Biological indicators of soil quality – The Emilia-Romagna project as example of application at regional scale









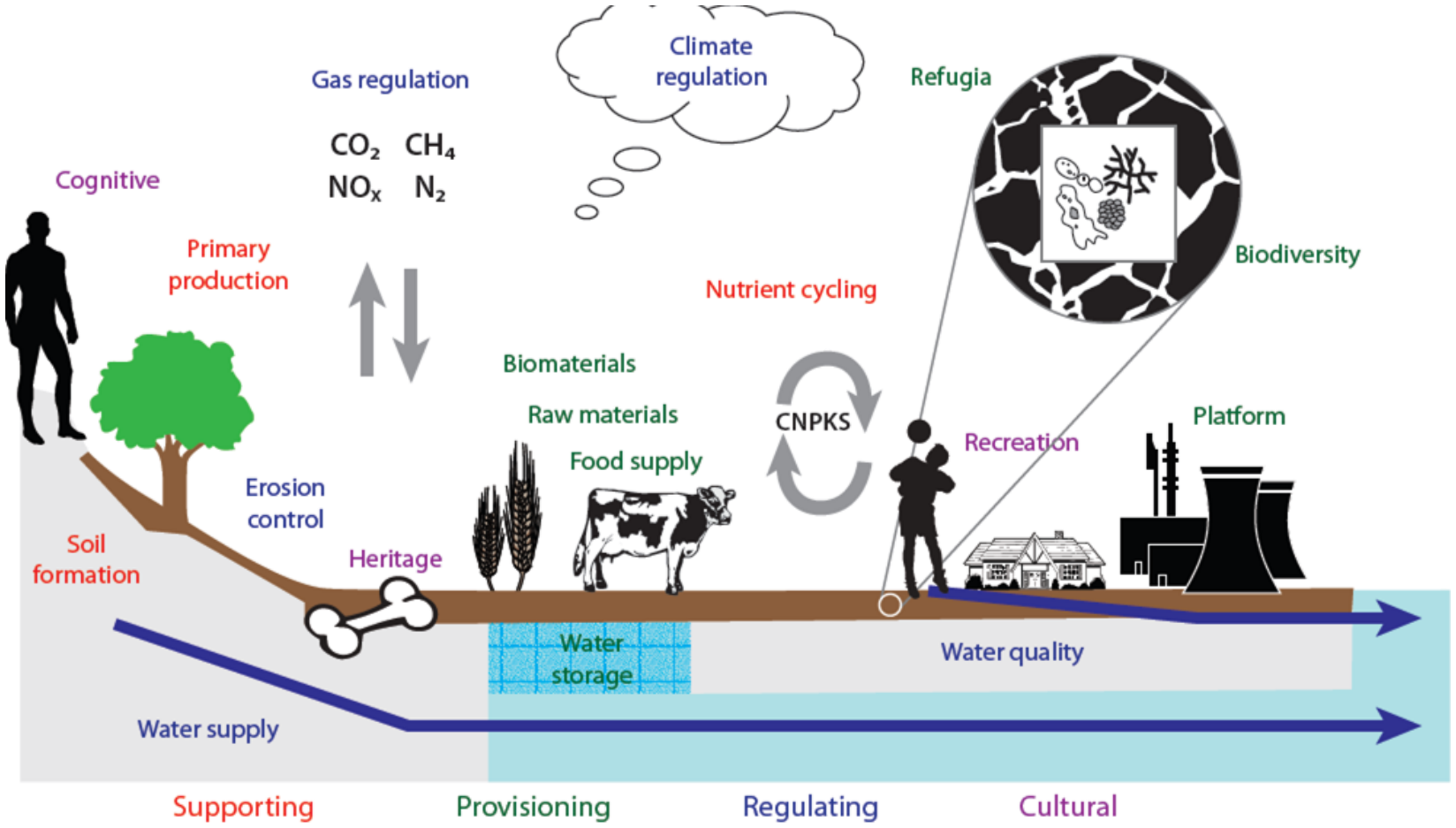
Cristina Menta

Department of Chemistry, Life Sciences and Environmental Sustainability - University of Parma - Italy

ECOSYSTEM SERVICES PROVIDED BY SOIL

2015 International Year of Soils

healthy soils for a healthy life

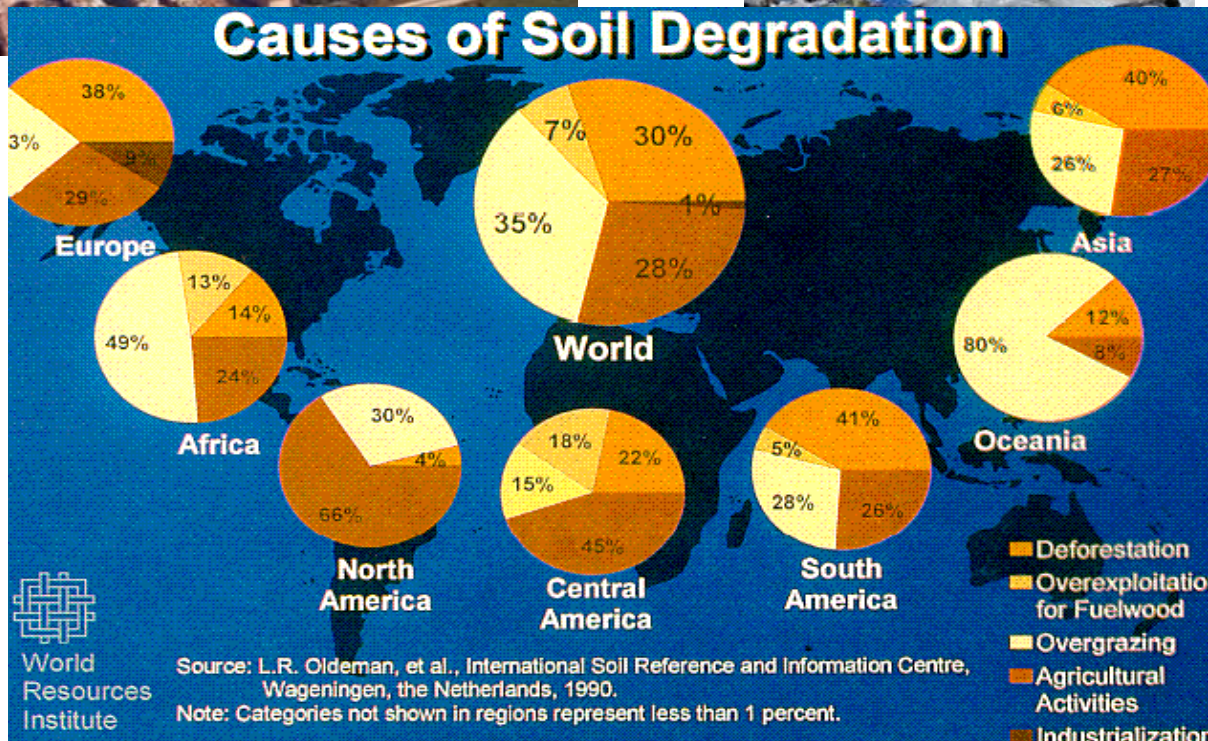


From Haygarth and Ritz, Land Use Policy 2009

SOIL DEGRADATION

Soil is a nonrenewable resource, considering the very long time required for its formation.

Soil degradation is caused by the loss of top soil - excessive farming, construction, overgrazing, burning of grass cover and deforestation, salinization, solid waste - this reduces soil fertility and the water holding capacity.

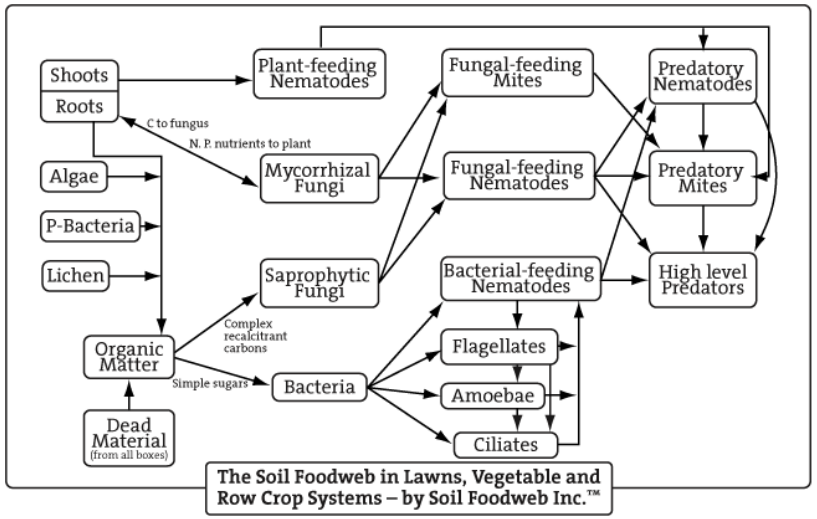


SOIL BIODIVERSITY: a wonderful world!

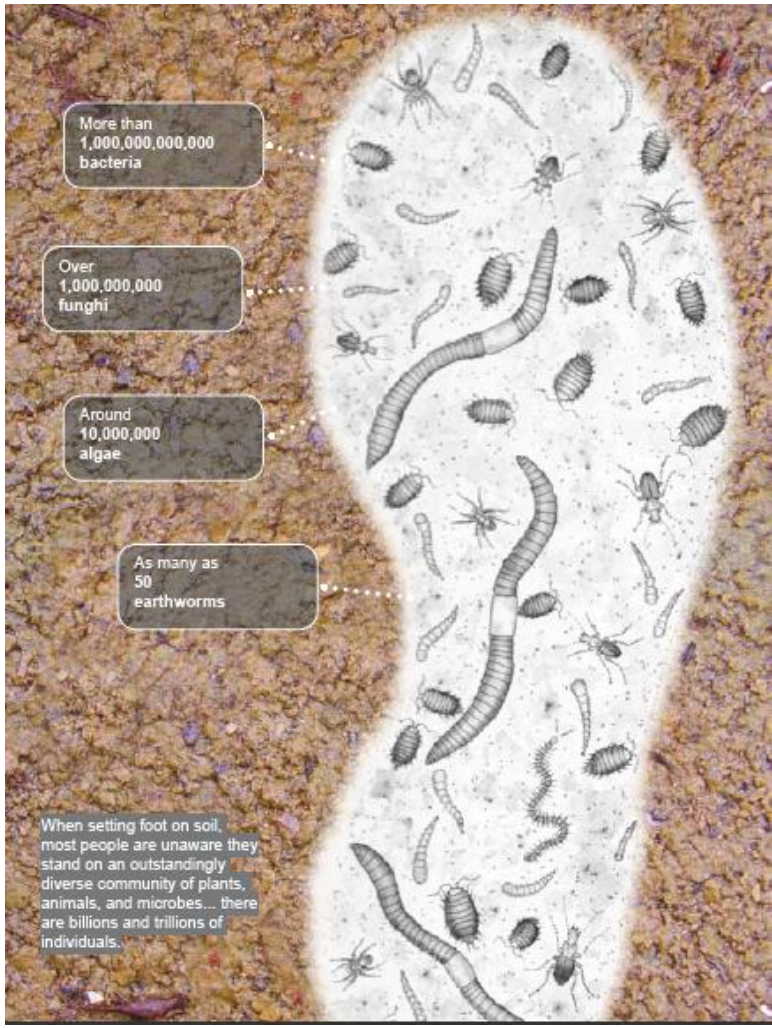
The n. of individuals under a single footprint is huge

Taxonomic group	Number of individuals	Biomass (g/m²)
Bacteria	10^{12} - 10^{14}	100 - 700
Funghi	10^{9} - 10^{12}	100 - 500
Algae	10^{6} - 10^{9}	20 - 150
Protozoa	10^{7} - 10^{9}	6 - 30
Nematodes	10^{4} - 10^{6}	5 - 50
Mites	2.10^{2} - 4.10^{3}	0.2 - 4
Springtails	2.10^{2} - 4.10^{3}	0.2 - 4
Insect larvae	up to 50	< 4.5
Diplopoda	up to 70	0.5 - 12.5
Earthworms	up to 50	30 - 200

Each member of the “soil team” performs a specific function.



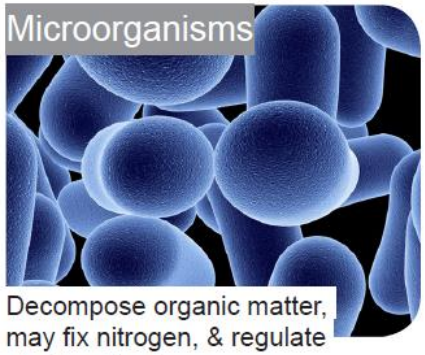
The cooperation of all team members guarantees the maintenance of soil fertility, and the diverse range of ecological services which are provided.



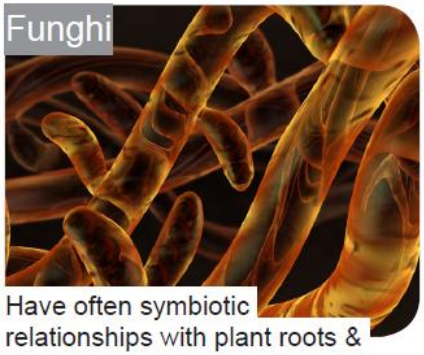
From Soil Biodiversity and Agriculture, 2010.

Key ecosystem services provided by soil organisms

- Humus formation
- Carbon cycling
- Fixation of atmospheric nitrogen
- Physical properties
- Bioturbation



Decompose organic matter, may fix nitrogen, & regulate plant nutrients.



Have often symbiotic relationships with plant roots & may decompose plant material.

Feed on dead organic material & therefore contribute to create humus.

Feed primarily on bacteria & are an import element of soil food chains.

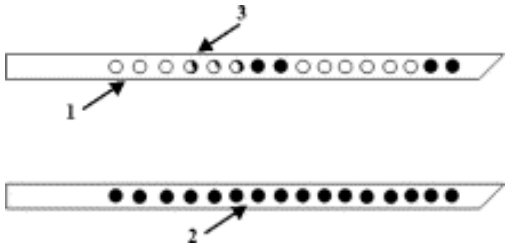
Contribute to the bioturbation of the soil and to the water balance. Earthworm burrows are an essential element of the soil pore system.

May be predators of other animals, or feed on plant material and contribute herewith to the degradation of plant material.

SOIL QUALITY AND INDICATOR SYSTEMS

Soil quality has been defined as 'The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation' (Karlen et al., 1997).

Soil quality can be evaluated using a large number of indicators (chemical, physical and biological) depending on the scale and the aim of the study.



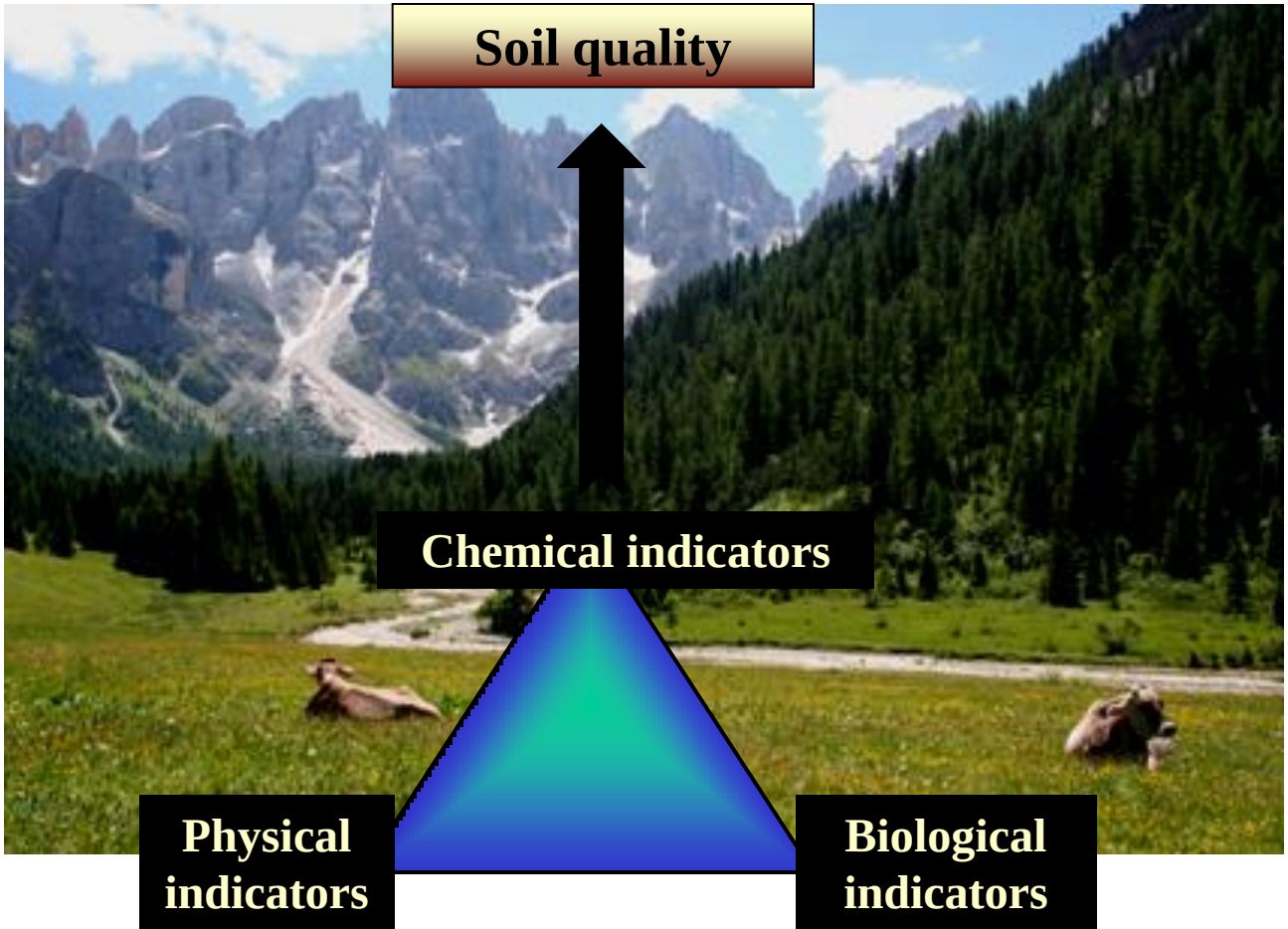
Biological monitoring is required to correctly assess soil degradation and correct risks.

There is a strong need to identify **indicators systems** able to express soil quality criteria, to be used as benchmarks in environmental remediation, as well as assess and monitor soil quality in soils subjected to degradation risk.

THERE IS NOT A “PERFECT” BIOINDICATOR

Indicators should be selected among **different levels** of biological organisation.

BIOINDICATOR SYSTEM *:* a set of indicators, each related to one particular aspect of the environment and jointly maximizing the amount of information (Van Straalen and Krivolutsky, 1996).



SOIL FAUNA: indicator of soil quality

Soil fauna meet many of the criteria asked to be useful soil indicators

- They respond sensitively to anthropogenic disturbance;
- The area covered during their life cycle is representative of the site under examination,
- Their life histories permit insights into soil ecological condition,
- Their abundance and diversity are well correlated with beneficial soil functions,
- They are useful for elucidating ecosystem processes.



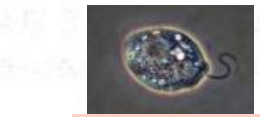


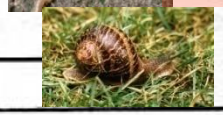

TAXA PROPOSED AS SOIL INDICATORS

- Maturity Index (MI)
- Acari/Collembola Ratio
- Oribatea/other Acari Ratio
- Biodiversity of oribatid acari
- QBS-ar and QBS-C
- Bait lamina

- Litter bags

- Pitfall





QBS-ar index

QBS-ar index: Soil Biological Quality index based on microarthropod community

Hypothesis - the higher the number of microarthropod groups well adapted to soil is, the higher soil quality will be.

QBS-ar considered soil microarthropods, separated following biological form approach

Epigeous surface dwelling form

Hemi-edaphic form

Hemi-edaphic form

Eu-edaphic form

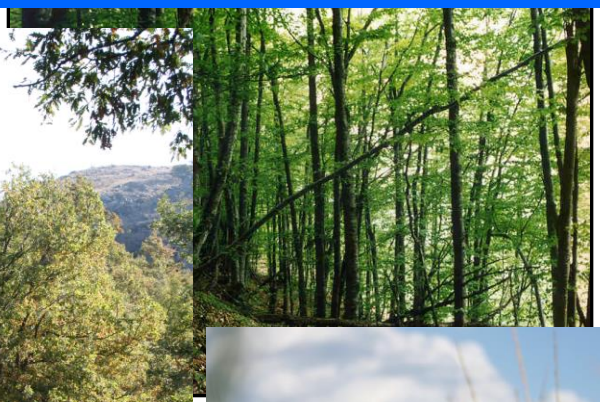
Eu-edaphic form

Overcoming the well-known difficulty of identifying the species level of edaphic mesofauna.

Parisi V., Menta C., Gardi C., Jacomini C., Mozzanica E. 2005. Microarthropod Communities as a Tool to Assess Soil Quality and Biodiversity: a new Approach in Italy. Agriculture, Ecosystems & Environment 105, p. 323-333.

Where the QBS-ar index has been applied

- Woods - beech forests, oak woods, conifers, different managements
- Wood areas burned
- Permanent grasslands
- Orchards and vineyards
- Different agricultural ecosystems (corn, wheat, beet, alfalfa, tomatoes …)
- Biological *versus* conventional agriculture
- Effects of sludge on soil biological quality
- Covered dumps
- Reclaimed lands



ExpeER project

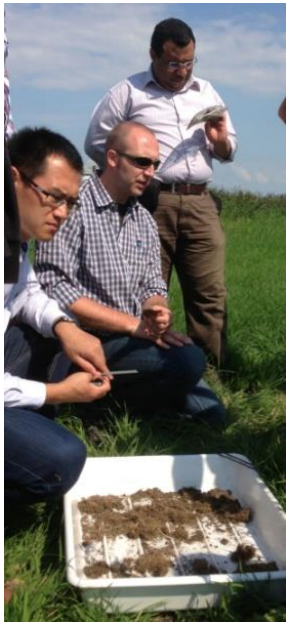
European project (2010-2014) Experimentation in Ecosystem Research: SCOPE: bringing together the major observational, experimental, analytical and modeling facilities in ecosystem science in Europe.

Selecting and developing protocols to measure data that are important indicators of the state of ecosystems states, that would be relevant to the ExpeER network and have not already been covered by international standard approaches.

http://www.expeeronline.eu/

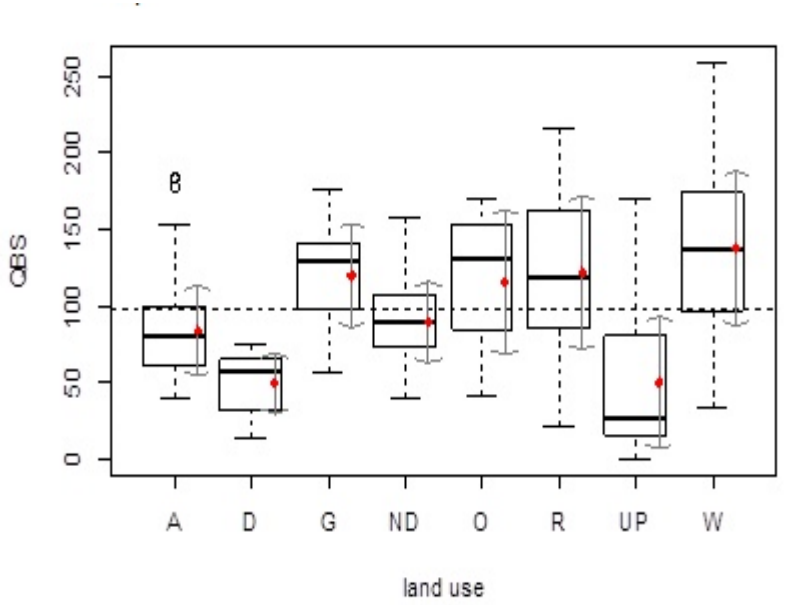
ExpeER concerned 19 countries across Europe

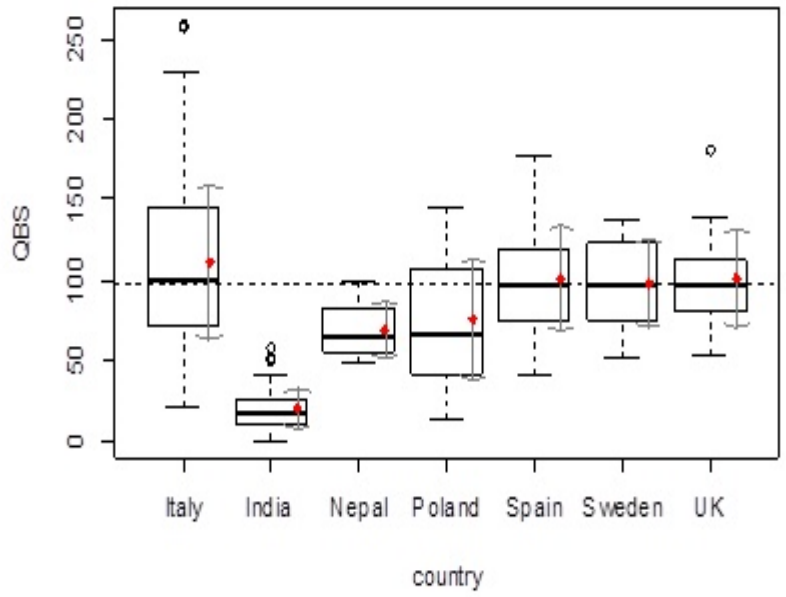
These parameters were chosen: **soil organic matter, soil nutrients, mesofauna, leaf area index, plant biomass, soil respiration, land use type and phenology.**



Firbank L.G., Bertora C., Blankman D., Delle Vedove G., Frenzel M., Grignani C., Groner E., Kertész M., Krab E.J., Matteucci G., Menta C., Mueller C.W., Stadler J., Kunin W.E., *in press.* Towards the co-ordination of terrestrial ecosystem protocols across European research infrastructures. Ecology and Evolution.

QBS-ar results at international scale





The dataset: 498 data collected from 1993 to 2015 (from 40 papers published)

Considering land uses, 8 groupages were identified:

A = Agriculture lands (several crops, till and no-tillage, organic, conventional)

W = Woods and forests (several species), Mediterranean maquis, bushes

R = Plant **remediation**, **restored** pit mine, peri-urban uncultivated areas, etc.

ND = Soils in **natural degraded** conditions (e.g. serpentine soils, soil into the brûlé etc.)

G = Permanent **grasslands**, pastures and meadows

O = Orchards

UP = Urban parks, residual urban woods, public gardens, botanical gardens, home gardens

D = Soils affected by human **degradation**.

From Menta et al., submitted

QBS-ar application in Italy

Published data.

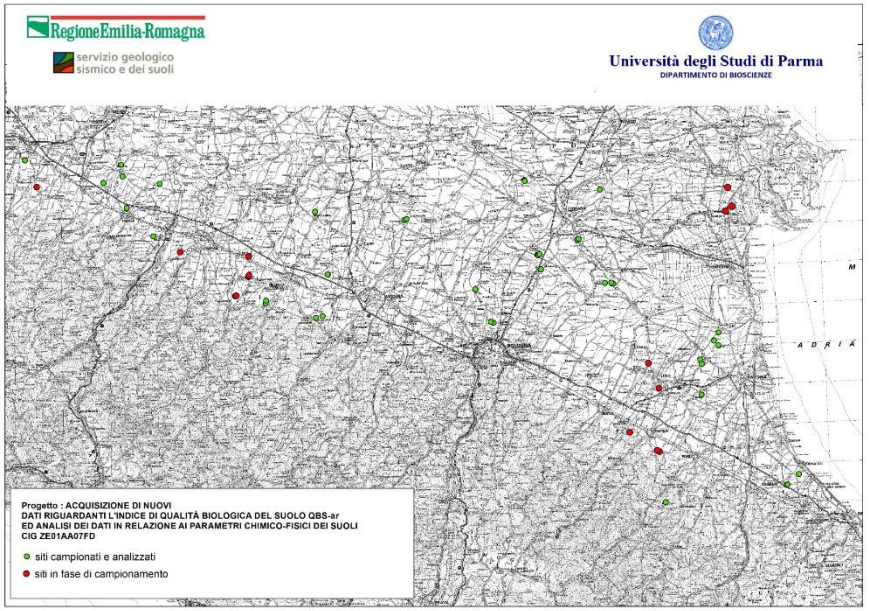
The authors know that there are collected data but they were not inserted in the computation because unpublished or un found in international databases.

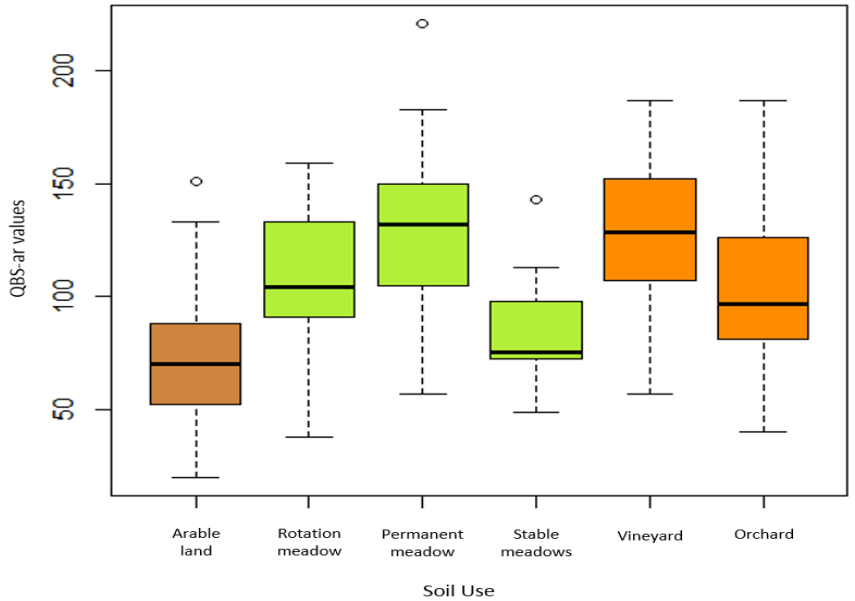
The authors weren't able to find published data.

Agricultural ecosystems
Degraded soils
Urban parks
Restored soils
Grasslands
Orchards
Woodlands

From Menta et al., submitted

QBS-ar application in the Emilia-Romagna region





Soil sampling in Spring and Autumn
- 2015: 43 sites (3 replicates per site): Piacenza, Parma, Reggio Emilia, Modena, Bologna, Ferrara, Ravenna, Forlì-Cesena provinces
- 2017: 15 sites

Soil Use	Number of sites	Croptypes	Practices
Arable Land	15	Wheat, Sorghum, Barley, Maize	Conventional Tillage, No-till, Subirrigation
Grassland	8	Alfalfa or polyphita	Rotation meadow (< 5 years)
	5	Polyphita	Permanent meadow (5-30 years)
	2	Polyphita	Stable meadow (> 30 years)
Orchard	9	Pear, Peachtrees	Integrated, Organic and Traditional farming
Vineyard	4	Grapes	Integrated, Traditional farming

From: Menta C, Bonati B, Staffilani F, Conti FD, 2017. Agriculture Management and Soil Fauna Monitoring: The Case of Emilia-Romagna Region (Italy). Agri Res & Tech: Open Access J. 4(5): 555649. DOI: 10.19080/ARTOAJ.2017.04.555649002

At the end ...

… only by knowing soil in all its complexity,
maintaining its functionality through actions aimed to protect its properties,
acknowledging the importance it assumes in the quality of life worldwide,
can we embark on a truly sustainable use of soil perceived as a resource and build a proper Man / Soil relationship to be left for future generations …

cristina.menta@unipr.it