Ecosystem condition assessment under SEEA EA requirements

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European Commission

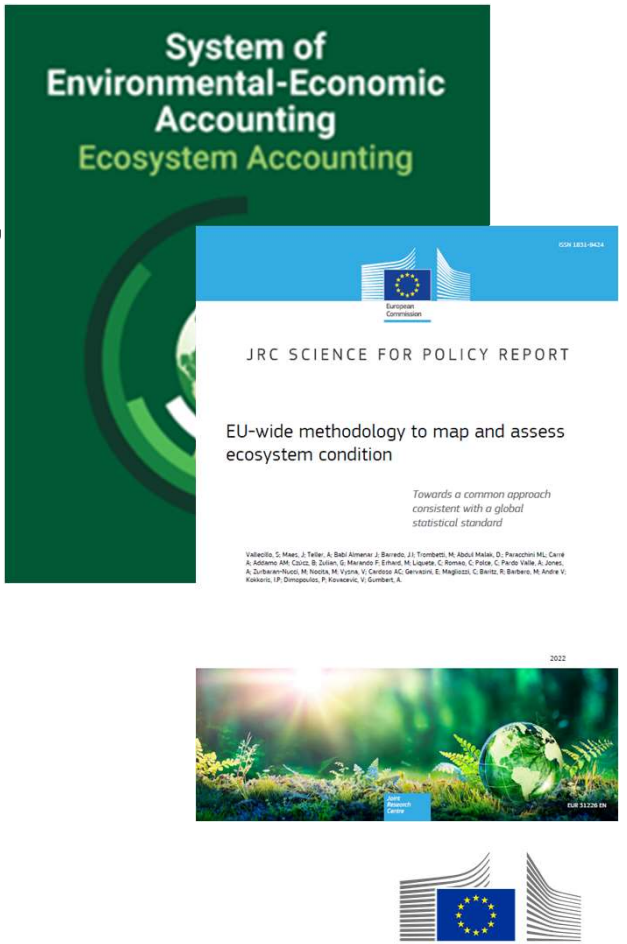
Outline

- The concept of ecosystem condition in the SEEA EA
- Ecosystem condition typology
- Steps to map ecosystem condition
- Thresholds/reference levels
- Case study 1: forest ecosystems
- Case study 2: agroecosystems
- Conclusions

The concept of ecosystem condition in the SEEA EA

In the SEEA EA, the concept of ecosystem condition is grounded in ecosystem integrity, understood as the capacity of ecosystems to sustain their natural composition, structure, function, and self-organisation over time.

An ecosystem is considered in good condition when it presents good physical, chemical, and biological condition (or quality) with self-reproduction or self-restoration capability, in which species composition, ecosystem structure and ecological functions are not impaired (cf. definition of the Taxonomy Regulation (EU) 2020/8528)



SEEA EA condition accounts

Main reference: selection of 'variables' using the ecosystem condition typology (ECT)

Ecosystem condition typology	
Abiotic	Physical state (soil, water)
	Chemical state (pollutants, nutrients in soil/water)
Biotic	Compositional state (species composition)
	Structural state (veg. cover, biomass)
	Functional state (functional groups, DMP)
Landscape	Land- and seascape (connectivity, land diversity)

Equivalent to indicators of Society Ecological Restoration

Mapping ecosystem condition in forest and agro-ecosystems

Mapping ecosystem condition at the continental scale poses some challenges:

Identifying suitable variables → EU wall to wall coverage; suitable resolution

Identifying reference values → identifying reference areas; to stratify or not to stratify? pessimal and optimal values, setting a good condition threshold

Normalising to 0-1 range → good condition level embedded or not?

Defining the aggregation scheme → weights? which ones?

Validating results → finding a suitable reference dataset

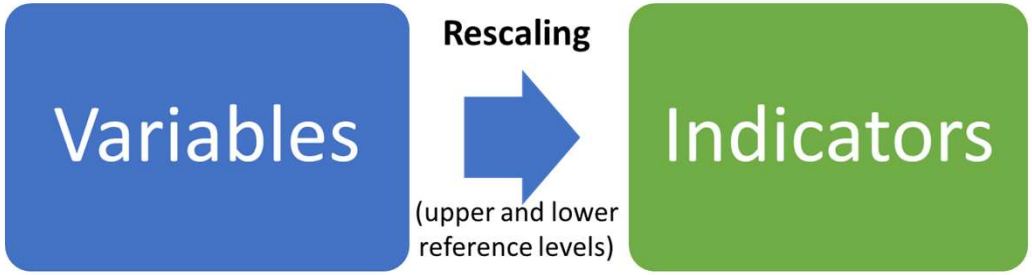
Reference levels (1)

Upper reference level (**high ecosystem integrity**)

Natural state: reference sites (minimally disturbed sites)

Statistical analysis : anthropogenic reference condition (urban, cropland)

Lower reference level (collapse)



Methods for setting reference values

Already defined reference values
1. Prescribed reference values: **scientific evidence**- e.g. critical loads for eutrophication, water exploitation index thresholds
2. Prescribed reference values: **legal thresholds/targets**- e.g. All species with good population status (aligned with the NRL)
3. **Contemporary condition** (defined reference year-baseline)- e.g. 100 for the Farmland Bird Index (value in 1990)

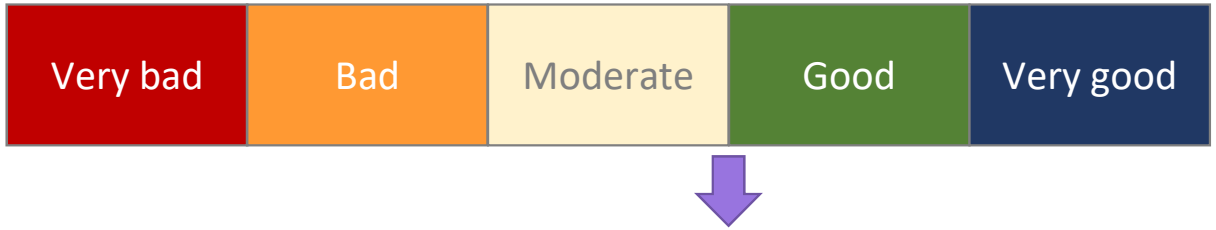
Definition of reference values based on data analysis	
1. **Reference sites**	Minimally-disturbed condition ('pristine' ecosystems)
2. **Modelled condition**	Example: potential vegetation models, historical condition
3**. Statistical methods** based on ambient distribution	
4. **Prescribed reference values** (scientific criteria)	
5. **Contemporary condition**	
6. **Expert opinion**	
7. **Combination of methods**	

Reference levels (2)

0= worst condition

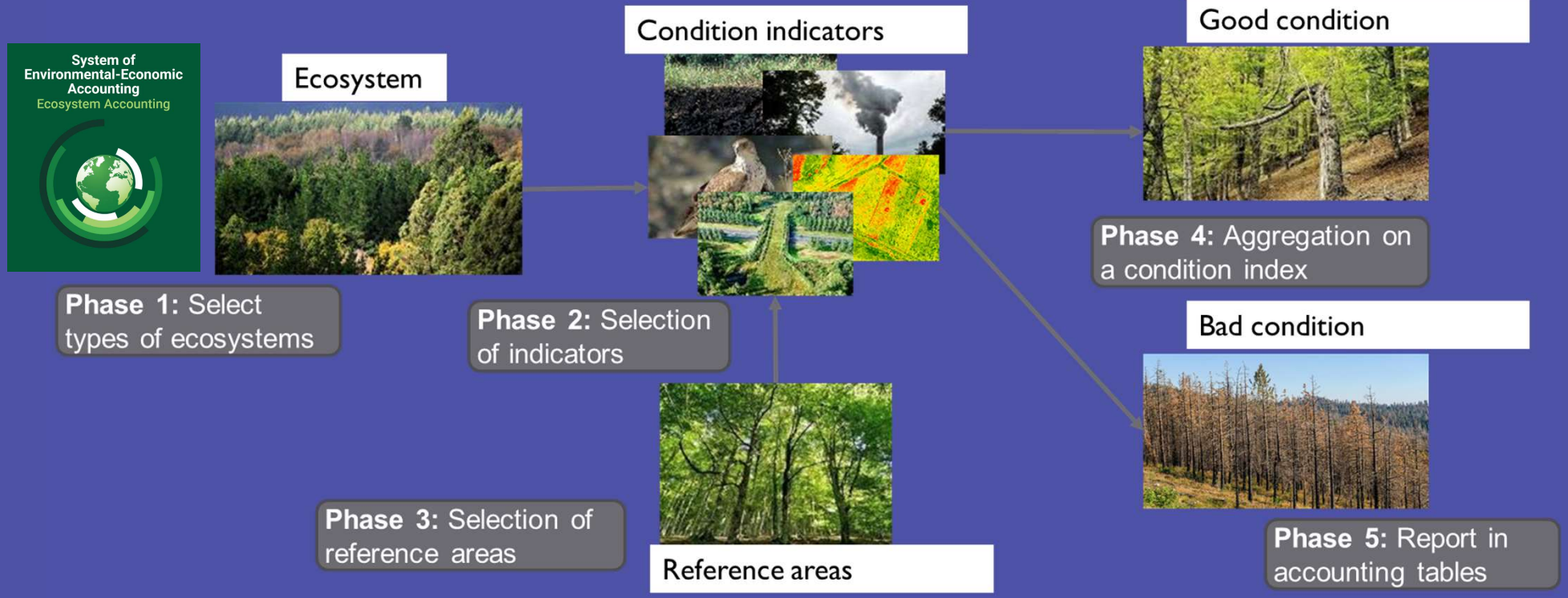
1= best condition (upper reference level)

Categories based on different **thresholds** (e.g. 0.6 WFD to define good)

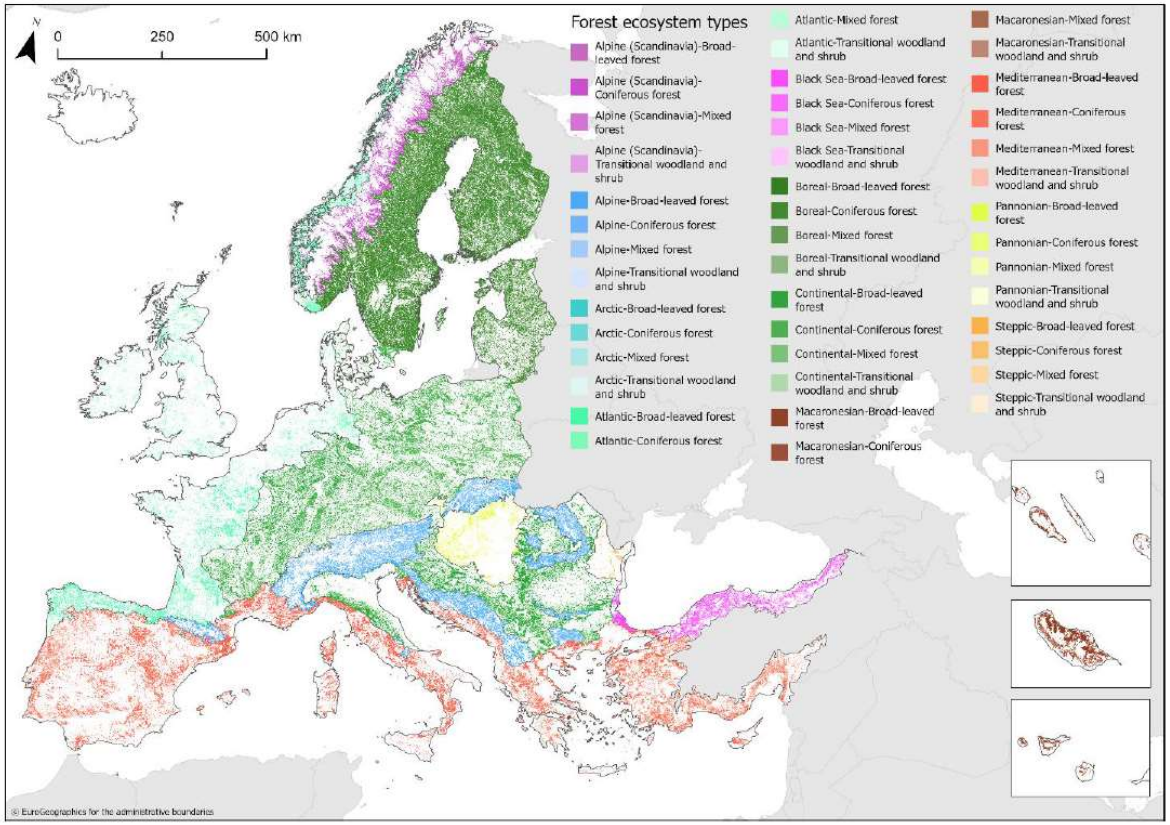


Critical levels / sustainability thresholds

Example 1 : forest ecosystems



Forest ecosystem types for condition assessment

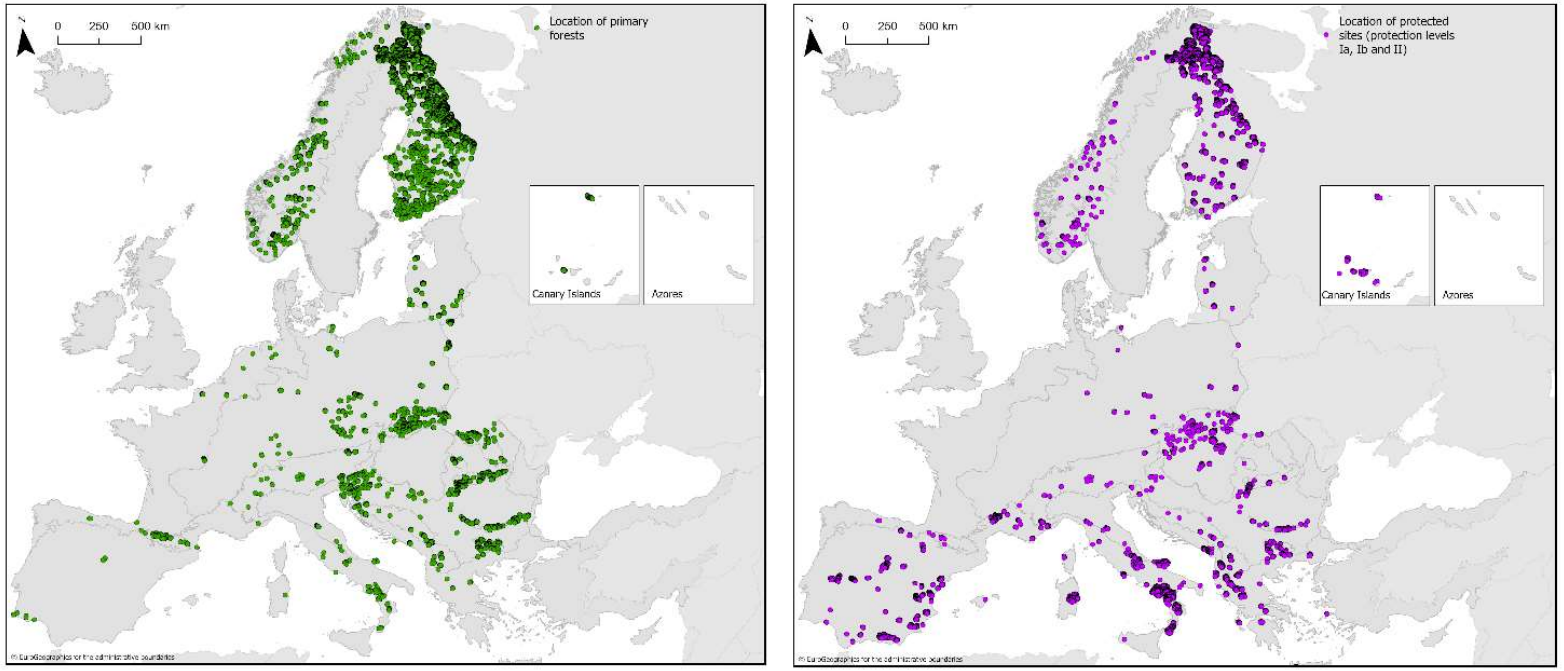


Need to stratify the approach to identify reference areas:

forest ecosystem typology identifying 44 forest ecosystem types which are implemented as the geographic intersection between 11 biogeographic regions and four forest classes, derived from Corine Land Cover

Maes, J., Bruzón, A.G., Barredo, J.I. et al. Accounting for forest condition in Europe based on an international statistical standard. Nat Commun 14, 3723 (2023). https://doi.org/10.1038/s41467-023-39434-0

References areas



Location of reference forests in Europe. Left panel: reference sites covered by primary forest; right panel: reference sites covered by protected sites. Overlap between primary and protected forest occurs frequently but is not quantified here

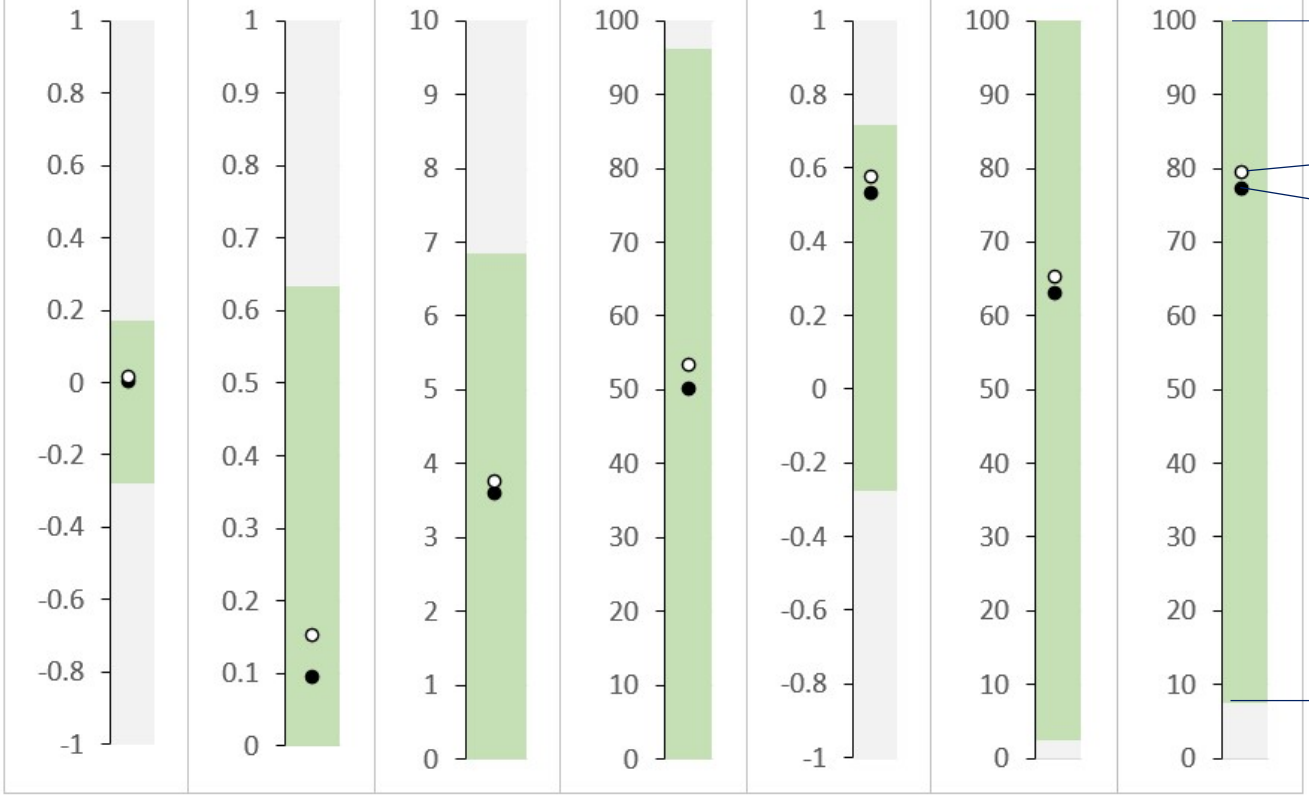
Forest condition indicators

Forest condition variables assorted per ecosystem condition type (SEEA ECT, System of Environmental Economic Accounting Ecosystem Condition Typology), their possible value range, and their weight in the calculation of the forest condition index

SEEA ECT group	SEEA ECT class	Forest condition variable	Abbreviation	Range	Weight in the forest condition index
Abiotic ecosystem characteristics	Physical state	Vegetation water content - Normalized difference water index (NDWI)	ndwi	−1 to1	0.08
	Chemical state	Soil organic carbon	soc	0 to 1	0.12
Biotic ecosystem characteristics	Compositional state	Species richness of threatened forest birds	birds	0 to 22	0.22
	Structural state	Tree cover density	trees	0 to 100	0.21
	Functional state	Forest productivity - Normalized difference vegetation index (NDVI)	ndvi	−1 to 1	0.13
Landscape level characteristics	Landscape characteristics	Forest connectivity	fad	0 to 100	0.13
		Landscape naturalness	lm	0 to 100	0.11

ECT: Ecosystem condition typology

Water content - Normalized difference water index (NDWI)	**Soil organic carbon**	**Species richness of threatened forest birds**	**Tree cover density**	**Forest productivity** - Normalized difference vegetation index (NDVI)	**Forest connectivity**	**Landscape naturalness**
Index between -1 and 1	Index between 0 and 1	Number	%	Index between -1 and 1	%	%



7 indicators based on typology and selection criteria from SEEA EA

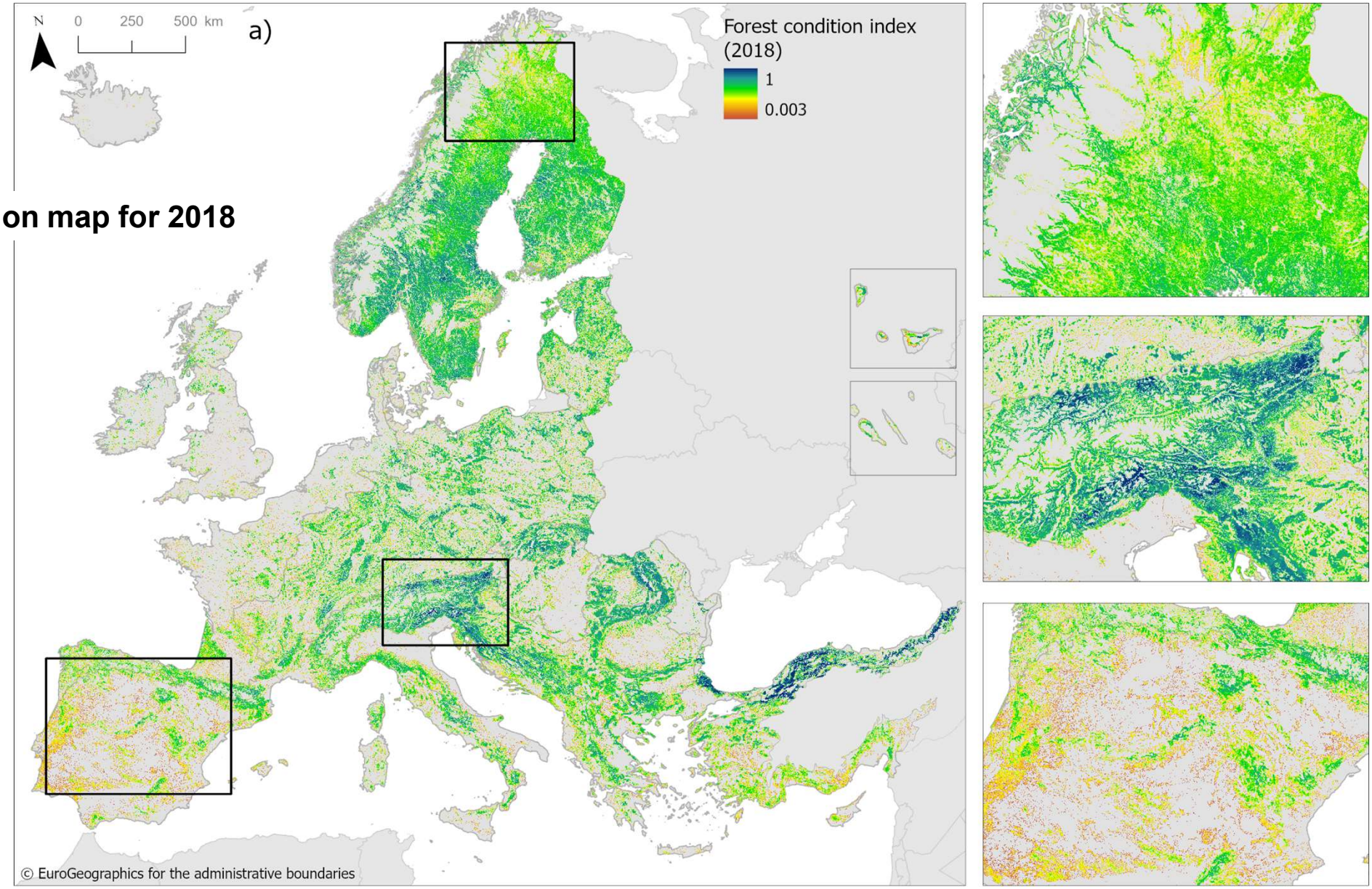
Upper reference level based on reference sites (primary forest or undisturbed protected forest)

Indicator value for 2018

Indicator value for 2000

Lower reference level

Forest condition map for 2018

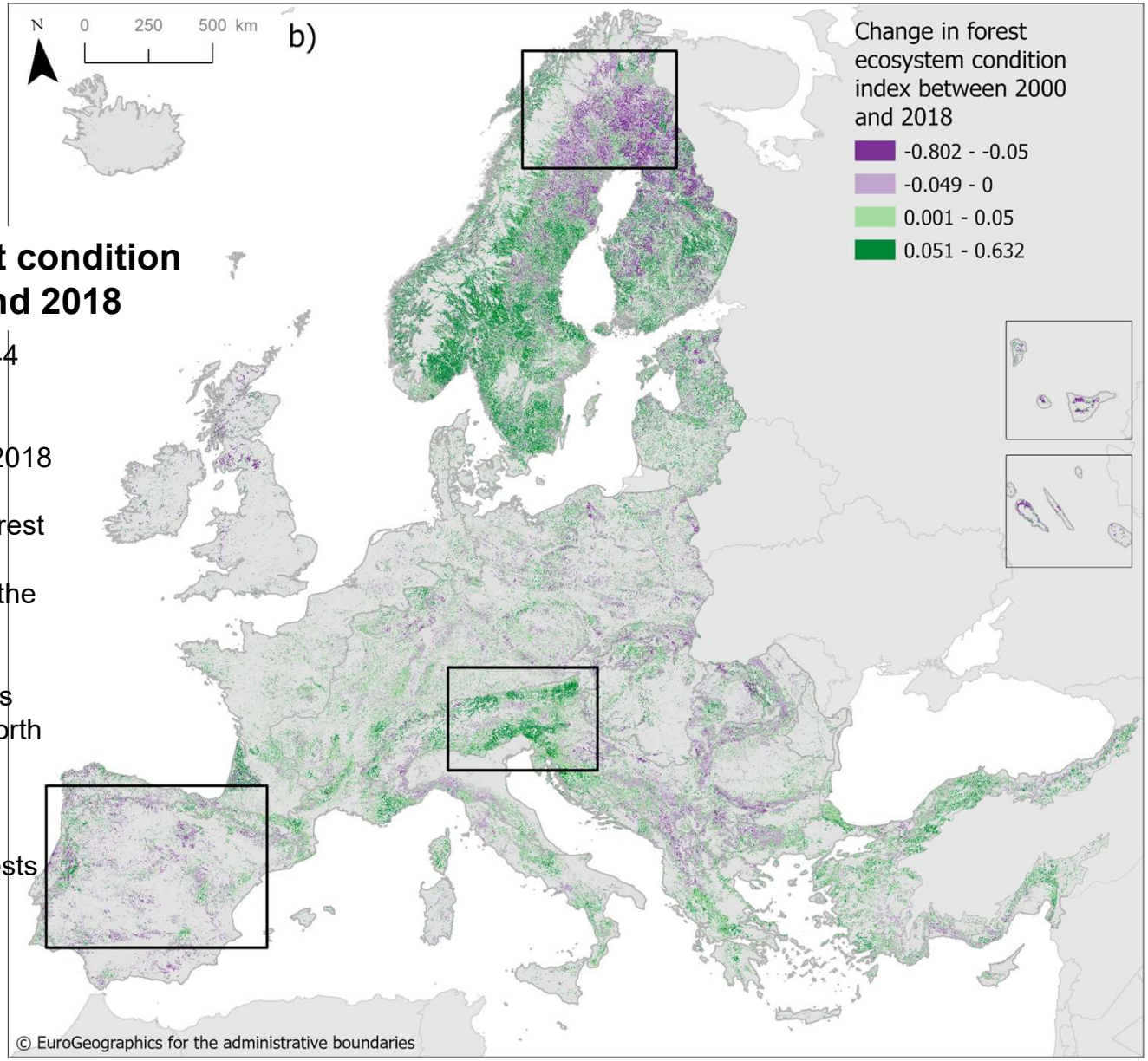


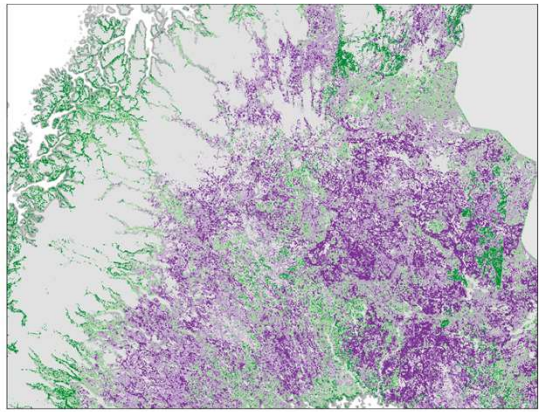
Change in forest condition between 2000 and 2018

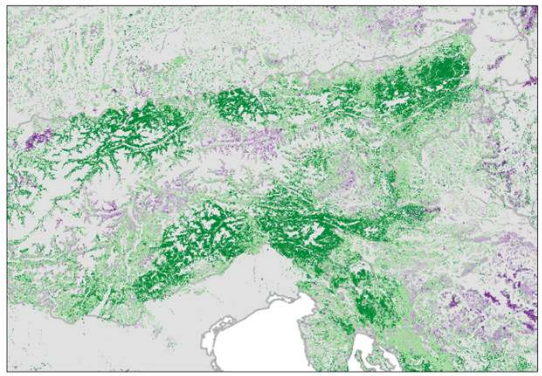
The condition across 44 forest types averaged 0.566 in 2000 and increased to 0.585 in 2018

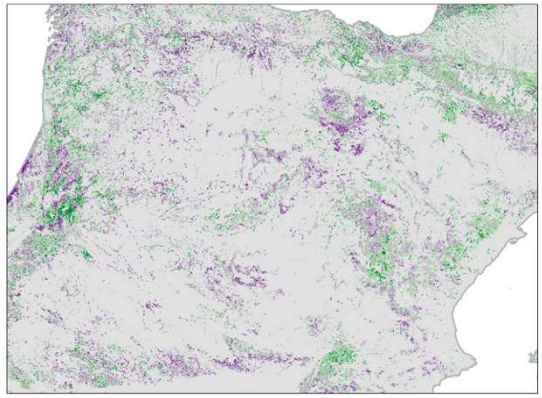
63% of the area the forest condition measured in 2018 was higher than the condition in 2000

Forest degradation was more pronounced in north Scandinavia, the Carpathians and the Balkan, the northern Apennines, and in forests throughout the Iberian Peninsula

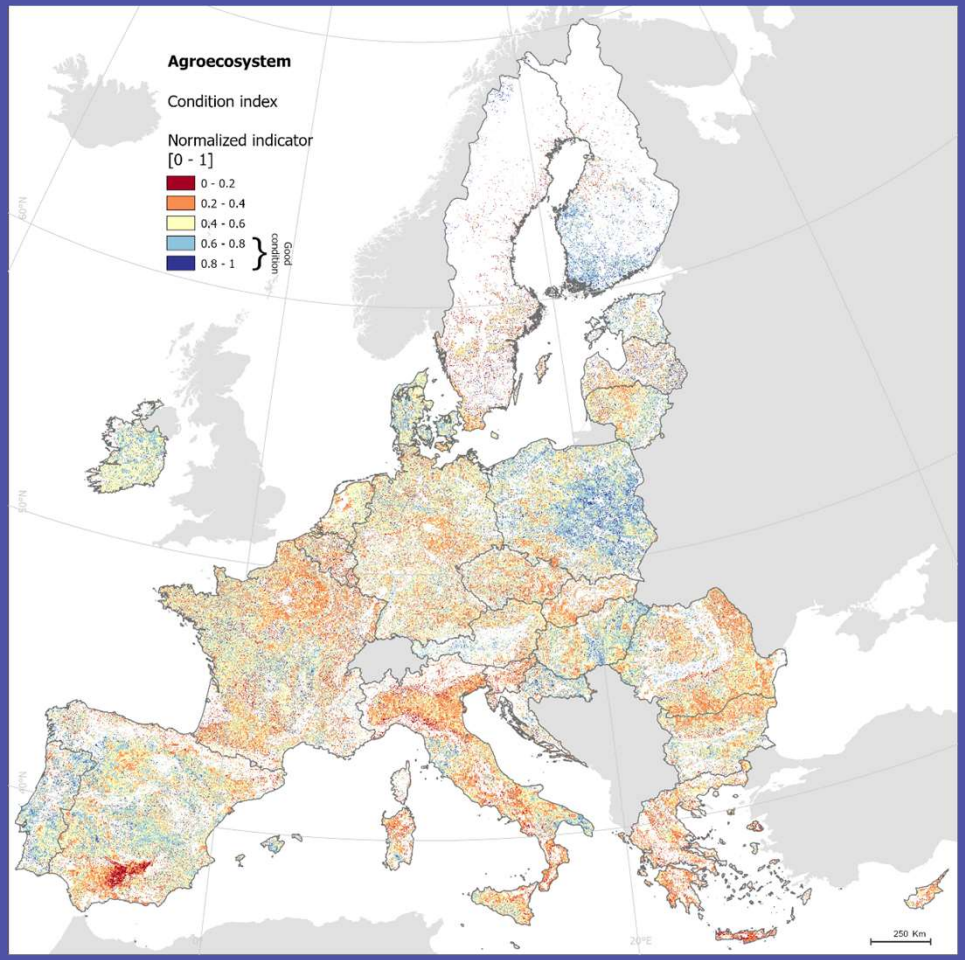








Example 2 : agroecosystems

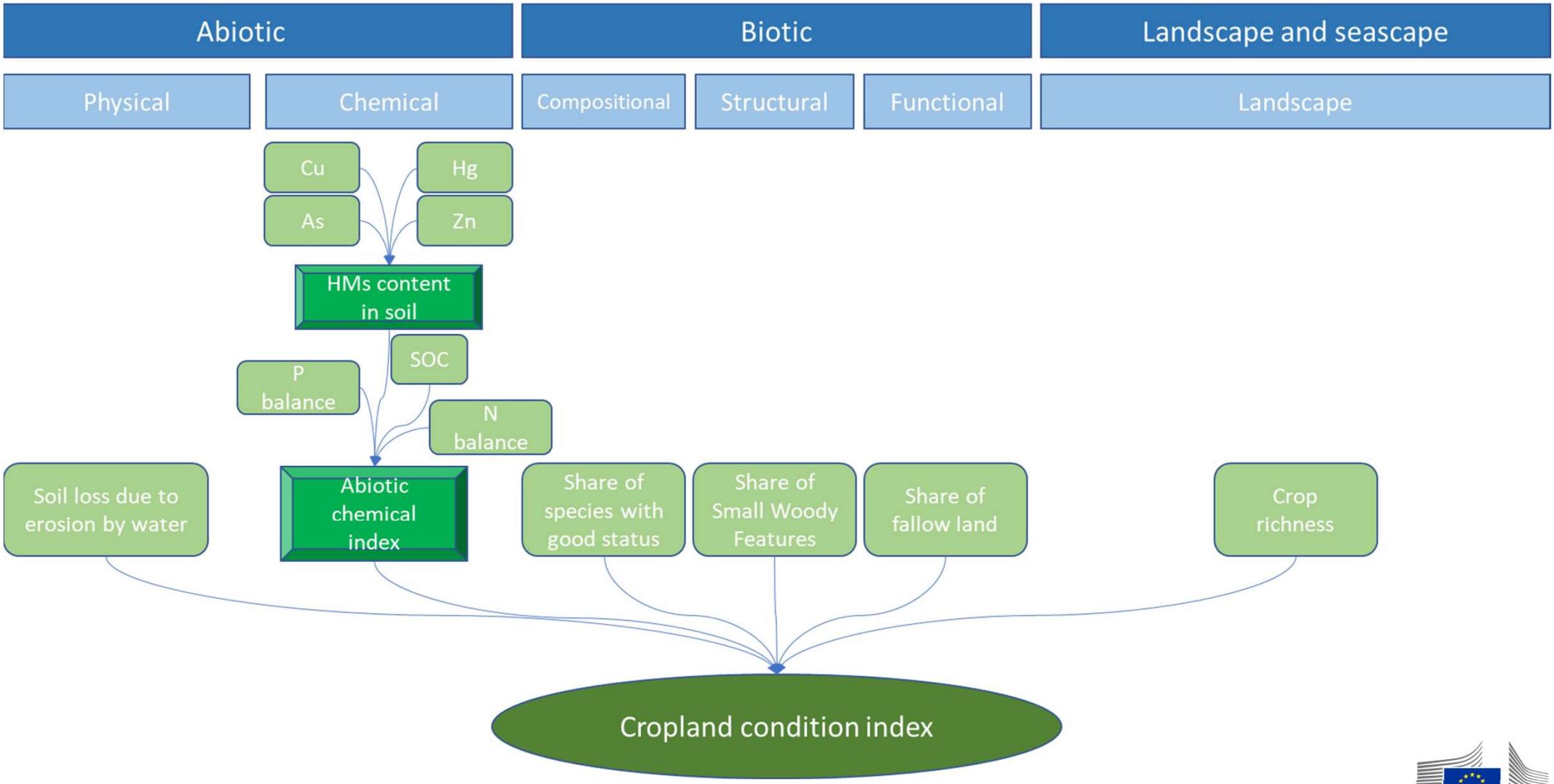


PARACCHINI, M.L., BARREDO, J.I., TROMBETTI, M., CATARINO, R., GUERRERO, I. et al., Towards the quantification of ecological boundaries for the bioeconomy, Publications Office of the European Union, Luxembourg, 2026, https://data.europa.eu/doi/10.2760/6629891, JRC142995

Assessment of good condition of the agroecosystem

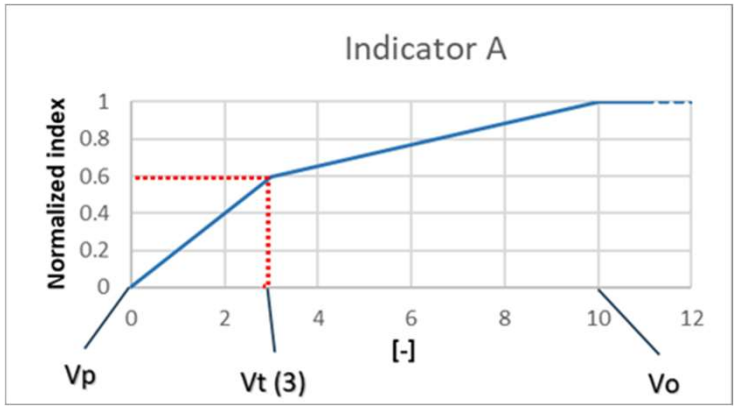
Indicators

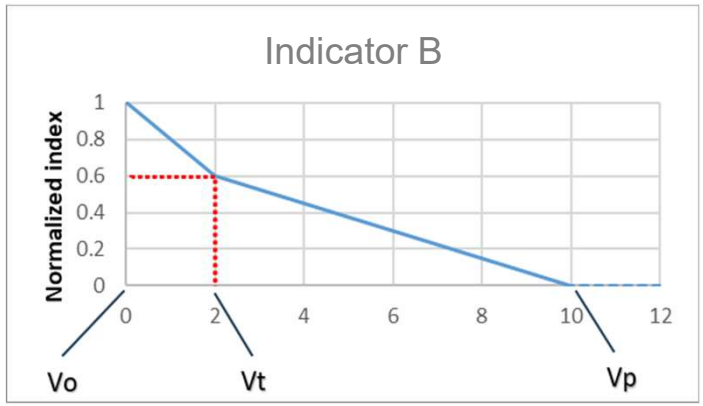
Ecosystem condition typology (ECT)		Cropland Assessment Indicator	Grassland Assessment Indicator	Spatial resolution
Group	Class			
Abiotic	Physical	Soil loss due to erosion by water		100m
	Chemical	Pesticides effect on biodiversity		
		Nitrogen balance in soil (Surplus)		1km
		Phosphorus (P) balance in soil		100m
		Soil Organic Carbon (SOC) in mineral soils		500m
		Heavy Metals content in soil (contamination and deficit)		500m, 250m
Biotic	Compositional	Percentage of farmland/grassland species with good population status (no birds)		1km
		Abundance of farmland/grassland bird species		
	Structural	Share of small woody features	-	100m
	Functional	Share of fallow land	Phyto-toxic Ozone Dose	1km, 10km
Landscape and seascape	Landscape	Crop richness	-	300m

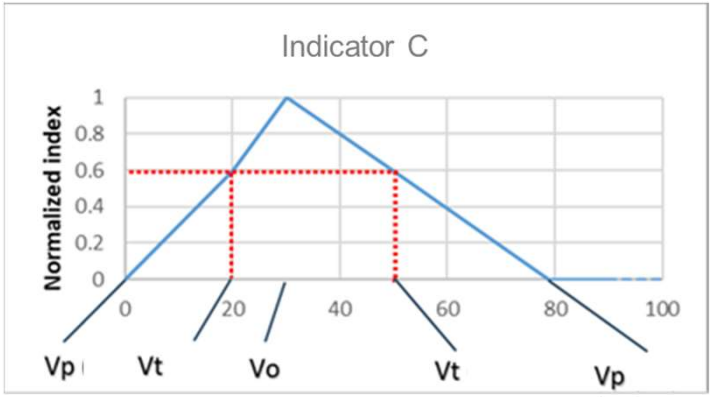

Abiotic
Biotic
Landscape and seascape
Physical
Chemical
Compositional
Structural
Functional
Landscape
Cu
Hg
As
Zn
HMs content in soil
SOC
P balance
N balance
Soil loss due to erosion by water
Abiotic chemical index
Share of species with good status
Share of Small Woody Features
Share of fallow land
Crop richness
Cropland condition index

Thresholds and normalisation

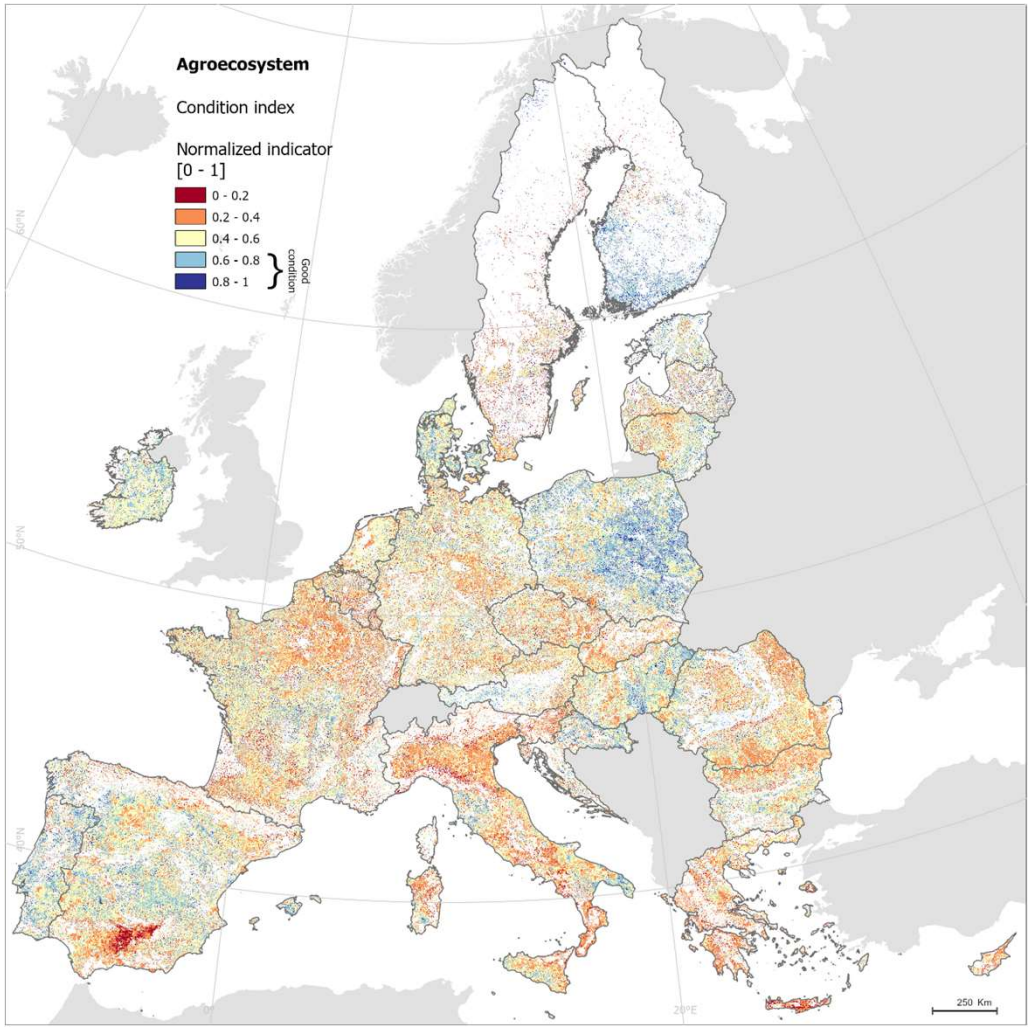
Level	Source	Indicator normalized value
Vo (Optimal value)	Literature or absolute physical boundary	1
Vt (Threshold value)	Literature, policy documents, data distribution	0.6
Vp (Pessimal value)	Literature or absolute physical boundary	0





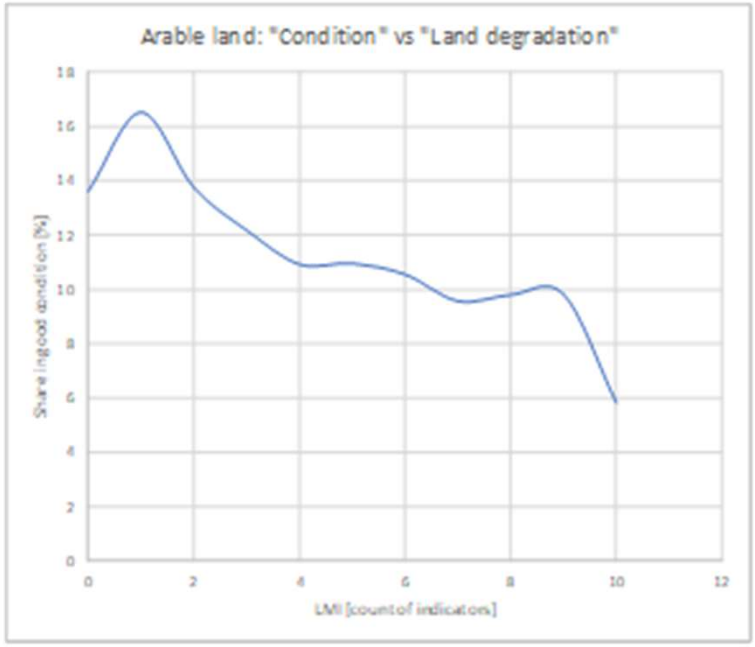


Aggregated agroecosystem condition index



Condition	Range of condition values	Share of extent [%]	
		Cropland	*Grassland*
Very bad	< 0.2	1.2	0.1
Bad	0.2 – 0.4	24.8	11.8
Moderate	0.4 – 0.6	54.3	46.7
Good	0.6 – 0.8	18.2	30.8
Very good	< 1	1.6	10.6

Comparison with a land degradation model



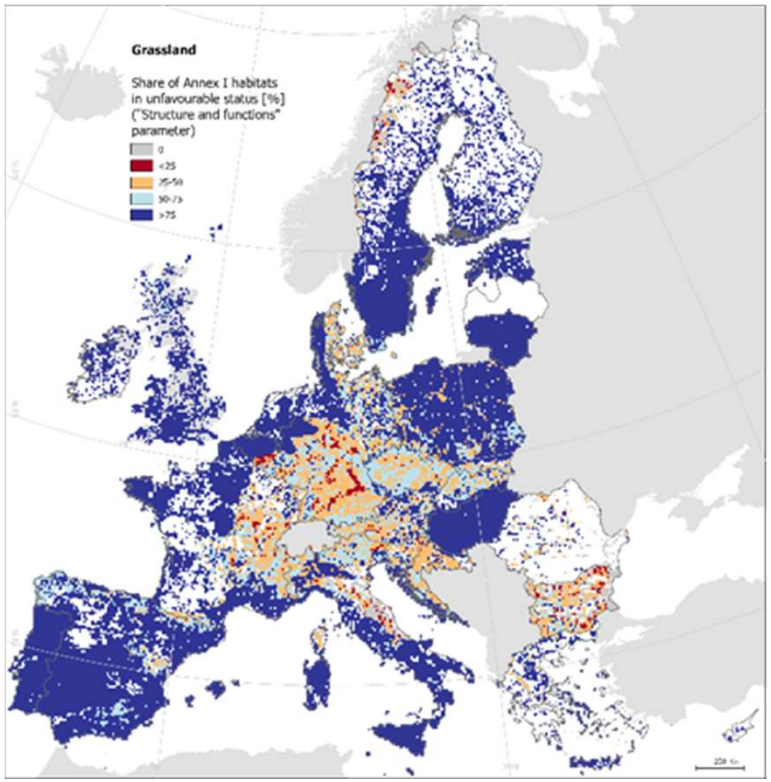
The share of arable land in good condition decreases with the number of concurrent land degradation processes

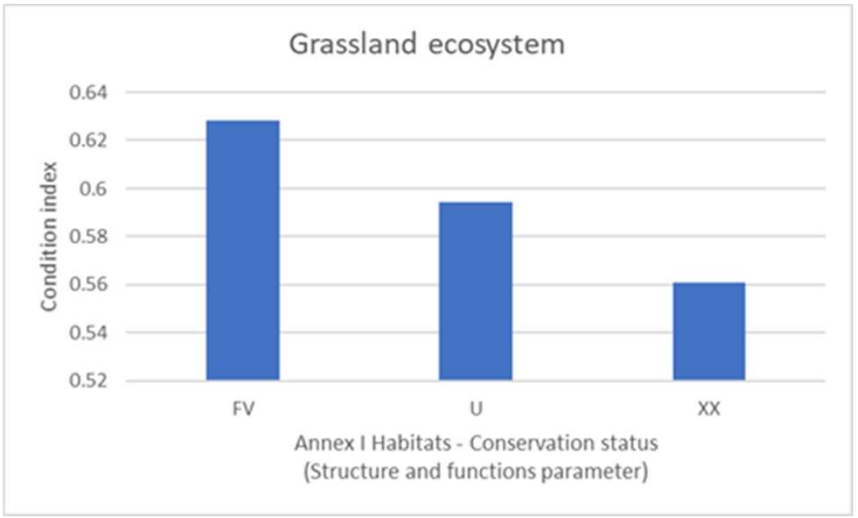
- Comparison with the outcome of a recent study on land degradation in Europe's agricultural environments (Prăvălie et al., 2024)
- Land Multi-Degradation index (LMI), based on 12 indicators (number of concurrent degradation processes)

Environmental EU legislation related to agroecosystems condition

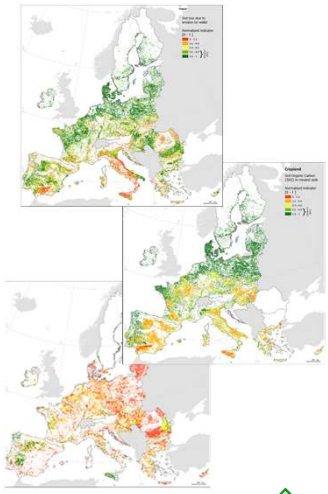
The Habitats Directive (HD) assesses the “habitat conservation status” based on four parameters:
a) range, b) area, ***c) structure and functions***, and d) future prospects

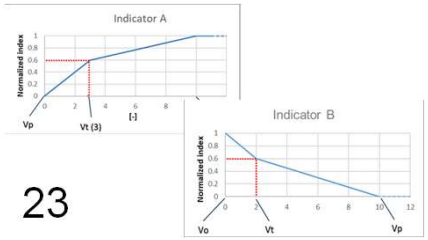
Only the parameter ‘structure and functions’ is considered under the HD in terms of habitat condition (EC, 2022) and defined as “Favourable (FV)”, “Unfavourable Inadequate (U1)”, “Unfavourable bad (U2)” or “Unknown (XX)” status

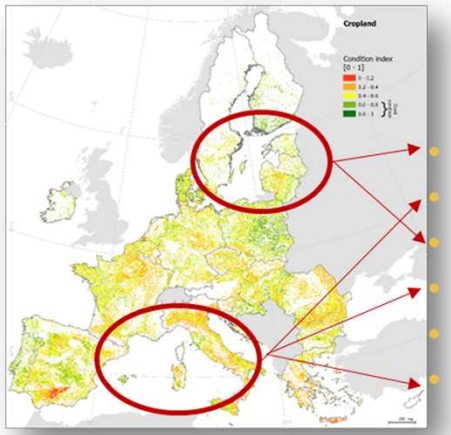




Application examples: restoration actions







- Soil erosion
- Soil organic carbon
- Crop diversity
- Landscape features
- Biodiversity
- .....

Nature restoration actions

Synergies/ financing

- Common Agricultural Policy
- Nature credits
- Soil Monitoring and Resilience Directive
- Nature Restoration Regulation
- Others..

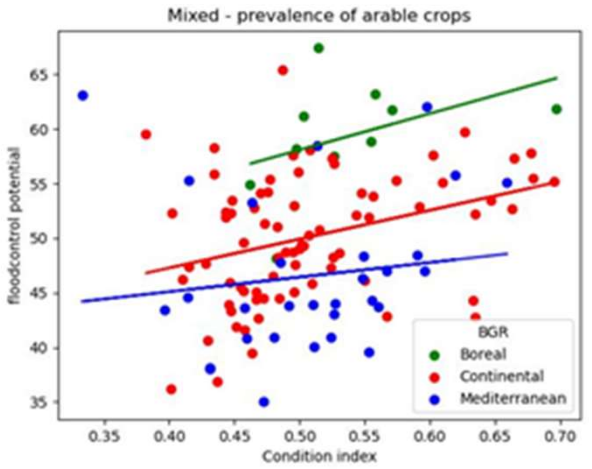
This approach allows identifying areas to be restored (where the problem is), set priorities, and identify appropriate measures on the basis of input information (what the problem is), by linking for example at the JRC Farming Practices dataset

Ongoing developments: impact of the condition of the ecosystem on its capacity to provide services

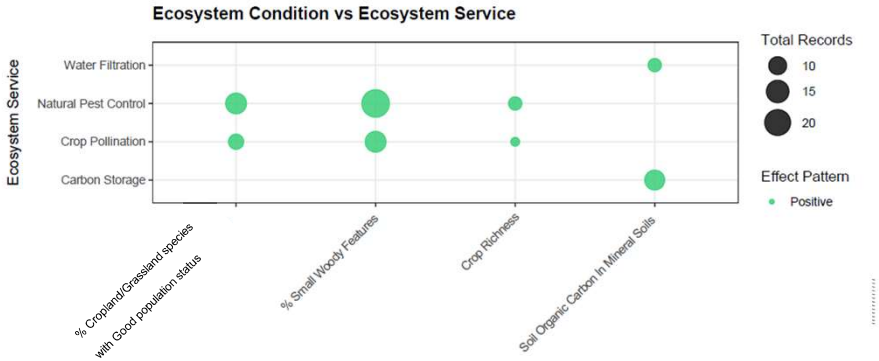
Assessment of the main components affecting each ESS

Dependant variable	Independent variables				
Ecosystem service	Sub-condition indexes included in the model and direction of the impact of their increase on the dependant variable				
Crop provision	Abiotic physical (↑)	Abiotic chemical (↓)	Biotic structural (↓)		
Flood control	Abiotic physical (↑)	Abiotic chemical (↑)	Biotic functional (↑)	Share of grassland (↑)	Share of forage crops (↑)
Natural pest control	Abiotic physical (↓)	Biotic functional (↑)	Share of cereals (↓)		
Crop pollination	Abiotic physical (↑)	Abiotic chemical (↑)	Biotic functional (↑)	Share of Specialist industrial crops (↓)	
Carbon retention	Abiotic physical (↓)	Share of grassland (↑)			
On-site soil retention	Biotic functional (↑)	Share of grassland (↑)	Share of cereals (↓)		
Water purification	Abiotic physical (↑)	Biotic compositional (↑)			

Relationships at NUTS2 level

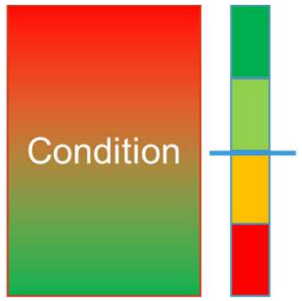


Support from literature

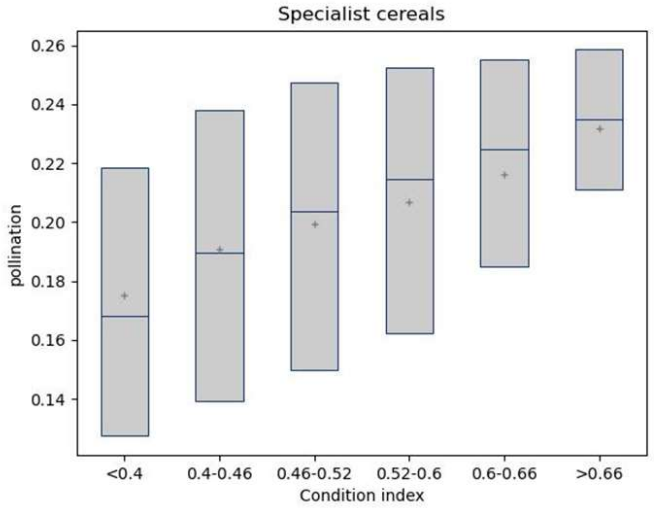


Ecosytem condition and service provision

- Crop pollination
- Crop provision
- Flood control
- Soil retention
- Pest control
- Carbon sequestration



Relationship between condition and the potential to provide the service



Conclusions

- Available datasets enable an initial spatially explicit mapping of ecosystem condition at a resolution appropriate for broad-scale assessment
- The proposed approaches are suitable to be applied to monitoring ecosystem condition
- Building on these developments, similar approaches are expected to be further refined and, where feasible, extended to additional ecosystem types within the Second EU Ecosystem Assessment (MAES2), planned for release in Q1 2027
- The methodology is designed to be scalable across spatial extents and potentially applicable at different governance levels
- Aspects that need to be further explored: data gaps, critical levels, normalisation procedures, the selection and justification of weighting and aggregation schemes
- An assessment of ecosystem condition providing geospatial results at an appropriate scale can support a range of applications e.g. setting priorities for restoration
- Through an integrated environmental-economic accounting system, like the SEEA EA, it is possible to create a cause-and-effect relationships between changes that occur in the ecosystem and their economic impacts. This is possible because the key variables that are used to measure condition often work as input data to model ecosystem services, which in turn are allocated to economic/human activities

Thank you

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