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Italian Society of Soil Science
School of Soil Biodiversity and Bioindication
XI cycle

BIODIVERSITY AND BIOINDICATORS IN MONITORING AND MANAGEMENT OF CONTAMINATED SOILS

4 - 7 JUNE 2019

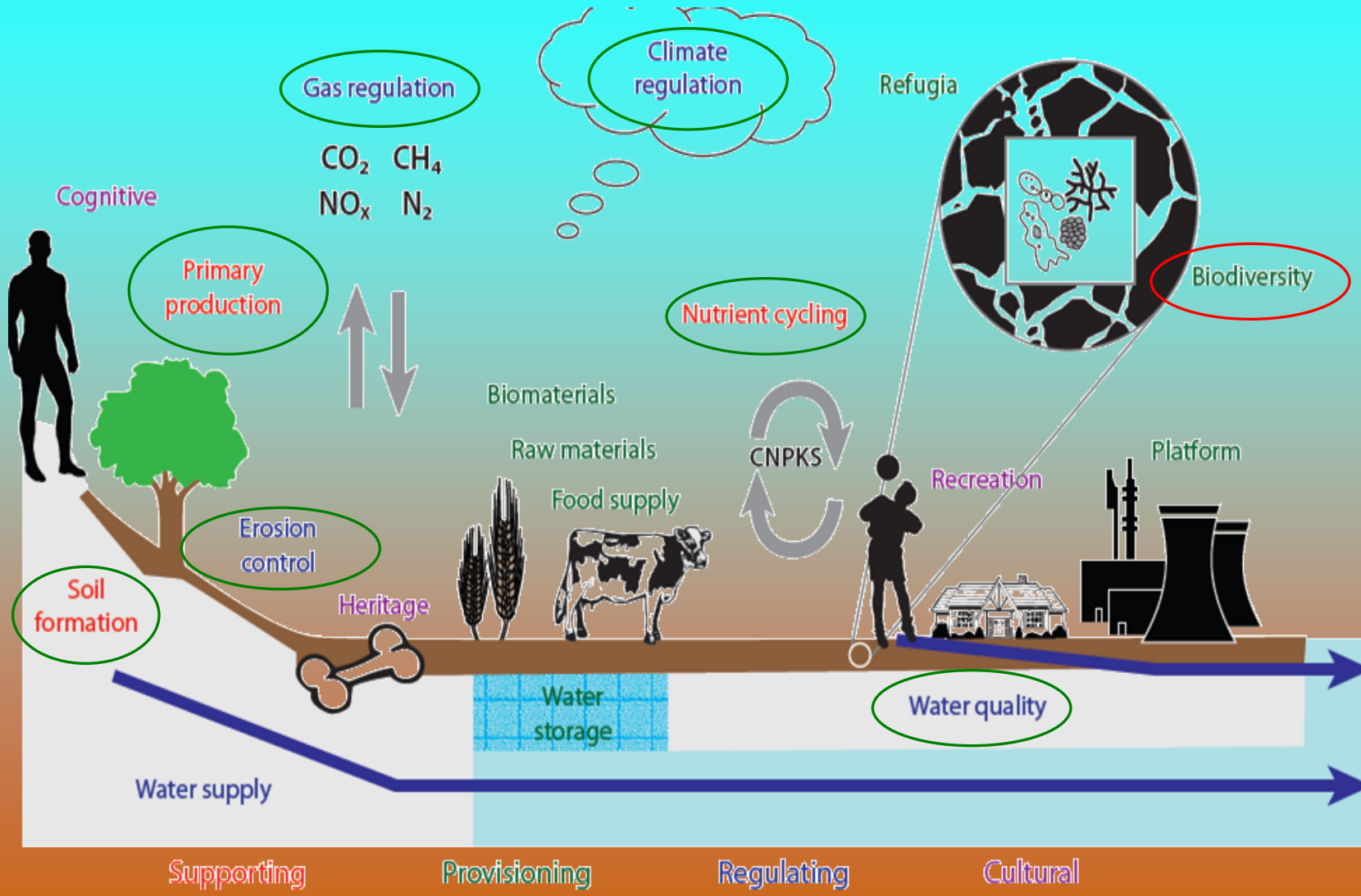
Department of Agricultural Sciences
University of Naples Federico II, Portici, Italy

Soil fauna as good tool for soil quality assessment

The application of the Soil Biological Quality QBS-ar index at international and regional scale

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

ECOSYSTEM SERVICES PROVIDED BY SOIL



From Haygarth and Ritz, Land Use Policy 2009

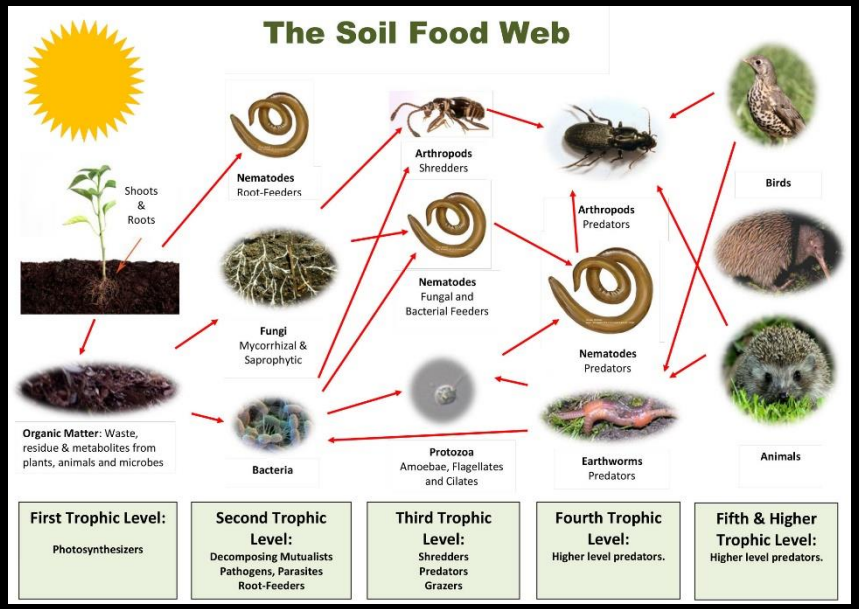
SOIL BIODIVERSITY

The multitude of **soil organisms and processes**, interacting in an ecosystem, providing society with a rich biodiversity source and contributing to a habitat for above ground organisms'.

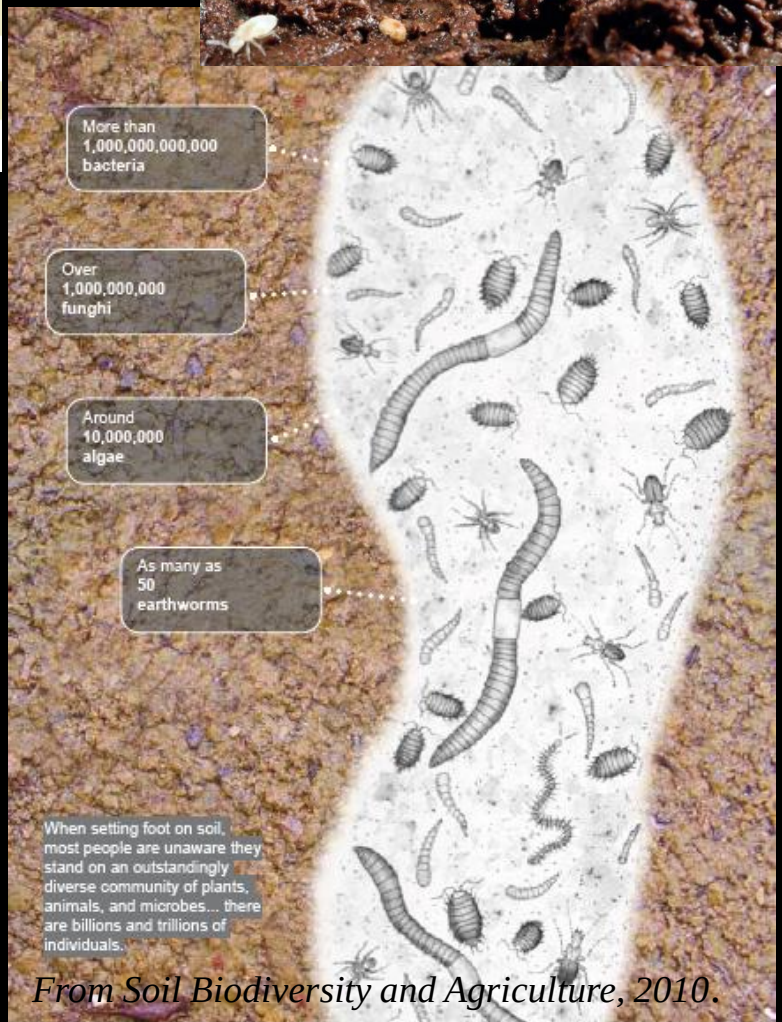
Van Leeuwen et al., in press

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.

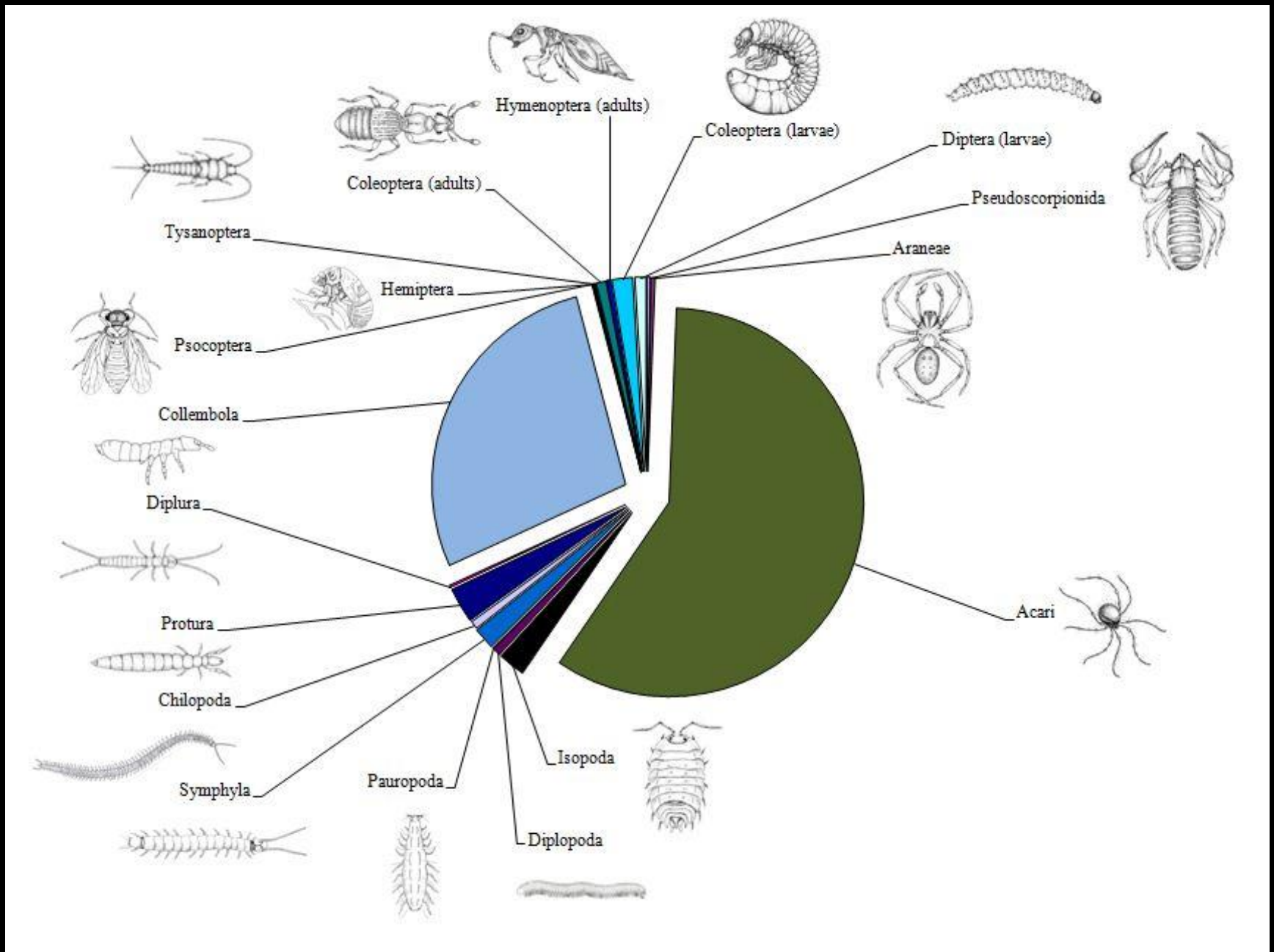


The cooperation of all team members guarantees the maintenance of soil fertility, and the diverse range of ecological services which are provided.

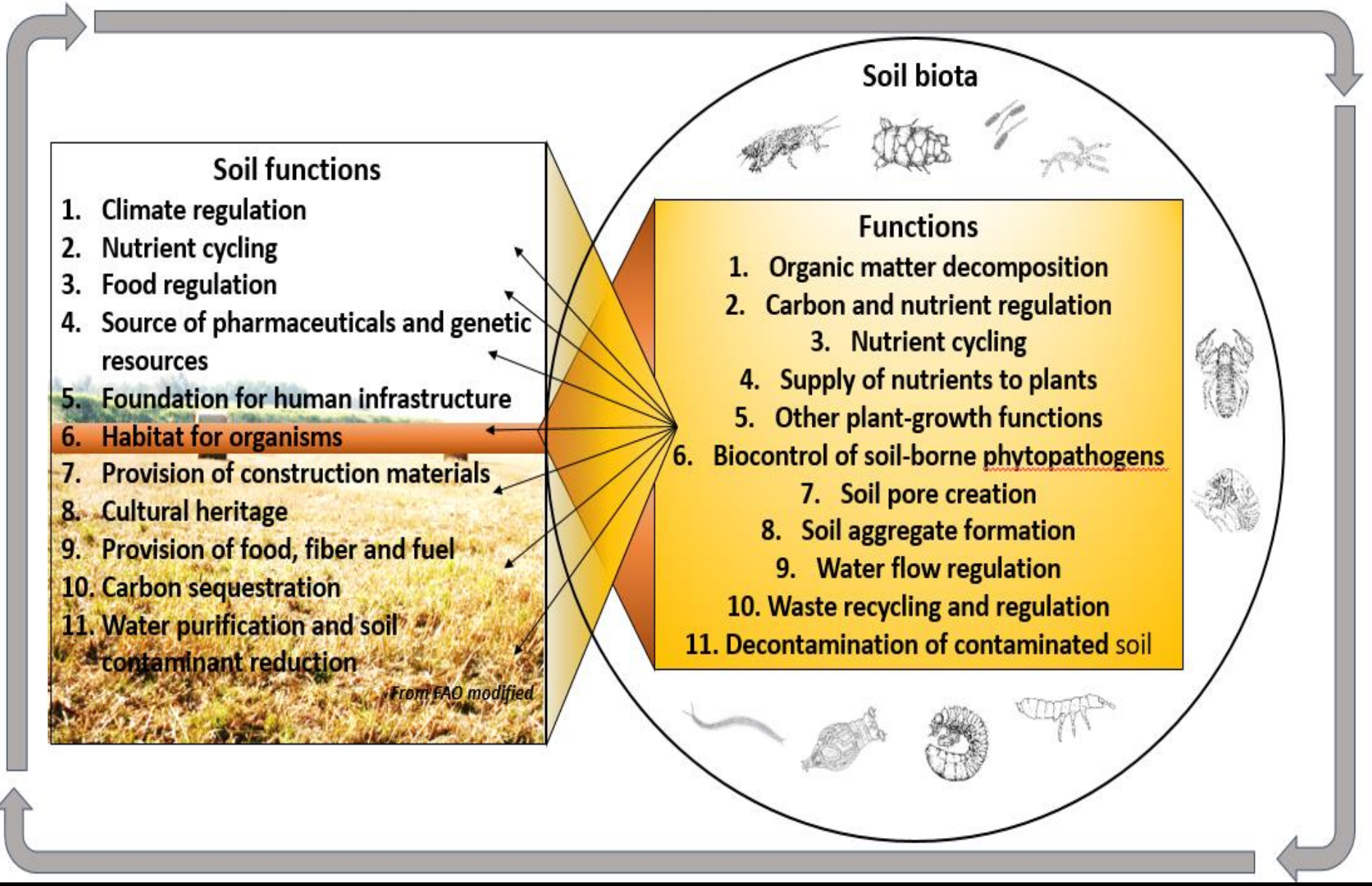


From Soil Biodiversity and Agriculture, 2010.

Soil arthropod community in a Northern Italian beech forest

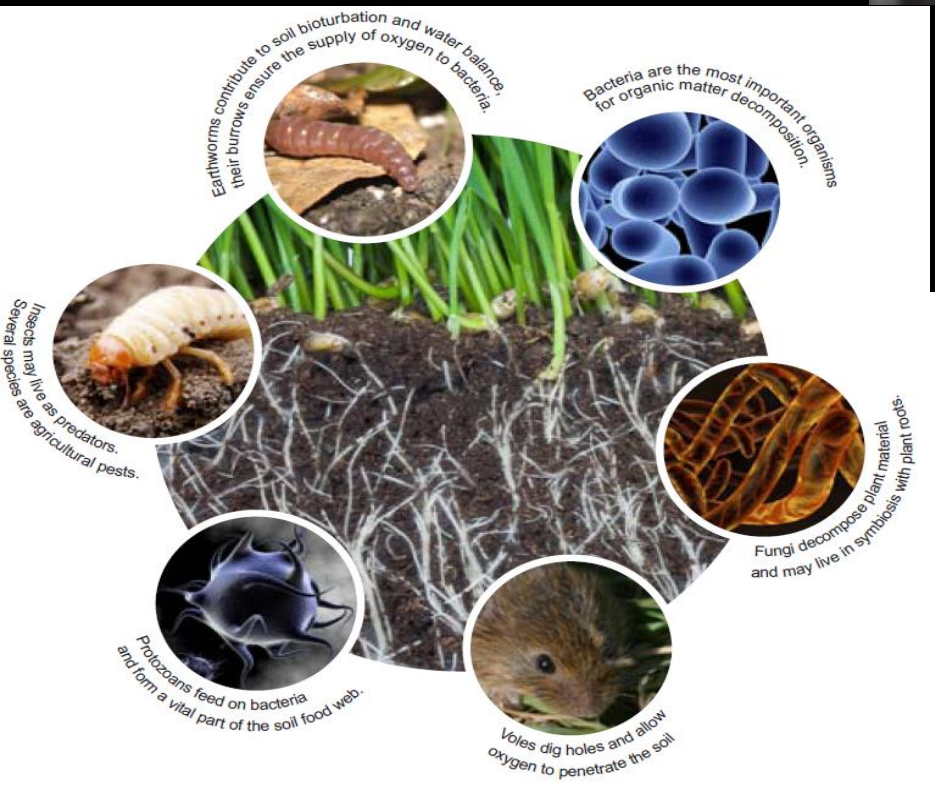


WHAT ARE THE FUNCTIONS OF SOIL BIOTA?



Organic matter decomposition

Soil fauna performs a mainly mechanical action, whereas chemical degradation is essentially performed by fungi and bacteria, both free and intestinal symbionts of other organisms.



Ecosystem engineers

Biological process	Epigeic	Endogeic	Anecic
Aggregation at the soil surface	high	low	high
Aggregation within the soil profile	low	high	low
Formation of biopores	low	high	high
Decomposition - surface residues	high	low	high
Decomposition - subsurface residues	low	high	low
Carbon sequestration	low	high	low
Nutrient mineralisation	high	high	high
Nutrient loss	low	low	high
Microbial activity	high	high	high
Primary production	low	high	high

Life strategies and relationship with soil

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ADAPTATION TO SOIL OF SOIL FAUNA

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- Reduction or loss of pigmentation
- Reduction or loss of eyes
- Streamlined body form
- Reduced and more compact hairs, antennae, legs
- Reduction or loss of flying, jumping or running adaptations
- Reduced water-retention capacity

Adaptation to soil makes soil animals unable to leave it

Effects: **more sensitive** to the change of physical and chemical parameters caused by natural or human activities.

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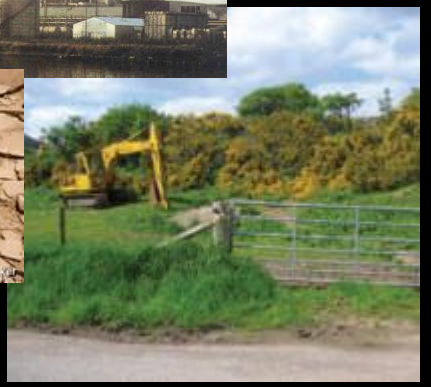
Abundance, biomass and species diversity of soil fauna are influenced by a wide range of human practices

Human activities frequently cause a degradation and pollution of soil

- Reduction of soil biota abundance and biodiversity
- Simplification of soil living communities
- Loss of ecosystem services provided by soil biota



Agricultural ecosystems

- Tillage
- Treatment of pasture and crop residues
- Crop rotation and cover crops
- Pesticides, fertilisers, manure, sewage
- Drainage and irrigation
- Vehicle traffic

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QBS-ar index
MESOFAUNA (0.2-10 mm) - MICROARTHROPODS

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Classification of soil fauna according to size (length)

MICROFAUNA

MESOFAUNA

MACROFAUNA

Insecta

Opiliones

Chelonethi

Diplura

Protura

Collembola

Araneida

Acari

Chilopoda

Diplopoda

Insectivora

Tardigrada

Isopoda

Rotifera

Mollusca

Protozoa

Enchytraeidae

Nematoda

Lumbricidae

0·02 0·04 0·08 0·16 0·32 0·64 1·3 2·6 5·2 10·4 20·8 41·6 83·2

mm

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QBS-ar index

Soil Biological Quality index based on microarthropod community

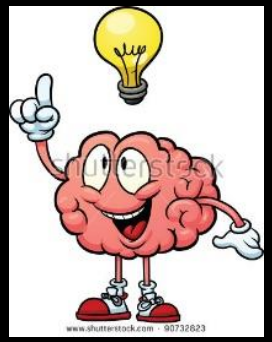
Parisi V., Menta C., Gardi C., Jacomini C., Mozzanica E. 2005. Microarthropod Communities as a Tool to Assess Soil Quality and Biodiversity: a new Approach in Italy. Agriculture, Ecosystems & Environment 105, p. 323-333.







Idea: higher number of microarthropod groups well adapted to soil in soil with "good quality"



Epigeous surface dwelling form

Hemi-edaphic form

Hemi-edaphic form

Eu-edaphic form

Eu-edaphic form

Eco-morphologic indices (EMIs) of edaphic microarthropod groups[a]

Group	EMI score
Protura 	20
Diplura	20
Collembola 	1–20
Microcoryphia	10
Zygentomata	10
Dermaptera	1
Orthoptera	1–20
Embioptera	10
Blattaria	5
Psocoptera	1
Hemiptera	1–10
Thysanoptera	1
Coleoptera	1–20
Hymenoptera	1–5
Diptera (larvae)	10
Other holometabolous insects (larvae)	10
Other holometabolous insects (adults)	1
Acari	20
Araneae	1–5
Opiliones 	10
Palpigradi	20
Pseudoscorpiones	20
Isopoda	10
Chilopoda 	10–20
Diplopoda	10–20
Pauropoda	20
Symphyla 	20

Microarthropods are separated following biological form approach overcoming the well-known difficulty of identifying the species level of edaphic mesofauna.

Epi-edaphic forms EMI = 1

Eu-edaphic forms EMI = 20

Hemi-edaphic forms EMI 1-20 in relation to the degree of soil adaptation

QBS-ar APPLICATION

1) SOIL SAMPLING

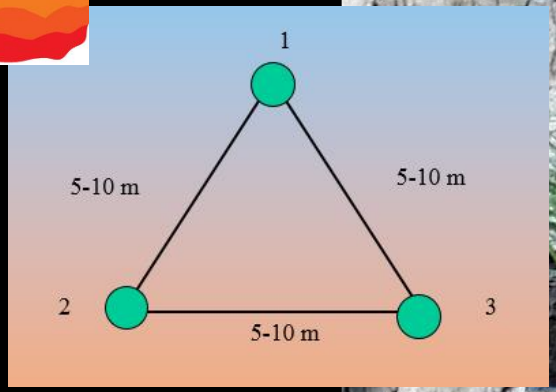
2) MICROARTHROPOD EXTRACTION

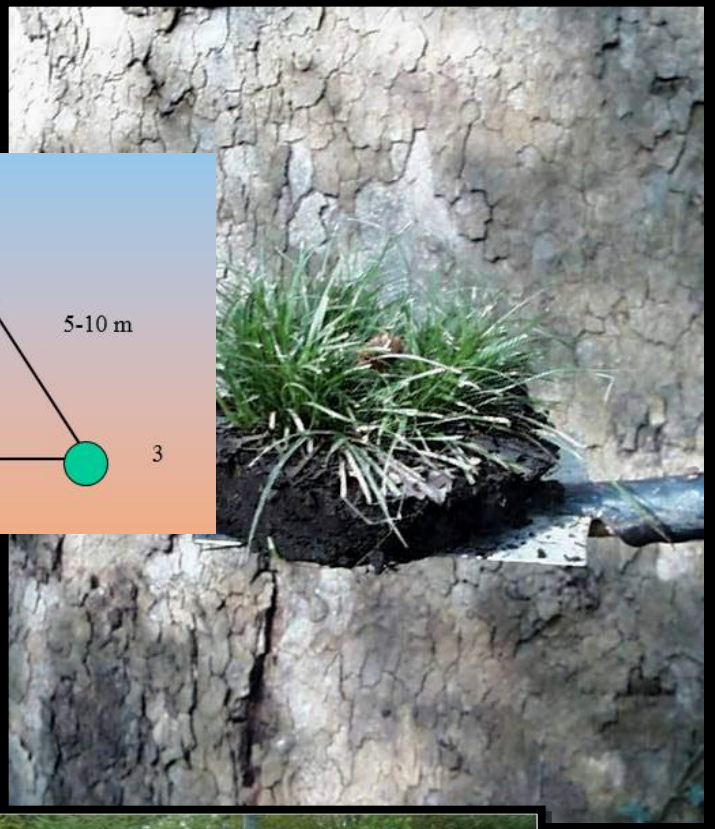
3) TAXA DETERMINATION AND EMI APPLICATION

1) SOIL SAMPLING

CLIMATE CONDITION

Geographical coordinates





FIELD ACTIVITIES

1- Cut the grass on the soil surface

2 -Using a spade, make four clean cuts (drawing a square) down to 10 cm in depth.

3- Using the spade, take the soil sample and put it in a plastic bag.

4- Close the plastic bag retaining 30% of the air volume

5- Label the plastic bag with “sample area, date, sample code and replication number”

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2) MICROARTHROPOD EXTRACTION

Not later than 48 hours from the sampling

Berlese-Tullgren funnel:

- a lamp (40-60 W) placed at 30 cm far from the sample
- a sieve (mesh of 2 mm, 20 cm in diameter)
- a funnel (plastic or glass)
- a container with 2/3 alcohol and 1/3 glycerol

Extraction TIME - 7 -10 days

	AREA 1			
	R1	R2	R3	QBS-ar max
Pseudoscorpions	20	20		20
Araneae				
Acari	20	20	20	20
Isopoda				
Diplopoda	10	20		20
Pauropoda	20	20	20	20
Symphyla		20		20
Chilopoda		20	10	20
Protura				
Diplura		20		20
Collembola	20	20	20	20
Hemiptera	1	1		1
Thysanoptera			1	1
Coleoptera	1	10	5	10
Hymenoptera	5	5		5
Diptera		1		1
Coleoptera (larvae)	10	10	10	10
Diptera (larvae)				
Hymenoptera (larvae)				
Lepidoptera (larvae)	10			10
QBS-ar	**117**	**187**	**86**	**198**

QBS-ar

Soil sample

Area (QBS-ar max)

Where the QBS-ar index has been applied

Woods: beech forests, oak woods, conifers .. different managements

Burned woods

Permanent grasslands

Orchards and vineyards

Different agricultural crops (corn, wheat, beet, alfalfa, tomatoes …)

Biological *versus* conventional agriculture

Urban parks

Effects of sludge

Covered dumps and reclaimed areas

Contaminated soils (metals, hydrocarbons …)

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In Italy

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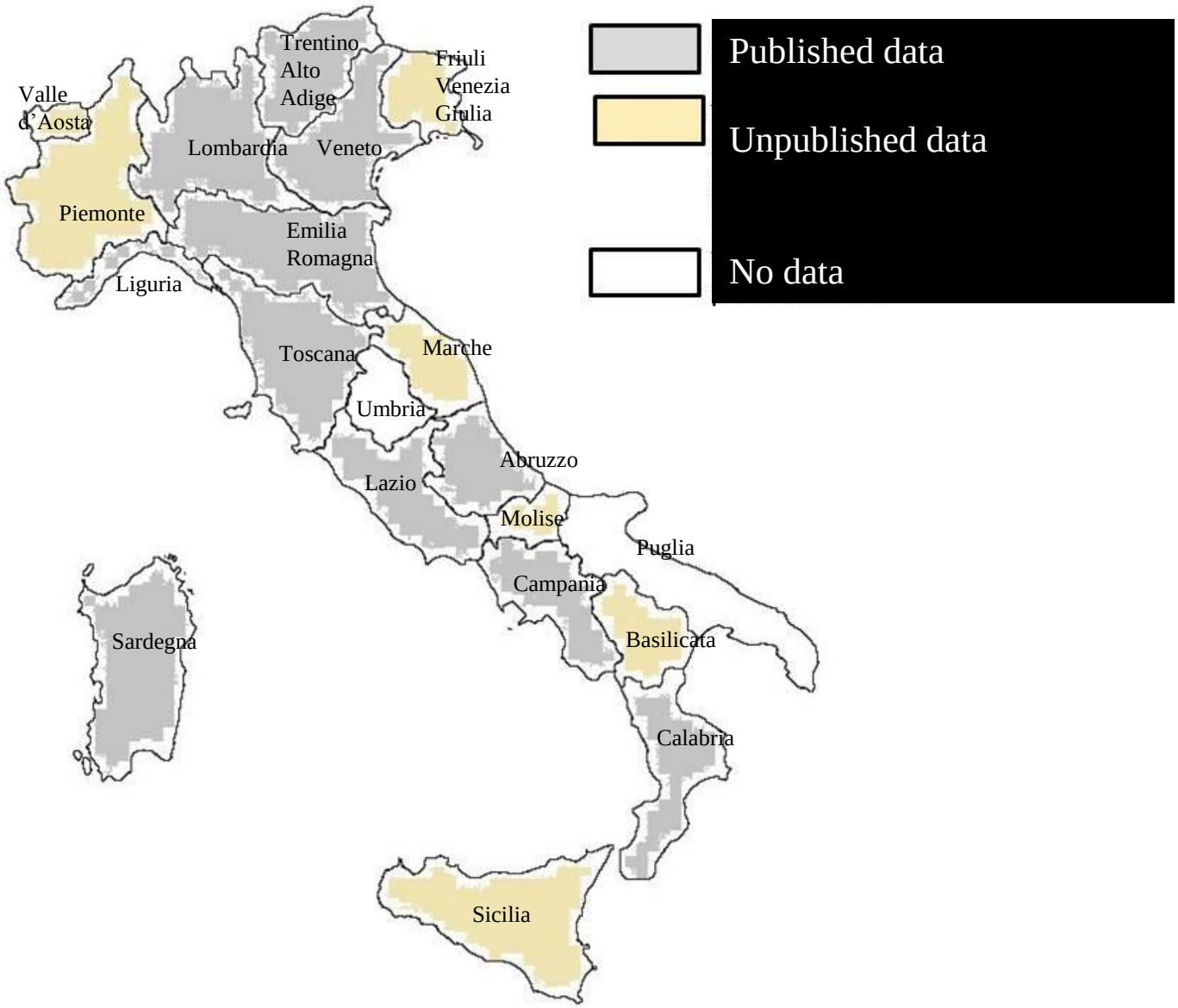
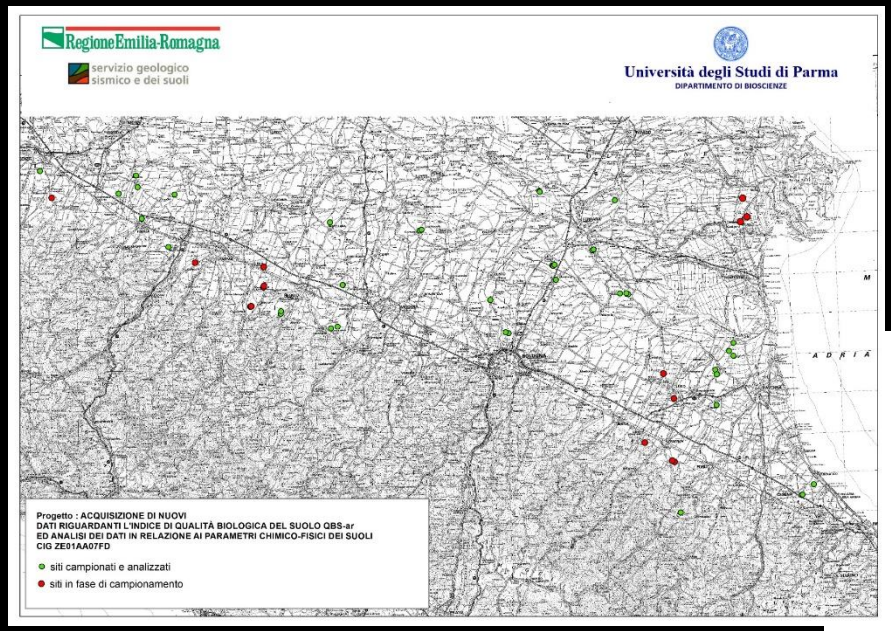
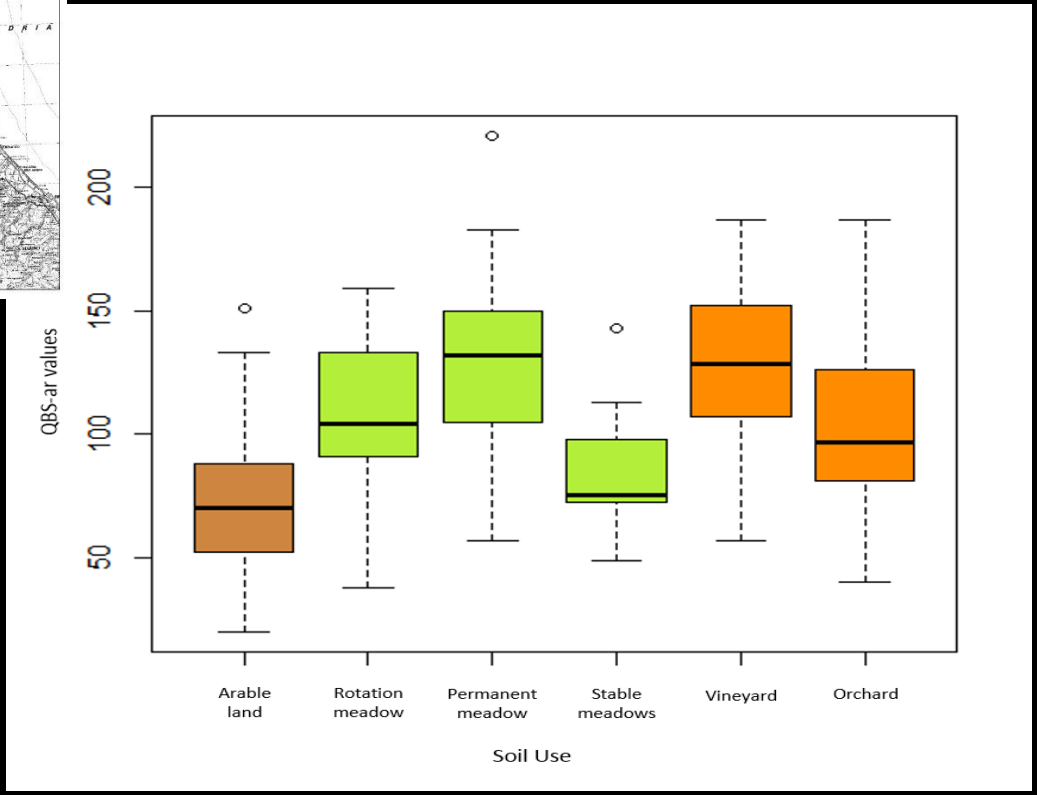


QBS-ar application in the Emilia-Romagna region



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



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.

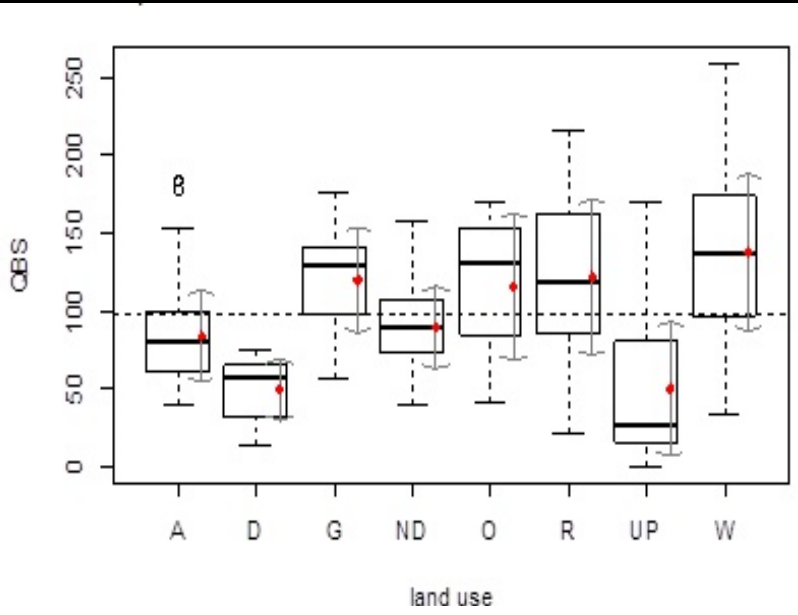
QBS-ar index at international scale

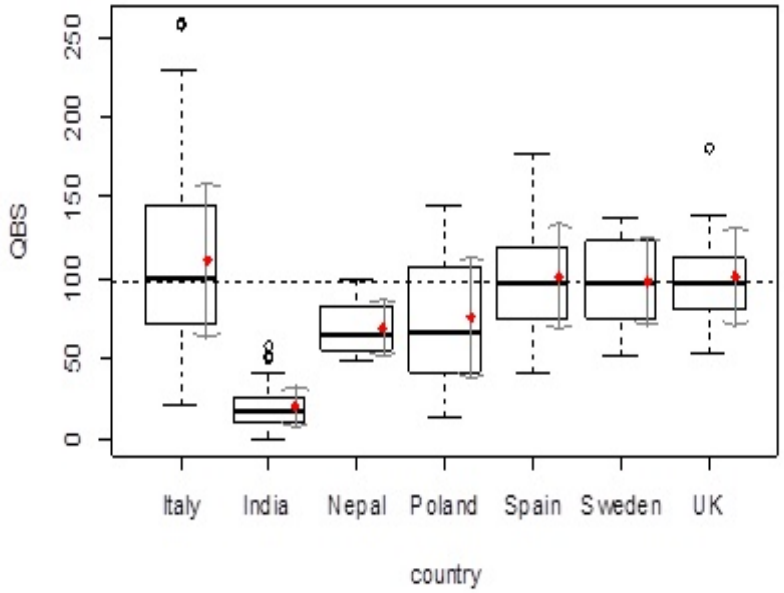
41 papers published

498 data collected

Period: from 1993 to 2015

7 countries





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

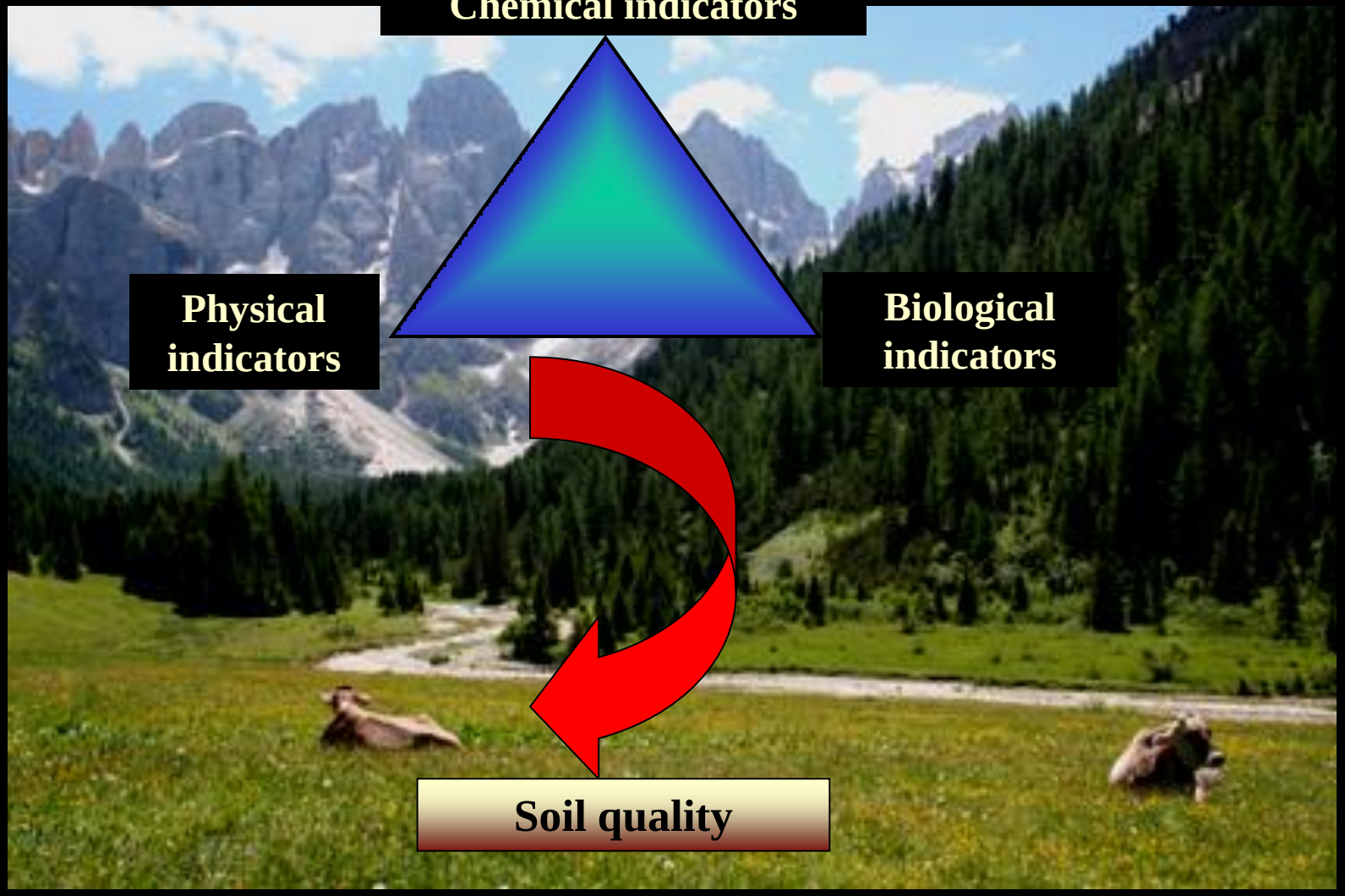
O = Orchards

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

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

Menta C., Conti F.D., Pinto S., Bodini A., 2018. Soil Biological Quality index (QBS-ar): 15 years of application at global scale. Ecol. Indic. 85, 773-780.

Indicators should be selected from **different levels** of biological organisation (Van Straalen, 1998) → ***Bioindicator system***



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ExpeER Ecosystem Research

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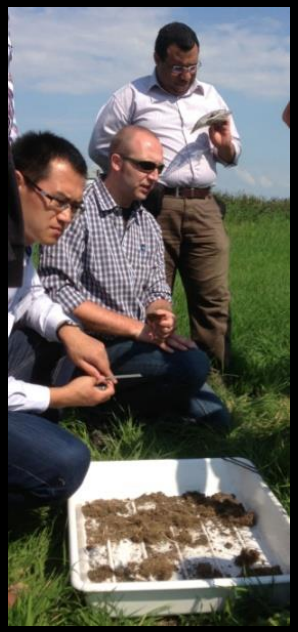
ExpeER - Experimentation in Ecosystem Research –

Dec 2010-May 2015

European project which aimed to bring together the major observational, experimental, analytical and modelling facilities in ecosystem science in Europe.

35 research institutes and universities from 19 countries across Europe.

Parameters: **soil organic matter, soil nutrients, mesofauna (QBS-ar), 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., 2017. Towards the co-ordination of terrestrial ecosystem protocols across European research infrastructures. Ecology and Evolution, 7(11), 3967-3975.

Web site: http://www.expeeronline.eu/

We can't breathe, eat, drink, or be healthy without sustainably managing soils.

Wall & Six, Science, 2015

Grazie per l'attenzione!

E-mail: ***cristina.menta@unipr.it***

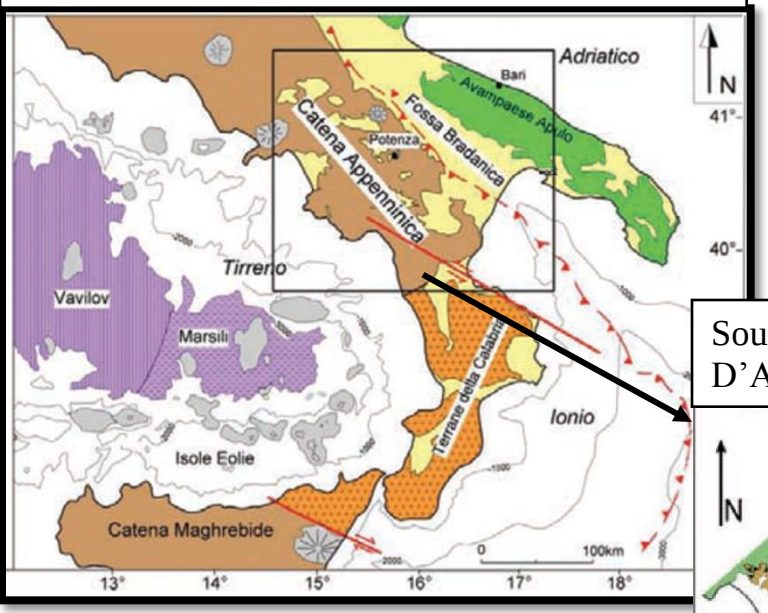
Effects of natural hydrocarbon seepages on soil fauna biodiversity

A case of study

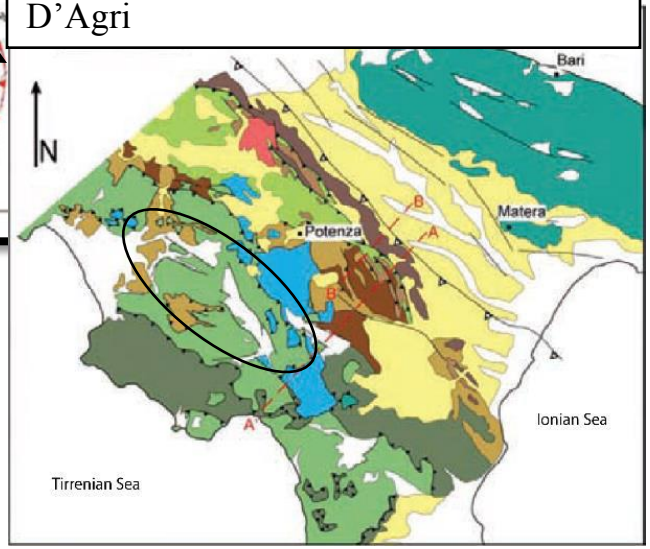
Sara Remelli
University of Parma

Area of study

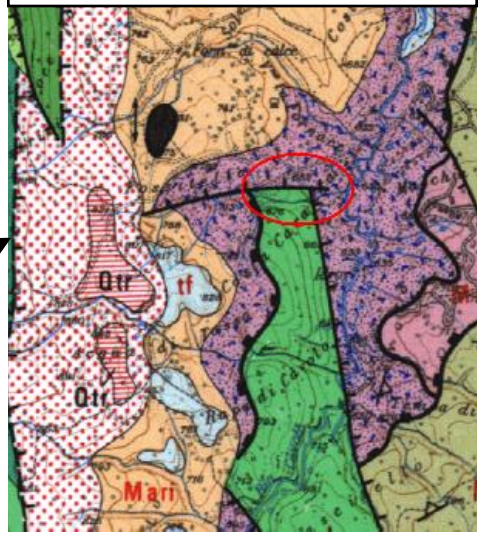
A strip parallel to the Apenninic chain

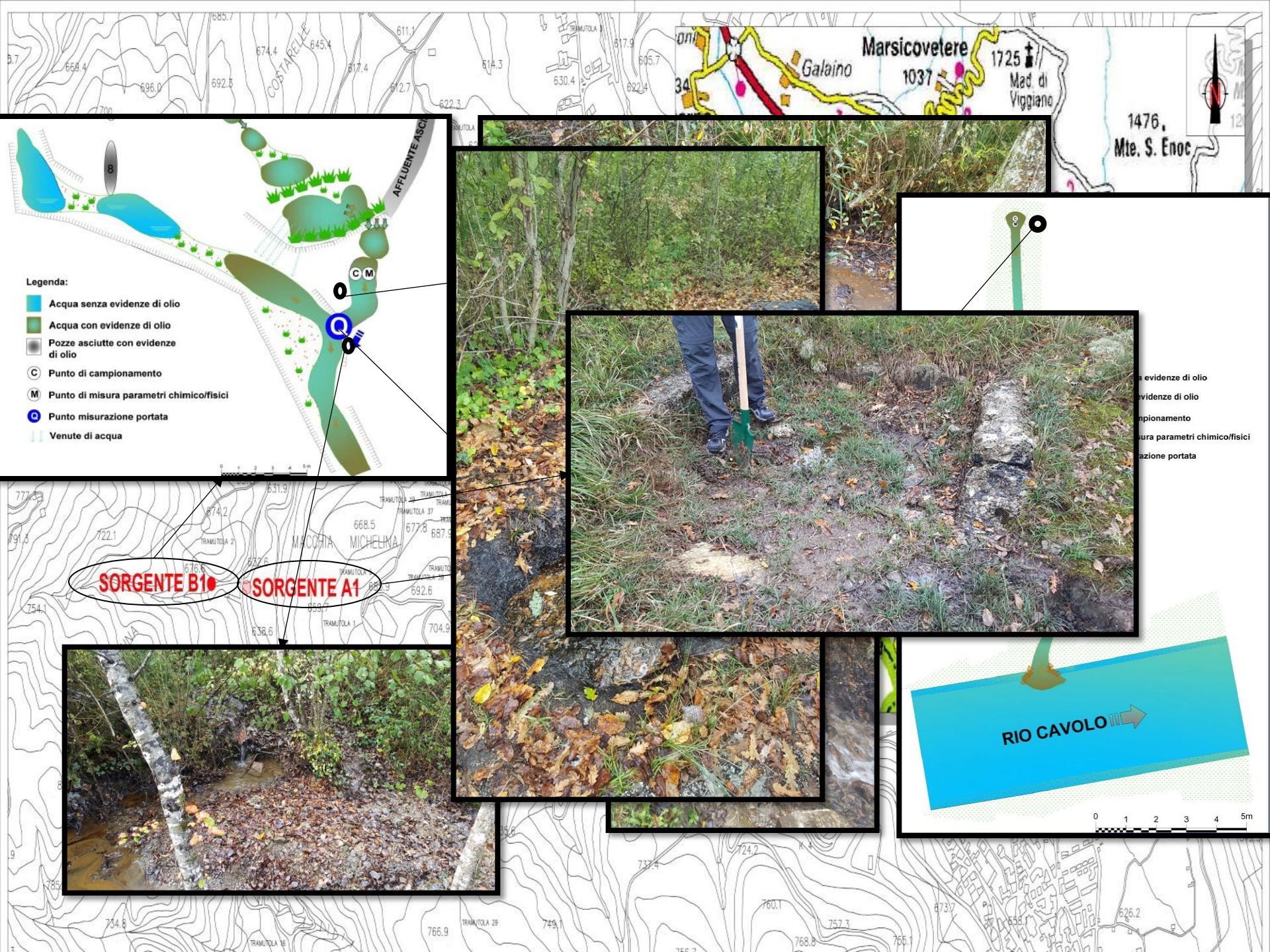


South Appennine Thrust Belt: Val D'Agri



2 km west to Tramutola: tectonic fault zone




Marsicovetere
Galaino
1725
Mad. di Viggiano
1037
1476,
Mte. S. Enoc
AFFLUENTE ASC
8
C
M
Legenda:
Acqua senza evidenze di olio
Acqua con evidenze di olio
Pozze asciutte con evidenze di olio
Punto di campionamento
Punto di misura parametri chimico/fisici
Punto misurazione portata
Venute di acqua
SORGENTE B1
SORGENTE A1
RIO CAVOLO
0 1 2 3 4 5m

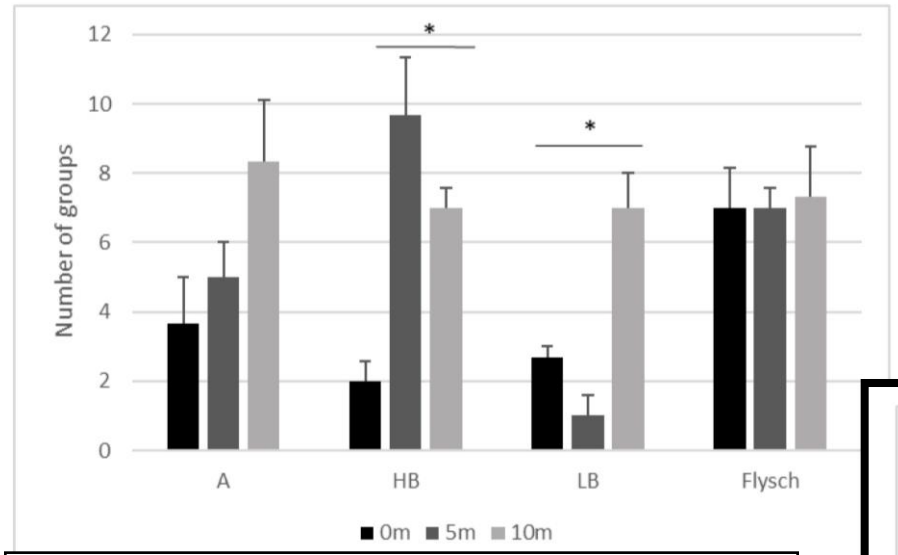
HB – Up stream

Flysch

A

LB – Down stream

- **4 sites**
  - **3 spots x site**: moving away from the seepage at intervals of about 5 m along the transect: 0m;5m and 10m
    - **3 replicates x spot**
      - **Microarthropods extraction** with Berlese–Tüllgren funnel in 3:1 ethyl alcohol:glycerol solution

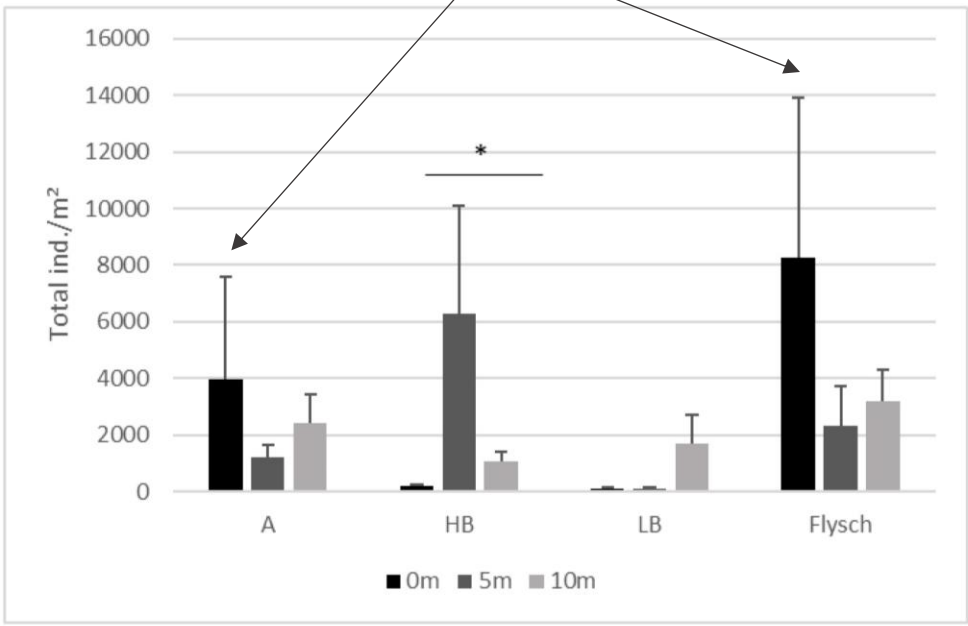


N° of groups generally increased along the transcect

Most abundant groups:

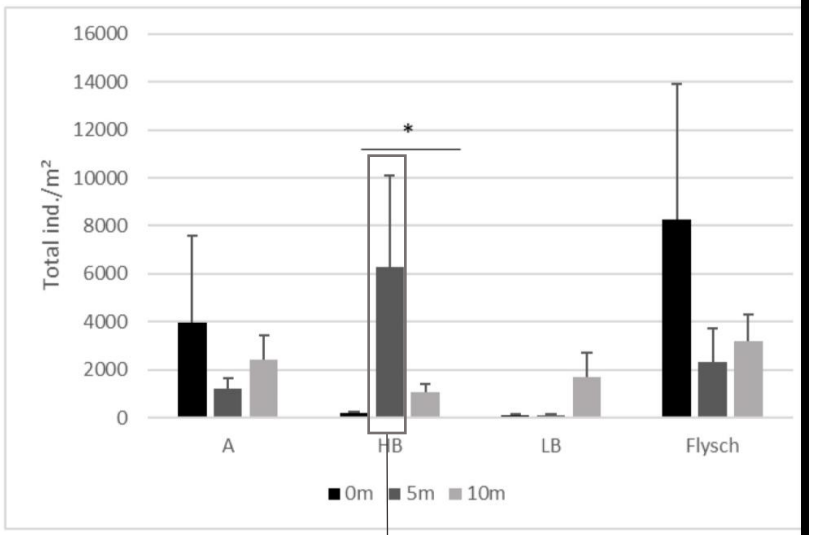
- Collembola
- Acari
- Diptera larvae

Higher n° of individuals/m² near the seepage

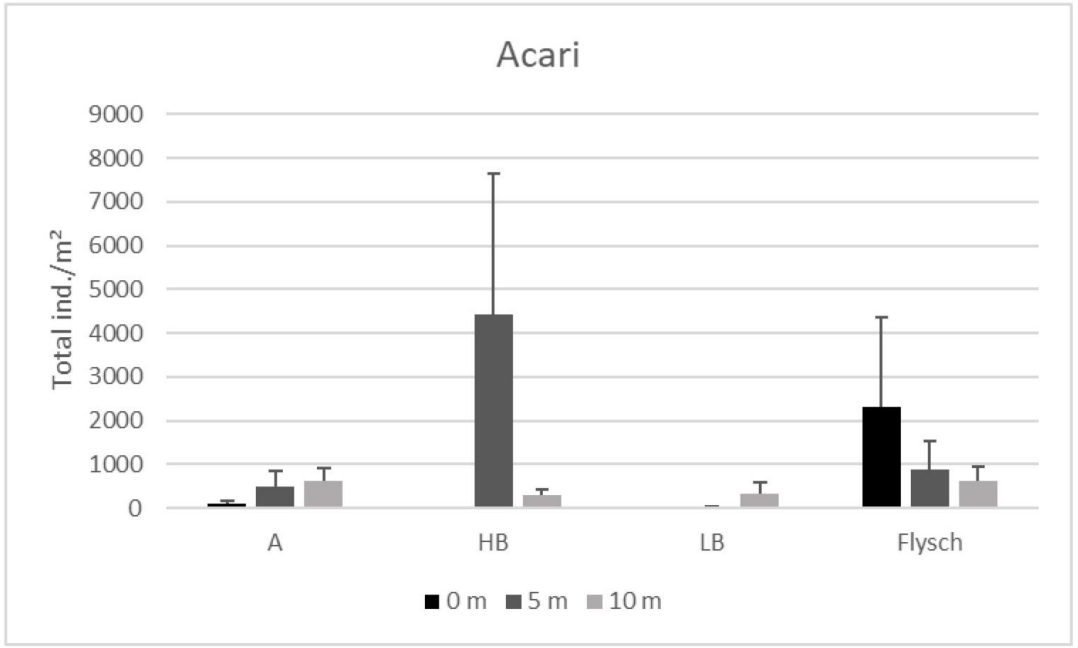


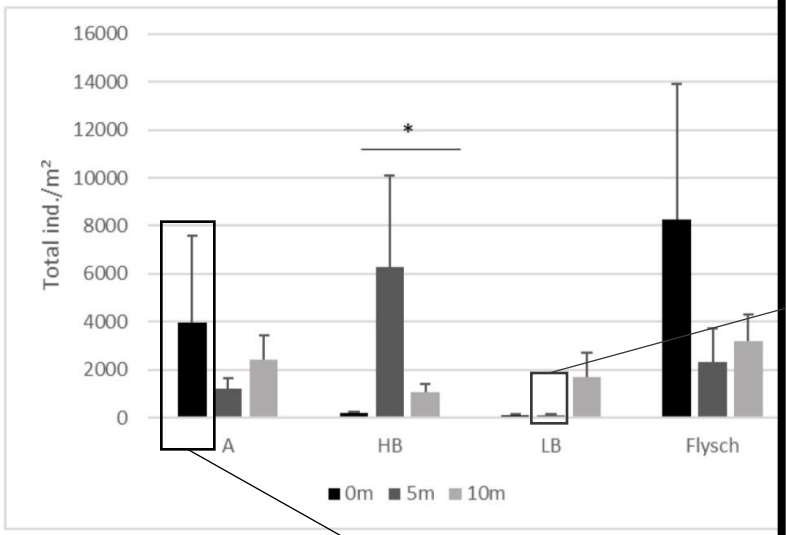
Similar faunal composition:

- Within a given site: 5m and 10 m
- Between transects of the different sites:
  - 5m and 10m
  - 0m for HB and LB



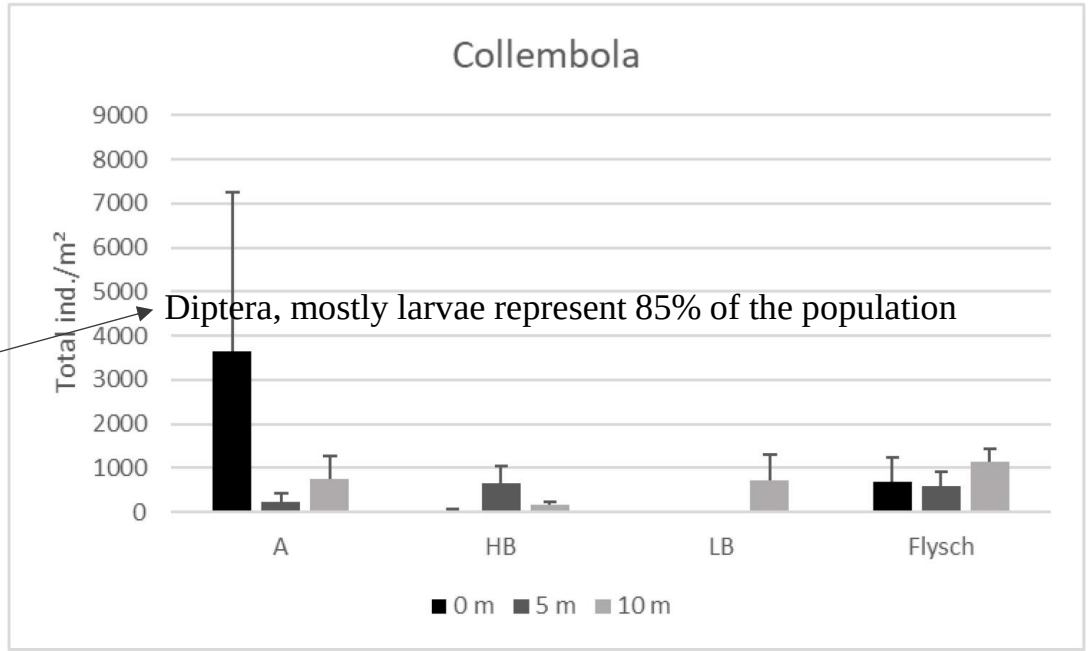
70% of the total HB-5m faunal composition





90% of the total A-0m faunal composition

Diptera, mostly larvae represent 85% of the population



The distribution of soil fauna reflects changes in habitat

- N° of groups increased moving away from the seepages

  $\Rightarrow$biodiversity is the most affected parameter
- Higher abundance was near the seepage A and the disused oil-well
  - Collembola: increased with some hydrocarbon contaminants,
  - Acari: corresponding to great biodiversity, and presence of litter and decomposition
  - Dipteran larvae: corresponding to lower biodiversity, maybe reduction of predators and competitors
- Fauna composition suggest that a greater presence of hydrocarbons may have allowed the dominance of some groups over the others

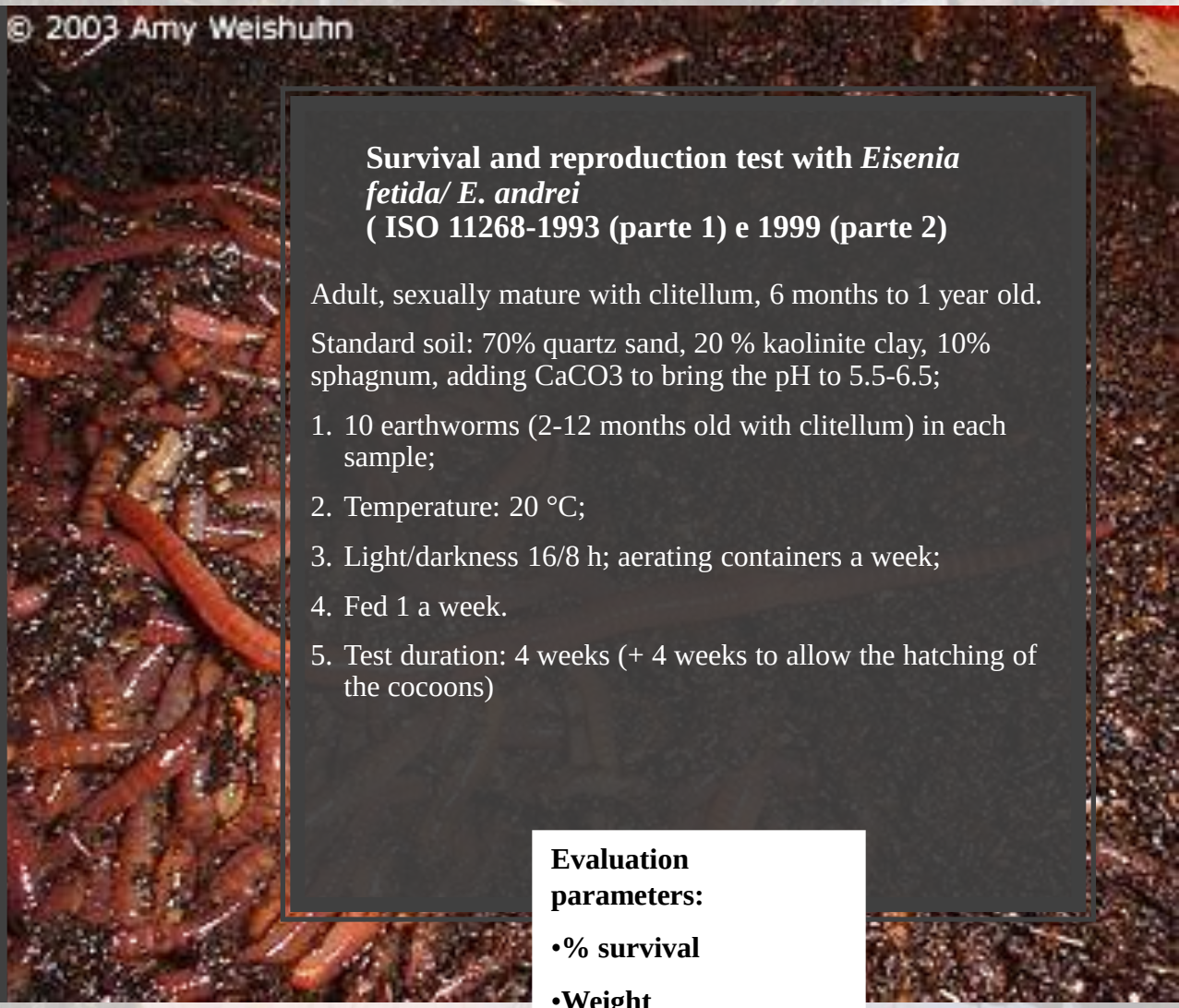
Reproduction test with *Folsomia candida* ISO 11267-99

Standard soil: 70% quartz sand, 20 % kaolinite clay, 10% sphagnum, adding $CaCO_3$ to bring the pH to 5.5-6.5;

- 10 springtails (10 to 12 day old) in each Petri dish;
- Temperature of 18-20 °C;
- Duration of the test: 4 weeks;
- Fed with granulated dry yeast.

Evaluation parameters:

Surviving springtails and juveniles



Survival and reproduction test with *Eisenia fetida/ E. andrei*
(ISO 11268-1993 (parte 1) e 1999 (parte 2)

Adult, sexually mature with clitellum, 6 months to 1 year old.

Standard soil: 70% quartz sand, 20 % kaolinite clay, 10% sphagnum, adding $CaCO_3$ to bring the pH to 5.5-6.5;

1. 10 earthworms (2-12 months old with clitellum) in each sample;
2. Temperature: 20 °C;
3. Light/darkness 16/8 h; aerating containers a week;
4. Fed 1 a week.
5. Test duration: 4 weeks (+ 4 weeks to allow the hatching of the cocoons)

Evaluation parameters:

•% survival

•Weight

Thanks for the attention