The new Soil Erosion map of Europe: A Contribution to soil conservation

Panos Panagos[1], Pasqualle Borrelli[1], Katrin Meusburger[2], Cristiano Ballabio[1], Emanuele Lugato[1], Jean Poesen[3], Christine Alewell[2], Luca Montanarella[1]

[1]European Commision – Joint Research Centre, Ispra, ITALY

[2]University of Basel, Environmental Geosciences, SWITZERLAND

[3]Division of Geography, KU Leuven, BELGIUM

Policy: Soil Thematic Strategy(2006)

Sealing

Soil Biodiversity loss

Decline of
Soil Organic Matter

Erosion

Soil Threats

Salinization

Compaction

Contamination

Landslides

Soil erosion

Soil degradation through erosion has been identified as major threat to European soils and agriculture

European Commission
requested new assessments to the Joint Research Centre

Water Erosion

Wind Erosion

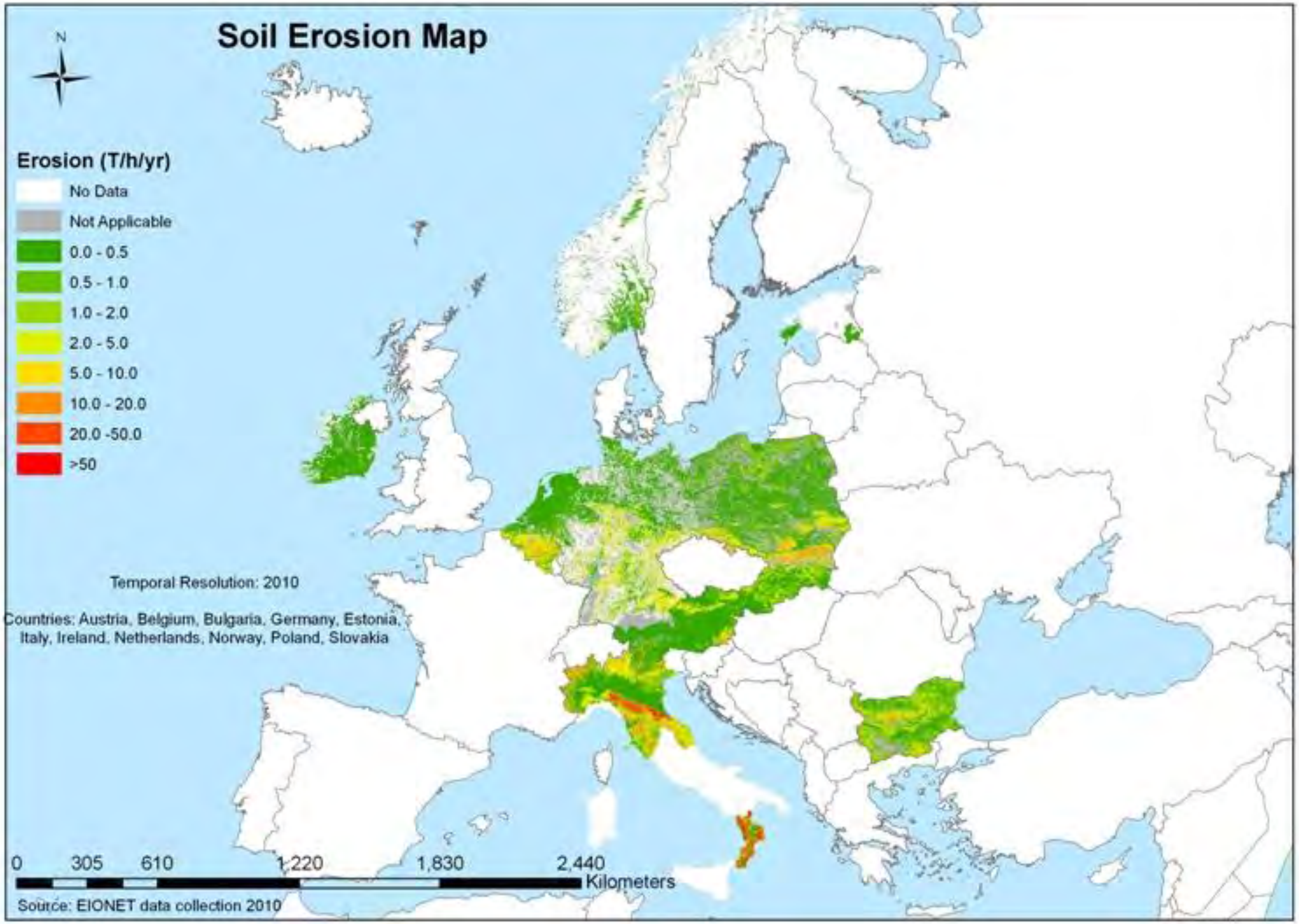
Forest Erosion

Why we do soil erosion modelling?

- **Develop Indicators for EU Statistical services (DG ESTAT):** Aggregated data at different regional levels (per country, Region, province)
- **Policy support to DG AGRI**: Common Agricultural policy impact. Provide aggregated data for agricultural areas with soil loss rates > 10 t ha^{-1} yr^{-1}
- **Policy Support to DG ENV**: Monitor the state of soils (Aggregated data & maps of soil erosion)
- **European Environmental Agency (EEA)**: State of the Environment report
- **EUROPE 2020**: Develop soil erosion indicator for Resource efficiency scoreboard
- Development of Green Growth Indicators for the **Organisation for Economic Co-operation and Development (OECD)**

- **Scientific Collaborations & "Open Data Access" through the European Soil Data Centre (ESDAC)**:
  - Distribute data (soil erodibility, rainfall erosivity, support practices, Cover Management, Topography, etc.) to the scientific community and policy makers in EU-countries
  - **400 datasets of K-factor** (April 2014–Aug 2015); **200 datasets of R-factor** (Jan - Aug 2015), **150 datasets** in Erosion RUSLE2015 (Sept 2015)…………

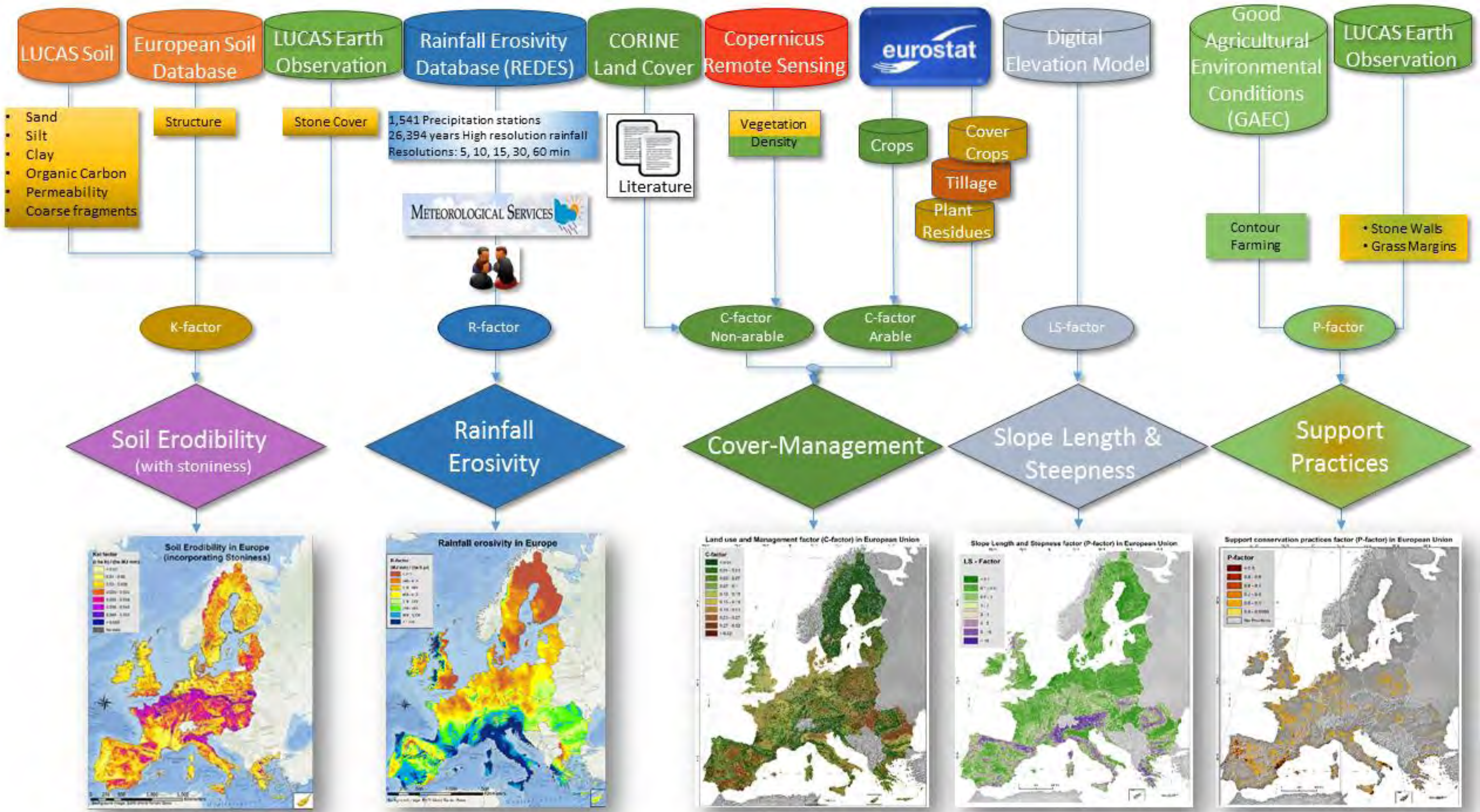
Soil Erosion EIONET Map (2009-2010)



Panagos et al. (2014), Soil Science & Plant Nutrition

RUSLE2015: New soil erosion model
A = K * R * C * LS * P

European Commission



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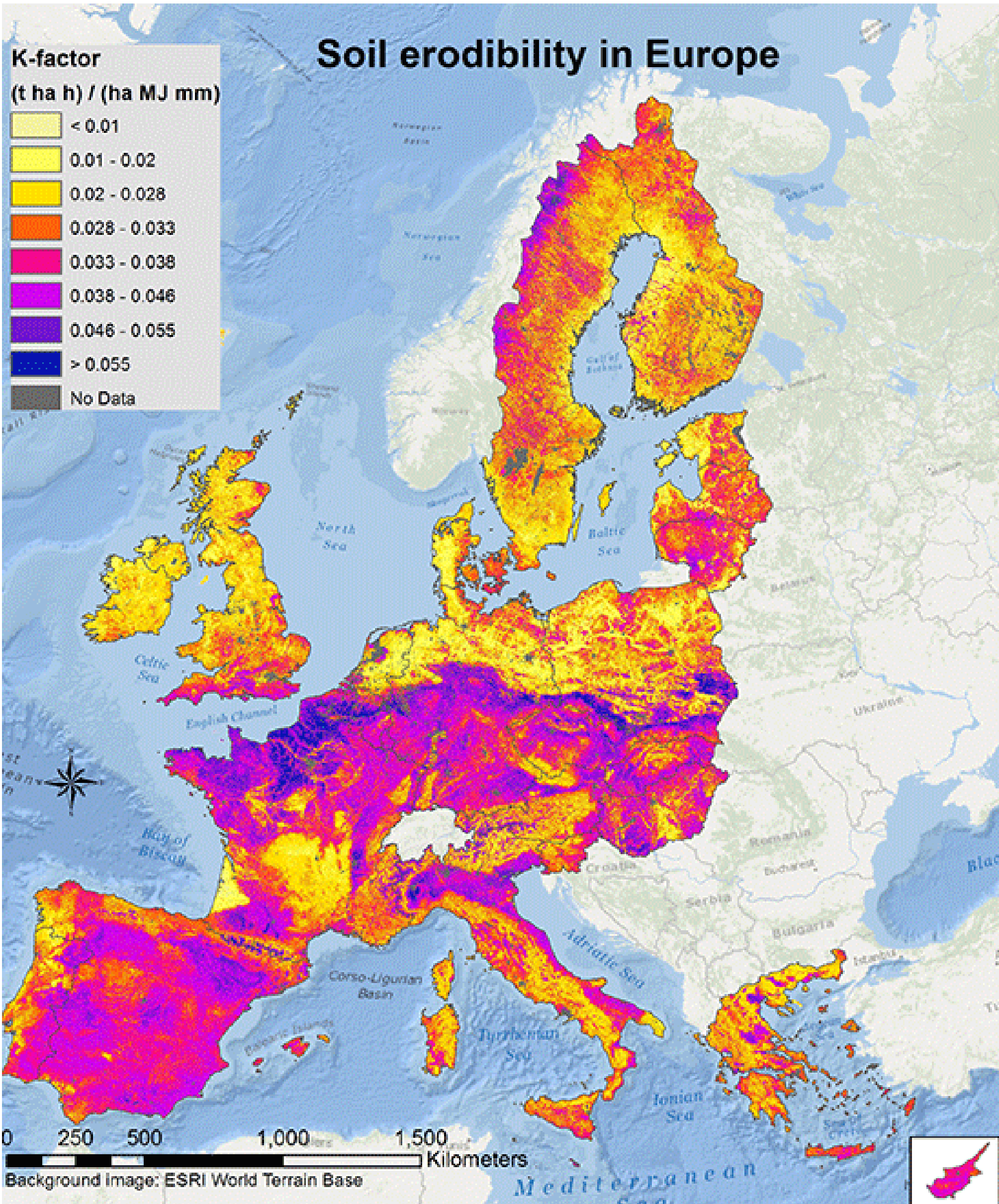
Panagos et al (2015) – Env.Science & Policy

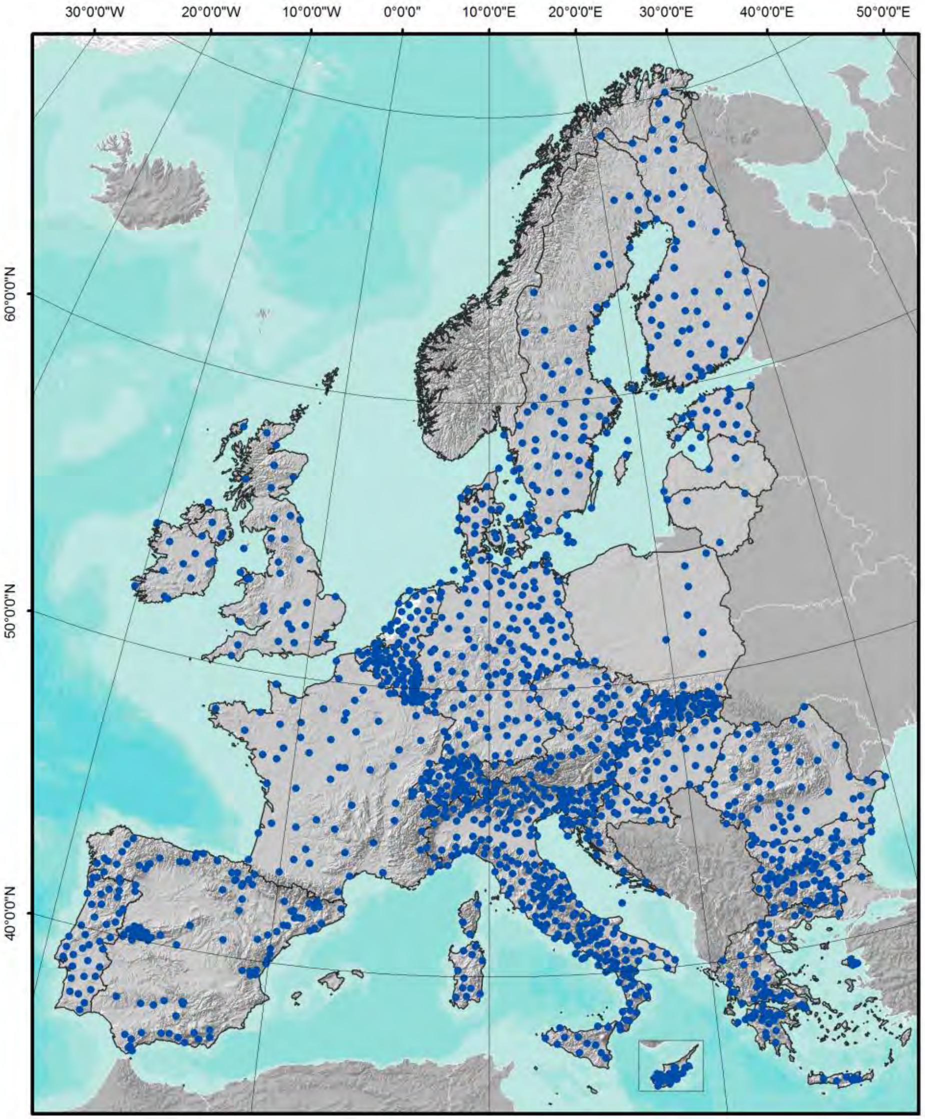
Soil Erodiblity (K-factor)



- **Soil Erodibility** is an integrated annual value of the soil profile reaction to the process of soil detachment and transport by raindrops & surface flow
- Combines the influence of **Texture, Organic carbon, soil structure, Permeability, coarse fragments and Stone cover**
- **20,000** Land use/cover survey (LUCAS) samples with measured data
- **Regression interpolation** using Terrain features, Lat/Long, vegetation covariates
- **Spatial Resolution**: 500m
- **Stone cover effect**: 15%; Important effect in Mediterrean
- **Verified** against 21 local, regional and national datasets from 13 countries

Panagos et al (2014), Science of Tot. Env.

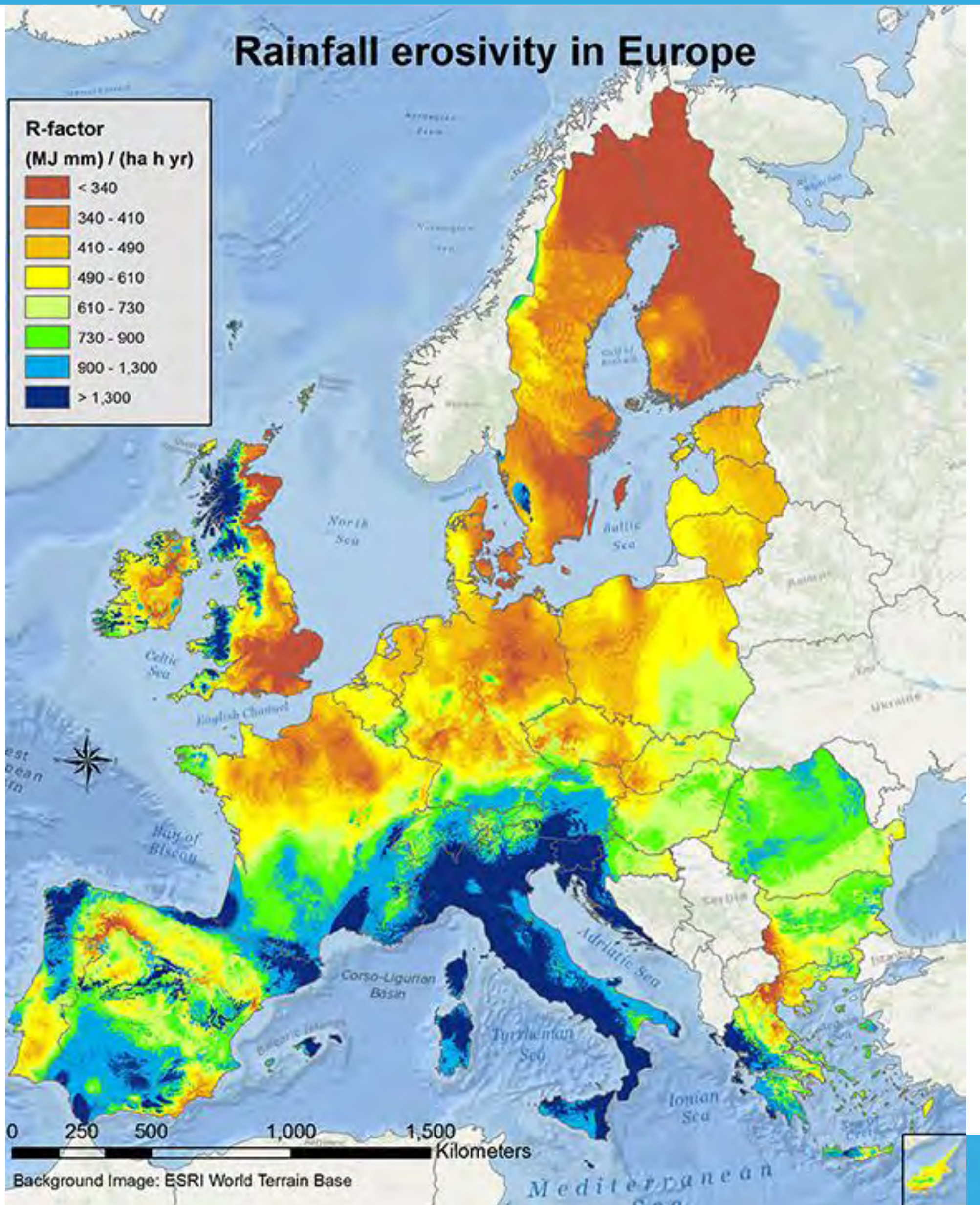
Rainfall erosivity and data collection



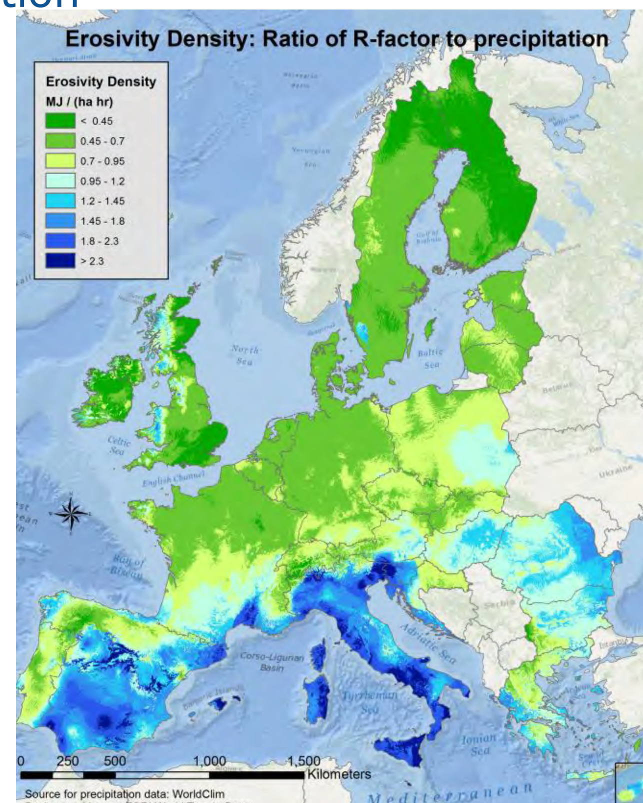
- **Rainfall erosivity** is the kinetic energy of rainfall (MJ mm ha^{-1} h^{-1} y^{-1})
- Combines the influence of **precipitation duration, magnitude** and **intensity**
- **Participatory approach**: Environmental & Meteorological Services from all Member States (Mar 2013 – Jun 2014).
- **1,541 Precipitation stations** with detailed rainfall intensity (all countries)
- **Calibration requested:** 5 min, 10-min, 15 min, 60 min.
- **Temporal Resolution**: 30-Minutes
- **Time series**: 7 – 56 Years (Mean: 17.1yr; 75% of time series in 2000-2010)
- **Data**: 26,394 years of High Temporal resolution precipitation records
- **REDES**: Rainfall Erosivity Database on the European Scale

Panagos, P., Ballabio, C., Borrelli, P.,.....et 14 others from MS ......(2015). Science of Total Env.

Rainfall Erosivity (R-factor)

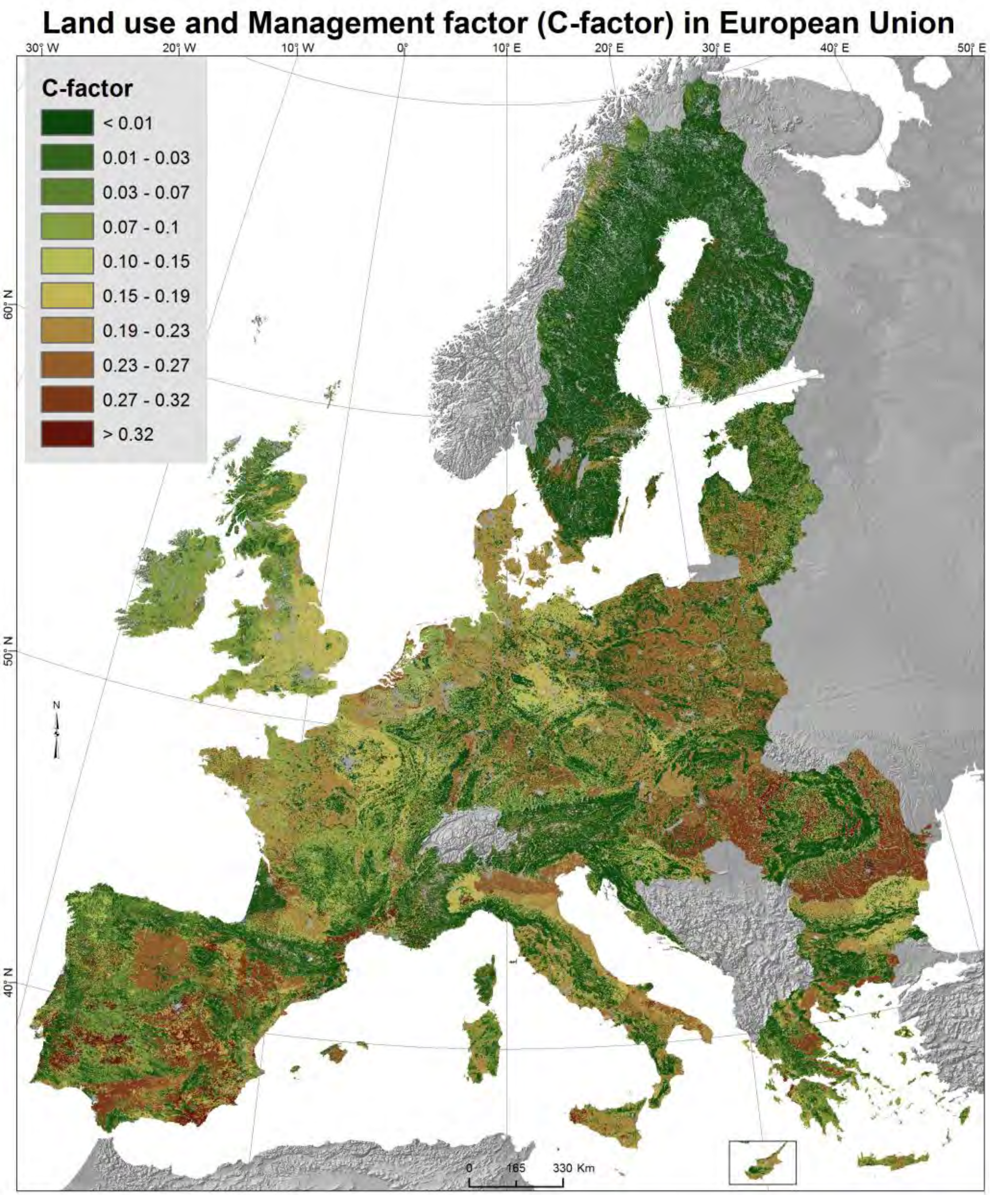


- **Resolution:** 500m; **Robust Geostatistical** model
- Highest R-factor in Mediterranean & Alpine regions and lowest in Scandinavia
- R-factor **not dependent** only from precipitation



Panagos et al.(2015)

Cover – Management (C-factor)



- Differentiate between **Arable lands** & **Non-Arable lands**
- **Non arable:** Forest – Shrub – sparse vegetation – Heterogeneous – Permanent crops - pastures/grasslands
- Use of CORINE Land Cover classes
  - ✓ **Calibrate** the C-factor from literature: 20 major published studies
  - ✓ with **Remote Sensing**(RS) images from Copernicus Programme: Vegetation Density layer: RS every 10 days

Example: Pastures C-factor

- Range from literature: 0.05 – 0.15
- Each pixel gets a value in this range depending on its Vegetation Density (0-100%)
- Pastures (mean) C-factor in Ireland: 0.077
- Pastures (mean) C-factor in Cyprus: 0.125

Panagos et al.(2015). Land Use Policy.

Arable lands C-factor: Crop factor & management

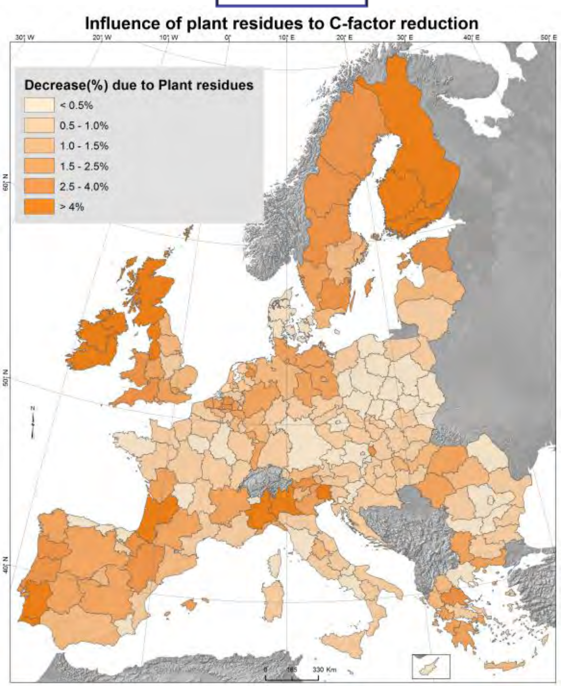
European Commission

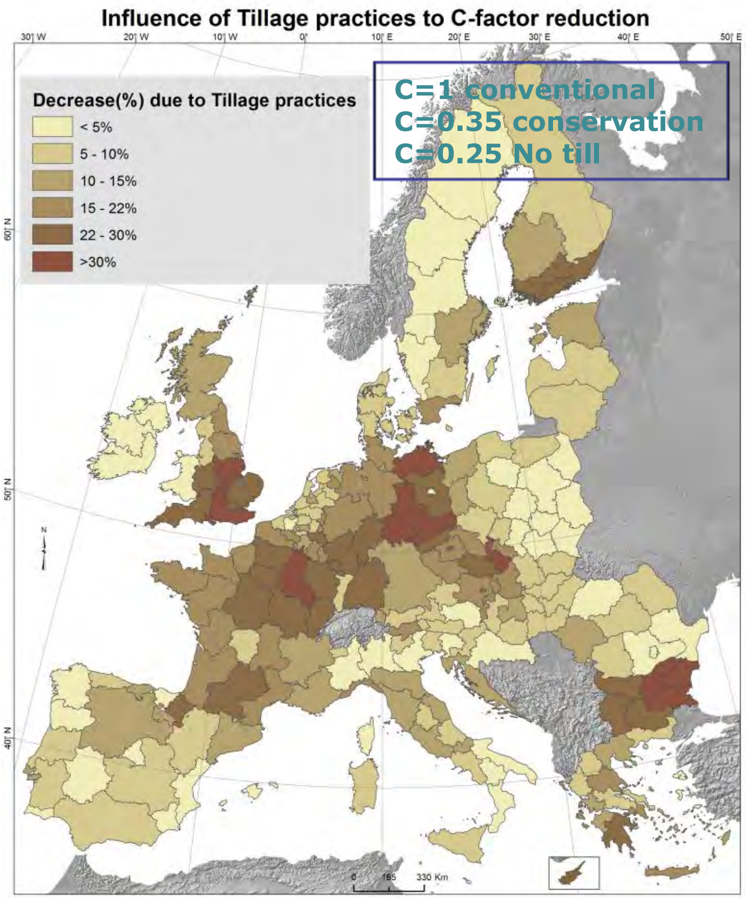
Crop factor: C-factor (from experimental sites in the European Union) for **17 crops**.
e.g wheat:0.20, Rice:0.15, Potatoes:0.34, Maize:0.38…………cotton seed:0.5

Estimate the **C-factor per region** based on its crop composition

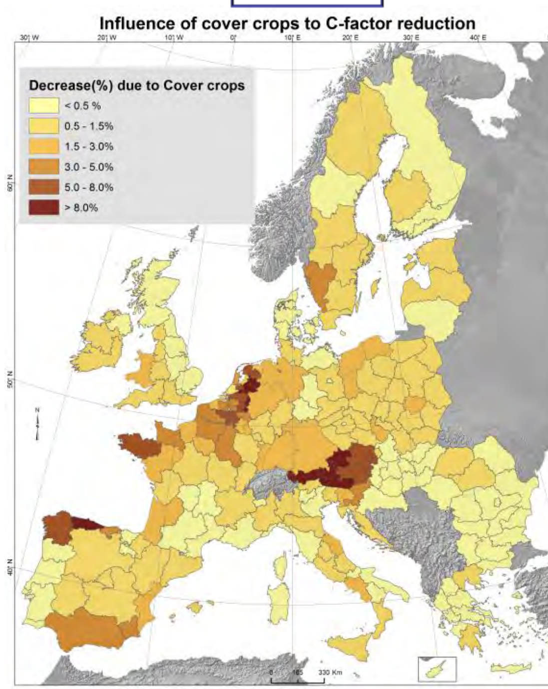
Plus **3 management sub-factors** (using input official data from EUROSTAT):

C=0.88





C=0.80

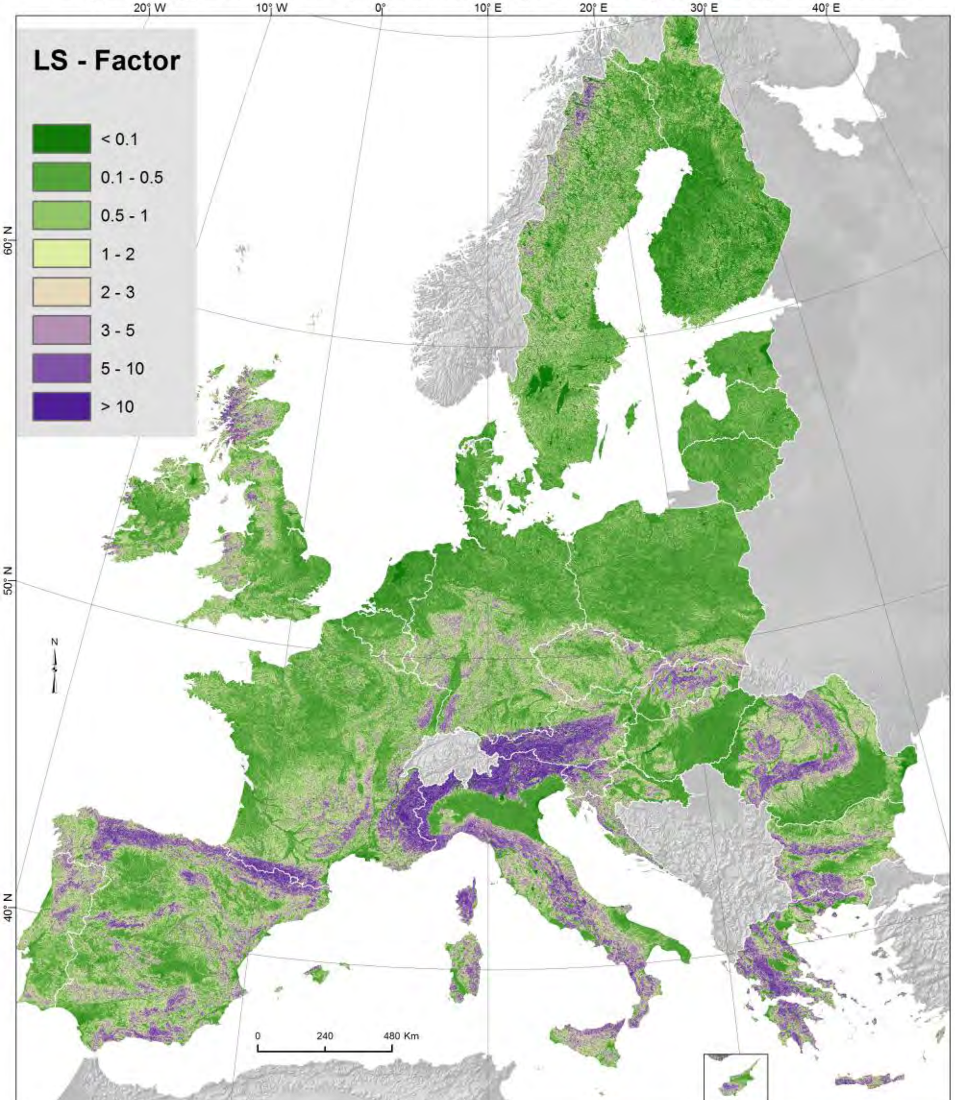


Research Centre

Panagos et al.(2015). Land Use Policy.

Topography (LS-factor)

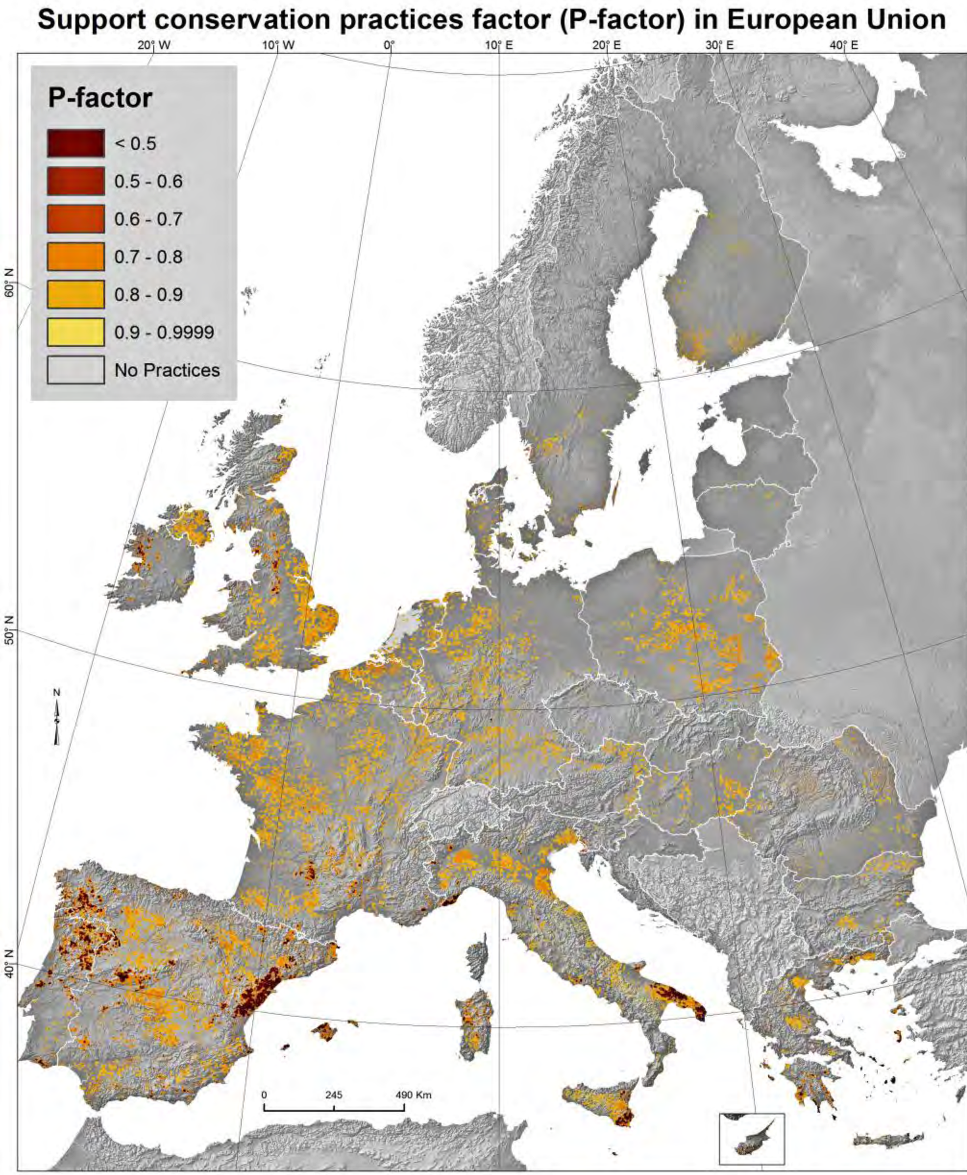
Slope Length and Steepness factor (LS-factor) in European Union



- **25m DEM → resolution 25m LS-factor** (capture geomorphological features compared to 100m DEM)
- Desmet & Govers algorithm (1996)
- Fast process with SAGA software
- **50GB** of dataset available in European Soil Data Centre (ESDAC)
- No arbitrary limitations in slope length
- Slope cutoff: 50% (after literature review & experimental results in Switzerland)

Panagos et al.(2015) , Geosciences, MDPI

Support Practices (P-factor)



Data input from:

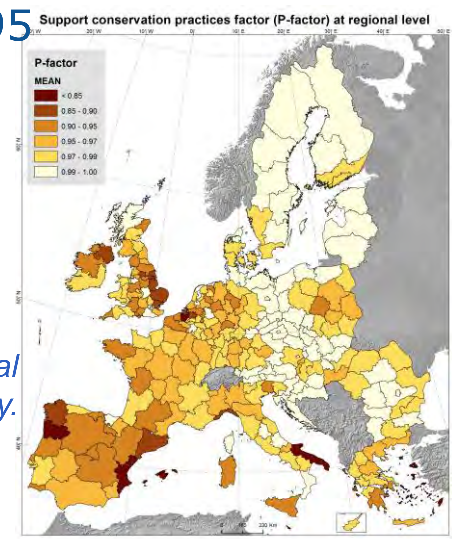
- Good Agricultural Environmental Conditions (GAEC) plus
- LUCAS 270,000 earth observations

Support practices Impact:

- Contour farming (5%)
- Stone Walls (38%)
- Grass Buffers (57%)

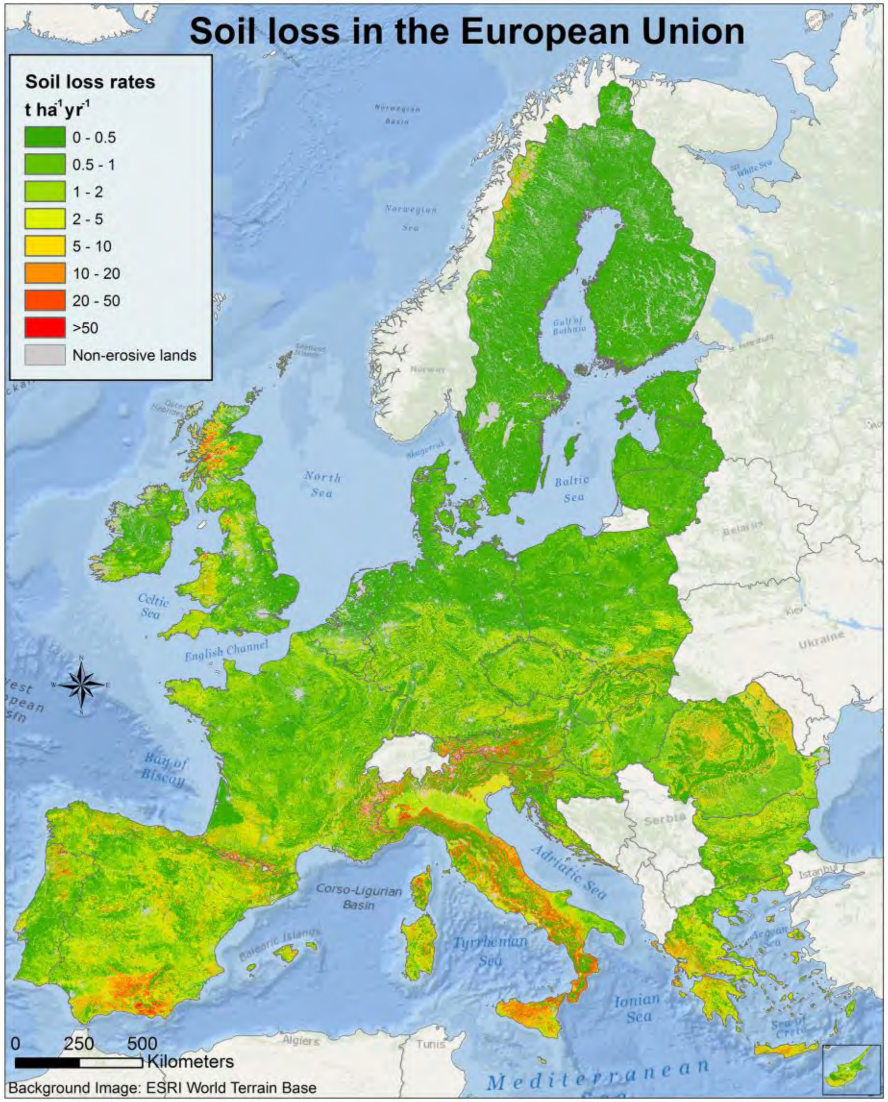
P-factor in EU-28: 0.97

P-factor in **arable**: 0.95



Panagos et al.(2015). Environmental Science and Policy.

Soil water erosion



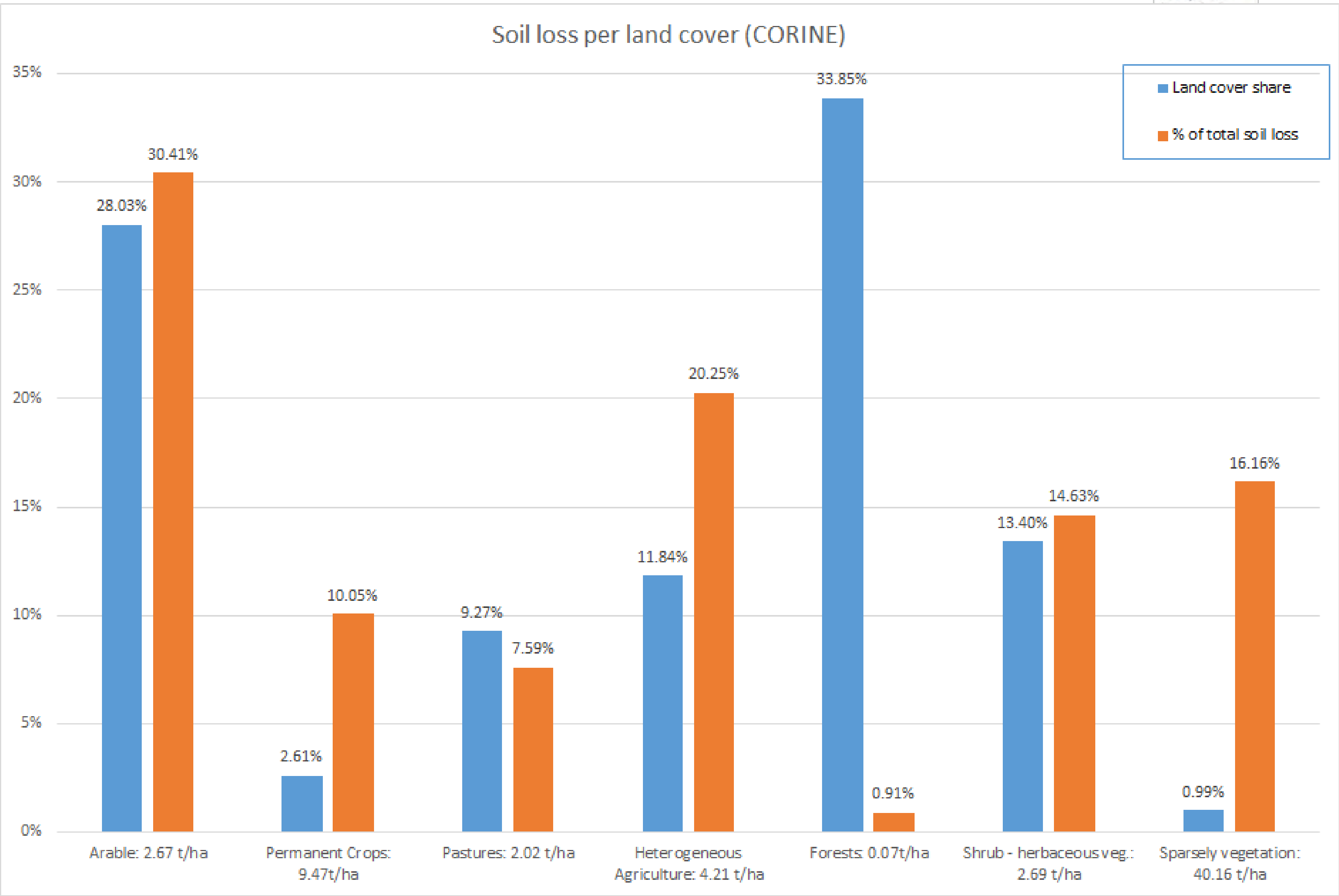
- Average EU-28: **2.46 t ha^{-1} yr^{-1}** (in the erosive prone areas: 91% of EU)
- Total Soil loss: **970 Mt annually**
- Spatial resolution: **100m**
- Reference year: **2010**

- **24%** of EU lands have rates >2 t/ha
- **11% of total area** contributes to almost **70% of total Soil Loss**

"Between 2000 and 2010, intervention measures through the CAP have reduced the rate of soil erosion by an average of 20% for arable lands"

Panagos, Borrelli, Robinson, 2015. NATURE.
Panagos et al (2015) – Environmental Science & Policy

EU Soil loss Statistics (RUSLE2015)



Panagos et al (2015) – Env.Science & Policy

Change on soil erosion potential 2000 - 2010

European Commission

Agricultural land

"…between 2000 and 2010, intervention measures through the Common Agricultural Policy have reduced the rate of soil loss in the European Union by an average of 9.5% overall, and by 20% for arable lands"

	Country	2000	2010	CAP's effect
AT	Austria	4.7	4.0	-15.6
BE	Belgium	[illegible]	[illegible]	[illegible]
BG	Bulgaria	3.8	2.5	-34.7
CY	Cyprus	2.7	1.9	-31.8
CZ	Czech Republic	[illegible]	[illegible]	[illegible]
DE	Germany	2.5	1.8	-30.6
DK	Denmark	0.7	0.6	[illegible]
EE	Estonia	0.9	0.7	[illegible]
EL	Greece	3.6	2.8	-22.5
ES	Spain	[illegible]	4.3	-22.8
FI	Finland	0.7	0.5	-28.7
FR	France	2.8	2.0	-28.4
HR	Croatia	1.8	1.7	-4.8
HU	Hungary	2.3	2.1	[illegible]
IE	Ireland	1.5	1.3	[illegible]
IT	Italy	9.6	8.4	-12.3
LT	Lithuania	1.0	1.0	-7.5
LU	Luxembourg	6.3	4.6	-27.1
LV	Latvia	1.1	1.0	-7.9
MT	Malta	17.5	15.9	-9.0
NL	Netherlands	0.7	0.5	-19.3
PL	Poland	1.8	1.6	-10.0
PT	Portugal	3.3	2.9	-11.2
RO	Romania	3.8	3.4	-9.7
SE	Sweden	1.3	1.1	-13.4
SI	Slovenia	5.4	4.6	-14.6
SK	Slovakia	4.1	3.5	-12.8
UK	United Kingdom	1.1	1.0	-8.8

"…the amount of soil lost to water erosion in Europe equates to an estimated economic loss of about US$20 billion per year"





Panagos , Borrelli , Robinson , 2015. *Nature,* 526

Joint Research Centre

RUSLE2015 & Soil Loss Map:
Concluding remarks

European Commission

- **Trend**: Decrease of 9% (20% in arable lands) due to impact of Common Agriculture Policy (CAP) and soil protection measures: **reduced tillage, plant residues, cover crop, contour farming, maintenance of stone walls, increase of Buffer strips**.
- Very good correspondence with **EIONET** (7 out of 9 Member States): The European model is as robust as national ones.
- **High resolution** (100m) & **best available** input data in EU
- **Transparent way** & **easily parameterization**
- **Peer-reviewed following literature** (> 20 publications during the last 3 years)
- **Replicable & comparable** with national estimates
- **Participatory**: involvement of countries (R-factor, K-factor, Statistics - EUROSTAT)
- **Scenario analysis**:
  - Land cover change (Land Use Modelling Platform – LUMP 2050)
  - Management changes (**Policies**: CAP 2014-2020, Biofuels directive)
  - Climate Change (precipitation & intensity trends in 2050)

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Panagos et al (2015) – Env.Science & Policy

Pilot area in ITALY: Potential Impact of GAEC Application

European Commission

The following scenarios were simulated to assess the impact of GAEC application on soil erosion and SOC conservation:

a) **'Baseline':** it refers to the conditions before cross-compliance introduction (2003)

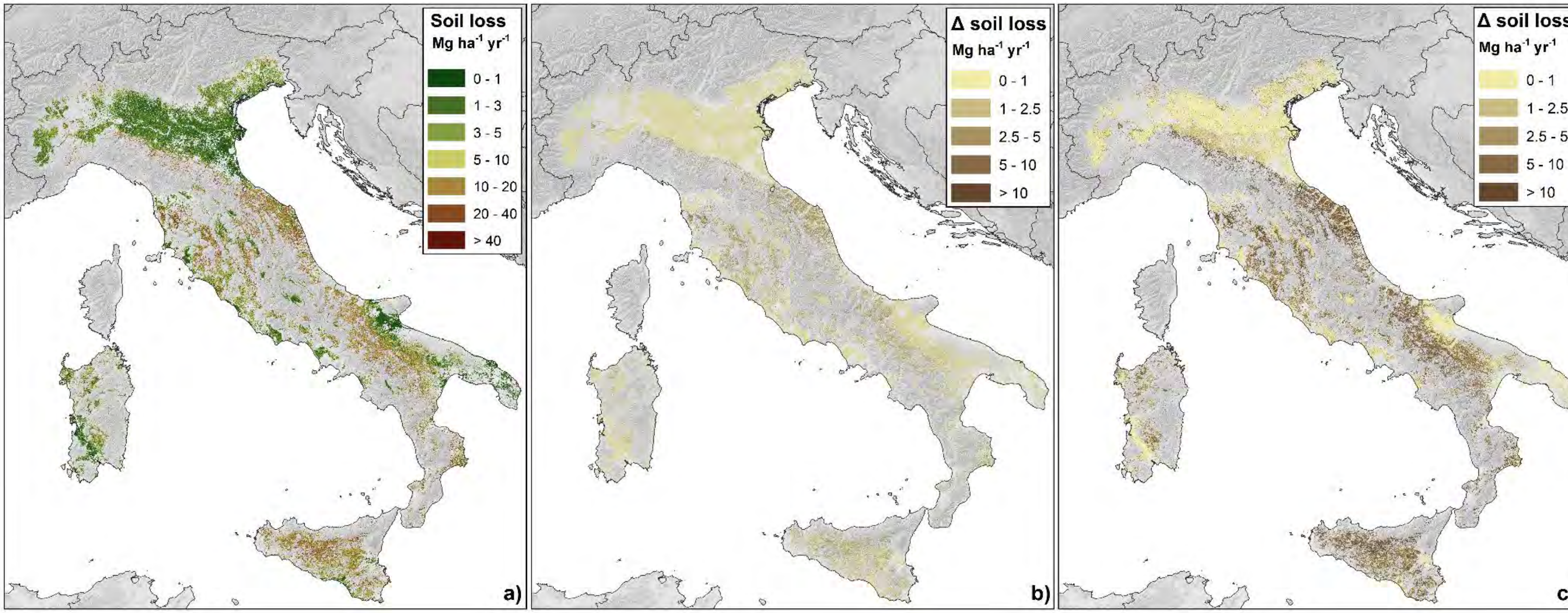
b) **'Current':** This scenario is based on the implementation of the compulsory GAEC standards.

c) **'Technical potential':** GAEC standards are applied to the entire surface for a long-term period (2050).

Pilot area: Potential Impact of GAEC Application – soil erosion

European Commission

'baseline scenario' | **'current scenario'** | **'technical potential'**



Soil loss:

- 8.33 t ha^{-1} yr^{-1}
- 29.2 % > 10 t ha^{-1} yr^{-1}

Soil loss:

- 7.43 t ha^{-1} yr^{-1}
- 25 % > 10 t ha^{-1} yr^{-1}
- Decrease ca. 11%

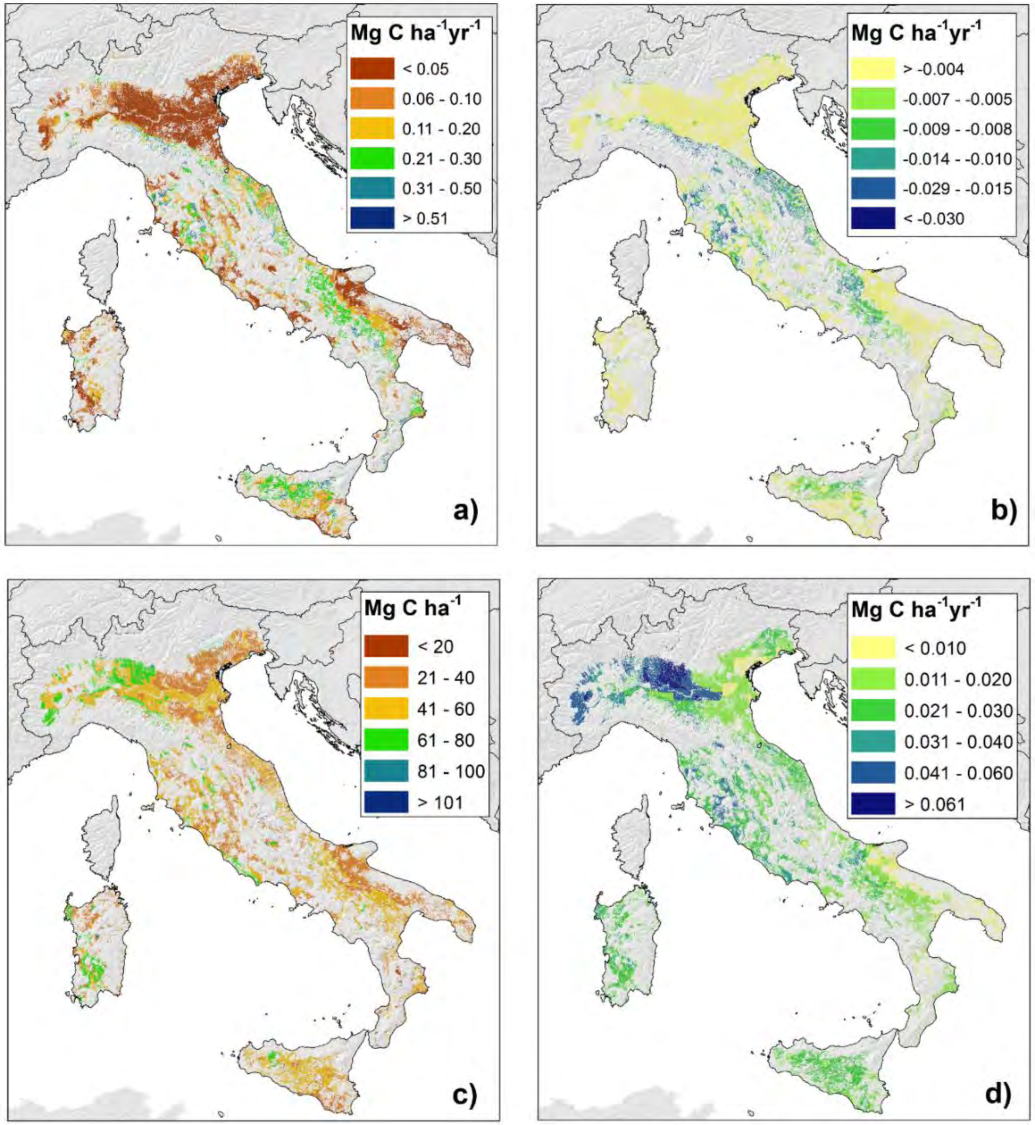
Soil loss:

- 4.1 t ha^{-1} yr^{-1}
- 10.2 % > 10 t ha^{-1} yr^{-1}
- Decrease ca. 50%

Borelli et al (2016) – Land Use Policy

Joint Research Centre

Soil organic carbon
Current scenario



a) organic carbon lost by erosion in the **baseline** scenario;

b) avoided eroded C with **GAEC** application;

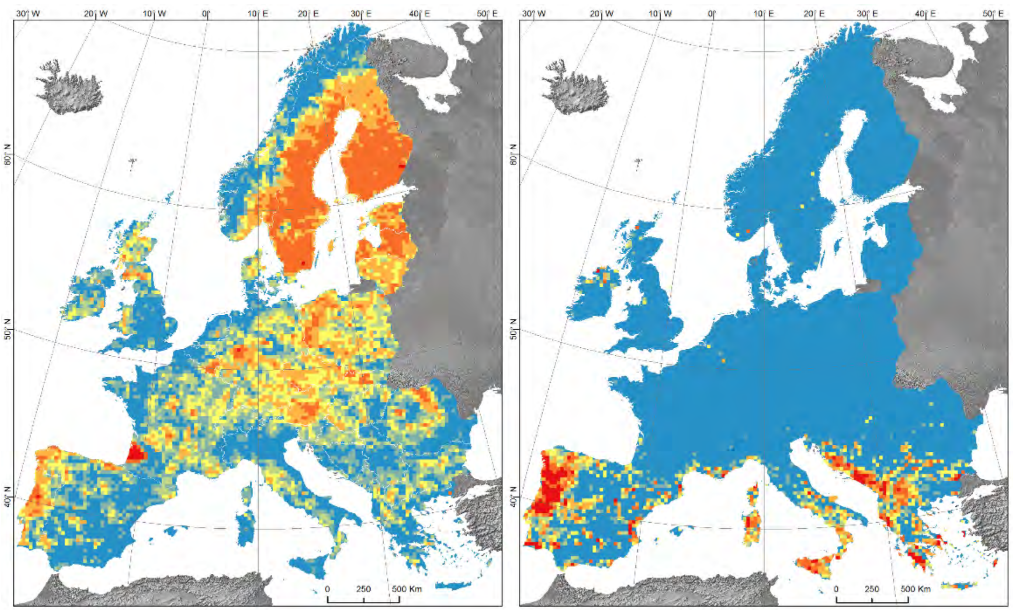
c) SOC stock (0-30 cm layer) in the **baseline** scenario;

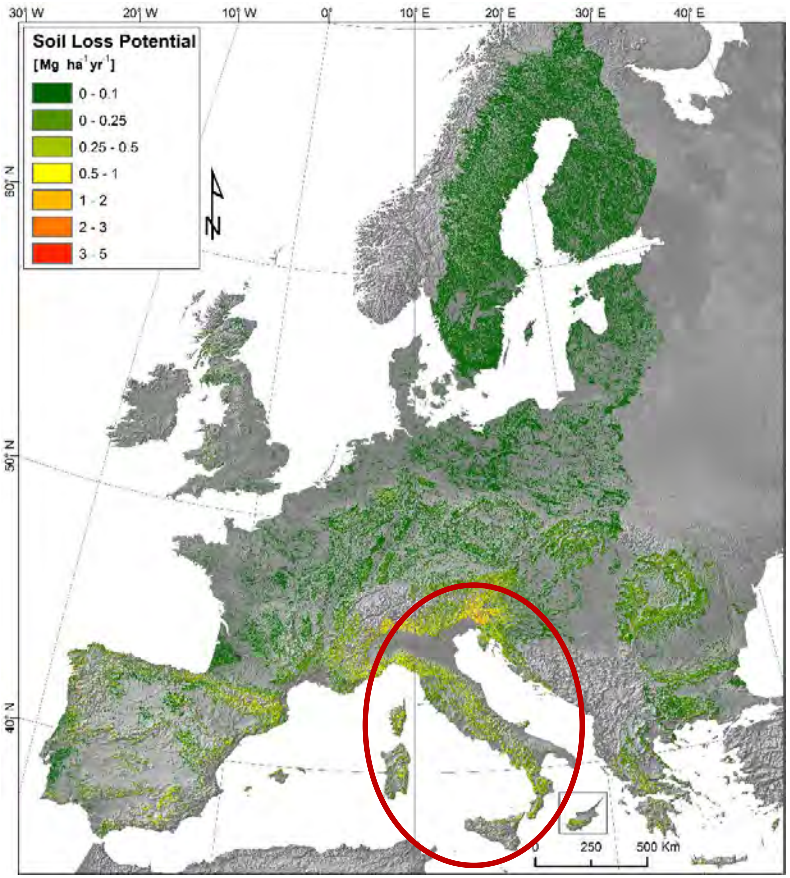
d) SOC accumulation due to **GAEC** application.

Borelli et al (2016) – Land Use Policy

Soil erosion in forestland: Europe

European Commission





Soil loss rates (30-year average)

- Undisturbed forest: 0.09 Mg^{-1} ha^{-1} yr^{-1}
- Logged forest: 0.45 Mg^{-1} ha^{-1} yr^{-1}

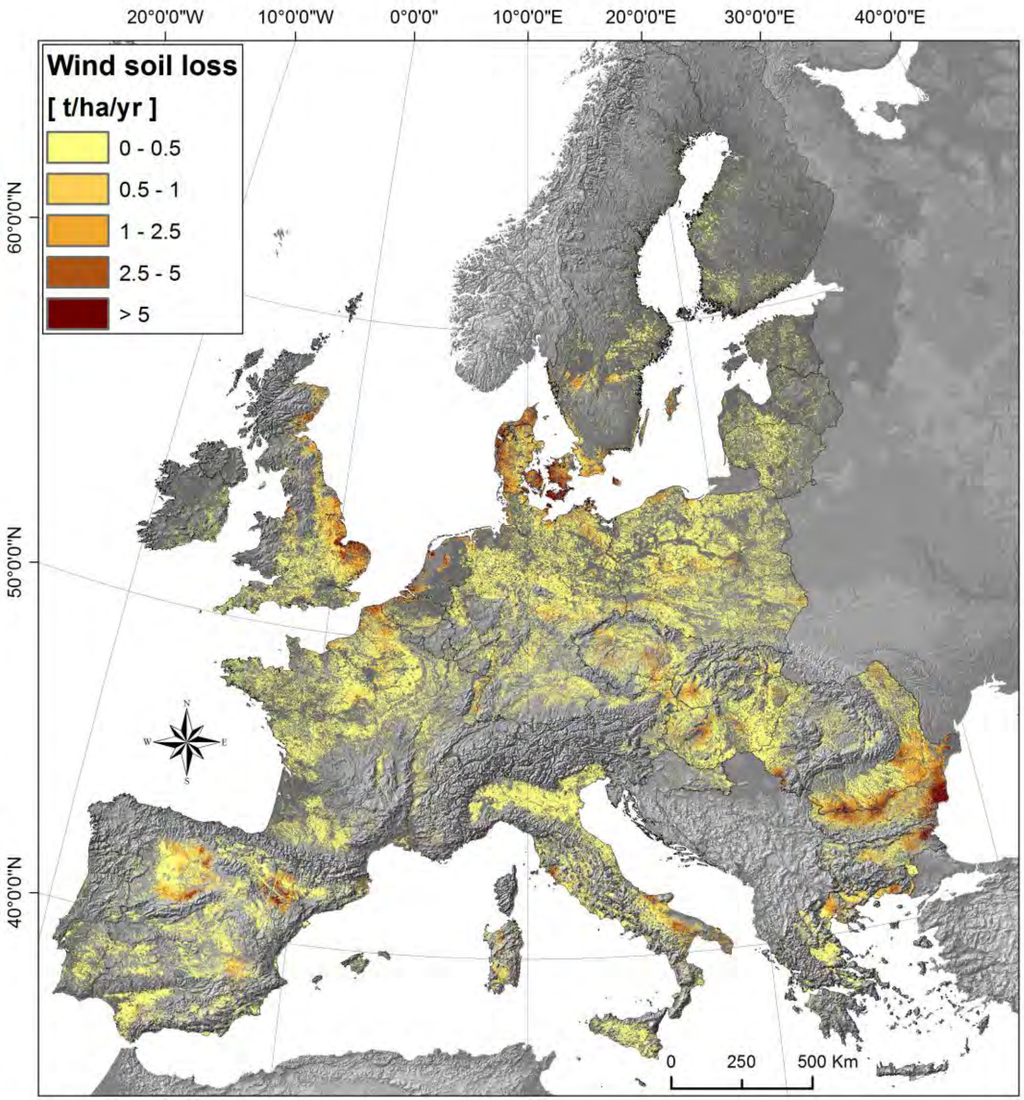
Undisturbed forest: 0.37 Mg^{-1} ha^{-1} yr^{-1}

Logged forest: 3.0 Mg^{-1} ha^{-1} yr^{-1}

Borrelli et al., 2016. Ecological Indicators 60, 1208–1220

Joint Research Centre

Wind Erosion



The first quantitative assessment at European level.

Main Factors influencing wind erosion:

Climate: wind velocity & direction, Rainfall and evaporation

Soil characteristics: sand, silt, clay, $CaCO_3$, organic matter, water-retention capacity and soil moisture

Land use: land use type, percent of vegetation cover and landscape roughness

Model used: RWEQ

Average erosion is 0.6 t/ha/yr.

Borrelli et al (2014) - Journal of Land Degradation
Borrelli et al (2014) - Geoderma
Borelli et al (2015) – Sustainability

Information in peer review publications:

Science of the Total Environment 511 (2015) 801–814
Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv

Rainfall erosivity in Europe

Panos Panagos [a,*], Cristiano Ballabio [a], Pasquale Borrelli [a], Katrin Meusburger [b], Andreas Klik [c], Svetla Rousseva [d], Melita Perčec Tadić [e], Silas Michaelides [f], Michaela Hrabalíková [g], Preben Olsen [h], Juha Aalto [i], Mónika Lakatos [j], Anna Rymszewicz [k], Alexandru Dumitrescu [l], Santiago Beguería [m], Christine Alewell [b]

[a] European Commission, Joint Research Centre, Institute for Environment and Sustainability, Via E. Fermi 2749, I-21027 Ispra, VA, Italy
[b] Environmental Geosciences, University of Basel, Switzerland
[c] Institute of Hydraulics and Rural Water Management, University of Natural Resources and Life Sciences, Vienna, Austria
[d] Institute of Soil Science, Agrotechnology and Plant Protection Sofia, Bulgaria
[e] Meteorological and Hydrological Service, Zagreb, Croatia
[f] Department of Meteorology, Nicosia, Cyprus
[g] Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Czech Republic
[h] Department of Agroecology, Aarhus University, Denmark
[i] Finnish Meteorological Institute, Finland
[j] Hungarian Meteorological Service, Budapest, Hungary
[k] UCD Dooge Centre for Water Resources Research, University College Dublin, Ireland
[l] National Meteorological Administration, Bucharest, Romania
[m] Estación Experimental de Aula Dei-Consejo Superior de Investigaciones Científicas (EEAD-CSIC), Zaragoza, Spain

Science of the Total Environment 479–480 (2014) 189–200
Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv

Soil erodibility in Europe: A high-resolution dataset based on LUCAS

Panos Panagos [a,*], Katrin Meusburger [b], Cristiano Ballabio [a], Pasqualle Borrelli [a], Christine Alewell [b]

[a] European Commission, Joint Research Centre, Institute for Environment and Sustainability, Via E. Fermi 2749, I-21027 Ispra, VA, Italy
[b] Environmental Geosciences, University of Basel, Bernoullistrasse 30, 4056 Basel, Switzerland

Soil Science and Plant Nutrition (2014), 60, 15–29 http://dx.doi.org/10.1080/003807

ORIGINAL ARTICLE

Assessing soil erosion in Europe based on data coll European network

Panos PANAGOS[1], Katrin MEUSBURGER[2], Marc VAN LIEDE ALEWELL[2], Roland HIEDERER[1] and Luca MONTANARELLA

[1]European Commission, Joint Research Centre, Institute for Environment and Sustainability, Via E. Italy, [2]Environmental Geosciences, University of Basel, Bernoullistrasse 30, 4056 Basel, Switzerlan

Ecological Indicators 60 (2016) 1208–1220
Contents lists available at ScienceDirect
Ecological Indicators
journal homepage: www.elsevier.com/locate/ecolind

Assessment of the cover changes and the soil loss potential in European forestland: First approach to derive indicators to capture the ecological impacts on soil-related forest ecosystems

Land Use Policy 48 (2015) 38–50
Contents lists available at ScienceDirect
Land Use Policy
journal homepage: www.elsevier.com/locate/landusepol

Estimating the soil erosion cover-management factor at the European scale

, Pasquale Borrelli [a], Katrin Meusburger [b], Christine Alewell [b], to [a], Luca Montanarella [a]

int Research Centre, Institute for Environment and Sustainability, Via E. Fermi 2749, I-21027 Ispra, VA, Italy
ces, University of Basel, Switzerland

Observation and Geoinformation 27 (2014) 147–155
available at ScienceDirect
Applied Earth Observation and Geoinformation
journal homepage: www.elsevier.com/lo

of soil erosion at regional scale: e focusing on agricultural land u

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, Institute for Environment and Sustainability, via E. Fermi 2749, Ispra
Forestry and Natural Environment, Lab of Forest Management and Re

Environmental Science & Policy 54 (2015) 438–447
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]

[a] European Commission, Joint Research Centre, Institute for Environment and Sustainability, Via E. Fermi 2749, I-21027, Ispra (VA), Italy
[b] Environmental Geosciences, University of Basel, Switzerland
[c] Division of Geography, KU Leuven, Belgium

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A New European Slope Length and Steepness Factor (LS-Factor) for Modeling Soil Erosion by Water

Panos Panagos [1,*], Pasquale Borrelli [1,†] and Katrin Meusburger [2,†]

European Soil Data Centre:
http://esdac.jrc.ec.europa.eu/

Panos.panagos@jrc.ec.europa.eu