# BEeS

## The LifeWatch ERIC Biodiversity & Ecosystem eScience Conference

LifeWatch ERIC

Heraklion, 30 June - 3 July 2025

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LifeWatch ERIC

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iMBBC ΙΘΑΒΒΥΚ

# Session: Biodiversity Observatory: Smart Systems for a Living Planet Revolutionising Biodiversity Monitoring with Automation

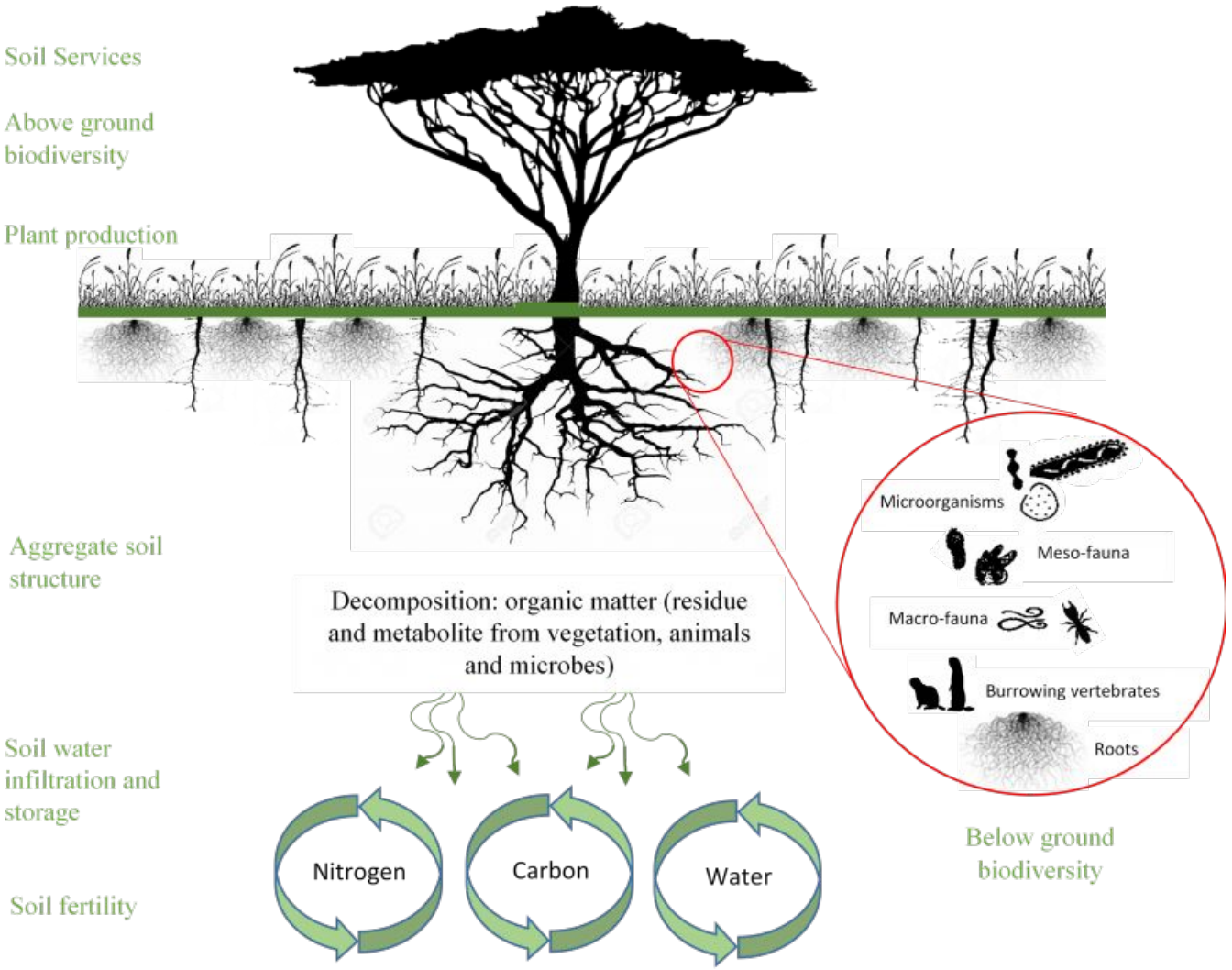
2 July 2025 | 11:30-13:00

# Integrating Earth Observations, eDNA and Computer Vision for automated assessment of soil health

*Presenter: Spyros Theodoridis*

Dimitris Bormpoudakis, Charalampos Kontoes
BEYOND Centre of Excellence, National Observatory of Athens

# Soil biodiversity: a key component of ecosystem health




iucn.org

Microbial diversity drives multifunctionality in terrestrial ecosystems

*Nature Communications 2016*

Fungal-bacterial diversity and microbiome complexity predict ecosystem functioning

*Nature Communications 2024*

# An ever increasing interest in soil biodiversity

BIOGEOGRAPHY

**A global atlas of the dominant bacteria found in soil**

*Science 2018*

Global analysis of soil bacterial genera and diversity in response to pH

*Soil Biology and Biochemistry 2024*

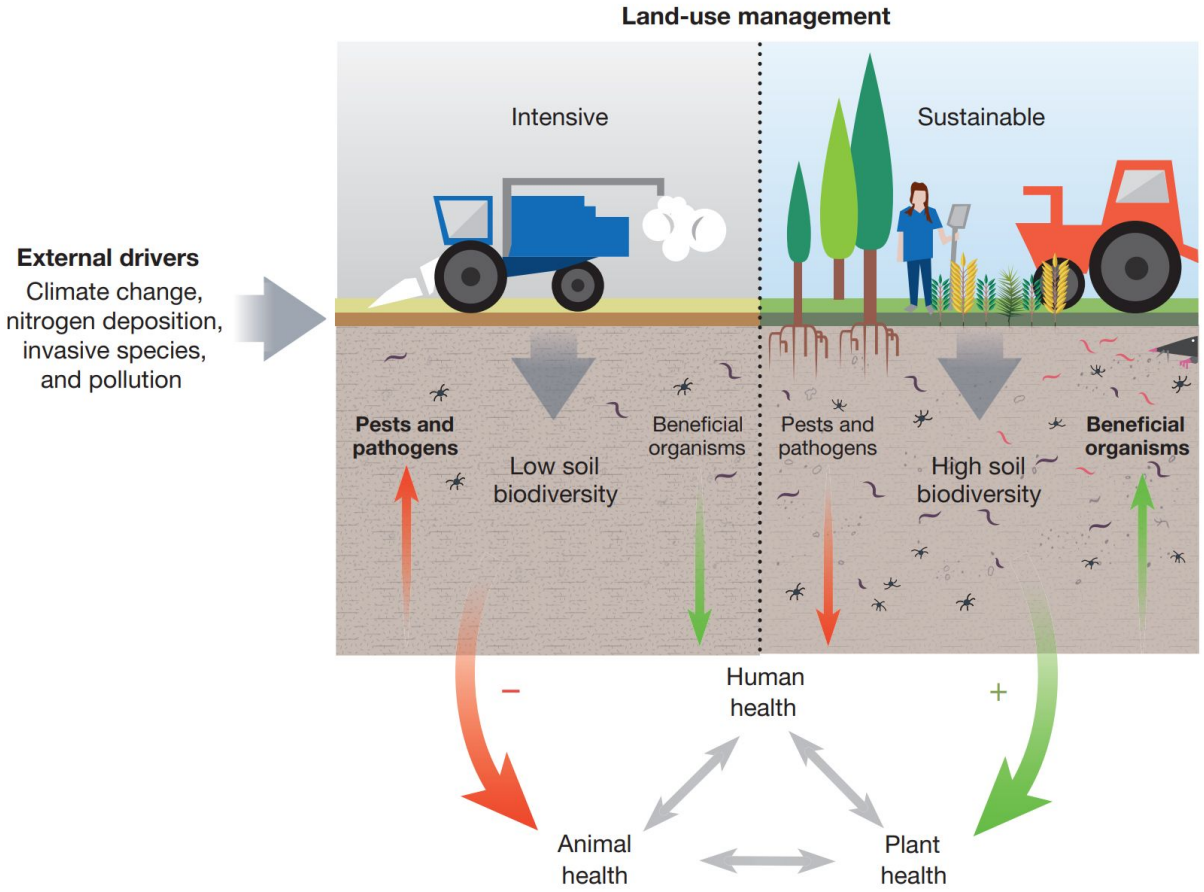
**Soil health is associated with higher primary productivity across Europe**

*Nature Ecology & Evolution 2024*

**Patterns in soil microbial diversity across Europe**

*Nature Communications 2024*

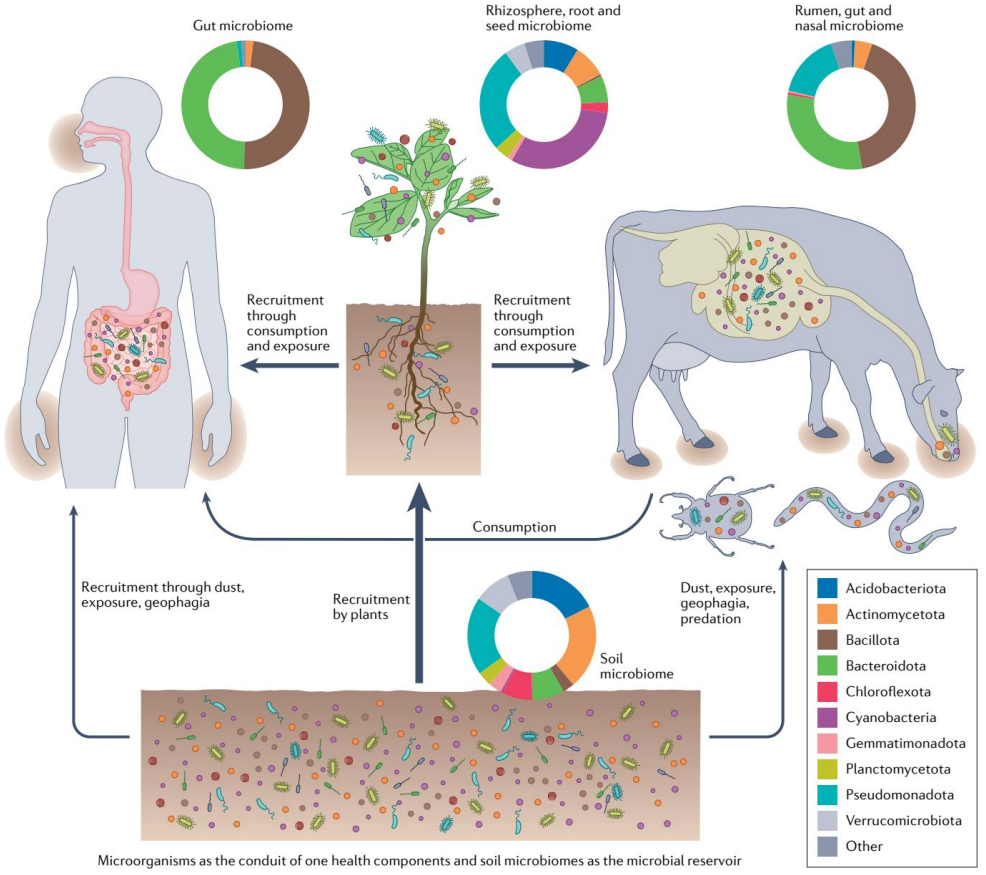
# Soil biodiversity: a key component of human health




## Soil biodiversity and human health

Diana H. Wall[1]*, Uffe N. Nielsen[2]* & Johan Six[3]*

*Nature 2015*

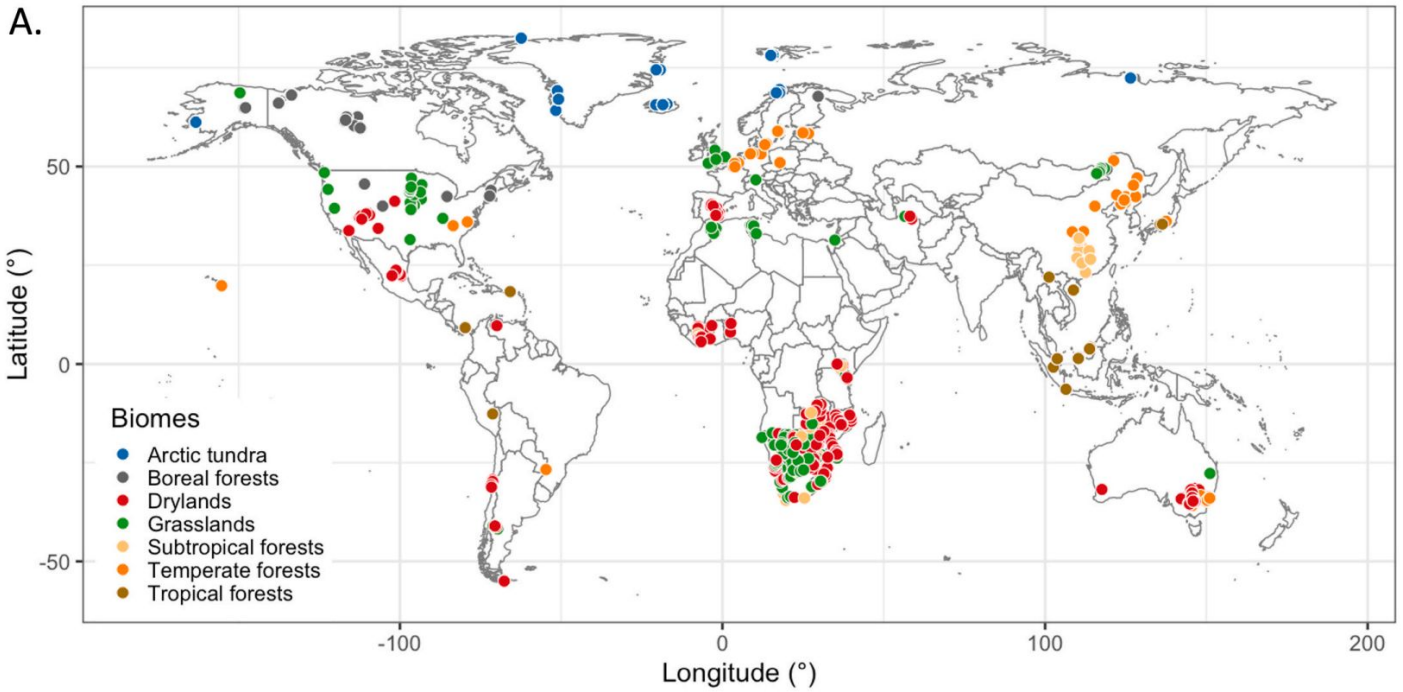


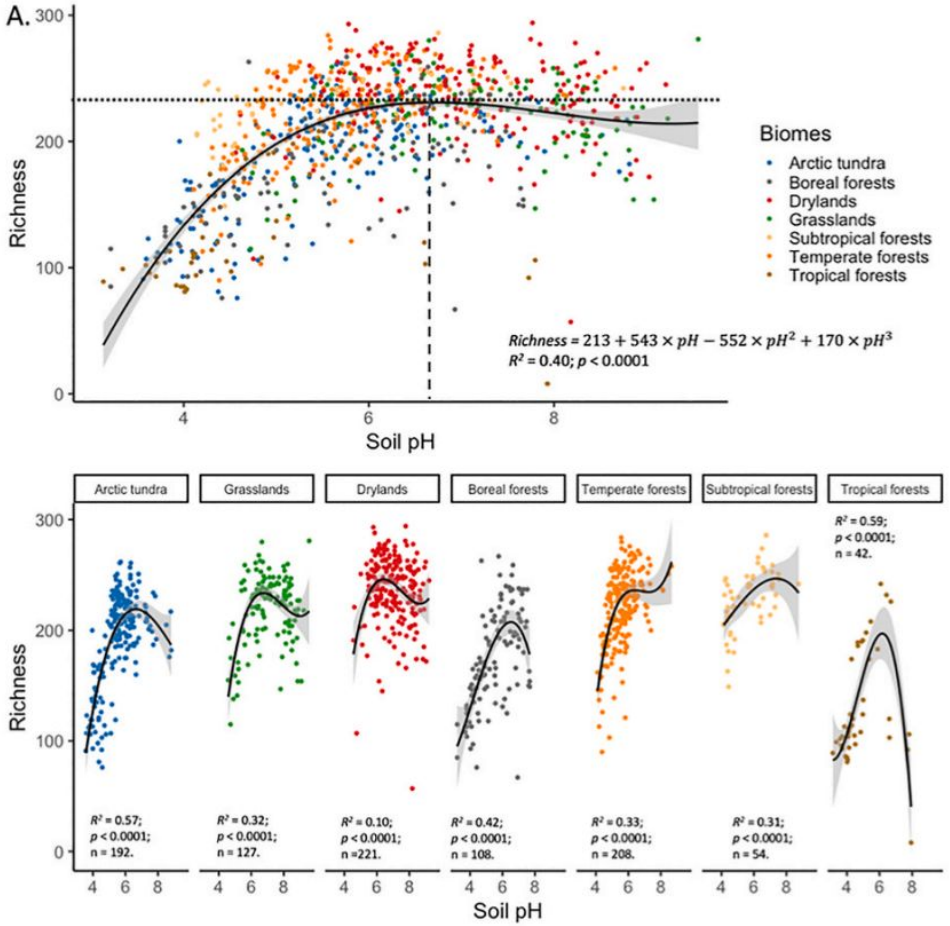

Microorganisms as the conduit of one health components and soil microbiomes as the microbial reservoir

## Soil microbiomes and one health

*Nature Reviews Microbiology 2022*

# Soil biodiversity: predictions

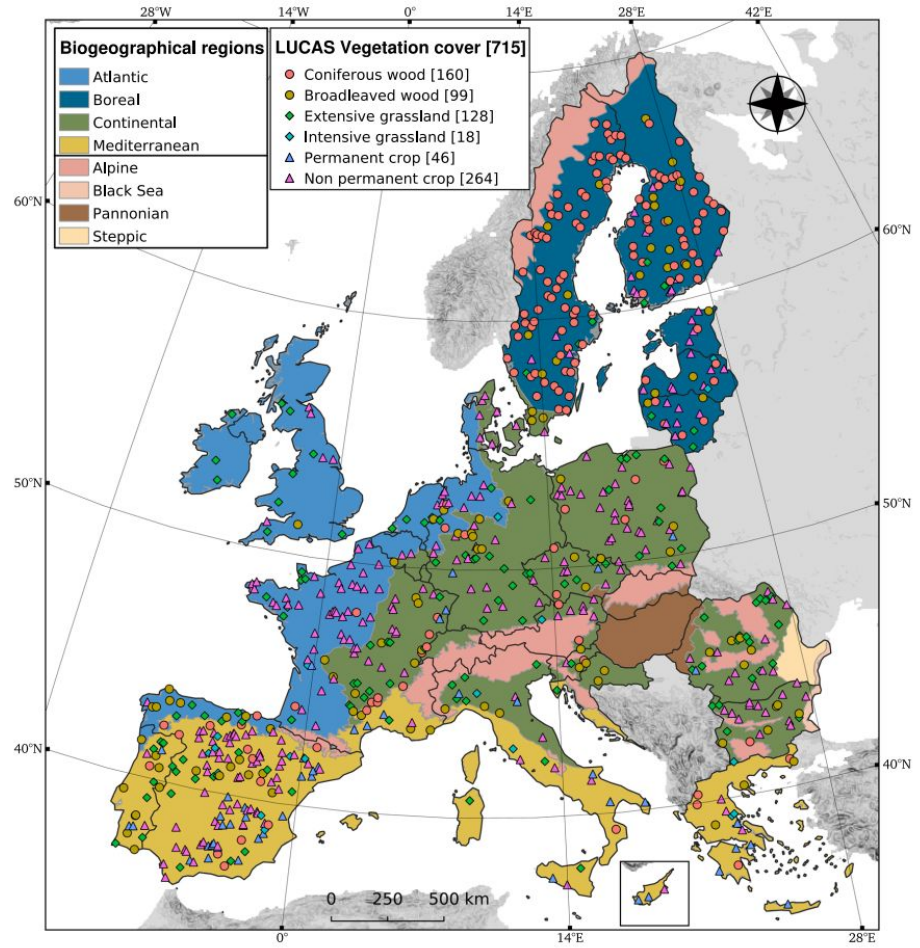


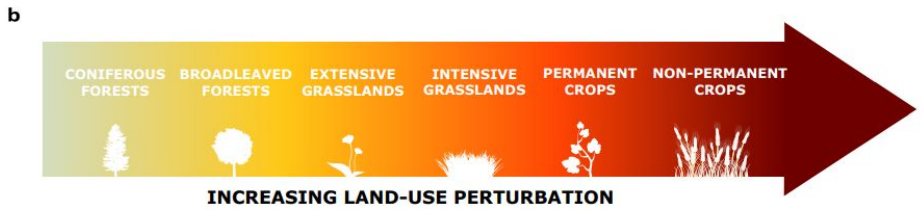



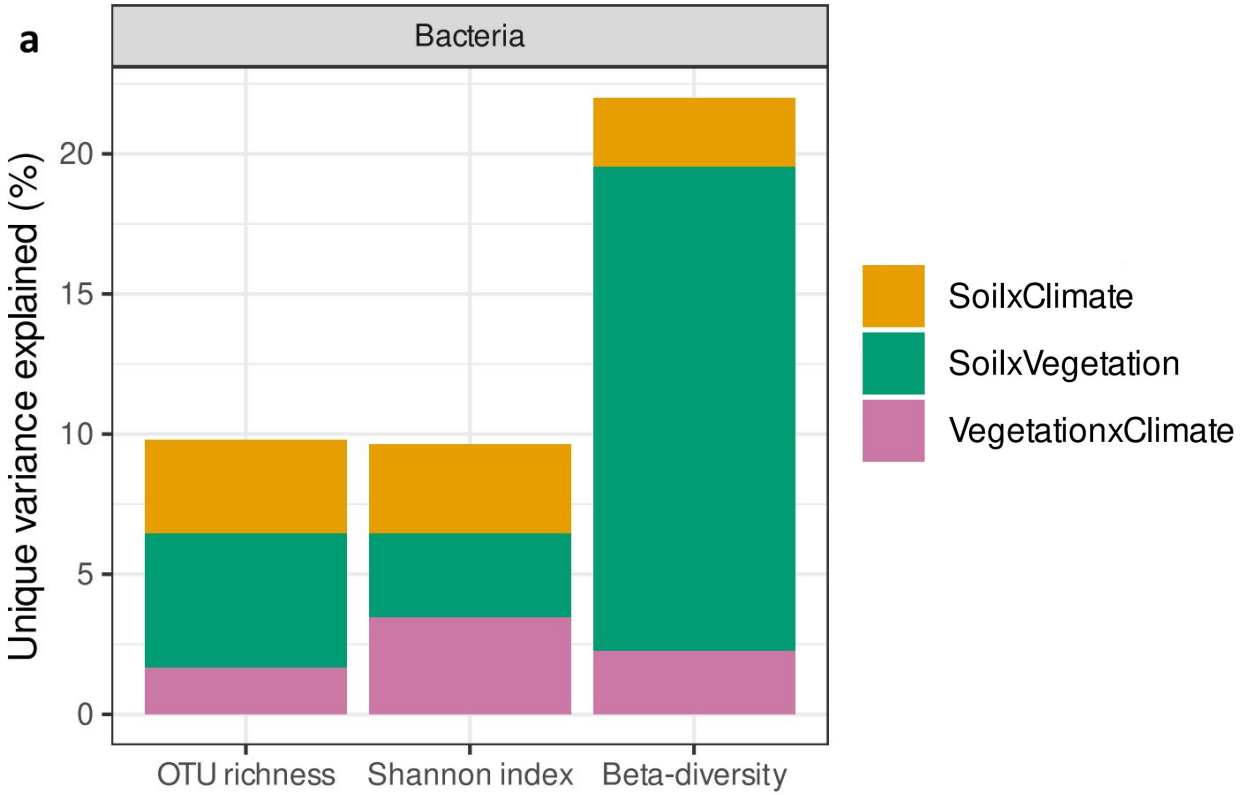

Global analysis of soil bacterial genera and diversity in response to pH

*Soil Biology and Biochemistry 2024*

# Soil biodiversity: predictions



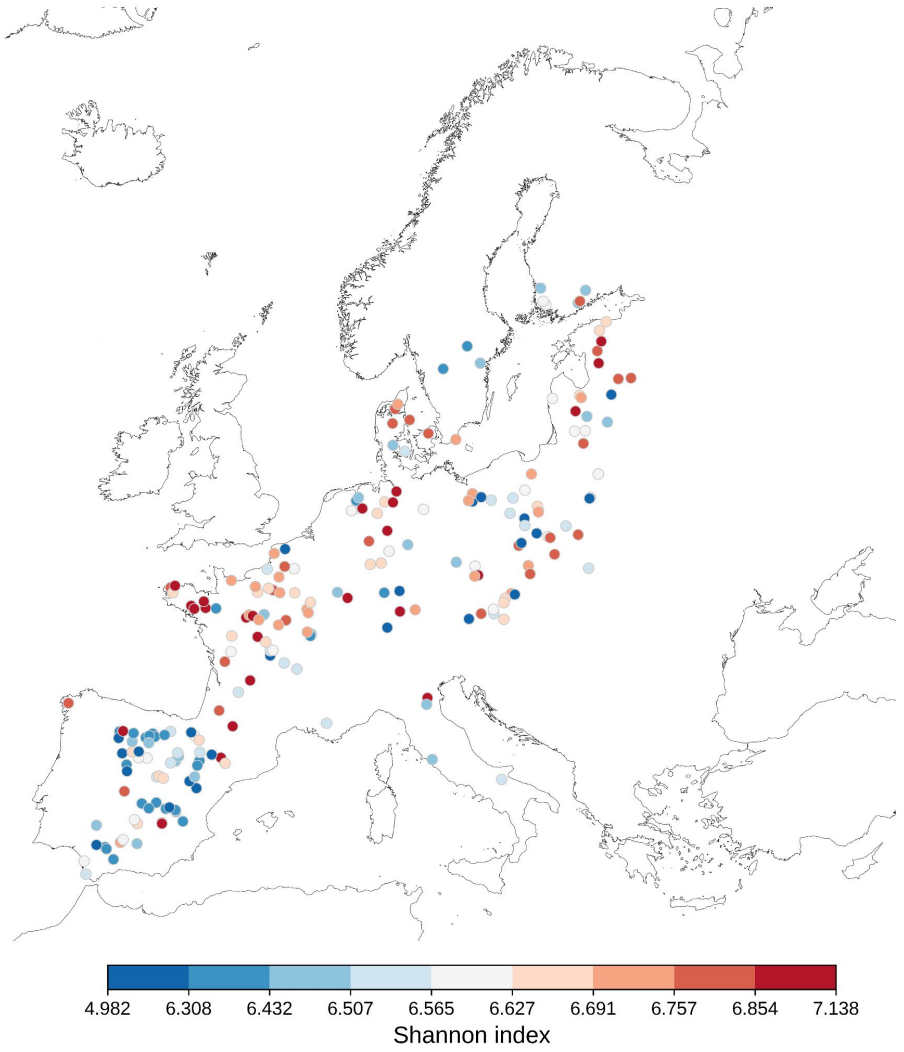




Eurostat's 2018 pan-European LUCAS Soil module

**Patterns in soil microbial diversity across Europe**

*Nature Communications 2024*

# Soil biodiversity: predictions using satellites




- **214** cropland soil samples collected in the context of Eurostat's 2018 pan-European LUCAS Soil module
- **12** spectral indices from Sentinel-2 images (point estimates)
- Predicted alpha diversity (Shannon) $R^2 \approx 0.11$

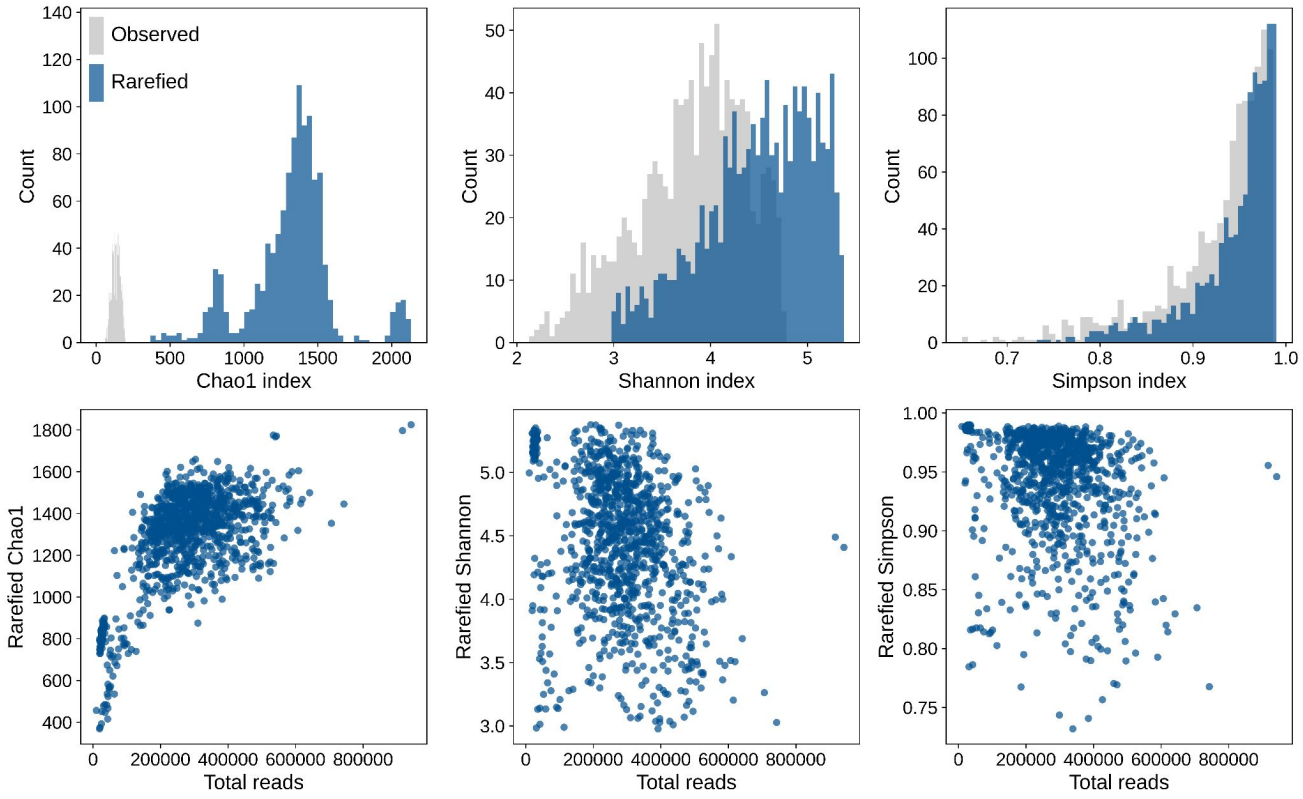
Predicting Bacterial Diversity in European croplands Using Earth Observation and Meteorological Data

Dimitrios Bormpoudakis, Pablo Sánchez-Cueto, Soraya González Sánchez, Spyros Theodoridis, Maëva Labouyrie, Alberto Orgiazzi, Panos Panagos, Arwyn Jones, Salvador Lladó, Martin Hartmann, Charalampos Kontoes

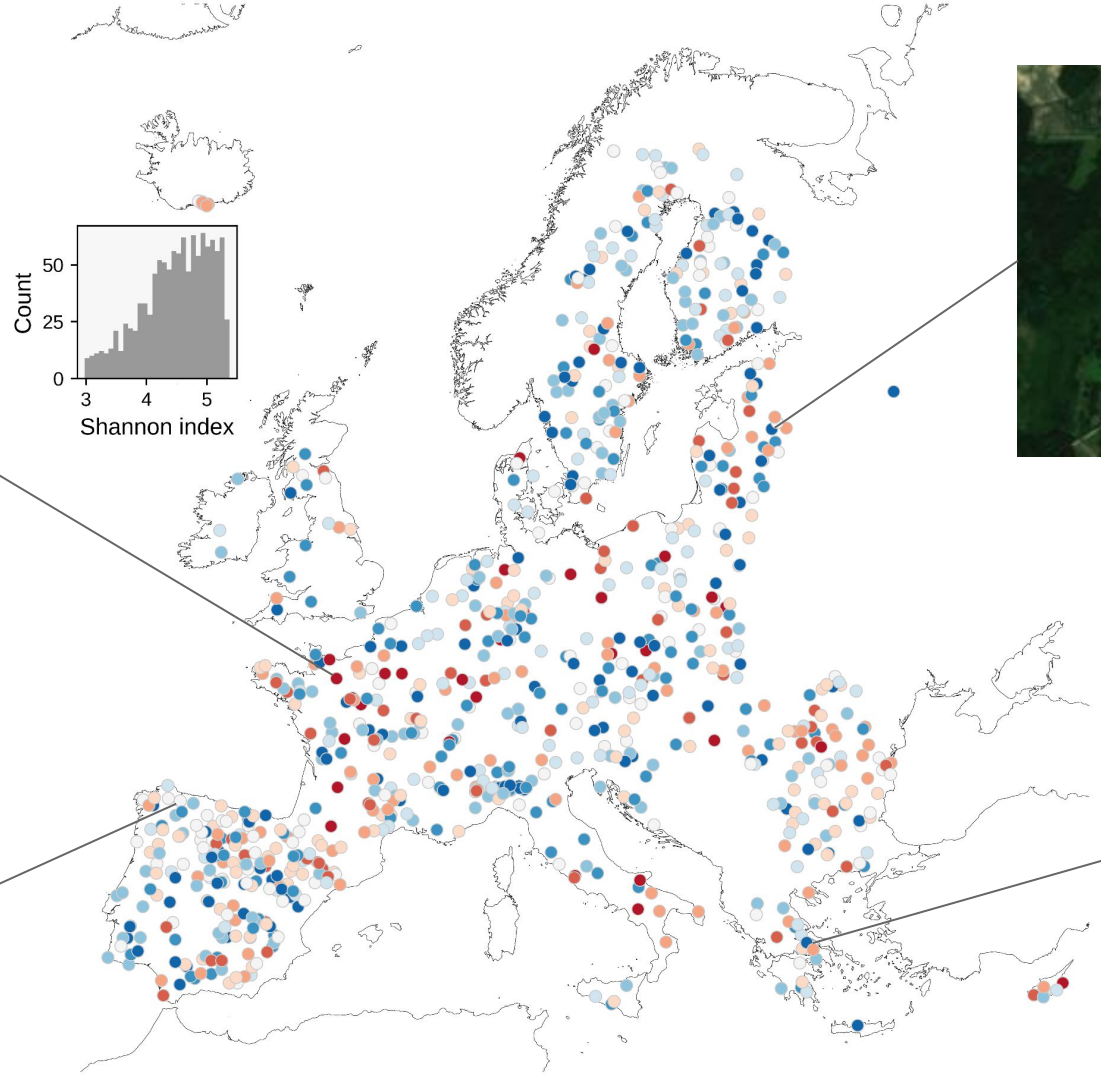
# Soil biodiversity: diversity observations

- Soil (max 50 cm depth) DNA sequences for ~**1'100** localities downloaded and reanalysed with custom bioinformatic pipelines and rarefied at 10'000 DNA reads

- The majority of observations (~750) were produced within Eurostat's 2018 pan-European LUCAS Soil module



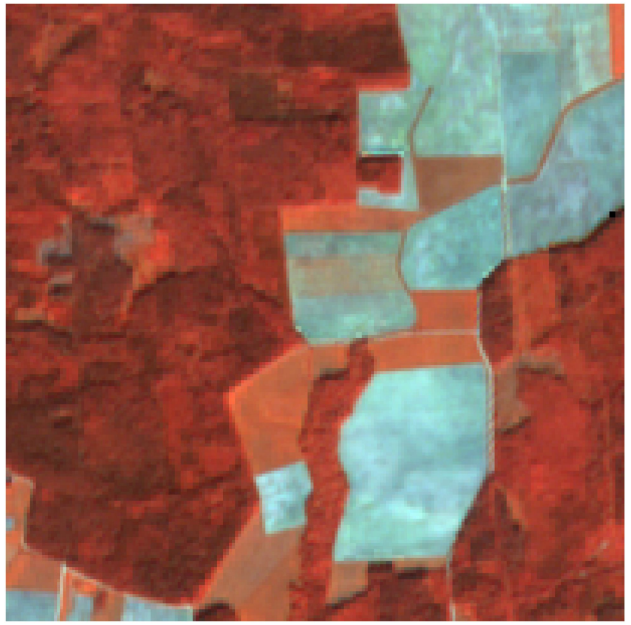
# Soil biodiversity: satellite observations



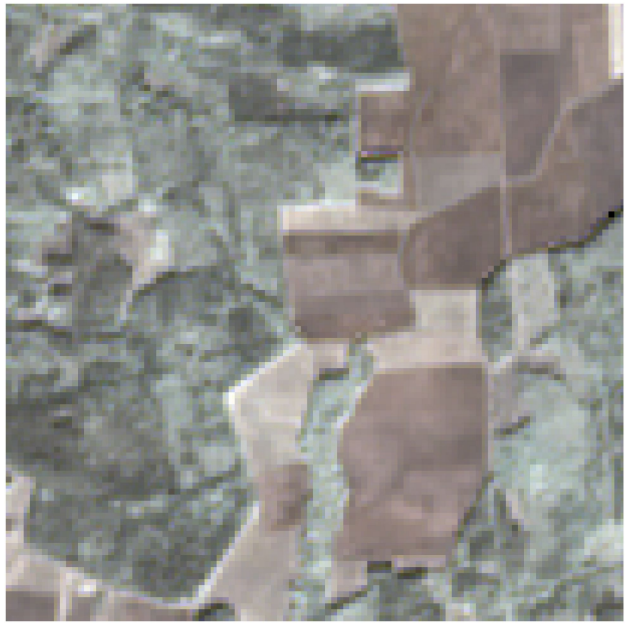
# Soil biodiversity: Sentinel 2 spectral bands as images

**Red (B4)**: 0.655 µm
**Green (B3)**: 0.560 µm
**Blue (B2)**: 0.490 µm

**Vegetation Red Edge (B6)**: 0.740 µm
**Green (B3)**: 0.560 µm
**Blue (B2)**: 0.490 µm

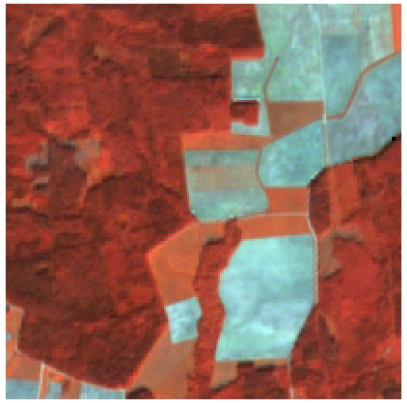


**Vegetation Red Edge (B6)**: 0.740 µm
**Vegetation Red Edge (B7)**: 0.783 µm
**Near infrared (B8)**: 0.842 µm

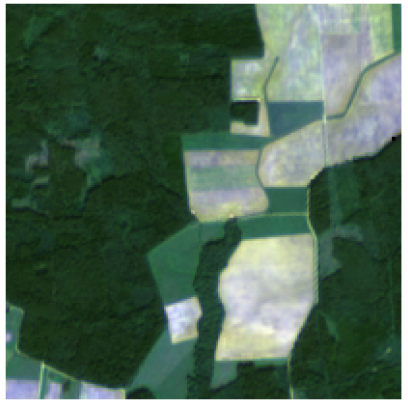


# Soil biodiversity: predictions using computer vision

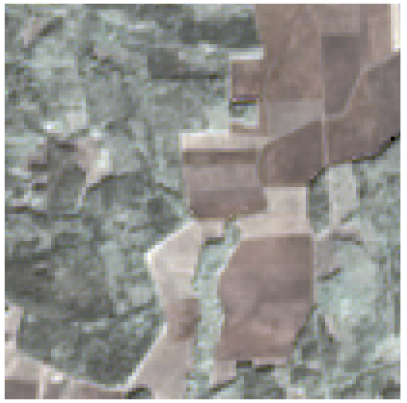
**B2, B3, B6**



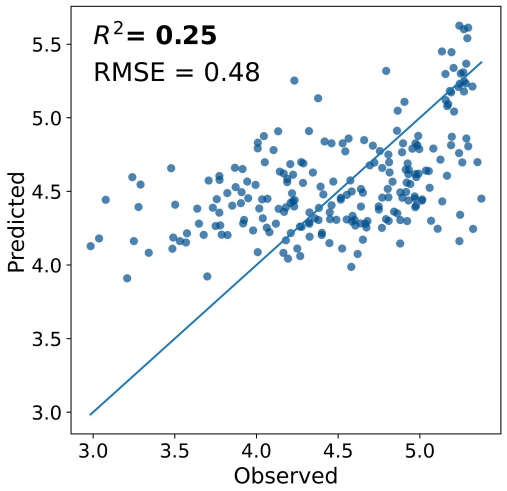
**B3, B4, B12**

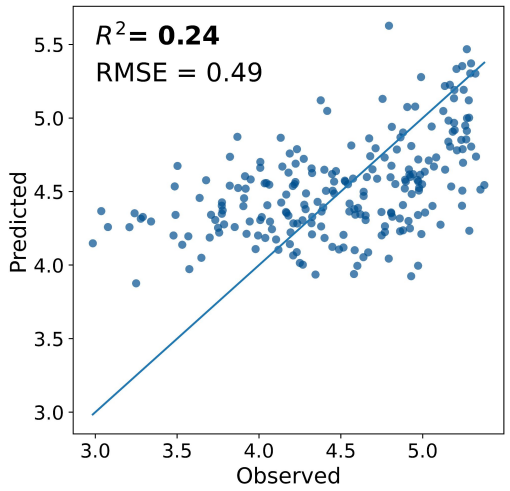


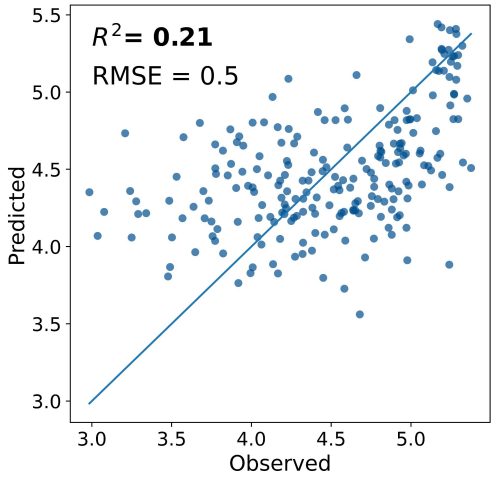
**B6, B7, B8**

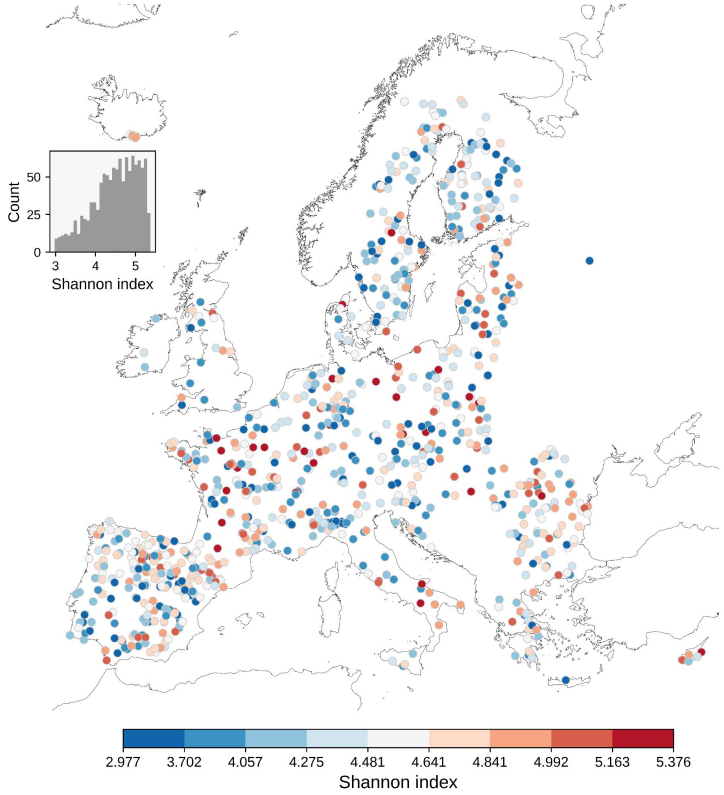


## Residual Networks
## Convolutional Neural Networks



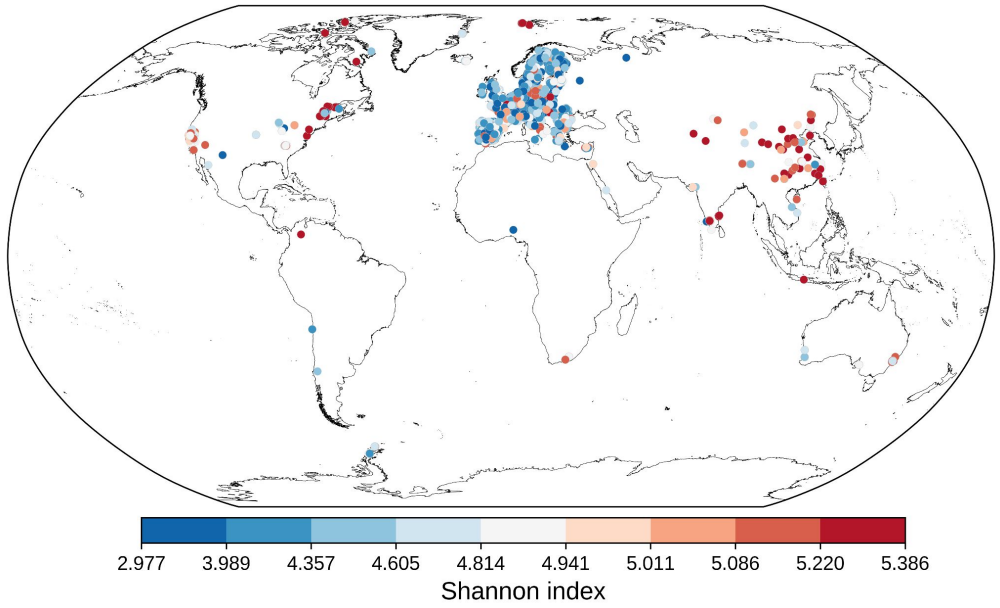



# Soil biodiversity: ongoing work

- Multi-band (more than three simultaneously) inference using pretrained foundation models
- Cloud filling / correction of Sentinel 2 images
- Inclusion of spectral indices as bands (e.g. NDVI, NDCI, SMI)
- Expand at global scale (~2'000 localities)
- Predictions for bacterial human pathogens



# Thank you!

*Questions?*
*sp.theodoridis@noa.gr*

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