

Opportunities for soil sustainability in Europe

Wim van der Putten

Netherlands Institute of Ecology (NIOO-KNAW) &

Wageningen University &

Royal Dutch Academy of Arts and Sciences

This presentation:

- 1. Opportunities for soil sustainability in Europe**
- 2. Soil biodiversity**

Pace of activities



- EU in hiatus since 2014 Soil Directive Withdrawal
- Globally:
 - IYS (2015)
 - IPBES global assessment of land degradation and restoration
 - FAO's Global Soil Partnership
 - G20 summit in Argentina (July 2018) included special meeting on soils
 - current UN and FAO Global Soil Biodiversity Assessment...
- The nexus of actions related to soil sustainability is thus shifting from the EU to the global dimension
- Time for Europe to restore its soil priorities?

Everything that we eat, drink, breath, clothes that we wear, and materials that we use pass through soil over and over again



2015

International
Year of Soils

healthy soils for a healthy life





Specialists from 18 European countries
Meeting 21-23 November 2016 at KNAW, Amsterdam
Introductions from EASAC ENV Director and invited speakers

The process

- First provide a background document (2 rounds)
- Use that to develop the report in its current shape
- Review by EASAC Environment Steering Panel
- Review by 13 reviewers appointed by the various Academies
- Final approval by Academies
- Presentation in Brussels 26 September 2018

Outline of the study

2 The role and importance of soils from recent science

3 Soil biodiversity and above-ground biodiversity

4 Soils and modern farming

4.1 Current challenges to soils in farming

4.2 Opportunities in the future Common Agricultural Policy

5 Soils, plant health and human health

5.1 Concept of soil 'health'

5.2 Plant health and food quality

5.3 Soils and human health

6 Soils and climate change

6.1 General considerations

6.2 Specific issues on peatlands

6.3 The '4 per mille' initiative

Introduction remarks

THE MAJOR SOIL TYPES OF EUROPE

Supporting the European Union's Thematic Strategy for Soil Protection



Alfisol Soils with moderate to high clay content in the subsoil.	Andisol Young soils developed in parent volcanic deposits.
Arrenosols Soils with significant concentrations of calcium carbonate.	Calcisols Soils with significant concentrations of calcium carbonate.
Calcisols Soils with significant concentrations of calcium carbonate.	Chernozems Dark, fertile soils with organic-rich topsoil.
Cryosols Soil influenced by permafrost or cryogenic processes.	Fluvisols Fertile soils, formed mainly on floodplains and river terraces.
Gleysols Soils saturated by groundwater for long periods.	Gypsisols Soils of dry lands with significant accumulations of gypsum.
Histosols Organic soils with layers of partially decomposed plant residues.	Kastanozems Soils of dry grasslands that depend that is rich in organic matter.

What is soil?

Soil is composed of mineral particles, organic matter, water, air and living organisms. It is an extremely complex, variable and living medium. Soil as the result of air, water, parent material (rocks and sediments), climate, position in the landscape, vegetation, living organisms, time and the effect of people. The patterns shown on the map reflect variations in the intensity of the various soil forming factors from one region to another, and explain why there are so many different types of soils in Europe. From the photographs on this map, it is clear that soils have distinct colours which are due to the varying proportions of organic and mineral matter. If the soil is rich in organic matter then the soil is dark and vice versa. If the soil is rich in a specific mineral, such as iron oxide (red) or calcium carbonate (white), then the soil will reflect that colour.

Soil functions

Soil is defined as the uppermost layer of the Earth's crust and is the interface between the ground, air and water. Soil performs many vital functions: food and other biomass production, storage, filtration and transformation of many substances including water, carbon, nitrogen. Soil acts as a habitat and gene pool reserve as a platform for human activities, landscape and heritage and acts as a provider of raw materials. Given the slow rate of soil forming processes, soil must be considered as a non-renewable resource and highly susceptible to land degradation pressures. Given the life-critical, socio-economic and environmental importance of soil functions, the European Commission has adopted a Soil Thematic Strategy with the objective to protect soils across the EU. <http://ec.europa.eu/environment/soil/>

The Soil Map of Europe

The Soil Map of Europe shown in the centre of this poster is derived from the 1:1,000,000 scale Soil Geographical Database of Europe. The database is the result of a collaborative project involving all the European Union Member States and neighbouring countries. Through participation in the European Commission Joint Research Centre's European Soil Bureau Network (ESBN), the map shows a simplified representation of the diversity and geographical variability of the soil cover across Europe. The underlying database has been processed to identify the most dominant soil type for a particular area of landscape. Each colour represents a specific type of soil (see WRB Reference Group's examples of which are presented on this poster).

For more information on this map and how to find out more information about the soils of your area, please visit the JRC Soil Atlas web site at: <http://soils.jrc.ec.europa.eu/>

WRB Reference Soil Groups

The World Reference Base for Soil Resources (WRB) uses objective criteria, derived from both field inspections and laboratory analysis, to systematically identify different soil types into one of three soil Reference Groups with specific characteristics derived through the use of pedon and surface. The WRB is meant to serve as a common denominator through which national soil classification systems can be compared and identified. <http://www.fao.org/soil/soilgroups/>

For more information on this map and how to find out more information about the soils of your area, please visit the JRC Soil Atlas web site at: <http://soils.jrc.ec.europa.eu/>

The Joint Research Centre

The mission of the JRC is to provide customer driven expert's and scientific support for the institutions, Member States and other stakeholders in the area of EU policies. As a part of the European Commission, the JRC has a long tradition of providing scientific and technical support to the Member States, who being independent of global crises, nuclear power or climate change. <http://ec.europa.eu/jrc/>

Leptosols Soils with little clay and low concentrations of organic matter.	Luvisols Active soils with clay accumulation in the subsoil.
Phaeozems Dark, moderately textured soils with organic rich topsoil.	Planosols Soils with moderate to high concentrations of clay in the subsoil, but with a change in texture between the topsoil and the subsoil that is not due to clay accumulation.
Podzols Acid soils with intensive accumulations of iron, aluminium and organic compounds.	Regosols Soils with little clay and low concentrations of organic matter.
Salinichaks Soils with salt accumulation due to the concentration of saline groundwater.	Solchaks Soils with high clay content and high concentrations of organic matter.
Stagnosols Soils with stagnating surface water for long periods.	Technosols Soils containing significant amounts of human products or waste or impermeable material.
Umbrisols Young, acid soils with thick topsoil that is rich in organic matter.	Vertisols Heavy clay soils that swell when wet and crack when dry.

Soils in Europe are physically and chemically highly diverse

Source:
Soil Atlas of Europe
Jones et al. 2005
JRC ISPRA, Italy

“A nation that destroys its soils destroys itself.”

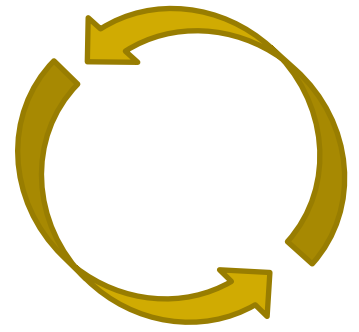
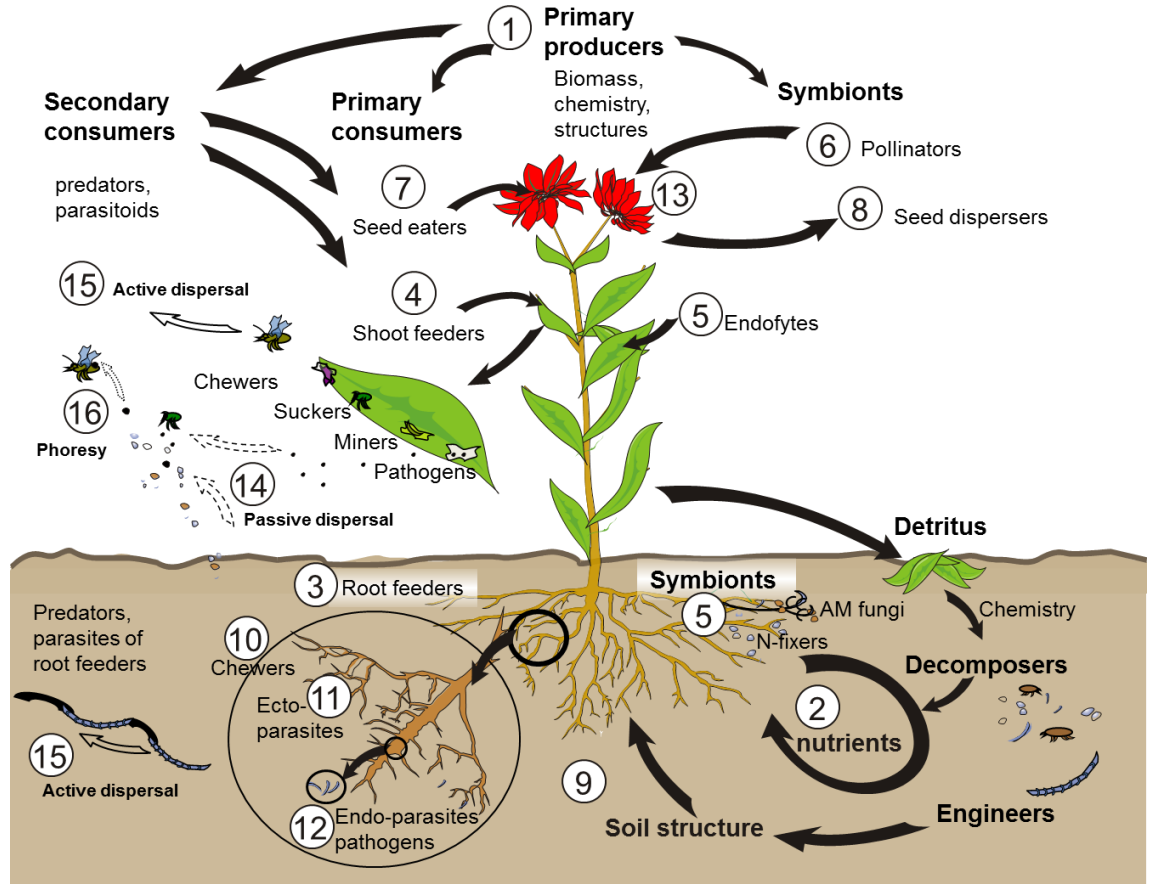
Franklin D. Roosevelt





Europe does a good job in this destroying of soils: major risks are erosion, degradation, pollution, mining of sand, gravel, fossil energy, etc.

Soils and aboveground biodiversity



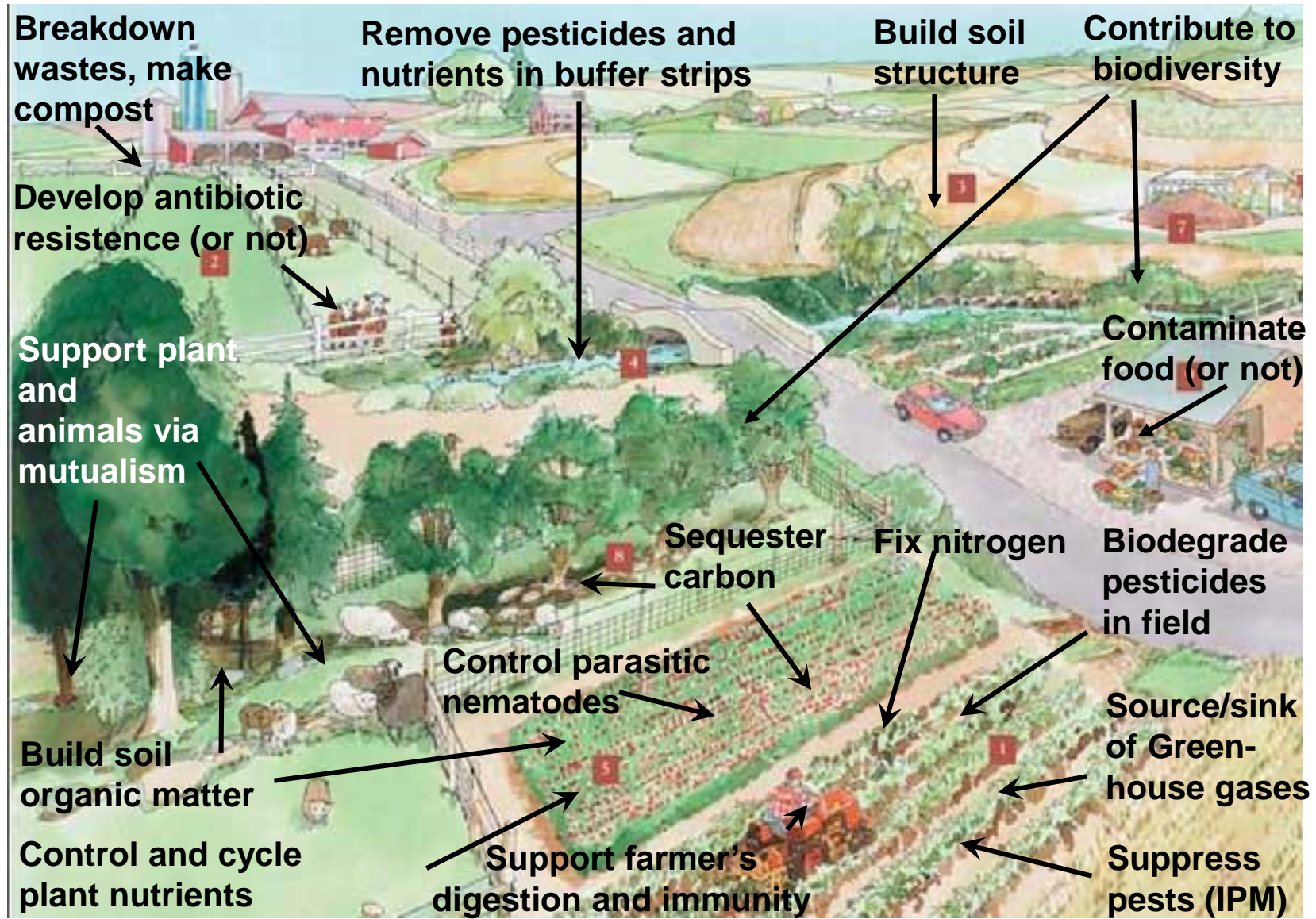
De Deyn, TREE 2005

Soil is the basis for aboveground biodiversity

However: no mentioning of soil biodiversity in Natura 2000 and Habitat Directive

Soils and modern farming





<http://images.google.com/imgres?imgurl=http://www.sare.org/publications/explore/images/scenewide2.jpg>

Modern farming reduces soil biodiversity and by-passes natural functions of soil life

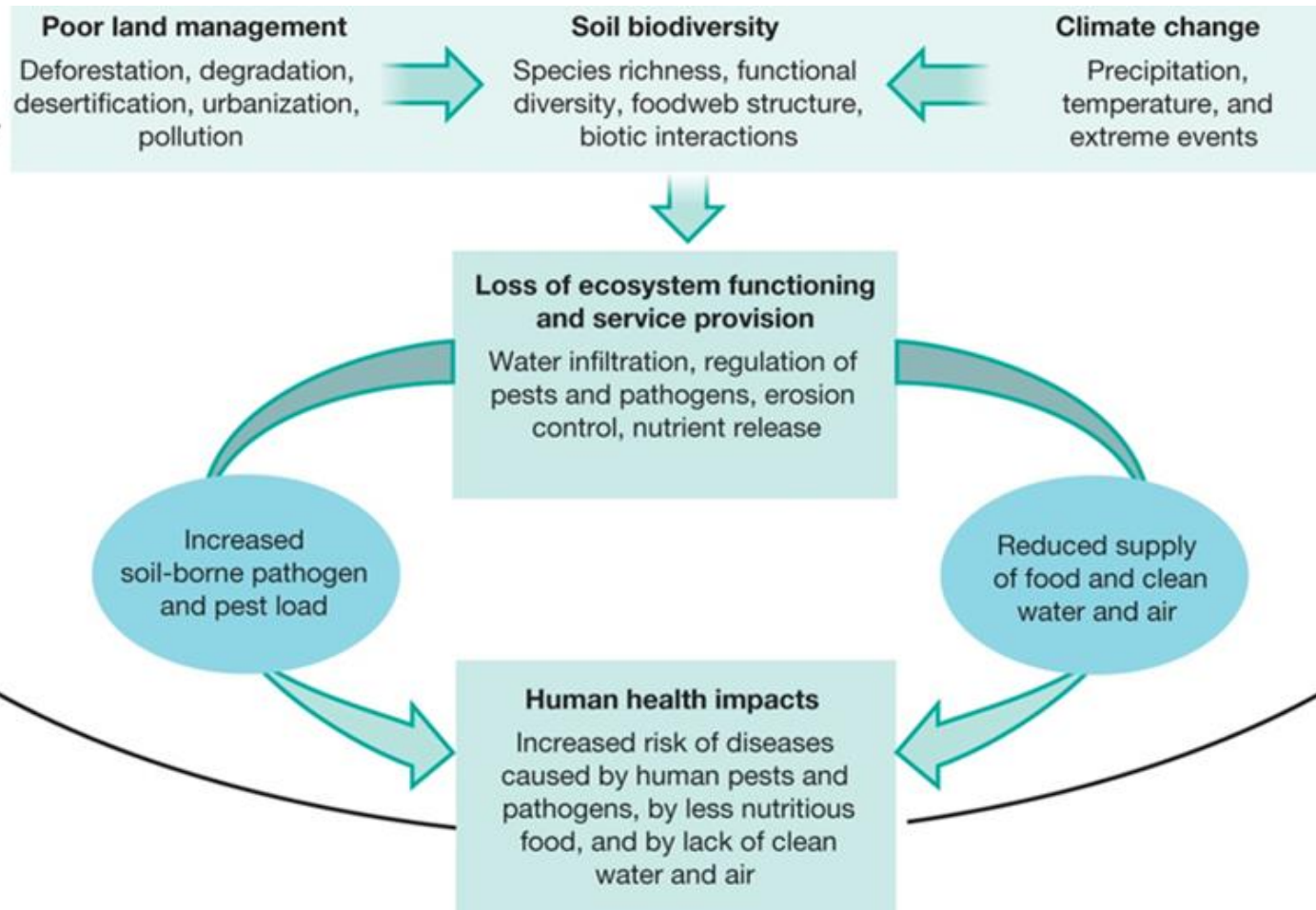


Rothamsted (UK) long-term trials: yields increase,
but crops take up less micronutrients (although still available in soil)

Socio-economics involved in sustainability: price comparison 1950-2015

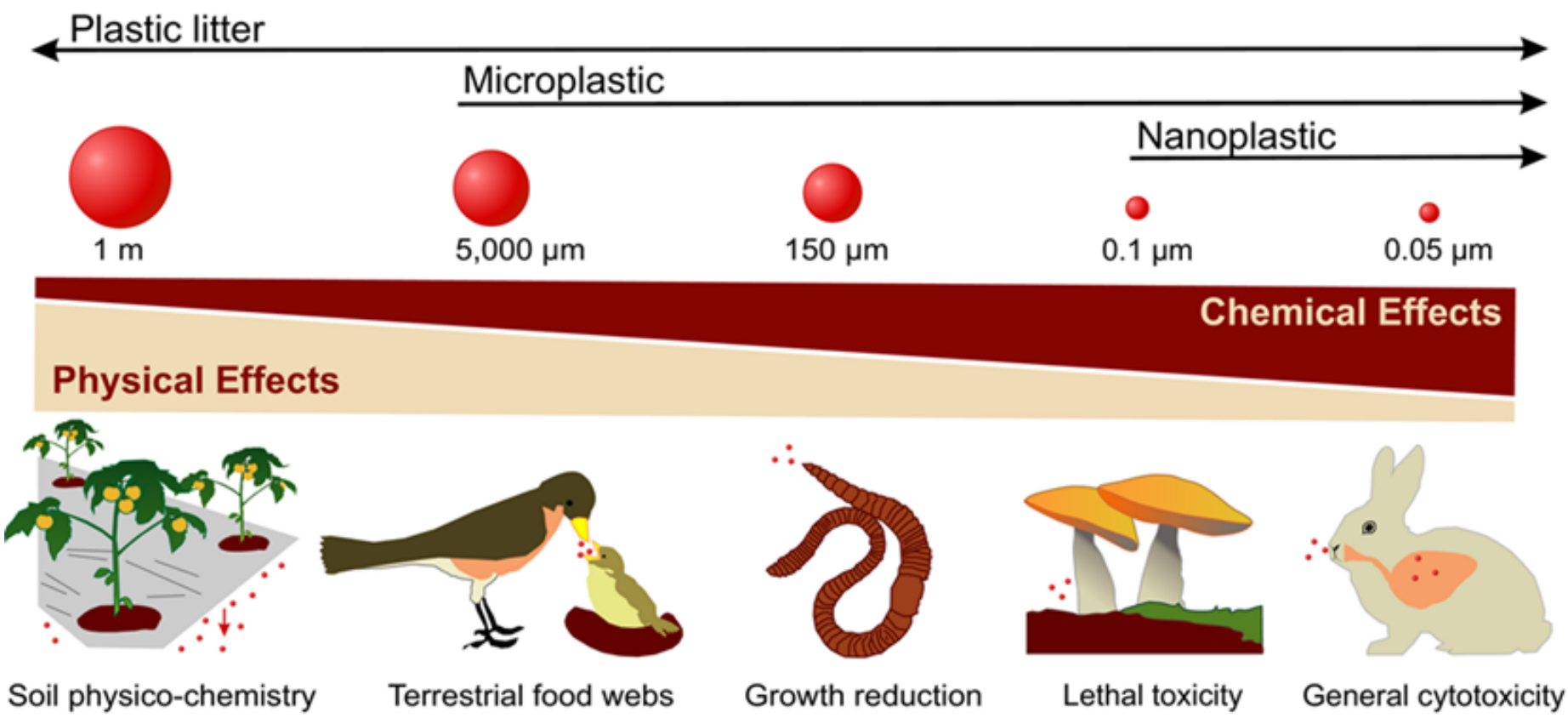
	1950	2015	Factor
Potato	0,07 E/kg?	0,9 E/kg?	13
Bread	0,17 E/bread	1,19 E/bread	7
Agricultural soil	2500 E/ha	50000 E/ha	20
Harvest winter wheat	4 ton/ha	12 ton/ha	3
Price wheat	800 E/ton	100 E/ton	0.125

Source: <http://statline.cbs.nl/>



Soil and plant / human health

Wall et al. 2016 Nature



New threat: (micro)plastics in soil

Machado et al. 2018 Global Change Biology



One-health concept provides unexplored opportunities!

Climate control and consequences of climate change

Some figures

- Since start of agriculture (12,000 years ago) soils have lost 133 billion tonnes of carbon to atmosphere.
- Currently, there is still appr. 70-75 billion ton carbon left in European soils.
- Soil organic carbon is being lost at a rate equivalent to 10% of the total fossil fuel emissions for Europe .
- To support COP 21, carbon levels should become restored in soil.

4 PER 1000

CARBON SEQUESTRATION IN SOILS FOR FOOD SECURITY AND THE CLIMATE

The quantity of carbon contained in the **atmosphere** increases by **4.3 billion tons** every year

+4.3 bn tons carbon / year

↑↑
CO₂ emissions



Forests ⊖ ⊖
Oceans ⊖ ⊖
Human activities ⊕ ⊕ ⊕ ⊕
Deforestation ⊕
⊖ absorption ⊕ emission

The world's **soils** contain **1 500 billion tons** of carbon in the form of organic material

absorption of CO₂ by plants



storage of organic carbon in soils

1500 bn tons carbon

If we increase by **4‰ (0.4%)** a year the quantity of carbon contained in soils, **we can halt the annual increase in CO₂ in the atmosphere**, which is a major contributor to the greenhouse effect and climate change

increased absorption of CO₂ by plants:



farmlands, meadows, forests...



+4‰ carbon storage in the world's soils

= more fertile soils
= soils better able to cope with the effects of climate change

HOW CAN SOILS STORE MORE CARBON?

The more soil is covered, the richer it will be in organic material and therefore in carbon. Until now, the combat against global warming has largely focused on the protection and restoration of forests. In addition to forests, we must encourage more plant cover in all its forms.



Never leave soil bare and work it less, for example by using no-till methods



Introduce more intermediate crops, more row intercropping and more grass strips



Add to the hedges at field boundaries and develop agroforestry



Optimize pasture management – with longer grazing periods, for example



Restore land in poor condition e.g. the world's arid and semi-arid regions

*“This international initiative can reconcile the aims of **food security** and the **combat against climate change**, and therefore engage every concerned country in COP21.”*

Stéphane Le Foll, French Minister of Agriculture, Agrifood and Forestry

Following COP 21: 4 per mil initiative

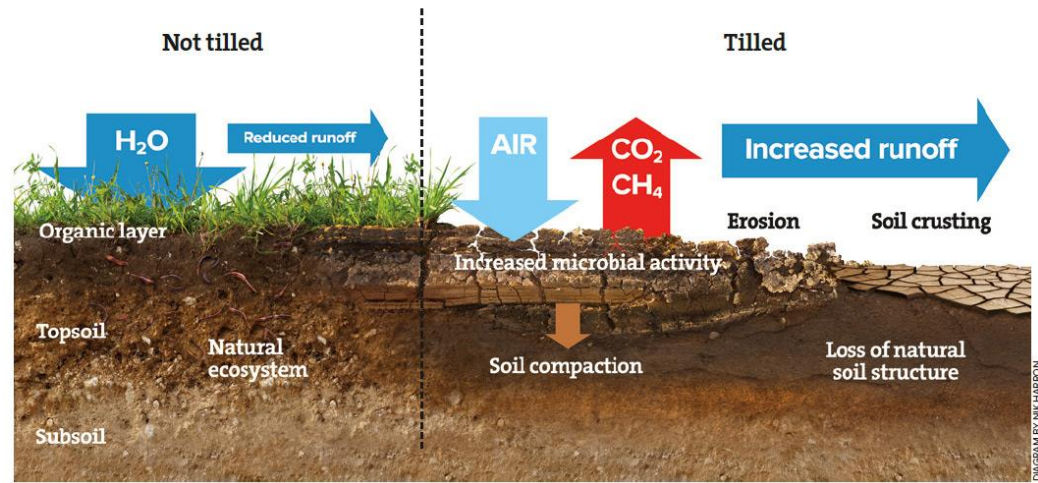
- Is overoptimistic
- Should not prevent taking other measures

But: is no-regret approach and should therefore be supported



Keep carbon where it is (peatlands)

Mother Earth Knows, but She's Not Tilling

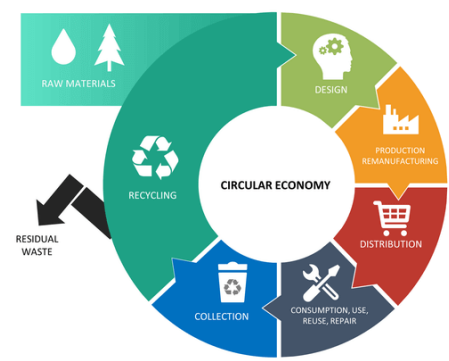


Prevent carbon loss by excessive tilling



Promote carbon storage and closing cycles

CIRCULAR ECONOMY
 Enter your sub headline here



Promote circular economy



Urbanization in Europe: in 10 years size of Luxembourg urbanized

bio Intelligence Service 

European Commission DG

Soil biodiversity: functions, threats and tools for policy makers
[Contract 07.0307/2008-517444/E/TU/B1]

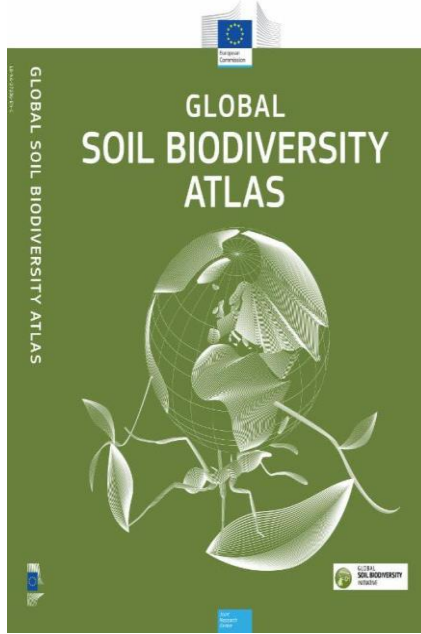
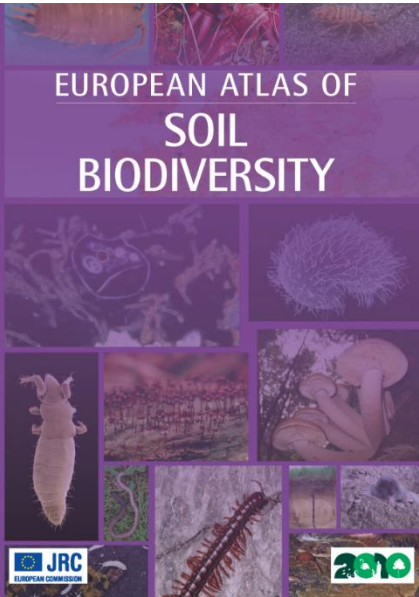
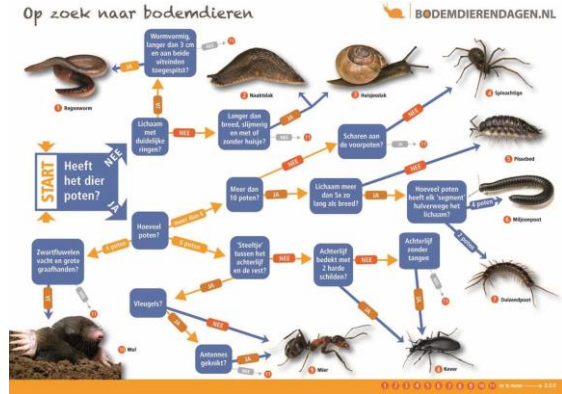
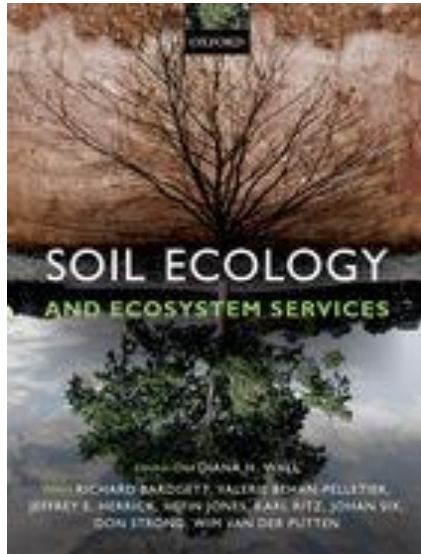
Draft final report

25th of November 2009

Bio Intelligence Service - Scoping sustainable development
Industrial Ecology - Nutritional Health
Bio Intelligence Service S.A.S. - 1000000000
50 000 Vals de France - 75018 Paris - France
Tel. +33 (0) 1 57 90 11 80 - Fax. +33 (0) 1 56 53 99 10

Soil Biodiversity synthesis report February 2010
<http://ec.europa.eu/environment/soil/biodiversity.htm>



Education and independent extension services needed

Soil Biodiversity

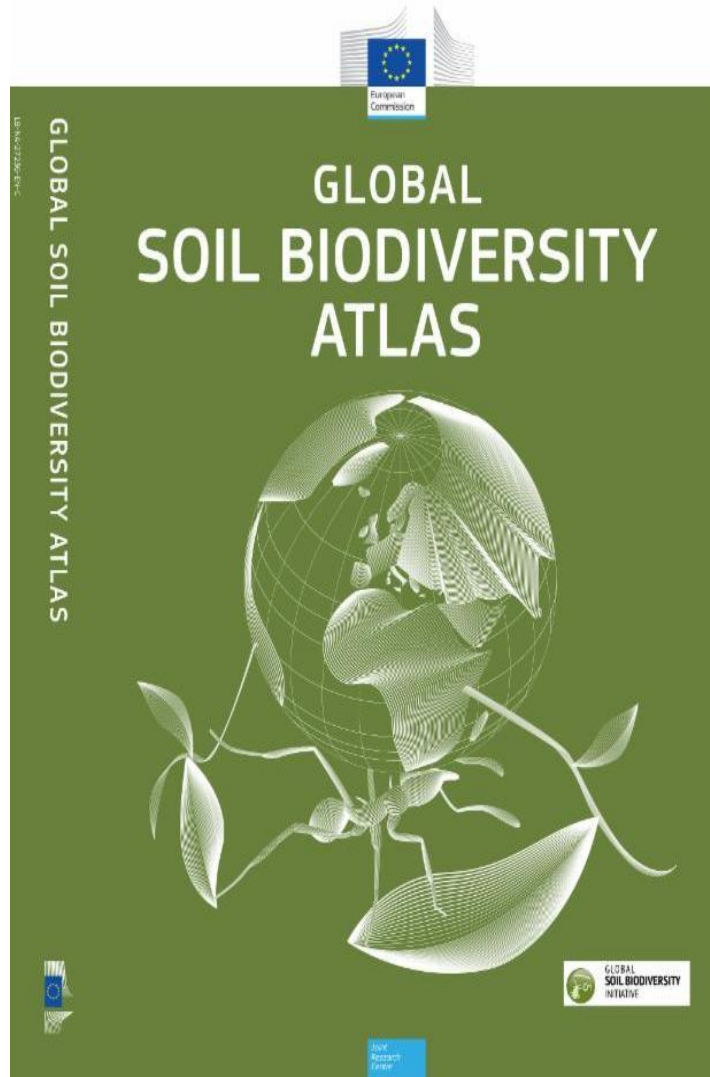
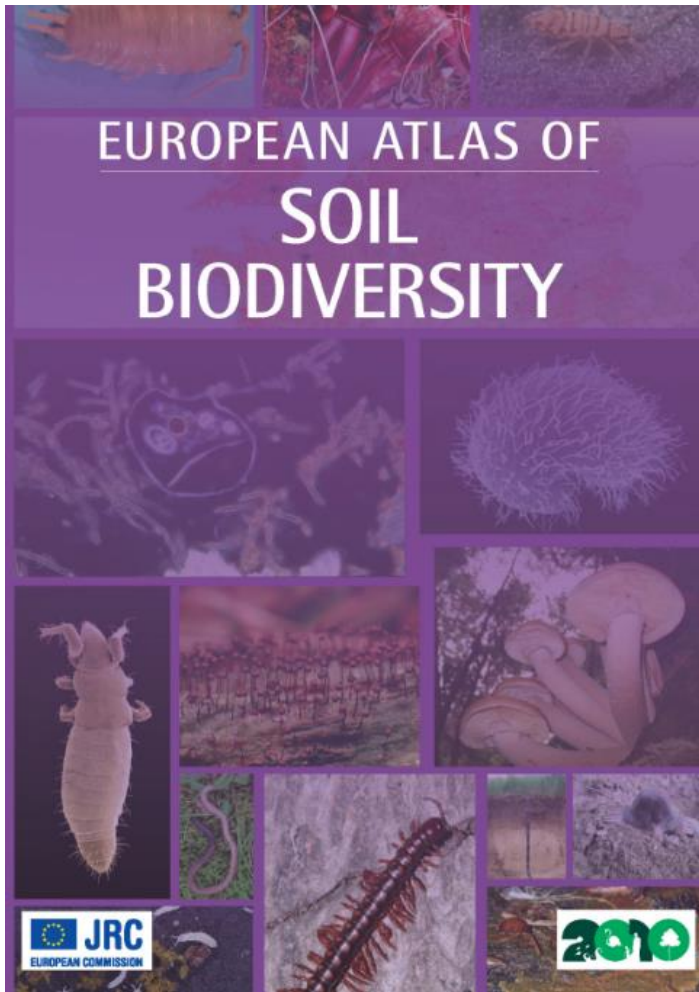


A hand full of soil: over 5,000 'species' of microbes, more individuals than humans on earth, more than 100 m fungal hyphae.



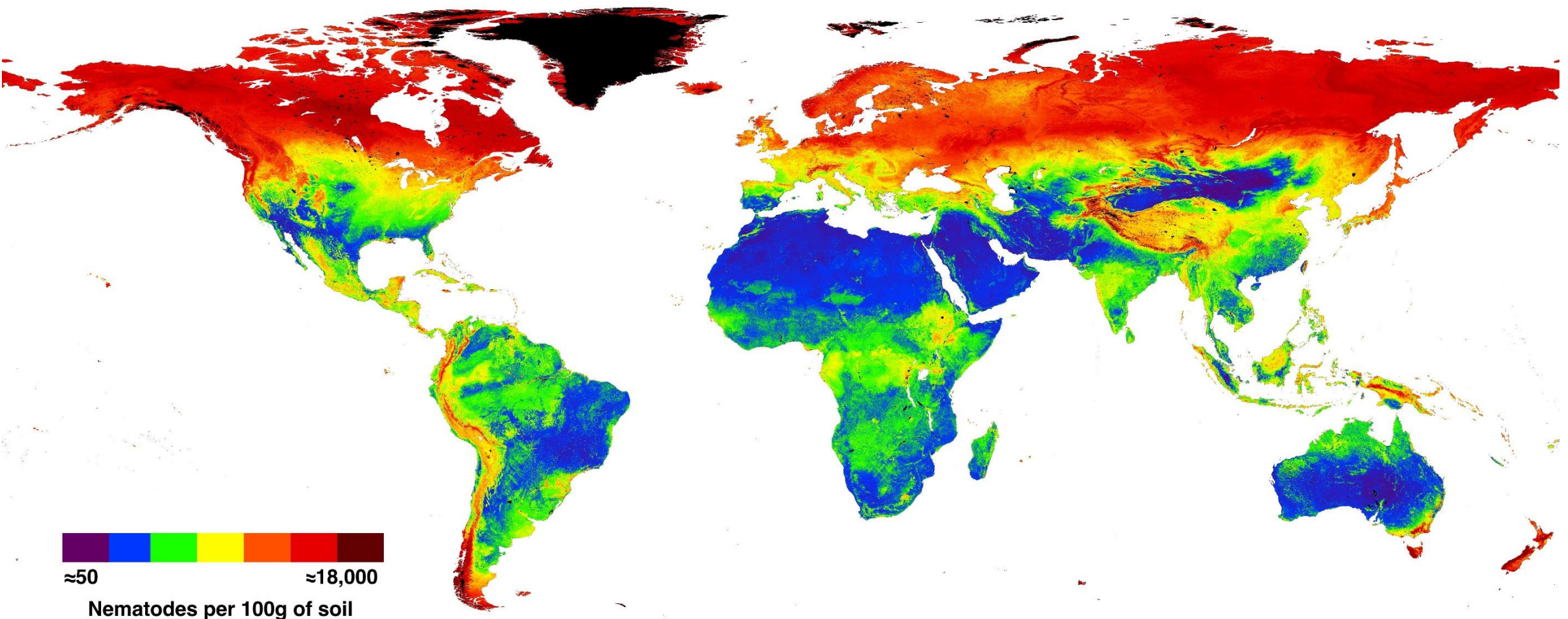
Estimated diversity and abundance of soil taxa according to published literature, supported by expert judgment.

Taxon	Diversity per amount soil or area (taxonomic units indicated below)	Abundance (approximate)
Prokaryotes ^a	100-9,000·cm ⁻³	4-20·10 ⁹ ·cm ⁻³
Fungi ^b	200 m.g ^{-1*}	100 m.g ⁻¹
AMF (species) ^c	10-20 m ⁻²	81-111 m.cm ⁻³
Protists ^d	150-1,200 (0.25 g) ^{-1**}	10 ⁴ -10 ⁷ ·m ⁻²
Nematodes (genera) ^e	10-100 m ⁻²	2-90·10 ⁵ m ⁻²
Enchytraeids ^f	1-15 ha ⁻¹	12,000-311,000 m ⁻²
Tardigrades ^g	?	?
Collembola ^g	20·m ⁻²	1-5 10 ⁴ m ⁻²
Mites (Oribatida) ^h	100-150 m ⁻²	1-10 10 ⁴ · m ⁻²
Isopoda ^g	10 · 100 m ⁻²	10 · m ⁻²
Diplopoda ^g	10 · 2,500 m ⁻²	110 · m ⁻²
Earthworms (Oligochaeta) ⁱ	10-15 ha ⁻¹	300 · m ⁻²



Global soil biodiversity
Assessment
(2020 COP Beijing)

Under development



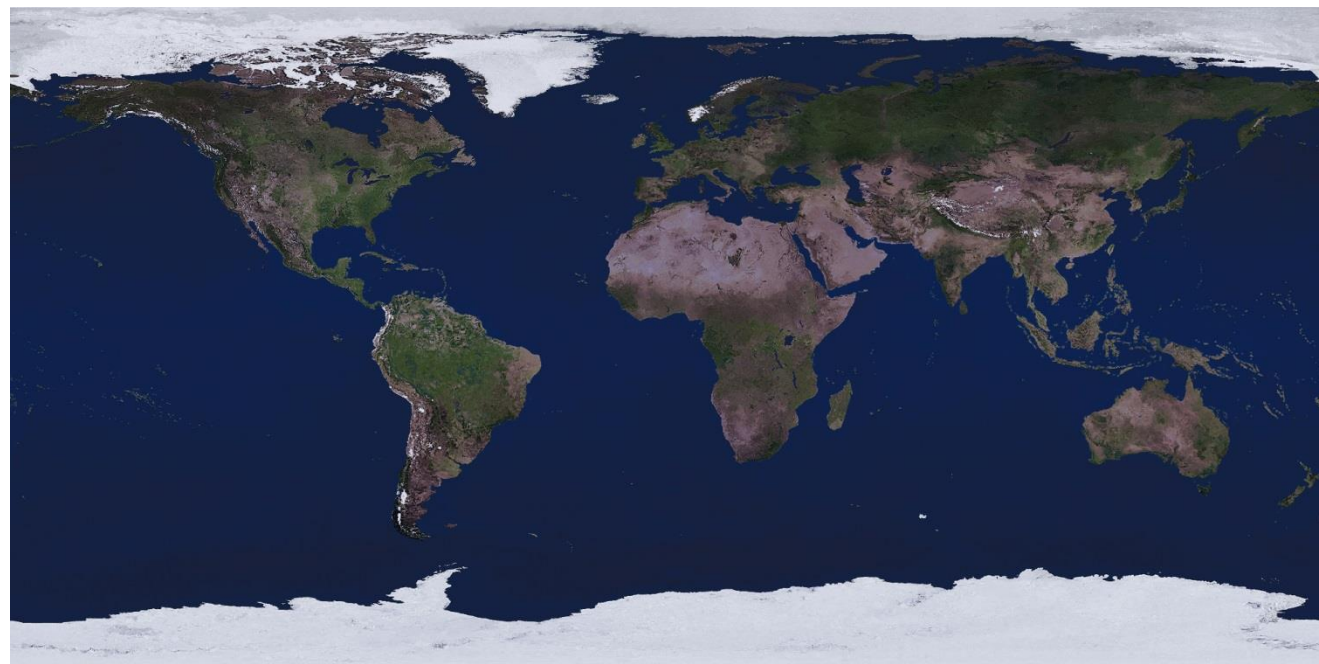
Global nematode survey

Gil Grissom (William Petersen) on CSI: Crime Scene Investigation.

THE
who's
who

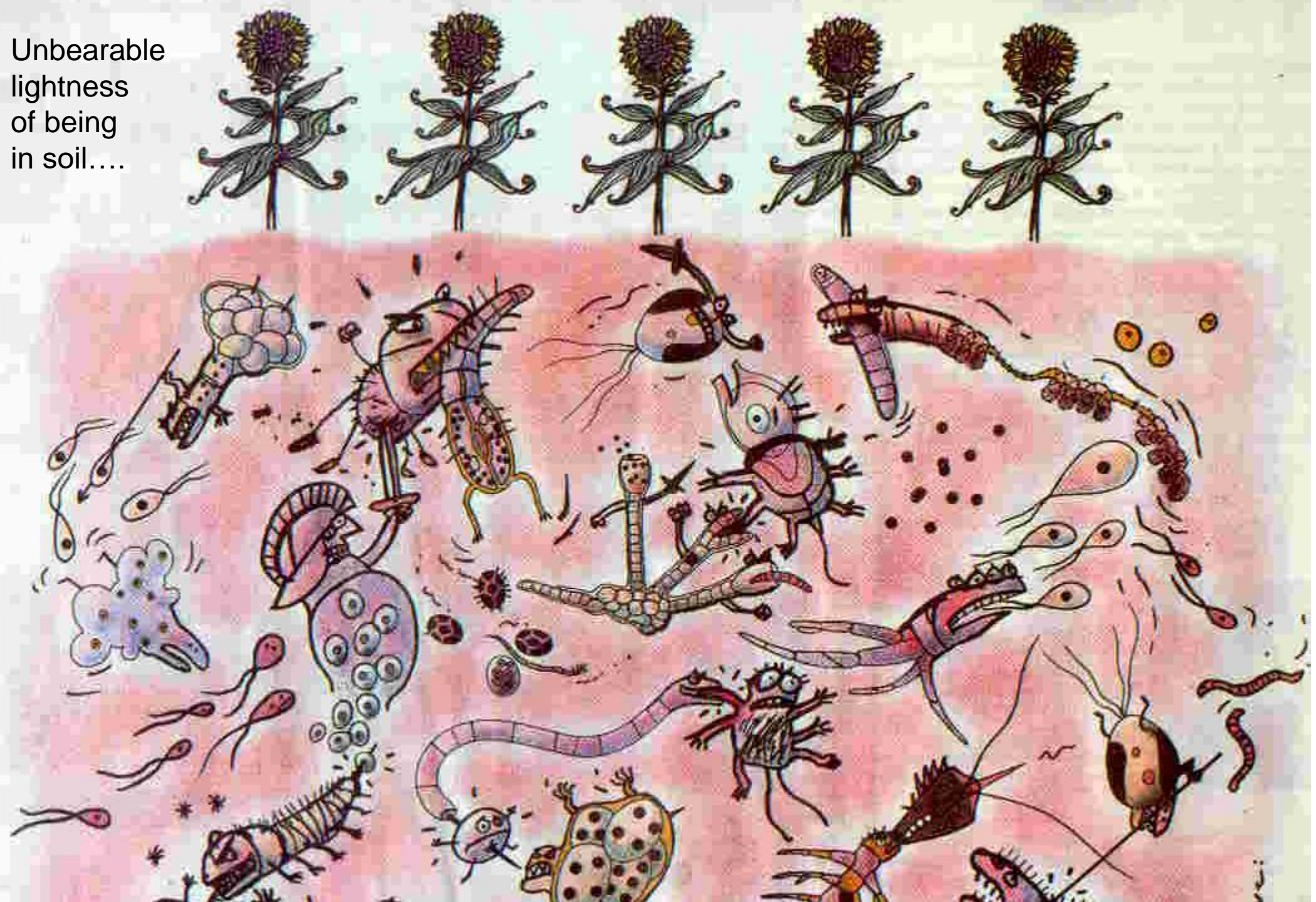


Who
Does
What



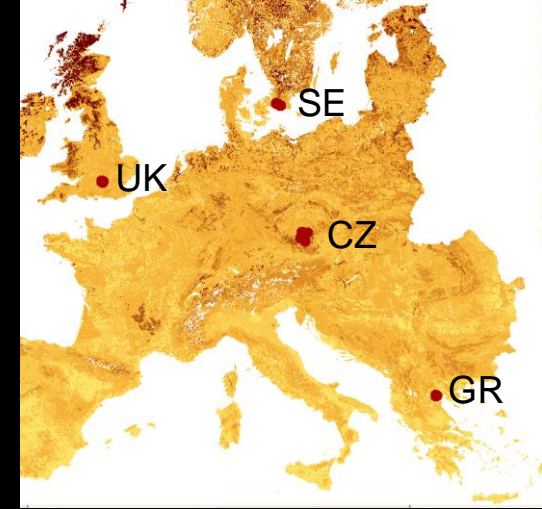
When and where

Unbearable
lightness
of being
in soil....





SOILSERVICE



tillage

tillage

at most every two years

each year

grazing

cutting, fertilizing

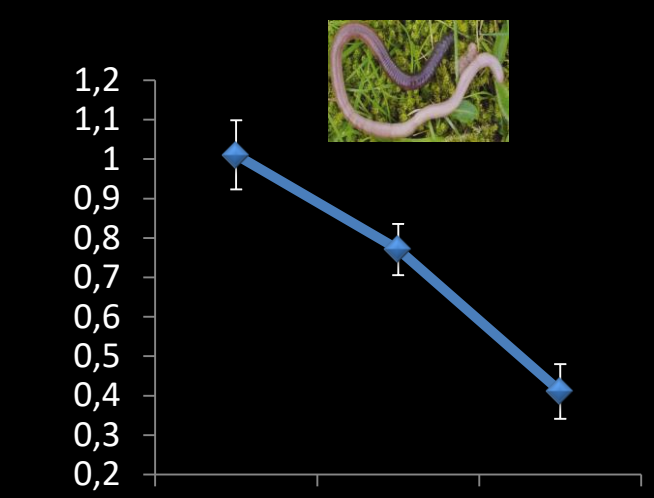
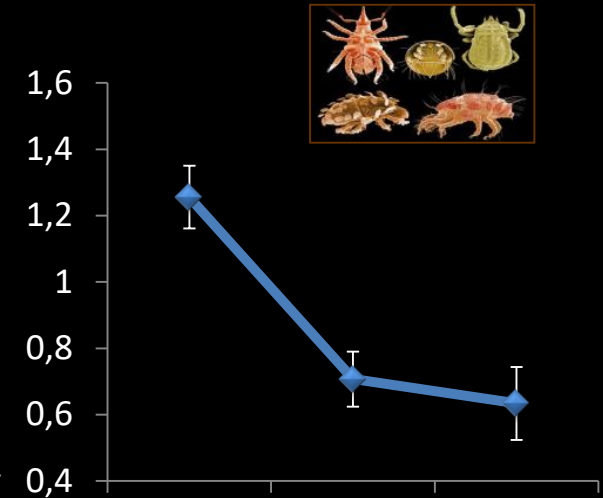
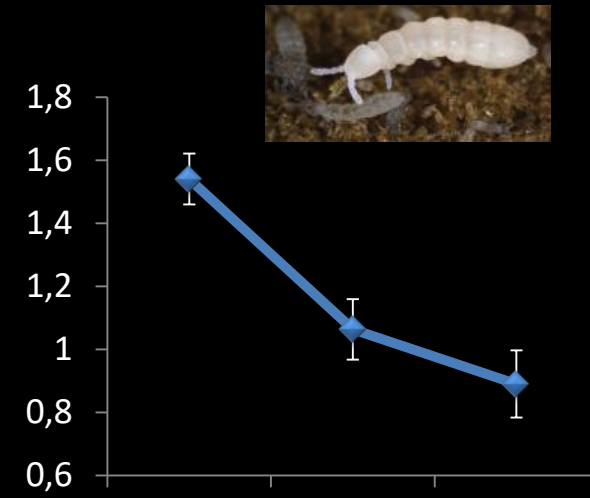


Pasture

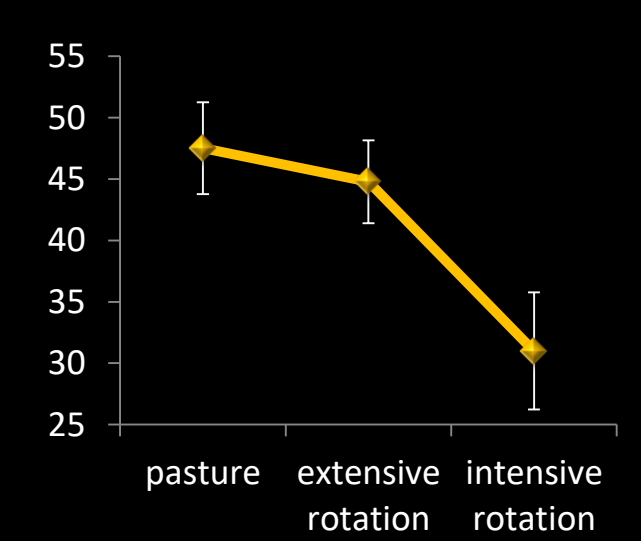
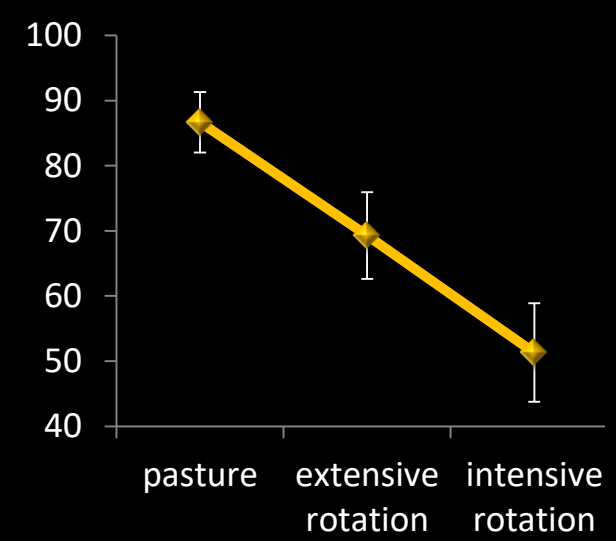
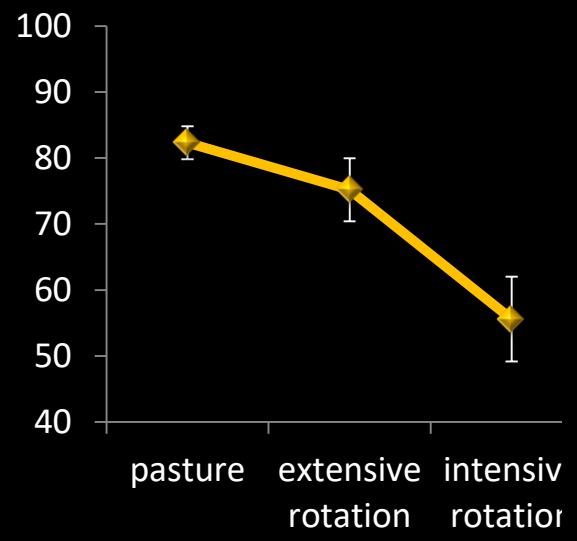
Extensive rotation

Intensive rotation

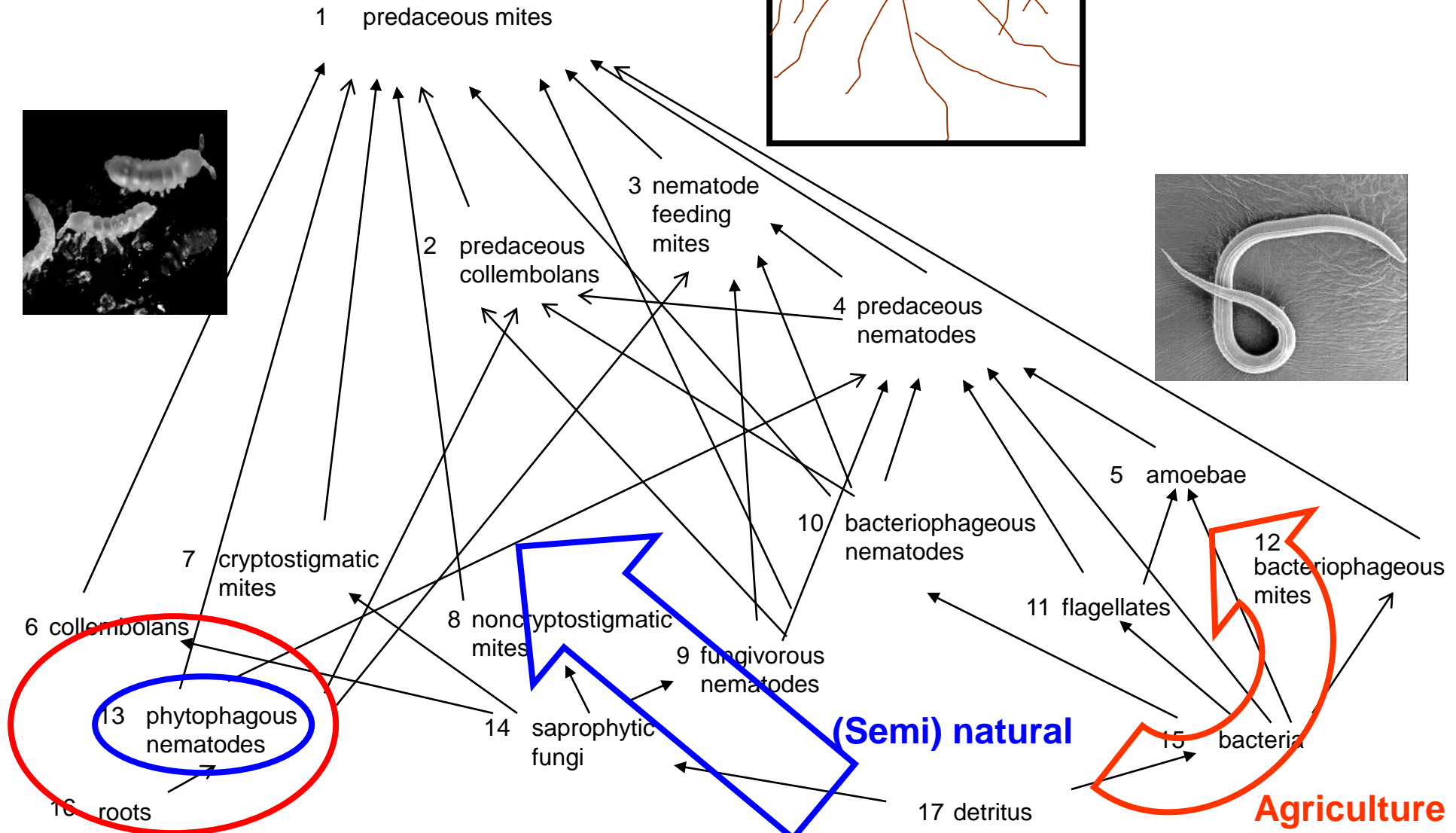
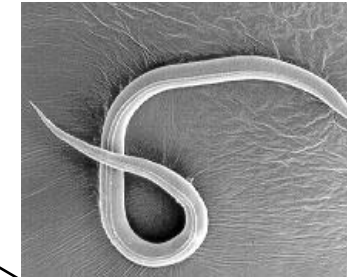
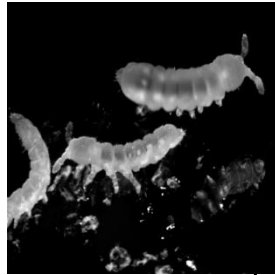
Shannons' index



Taxonomic Diversity (Breath)

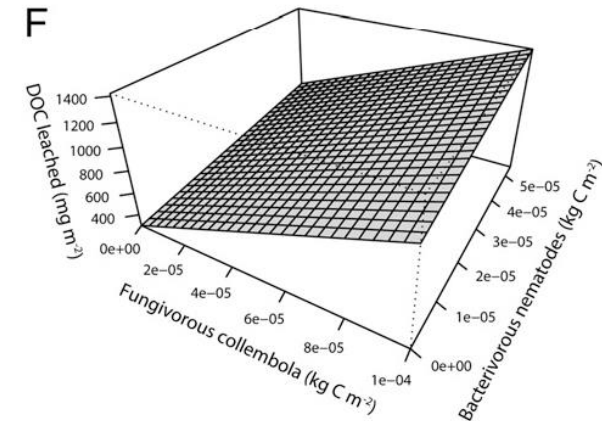
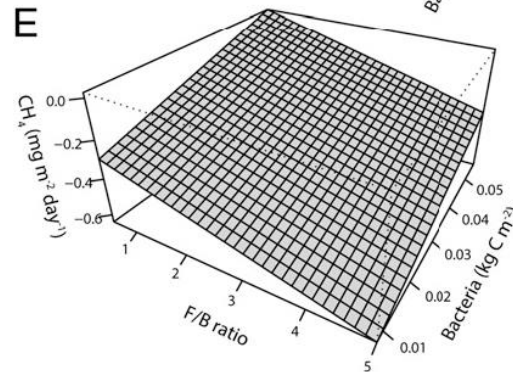
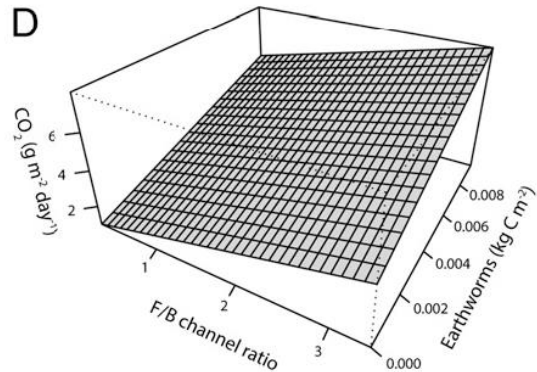
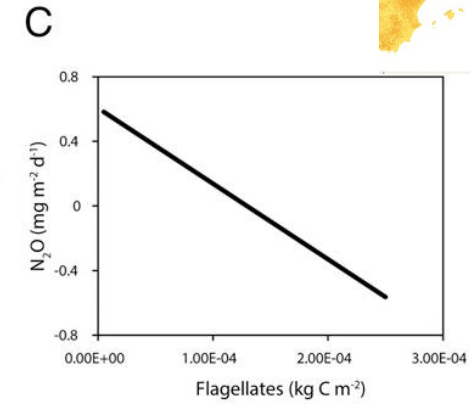
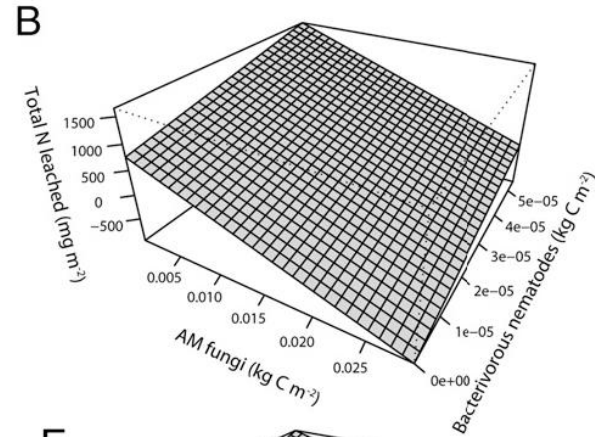
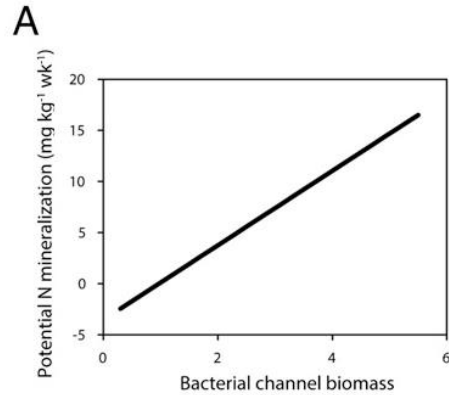
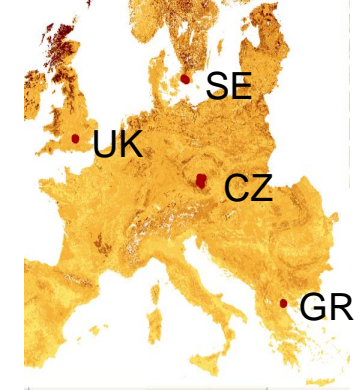


Soil food web





SOILSERVICE



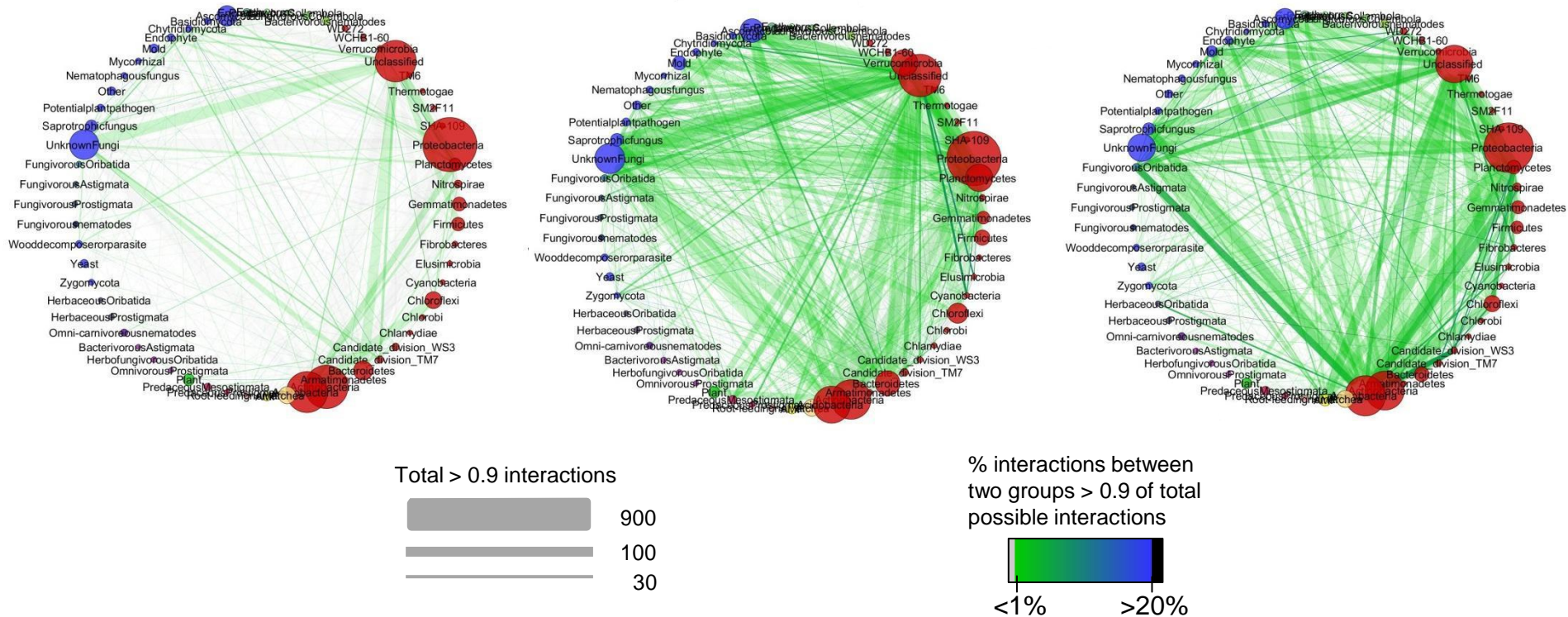
Soil food web analysis: change different ecosystem processes due to land use intensification relate to different soil food web properties: all needed for multifunctionality!



Recent

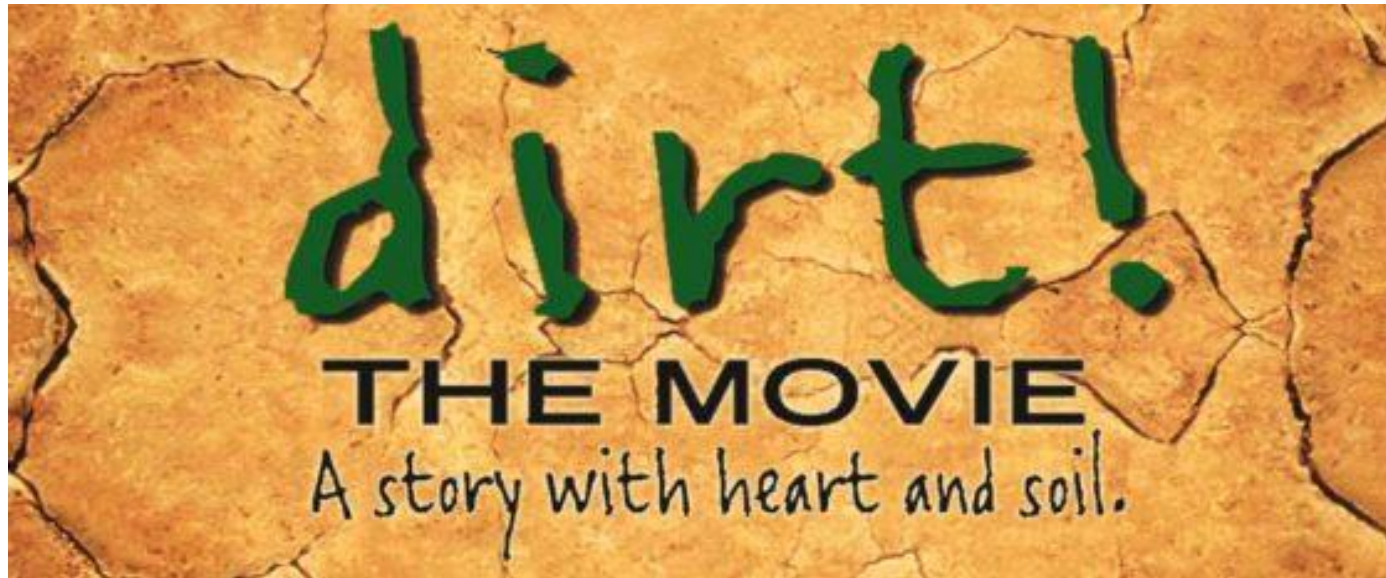
Mid-term

Long-term



Soil biodiversity restoration takes a lot of time!
 Correlation-based networks in three phases of land abandonment: roughly 5, 15 and 30 years ago

Morriën, Hannula, Snoek, & EcoFinders
 Nature Communications (2017)



Why first destroy soil and then restore?

Let's act now!

Thank you for your attention!