Modelling and monitoring soil organic carbon in European soils

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European Commission, Joint Research Centre (JRC) - Directorate Sustainable Reources (Ispra)

EUROPEAN CARBON FARMING SUMMIT

European Commission

Soil is cross cutting within many policy initiatives

Zero Pollution Action Plan

Circular Economy Action Plan

Chemicals Strategy

Biodiversity Strategy for 2030

Fit for 55 Package

Climate Adaptation Strategy

Farm to Fork Strategy

EU Soil Strategy

Rio Conventions and SDGs

Green Financing & Taxonomy

Common Agricultural Policy

Mission 'A Soil Deal for Europe'

Bioeconomy Strategy

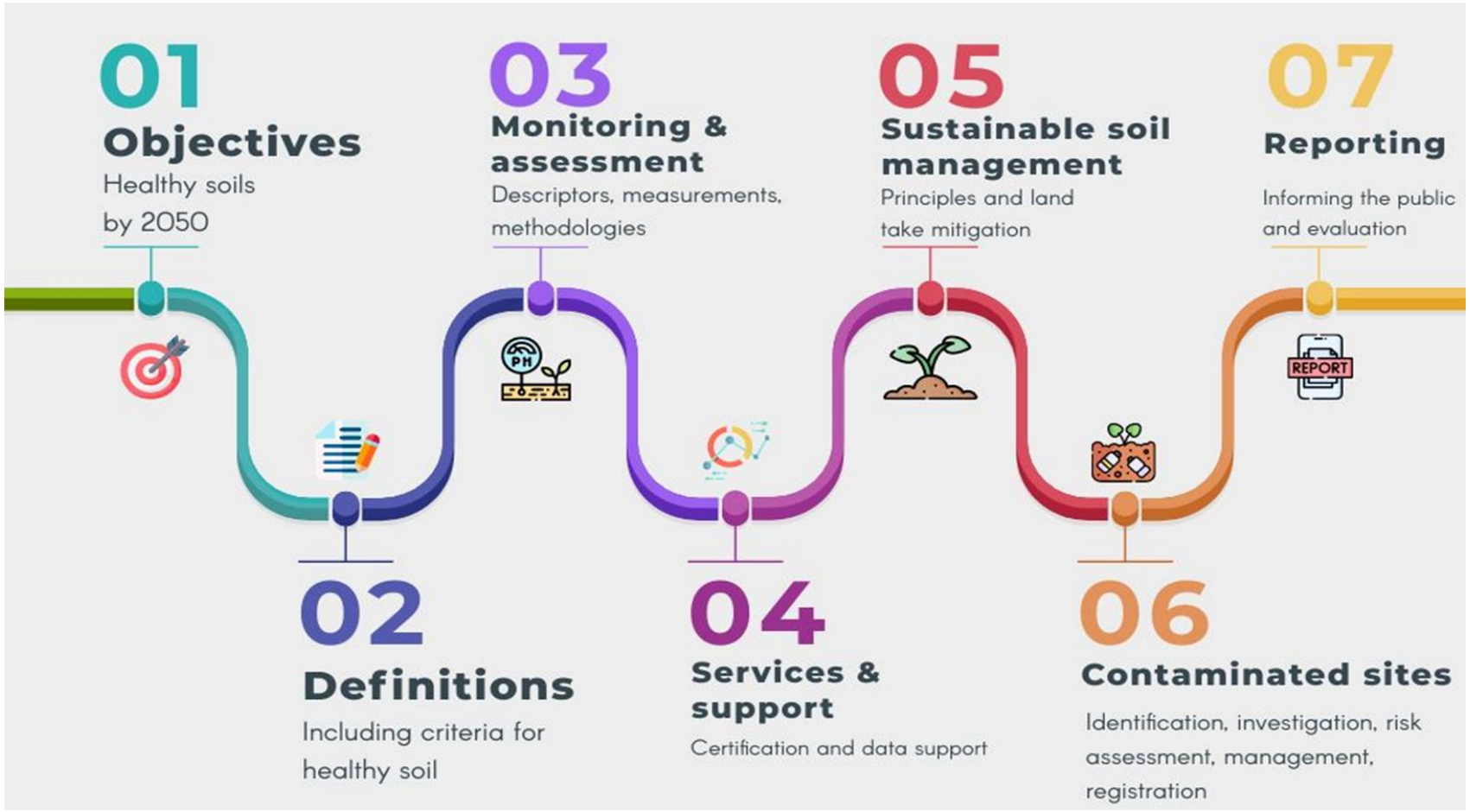
Forest Strategy

Carbon Removal Certification

European Commission

Proposal for a Directive on Soil Monitoring and Resilience
(Soil Monitoring Law, 5 July 2023)

Proposal for the first-ever EU legislation on soils provides a harmonised definition of soil health, puts in place a comprehensive and coherent monitoring framework and fosters sustainable soil management and remediation of contaminated sites.



Soil Organic Carbon concentration is among the 11 descriptors

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The EU Soil Observatory (EUSO)

KNOWLEDGE FOR SOIL POLICY

EU-wide soil monitoring

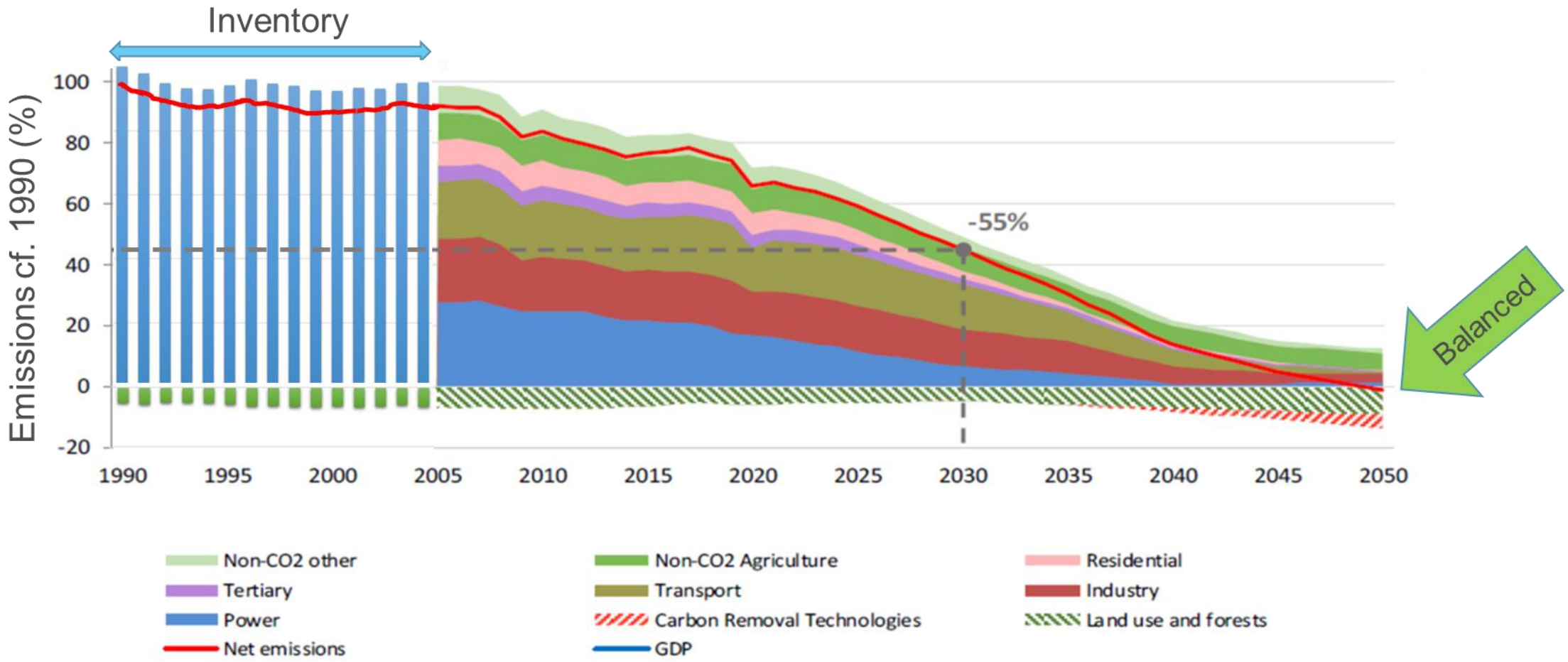
Monitoring soil health and policies

Research & Innovation

Stronger European Soil Data Centre (ESDAC)

EUSO Stakeholder Forum

Pathway to climate neutrality: Climate Law



European Commission

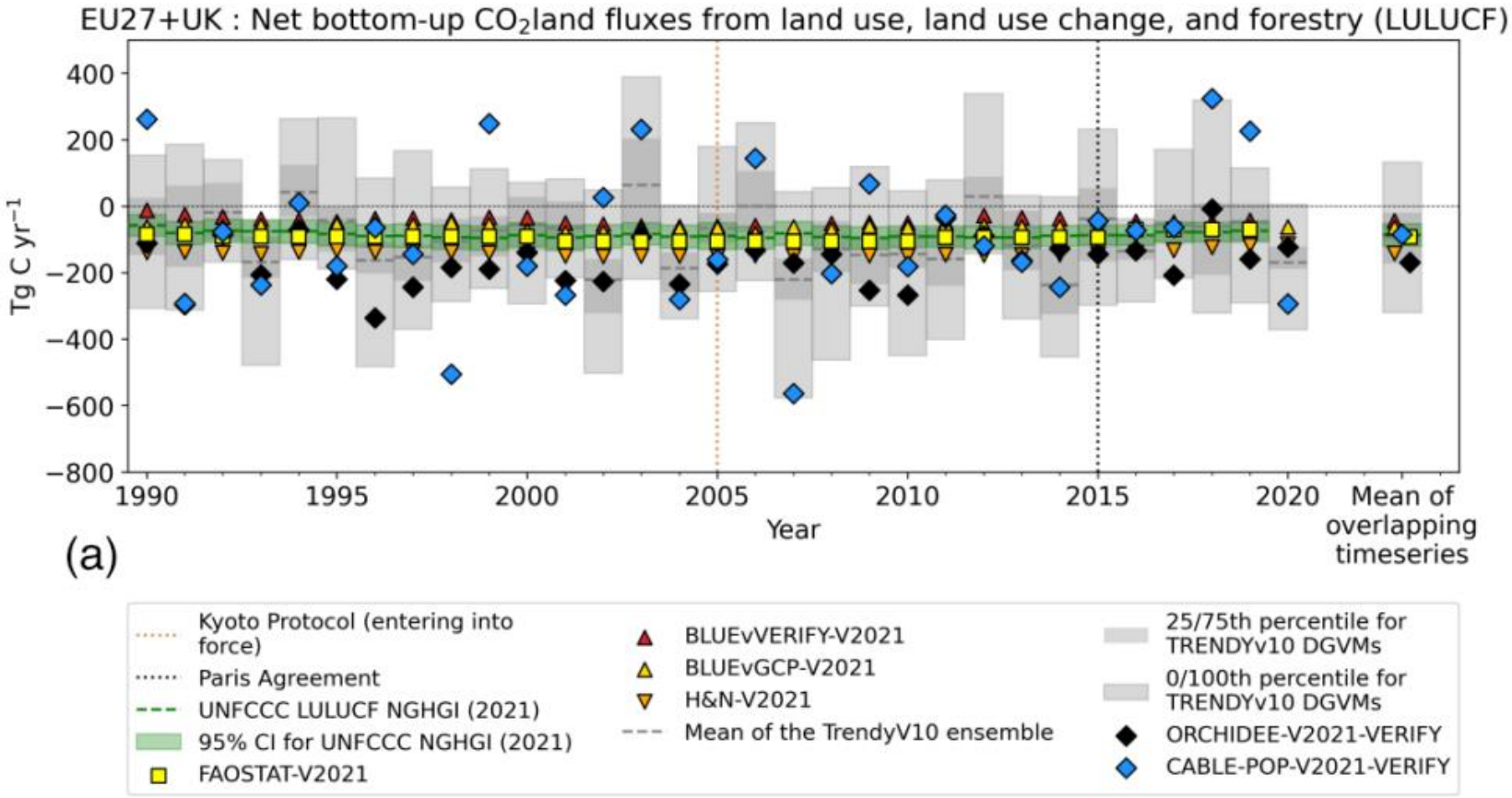
What is the current situation in the EU?

Earth Syst. Sci. Data, 15, 4295–4370, 2023
https://doi.org/10.5194/essd-15-4295-2023

Open Access Earth System Science Data

**The consolidated European synth
and removals for the Europ
United Kingdom: 19**

Matthew J. McGrath[1], Ana Maria Roxana Petrescu[2], Pl
Bradley Matthews[4], Frank Dentener[5], Juraj Balkovič[6], V
Gregoire Broquet[1], Philippe Ciais[1], Audrey Fortems-C
Giacomo Grassi[5], Ian Harris[11,12], Matthew Jones[13], Jür
Guillaume Monteil[16], Saqr Munassar[17], Paul I. Palmer
Mart-Jan Schelhaas[19], Oksana Tarasova[20], Matteo V
Gianpaolo Balsamo[23], Antoine Berchet[1], Peter Briggs[14], Pat
Giulia Conchedda[24], Monica Crippa[5,25], Stijn N. C. Dellaer
Sara Filipek[19], Pierre Friedlingstein[27], Richard Fuchs[22], M
Diego Guizzardi[5], Dirk Günther[29], Richard A. Hough
Ronny Lauerwald[31], Bas Lerink[19], Ingrid T. Luijkx[32], Ge
Gert-Jan Nabuurs[19], Aurélie Paquirissamy[1], Lucia Perugin
Julia Pongratz[10,37], Pierre Regnier[38], Marko Scholze[16], Yusuf
Rona L. Thompson[40], Francesco N. Tubiello[24], Timo



The land is acting as a C sink mainly because of forests

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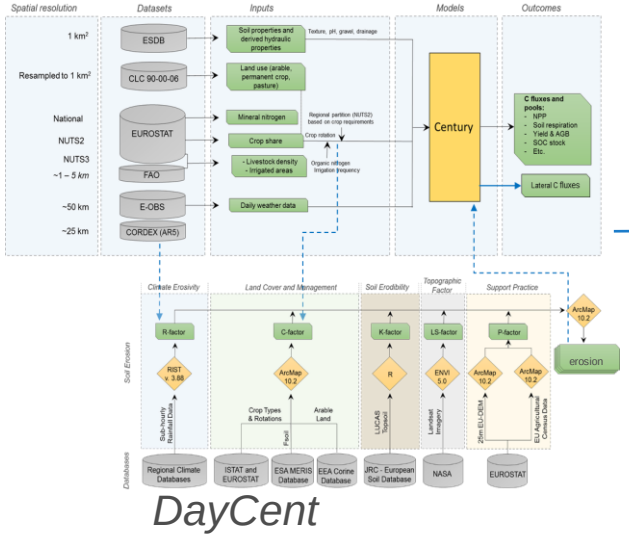
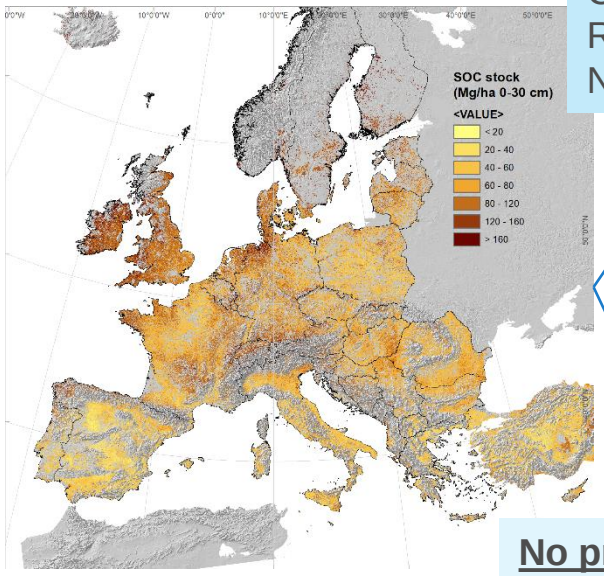
SOC stocks in agricultural soils? Modelling approach

Biogeochemistry model framework



Carbon and nitrogen fluxes

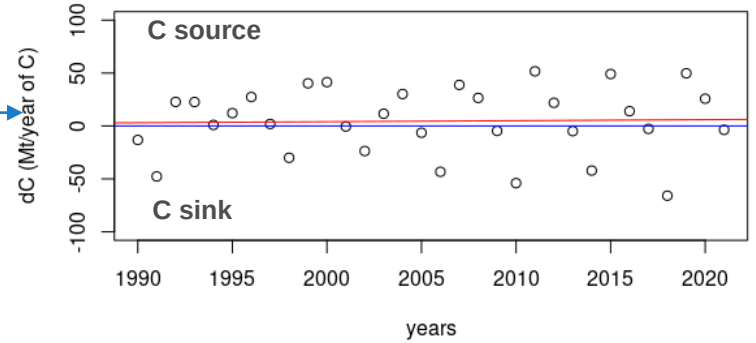


Including practices
Cover crop
Reduced till.
No-till

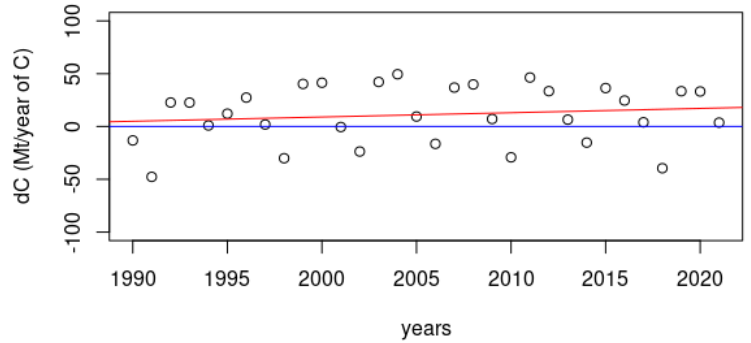
No practices scenario

Data Source: FSS Farm Structural survey

dC=5.3 Mt yr^{-1} average loss



dC=11.9 Mt yr^{-1} average loss



Lugato E. *et al., Nature Climate Change* **8**, 219–223 (2018)
Lugato E. *et al., Science Advances* **4 (11)**, 2018
Lugato E. *et al., GCB,* **20 (11)**, 2014

dC stock in agricultural land =
$- NPP + Rh + C_{exp} + C_{lat}$

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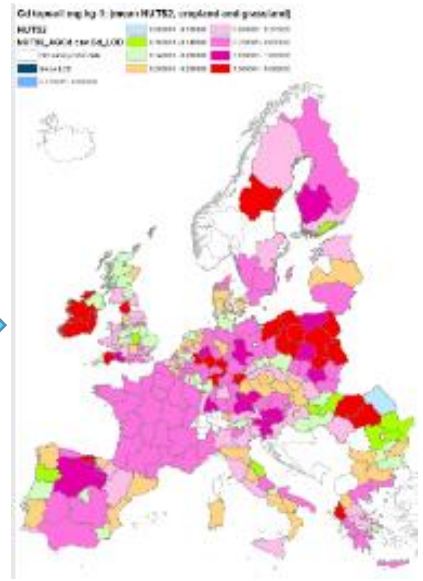
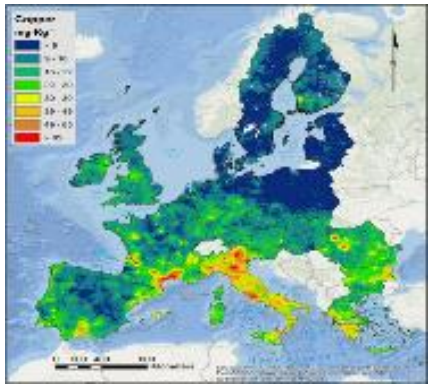
SOC stocks in agricultural soils: Data Driven approach with LUCAS SOIL survey

The JRC manages the LUCAS SOIL survey: sample design, measurement protocols through integrated analysis and monitoring, training of surveyors

EU-wide soil monitoring



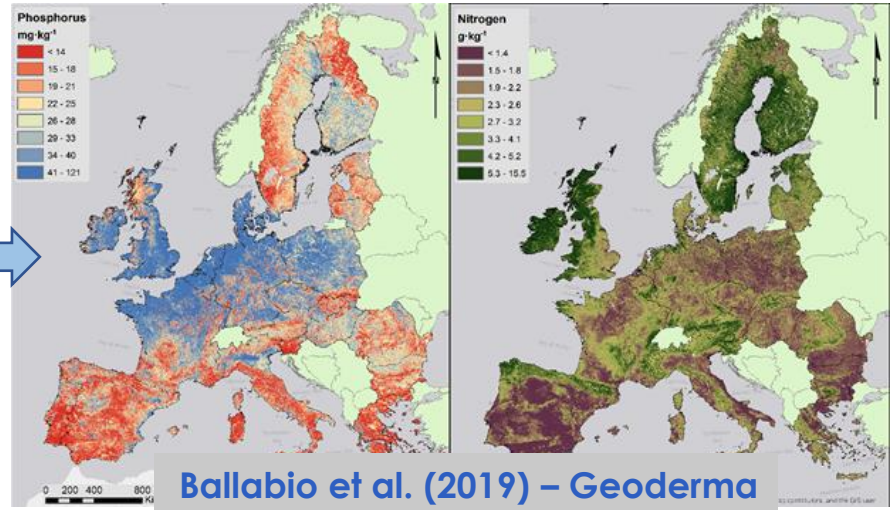


- Surveys (and the resulting data) span multiple years 2009, 2015, 2018, 2022
- 42,000 observations
- Soil archive at the JRC premises in Ispra (IT)
- Close cooperation with MSs

LUCAS Contributes to EU-Wide Soil Monitoring

From monitoring chemical, physical and biological soil properties to modelling the spatial distribution of soil properties in the EU

- **Coarse fragments**
- **Particle-size distribution (clay, silt, sand)**
- **pH**
- **Organic carbon**
- **Carbonate content**
- **Total nitrogen content**
- **Extractable potassium content**
- **Phosphorous content**
- **Cation exchange capacity**
- **Electrical conductivity**
- **Heavy Metals**
- **Multispectral properties**
- **Pesticides (90 substances)**
- Neonicotinoid **insecticides**
- **Fungicides (e.g. copper in soils)**
- **Herbicides**
- **Antibiotics**
- **Soil Biodiversity**



Ballabio et al. (2019) – Geoderma

Is LUCAS a SOC monitoring framework?

- Only topsoil 0-20 cm – For 2022 survey 0-30cm
- No systematic bulk density – Only a subset of all samples in 2018 and 2022
- Limited management information (tillage, cover crops, etc)

2024+

LUCAS 2.0

Better integrated in MS programmes

New parameters

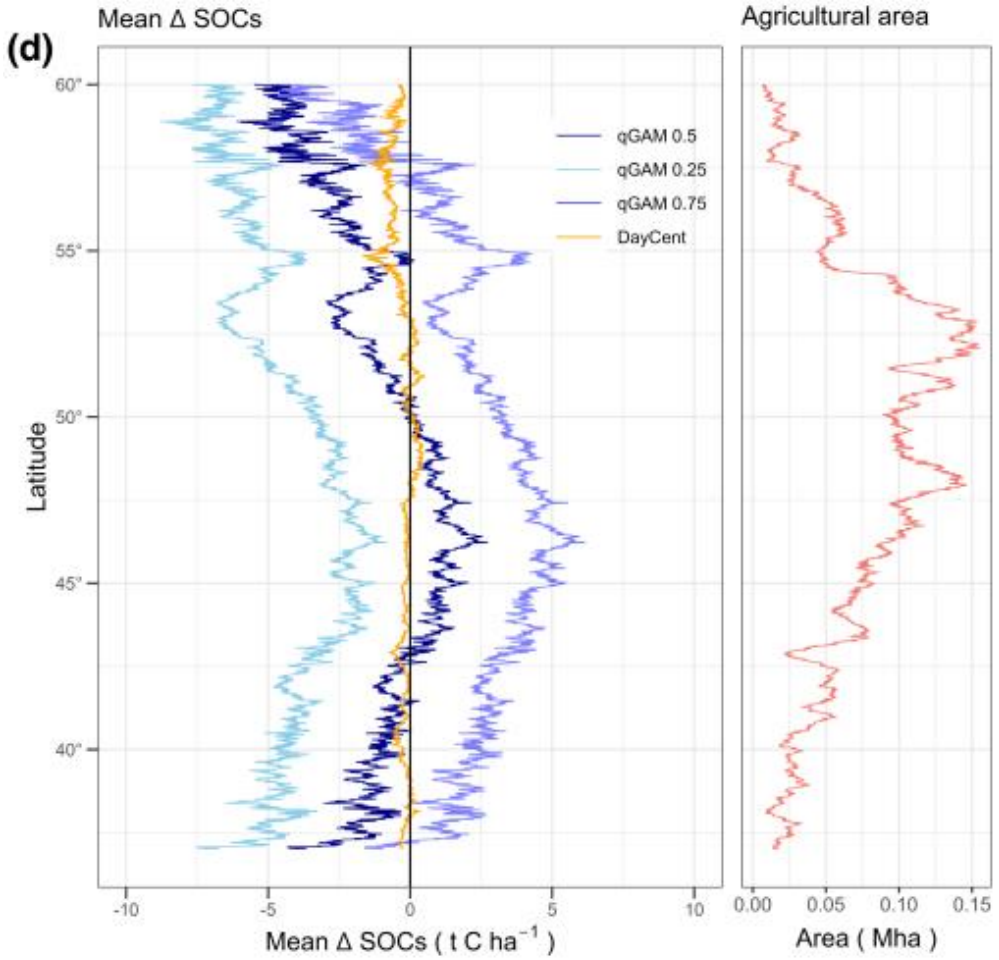
Depth aspects

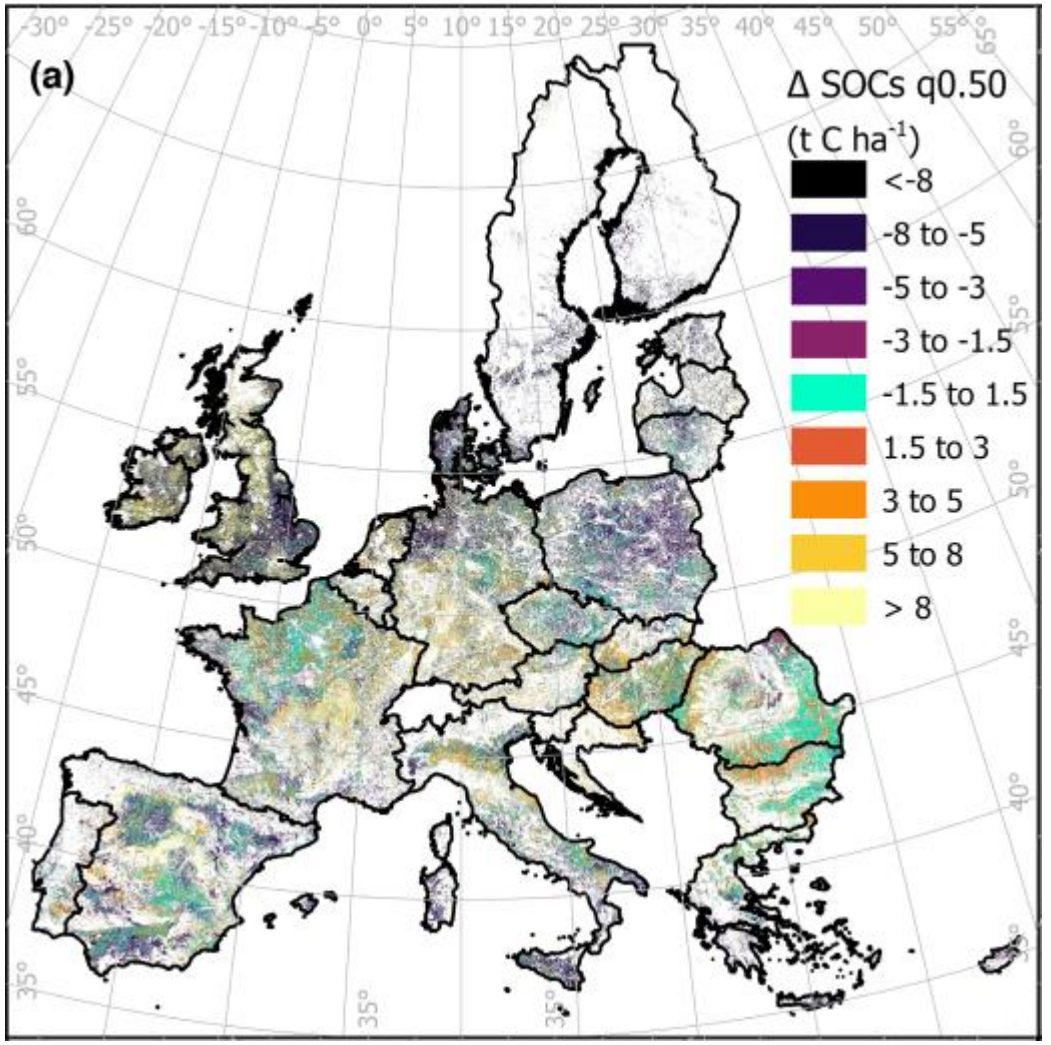
Harmonisation with MS laboratories

Soil organic carbon stocks in European croplands and grasslands: How much have we lost in the past decade?

Daniele De Rosa[1] | Cristiano Ballabio[1] | Emanuele Lugato[1] | Matteo Fasiolo[2] | Arwyn Jones[1] | Panos Panagos[1]

Data Driven approach





2018-09 losses ~ 70 Mt C (0-20cm depth) = **7.7 Mt C loss per year**

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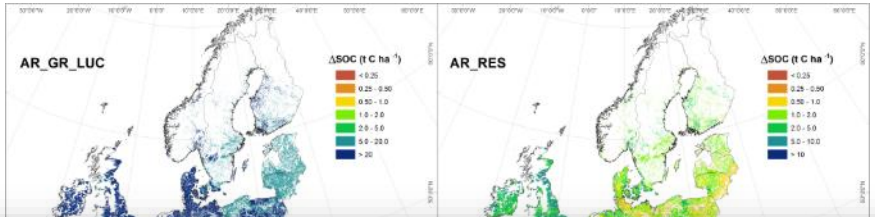
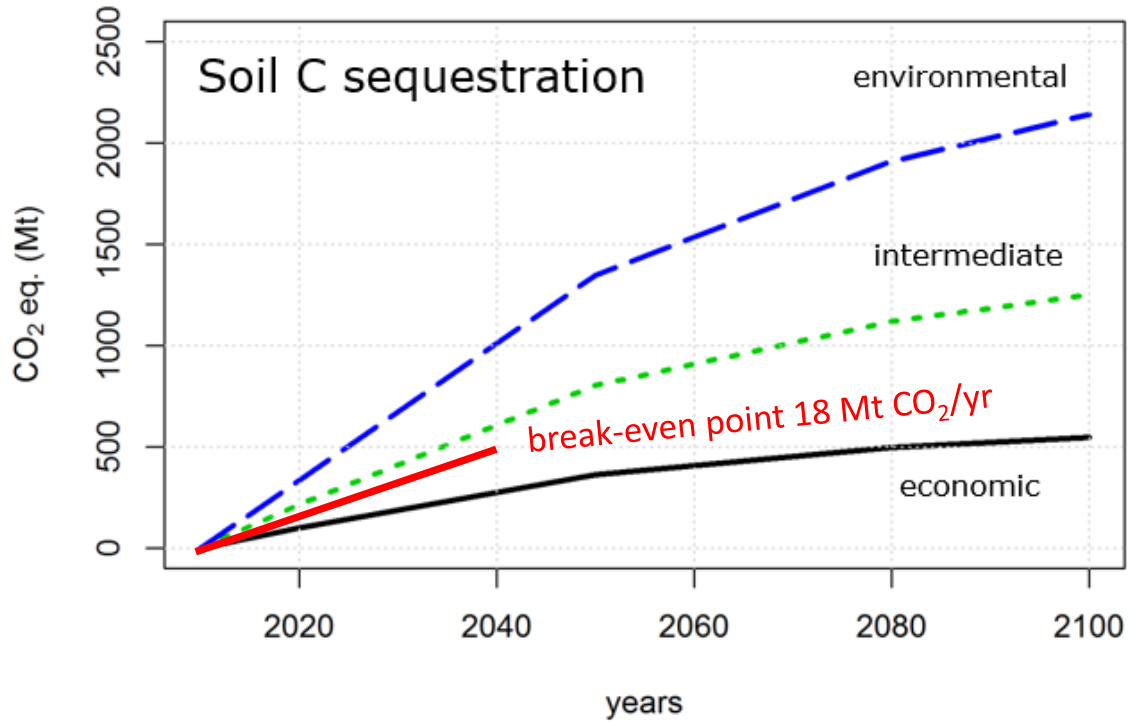
Scenario analysis
(SOC stock changed by 2050)

1) Conversion from arable to grassland (**LUC_AR_GR**);
2) Crop residue management (**AR_RES**);
3) Reduced tillage scenario (**AR_RT**)
4) Combined residue incorporation + reduced tillage (**AR_RET**);
5) Ley in rotation (**AR_LEY**);
6) Cover crop (**AR_CC**);



Arable land allocated to AMP (%)

Scenario	AR_GR_LUC	AR_RES	AR_RT	AR_RET	AR_LEY	AR_CC	Total
Economic	2	2	2	2	2	2	12
Intermediate	5	5	5	5	2	2	24
Environmental	10	2	2	2	5	7	28



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Organic soils: a key “special” issue

EU emissions from organic soils

Source: Annual European Union greenhouse gas inventory 1990–2018

17 Mha -> 95 Mt CO_2

≠

GREIFSWALD MIRE CENTRE

>160 Mt CO_2e

ORGANIC SOILS IN NATIONAL INVENTORY SUBMISSIONS OF EU COUNTRIES

Martin, N. & Couwenberg, J.

Land use subcategory	Area (Kha)	ICECF (tC/ha)	Emissions from Org. Soils. (Kt CO_2)
 4A1	12 264	[-2.60; 0.65]	13 631
4A2	407		1 494
 4B1	1 242	[-10.01; -1.00]	25 813
4B2	273		5 814
 4C1	4 132	[-6.80; 0.25]	42 150
4C2	354	Large uncertainty EF	5 683

85%

The EU emissions from organic soils are at least 4-5 times (7-8 times Greifswald estimates) higher those from croplands

Peatlands as a hotspot of emissions

European Commission

Carbon farming

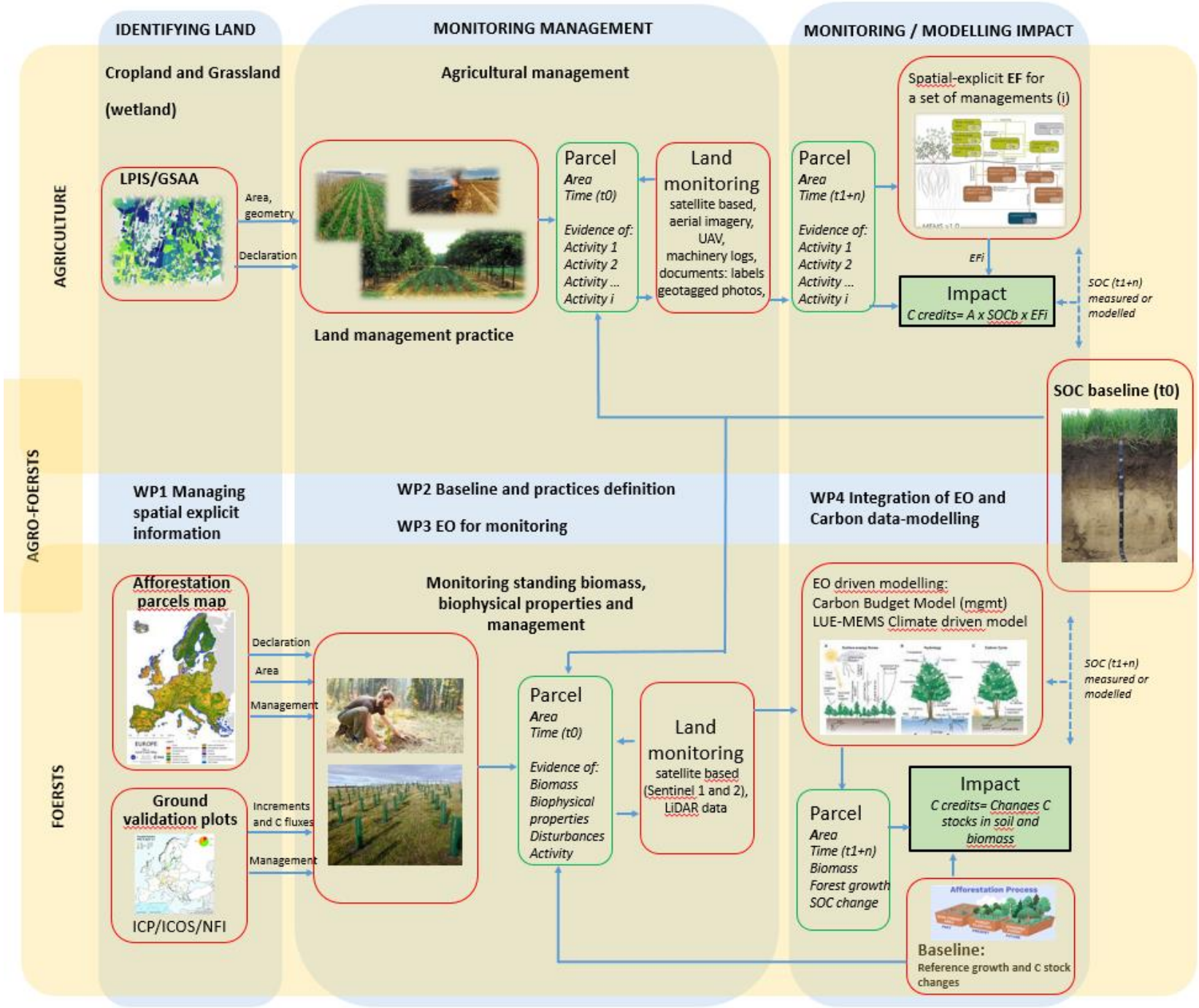
*A **green business model** rewarding land managers for improved land management practices, resulting in carbon sequestration in ecosystems and reducing the release of carbon to the atmosphere.*

Benefits of carbon farming:

- Increased carbon removals
- Additional income for land managers
- More biodiversity and nature
- Increased climate resilience of farm and forest land

Afforestation and reforestation	Use of conservation tillage, catch crops, cover crops and increasing landscape features	Restoration, rewetting and conservation of peatlands and wetlands	Targeted conversion of cropland to fallow, or of set-aside areas to permanent grassland	Agroforestry and other forms of mixed farming	
+++	+/++	+	+/+++	++	C removal
+/++	+/++	+++	+/+++	+	Reduced emissions
+++	+	+/+++	+/+++	++	LC/LU change

Proposal for a Regulation on an EU certification for carbon removal COM(2022) 672 final



Carbon farming will require the development of a robust MRV scheme:

- in a cost effective way to monitor the carbon changes
- Including emission removal at parcel scale

JRC develops Carbon Removal Land (CRL) project (funded by DG CLIMA)

Test /design new methods (MRV) for monitoring – calculating the carbon budget at parcel scale.

Integrates spatial explicit data from LPIS, Remote Sensing and LUCAS

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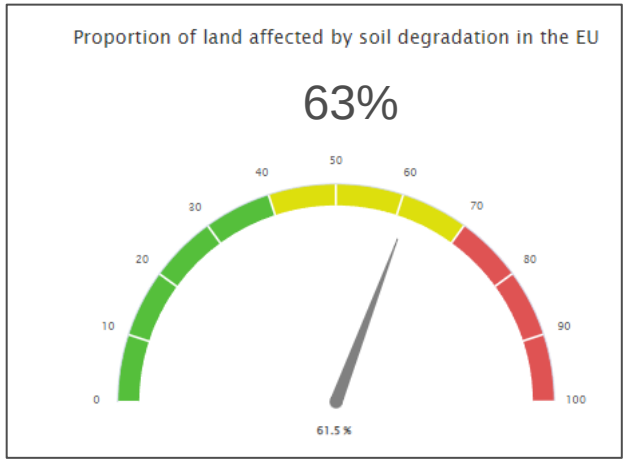
Monitoring soil health and policies

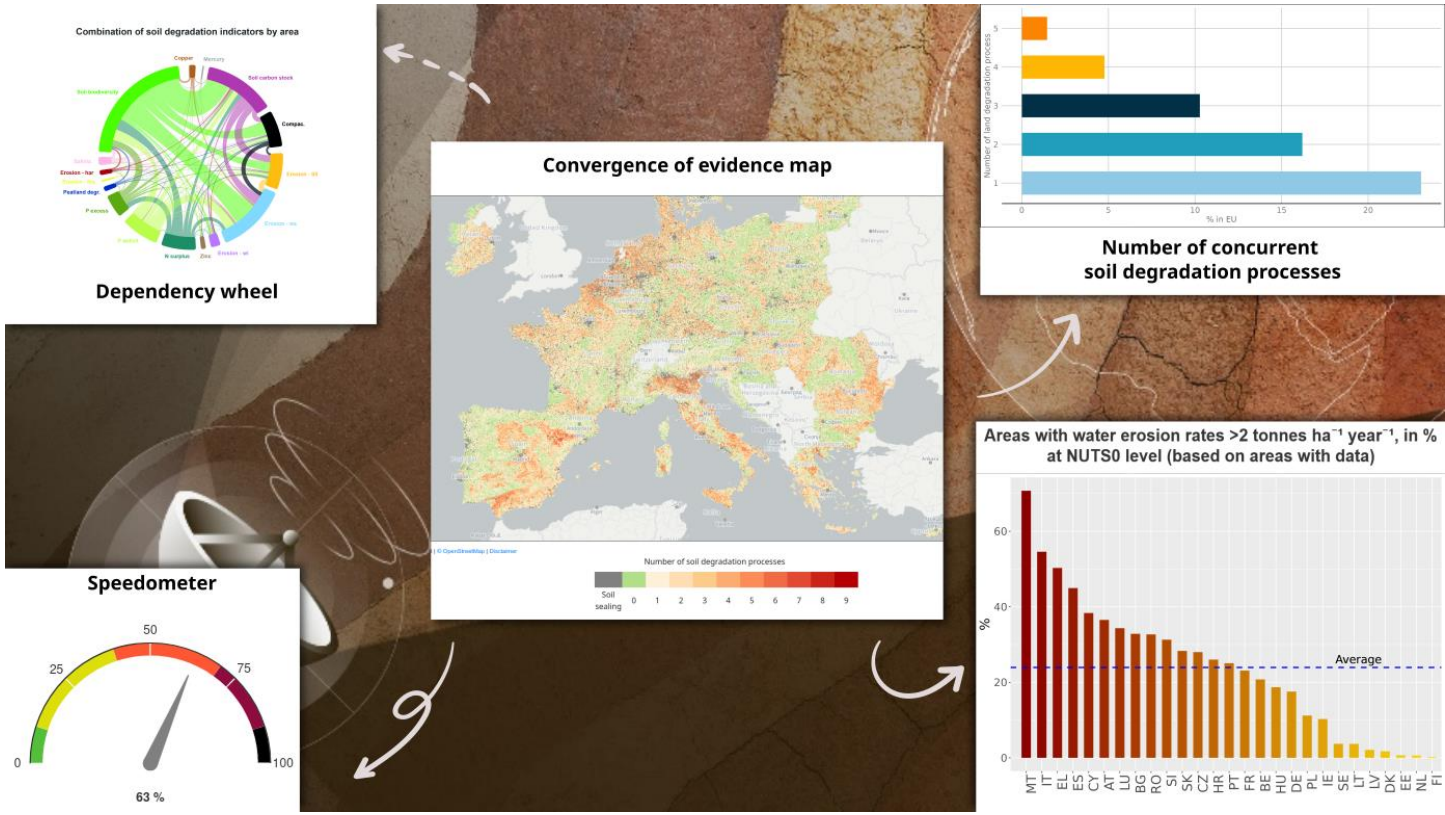
EUSO: Assessing Policy Impact

EUSO Soil Dashboard

Convergence of scientific evidence

- 18 Soil degradation indicators
- 63 % of unhealthy soils
- Dashboard shows location and different types of soil degradation in the EU





https://esdac.jrc.ec.europa.eu/esdacviewer/euso-dashboard/

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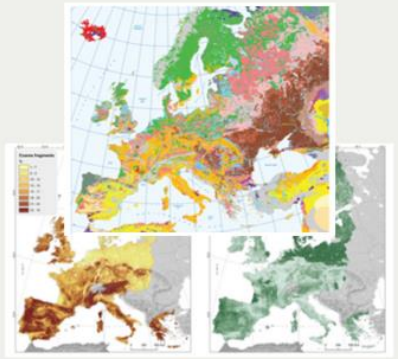
Roadmap towards healthy soils by 2030

Top-down mapping

Bottom-Up mapping



EUSO Soil Health Dashboard

SOIL LIVE
Soil Health BENCHMARKS

AI 4 Soil Health

Soil Wise

SOLO

~1 billion € budget

2012

2021

2023

2025

2027

2030

100 Living Labs

Soil Monitoring Law

JOINT RESEARCH CENTRE
EUROPEAN SOIL DATA CENTRE (ESDAC)

European Commission

Conclusions

- Agricultural soils are a small C source with regional variations in the EU (mostly related to climate change)
- Carbon farming (CF) can have significant mitigation potential (net removal) potential but requires large up-take of CF activties
- Promp effect of re-wetting organic soils (reduced emissions)
- JRC has developed estimates of carbon trends (Biophysical models, Data driven approaches) – with high uncertainties
- Three Soil Mission projects – (MRV) : CREDIBLE, MRV4SOC, MARVIC (Collaboration with Soil research community and upcoming Soil Mission projects)
- Soil Mission Workprogramme 2024: even more ambitious calls for proposals on carbon farming and Living Labs
- Soil Monitoring Law: from 20,000 points to 200,000 points measured points

Thank you

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