Soil Biodiversity and functioning: Lessons/Examples from EcoFINDERS

http://www.ecofinders.eu/

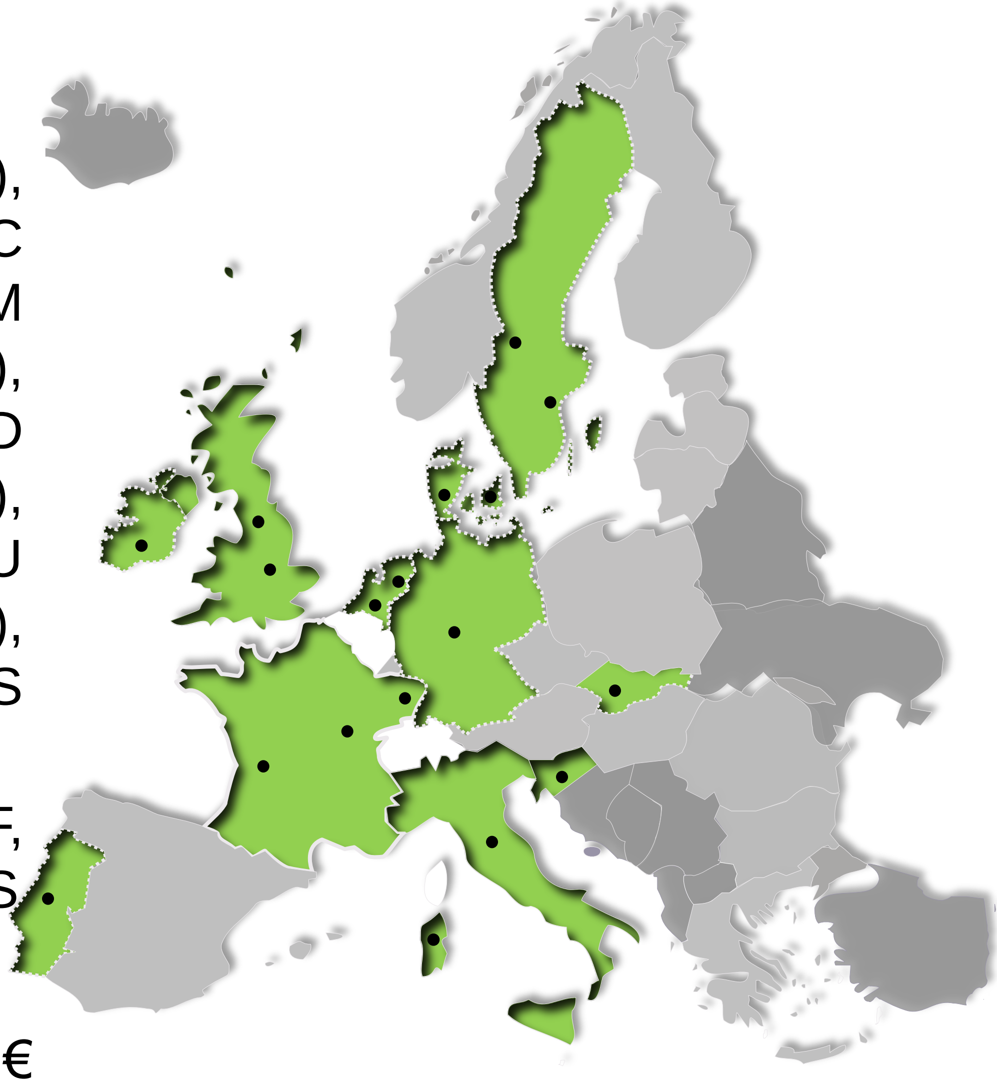
Main information

- Coordination: INRA

- 23 partners

INRA (F), CEH (UK), AU (DK), ECT (DE), UCO (DE), IT (F), JRC (BE), LU (SE), NIOO (NL), RIVM (NL), SLU (SE), Teagasc (IRL), IMAR (P) UNITO (IT), NUID UCD (IRL), UNIABDN (UK), WU (NL), ALTERRA-DLO (NL), CAU (China), UL (SVN), UNISS (IT), BC3 (ES), SRUC (UK), IFE SAS (SK), UOM (UK)

- 12 European countries: D, DK, F, I, IRL, NL, P, S, SK, SLO, UK, ES
- Non-European country: China
- Total EC contribution: 6 999 930 €

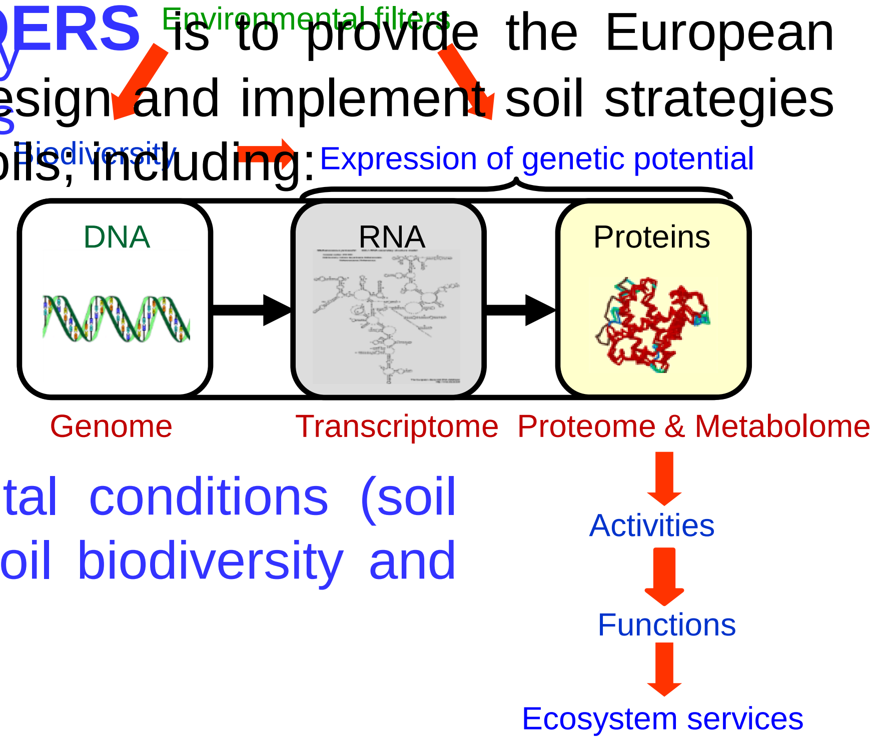


General Aims

The strategic aim of EcoFINDERS is to provide the European Commission with necessary tools to design and implement soil strategies aimed at ensuring sustainable use of soils, including:

- Characterization of biodiversity (microbes and fauna) of European soils

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



- Assessing the impact of environmental conditions (soil types, climatic zones, land use) on soil biodiversity and relations biodiversity-activities

- Analysing the interactions between below- and above-ground in food web models and consequences for community and ecosystem stability

- Designing policy-relevant and cost-effective indicators for monitoring soil biodiversity and activity.

Case studies

- Development of Standard Operating Procedures (SOPs)
- Characterization of soil biodiversity across Europe
- Deciphering relations between soil biodiversity and functioning
- Identification of bioindicators of soil biodiversity and functioning

SOPs – Preliminary results

- Standardization of soil sampling and storage for microbial analyses

  ✓ Where, when and how to sample, number of replicates, sampling depth, use of composite samples, ...

  https://www.youtube.com/watch?v=_k7BEInBXEc

- Optimization of DNA extraction

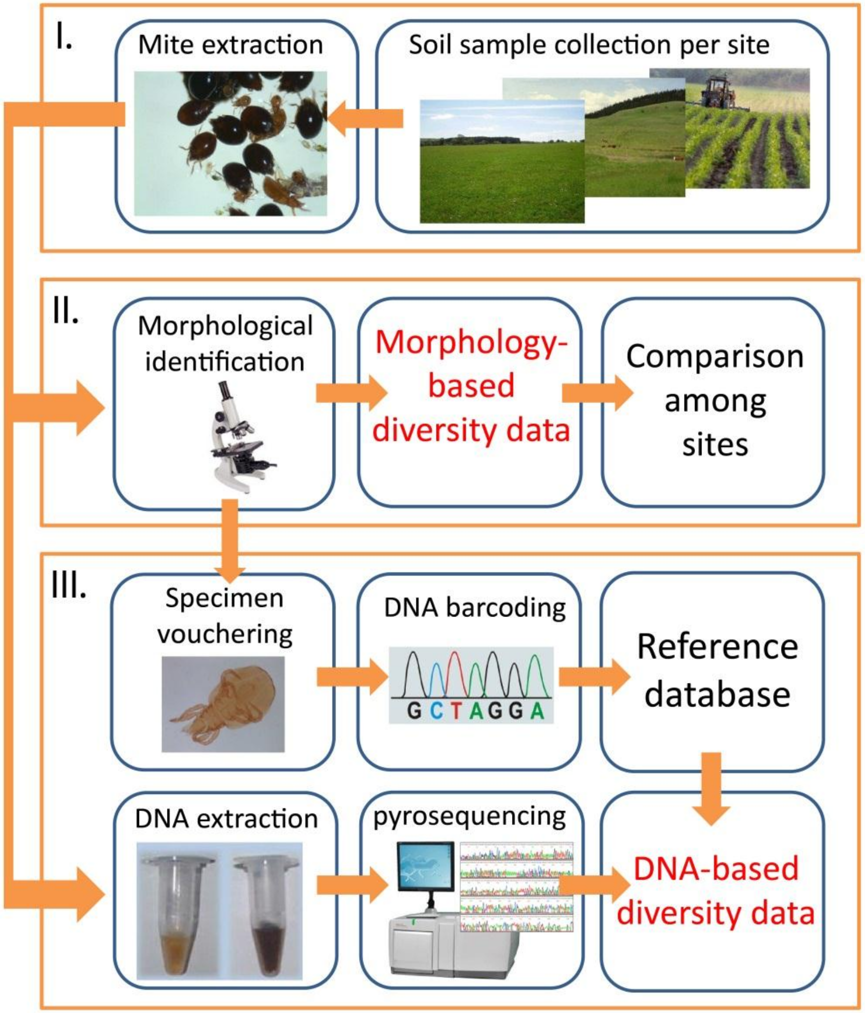
  ✓ allowing extraction of DNA from archaea, bacteria & fungi

OPEN ACCESS Freely available online PLOS | ONE

Evaluation of the ISO Standard 11063 DNA Extraction Procedure for Assessing Soil Microbial Abundance and Community Structure

Pierre Plassart[1,2,9], Sébastien Terrat[2,9], Bruce Thomson[3,9], Robert Griffiths[3], Samuel Dequiedt[2], Mélanie Lelievre[2], Tiffanie Regnier[2], Virginie Nowak[1,2], Mark Bailey[3], Philippe Lemanceau[1], Antonio Bispo[4], Abad Chabbi[5], Pierre-Alain Maron[1,2], Christophe Mougel[1,2], Lionel Ranjard[1,2*]

Rapid screening of soil mite diversity via DNA barcoding

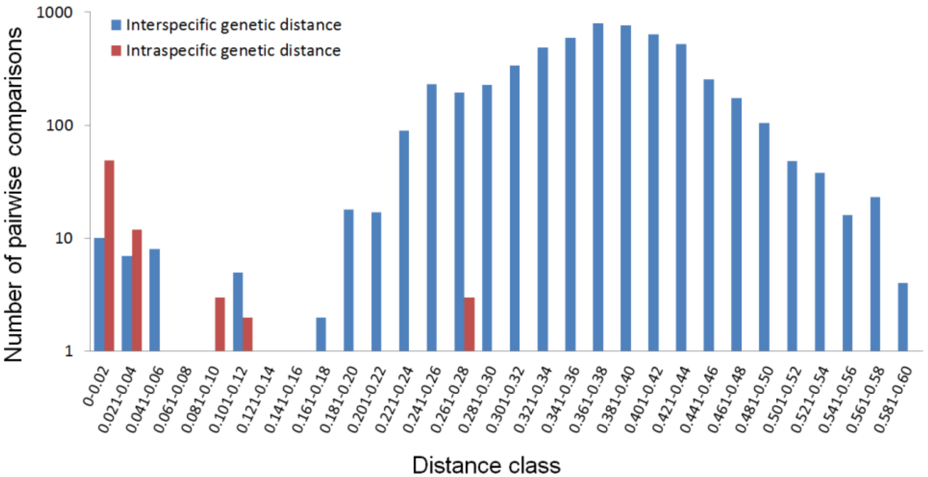


Barcode database construction:

- Successful methods for vouchering, DNA extraction and barcode sequencing of individual specimens
- Database shows proper discrimination for 89% of the species

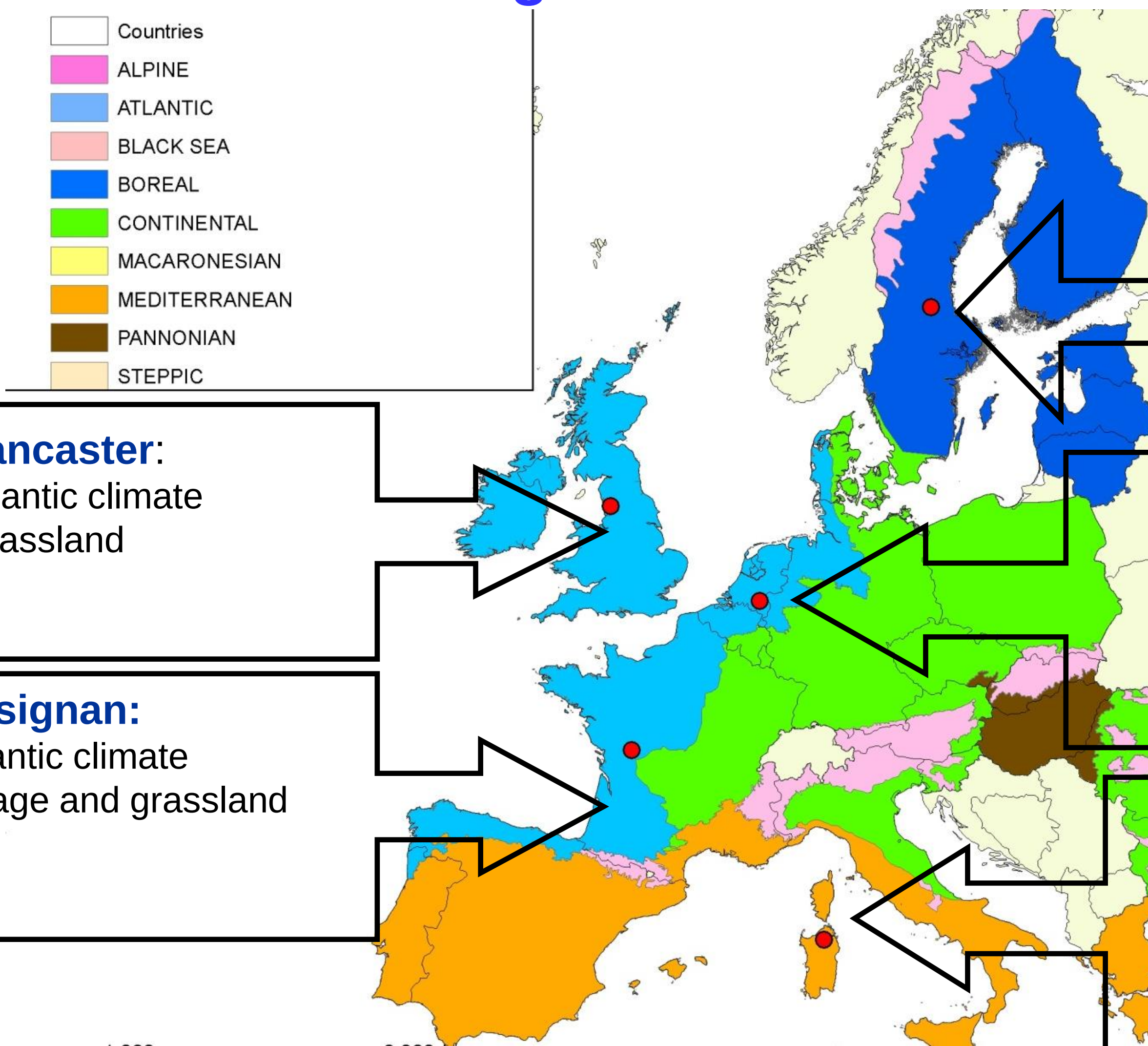
Community characterization:

- 454 sequencing of community samples in progress to validate similarity in species composition between conventional identification and DNA barcoding



Soil biodiversity across Europe – Preliminary Results

Long Term Observatories



Lamborn:
Boreal climate
Forest

Lancaster:
Atlantic climate
Grassland

Veluwe:
Atlantic climate
Grass land
Chronosequence

Lusignan:
Atlantic climate
Tillage and grassland

Berchidda:
Mediterranean climate
Grass land
Forest

- For each LTO: three levels of intensification

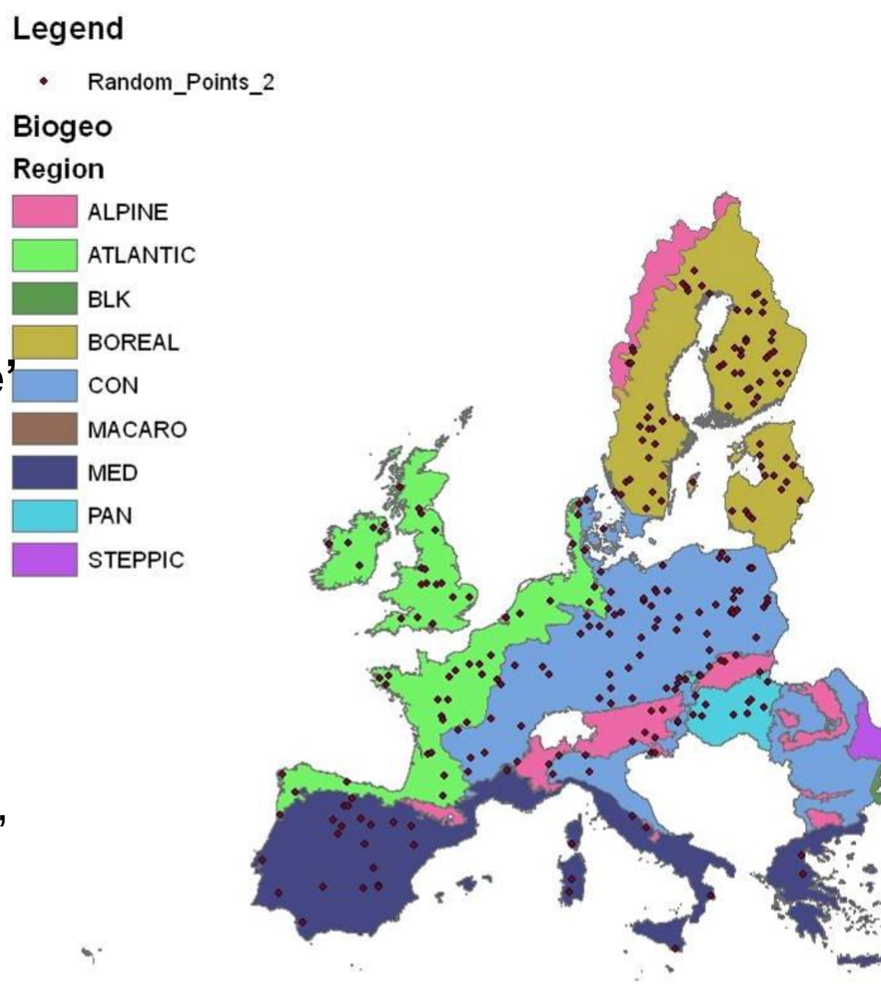
Soil biodiversity across Europe – Preliminary results

European Transect

Aims at assessing:

- ✓Range of **biodiversity** 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'**

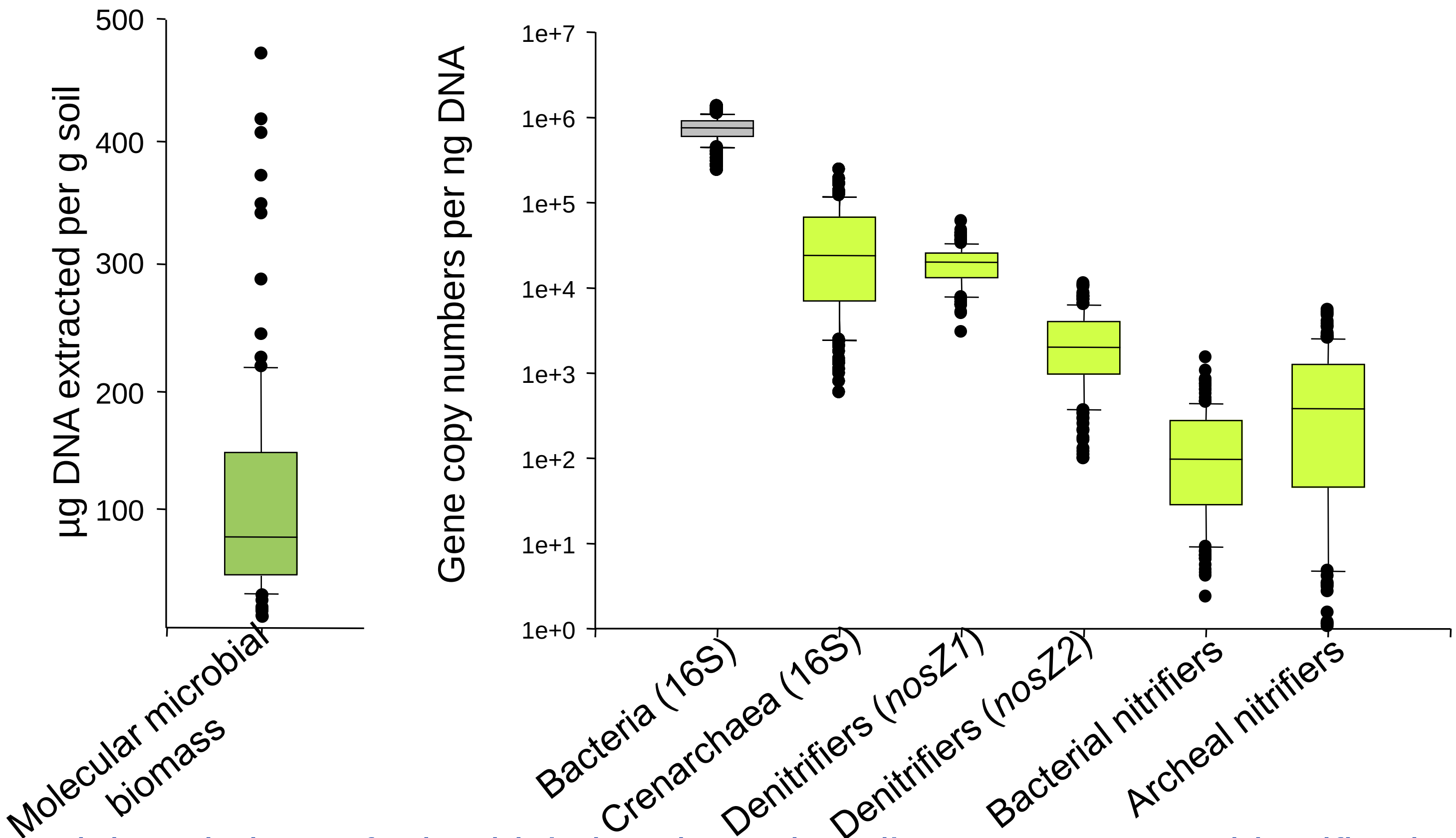


Strategy:

- ✓Using data derived from the JRC, 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

Soil biodiversity across Europe – Preliminary Results

- Range of variations of microbial abundance



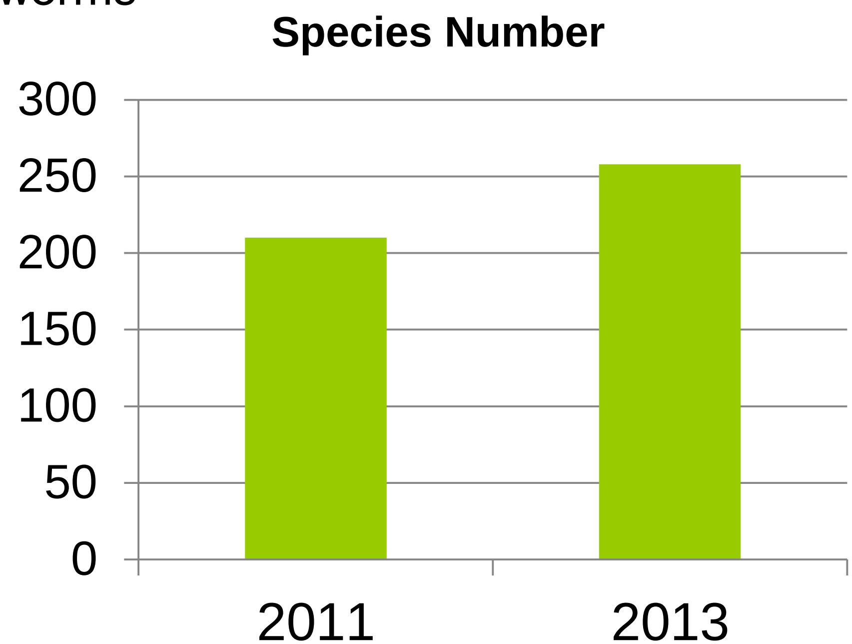
Lessons: High variations of microbial abundance in soils across Europe; identification of the range of variations of microbial abundance

Activities undergoing: Specification of the impact of the soil type, climatic zone and land use on this range of variation ⇨ **Definition of the NOR**

Soil biodiversity across Europe - Preliminary Results -

■ Biodiversity of potworms: Enchytraeidae, Annelida

Ecologically relevant group of small ‘earthworms’



Number of species known in Europe:

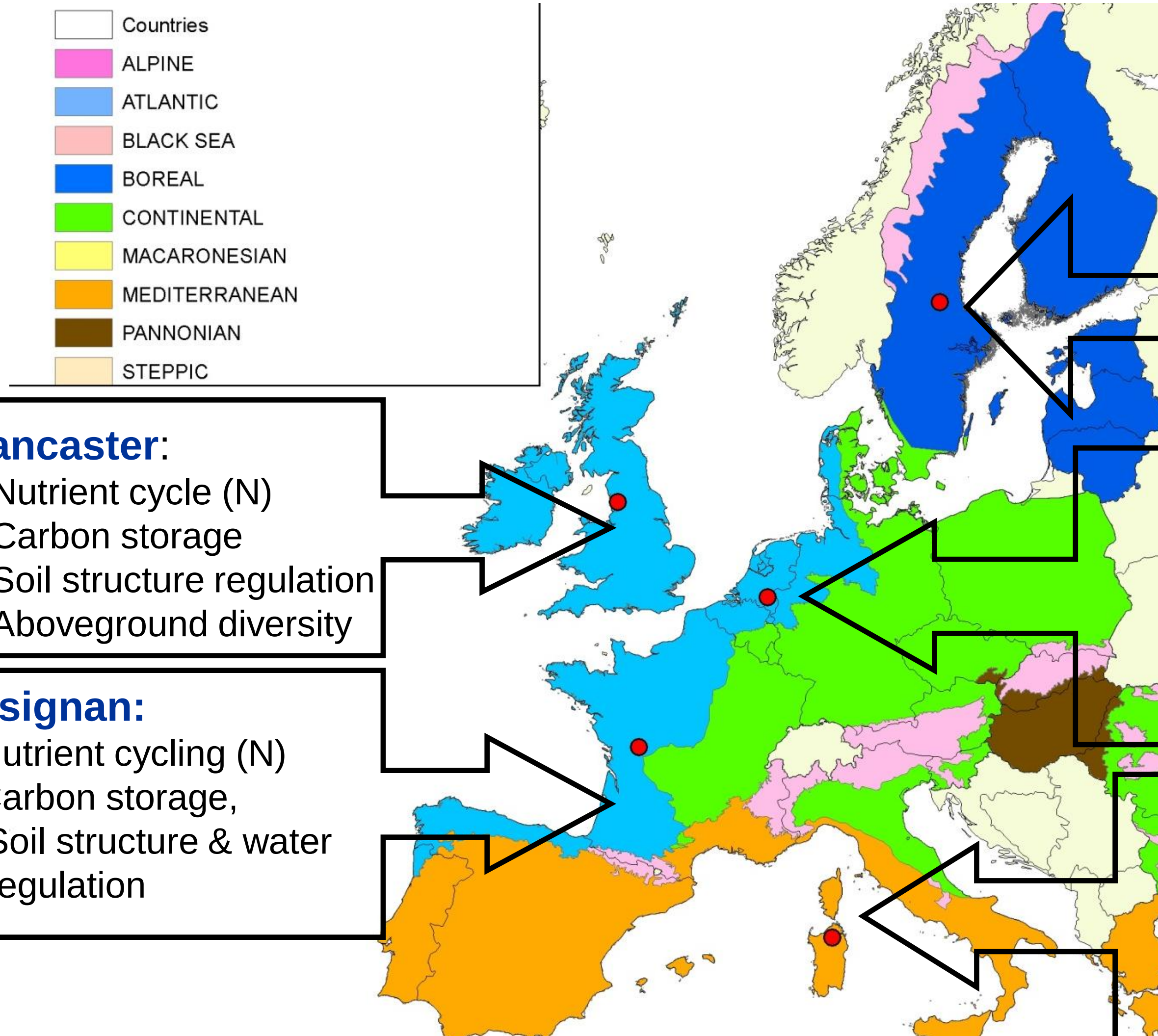
At the start of EcoFINDERS: 210

After two years of research: 258

Increase of 23% : > 40 species new to science

Lesson: Soil biodiversity still needs to be explored. Major contribution of EcoFINDERS to soil biodiversity description.

Connecting soil biodiversity, functions and ecosystem services



Lancaster:
- ✓Nutrient cycle (N)
- ✓Carbon storage
- ✓Soil structure regulation
- ✓Aboveground diversity

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

Lamborn:
- ✓Nutrient cycling (N)
- ✓Carbon storage

Veluwe:
- ✓Nutrient cycling (N)
- ✓Carbon storage
- ✓Soil structure regulation
- ✓Aboveground diversity

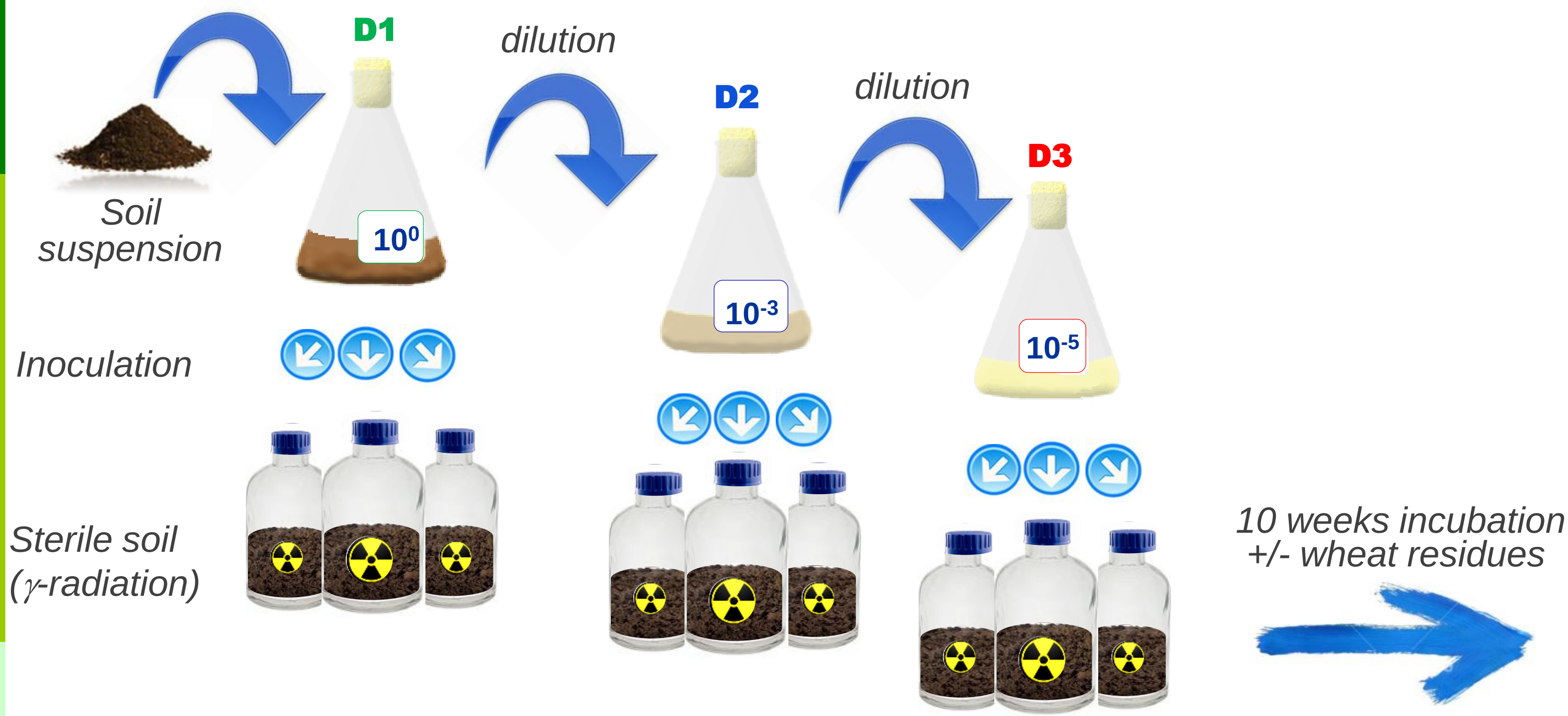
Berchidda:
- ✓Nutrient cycling (N)
- ✓Carbon storage
- ✓Aboveground diversity

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

Relation Biodiversity/Functioning – Preliminary results

Impact of the microbial diversity on soil functioning

Manipulation of the microbial diversity using a removal by dilution approach



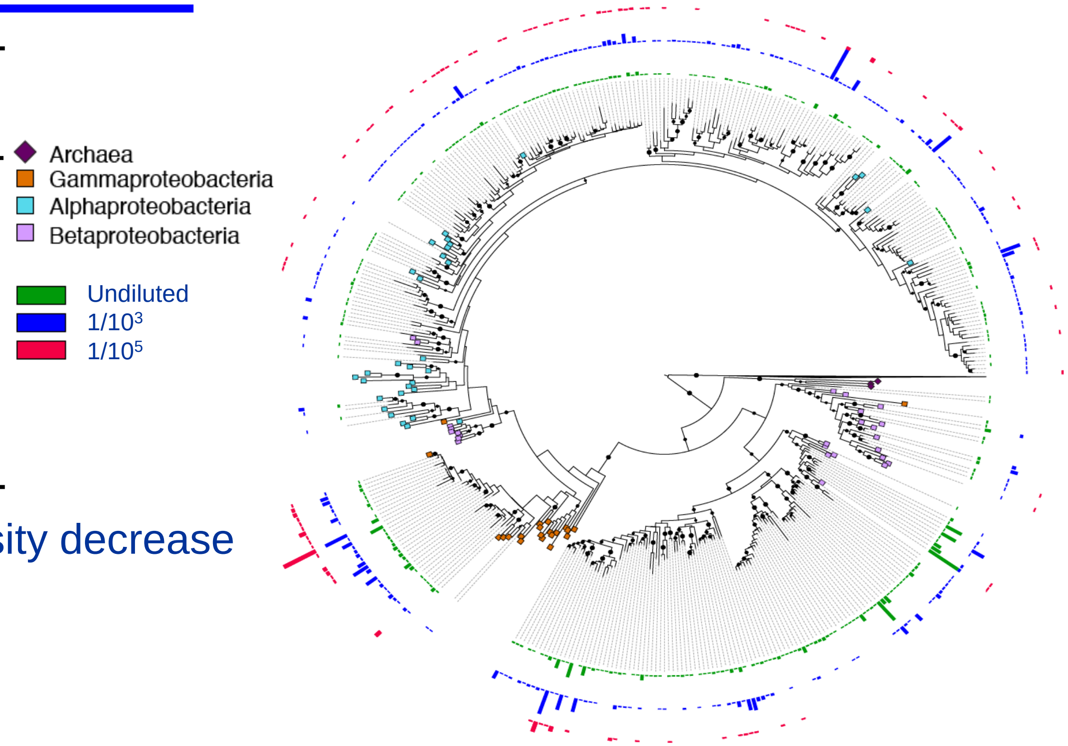
(total of 63 microcosms with 40g soil)

Denitrifiers:

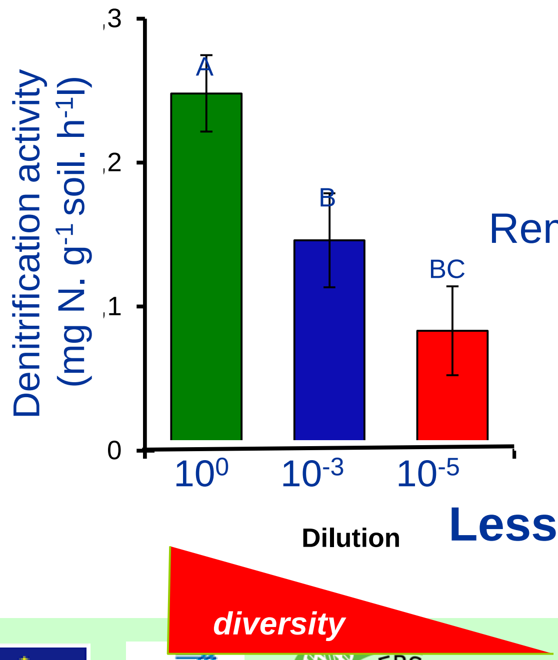
- Abundance (Real -Time PCR)
- Diversity (454 sequencing)
- Activity (Gas chromatography)

Relation Biodiversity/Functioning – Preliminary results

Treatment	*OTU richness*	*Shannon*
Undiluted	235.8 ± 8.15	6.18 ± 0.00
$1/10^3$	177.8 ± 11.1	5.89 ± 0.12
$1/10^5$	57.3 ± 3.2	3.16 ± 0.49



As expected, soil dilution led to a diversity decrease

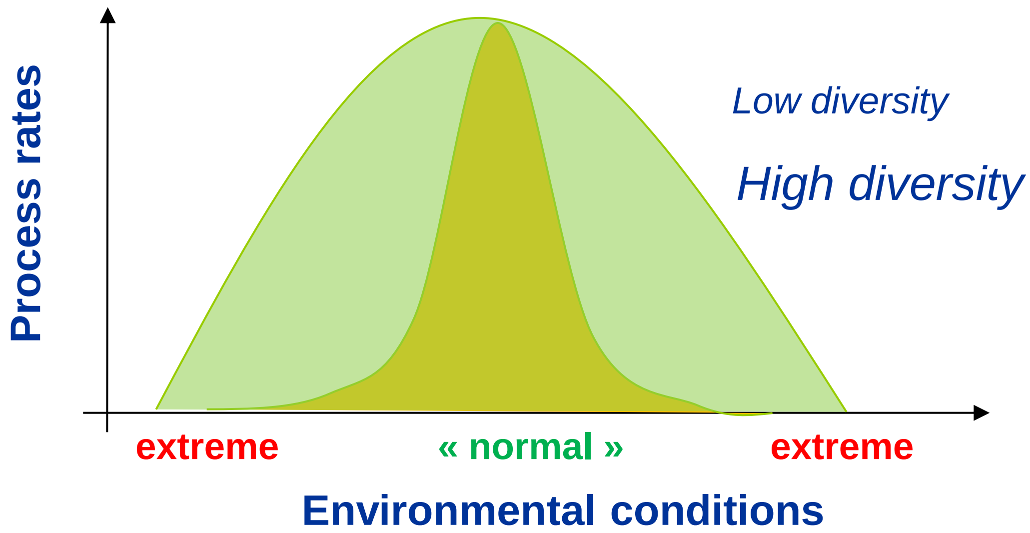


Removal of 75% of the total OTU at the $1/10^5$ dilution treatment led to a decrease of denitrification activity of up to 88%.

Philippot et al. 2013. ISME J

Lesson: Microbial diversity loss can alter ecosystem processes

Relation Biodiversity/Functioning – Preliminary results



Do soil communities with the highest diversity also have highest functional dissimilarity or complementarity, and thereby higher tolerances to extreme conditions?

functional operating range (FOR)
(=range of environmental conditions under which a community or ecosystem is able to maintain its functions)

Relation Biodiversity/Functioning – Preliminary results

Mesocosm experiments

- ✓ Minimal diversity for a function to be expressed
- ✓ Impact of above and belowgraound diversity on soil resiliency
- ✓ 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.
- ✓ Validation of bioindicators

	Biodiversity	Function
DNA	TRFLP	
DNA	Protozoa	
	PLFA	
	Fungi (ergosterol)	
DNA	FG nitrification	FG nitrification
DNA	FG denitrification	FG denitrification
	Earthworms	Earthworms
	Enchytraeids	Enchytraeids
	Micro-arthropods	Micro-arthropods
	Nematodes	Nematodes
		Bait Lamina
		Water infiltration
		Resilience
		Nitrification
		HWC & PM-N
		Micro-resp
		Enzyme Activity

Bioindicators – Preliminary results

Selection of bioindicators

ECOFINDERS
GLOBAL BIODIVERSITY SURVEYS

Home | Mapping of Threats | Global Biodiversity Questionaire

Selection of Biological Indicators for monitoring of Biodiversity and Ecosystem Function

Measurement Section - Q1

Skills - What is the amenability of the method to ready application via a standard operating procedure when presented to a competent technician? Does it include a training element? (Ritz et al., 2009) *

	Specialised	Moderate	Straightforward	No Knowledge
Fauna				
Earthworms-Morphology				
Earthworms-Molecular				
Enchytraeids-Morphology				
Enchytraeids-Molecular				
Mites-Morphology				
Mites-Molecular				
Collembola-Morphology				
Collembola-Molecular				
Nematodes-Morphology				
Nematodes-Molecular				
Microbes Classical				
Protozoa-Morphology				
Protozoa-Molecular				
Bacteria and Archaea-Molecular				
Fungi-Morphology				
Fungi-Molecular				
Microbes Modern				
Functional Genes (targetting antibiotic producers, nitrifiers, denitrifiers,....)				
Bacteria & Fungi-fingerprints (TRFLP, ARISA,...)				
Pyrosequencing				
ChipTechnology				
PLFA				
General Function				
Molecular microbial biomass				
Respiration (All basal methods)				
Respiration (SIR-Glucose)				
Respiration (Multiple Substrate Induced Respiration)				
Nitrification				
Multiple Enzyme Assay				
Biolog				
Bait Lamina				
Litter Bags				

Specialised: A fully trained specialist is required full time to carry out the analysis Moderate: A PhD student or skilled technician can carry out the analysis

2007 - 2013

Dissemination - Publications

Andriuzzi, W.S., Bolger, T, Schmidt, O. 2013. The drilosphere concept: Fine-scale incorporation of surface residue-derived N and C around natural Lumbricus terrestris burrows. Soil Biology & Biochemistry 64, 136-138.

Bardgett R.D., Manning P., Morriën E., de Vries F.T. 2013. Hierarchical responses of plant-soil interactions to climate change: consequences for the global carbon cycle. Journal of Ecology 101:334-343.

Brussaard L. 2012. Ecosystem services provided by the soil biota. pp. 45-58. In Wall D.H. et al. (eds) Soil Ecology and Ecosystem Services, Oxford University Press.

Faber J.H, Creamer R.E., Mulder C., Römbke J., Rutgers M., Sousa J.P., Stone D., Griffiths B.S. The practicalities and pitfalls of establishing a policy-relevant and cost-effective soil biological monitoring scheme. Integrated Environmental Assessment and Management 9, 276-284.

Griffiths, B.S, Philippot, L. Insights into the resistance and resilience of the soil microbial community. FEMS Microbiology Reviews. 37, 112-129.

Jones, C.M., Graf, D., Bru, D., Philippot, L., Hallin, S. The unaccounted yet abundant nitrous oxide reducing microbial community - a potential nitrous oxide sink. ISME J. 7, 417-426.

Hallin S., Welsh A., Stenström J., Hallet S., Enwall K., Bru D., Philippot L. 2012. Soil functional operating range linked to microbial biodiversity and community composition using denitrifiers as model guild. PLoS ONE 7:e51962. doi:10.1371/journal.pone.0051962.

Maron, P.A., Lemanceau P. Soil as support of biodiversity and functions. SCOPE Volume Benefits of Soil Carbon Chapter 4, in revision.

Mulder C., Helder J., Vervoort M.T.W., Vonk J.A. 2011.Trait-mediated diversification in nematode predator-prey systems. Ecology and Evolution 36, 386-391.

Mulder, C., Boit, A., Bonkowski, M., De Ruiter, P.C., Mancinelli, G., Van der Heijden, M.G.A., Van Wijnen, H.J., Vonk, J.A., Rutgers, M. 2011. A Belowground Perspective on Dutch Agroecosystems: How Soil Organisms Interact to Support Ecosystem Services. Advances in Ecological Research, Academic Press, 2011, Volume 44, Pages 277-357.

Mulder, C., Vonk, A.J. 2011. Nematode traits and environmental constraints in 200 soil systems: scaling within the 60–6000 μm body size range. Ecology, 92:10.

Philippot, L., Ritz, K., Pandard, P., Hallin, S. and Martin-Laurent, F. 2012. Standardisation of methods in soil microbiology: progress and challenges. FEMS Microbiology Ecology 82,1-10.

Plassart, P., Terrat, S.., Thomson, B., Griffiths, R., Dequiedt, S., Lelievre, M., Regnier, T., Nowak, V., 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. PLOSOne 7: e44279.

Philippot, L, Spor, A, Hénault, C, Bru, D, Bizouard, Jones, CM, Sarr A, Maron, P-A. Loss in microbial diversity affects nitrogen cycling in soil. ISME J., in press.

Philippot L., Raaijamkers J.M., Lemanceau P. ,Van der Putten W.H. Going back to the roots: the microbial ecology of the rhizosphere. Nature Microbiological Reviews, in revision.

Powlson D., Cai Z., Lemanceau P. Soil carbon dynamics and nutrient cycling. SCOPE Volume Benefits of Soil Carbon Chapter 11, in revision.

van Wesemael B., Stocking M., Bampa F., Bernoux M., Feller C., Gicheru P., Lemanceau P., Milne E., Montanarella L. A strategy for taking soil carbon into the policy arena. SCOPE Volume Benefits of Soil Carbon, in revision.

Dissemination - Publications

Andriuzzi, W.S., Bolger, T, Schmidt, O. 2013. The drilosphere concept: Fine-scale incorporation of surface residue-derived N and C around natural Lumbricus terrestris burrows. Soil Biology & Biochemistry 64, 136-138.

Bardgett R.D., Manning P., Morriën E., de Vries F.T. 2013. Hierarchical responses of plant-soil interactions to climate change: consequences for the global carbon cycle. **Journal of Ecology** 101:334-343.

Brussaard L. 2012. Ecosystem services provided by the soil biota. pp. 45-58. In Wall D.H. et al. (eds) Soil Ecology and Ecosystem Services, Oxford University Press.

Faber J.H, Creamer R.E., Mulder C., Römbke J., Rutgers M., Sousa J.P., Stone D., Griffiths B.S. The practicalities and pitfalls of establishing a policy-relevant and cost-effective soil biological monitoring scheme. Integrated Environmental Assessment and Management 9, 276-284.

Griffiths, B.S, Philippot, L. Insights into the resistance and resilience of the soil microbial community. FEMS Microbiology Reviews. 37, 112-129.

Jones, C.M., Graf, D., Bru, D., Philippot, L., Hallin, S. The unaccounted yet abundant nitrous oxide reducing microbial community - a potential nitrous oxide sink. ISME J. 7, 417-426.

Hallin S., Welsh A., Stenström J., Hallet S., Enwall K., Bru D., Philippot L. 2012. Soil functional operating range linked to microbial biodiversity and community composition using denitrifiers as model guild. PLoS ONE 7:e51962. doi:10.1371/journal.pone.0051962.

Maron, P.A., Lemanceau P. Soil as support of biodiversity and functions. SCOPE Volume Benefits of Soil Carbon Chapter 4, in revision.

Mulder C., Helder J., Vervoort M.T.W., Vonk J.A. 2011.Trait-mediated diversification in nematode predator-prey systems. Ecology and Evolution 36, 386-391.

Mulder, C., Boit, A., Bonkowski, M., De Ruiter, P.C., Mancinelli, G., Van der Heijden, M.G.A., Van Wijnen, H.J., Vonk, J.A., Rutgers, M. 2011. A Belowground Perspective on Dutch Agroecosystems: How Soil Organisms Interact to Support Ecosystem Services. Advances in Ecological Research, Academic Press, 2011, Volume 44, Pages 277-357.

Mulder, C., Vonk, A.J. 2011. Nematode traits and environmental constraints in 200 soil systems: scaling within the 60–6000 μm body size range. Ecology, 92:10.

Philippot, L., Ritz, K., Pandard, P., Hallin, S. and Martin-Laurent, F. 2012. Standardisation of methods in soil microbiology: progress and challenges. FEMS Microbiology Ecology 82,1-10.

Plassart, P., Terrat, S.., Thomson, B., Griffiths, R., Dequiedt, S., Lelievre, M., Regnier, T., Nowak, V., 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. PLOSOne 7: e44279.

Philippot, L, Spor, A, Hénault, C, Bru, D, Bizouard, Jones, CM, Sarr A, Maron, P-A. Loss in microbial diversity affects nitrogen cycling in soil. ISME J., in press.

Philippot L., Raaijamkers J.M., Lemanceau P. ,Van der Putten W.H. Going back to the roots: the microbial ecology of the rhizosphere. **Nature Microbiological Reviews**, in revision.

Powlson D., Cai Z., Lemanceau P. Soil carbon dynamics and nutrient cycling. SCOPE Volume Benefits of Soil Carbon Chapter 11, in revision.

van Wesemael B., Stocking M., Bampa F., Bernoux M., Feller C., Gicheru P., Lemanceau P., Milne E., Montanarella L. A strategy for taking soil carbon into the policy arena. SCOPE Volume Benefits of Soil Carbon, in revision.

Dissemination – International Conference

THE FIRST GLOBAL
SOIL BIODIVERSITY CONFERENCE
Assessing soil biodiversity and its role for ecosystem services

GLOBAL
SOIL BIODIVERSITY
INITIATIVE

Palais des Congrès, Dijon, France
2-5 DECEMBER 2014

The Global Soil Biodiversity Initiative and EcoFINDERS are pleased to announce:

THE FIRST GLOBAL **SOIL BIODIVERSITY** CONFERENCE

Assessing soil biodiversity and its role for ecosystem services

Conference chair:

Dr. Diana H. Wall, Colorado State University and Scientific Chair of the GSBI.

Confirmed Keynote Speakers include:

Dr. Noah Fierer, University of Colorado, Boulder, USA
Dr. Laurent Philippot, INRA, Dijon, FR
Dr. Kate Scow, University of California, Davis, USA
Dr. Wim van der Putten, Netherlands Institute of Ecology, Wageningen, NL
Dr. David Wardle, Swedish University of Agricultural Sciences, Umea, SE
Dr. Junling Zhang, China Agricultural University Beijing, CH

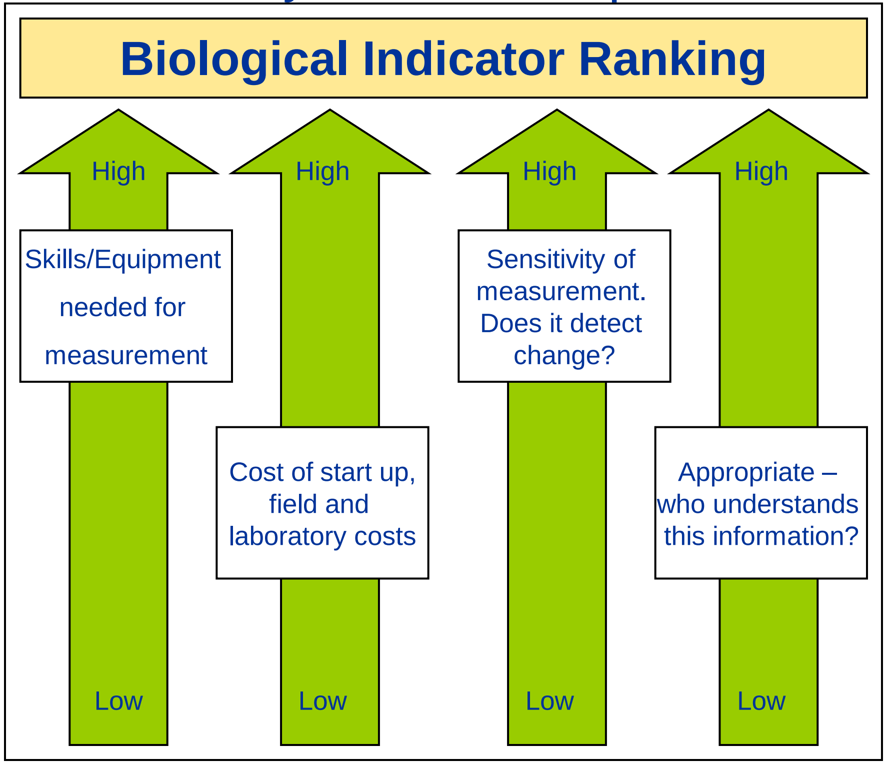
Read more about this conference on http://colloque.inra.fr/gsbi1

EcoFINDERS INRA SCIENCE & IMPACT uB UNIVERSITE DE BOURGOGNE Grand Dijon Bourgogne Conseil régional 2007 - 2013 AGRO SUP DIJON Institut national supérieur des sciences agronomiques de l'alimentation et de l'environnement Agrale DIJON

Dissemination – Global Atlas of Soil Biodiversity

Exploitation plan

- Development of ISO standard for soil biological analyses
- Building-up a referential for interpretation of soil biological analyses with inclusion of the Normal Operating Range
- Logical Sieve Selection of Biological Indicators for Assessment of Biodiversity across Europe



- Used to inform scientists on the best indicator methods available, with details of the cost, skill and labour requirements.
- Used to inform policy makers on the best indicators for monitoring of biodiversity across Europe.
- Used to inform stakeholders on techniques to apply at the smaller scale for assessment of biodiversity.

- Periodical identification of quick wins tested by stakeholders for possible implementation and adjustments.

Future Research priorities

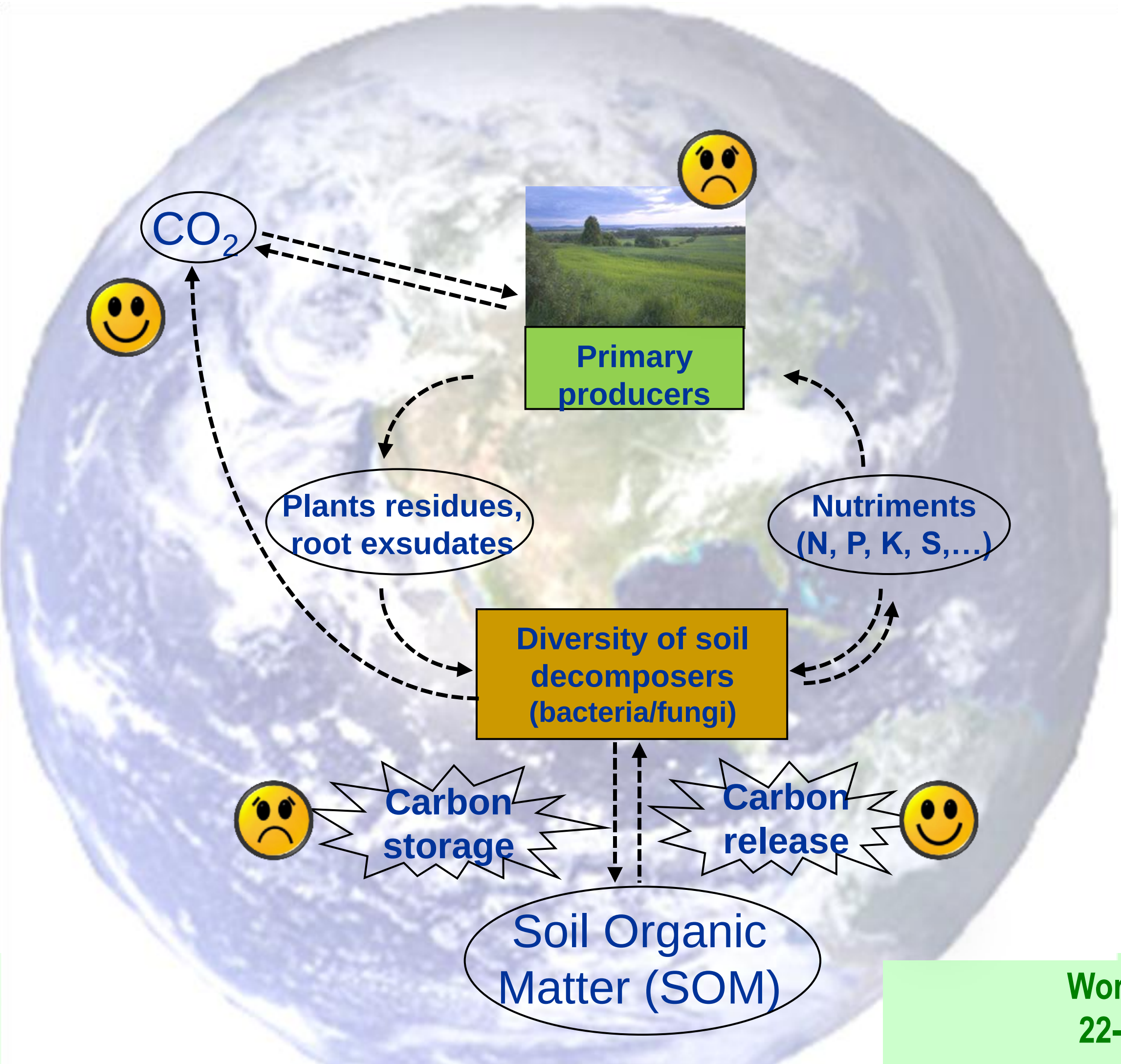
- Major progresses in SOPs and referential to achieve soil diagnosis for application of the EC Soil Thematic Strategy.-

- Challenges: Moving from diagnosis to action
  - ✓Based on diagnosis, define strategies for sustainable soil management to meet food security in a context of global change
  - ✓This requires :
    - the development of agro-ecological and urban-ecological land management contributing to food and environment security
    - the combination of expertises in soil physics, chemistry, ecology, landscape ecology, economy and sociology

Conclusions and challenges

Challenges: Moving from diagnosis to action

✓ dealing with possible trade-offs



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 (EU project SoilTrEC) and Long Term Observatories
- ✓ to match with world global initiatives

GLOBAL SOIL BIODIVERSITY INITIATIVE — A SCIENTIFIC EFFORT

GLOBAL SOIL PARTNERSHIP