Regenerative Agriculture: What makes it unique?

Shared principles.

Different contexts.

Varying soil responses.

What does biology tell us?



Gerhard du Preez

Unit for Environmental Sciences & Management, North-West University, South Africa

6 Core Principles of REGENERATIVE AGRICULTURE

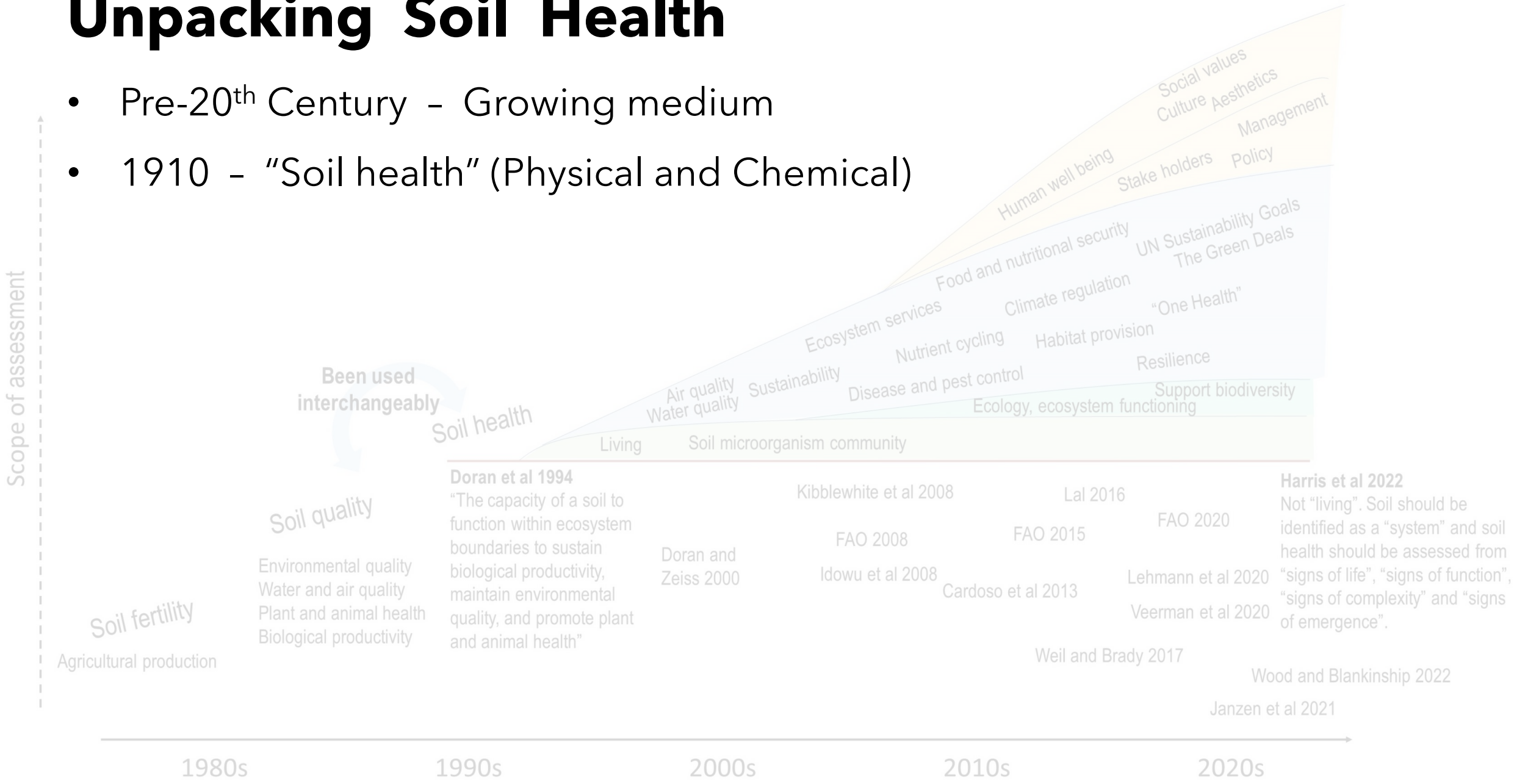


AgriCaptureCO_2

Underpinned by Healthy Soils

Unpacking Soil Health

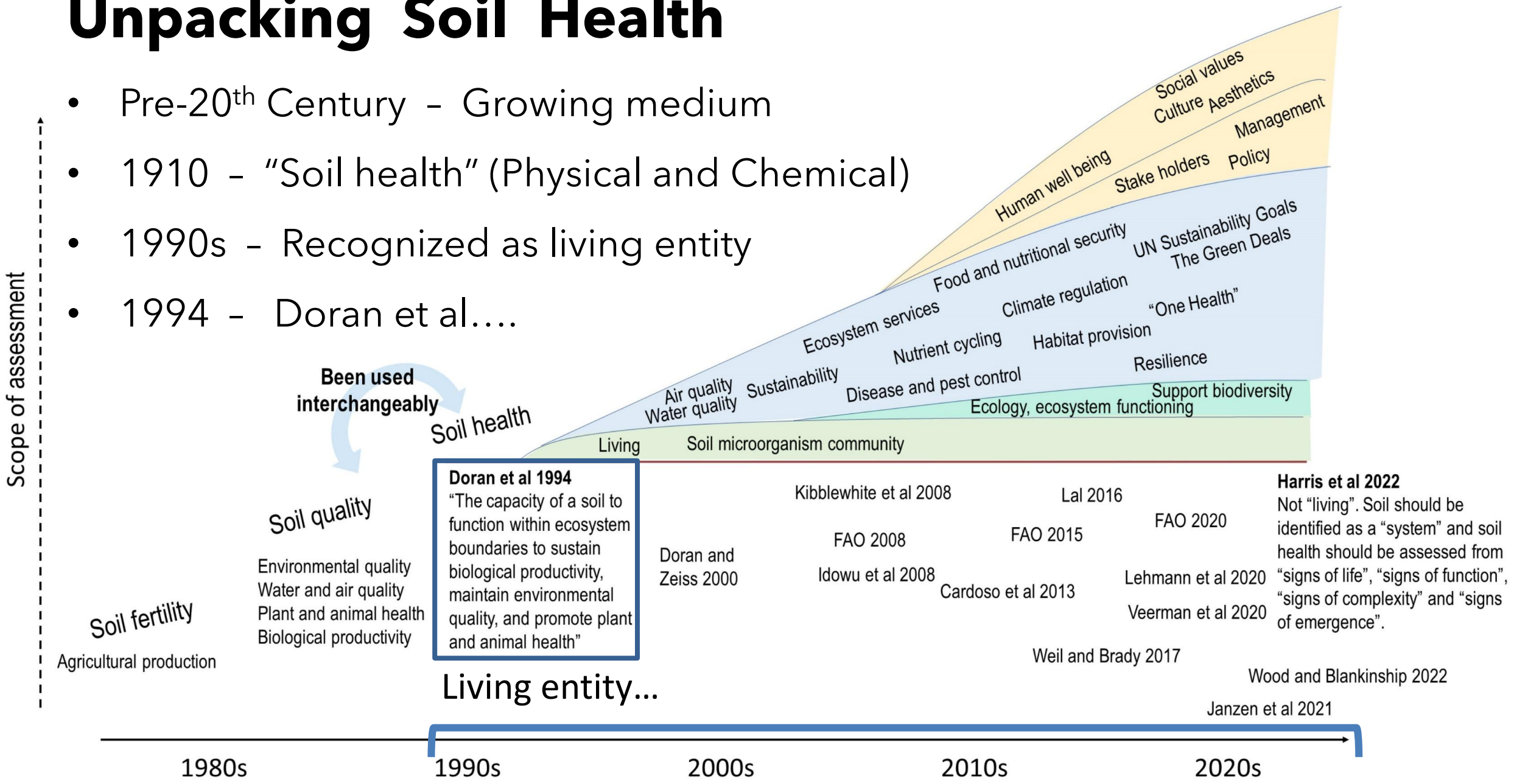
- Pre-20th Century – Growing medium
- 1910 – "Soil health" (Physical and Chemical)



Hu et al. (2026)

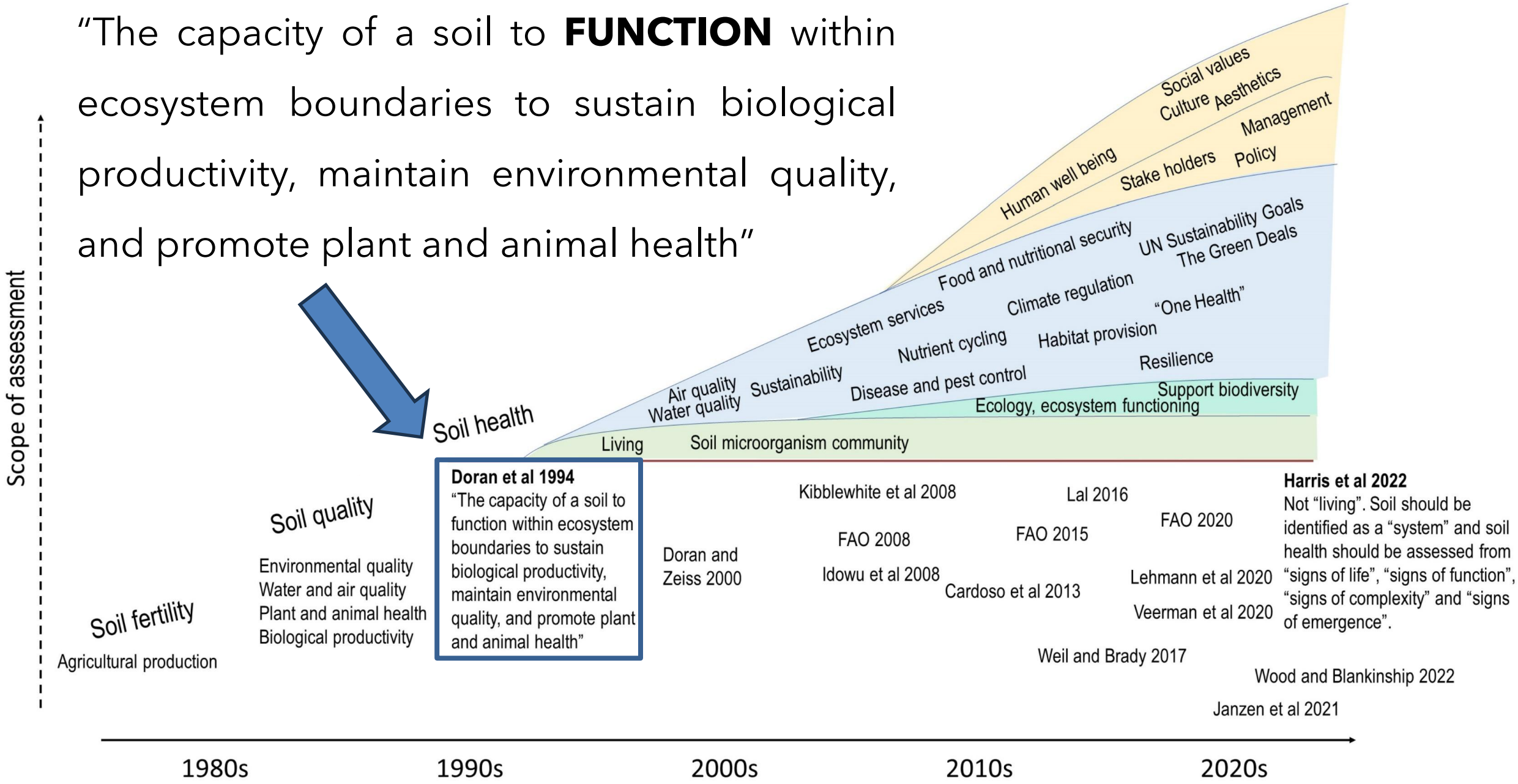
Unpacking Soil Health

- Pre-20th Century – Growing medium
- 1910 – "Soil health" (Physical and Chemical)
- 1990s – Recognized as living entity
- 1994 – Doran et al….



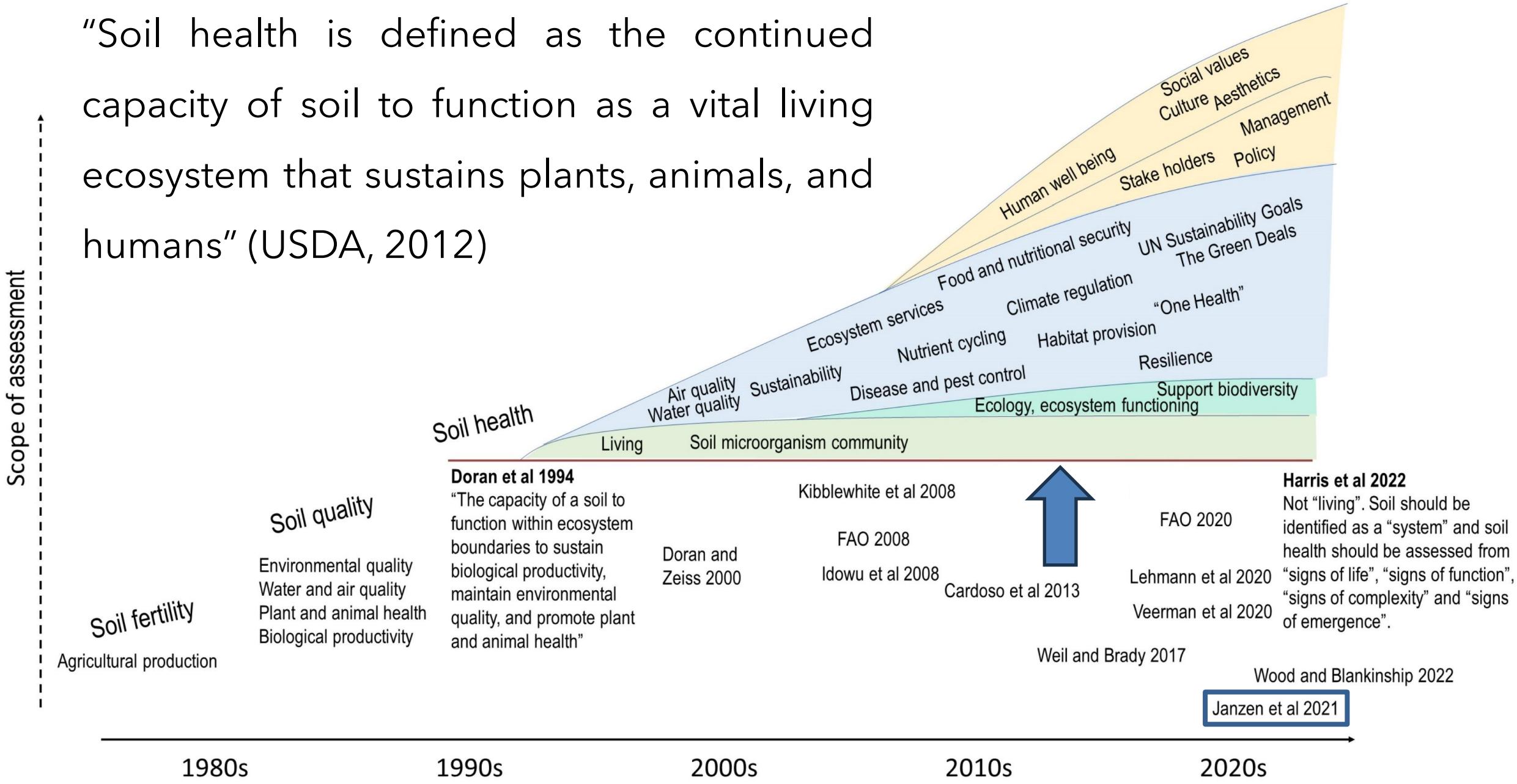
Hu et al. (2026)

"The capacity of a soil to **FUNCTION** within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health"



Hu et al. (2026)

"Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans" (USDA, 2012)

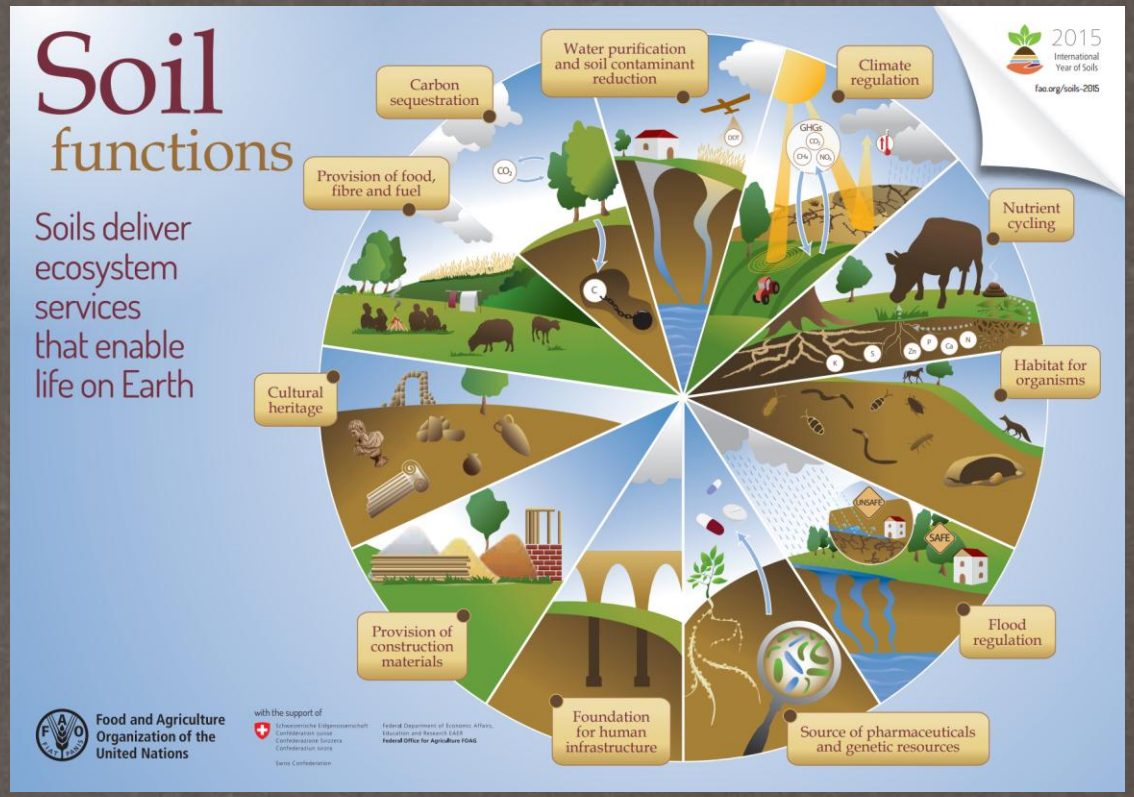


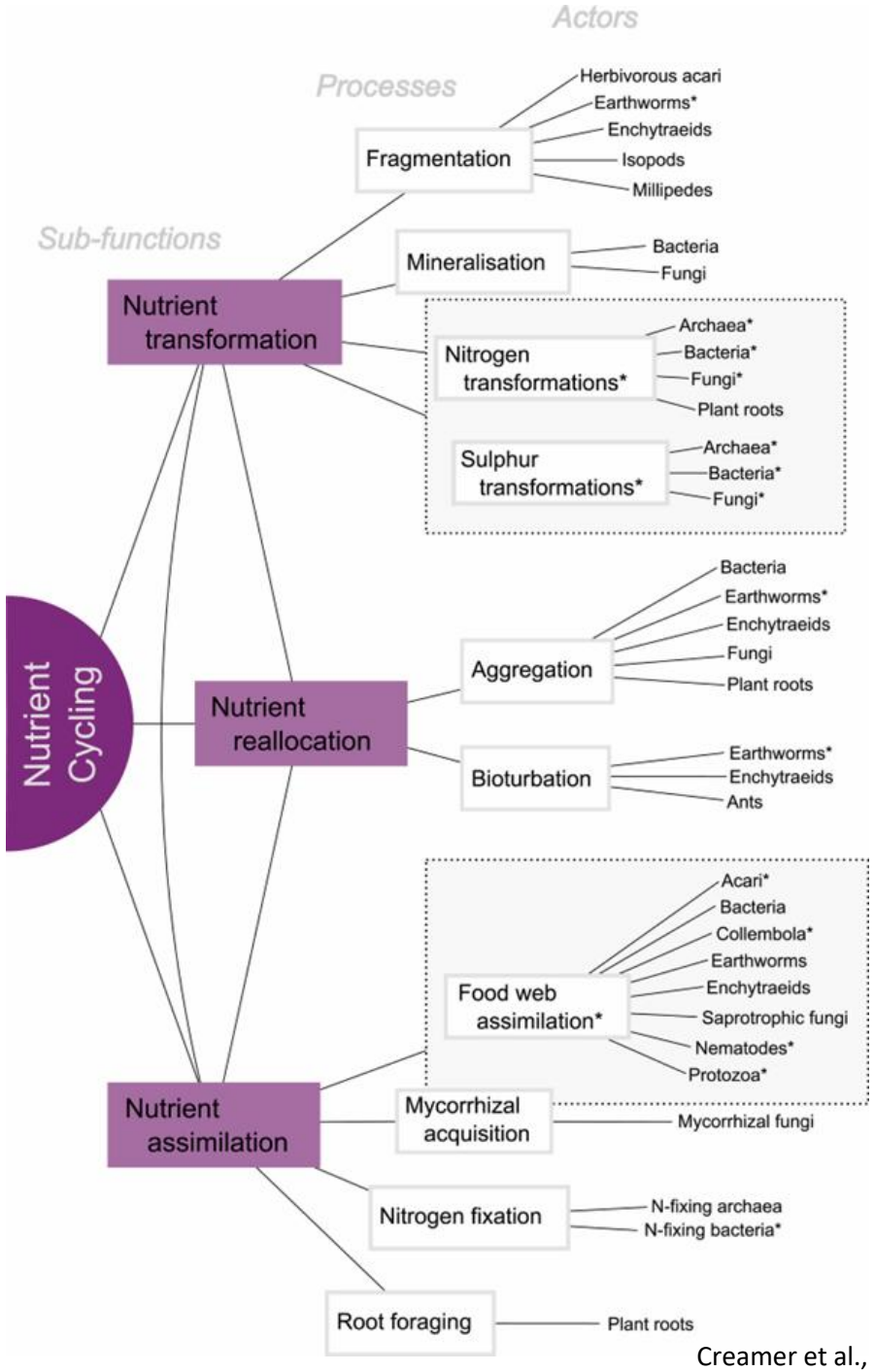
Hu et al. (2026)

Unpacking Soil Health

Jenzen et al. (2021):

Soil health is not an inherent property of soil, but a measure of its ability to deliver **ECOSYSTEM FUNCTIONS** in a given context.

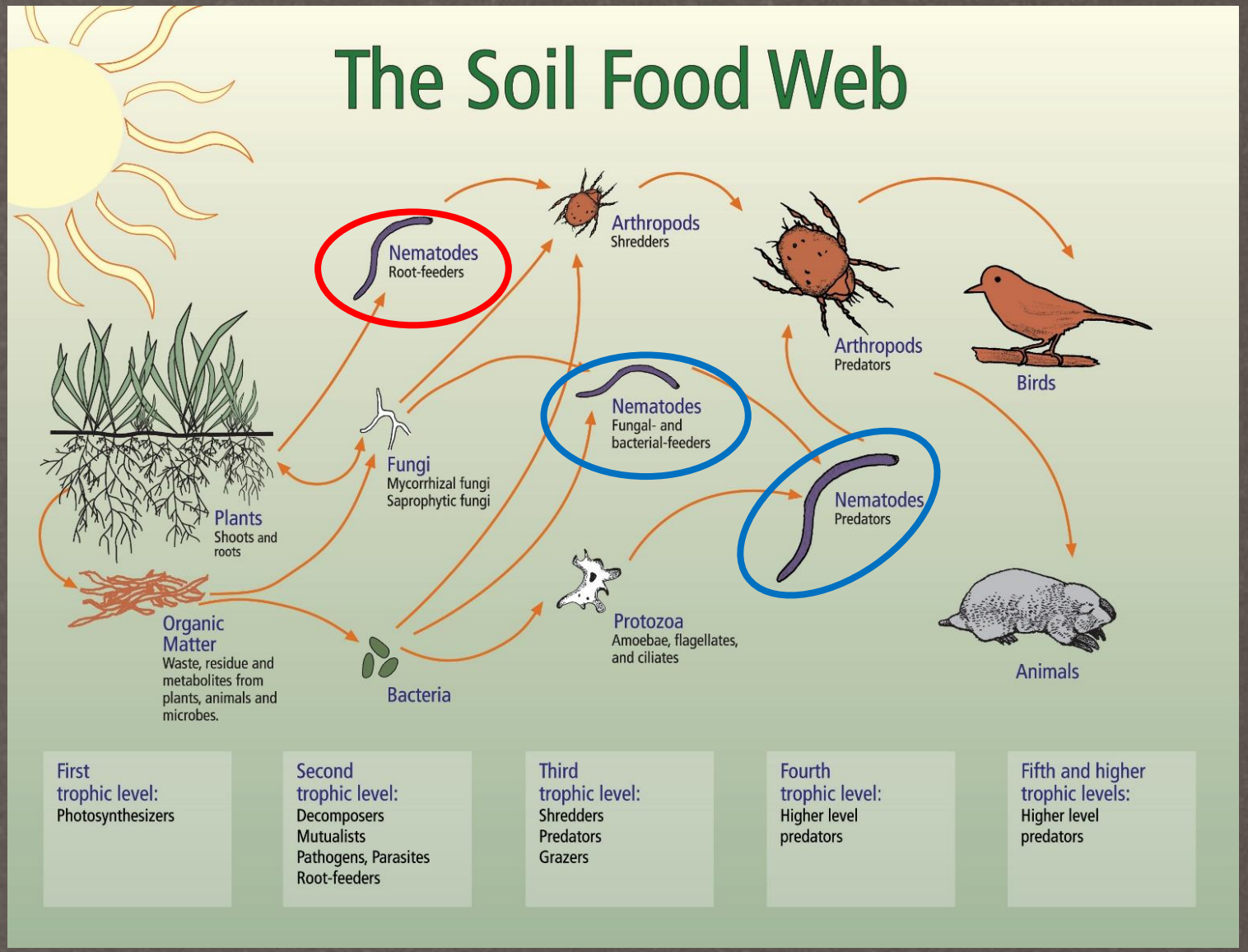




Creamer et al., 2022



Nematodes


The Soil Food Web
Nematodes
Root-feeders
Arthropods
Shredders
Arthropods
Predators
Birds
Nematodes
Fungal- and
bacterial-feeders
Fungi
Mycorrhizal fungi
Saprophytic fungi
Nematodes
Predators
Plants
Shoots and
roots
Organic
Matter
Waste, residue and
metabolites from
plants, animals and
microbes.
Bacteria
Protozoa
Amoebae, flagellates,
and ciliates
Animals
First
trophic level:
Photosynthesizers
Second
trophic level:
Decomposers
Mutualists
Pathogens, Parasites
Root-feeders
Third
trophic level:
Shredders
Predators
Grazers
Fourth
trophic level:
Higher level
predators
Fifth and higher
trophic levels:
Higher level
predators





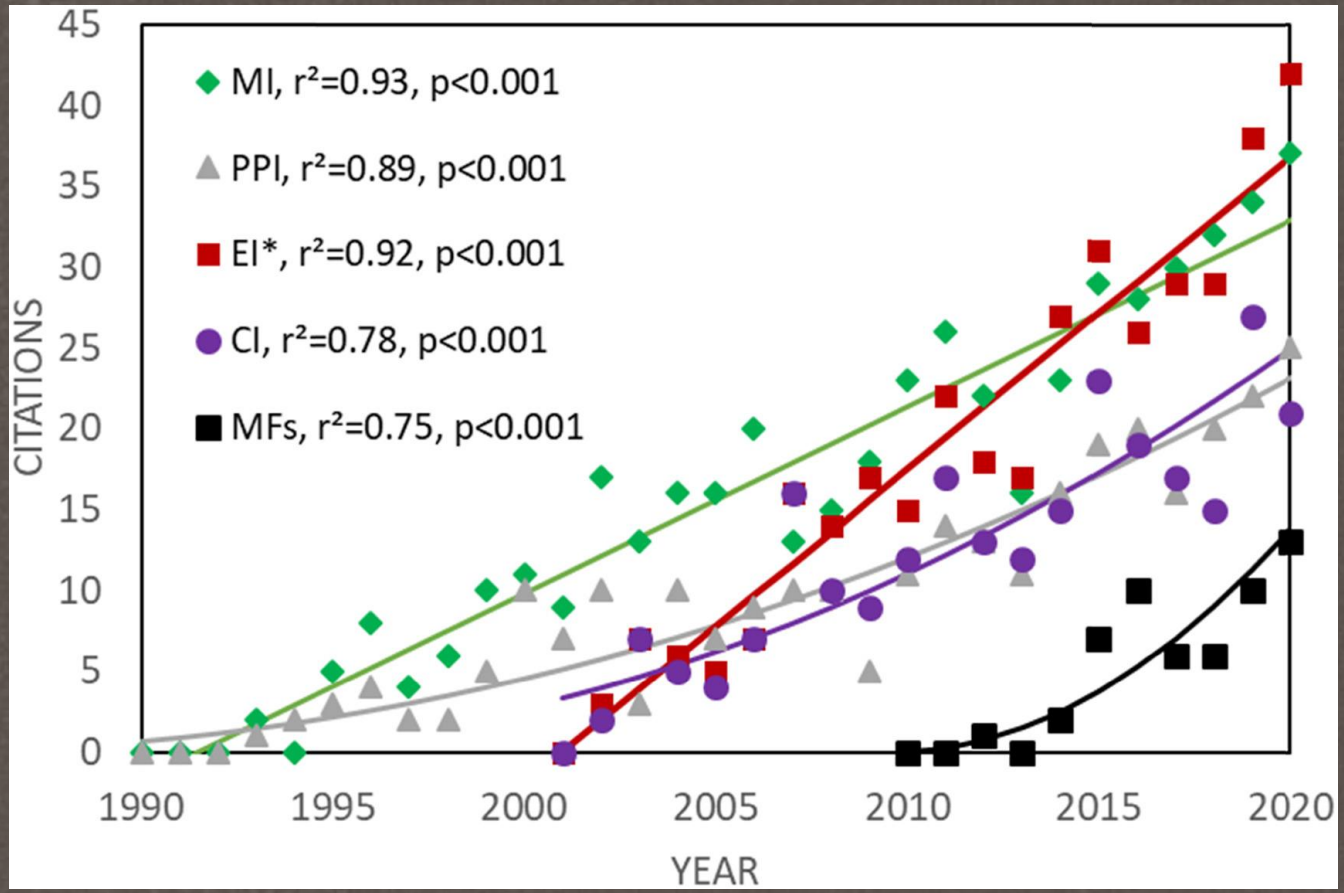
Nematode Indices in Soil Ecology

NBIs assess:

- Ecosystem disturbance
- Food web status
- Ecosystem functioning

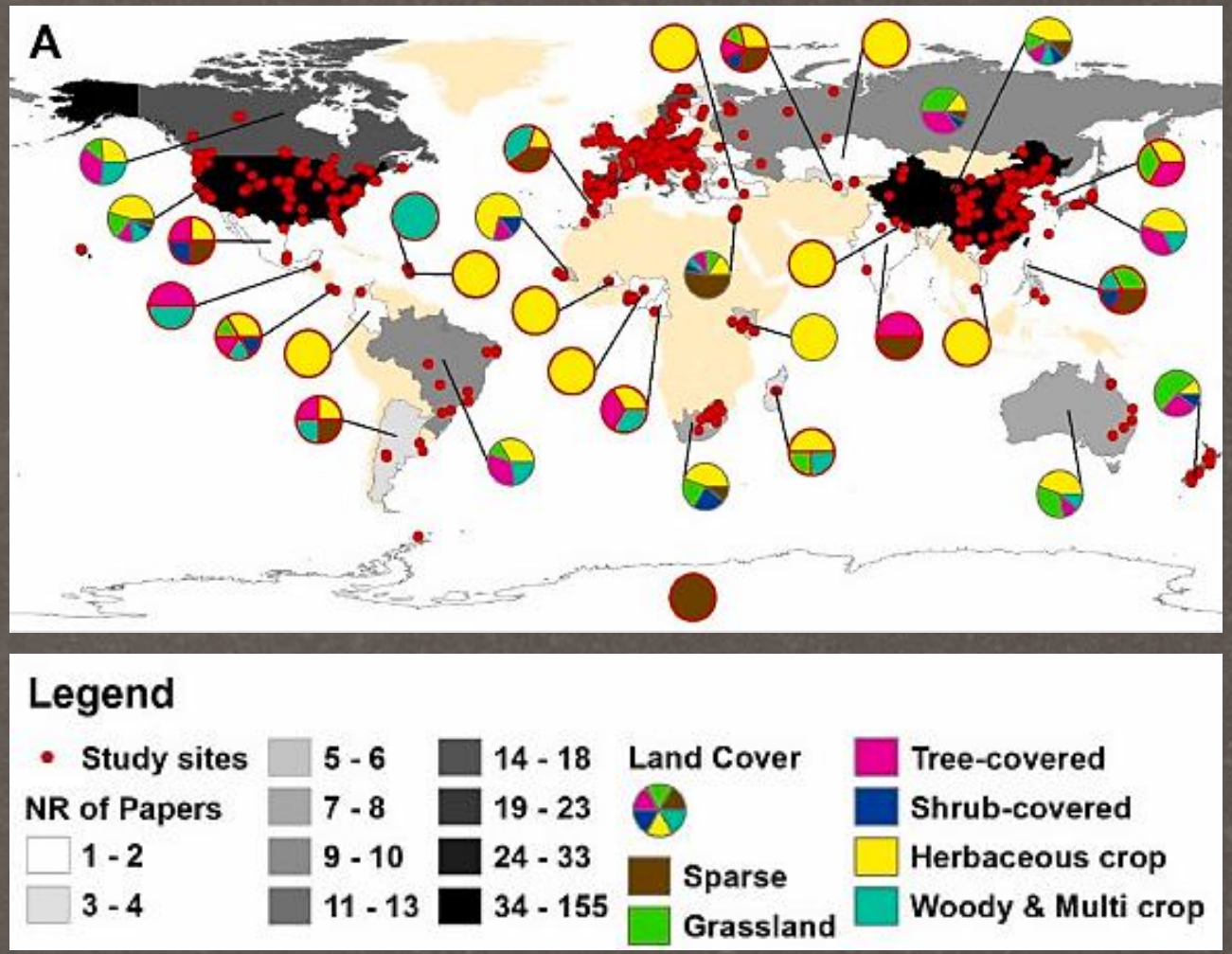
Key indices:

- MI, EI, SI, CI, MFs



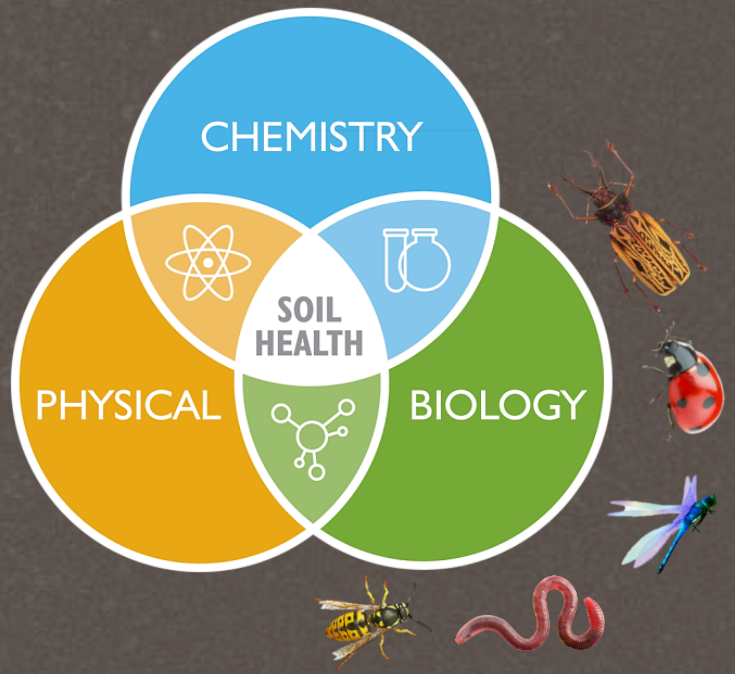
Du Preez, G., Daneel, M., De Goede, R., Du Toit, M. J., Ferris, H., Fourie, H., Geisen, S., Kakouli-Duarte, T., Korthals, G., Sánchez-Moreno, S., and Schmidt, J. H. 2022. Nematode-based indices in soil ecology: Application, utility, and future directions. Soil Biology and Biochemistry 169:108640. https://doi.org/https://doi.org/10.1016/j.soilbio.2022.108640

Use of NBIs by Land Cover



NBIs:

- Validated in ecological research
- Underutilised in **applied** SH Assess

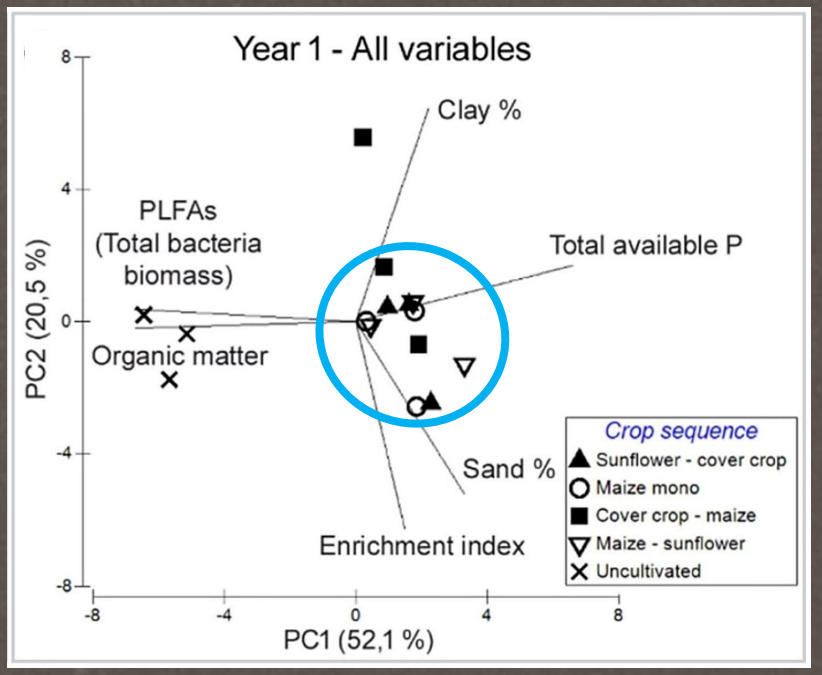


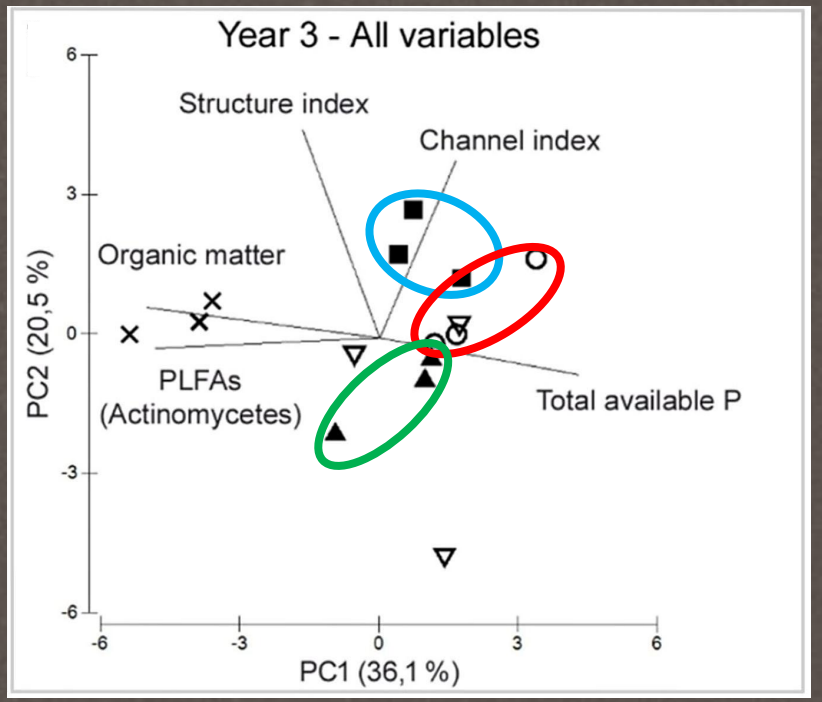
Du Preez, G., Daneel, M., De Goede, R., Du Toit, M. J., Ferris, H., Fourie, H., Geisen, S., Kakouli-Duarte, T., Korthals, G., Sánchez-Moreno, S., and Schmidt, J. H. 2022. Nematode-based indices in soil ecology: Application, utility, and future directions. Soil Biology and Biochemistry 169:108640. https://doi.org/https://doi.org/10.1016/j.soilbio.2022.108640

STUDY 1: Temporal Responses under RA

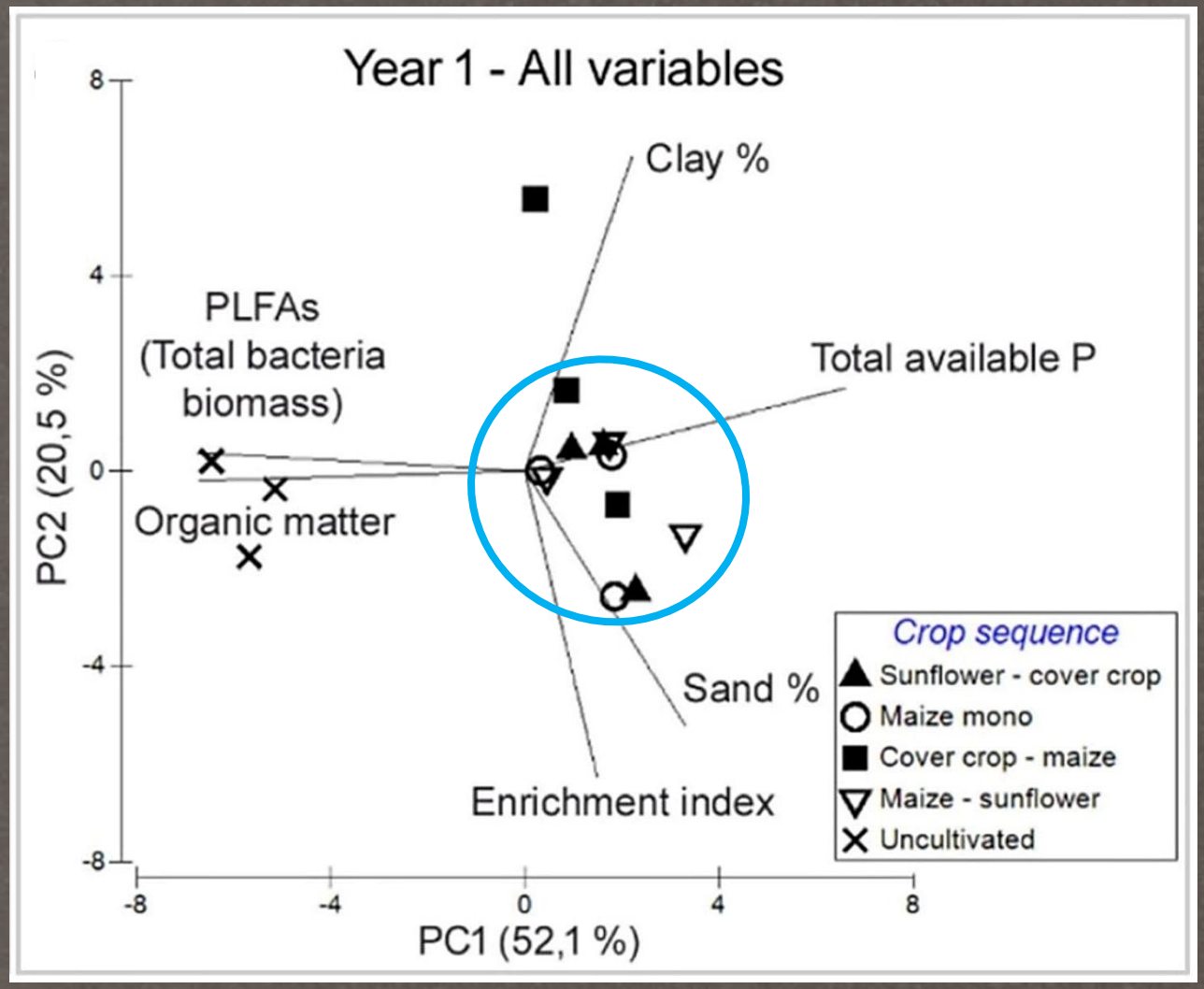
- 3-ye **rassland**
- Yr 1 g. P, text
- Yr 2 CI)

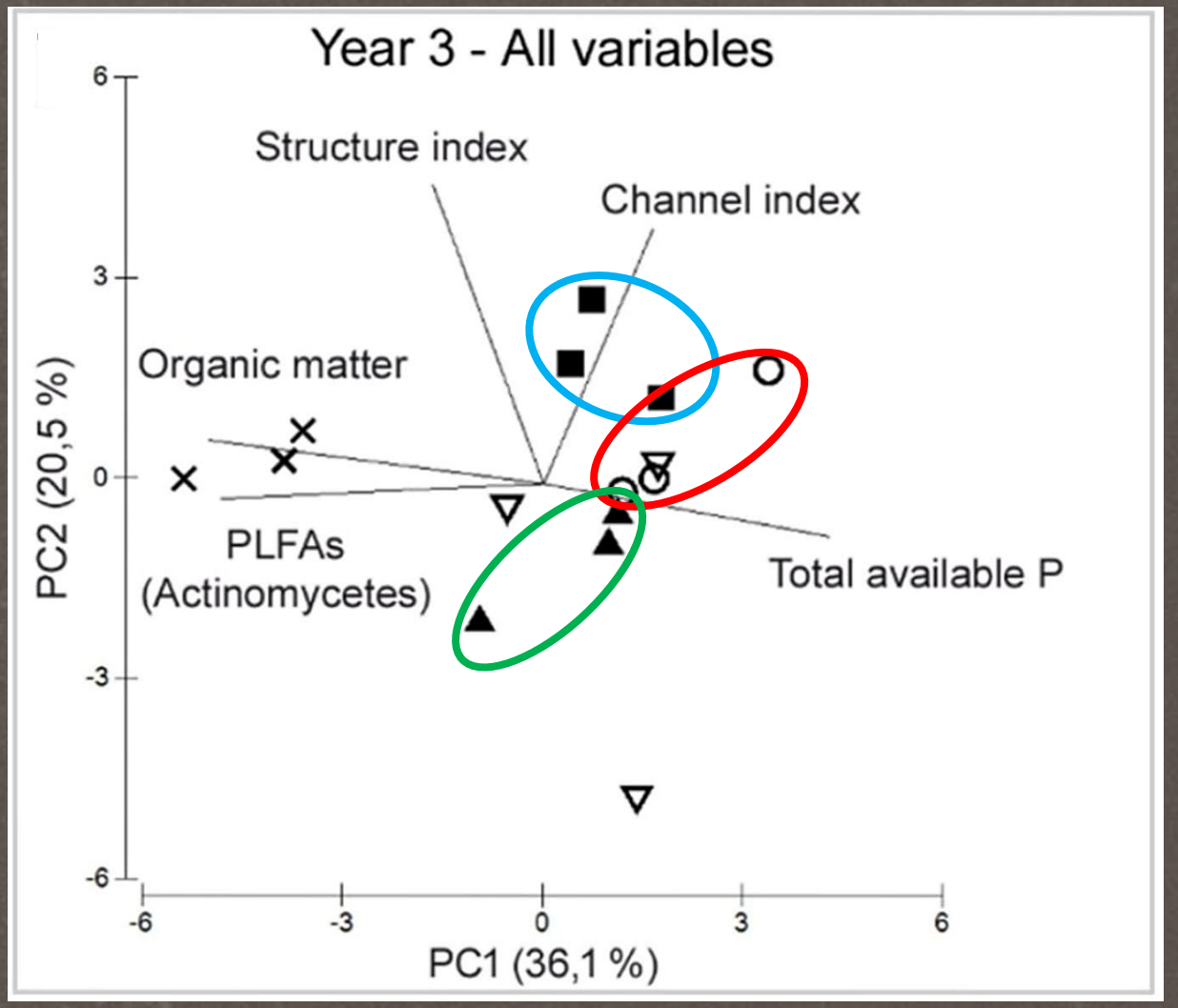






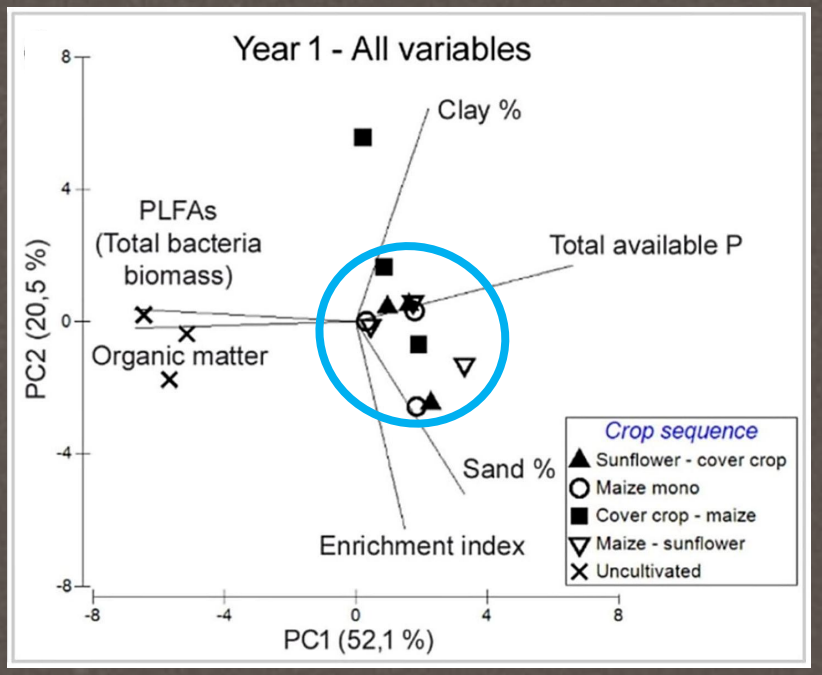
Du Preez, G.C., Marcelo-Silva, J., Azizah, N., Claassens, S., and Fourie, F. 2024. Time Matters: A short-term longitudinal analysis of conservation agriculture and its impact on soil health. Journal of Soil Sciences and Plant Nutrition 24, 1319–1334. https://doi.org/10.1007/s42729-024-01636-w

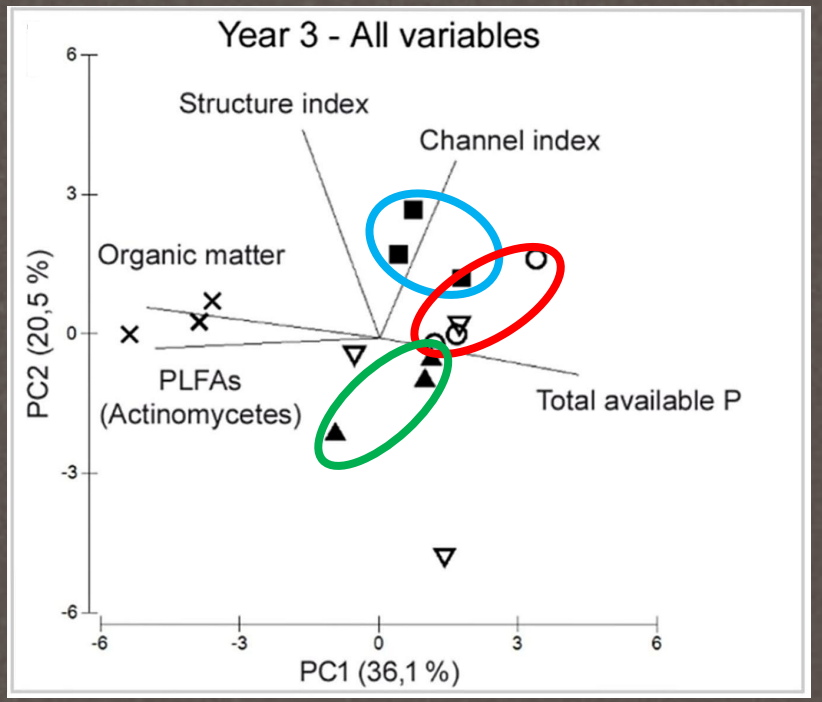

Year 1 - All variables
Clay %
PLFAs
(Total bacteria
biomass)
Total available P
Organic matter
Sand %
Enrichment index
Crop sequence
Sunflower - cover crop
Maize mono
Cover crop - maize
Maize - sunflower
Uncultivated
PC2 (20,5 %)
PC1 (52,1 %)
8
4
0
-4
-8
-8
-4
0
4
8


Year 3 - All variables
Structure index
Channel index
Organic matter
PLFAs
(Actinomycetes)
Total available P
PC2 (20,5 %)
PC1 (36,1 %)
6
3
0
-3
-6
-6
-3
0
3
6

STUDY 1: Temporal Responses under RA

- 3-year Trial: **Maize mono** vs **RA** vs **Grassland**
- Yr 1: Abiotic parameters = drivers (e.g. P, texture)
- Yr 2-3: Biotic responses emerge (↑SI, CI)
- Cover crop - maize: ↑ fungal pathways (CI), ↑ food web structure

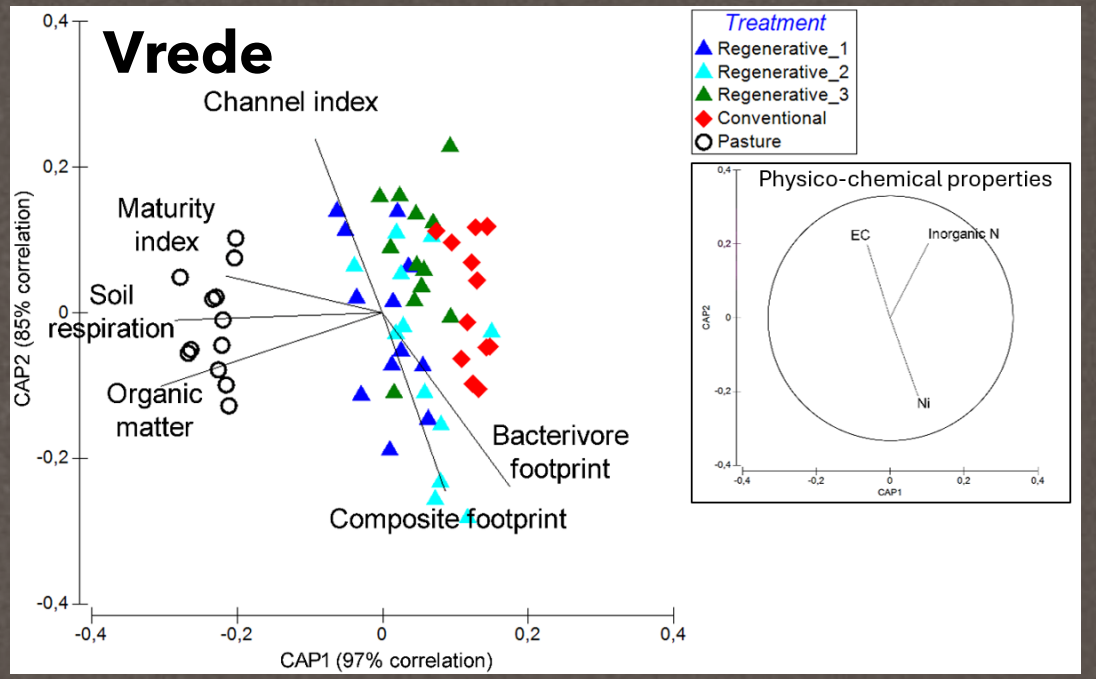


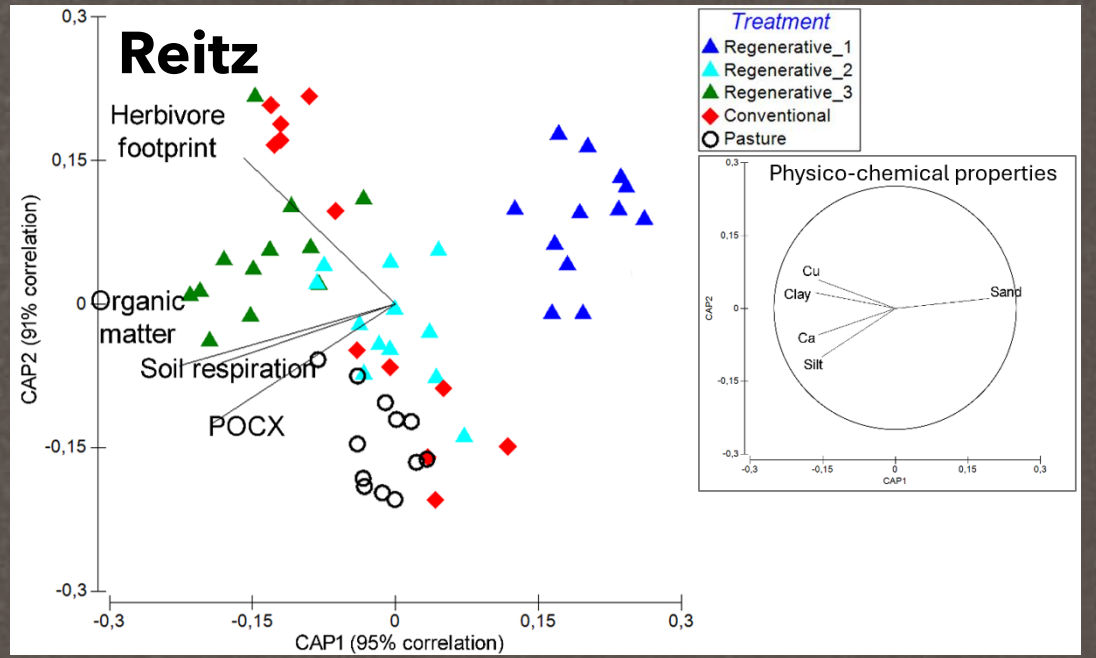


Du Preez, G.C., Marcelo-Silva, J., Azizah, N., Claassens, S., and Fourie, F. 2024. Time Matters: A short-term longitudinal analysis of conservation agriculture and its impact on soil health. Journal of Soil Sciences and Plant Nutrition 24, 1319–1334. https://doi.org/10.1007/s42729-024-01636-w

STUDY 2: Varying On-Farm Contexts

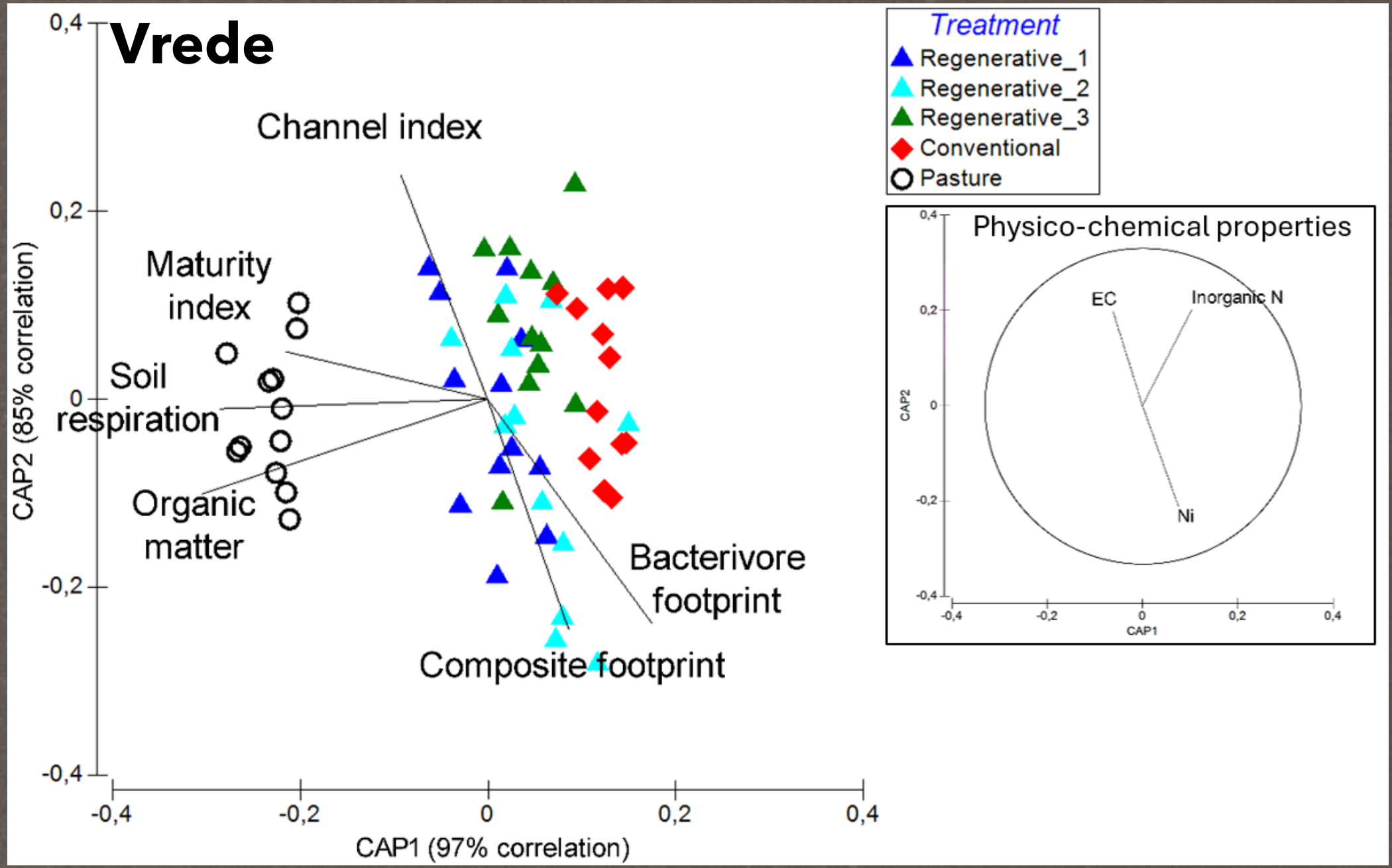
- On-farm = **Conv Rot** vs **RA** vs **Pasture**
- 2 x seasons, 2 x contexts (Reitz, Vrede)
- Vrede: RA = ↑MI, ↑OM, ↑respiration
- Reitz: RA = No sig biological response

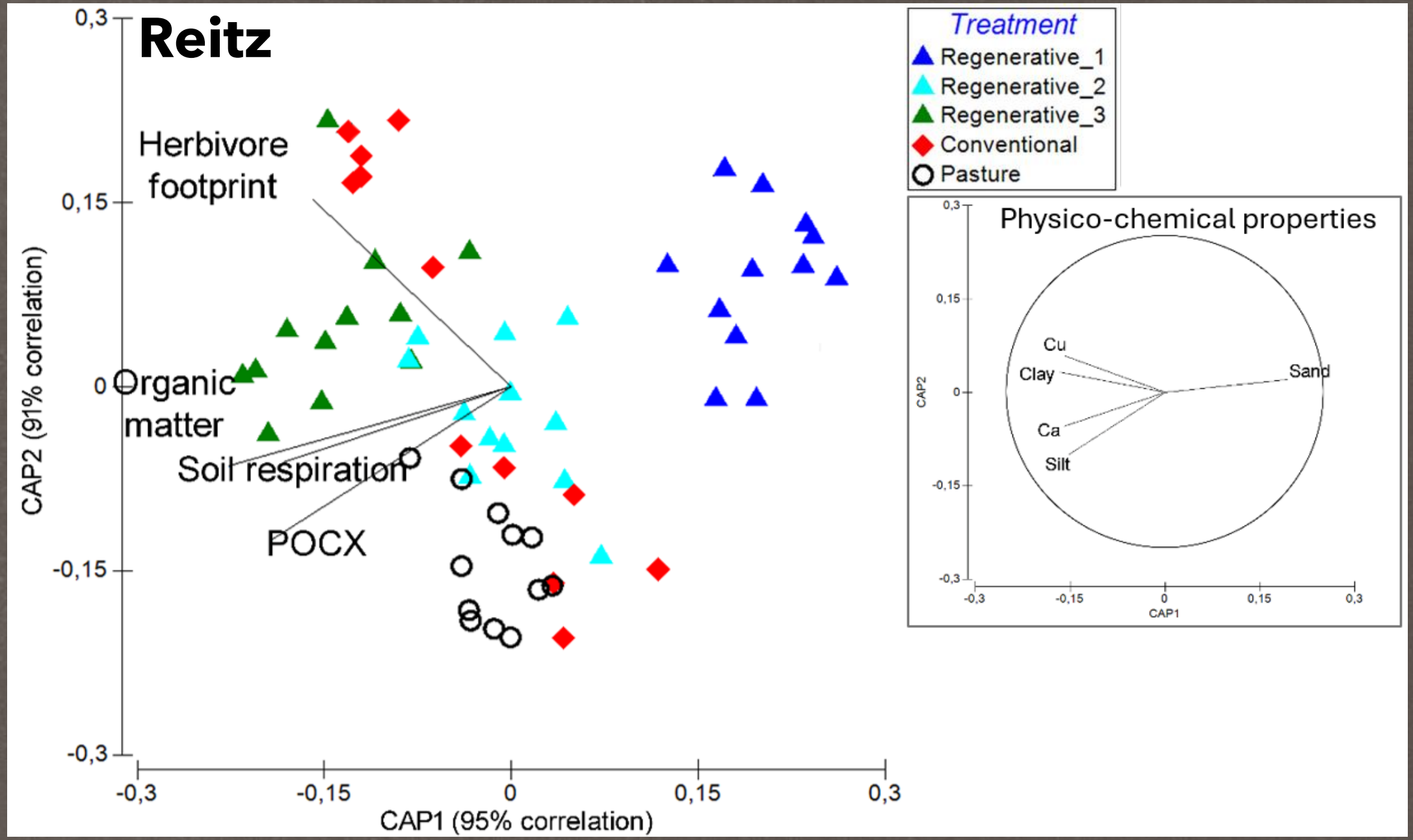




Du Preez, G.C., Loggenberg, A., Fourie, D. Marcelo-Silva, J., Martin, T., Ramphisa-Nghondzweni, D., Smith, H, and Sprunger, C. 2025. Context matters: soil ecosystem status varies across diverse conservation agriculture systems. Journal of Soil Sciences and Plant Nutrition 25, 2576-2589. https://doi.org/10.1007/s42729-025-02285-3

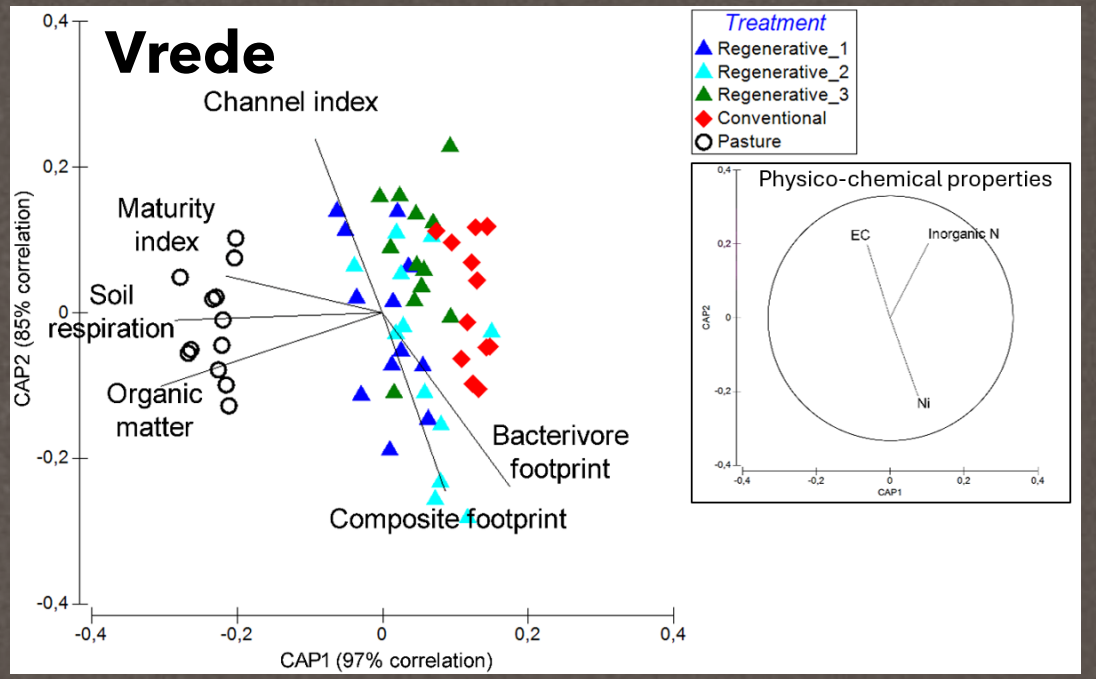
Vrede

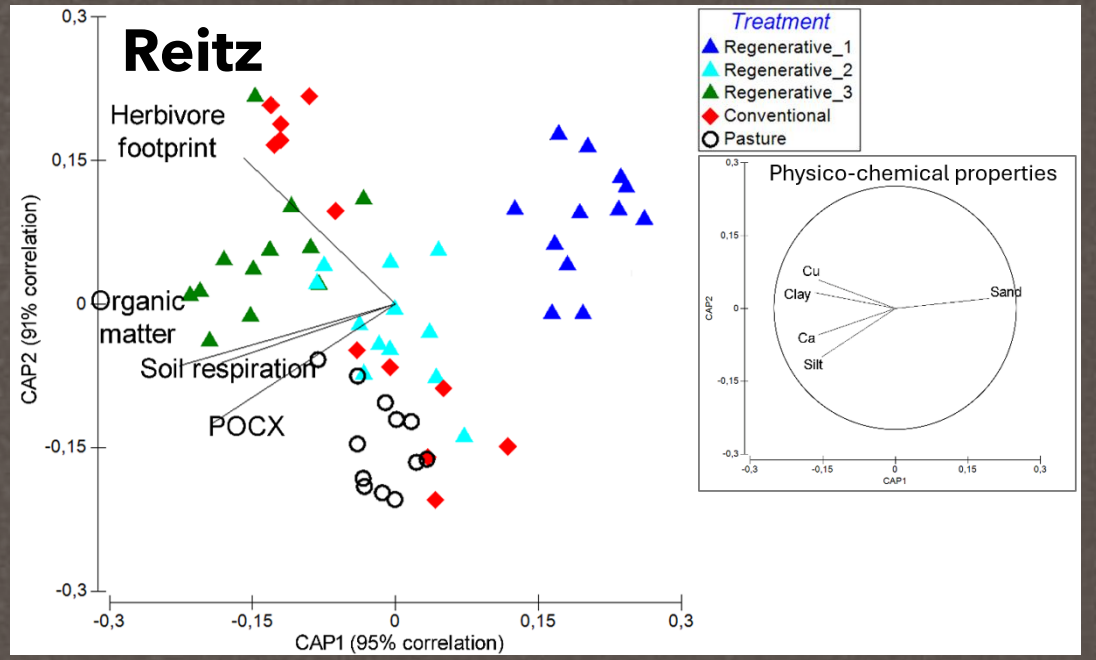

Treatment
Regenerative_1
Regenerative_2
Regenerative_3
Conventional
Pasture
Channel index
Maturity index
Soil respiration
Organic matter
Bacterivore footprint
Composite footprint
CAP2 (85% correlation)
CAP1 (97% correlation)
0,4
0,2
0
-0,2
-0,4
-0,4
-0,2
0
0,2
0,4
Physico-chemical properties
EC
Inorganic N
Ni
CAP2
CAP1


Reitz
Treatment
Regenerative_1
Regenerative_2
Regenerative_3
Conventional
Pasture
Herbivore footprint
Organic matter
Soil respiration
POCX
CAP2 (91% correlation)
CAP1 (95% correlation)
0,3
0,15
0
-0,15
-0,3
Physico-chemical properties
Cu
Clay
Sand
Ca
Silt
CAP2
CAP1

STUDY 2: Varying On-Farm Contexts

- On-farm = **Conv Rot** vs **RA** vs **Pasture**
- 2 x seasons, 2 x contexts
- Vrede: RA = ↑MI, ↑OM, ↑respiration
- Reitz: RA = No sig. biological response
- Same practices ≠ same outcomes

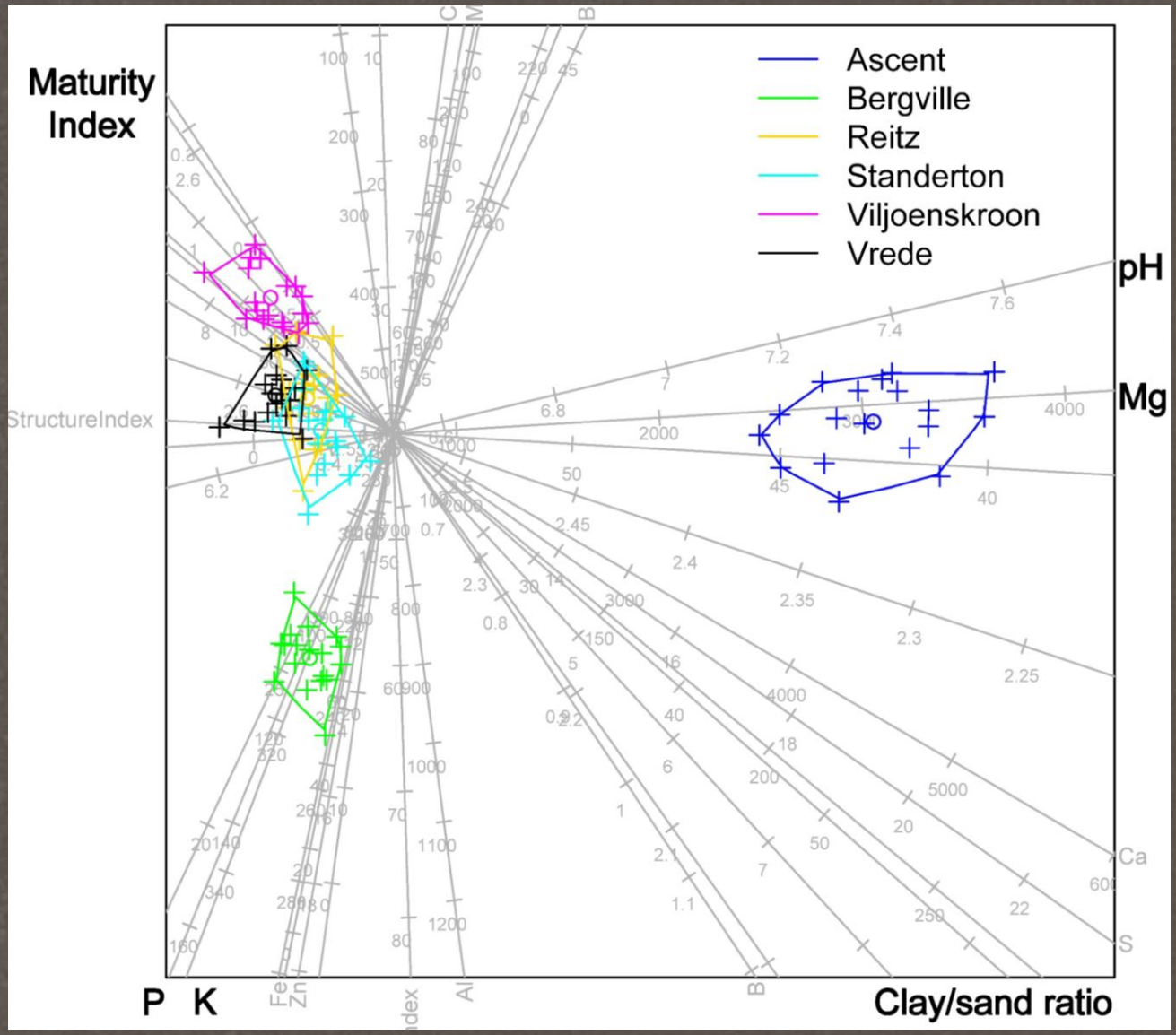




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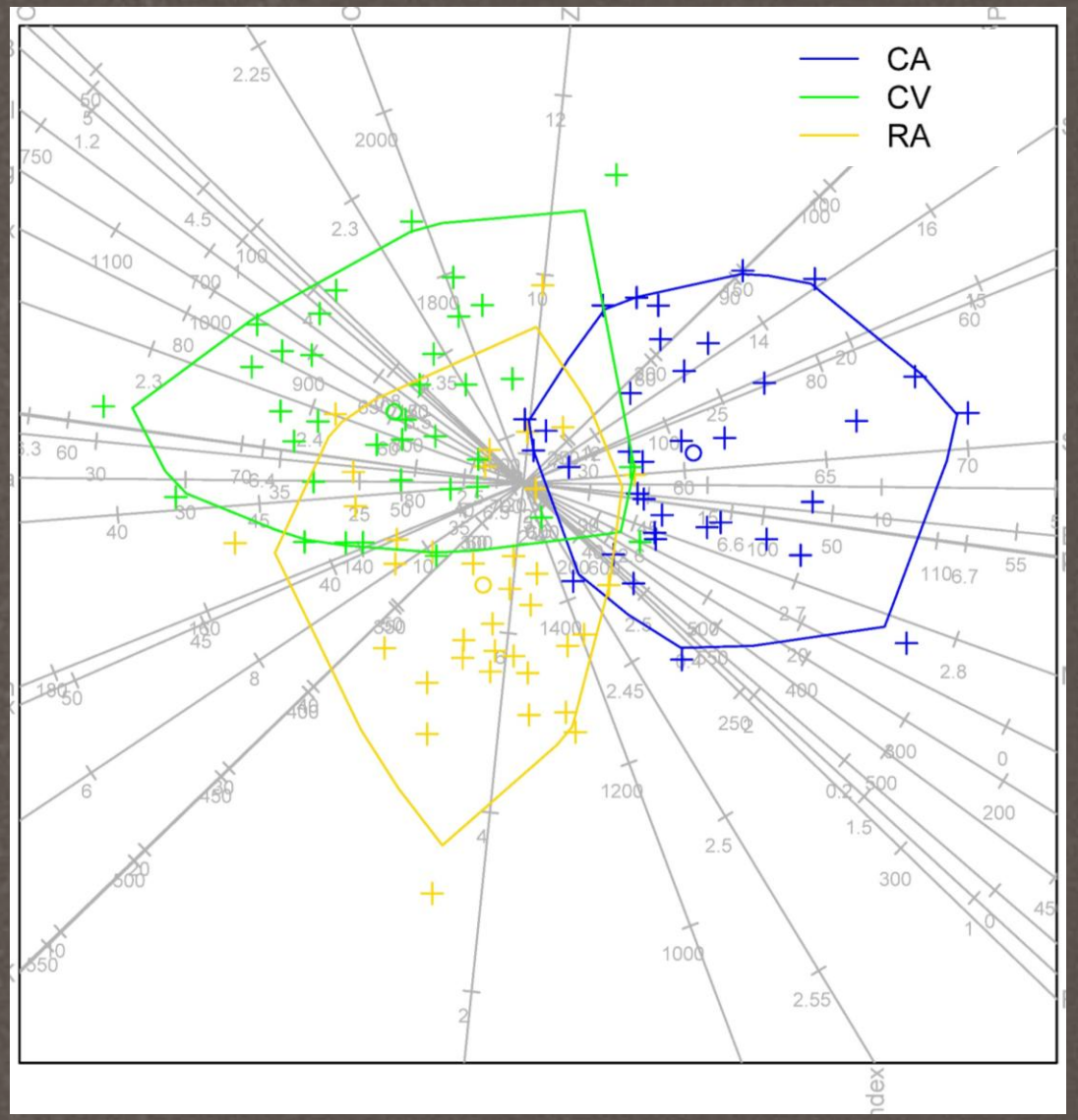
STUDY 3: Regional Patterns

- CV, CA, RA × 6 ecotopes
- MI, SI, BI, EI varied by ecotope



STUDY 3: Regional Patterns

- CV, CA, RA × 6 ecotopes
- MI, SI, BI, EI varied by ecotope
- CI + MFs varied by ecotope + system
- Diff management + environ contexts = varying ecosystem responses



Cross-Study Synthesis

- NBIs =
  - ➢ Responsive and directional
  - ➢ Detection of early ecological shifts
  - ➢ Evidence of ↑ ecosystem status under CA/RA
- Interpretation needs context:
  - ➢ Environmental (e.g., climate + edaphic)
  - ➢ Management (e.g., system, variations, history)
- Best used in multi-indicator bundles (phys, chem, biol)



Acknowledgements











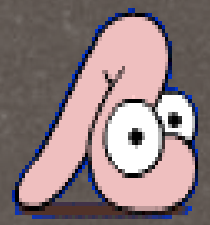






MAIZE TRUST





THANK YOU

