Contaminated sites and eDNA: how can metabarcoding support consultants and authorities' goal of achieving remediation and governing restoration?

Adrienn Micsinai

Eurofins BIOMI Kft.

ATV Jord og Grundvand Vintermøde 2026

4th March 2026.

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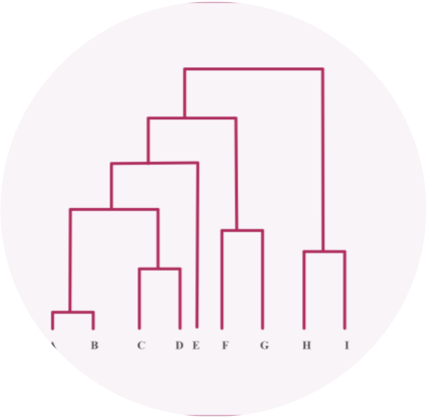
Testing for Life

Question for a PhD student at the end of the 20th century

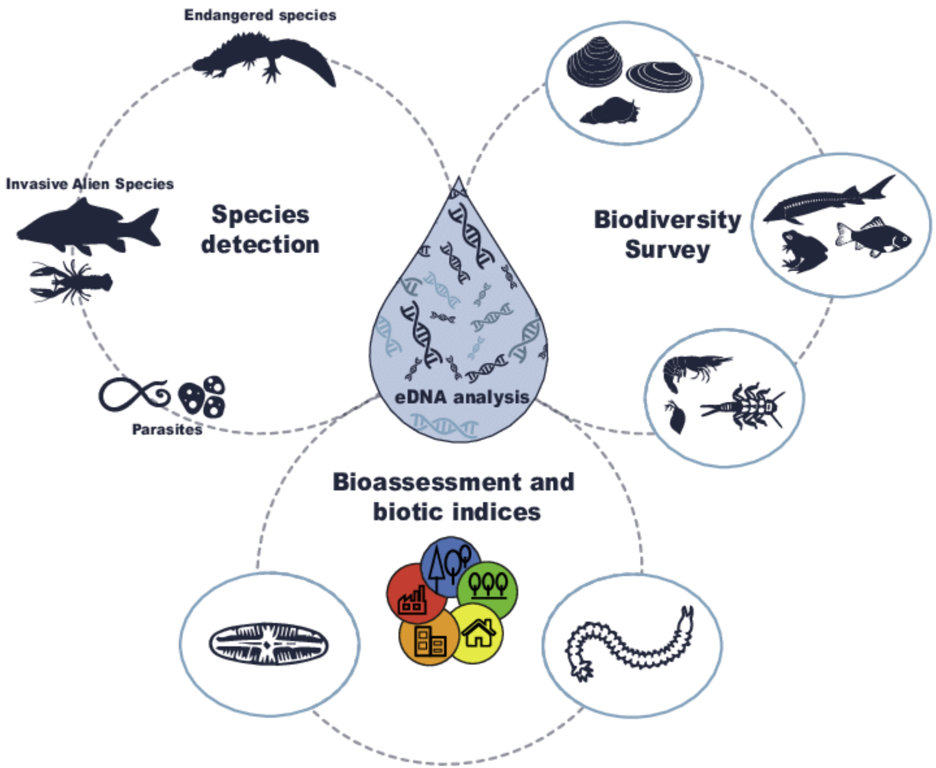


WHO IS THERE?
Taxonomic composition

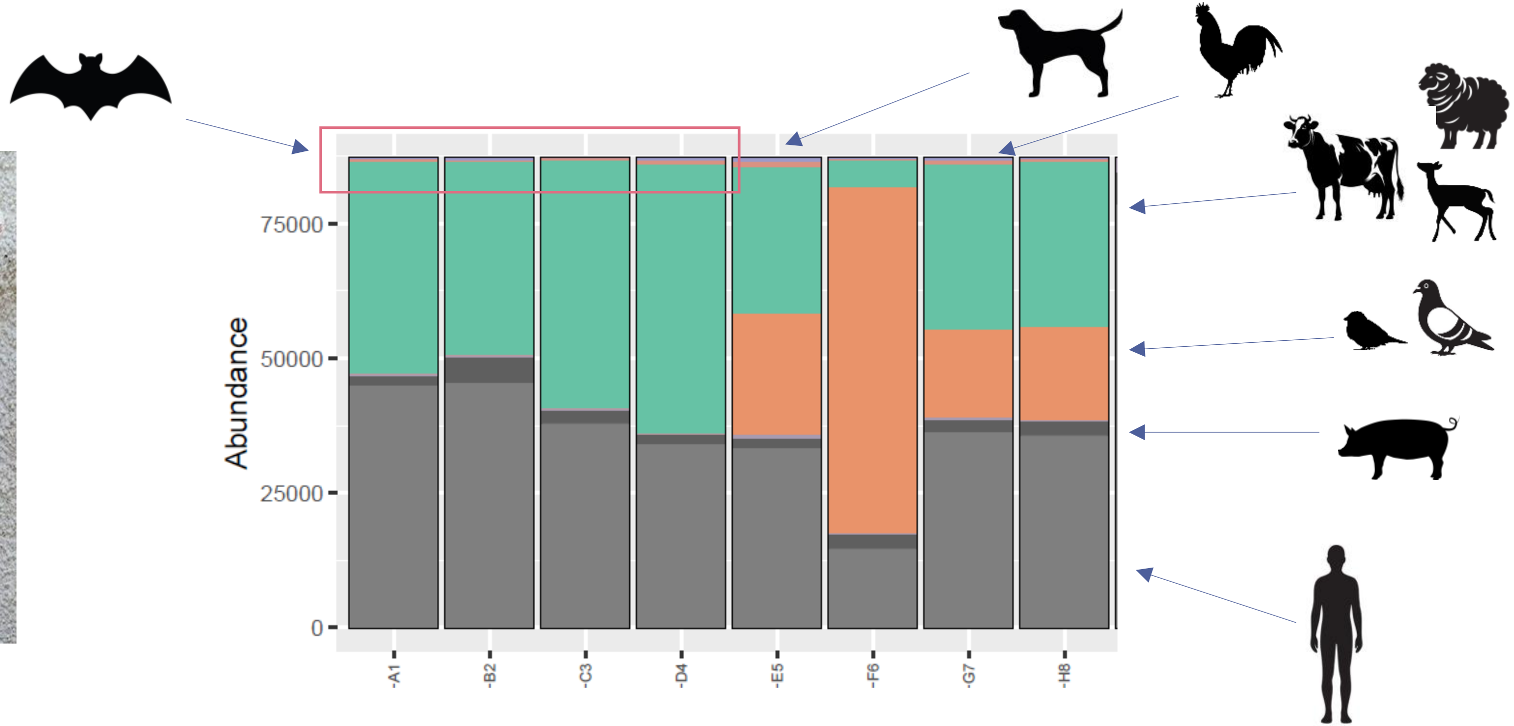
HOW MUCH?
Microbial/other biomass, diversity, abundance

WHAT ARE THEY DOING?
Respiration, enzymatic activity, trophic/food-web indices

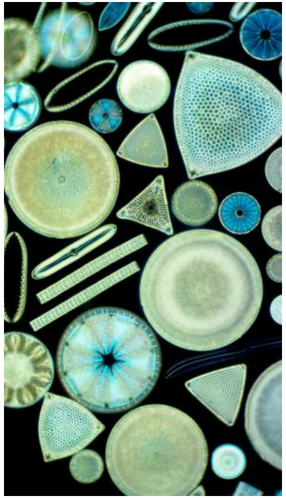
eDNA applications

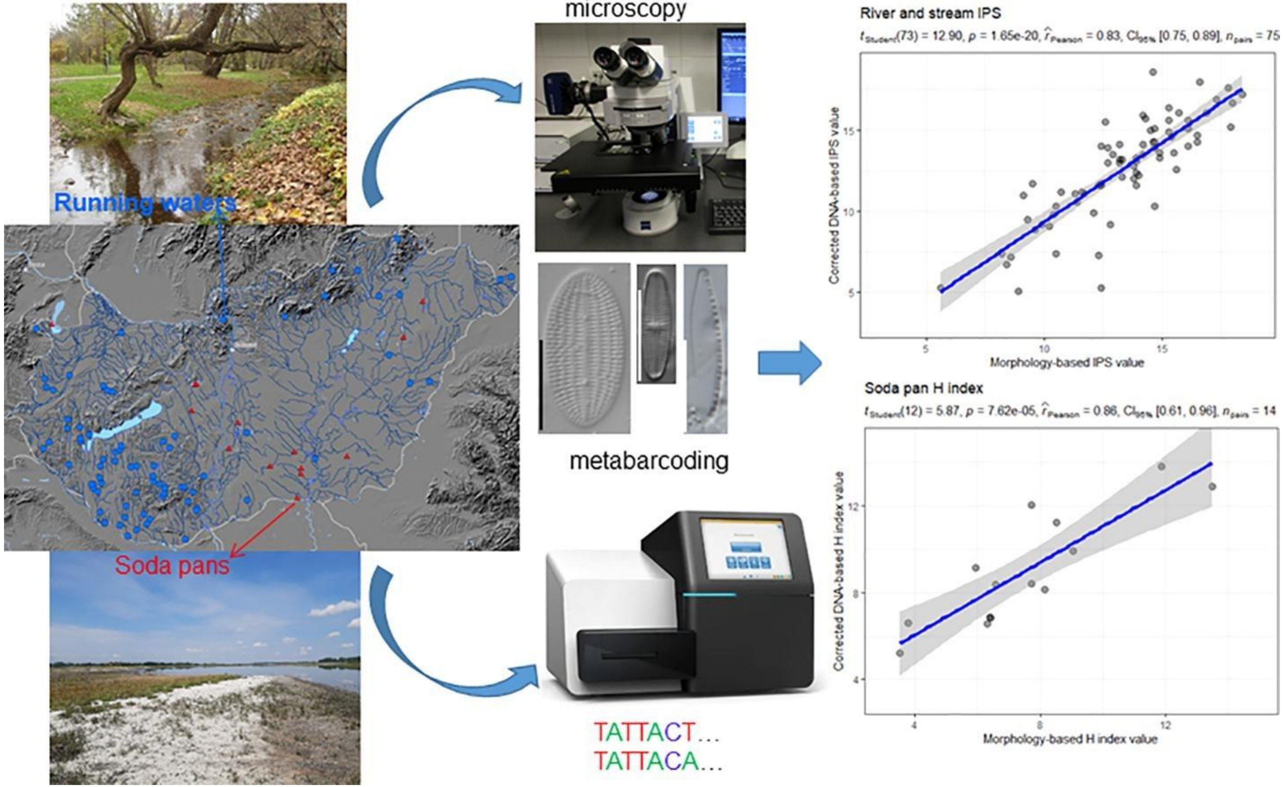


eDNA application - species detection



eDNA application – diatom barcoding and ecological status assessments





(Duleba et al, 2021)

ACHIEVING REMEDIATION AND GOVERNING RESTORATION OF CONTAMINATED SOILS NOW

PC

WPLs

Partners

Sites

- 27 sites covering 8 countries
  - 15 sites: Chemical suspect + group screening
    - 9 test sites for remediation: chemical/eDNA analyses and modelling, and human/env. risk/socio economic assessment
      (2 sites/ pollutant group, at Tier 1/2/3 remediation level)
      PFAS: AFFF (DK), 3M (BE)
  - 2 sites: Ecological evaluation of (short/long time after remediation)
    Soil and biodiversity restoration by biochar and nature-based solutions

Duration: October 1st 2023 – September 30th 2027

Coordinator: University of Copenhagen (UCPH), **Xenia Trier**

Funded by the European Union.

aragorn impact

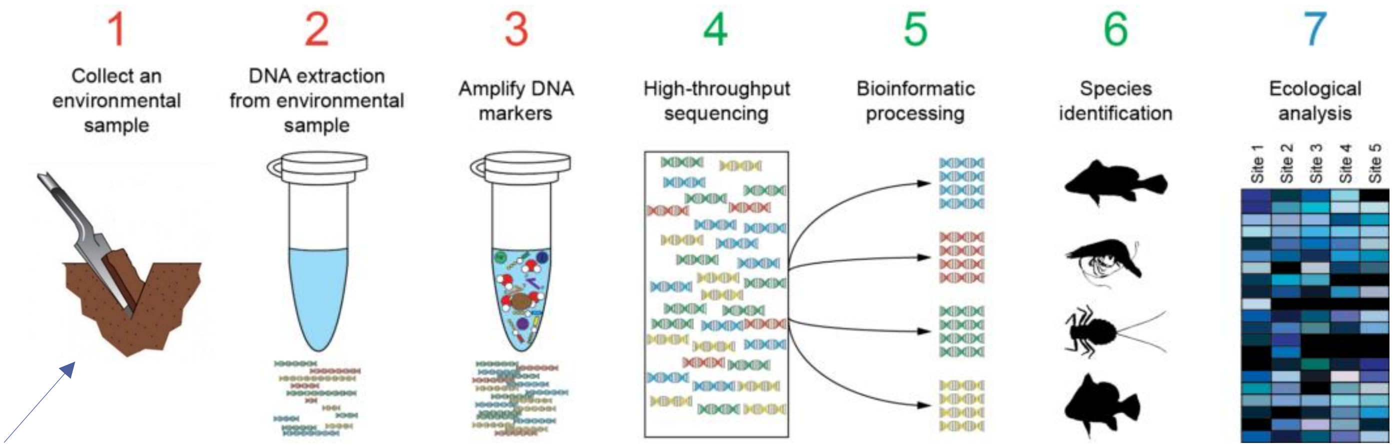
- **Direct input to the EU Soil Monitoring and Resilience Law**
    - Protection goals for soil, and indicators for human and ecotoxicological risks at remediated sites
    - Overview of soil threshold values, and principles across 31 countries
    - Monitoring strategies for groups of pollutants, prioritization of chemicals for priority/watch/site lists
    - Defining data parameters, metadata and architecture for data platforms
    - Fast policy responses: PFAS monitoring in soil (Feb 2025) and Pesticide monitoring in soils (March 2025)
- **Mapping of typical polluting activities** for four pollutant groups of PFAS, PETCO, OCB and metals
- **Sampling strategies** for soil and biota
- **Quantitative and screening methods,** and **data** for 9 **contaminated sites** in Europe, for PFAS, PETCO, OCB, metals, **eDNA** and soil characteristics and longitudinal ecosystem assessment of 2 sites
- Framework to **plan and assess risks, costs/benefits** and **resilience** of soil remediation and restoration strategies
- Alignment of regulations – water, soil, industrial emissions directives, biodiversity, climate change, circular economy

Can eDNA add to evaluation and monitoring of contaminated sites by capturing biodiversity and biotic indices and contribute to reslience modelling?

ARAGORN site in France

- Former coking factory site (PETCO+metals)
- Remediated 20 years ago
- Restoration objective: **biodiversity** restoration using bio-based methods (**pedological engineering, phytomanagement – assisted natural attenuation**)

ARAGORN eDNA for site in France

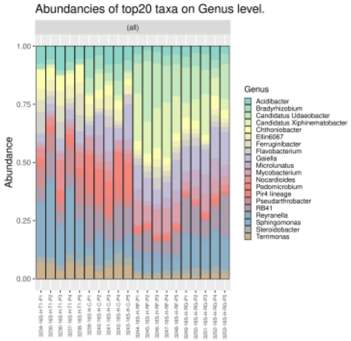


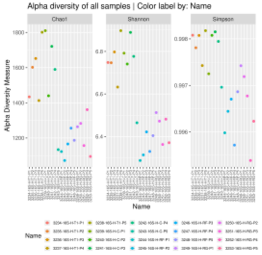
Based on LUCAS protocol

Control	Treatment	Reference Grassland	Reference Forest
• 5 subsamples • Contaminated but not treated	• 5 subsamples • Treated	• 5 subsamples • Not contaminated, not treated	• 5 subsamples • Not contaminated, not treated

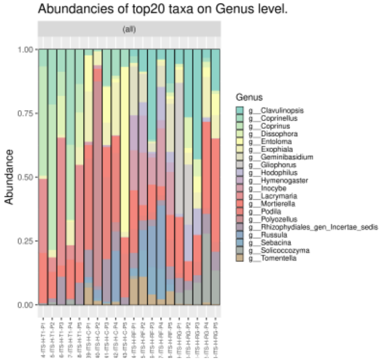
ARAGORN eDNA - taxonomic abundance and biodiversity index data

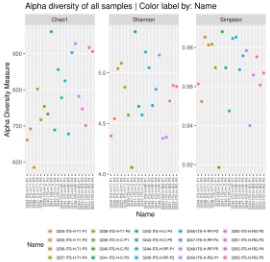
Bacteria – target: 16S gene



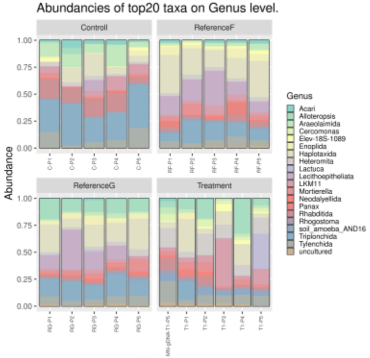


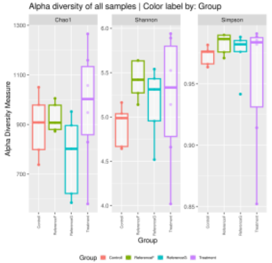
Fungi – target: ITS gene



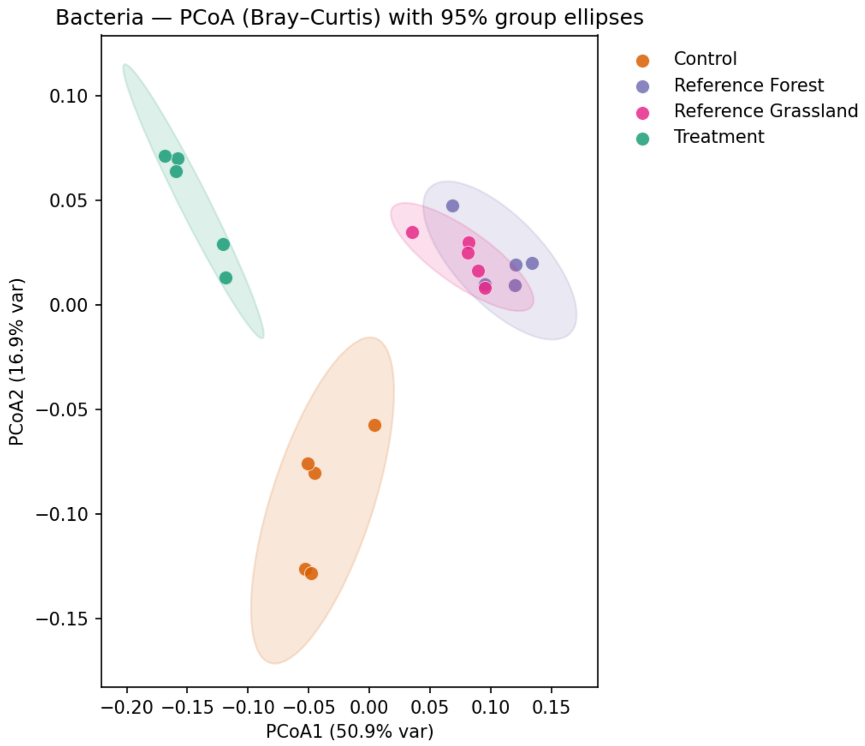


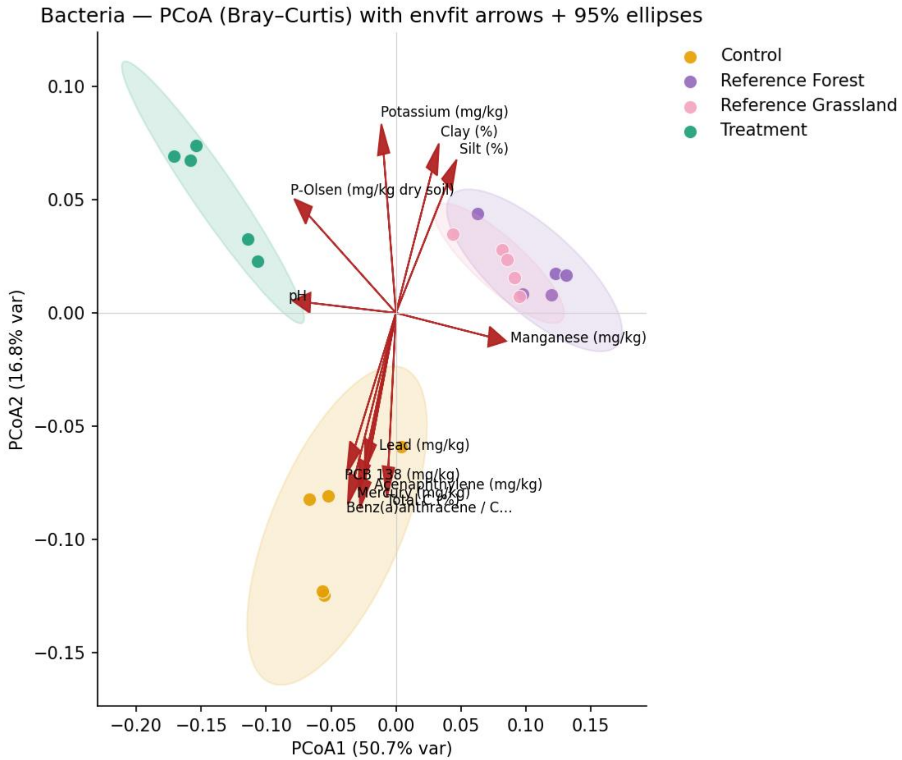
Eukaryotes – target: 18S gene



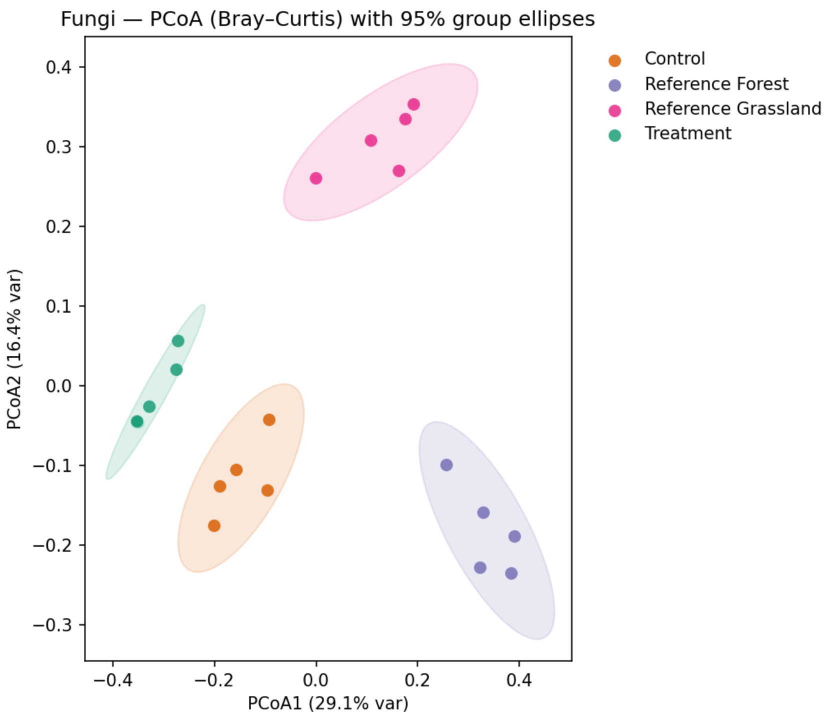


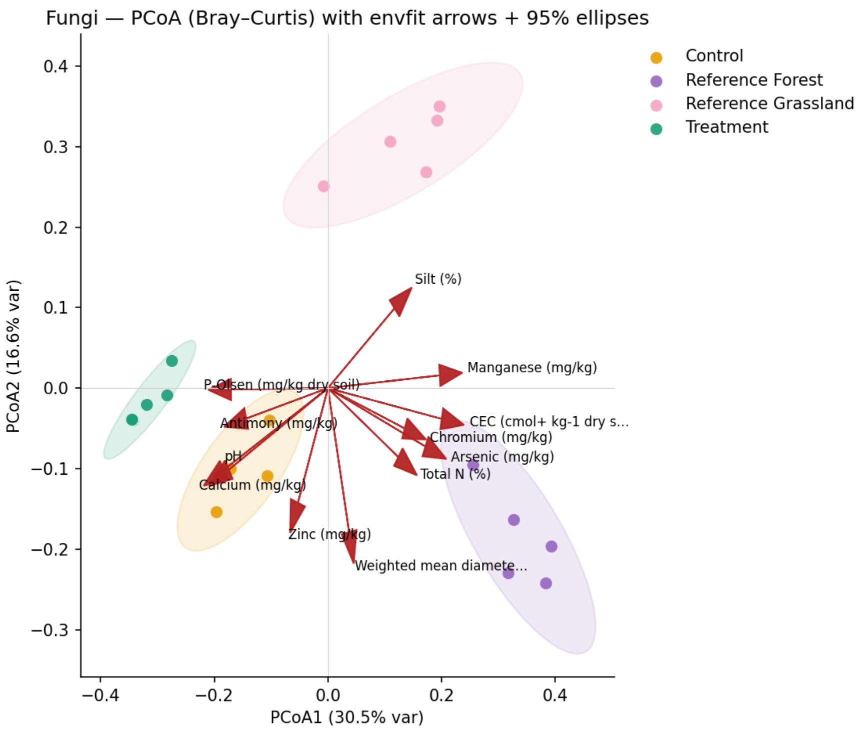
eDNA in ARAGORN - BACTERIA



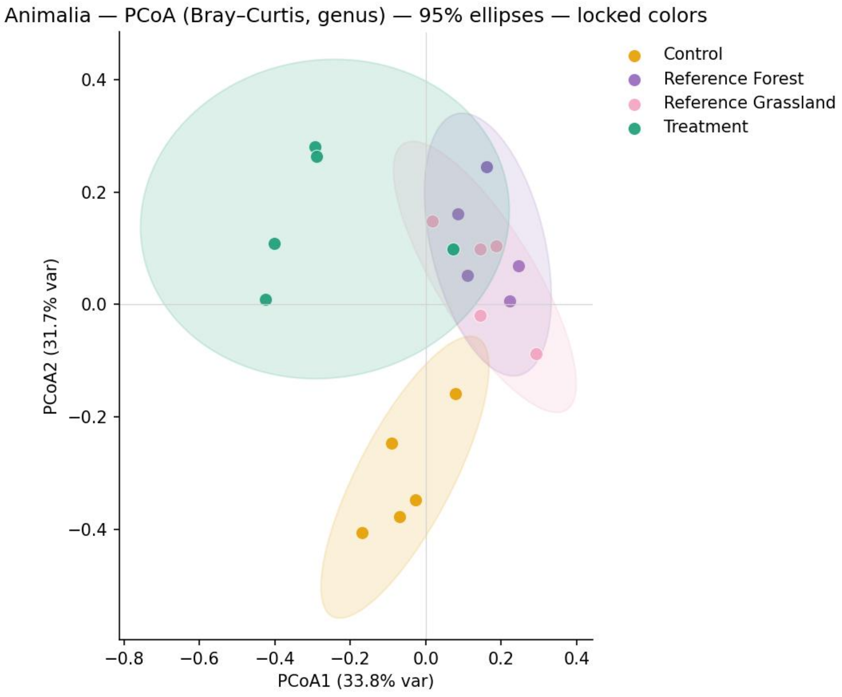


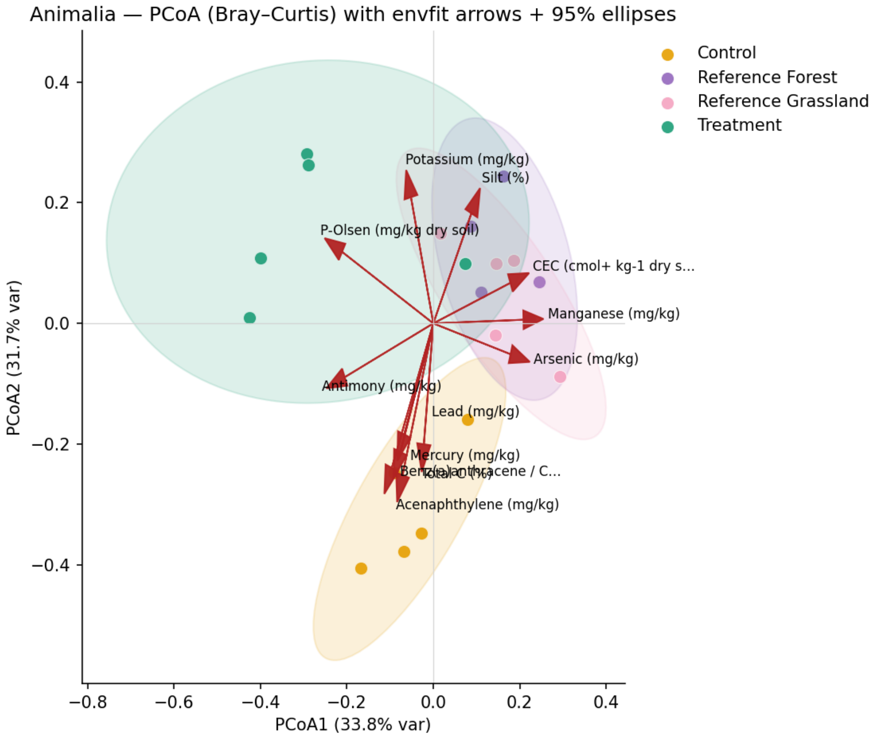
eDNA in ARAGORN - FUNGI





eDNA in ARAGORN – Eukaryotes (Animalia)





ARAGORN eDNA – biodiversity and functionality

Taxonomic abundance tables to be translated to **ecosystem functionality**

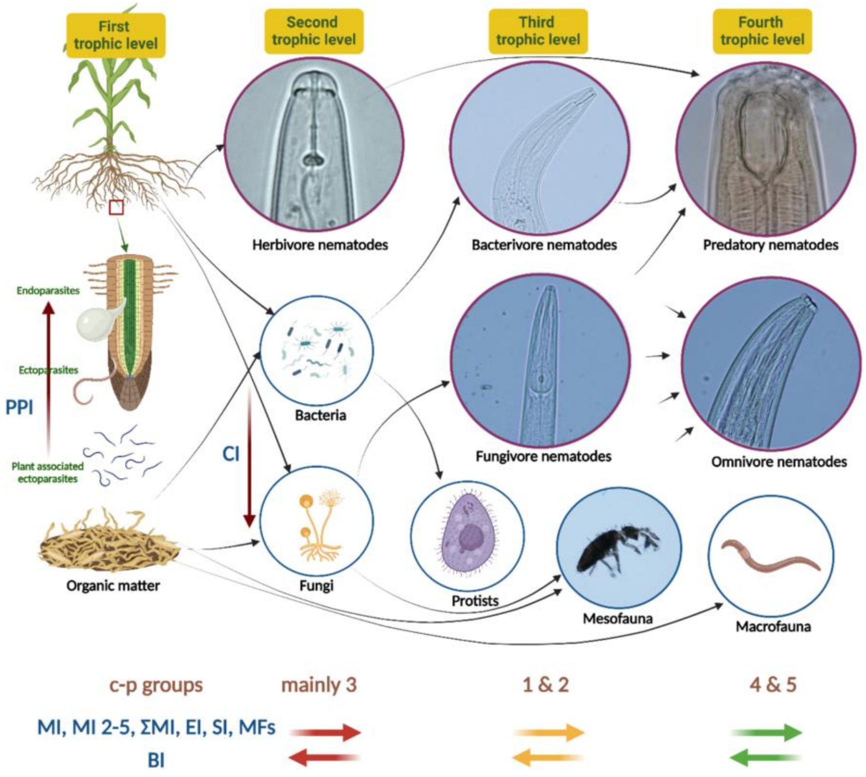
1. **mapping taxa to trait/guild frameworks**
2. **coupling ordination with environmental covariates** and **functional indices/footprints** to translate community composition into **process-level interpretations**.

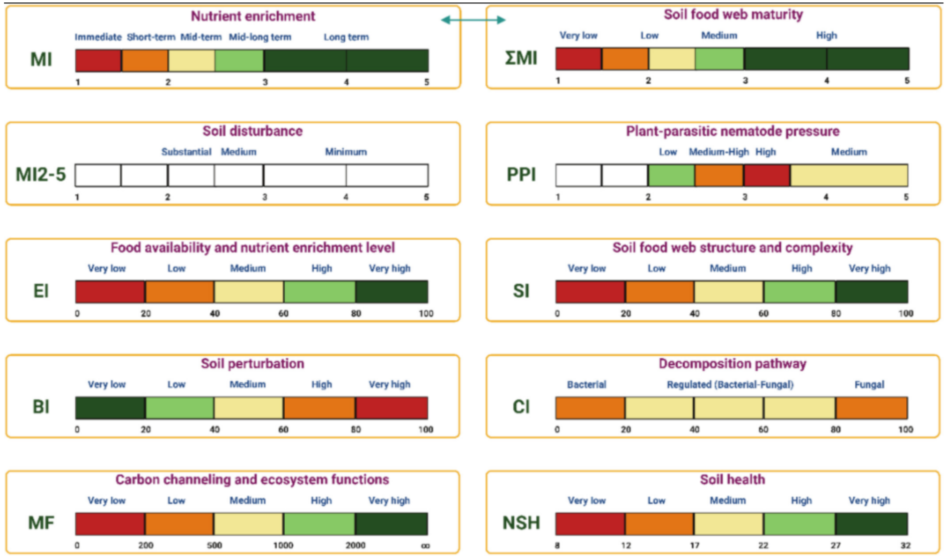
Fungi

Microarthropods

Nematodes

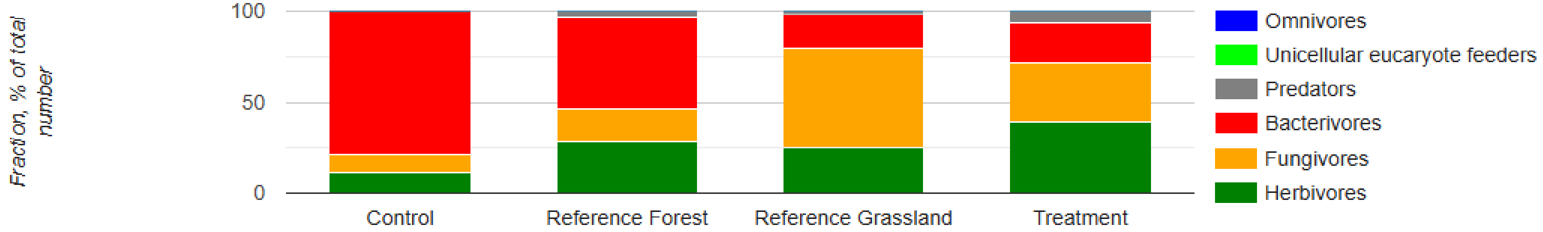
Nematode-based indices



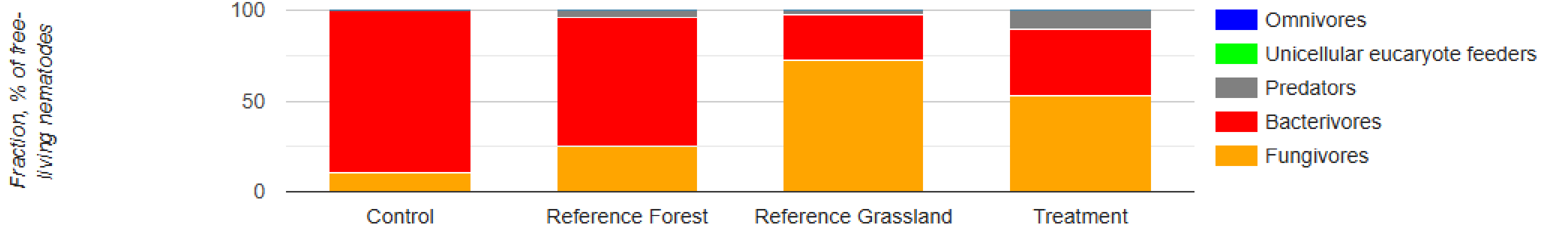


Ghaderi et al, 2025

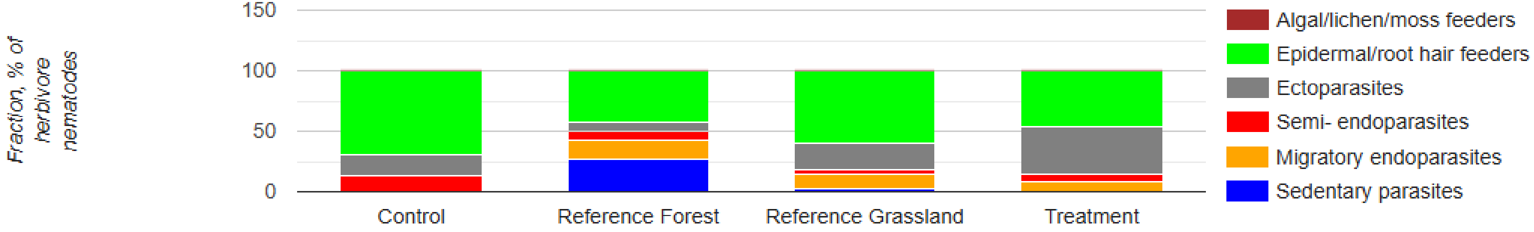
Feeding type composition of nematode assemblage



Feeding type composition of the free-living nematode assemblage

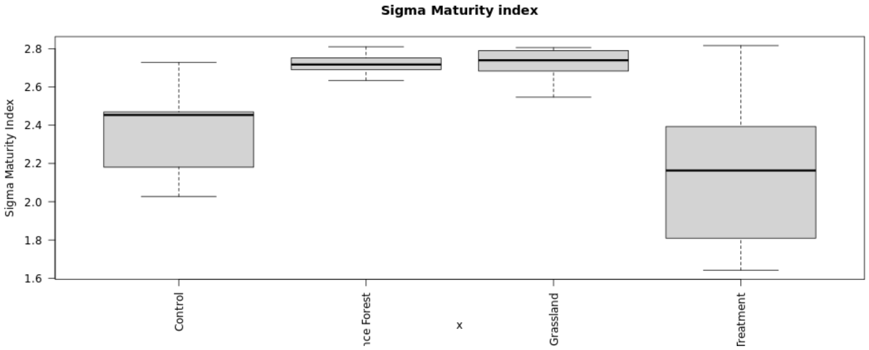


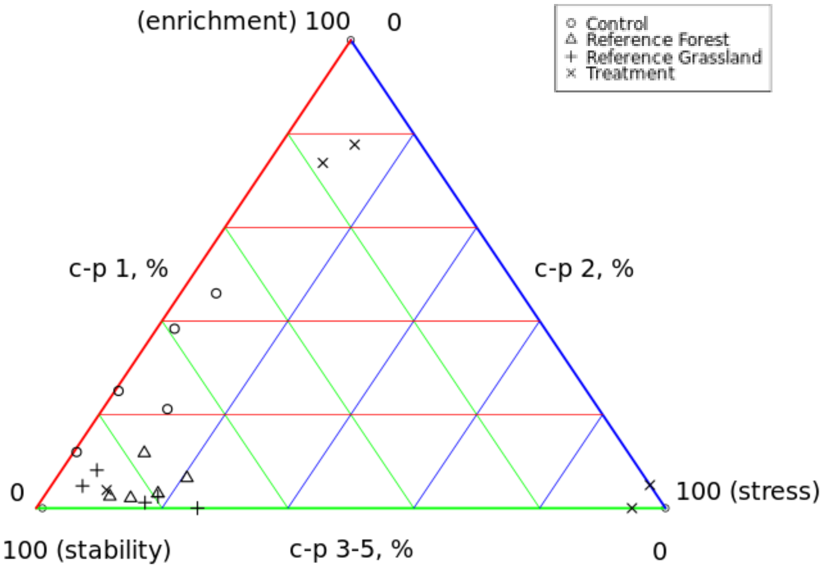
Feeding type composition of the herbivore nematode assemblage



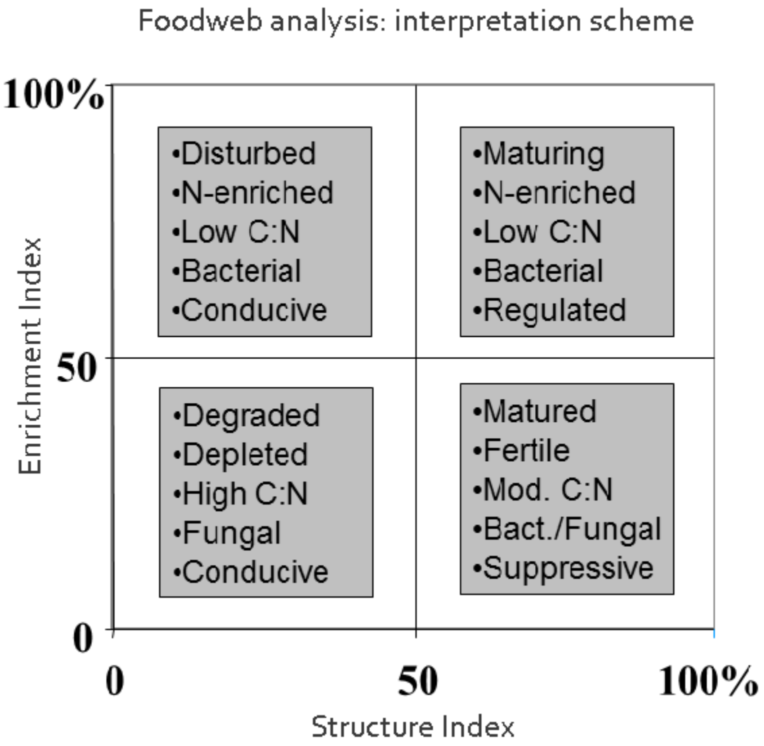
Coloniser-persister structure of the free-living nematode assemblage

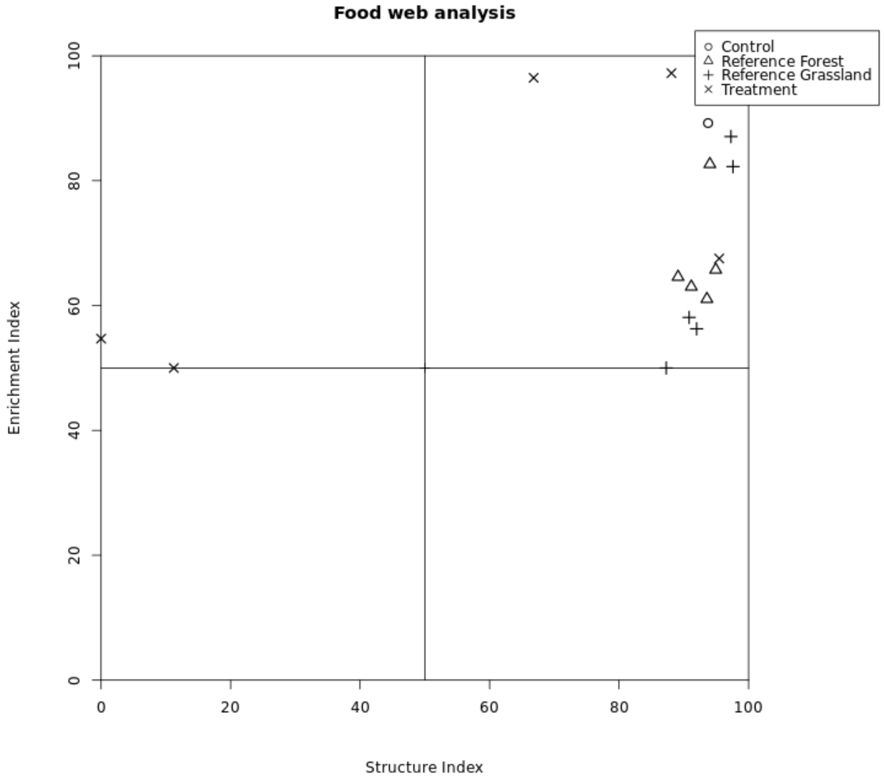
eDNA in ARAGORN – Nematode base indices





eDNA in ARAGORN – Nematode base indices





Can we make a conclusion?

ARAGORN project goal

- Map and monitor **functional recovery trajectories** by tracking key indices over time
- Deliver a framework to plan and assess risks, costs/benefits and resilience of soil remediation and **restoration strategies**

A common goal with a wider outlook

OUTLOOK - Nature Restoration Law – National Recovery and Resilience Plans

Denmark's National Recovery and Resilience Plan

Latest state of play

From Agriculture to Nature

The national green plan aims to:

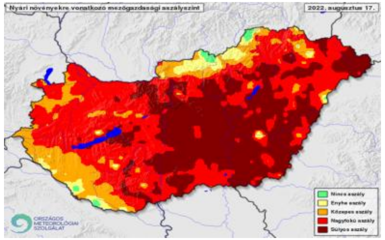
- Plant 250,000 hectares of new forest – an area equivalent in size to Luxembourg
- Restore natural meadows, bogs, and river valleys – 140,000 hectares of lowland farmland will be converted into nature
- Improve the aquatic environment – making fjords, lakes, and coastal waters healthier
- Reduce CO_2 emissions – including by phasing out farming on the most climate-damaging agricultural land

What Does This Mean for You?

The green transition will reshape landscapes across the country. As a result, you may notice:

- More natural areas near you
- Cleaner water in fjords, rivers, and lakes
- Local projects that offer insights into how your municipality is changing

Hungary – no central national activity
Citizens are motivated to build a more resilient environment



THANK YOU FOR YOUR ATTENTION