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Sudoe



PhytoSUDOE

European Regional Development Fund

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

IMPROVEMENTS IN SOIL BIODIVERSITY AND FUNCTION AFTER LONG-TERM IMPLEMENTATION OF PHYTOMANAGEMENT OPTIONS

CARLOS GARBISU
NEIKER-Tecnalia

17th April 2018
2nd PhytoSUDOE STAKEHOLDER WORKSHOP
UNIVERSIDADE CATÓLICA PORTUGUESA, PORTO



El proyecto PhytoSUDOE (SOE1/P5/E0189) está financiado por el Fondo Europeo de Desarrollo Regional (Comisión Europea) a través del V programa Interreg Sudoe.

DO WE NEED TO STUDY AND PROTECT BIODIVERSITY IN CONTAMINATED SITES?

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

YES!! >>> Many times, contaminated sites harbour a unique biodiversity!

PLANTS

PHYTOEXTRACTION

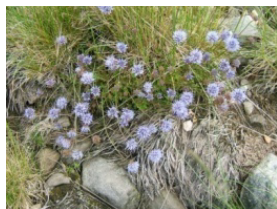
PHYTOSTABILIZATION

Hyperaccumulator



Noccaea caerulea

Acumulators



Jasione montana

Excluders



Molinia caerulea

MICROBES



Metal tolerant plant growth-promoting bacteria
Degraders of organic contaminants

DO WE NEED TO PROTECT / PROMOTE BIODIVERSITY IN PHYTOMANAGED SITES?

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YES!!! BECAUSE ...

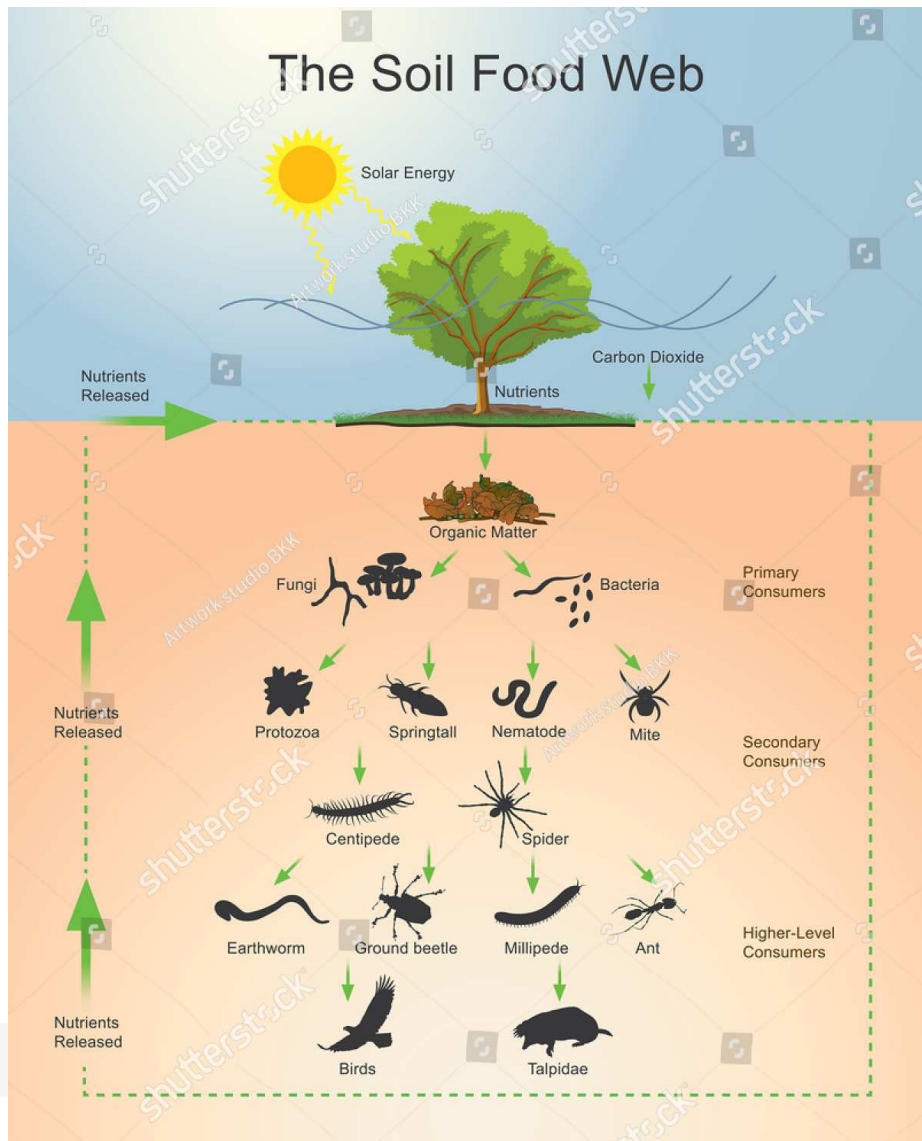
- ✓ **INTRINSIC VALUE:** we have an inherent obligation to live as harmoniously as possible with other organisms on this planet
- ✓ **UTILITARIAN VALUE:** materials-products, provision of ecosystem services

SOIL BIODIVERSITY

- **Intrinsic** (“non-use”) value, which comprises social, aesthetic, cultural and ethical benefits
- **Utilitarian** (“direct use”) value, which covers the commercial and subsistence benefits of soil organisms to humankind
- **Functional** value, relating to the natural services that the soil biota provides, the associated preservation of ecosystem structure and integrity, and ultimately the functioning of the planetary system via connections with the atmosphere and hydrosphere
- **Bequest** (“serpendic”) value, relating to future but as yet unknown value of biodiversity to future planetary function or generations of humankind

ECOSYSTEMS GOODS AND SERVICES PROVIDED BY SOIL BIOTA

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE



GOODS

- Food production
- Fibre production
- Provision of secondary compounds

SERVICES

- Driving nutrient cycling
- Regulation of water flow and storage
- Regulation of soil and sediment movement
- Regulation of other biota
- Detoxification of xenobiotics and pollutants
- Regulation of atmospheric composition

MECHANISMS THAT UNDERLIE THE RELATIONSHIPS BETWEEN BIODIVERSITY AND FUNCTION

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REPertoire: a diverse system will inherently carry a wider suite of potential abilities that will underwrite a wider range of functions

INTERACTIONS: a greater diversity of organisms offers a greater potential for interactions, and a more complex network of interactions may be more *adaptive to change and resilient to disturbance*

REDUNDANCY: the more organisms there are that can carry out a function, the more likely it is that if some are incapacitated or removed the process will remain unaffected; those that remain may fill the gap

Biodiversity forms a structural and functional **network** (ecological infrastructure) that provides ecological **stability** (resistance and resilience) through a higher **repertoire** of processes, a higher number of **interactions** and a higher functional **redundancy**

REDUNDANCY

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Redundancy is highly context-dependent: while two species may appear to perform the same decomposition function, they may not perform it under the same range of conditions, or at all time

Soil organisms can contribute to more than one function: species that are redundant for one function may play a key functional role elsewhere in the food web

Not all functions exhibit redundancy: the breakdown of some toxic chemicals may only be performed by a single species of bacteria

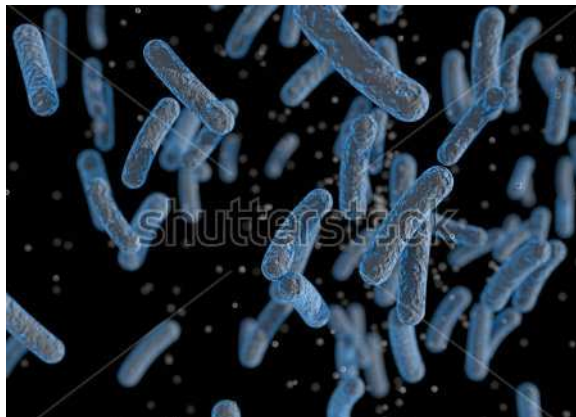
SOIL ORGANISMS CAN BE DIVIDED INTO 3 FUNCTIONAL GROUPS

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CHEMICAL ENGINEERS: bacteria, fungi and protozoans. Responsible for the decomposition of organic matter into nutrients

BIOLOGICAL REGULATORS: small invertebrates (nematodes, pot worms, springtails, mites). Predators of plants, other invertebrates or microorganisms, by regulating their dynamics in space and time

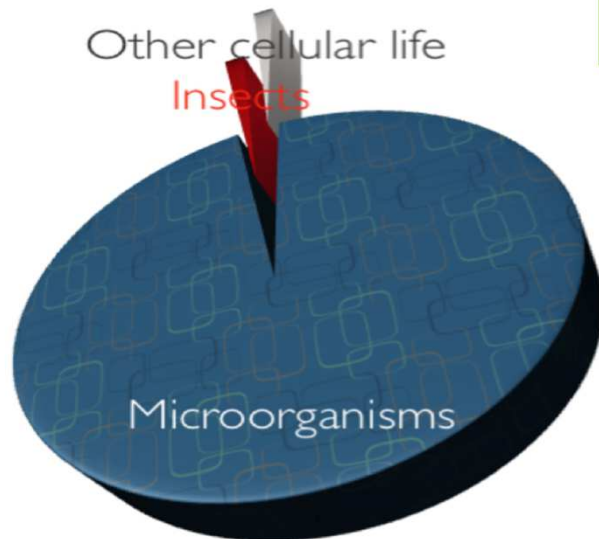
ECOSYSTEM ENGINEERS: earthworms, ants, termites, small mammals. They modify or create habitats for smaller soil organisms by building resistant soil aggregates and pores



SOIL MICROBIAL DIVERSITY

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

80% OF SOIL BIOMASS
80-90% OF SOIL BIOLOGICAL ACTIVITY
MOST OF THE SOIL BIODIVERSITY



BIOINDICATORS OF SOIL CONTAMINATION

- Quick response
- Sensitivity
- Ecological relevance

If I could do it all over again, and relive my vision in the twenty-first century, I would be a microbial ecologist. Ten billion bacteria live in a gram of ordinary soil, a mere pinch held between thumb and forefinger. They represent thousands of species almost none of which are known to Science.....



Edward O. Wilson

WORKING PACKAGE 2: Characterization and assessment of biodiversity in relation to phytomanagement options

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

- **OBJECTIVE:** Study the links between structural and functional biodiversity in phytomanaged soil, compared to contaminated non-phytomanaged soil and non-contaminated soil
- **QUESTION:** Does soil functioning depend on species richness, keystone species, species functional traits or community composition?
- **SPECIFIC OBJECTIVES:**
 - Assess the effect of phytomanagement on soil structural biodiversity
 - Assess the effect of phytomanagement on soil functional biodiversity
 - Identify the links between (1) soil structural and functional biodiversity, (2) soil biodiversity and plant biodiversity, and (3) biodiversity and ecosystem services
- **PRODUCT:** Guide of Best Practices for the recovery of biodiversity in degraded and contaminated sites through phytomanagement

PhytoSUDOE network of field sites

- **S1. St Médard d'Eyrans (Bordeaux, France)**
- **S7. Piedrafita de Cebreiro (Lugo, Spain)**
- **S8. Touro (A Coruña, Spain)**



COPPER POLLUTION

Amendments

- OM: compost
- DL: dolomitic limestone
- OMDL: OM + DL
- Untreated (control)

Cropping systems

- Short Rotation Coppice (*Populus / Salix*)
 - PM: mycorrhizal inoculum
 - PNM: non-inoculated
- Grass crops
 - PG: *Agrostis*

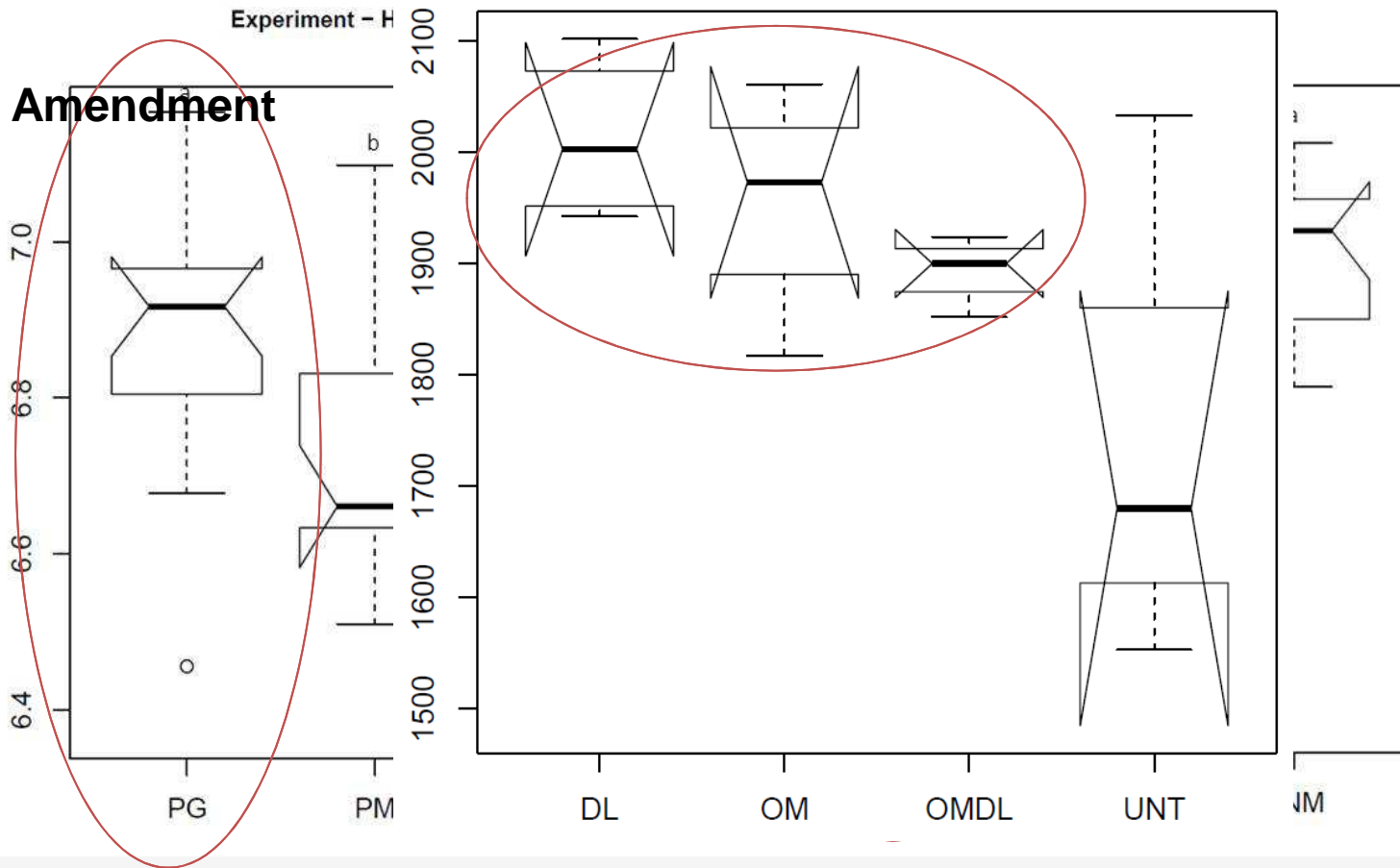


S1. St Médard d'Eyrans (Bordeaux, France)

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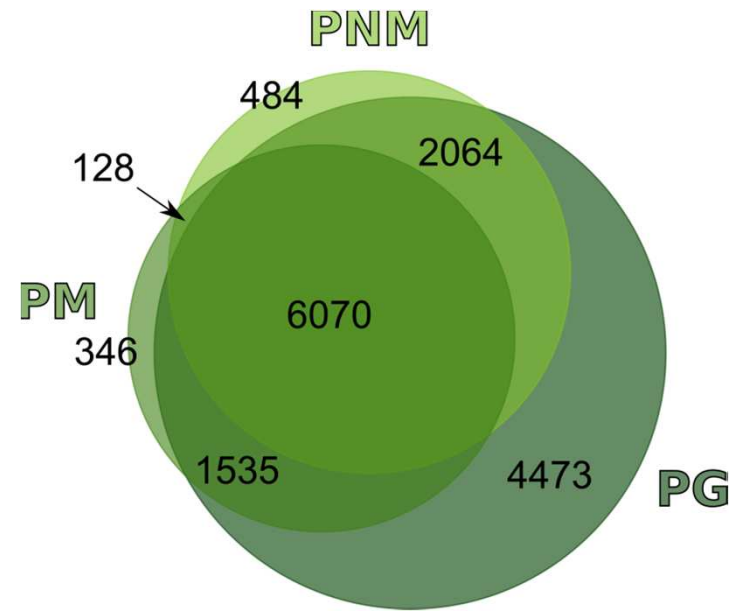
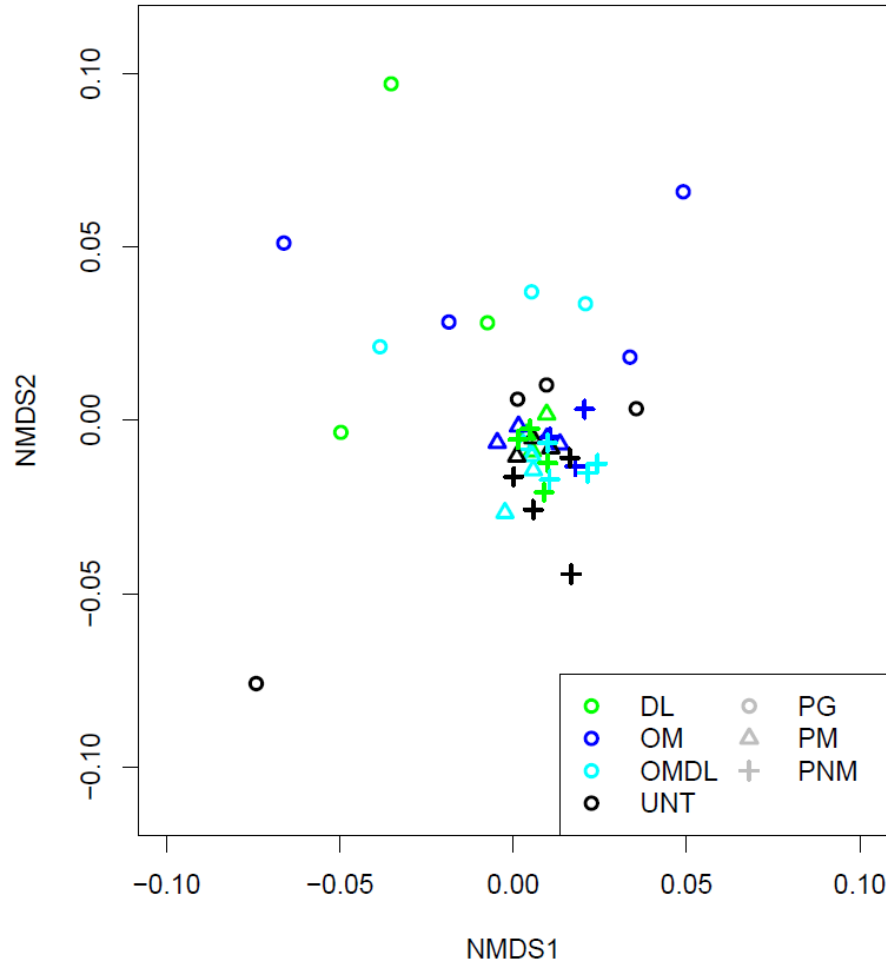
α-DIVERSITY INDEXES

Amendment - Rarefied.richness , p= 0.04



S1. St Médard d'Eyrans (Bordeaux, France)

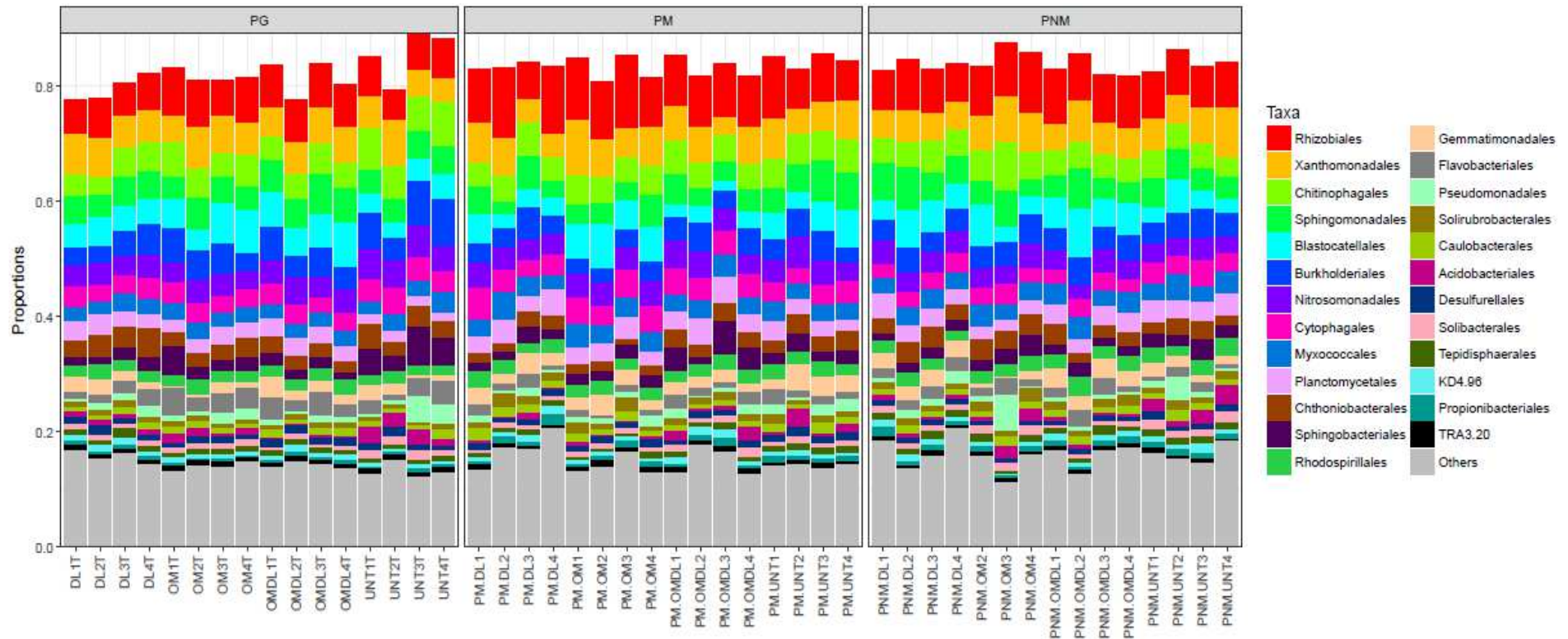
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CROPPING SYSTEM: GREATEST INFLUENCE ON PROKARYOTIC COMMUNITY COMPOSITION

S1. St Médard d'Eyrans (Bordeaux, France)

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE



S7. Piedrafita de Cebreiro – (Lugo, NW Spain)

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

Pb/Zn/Cd POLLUTION

Amendments

- RC: amended with compost
- R: **not amended or NPK**

Cropping systems

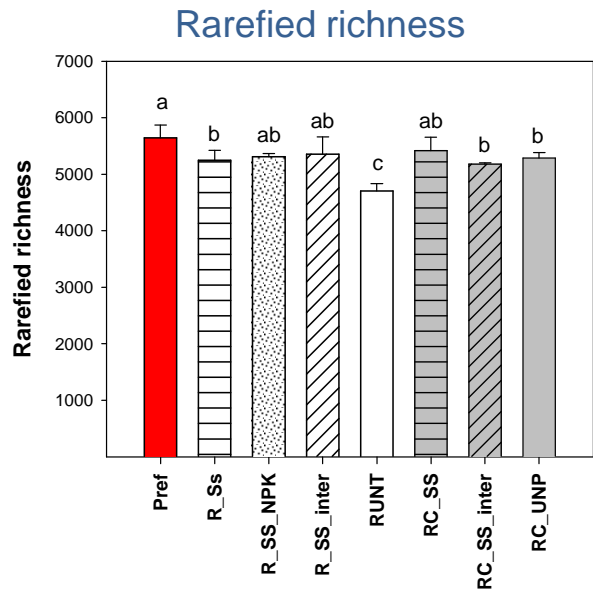
- Monoculture (*Salix smithiana*)
- Intercropping (*S. smithiana* + *Alnus glutinosa*)
- Unplanted



S7. Piedrafita de Cebreiro – (Lugo, NW Spain)

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

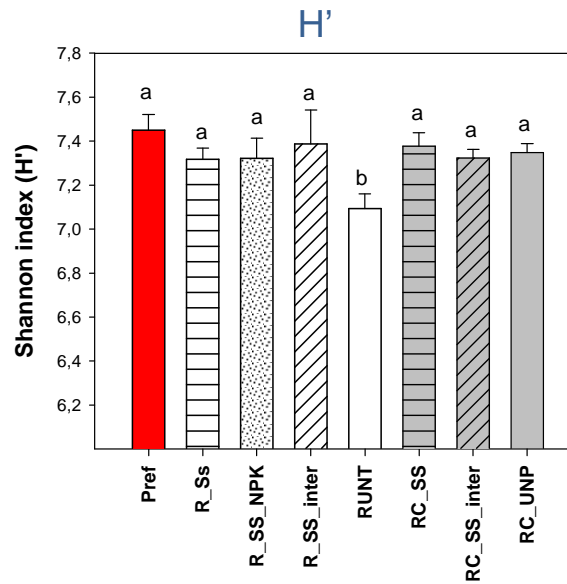
α-DIVERSITY INDEXES



Crop: Monoculture > Intercrop > Unplanted

Amendment: ns

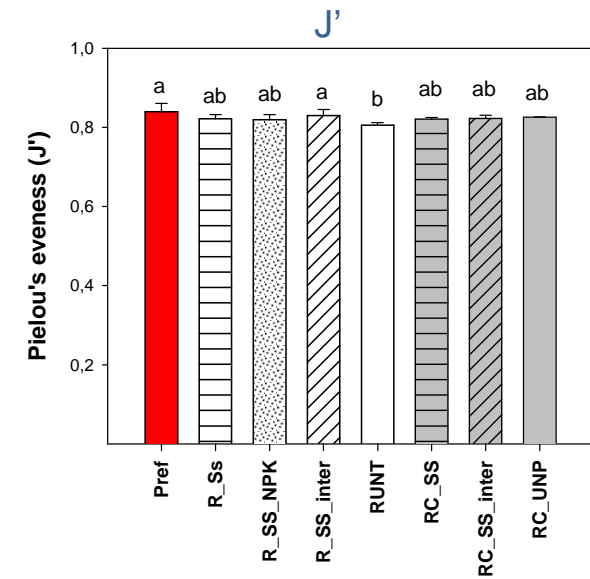
Planted > Unplanted



Crop: Monoculture > Intercrop > Unplanted

Amendment : ns

Planted > Unplanted



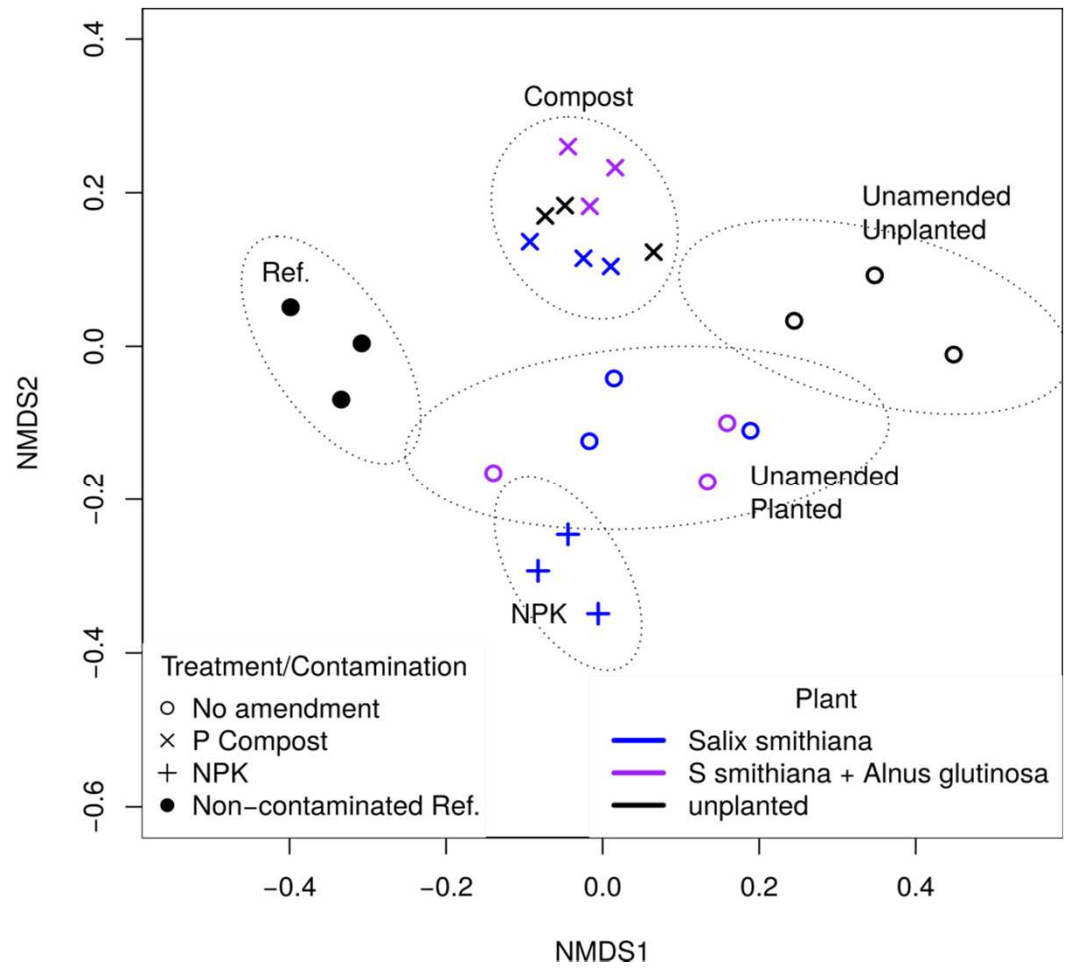
Crop: Monoculture > Intercrop > Unplanted

Amendment : ns

Planted / Unplanted: ns

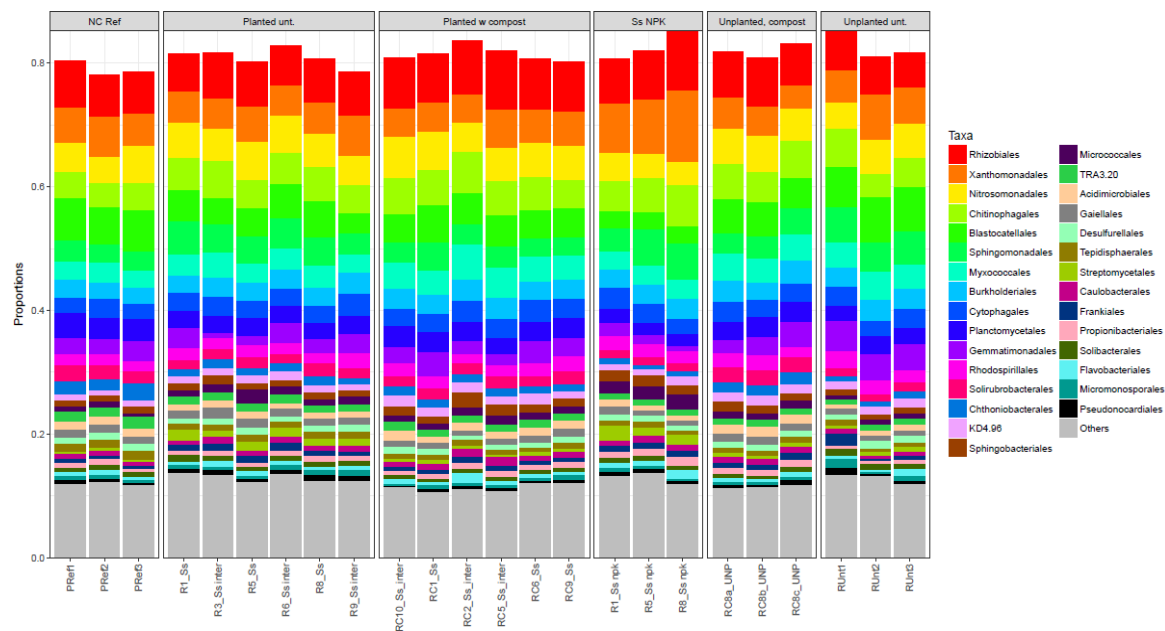
S7. Piedrafita de Cebreiro – (Lugo, NW Spain)

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE



COMPOSITION: ORDER LEVEL

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE



AMENDED > NPK / UNAMENDED (p<0.05)

- Acidimicrobiales
- Fibrobacteriales
- Verrucomicrobiales

NPK > AMENDED / UNAMENDED (p<0.05)

- Chthoniobacteriales
- Xanthomonadales



S8. Touro Cu mine – (A Coruña, NW Spain)

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

COPPER POLLUTION (moderate) Mine tailings 550 ha

3 amendments (+1 unamended)

- PC: amended with compost
- PT1: waste mixture 1
- PT2: waste mixture 2

3 cropping systems

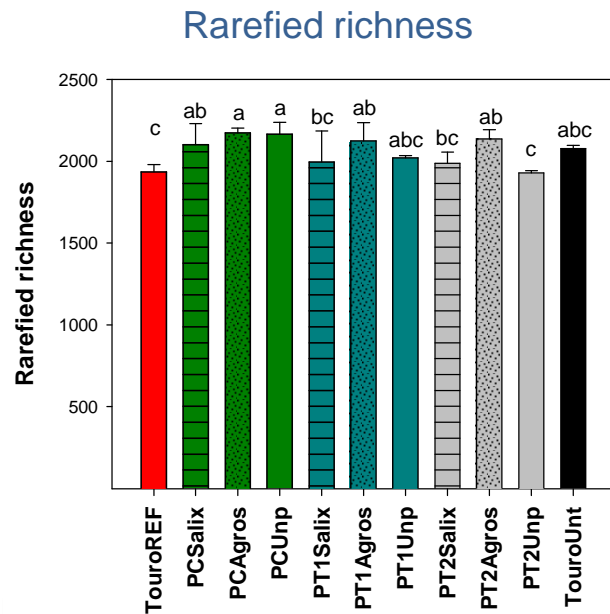
- *Salix viminalis*
- *Agrostis capillaris*
- Unplanted



S8. Touro Cu mine – (A Coruña, NW Spain)

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α-DIVERSITY INDEXES

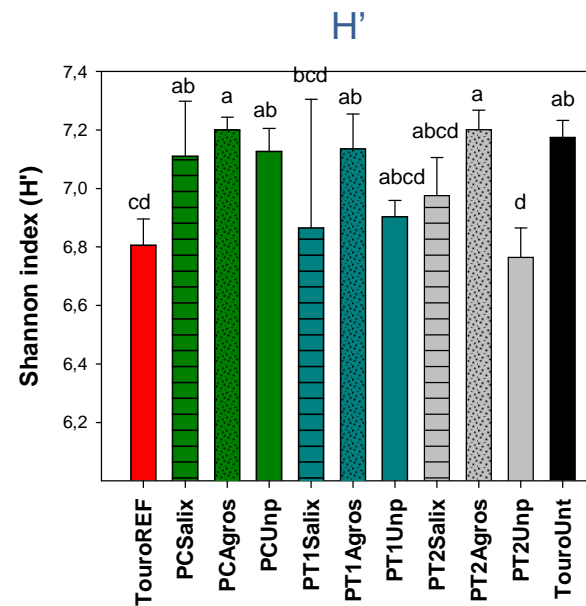


Crop: Salix = Agrostis > Unplanted > Ref

Amend: PC = Unamended > PT1 = PT2 > Ref

Plant / No plant = ns

Amended/Unamended: ns

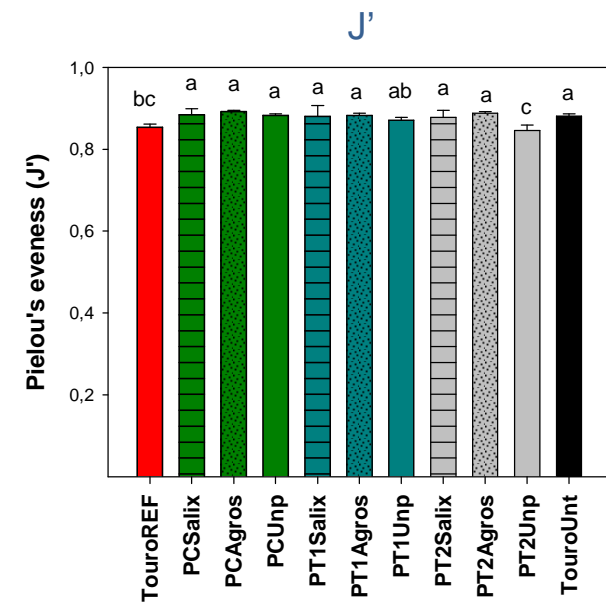


Crop: Salix = Agrostis > Unplanted > Ref

Amend: Unamended = PC > PT2 = PT1 > Ref

Plant / No plant = ns

Amended/Unamended: ns



Crop: Salix = Agrostis > Unplanted > Ref

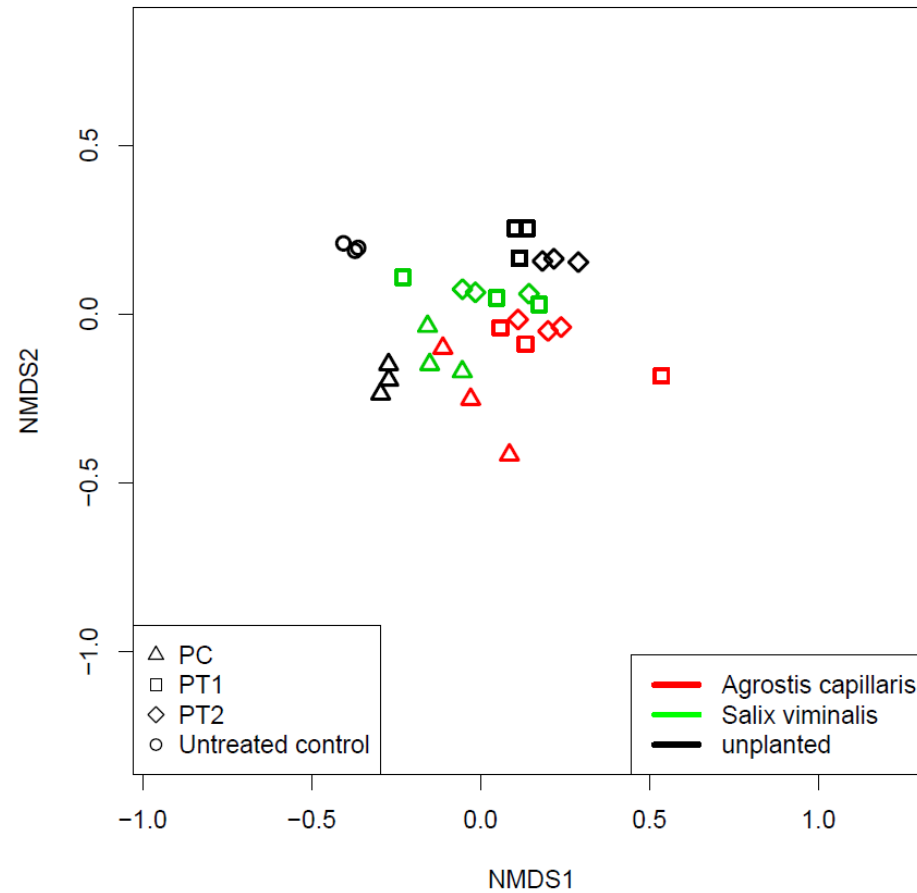
Amend: PC = Unamended = PT1 > PT2 > Ref

Plant > No plant

Amended/Unamended: ns

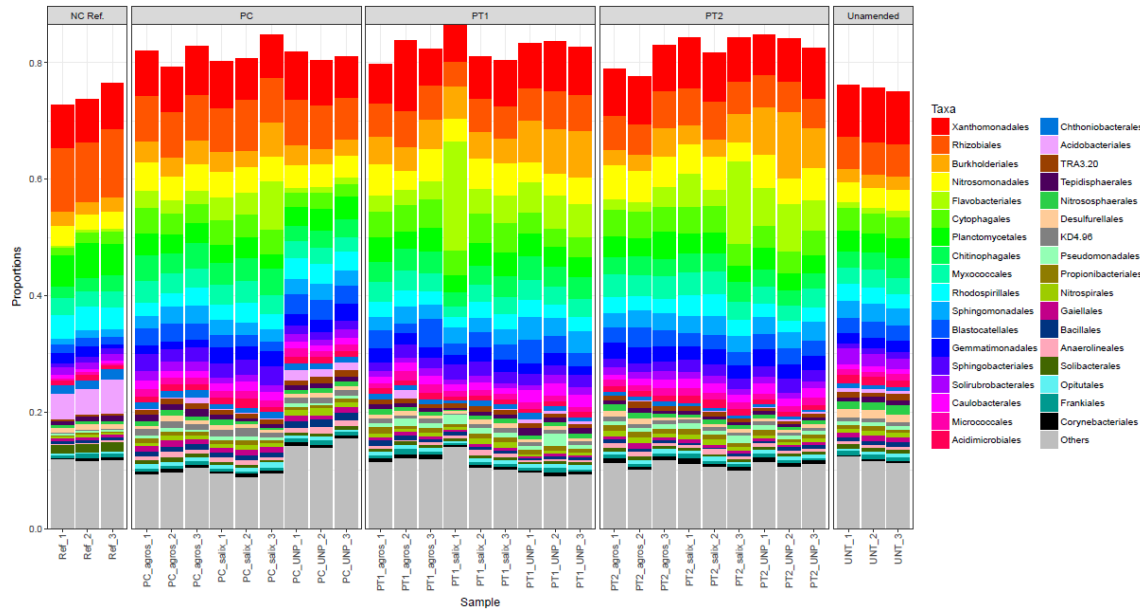
S8. Touro Cu mine – (A Coruña, NW Spain)

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COMPOSITION: ORDER LEVEL

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE



UNAMENDED > AMENDED (PC, PT1, PT2) ($p < 0.05$)

Catenulisporales

Chlamydiales

Desulfurellales

Gnavibacterides

Ktedonobacteriales

Nostocales

Solirubrobacteriales

Thermogemmatissporales

PC > PT1, PT2, UNAMENDED ($p < 0.05$)

Rhizobiales

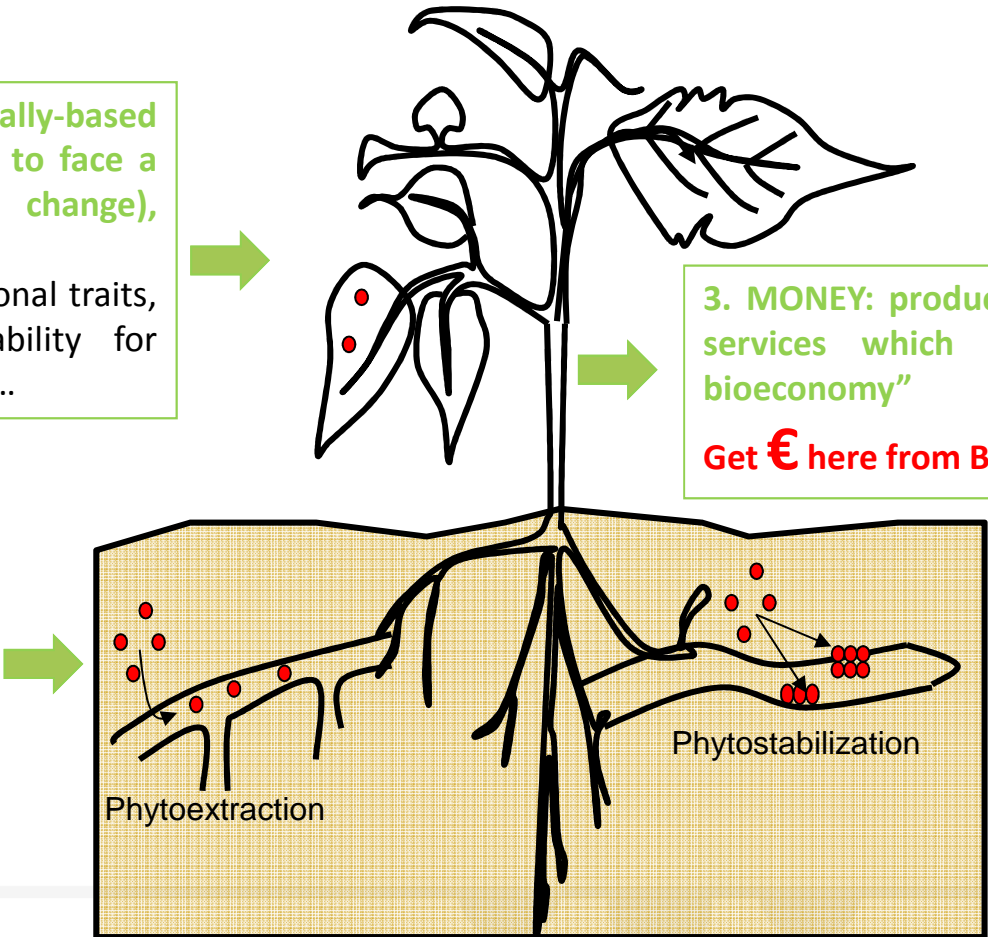
Paraphrasing the three M'S of successful trading (MIND, MONEY MANAGEMENT, METHOD)...

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

THE 3 M'S OF SUCCESSFUL PHYTOMANAGEMENT: MIND + MANAGEMENT + MONEY

2. MANAGEMENT: apply scientifically-based management, adaptive management to face a changing environment (climate change), adaptive monitoring
 BIODIVERSITY provides species, functional traits, interspecific and intraspecific variability for resilience, biological tools and options...

1. MIND: fertilize with creativity & high quality research. **Put € here...**
 BIODIVERSITY provides ideas, models, strategies, etc. (millions of today's champions of evolution to learn from...).



3. MONEY: products & ecosystem services which will "fuel our bioeconomy"
Get € here from BIODIVERSITY!!

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**PROMOTE BIODIVERSITY IN
PHYTOMANAGED SITES!!**



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