Ecological Function and Biodiversity Indicators in European Soils

EcoFINDERS

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

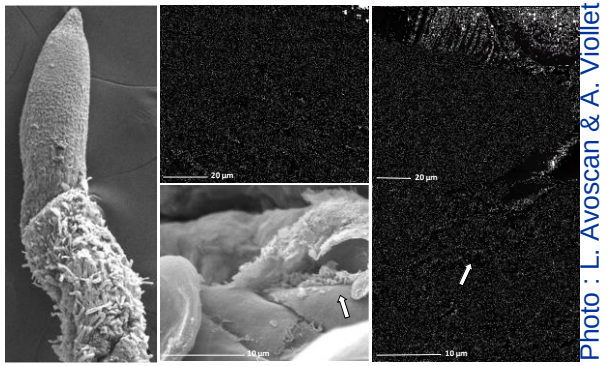
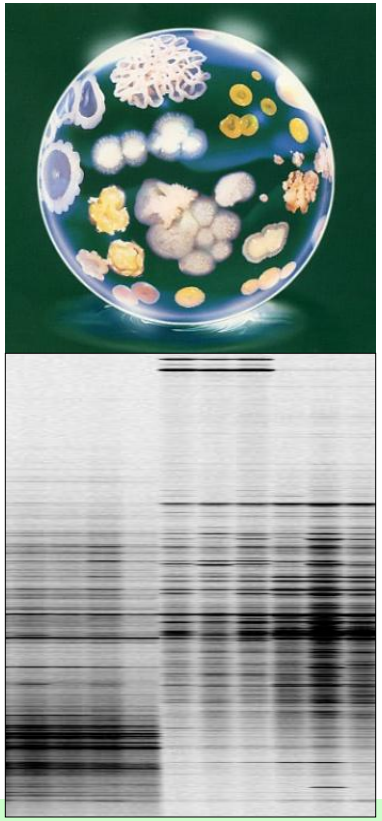
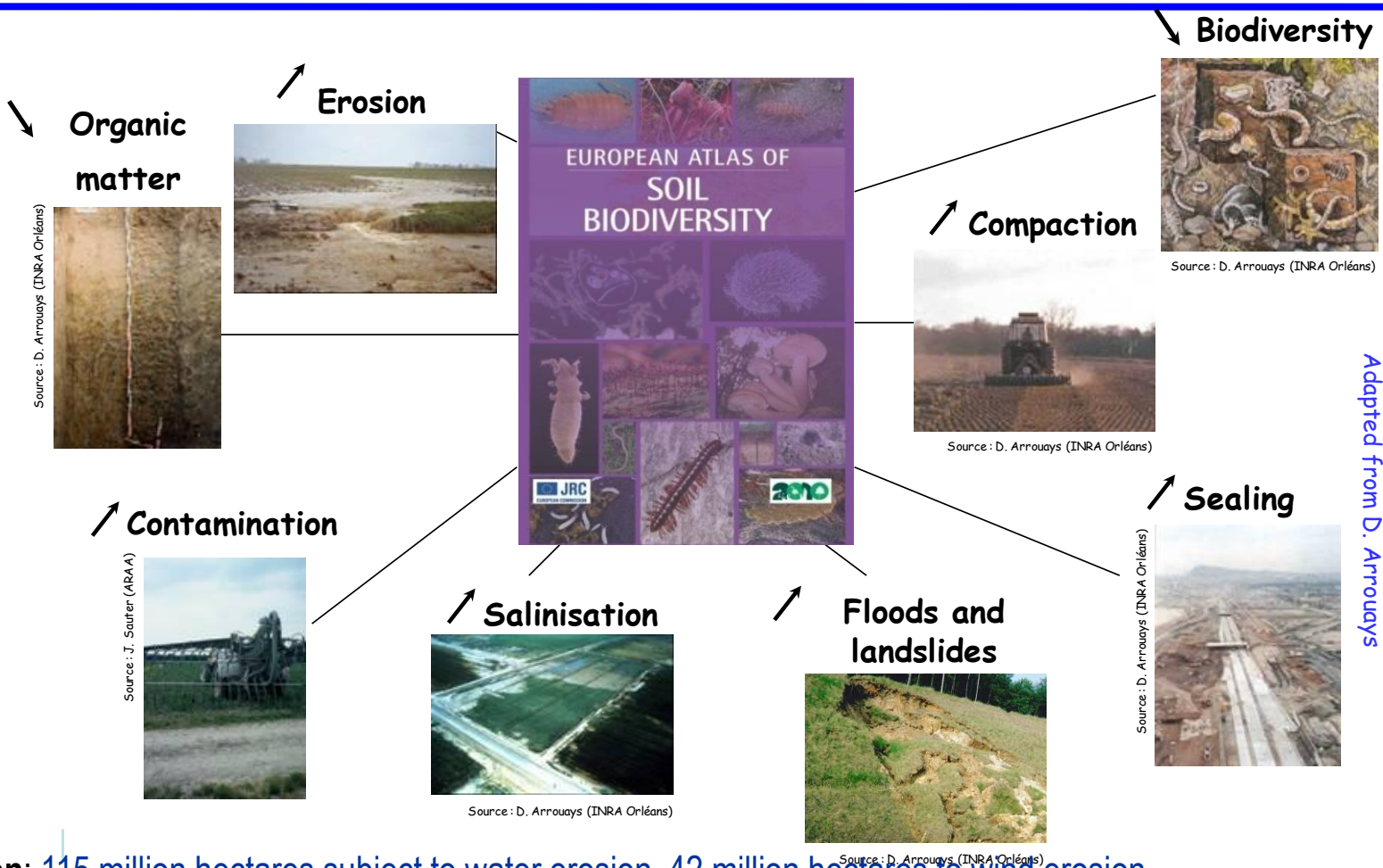


Photo : L. Avoscan & A. Viollet

- 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



- **Erosion**: 115 million hectares subject to water erosion, 42 million hectares to wind erosion.
- **Contamination**: 3.5 million sites 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/year , 2000-2006, the average loss increased by 3%

In 2010, EC considered that for establishing Soil Thematic strategy, further knowledge was required on:

- soil biodiversity
- functions and resulting ecosystem services supported by this diversity

This requires:

- the development of standardised methods for the characterisation of soil biodiversity
- the establishment of policy-relevant and cost-effective indicators for biological diversity

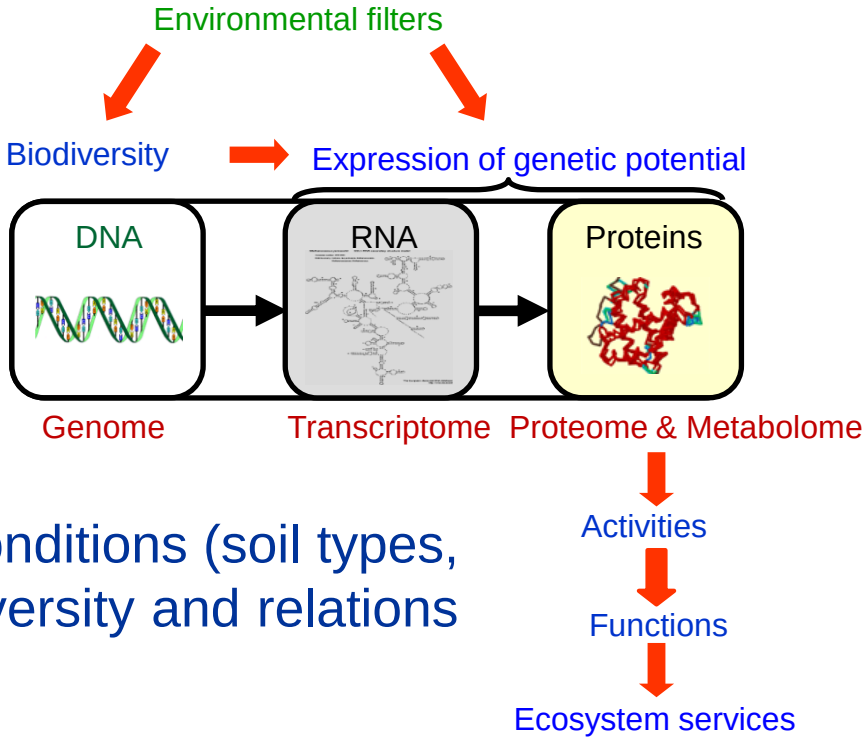
Finally, convincing policy makers of the relevance of such Strategy also requires:

- the assessment of the economic value of the ecosystem services provided.

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

EcoFINDERS - Concepts

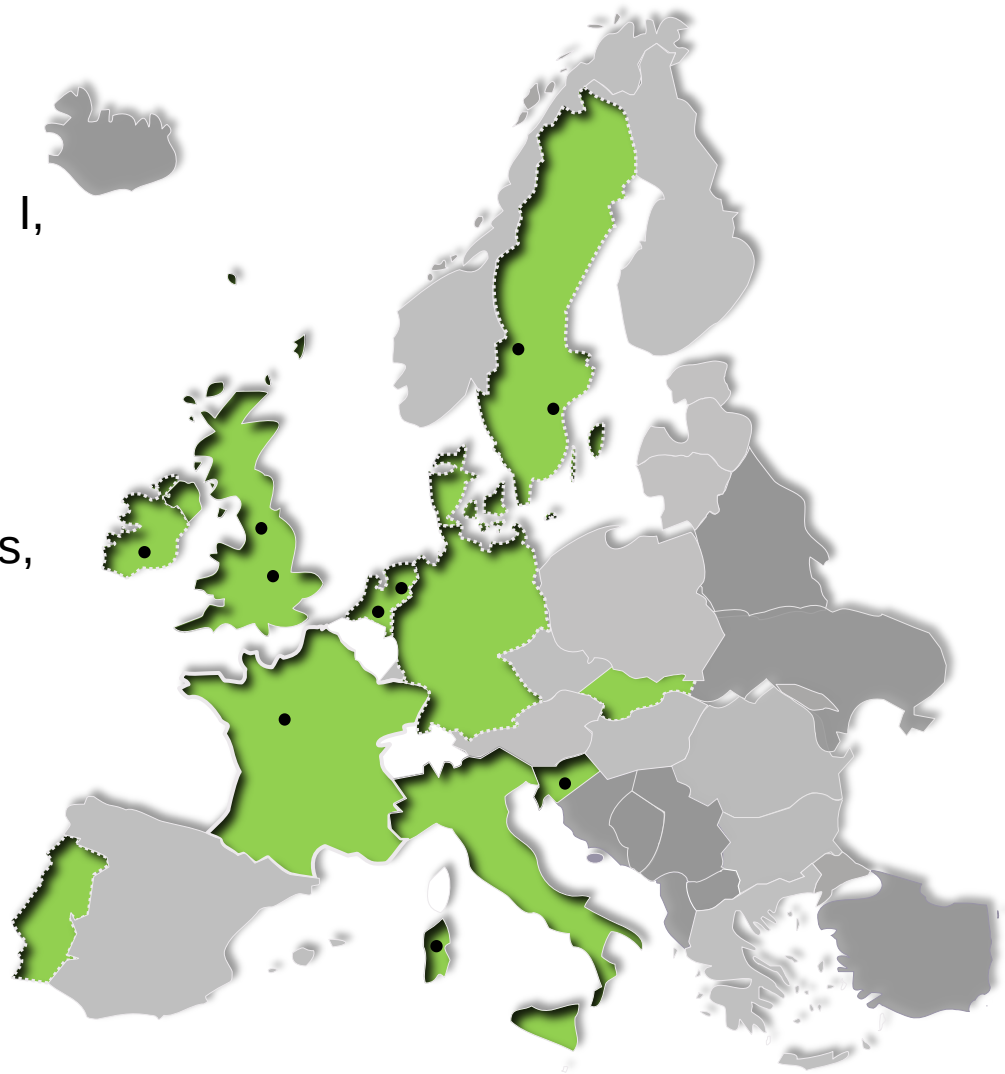
- Decipher relations between soil biodiversity, activities, functions and ecosystem services



- Assess the impact of environmental conditions (soil types, climatic zones, land use) on soil biodiversity and relations biodiversity-activities
- Integrate information on microbial, faunal and plant communities
- Analyse their interactions in food web models and consequences for community and ecosystem stability

Consortium

- 23 partners
- 10 European countries: D, DK, F, I, IRL, NL, P, S, SK, SLO, UK
- Non-European country: China
- Bringing expertises in various :
  - ✓disciplines: biodiversity, ecological functions, trophic nets, risk assessment, biological indicators, environmental economics
  - ✓soil organisms: archaea, bacteria, fungi, protozoa, microarthropods, oligochatea



Standardization of sampling procedures

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

  Plassart *et al.*, in preparation

INTERNATIONAL STANDARD **ISO 10381-1**

First edition 2002-12-15

Soil quality — Sampling —

Part 1:
Guidance on the design of sampling programmes

Identification of bioindicators

- Sensitive
- Consistent – reliable
- Cost-effective
- Table Annual Reports.docx

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)

    Plassart *et al.* 2012. PLoS One
  - ✓Fauna (protozoa, nematodes,....)

Standardization of methods for biodiversity characterization

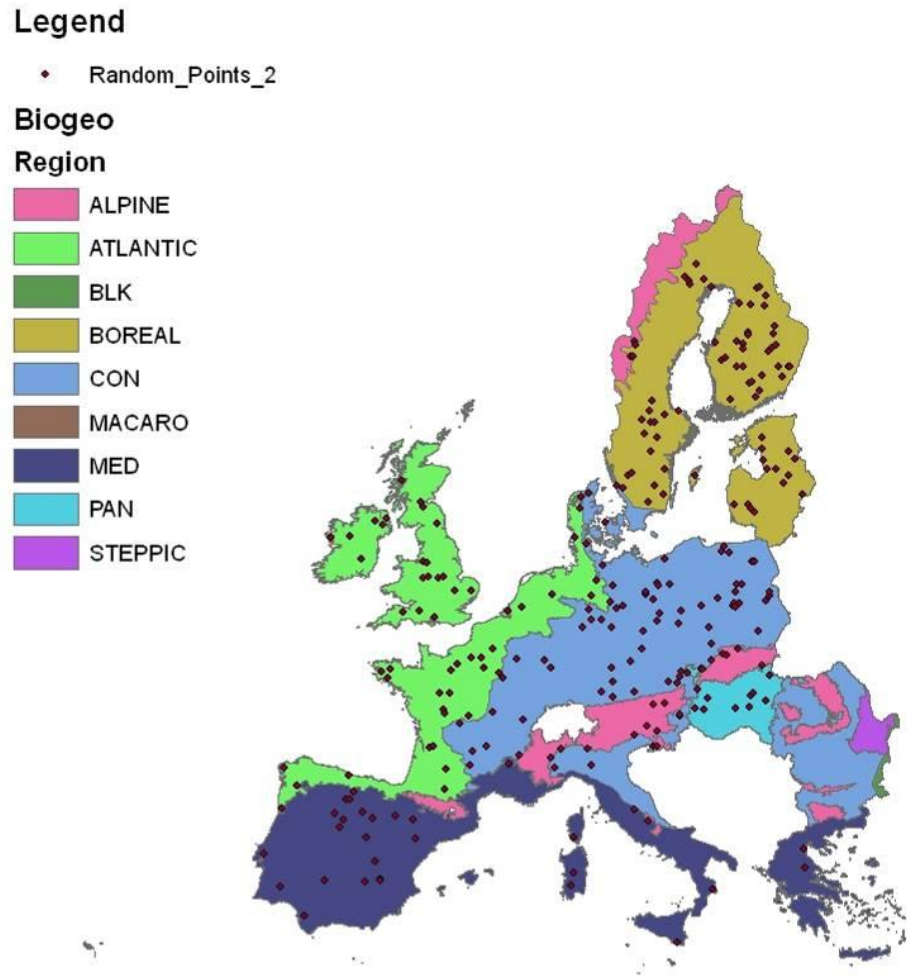
Characterization of biodiversity across Europe

Aims at assessing:

- ✓Range of variations according to soil types, to climatic zones and to land uses
- ✓Range of variations of the identified bioindicators 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 80 sites per land-use type across Europe to give a range of the above soil properties



EcoFINDERS - LTOs

Connecting soil biodiversity, functions and ecosystem services

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

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

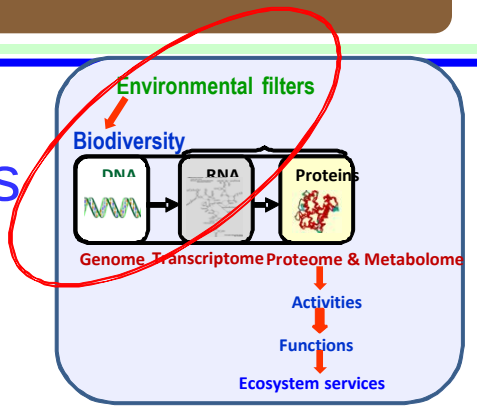
Tonnersjoheden:
Nutrient cycling (N)
Carbon storage

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

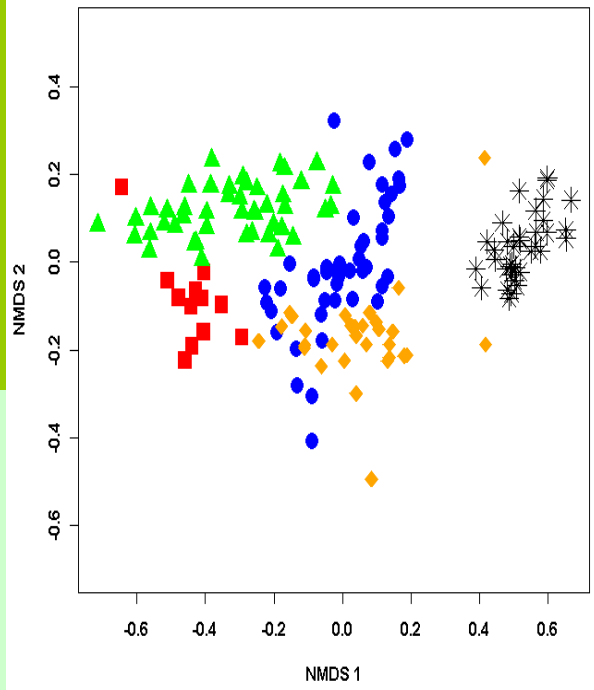
Berchidda:
Nutrient cycling (N),
Carbon storage,
Above ground diversity

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

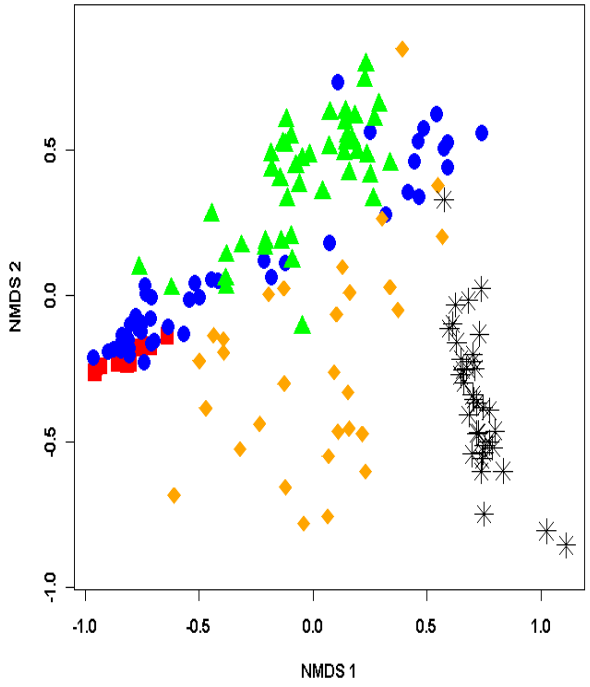
Microbial diversity varies according to the LTOs



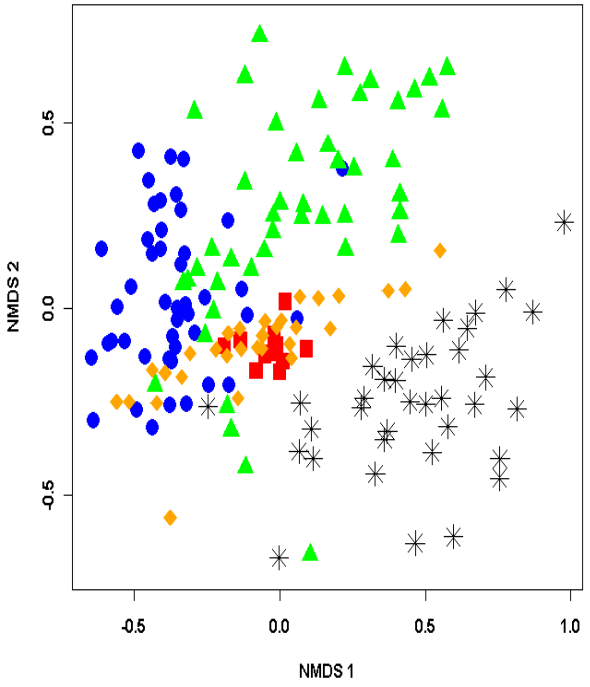
Bacteria



Archaea

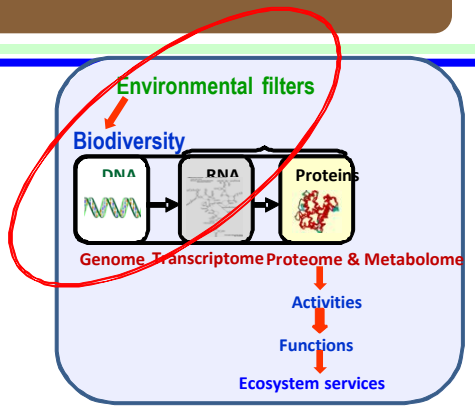


Fungi



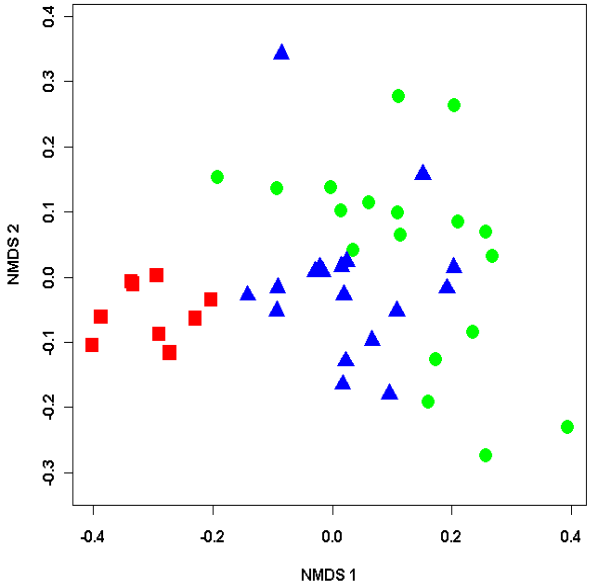
Lusignan Berchidda Lancaster Veluwe Tonnersjoheden

Within a given LTO, microbial diversity differ according to the level of intensification

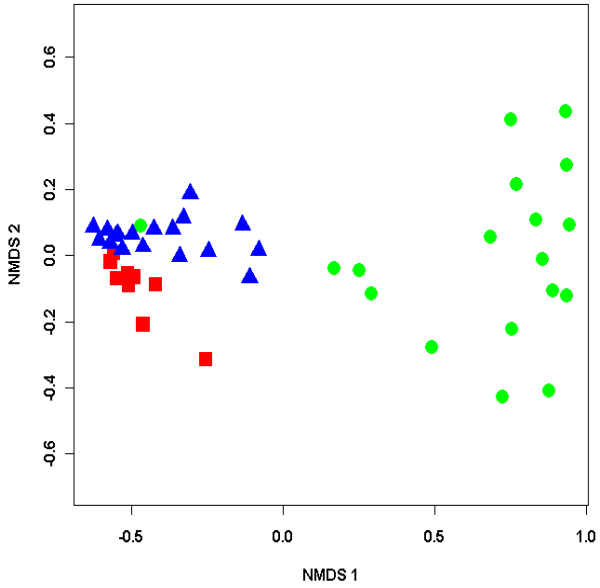


e.g. Berchidda, Sardinia, Italy

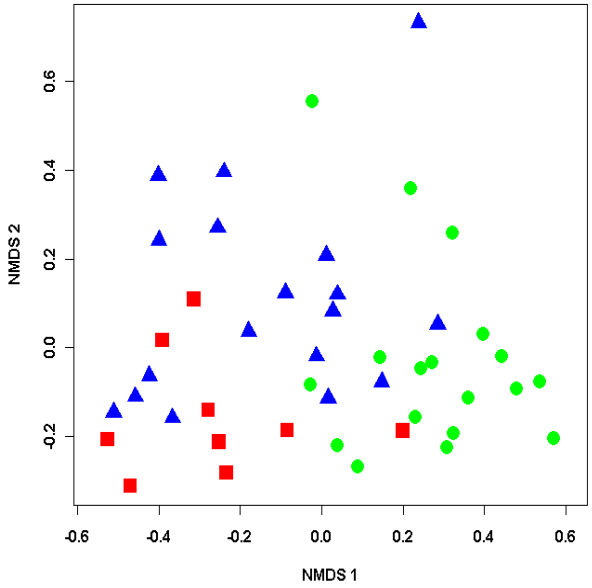
Bacteria



Archaea



Fungi

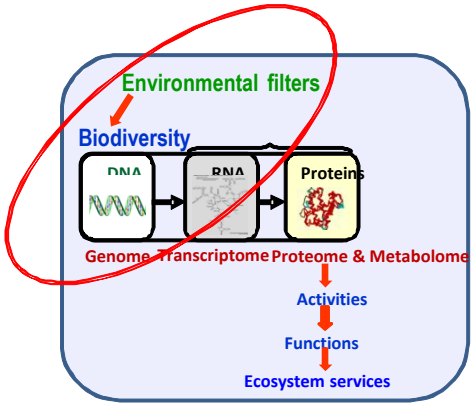


Wooded land (Low intensity)

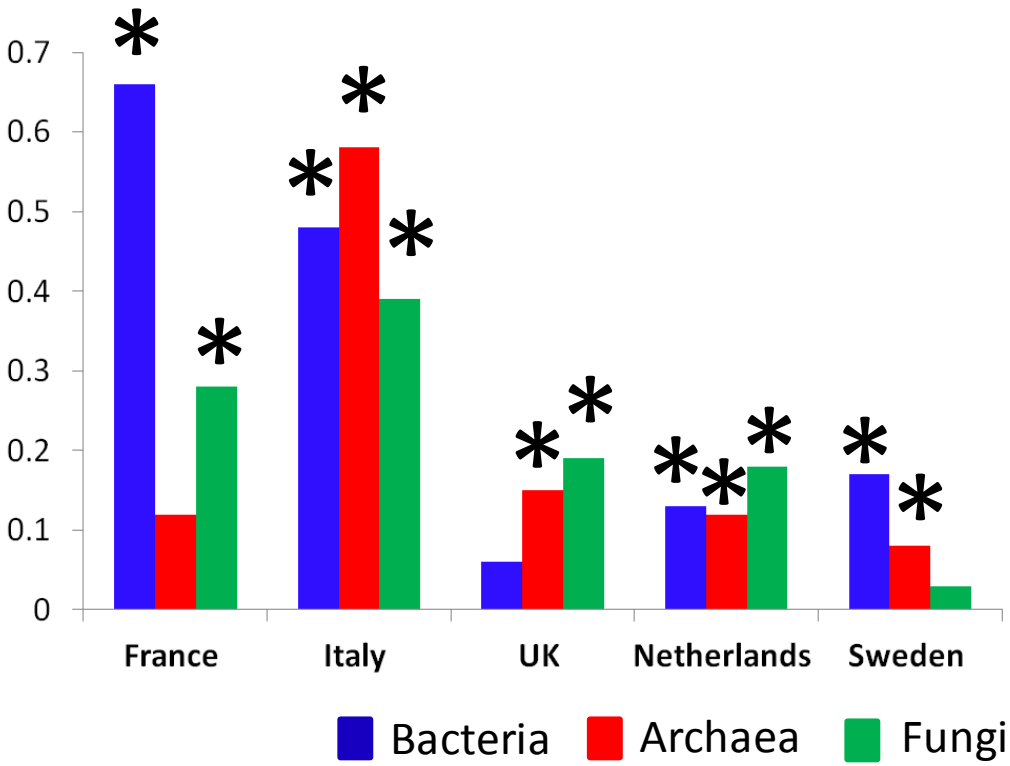
Wooded pasture (Medium intensity)

Intensive grassland (High intensity)

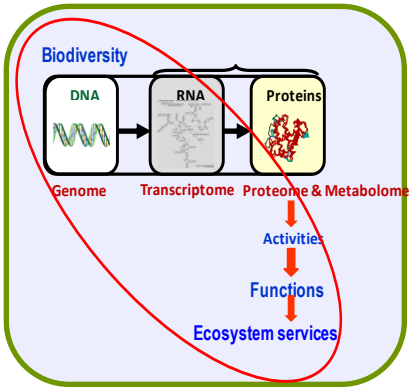
Within a given LTO, microbial diversity differ according to the level of intensification



Overall effect of land-use intensity



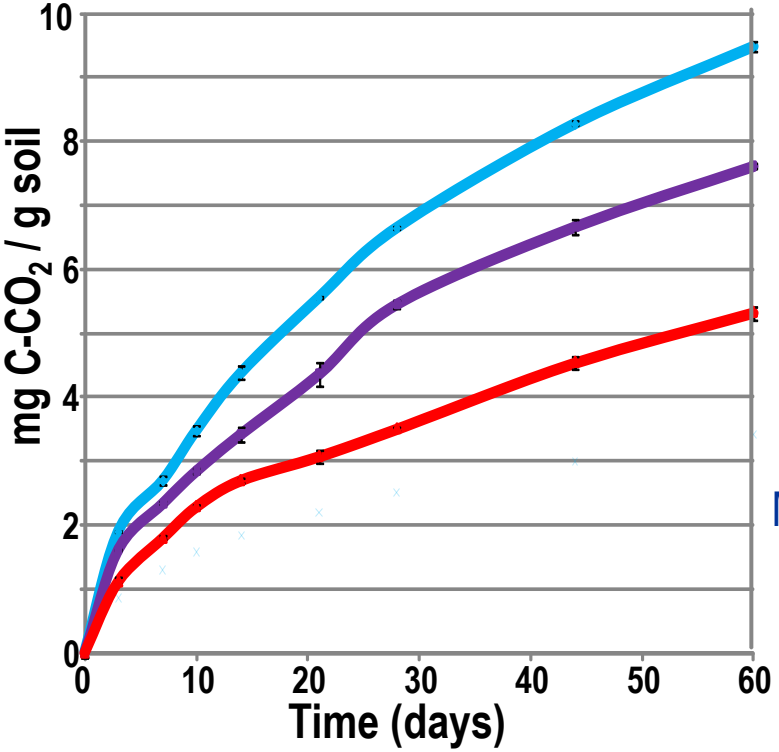
How these variations translate in soil functioning?

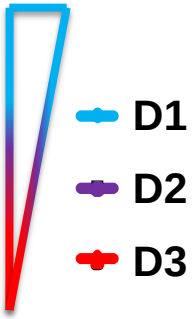


SOM mineralization

D1 > D2 > D3

Black box | Black box | Black box



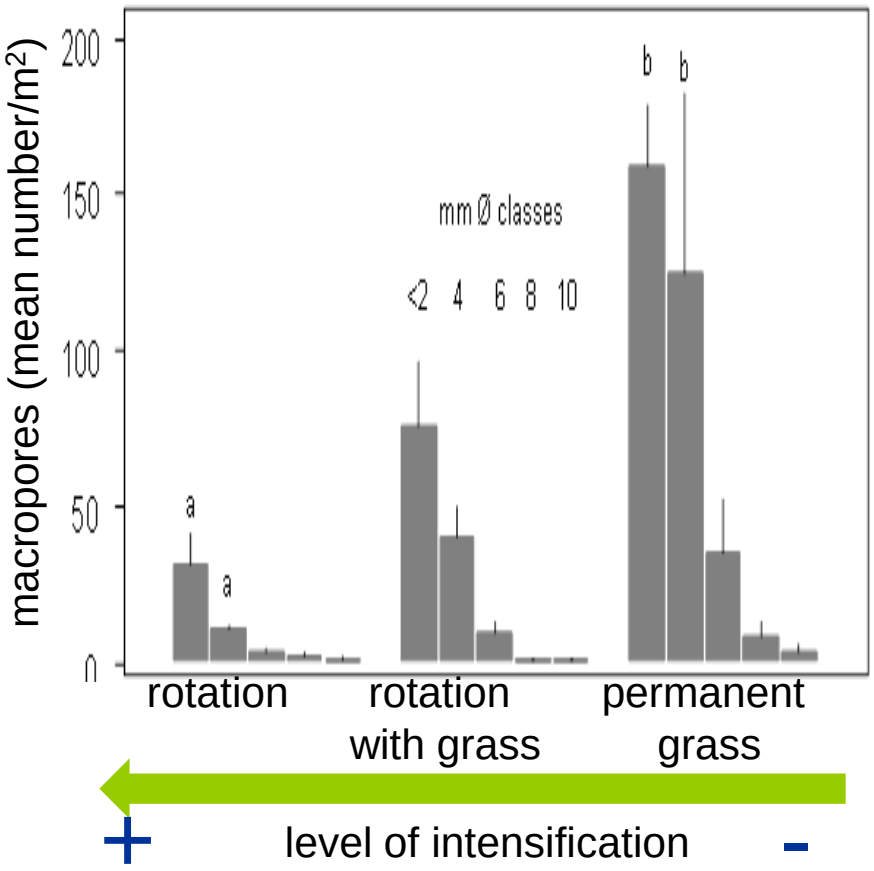


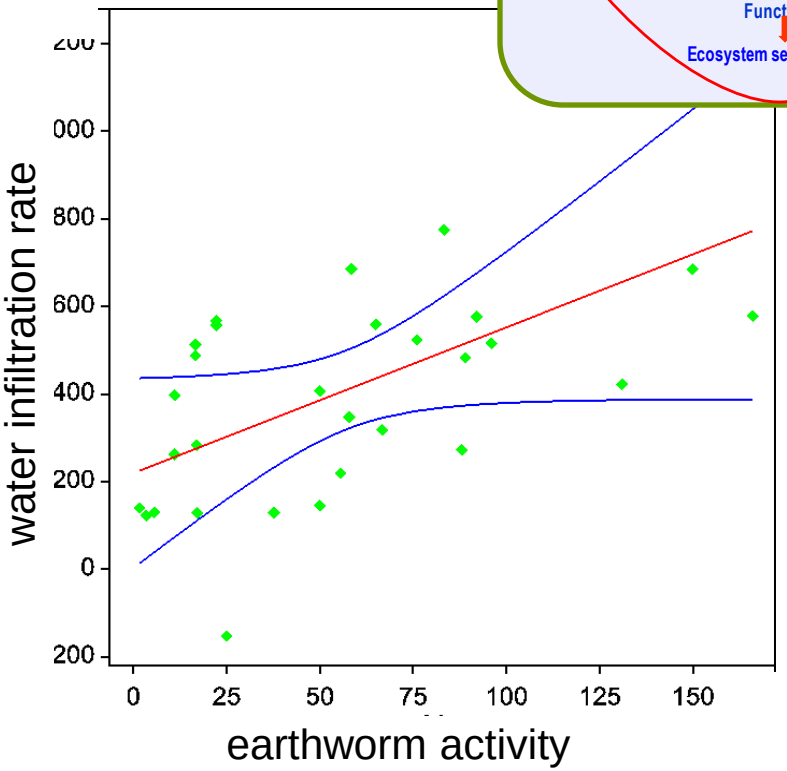
Mineralization D1 > D2 >D3

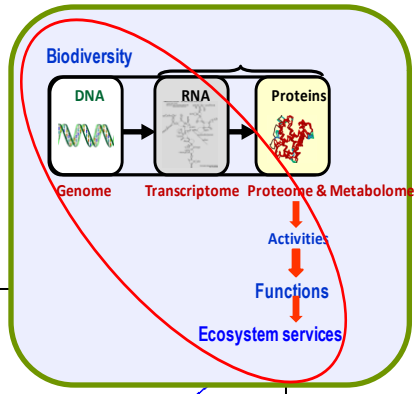
Mineralization SOM = f (Microbial diversity)

How these variations translate in soil functioning?

Water regulation

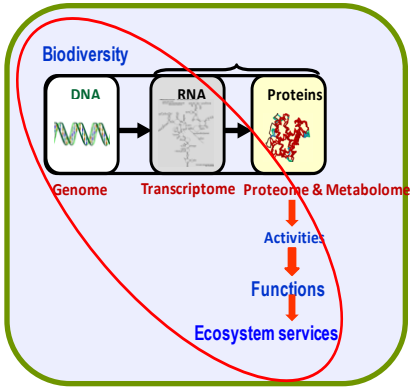






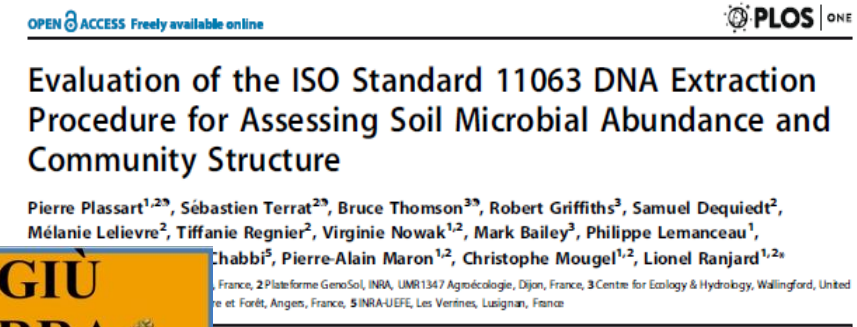
Mesocosm experiments

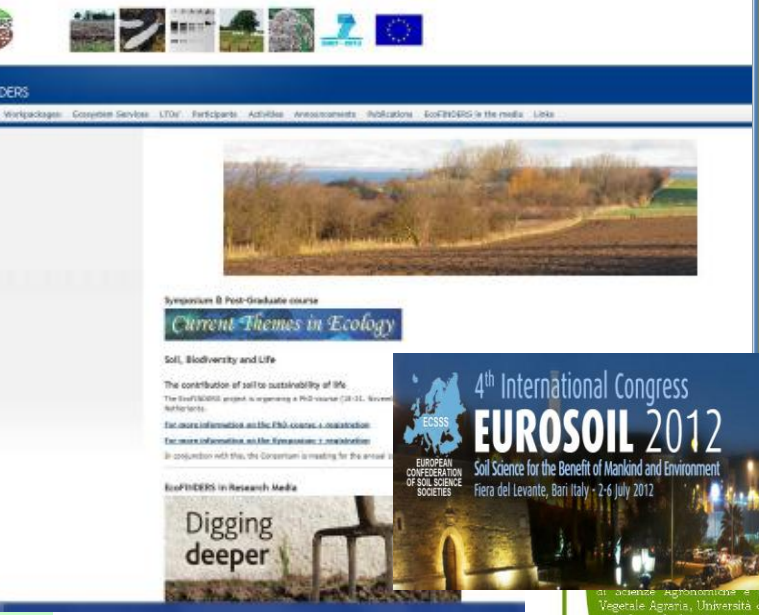
Assessing hypotheses raised from LTOs studies

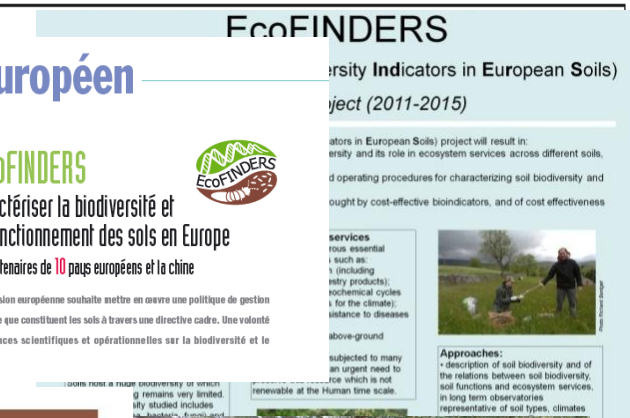


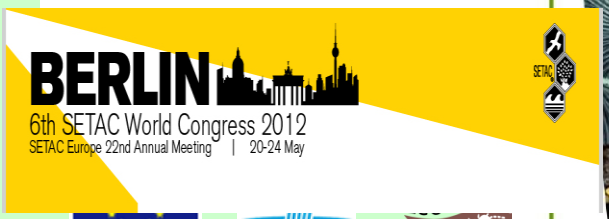
- ✓ . **Minimal diversity for a function to be expressed**
- ✓ **Relations between above and below ground biodiversity**
  - How plant communities affect the resistance and resilience of belowground communities to drought?
  - Impact of plant-derived C into the soil and different soil biota, in connections with soil food web and associated processes.

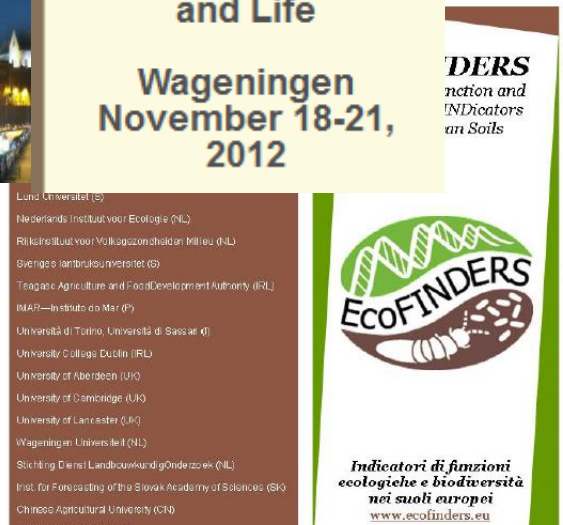
Dissemination











Publications

Griffiths BS, Philippot L. 2012. Insights into the resistance and resilience of the soil microbial community. FEMS Microbiol Rev. doi: 10.1111/j.1574-6976.2012.00343.x.

Hallin S. et al. Loss in microbial diversity affects nitrogen-cycling in soil. ISME J.

Philippot L, Ritz K, Pandard P, Hallin S, Martin-Laurent F. 2012. Standardisation of methods in soil microbiology: progress and challenges. FEMS Microbiol Ecol. doi: 10.1111/j.1574-6941.2012.01436.x.

Plassart P., Terrat S., Thomson. B., Griffiths R. , Dequiedt S., Lelievre M., Regnier T., Nowakv., Bailey M., Lemanceau P., Bispo A., Chabbi A., Maron P.-A., Mougel C., Ranjard L. 2012. Evaluation of the ISO standard 11063 DNA extraction procedure for assessing soil microbial abundance and community structure. PLoS One 7: e44279.

Ranjard L. et al. Evaluation of the ISO standard 11063 DNA extraction procedure for assessing soil microbial abundance and community structure.

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Conclusions and challenges

Conclusions

- ✓In contrast with the statement made by Beijerinck in1913, everything is **not** everywhere, biodiversity is not randomly distributed
- ✓The same organisms are not found everywhere
- ✓Progresses in the knowledge of the environmental filters impacting soil biodiversity: soil physico-chemical, especially pH, and land use
- Relevance of the 'Normal Operating Range' concept
- Need of data bases for diagnostic of the soil biodiversity
- Need of Standard Operating Procedures

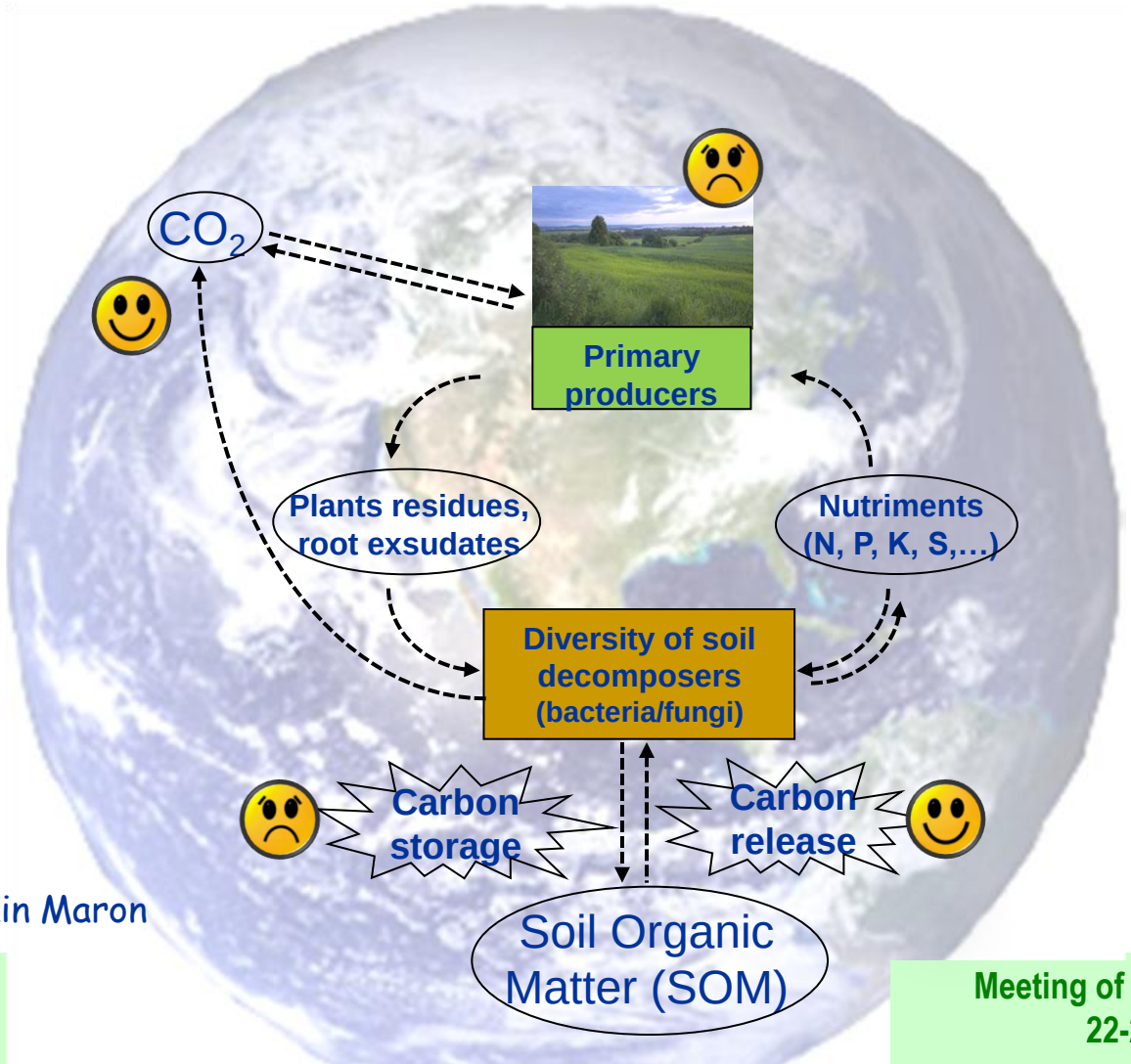
Challenges: Moving from diagnosis to action

- ✓Based on diagnosis, define strategies of mitigation and soil restoration
- ✓This requires
  - ✓ to further progress in our knowledge of the soil functioning as supported by biodiversity
  - ✓ to combine expertises in soil physics, chemistry, ecology

Conclusions and challenges

Challenges: Moving from diagnosis to action

- ✓ to deal with possible trade-offs



Courtesy of Pierre-Alain Maron

Conclusions and challenges

- Challenges: Moving from diagnosis to action
  - ✓ to guarantee the soil multifunctionalities at different spatial and temporal scales

Alterre Bourgogne

  - ✓to capitalise European and National means and information on a set of Critical Zones Observatories and Long Term Observatories
  - ✓to match with world global initiatives

GLOBAL SOIL BIODIVERSITY INITIATIVE — A SCIENTIFIC EFFORT