

Characterising soil microbial diversity for conservation and restoration using large-scale DNA-based methods in New Caledonian ultramafic ecosystems

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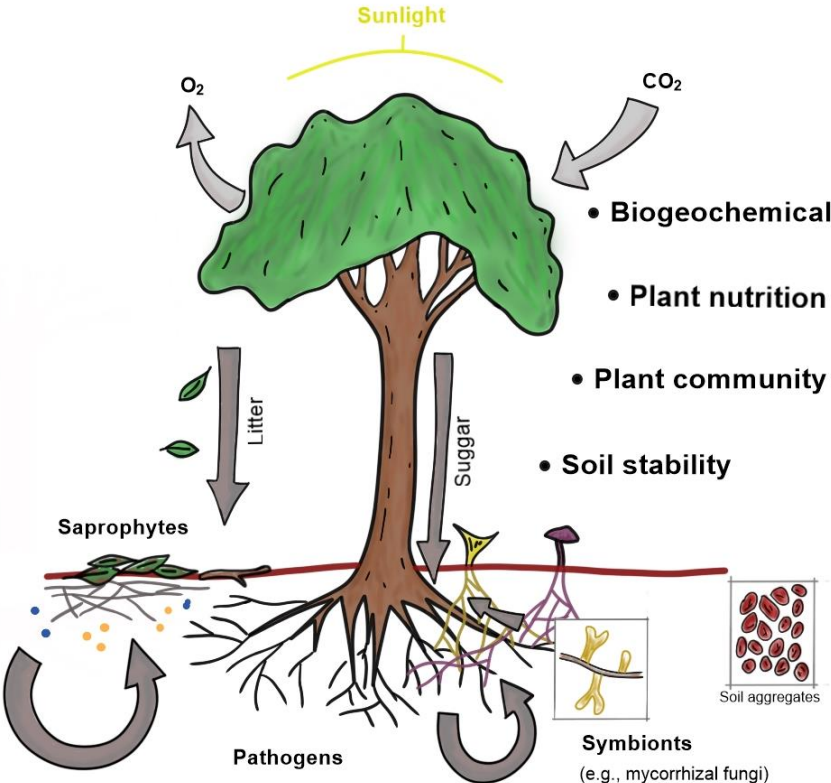


Few words on soil microorganisms



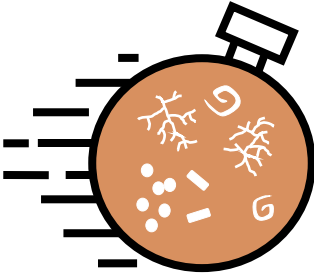
- 10 millions to 1 billion bacteria cells (Godat et al., 2010)
- Thousands of species (e.g., Buée et al., 2009 ; Torsvik et al., 2002)
- 200m of fungal hyphae (Finlay & Söderström 1989 in Leake et al. 2004)

Crucial roles in ecosystems functioning



- Biogeochemical cycles (e.g., carbon cycle)
- Plant nutrition
- Plant community dynamics
- Soil stability

Rapidly respond to environmental changes

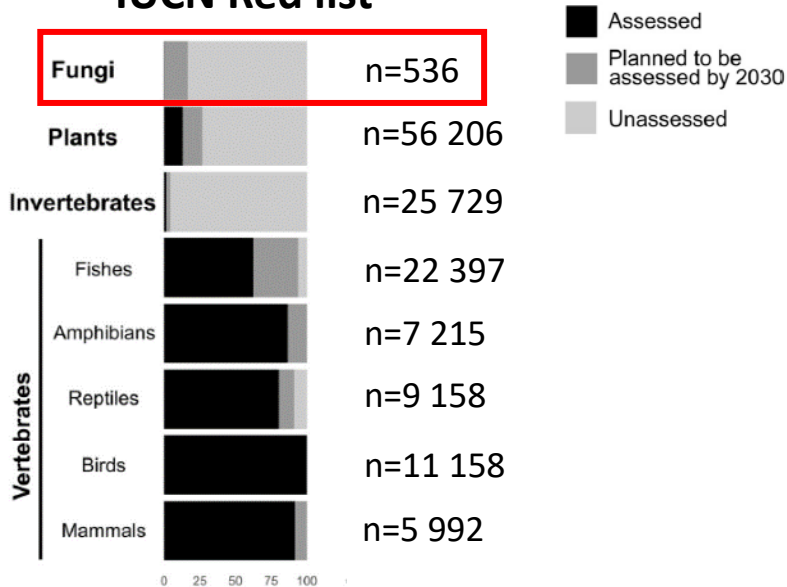


(Nemergut et al. 2007)

Major interests in conservation and ecological restoration

Soil microorganisms in conservation and restoration

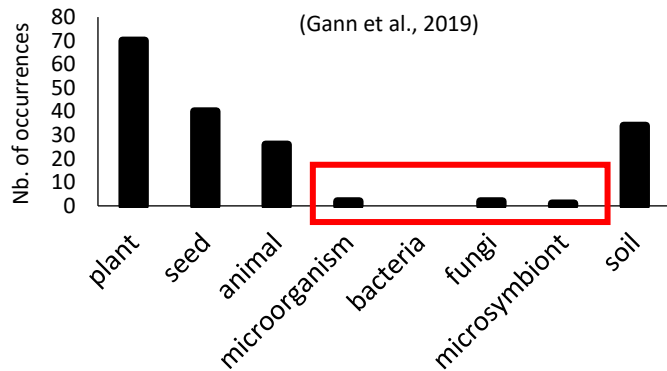
IUCN Red list



(Cazalis et al. 2022)

• Traditionally not considered in biodiversity conservation

International principles and standards for the practice of ecological restoration



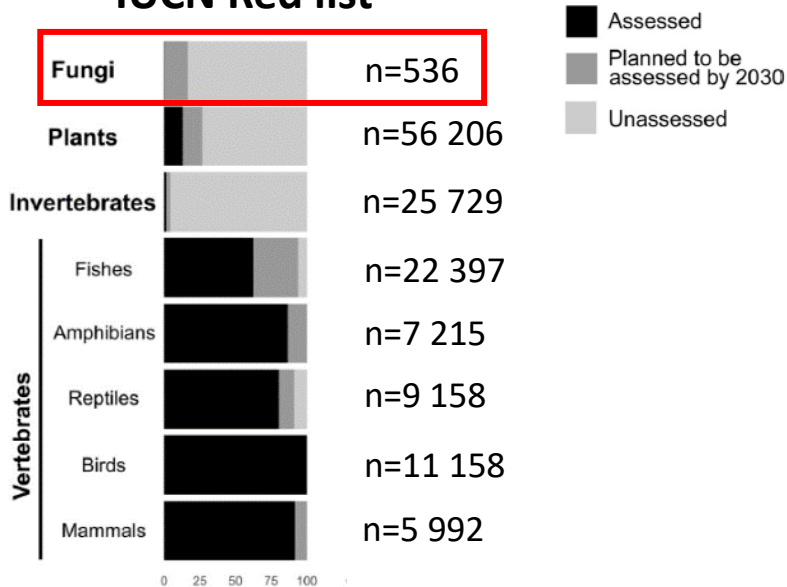
(Gann et al., 2019)

• Not currently considered in the international restoration guidelines

➔ A hidden biodiversity widely neglected!

Soil microorganisms in conservation and restoration

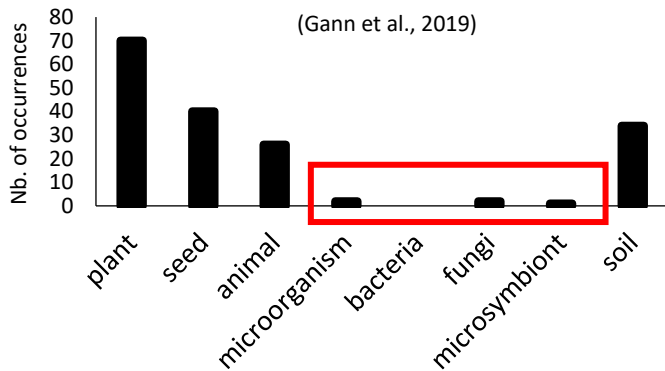
IUCN Red list



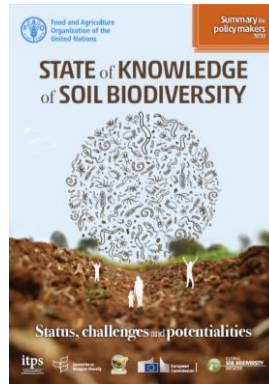
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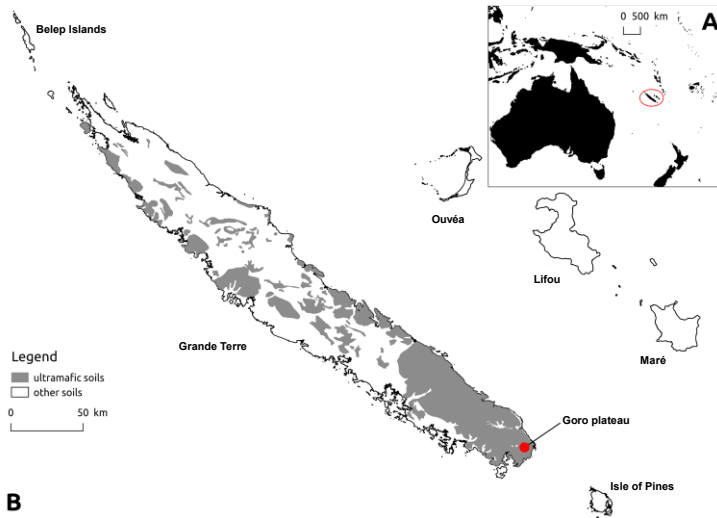
(Gann et al., 2019)



FAO (2021) : for policy makers

- A lack of knowledge!
- Necessity of studying soil biodiversity, especially in southern hemisphere!

Our playground: New Caledonia



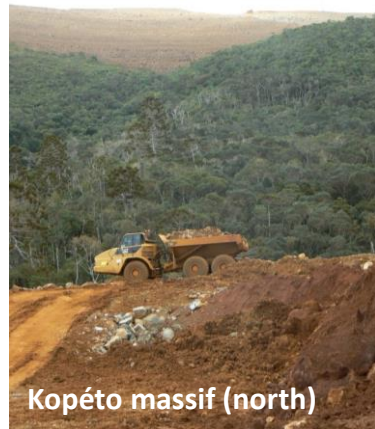
Ultramafic soils:

- Cover ~1/3 of the territory
- High concentrations of heavy metals: Ni, Co, Cr and Mg
- Divers vegetation types and a remarkable plant diversity

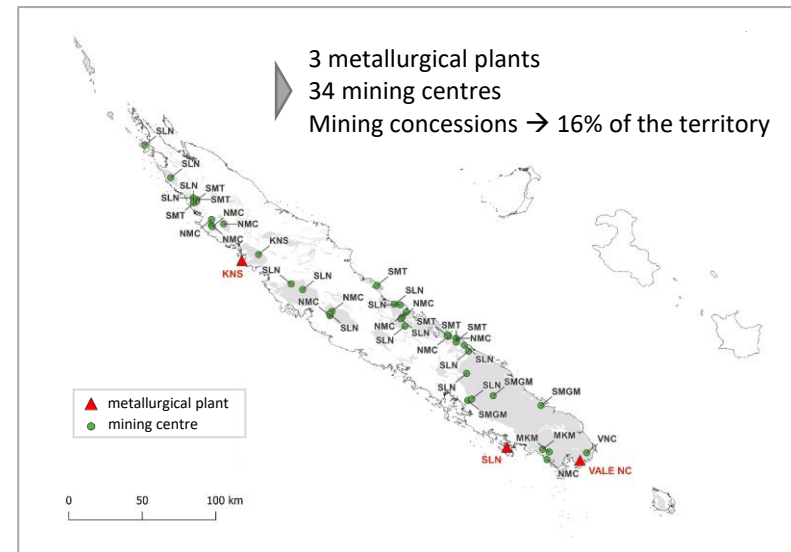
Intensive mining activities



Goro plant (south)



Kopéto massif (north)

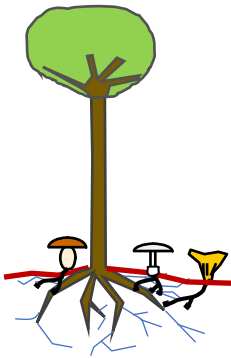


(Data DTSI ; downloaded November 23, 2021)

Large impact on New Caledonian biodiversity

Our main objectives

- (i) Characterize soil microbial biodiversity (in terms of diversity, composition and structure);
- (ii) Identify the main factors (biotic and abiotic) influencing soil microbial communities;
- (iii) Infer their potential use in conservation and ecological restoration (as biological indicators) .

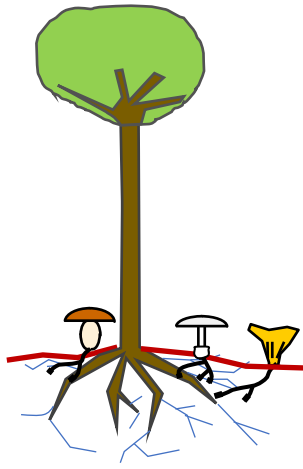


Ectomycorrhizal fungal communities



Global fungal and bacterial communities in soil

Ectomycorrhizal (ECM) fungal communities



n = 2369 (1 year survey)

**Fruit bodies
(above-ground community)**



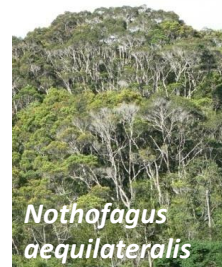
**Ectomycorrhizae
(below-ground community)**

n = 587



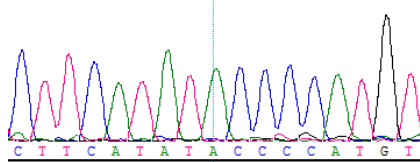
Monodominant rainforests

Mixed rainforests



Molecular approach : first sequencing generation

(Sanger sequencing)



ITS (Internal transcribed spacer)

- Fungi (fruit bodies and ectomycorrhizae)
- Host plant (ectomycorrhizae)

***N. aequilateralis* & *A. gummiferum* (chêne gomme)**

- Ectomycorrhizal trees
- Restricted to ultramafic substrates
- Distinct types of monodominance (**Demenois et al. 2017a**)
- Forest pioneer species leading to mixed rainforests
=> interest in ecological restoration

Ectomycorrhizal (ECM) fungal communities

→ Diversity:

- ❑ In total, 311 molecular species (OTUs)
- ❑ An hypothetical endemism rate of 95 % !



A high ECM fungal diversity of
New Caledonian rainforests

Conservation issues

Ectomycorrhizal (ECM) fungal communities

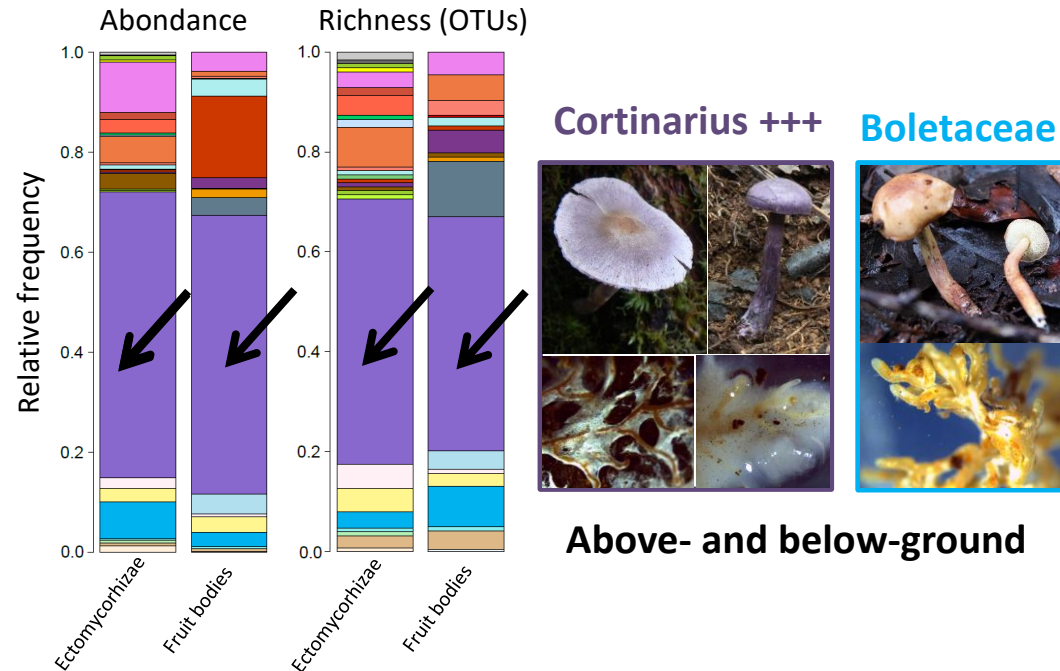
→ Diversity:

- ❑ In total, 311 molecular species (OTUs)
- ❑ An hypothetical endemism rate of 95 % !

A high ECM fungal diversity of
New Caledonian rainforests

Conservation issues

→ Composition:



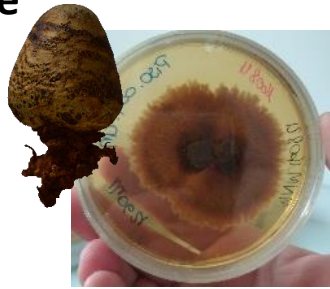
Above- and below-ground

Cortinarius → major roles in
ultramafic ecosystems functioning ?

Cortinarius + Boletaceae → groups
of interest for plant inoculations (for
restoration)?

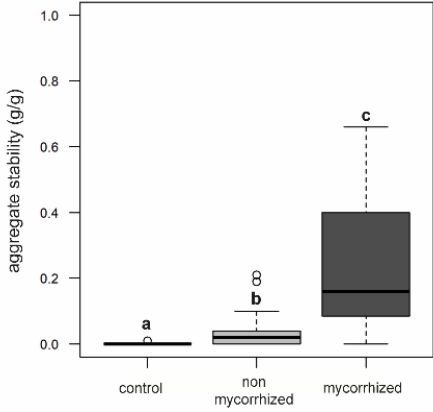
ECM fungi: their use in greenhouse experiments for ecological restoration

Boletaceae

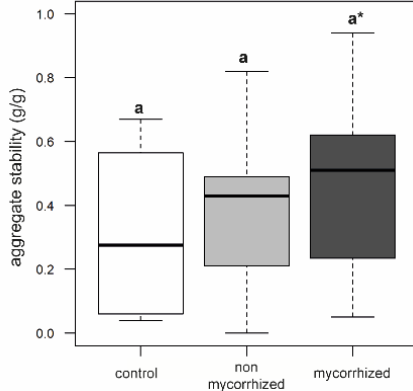


Pisolithus microcarpus

Tristaniopsis glauca



Arillastrum gummiferum



Increase of aggregate stability & plant growth

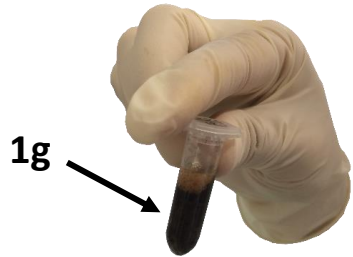
(Demenois et al., 2017b)

Implications in erosion mitigation of UM soils and ecological restoration practices

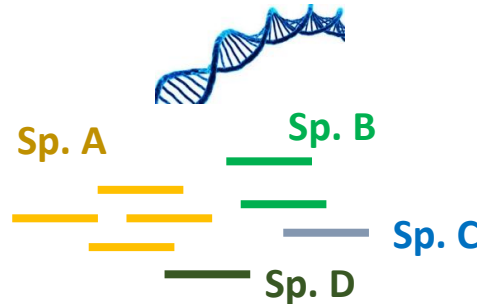
eDNA metabarcoding of soil microbial communities



Global fungal and bacterial communities in soil



1g



Bioinformatics analyses

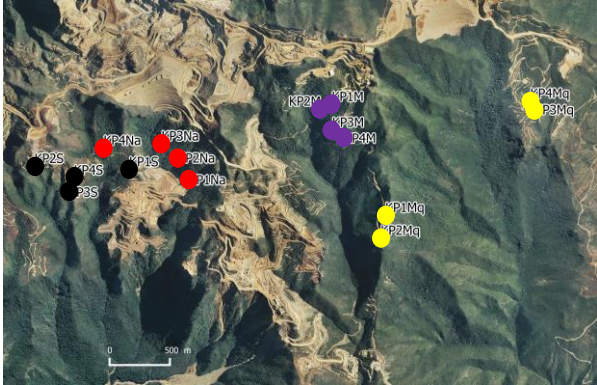
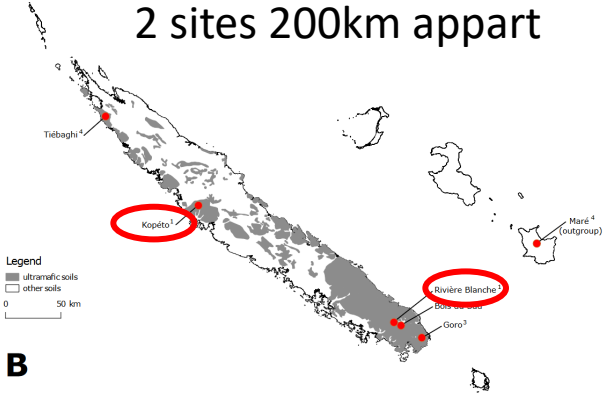
→ soil communities

DNA extraction from soil samples
= environmental DNA (eDNA)

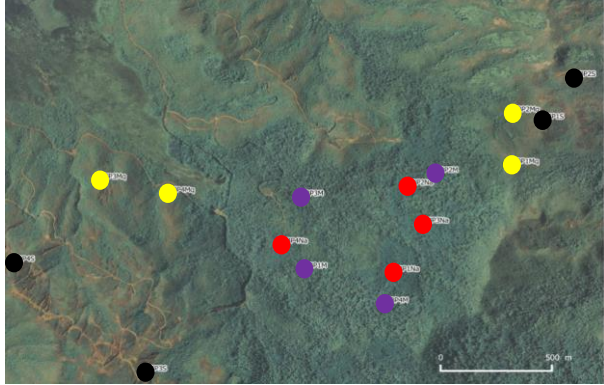
Next generation sequencing
(massive and parallel sequencing)

= metabarcoding of eDNA

eDNA metabarcoding and soil microbial communities: conservation implications



Kopéto sites (north)



Rivière Blanche site (south)

Chronosequence



Sedge maquis



Tristaniopsis spp. maquis



N. aequilateralis rainforest

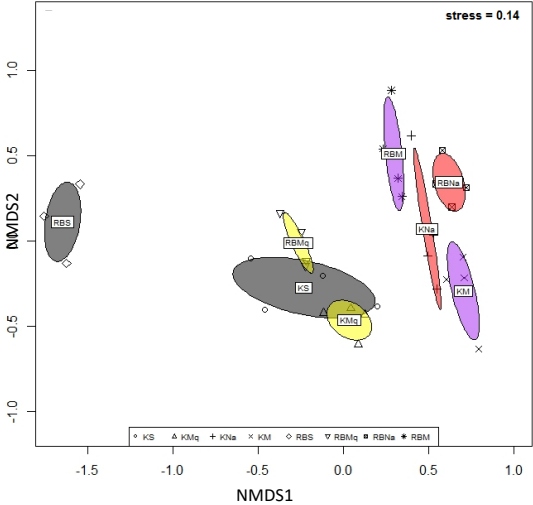


Mixed rainforest

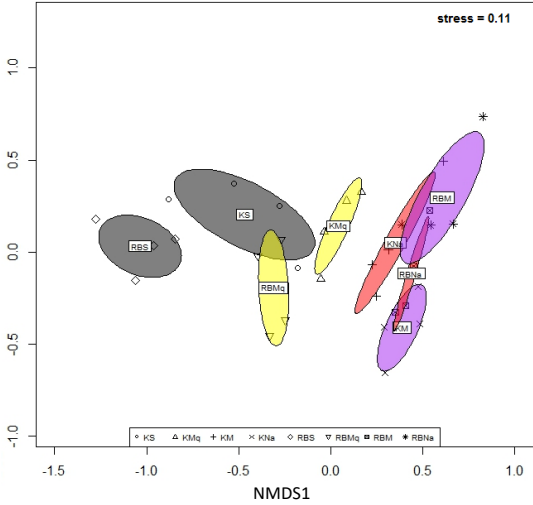
(Gourmelon et al. 2016)

eDNA metabarcoding and soil microbial communities: conservation implications

Fungi



Bacteria



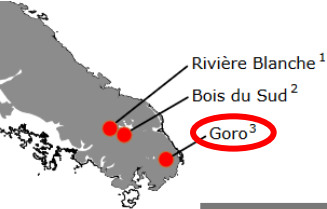
A plant formation effect

A site effect
→ each site display its own microbial community

(Gourmelon et al. 2016)

eDNA metabarcoding and soil microbial communities: restoration monitoring

Bioindic CNRT project



Identify biological indicators of restoration progress and success

Reference chronosequence



Open low maquis



Closed low maquis



Gymnostoma deplancheanum-dominated maquis



Preforest maquis



Old Nursery site 1



Old Nursery site 2



Old Nursery site 3



Kuebini site

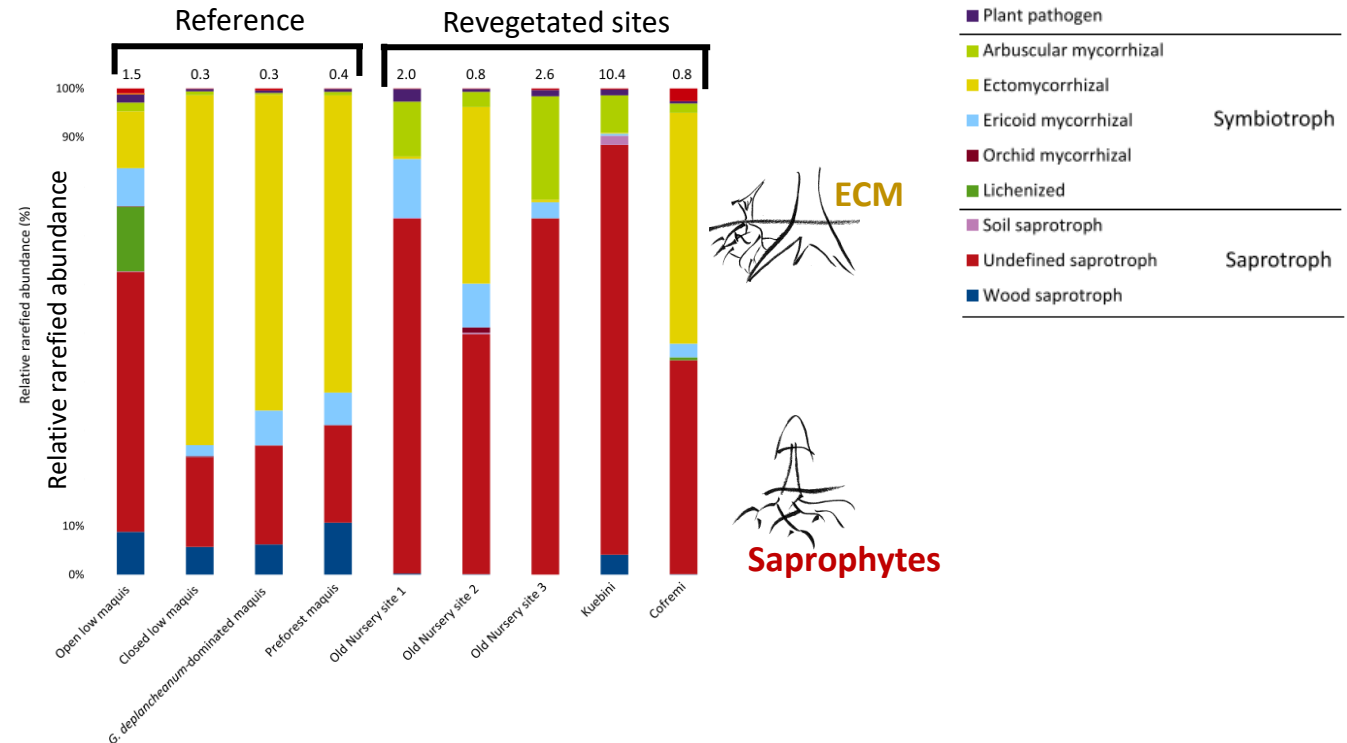


Cofremi site



eDNA metabarcoding and soil microbial communities: restoration monitoring

Fungi - Functional groups

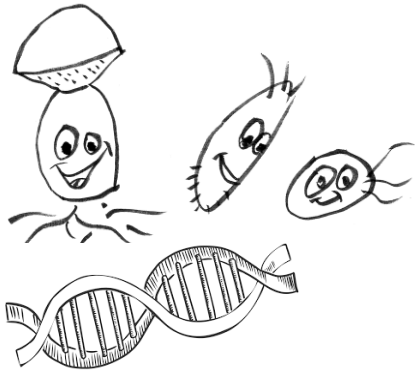


- Reference ecosystems → changes in functional groups : open vs. closed.
- Revegetated sites → two sites similar to the closed native vegetation → in a good trajectory of recovery !

Fungal soil communities (bacteria as well)

- Good biological indicators of soil recovery
- 3 metrics proposed for restoration monitoring

Conclusion



Major interest of considering soil microbial communities and molecular approaches (metabarcoding of eDNA) in restoration and conservation

Perspectives

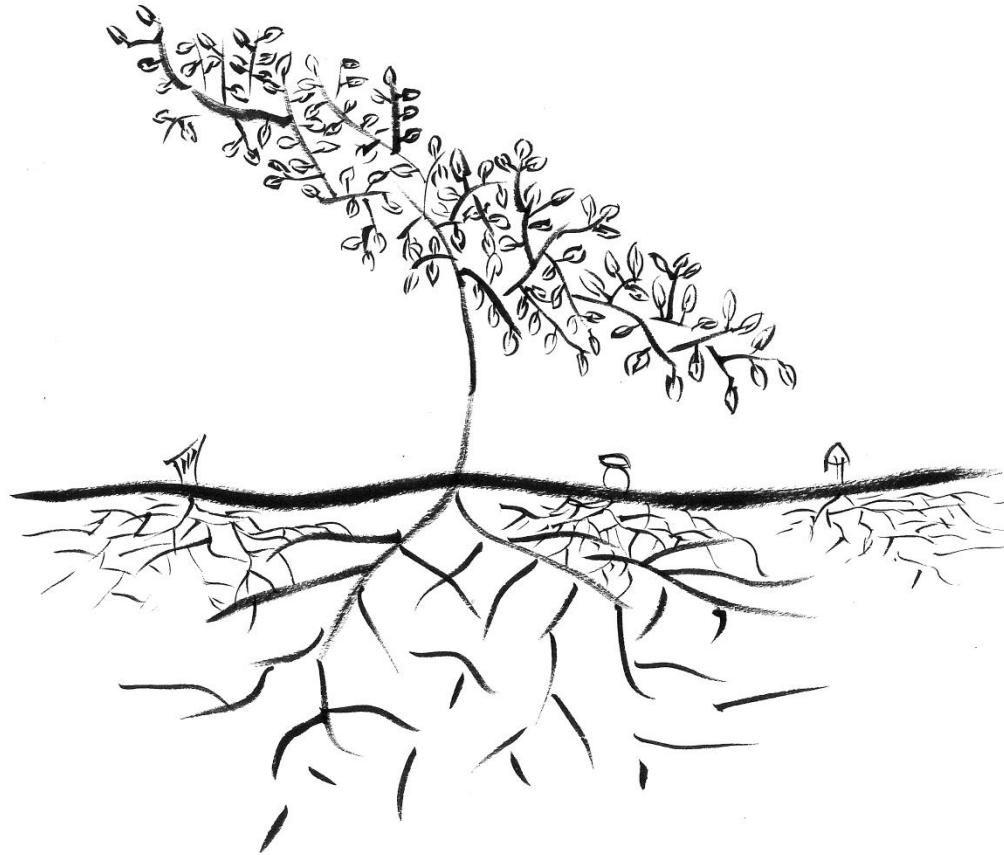


- Species description and IUCN Red List assessment
- Conservation unit definition
- Suitable symbiont selection and greenhouse plant production
- Soil restoration progress and success assessment (ongoing validation on another restored system – topsoils, 7 years survey at Tiébaghi site)

Acknowledgments



THANK YOU FOR YOUR ATTENTION



MONASH
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