

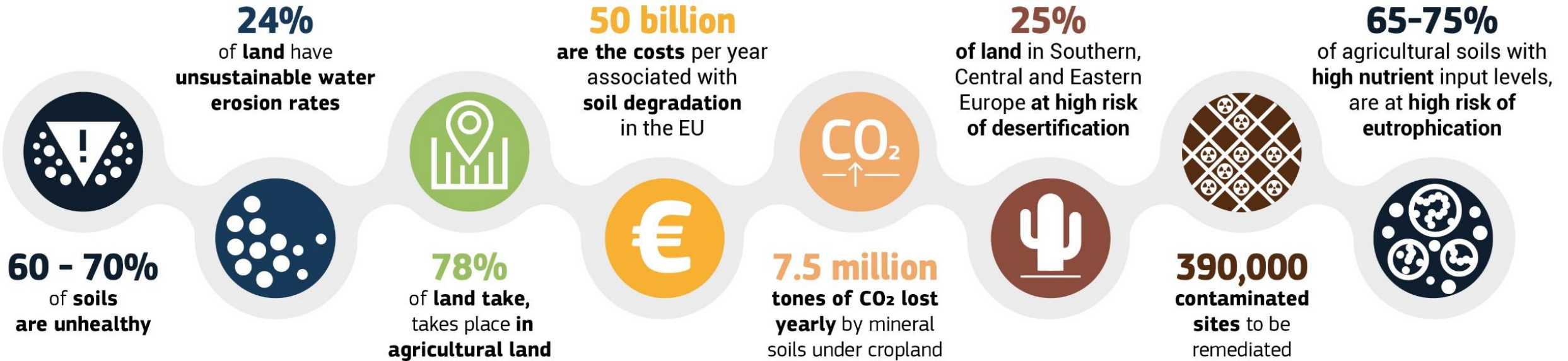
The role of EU Soil Observatory (EUSO) in soil monitoring in the EU

Dr. Panos Panagos

European Commission
Joint Research Centre (JRC)
Directorate D Sustainable Resources

Soil Degradation in the EU

The time to act is now!



erosion desertification sealing land take compaction } SOIL THREATS
loss of biodiversity pollution
organic matter decline salinisation

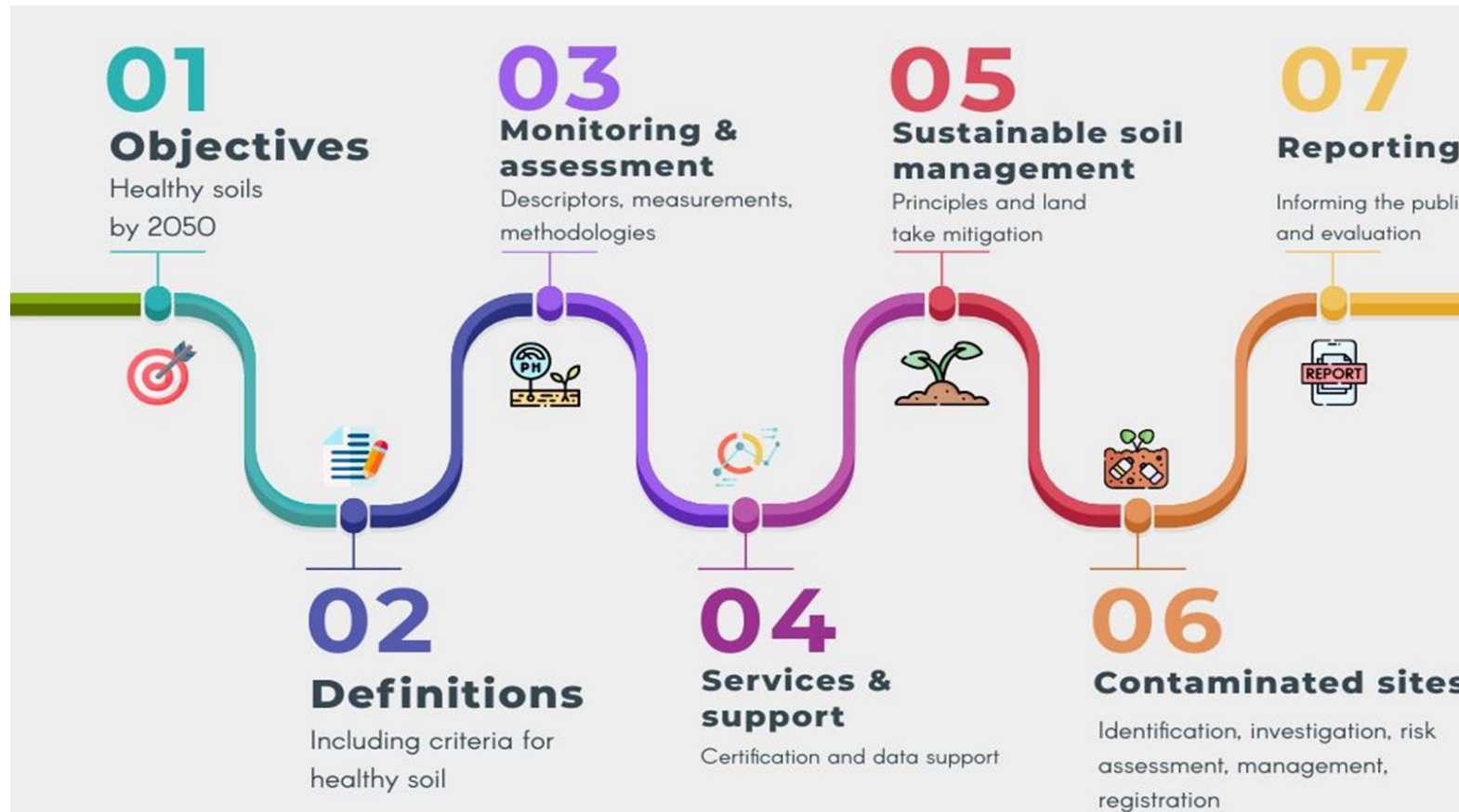
Soil is cross cutting within many policy initiatives



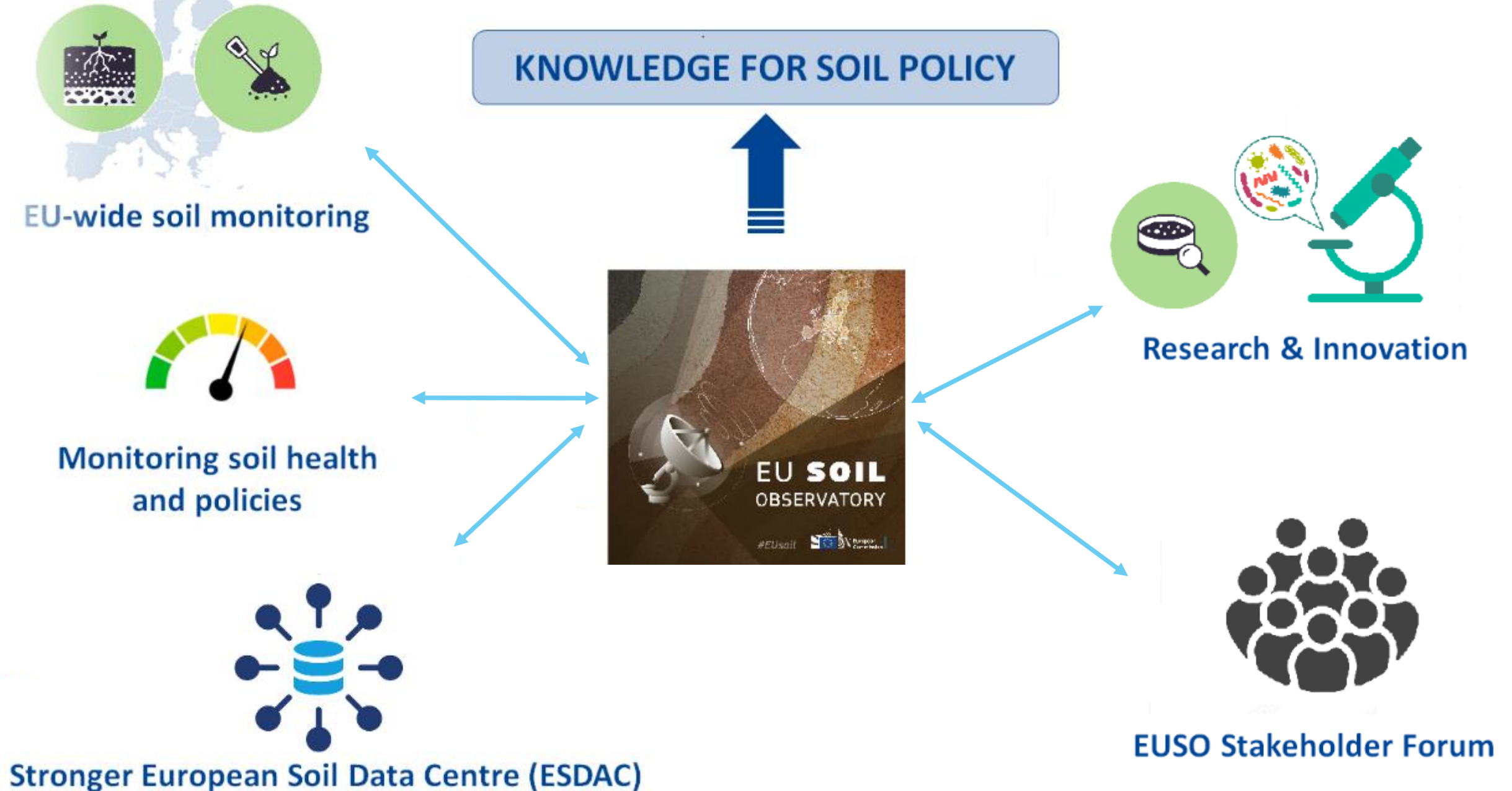
November 2021

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.



The EU Soil Observatory (EUSO)

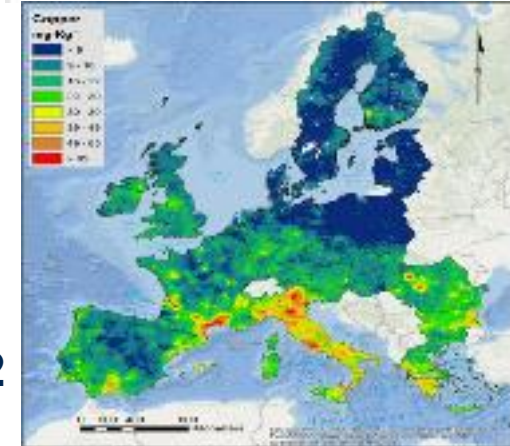
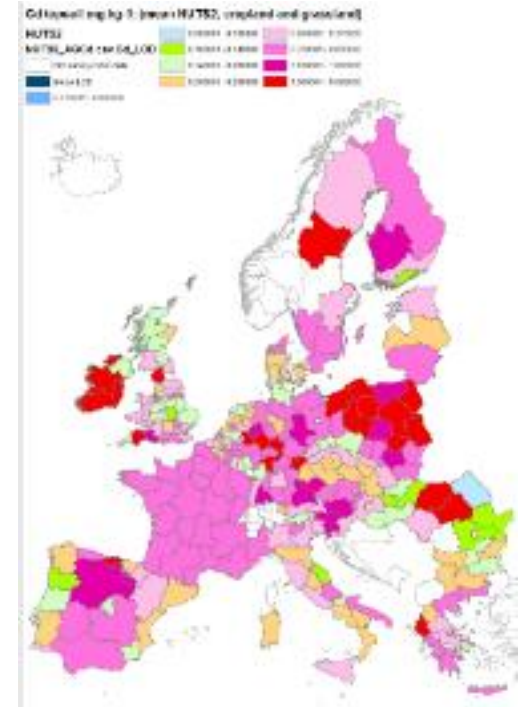
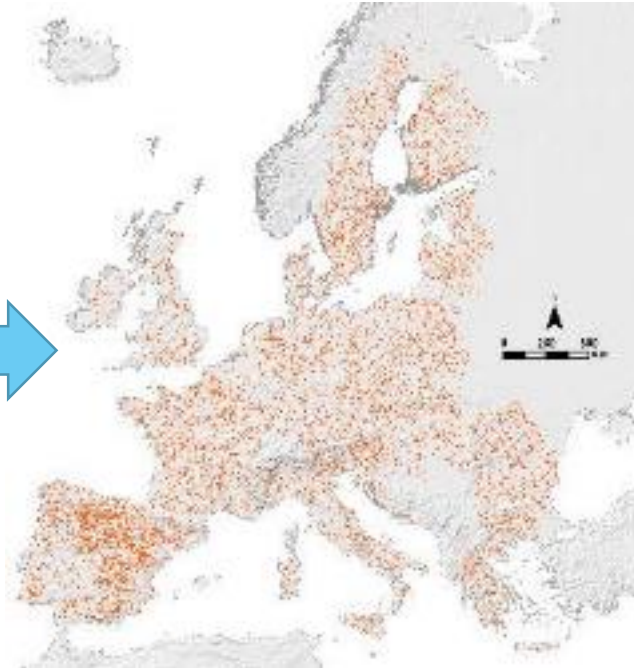




EU-wide soil monitoring

LUCAS SOIL survey

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



- Surveys (and the resulting data) span multiple years 2009, 2015, 2018, 2022
- 40,000 observations
- Soil archive at the JRC premises in Ispra (IT)
- Close cooperation with Member States

LUCAS Contributes to EU-Wide Soil Monitoring

From monitoring physical, chemical and biological soil properties to support EU policies



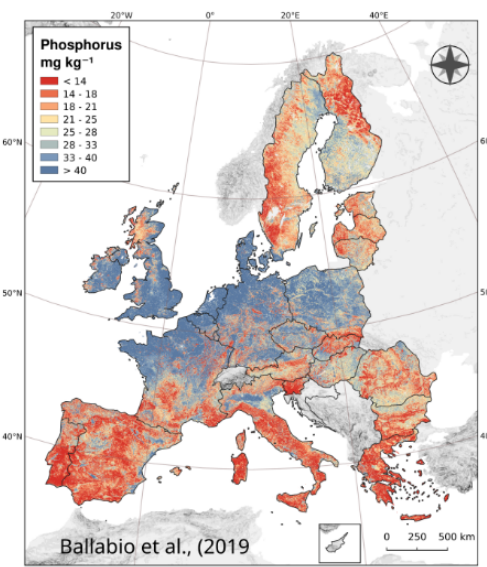
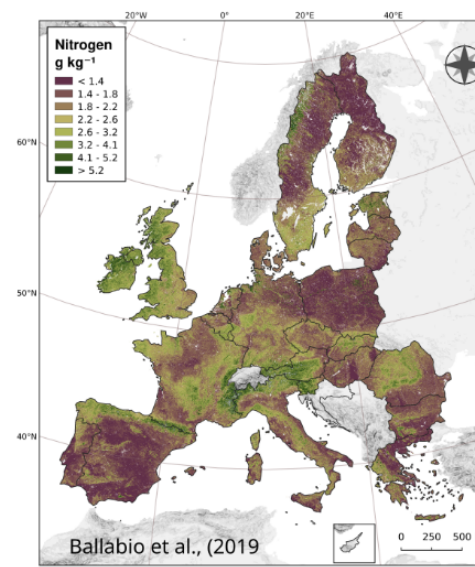
SOIL PROPERTIES

Organic carbon
Total nitrogen content
Phosphorus content
Heavy Metals
Pesticides
Fungicides
Antibiotics
Soil Biodiversity



MODELLING + AI

DayCent
Cubist
Gaussian process
GAM



COM(2023)416 - Directive
Soil Monitoring and Resilience
(Soil Monitoring Law)

POLICY MAKING

- EU Soil Strategy 2030
- Soil Mission
- Carbon Farming Certification
- Nature Restoration Law
- Zero Pollution Action Plan
- Common Agricultural Policy (CAP)
- Biodiversity Strategy 2030
- Chemical Strategy



EU wide Soil Monitoring System

EU-wide soil monitoring

Is LUCAS a sufficient soil 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)
- Limited to 1,000m altitude

A step further on collaboration with EJP

- Data harmonization of paramount importance
- MS follow different methods for soil properties sampling and analysis
- LUCAS 2022 (0-30 cm) single Lab analysis Vs. 13 MS laboratory analysis
- Develop of (pedo) transfer functions to valorize legacy data
- Possible further research on this?



EU-wide soil monitoring

EUSO proposal for stratified sampling in the Law

Requirements from policy

- Representative in terms of physical, chemical and biological properties
- Maintaining sufficient accuracy
- Minimizing the costs for Member States

What is done?

- Minimum sampling size by implementing the Bethel algorithm (Ballin and Barcoli 2013)
- Selection of independent variables that are strongly correlated with target variables (pH, SOC, etc)
- Selection of x number of points which have been delivered and tested per MS

European Soil Data Centre (ESDAC) 2.0

The European Soil Data Centre (ESDAC)

Performance



- ✓ 120 datasets
- ✓ over 6,000 maps
- ✓ 600 scientific documents
- ✓ 600,000 visits per year
- ✓ 12,000 data downloads in 2023

Soil Monitoring Law and the Soil Mission

ESDAC 2.0

- ✓ Soil data flows from Member States to EUSO
- ✓ Collect data outputs from the Soil Mission
- ✓ Incorporate products from other technological streams



EU Soil Health Portal

ESDAC 3.0



- ✓ Knowledge, science evidence and EU soil-related policies
- ✓ Update indicators and Soil Health Dashboard
- ✓ Trends on implementation and performance of EU soil policies
- ✓ A first stop shop for all stakeholders in the EU

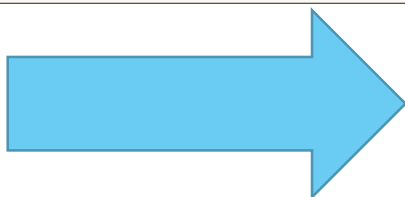


Challenges and obstacles

- ✗ Fragmentation of data management in MS
- ✗ Reluctance of data holders to share their data
- ✗ Technical issues



2024+



Accommodate data flows from MS
Outcomes of Soil Mission
Enhanced functionality





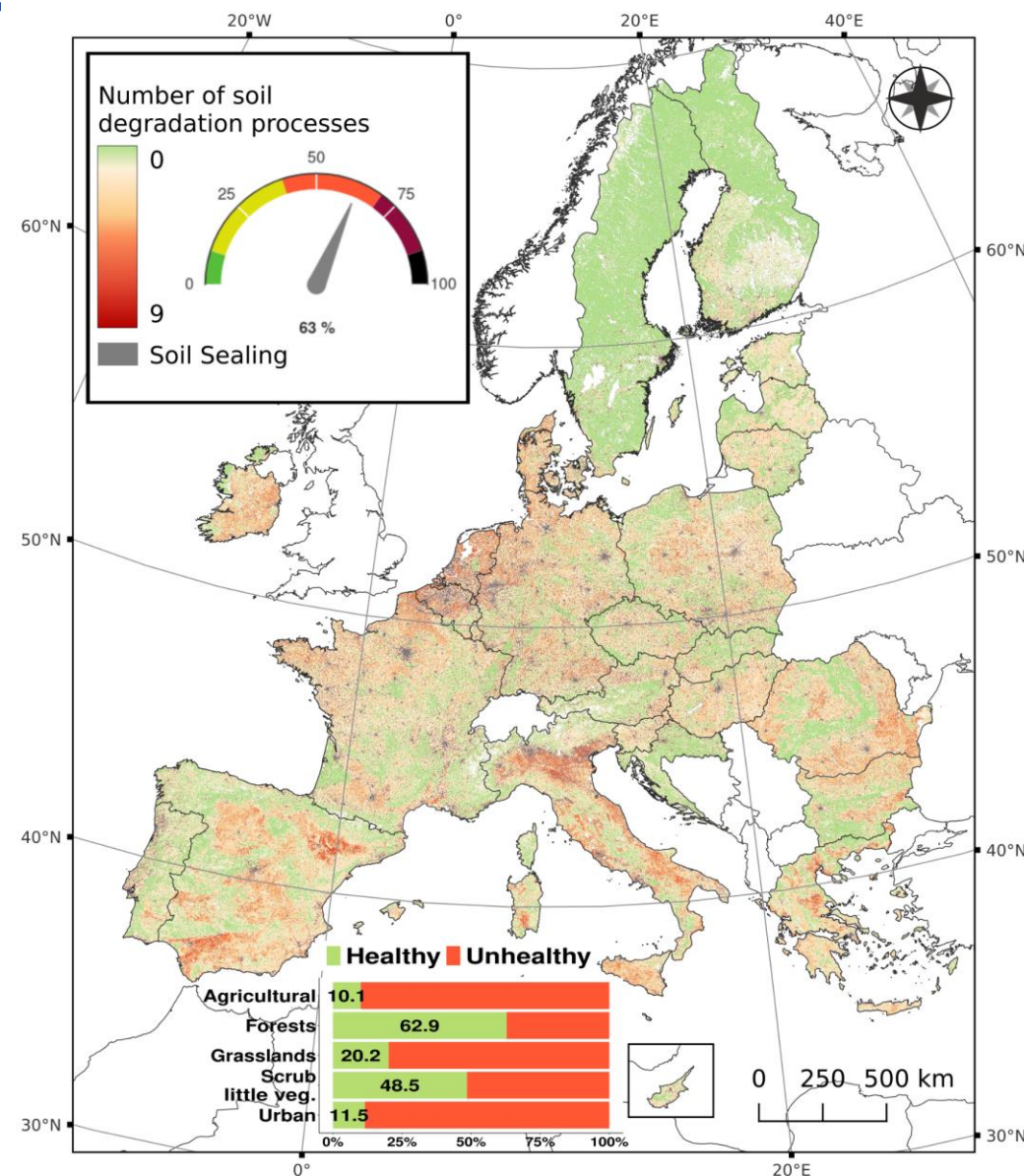
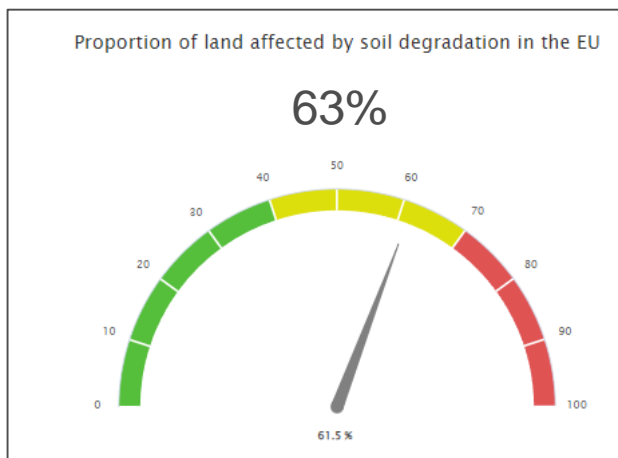
Monitoring soil health
and policies

Assessing Policy Impact

EUSO Soil Dashboard

Convergence of scientific evidence

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

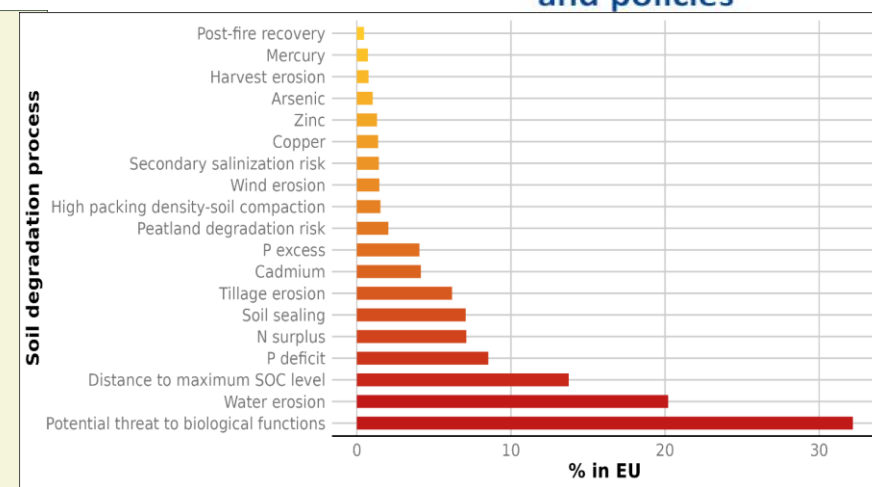
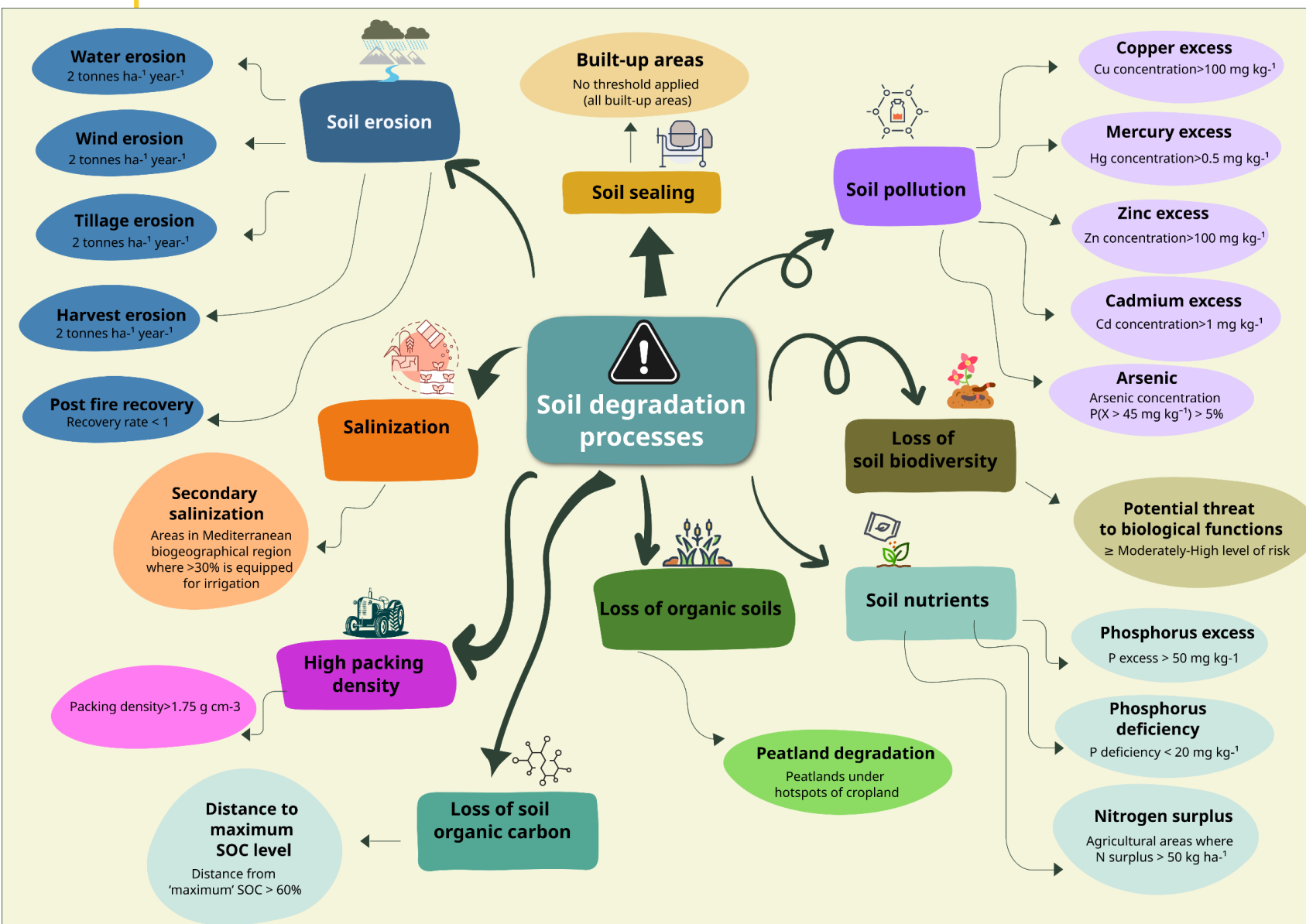


<https://esdac.jrc.ec.europa.eu/esdacviewer/euso-dashboard/>



Monitoring soil health
and policies

Soil Degradation processes in the Dashboard



Received: 22 February 2024 | Revised: 6 May 2024 | Accepted: 7 May 2024
DOI: 10.1111/ejss.13507

REVIEW ARTICLE

European Journal of
Soil Science WILEY

How the EU Soil Observatory is providing solid science for healthy soils

Panos Panagos¹ | Nils Broothaerts¹ | Cristiano Ballabio¹ |
Alberto Orgiazzi² | Daniele De Rosa³ | Pasquale Borrelli⁴ |
Leonidas Liakos⁵ | Diana Vieira¹ | Elise Van Eynde¹ |
Cristina Arias Navarro¹ | Timo Breure¹ | Arthur Fendrich⁶ |
Julia Königer⁷ | Maeva Labouyrie⁸ | Francis Matthews⁹ |
Anna Muntwyler¹⁰ | Juan Martin Jimenez¹¹ | Piotr Wojda¹ |
Felipe Yunta¹ | Anne Marechal¹² | Serenella Sala¹ | Arwyn Jones¹

Land Degradation in the EU



Monitoring soil health
and policies

nature communications



Article

<https://doi.org/10.1038/s41467-024-48252-x>

A unifying modelling of multiple land degradation pathways in Europe

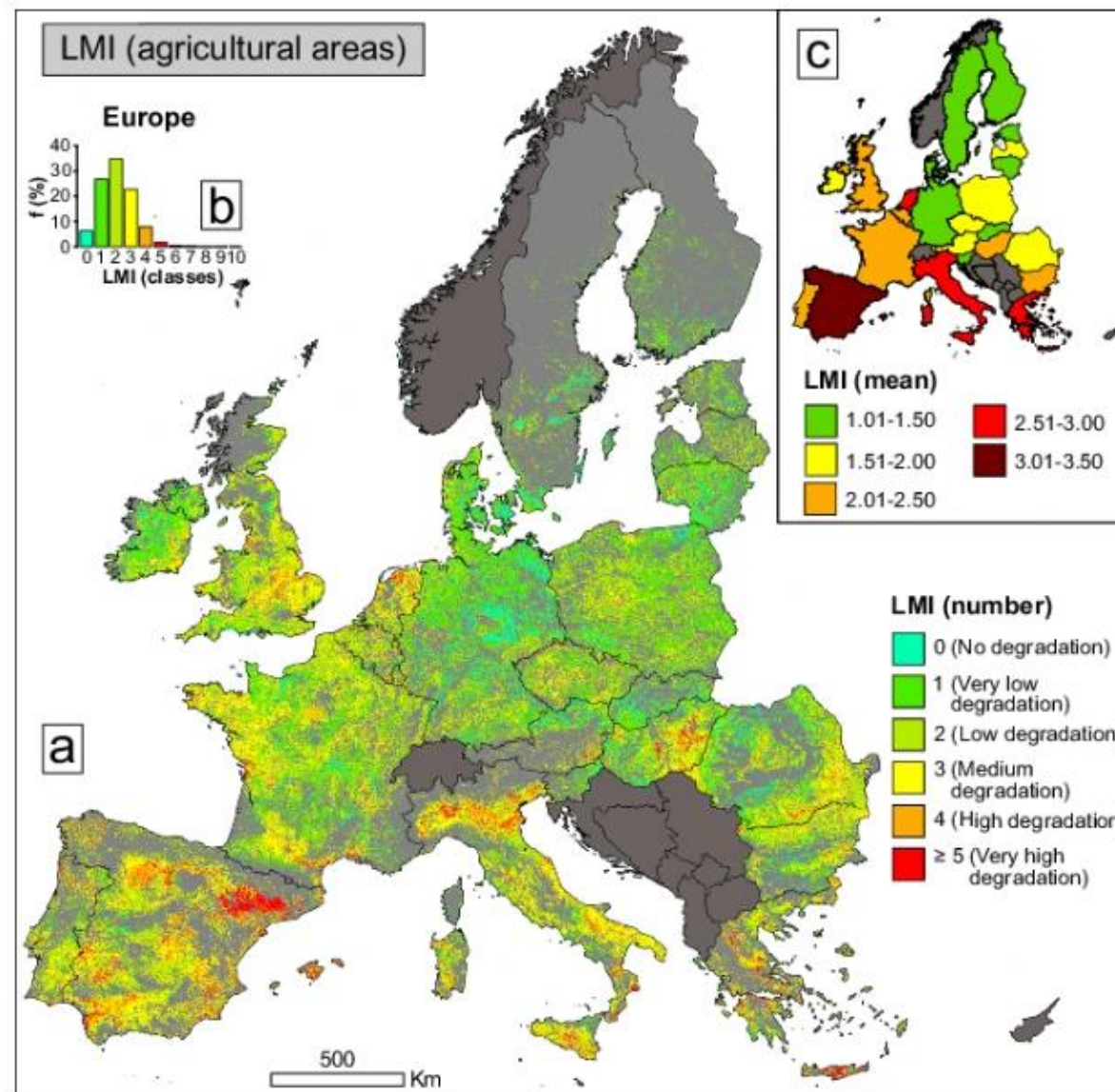
Received: 1 April 2023

Accepted: 23 April 2024

Published online: 08 May 2024

Check for updates

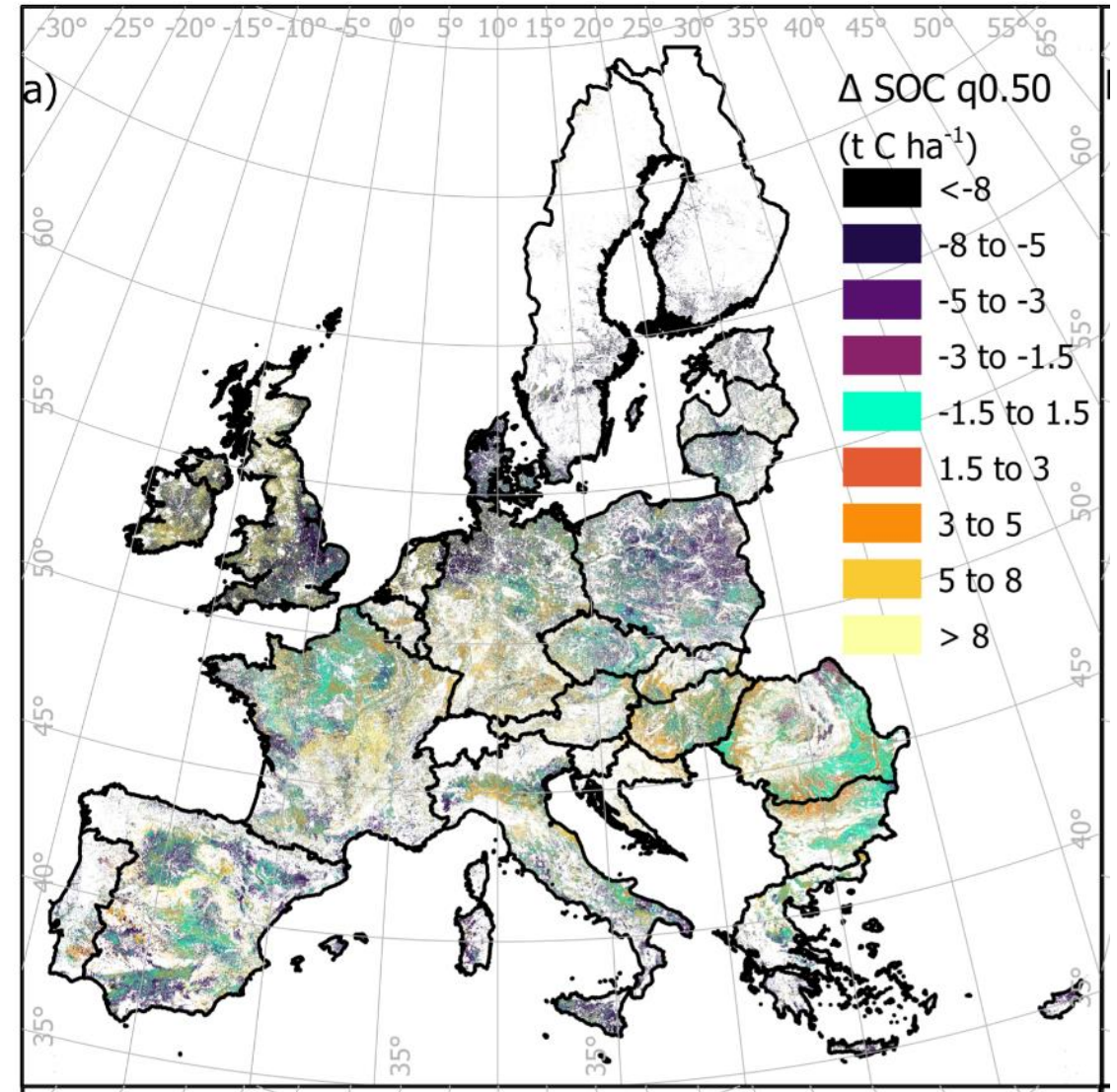
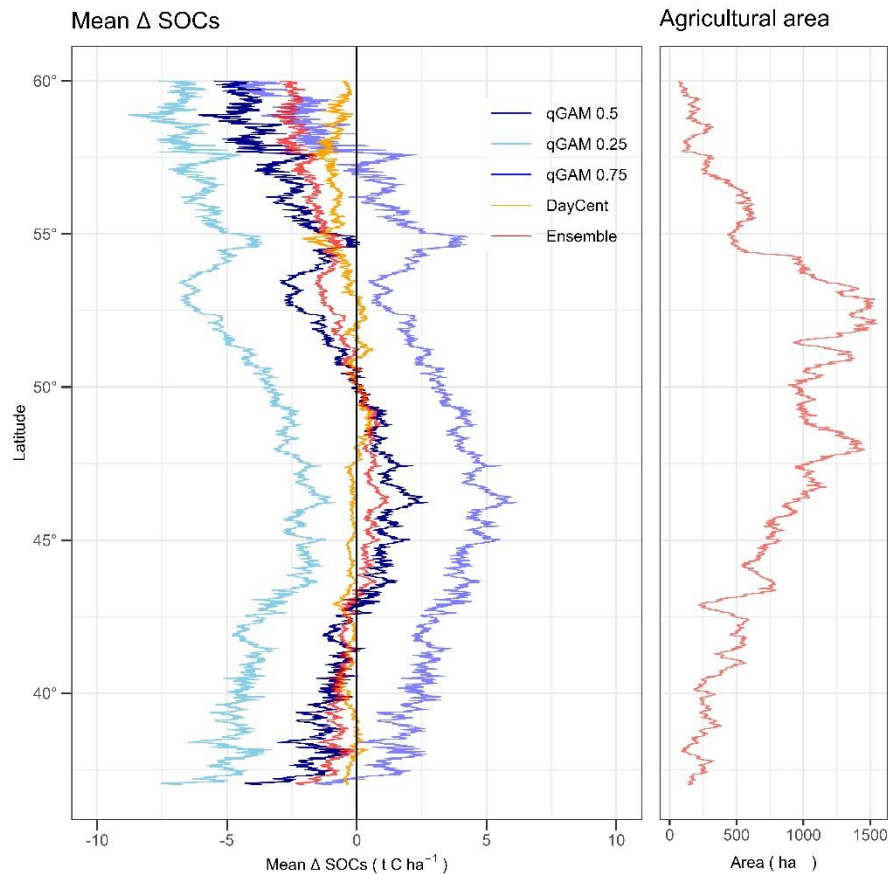
Remus Prăvălie^{1,2,3}✉, Pasquale Borrelli^{4,5}, Panos Panagos⁶,
Cristiano Ballabio⁶, Emanuele Lugato⁶, Adrian Chappell⁷,
Gonzalo Miguez-Macho⁸, Federico Maggi⁹, Jian Peng¹⁰, Mihai Niculiță¹¹,
Bogdan Roșca¹², Cristian Patriche¹², Monica Dumitrașcu¹³, Georgeta Bandoc^{1,3},
Ion-Andrei Nita¹⁴ & Marius-Victor Birsan¹³



- Based on EU Soil Dashboard Indicators
- Combine Soil Degradation indicators + Groundwater decline, Aridity & Vegetation degradation
- >80% of agricultural soils in un healthy condition

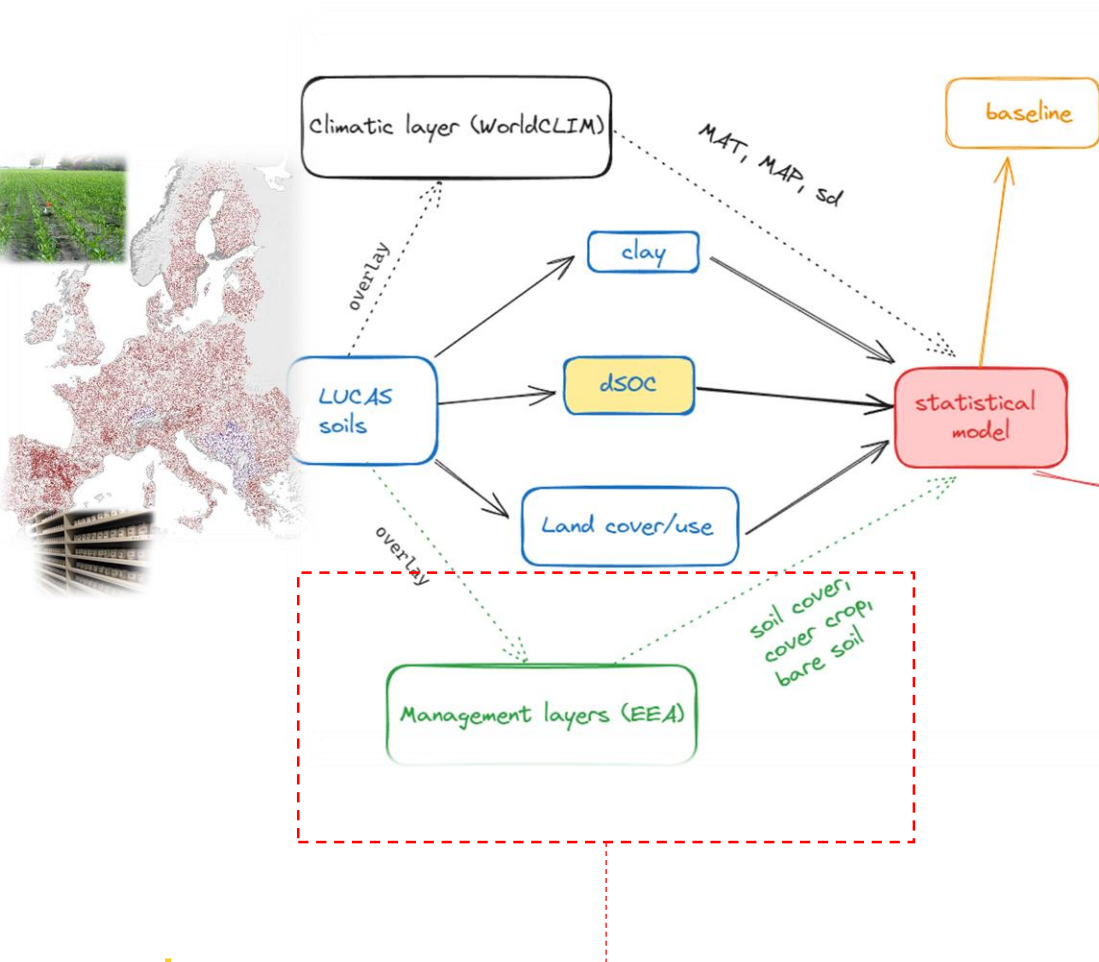
SOC, how much have we lost in the past decade?

-0.75% between 2009 and 2018
~ 70 Mt C (0-0.2m depth) =
28 MtCO₂e per year

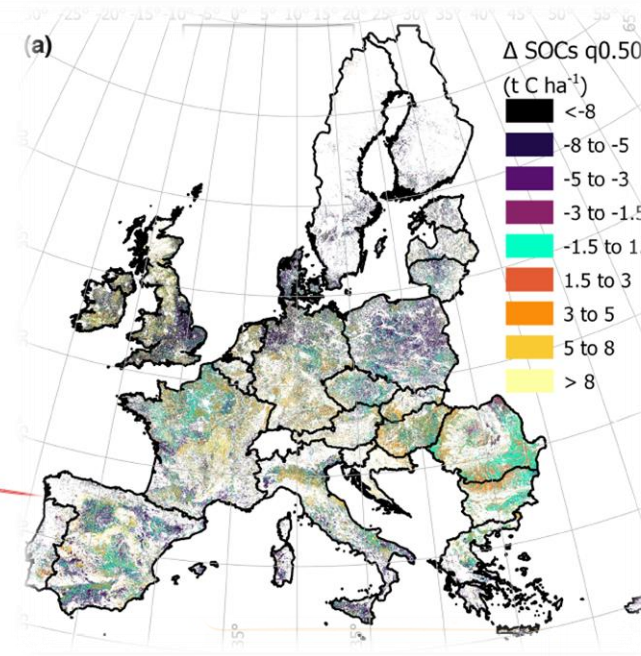


LUCAS data-driven baseline

Training



Extrapolation



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

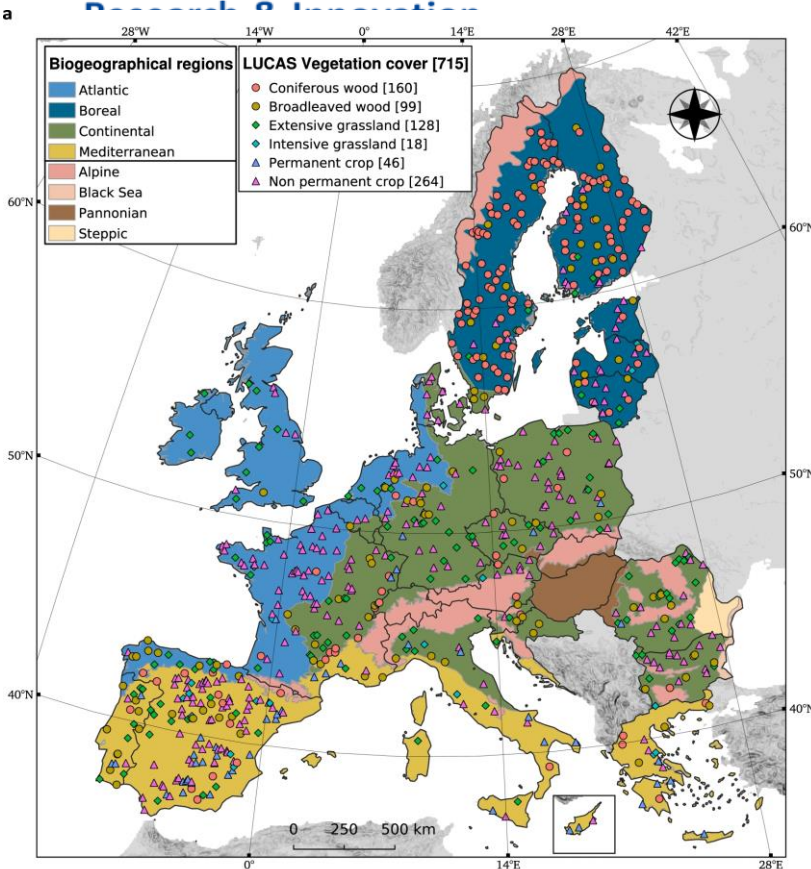
Daniele De Rosa¹ | Cristiano Ballabio¹ | Emanuele Lugato¹ |
Matteo Fasiolo² | Arwyn Jones¹ | Panos Panagos¹

Baseline = $f(\text{climate, soil properties, LC})$

- Permanent grassland
- Cropland
arable
low ley-cropping systems
high ley-cropping systems
conventional, conservative



Novel assessments of Soil Biodiversity



Diversity increases with land use intensification

Increase in pathogens in agricultural soils

Strong effect of soil properties on biodiversity

pH is the strongest driver among soil properties

Climate and Land cover are also relevant

nature communications

Received: 6 March 2023 | Revised: 5 June 2023 | Accepted: 12 June 2023

DOI: 10.1111/gcb.16871

Article

<https://doi.org/10.1038/s41467-023-29146-7>

RESEARCH ARTICLE

Global Change Biology WILEY

Patterns in soil microbial diversity across Europe

Ecosystem type drives soil eukaryotic diversity and composition in Europe

Received: 25 August 2022

Accepted: 6 April 2023

Published online: 08 June 2023

Maëva Labouyrie^{1,2,3}, Cristiano Ballabio², Ferran Romero³, Panos Panagos², Arwyn Jones², Marc W. Schmid⁴, Vladimir Mikr⁵, Olesya Dulya^{5,6}, Leho Tedersoo⁵, Mohammad Bahram^{5,7}, Emanuele Lugato², Marcel G. A. van der Heijden^{1,3} & Alberto Orgiazzi²

Julia Königer^{1,2} | Cristiano Ballabio² | Panos Panagos² | Arwyn Jones² | Marc W. Schmid³ | Alberto Orgiazzi² | Maria J. I. Briones¹

Check for updates





A Soil Deal for Europe

Goal: 100 living labs and lighthouses to lead the transition towards healthy soils by 2030

Specific objectives

1. Reduce **desertification**

2. Conserve soil organic carbon stocks

3. Stop soil sealing and increase re-use of urban soils

4. Reduce soil pollution and enhance restoration

5. Prevent erosion

6. Improve soil structure to enhance soil biodiversity

7. Reduce the EU global footprint soils

8. Improve soil literacy in society



Each specific objective is backed by **one or more quantified targets** and **measurable indicators**. Objectives apply to **all types of land use**.



Roll-out of Mission Work Programmes

WP 2021

Topics on e.g.
soil monitoring and
soil health indicators,
businesses models
for soil health, link
between soil health
and food quality and
safety

Budget: 67 M€
11 projects



WP 2022

Topics on e.g.
remediation
strategies for
contaminated sites,
soil biodiversity,
use of biowaste for
soil improvement,
carbon farming

Budget: 95 M€
17 projects



WP 2023

Topics on e.g. **Living Labs** (incl. carbon farming), on-site digital tech to monitor chemical stressors in soil and plants, soil friendly practices in horticulture, combat desertification

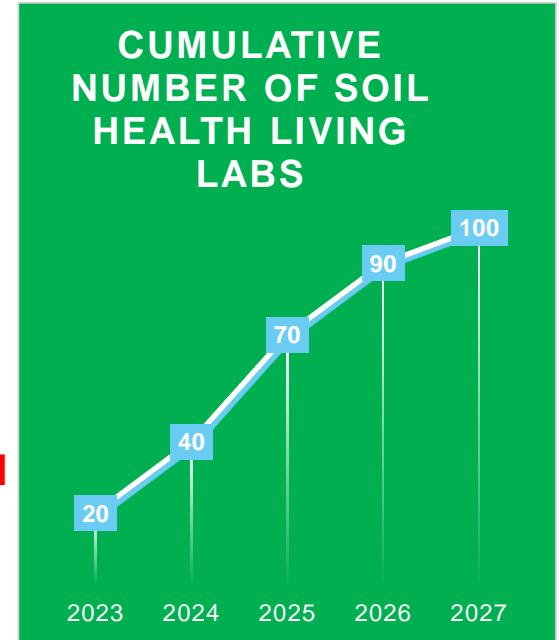
Budget: 139 M€
+19 projects



WP 2024

Topics on e.g. **Living Labs** (incl. urban soils), Soil erosion, nutrient fluxes, carbon farming, Pollinators, Soil Health Dashboard for Africa,

Budget: 135 M€
+13 projects expected



Phase 1 (2021-2024)
Induction and pilot

Phase 2 (2025-2026)
Gradual expansion

Phase 3 (2027-)
Scaling-up
and mainstreaming

Mission Soil Living Labs and Lighthouses

Framework for Soil Protection in the EU



ESDAC in 2015 – EUSO in 2030

Top-down mapping

Bottom-Up mapping



European Journal of Soil Science

OPINION | Open Access | CC BY

A 1 billion euro mission: A Soil Deal for Europe

Panos Panagos, Pasquale Borrelli, Arwyn Jones, David A. Robinson

First published: 26 February 2024 | <https://doi.org/10.1111/ijss.13466>

SECTIONS

PDF TOOLS SHARE

Abstract

Soils have achieved prominence in the political agenda of the European Commission with the proposal for a Soil Monitoring Law and the ambitious Soil Mission research framework. The EU Soil Observatory (EUSO) used the latest state-of-the-art pan-European datasets to propose a preliminary assessment of soil health in the EU based on 18 soil degradation proxy indicators. The body of knowledge will soon be enriched thanks to the investment of 1 billion euros towards the Mission 'A Soil Deal for Europe', which

What's next for EUSO

- State of European Soils Report
 - FAO State of World Soil Resources 2025, SOER 2025
- LUCAS SOIL 2.0
- EU Soil Health portal (ESDAC 3.0)
- EU Biodiversity and Antimicrobial resistance (AMR) Assessments
- Soil Biodiversity and Pesticides
- Soil Fertility Report (for Taxonomy)
- Land Degradation / Desertification methodology
- Soil organic carbon baselines for Carbon Farming
- Innovative Soil Health Assessments

Thank you

Contacts



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