TEADUSE TIPPKESKUS
ECOLCHANGE
CENTRE OF EXCELLENCE

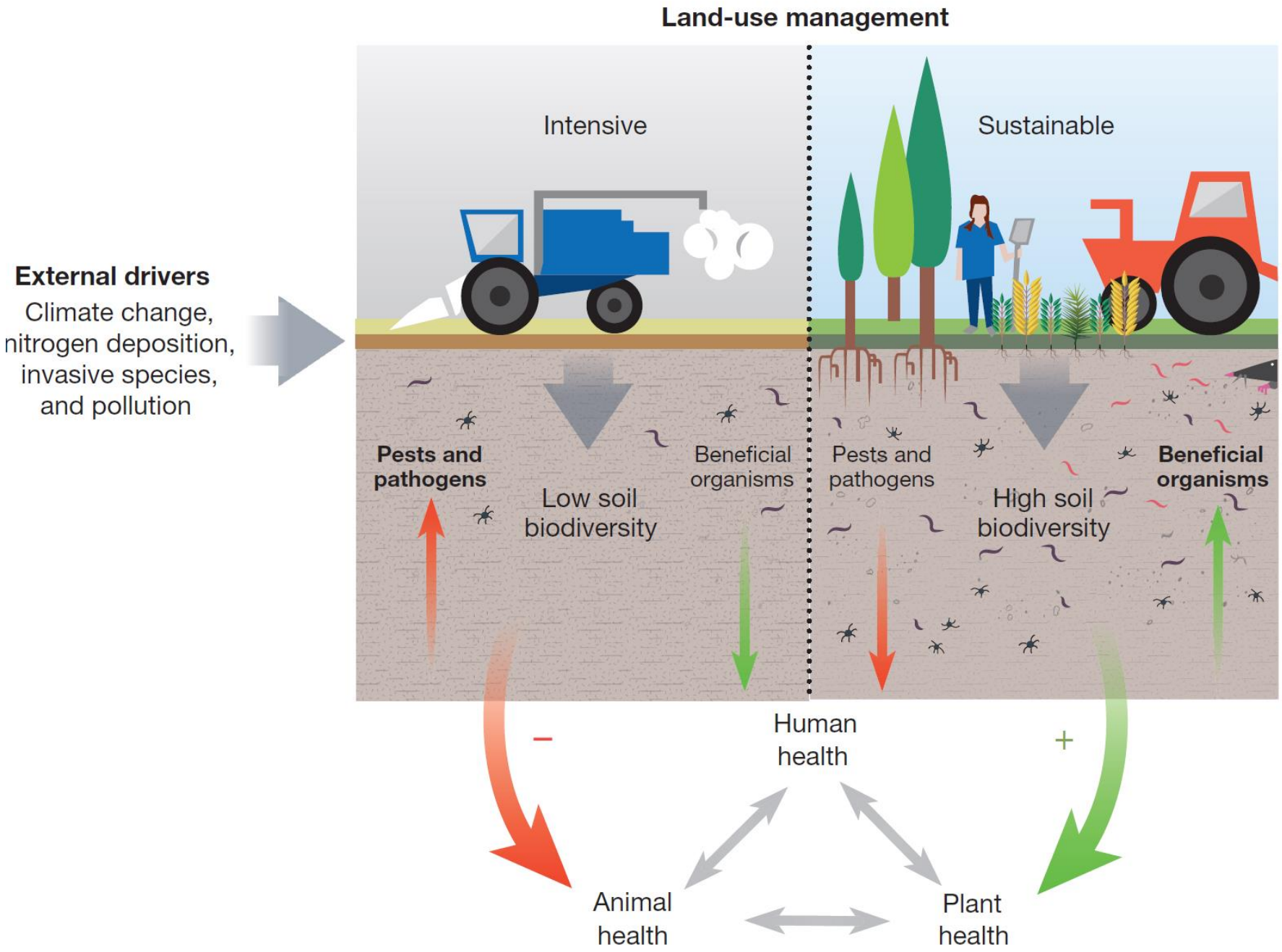
Plant symbiotic mycorrhizal fungi in agriculture

Maarja Öpik

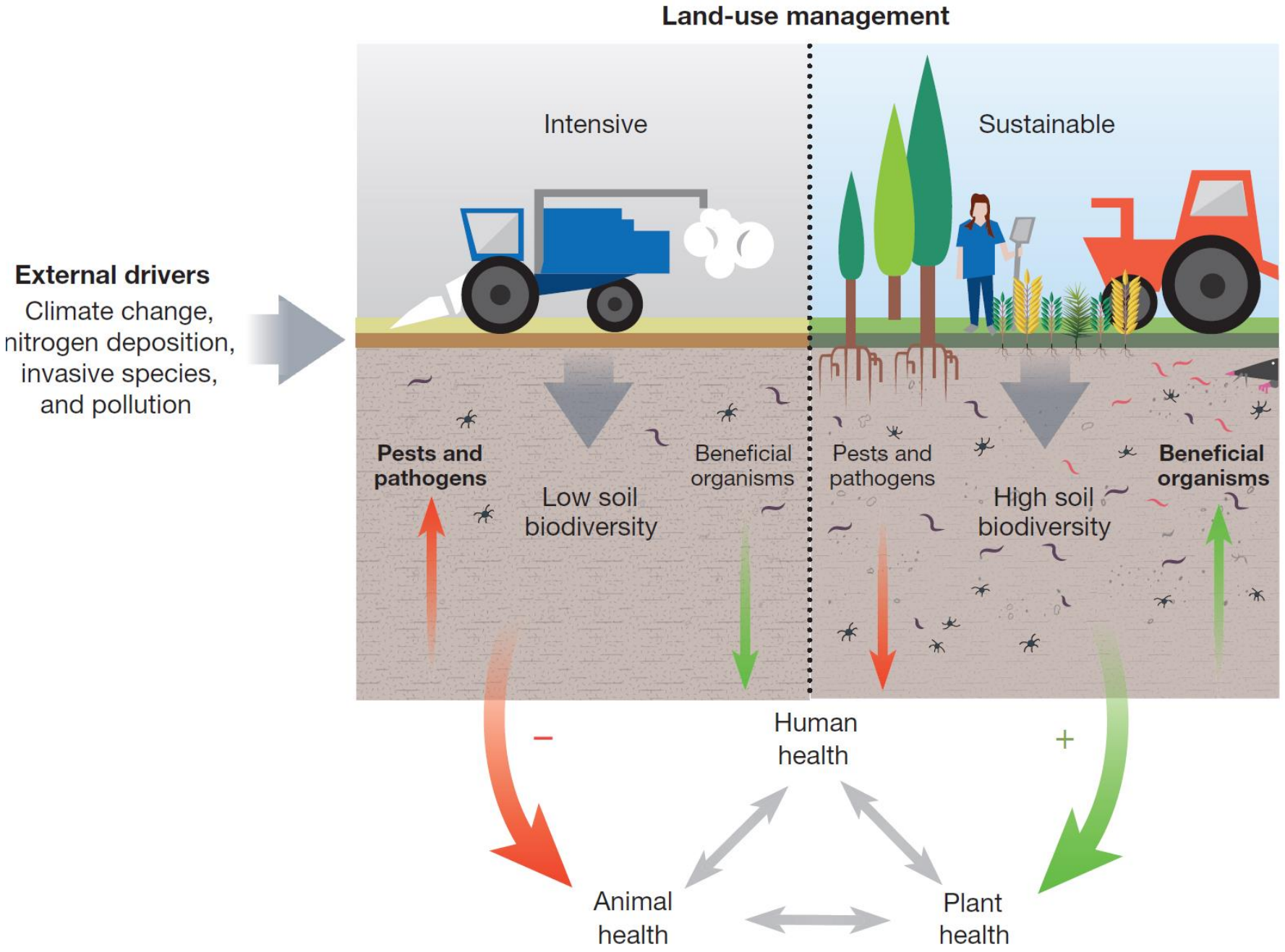
maarja.opik@ut.ee, @maarja_opik

22. October 2019

TARTU ÜLIKOOL
1632



Wall et al. 2015, Nature 528: 69-76



1. **Change the land management**
   - **Wait for soil biota to respond**

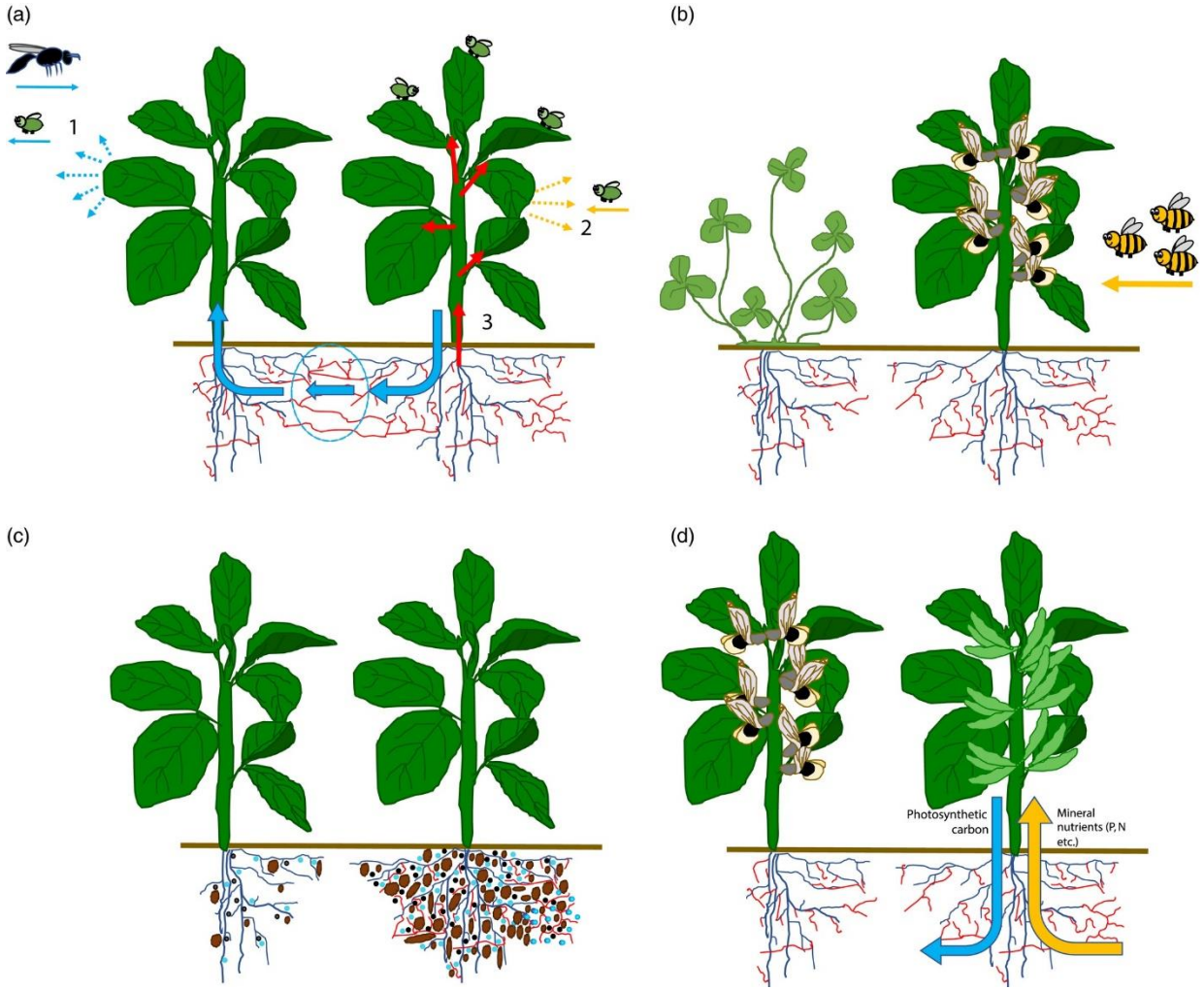
OR

2. **Reintroduce / manage soil biota**

Functions of arbuscular mycorrhizal (AM) fungi

3. Biotic stress protection: pathogens, herbivores

2. Abiotic stress protection: drought, salinity, heavy metal pollution



1. Plant nutrition; ecosystem-level nutrient cycling

Thirkell et al. 2017. J. Ecol. 105:921-929

AM fungi can importantly affect plant growth

pasque flowers (*Pulsatilla* spp.):

1. Some plant species very strongly depend on AM fungi
2. Some AM fungi work „better“ than others

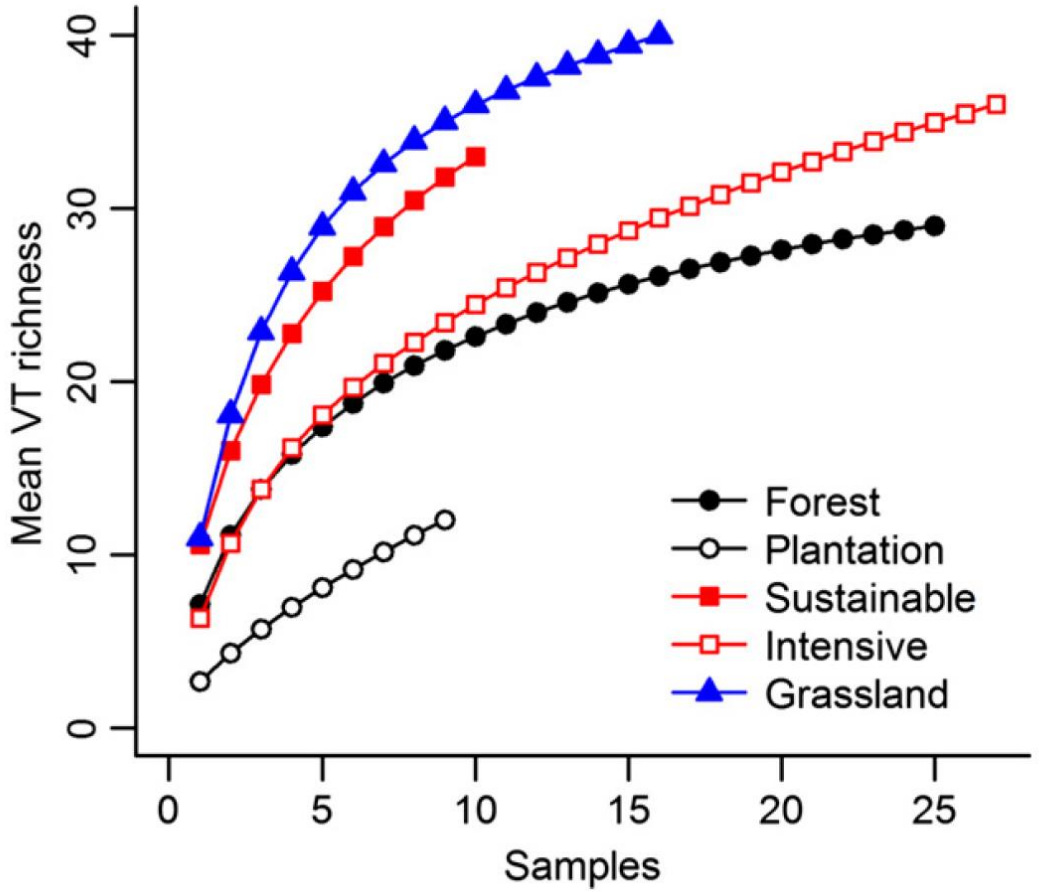
No AM fungi | AM fungi from forest | AM fungi from grassland

P. patens

P. pratensis

Moora et al. 2004. Fun. Ecol. 18:554-562

AM fungal diversity differs depending on land use

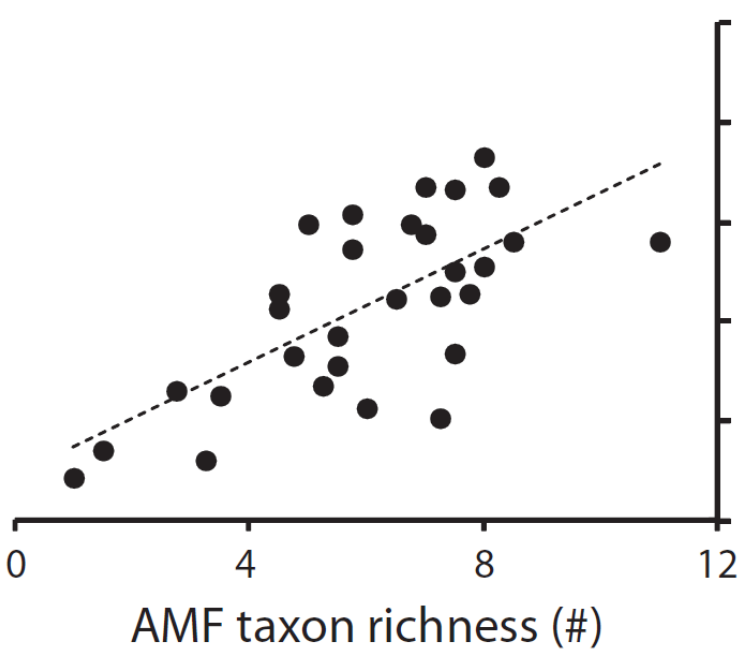


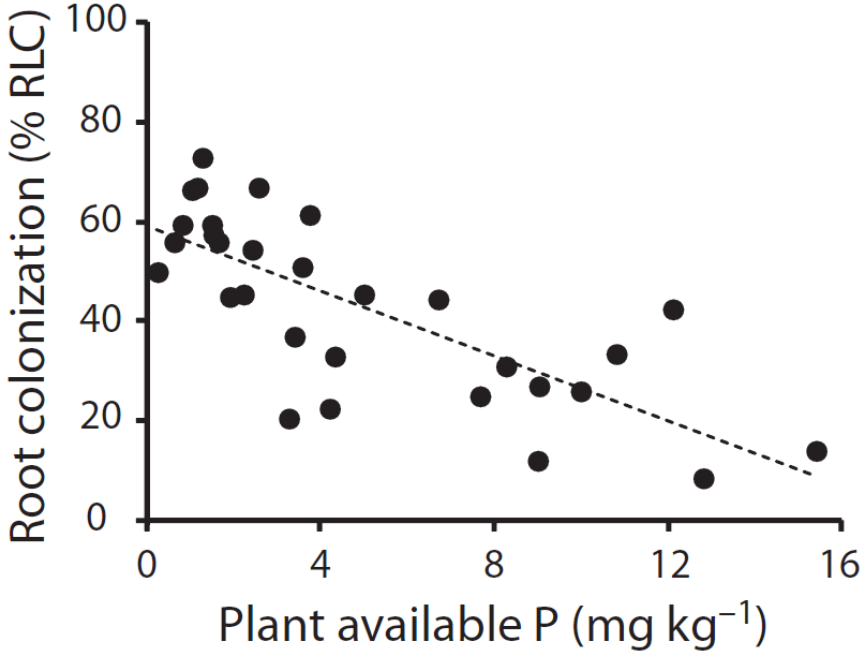
Grassland

Arable field

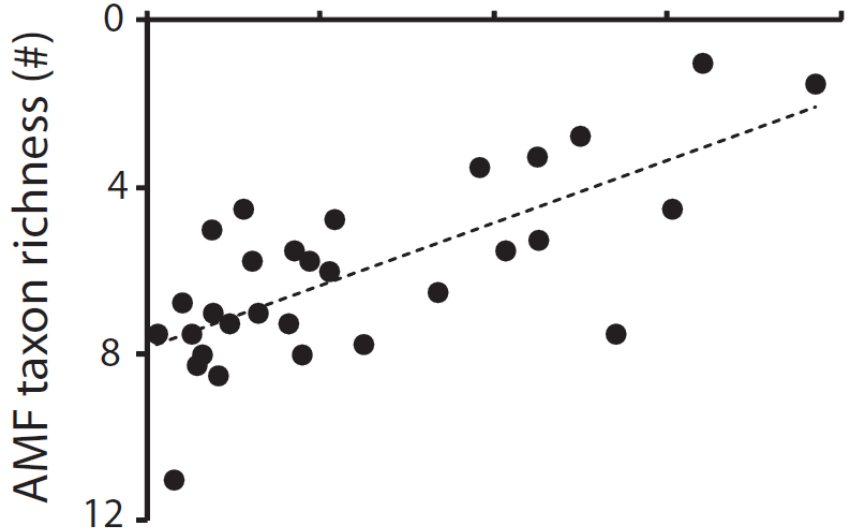
Forest

Moora *et al.* 2014, FEMS Microbiol Ecol 90: 609-621

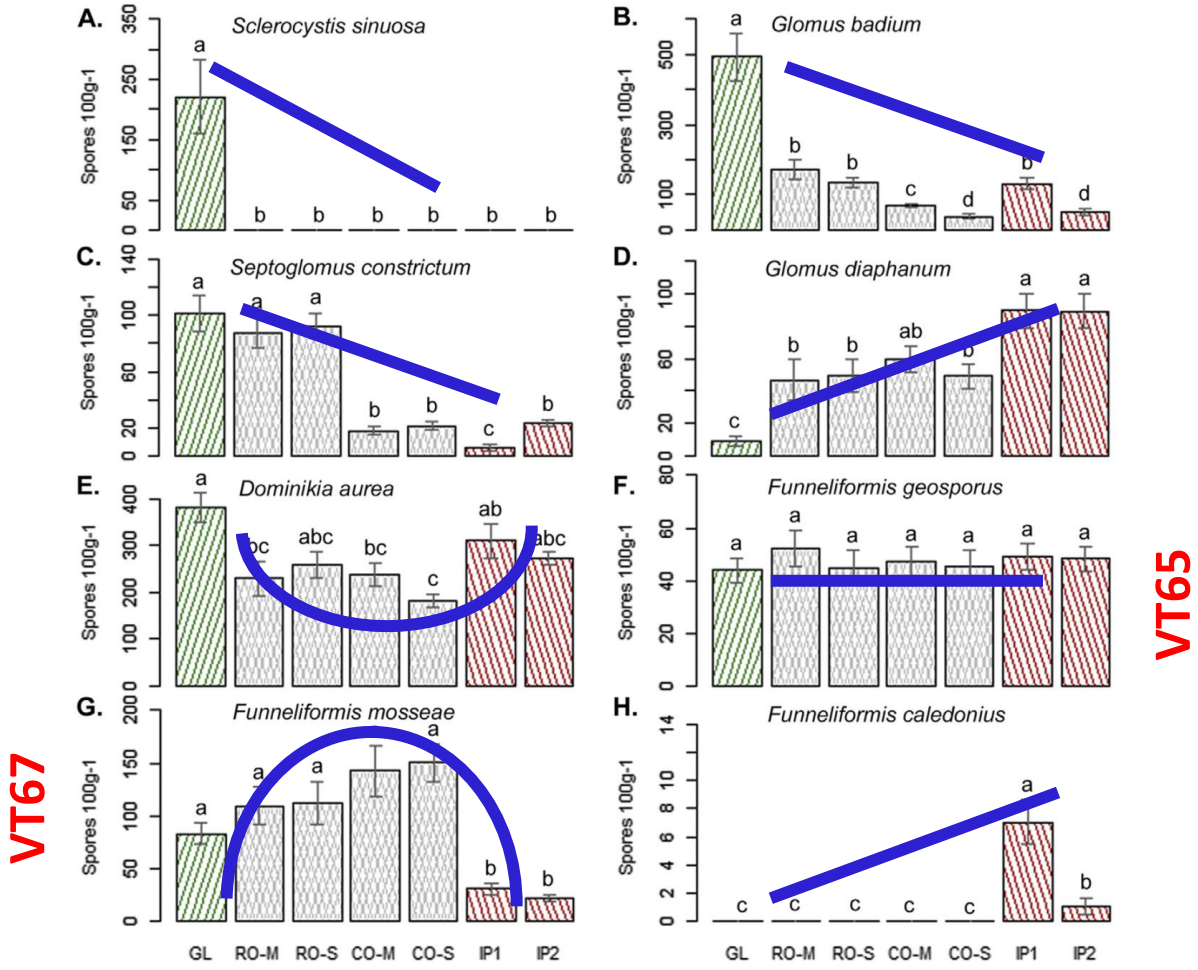




AM fungal abundance and diversity depend on soil fertility / fertiliser addition



Verbruggen *et al.,* **2013.** New Phytol. 197:1104-1109



AM fungal species respond differently to management:

- **prevail in grassland (disturbance intolerant)**
- **prevail in arable field (disturbance tolerant)**
- **insensitive**
- **intolerant to plowing (C)**
- **intolerant to intensive management (G)**

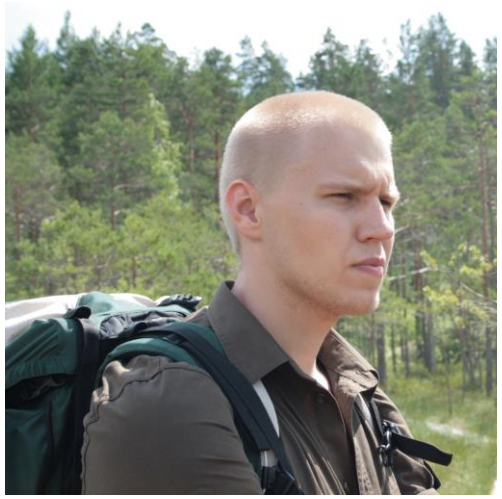
GL - grassland
RO – reduced plowing, organic management
CO – conventional plowing, organic management
IP – intensive management

Säle *et al.*, **2015.** FEMS Microbiol. Ecol. 90:609-621

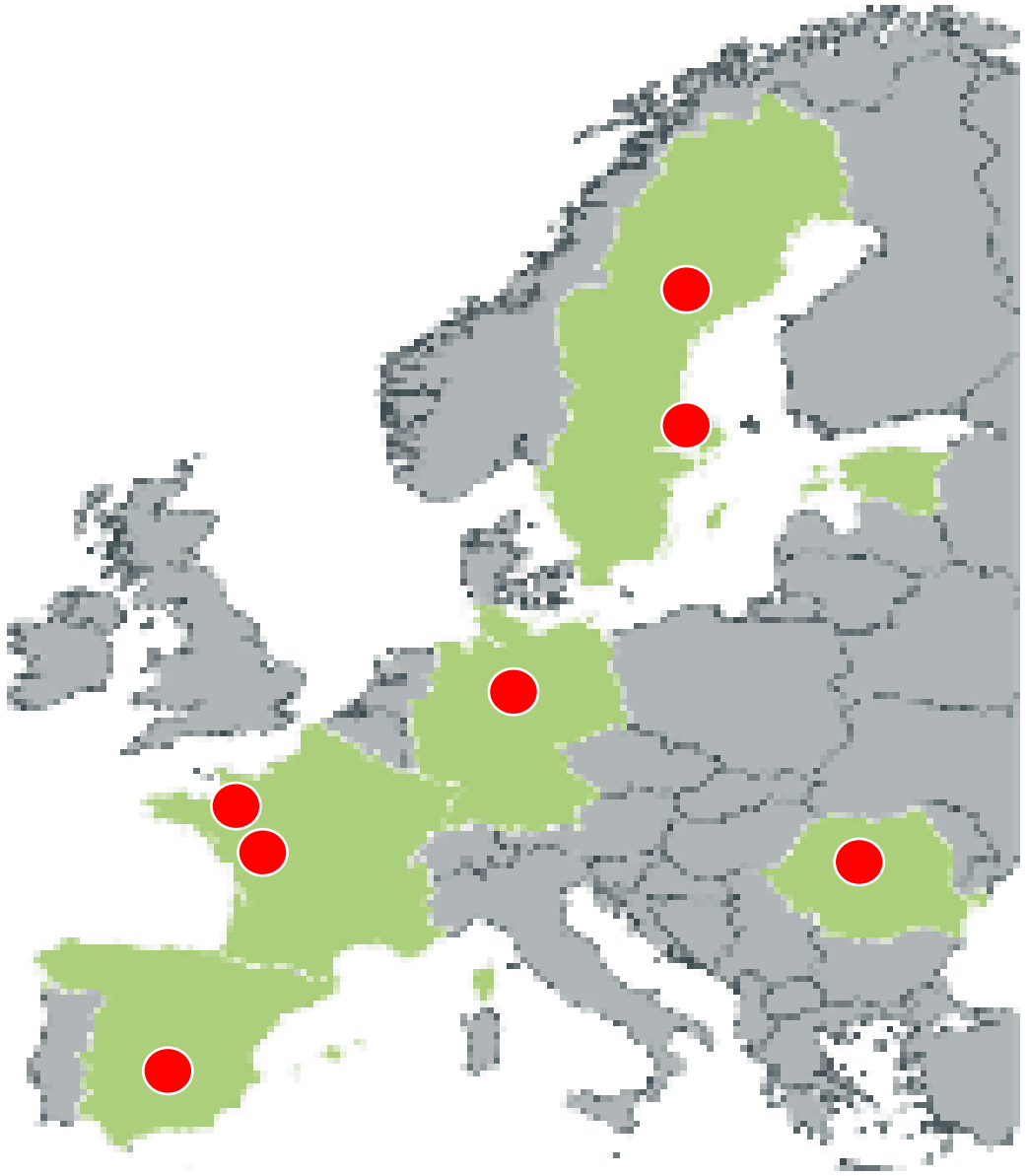
Tanel Vahter

Farming practices

Biodiversa3 Project SoilMan: tillage effect



Siim-Kaarel Sepp



Cross-European study in Long-term experimental farm sites

Focus on **tillage:**
- conventional tillage
- reduced tillage

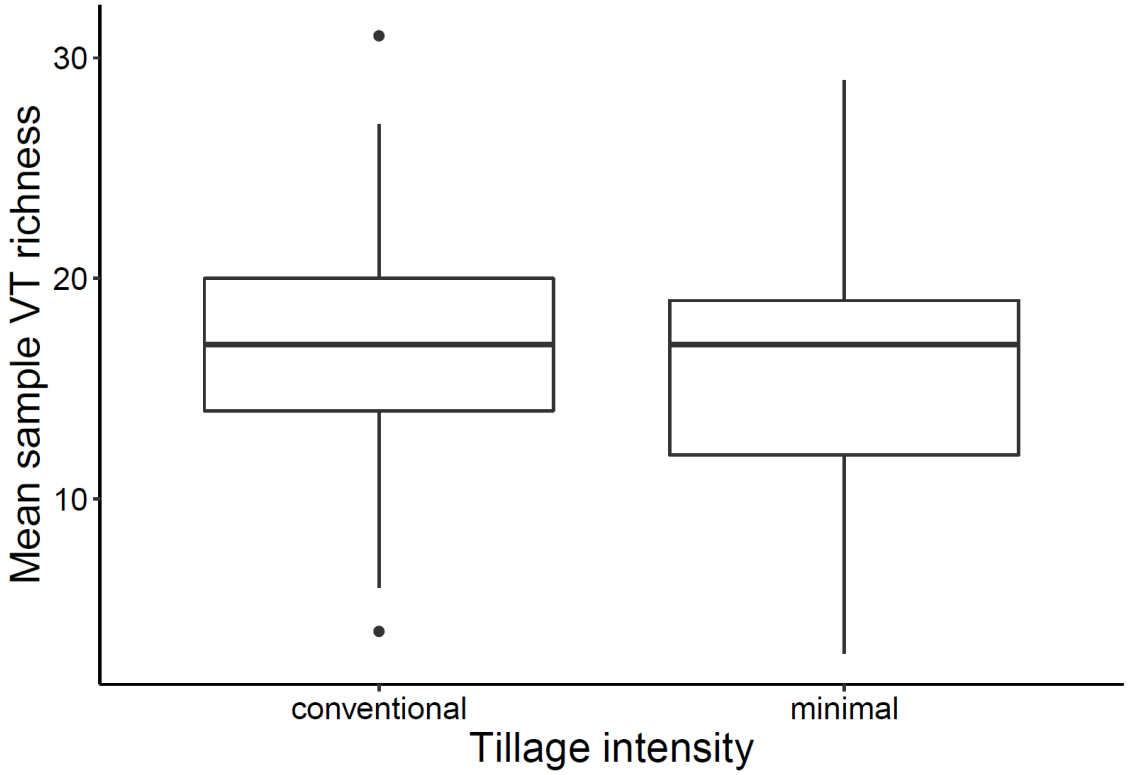
Soil biota:
- fungi
- AM fungi
- bacteria
- earthworms
- etc.

Top 5 AM fungi

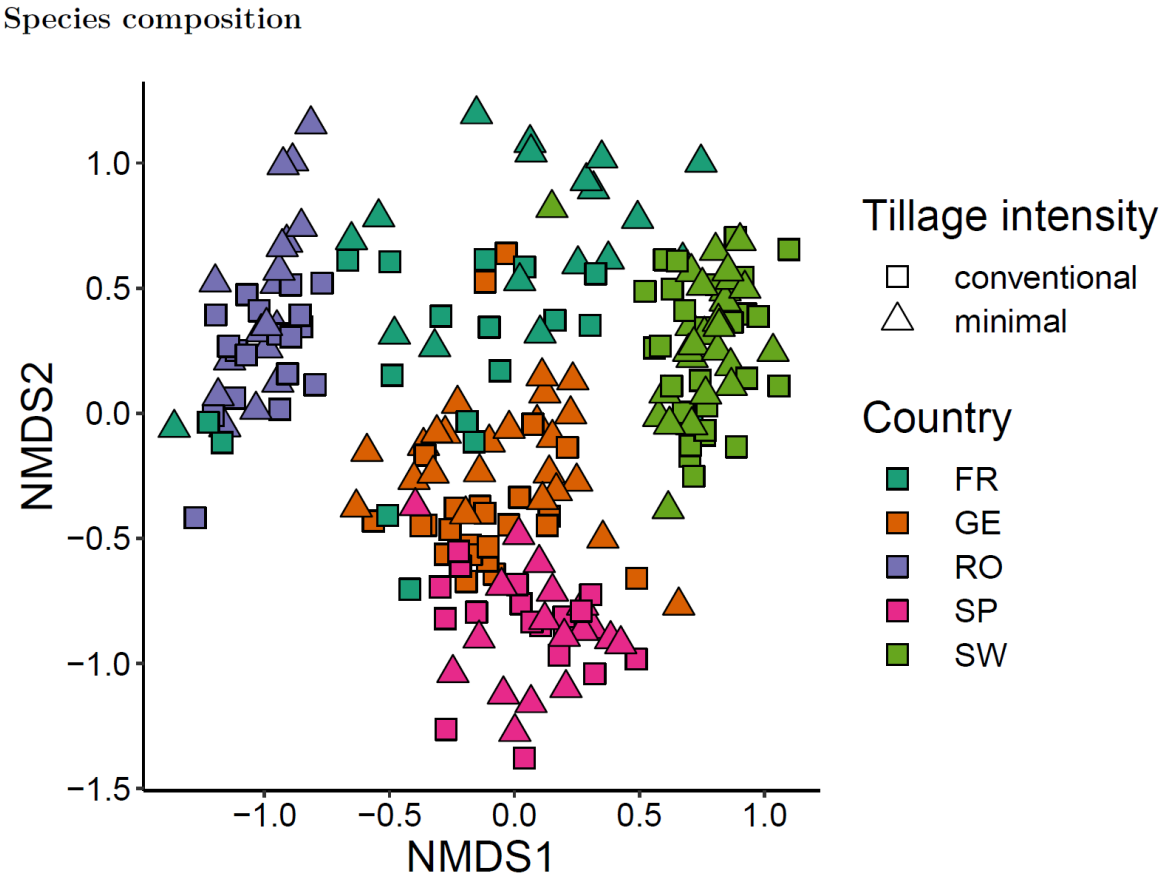
= 4 families: Paraglomeraceae, Glomeraceae, Claroideoglomeraceae, Diversisporaceae

		proportion of sequences	proportion of samples (= frequency)
VT281	Paraglomus laccatum	0,29	0,84
VT143	Glomus sp (DNA-based)	0,15	0,68
VT65	Glomus caledonium/geosporum	0,09	0,78
VT193	Claroideoglomus claroideum complex	0,08	0,64
VT306	Diversispora sp	0,06	0,72

1. In cross-country comparison **tillage had minor effect** on AMF diversity
2. **Country** was the main predictor of community composition



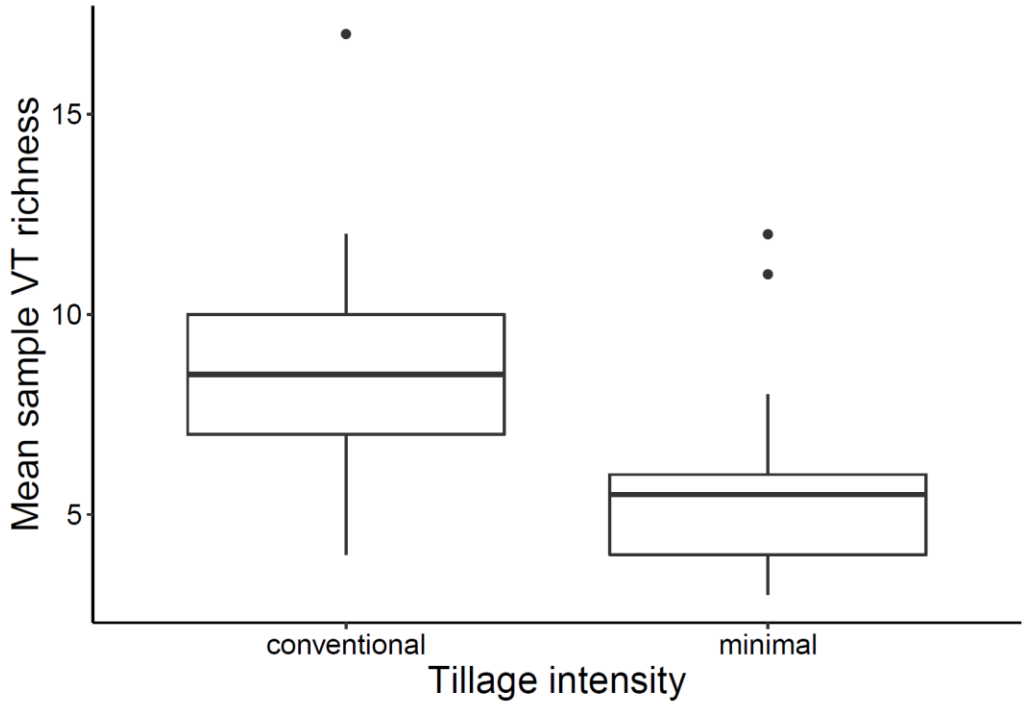
GLMM p = 0.048, effect size = −0.07, 95% CI [−0.13, 0]



Tillage intensity effect: PERMANOVA $R^2 = 0.02$, p = 0.001. Permutations restricted to replication within country.

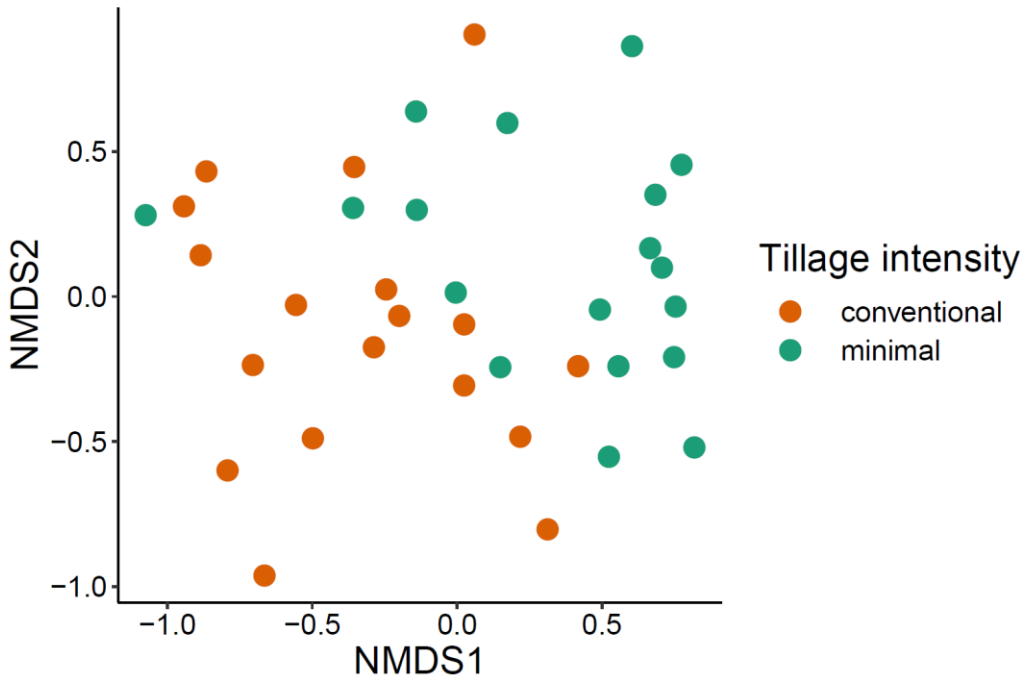
France

Species richness



GLMM $p < 0.001$, effect size $= -0.42$, 95% CI $[-0.67, -0.18]$

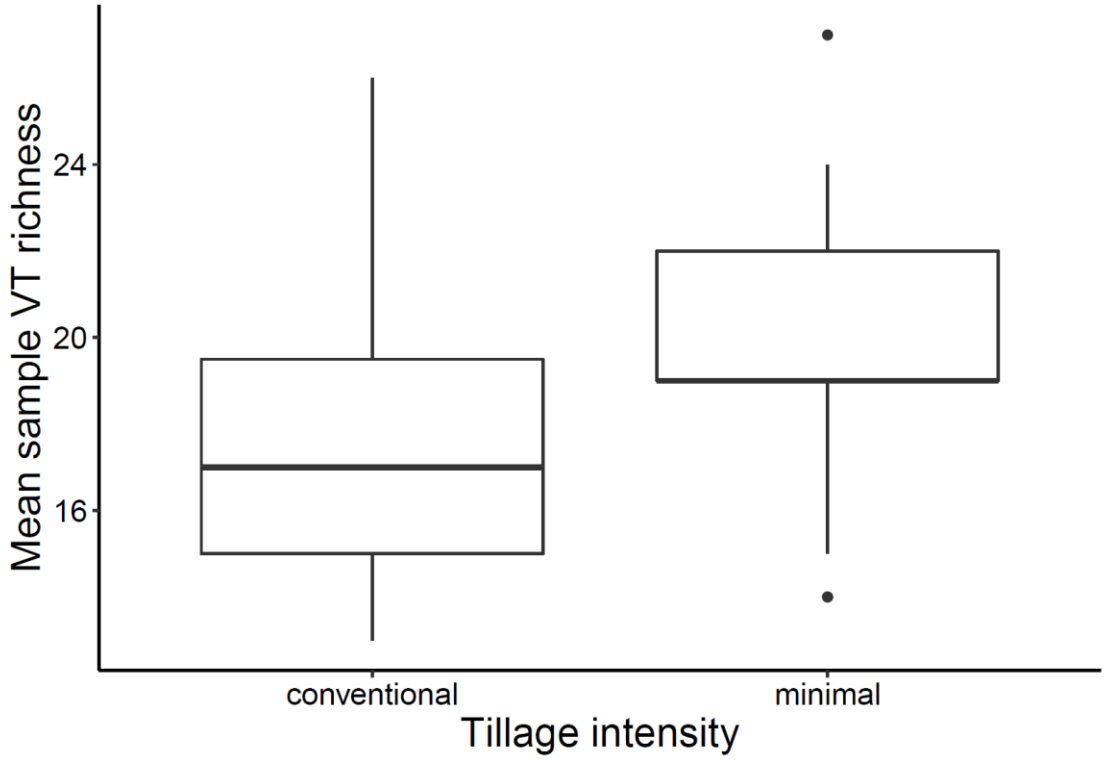
Species composition



PERMANOVA $R^2 = 0.18$, $p = 0.001$

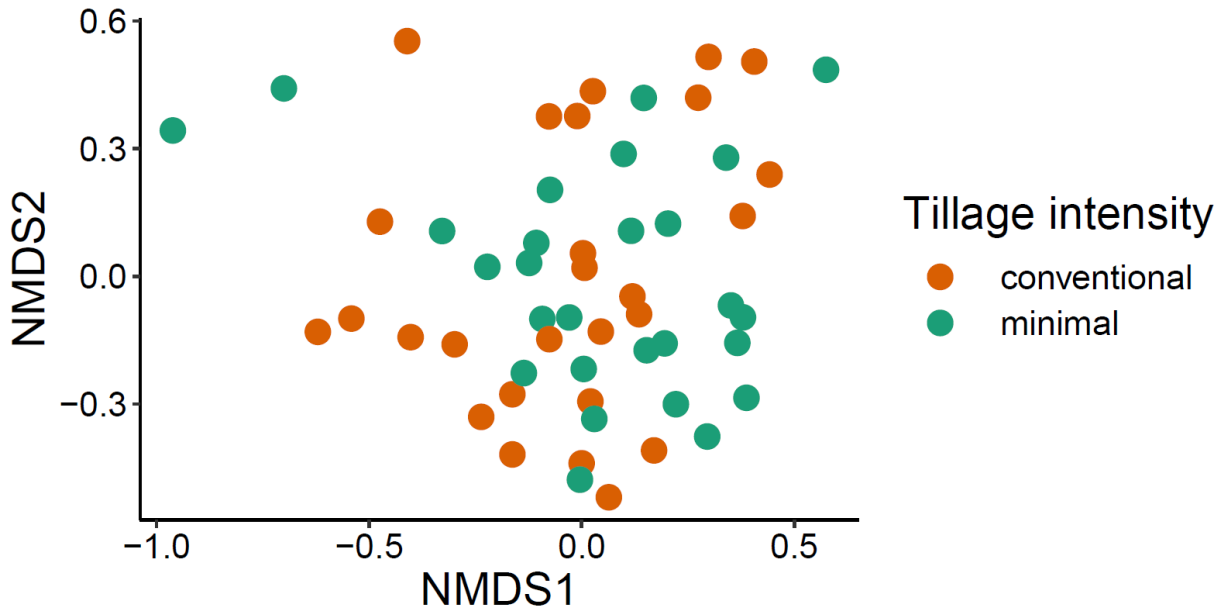
Sweden

Species richness



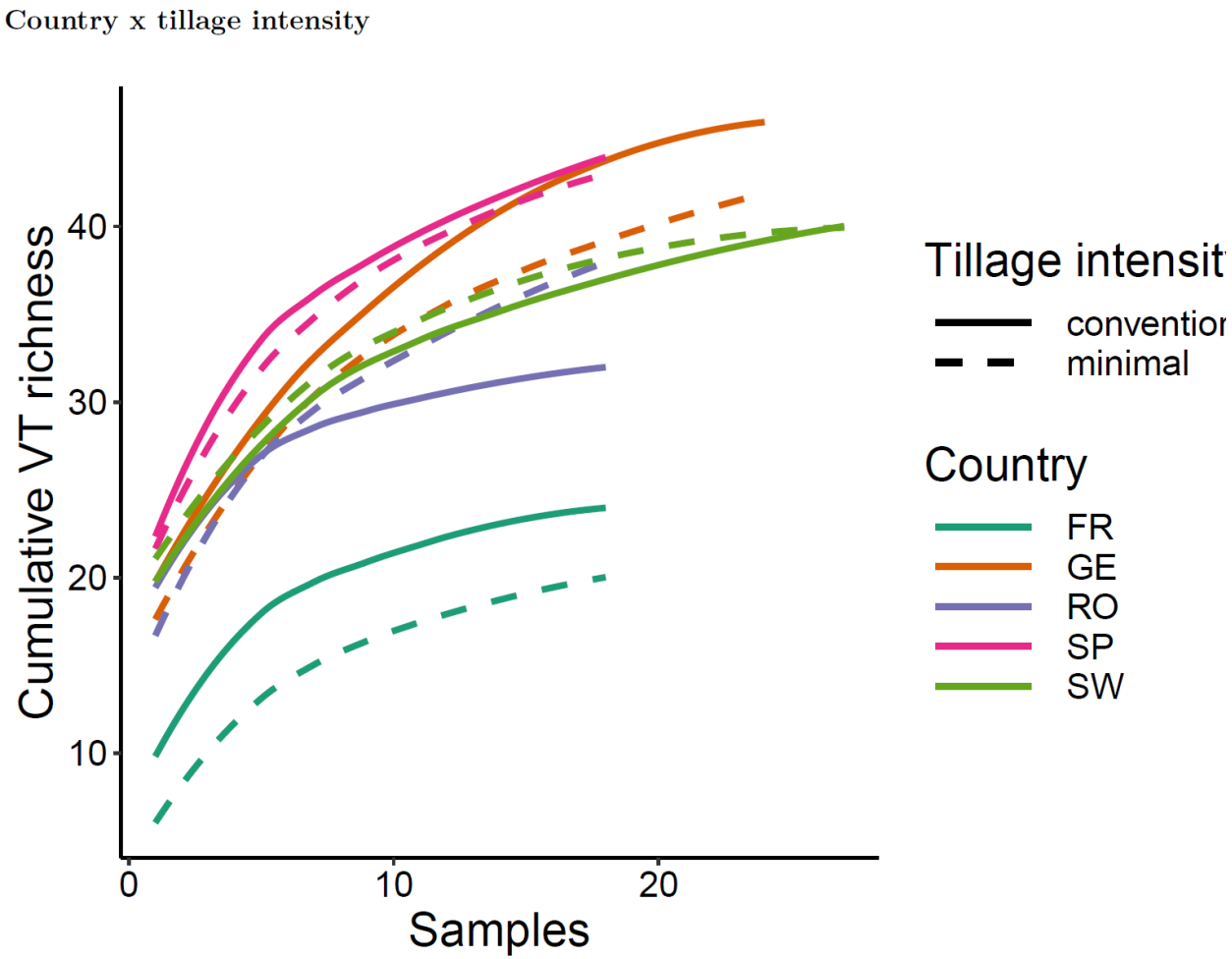
GLMM p = 0.074, effect size = 0.11, 95% CI [−0.01, 0.23]

Species composition

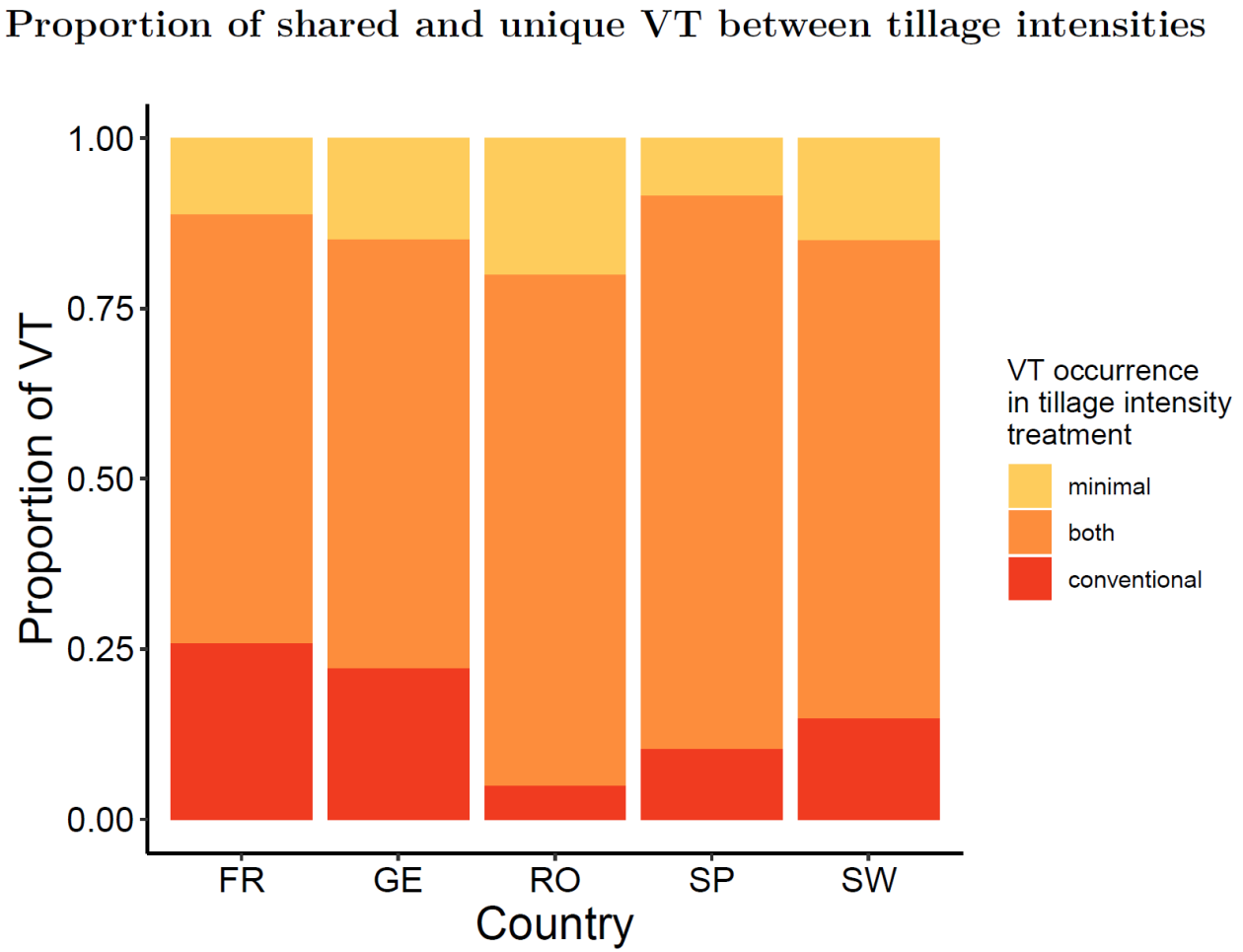


PERMANOVA R^2 = 0.11, p = 0.001

Species number in the system



Unique, lost and gained AM fungi



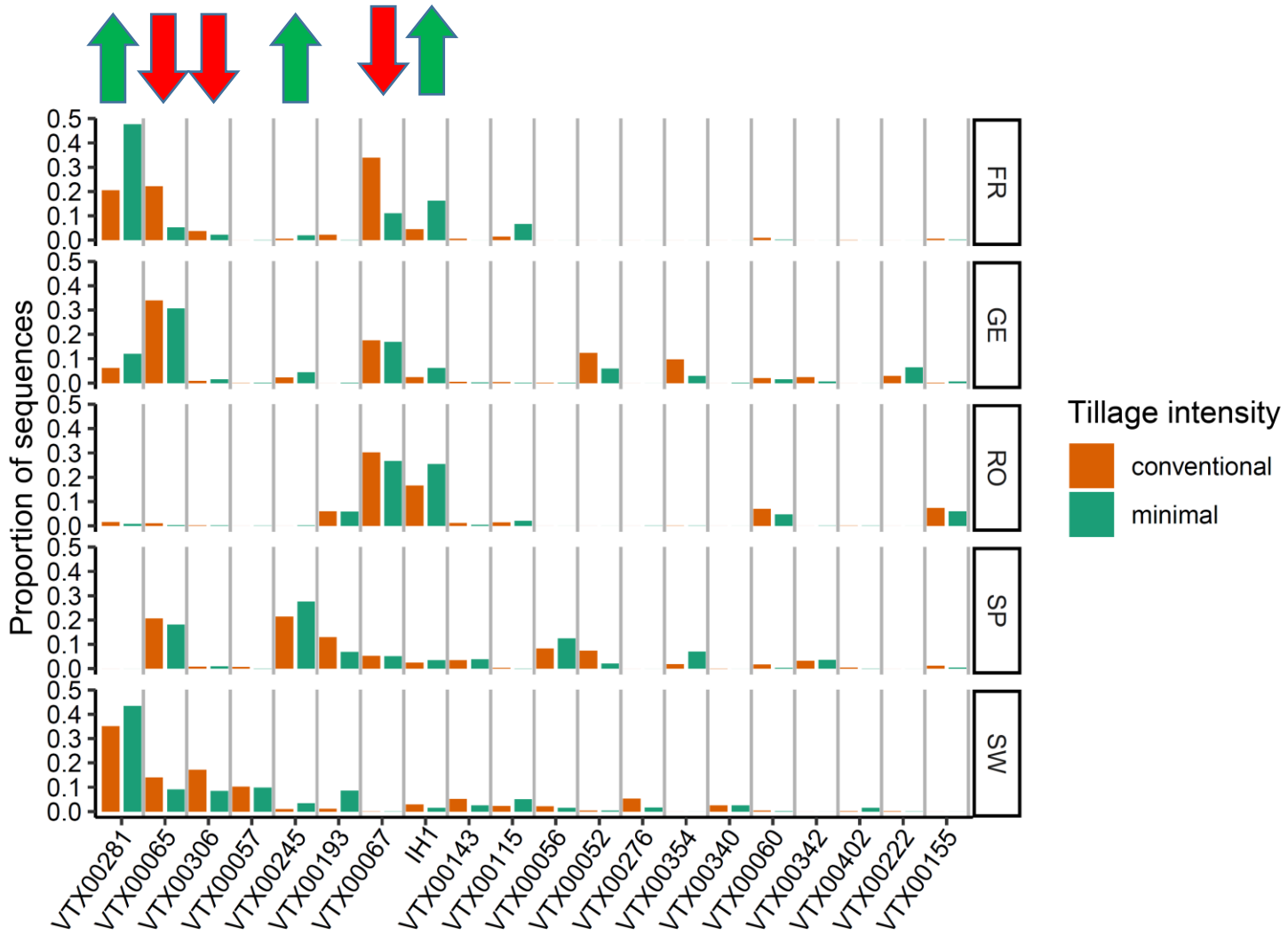
Proportions of VT occurring in case of either minimal, conventional or both treatment intensities. Separated by country..

Tendency to:

- lose more **conventional-tillage adapted AMF** than

- gain **minimal-tillage adapted AMF**

AM fungal species respond to reduced tillage in a consistent and differential manner

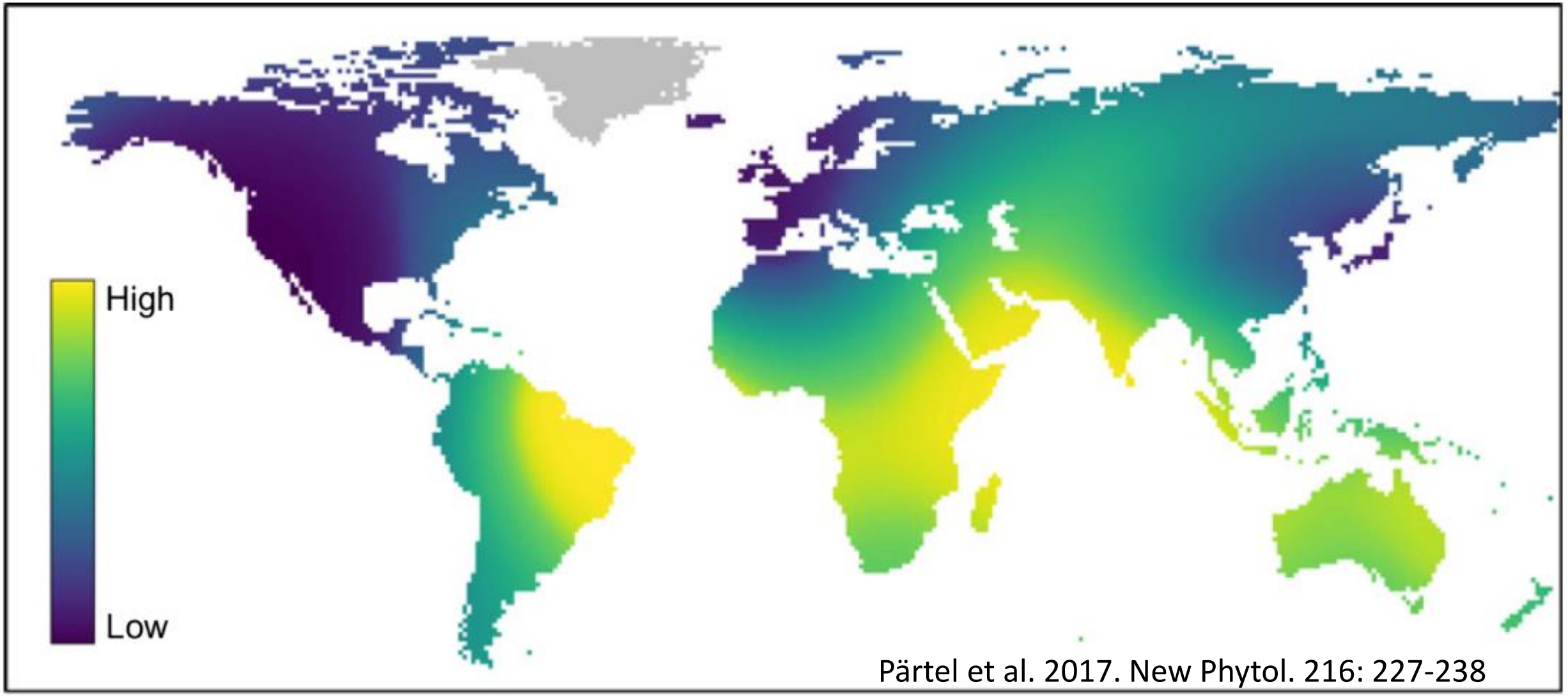


Abundance changes:

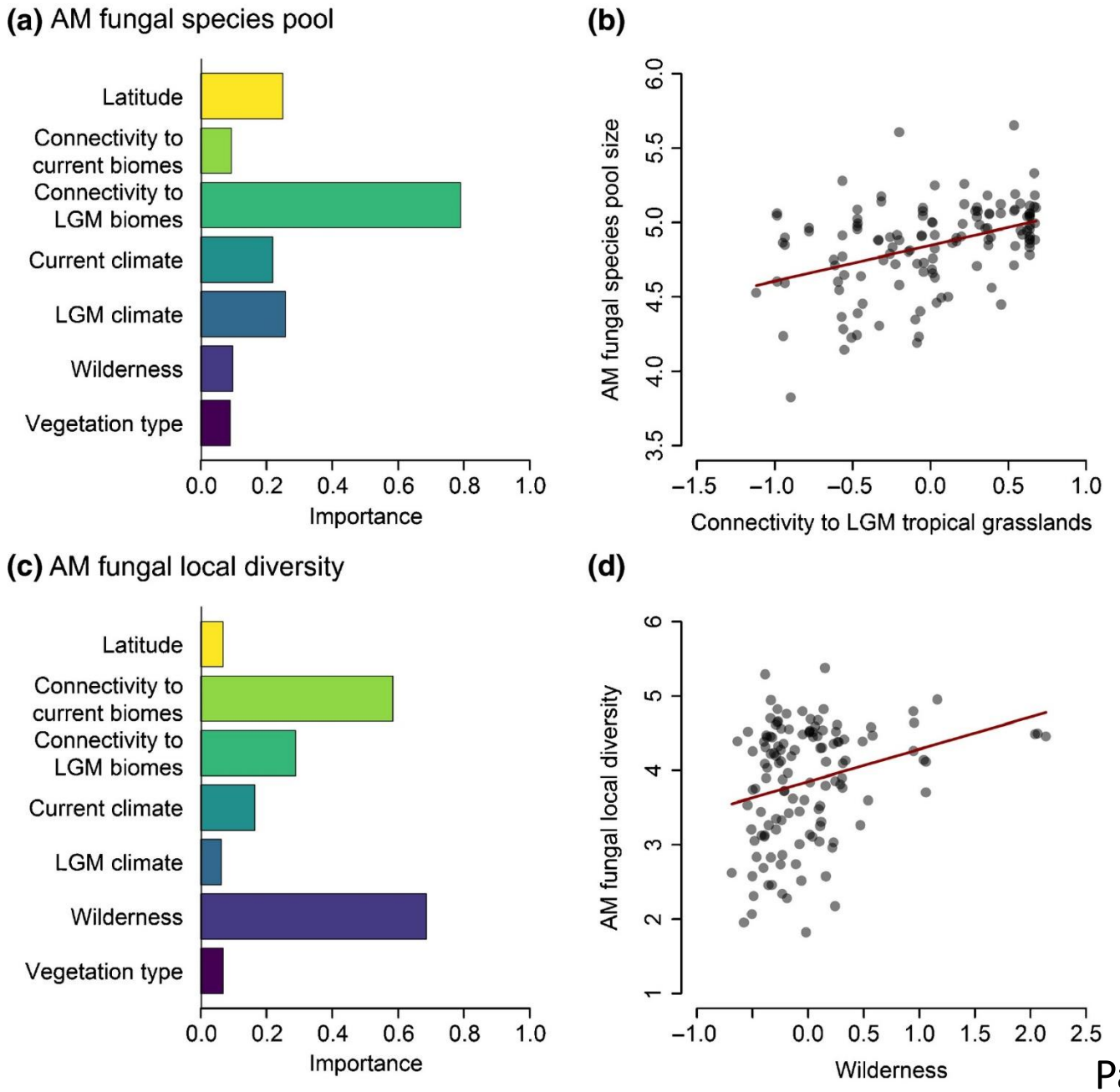
- Increases with minimal tillage
  - VT281 P laccatum
  - VT245 A trappei
  - VT444 Archaeospora sp
- Decreases with minimal tillage
  - VT65 R geosporum
  - VT306 Diversispora sp
  - VT67 F mosseae

AM fungal species pools

Species pool size patterns of AM fungi



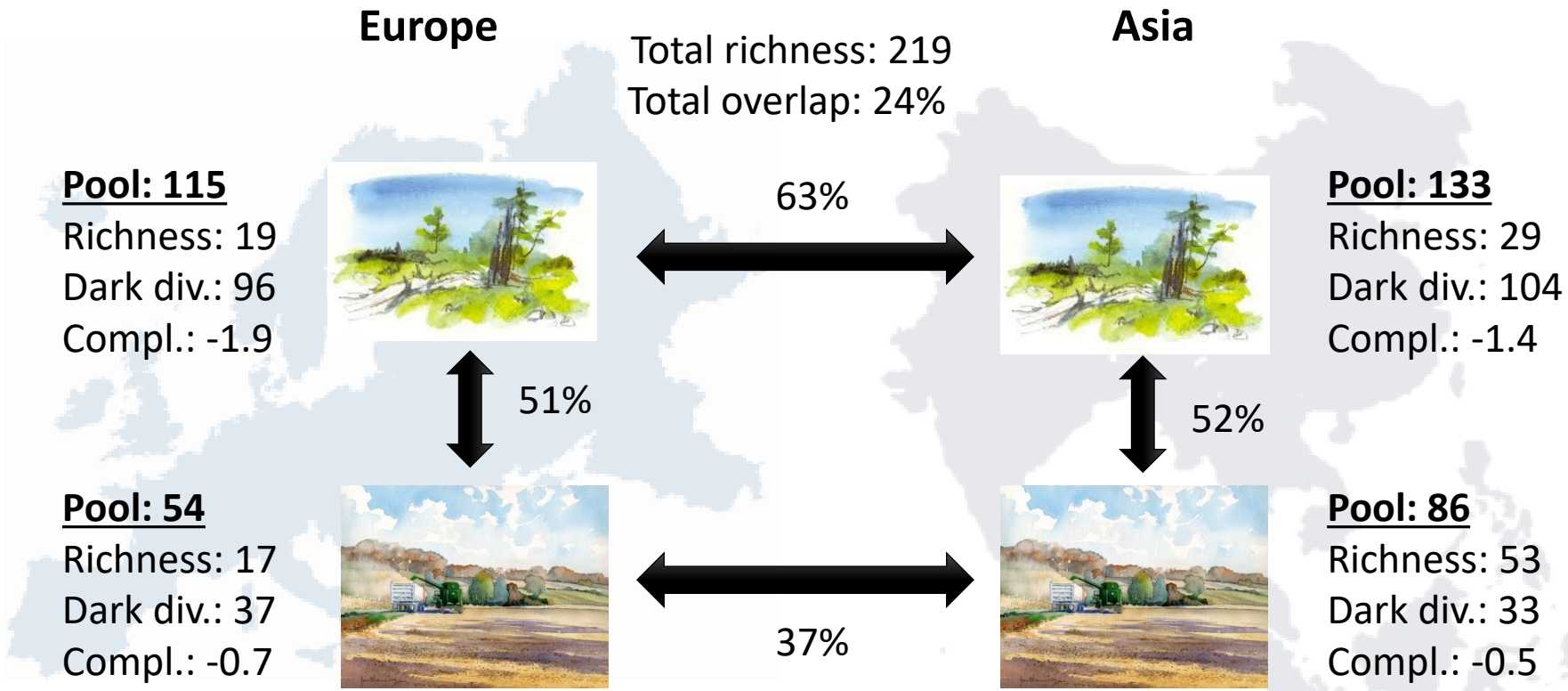
Pärtel et al. 2017. New Phytol. 216: 227-238



- **Species pool** = species that can potentially inhabit the site
- AMF **species pool** is mostly related to Last Glacial Maximum biomes (tropical grasslands) (=**historical predictors**)
- AMF **local diversity** is related to current biomes and wilderness (=**current predictors**)

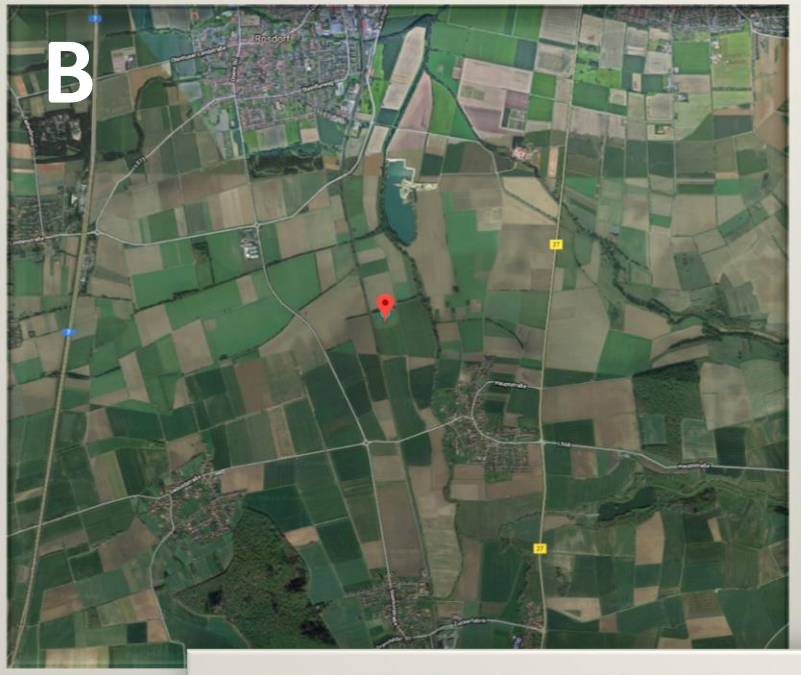
Pärtel et al. 2017. New Phytol. 216: 227-238

1. AMF species pool is higher in natural habitats
2. Largely different AMF in natural and agricultural habitats (small overlap of spp lists)



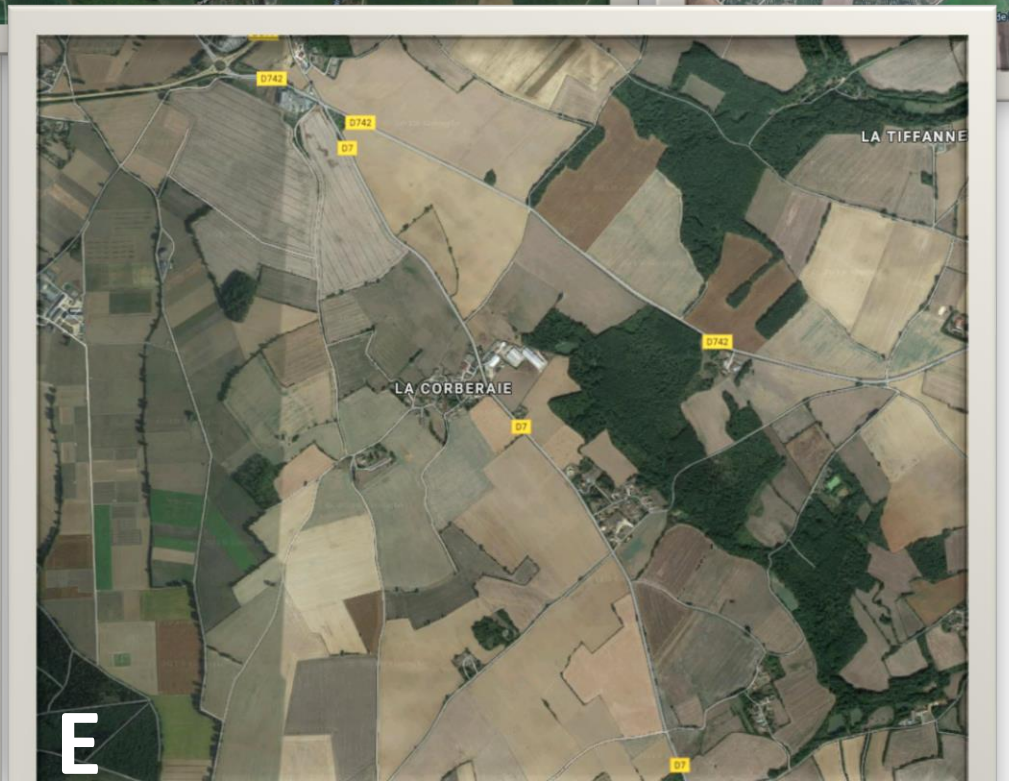
Öpik et al. In revision


A

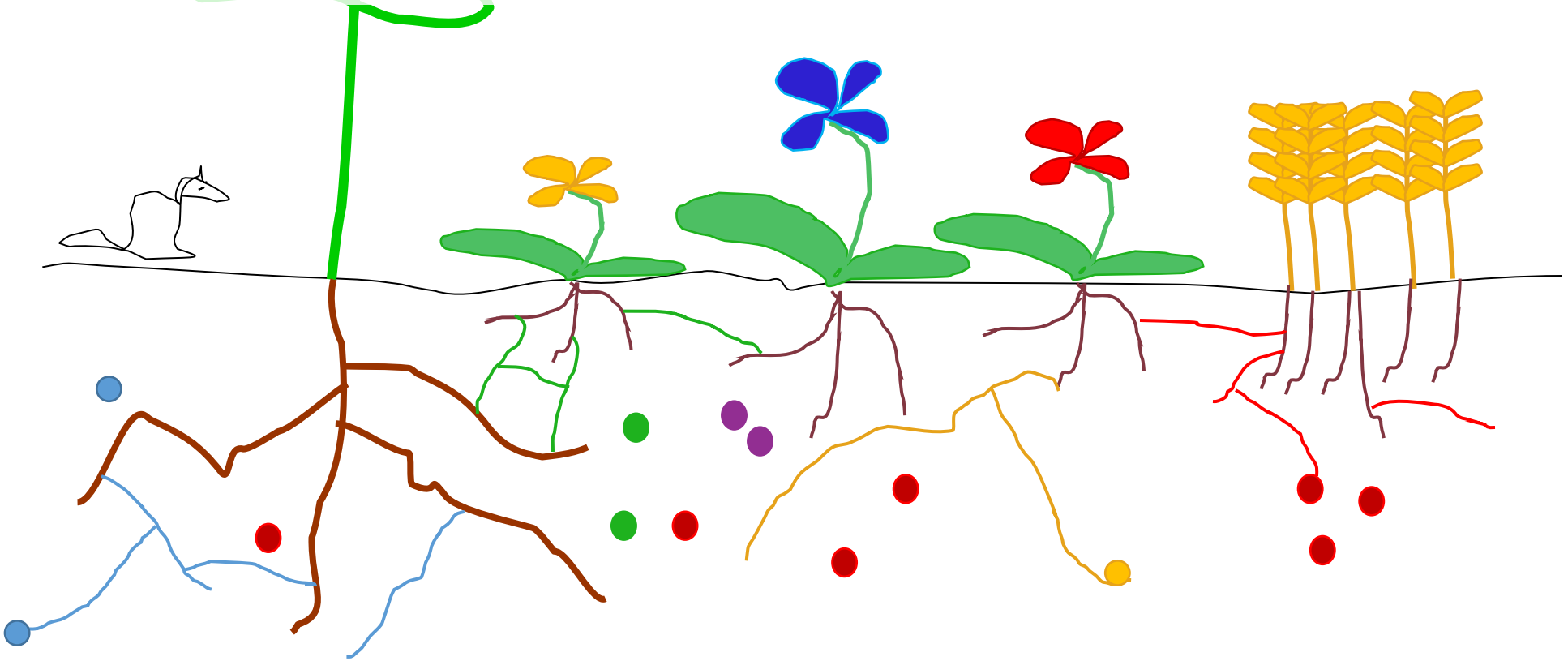

B


C


D


E
LA TIFFANNE
LA CORBERAIE
D742
D7

- Current land use practices shape AM fungal diversity somewhat differently in every country
- Historical biomes shape the potential diversity (species pool) of AM fungi
- Consider landscape context for sustainable management of soil biota (incl. for agricultural benefit)



Plant Ecology Laboratory (& co.), Tartu University:

SoilMan
Ecosystem services of soil biota in agriculture

Eesti Teadusagentuur
Estonian Research Council

TEADUSE TIPPKESKUS
ECOLCHANGE
CENTRE OF EXCELLENCE

biodiversa

New Phytologist Trust

European Union
European Regional Development Fund

Investing in your future

Martin Zobel, Mari Moora, Maarja Öpik
Guillermo Bueno, John Davison, Inga Hiiesalu, Kadri Koorem, Lena Neuenkamp, Claudia Paz
Maret Gerz, Daniela Leon, Siim-Kaarel Sepp, Tanel Vahter, Martti Vasar