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

Soil ecosystem services

Food & biomass production

A. Richer de Forges (CA 45)

Infosol (INRA Orléans)

Habitat, gene pool

Infosol (INRA Orléans)

J. Moulin (CA 36)

Storing, filtering & transformation

A. Richer de Forges (CA 45)

Source of raw materials

J. Moulin (CA 36)

Physical & cultural environment for mankind

C. Schvartz (ISAL)

Courtesy of Antonio Bispo, ADEME

Living soils

- Huge quantity of organisms

  - Fauna: 1-5 T/ha
  - Fungi: 3.5 T/ha
  - Bacteria: 1.5 T/ha

F. Ippolito

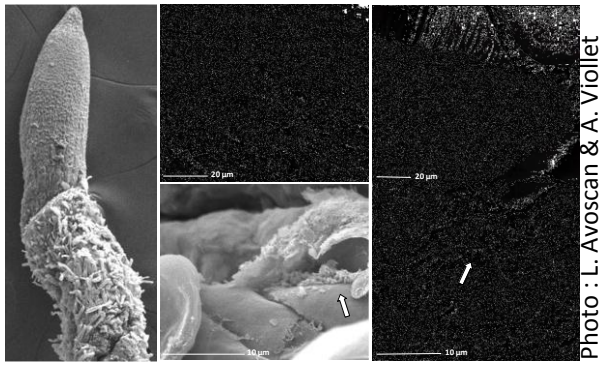
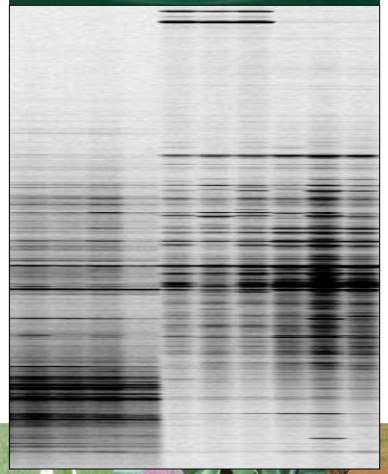


Photo : L. Avoscan & A. Viollet

- 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

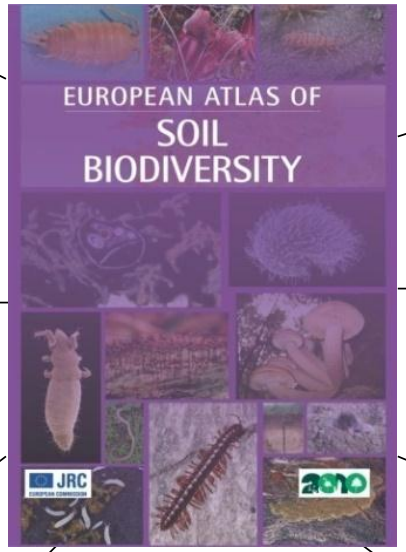


Soils and biodiversity are submitted to major threats

↘ Organic matter

Source : D. Arrouays (INRA Orléans)

↗ Erosion



↘ Biodiversity

Source : D. Arrouays (INRA Orléans)

↗ Compaction

Source : D. Arrouays (INRA Orléans)

↗ Contamination

Source : J. Sauter (ARAA)

↗ Salinisation

Source : D. Arrouays (INRA Orléans)

↗ Floods and landslides

Source : D. Arrouays (INRA Orléans)

↗ Sealing

Source : D. Arrouays (INRA Orléans)

Adapted from Dominique Arrouays, InfoSol

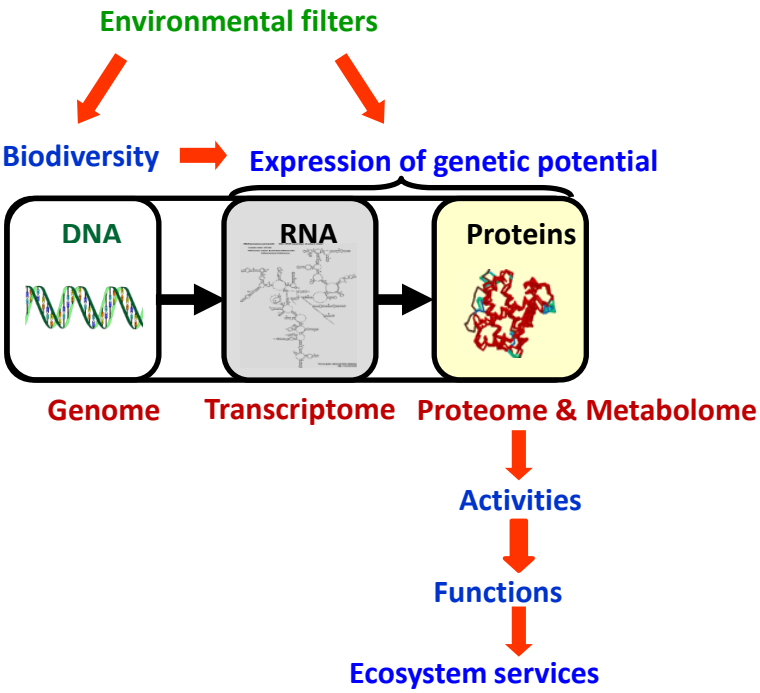
- **Erosion**: 115 million hectares (12% of Europe's total land area) subject to water erosion, 42 million hectares to wind erosion.
- **Contamination**: 3.5 million sites within the EU could be contaminated
- **Decrease of organic matter:** About 45% of European soils have low organic matter content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

http://ec.europa.eu/environment/soil/

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

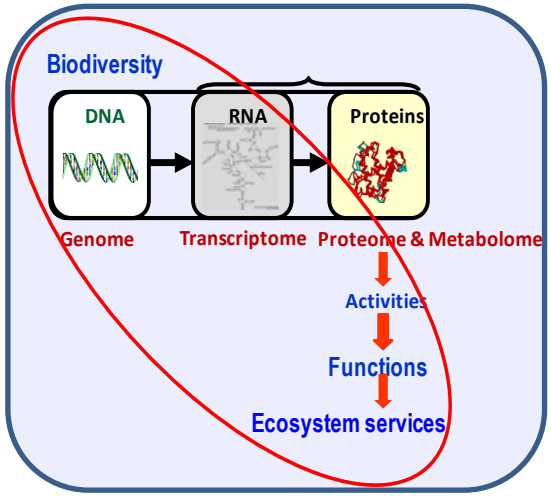
Major need for monitoring soil biodiversity

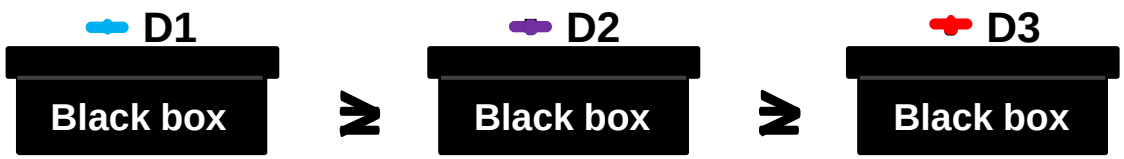
- This requires a better knowledge in:
  - Soil biodiversity
  - Relationships between soiil biodiversity-functions-ecosystem services
  - Impact of the variety of environmental situations

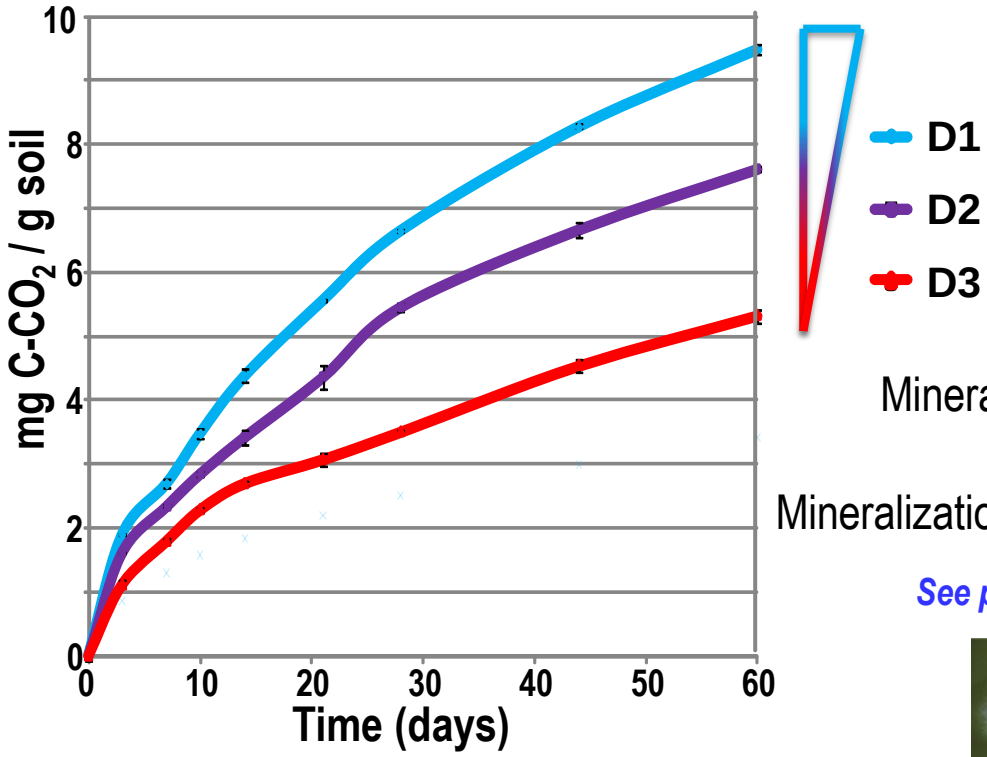


Connecting soil biodiversity to functions

1srt case study - C cycle: SOM mineralization







Mineralization D1 > D2 >D3

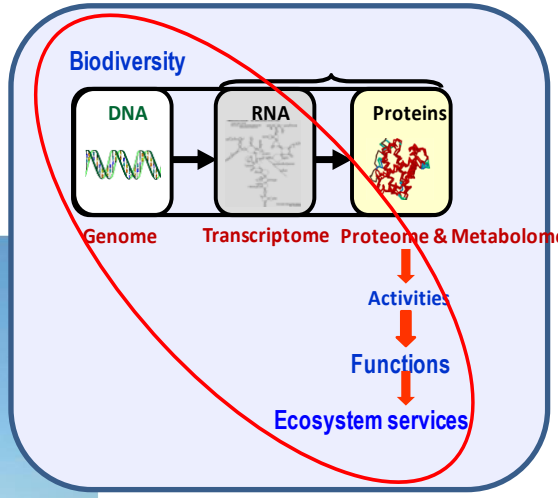
Mineralization SOM = f (Microbial diversity)

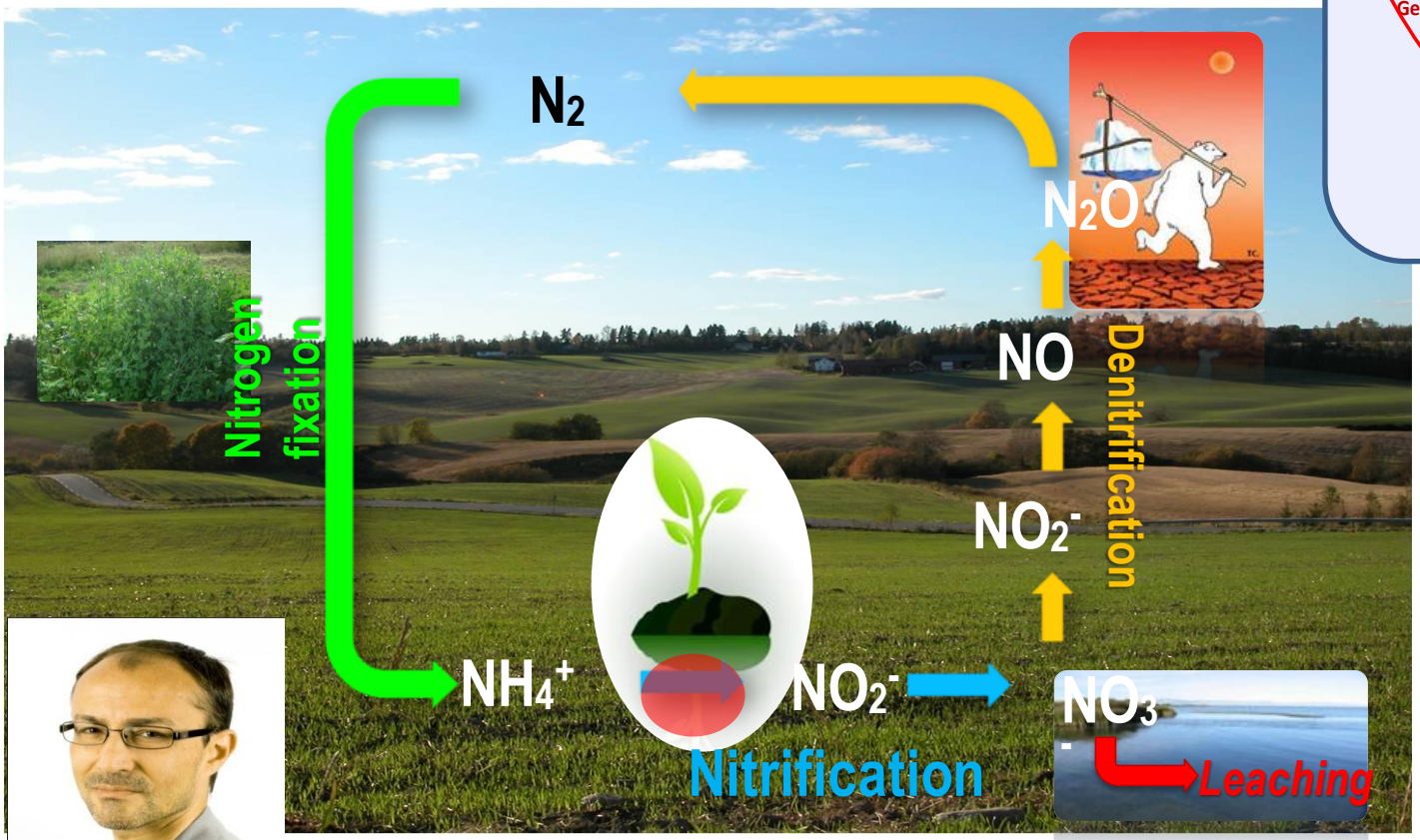
See presentation S11.02c-5 by V. Tardy

P.-A. Maron

Connecting soil biodiversity to functions

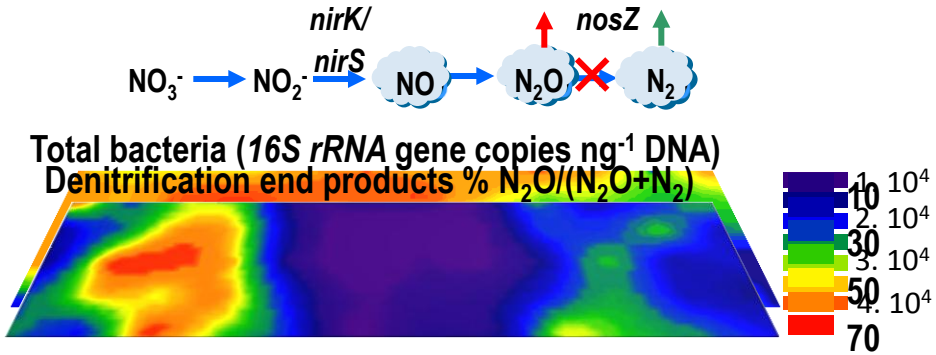
2nd case study - N cycle: denitrification

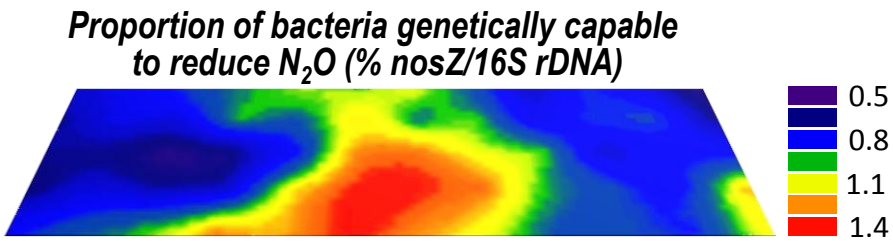


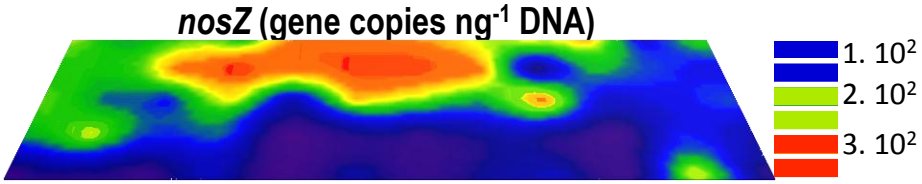


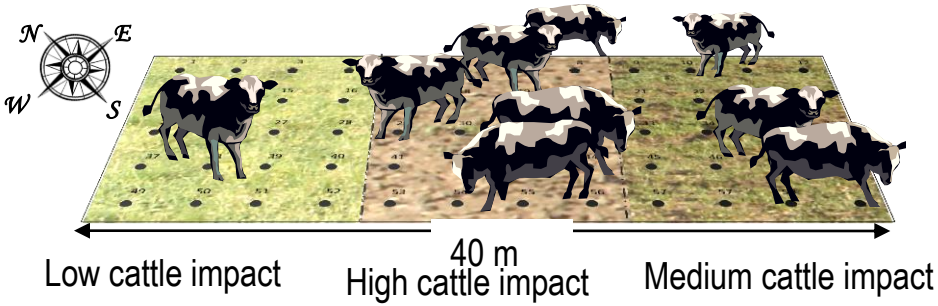
L. Philippot

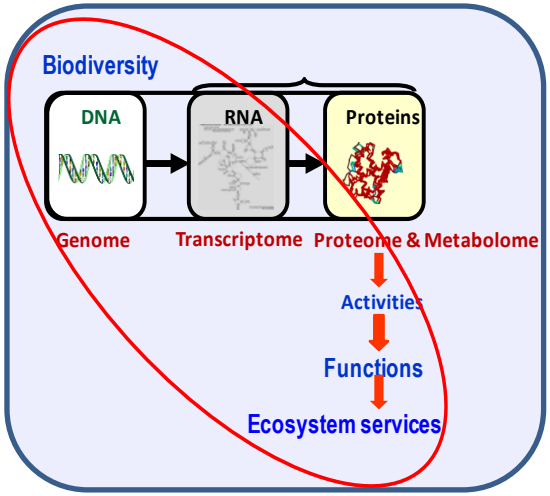
Connecting soil biodiversity to functions











> Negative correlation between the % of bacteria capable to reduce N_2O and the % $N_2O/(N_2O+N_2)$

Philippot et al. 2009. Environ. Microbiol. 11:3096-3104.

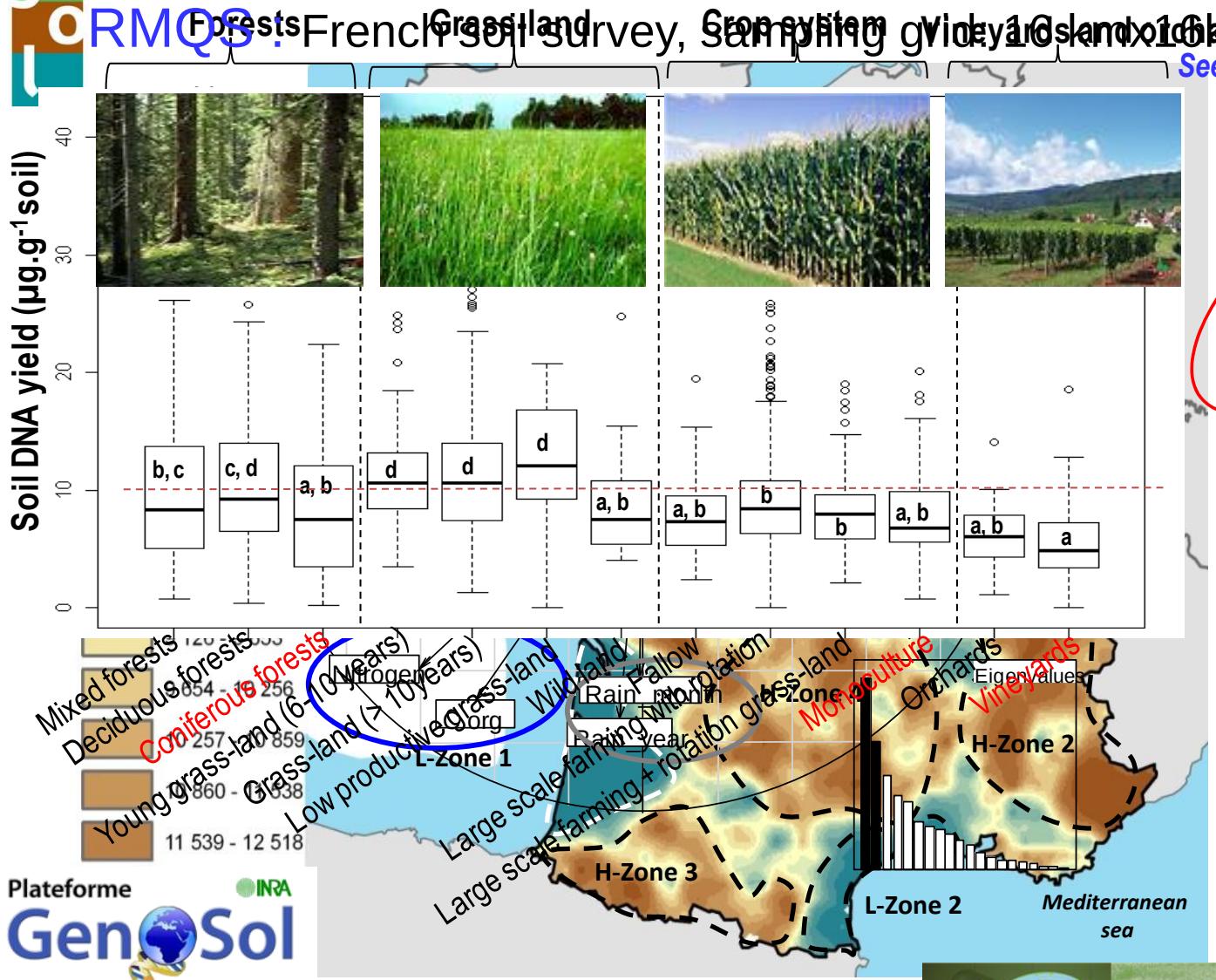
Impact of environmental filters

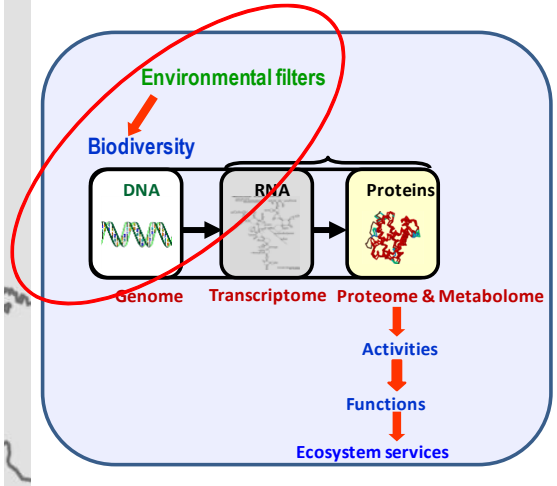
Inventaire, gestion et conservation des sols

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

RMQS : French soil survey, sampling grid 1 Gland 1 Gland ⇔ 2200 sites

See poster S04.02-P-1 by L. Boulonne





L. Ranjard

Plateforme GenoSol INRA

Exploring the microbial world To better protect our environment

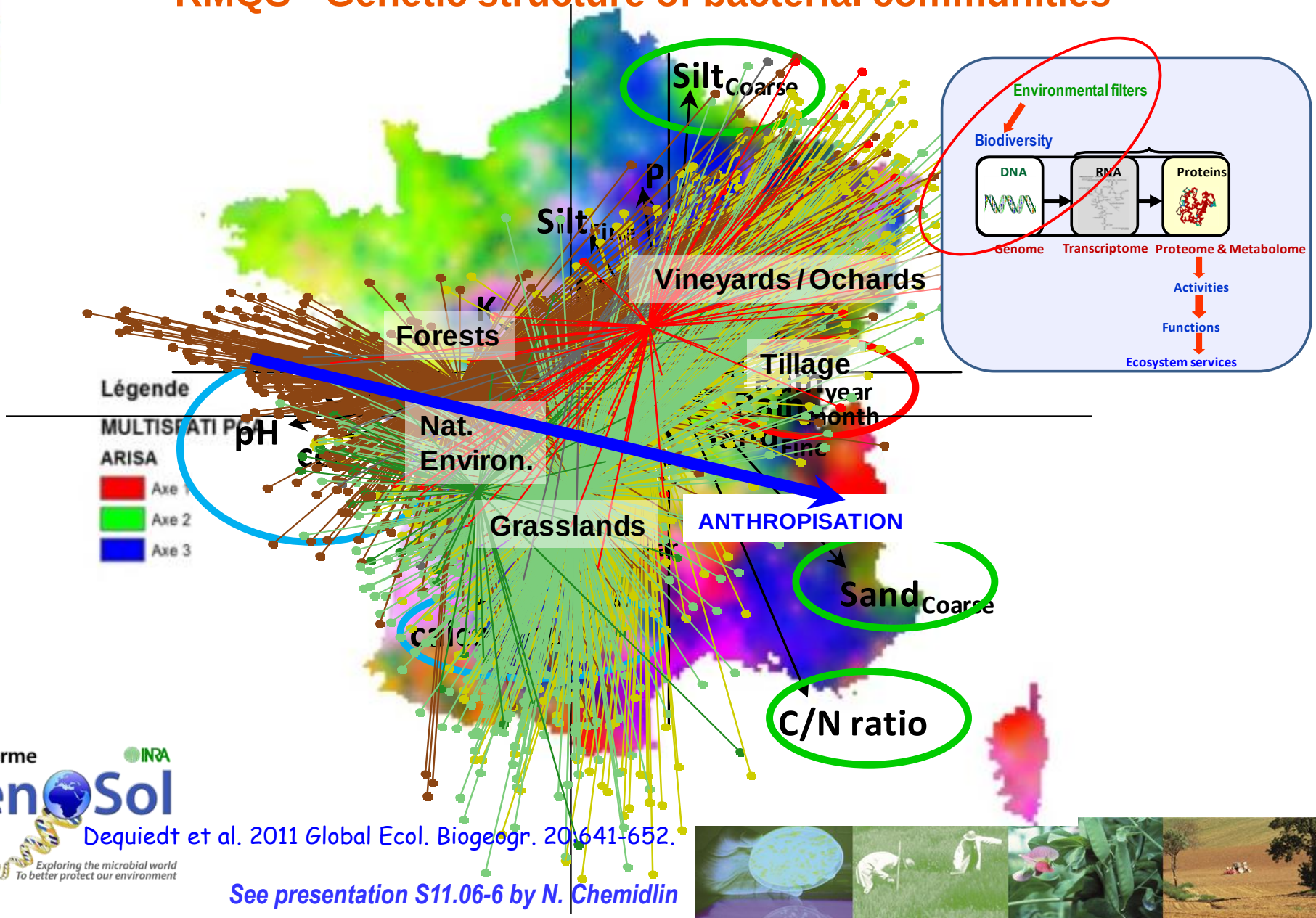
Dequiedt et al. 2009. Environ. Microbiol. Rep. 1:251-255.

See presentation S11.06-6 by N. Chemidlin

Impact of environmental filters

Inventaire, gestion et conservation des sols

RMQS - Genetic structure of bacterial communities



Plateforme GenoSol INRA

Exploring the microbial world To better protect our environment

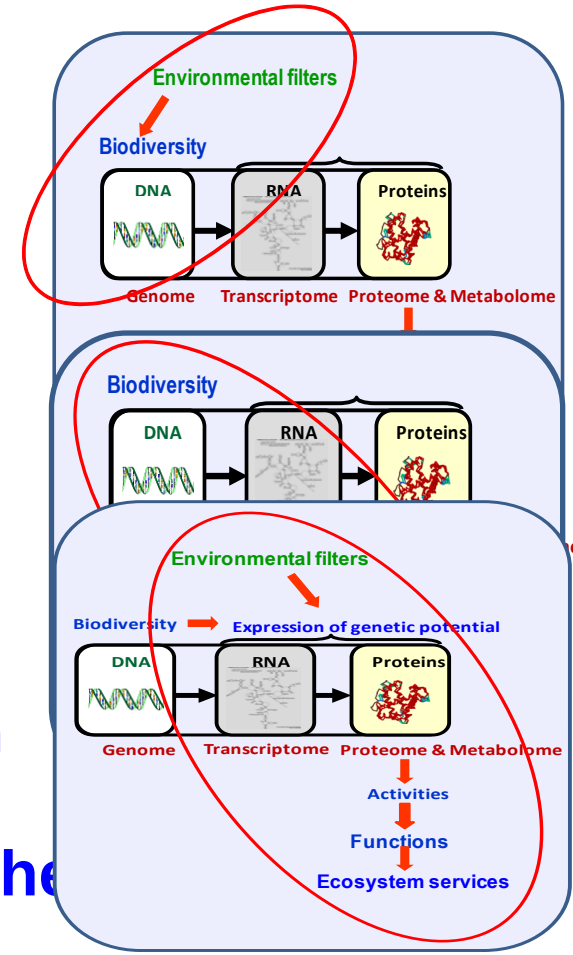
Dequiedt et al. 2011 Global Ecol. Biogeogr. 20:641-652.

See presentation S11.06-6 by N. Chemidlin

European Soil Thematic Strategy

Studies on national surveys in France but also UK (Griffiths et al. 2011 Environ. Microbiol. 13:1642-1654), The Netherlands (Rutgers et al. 2009. Eur. J. Soil Sci. 60:820-832), Germany (see presentation S04.06-5 by C. Schilli):

- ✓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

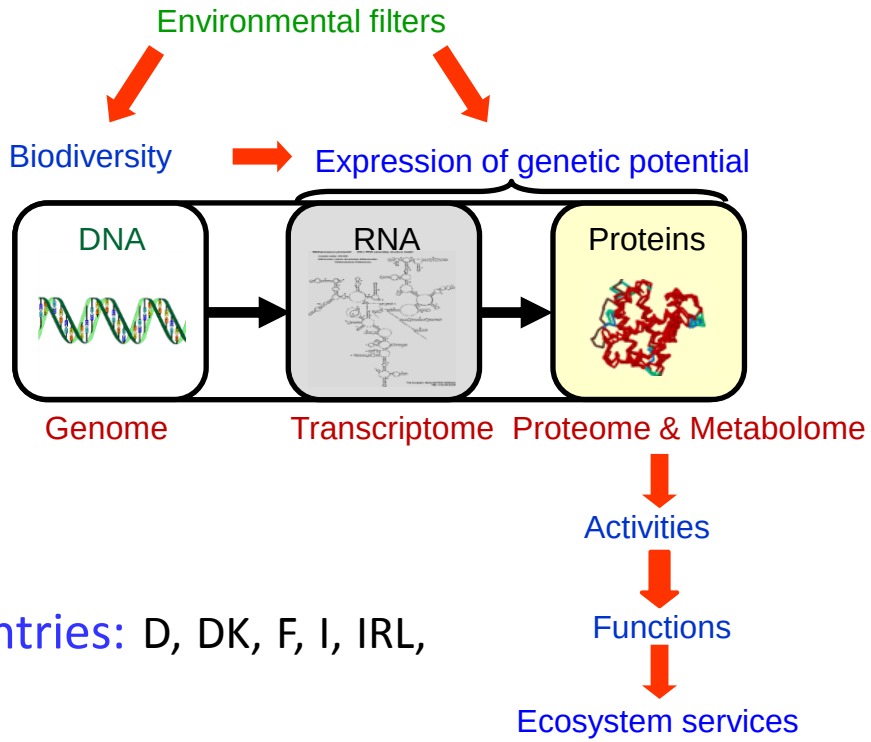
In 2010, EC considered that for establishing **Soil The** **further** knowledge was required.

ENV.2010.2.1.4.4 Increasing the understanding of the role of soil biodiversity in ecosystem functioning

EcoFINDERS

Ecological Function and Biodiversity Indicators in European Soils

2011-2015



- 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, ...

INTERNATIONAL STANDARD

ISO 10381-1

First edition
2002-12-15

Soil quality — Sampling —

Part 1:
Guidance on the design of sampling programmes

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

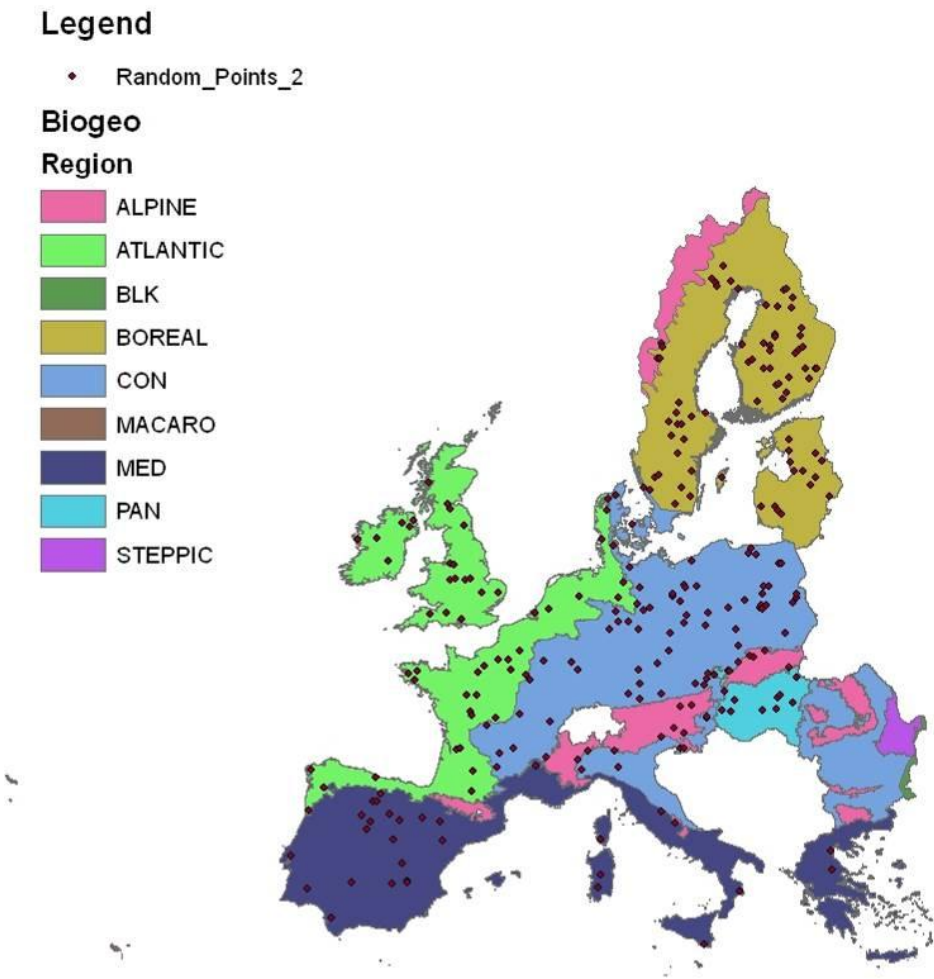
Characterization of biodiversity across Europe

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
- ↳Definition of the 'Normal Operating Range'

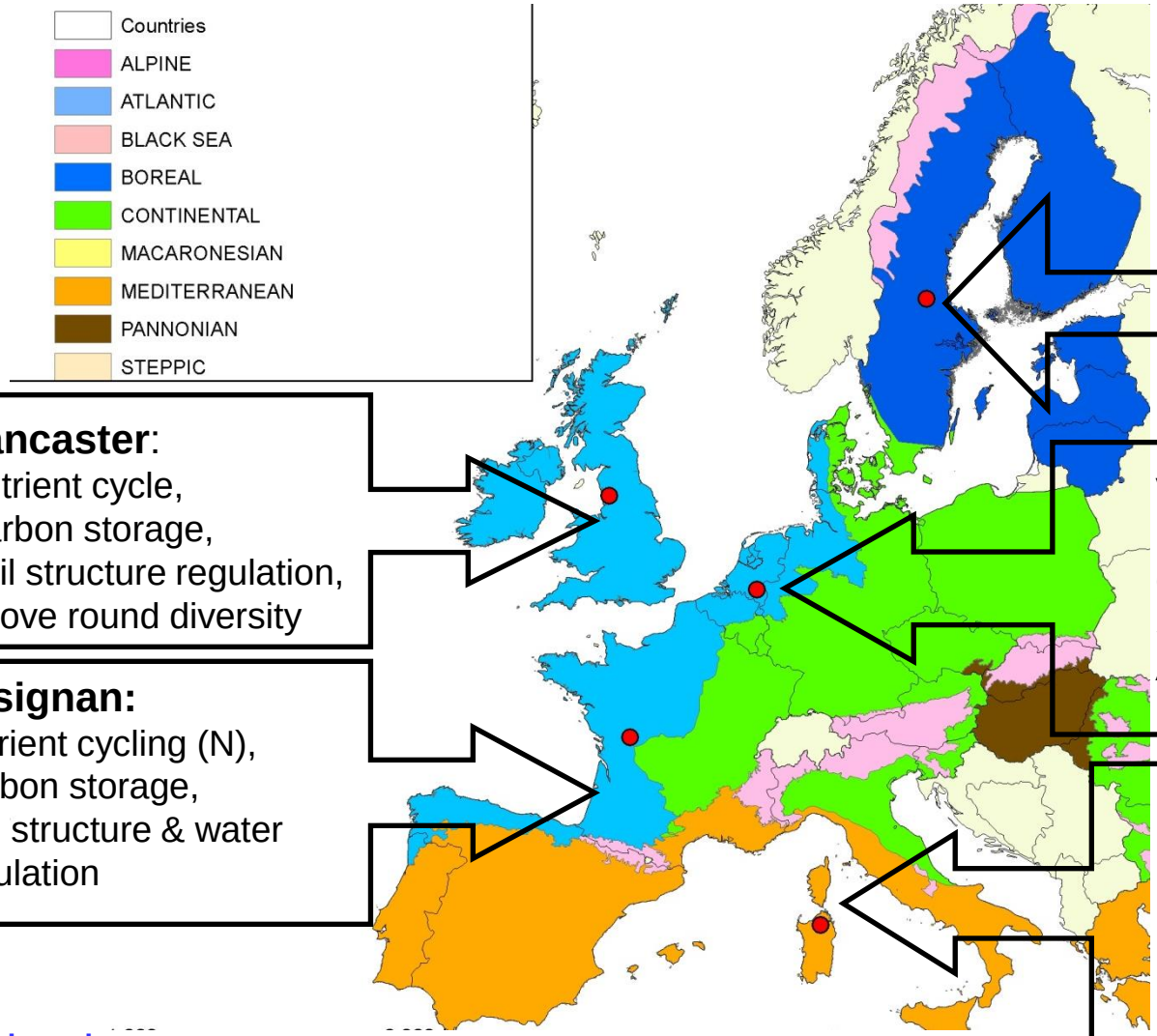
Strategy:

- ✓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



Lamborn:
Nutrient cycling (N)
Carbon storage

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

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

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

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

Further challenges

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