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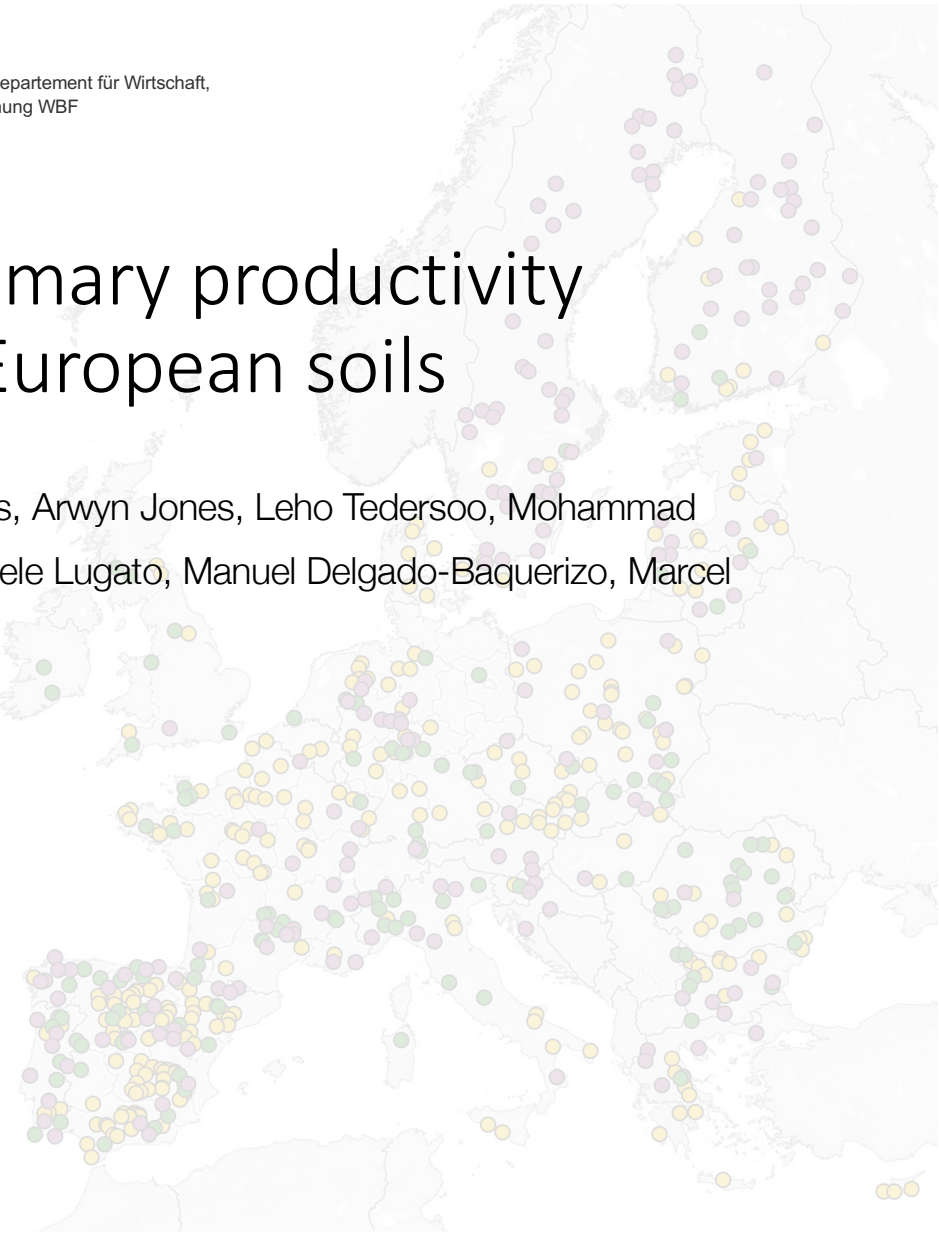
Agroscope

Microbial diversity promotes primary productivity across contrasting land uses in European soils

Ferran Romero, Maëva Labouyrie, Alberto Orgiazzi, Panos Panagos, Arwyn Jones, Leho Tedersoo, Mohammad Bahram, Gergely Tóth, Tamás Hermann, Cristiano Ballabio, Emanuele Lugato, Manuel Delgado-Baquerizo, Marcel van der Heijden

Plant-Soil Interactions group
Agroscope - Reckenholz (Zürich)

13.06.2023 Riga, Latvia

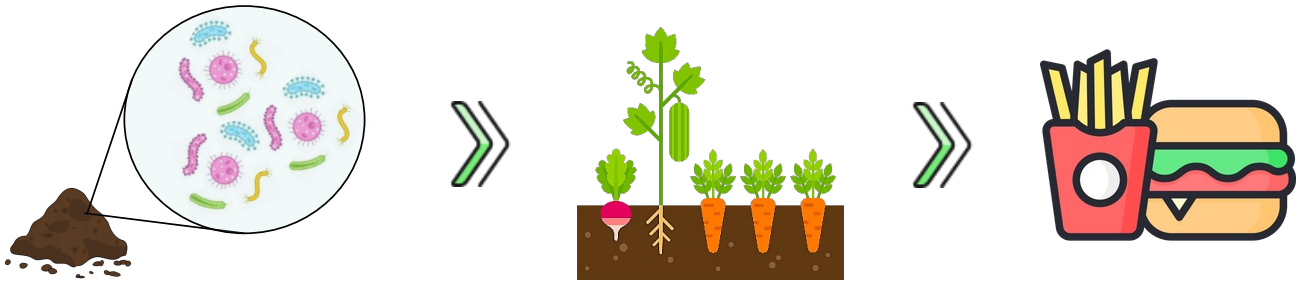


Background
Soil biodiversity and primary productivity

Soils are one of the main global reservoirs of **biodiversity**, including bacteria, archaea, fungi, protists, and other eukaryotes.

Soil microbial diversity is of outermost importance to keep **ecosystem functions** (nutrient cycling, primary production, decomposition…)

Ecosystem services such as food provisioning rely on these ecosystem functions



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Background
Soil biodiversity and primary productivity

ARTICLE

Received 25 Jun 2015 | Accepted 23 Dec 2015 | Published 28 Jan 2016 DOI: 10.1038/ncomms10541 OPEN

Microbial diversity drives multifunctionality in terrestrial ecosystems

Manuel Delgado-Baquerizo[1], Fernando T. Maestre[2], Peter B. Reich[1,3], Thomas C. Jeffries[1], Juan J. Gaitan[4], Daniel Encinar[2], Miguel Berdugo[2], Colin D. Campbell[5] & Brajesh K. Singh[1,6]

Received: 6 July 2016 | Accepted: 9 June 2017
DOI: 10.1111/1365-2435.12924

RESEARCH ARTICLE

Functional Ecology

Microbial richness and composition independently drive soil multifunctionality

Manuel Delgado-Baquerizo[1,2] | Pankaj Trivedi[1,3] | Chanda Trivedi[1] | David J. Eldridge[4] | Peter B. Reich[1,5] | Thomas C. Jeffries[1] | Brajesh K. Singh[1,6]

ARTICLE

https://doi.org/10.1038/s41467-019-12798-y OPEN

Fungal-bacterial diversity and microbiome complexity predict ecosystem functioning

Cameron Wagg[1,2,3*], Klaus Schlaeppi[1,4], Samiran Banerjee[1], Eiko E. Kuramae[5] & Marcel G.A. van der Heijden[1,6*]

ARTICLES
https://doi.org/10.1038/s41559-022-01756-5
nature ecology & evolution
Check for updates

Phylotype diversity within soil fungal functional groups drives ecosystem stability

Shengen Liu[1,2,3], Pablo García-Palacios[4], Leho Tedersoo[5,6], Emilio Guirado[7,8], Marcel G. A. van der Heijden[9,10], Cameron Wagg[11], Dima Chen[1], Qingkui Wang[3,12], Juntao Wang[13], Brajesh K. Singh[13,14] and Manuel Delgado-Baquerizo[2,15] ✉

Studies to date addressing B-PP at a large scale have mostly covered natural or semi-natural ecosystems (woodlands, grasslands, shrublands…)

Background
Soil biodiversity and primary productivity

Plant Soil
https://doi.org/10.1007/s11104-022-05853-z

RESEARCH ARTICLE

Land use intensity constrains the positive relationship between soil microbial diversity and multifunctionality

Jiyu Jia · Jiangzhou Zhang · Yizan Li · Muxi Xie · Guangzhou Wang · Junling Zhang

Contents lists available at ScienceDirect
Geoderma
journal homepage: www.elsevier.com/locate/geoderma

Land-use- and climate-mediated variations in soil bacterial and fungal biomass across Europe and their driving factors

José A. Siles [a,*], Alfonso Vera [a], Marta Díaz-López [a], Carlos García [a], Johan van den Hoogen [b], Thomas W. Crowther [b], Nico Eisenhauer [c,d], Carlos Guerra [c,e], Arwyn Jones [f], Alberto Orgiazzi [f], Manuel Delgado-Baquerizo [g,h], Felipe Bastida [a]

Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv

Soil microbial biodiversity promotes crop productivity and agro-ecosystem functioning in experimental microcosms

Ferran Romero [a,*], Sarah Hilfiker [a], Anna Edlinger [a], Alain Held [a], Kyle Hartman [a], Maëva Labouyrie [a,b,c], Marcel G.A. van der Heijden [a,b,**]

Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv

Responses of soil microbial diversity, network complexity and multifunctionality to three land-use changes

Yi Yang [a], Yabo Chai [a], Hanjie Xie [a], Lu Zhang [b], Zhiming Zhang [c], Xue Yang [a], Shenglei Hao [a], Jingping Gai [a,*], Yongliang Chen [a,*]

Contents lists available at ScienceDirect
Applied Soil Ecology
journal homepage: www.elsevier.com/locate/apsoil

Agricultural intensification weakens soil multifunctionality by reducing fungal diversity

Rui Xue, Chong Wang [*], Lei Zhao, Jia Cao, Mengli Liu, Dong Zhang

College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, PR China
Beijing Key Laboratory of Biodiversity and Organic Farming, Beijing 100193, PR China

B-PP relationships seem to be also important in disturbed ecosystems (e.g., croplands) …
local-scale studies / greenhouse experiments

Research question

How does soil biodiversity relate to primary productivity across contrasting land use types at the continental scale?

Materials & Methods

Continental-scale survey (2018)

Dataset: LUCAS (Land Use/Cover survey European Commission, every 3 years)

589 sampling sites:
186 woodlands
126 grasslands
277 croplands

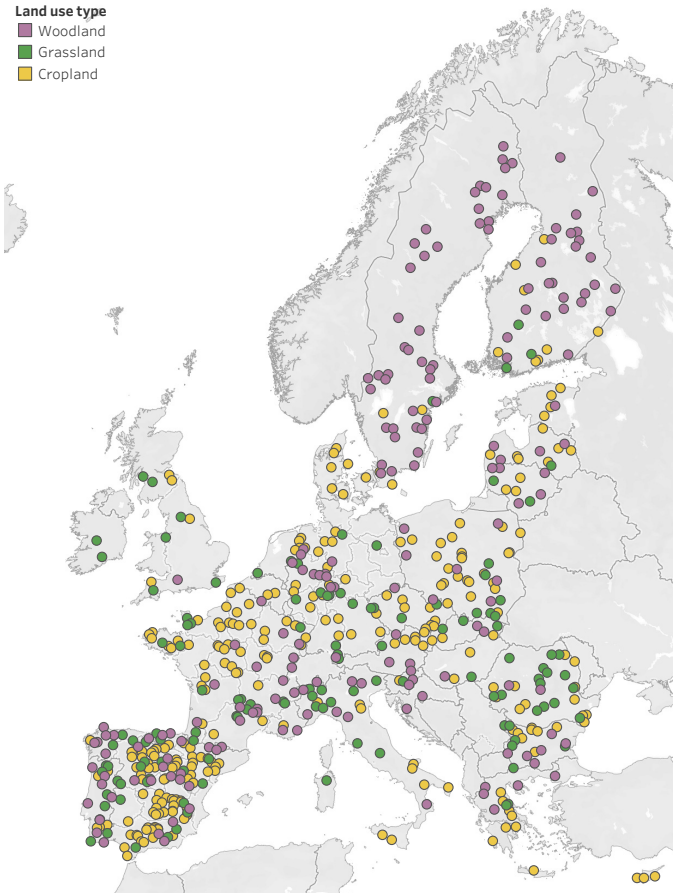
Predictor variables:

Spatial factors: GPS position, altitude

Climatic factors: air temperature, precipitation, aridity

Edaphic factors: microbial biomass, pH, phosphorus, nitrogen, organic carbon, bulk density, soil texture

Soil biodiversity: bacteria, fungi



Map by: Joan Muñoz-Liesa
Universitat Autònoma de Barcelona

Materials & Methods

nature communications

Article

https://doi.org/10.1038/s41467-023-37937-4

Patterns in soil microbial diversity across Europe

Received: 25 August 2022

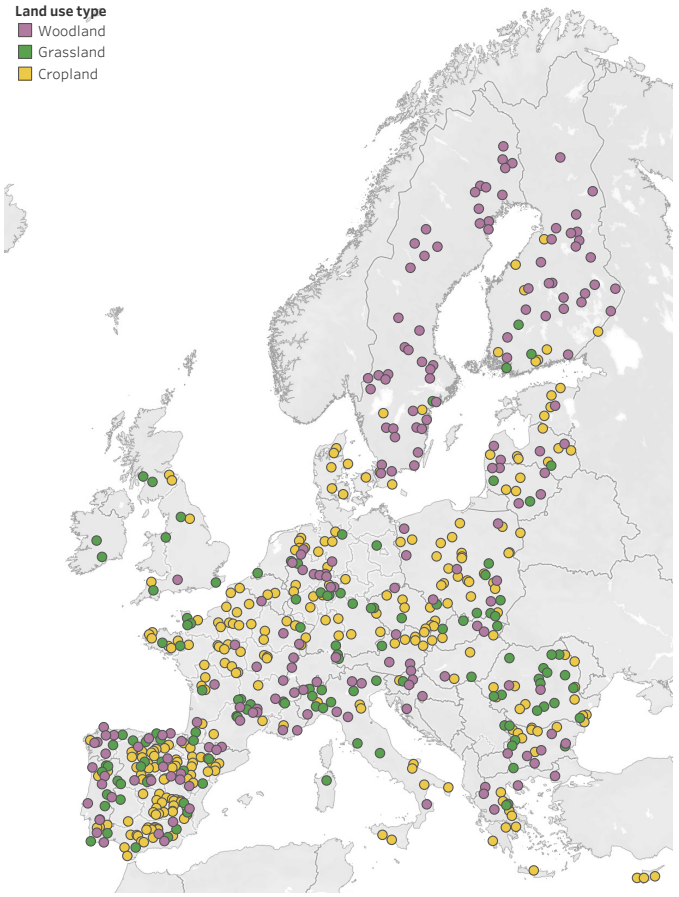
Accepted: 6 April 2023

Published online: 08 June 2023

Maëva Labouyrie[1,2,3], Cristiano Ballabio[2], Ferran Romero[3], Panos Panagos[2], Arwyn Jones[2], Marc W. Schmid[4], Vladimir Mikryukov[5,6], Olesya Dulya[5,6], Leho Tedersoo[5], Mohammad Bahram[6,7], Emanuele Lugato[2], Marcel G. A. van der Heijden[1,3] & Alberto Orgiazzi[2]

Impact of land use on microbial co-occurrence networks

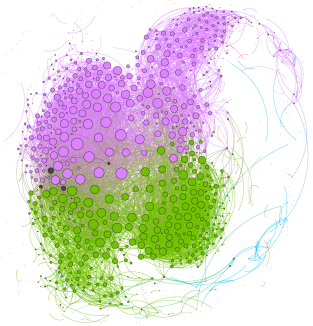
Relationship between soil microbial diversity and primary productivity (Sentinel-2, ESA)



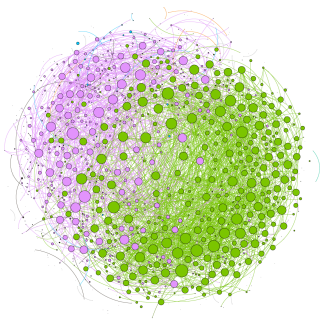
Map by: Joan Muñoz-Liesa
Universitat Autònoma de Barcelona

Results: co-occurrence networks

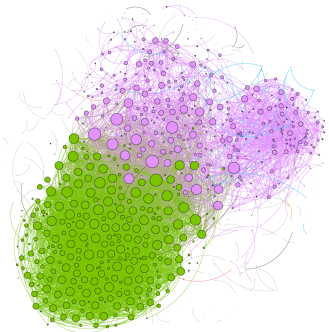
Bacterial co-occurrence networks



CROPLANDS	
Nodes	1258
Edges	40405
Keystone taxa	293



GRASSLANDS	
Nodes	1405
Edges	44414
Keystone taxa	297



WOODLANDS	
Nodes	1142
Edges	31962
Keystone taxa	233

Small effect of land use on bacterial co-occurrence networks (although less connectivity in woodlands)

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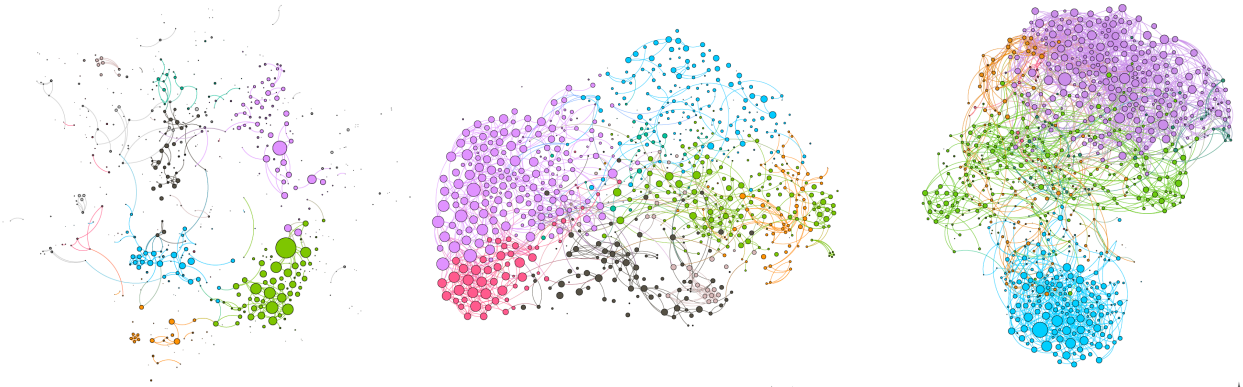
Results: co-occurrence networks

Fungal co-occurrence networks



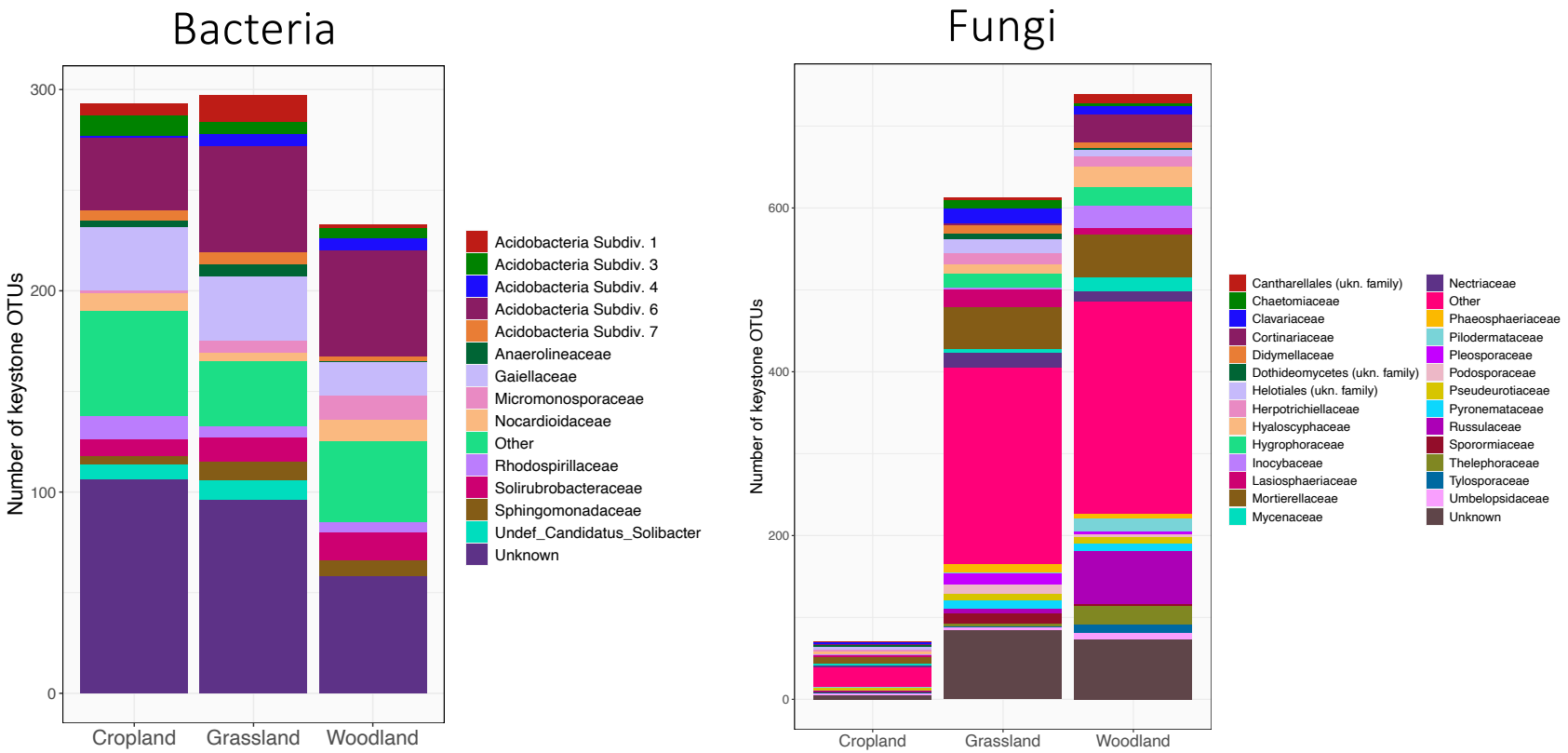
CROPLANDS	
Nodes	652
Edges	1649
Keystone taxa	70

GRASSLANDS	
Nodes	806
Edges	6629
Keystone taxa	613

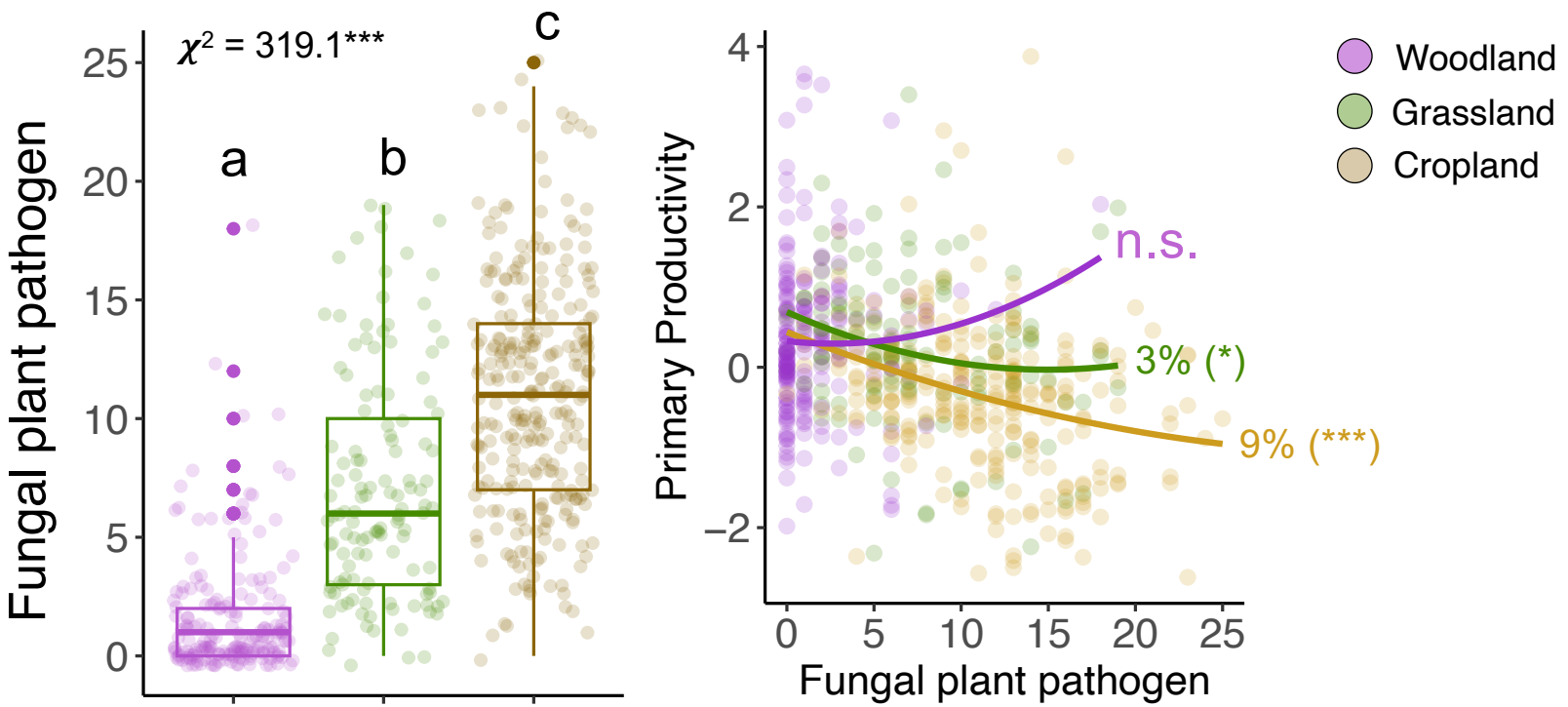
WOODLANDS	
Nodes	822
Edges	8809
Keystone taxa	740

Croplands → decreased fungal network complexity and number of identified keystone taxa

Results: keystone taxa



Results: biodiversity vs. primary productivity



Pathogens were specially abundant in croplands, where they negatively correlated to plant productivity

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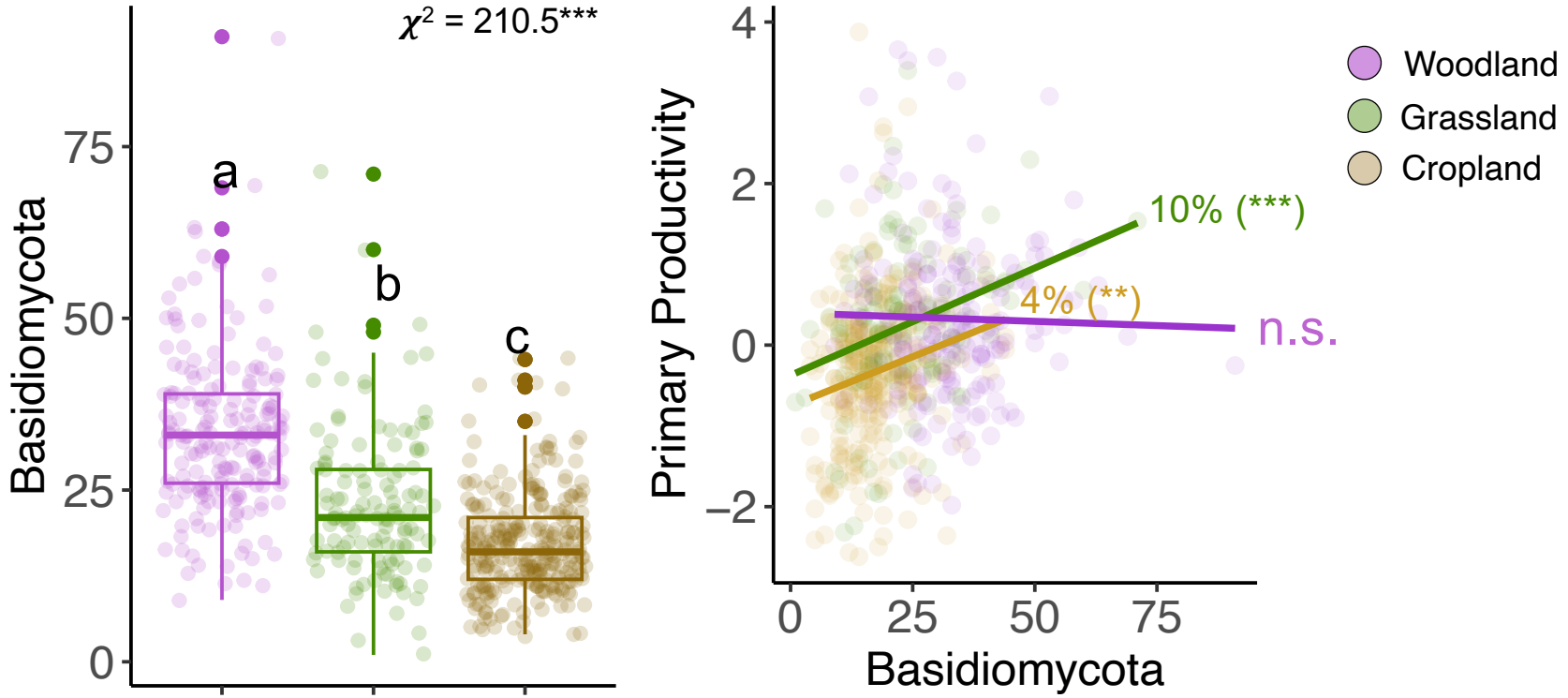
Results: biodiversity vs. primary productivity



Basidiomycota were more abundant in woodlands; they positively correlated to plant productivity in grasslands, and croplands.

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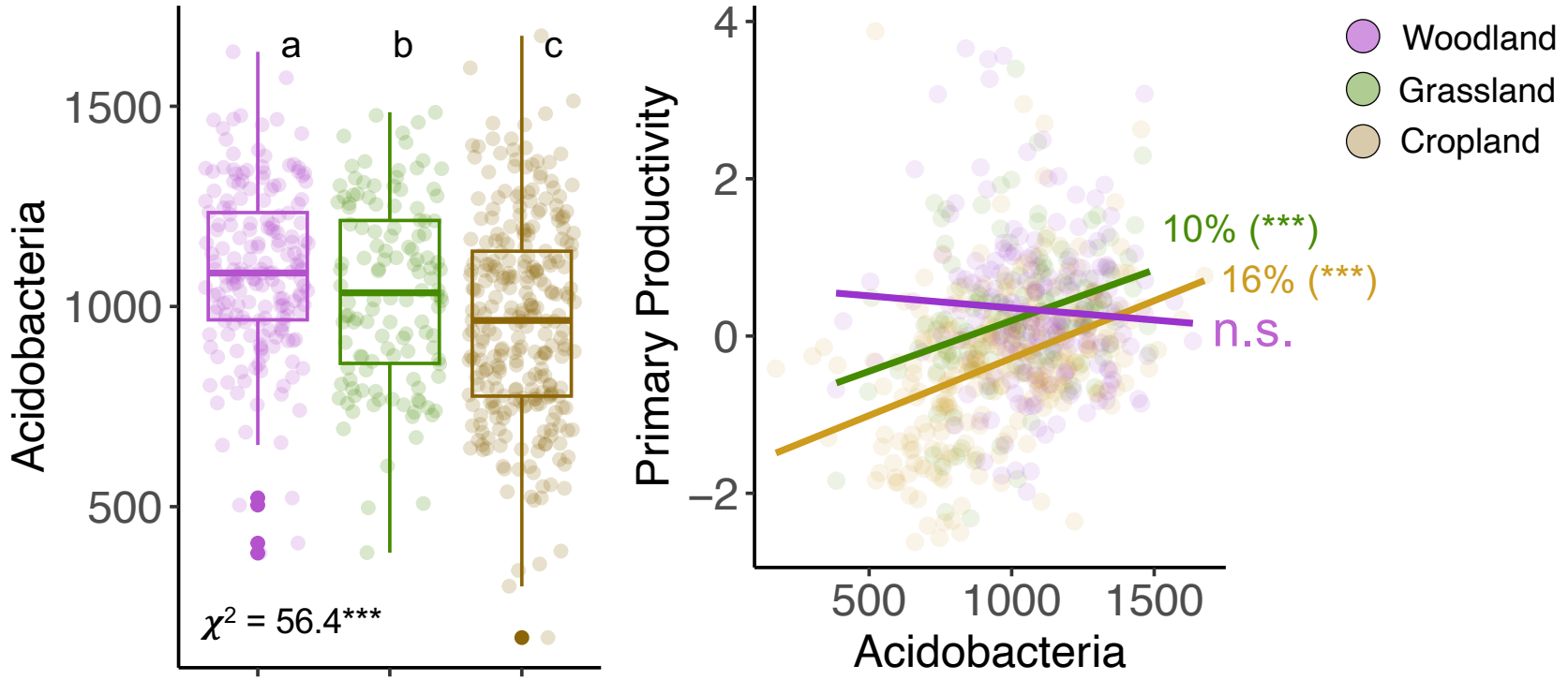
Results: biodiversity vs. primary productivity



Acidobacteria were more abundant in woodlands; they positively correlated to plant productivity in grasslands, and croplands.

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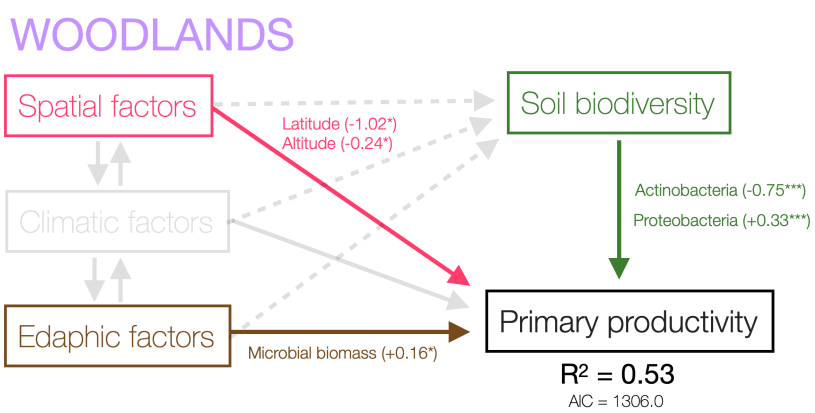
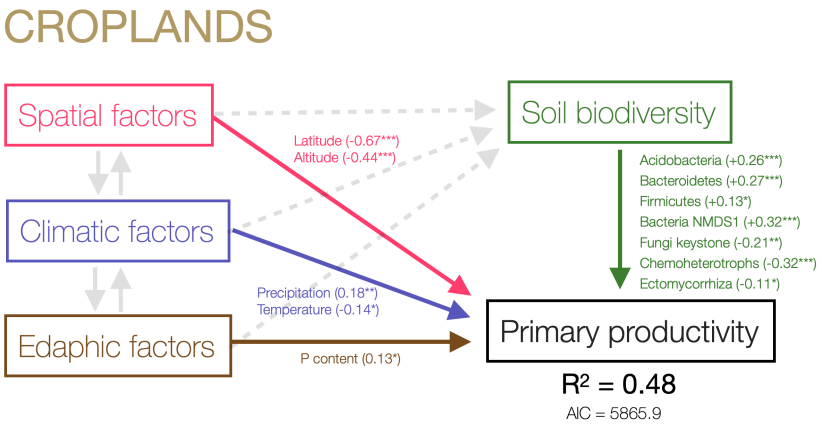
Results: biodiversity vs. primary productivity





The combination of spatial, climatic, and edaphic factors, together with soil biodiversity, explained ≈50% of the variation in primary productivity.

Conclusions

We surveyed biotic and abiotic variables across 589 sites across Europe. This included all major land use types and climatic regions

Natural and semi-natural sites (grasslands and woodlands) displayed higher microbial network complexity and connectivity than more disturbed sites (croplands) Fungal keystone taxa were much more abundant in woodlands and grasslands than in croplands → effect of agricultural practices?

Specific microbial groups related to primary productivity across contrasting land use types (Acidobacteria and fungal plant pathogens in croplands, Actinobacteria in woodlands, Basidiomycota in grasslands…)

Soil biodiversity explained unique variation in primary productivity patterns at the continental scale

The combination of spatial, climatic, and edaphic factors, together with soil biodiversity, explained ≈50% of the variation in primary productivity.

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Next steps…

nature communications

Article

https://doi.org/10.1038/s41467-023-37937-4

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Impact of land use on microbial co-occurrence networks

Relationship between soil microbial diversity and primary productivity

Relationship between soil microbial diversity and multifunctionality

Special thanks
Maëva Labouyrie (University of Zurich)
Plant-Soil interactions group (Agroscope)
EJP Soil – MINOTAUR
Alberto Orgiazzi, Cristiano Ballabio - JRC (Italy)

Thank you!
Vielen dank / Merci beaucoup

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