

# Bundles and indicators of Soil-based ecosystem services and soil threats from SERENA project

I. Cousin, C. Calzolari, F. Ungaro, A. Bispo  
and SERENA consortium (esp. J. Reyes Rojas)



**EJP SOIL**  
European Joint Programme

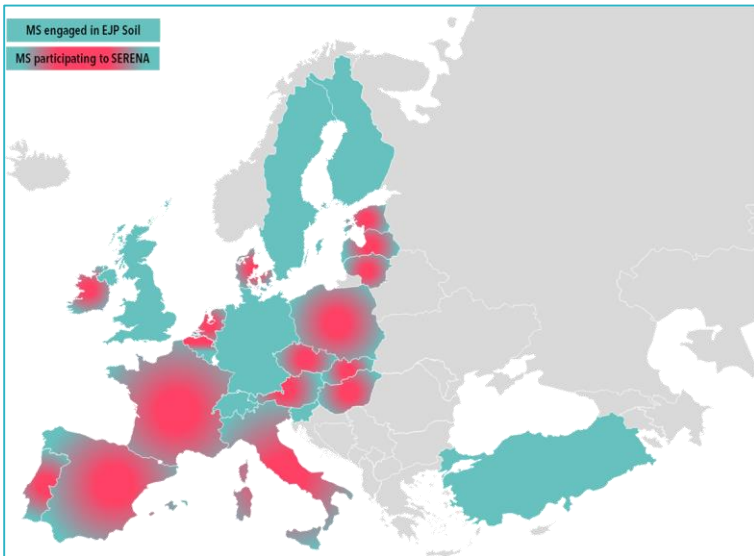
EJP SOIL has received  
funding from the European  
Union's Horizon 2020  
research and innovation  
programme: Grant  
agreement No 862695



# The EJP SOIL SERENA project, and some of its definitions

## SERENA

**S**oil **E**cosystem **s**er**v**ices and soil  
threats mod**e**lling a**n**d m**a**pping



## Some SERENA definitions

**Soil(-based) Ecosystem service:** Soil Ecosystem Services is the soil-related subset of ecosystem services, directly and quantifiably controlled or provided by soils and their chemical, physical and biological properties, processes and functions.

**Soil Threat:** Soil threats are processes that could degrade (some of) the functions of soils and the services that soils provide

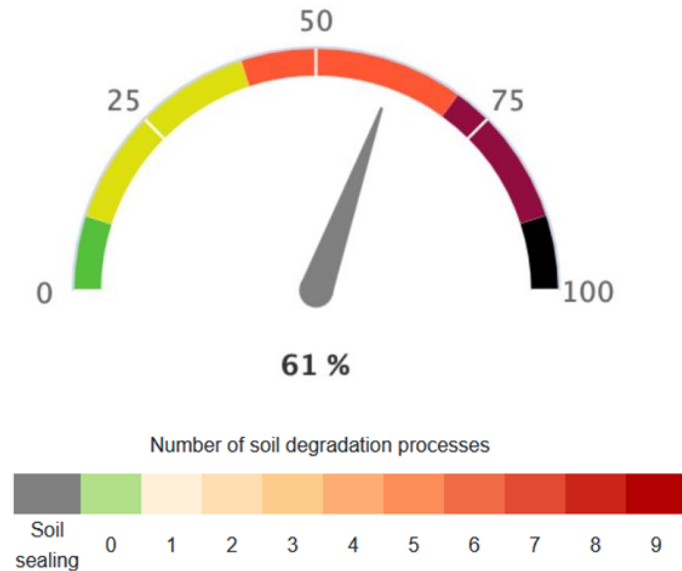
**Bundle:** a set of ecosystem services, soil threats, or the combination of the two, that appear together repeatedly in time or space, as related to a specific context.

# Why analysing bundles of soil threats and soil-based ecosystem services ?

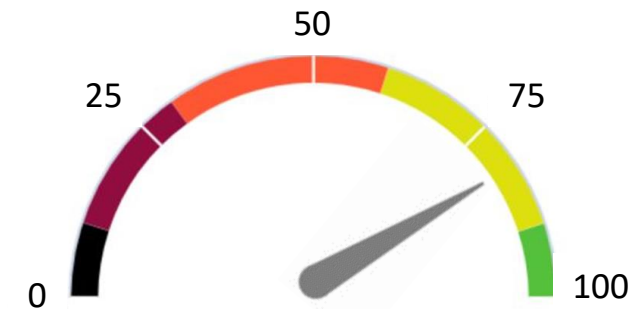
## Soil Health Law



Proportion of land affected by soil degradation in the EU



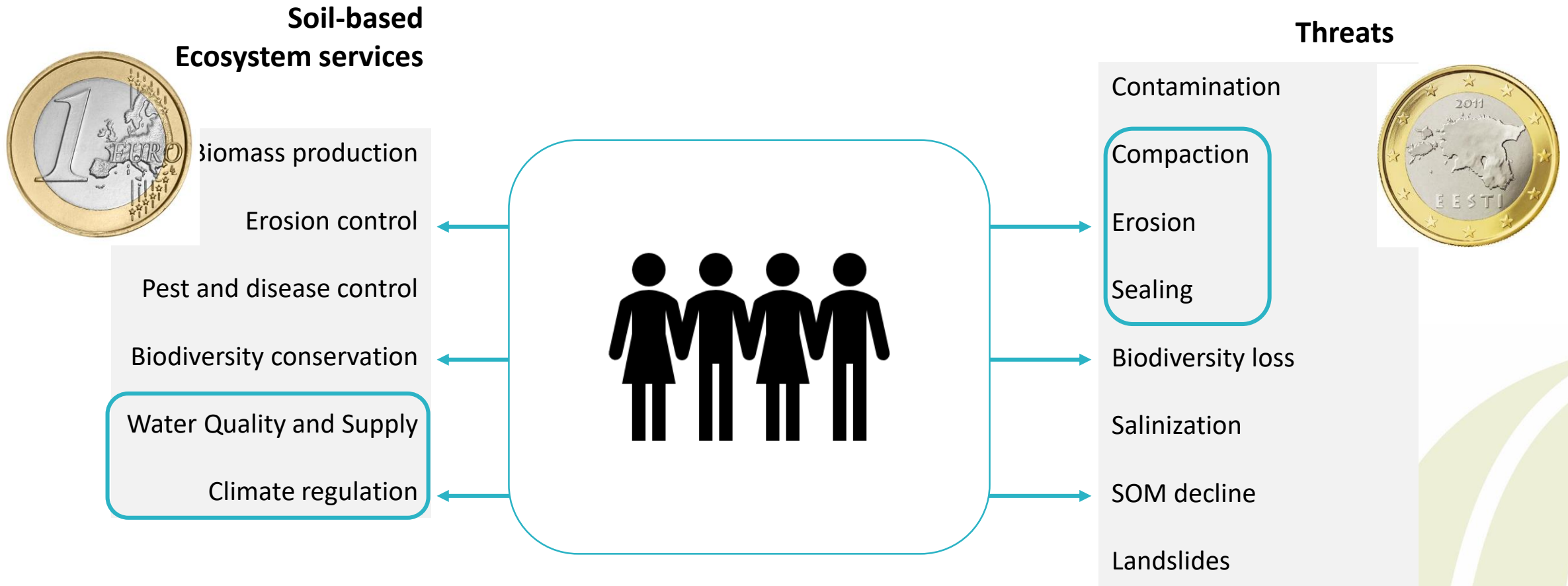
Proportion of healthy soils providing soil-based ecosystem services to enhance land capacities



? Sum of level of ecosystem services ?

└─> Land specialisation ?

# The 3 pillars of the SERENA philosophy



*We do want to deal with threats and SES bundles*

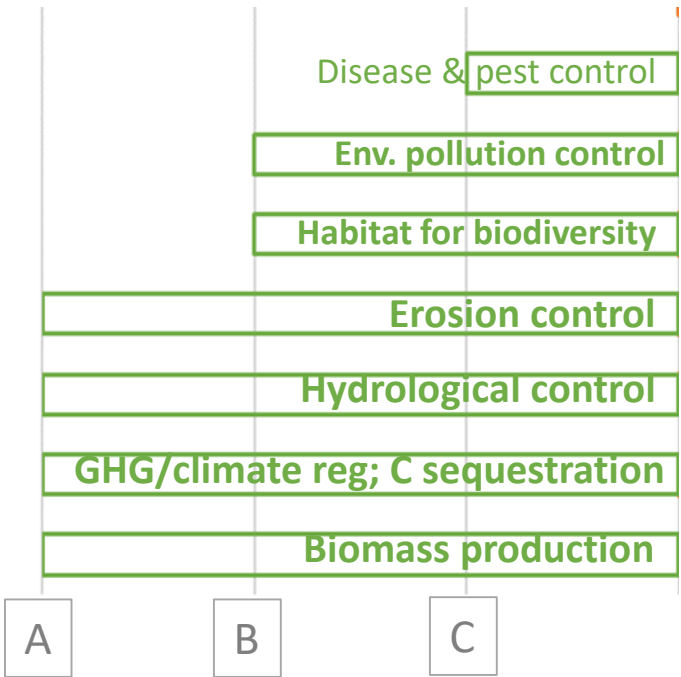
*Stakeholders are at the core of the project*

*Soil threats and SES may be the 2 sides of a same coin*

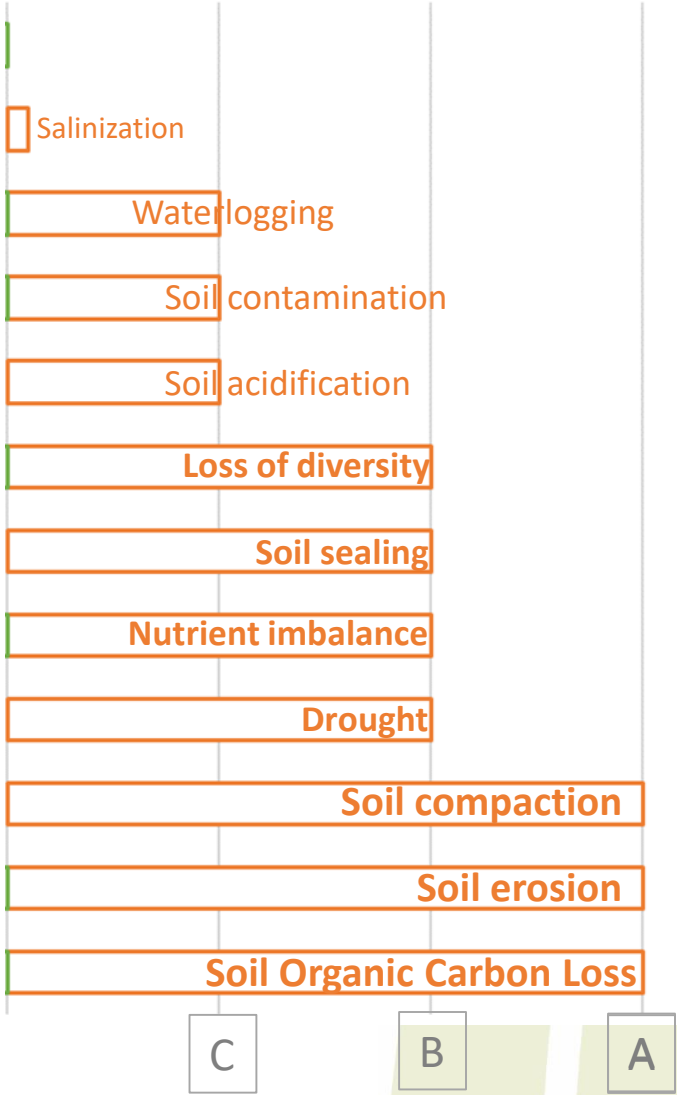
# Prioritization of **Soil-based Ecosystem Services** and **Soil Threats** in the SERENA consortium

A : « very important »  
 B : « important »  
 C : « less important »

## Soil-based Ecosystem Services

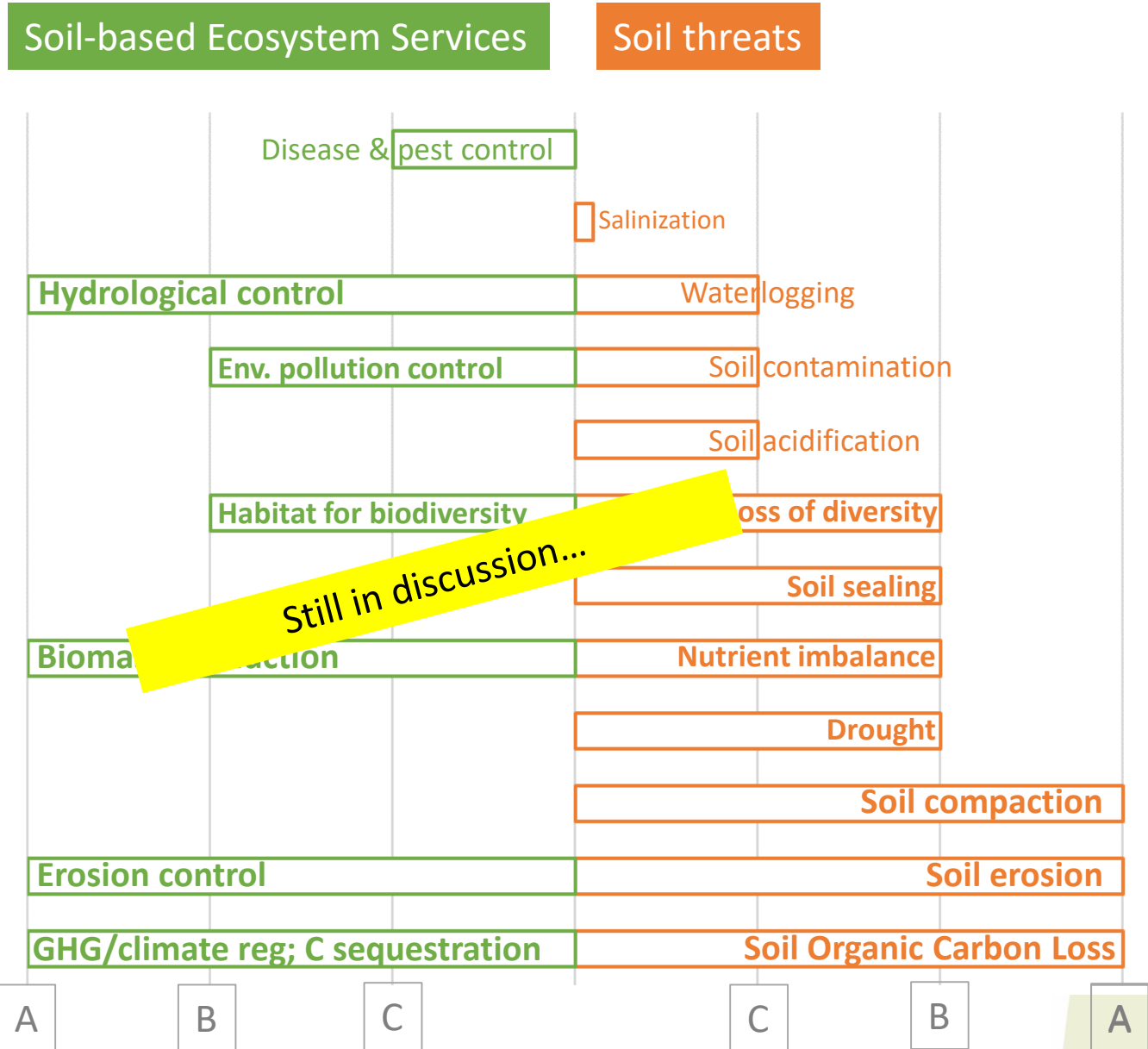


## Soil threats



# Prioritization of Soil-based Ecosystem Services and Soil Threats in the SERENA consortium

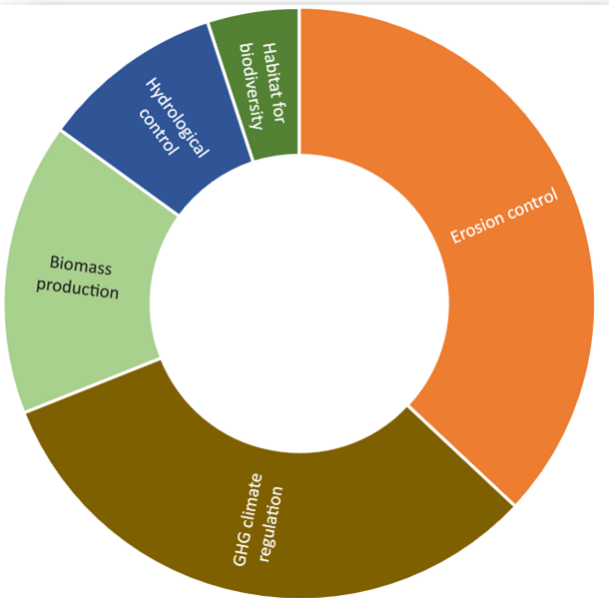
A : « very important »  
 B : « important »  
 C : « less important »



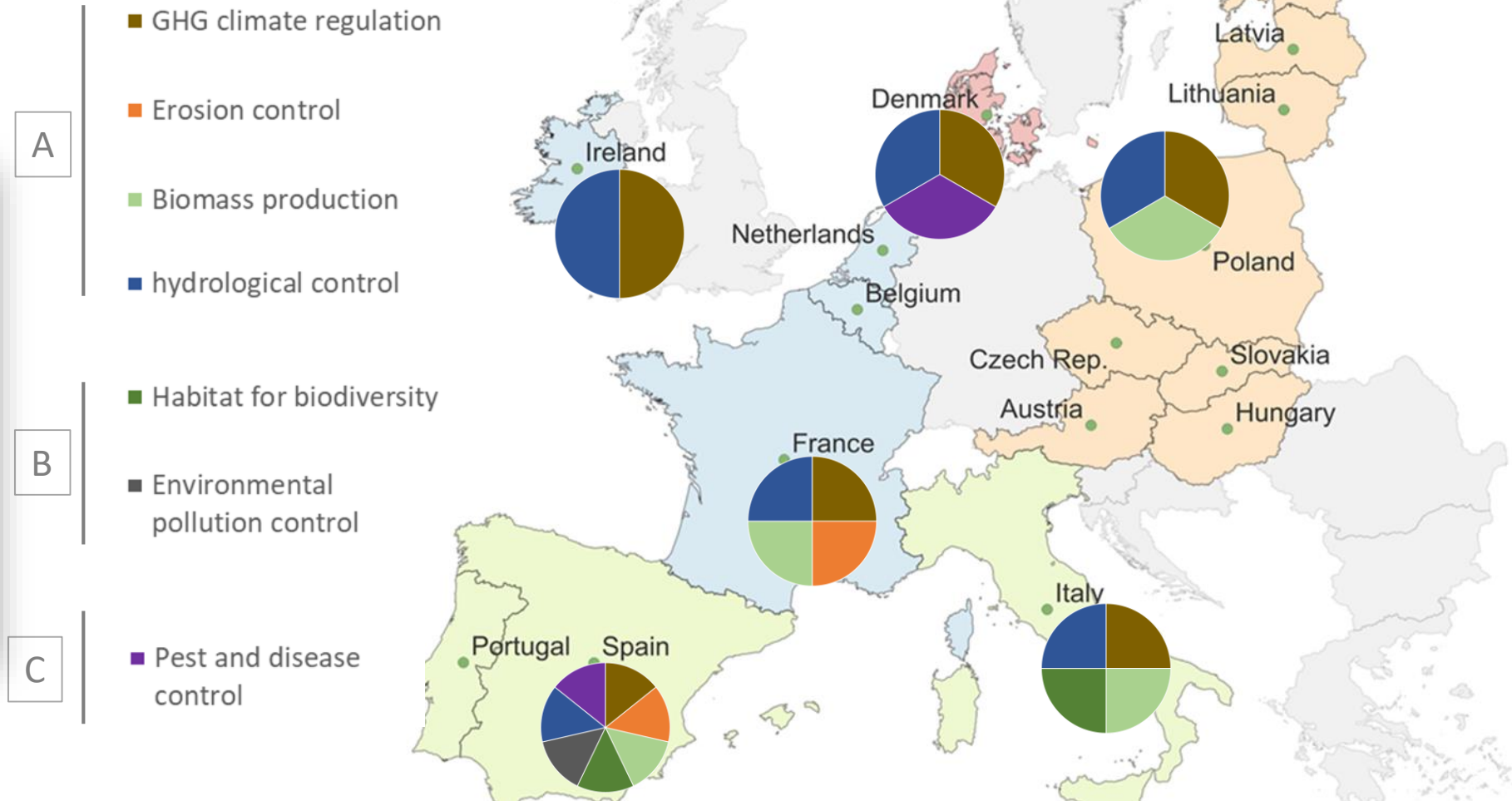


# Main Soil-based Ecosystem services

Proportion of literature studies dealing with **Soil-based Ecosystem Services** at the EU scale

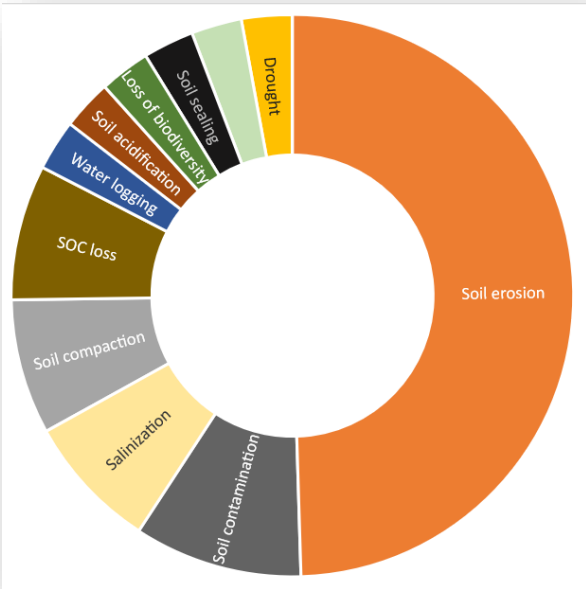


Soil-based ecosystem services prioritization by Member states

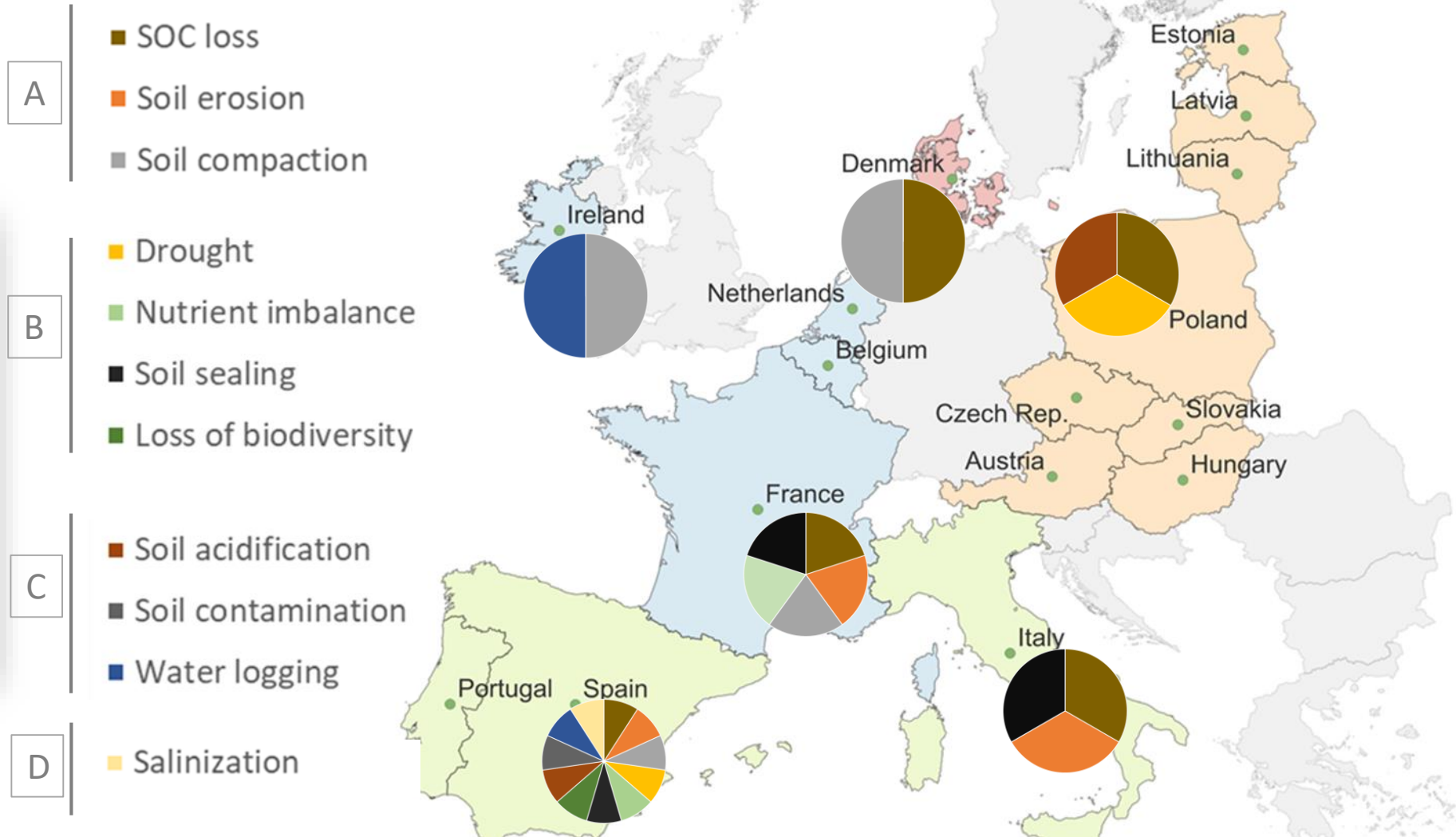


# Main Soil threats

Proportion of literature studies dealing with **Soil Threats** at the EU scale



## Soil Threats prioritization by Member states





# List of indicators

Table D.2.3.1.1: List of indicators used to assess selected soil threats and soil-based ecosystem services at the E from SERENA T5.1 and T5.2)

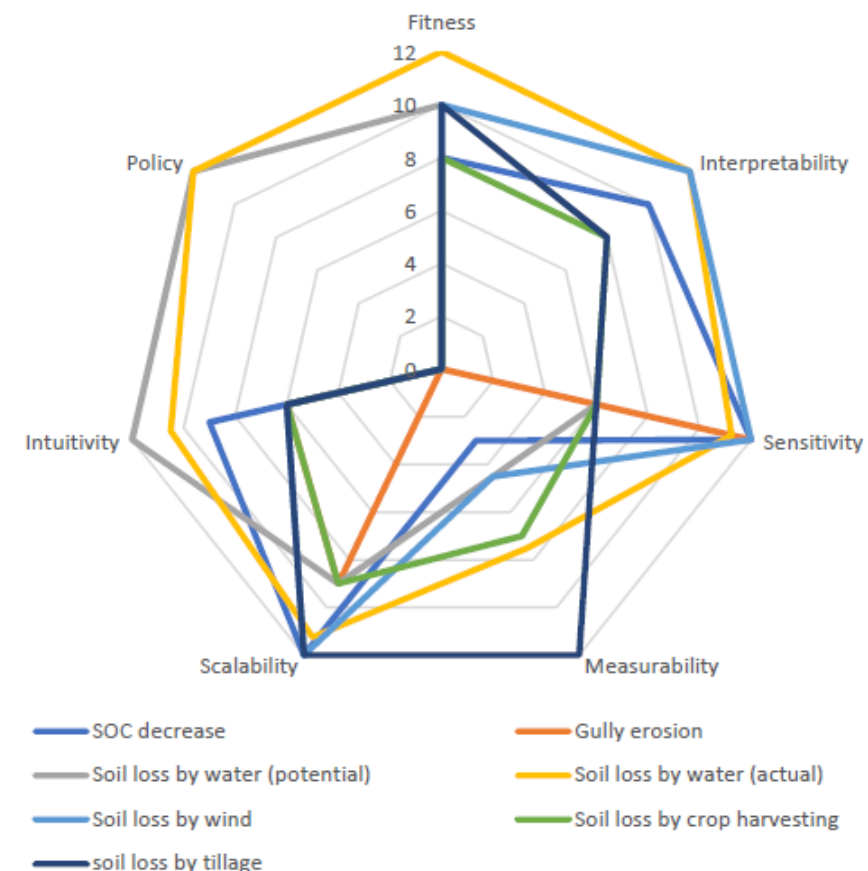
Indicator	Unit	Example of referenc
<b>ST - Soil organic carbon (SOC) loss</b>		
SOC content	kgC kg <sup>-1</sup>	JRC et al., 2015
SOC stock	kgC ha <sup>-1</sup>	JRC et al., 2015
SOC stock loss	kgC ha <sup>-1</sup> yr <sup>-1</sup>	Grace and Robertson, 2021
<b>ST - Soil erosion</b>		
SOC decrease	kgC ha <sup>-1</sup> yr <sup>-1</sup>	Lugato et al., 2016
Gully erosion	Number of occurrences	Borrelli et al., 2022
Soil loss by water (potential)	t ha <sup>-1</sup> yr <sup>-1</sup>	Cerdan et al., 2010
Soil loss by water (actual)	t ha <sup>-1</sup> yr <sup>-1</sup>	Panagos et al., 2020
Soil loss by wind	t ha <sup>-1</sup> yr <sup>-1</sup>	Borrelli et al., 2017
Soil loss by crop harvesting	t ha <sup>-1</sup> harvest <sup>-1</sup>	Panagos et al., 2019
Soil loss by water and tillage	t ha <sup>-1</sup> yr <sup>-1</sup>	Van Oost et al., 2009
<b>ST - Soil compaction</b>		
Wheel load carrying capacity	kN	Lamande et al., 2018
Soil stress	kPa	Lamande et al., 2018
Degree of compaction	%	Piccoli et al., 2022
Relative normalized density	%	Piccoli et al., 2022
Air-filled porosity	%	Piccoli et al., 2022
<b>ST - Soil sealing</b>		
Degree of soil sealing	%	
Imperviousness	%	EEA, 2018
Land take	km <sup>2</sup>	EEA, 2021
<b>SES - Greenhouse gas and climate regulation including carbon sequestration</b>		
Net ecosystem productivity	kgC km <sup>-2</sup> yr <sup>-1</sup>	JRC et al., 2011
Carbon offset	%	Schulp et al., 2012
Carbon stocks (in living materials)	kgC ha <sup>-1</sup>	JRC et al., 2011
<b>SES - Primary biomass production</b>		
Potential net primary production	kg (dry matter) ha <sup>-1</sup> yr <sup>-1</sup>	Mayer et al., 2021
Used biomass harvest	kg (dry matter) ha <sup>-1</sup> yr <sup>-1</sup>	Mayer et al., 2021
Proportion of biomass harvest	%	Mayer et al., 2021
Energy output from agricultural biomass	J ha <sup>-1</sup> yr <sup>-1</sup>	Mouchet et al., 2017
Volume of stemwood	m <sup>3</sup> km <sup>-2</sup> (forest) yr <sup>-1</sup>	Mouchet et al., 2017
<b>SES - Erosion control</b>		
Capacity of vegetation to reduce erosion risk	dimensionless	Schulp et al., 2012
Decrease of erosion risk by vegetation	dimensionless	Schulp et al., 2012
Capacity of ecosystem to avoid soil loss	dimensionless	Rendon et al., 2022
Total amount of soil not eroded	t ha <sup>-1</sup> yr <sup>-1</sup>	Rendon et al., 2021
Surface area of natural vegetation with a function of erosion control	ha (weighed by erosion risk) ha <sup>-1</sup> (NUTS area)	JRC et al., 2011
Surface area of forest with a protective function		Holting et al., 2019

# Choosing soil-based ES and threats indicators





## Strategy for characterizing the indicators

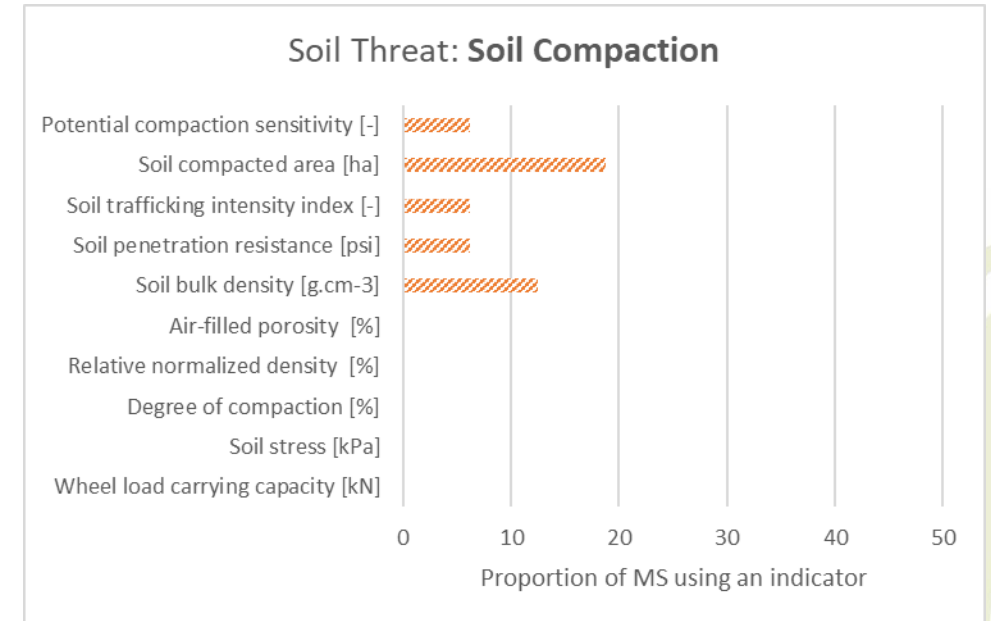
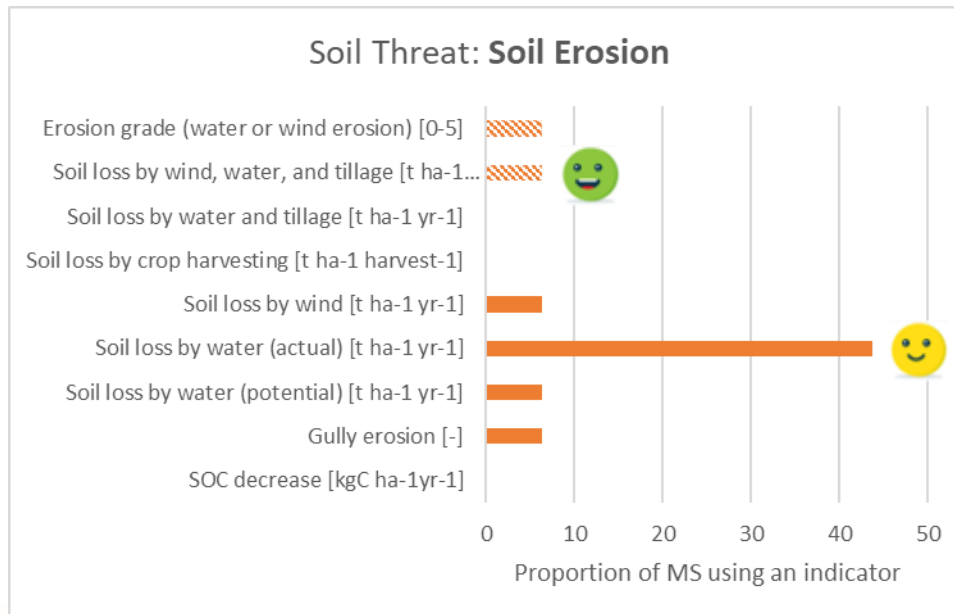
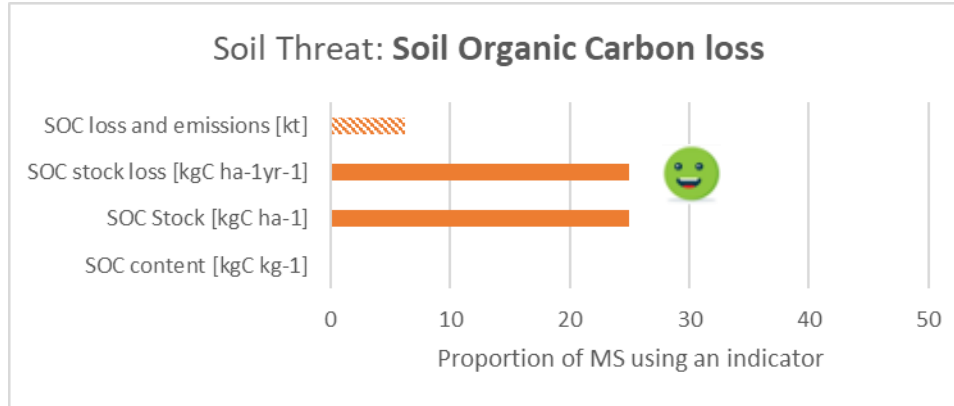
Family of criteria	Characteristics
Scientific soundness	<ul style="list-style-type: none"> <li>• Fitness-to-purpose</li> <li>• Interpretability</li> <li>• Sensitivity</li> </ul>
Data availability	<ul style="list-style-type: none"> <li>• Measureability</li> <li>• Scability</li> </ul>
Ability to convey information	<ul style="list-style-type: none"> <li>• Intuitivity</li> <li>• Policy implementation</li> </ul>

## Evaluation of ranking and selecting the indicators



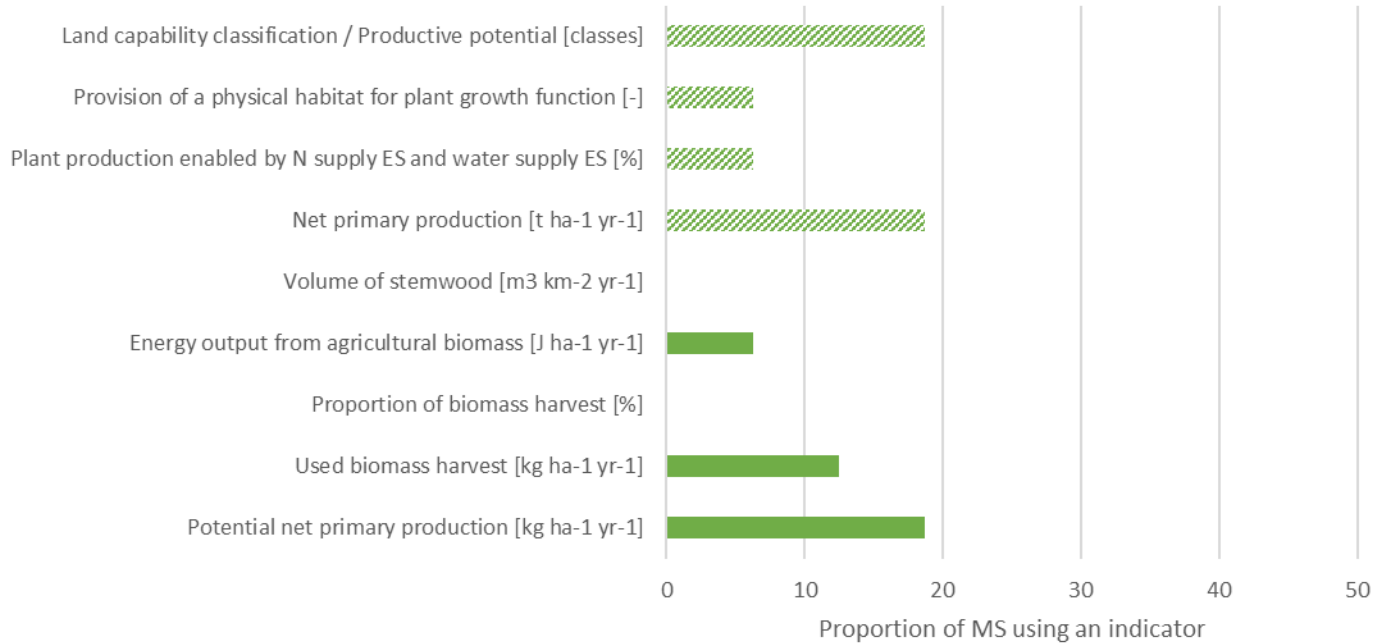
# Soil threats indicators / potential for harmonization accross Europe

-  Indicator selected from the literature
-  Other indicator used by MS at regional or national level
-  « Ideal » indicator for harmonisation
-  « realistic » indicator for harmonisation

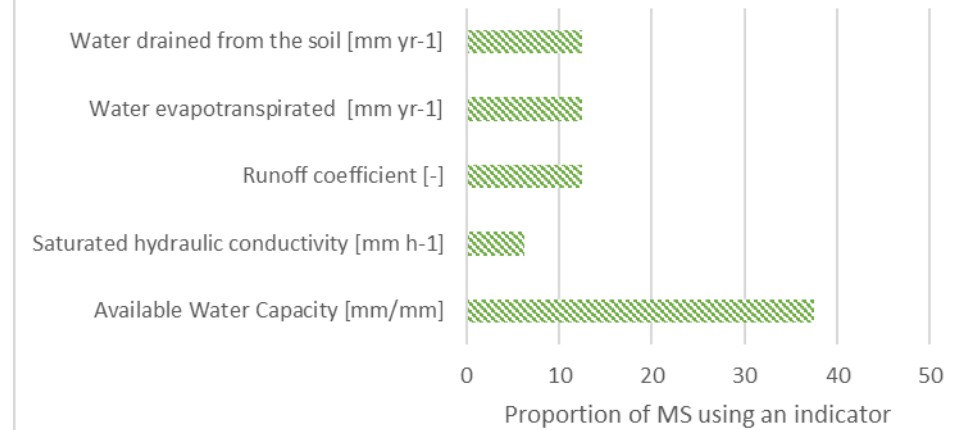


# Soil-based ecosystem services indicators / potential for harmonization across Europe

Soil-based ES: Primary Biomass Production



Soil-based ES: Hydrological control



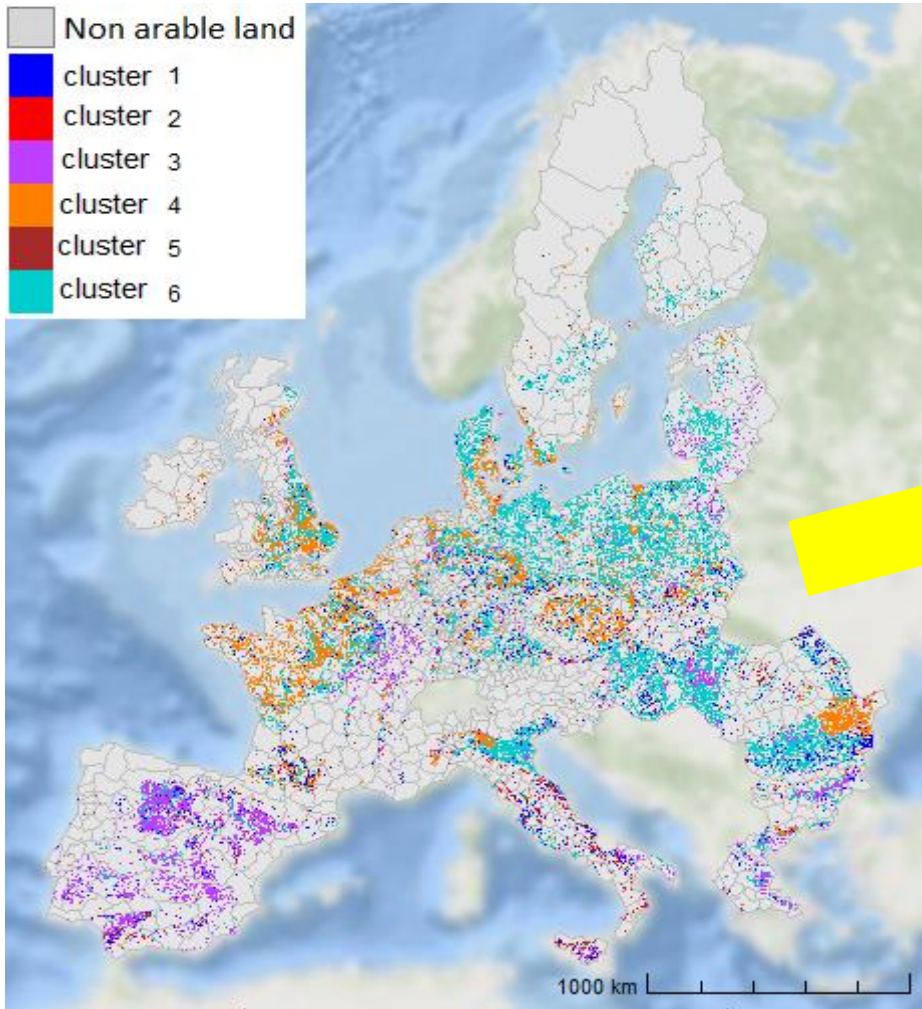
■ Indicator selected from the literature

▨ Other indicator used by MS at regional or national level

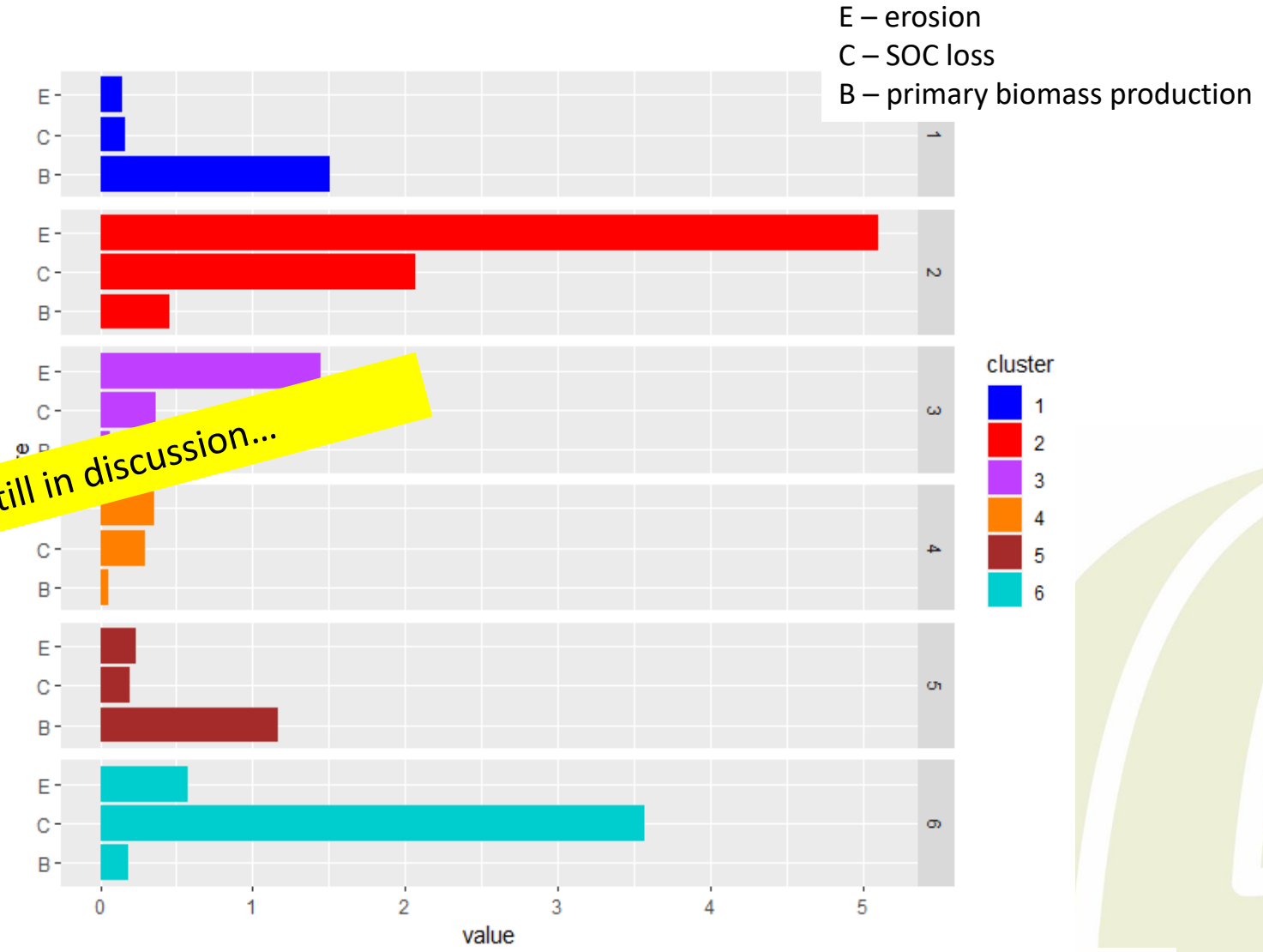
# A first evaluation of some soil-based ES and threats at the EU scale

SES/ST	Database	Indicator	Unit	Extent	Land use
<b>SOC loss</b>	Pan-European SOC stock of agricultural soils	Eroded soil organic carbon: C_eroded_prj.tif	t C ha <sup>-1</sup> yr <sup>-1</sup>	pan-European scale (EU + Serbia, Bosnia and Herzegovina, Croatia, Montenegro, Albania, Former Yugoslav Republic of Macedonia and Norway)	Agriculture land
<b>Primary biomass production</b>	Soil Biomass Productivity maps of grasslands and pasture, of croplands and of forest areas in the European Union (EU27)	Biomass production	Dimensionless (1-10)	EU27	Agriculture land, grassland, forest
<b>Soil erosion</b>	Multiple concurrent soil erosion processes	Water erosion	t ha <sup>-1</sup> yr <sup>-1</sup>	EU & UK arable lands (110 million ha )	Agriculture land

# A first evaluation of some soil-based ES and threats at the EU scale



Still in discussion...





## To conclude... next SERENA EJP SOIL activities

Finalising the **selection of soil indicators** for characterizing agricultural **soil threats**, **soil-based ecosystem services**, and their **bundles** at national and EU levels



Develop **cookbooks** for a harmonized assessment of indicators at national and EU scales



**Mapping soil threats, soil-based ES**, their associated bundles, and their **evolution over scenarios of change**