Biowaste to soil:

Contribution of biowaste to tackle climate change

life-cycle benefits and relevance to policy-making

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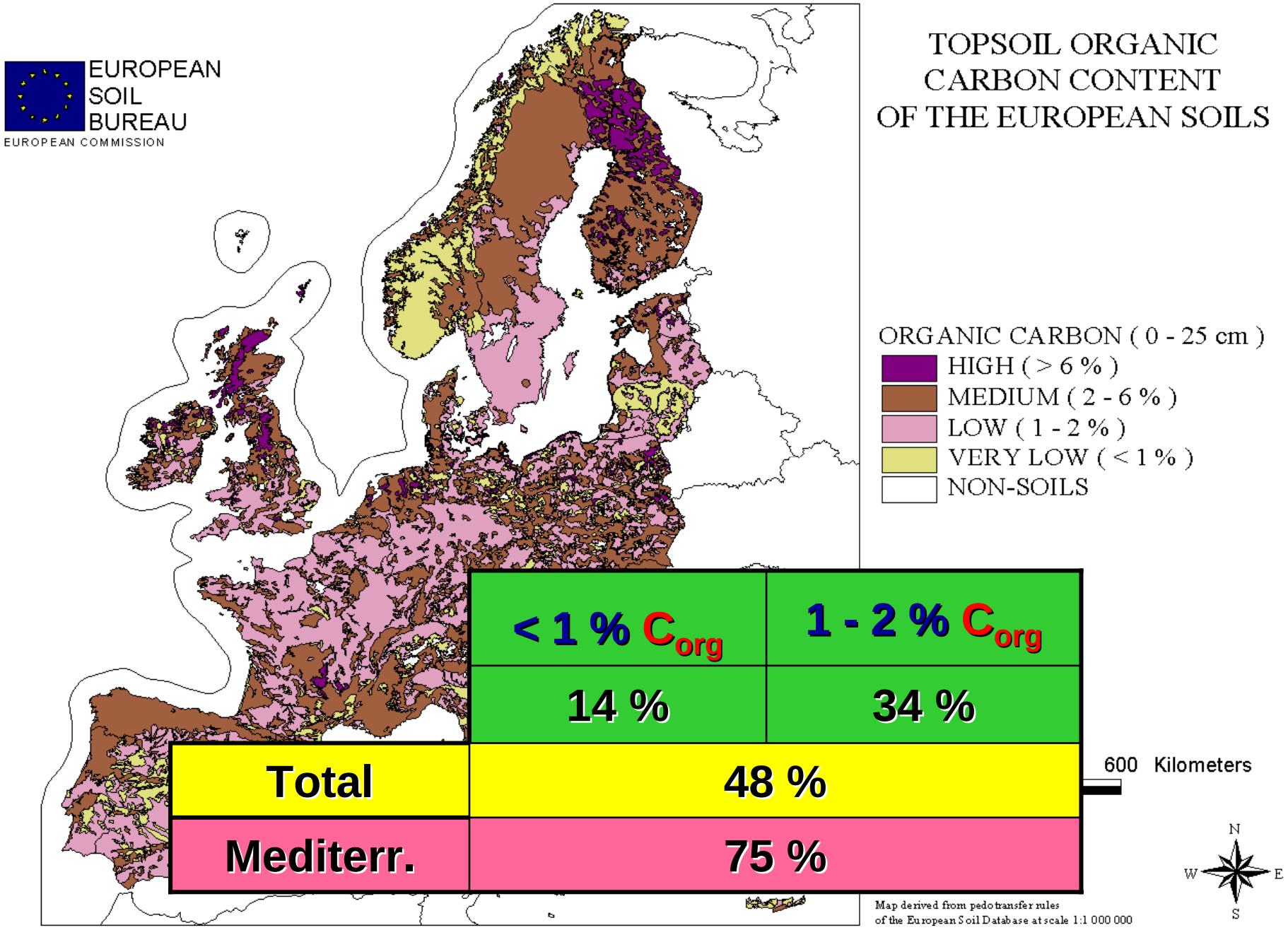
Benefits of SOM – at a glance

- Enhances biodiversity
- Resilience of soils
- Reduces erosion
- Slow-release N source
- Supports biological activity → prevents "desertification"

Key policy recommendation by the Soil Strategy

- ✓ **Decline of Soil Organic Matter one of the 7 threats to soil**
- ✓ **Land use patterns in areas where soil OC < 2.0% should consider agricultural and other land management practices in order to stabilise or increase soil OC levels.**


EUROPEAN SOIL BUREAU
EUROPEAN COMMISSION
TOPSOIL ORGANIC CARBON CONTENT OF THE EUROPEAN SOILS
ORGANIC CARBON (0 - 25 cm)
HIGH (> 6 %)
MEDIUM (2 - 6 %)
LOW (1 - 2 %)
VERY LOW (< 1 %)
NON-SOILS
< 1 % Corg
1 - 2 % Corg
14 %
34 %
Total
48 %
Mediterr.
75 %
600 Kilometers
N
W
E
S
Map derived from pedotransfer rules
of the European Soil Database at scale 1:1 000 000

Organic waste and climate change

- Organics emits CO2 – short-term (biogenic) carbon → C neutral
- Use of compost replaces fertilisers – avoidance of CO2 and other GHG's ought to be considered
- Use of compost may lock-up carbon in the soil – "sequestration" ought to be considered
- AD turns carbon into a substitute fuel (biogas: 100-150 m^3/tonne d.m.) – this replaces fossil fuels

Some savings – still to be discussed !!

- Replacement of mineral fertilisers → 30-50 kg CO_2-eq/tonne
- Peat replacement → 300-400 kg CO_2-eq/tonne
- C sequestration (considering only long-term C !!) → 11 to 326 kg CO_2-eq/tonne
  - ✓ depending on HL times
  - ✓ *calculated only as C retained after 100 years !!*)
- Biogas Production → 100-150 kg CO_2-eq/tonne
- Reduced N_2O release ? Improved Workability ? Water retention? Replacement of pesticides? …..

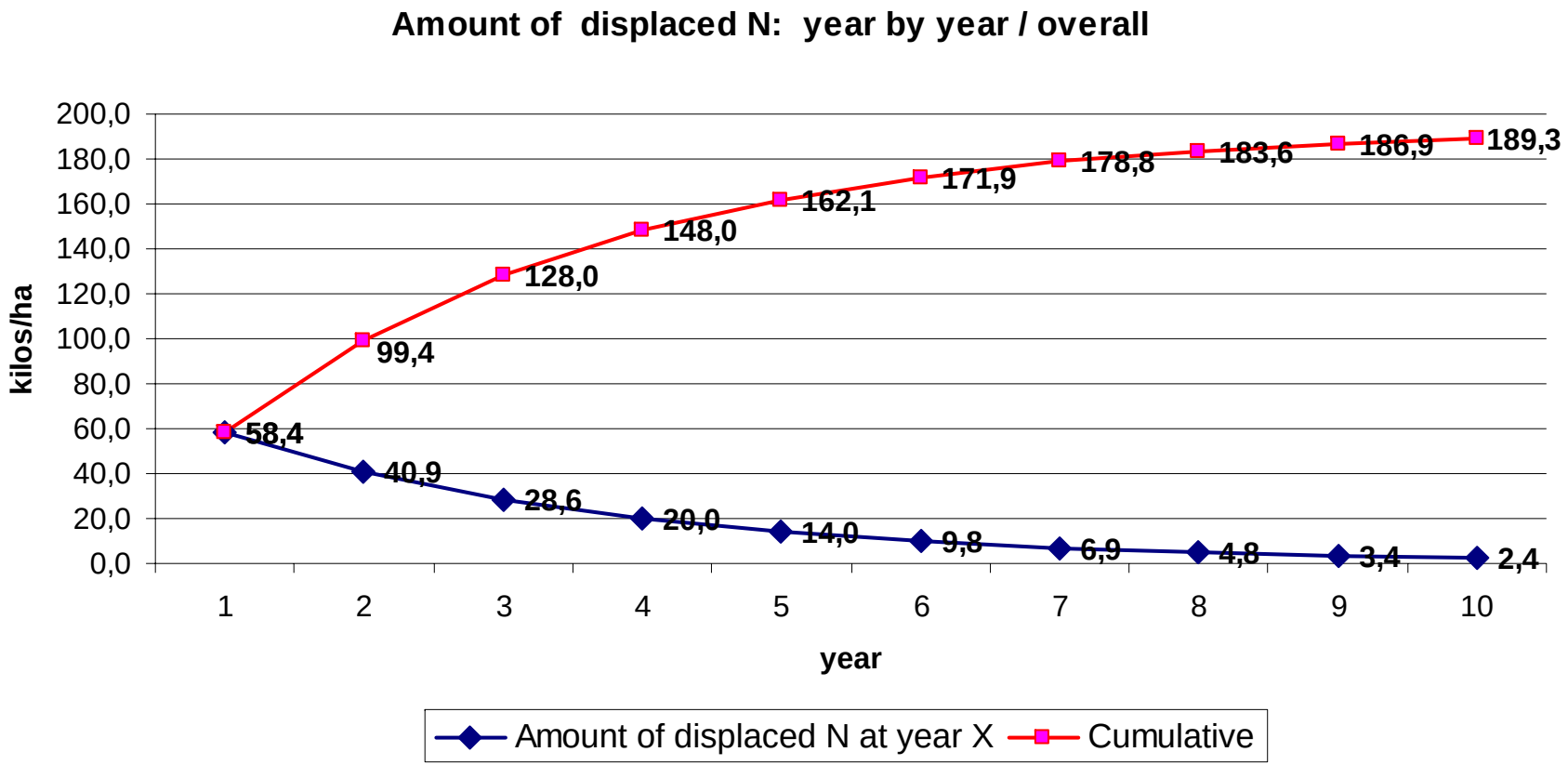
Problems with LCAs ("limitations")

- LCAs often tend to account for material replacement, not for induced effects (e.g. soil improvement / improved workability)
  - ✓ Only nutrients (NPK) considered, organic matter neglected!
- Many beneficial effects of soil improvers difficult to quantify - anyway important !!
  - ✓ Improved workability
  - ✓ Better water retention
  - ✓ C sequestration

Based On…

- **Survey carried out on behalf of the European Commission – DG ENV**
- **Other International Research**
- **Results of WG Soils in the European Climate Change Programme (ECCP)**

Benefits – Replacement of chemical fertilisers



Savings due to nutrient replacement

Nutrient element	Nutrient content [kg / $ton_{biowaste}$]	Emissions from mineral fertilizers [$kg_{CO2\ eq.}$ / $kg_{element}$]	Avoided CO_2 emissions [$kg_{CO2\ eq.}$ / $ton_{biowaste}$]
N	4.0	5.30	21.2
P	1.5	0.52	0.78
K	3.0	0.38	1.14

GHG savings due to substitution of mineral fertilizers, per ton of biowaste treated

Source: *AEA Technology, 2001 Waste Management Options and Climate Change, Report to the European Commission*

Avoided N_2O Emissions from soils

- **Dynamics of N release from humified organic matter are much less likely to promote N_2O production – it might be considered as negligible**
- **The massive release of N from chemical fertilisers promotes kinetics which are far more likely to produce N_2O**

year	N displaced			N20 avoided 0,5%	N20 avoided 0,05%
1	58,4	kilos	**58,4**	0,292207792	0,02922078
2	40,9	"	**99,4**	0,496753247	0,04967532
3	28,6	"	**128,0**	0,639935065	0,06399351
4	20,0	"	**148,0**	0,740162338	0,07401623
5	14,0	"	**162,1**	0,810321429	0,08103214
6	9,8	"	**171,9**	0,859432792	0,08594328
7	6,9	"	**178,8**	0,893810747	0,08938107
8	4,8	"	**183,6**	0,917875315	0,09178753
9	3,4	"	**186,9**	0,934720513	0,09347205
10	2,4	"	**189,3**	0,946512151	0,09465122
	189,3	**kilos**	**Cumulative**	**Cumulative**	**Cumulative**

Carbon Sequestration – key remarks

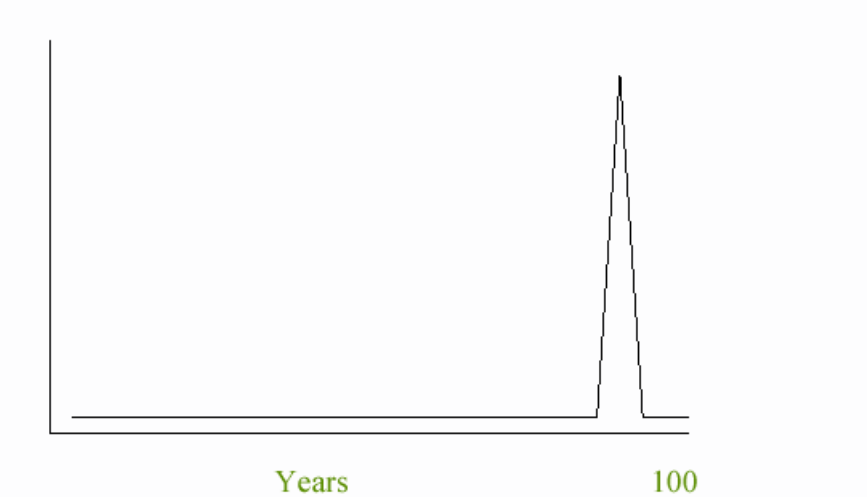
- Compost Leads to Carbon Emissions over Extended Periods of Time
- Biogenic Fraction Partially Retained In Soil Over Time – provides for a “build up” of Carbon
- Provides Soil Organic Matter – Much Wider Benefits than C sequestration alone
- IPCC has chosen the 100 years span to consider C „sequestered“ - but only an arbitrary threshold for calculation purposes

Stretching concepts to extreme consequences

Would it preferable to have a time-profile

Like this…?

Or like this…?



Importance of C in soils

545.000	**Gg CO2**	**Source: "National Communications from Parties included in Annex 1 to the Convention: Greenhouse Gas Inventory Data"**	
148.636.364	**ton C**		
16.000.000	**hectares**	**Arable Land Area**	
3600	**ton/ha**	**unit weight of the soil**	
57.600.000.000,00	**ton soil**		
0,258%	**% of Carbon to be locked up in the soil in order to balance the overall national emissions of carbon dioxide in 1 year**		

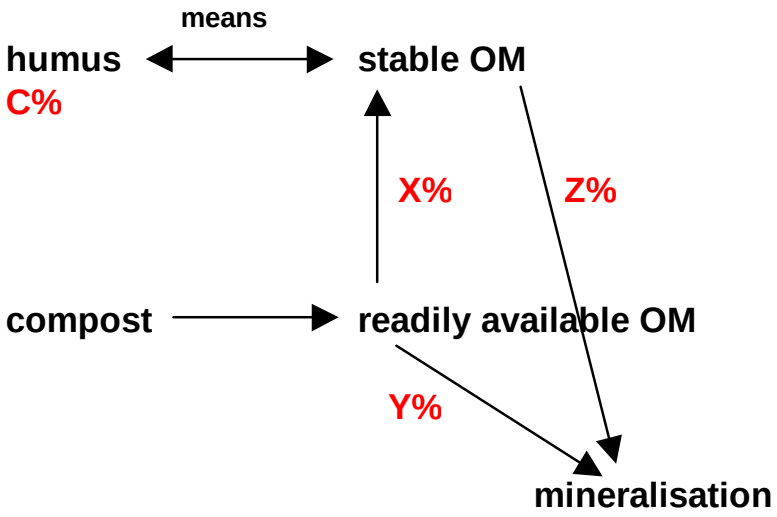
Decline of Soil OM – recent findings

NATURE (Vol. 437) of 8 September 2005

- ***CARBON CONTENT OF SOIL in England and Wales fell steadily in the period 1978-2003, with some 13 million tonnes of carbon released from British soil each year. On average, British soils have lost 15% of their carbon.***
- ***losses of soil carbon in the UK, and in other temperate regions, are likely to have been offsetting absorption by terrestrial sinks***

Model Outline

Description of methabolic / agronomic pathways



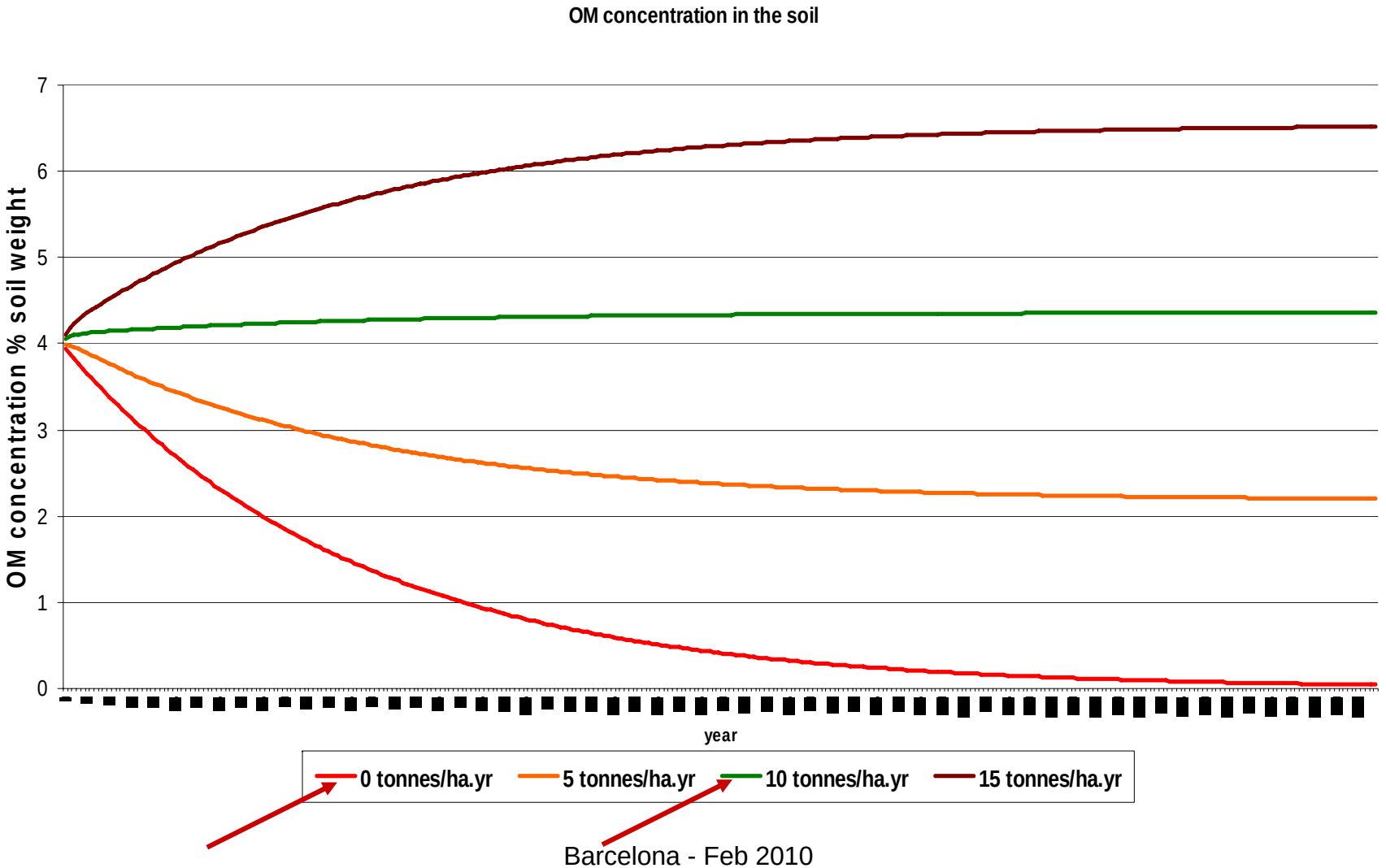
C ranging from 1 to 5%

X ranging from 10 to 20 %

Y ranging from 10 to 30%

Z ranging from 0,1 to 2%

Soil Carbon trends



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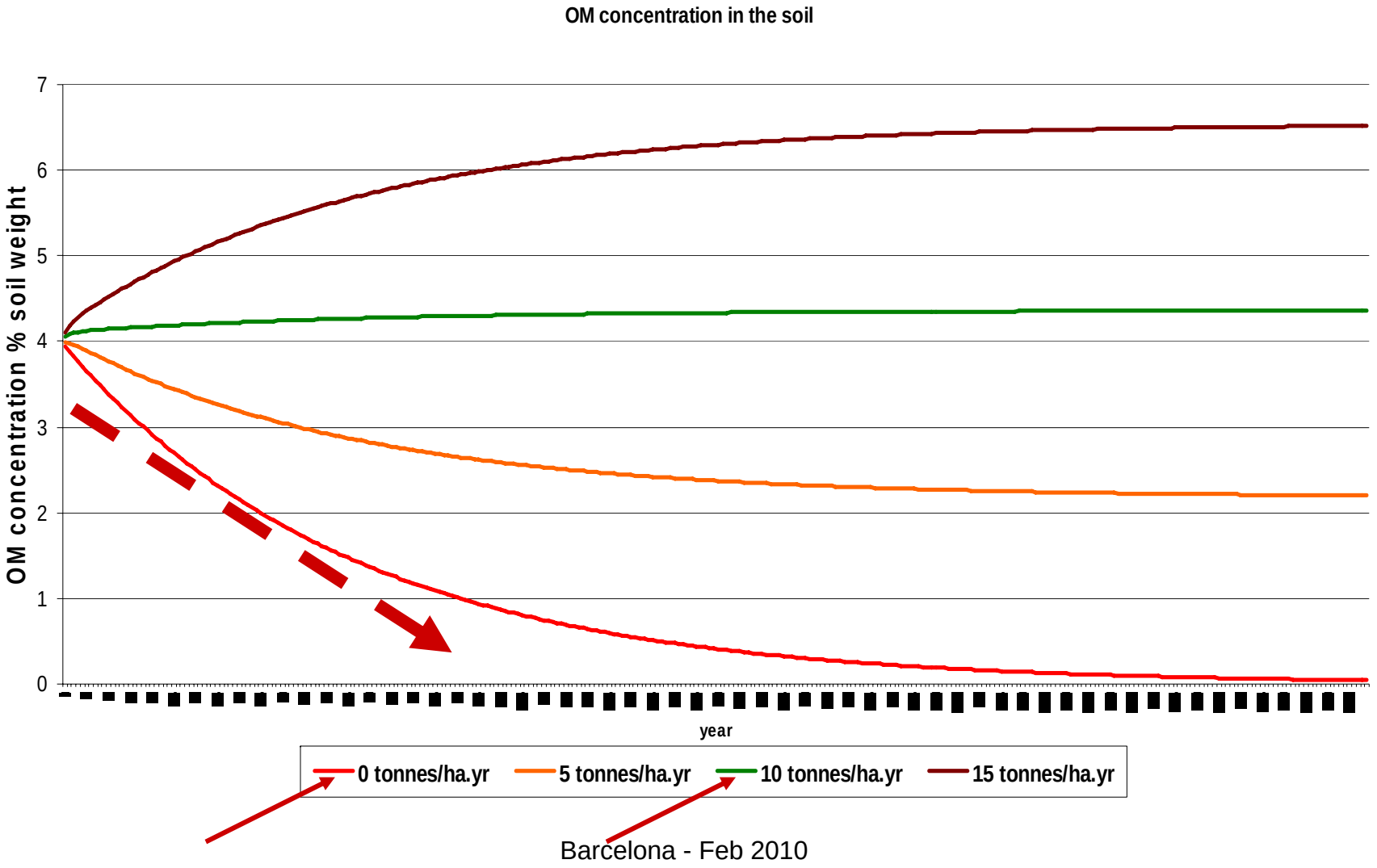

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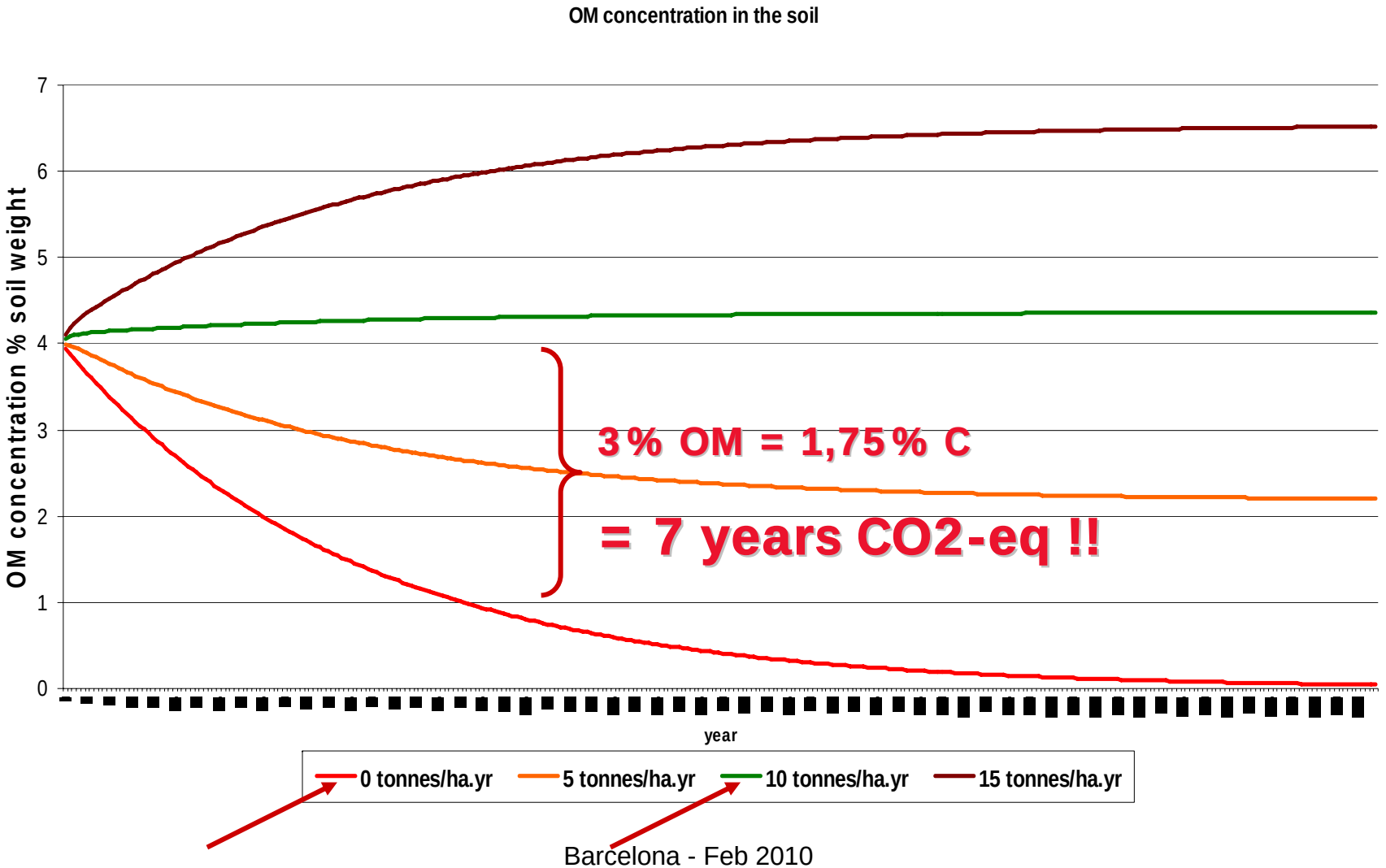

Rothamstead field trials

Type of vegetation or crop	% C
Pasturelands	1.52
Under a forest	2.38
After cropping wheat continuously for 50 years, 1893	
No manure added since 1839	0.89
Only chemical fertilisation since 1843	1.10
14 tonnes manure yearly since 1843	2.23

Other benefits – an overview

- Disease suppression
  - ✓ Less energy required to produce pesticides
- Reduced susceptibility to soil erosion
  - ✓ lower loss of soil, therefore lower mineralisation of organic matter
- Reduced irrigation requirement
  - ✓ lower energetic input
- Improved soil structure and workability
  - ✓ lower energetic input for ploughing, tilling, etc.

Uncertainty C-balancing

(according to Smith, 2002)

- Models may have 6.8-8.5% error
- For average European arable soil this is equivalent to 3.6-4.5 t C ha^{-1}
- For whole arable area of Europe this is equivalent to 0.49-0.54 Pg = *five times greater than Europe's total Kyoto emission reduction target (!!!)*.
- As seen from another standpoint, the magnitude of numbers shows that *despite uncertainties, the role of sequestration is a primary issue in fighting climate change, beyond any accuracy !!!*

Trading Schemes

- **Strategies to tackle climate change often do not recognise the potentially important role of LULUCF (Land Use, Land Use Change and Forestry, i.e. farm- and soil-based activities)**
- **e.g. EU Emission Trading Schemes (Dir. 2003/87)**
  - ✓ **<u>Excludes</u> C sinks and LULUCF from crediting/trading !!**

Composting in CDMs

- Composting included in CDM schemes by the CDM Board (2005)
- A standard calculation method to assess GHG savings has been defined
- *Only methane savings from landfills are allowed for, yet*
- No crediting of soil-related benefits

Signs of a future approach?

- **10 Italian Regions subsidising farmers to use soil improvers, including compost, in order to promote a build-up of C in depleted soils**
- **Unit subsidies in the range 200-700 Euro/ha**
- **Grant schemes established in the frame of Rural Development plans**

“Climsoil” Report, EC 2009.

"The report underlines the need to sequester carbon in soils. The technique is cost competitive and immediately available, requires no new or unproven technologies, and has a mitigation potential comparable to that of any other sector of the economy."

http://ec.europa.eu/environment/soil/review_en.htm

Conclusions on LCAs concerning compost, soils and climate change

- Most benefits are dfficult to be quantified – nevertheless, they are important !
- LCAs currently *showing limitations*
- *Discrepancy between accountability and efficacy of actions*
- Waste Policies, Climate Change Policy and Inventories of Carbon Should Recognise Role of Soils (and compost)
- Therefore: a Directive establishing drivers for AD and composting a remarkable step forward

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Total possible GHG savings from biowaste treatment

GHG saving by	kg CO_2 eq.
Anaerobic digestion with CHP option	135
C-sink in the soil by added humus	80
Peat substitution and avoided transport	200 - 300[1]
Replaced mineral fertiliser	30
Total	**400 - 500**

[1] 94 to 188 (substitution) + 120 to 180 (transport)

GHG-balance for a modelled scenario

(100 ktpa MSW; 60% recycling, including AD + composting; 40% incineration)

	Quanti-ties	CO_2 emitted	CO_2 saved	CO_2 net
collection	100000	741		741
recycling	40000	28580	36220	-10650
biological treatment	20000	2210	7959	-5749
incineration	40000	16427	18403	-1976
total	**100000**	**47951**	**62581**	**-17640**

What are the GHG-savings related to?

use of biogas as a fuel (diesel trucks)	2792
displacing mineral fertiliser	723
displacing organic matter: peat (1/3)	2401
displacing organic matter: straw (2/3)	400
TOTAL SAVINGS	7959

Conclusions

- CO_2 savings by **AD** may be easily calculated and represent a net benefit
- The savings due to **peat substitution** by 1/3 of the compost (going to horticulture) are much larger
- The savings by **nutrient substitution** are rather marginal
- The benefits brought by **physical effects** on the soil (water retention, less erosion.....) are promising, but…
- A **lot of research** is still necessary to integrate these aspects correctly in LCAs
- But only if LCA is **really** comprehensive will we get the right picture!
- *Benefits of biological treatment, typically much larger than what may be accounted for.*

AND:

Organics still a big part of MSW

optimising management of organics with ready-to-implement strategies a key driver for improvement in C management.

Thank you

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