Bellemain E.[1], Bonin, A. [1],
Pierron, M. [1], Baptist, F. [3]

Bioindication of soil quality based on environmental DNA

1 ARGALY
Evidence Everywhere

2 biotope

Why a global indicator of soil quality?

- More and more money spent on soil restauration for polluted or degraded sites (>470M€ in 2010).

- But lack of adapted protocols and indicators to assess the recovery of ecosystems (function, biodiversity)

→Construction of dedicated indicators in link with the ecosystem services for an efficient monitoring of the soil compartment : standardized / reliable / cheap / easily applied

Limits of ‘traditional’ indicators

- **Physicochemical** (pH, N, C, P…) → Do not allow to assess the level of soil functionality
- **Biological** (Description richness and abundance of specific groups, e.g. annelids, nematods, microarthropods, bacteria, fungi)
  - →High temporal and spatial variability according to soil and climatic conditions
  - →Morphological identification can be tedious, time-consuming, subjective, and expensive

Why using eDNA metabarcoding?

ATCGCTA

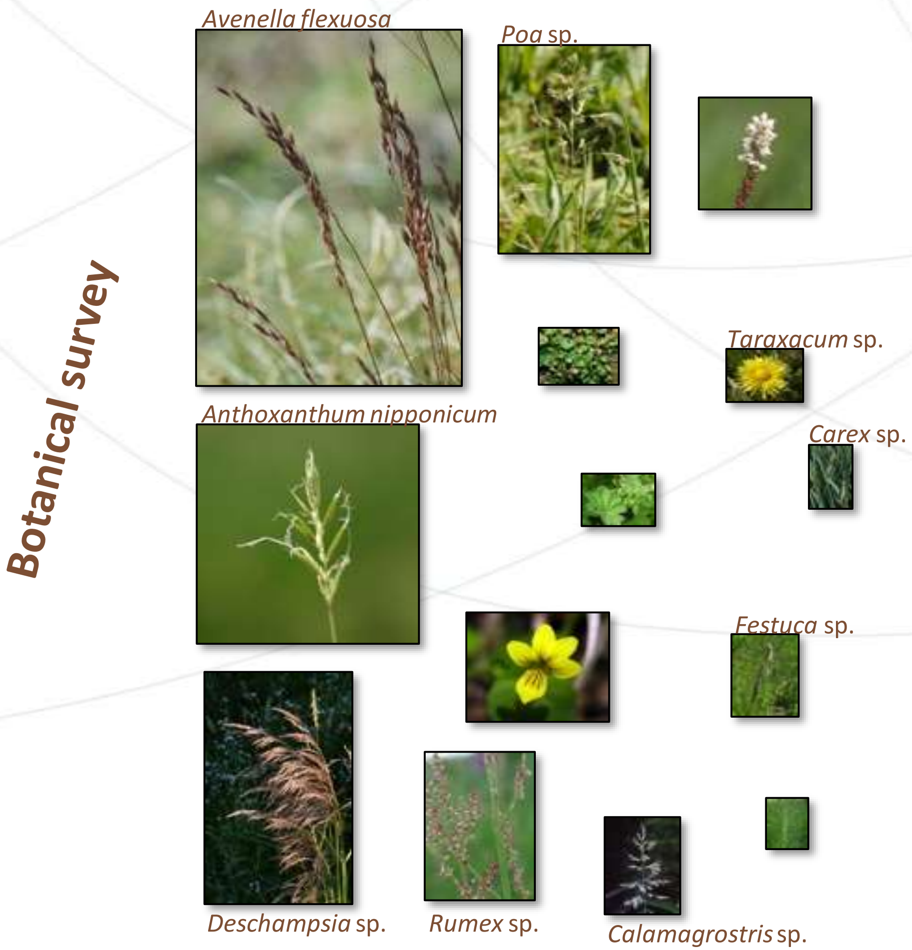
TCGCTACG

GCTACAG

GGCTAG

- A single analysis → diversity of taxa of the target group
- Temporal and spatial standardisation
- Independant of climatic conditions or seasons
- Analysis without « a priori »
- Sampling of soil easy, fast and standardized.

First study on soil eDNA comparing…

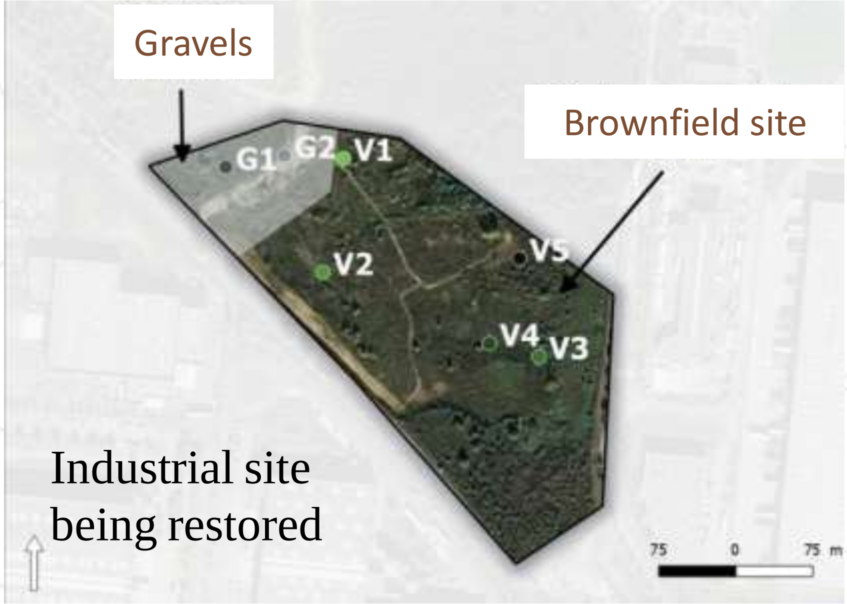


Yoccoz *et al.* (2012)

Pilot study on a polluted site

Field work:
Pollution: hydrocarbons / heavy metals

- Quadrats 1m^2 - Horizon 0-10cm
- 7 samples (20 pooled subsamples) – 15g
- 2 replicates per sample
- Preserved dry (with silica)

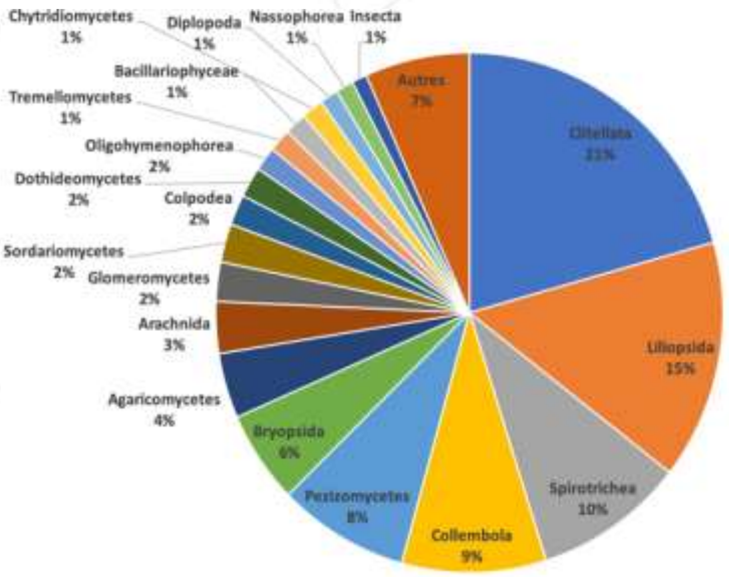


Industrial site being restored

Lab work:
Extraction of extracellular DNA
Amplification using eukaryote primers
4 PCR replicates / sample.
Miseq sequencing run (2*125 bp).

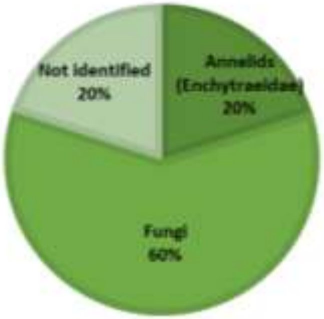
Bioinformatic / biostatistics analyses
(OBItools – ROBItools)

First results: Taxonomic composition

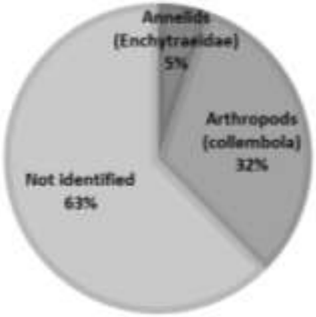


All samples

- Animals: mainly annelids, protozoans, collembols
- Plants: mainly monocotyledons, mosses



Polluted fields

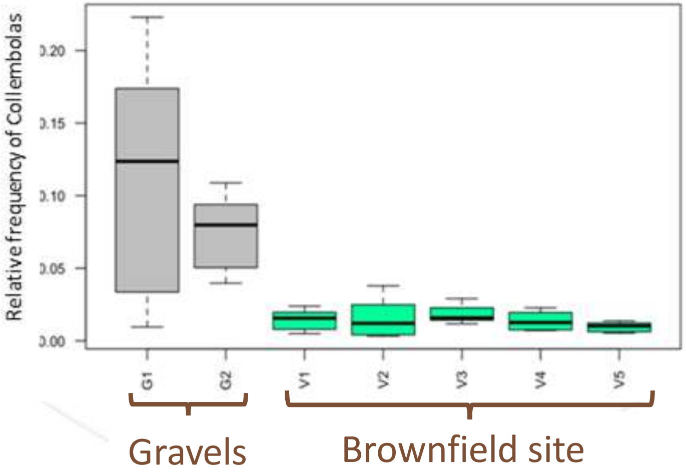


Fields being restored

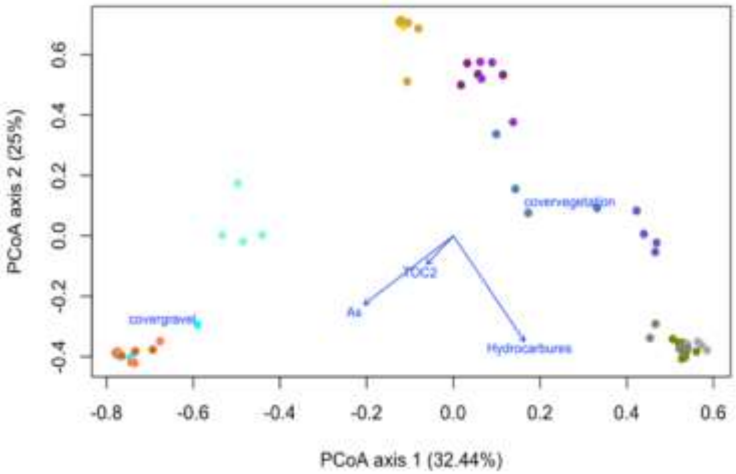
Identification of different ‘composite’ bioindicators, depending on habitat type

→ can testify of the soil restoration without any a priori knowledge

First results: Focus on collembola



Relative frequency of collembolas between samples.

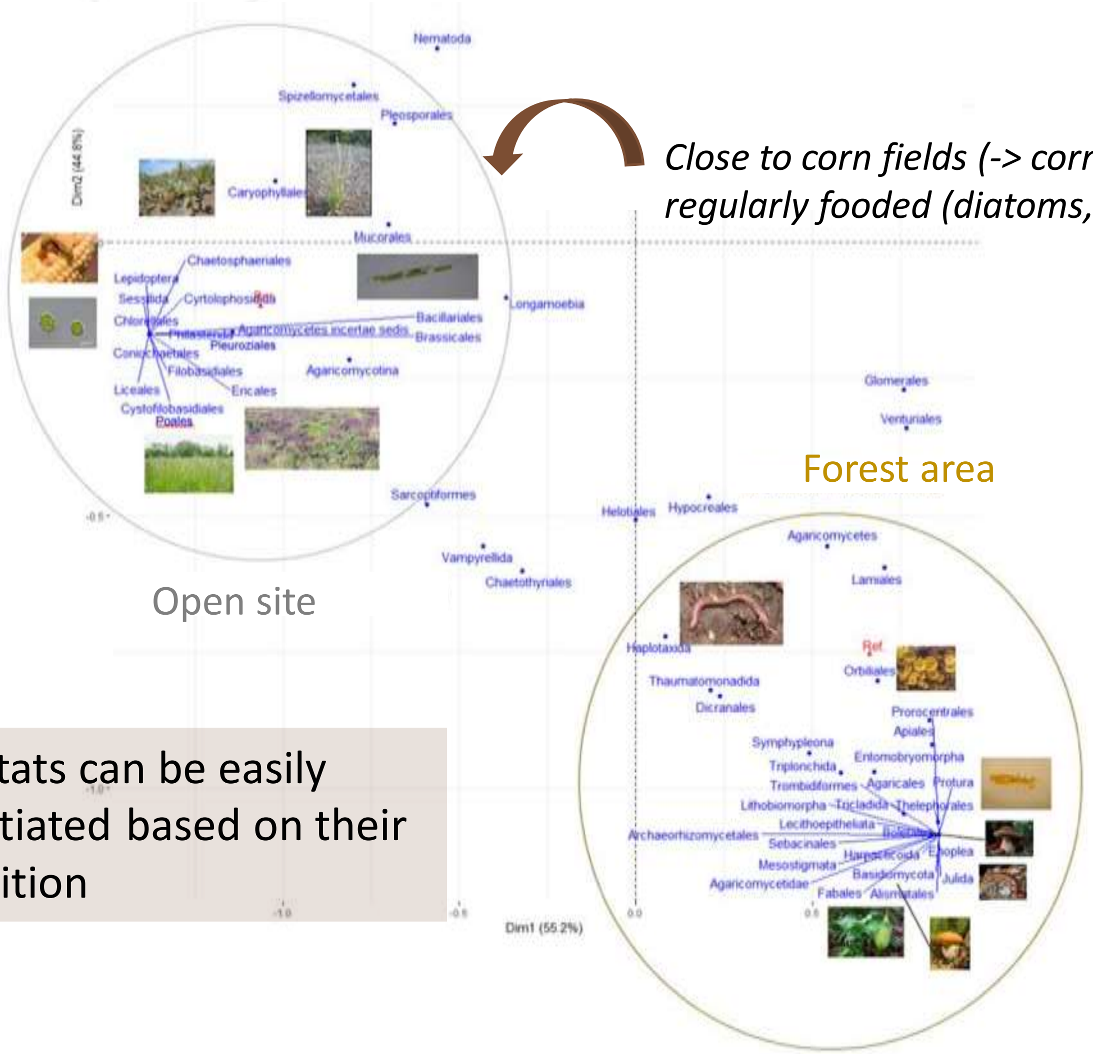


Structure of samples (multivariate analysis)

→ This group responds well to environmental variables, i.e. habitats or pollution type

→ Pioneer species?

Other study on a rehabilitation site



Close to corn fields (-> corn moth)
regularly fooded (diatoms, chlorella…)

Rehabilitation
after landfill mining

Forest area

Open site

→ Habitats can be easily differentiated based on their composition

Low anthropic pressure, close to a river (sometimes flooded)

Conclusions

- A DNA signature can be established from soil samples

→ With the objective to assess the degree of restoration of soil quality in polluted environments.

- eDNA tool as a global indicator for biological assessment of soils:
  - standardized
  - relatively inexpensive
  - easily applied regardless of climatic conditions.

Perspectives

- R&D project on a pilot site with different levels of pollution.

CRISALID

- Ultimately, a database considering different type of soils will be built at national scale → correlation between DNA signatures and ecosystem functions ('Machine learning' approaches)

- Can also be used in the agriculture sector, to contribute to the assessment of soil biological quality and guide cultural practices.

Thanks for your attention!