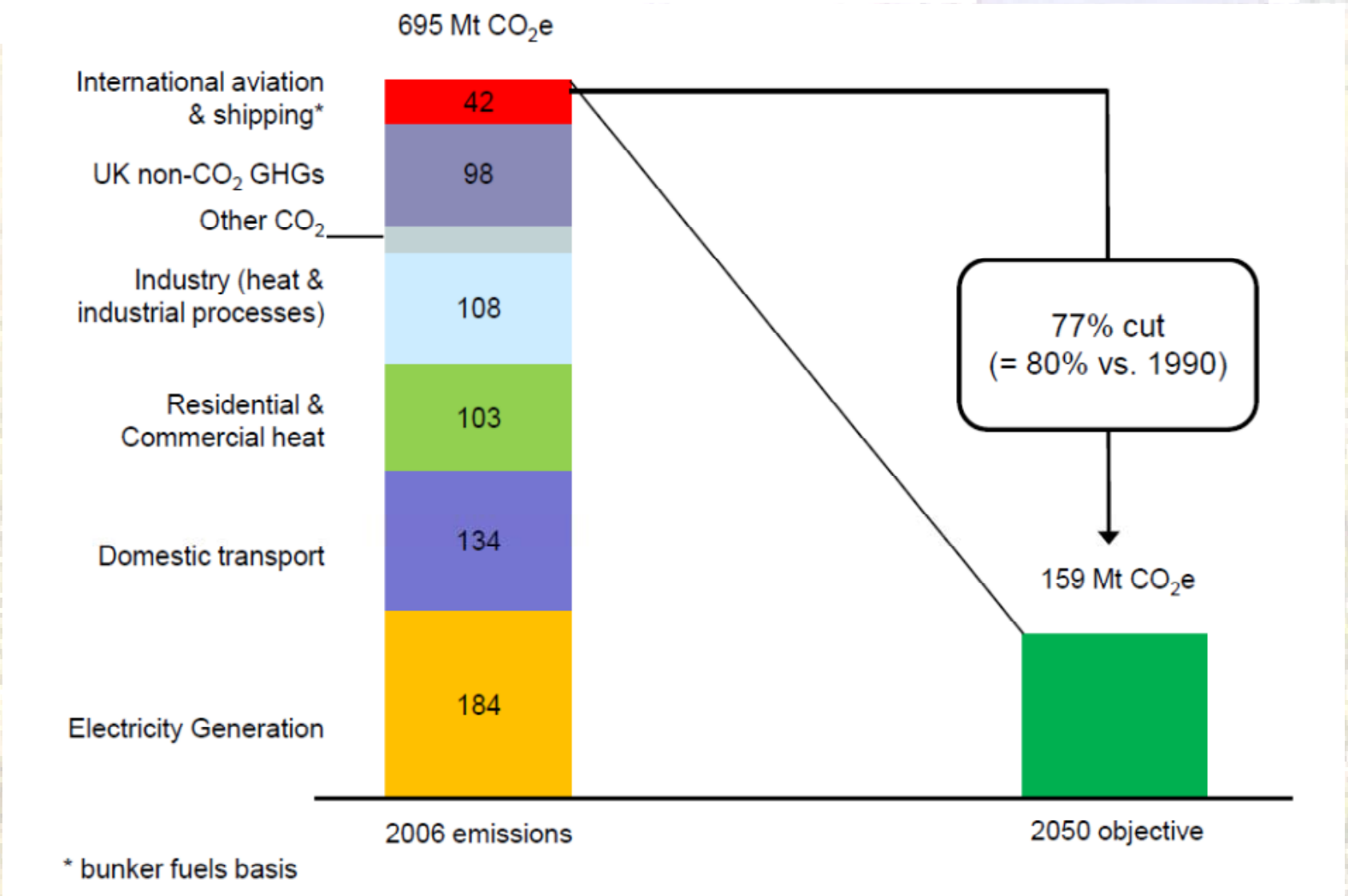
Outline

- 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? The UK as an example

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

UK emissions now and in 2050



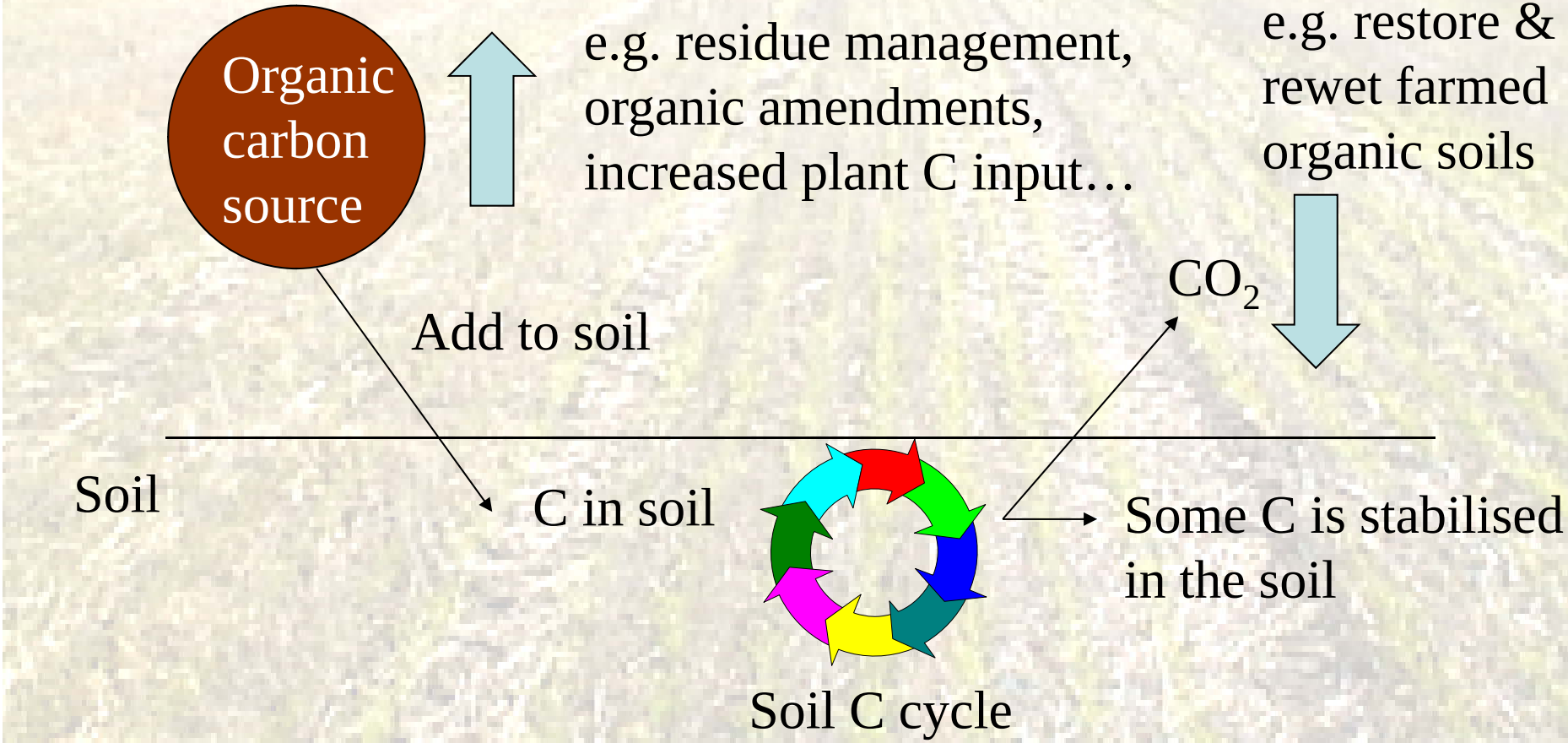
Source: UK Committee on Climate Change

What will it cost?

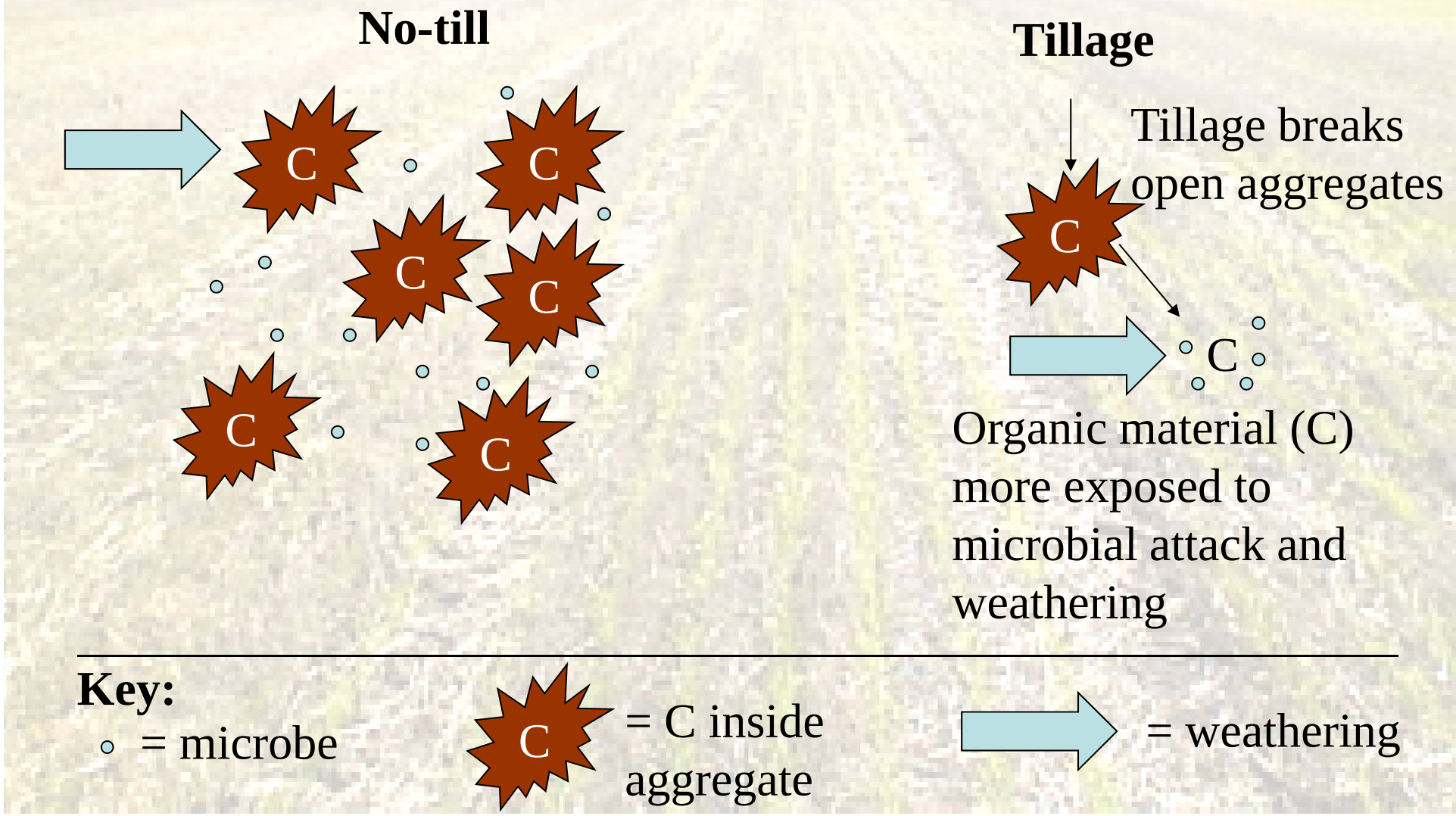
- 80% cut in GHG emission by 2050 relative to 1990: all GHGs, aviation and shipping included
- 42% cut in GHGs by 2020 relative to 1990 (31% relative to 2005)
- 2020 cost less than 1% of GDP

How does soil C sequestration work?

Increase C inputs…..or reduce C losses



How does soil C sequestration work? – reduced disturbance

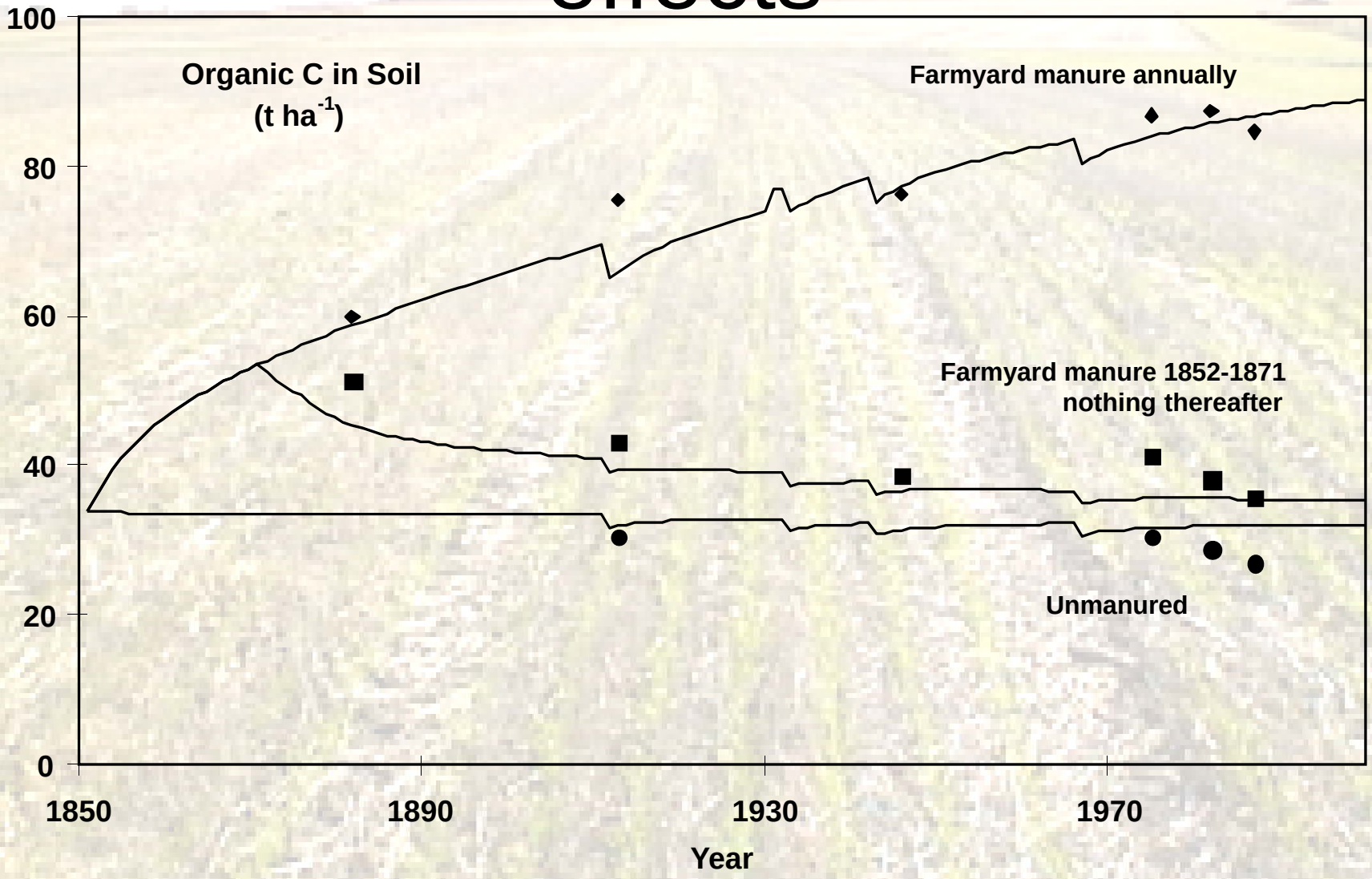


Mechanisms for soil C sequestration in agriculture

Activity	Practice	Specific management change	Increase C inputs	Decrease C losses	Reduce disturbance
Cropland management	Agronomy	Increased productivity	X		
		Rotations	X		
		Catch crops	X		
		Less fallow	X		
		More legumes	X		
		Deintensification			X
		Improved cultivars	X		
	Nutrient management	Fertilizer placement	X		
		Fertilizer timing	X		
	Tillage / residue management	Reduced tillage			X
		Zero tillage			X
		Reduced residue removal	X		X
		Reduced residue burning	X		X
	Upland water management	Irrigation	X		
		Drainage	X		
	Set-aside and land use change	Set aside	X		X
		Wetlands	X	X	
	Agroforestry	Tree crops inc. Shelterbelts etc.	X		X
Grazing land management	Livestock grazing intensity	Livestock grazing intensity		X	
	Fertilization	Fertilization	X		
	Fire management	Fire management		X	
	Species introduction	Species introduction	X		
	More legumes	More legumes	X		
	Increased productivity	Increased productivity	X		
Organic soils	Restoration	Rewetting / abandonment		X	X
Degraded lands	Restoration	Restoration	X	X	X

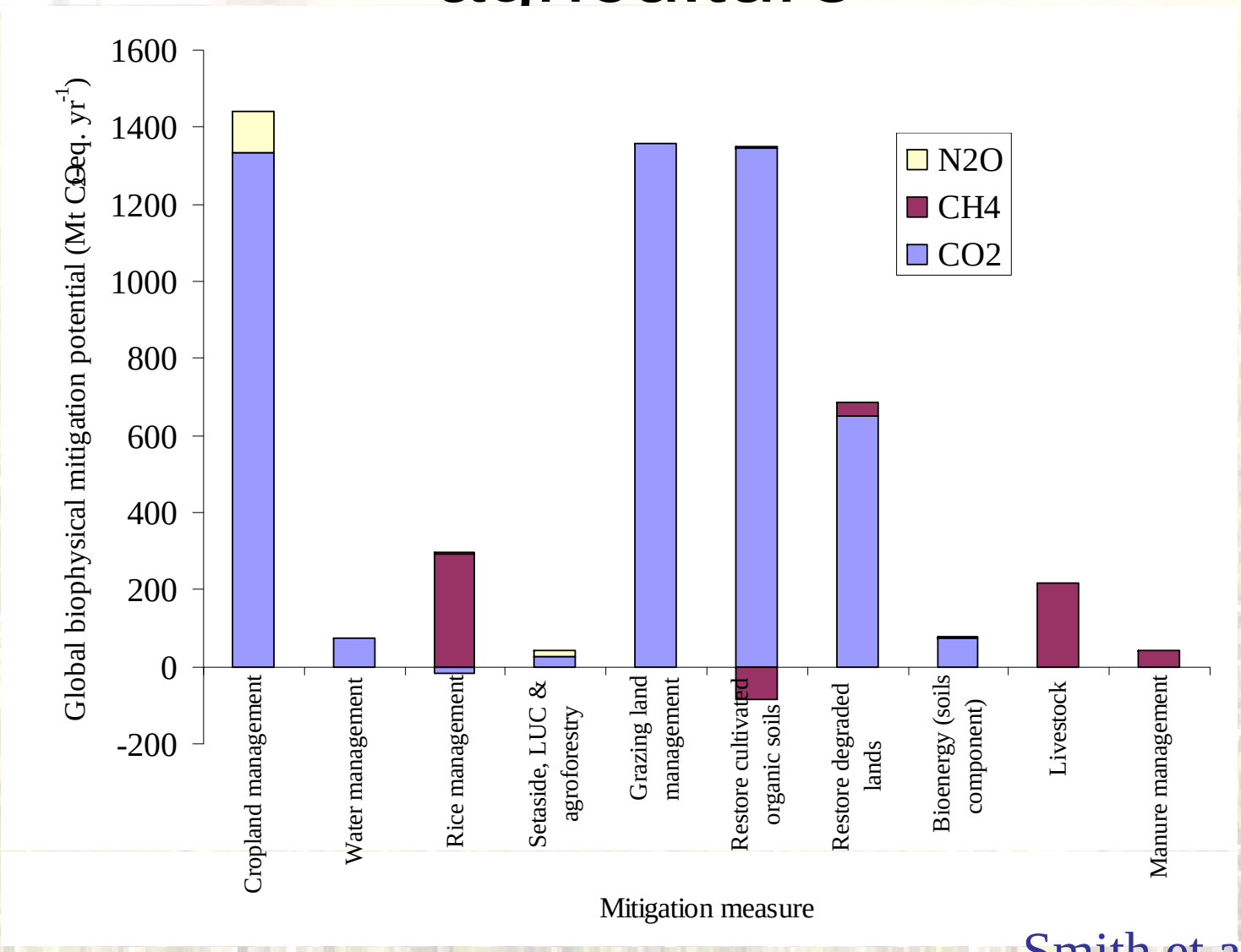
Smith et al. (2008)

Manure – large & long-lasting effects



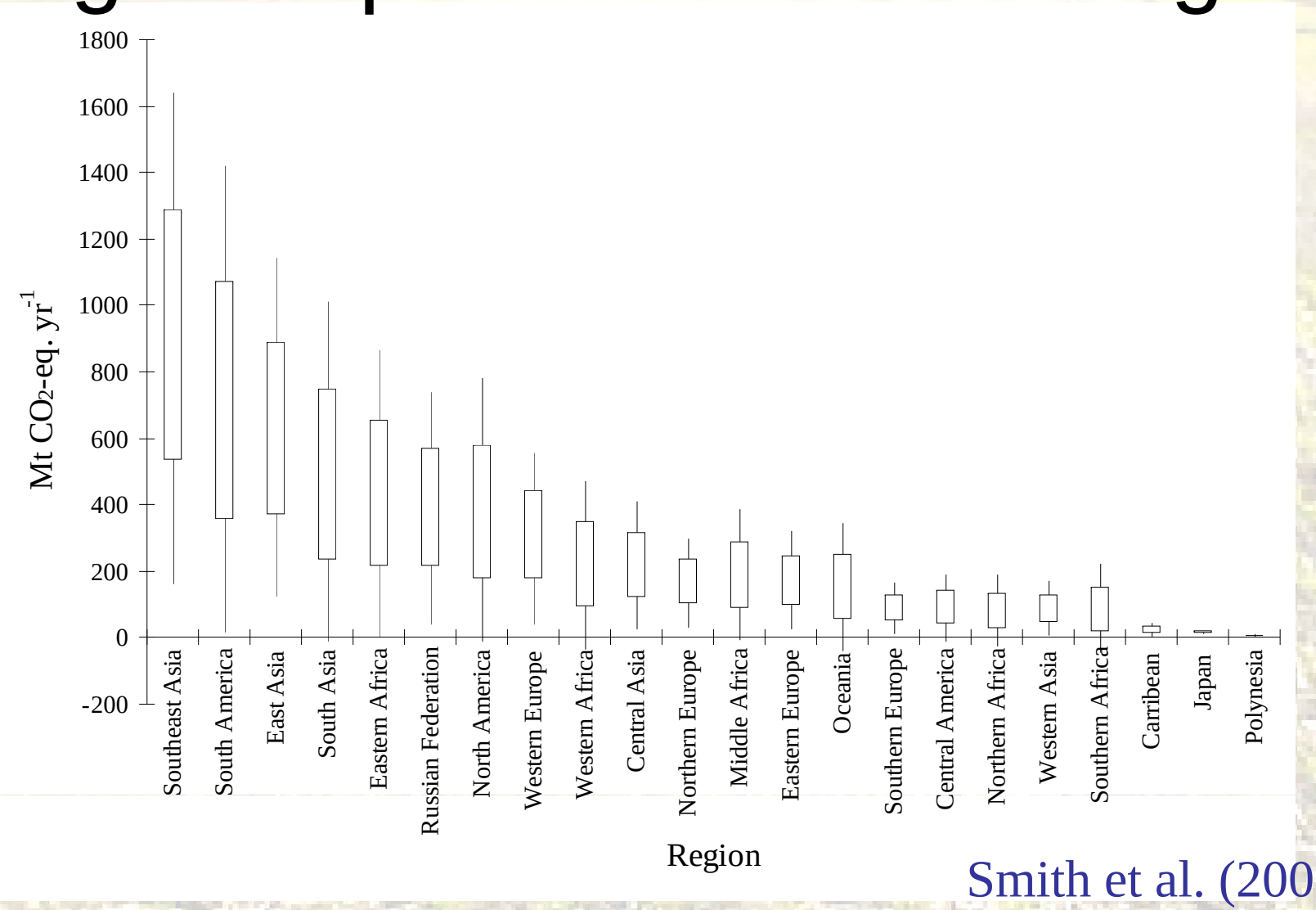
Rothamsted Hoosfield – Jenkinson 1998

Global mitigation potential in agriculture



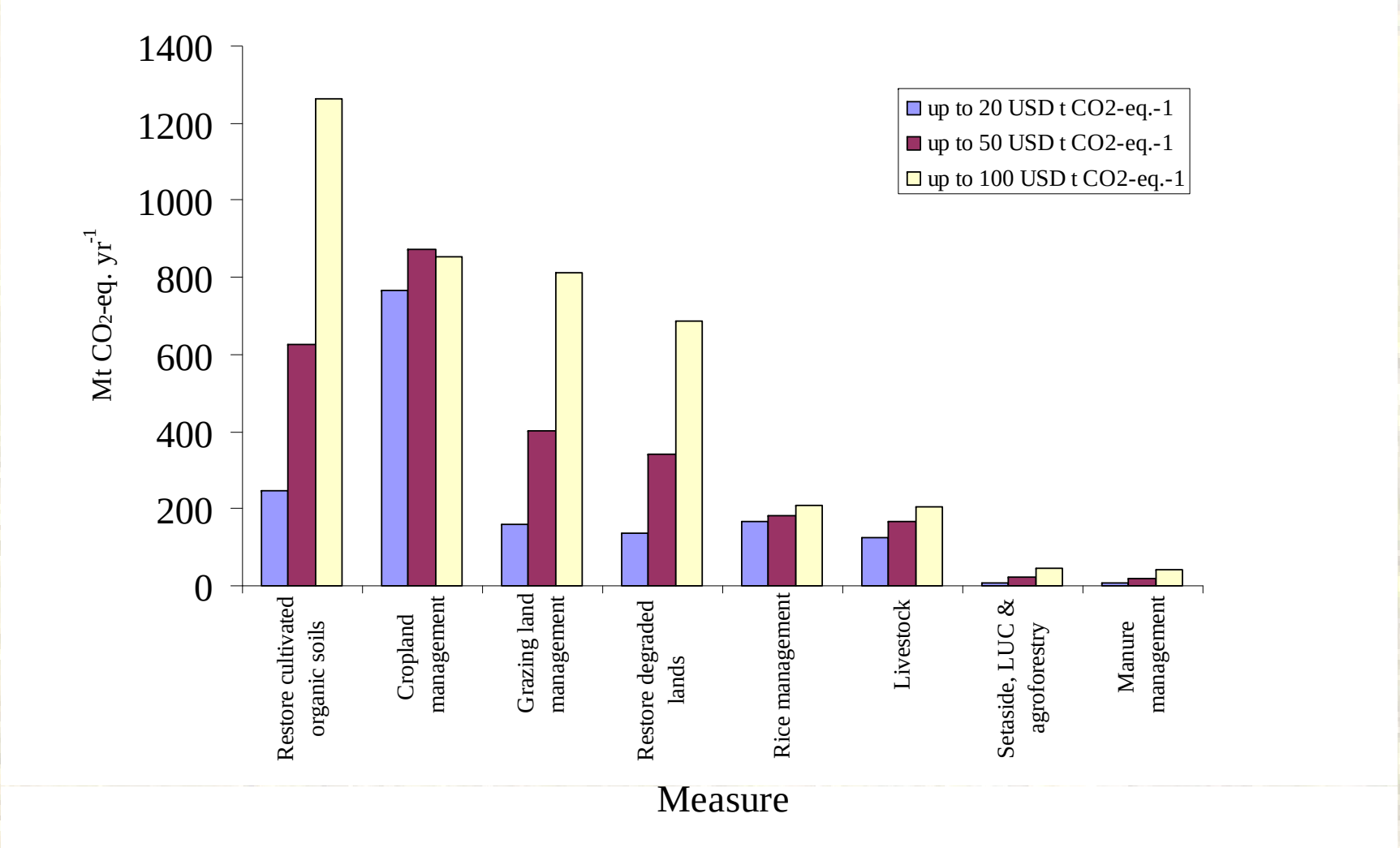
Smith et al. (2008)

High and low estimates of the mitigation potential in each region



Smith et al. (2007)

Effect of C price on implementation



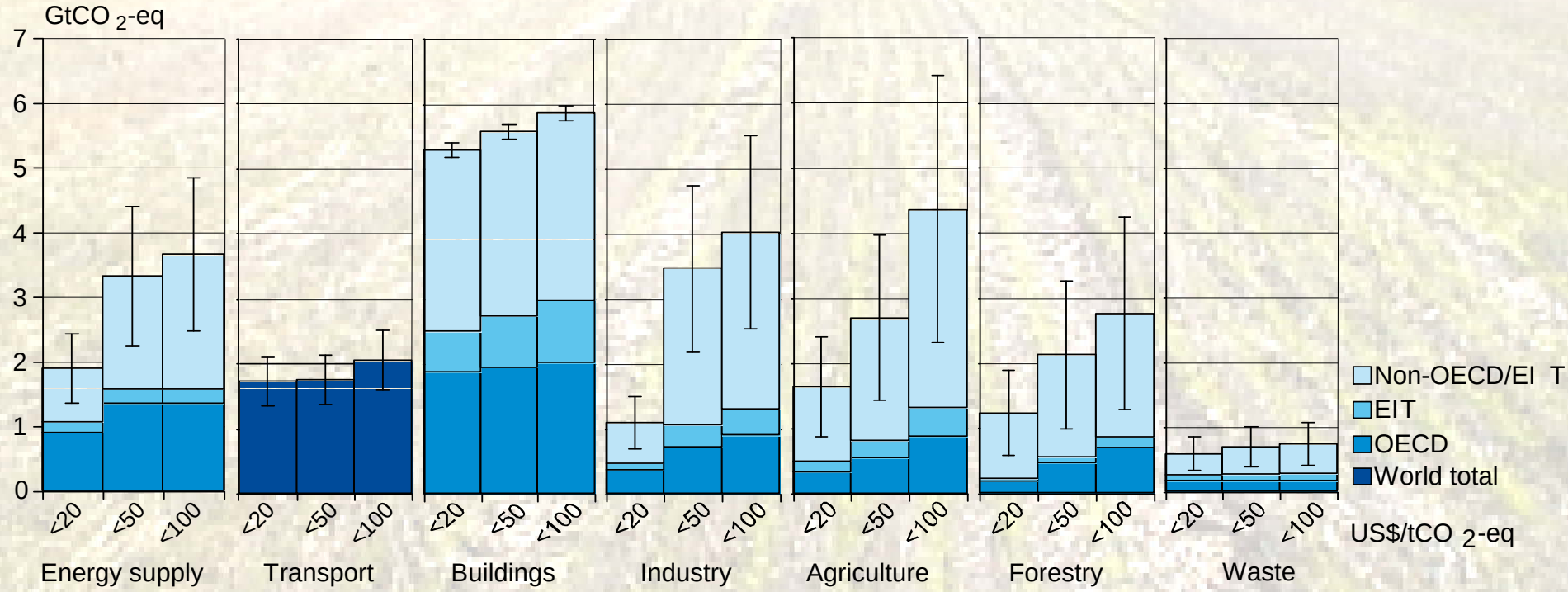
Smith et al. (2007)

Global mitigation potential in agriculture (Mt CO_2-eq. yr^{-1})

	Price range (USD t CO_2-eq. $^{-1}$)			
Scenario	**0-20**	**0-50**	**0-100**	**0->>100 (technical potential)**
B1	1925	2384	3149	5480
A1b	1982	2439	3254	5670
B2	2047	2495	3330	5844
A2	2119	2549	3330	5957

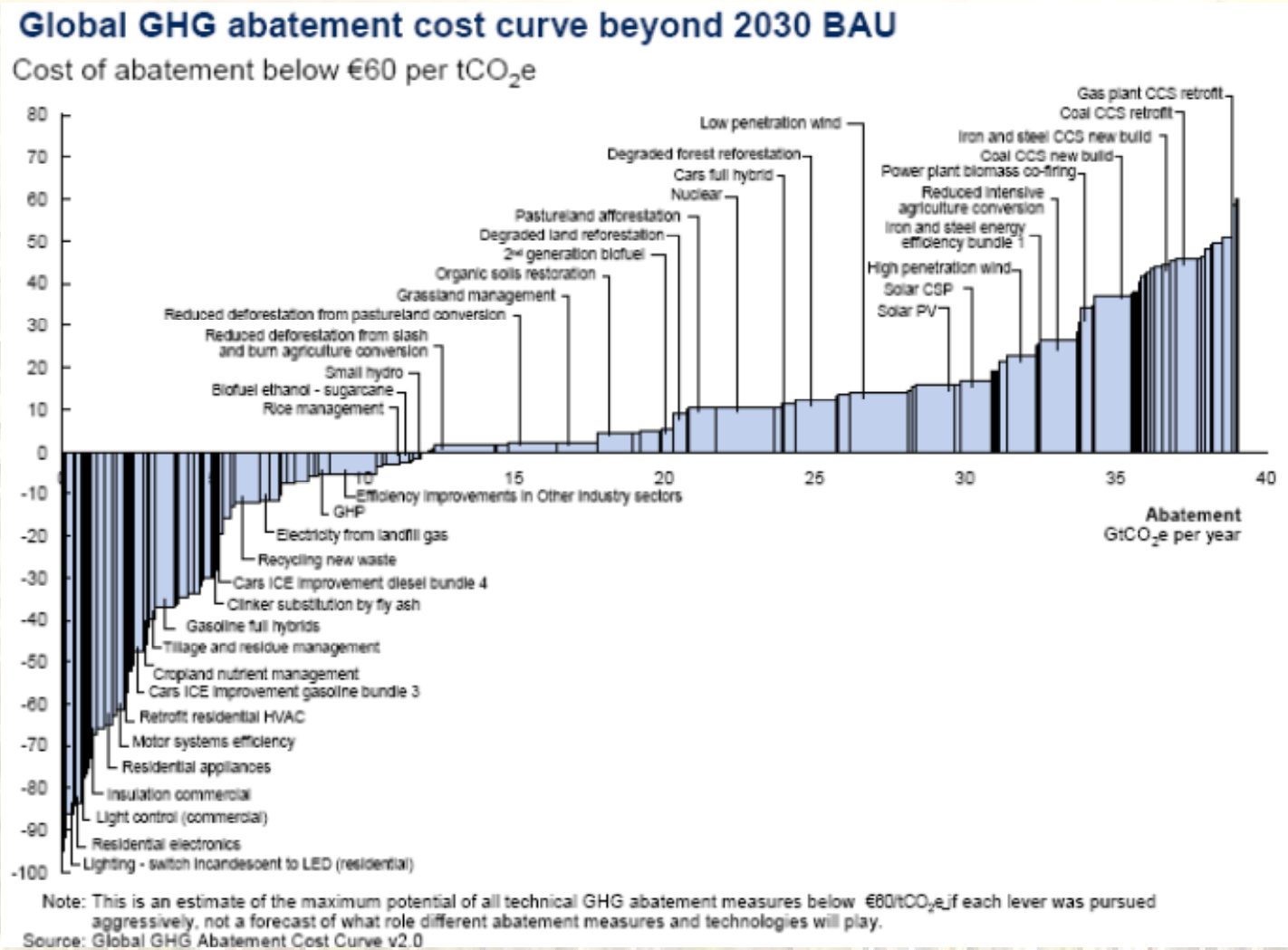
Smith et al. (2007)

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?



From: McKinsey (2009) - Pathways to a low-carbon economy *Version 2 of the Global Greenhouse Gas Abatement Cost Curve*

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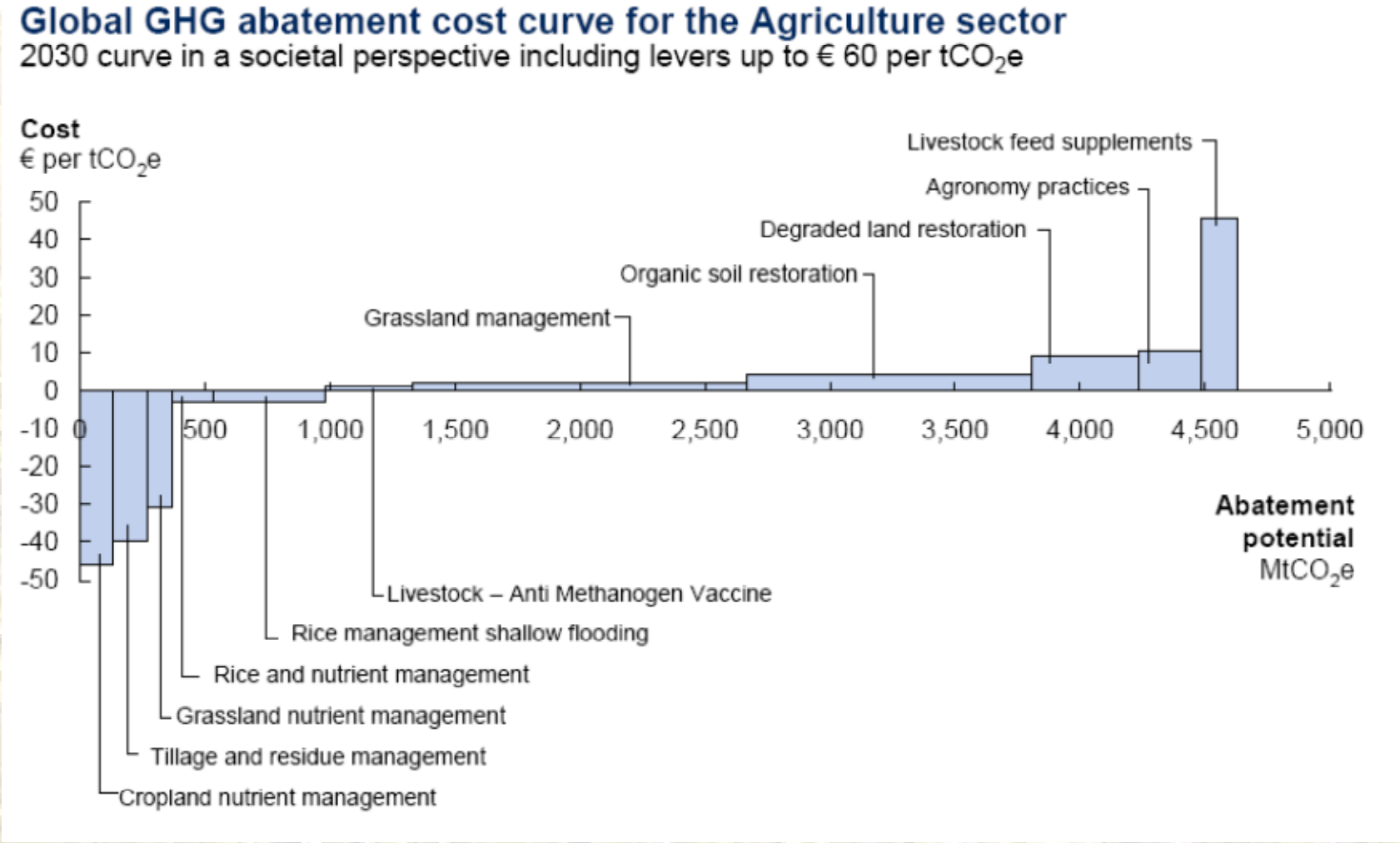
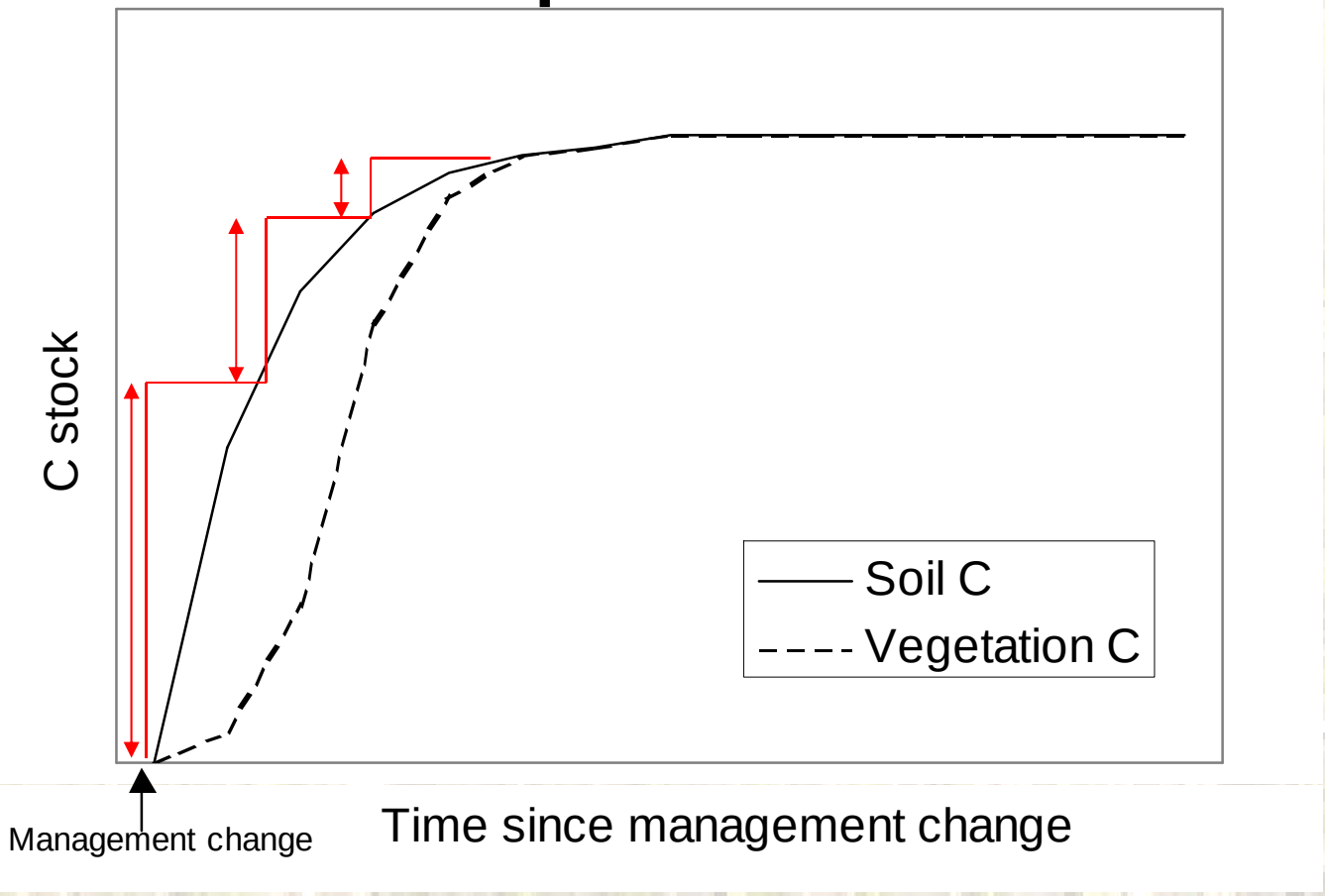


From: McKinsey (2009) - Pathways to a low-carbon economy *Version 2 of the Global Greenhouse Gas Abatement Cost Curve*

Smith (2008) International Journal of Agricultural Sustainability 6(3),169–170

- “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)”.

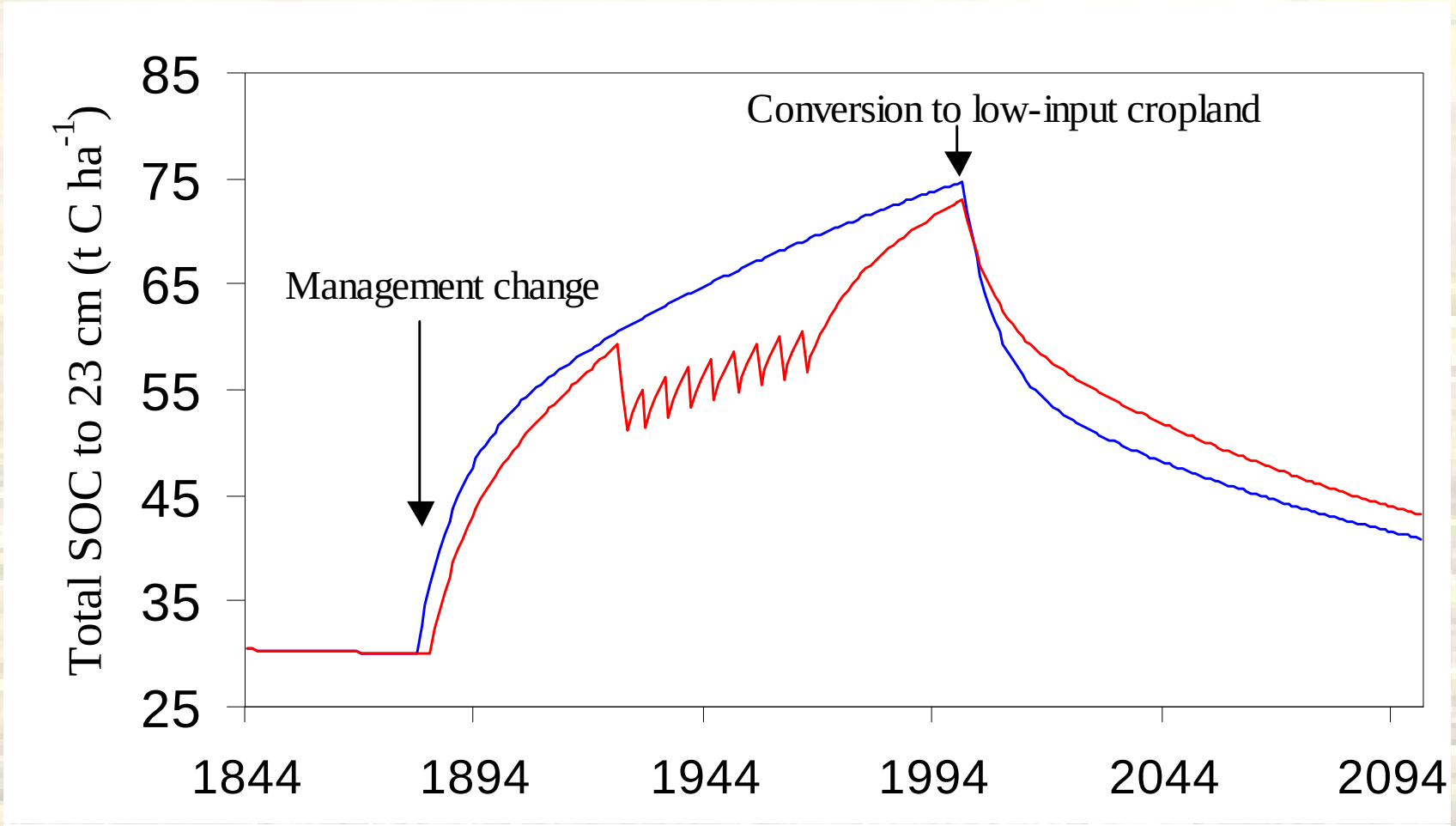
Saturation – the time course of C sequestration



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

Smith (2004a)

Permanence



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

Manure

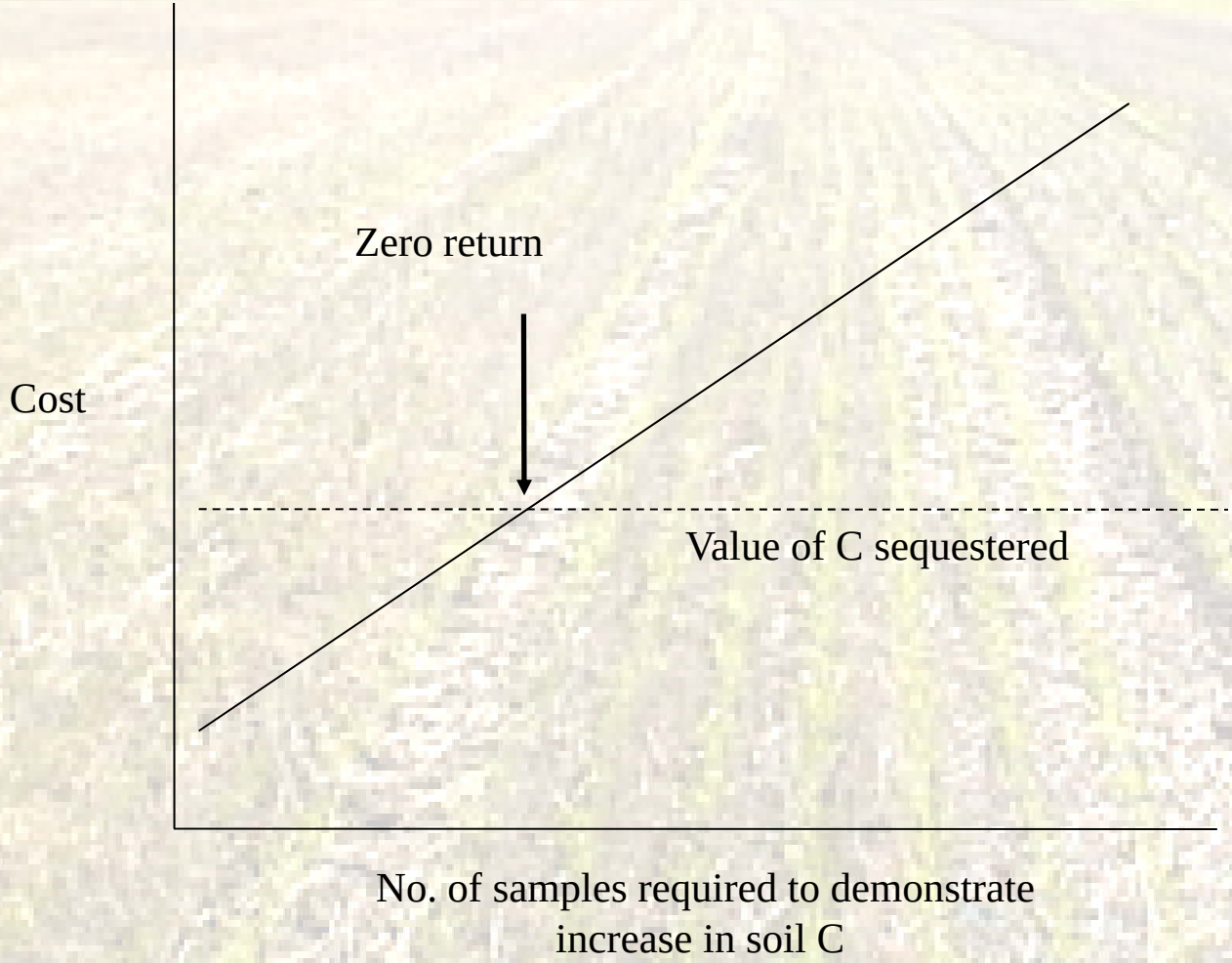
Farm with more manure

Manure Mineral N

Farm with less manure

Effect over the whole cropland area = zero

Verification



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 CO_2 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