The European Commission's science and knowledge service

Joint Research Centre

European Commission

The role of EU Soil Observatory in developing data, knowledge and indicators for science and policy

Panos Panagos

European Commission, Joint Research Centre

European Commission

Outline

- Who we are (JRC)?
- Main policies to drive our research
- EU Soil Observatory
- European Soil Data Centre (ESDAC)
- Examples of soil data in ESDAC
  - Soil erosion & Land degradation
  - Climate change and soil organic carbon
  - Soil diffuse pollution & nutrients
  - Global scale
- Soil Mission

EC – the Join Research Centre

"As the science and knowledge service of the Commission our mission is to support EU policies with independent evidence throughout the whole policy cycle"

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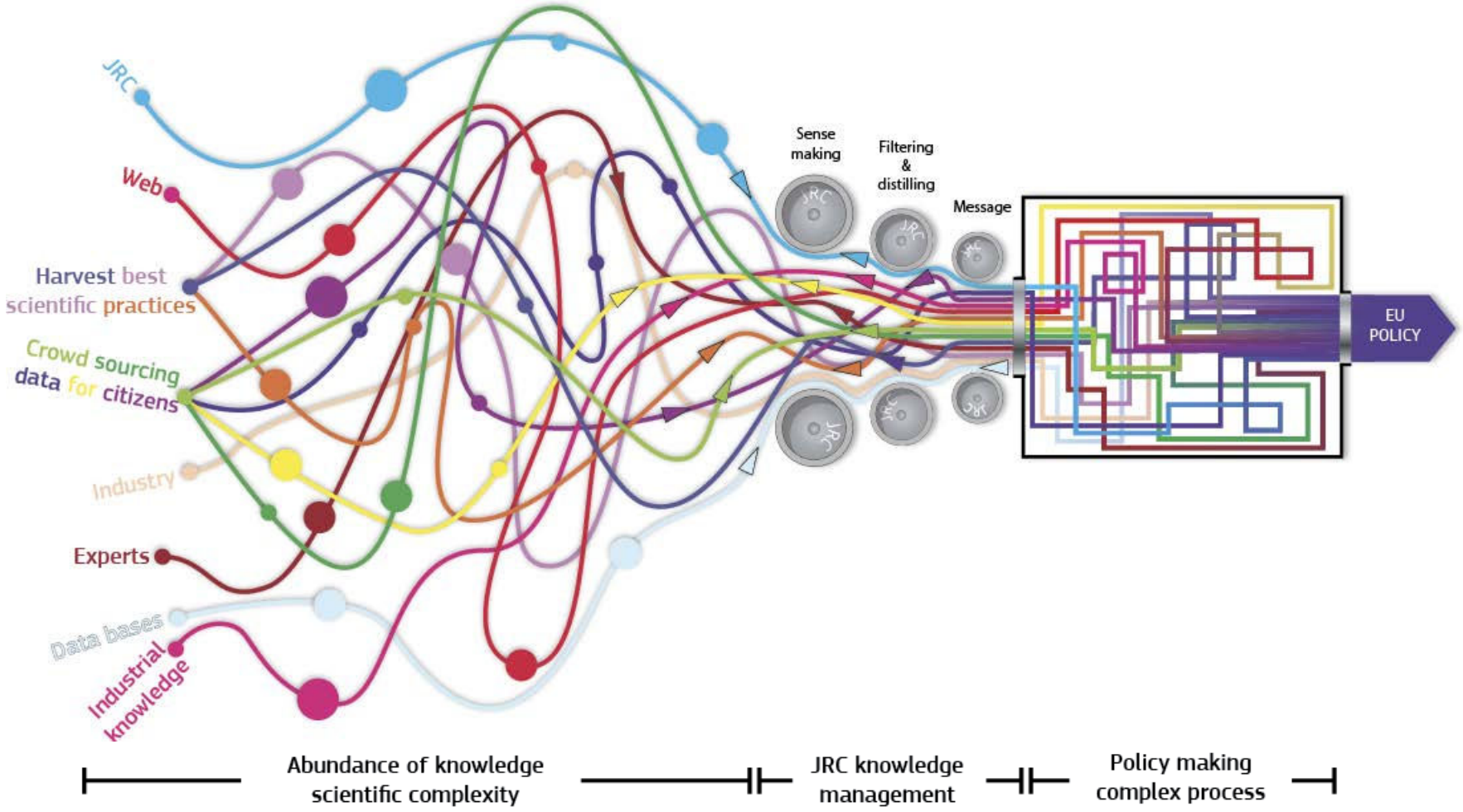
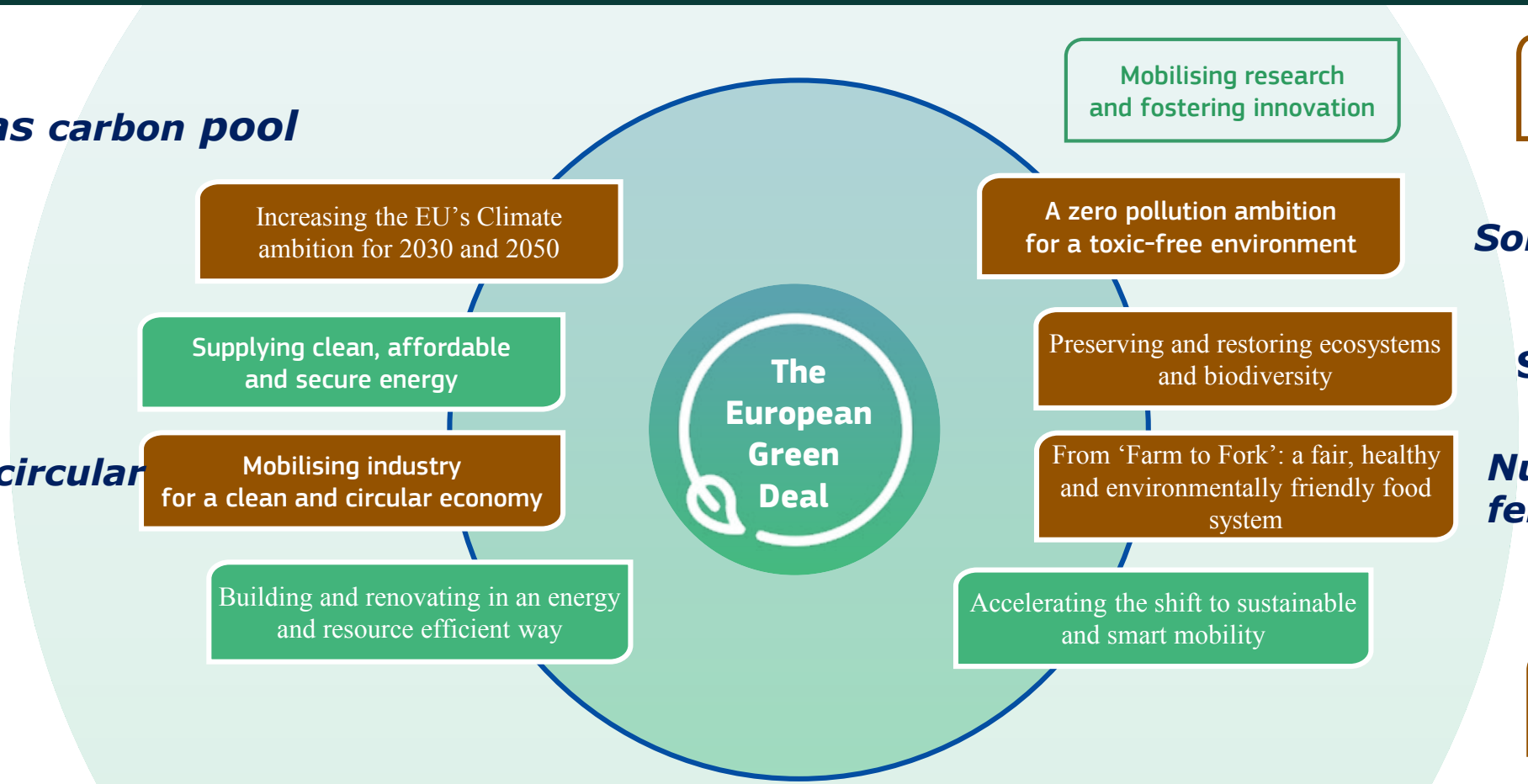
Dealing with the information overload



Soils in the European Green Deal

Soils as carbon pool

Soil in the circular economy



Mission "A Soil Deal for Europe"

Soil contamination

Soil *biodiversity*

Nutrient excess; fertilizers; pesticides

Soil Thematic Strategy (2021)

Common Agricultural Policy (CAP)

Soils are a cross-cutting theme within the European Green Deal

AGRI CLIMA CNECT ENV ESTAT INTPA NEAR RTD SANTE

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Policy framework under the Green Deal

Reaping the benefits of healthy soils for people, food, nature and climate

COM(2021) 699 final, SWD (2021) 323 final **adopted November 2021**

- Provides a long-term **framework for the protection, restoration and sustainable use of soils** with set of existing objectives and actions to achieve them.
- The Strategy answers to the **request of the European Parliament** to propose a legal framework for soil.
- **By 2050, all EU soil ecosystems are in healthy condition**

Soil Health Law objectives

- The Mission Board report '*Caring for soil is caring for life*' estimated **60-70% of "unhealthy soils"** in the EU
- Healthy soils by 2050
  - Soil pollution should be reduced to levels no longer considered harmful to human health and natural (i.e. a toxic-free environment)
  - No net land take by 2050 (voluntary intermediary MS targets on by 2030)
  - Reduce nutrient losses by at least 50% (no deterioration of soil fertility)
  - Soils are healthy when they are in good chemical, biological and physical condition, and thus able to continuously provide as many ecosystem services as possible
  - Achieve a land degradation-neutral world
  - Restore degraded and carbon-rich ecosystems

How to determine whether a soil is healthy?

- **Minimum set of parameters and descriptors** for being healthy?

Chemical

- **Acidification** (pH)
- **Salinisation** (Electrical conductivity)
- **Loss of carbon** (changes in SOC change)
- **Nutrient balance** (Total N + Extractable P)
- **Pollution** (metals, pesticides/organics, plastic, pharmaceuticals, emerging pollutants)

Physical

- **Subsoil compaction** (bulk density)
- **Soil erosion** (unsustainable erosion by water, wind, tillage, harvest)
- **Water holding capacity**

Biological

- **Soil basal respiration**
- **Metabarcoding of bacteria, fungi and animals** (eDNA)
- **Abundance and diversity of nematodes**
- **Microbial biomass**
- **Abundance and diversity of earthworms**


#EUSO
https://esdac.jrc.ec.europa.eu/euso
EU SOIL
OBSERVATORY

EU Soil Observatory

Vision

Should become the principal provider of reference data and knowledge at EU-level for all matters relating to soil.

Research & Innovation

Monitoring soil related policies

EU-wide Soil Monitoring

Stronger European Soil Data Centre (ESDAC)

European Soil Forum

European Commission

EU Soil Observatory Working Groups

5 working groups were launched during the first stakeholder meeting in October 2021

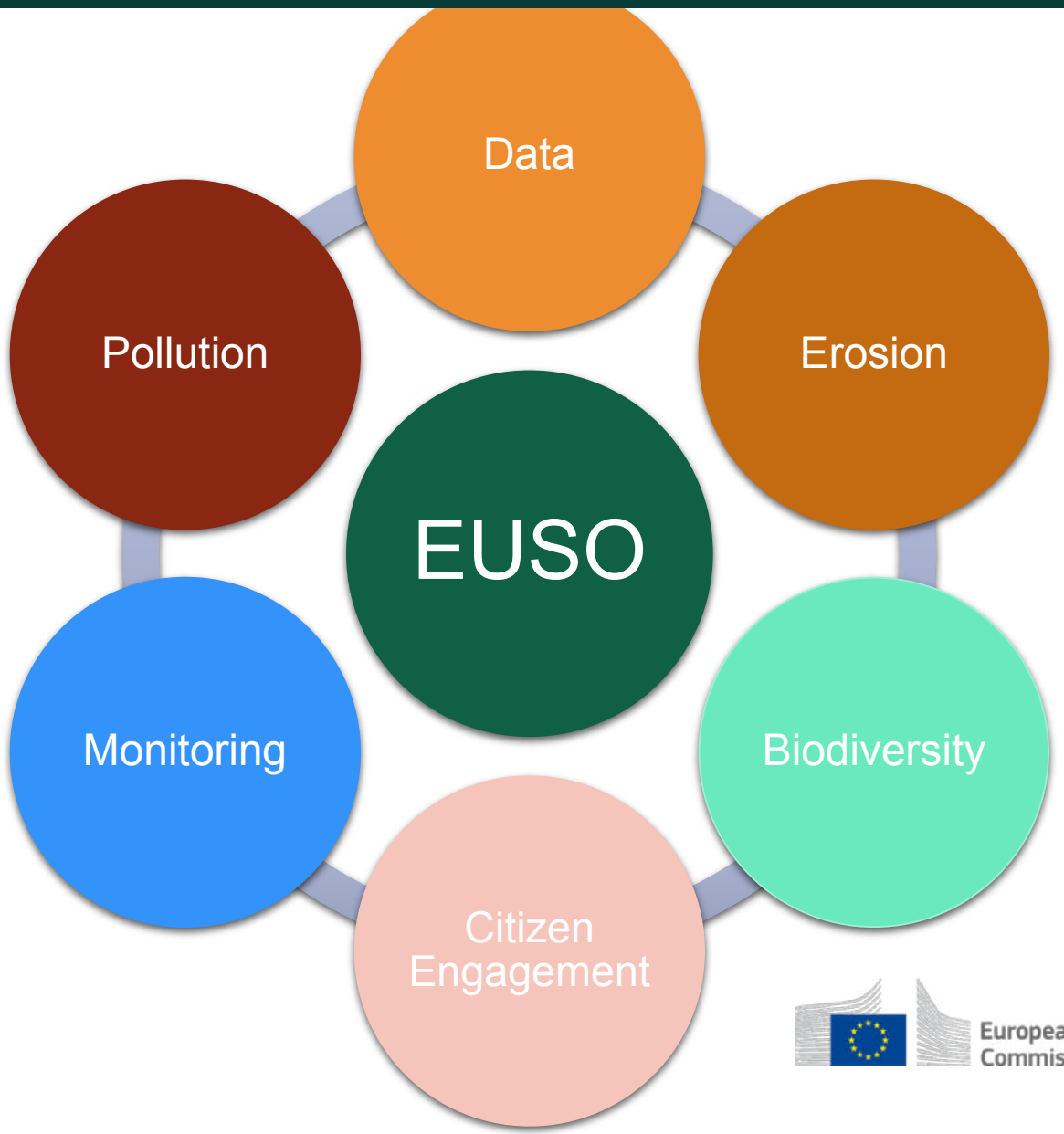
Soil Monitoring
(Arwyn Jones, Anne Marechal, JRC)

Soil biodiversity
(Luca Montanarella, Alberto Orgiazzi JRC)

Soil data sharing
(Marc van Liedekerke, Calogero Schillaci JRC)

Soil erosion
(Panos Panagos, Diana Vieira, JRC)

Soil pollution
(Piotr Wojda, Diana Vieira, JRC)



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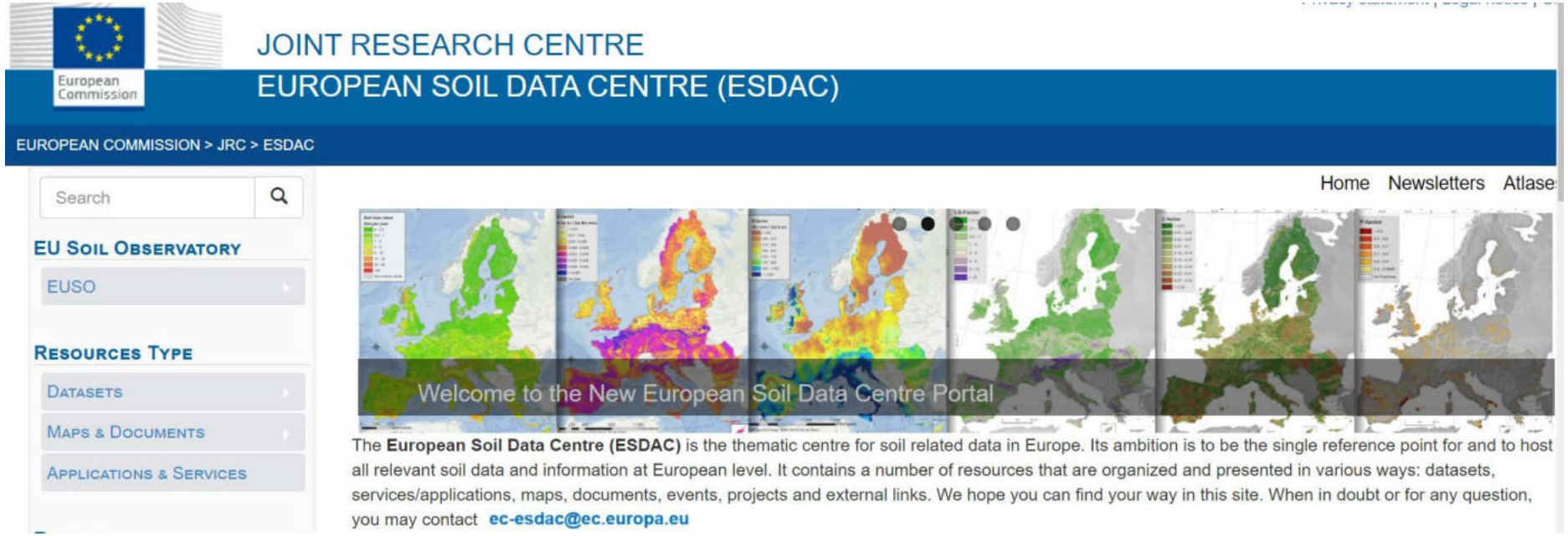
European Soil Data Centre (ESDAC)

- ESDAC as **group of datasets**
- ESDAC is **part** of the European Soil Observatory (EUSO)
- First release in 2006
- **Main focal point for soil data**, support to policy making and awareness raising for the European Union.
- **Hosts 90 blocks of data**, 6,000 maps, 6 Atlases and >500 publications

ESDAC : What makes the difference?

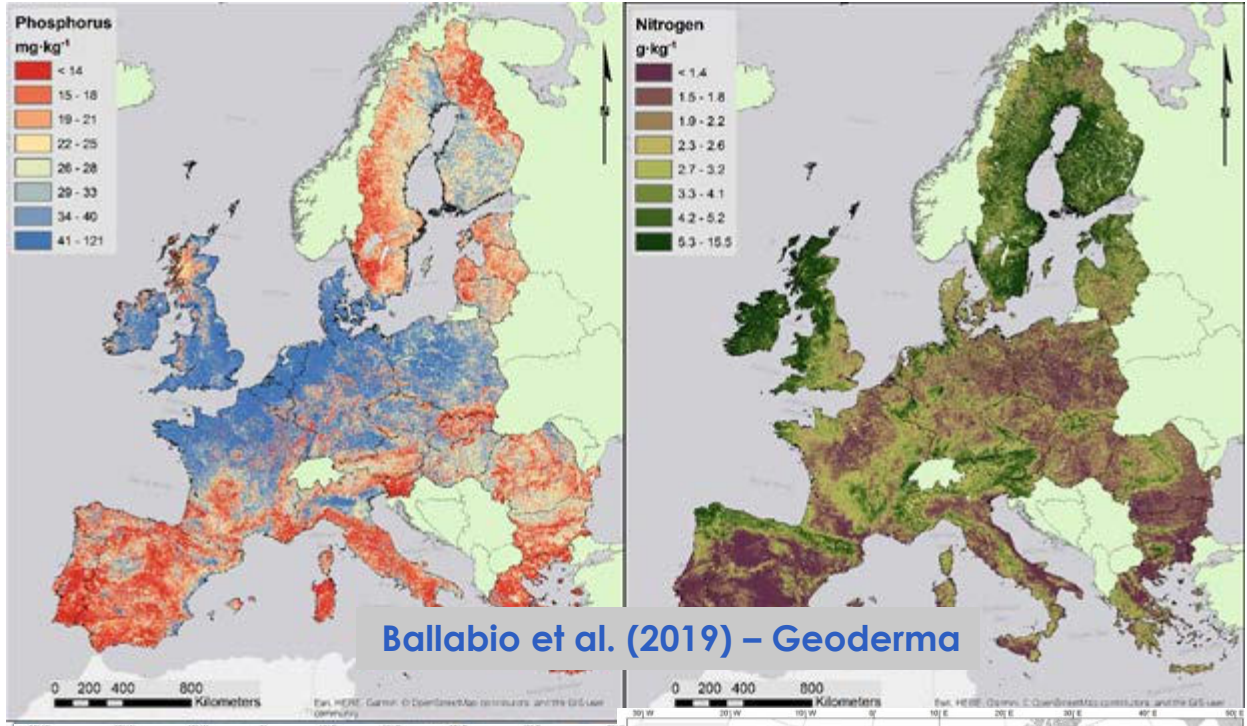
- A one-stop hub for soil data at EU-scale with a long-term commitment by JRC
- it is providing EU and European-wide datasets, and associated documentation
- Permanent and timely active helpdesk, continuous updates and news (Newsletters)
- wide audience; mailing lists (for ESDAC and EUSO) most visited website in JRC
- Data are FAIR (findable: try Google "European soil data etc"!)

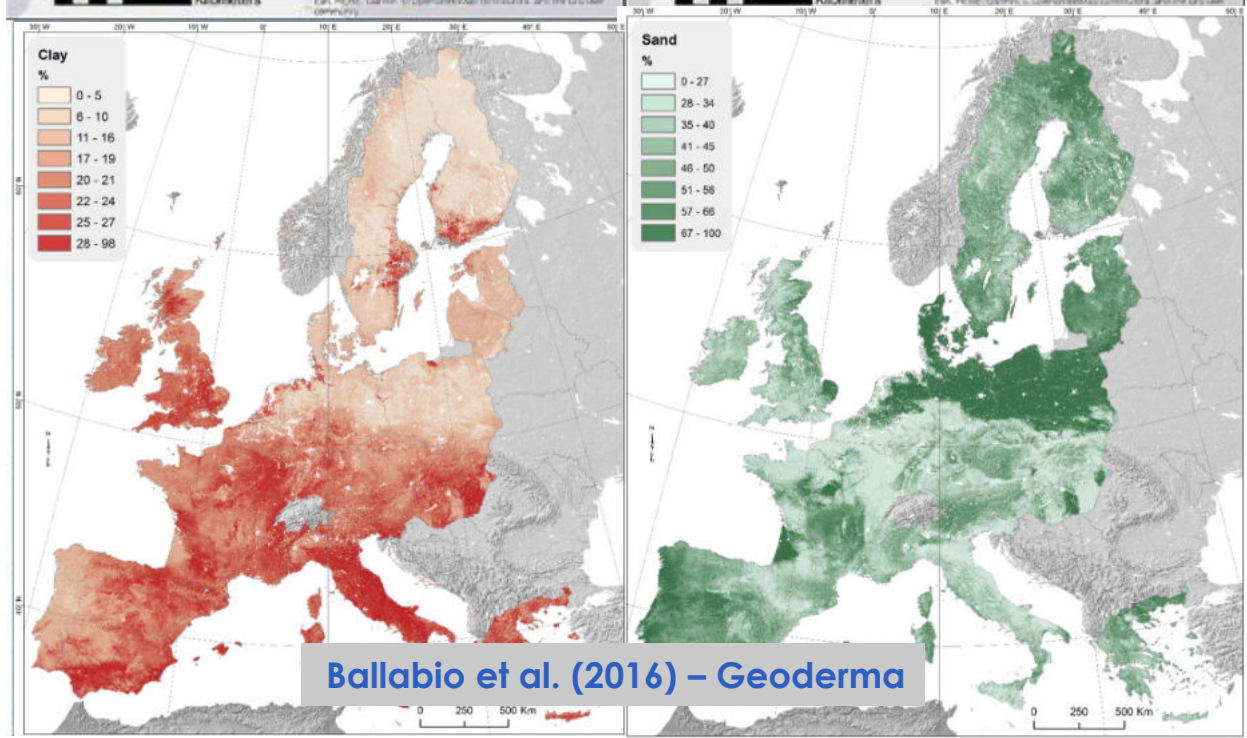


Contributes to EU-Wide Soil Monitoring

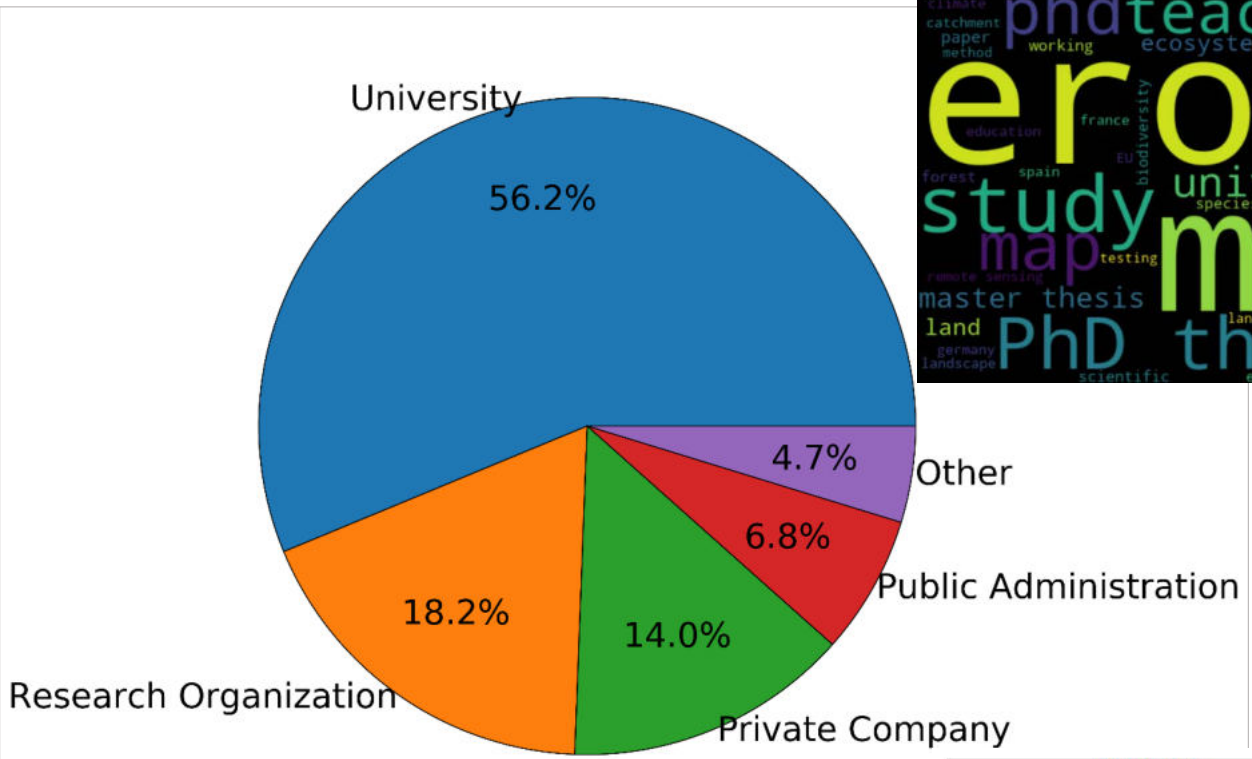
From monitoring chemical, physical and biological soil properties to modelling the spatial distribution of soil properties in the EU

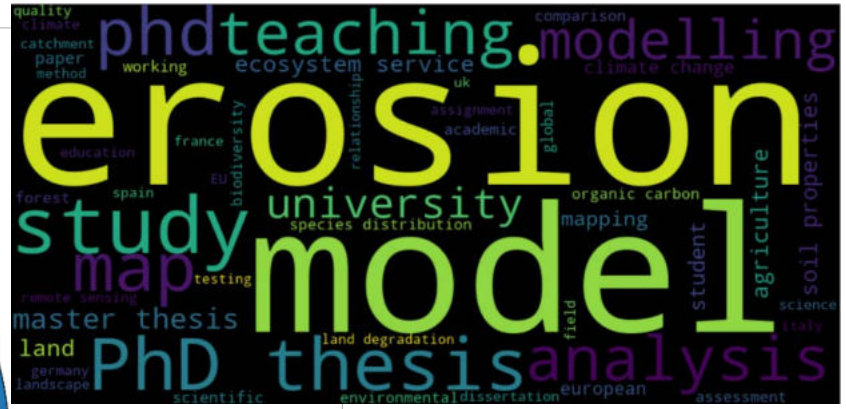
- Coarse fragments
- particle-size distribution (clay, silt, sand)
- pH
- Organic carbon
- Carbonate content
- Total nitrogen content
- Extractable potassium content
- Phosphorous content
- Cation exchange capacity
- Electrical conductivity
- Heavy Metals
- Multispectral properties
- Pesticides (90 substances)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

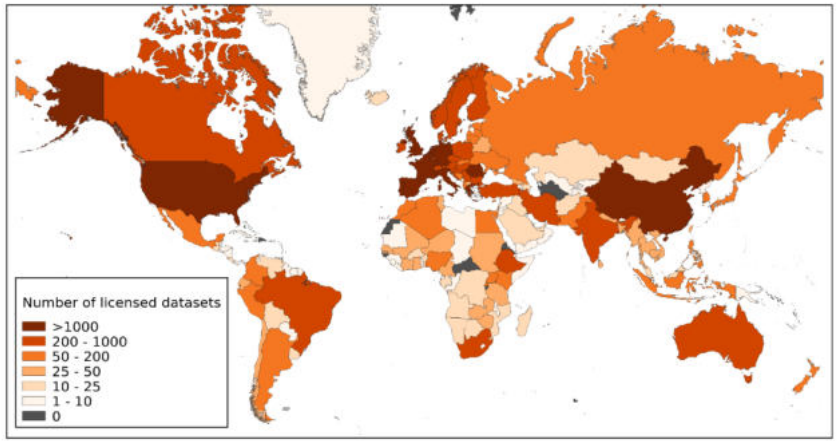




ESDAC: Who are the users







- > **50,000 data downloads** during last 10 years
- 8,431 data downloads in 2021 (double to 2017)
- Support to policies: Soil Strategy for soils 2030, Common Agricultural Policy, Mission "Soil Deal for Europe, Zero pollution
- Mapping, database, developments, evaluation, planning, risk assessment, registration and modelling are the **most dominant uses**

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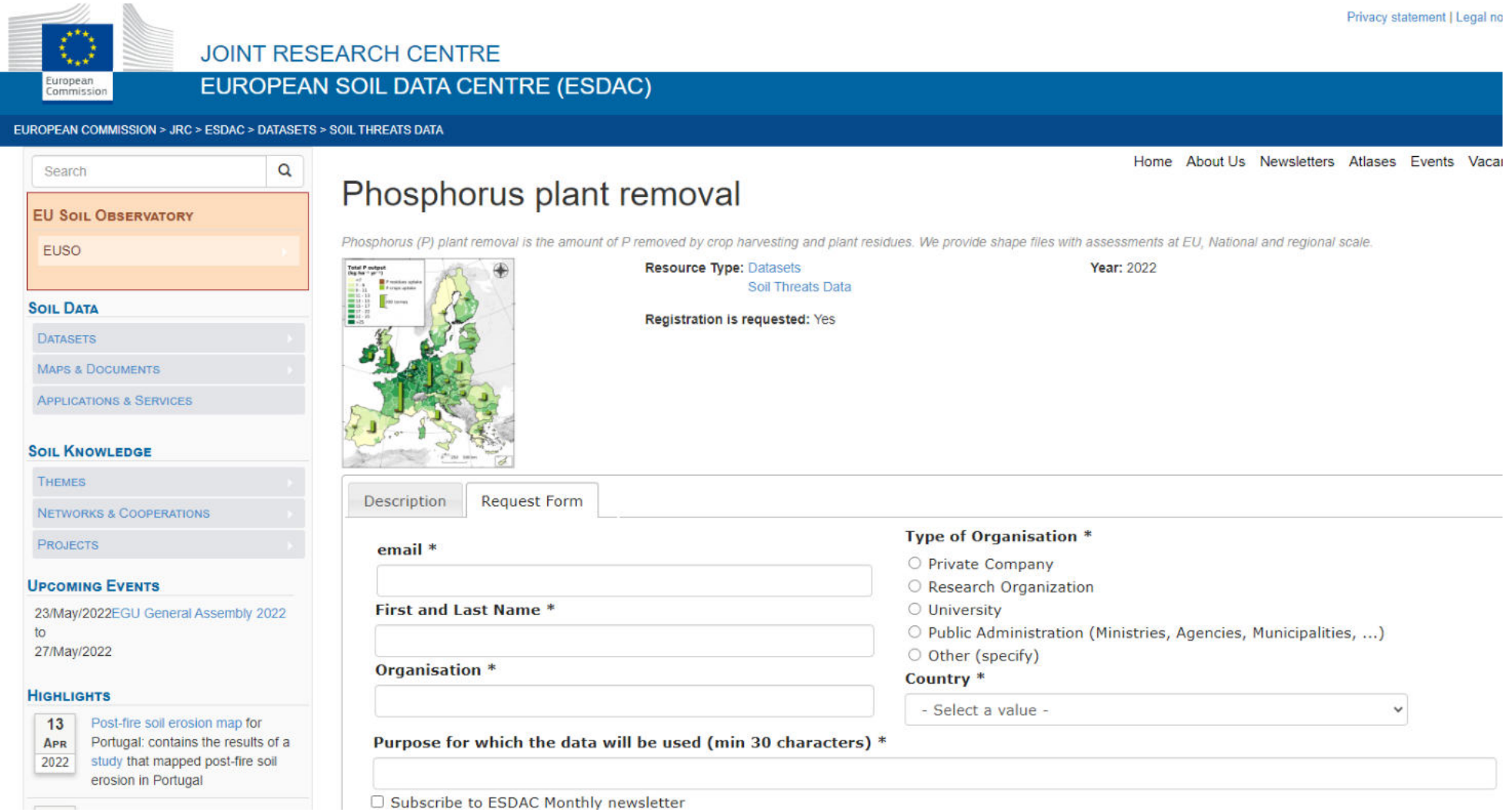
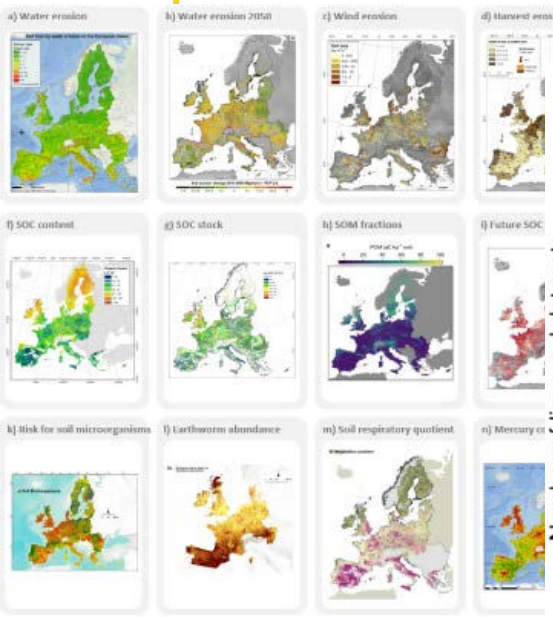
ESDAC: How to acces the data?

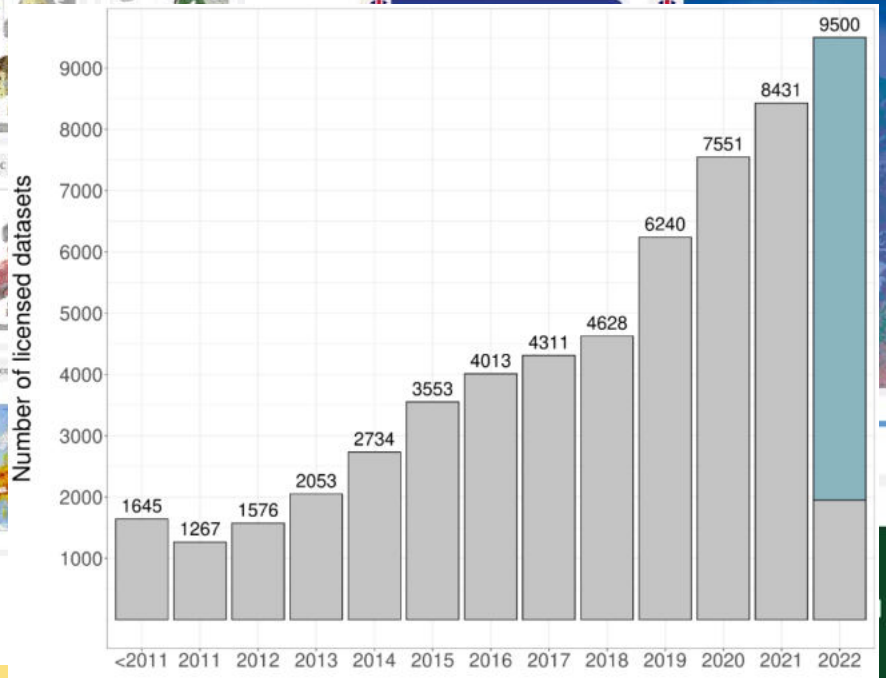
https://esdac.jrc.ec.europa.eu/

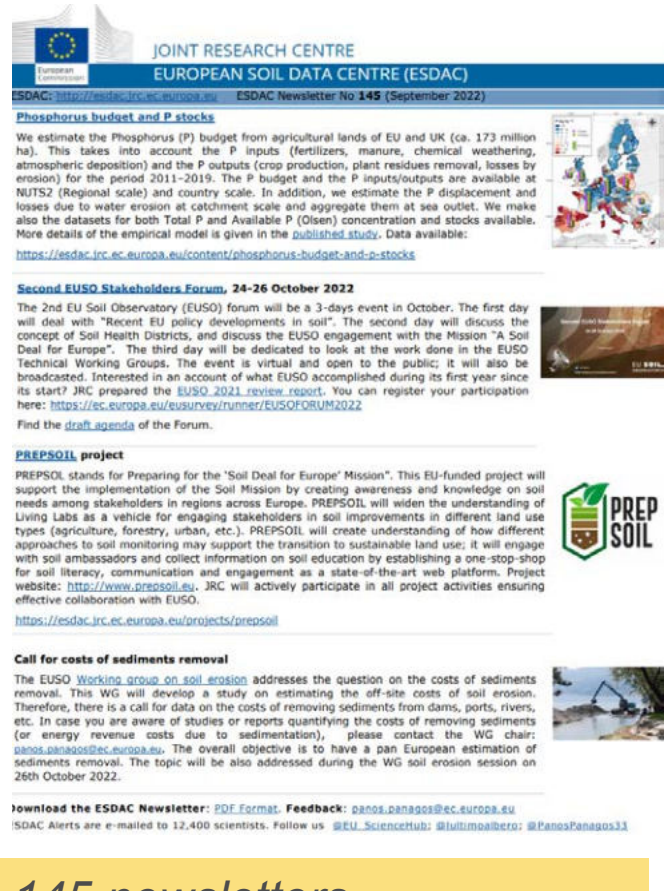


- Easy way to get the data
- Helpdesk
  EC-ESDAC@ec.europa.eu
- Metadata
- Documentation & publication
- Dissemination through our networks

European Soil Data Centre (ESDAC) 2.0







95 blocks of data
50,000 data distributions

Coverage: EU, European or Global
Format: Point, shape or raster
Documentation: Metadata, publications, web info

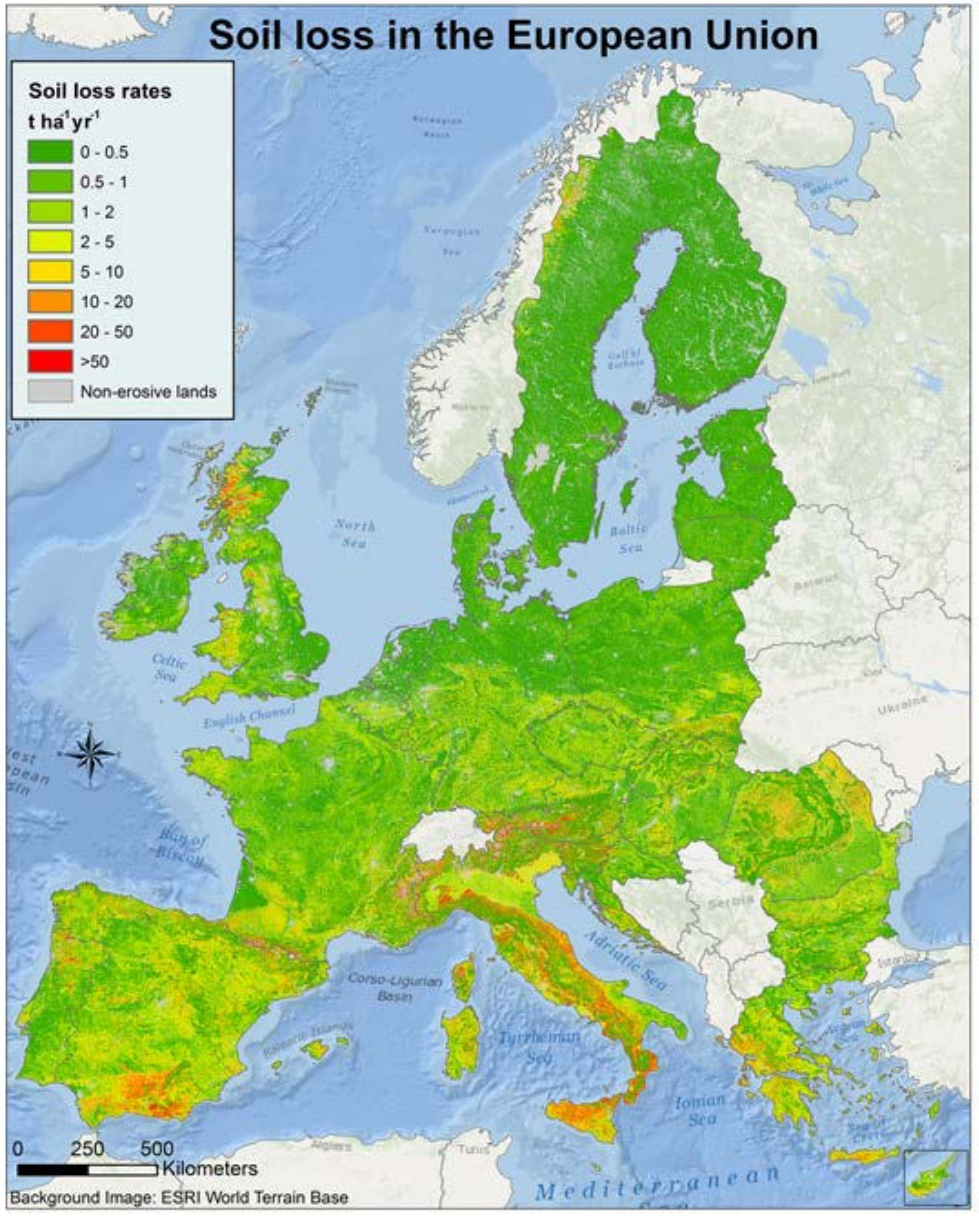
6,000 maps,
6 Atlases
>500 publications

145 newsletters
12,000 followers/subscribers in our newsletter

Top JRC thematic portal with 300,000 unique visitors per year

Commission

Soil Loss by water erosion



Average EU-28: **2.45 t ha^{-1} yr^{-1}** (in the erosive prone areas: 91% of EU)

Total Soil loss: 950 Mt annually

Data produced for years: **2000 – 2010 – 2016**

Mean erosion rate in agricultural areas: 3.2 t ha^{-1} yr^{-1}

Soil formation rate: 1.4-2.0 t ha^{-1} yr^{-1}

24% of EU lands have rates >2 t ha^{-1} yr^{-1}

11% of total area contributes to almost 70% of total Soil Loss

2000-2012: decrease by 9% in erosion rates

- 1/3 due to increase of forestlands (decrease of croplands)
- 2/3 due to change of management practices (proposed by *CAP, Soil Thematic Strategy)*

2010-2016: decrease by 0.4% in erosion rates

Contents lists available at ScienceDirect
Environmental Science & Policy
journal homepage: www.elsevier.com/locate/envsci

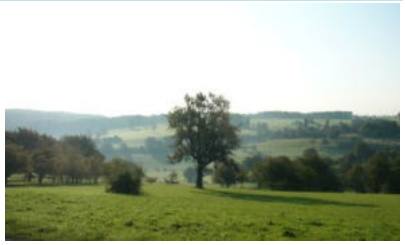
The new assessment of soil loss by water erosion in Europe

Panos Panagos [a,*], Pasquale Borrelli [a], Jean Poesen [c], Cristiano Ballabio [a], Emanuele Lugato [a], Katrin Meusburger [b], Luca Montanarella [a], Christine Alewell [b]

Crop distribution – Management practices

Low erosive — **Medium erosive** — **High erosive**

0.05	0.15	0.20	0.22-0.25	0.30 -0.32	0.35	0.38	0.50
Permanent Grasslands	Other fodder areas (Alfa,etc)	Wheat, Barley	Olives, other Fruits..	Energy crop, sunflower	Sugar beets, Potatoes		Maize, Tobacco







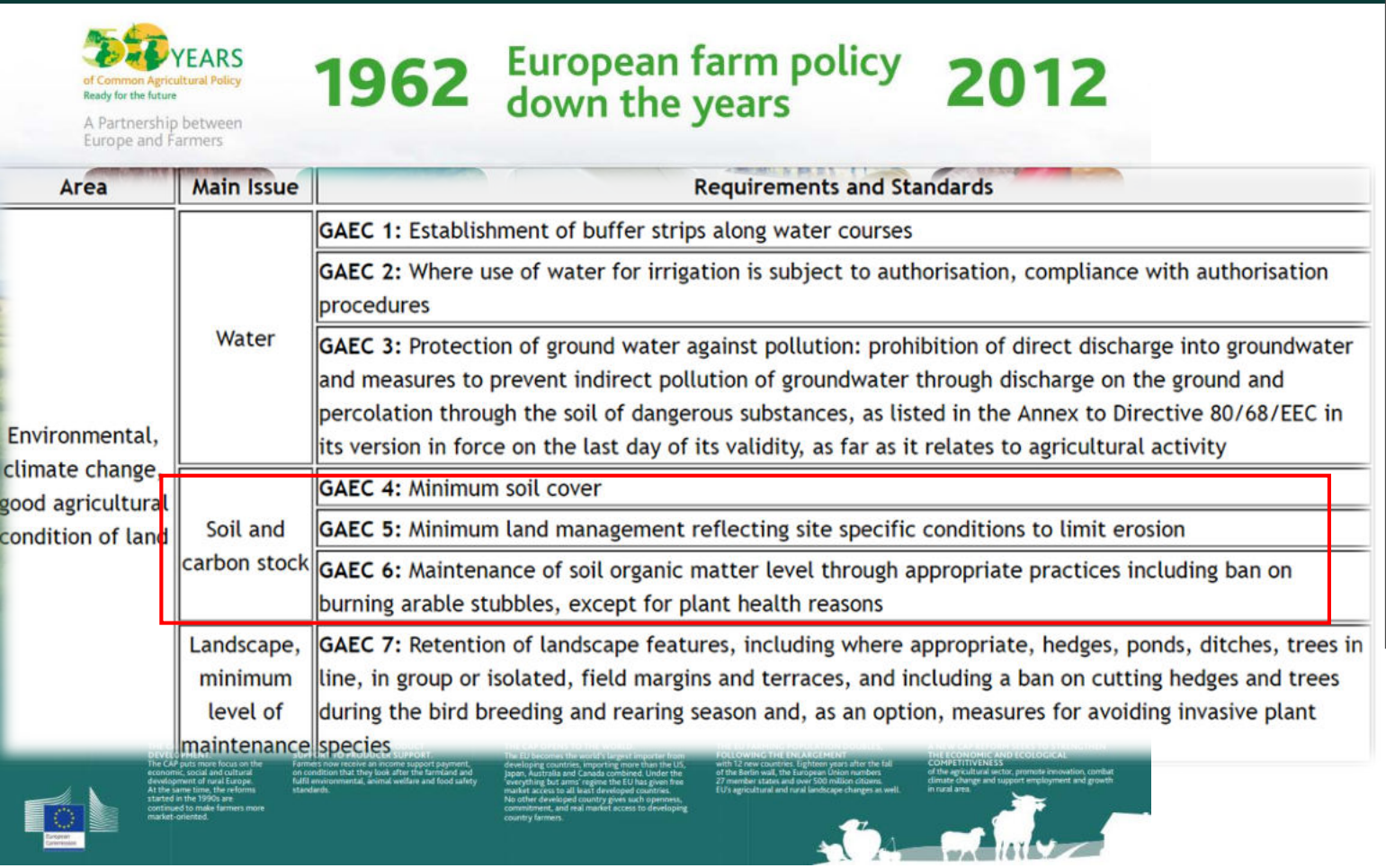
Modelled Management practices against erosion

-65%	-12%	-20%	-25%	-10-15%(density)	-40% - 5%(slope)
Reduced Tillage	Plant Residues	Cover Crops	Stone walls	Grass margins	Contour farming





Common Agricultural Policy (CAP)



Area	Main Issue	Requirements and Standards
Environmental, climate change good agricultural condition of land	Water	**GAEC 1:** Establishment of buffer strips along water courses
		GAEC 2: Where use of water for irrigation is subject to authorisation, compliance with authorisation procedures
		GAEC 3: Protection of ground water against pollution: prohibition of direct discharge into groundwater and measures to prevent indirect pollution of groundwater through discharge on the ground and percolation through the soil of dangerous substances, as listed in the Annex to Directive 80/68/EEC in its version in force on the last day of its validity, as far as it relates to agricultural activity
	Soil and carbon stock	**GAEC 4:** Minimum soil cover
		GAEC 5: Minimum land management reflecting site specific conditions to limit erosion
		GAEC 6: Maintenance of soil organic matter level through appropriate practices including ban on burning arable stubbles, except for plant health reasons
	Landscape, minimum level of maintenance	**GAEC 7:** Retention of landscape features, including where appropriate, hedges, ponds, ditches, trees in line, in group or isolated, field margins and terraces, and including a ban on cutting hedges and trees during the bird breeding and rearing season and, as an option, measures for avoiding invasive plant species

New CAP 2023-2027

- GAEC 2: Protection of carbon-rich soils *(protection of wetland and petland)*
- GAEC 3: Maintenance of soil organic matter *(ban on burning arable stubble)*
- GAEC 5: Minimum land management *(Tillage management reducing the risk of soil degradation including slope consideration)*
- GAEC 6: Minimum soil cover *(No bare soil in most sensitive period →cover crops)*
- GAEC 7: Preserve soil potential *(crop rotation)*
- GAEC 8: Minimum share of agricultural land to non productive features *(retention, ban cutting hedges)*

Cross-compliance and GAEC (Good Agricultural and Environmental Conditions)

Farmer received an income aid, on condition that they respect strict food safety, environmental and animal welfare standards.

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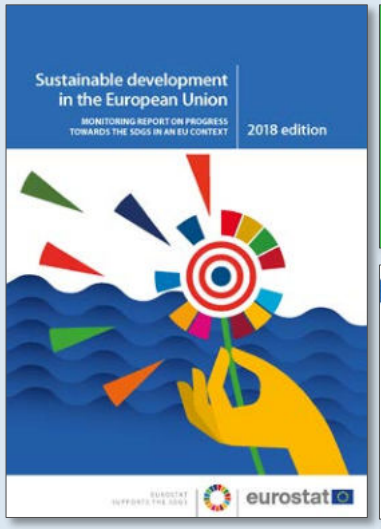
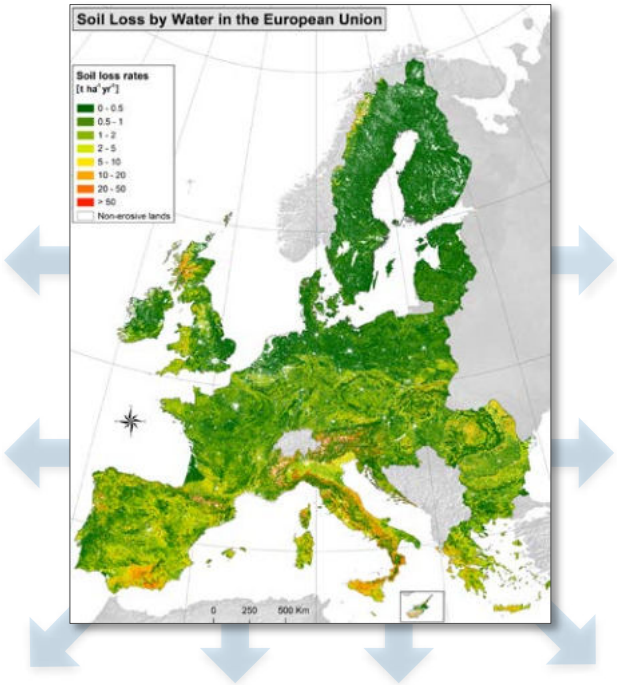
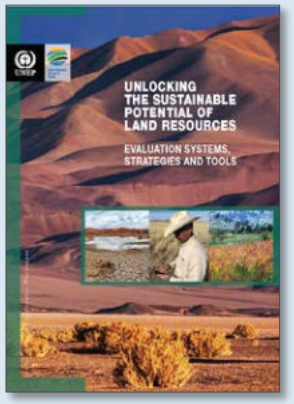
Indicators & policy support

UN Sustainable Development Goals

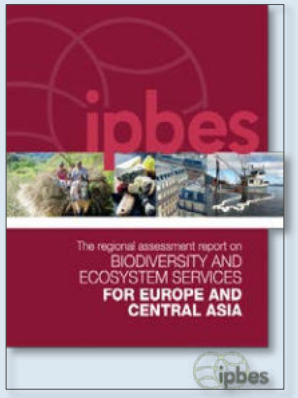




UNEP



IPBES

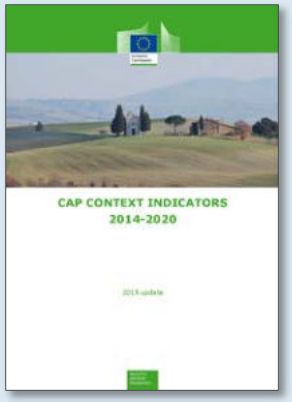


UNCCD
United Nations Convention to Combat Desertification

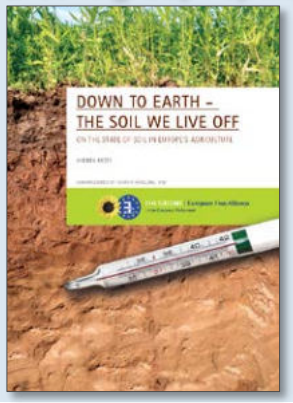
OECD

GLOBAL SOIL PARTNERSHIP

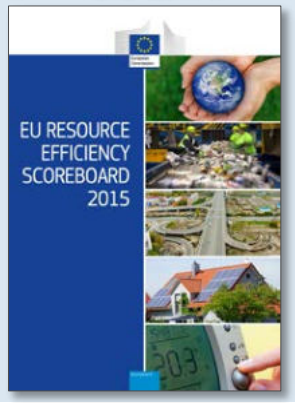
DG AGRI: CAP context Indicator



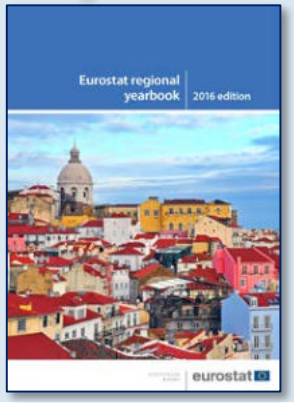
European Parliament Greens group report



DG ENV- DG ESTAT



DG ESTAT: Regional stats



DG AGRI: EU Agricultural

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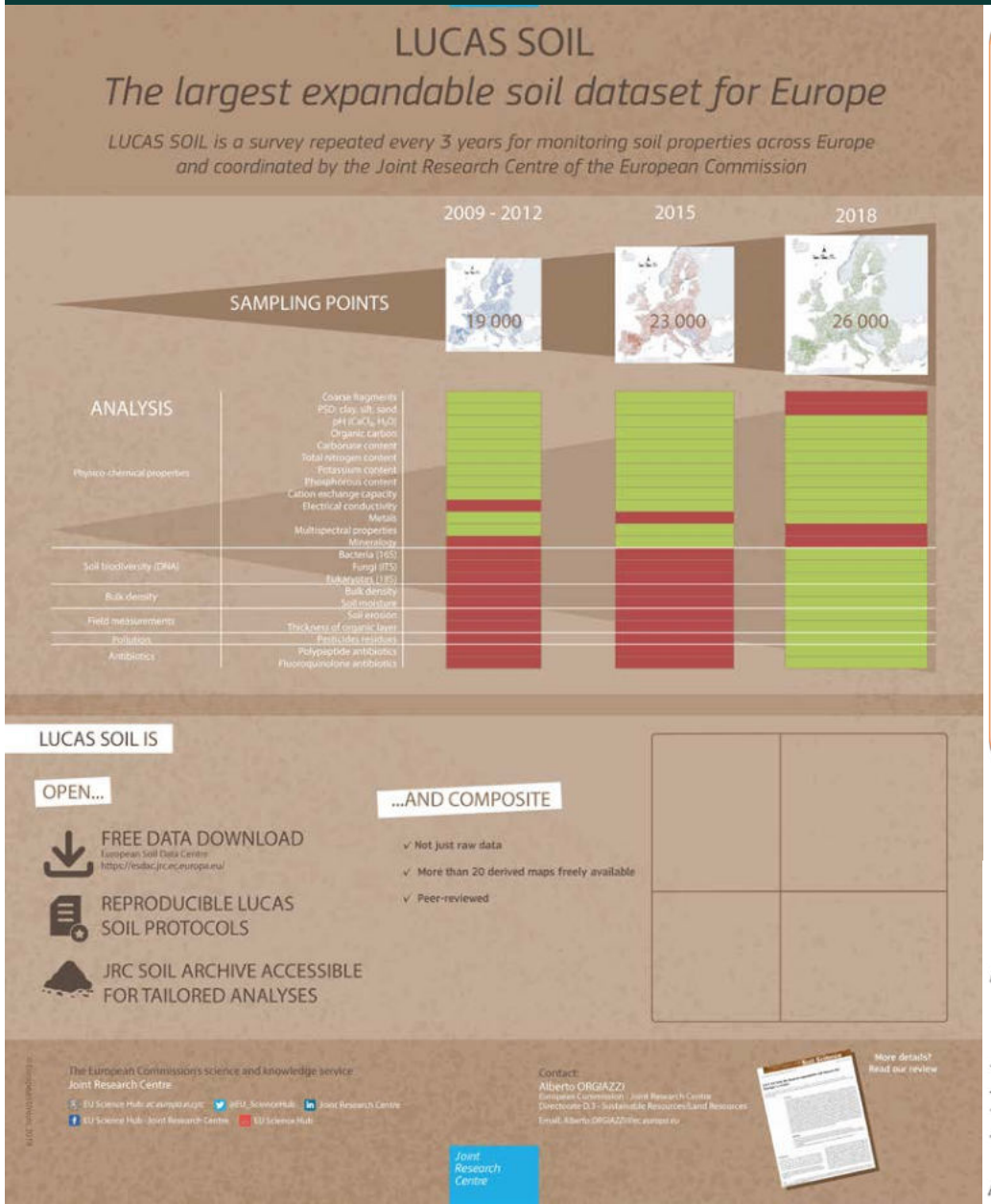
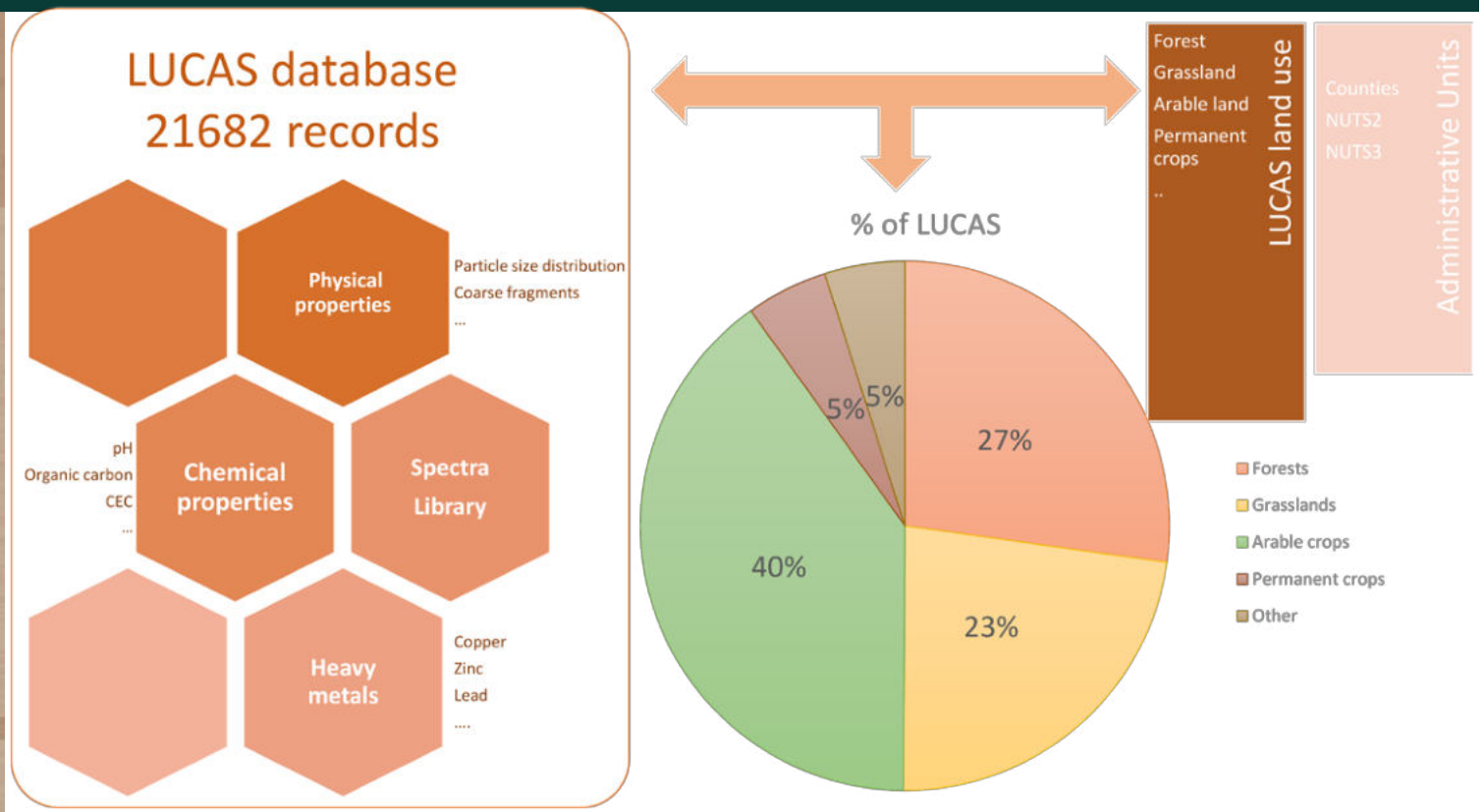
Panagos & Katsogiannis 2019. *Environmental Research*. 470-474

LUCAS: Land use / Land Cover Survey including soil





European Journal of Soil Science

European Journal of Soil Science, January 2018, **69**, 140–153 doi: 10.1111/ejss.

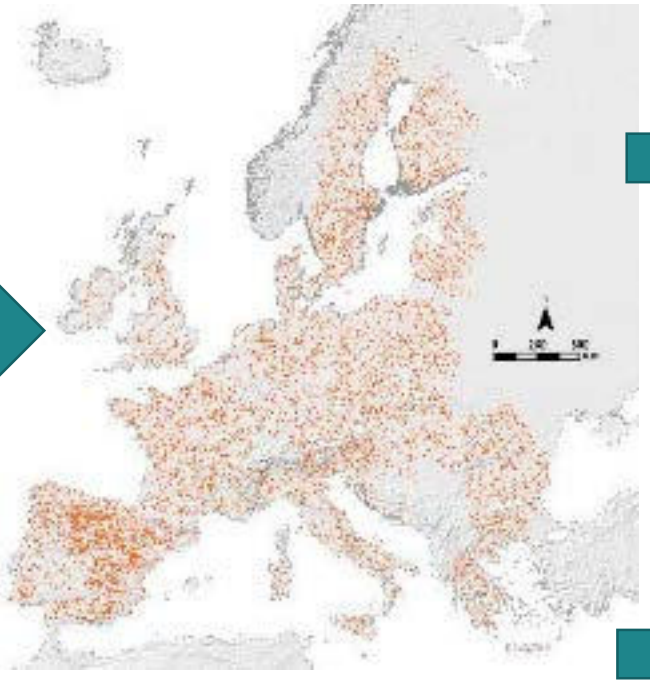
LUCAS Soil, the largest expandable soil dataset for Europe: a review

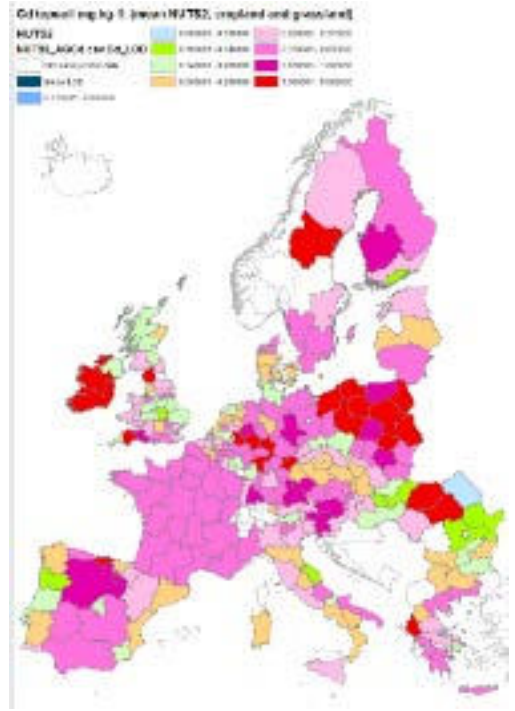
A. Orgiazzi, C. Ballabio, P. Panagos, A. Jones & O. Fernández-Ugalde

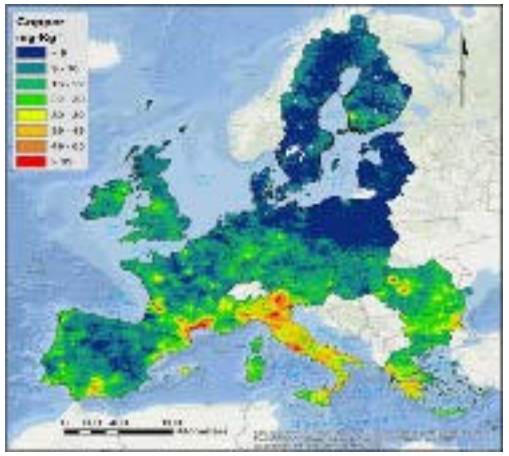
European Commission

JRC manages the LUCAS SOIL survey; sample design, measurement protocols through to integrated analysis and monitoring

DATA, TOOLS and MODELS







- **Surveys (and the resulting data) span multiple years 2009, 2015, 2018, 2022**
- **42,000 observations**
- **Close cooperation with Member States**

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Soil Organic Carbon

NO NET EMISSIONS OF GHG BY 2050

Lugato et al., 2014. Global Change Biology

Process based models (CENTURY) **and Geostatistical** application in 20,000 LUCAS point data

17.63 Gt carbon stocks in agricultural lands (0-30cm)

Agriculture still emits **10%** of total EU GHG emissions

No decreasing trend in the last years!

Need to reduce non-CO_2 emission and **sequester C in soils**

Scenario analysis on which are the best practices to sequester carbon

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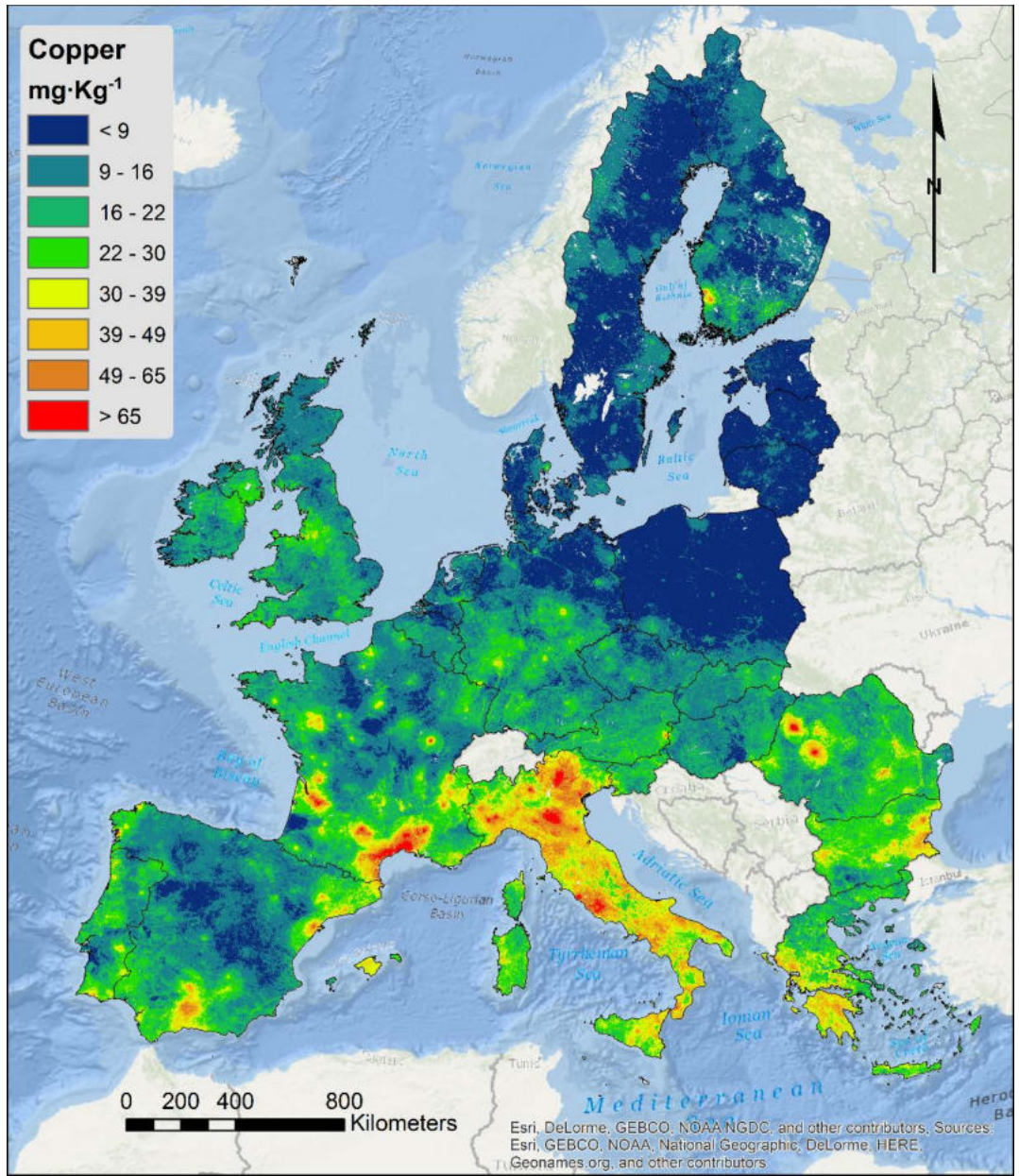
Copper distribution in European Union



21,682 LUCAS soil samples for an analysis of copper(Cu) in EU

Copper (Cu) is **correlated** to soil properties(pH, texture, Organic Carbon), climate, geology and management.

Vineyards has the highest mean Cu concentration: 49.3 mg kg^{-1}. Cu is relatively high also in **olive groves**(33.5 mg kg^{-1}) and **orchards**(27.3 mg kg^{-1}) [**Threshold**: 100 mg kg^{-1}]

Cu highest concentration is found in **wet areas** due to frequent fungicide treatments

Similar developments for Mercury (2021).
Under development: Cadmium, Zinc, Arsenic


Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Copper distribution in European topsoils: An assessment based on LUCAS soil survey

Cristiano Ballabio [a], Panos Panagos [a,*], Emanuele Lugato [a], Jen-How Huang [b], Alberto Orgiazzi [a], Arwyn Jones [a], Oihane Fernández-Ugalde [a], Pasquale Borrelli [b], Luca Montanarella [a]

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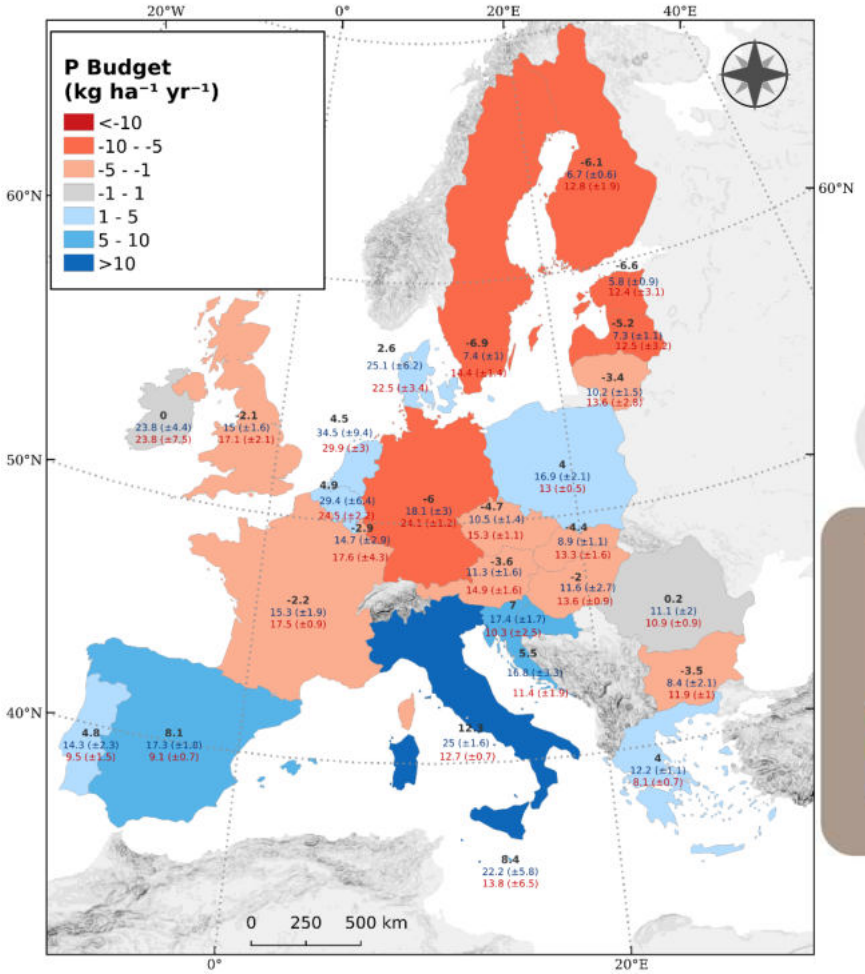
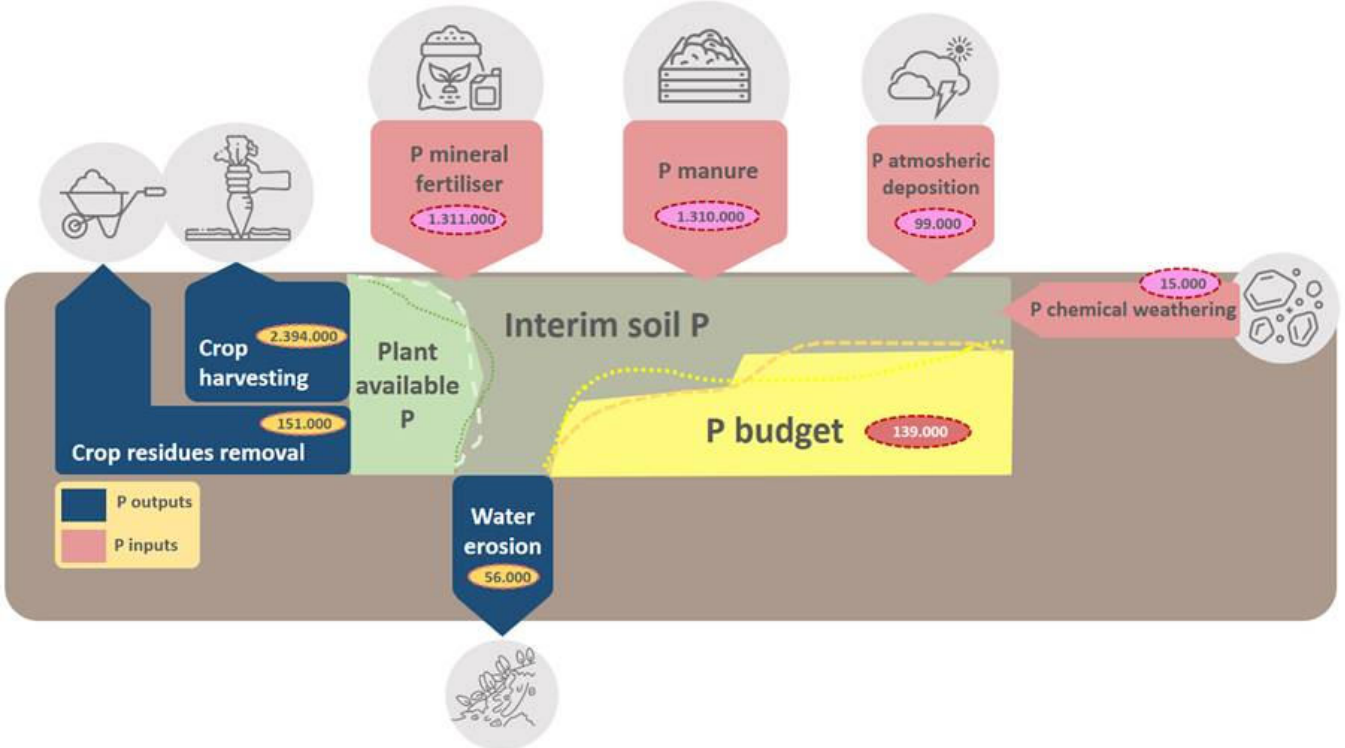
Phosphorus budget in EU Agricultural soils

Inputs: inorganic fertilizers, manure, atmospheric deposition, and chemical weathering

Outputs: crop production, plant residues removal, losses by erosion





- High spatial variation of P budget across countries/regions.
- Reduction of P should be focused on specific

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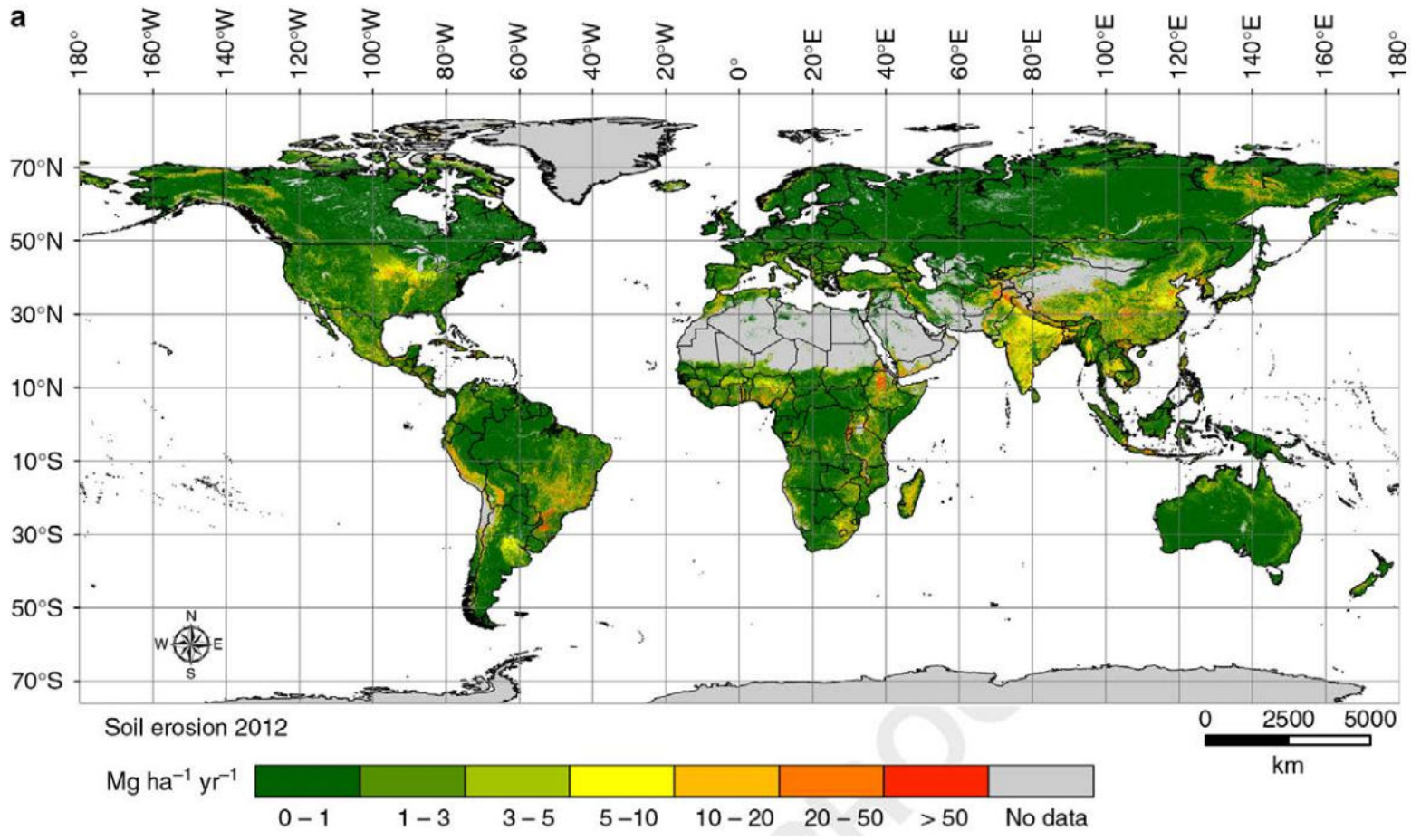
Global Soil Erosion



- 35.9 Billion tons of soil erosion (2012)
- 4 Million Km^2 change land use between 2000-2012
- Increase of total erosion by 2.5% due to decrease in forestlands (Africa has the highest increase +8%)

- Focus in croplands: $17^{+1}_{-0.7}$ *Pg yr⁻¹*
- Croplands are 11.2% of study and are responsible for 50.5% of soil erosion

nature COMMUNICATIONS

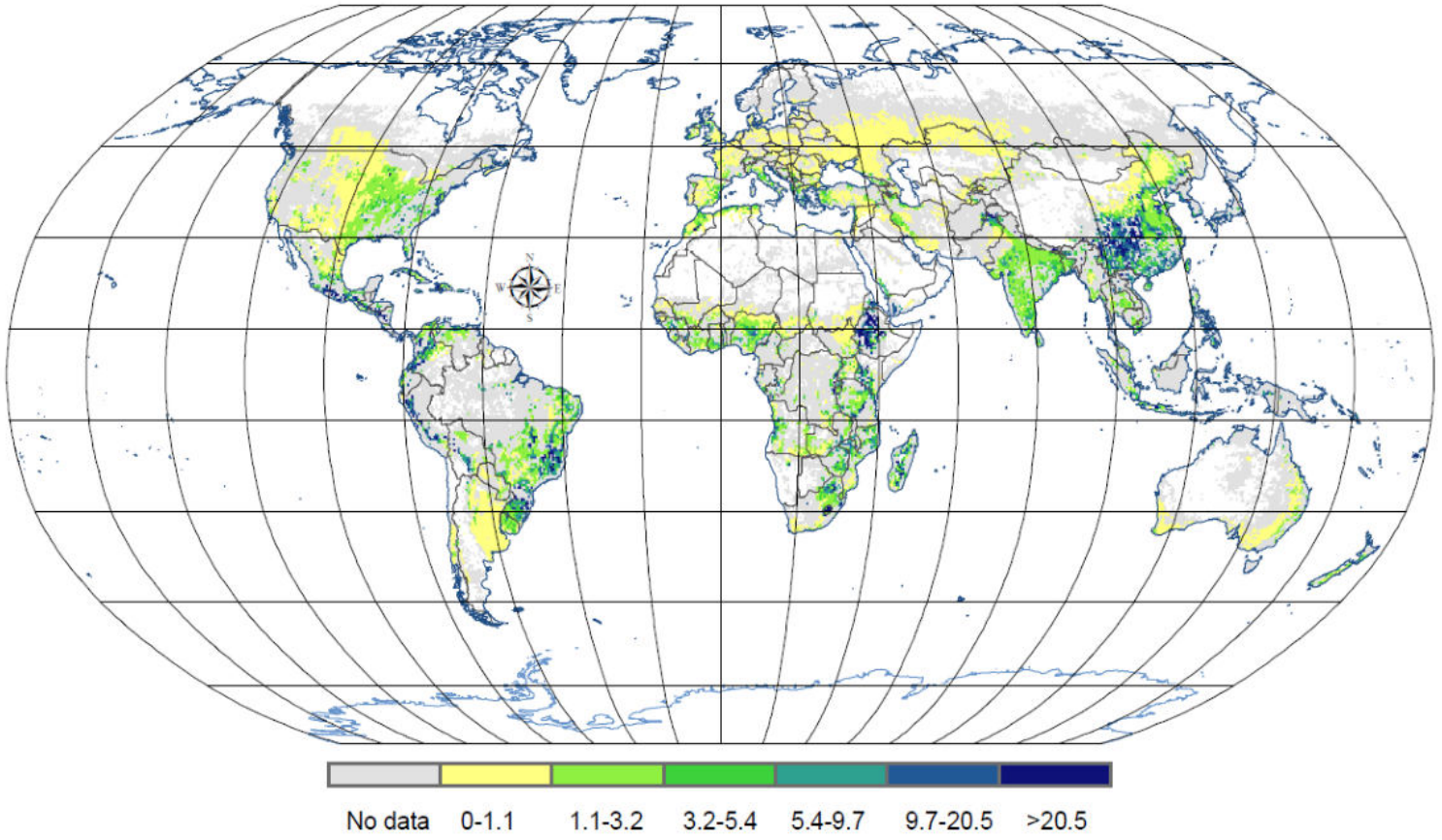
ARTICLE

DOI: 10.1038/s41467-017-02142-7 OPEN

An assessment of the global impact of 21st century land use change on soil erosion

Pasquale Borrelli[1,2], David A. Robinson[3], Larissa R. Fleischer[4], Emanuele Lugato[2], Cristiano Ballabio[2], Christine Alewell[1], Katrin Meusburger[1], Sirio Modugno[5], Brigitta Schütt[6], Vito Ferro[7], Vincenzo Bagarello[8], Kristof Van Oost[9], Luca Montanarella[2] & Panos Panagos[2]

Spatially discrete global soil P losses due to erosion



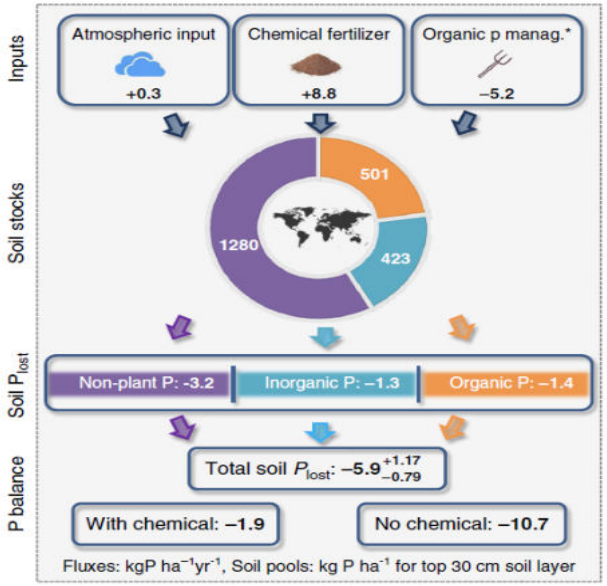
Global P losses due to soil erosion in kg P ha^{-1} yr^{-1}

Alewell et al., Nature Comm (2020)

P loss from agricultural systems due to erosion is substantial (dependent on region and continent between 1 – 12 kg $ha^{-1}yr^{-1}$)

Very high losses: Eastern China, Indonesia, regions of south-eastern Africa, Central America and South America

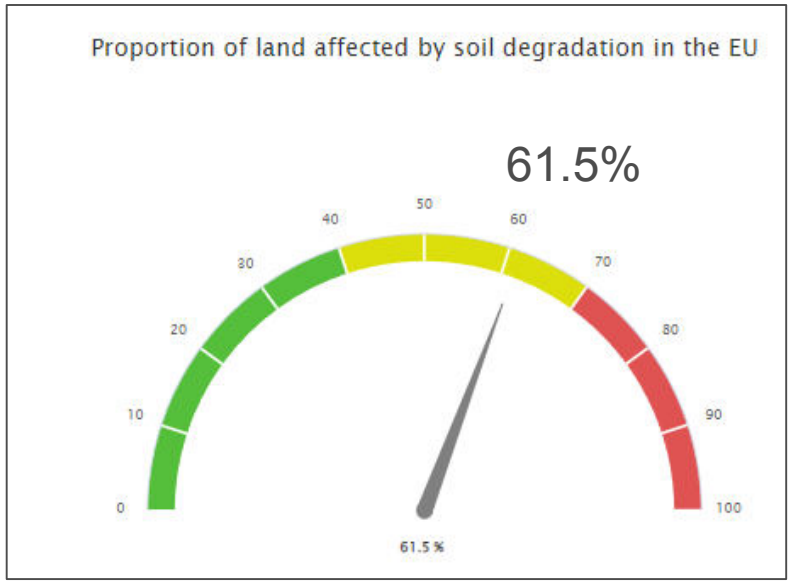
High losses: most of India, regions of Southern Africa and South America



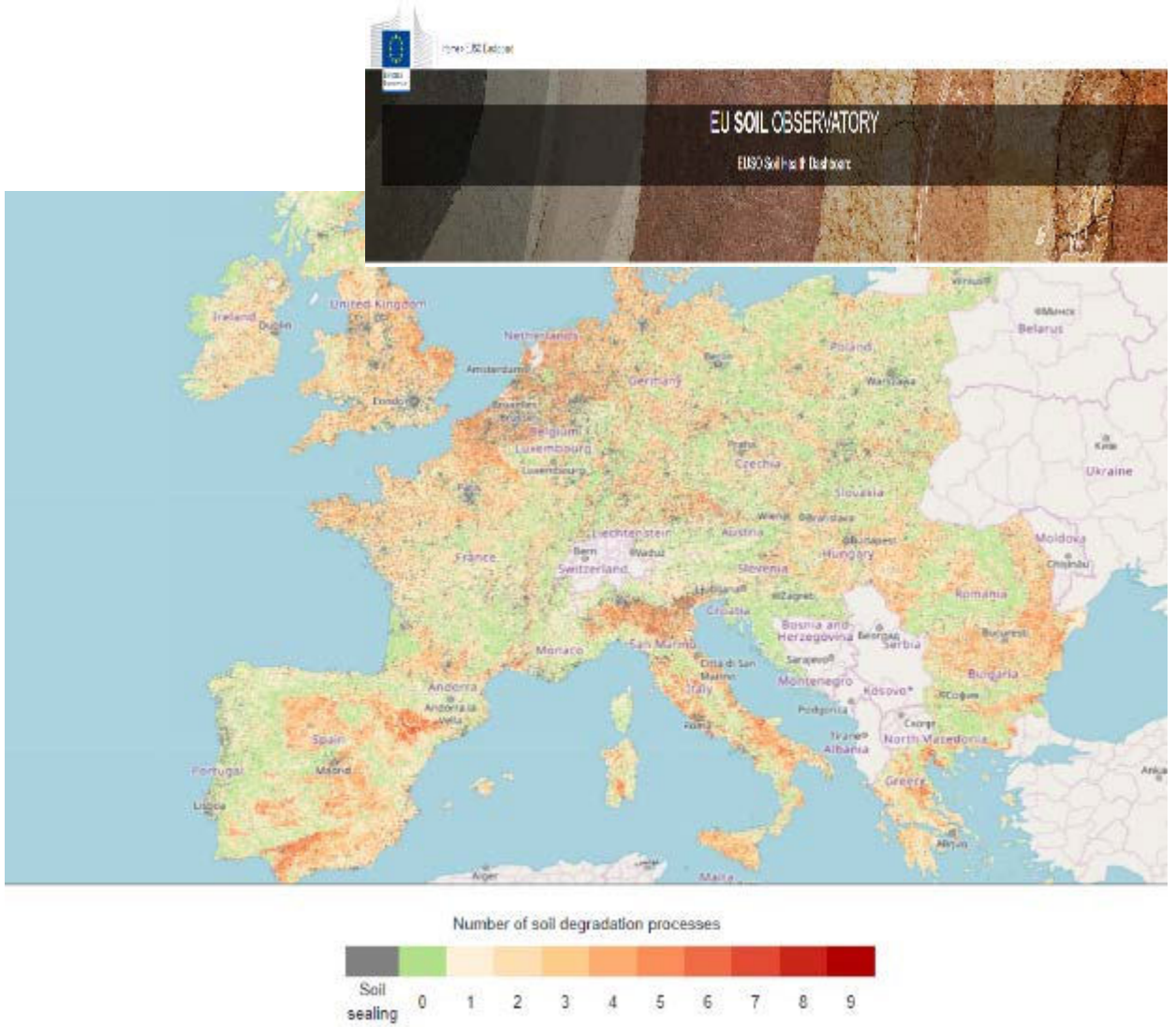
Soil Health Dashboard

EUSO Soil Health dashboard:
- At least 61.5 % of unhealthy soils
- Dashboard shows location and different types of soil degradation in the EU

→ Launch in March



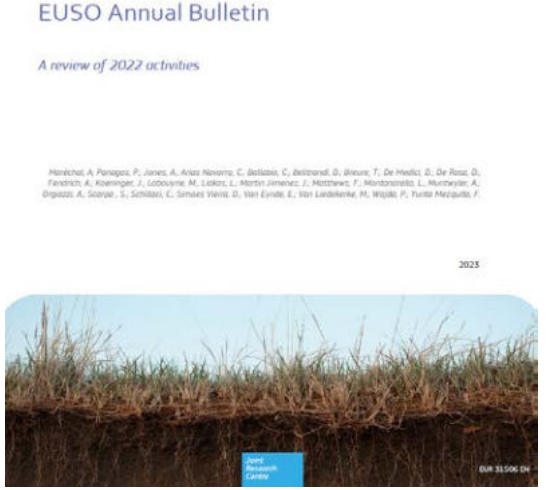
- Nitrogen inputs (refined) for the dashboard

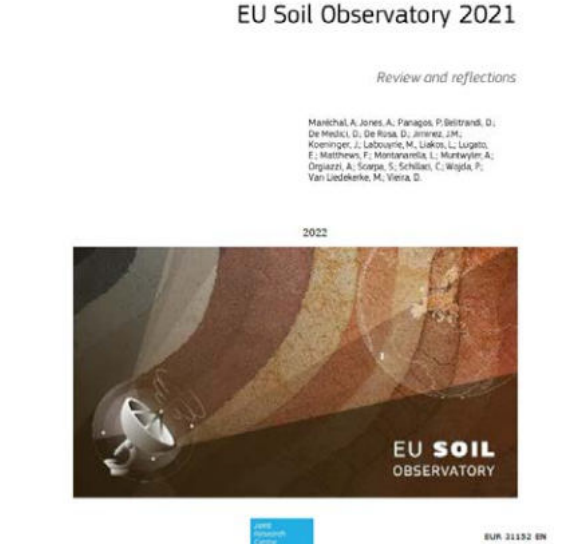


https://esdac.jrc.ec.europa.eu/esdacviewer/euso-dashboard/

EUSO Stakeholders Forum 2021-2022

- 1,000 participants per Forum
- High level participants
- 70+ presentations over three days
- 2022 Forum: first presentation of Soil Mission funded projects
- Establishment of 6 Technical Working Groups
- Lead to a more complete knowledge base for policy
  - Soil pollution
  - Soil monitoring
  - Soil data sharing
  - Soil erosion
  - Soil biodiversity
  - Soil Carbon MRV
- 2023: jointly with SOIL Mission Conference





A supportive framework for soil protection in the EU

The new EU Soil Strategy and upcoming Soil Health Law (2023), European Soil Observatory and Mission A Soil Deal for Europe together are the main **framework for soil protection and restoration in the EU.**

Policy framework

Knowledge management

Policy support

Soil monitoring + data/legacy repository

Mechanism for research and innovation, Knowledge gaps, citizen engagement and wide outreach

European Commission

EUROPEAN UNION

EU MISSIONS
SOIL DEAL FOR EUROPE

Mission “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 on 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**.

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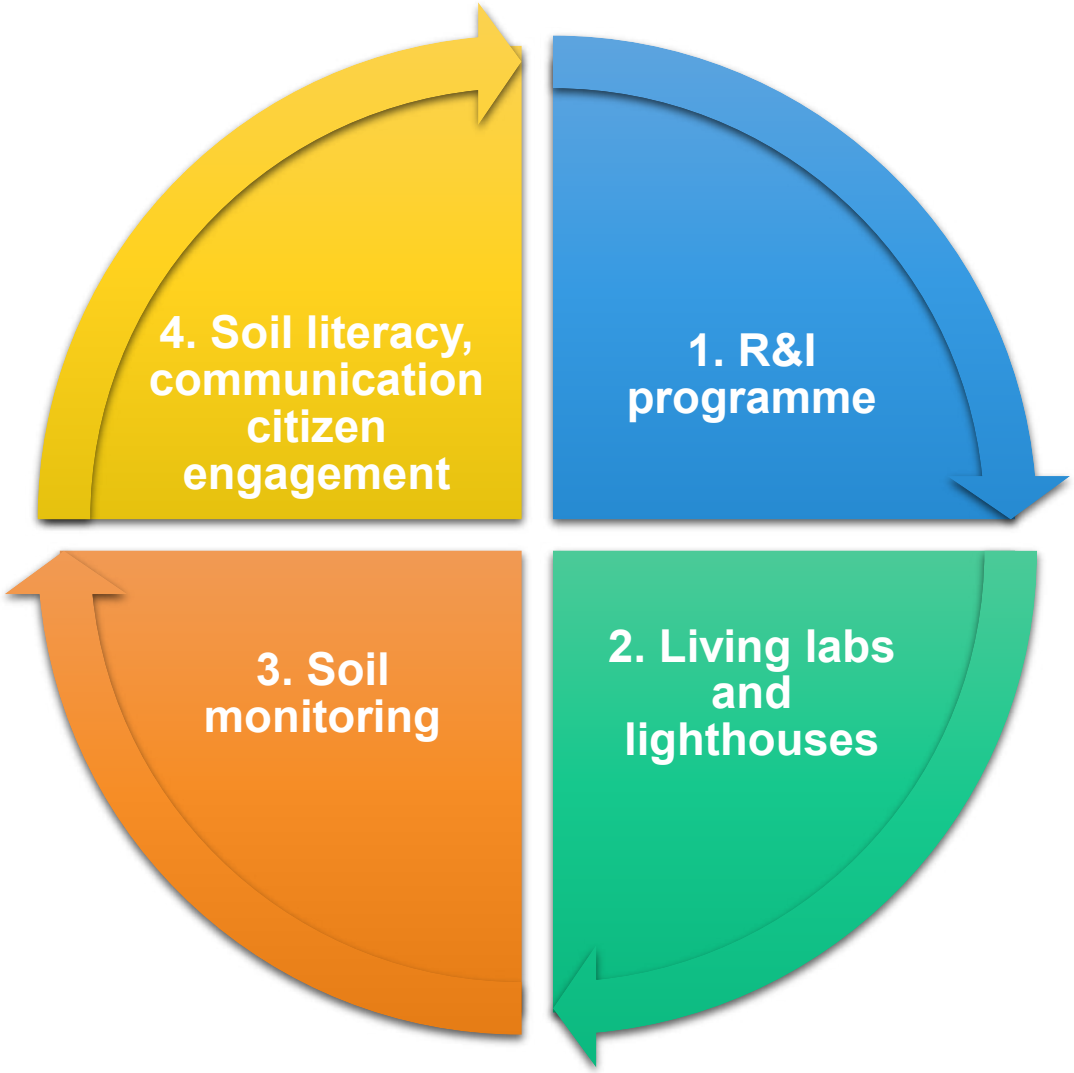
Soil Mission Building Blocks

- Support to citizen science initiatives for soil monitoring
- Promote self-assessment of soil health by land managers and citizens

Building on JRC Awareness and Education WG

- Harmonisation of indicators, measuring and reporting for soil health across Europe;

Managed by EU Soil Observatory



- **Knowledge, data, technologies and infrastructures** to support soil health
- Support validation of soil health indicators;

EUSO as beneficiary

A network of real-life sites to

- test and validate novel measuring techniques

Living Labs Portal on EUSO

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SOIL DEAL FOR EUROPE

The emerging landscape of Mission projects

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, engagement of municipalities and regions

Budget: 67 M€

11 grant agreements signed

WP 2022

Topics on e.g.

remediation strategies for contaminated sites, soil biodiversity, use of biowaste for soil improvement, carbon farming, soil literacy

Budget: 95 M€

17 grant agreements to be signed in June ‘23

WP 2023

Topics on e.g.

Living Labs, spatial planning, soil and cultural and creative industries

Opening of call: 17 January ’23

Deadline for applications:
20 September 2023

Budget: 139 M€

≈ 19 grant agreements expected

panos.panagos@ec.europa.eu

http://esdac.jrc.ec.europa.eu

@PanosPanagos33

Thank you for your attention!

EU SOIL OBSERVATORY