Mountain Soil Biodiversity

Ciro Gardi

Joint Research Centre (JRC)
IES - Institute for Environment and Sustainability
Ispra - Italy

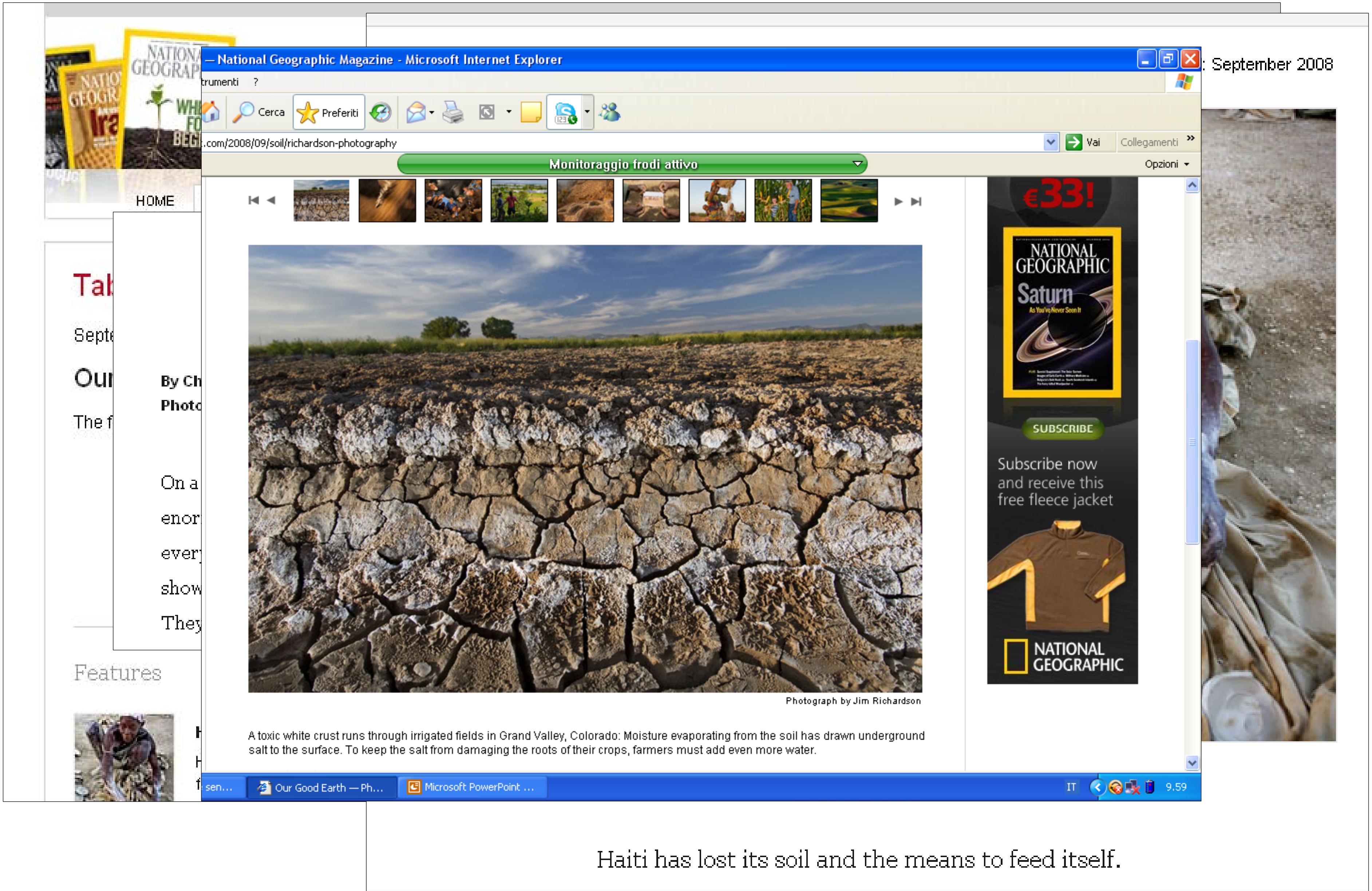
http://ies.jrc.ec.europa.eu/
http://eusoils.jrc.ec.europa.eu/library/themes/biodiversity/

2010 International Year of Biodiversity

EUROPEAN COMMISSION

INCREASING INTEREST ON SOIL

Institute for Environment and Sustainability



COMMUNICATION COM(2006) 231 on the Thematic Strategy for Soil Protection

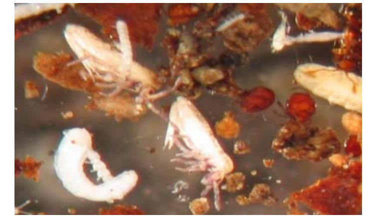
DIRECTIVE COM(2006) 232 establishing a framework for the protection of soil and amending Directive 2004/35/EC

IMPACT ASSESSMENT SEC(2006) 620 of the Thematic Strategy for Soil Protection

SOIL ECOSYSTEM SERVICES

- Food and other biomass production
- Environmental Interaction: storage, filtering, and transformation
- **Biological habitat and gene pool**
- Source of raw materials
- Physical and cultural heritage
- Platform for man-made structures: buildings, highways

Threats to soil



Soil biodiversity decline

Sealing

Erosion

Organic matter decline

Compaction

Salinisation

Landslides

Contamination

WHAT DO WE MEAN BY SOIL BIODIVERSITY ?

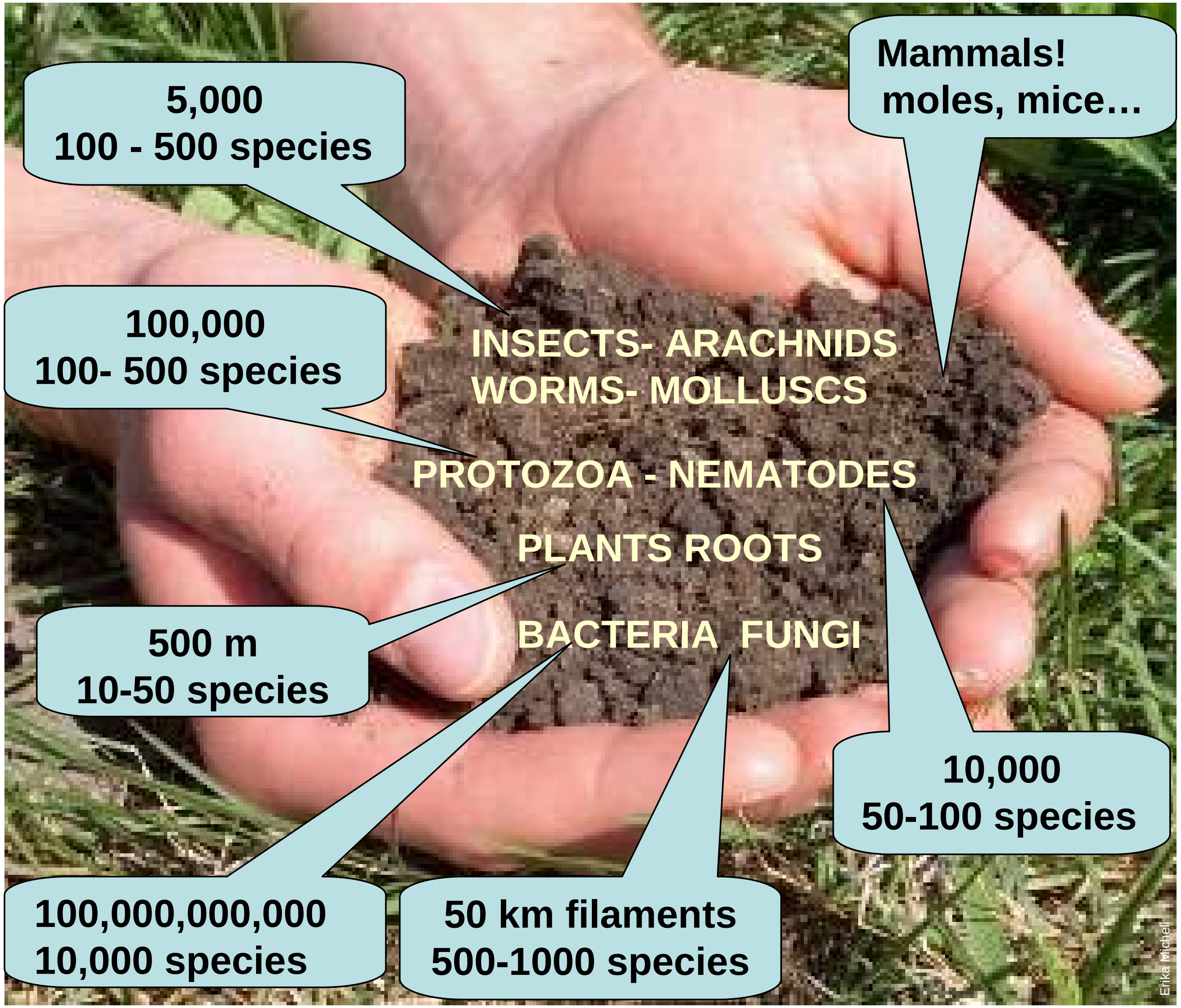
- The range of organisms present in soil

- The variety and variability among living organisms and the ecological complexes in which they occur

Smaller → Larger

Microfauna	Mesofauna	Megafauna
Size range 1-100 µm	*Size range 100 µm – 2 mm*	*Size range > 2 mm*
Bacteria: 100 billion cells from 10,000 species	**Tardigrades:**	**Earthworms:**
Fungi: 50 km of hyphae from 500's of species	**Collemobla:**	**Ants:**
Protozoa: 100,000 cells from 100's of species	**Mites:**	**Woodlice:**
Nematodes: 10,000 individuals from 100's of species	Combined: 1,000's individuals from 100's of species	**Centipedes:**
		Combined: 100's individuals from 10's of species

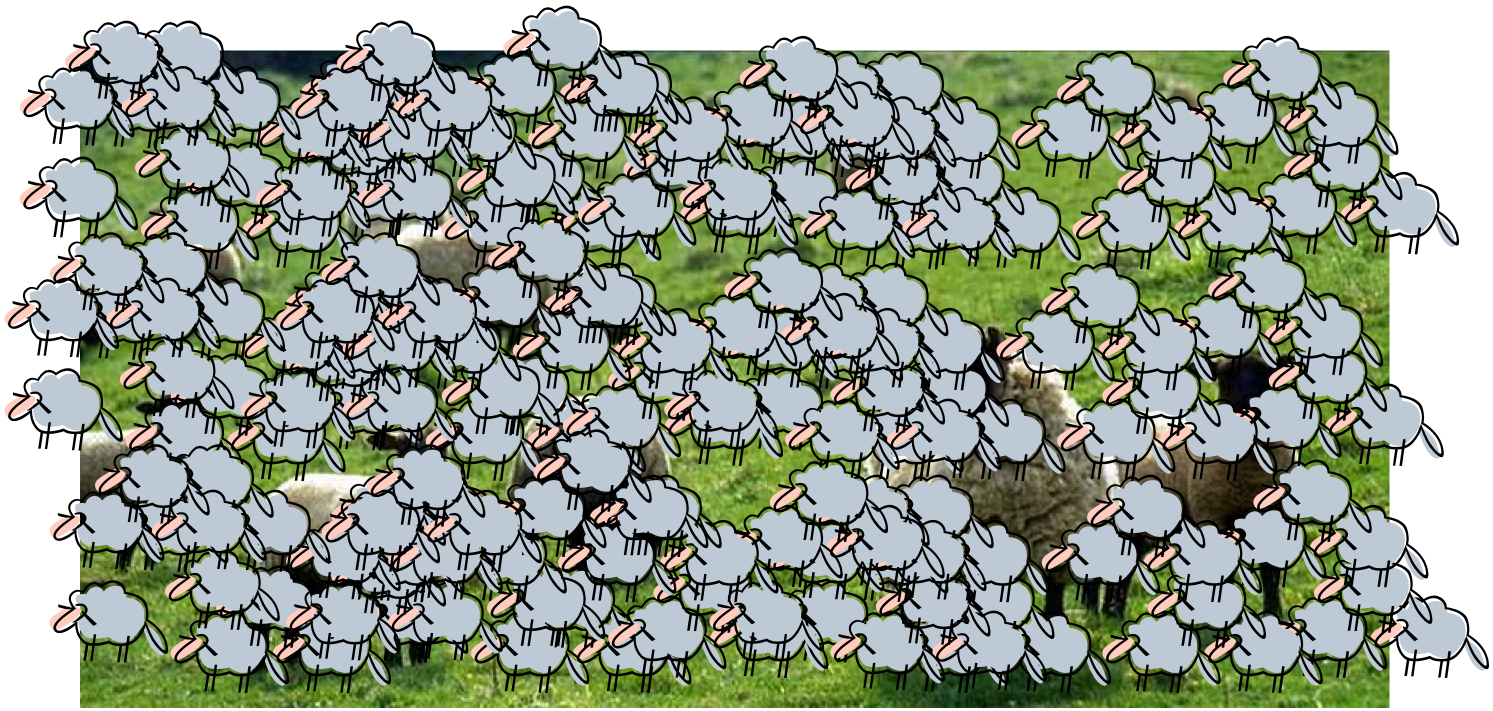
SOIL AS BIODIVERSITY RESERVOIR



K.Ritz

SOIL AS BIODIVERSITY RESERVOIR

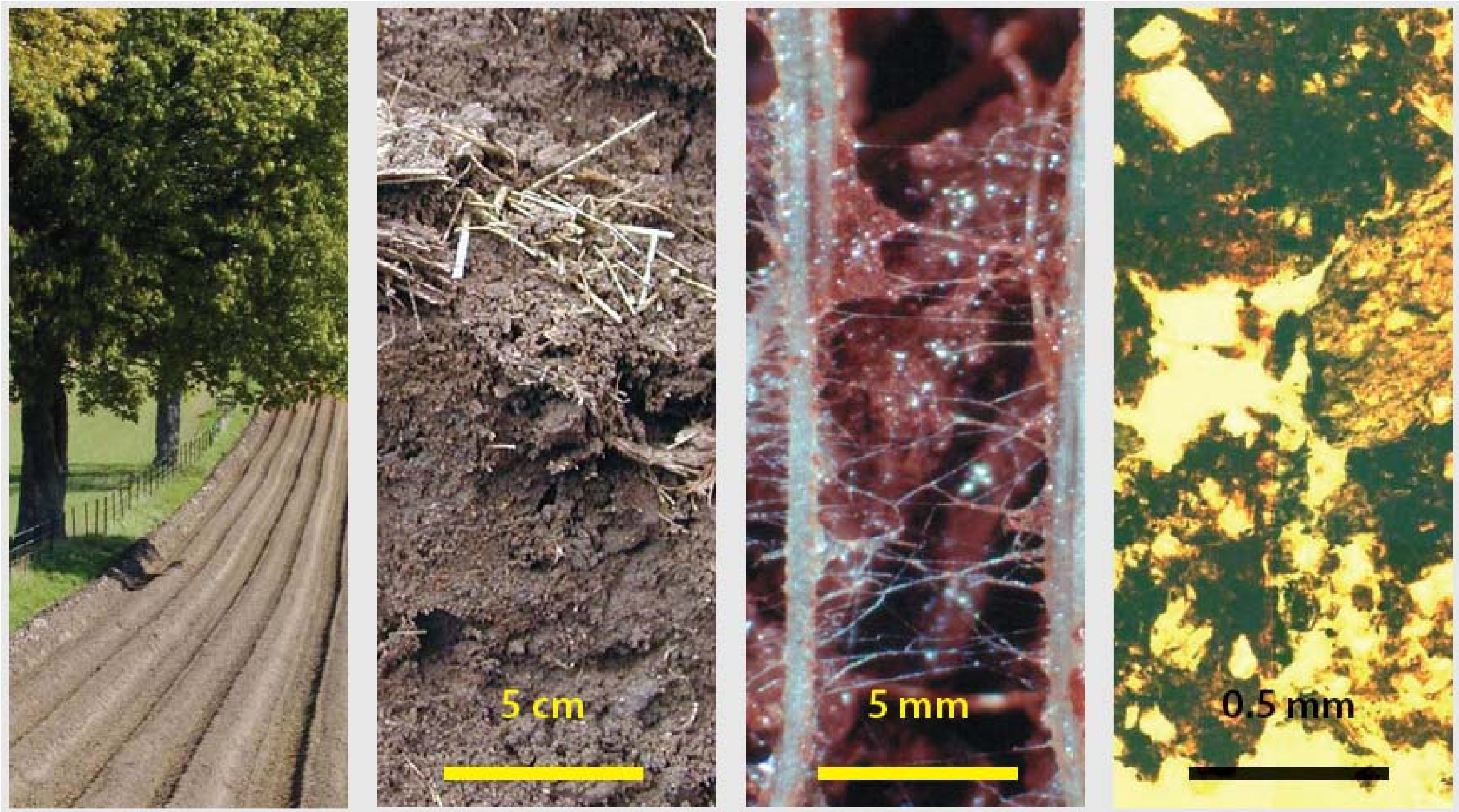
- **in 1 ha of arable soil there are approximately 5 tonnes of living organisms (equivalent to 100 sheep)**



K.Ritz

- **if we consider a grassland soil the quantity of living organisms will be equivalent to 2000 sheep!!!**

SOIL VARIABILITY AT DIFFERENT SCALES



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VERTICAL DISTRIBUTION OF SOIL BIOTA

This highly simplified figure aims to give some idea of the distribution of organisms vertically through the soil profile:

• microorganisms such as bacteria (c) and protozoa (e) are distributed throughout the soil profile, although with the highest biomass being found near the soil surface which is richer in organic matter

• the two collembolans are adapted for living at different soil depths with the species shown in (a) being more adapted for living on or near the soil surface and that shown in (b) being more adapted to living at deeper levels

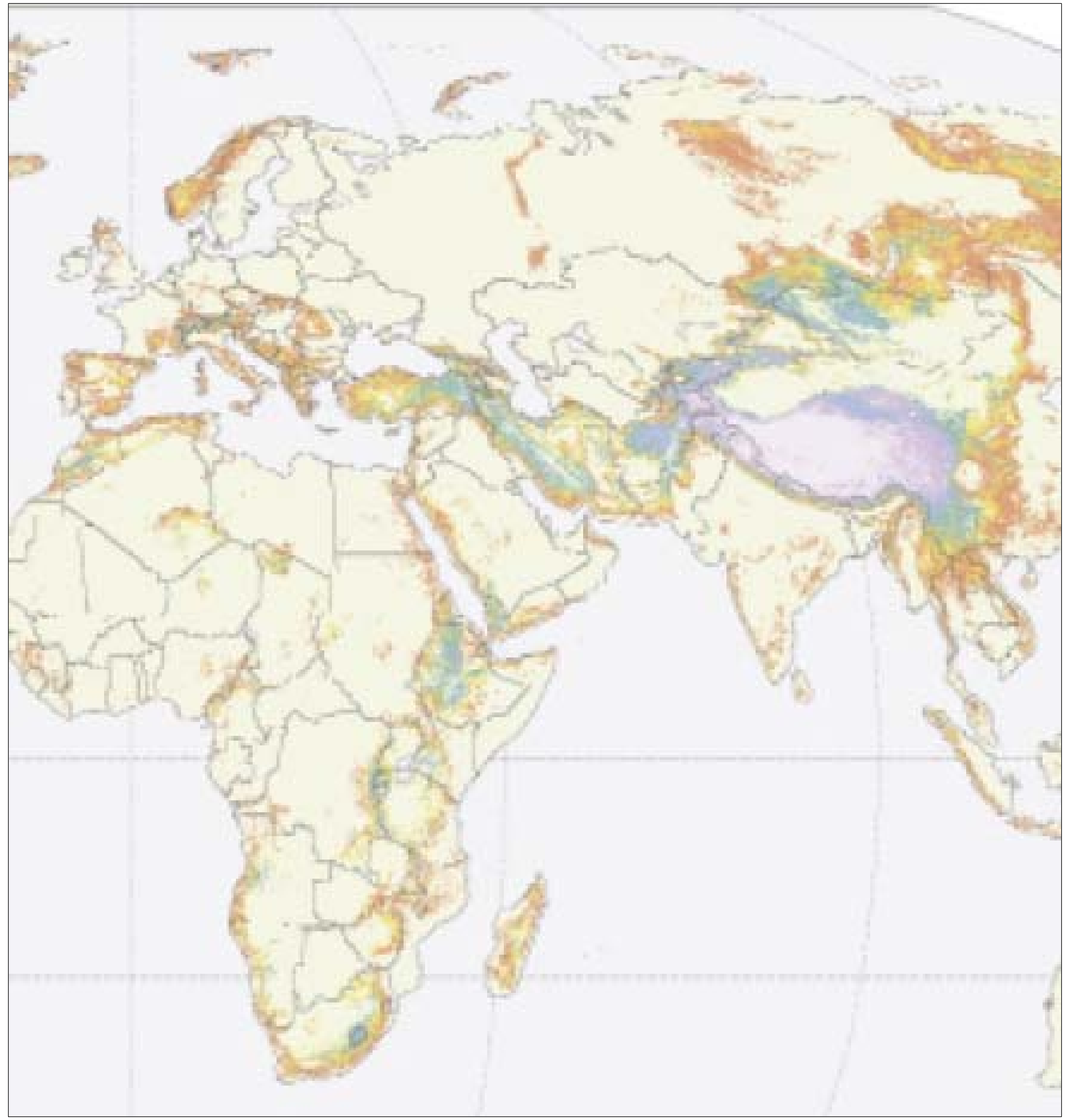
• earthworms are also found in greater numbers closer to the soil surface but can also be found down to depths of 1 meter or more

MOUNTAINS: A MOSAIC OF ECOSYSTEMS

Categories of mountain terrain

- ‡ 4 500 m
- 3 500 – 4 500 m
- 2 500 – 3 500 m
- 1 500 – 2 500 m and slope > 2°
- 1 000 – 1 500 m and slope > 5° or local elevation range > 300 m
- 300 – 1 000 m and local elevation range > 300 m

Source: UNEP



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MOUNTAINS: A MOSAIC OF ECOSYSTEMS

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MOUNTAIN BIODIVERSITY

- Many mountain ecosystems are host to higher species richness and levels of endemism than adjacent lowlands.
- Mountains at lower altitudes can support exceptional biodiversity, due to compression of a wide range of ecosystems into a relatively short distance.
- Mountains also often provide islands of suitable habitat, isolated from unfavourable surrounding lowlands.
- Endemism levels are often high, particularly on mountains at medium elevations in the tropics and warmer temperate zones.
- For some taxa, mountains have acted as refuges from environmental change or competing species, and they often represent sites of *in situ* speciation.
- Mountain species with narrow habitat tolerance, particularly higher elevation forms and those with low dispersal capacity, are at high risk from the environmental effects of climate change.

Source: CBD

SOIL BIODIVERSITY IN EXTREME ENVIRONMENTS

- There are a number of terrestrial soil environments that can be considered extreme, from underground caves that stretch deep into the Earth, to cold or hot deserts and including the highest mountain tops.
- Many of these extreme ecosystems, once thought to lack life, are now known to host many organisms that have adapted physiologically to survive and perform critical ecosystem functions, such as biogeochemical cycling.
- Although extreme soil environments often support food webs that are limited in the number of species present, their diversity provides unique species and an often seperate gene pool for global biodiversity.
- Therefore, organisms of extreme ecosystems are viewed as valuable by many as a source for bioprospecting for commercial, medical or industrial use. Furthermore, recent evidence has shown that there is much to learn from extreme environments and their soils.

SOIL BIODIVERSITY IN EXTREME ENVIRONMENTS

- The coldest environments on Earth are found at high latitudes and/or high altitude (i.e. Polar Regions and alpine areas) and cover a large proportion of the Earth's land surface area.
- All of these areas are undergoing significant changes in biodiversity due to climate warming
- One dominant feature of cold environments is the presence of a permafrost layer (i.e. ground that remains frozen for more than 2 years).
- Permafrost presents some adverse growing conditions for biota including extreme cold, and frequent freeze-thaw cycles, enabling the selection of peculiar soil biota communities

SOIL BIODIVERSITY FUNCTIONS

• Soil organisms are responsible for supplying the environment with a number of critically important ecosystem services

- **Soil formation**
- **Decomposition of organic matter**
- **Soil fertility and plant growth**
- **Water infiltration and retention**
- **Degradation of pollutants**
- **Pollination**

•However the knowledge on the function performed by soil biota is still very limited…..

ABOVE-BELOW GROUND

• … such as the knowledge on the relationships between above and below-ground biodiversity…

SOIL BIOTA AND HUMUS FORM

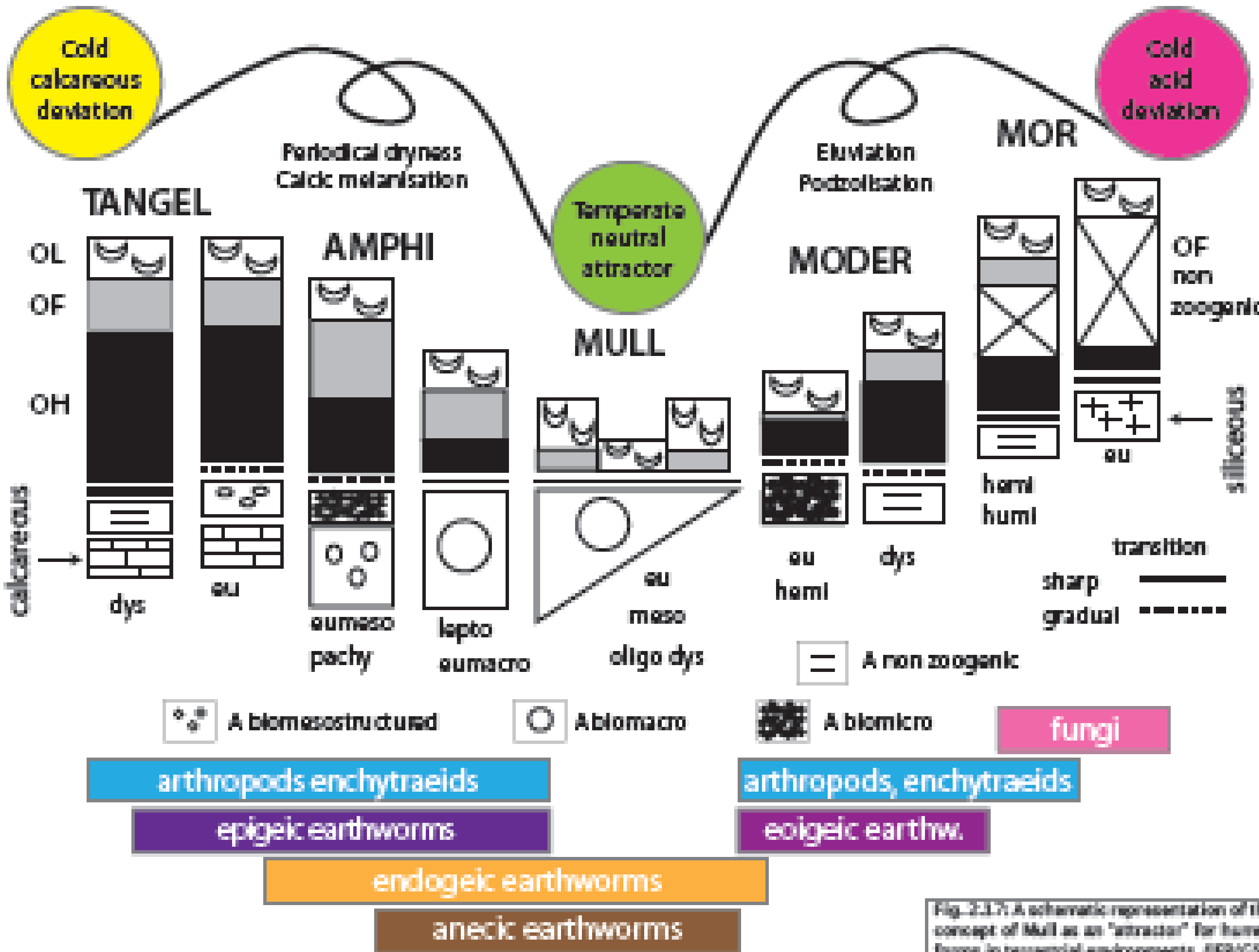
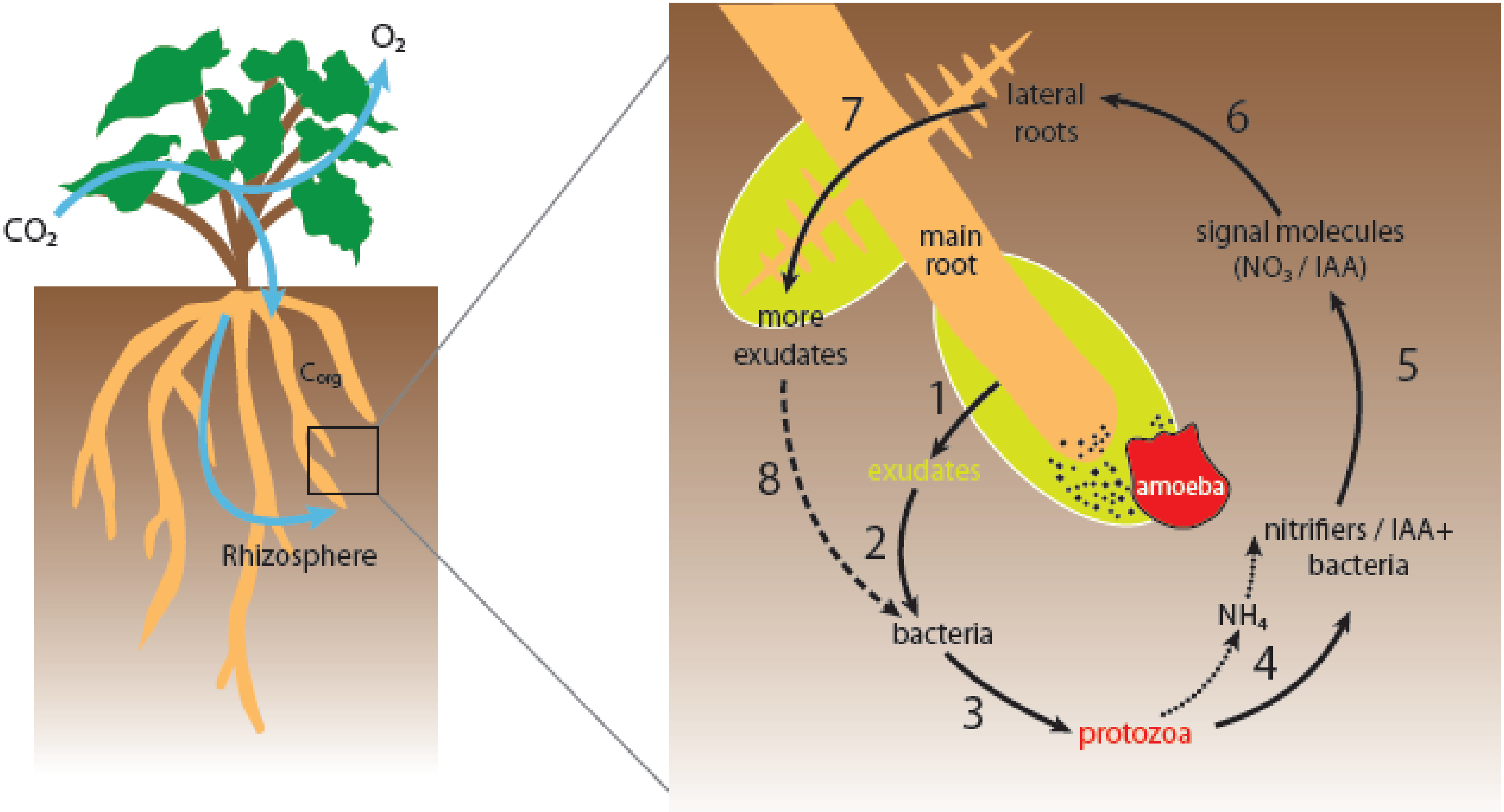


Fig. 2.1.7: A schematic representation of the concept of Mull as an "attractor" for humus forms in terrestrial environments. (EP/CSa)

RHIZOSPHERE



Biodiversity

Functional redundancy

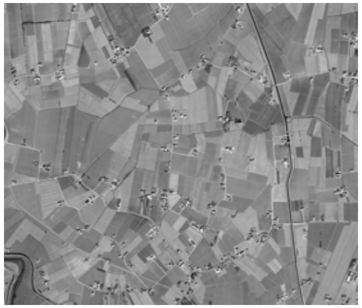
Stability: ability to perform functions under large variation of environmental conditions

Resilience: ability of a system to recover after disturbance

THE SPATIAL SCALE OF SOIL BIODIVERSITY FUNCTIONS

Farm level:

- Contributes to the productive capacity of the system by ensuring the mineralisation of nutrients from organic resources and nitrogen fixation;
- Buffers the functions of the soil and their resilience to climatic and environmental risks.



Regional/national level:

- Ensure short term and long term resilience of food security;
- Increases the aesthetic appeal of rural landscapes, assuming a positive relation between below- and above-ground diversity.

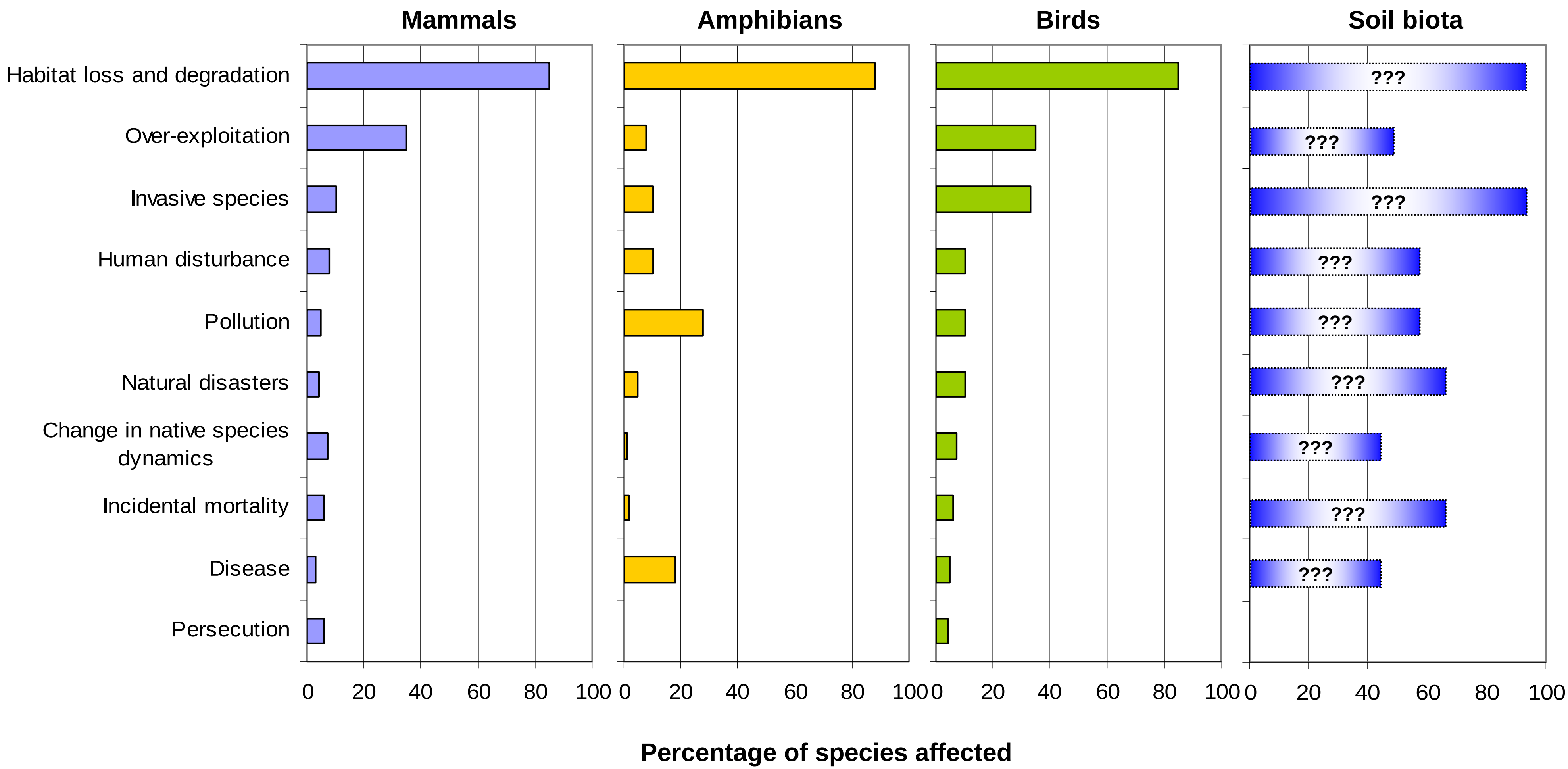
Global level:

- Biogeochemical cycles (organic matter mineralization, nitrogen fixation, etc);
- Value of future possible but as yet unknown uses or functions associated with some aspects of soil diversity.

SOIL BIODIVERSITY DECLINE

- Species extinction is a natural process
- The natural rate of extinction is 12 species/year
- We are actually experiencing the 6th Mass Extinction, losing 15,000-30,000 species every year
- Soil organisms are not excluded by this process, that represent one of the main threats for the future of the Earth

BIODIVERSITY LOSSES



WHY WE NEED TO PROTECT SOIL BIODIVERSITY?

Economical/utilitarian reasons

Ecological reasons

Ethical reasons

".. Everyday we use living organisms, and without them we can't live. And everyday we take this great benefit for granted ….."

Saint Francis of Assisi, 1225

Taxonomic diversity

Functional diversity

THE ECONOMIC VALUE OF SOIL BIODIVERSITY

Actvity	World economic benefits *(Billions of $/year)*
Waste recycling	760
Soil formation	25
Nitrogen fixation	90
Bioremediation of chemicals	121
Biotechnology	6
Biocontrol of pests	160
Pollination	200

(from Pimentel et al., 1997)

Many scientist are looking at soil biodiversity, especially in remote areas, in an attempt to find the most promising medicines for the future.

Crops are threatened by soil-borne disease which can cause severe yield decreases and economic damage. Soil biodiversity has the potential to limit the effects of soil-borne diseases.

THE CATACLYSMIC IMPLICATIONS OF FUNGI EXTINCTION

- Many species of trees cannot grow without a symbiotic relationship with certain soil-based fungi such as arbuscular mycorrhizal fungi (AMF)
- Invasive plant species, such as garlic mustard, is causing a decline of AMF in many native hardwood forests in North America
- Mass extinction of soil-fungi would be the corollary to a mass extinction of trees in both tropical and temperate settings

DECLINE IN SOIL BIODIVERSITY: SOME EVIDENCE

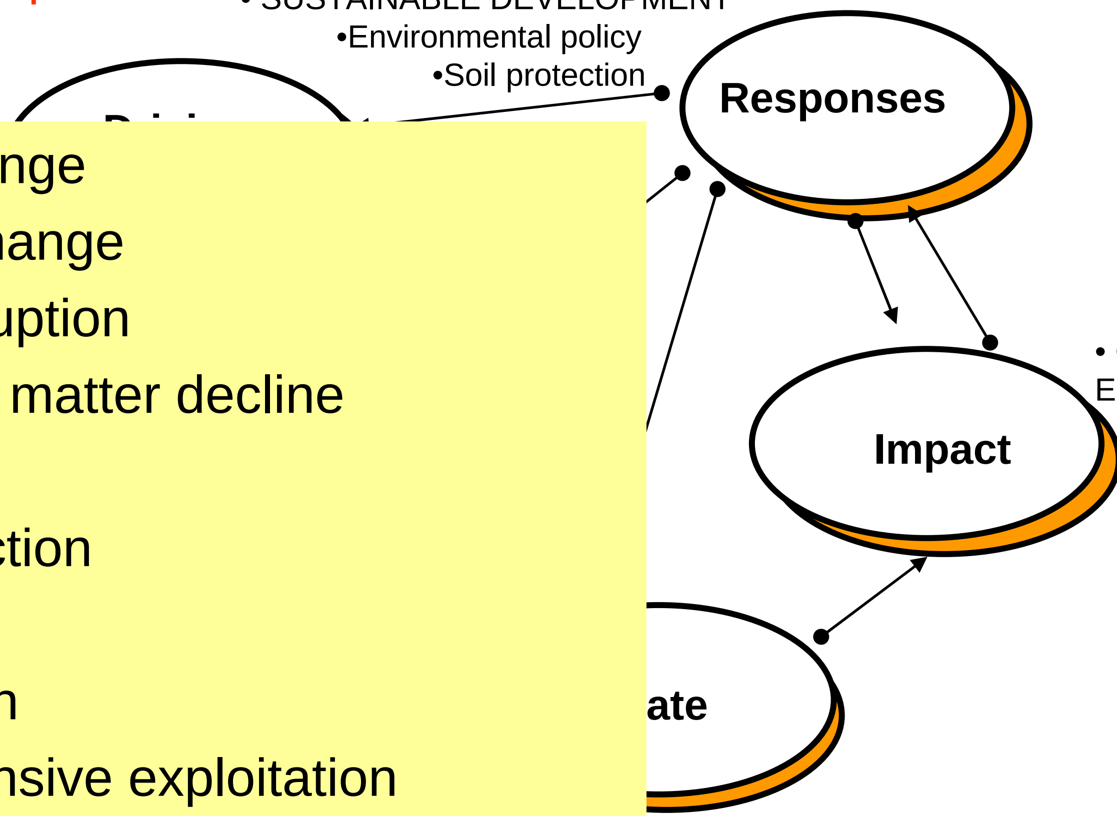
- Strict records of mushrooms species have been kept in Europe since 1912
- Data show a sharp decline in mushroom diversity (e.g. a 65% decrease in mushroom species in The Netherlands over a 20 year period)
- Swiss Federal Environment Office has published the first-ever “Red List” of mushrooms detailing 937 known species facing possible extinction in the country

DPSIR FRAMEWORK

•Increase of human population
•Change of life style

Energy consumption
Land use change

• SUSTAINABLE DEVELOPMENT
•Environmental policy
•Soil protection

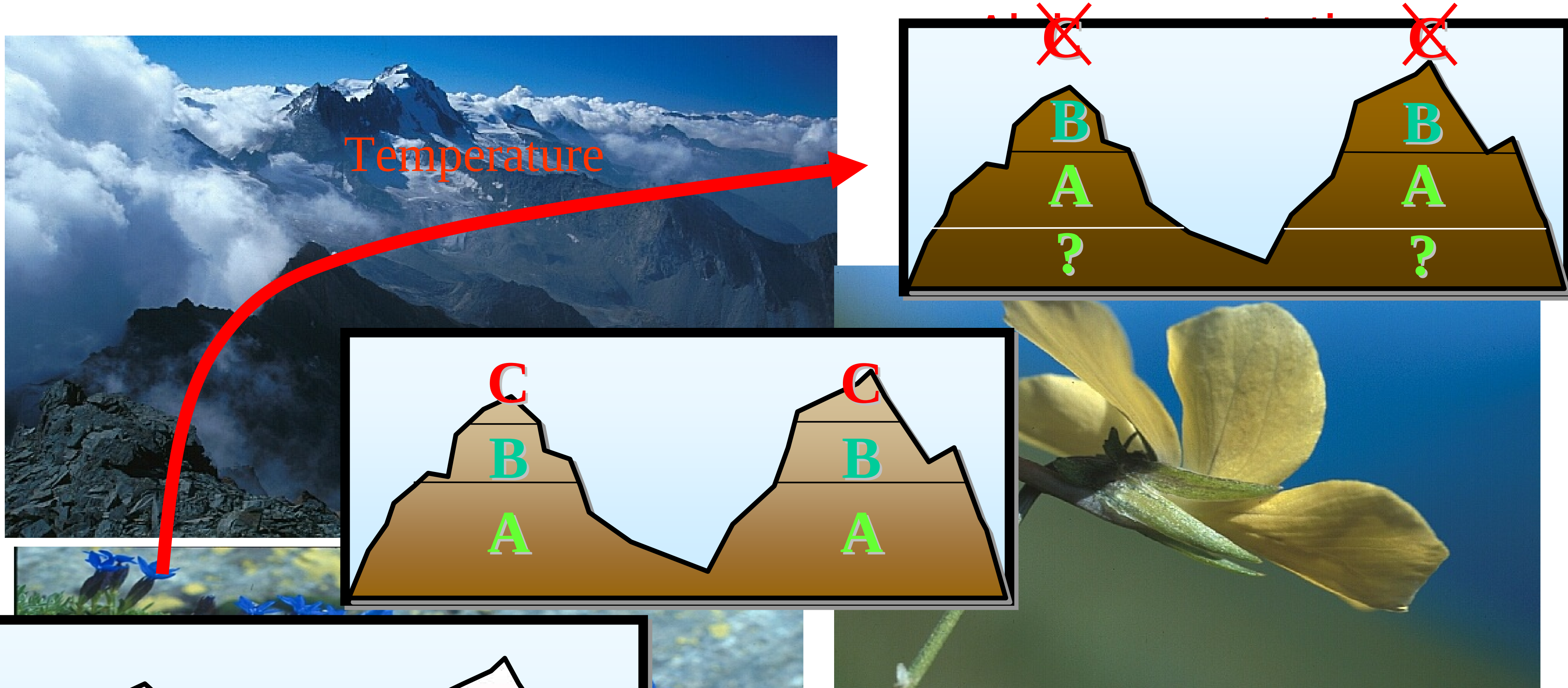


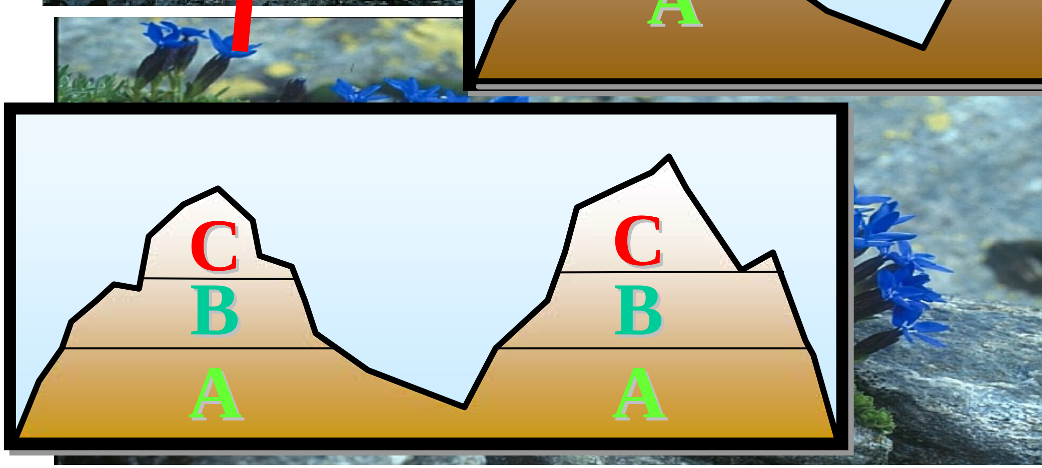
Climate change
Land use change
Habitat disruption
Soil organic matter decline
Soil erosion
Soil compaction
Soil sealing
Soil pollution
Human intensive exploitation
GMO pollution
Invasive species
Habitat fragmentation

• CHANGE OF THE ECOLOGICAL STRUCTURE
•Change of ecosystem functions
•Loss of ecosystem goods and services

DIVERSITY DECLINE
biological diversity
on of soil organisms

CLIMATE CHANGE



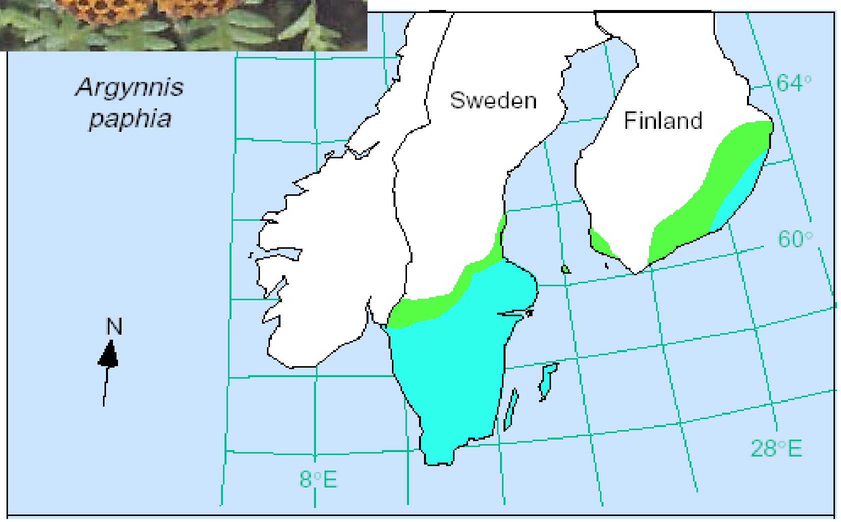


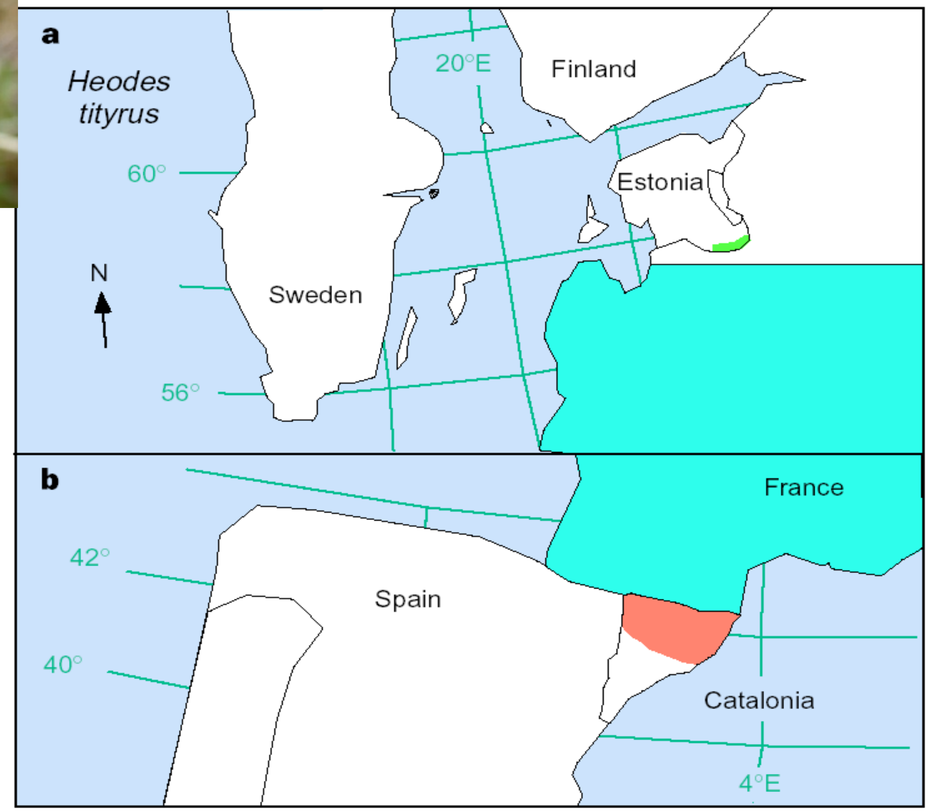
Observed displacement:

1-4 m/10 years

MARCHING TOWARDS THE POLES

Parmesan C. *et al.* (1999), *Nature* **399**:579-583

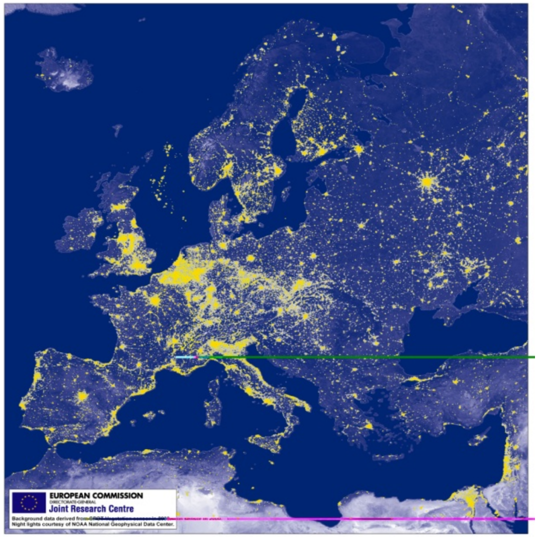


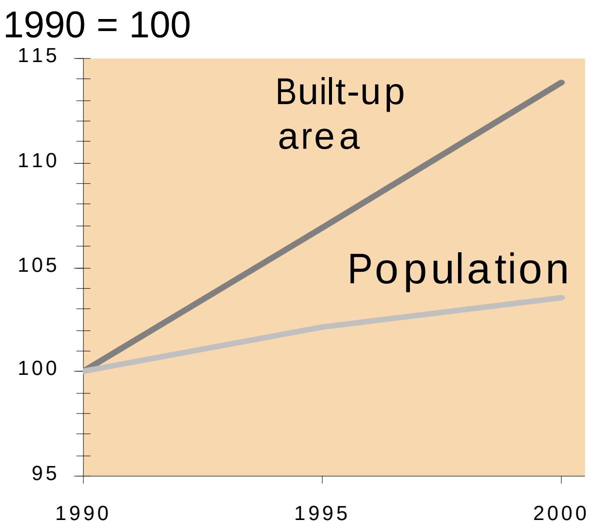


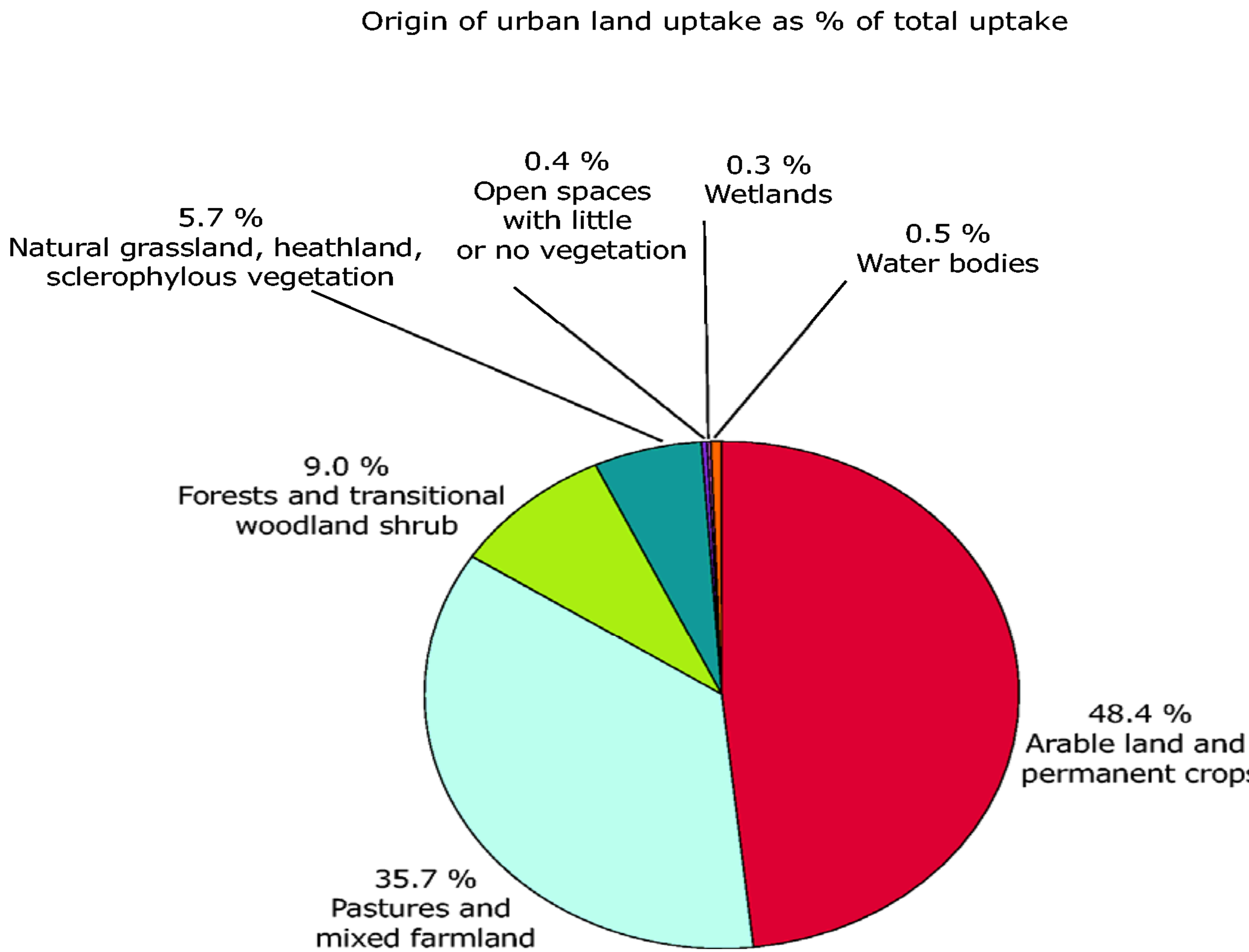
Extending northern boundary 1970-1997

Extending northern boundary + rectracting southern boundary

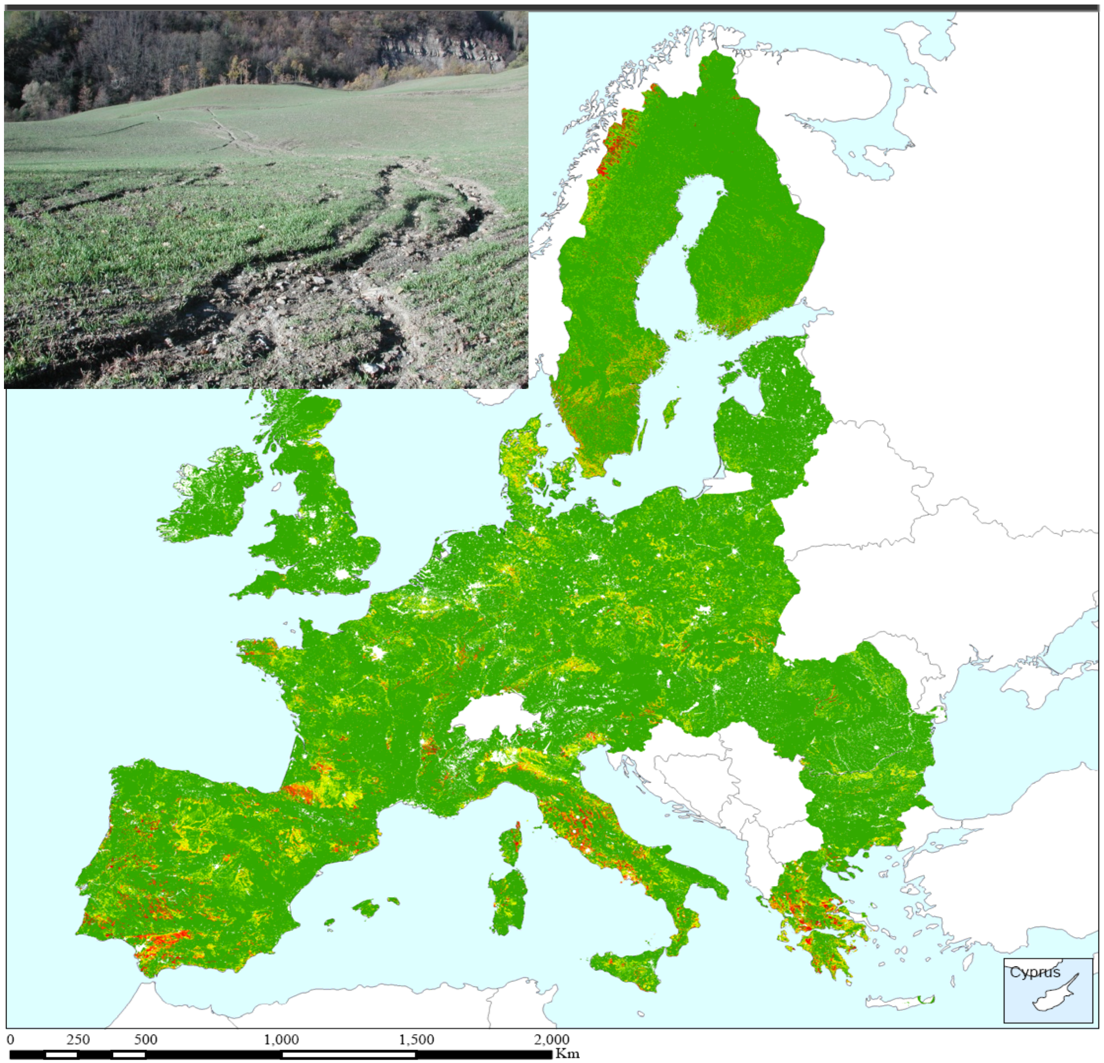
Ecosystem Disruption - Sealing







Susceptibility to Soil Erosion



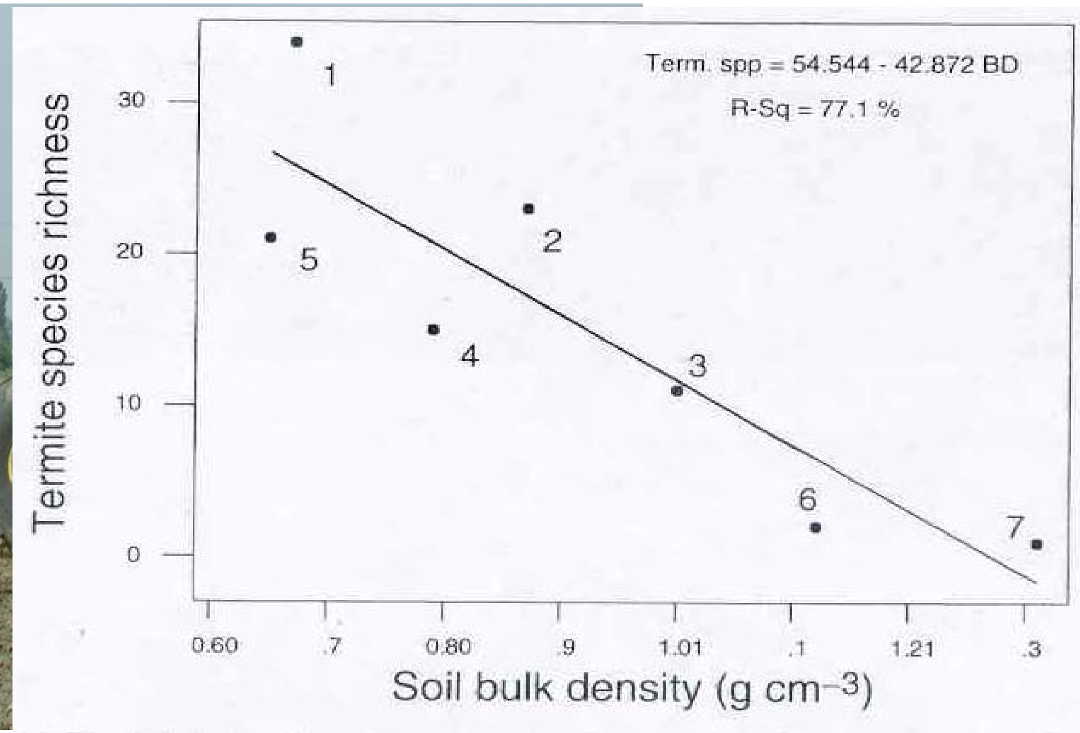
This map provides a complete picture of the erosion risk for the 27 member states. It is derived from the Pan European Soil Erosion Risk Assessment (PESERA) and the RUSLE (Revised Universal Soil Loss Equation) model for Finland and Sweden

Erosion risk in t/ha/yr

- 0 - 0.5
- 0.5 - 1
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0
- 20.0 - 50.0
- >50

Source: PESERA Project, JRC – Kirby et al., 2004

Soil Compaction



Potential Loss of Organic Carbon

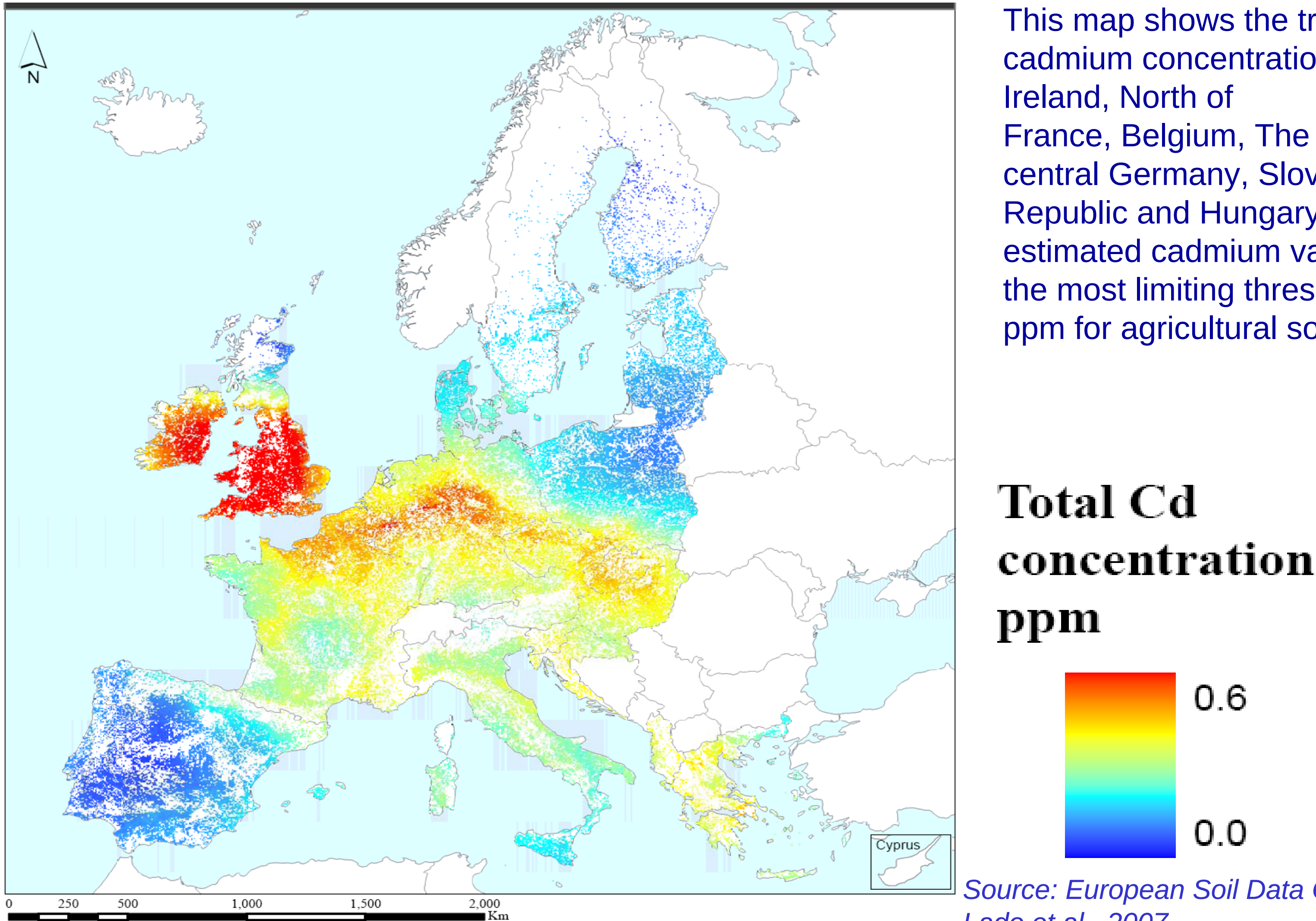
The potential of soil organic carbon (SOC) loss refers to the amount of SOC (in tC ha^{-1}) that can be lost by a given Soil Typological Unit within a bioclimatic region.
The potential of SOC loss is calculated from the equation:
Potential of SOC loss = Mean SOC - Min SOC

Risk classes

- Limited
- Enhanced
- High

Source: SOCO Project, JRC
Stolbovoy et al., 2008

Soil Contamination



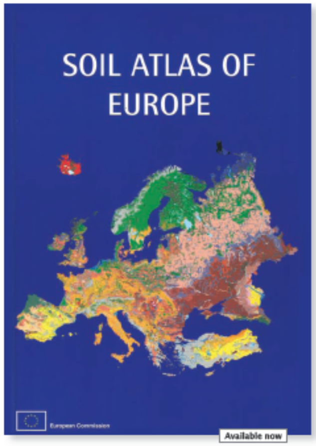
This map shows the trend to find higher cadmium concentrations in the UK, Ireland, North of France, Belgium, The Netherlands, central Germany, Slovakia, Czech Republic and Hungary. However, the estimated cadmium values are below the most limiting threshold value of 1 ppm for agricultural soils.

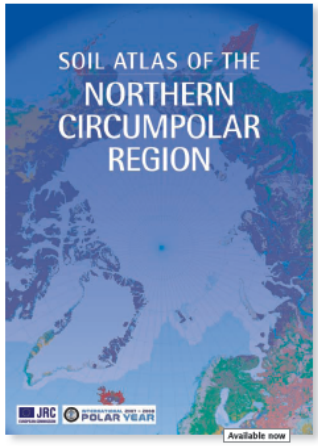
Source: European Soil Data Center, JRC Lado et al., 2007

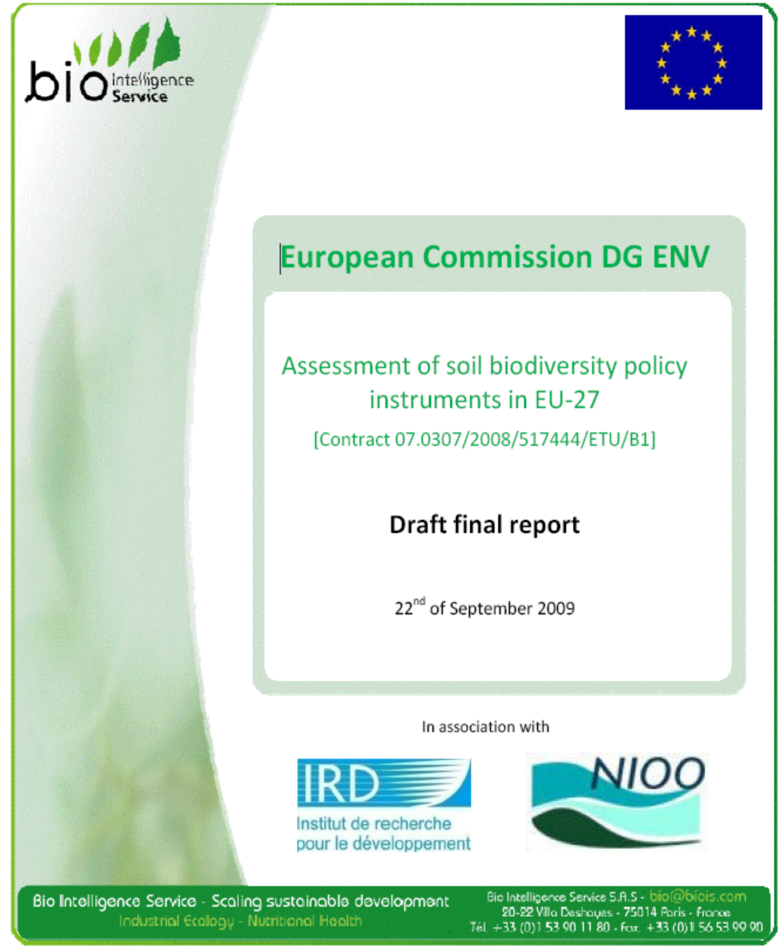
Occurrence of Threats

THREATS	DEVELOPED COUNTRIES	DEVELOPING COUNTRIES	FAST GROWING COUNTRIES
Habitat disruption (Land use change, land use intensity, Climate change)	+	++	++
Climate change	++	++	++
Habitat fragmentation	+	+	++
Soil erosion	-/+	++	++
Soil compaction	+	-	++
Soil organic matter decline	+	++	++
Soil sealing	+	+	++
Invasive species	+	++	++
GMO	-	++	++

FURTHER READINGS






bio Intelligence Service

European Commission DG ENV

Assessment of soil biodiversity policy instruments in EU-27

[Contract 07.0307/2008/517444/ETU/B1]

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NIOO

Bio Intelligence Service - Scaling sustainable development
Industrial Ecology - Nutritional Health

Bio Intelligence Service S.A.S - bio@biois.com
20-22 Villa Deshayes - 75014 Paris - France
Tél. +33 (0)1 53 90 11 80 - Fax. +33 (0)1 56 53 99 90

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