Connecting soil biodiversity to functions and ecosystem services: presentation of case studies and of the EU project EcoFINDERS

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http://www.ecofinders.eu/
Soils deliver many ecosystem services

**Food & biomass production**

**Soil ecosystem services**

**Habitat, gene pool**

**Storing, filtering & transformation**

**Source of raw materials**

**Physical & cultural environment for mankind**

*Courtesy of Antonio Bispo, ADEME*
- **Huge quantity of organisms**
  - Fauna: 1-5 T/ha
  - Fungi: 3.5 T/ha
  - Bacteria: 1.5 T/ha

- **Fantastic diversity ...but so little explored...**
  - Until recently: only access to culturable microorganisms
  - Methodological progresses
    - possibility to extract DNA from soils
    - $10^4$ – $10^6$ bacterial genotypes / g sol
Soils and biodiversity are submitted to major threats

- **Erosion**: 115 million hectares (12% of Europe’s total land area) subject to water erosion, 42 million hectares to wind erosion.
- **Contamination**: 3.5 million sites within the EU could be contaminated
- **Decrease of organic matter**: About 45% of European soils have low organic matter content
- **Soil sealing**: 1990-2000: 1,000 km² of soil lost per year in the EU, 2000-2006, the average loss increased by 3%

See presentation S03.02c-1 by L. Montanarella

Adapted from Dominique Arrouays, InfoSol

[Source: D. Arrouays (INRA Orléans)]
Major need for monitoring soil biodiversity

- This requires a better knowledge in:
  - Soil biodiversity
  - Relationships between soil biodiversity-functions-ecosystem services
  - Impact of the variety of environmental situations
Connecting soil biodiversity to functions

1st case study - C cycle: SOM mineralization

Mineralization SOM = f (Microbial diversity)

Mineralization D1 > D2 > D3

See presentation S11.02c-5 by V. Tardy

P.-A. Maron
Connecting soil biodiversity to functions

2nd case study - N cycle: denitrification

Leaching

NO3-

N2

N2O

Nitrification

NO2-

Denitrification

NO2-NH4+

Nitrogen fixation

Biodiversity

DNA

RNA

Proteins

Genome

Transcriptome

Proteome & Metabolome

Activities

Functions

Ecosystem services

L. Philippot

NH4+

N2

NO

NO2-

N2O

N2

NO3-

Leaching
Connecting soil biodiversity to functions

Total bacteria (16S rRNA gene copies ng\(^{-1}\) DNA)

Denitrification end products % N\(_2\)O/(N\(_2\)O+N\(_2\))

Proportion of bacteria genetically capable to reduce N\(_2\)O (% nosZ/16S rDNA)

nosZ (gene copies ng\(^{-1}\) DNA)

> Negative correlation between the % of bacteria capable to reduce N\(_2\)O and the % N\(_2\)O/(N\(_2\)O+N\(_2\))

Impact of environmental filters

Case study - French national soil survey (RMQS) – Molecular biomass

**DNA yield (µg.g⁻¹ soil)**

- **H-Zone 1**
- **H-Zone 2**
- **H-Zone 3**
- **L-Zone 1**
- **L-Zone 2**

**Biodiversity**

- **DNA**
- **RNA**
- **Proteins**

**Activities**

**Functions**

**Ecosystem services**

**Environmental filters**


**See presentation S11.06-6 by N. Chemidlin**
Impact of environmental filters

RMQS - Genetic structure of bacterial communities


See presentation S11.06-6 by N. Chemidlin

- Heterogeneous distribution but spatial structuration of microbial communities
- Relevance of the ‘Normal Operating Range’ concept
- Need of data bases for diagnostic of the soil biodiversity
- Need of Standard Operating Procedures
- Need for a broader approach at the European level

Demonstration of the connection between soil biodiversity and functioning

But lack of information on the impact of environmental filters on this connection

In 2010, EC considered that for establishing Soil Thematic Strategy further knowledge was required.

ENV.2010.2.1.4.4 Increasing the understanding of the role of soil biodiversity in ecosystem functioning
Ecological Function and Biodiversity Indicators in European Soils

2011-2015

Environmental filters

Biodiversity

Expression of genetic potential

DNA
RNA
Proteins

Genome
Transcriptome
Proteome & Metabolome

Activities
Functions
Ecosystem services

- 23 partners
- 10 European countries: D, DK, F, I, IRL, NL, P, S, SK, SLO, UK
- Non-European country: China
EcoFINDERS - Standard Operating Procedures - Bioindicators

Standardization of sampling procedures

- Where, when and how take samples, number of replicates, sampling depth, use of composite samples, ...

Optimisation of DNA extraction

- Assessment of possible biases according to the soil type
- Optimisation to allow extraction of DNA of the major types of organisms targeted
  - Microorganisms (archaea, bacteria, fungi)
  - Fauna (protozoa, nematodes,....)

Standardization of methods for biodiversity characterization

Identification of bioindicators

(See presentation S11.02b-3 by B. Griffiths)

- Sensitive
- Consistent – reliable
- Cost-effective
- Range of variations
EcoFINDERS – Transect

Characterization of biodiversity across Europe

Aims at assessing:
✓ Range of variations according to soil types, to climatic zones and to land uses
✓ Range of variations of the identified biodindicators according to soil types, climatic zones and land uses
美股 Definition of the ‘Normal Operating Range’

Strategy:
✓ Using data derived from the Joint Research Council, 255 points sampled across Europe to derive indicative values for: Organic Carbon, Texture, pH
✓ Overlaid onto the LUCAS – landcover survey and sites identified as either forest, grass or tillage.
✓ Identification of 85 sites per land-use type across Europe to give a range of the above soil properties
EcoFINDERS – Long Term Observatories

Connecting soil biodiversity, functions and ecosystem services

- Countries
  - ALPINE
  - ATLANTIC
  - BLACK SEA
  - BOREAL
  - CONTINENTAL
  - MACARONESIAN
  - MEDITERRANEAN
  - PANNONIAN
  - STEPPIC

Lamborn:
- Nutrient cycling (N)
- Carbon storage

Lusignan:
- Nutrient cycling (N)
- Carbon storage
- Soil structure & water regulation

Veluwe:
- Nutrient cycling, Carbon storage, Soil structure regulation, Aboveground diversity

Lancaster:
- Nutrient cycle, Carbon storage, Soil structure regulation, Above ground diversity

Berchidda:
- Nutrient cycling (N), Carbon storage, Above ground diversity

- Different land uses: grasslands, tillage, forests
- For each LTO: three levels of intensification

See presentation S11.02c-2 by B. Thomson
Moving from diagnosis to action

- Based on diagnosis, define strategies of mitigation, biodiversity and soil restoration
- This requires further progresses in our knowledge between soil biodiversity and functioning
- Capitalisation of European and National means and information on a set of long term observatories sites