CAPRESE

CArbon PREservation and SEquestration in agricultural soils: Options and implications for agricultural production

Potential Options

Land Resource Management Unit
Soil Action (coordination)
Francesca Bampa, **Emanuele Lugato,** Roland Hiederer, Luca Montanarella, Delphine, De Brogniez, Cristiano Ballabio, **Arwyn Jones**

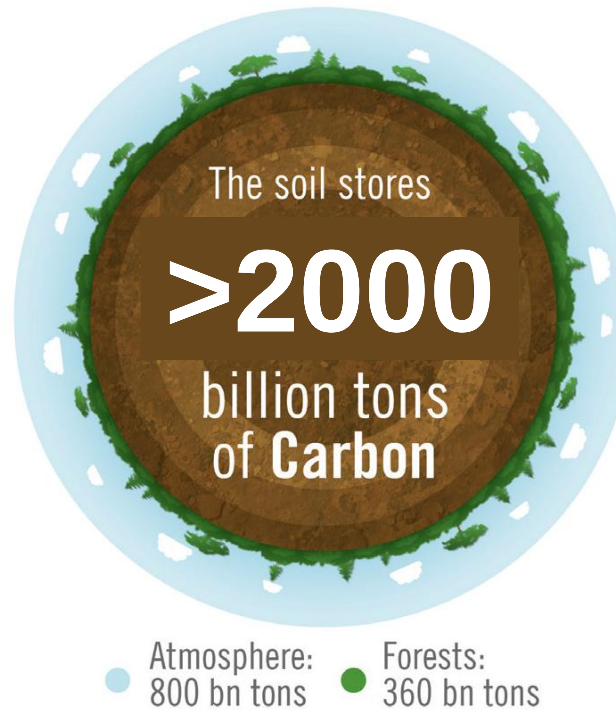
Monitoring Agricultural Resources Unit – GeoCap, Agri4Cast, AgriEnv Actions
Vincenzo Angileri, Marco Bertaglia, Andrej Ceglar, Adrien Leip, Stefan Niemeyer, Philippe Loudjani,

Forest Resources and Climate Unit
ForestMod Action
Giacomo Grassi, Raul Abad Viñas Viorel Blujdea

IPTS
Maria Espinosa, Guna Salputra, Benjamin Van Doorslaer, Sergio Gomez y Paloma

organic matter

1 kg soil organic matter
= 580 g C =
2.01 kg CO_2 equivalent



Of which around 20 Gt is found in agricultural topsoils of the EU

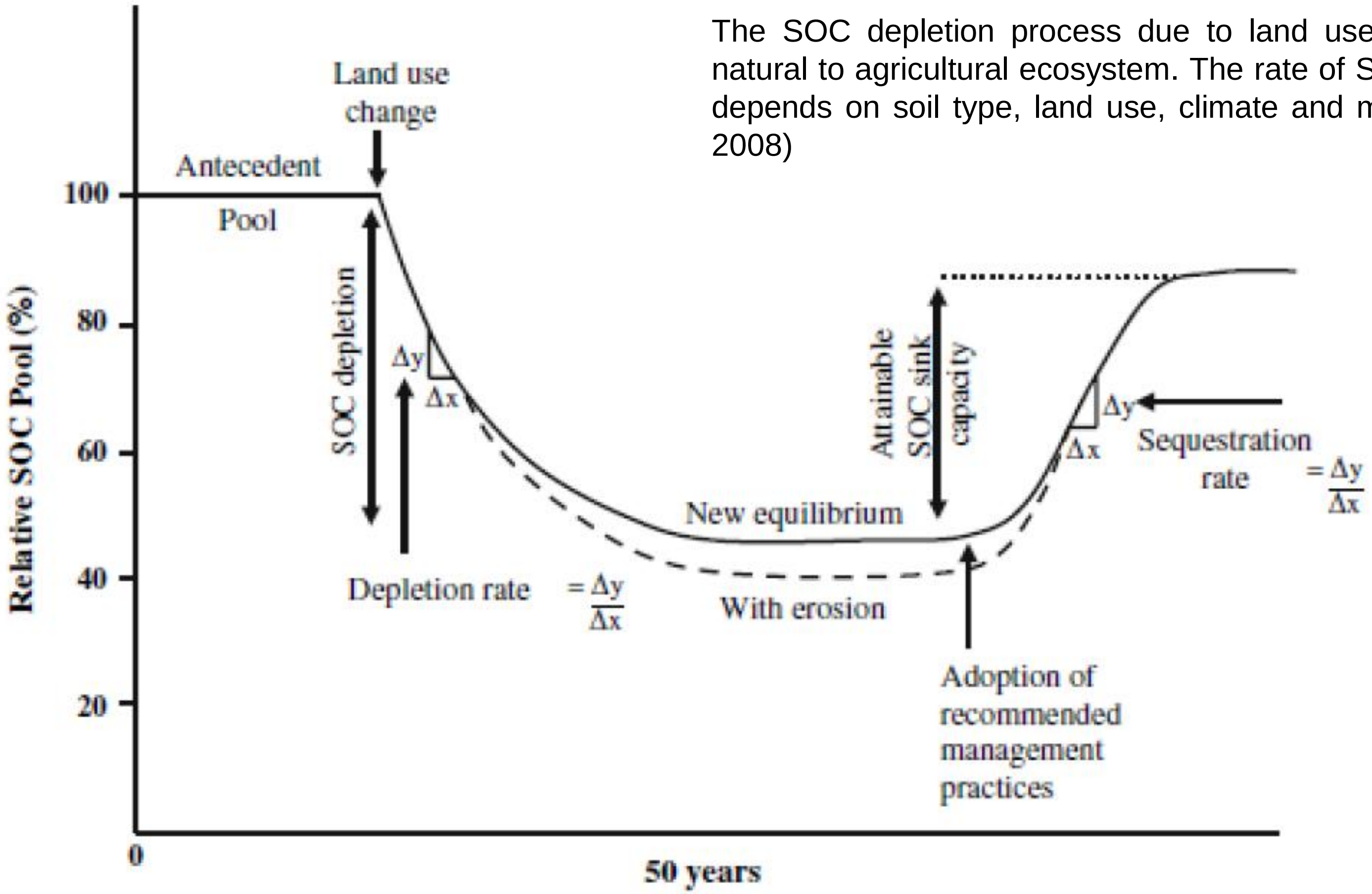
Assess the potential of land management practices to preserve or sequester C in agricultural soils

Land management has a notable impact on the fluxes of greenhouse gases, especially CO_2. Several agricultural activities have been shown in scientific literature to sequester carbon in soil

Some managed soils contain a SOC pool, which is below their potential. Such soils are potentially a sink for C through adoption of appropriate land use and sustainable management practices.

Concept

The SOC depletion process due to land use conversion from natural to agricultural ecosystem. The rate of SOC sequestration depends on soil type, land use, climate and management. (Lal, 2008)



Potential measures: 1. Grassland management

1.1. Maintenance of permanent grasslands

1.2. Improved grazing production

1.3. Controlled grazing intensity (length and timing)

1.4. Minimum grass coverage

1.5. Fire management

European
Commission

Potential measures: 2. Cropland management

2.1. Crop variety and species management

2.2. Crop rotations

2.3. Cropping patterns

2.4. Residue management

2.5. Tillage related practices

2.6. Agroforestry

2.7. Conservation Agriculture

2.8. Organic farming

2.9. Pesticides and Integrating Pest Management

2.1.1. Nitrogen-fixing crops
2.1.2. Plant breeding
2.1.3. Perennial and permanent crops
2.2.1. Rotation type and species selection
2.2.2. Stale seedbed
2.2.3. Fallow and set-aside
2.3.1. Intercropping or mixed cropping
2.3.2. Contour strip cropping
2.3.3. Relay cropping
2.3.4. Undersowing
2.3.5. Terracing
2.4.1. Crop residues removal for biofuel use
2.4.2. Avoiding the use of Sphagnum peat
2.4.3. Mulching
2.4.4. Contour trash lines
2.4.5. Weed management
2.5.1. Conventional Tillage
2.5.2. Conservation tillage (CT)
2.5.3. No tillage (NT)
2.5.4. Minimum Tillage (MT)
2.5.5. Reduced Tillage (RT)
2.5.6. Ridge tillage
2.5.7. Contour ploughing
2.5.8. The impact of soil compaction on C
2.6.1. Alley Cropping
2.6.2. Silvopasture
2.6.3. Boundary systems

Joint
Research
Centre

Potential measures: 3. Nutrient management

3.1. Organic amendments

- 3.1.1. Compost
- 3.1.2. Animal manure
- 3.1.3. Biosolids (Sewage sludge)
- 3.1.4. Wood by-products
- 3.1.5. Other organic wastes

3.2. Inorganic amendments

- 3.2.1. Synthetic fertilisers
- 3.2.2. Liming of acid soils
- 3.2.3. Natural adsorbents (ameliorative)

3.3. Biochar

Potential measures: 4

4. High technologies

4.1. Precision farming

4.2. Regulation of oxy-reduction processes of SOM decomposition

5. Water management practices

5.1. Waterlogging & higher ground water table (inc. restoration peatlands)

5.2. Drainage of waterlogged mineral soils

5.3. Irrigation and water harvesting

6. The management of degraded land

Analysis

Option	SOC sequestration ($MgCha^{-1}yr^{-1}$)	Reference	Location, soil type and climate	LTE duration (yr^{-1})	Management
LAND USE CONVERSION	0.3- 0.8	IPCC (2000)	Temperate dry, marginal land	50-yr	Arable land to grassland
	0.5	Arrouays (2002)	FRA	n/d	Arable to permanent grassland
	0.35	Conant, Paustian et al. (2001)	Temperate grasslands, rain forests, ambient	Meta-analysis on 115 global studies	Native LC to pasture
	1.01				Cultivation to pasture
	negative	(Soussana, Loiseau et al. 2004); Kätterer, Andersson et al. (2008)	SW, Uppsala, Kungsangen, mean annual temperature 5.1C, precipitation 542mm, gleyic cambisol	Conversion 1850-1920	Grassland to arable land
	0.4			Re-conversion 1971	Arable land to grassland
	0.332	Post and Kwon (2000)	US, cool temperate grassland, Ambient	n/d	Recently established permanent grasslands
	0.51	Powlson, Whitmore et al. (2011)	n/d	LTE 35yr	Arable sown to permanent grass
	18 ± 11 $MgCha^{-1}$	Poeplau and Don (2012)	Europe SC, D, S, LT	24 LTE study sites	Arable land to grassland
	-19 ± 7 $MgCha^{-1}$		Europe, I,D,S,CH,		Grassland to arable land
	21 ± 13 $MgCha^{-1}$		Europe, S, D, I, DK, NL, LT		Arable land to forest
	-10 ± 7 $MgCha^{-1}$		Europe D, IR, SC, CH, A I		Grassland to forest
	1.99	Poeplau, Don et al. (2011)	Mean annual temperature of a test site had	95 studies In 30 years [modelled]	Arable land to grassland
	-1.805				Grassland to arable land
	-1.57				Forest to arable land

Analysis

GRASSLAND MANAGEMENT	Improved grazing production	3	Lal R, Henderlong P et al. (1998)	n/d	6 yr period	Using forage grasses: tall fescue (*Festuca arundinacea*) and smooth bromegrass (*Bromus inermis*)
		0.30	Conant, Paustian et al. (2001)	Temperate grasslands, Ambient	Meta-analysis on 115 global studies	Fertilization (superphosphate, N and manure)
		2.35				Introduction of earthworms
		0.75				Sowing legumes
		0.11				Irrigation
		3.04				Sowing of improved grass species (over seeding, endophyte-infected, endophyte-free fescue)
		0 to 8	Jones and Donnelly (2004)	Temperate grassland	Meta-analysis	Improved grazing (NT)
		1.1	Jones and Donnelly (2004)	relatively productive area, US, Central Plains	50 yr period	Improved grazing
		0.03		US, Colorado arid shortgrass steppe		
		0.3	(Arrouays 2002); Soussana, Loiseau et al. (2004) (Arrouays 2002); Freibauer,	FRA, managed nutrient poor ley grasslands, ambient	[modelled]	Reduction in N-fertilizer inputs in intensive leys grasslands
		−0.9 - −1.1				Intensification of nutrient-poor grassland

European Commission

Results

High Potential

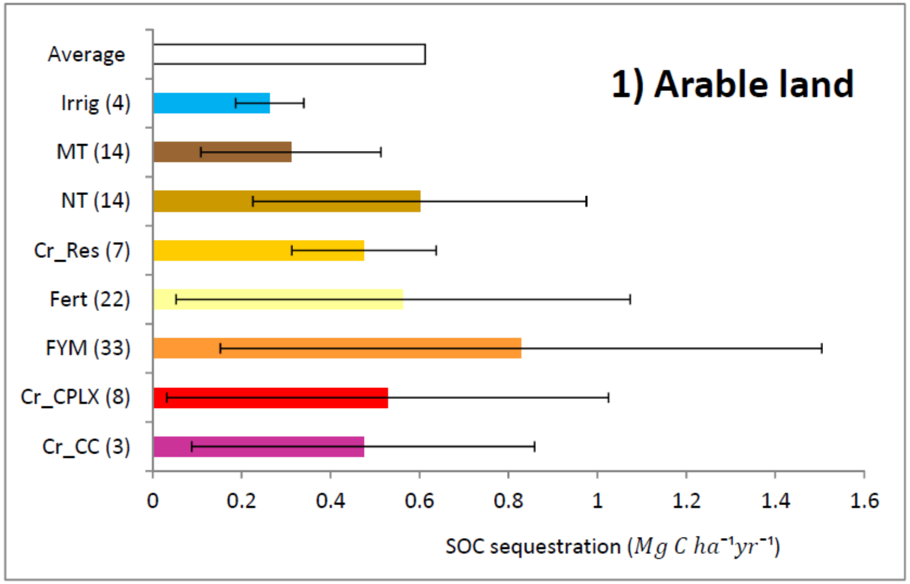
Land use conversion (arable > grassland, preservation of grasslands)
Improved and controlled grazing
Maintaining minimum grass coverage
N-fixing crops
Crop rotation
Cover crops
Agroforestry
No Tillage
Conservation agriculture
Compost & manure, Green manure
Organic farming
Balanced nutrient applications
Degraded land and peatland restoration

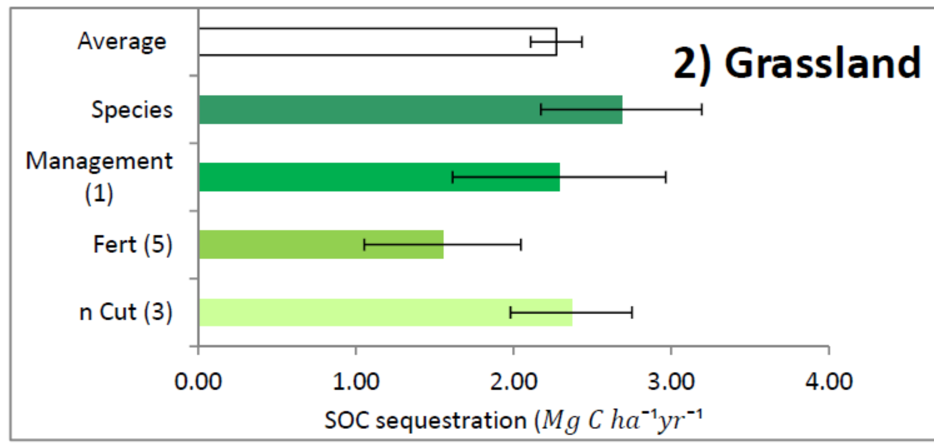
Medium Potential

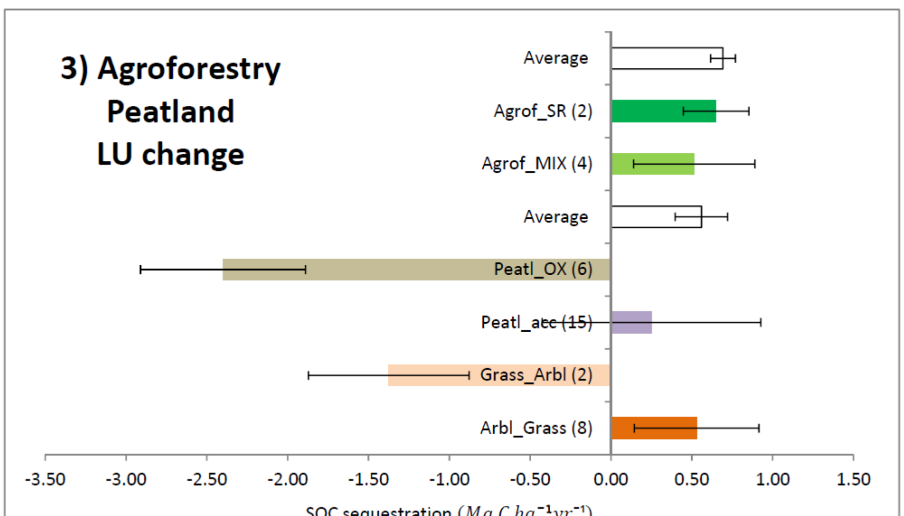
Perennial grasses and permanent crops
Set aside
Reduced Tillage
Biosolids & Biochar
High technologies
Small-scale irrigation system

Joint Research Centre

Meta Analysis







Meta Analysis

In general SOC sequestration of selected promising mitigation options range from 0.2 to 1 Mg C ha-1 yr-1. However, no single optimum option that, if applied across the EU, could give an absolute certain rate of SOC sequestration.

Arable land related practices: range 0.25 and 0.85 Mg C ha-1 yr-1.

Grassland related practices: range 1.5 and 2.85 Mg C ha-1 yr-1.

Agroforestry/peatland/Land Use change related practices: agroforestry mixed and short rotations give positive values around 0.5-0.6 Mg C ha-1 yr-1.

The oxidation of peatland and the conversion from grassland to arable give negative values. Peatland accumulation and conversion from arable land to grassland gives positive ranges.

Many studies were based on short term experiments or were lacking clear comparison or information.

Most practises characterised by a high variability due to the relative small number of studies and unique characteristics (i.e. soil type, location, and climate).

Conclusions

While several practices have been shown to be effective at C sequestration, many land management procedures lack robust assessments both geographically and over time.

The effectiveness of potential mitigation practices vary according to climatic conditions. Sequestration rates tend to be higher in more humid climates (both cool and warm).

Many practices display pronounced secondary benefits ranging from improvements in soil, crop and environmental quality and water retention to the prevention of erosion and land degradation. Many show strong correlations with an enhancement in soil biodiversity.

Some measures may result in an increased environmental burden (e.g. because of > herbicide use).

Actual changes in climatic conditions may affect long-term effectiveness of specific management practices (e.g. plant growth rates, litter composition, drought and increasing temperatures, growing season…).

Thank You

http://eusoils.jrc.ec.europa.eu/library/Themes/SOC/CAPRESE/

arwyn.jones@jrc.ec.europa.eu