



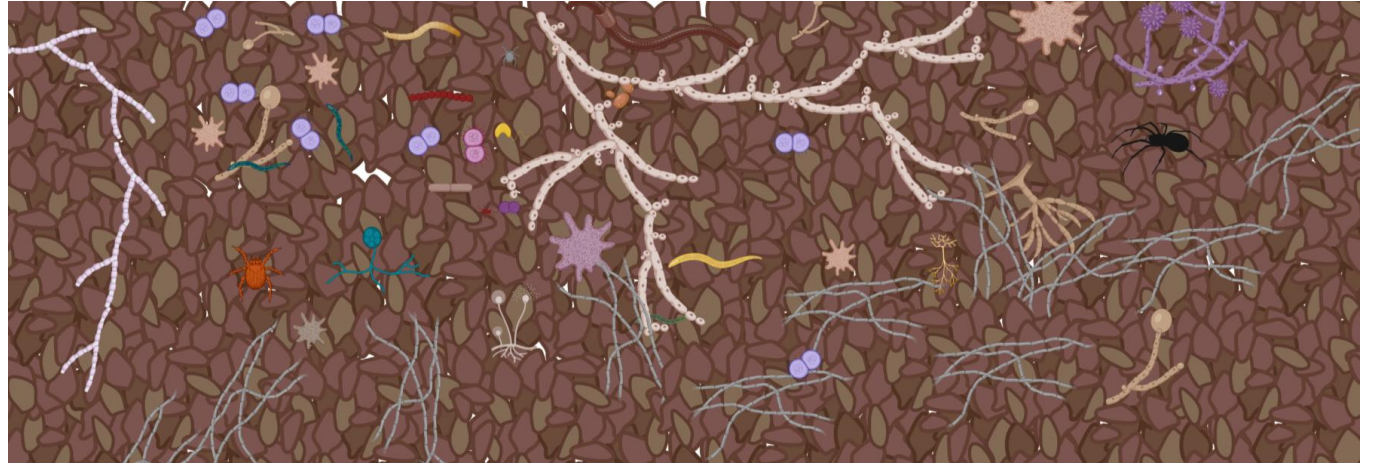
# Soil microbiomes and soil 'health'

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Leiden University, CML



Universiteit  
Leiden

# The hidden biodiversity in the soils



Kilometers of hyphae

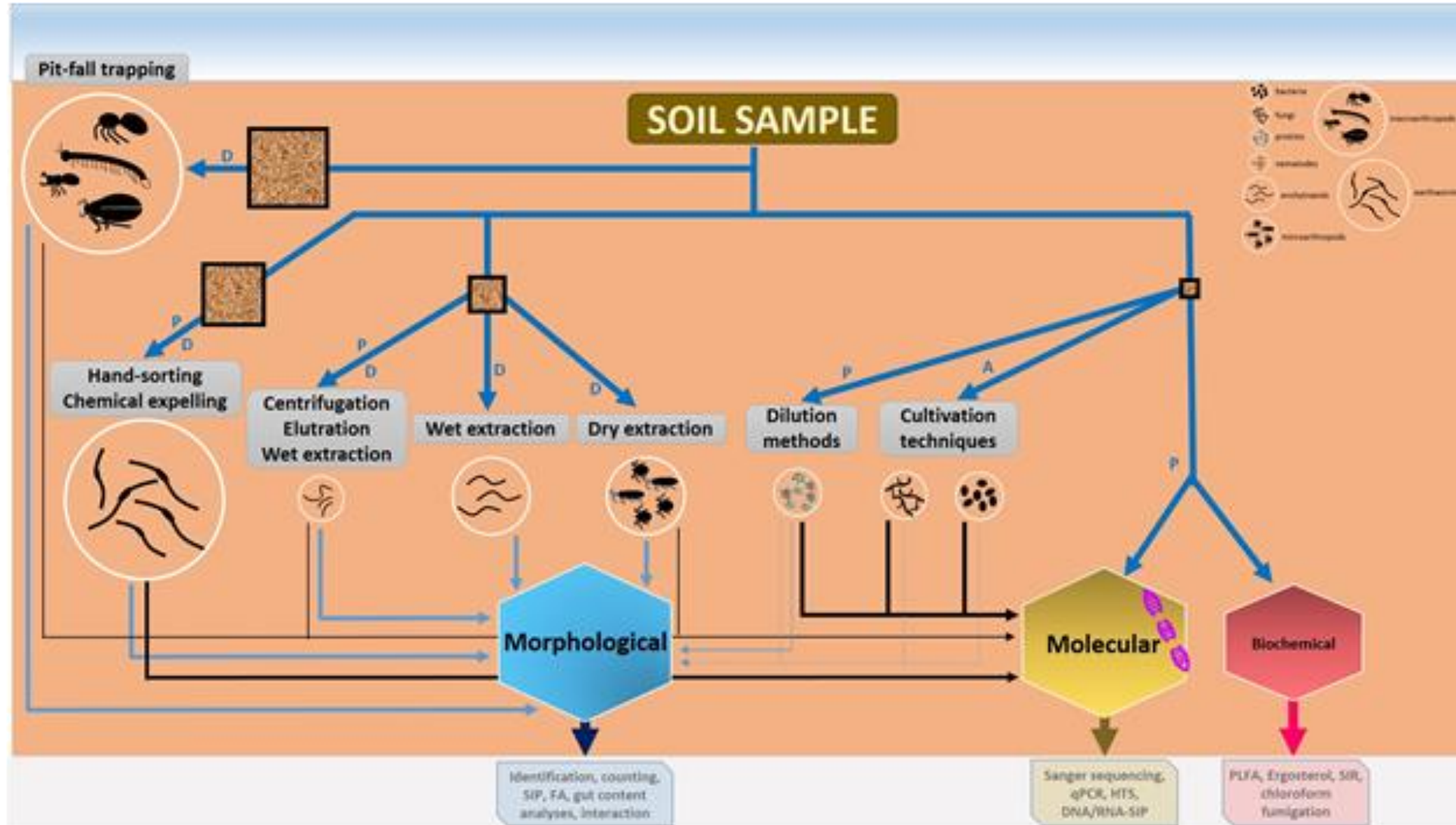
Thousands of (invisible) species

Hundreds of interactions

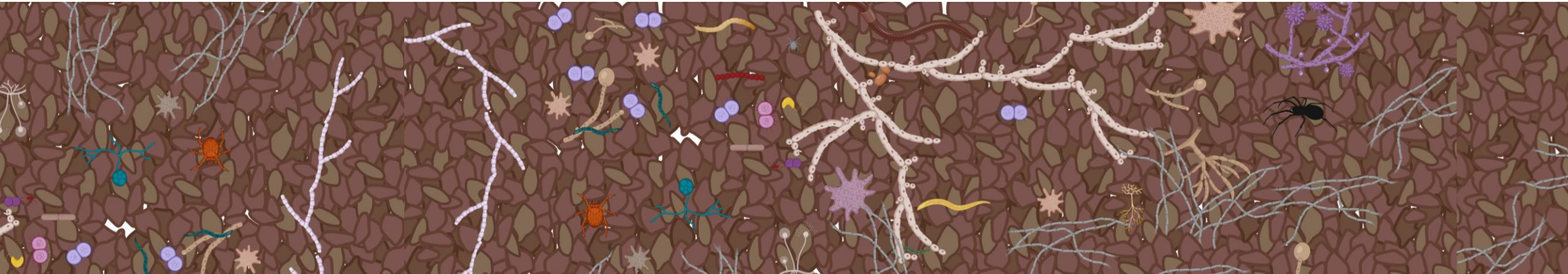
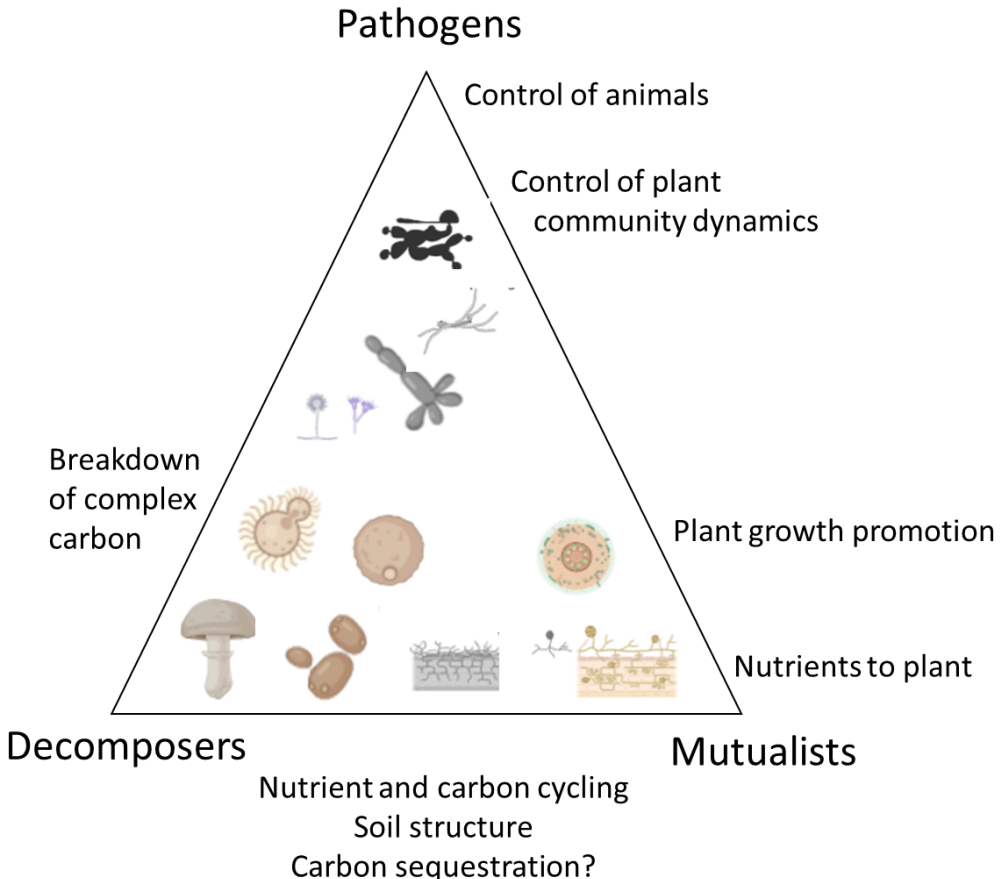
# The hidden biodiversity in the soils



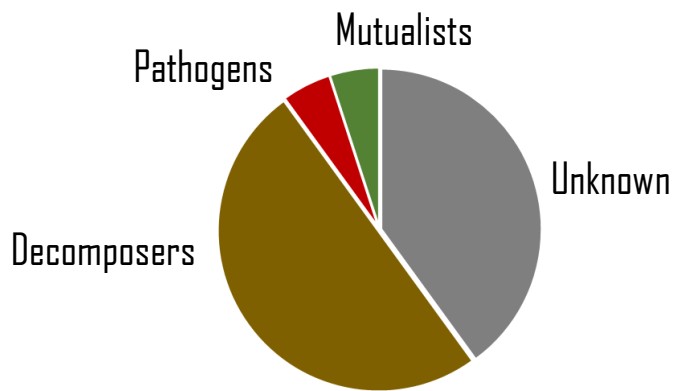
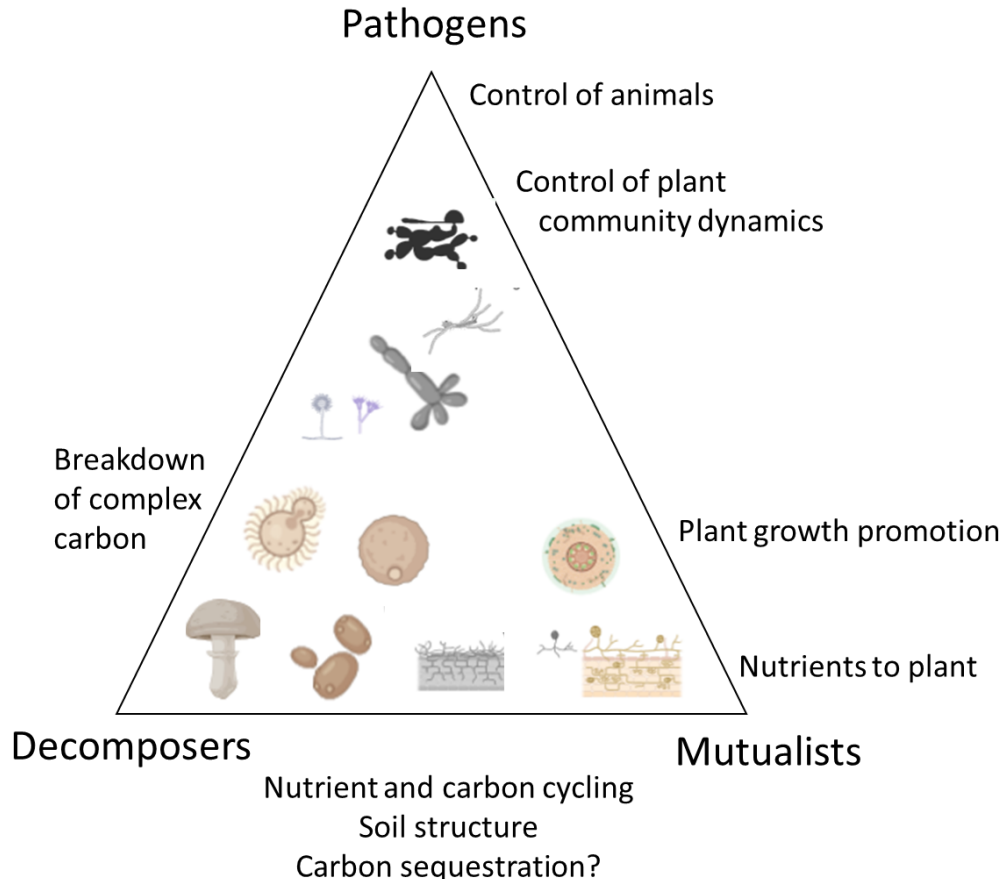
# How to study soil diversity



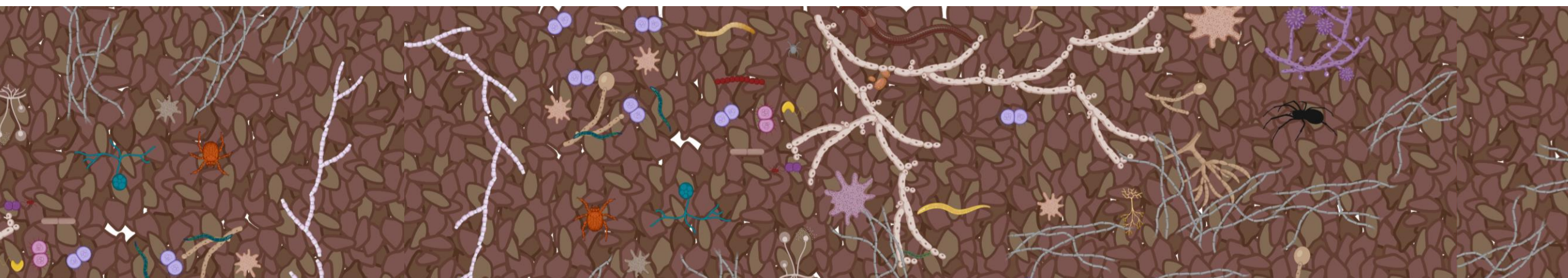
# Functional diversity

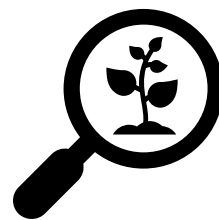
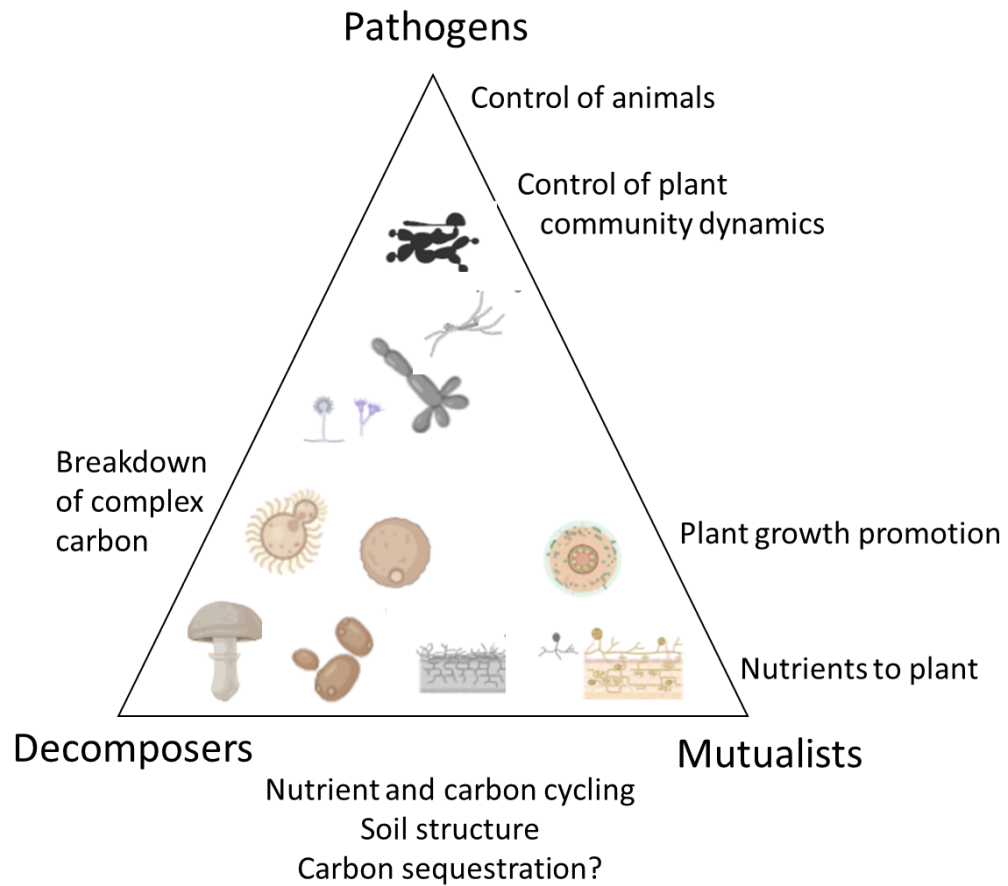


# Functional diversity



Data from Hannula et al. 2019 Nature communications;  
Heinen, Hannula et al. 2020 Ecology Letters





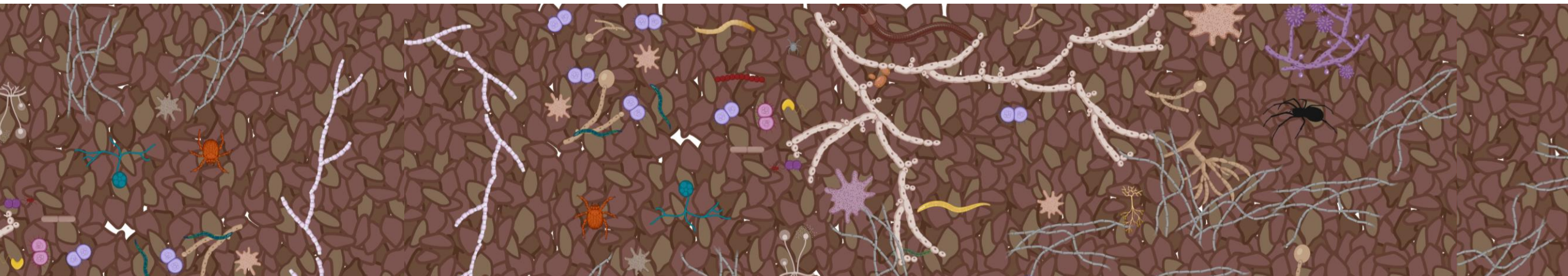
## Plant growth promotion and pathogens

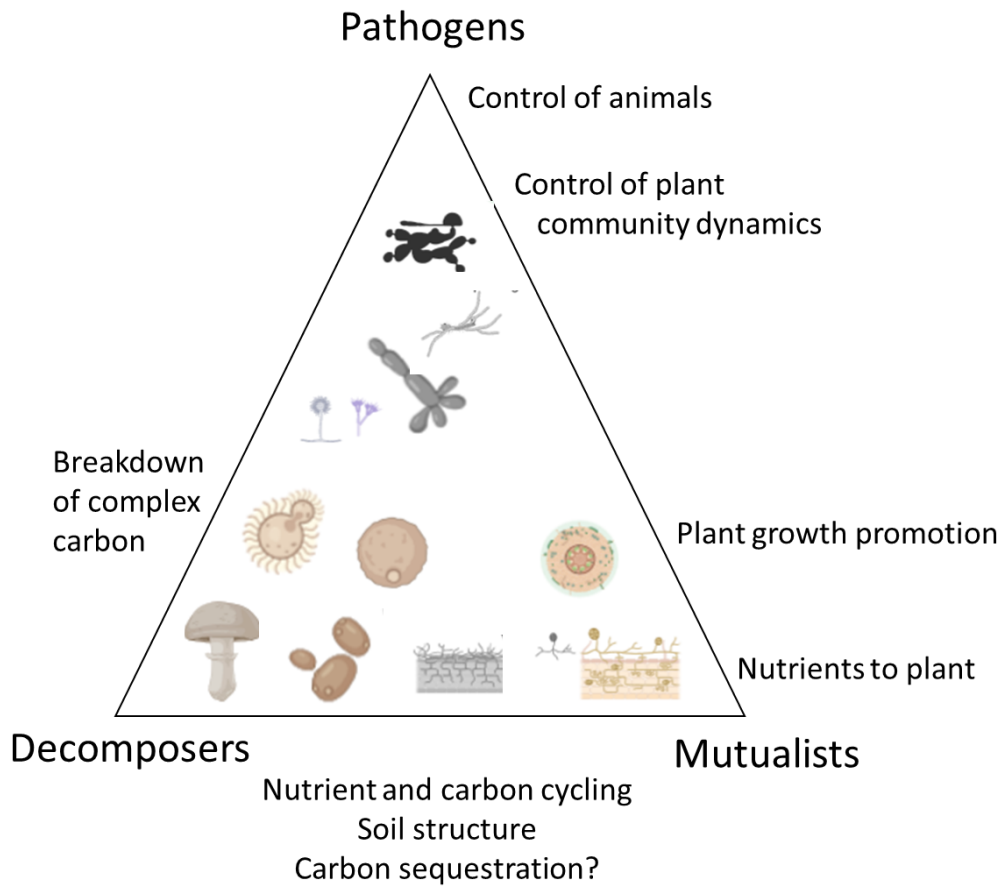
Morrien, Hannula et al. 2017 Nature communications;  
Hannula et al. 2017 ISMEj  
Hannula et al. 2020 Environmental Microbiology;  
Heinen, Hannula et al. 2020 Ecology Letters



## Food for animals (and pathogens)

Hannula et al. 2019 Nature Communications;  
Hannula et al. 2020 Fungal Ecology  
Gomes et al. 2021 Animal microbiome

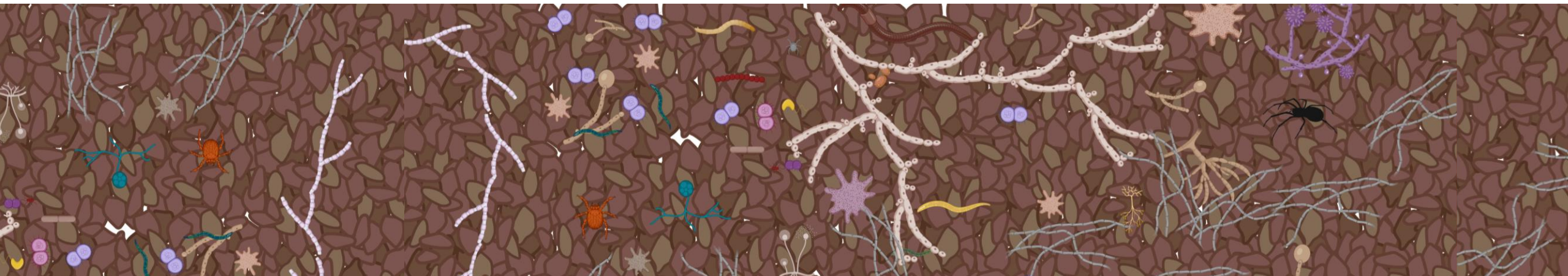




Decomposition and nutrient cycling  
 Clocchiatti, Hannula et al. 2020 Applied soil ecology  
 Veen et al. 2022 Functional Ecology



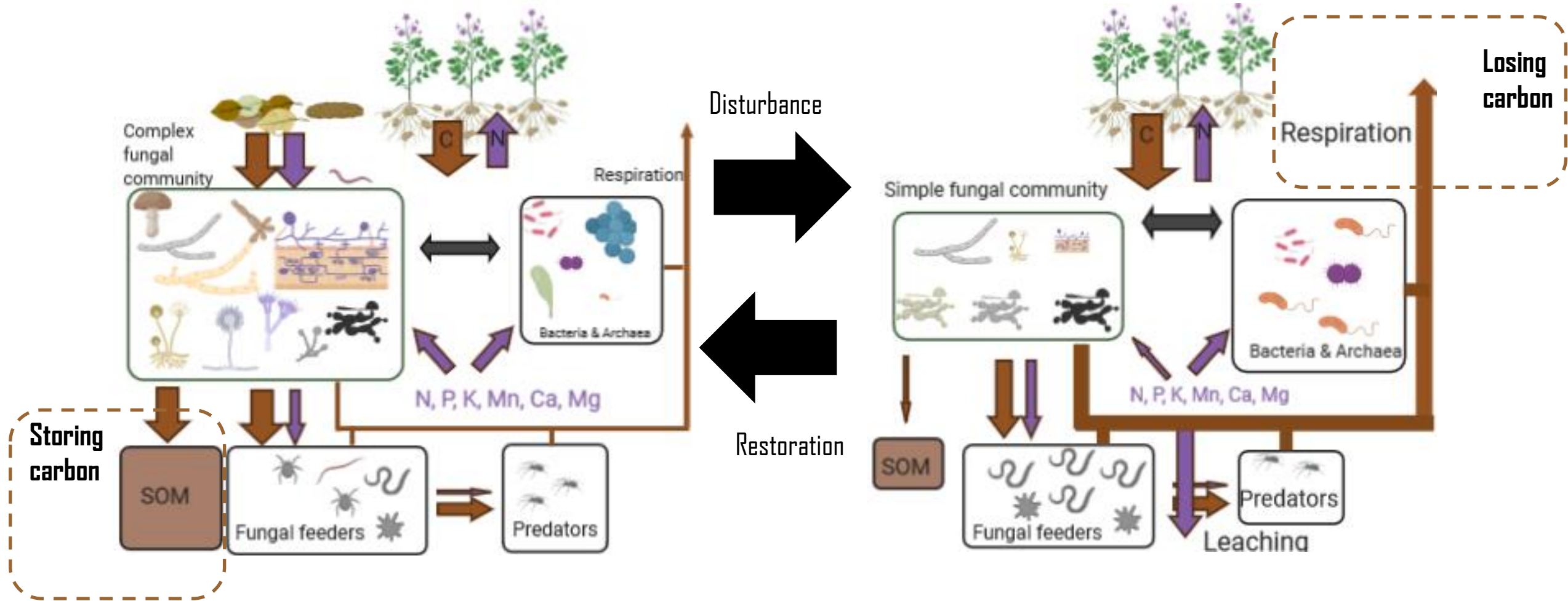
Soil structure





## Well functioning community

## Dysbiosis



Hannula & Morriën 2022, Geoderma

# Essentially how to transform the system...



# And restore its functions



Plant growth promotion and pathogens



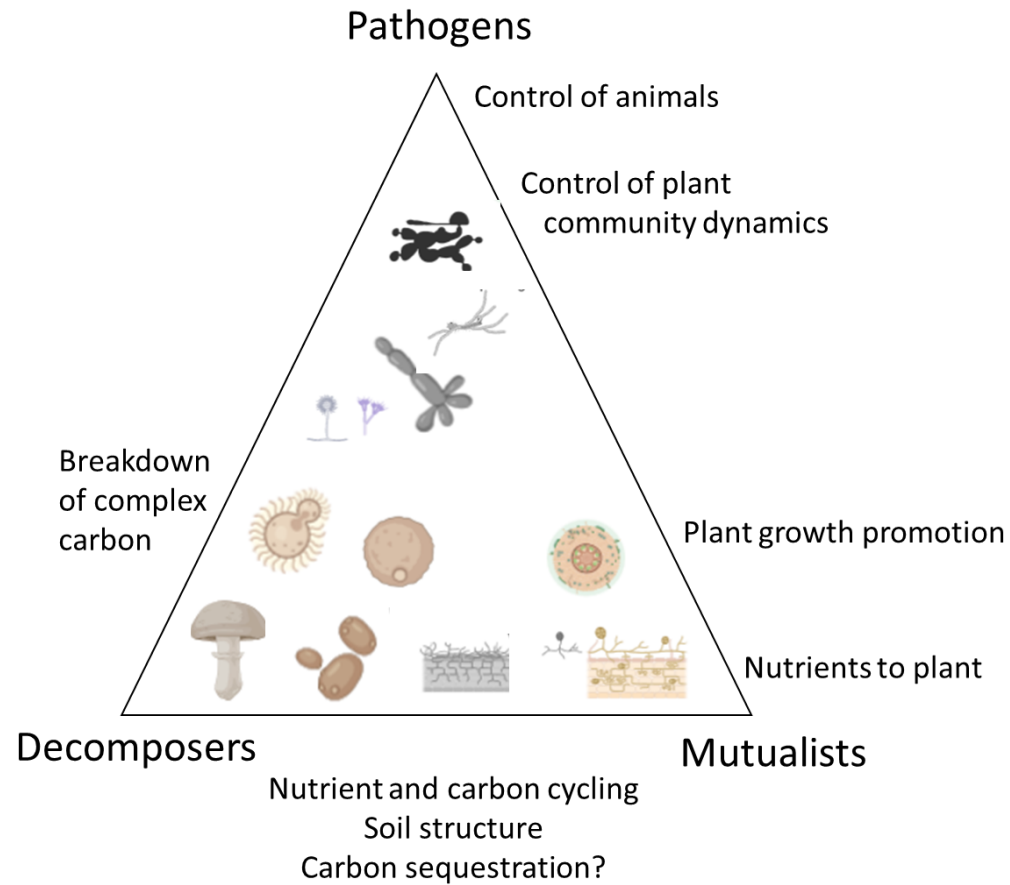
Food for animals



Decomposition and nutrient cycling



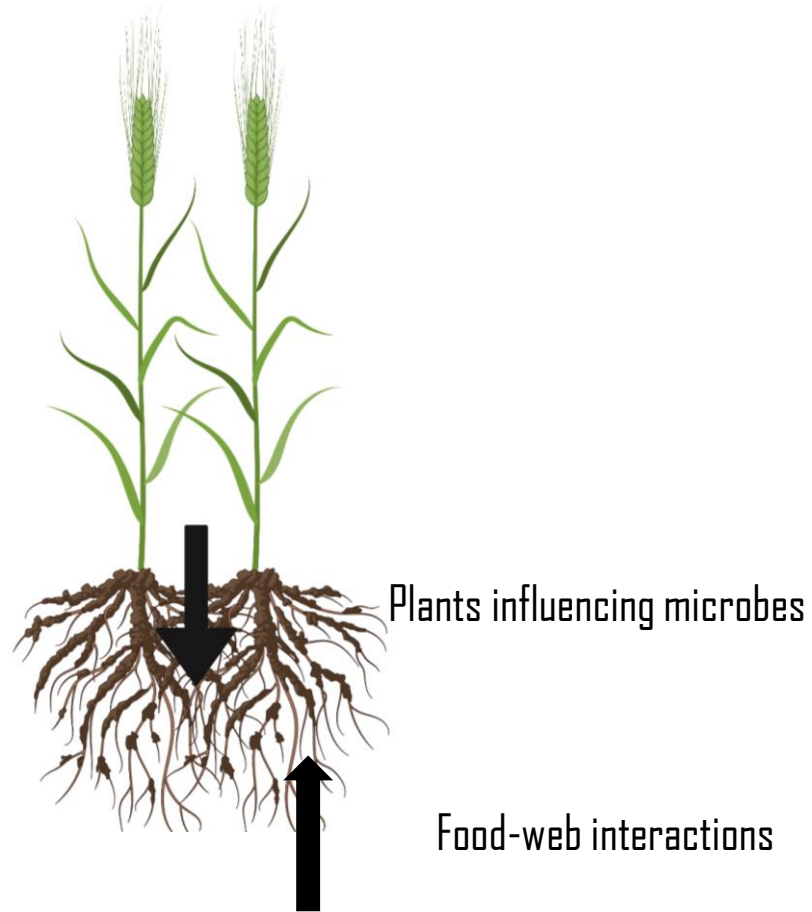
Soil structure



# Many options for restoration

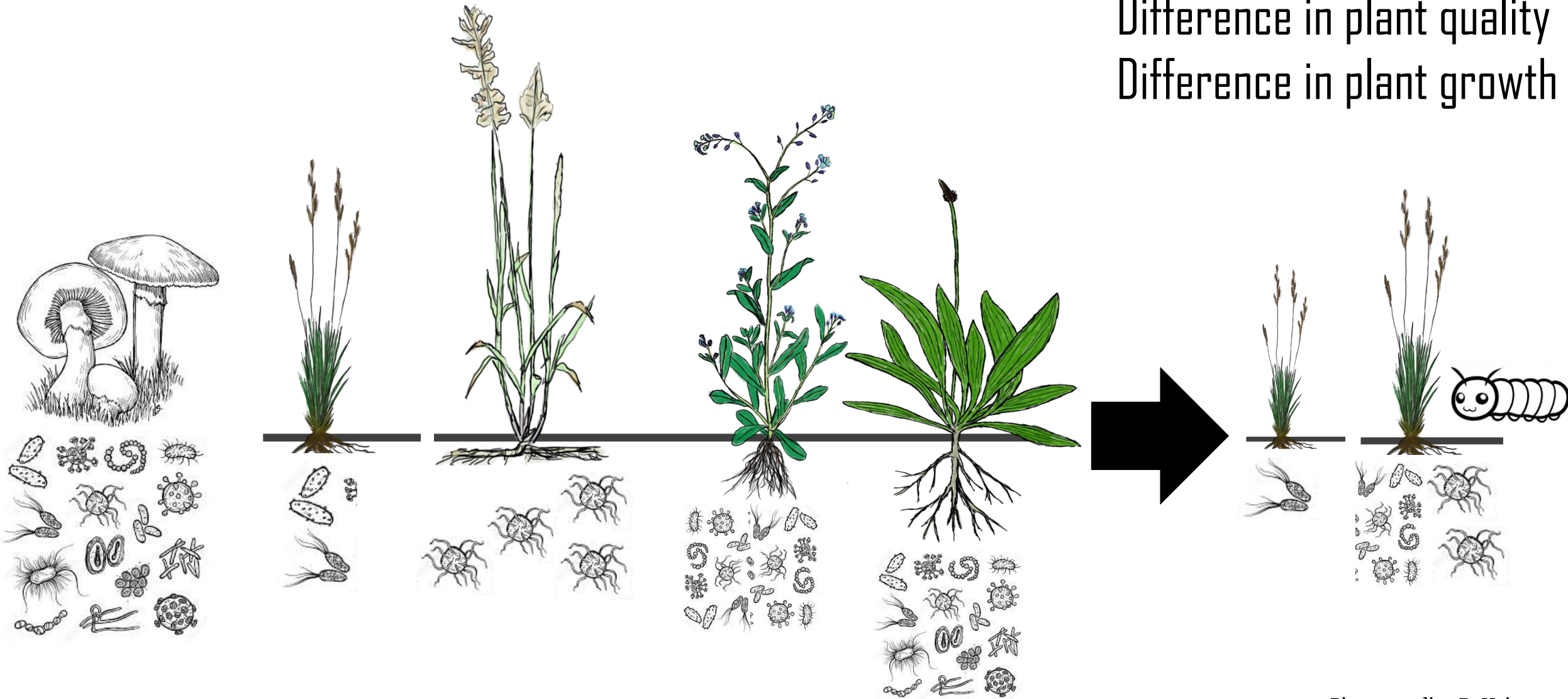
1. Restoration with interactions
2. Restoration with resource manipulation
3. Restoration with management
4. Restoration with replacing organisms

# 1. Restoration with interactions

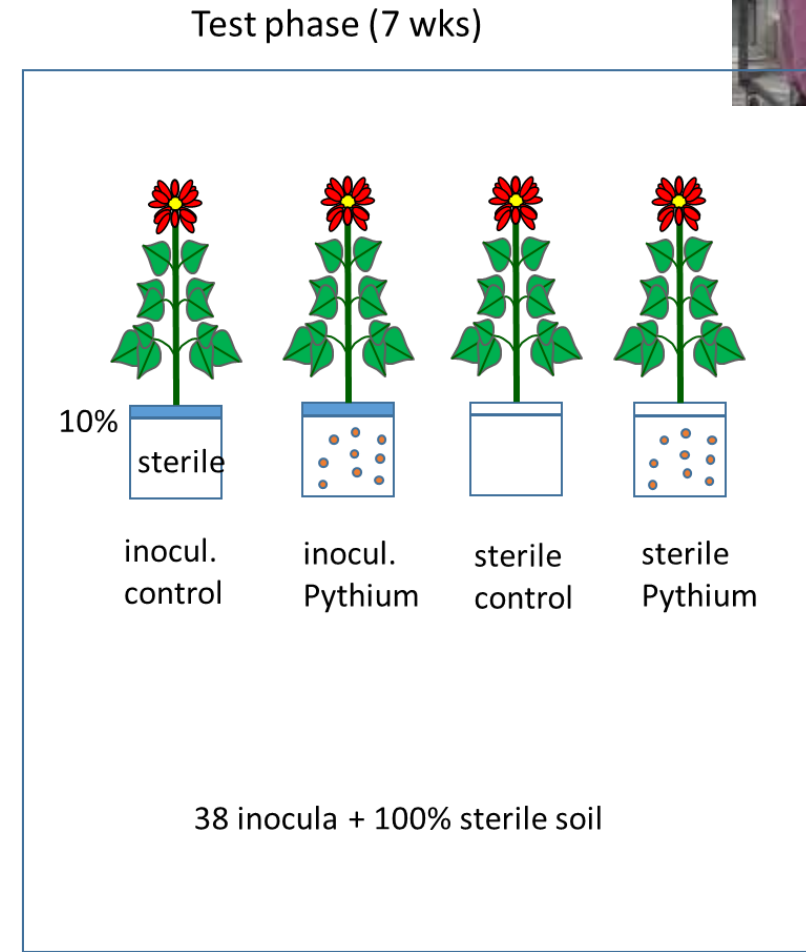
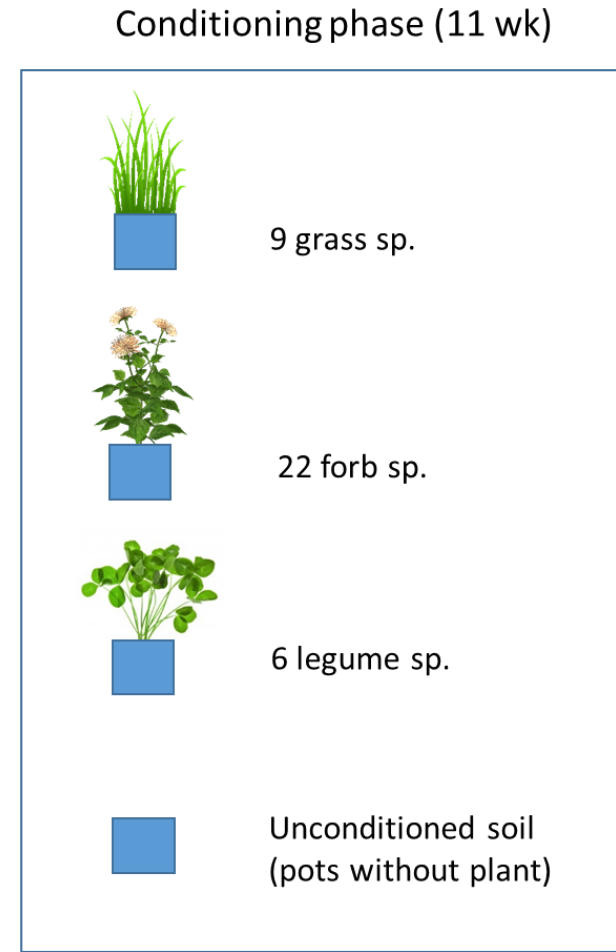
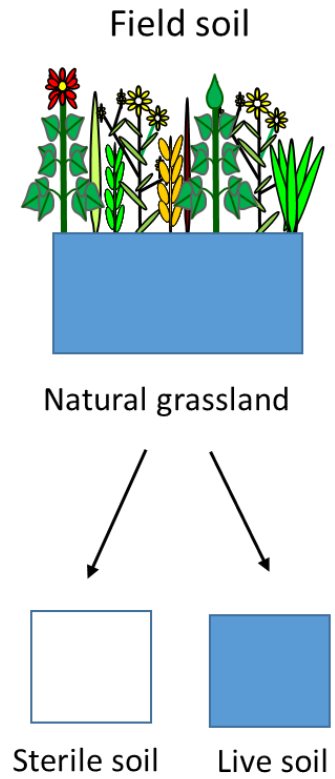


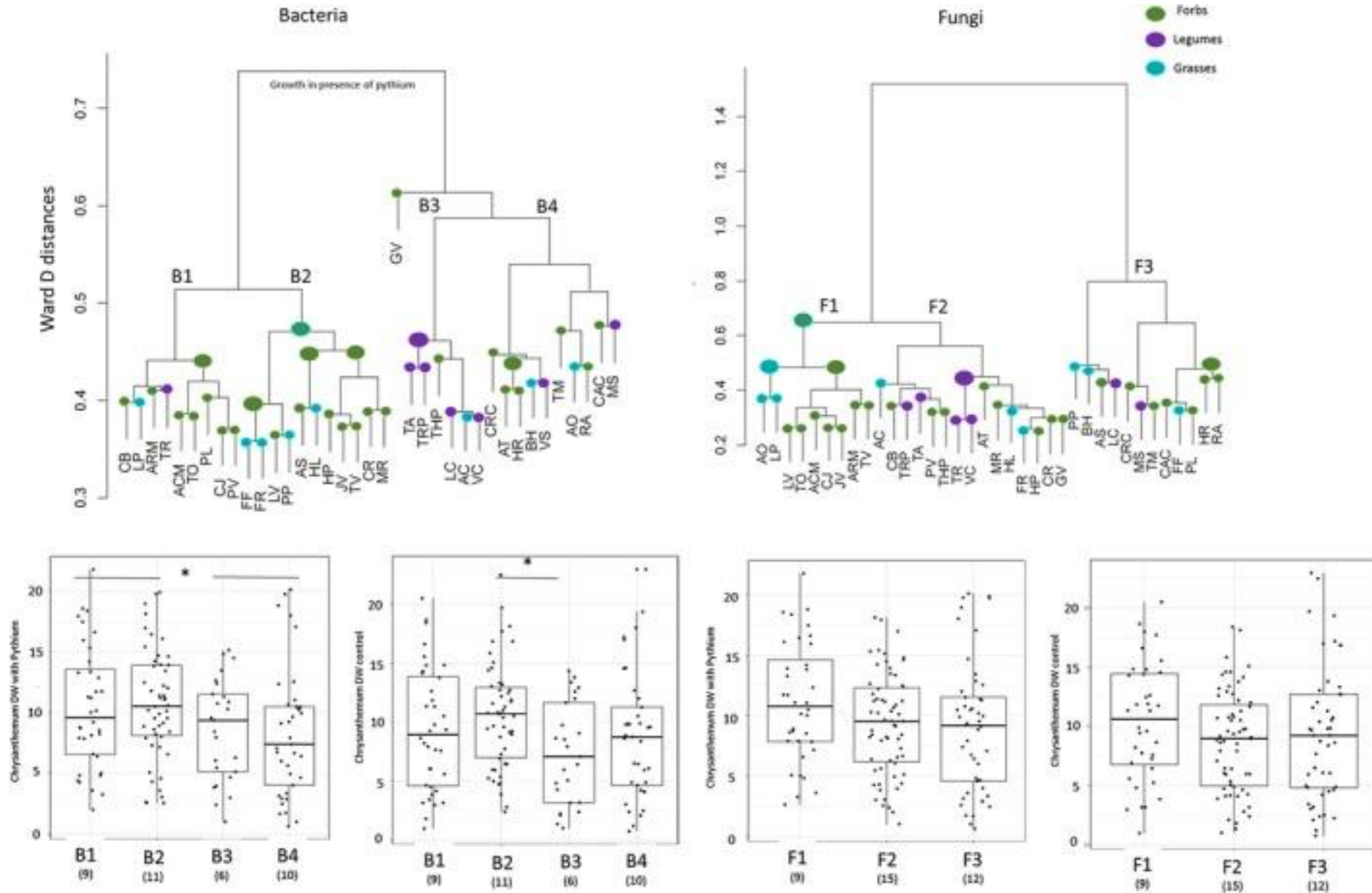
Plant-soil feedbacks

Difference in plant quality  
Difference in plant growth



Picture credits: R. Heinen



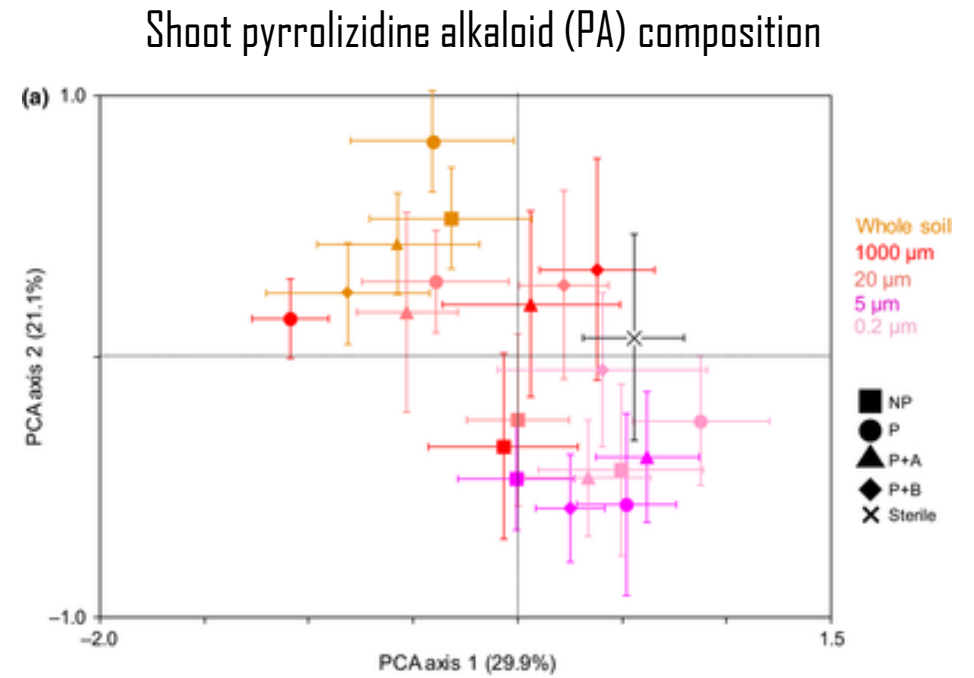
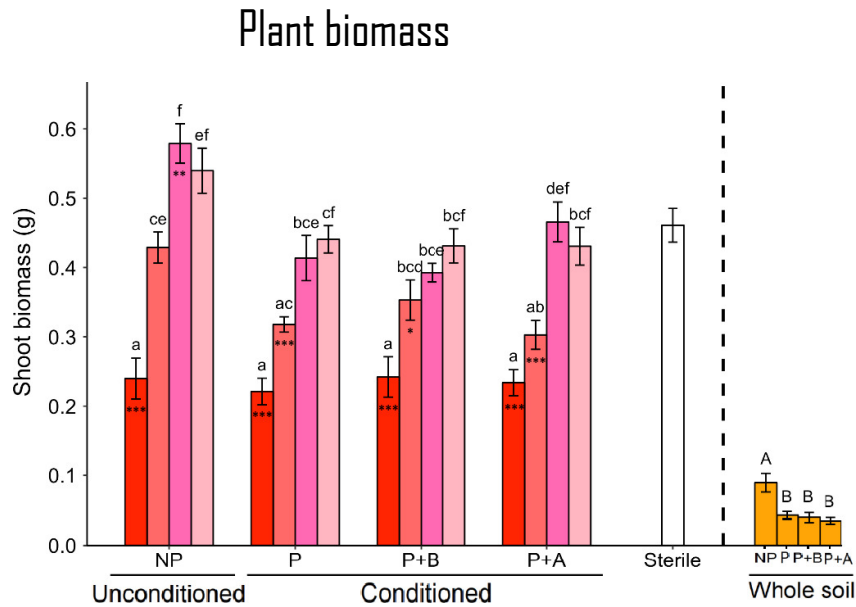
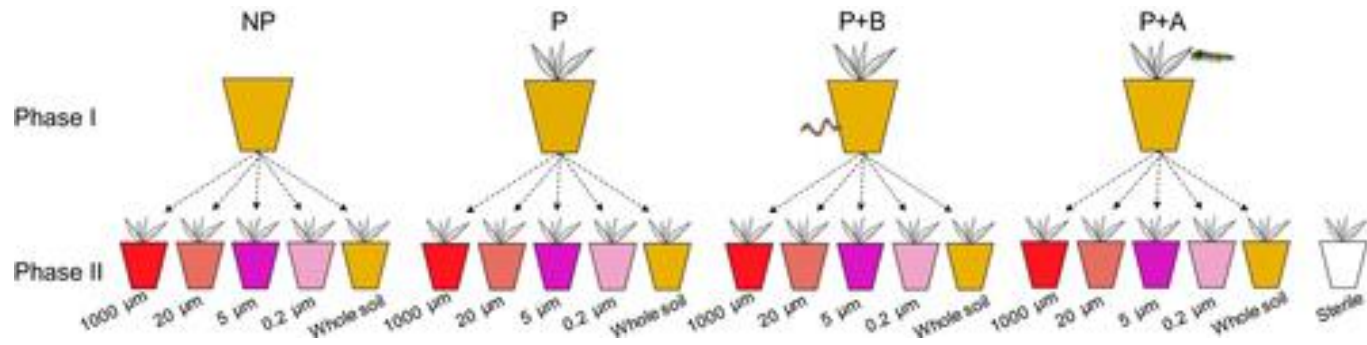


We found out that some plants form a microbiome much more beneficial for following plant changing also its interactions with soil-borne pathogens and thrips

Ma et al. 2017 *Frontiers in plant sciences*  
 Hannula et al. 2020 *Env. microbiology*

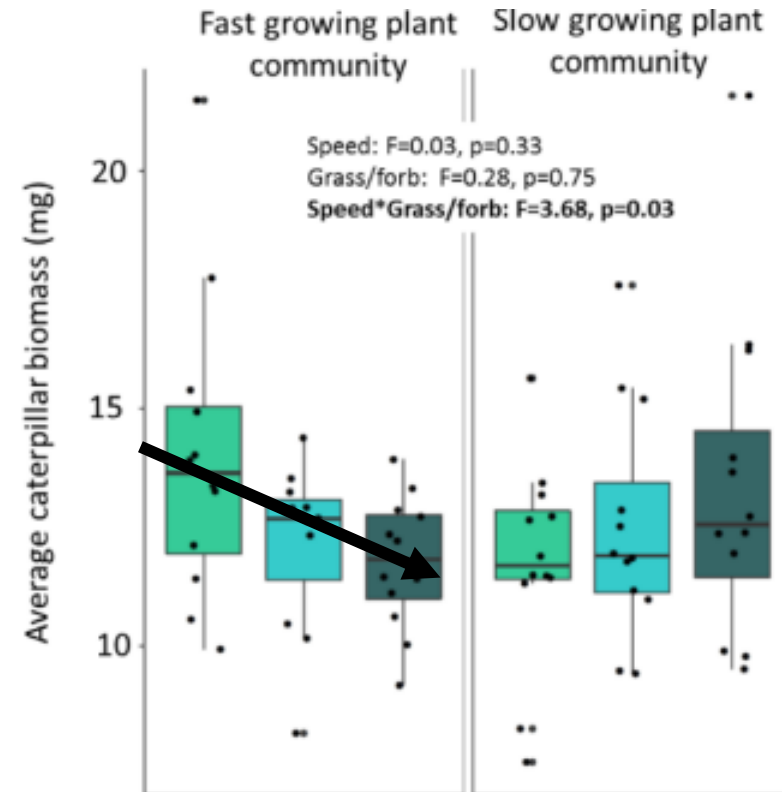
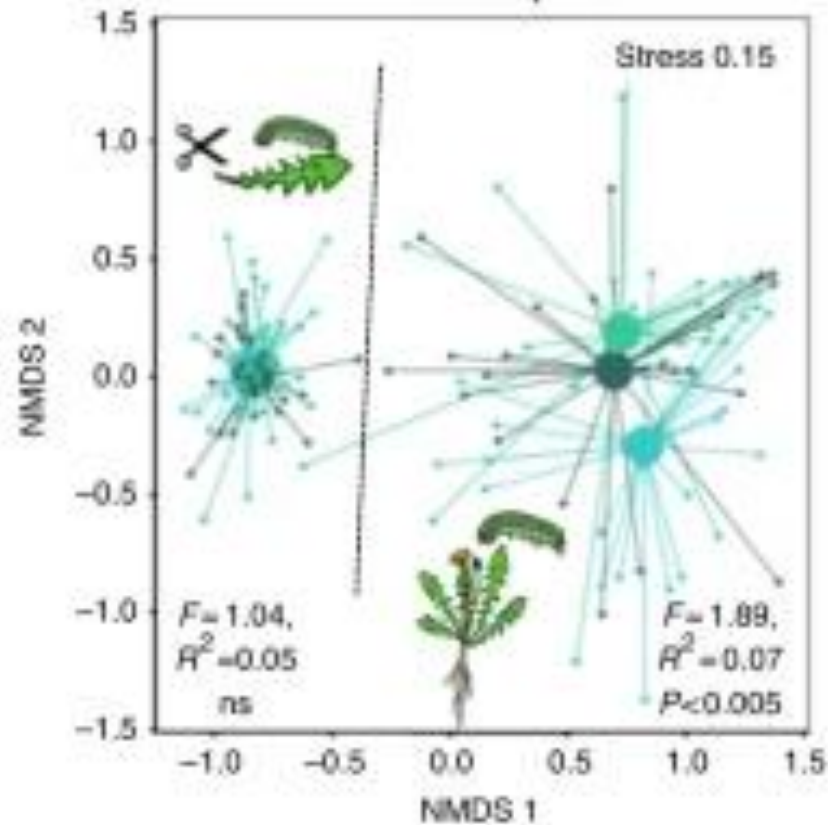


# Changing the microbiome affects the plant quality (here defence compounds)



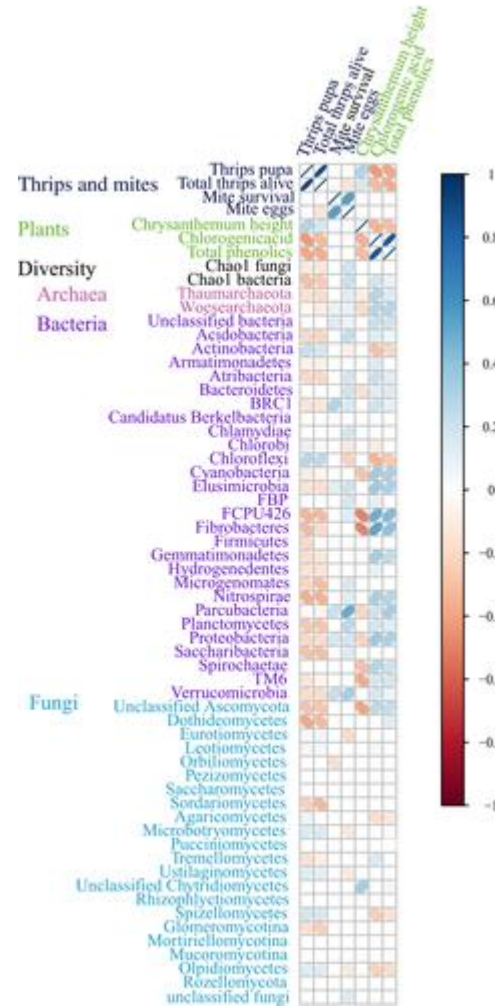
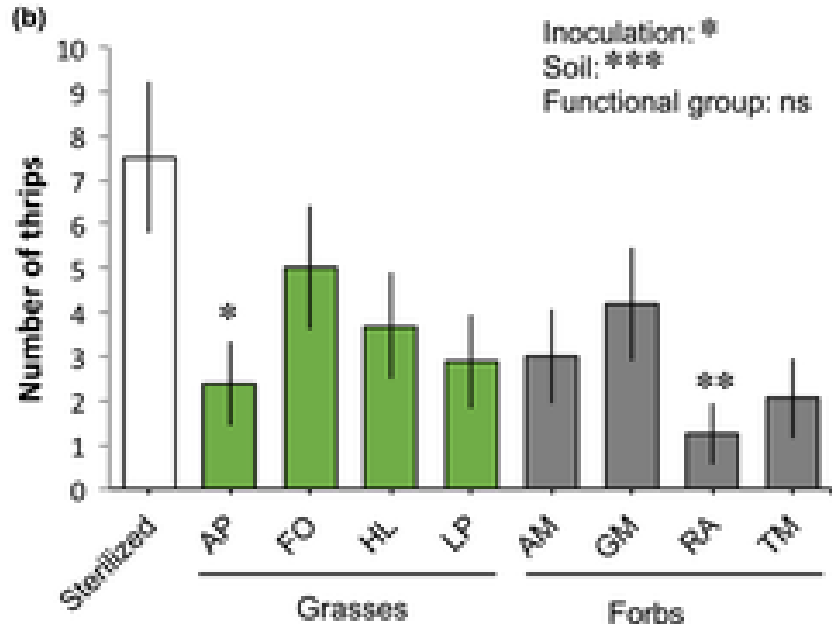
Wang et al. 2018 New Phytologist

Using plant-soil feedback experiment, we found that this 'legacy effect' also affects plant feeding caterpillars



Hannula et al. 2019 Nature communications

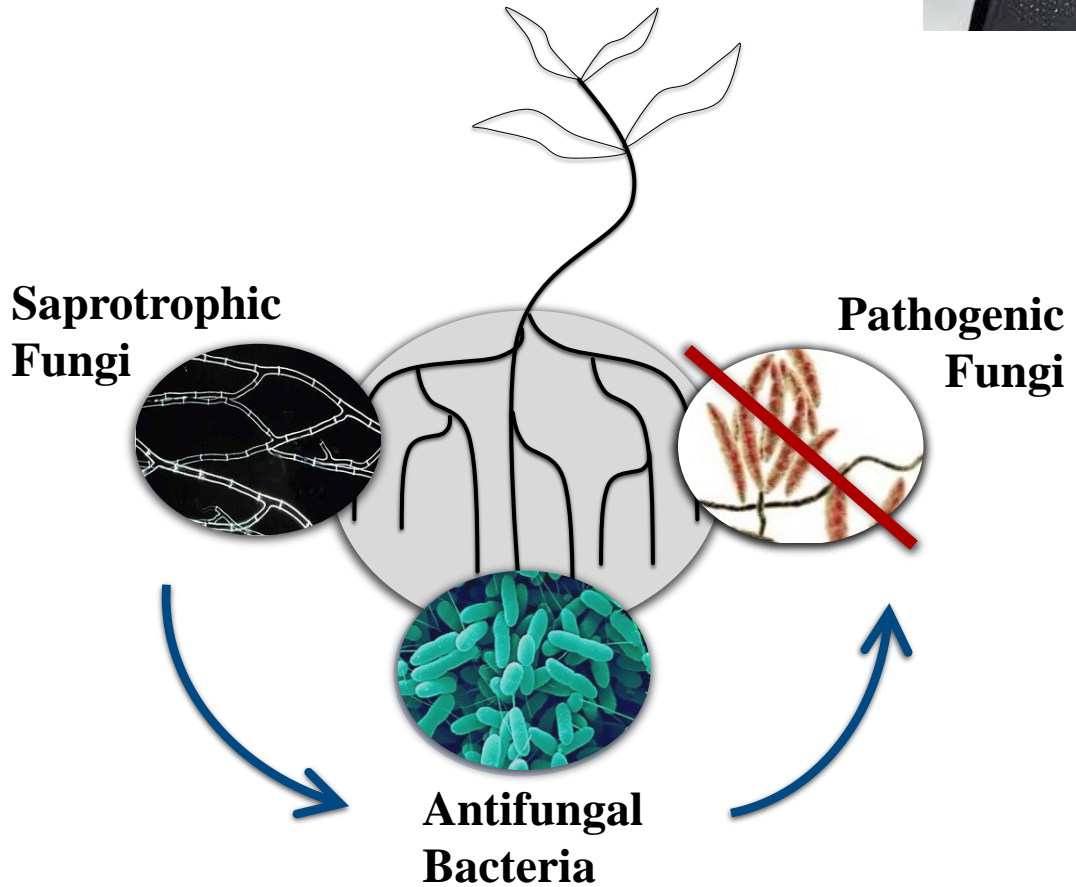
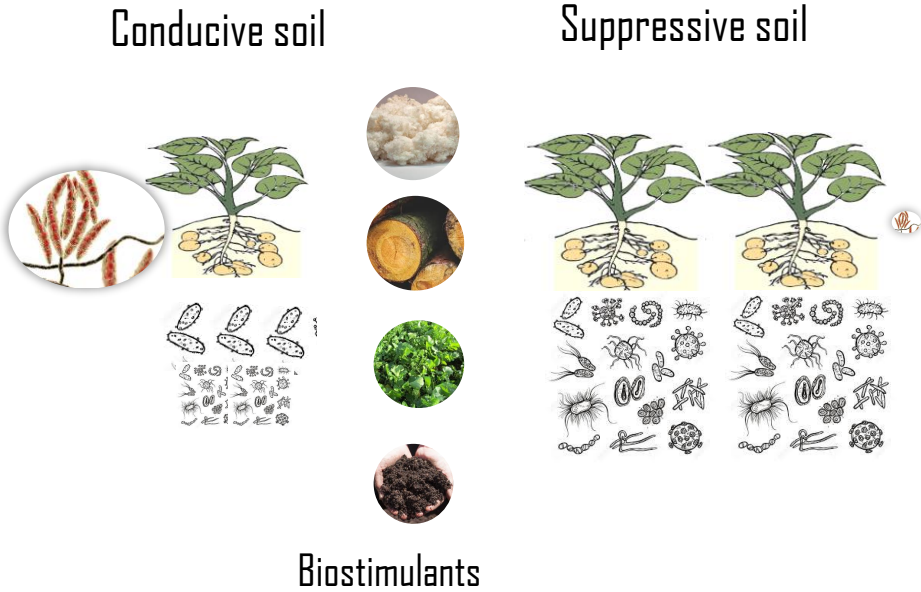
And thrips..



And could relate it to  
microbiomes

Pineda et al. 2019 New Phytologist

# 2. Steering with resource addition





High C:N  
Wood,  
Paper pulp

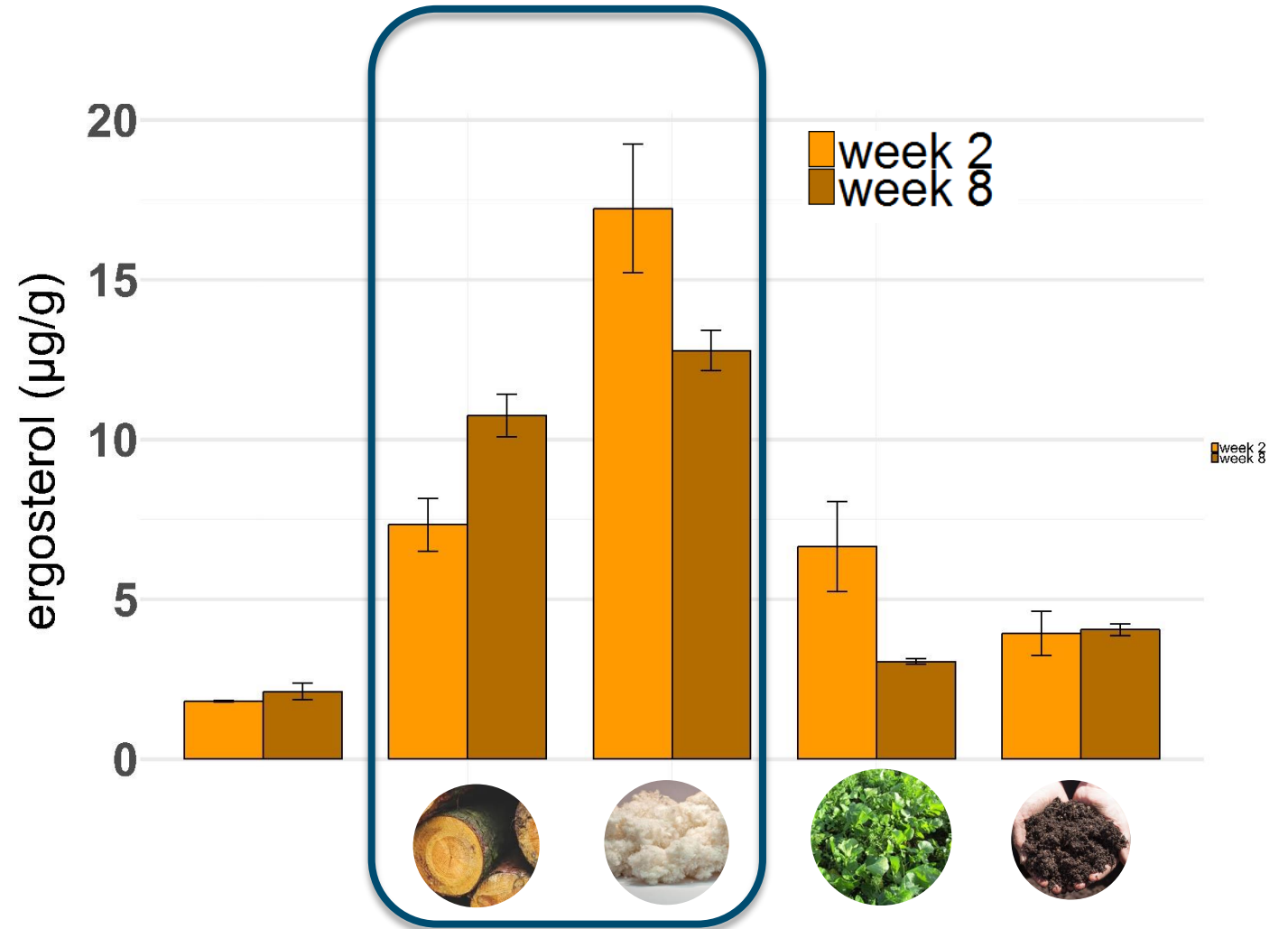


Cover crops



Compost /  
Waste materials

# Fungal biomass in soil

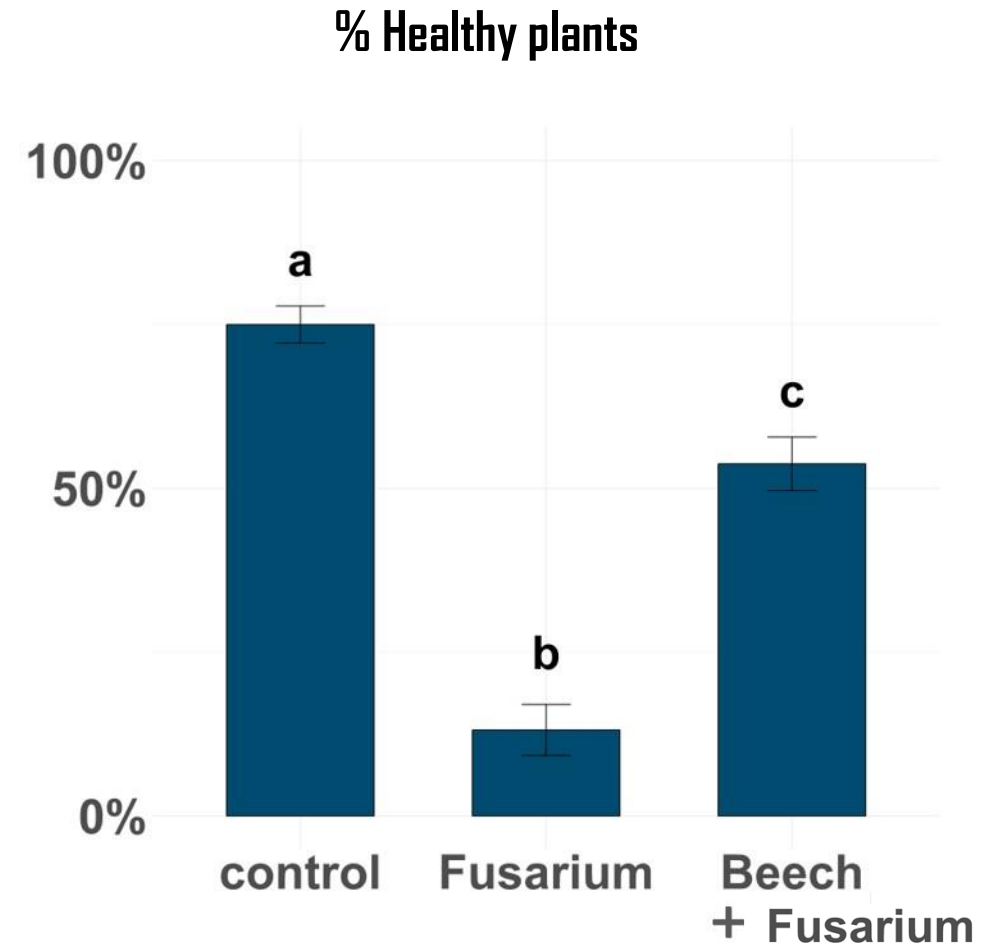
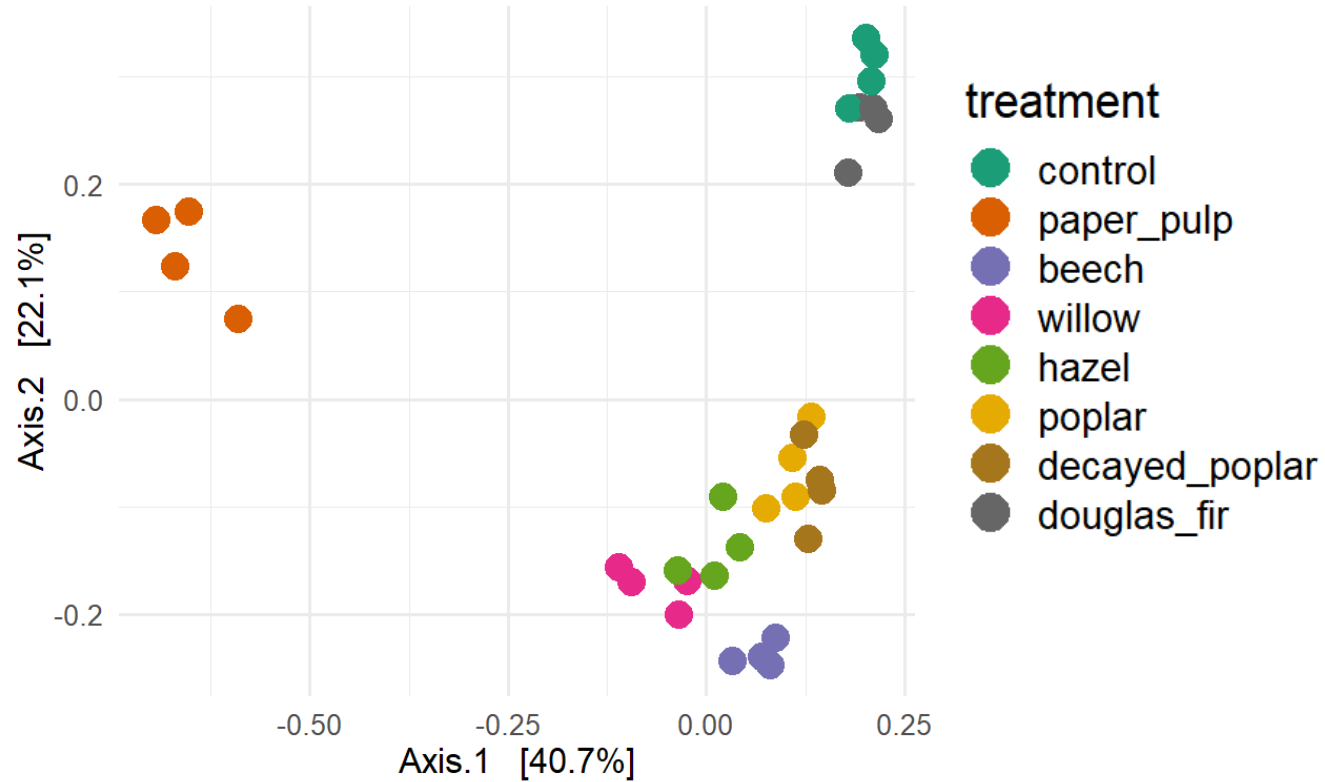


Long term stimulation of fungi

Clocchiatti et al. 2020 Applied soil ecology

Clocchiatti et al. 2021 Env. microbiology

# Soil microbiomes also changed

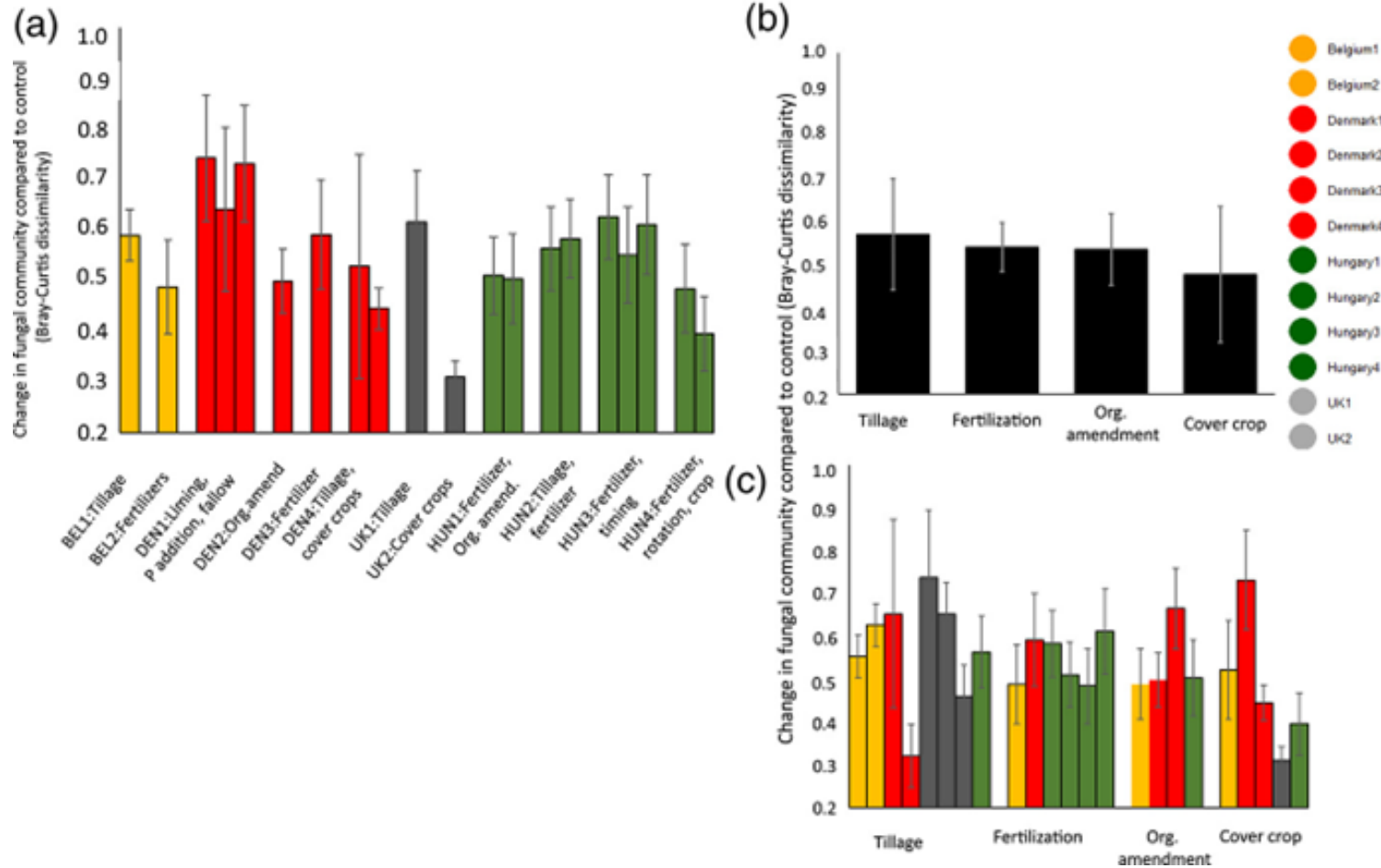


Clocchiatti et al. 2020 Applied soil ecology

Clocchiatti et al. 2021 Env. microbiology

## Leading to change in disease suppression

# 3. Restoration with management



From individual treatments tillage had the biggest effect on microbiome but very variable responses across countries/soils. Bigger transition when whole system changes

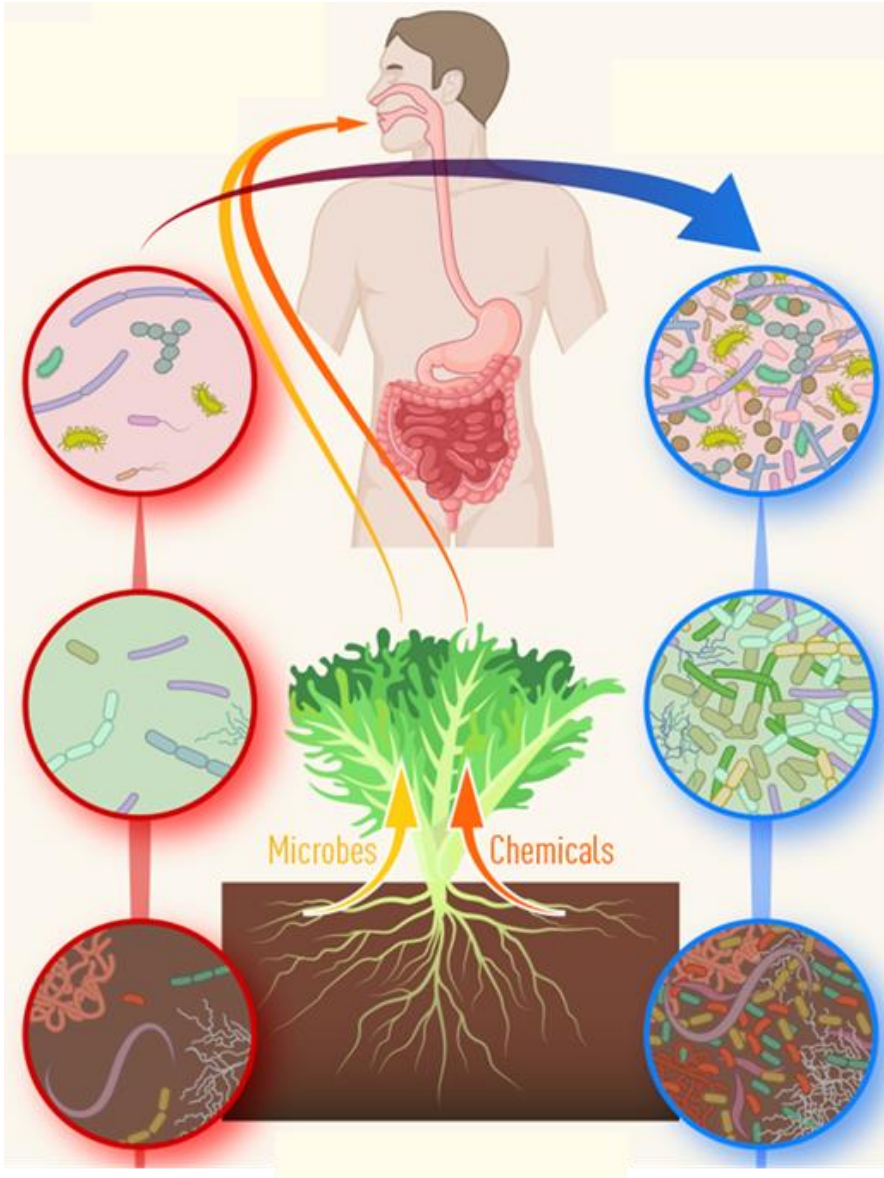
## 4. Restoration with replacing and adding

Soil transplantation shows promising results in grasslands, forests and heathlands. Adding individual species also possible.



# Summary and take home

1. Soil microbes provide many functions –including effects on organisms feeding on them or organisms feeding on plants
2. Soil management affects soil microbiomes
3. Which in turn affect the functions
4. Both microbiomes and functions can be steered



Hypotheses to be tested:

Soil microbiome affects human gut microbiome and health

And by changing the soil management and steering the soil microbiomes, change in human health can be obtained