



Advances in soil erosion modelling and monitoring in Europe

Prof. Dr. Pasquale Borrelli

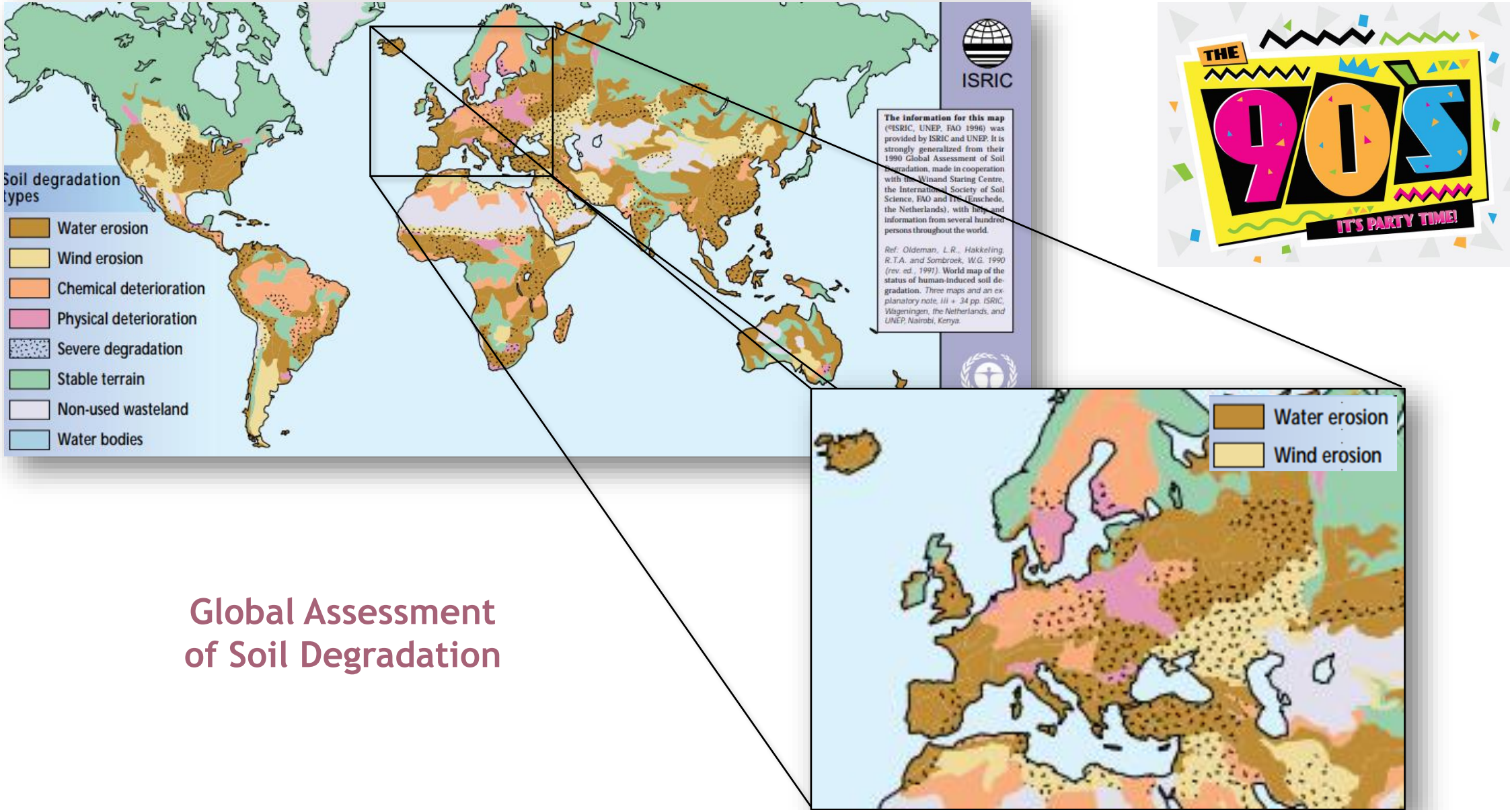


Image © 2024 Maxar Technologies

Google Earth

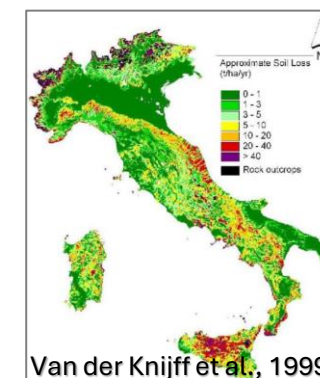
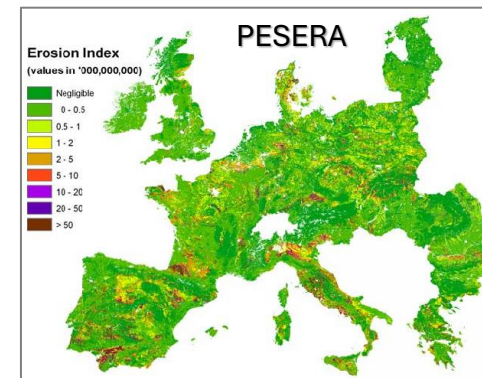
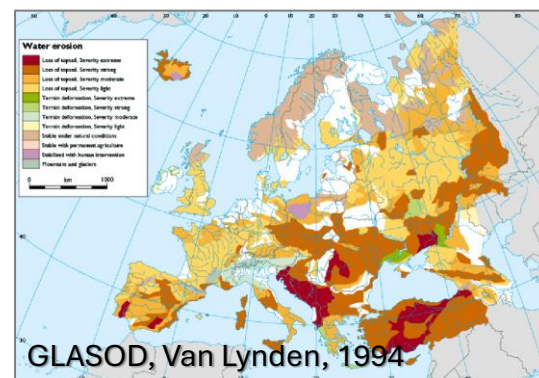
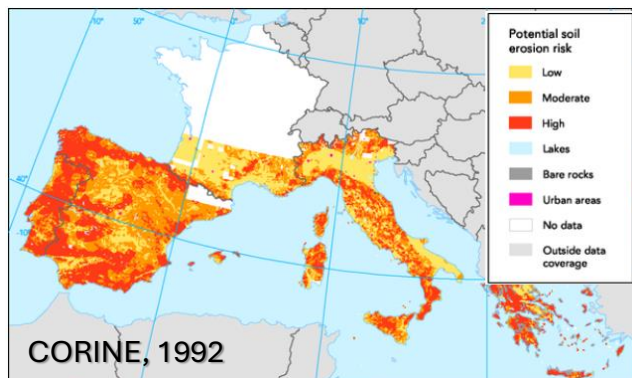






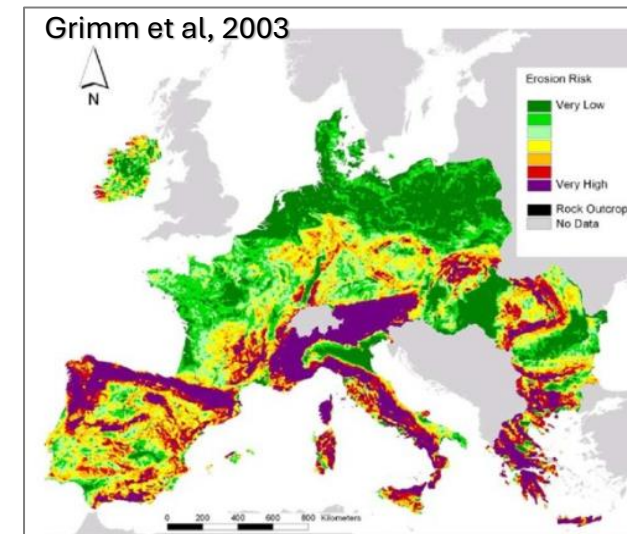
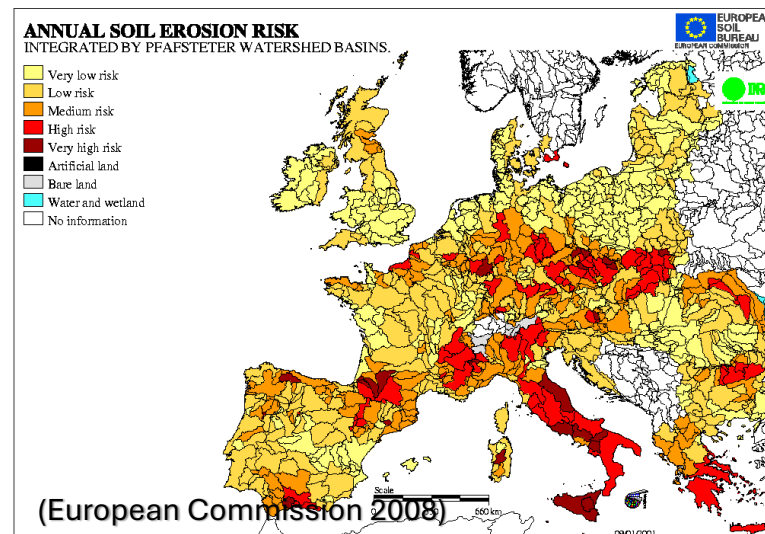
Global Assessment
of Soil Degradation

The recent report 'The implementation of the Soil Thematic Strategy and on-going activities' (Jones et al., 2012) stated that **20% of Europe's land** surface is subject to erosion rates above **10 t ha⁻¹ yr⁻¹**



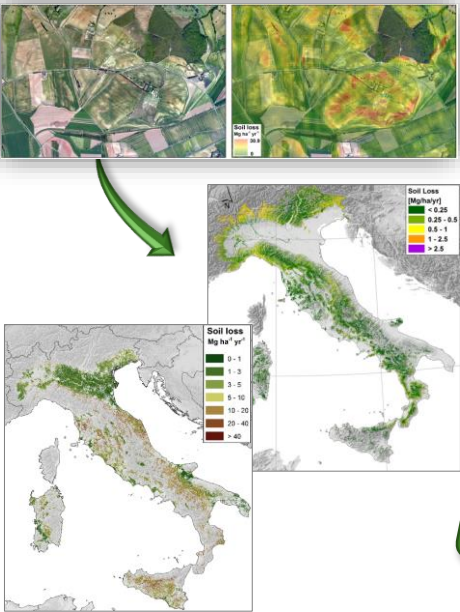
Limitations

- Spatial resolution
- Static land uses
- Crop systems
- Conservation practices (CAP)
- Remote sensing data

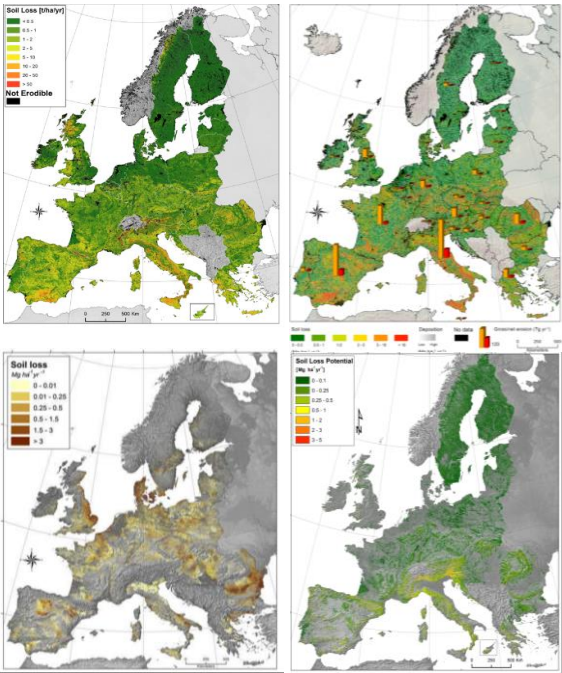




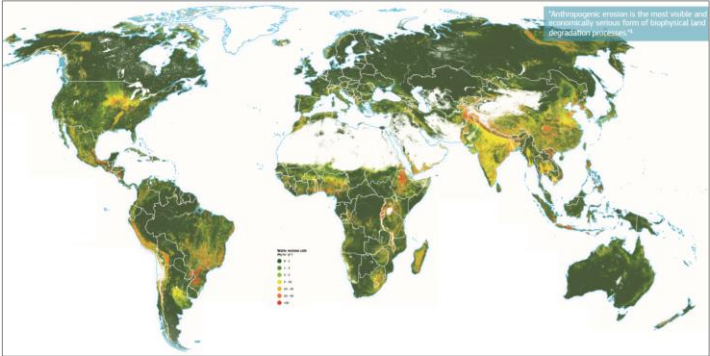
Watershed scale

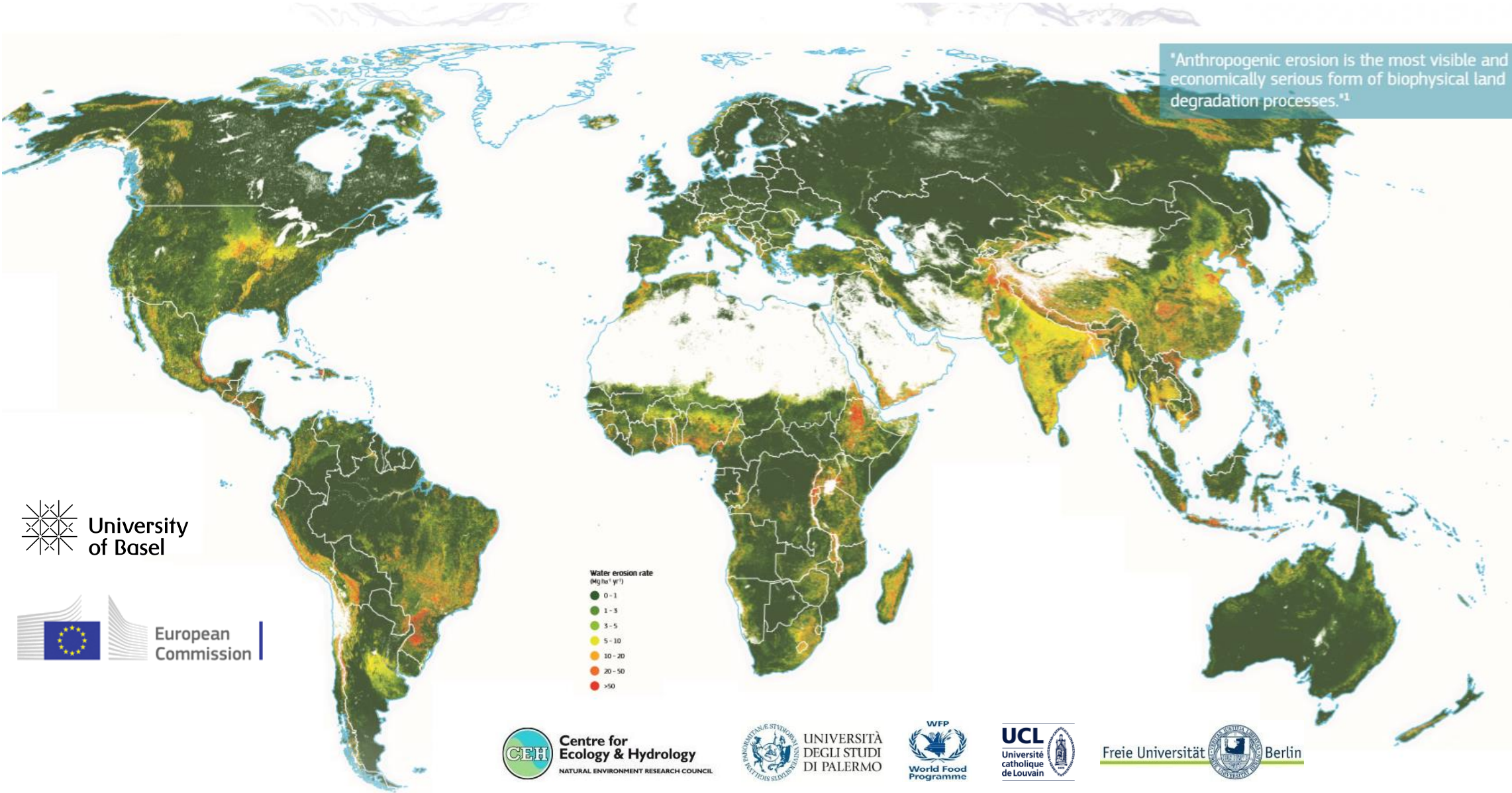


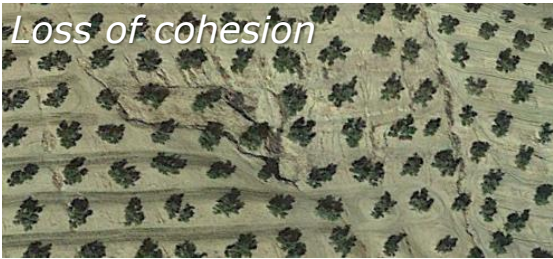
Pan-European



Global Modelling







nature COMMUNICATIONS

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

Pasquale Borrelli^{1,2}, David A. Robinson³, Larissa R. Fleischer⁴, Emanuele Lugato^{5,6}, Cristiano Ballabio⁷, Christine Alewell⁸, Katrin Meusburger⁹, Sirio Modugno⁵, Brigitta Schütt⁴, Vito Ferro⁷, Vincenzo Bagarello⁸, Kristof Van Oost⁹, Luca Montanarella² & Panos Panagos²

nature COMMUNICATIONS

Global phosphorus shortage will be aggravated by soil erosion

Christine Alewell¹¹⁸, Bruno Ringeval², Cristiano Ballabio³, David A. Robinson⁴, Panos Panagos³ & Pasquale Borrelli¹⁵

ARTICLE nature

Mapping the world's free-flowing rivers

G. Grill^{1,4}, B. Lehner^{1,4}, M. Thieme¹, B. Gemen¹, D. Tickner⁴, F. Antonelli¹, S. Babu⁵, P. Borrelli^{7,8}, L. Cheng², H. Crochetiere¹⁰, H. Ehalt Macedo⁹, R. Filgueiras^{11,12}, M. Goichot¹², J. Higgins¹³, Z. Hogan¹⁴, B. Lip¹⁵, M. E. McClain^{16,17}, J. Meng^{18,19}, M. Mulligan²⁰, C. Nilsson^{21,22}, J. D. Olden²³, J. I. Opperman²⁴, P. Petry^{25,26}, C. Reidy Liermann²⁷, L. Sáenz^{28,29}, S. Salinas-Rodriguez³⁰, P. Schelle³¹, R. J. P. Schmitt³², J. Snider³³, F. Tan³⁴, K. Tockner^{35,36}, P. H. Valdujo³⁷, A. van Soestbergen³⁸ & C. Zarfi³⁹

Global Change Biology

PRIMARY RESEARCH ARTICLE

Global forest restoration opportunities to foster coral reef conservation

Andrés F. Suárez-Castro[✉], Hawthorne L. Beyer, Caitlin D. Kuempel, Simon Linke, Pasquale Borrelli, Ove Hoegh-Guldberg

PNAS Proceedings of the National Academy of Sciences of the United States of America

Land use and climate change impacts on global soil erosion by water (2015-2070)

Pasquale Borrelli^{1,4,11}, David A. Robinson⁵, Panos Panagos⁶, Jae E. Yang⁷, Christine Alewell⁸, David Wuepper⁹, Luca Montanarella², and Cristiano Ballabio⁴

Conservation Biology

CONTRIBUTED PAPERS | Open Access | CC BY

Retaining natural vegetation to safeguard biodiversity and humanity

Jeremy S. Simmonds[✉], Andres Felipe Suarez-Castro, April E. Reside, James E. M. Watson, James R. Allan, Scott C. Atkinson, Pasquale Borrelli, Nigel Dudley, Stephen Edwards, Richard A. Fuller ... See all authors

Up to data, 19 studies based on GloSEM

nature sustainability ANALYSIS

Countries and the global rate of soil erosion

David Wuepper^{1,4}, Pasquale Borrelli² and Robert Finger¹

nature communications Article

Projected landscape-scale repercussions of global action for climate and biodiversity protection

Received: 10 March 2023 Accepted: 13 April 2023 Published online: 16 May 2023

Patrick José von Jeetee^{1,2}, Isabelle Weindl³, Justin Andrew Johnson⁴, Pasquale Borrelli^{5,6}, Panos Panagos⁶, Edna J. Molina Bacca^{7,8}, Kristine Karstens^{1,2}, Florian Humenöder⁹, Jan Philipp Dietrich¹, Sara Minoli¹, Christoph Müller¹, Hermann Lotze-Campen^{1,2} & Alexander Popp¹

nature sustainability Analysis

Policy implications of multiple concurrent soil erosion processes in European farmland

Received: 4 May 2022 Accepted: 27 September 2022 Published online: 27 October 2022

Pasquale Borrelli^{1,12}, Panos Panagos³, Christine Alewell⁴, Cristiano Ballabio⁵, Hugo de Oliveira Fagundes⁶, Nigussie Haregeweyn⁷, Emanuele Lugato⁸, Michael Maerker⁹, Jean Poesen^{10,11}, Matthias Vanmaercke¹² and David A. Robinson¹⁰

Global Change Biology

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A 'debt' based approach to land degradation as an indicator of global change

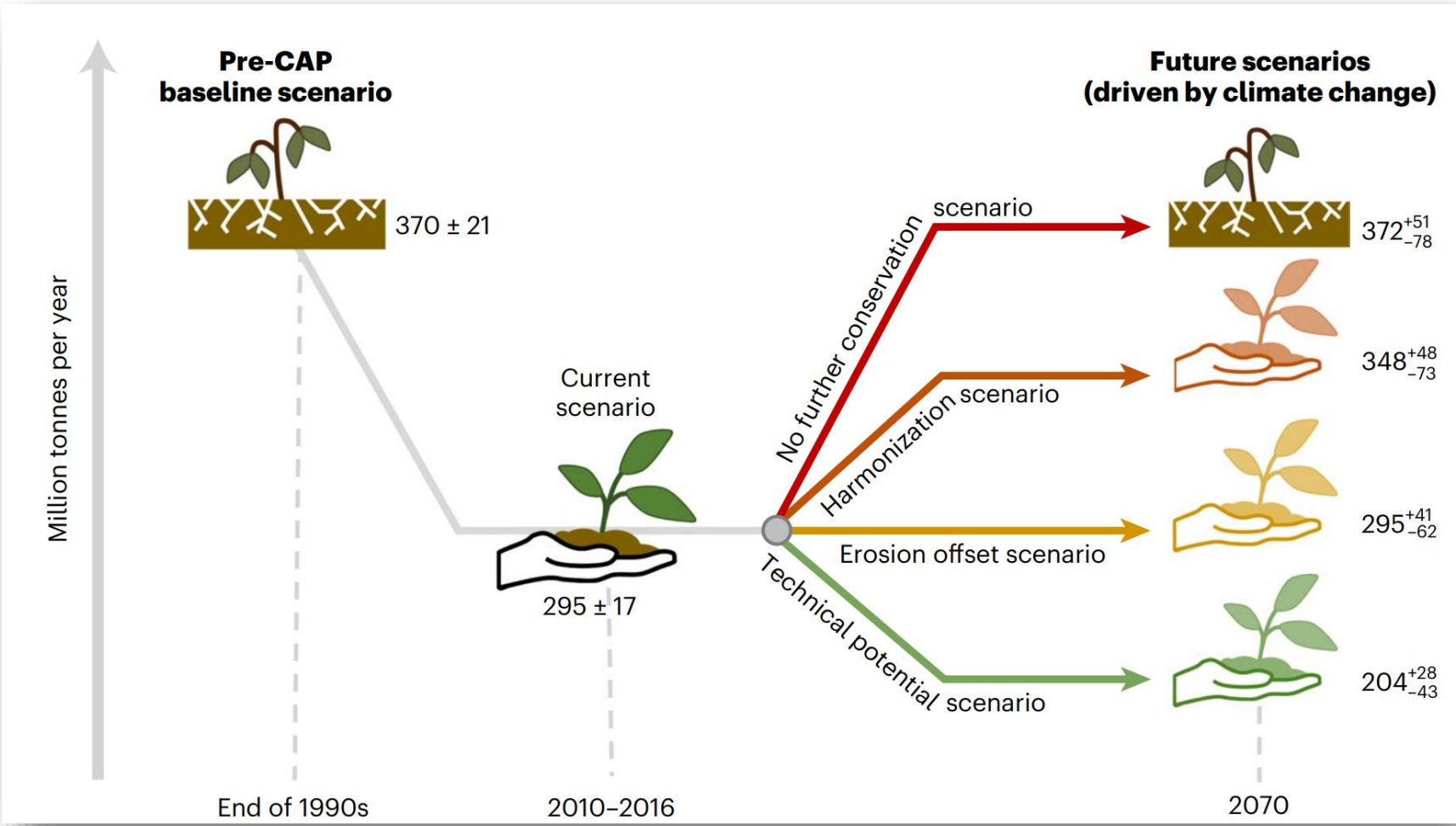
David Wuepper[✉], Pasquale Borrelli, Panos Panagos, Thomas Lauber, Thomas Crowther, Amy Thomas, David A. Robinson



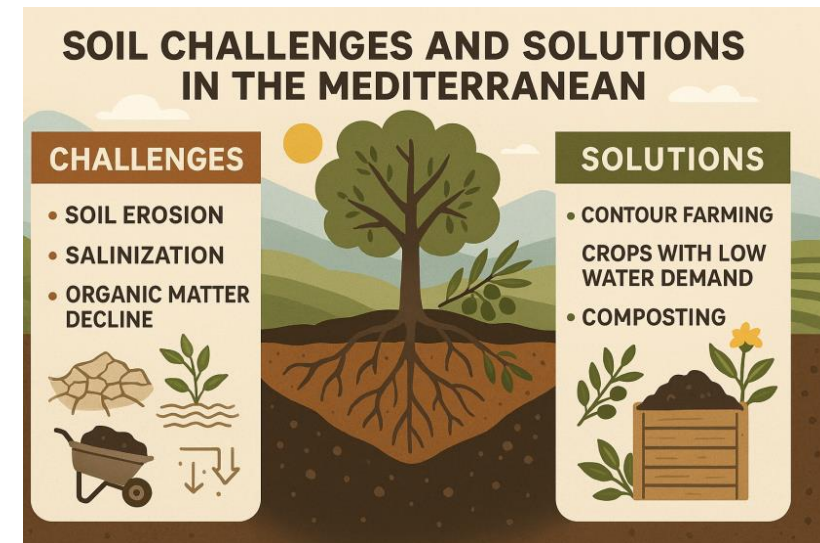


The modelling approach suggests that compared to the pre-CAP, if we assume no implementation of soil conservation measurements, the EU policy could phonetically reduce soil displacement of a computed:

- ✖ -20% water erosion
 - -75 Tg yr⁻¹
- ✖ -27% tillage erosion
 - -55 Tg yr⁻¹
- ✖ -9% wind erosion
 - -5.3 Tg yr⁻¹



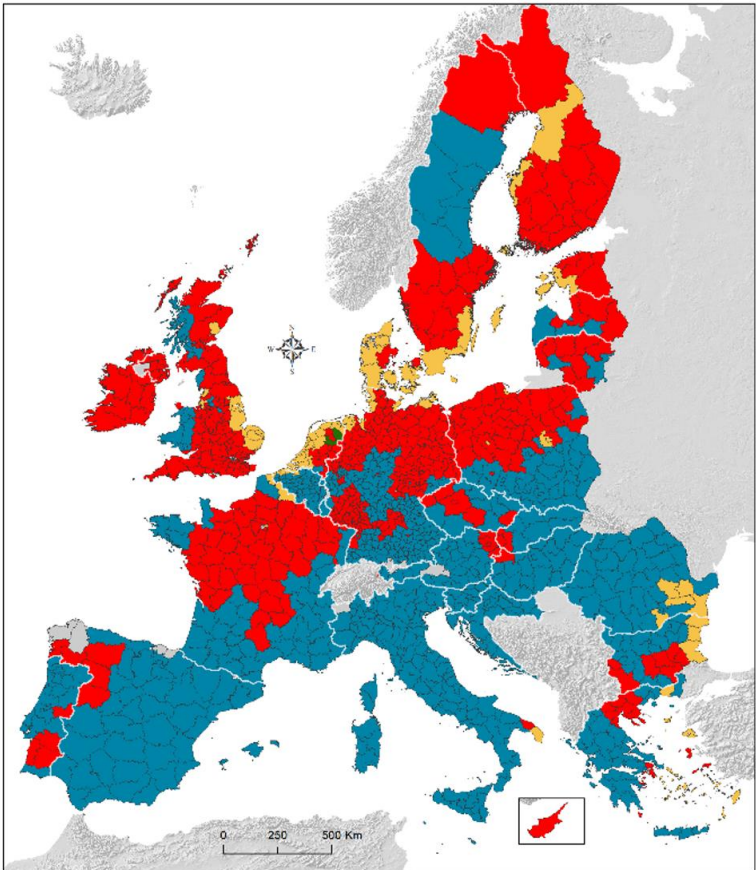
Joint research activities promoted by the EU Soil Observatory (EUSO)–Soil Erosion Working Group



This is what we need to **investigate** through *ad hoc* research questions and activities.

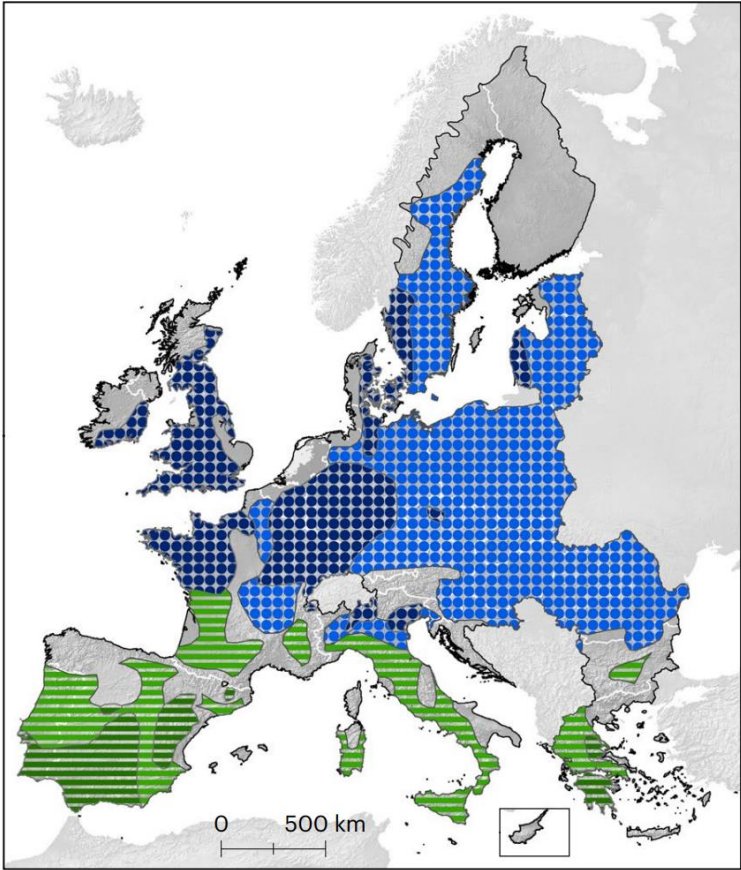


We can gather knowledge, but there is still more work to be done.



Dominant soil loss process (by cell)

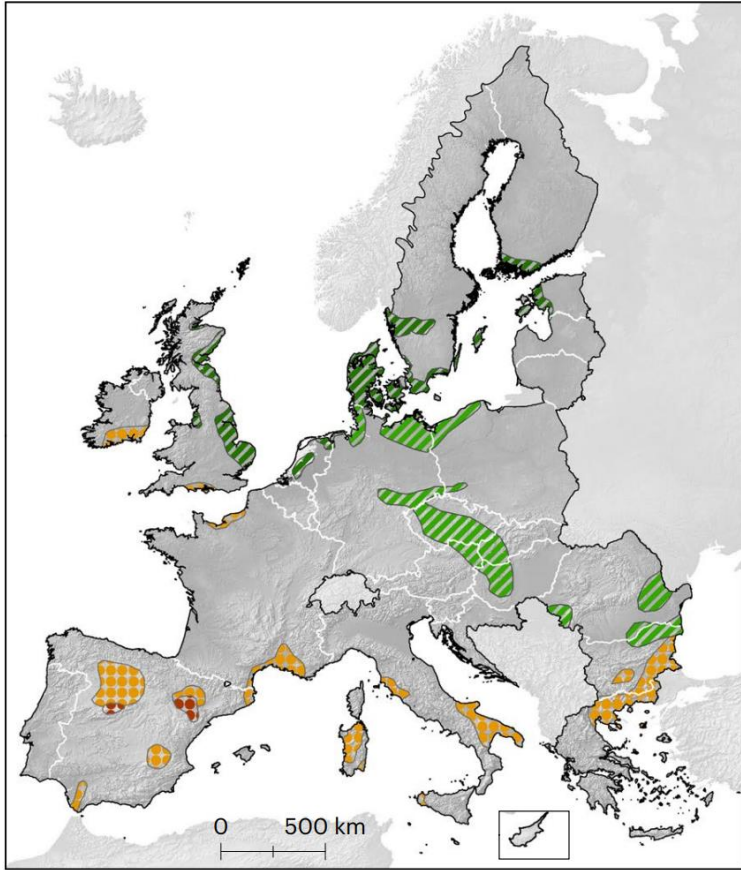
No data Water Wind Tillage SLCH



Future water erosion vulnerability (WaEV)

Wettest quarter
● WaEV (increasing rain)
○ WaEV (decreasing drought)
■ WaEV (decreasing rain)
□ WaEV (increasing drought)

Driest quarter
● WaEV (increasing rain)
○ WaEV (decreasing drought)
■ WaEV (decreasing rain)
□ WaEV (increasing drought)



Future wind erosion vulnerability (WiEV)

Wettest quarter
● WiEV (decreasing rain)
○ WiEV (increasing drought)
■ WiEV (increasing rain)
□ WiEV (decreasing drought)

Driest quarter
● WiEV (decreasing rain)
○ WiEV (increasing drought)
■ WiEV (increasing rain)
□ WiEV (decreasing drought)

Joint research activities promoted by the EU Soil Observatory (EUSO)–Soil Erosion Working Group



EUROPEAN UNION



EU MISSIONS

SOIL DEAL FOR EUROPE



AI 4 Soil
Health



Soil Health
BENCHMARKS



TERRASAFE
Cultivating resilience, restoring the earth.



MONALISA

Nemesis LLs

European
Network of
Living Labs

A new 12 million erosion
project led by WUR

scientific data

nature
portfolio

Check for updates

OPEN

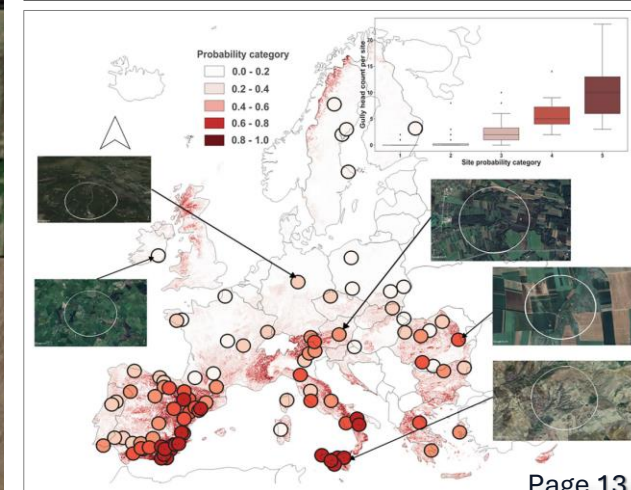
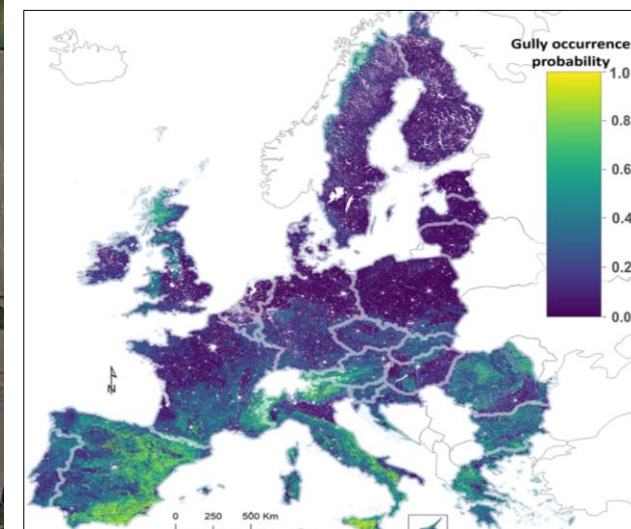
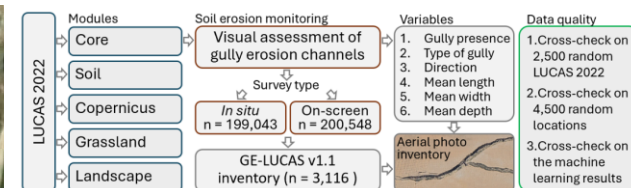
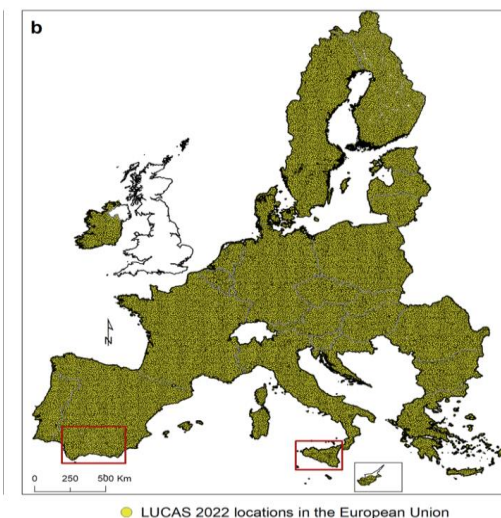
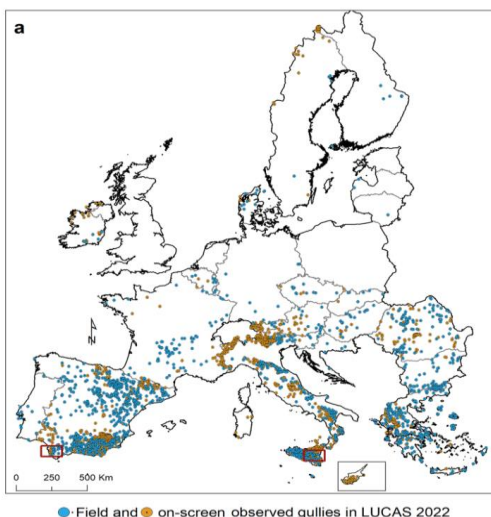
DATA DESCRIPTOR

A hybrid *in situ* and on-screen survey to monitor gully erosion across the European Union

Pasquale Borrelli^{1,2}, Francis Matthews¹, Christine Alewell², Konstantinos Kaffas¹, Jean Poesen^{3,4}, Philipp Saggau¹, Remus Prăvălie^{5,6,7}, Matthias Vanmaercke³ & Panos Panagos^{1,8}

GE-LUCAS v1.1 2022

(200,000 *in situ* + 200,000 onscreen sites)



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Comment

nature sustainability

<https://doi.org/10.1038/s41893-025-01628-3>

Unsustainably losing ground

Pasquale Borrelli, Francis Matthews, Philipp Saggau, Antonio J. Manzaneda, Panos Panagos, Konstantinos Kaffas & Christine Alewell

 Check for updates

Mediterranean olive groves, which have long been symbols of tradition and culinary

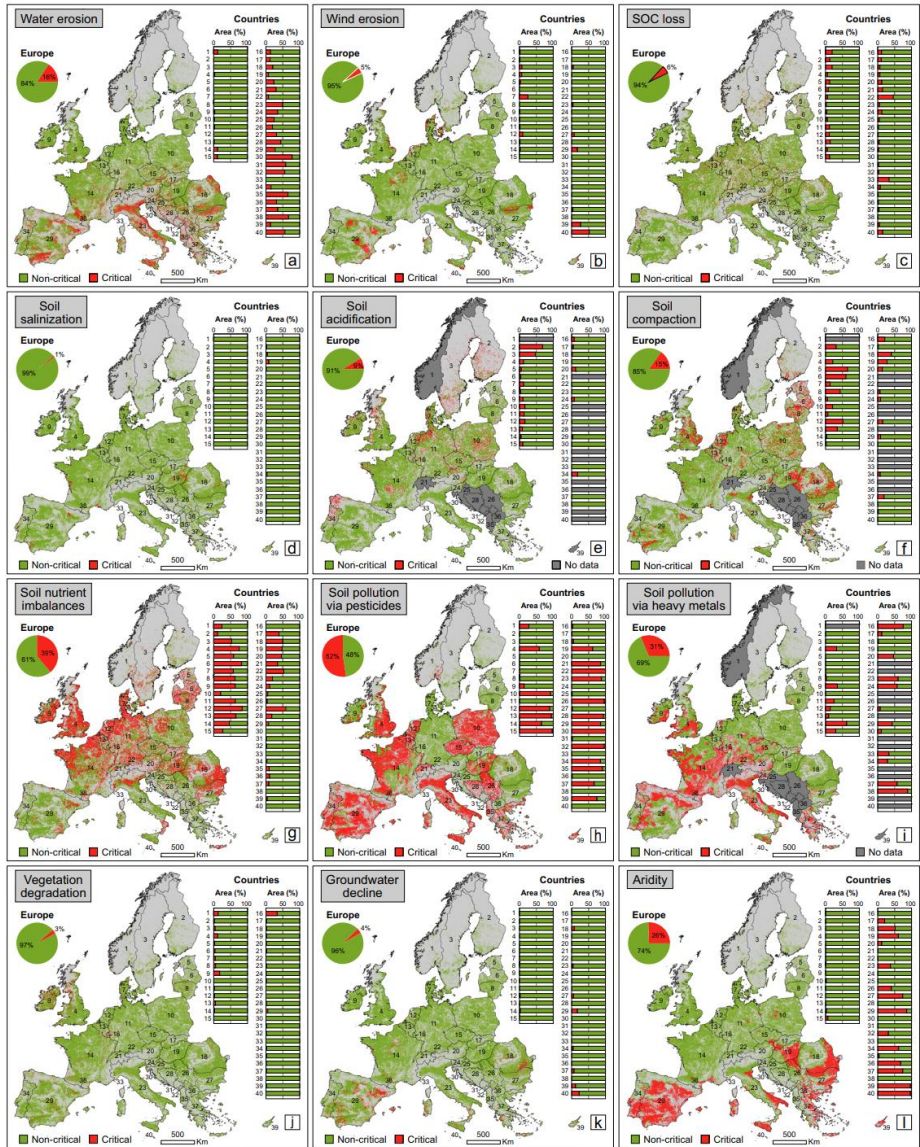
impacts of EU olive production and its derivatives, such as olive oil, serve as a clear example of the complex interplay between policy choices, soil management, market dynamics and climate pressures.



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We found that up to **27%**, **35%** and **22%** of continental agricultural (~2 million km²) lands are currently threatened by **one**, **two**, and **three** drivers of degradation.

nature communications



Article

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

A unifying modelling of multiple land degradation pathways in Europe

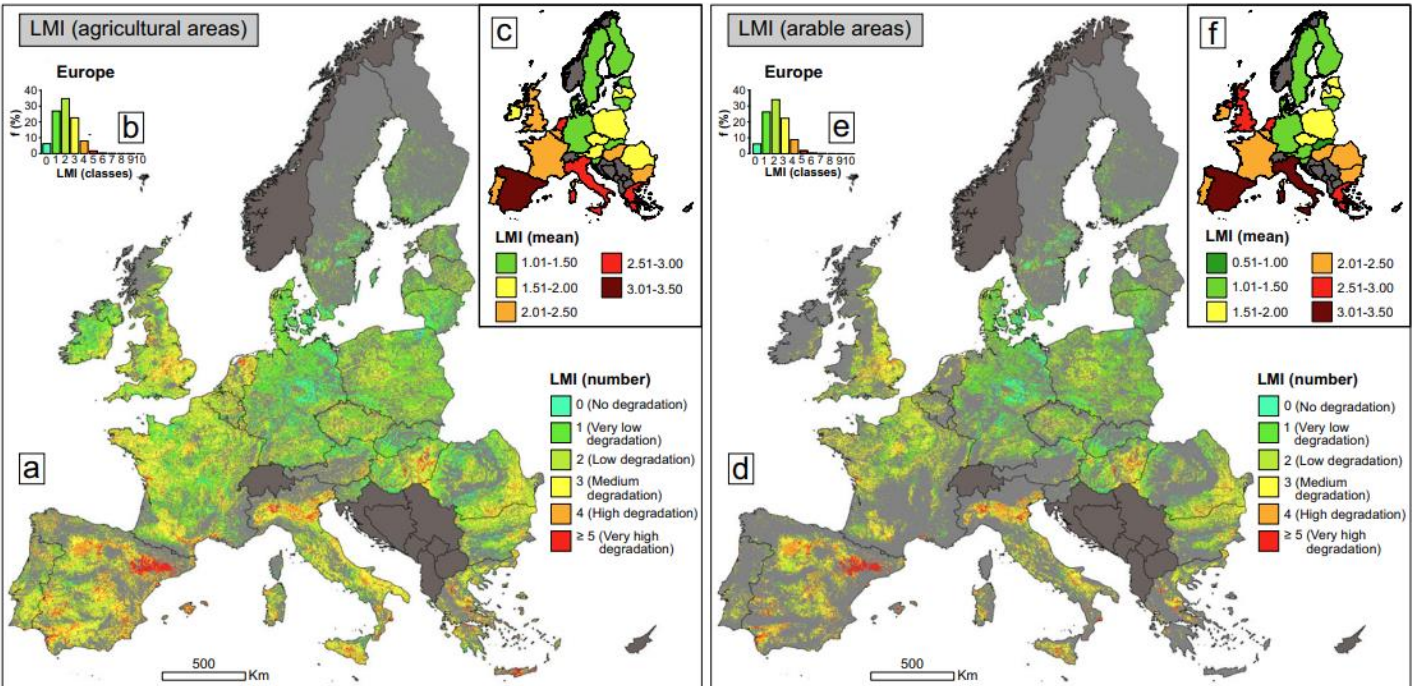
Received: 1 April 2023

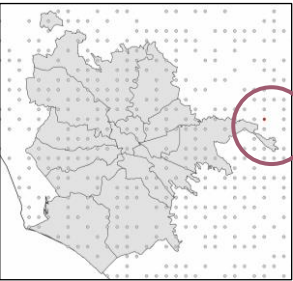
Accepted: 23 April 2024

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 Dumitrascu¹³, Georgeta Bandoc^{1,3}, Ion-Andrei Nita¹⁴ & Marius-Victor Birsan¹³

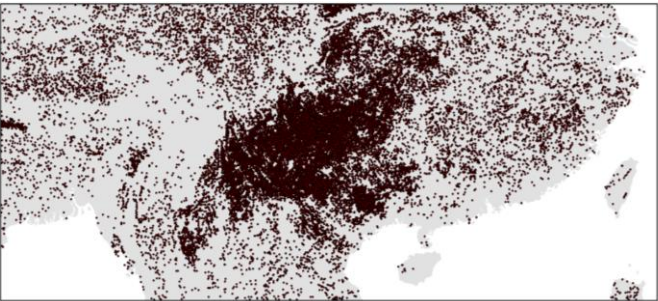
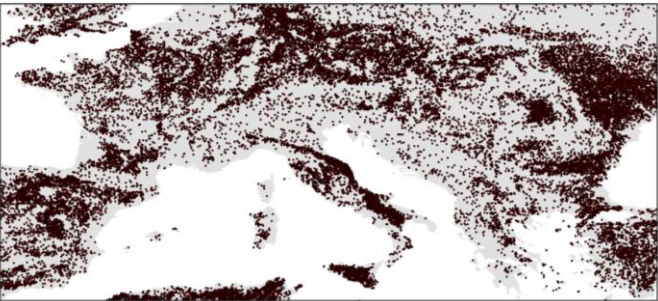
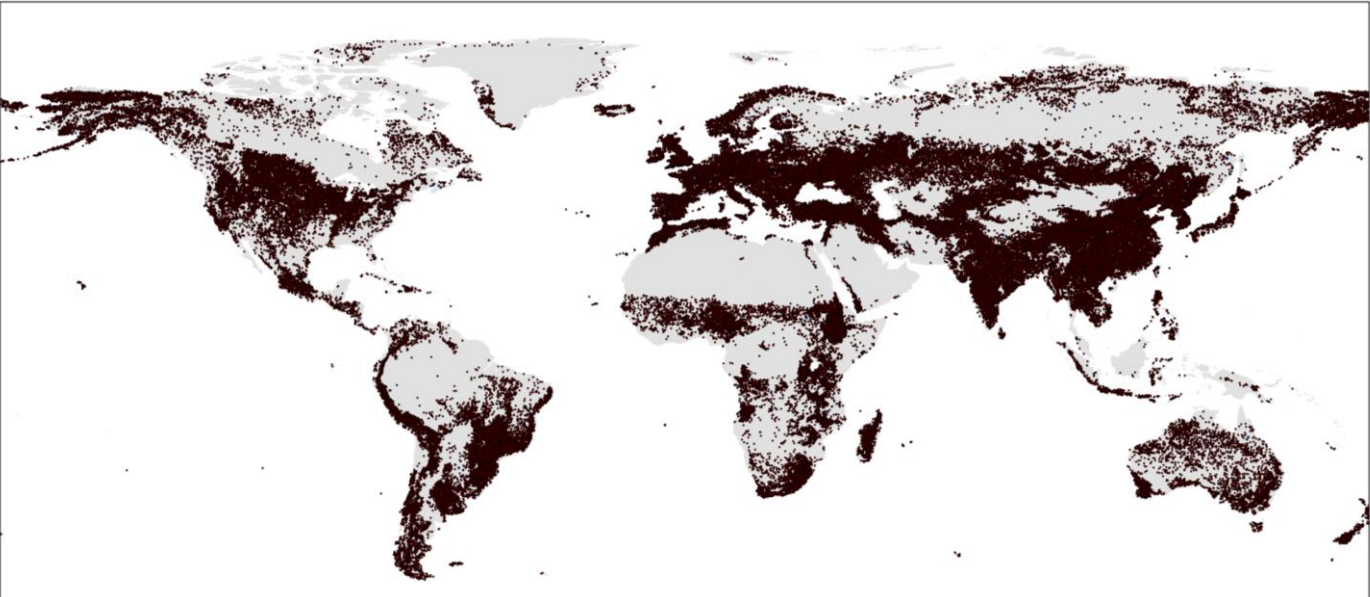
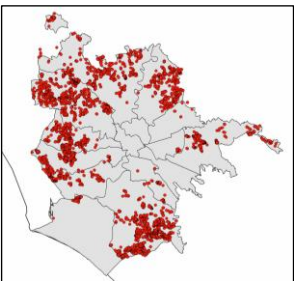




LUCAS = 1 gully

vs

Mapping = 3654 gullies



- ❑ Long-Term Research Initiative Overview
- ❑ We're starting a 2–5-year joint effort aiming at mapping 1,000,000 sites.
- ❑ Stage 1: Completion by December 2025
 - Target: **300,000 sites**
 - Mapping box: **~340x340m**
 - Outcomes: **2** peer-reviewed publications planned for early 2026

Soil sampling for radionuclides (^{137}Cs , ^{239}Pu , ^{240}Pu)



SOIL-O-LIVE

Cordoba, Spain – September 2023



Funded by the
European Union
NextGenerationEU



Planul Național
de Redresare și Reziliență

<https://euld.unibuc.ro/>

EUroLand

Complex modelling of multiple land degradation processes in Europe. Towards an integrative scientific framework for sustainable land management across the continent

Acknowledgements

This work was funded by the EU's NextGenerationEU instrument through the National Recovery and Resilience Plan of Romania – Pillar III-C9-2022-I8, managed by the Ministry of Research, Innovation and Digitalization, within the project entitled “Complex modelling of multiple land degradation processes in Europe. Towards an integrative scientific framework for sustainable land management across the continent”, contract no. 760051/23.05.2023, code CF 216/29.11.2022.