South African
NATIONAL PARKS

Savanna Science Network Meeting 2025

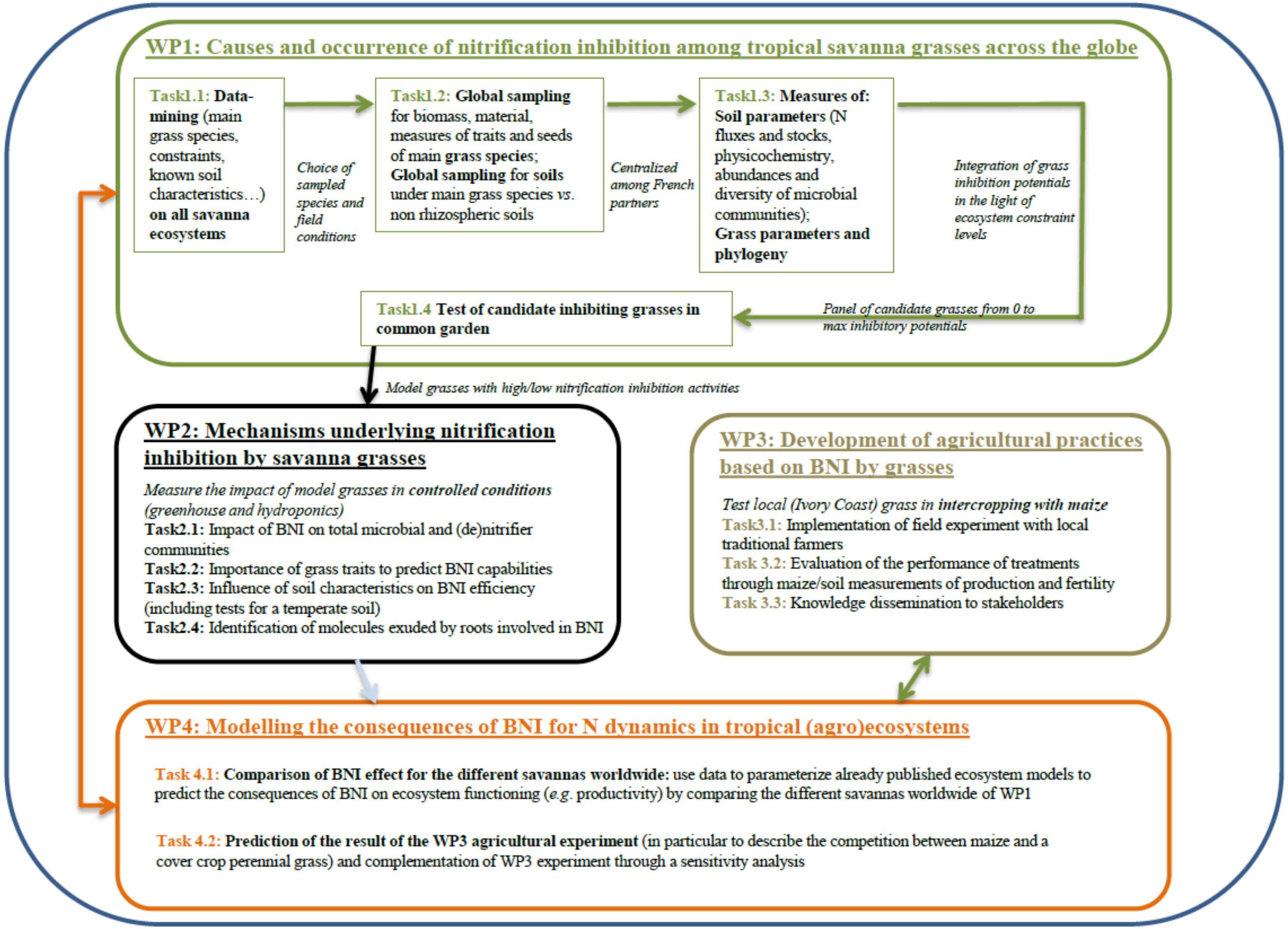
Soil microbial diversity across savanna ecosystems: a first worldwide assessment

AGENCE NATIONALE DE LA RECHERCHE ANR

INSTITUT D'ÉCOLOGIE ET DES SCIENCES DE L'ENVIRONNEMENT DE PARIS iEES PARIS

SORBONNE UNIVERSITÉ

Global Assessment of Nitrification Inhibition by tropical Grasses (GAIN-GRASS) (672k€, 2020-2025)



Main partners from 3 countries: France +Japan+ Ivory Coast

Institute of Ecology and Environmental Sciences of Paris (iEES Paris)

Biological Nitrification Inhibition (BNI) International Consortium

Université Claude Bernard Lyon, Laboratoire d'Écologie Microbienne (LEM)

The Institut de Systématique, Évolution, Biodiversité

Eco&Sols

Lamto Tropical Ecology Station

iEES PARIS

JIRCAS

Centre de Recherche en Ecologie

PROJET FINANCÉ PAR L'ANR - PROJECT FUNDED BY THE ANR

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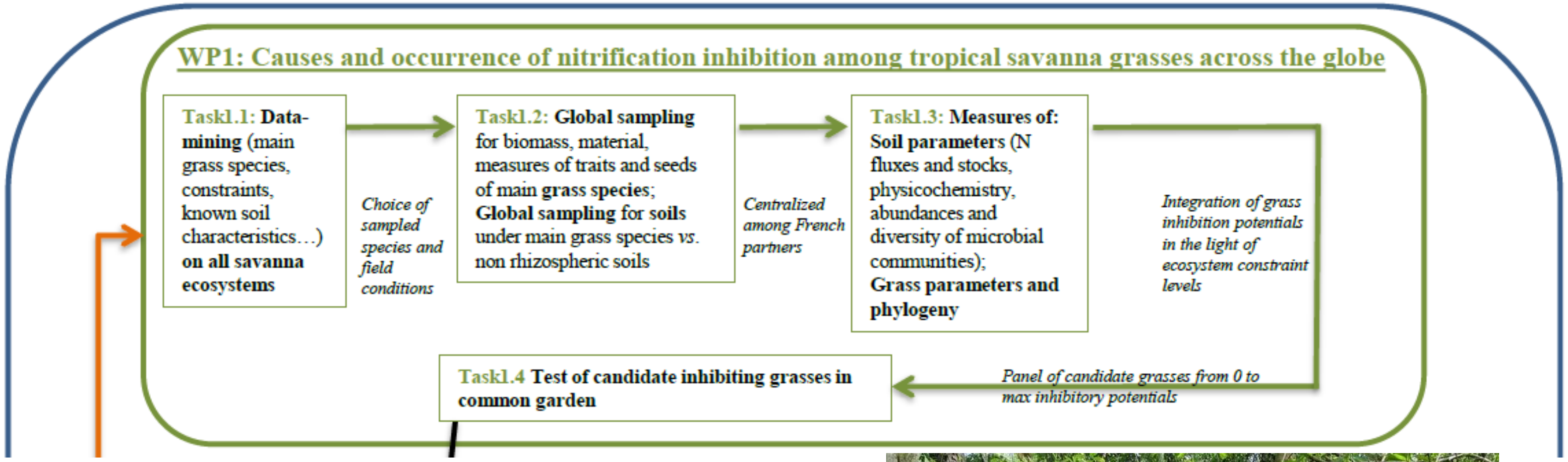

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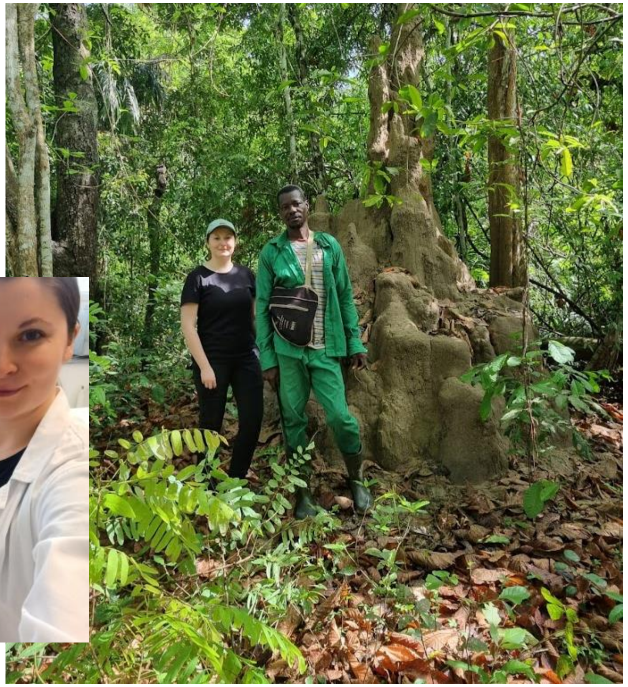
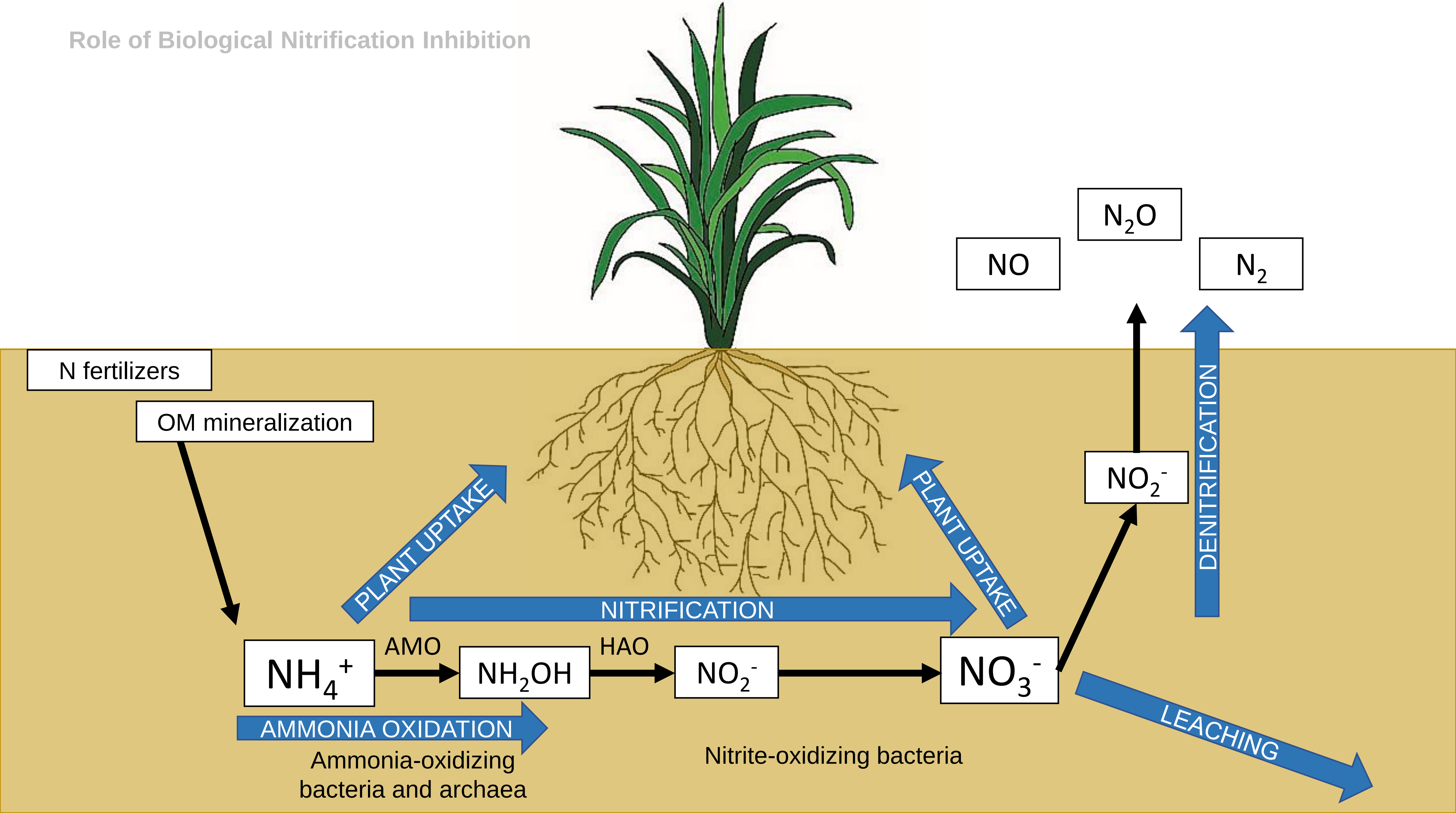
Lea Nosalova
lea.nosalova@sorbonne-universite.fr
(post-doc position: 10/2023-12/2025)
Genetics and environmental microbiology



Role of Biological Nitrification Inhibition



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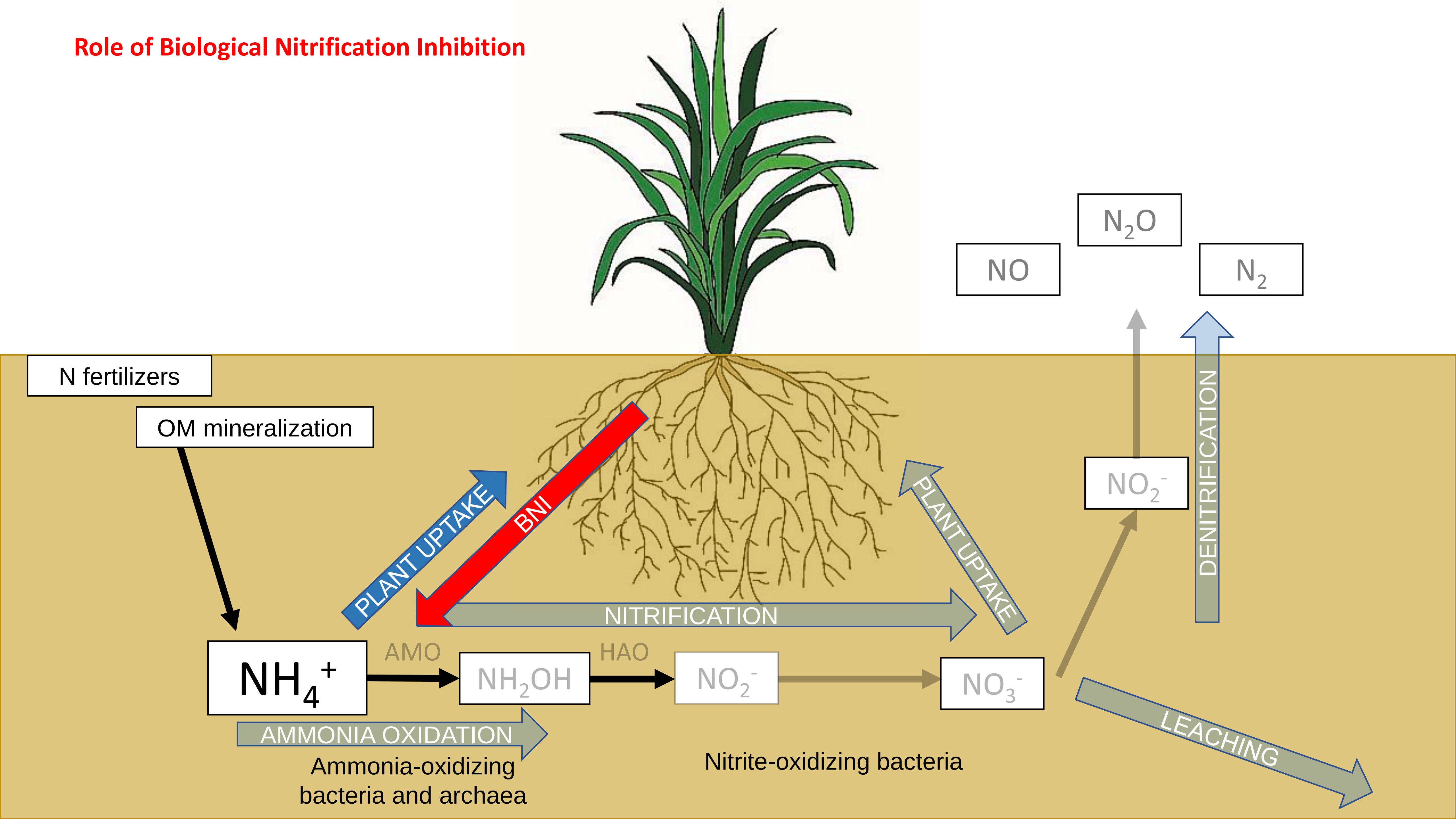
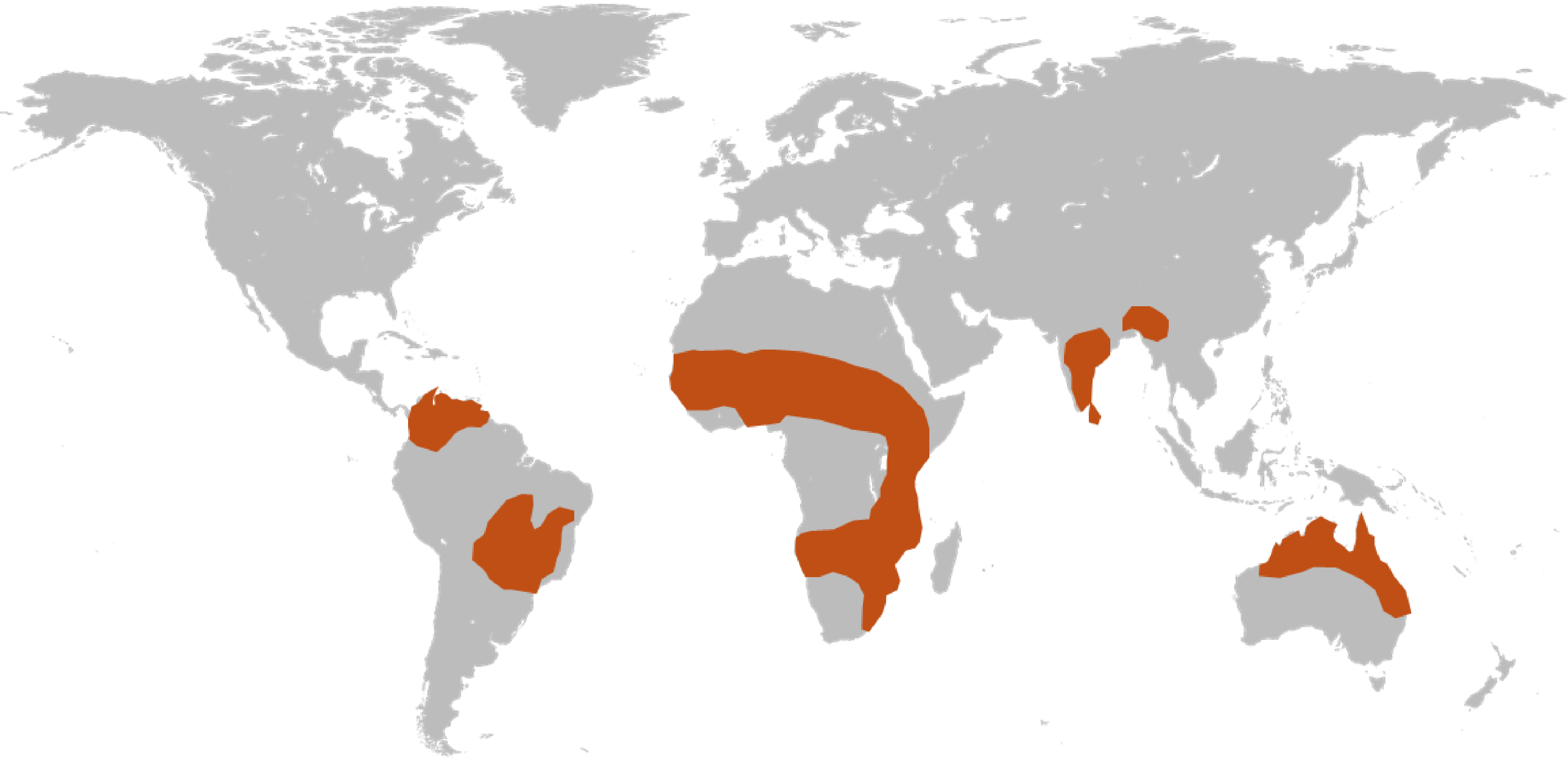


- Savannas and tropical grasslands ~ 25% of terrestrial ecosystem
- Human population strongly depends on savanna ecosystems –ecosystem services
- Many constraints: fire, herbivory, nutrient unavailability, heavy rainfalls

But very high primary productivity of wet savanna ecosystems



Role of Biological Nitrification Inhibition

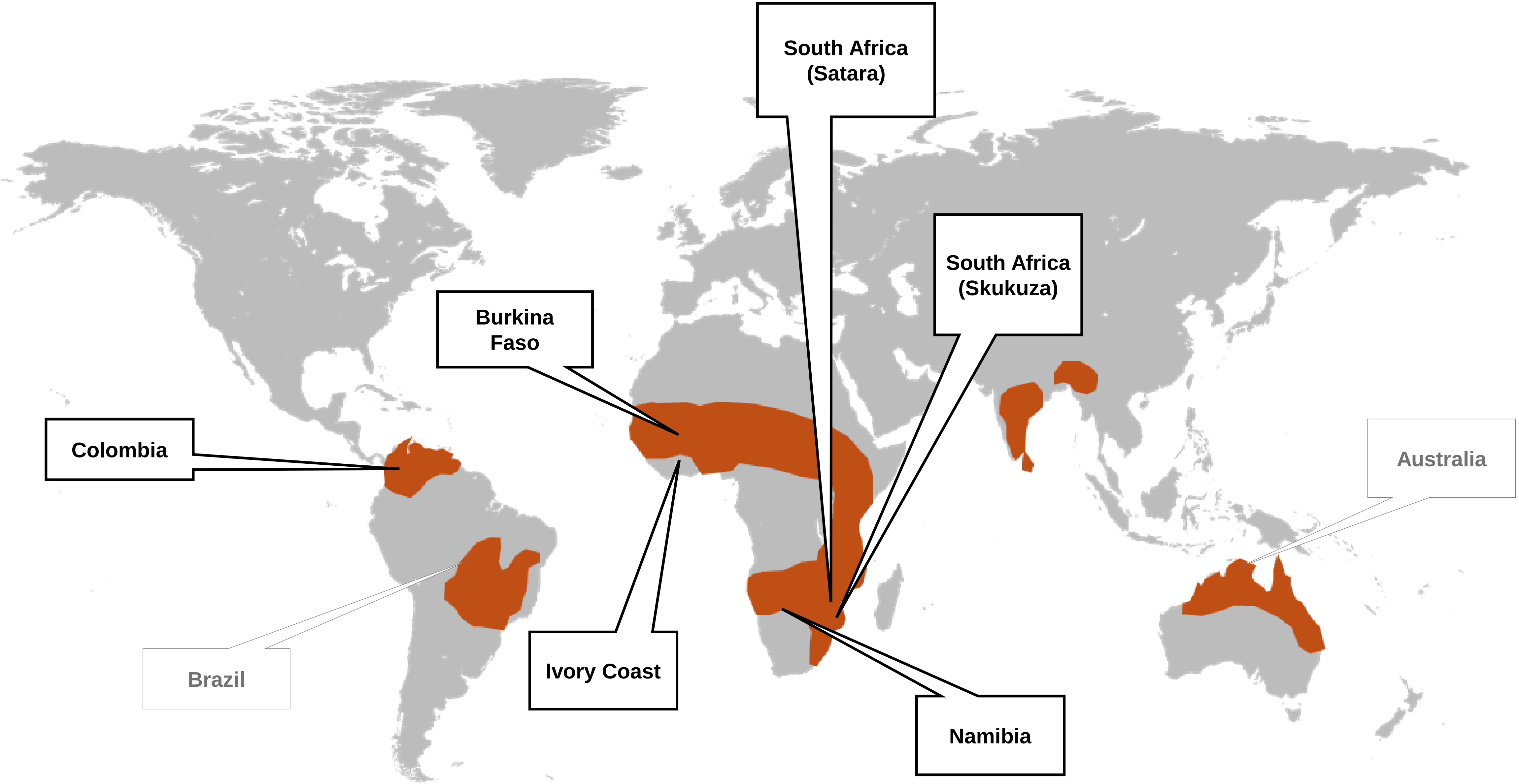
Huge potential in development of N-efficient crops

BNI non-BNI

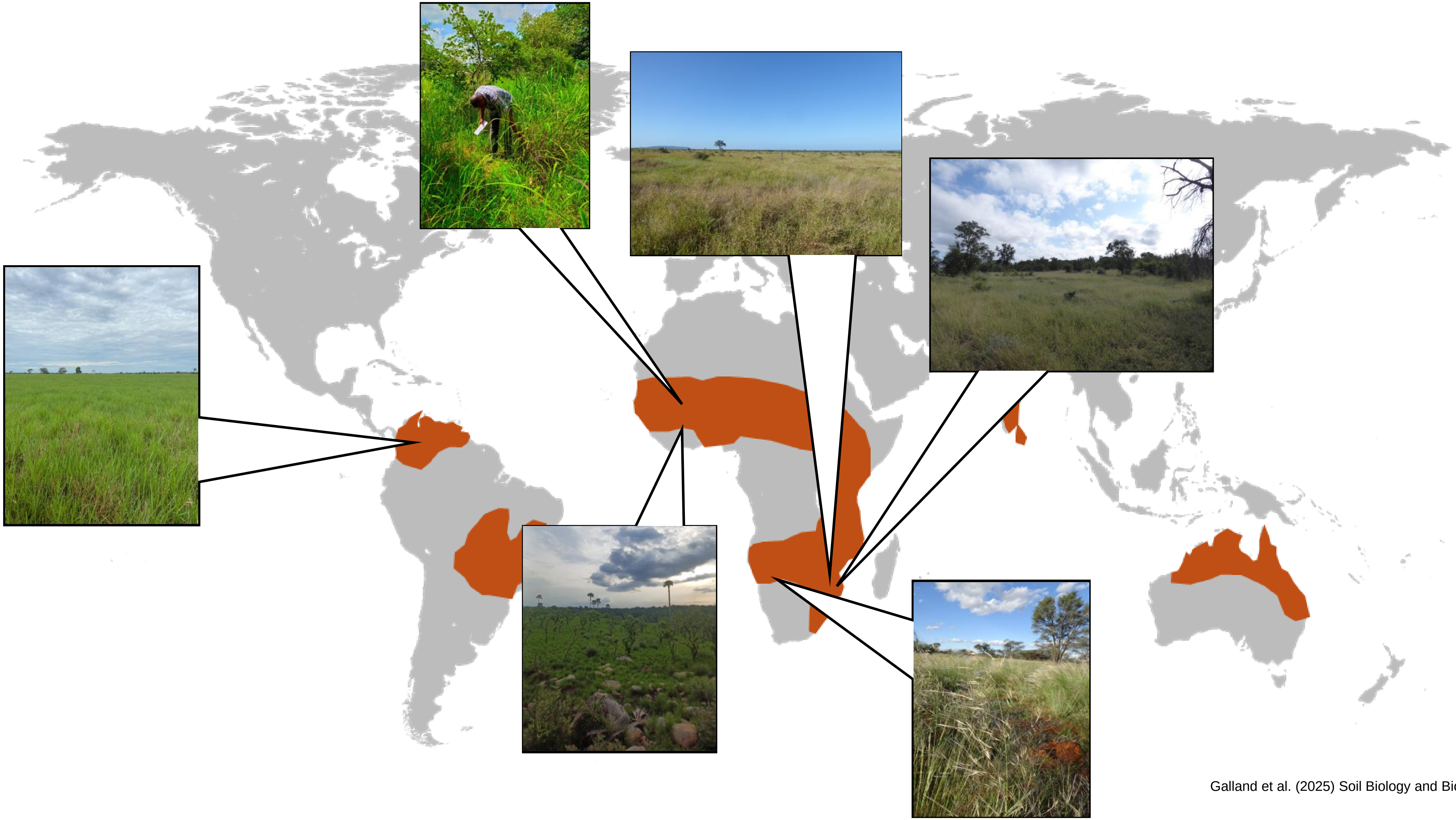
Galland et al. (2024; Soil Biology and Biochemistry submitted manuscript)

Hypothesis

- What is the microbial diversity in tropical savanna biome? What are the main driving factors in rhizosphere and in bulk soil?
- What is the impact of grasses on N cycle ? (new potential BNI grasses)
- Is the BNI correlated to particular environmental parameters/constraints ? (herbivory, fire, N limitation, distance, limitation of water, limitation of P, and also biodiversity)
- How it impacts the microbiota? Bacteria or archaea? Or both? Or specific functional groups?



Galland et al. (2025) Soil Biology and Biochemistry (under review)



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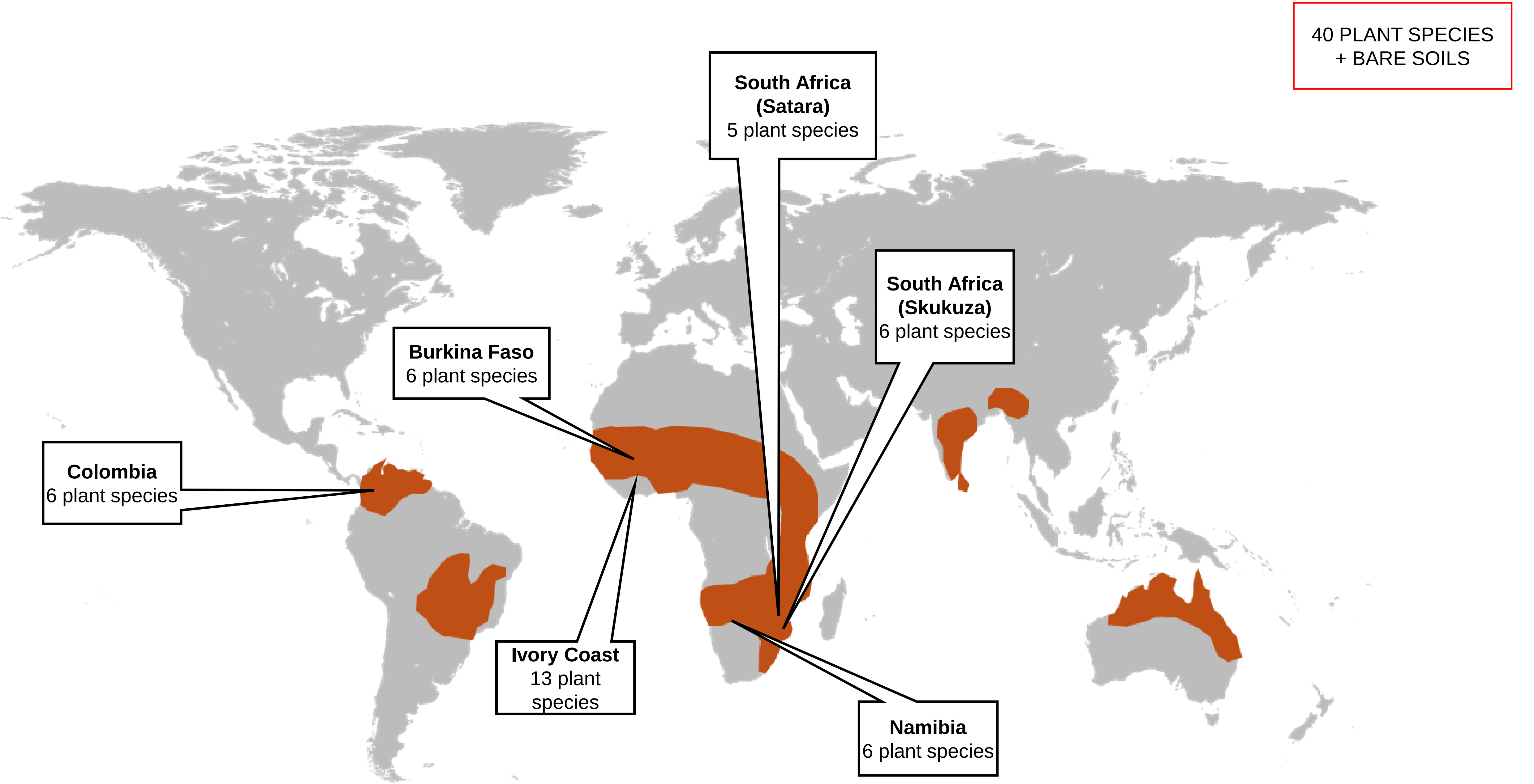

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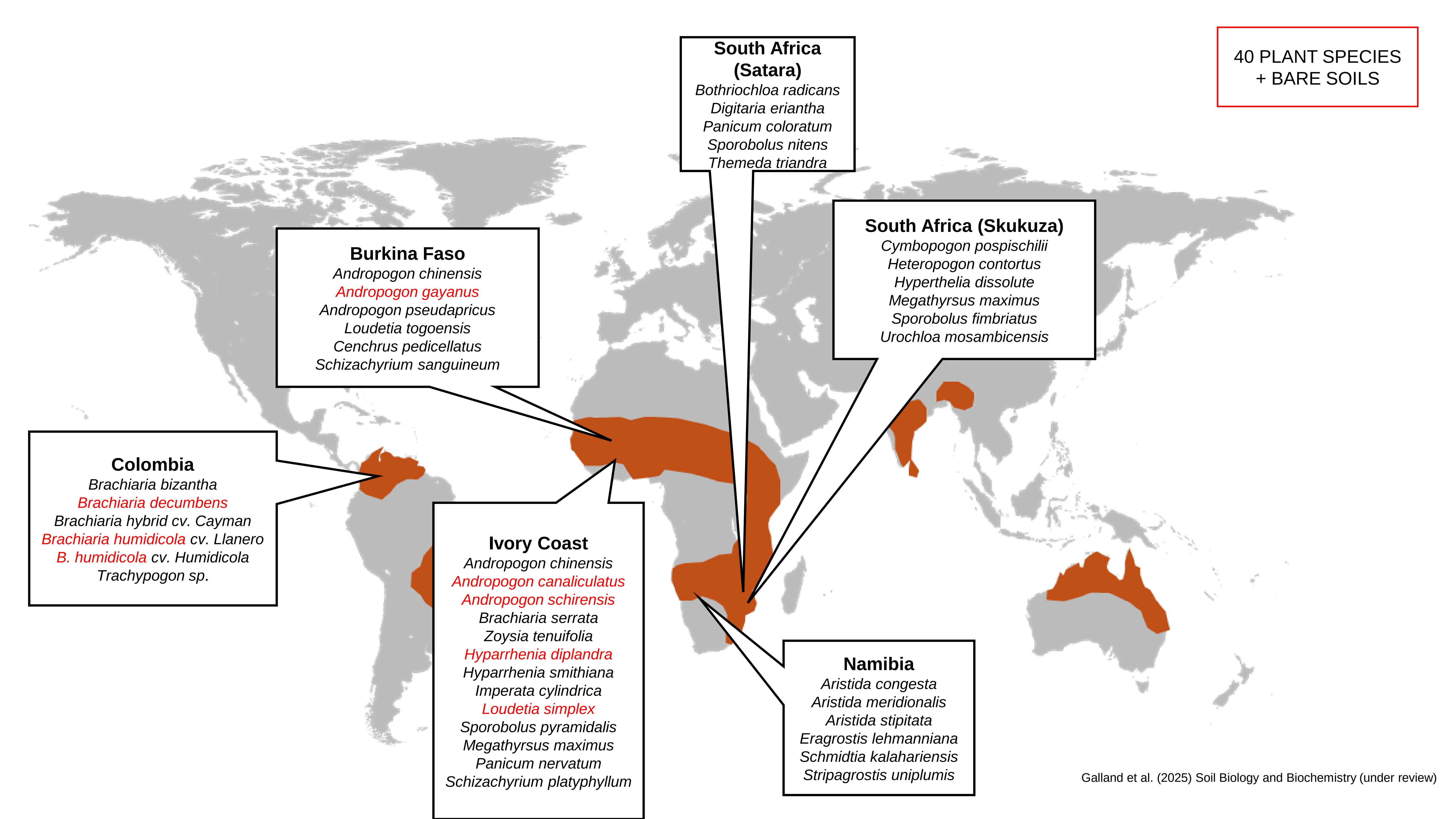

40 PLANT SPECIES
+ BARE SOILS
South Africa (Satara)
Bothriochloa radicans
Digitaria eriantha
Panicum coloratum
Sporobolus nitens
Themeda triandra
South Africa (Skukuza)
Cymbopogon pospischilii
Heteropogon contortus
Hyperthelia dissolute
Megathyrsus maximus
Sporobolus fimbriatus
Urochloa mosambicensis
Burkina Faso
Andropogon chinensis
Andropogon gayanus
Andropogon pseudapricus
Loudetia togoensis
Cenchrus pedicellatus
Schizachyrium sanguineum
Colombia
Brachiaria bizantha
Brachiaria decumbens
Brachiaria hybrid cv. Cayman
Brachiaria humidicola cv. Llanero
B. humidicola cv. Humidicola
Trachypogon sp.
Ivory Coast
Andropogon chinensis
Andropogon canaliculatus
Andropogon schirensis
Brachiaria serrata
Zoysia tenuifolia
Hyparrhenia diplandra
Hyparrhenia smithiana
Imperata cylindrica
Loudetia simplex
Sporobolus pyramidalis
Megathyrsus maximus
Panicum nervatum
Schizachyrium platyphyllum
Namibia
Aristida congesta
Aristida meridionalis
Aristida stipitata
Eragrostis lehmanniana
Schmidtia kalahariensis
Stripagrostis uniplumis
Galland et al. (2025) Soil Biology and Biochemistry (under review)

Experimental design

Sampling

n=240
Rhizosphere and bare soil samples

+

Metadata

Climate
Geology
Herbivory
Plant type
Savanna type
Anthropogenic factors

DNA extraction

DNA was extracted using NucleoSpin® Soil kit (MACHEREY-NAGEL) quantified by Nanodrop and Qubit

Soil physicochemical analysis

pH
Available phosphorus (Olsen)
Total nitrogen
Total carbon
Organic carbon
Organic matter
Granulometric analysis (% clay, slit and sand)

qPCR quantification

Nitrification
amoA-AOA and *amoA*-AOB
amoA-comA and *amoA*-comB
Nitrobacter: nxrA
Nitrospira: 16S rRNA gene

Denitrification
nirK and *nirS*

+

Enzymatic activities

Nitrification Enzyme Activity (NEA)
Denitrification Enzyme Activity (DEA)

Ecologie microbienne Lyon

William Galland (post-doc)

16S and ITS metabarcoding analysis

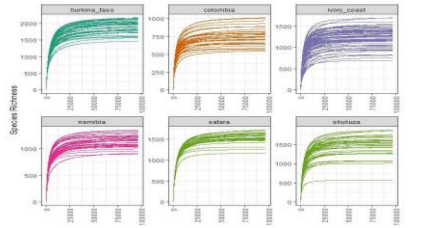
Illumina NextSeq2000

INSTITUT PASTEUR

Sequence data analysis

Processing in R using DADA2 tool and IFB cluster
Statistical analyses

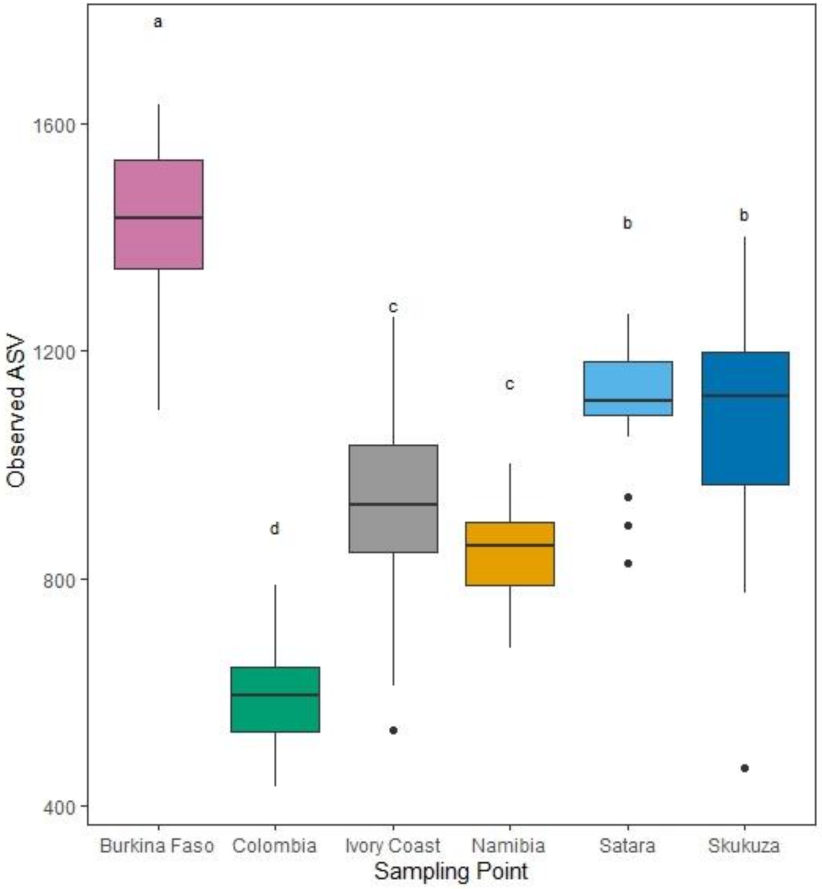
IFB INSTITUT FRANÇAIS DE BIOINFORMATIQUE



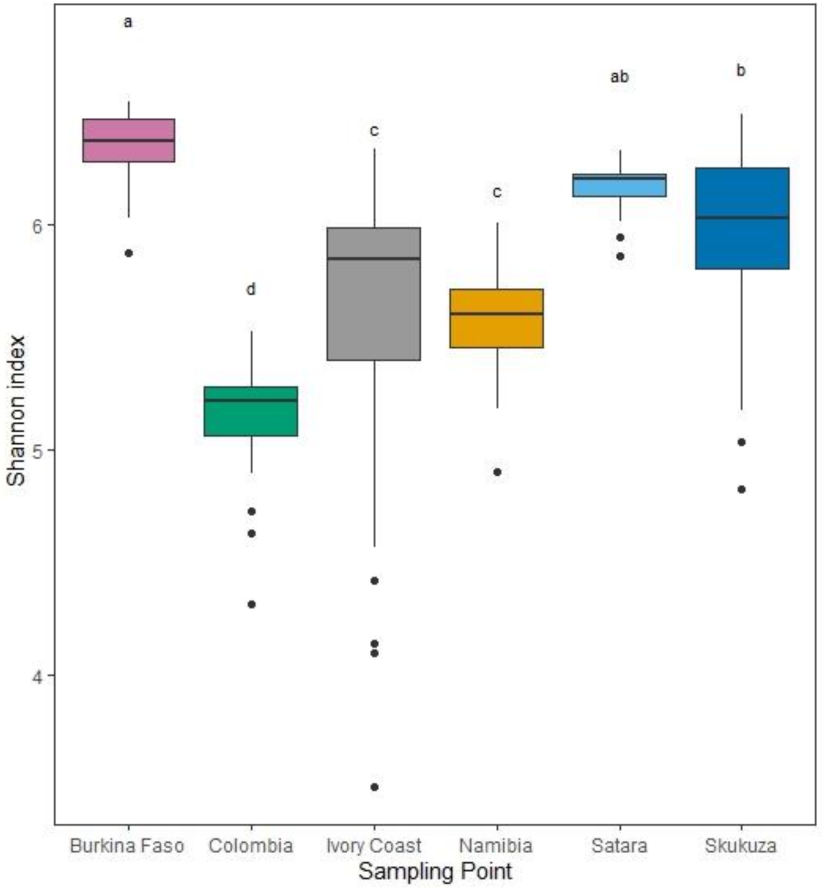
Alpha diversity

Rhizosphere + bare soils
ASV (amplicon sequence variants)
~2300 ASV observed in total

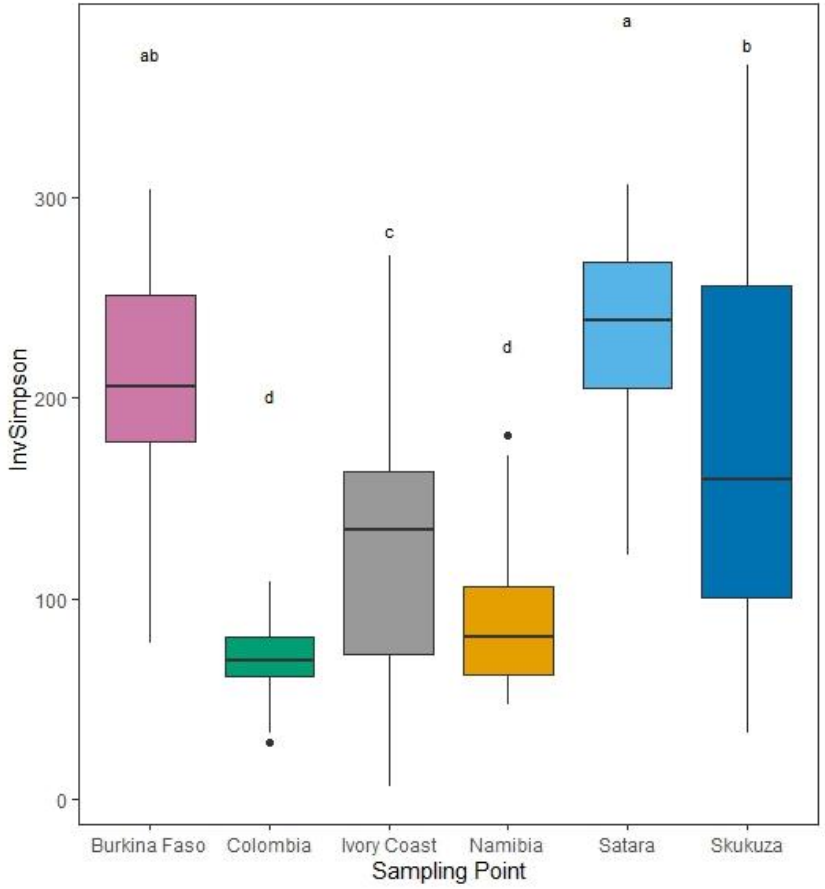
Observed ASV



Shannon index

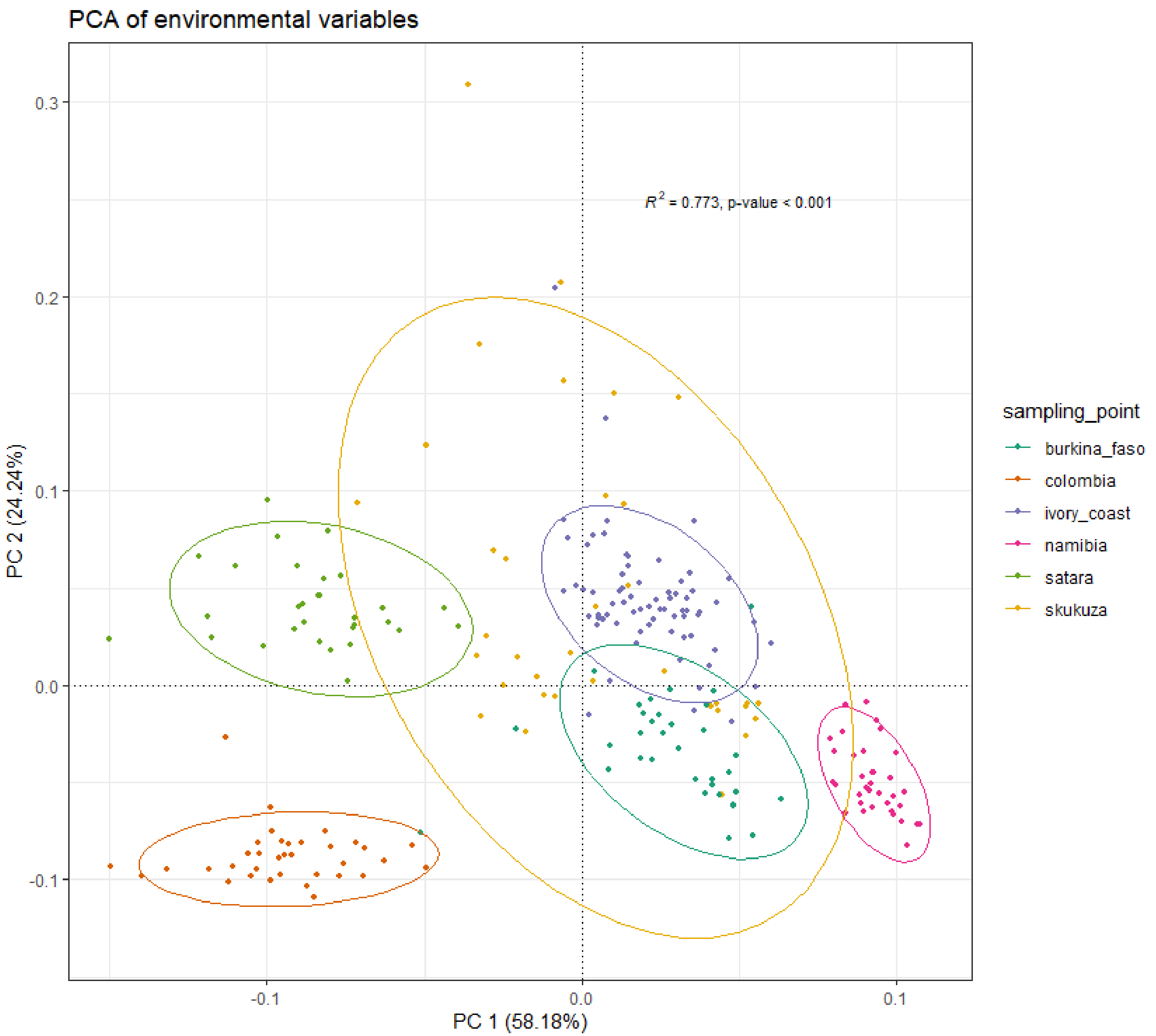


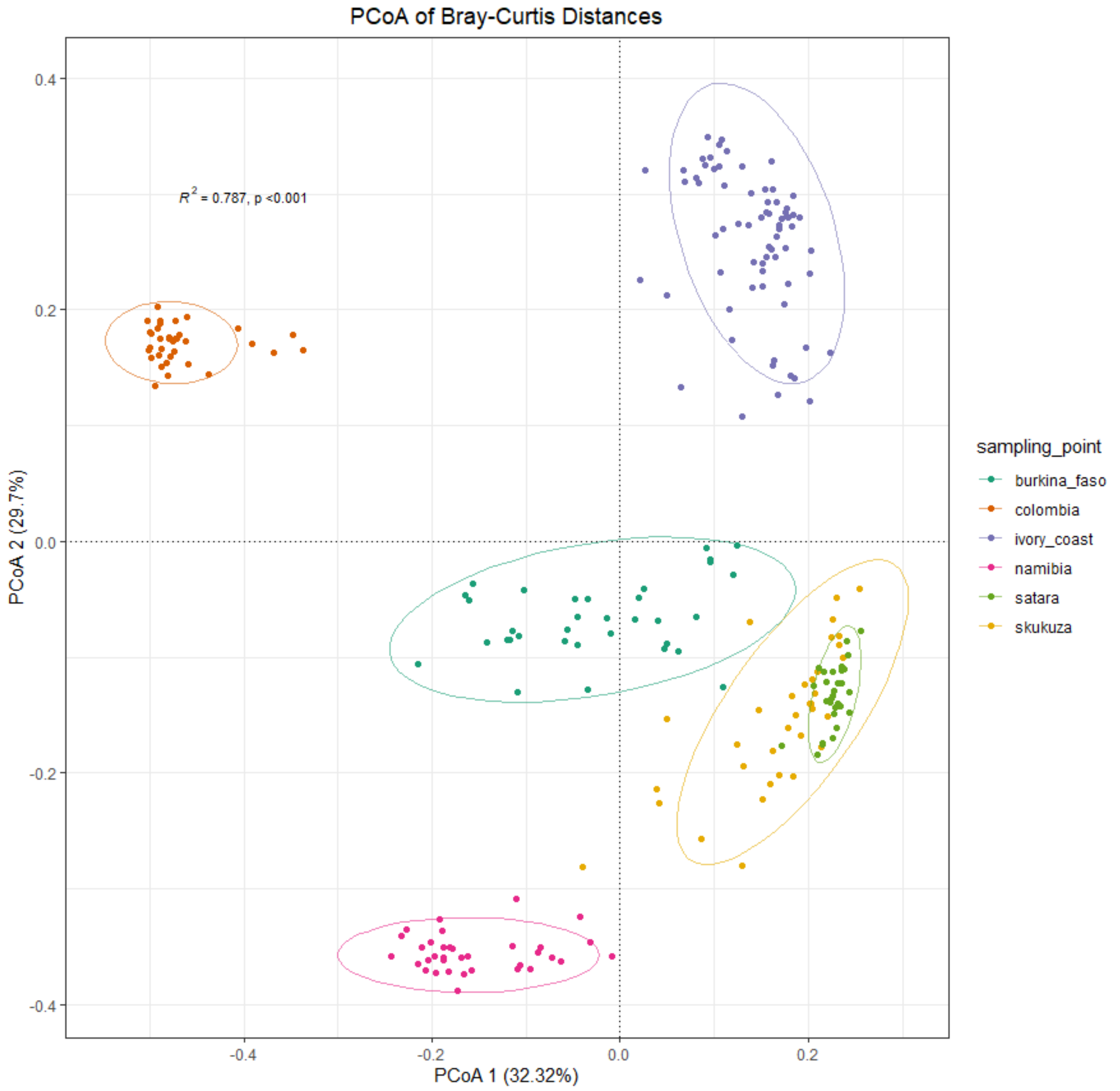
Inverse Simpson



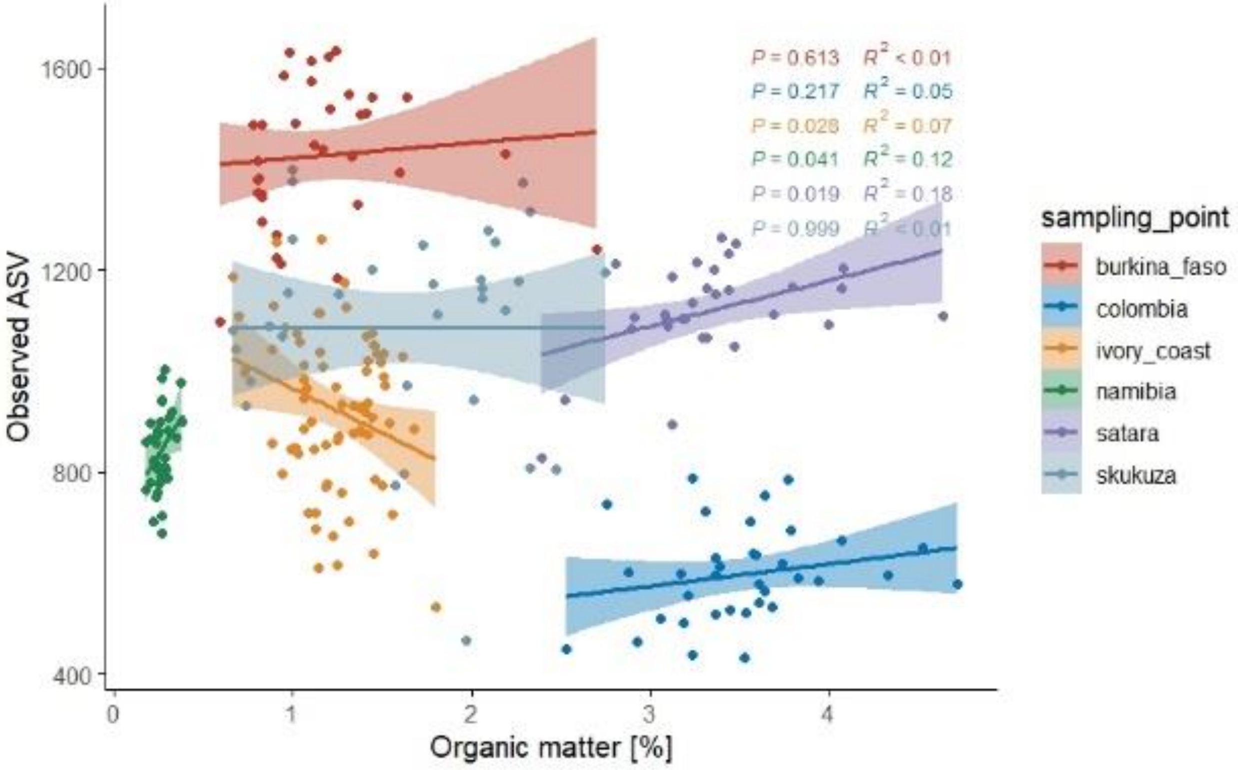
Differences in calculated diversity indexes of bacteria and archaea, with significant differences among the sampling sites determined by ANOVA followed by pair-wise comparison using Tukey`HSD post-hoc test. Different lowercase letters above each box in the same subfigure represent significant differences between groups (Tukey`HSD , $p < 0.05$)

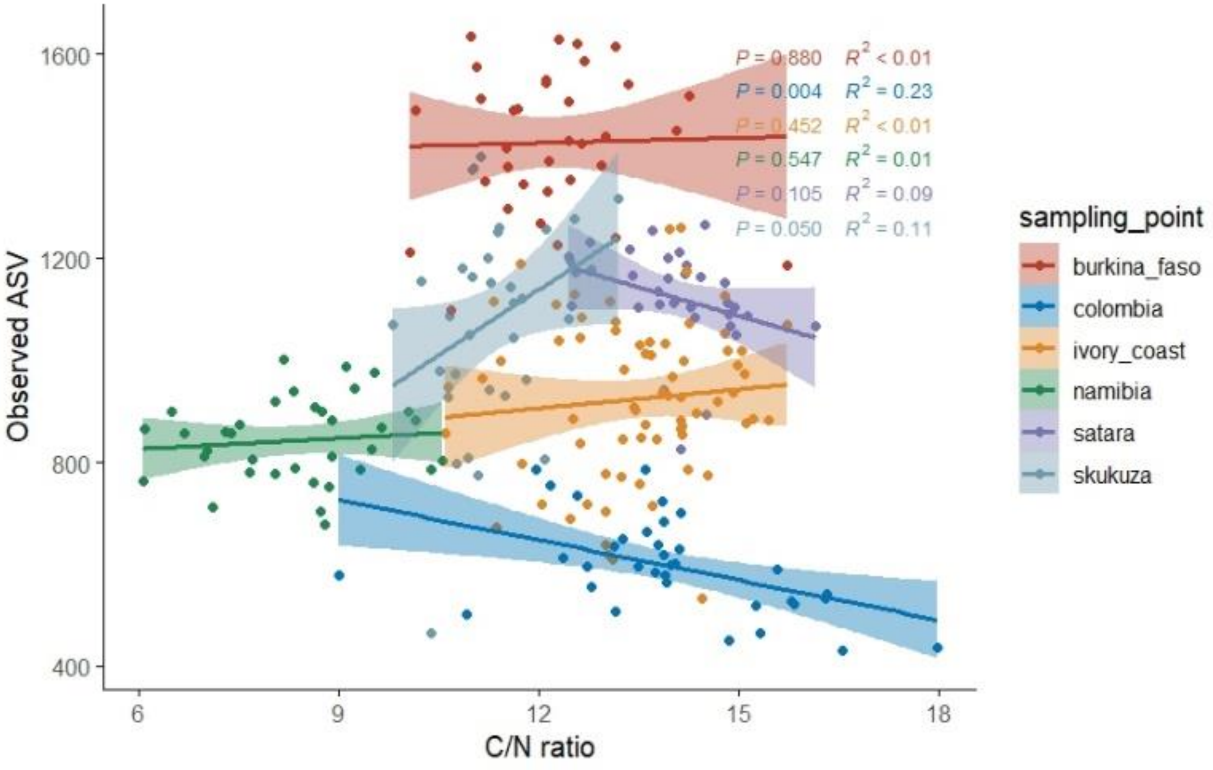
Beta diversity



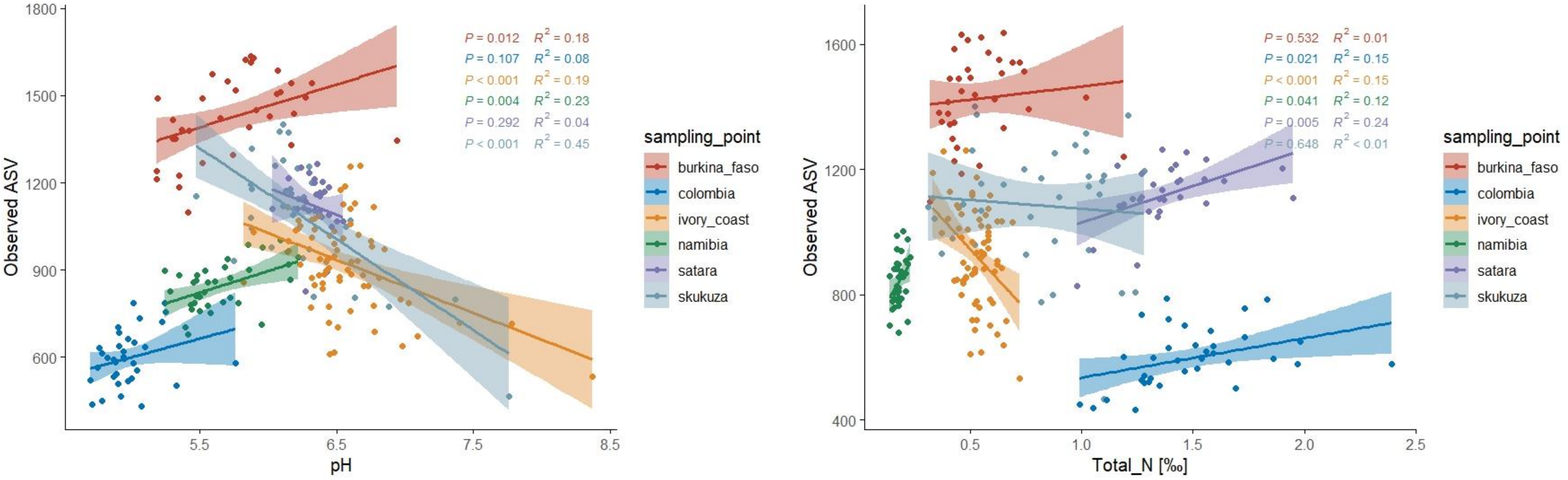


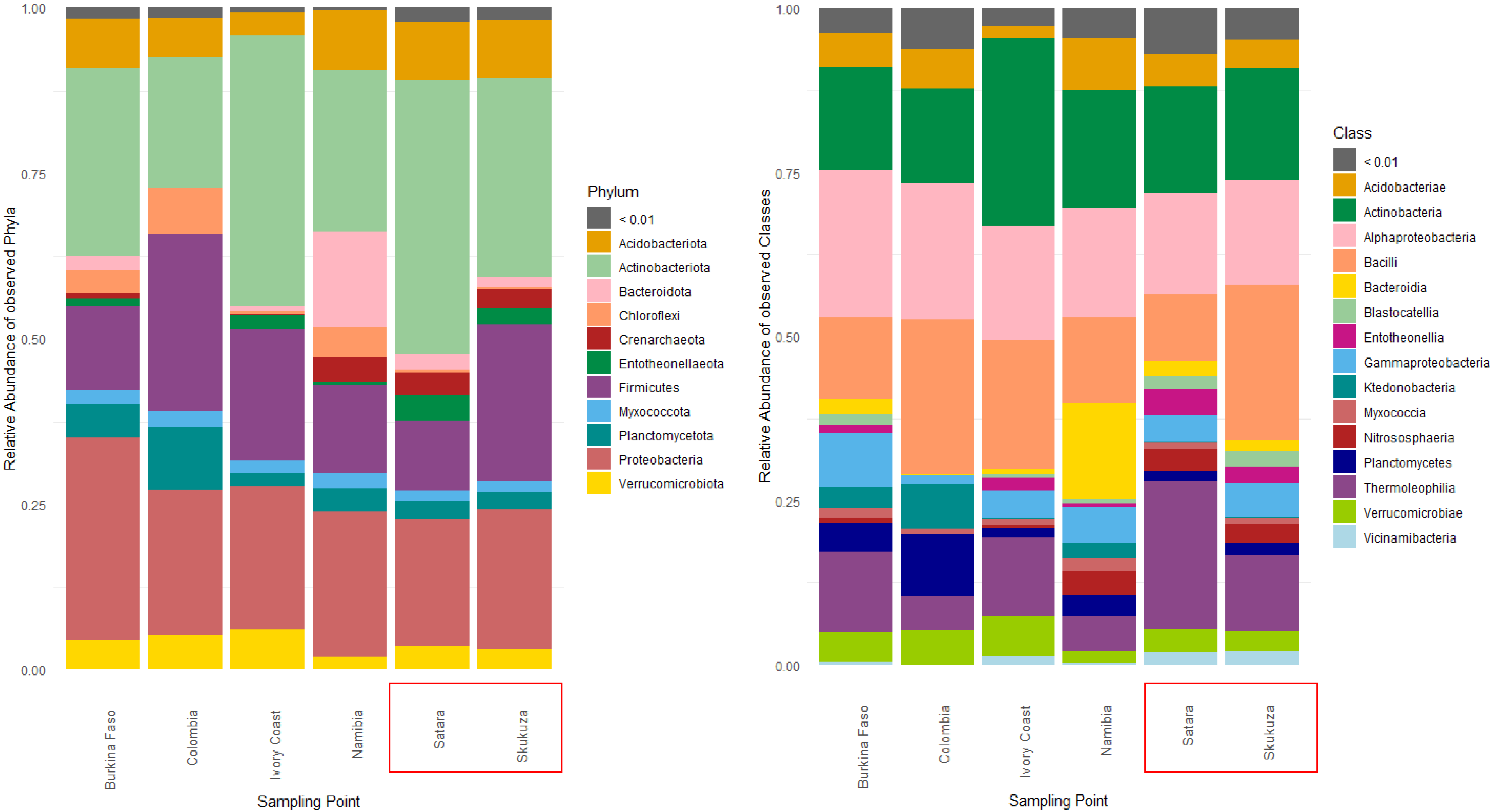
Correlations between alpha diversity indices and environmental variables





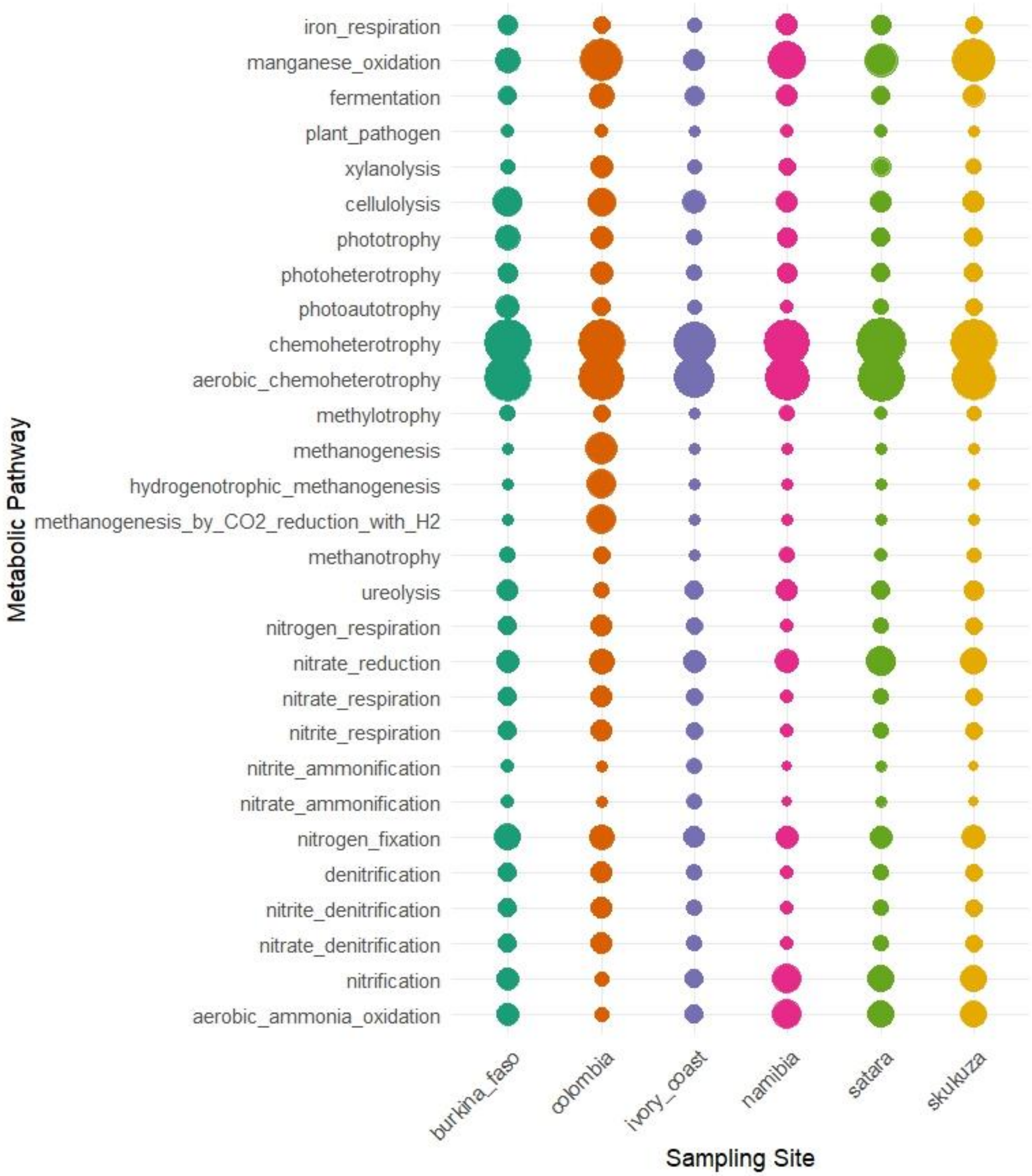
Correlations between alpha diversity indices and environmental variables





Relative Abundance of observed Phyla
1.00
0.75
0.50
0.25
0.00
Burkina Faso
Colombia
Ivory Coast
Namibia
Satara
Skukuza
Sampling Point
Phylum
< 0.01
Acidobacteriota
Actinobacteriota
Bacteroidota
Chloroflexi
Crenarchaeota
Entotheonellaeota
Firmicutes
Myxococcota
Planctomycetota
Proteobacteria
Verrucomicrobiota
Relative Abundance of observed Classes
Class
Acidobacteriae
Actinobacteria
Alphaproteobacteria
Bacilli
Bacteroidia
Blastocatellia
Entotheonellia
Gammaproteobacteria
Ktedonobacteria
Myxococcia
Nitrososphaeria
Planctomycetes
Thermoleophilia
Verrucomicrobiae
Vicinamibacteria

Functional prediction analysis



related to element cycling in soils

related to plants

related to general ways of obtaining energy

related to methanogenesis

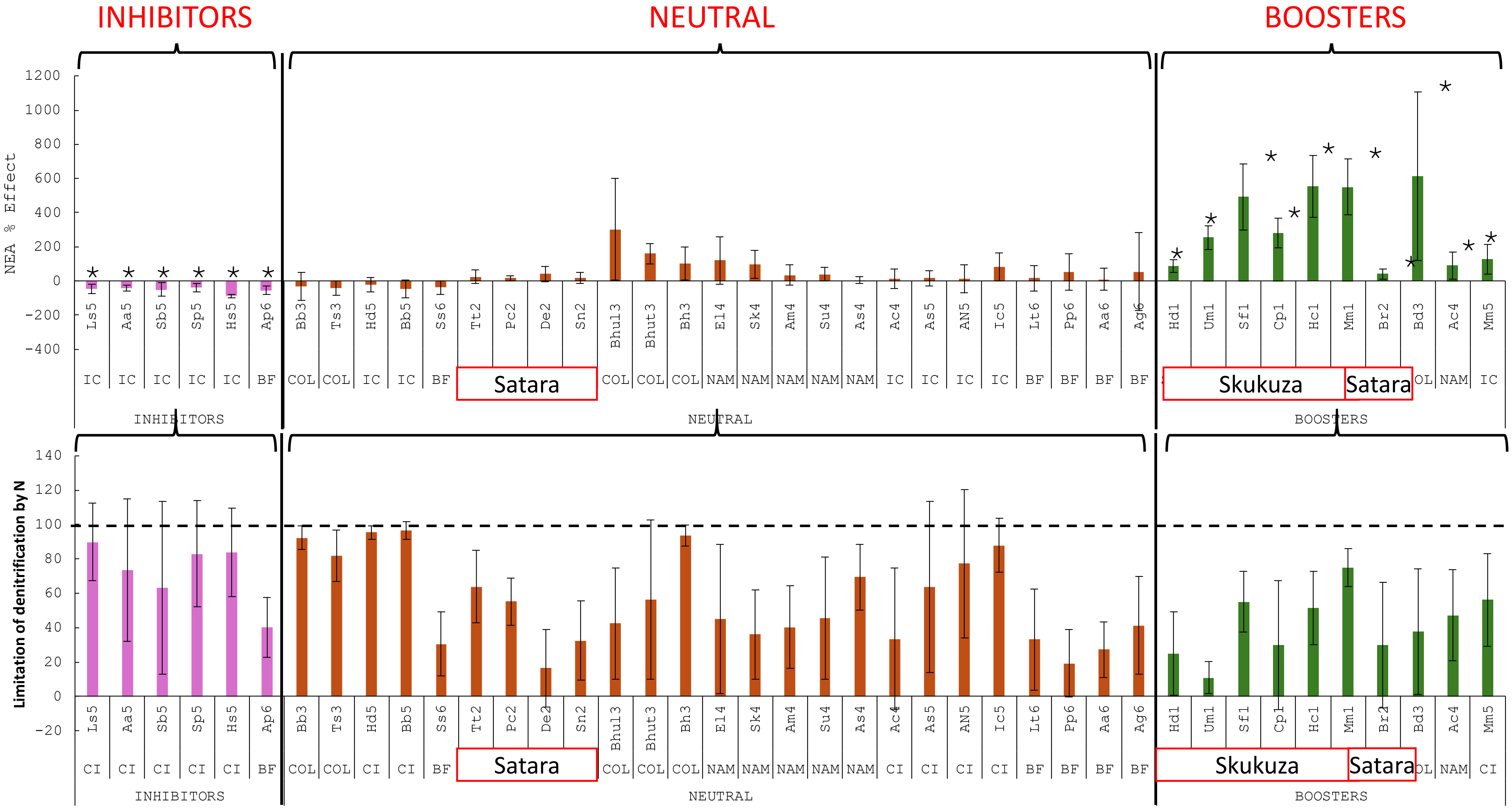
related to nitrogen cycle

FAPROTAX

Louca et al. (2016) Science

Effect of Poaceae species on nitrification (top) and denitrification (bottom)

BNI species observed only in Ivory Coast
(+ 1 sample from Burkina Faso)



William Galland
(postdoc 2023-2025)
Soil Biology and Biochemistry (under review)

Preliminary conclusions and future aspects

- Colombia strongly differs in terms of bacterial/archaeal diversity and functional groups (differences in geology, organic matter, P vs N limitation, plant impact ???)
- Despite the fact that Satara and Skukuza differed in environmental variables, the difference in microbial diversity and taxonomy was weak
- It is not clear <u>what are the main driving factors </u>– pH has a huge influence on alpha diversity

  → co-influence of several factors ???

- The BNI plants were observed only in Ivory Coast and Burkina Faso based on nitrification/ denitrification -> link to wet climate and N limitation?

- Can we distinguish the grasses as BNI using metabarcoding data? (confirm our first results on nitrification/ denitrification)
- To decipher the main factors shaping the microbiota – including BNI
- What is the core microbiota, and what can we learn from co-occurrence networks ?

+ FUNGI

Coetsee C[1,2], Wigley BJ[1,2], Koffi FG[3], Konan M[4], Lambienou YE[5], Nignan S[6], Arango J[7], Villegas DM[7], Geißler K[8], Blaum N[9], Galland W[10], Cantarel AAM[10], Florio A[10], Le Roux X[10]

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Thank you!

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