Agricultural systems
by design

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FAB4Farming: assessing the impact of disturbance gradients on agrobiodiversity for sustainable farming systems design

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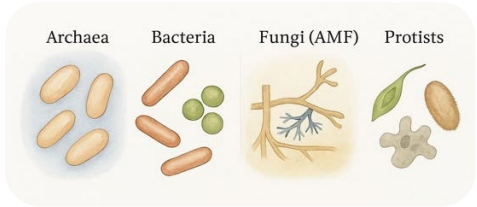
Project Background

FAB4Farming (**F**unctional **A**gro**B**iodiversity for **F**arming)

A 4-year project assessing how pesticide use and tillage affect functional agrobiodiversity in **Wallonia**, Belgium.

Focus on:

- winter cereal crops
- **Carabids** (including prey: aphids and slugs)
- **Earthworms**
- Pollinators (circulating entomofauna)
- Soil microorganisms



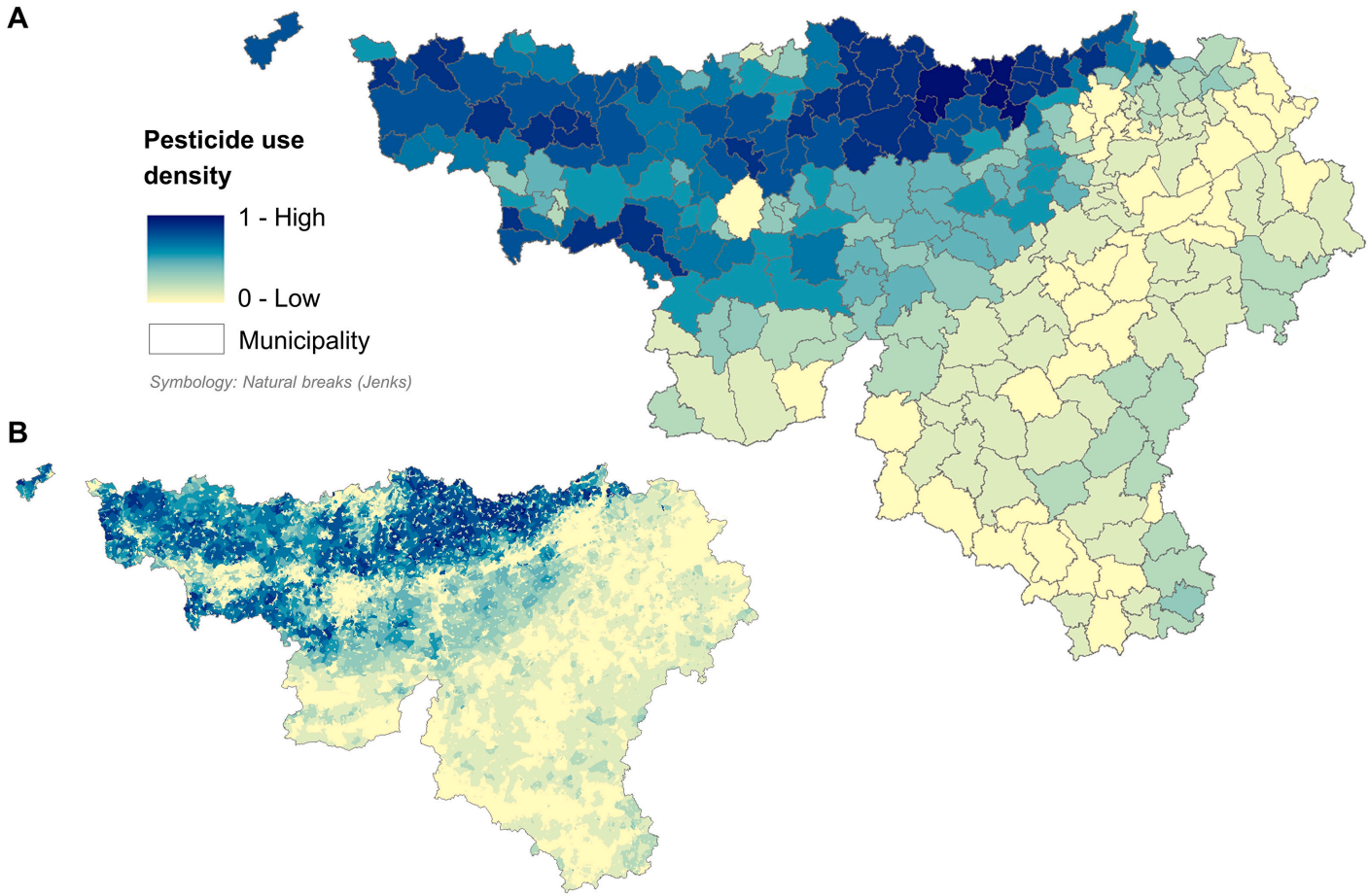
Context

A need for pesticide reduction in Wallonia

- Belgium = 5th largest consumer of pesticides in the EU[1]
- Wheat = 3rd most pesticide-consuming crop in Wallonia[2]
- Wheat = largest cultivated crop in Wallonia (by area)[2]

→ Strong pesticide dependency in Walloon cereal systems

Key question: how to plan sustainable agricultural pathways?

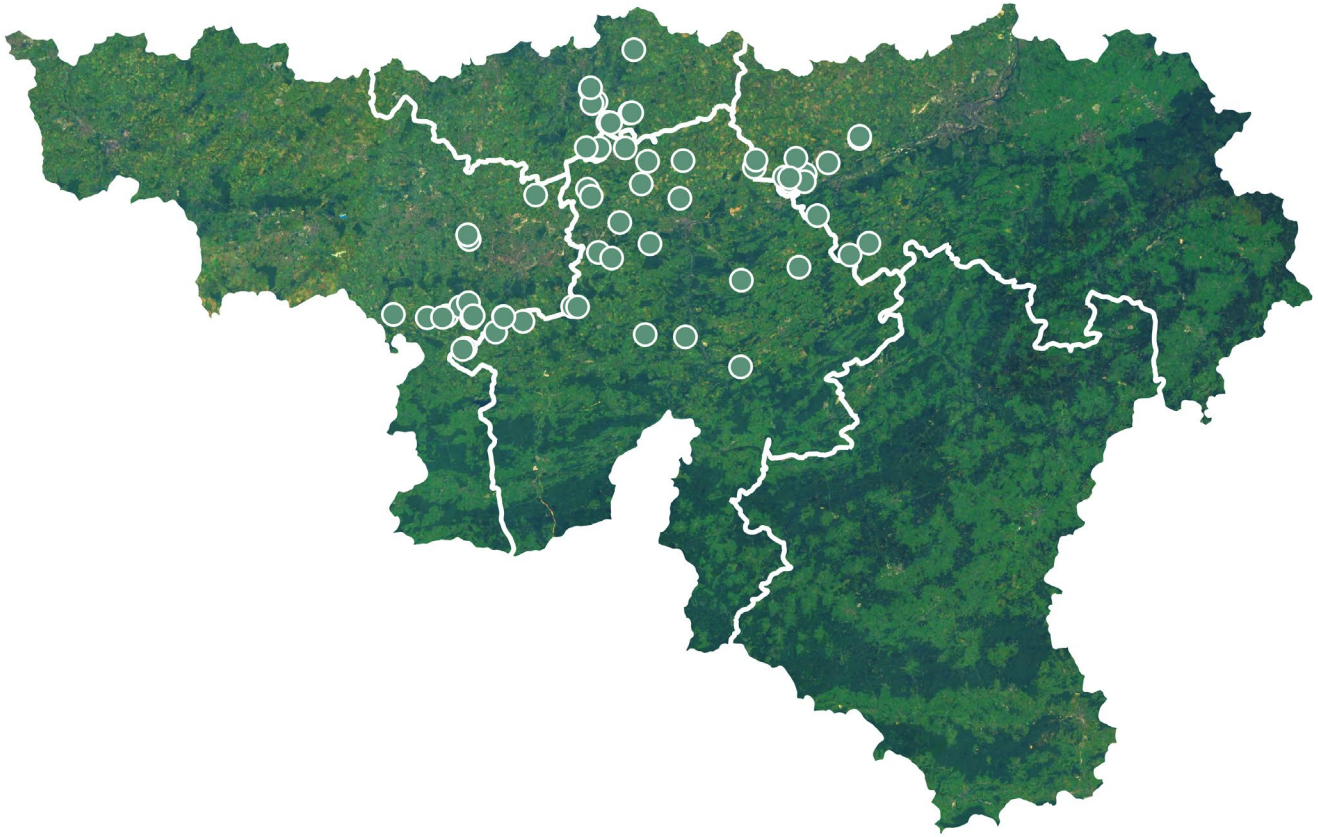


From Habran *et al.*, 2022: Indicators of pesticide use density (total quantity of active substance applied to crops) by municipality.

1: FAOSTAT, 2021.
2: Report on the use of plant protection products in Wallonia (SPW ARNE, 2023).

Methods

Sampling Sites



63 in-farm plots (2024-2025), +40 planned in 2026

Winter cereal fields (excluding barley)

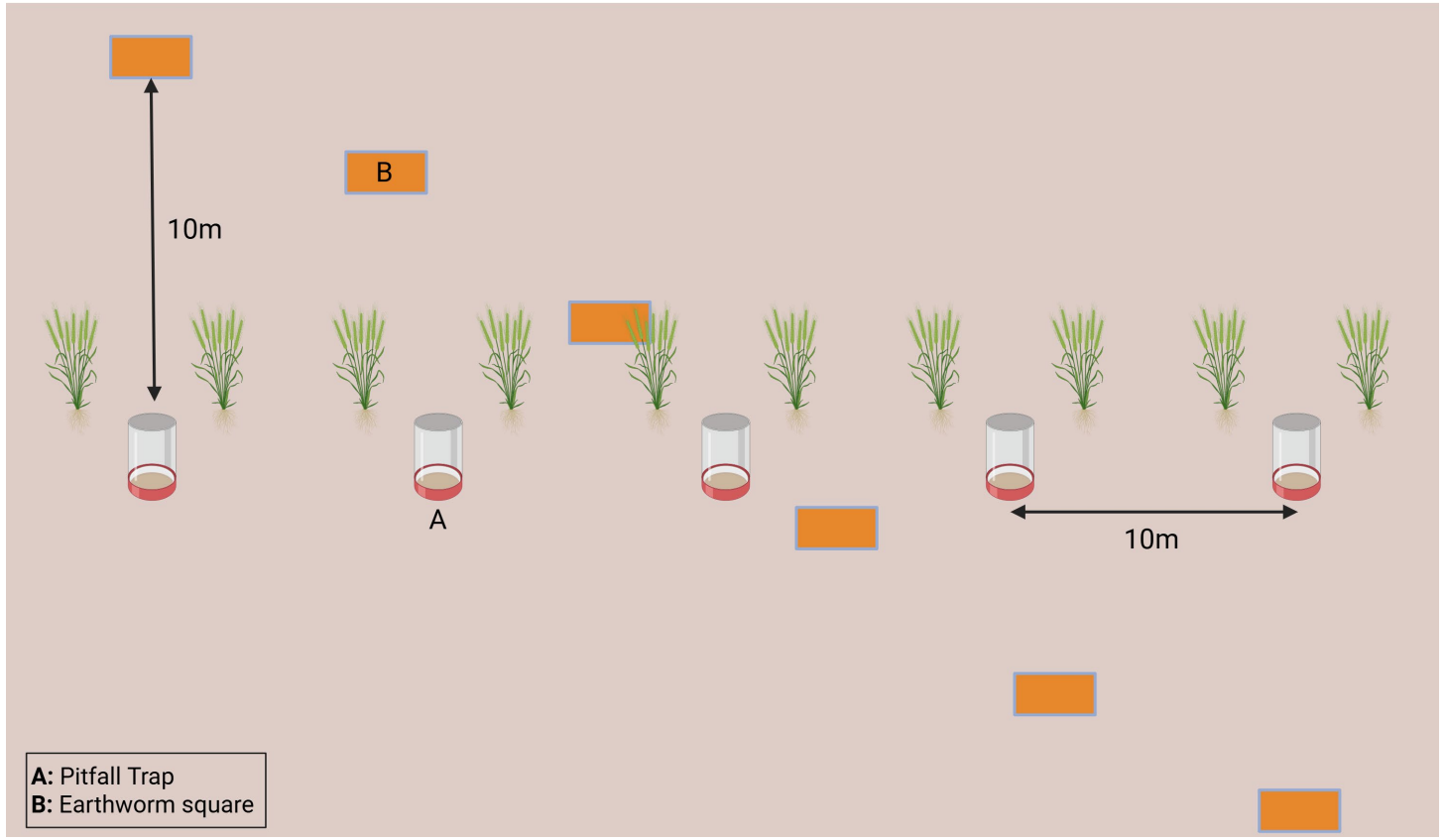
4 farming systems:

- Conventional (CVL)
- Organic (BIO)
- Conservation agriculture (CST)
- Organic conservation (ABC)

43 farmers involved

Methods

Agrobiodiversity Sampling protocol



Earthworms :

- 1 sampling – 6 soil pits per site

→ Spade test (25 x 15 x 25 cm) + chemical extraction (AITC, 0.1 g/L)

Carabids :

- 6 samplings – 5 pitfalls per site

→ Pitfalls centred in the plot, filled with vinegar + soap.

Methods

Data collection through farmers' interviews

Chemical disturbance

Phytosanitary Products (PPP) applied in the field

- Date, Dose, Formulation -

Active substances (a.s.) extraction

ISAC (Active Substance per Crop Index) calculation

$$ISAC = \sum \frac{a.s.\ \textbf{Applied quantity}}{a.s.\ \textbf{Maximal authorized dose}}$$

Mechanical disturbance

Tillage and mechanical operations in the field

(Covercrop + main crop)

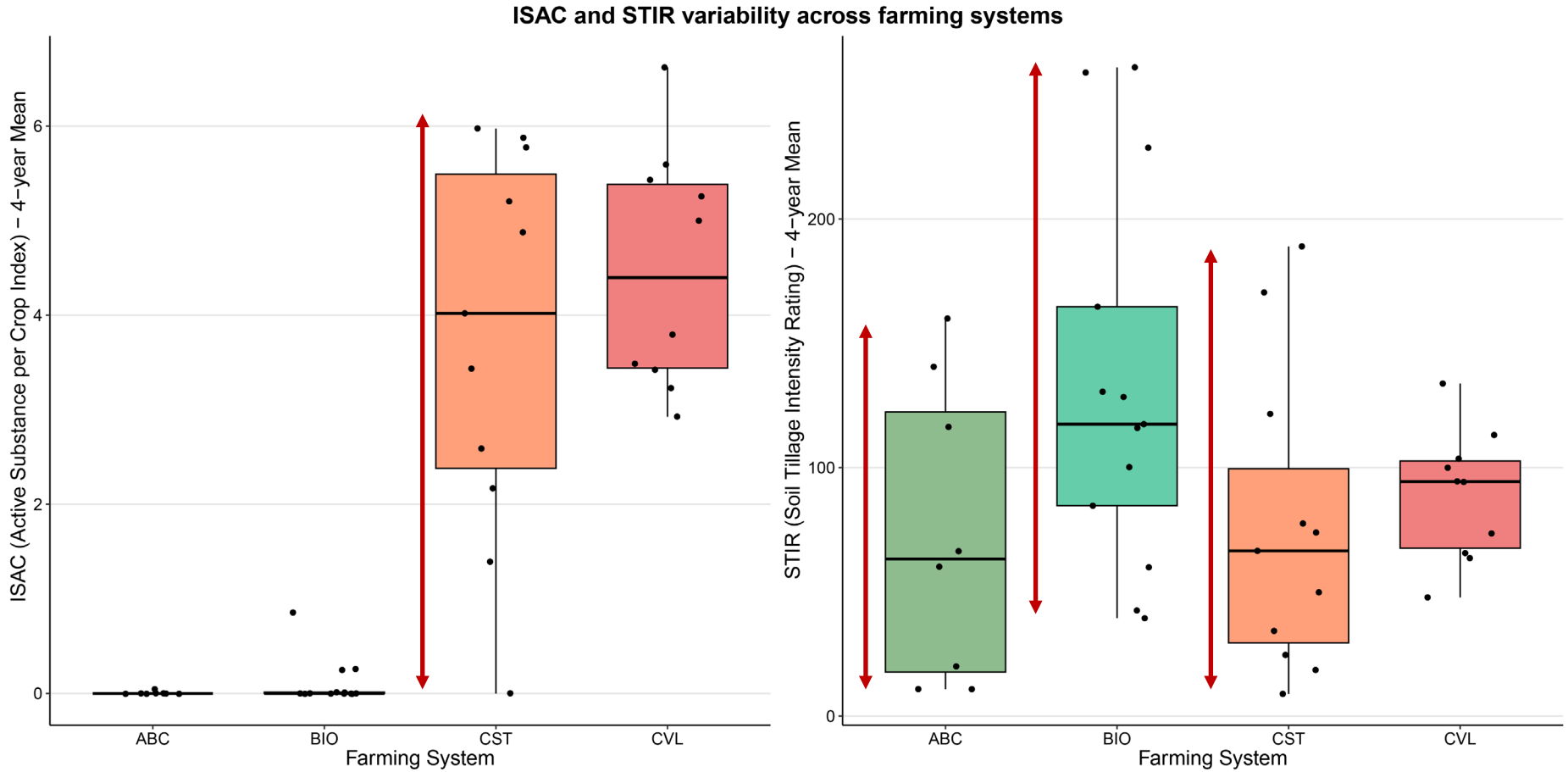
- Machine, Date, Depth, Speed -

STIR (**S**oil **T**illage **I**ntensity **R**ating) calculation

$$STIR = \sum(0.5 * \textbf{Speed}) * (3.25 * \textbf{Work type}) * \textbf{Depth} * \textbf{Perturbated area}$$

Methods

Unravelling variability in agricultural systems



- High within-system variability in tillage
- High variability in pesticide use within non-organic systems

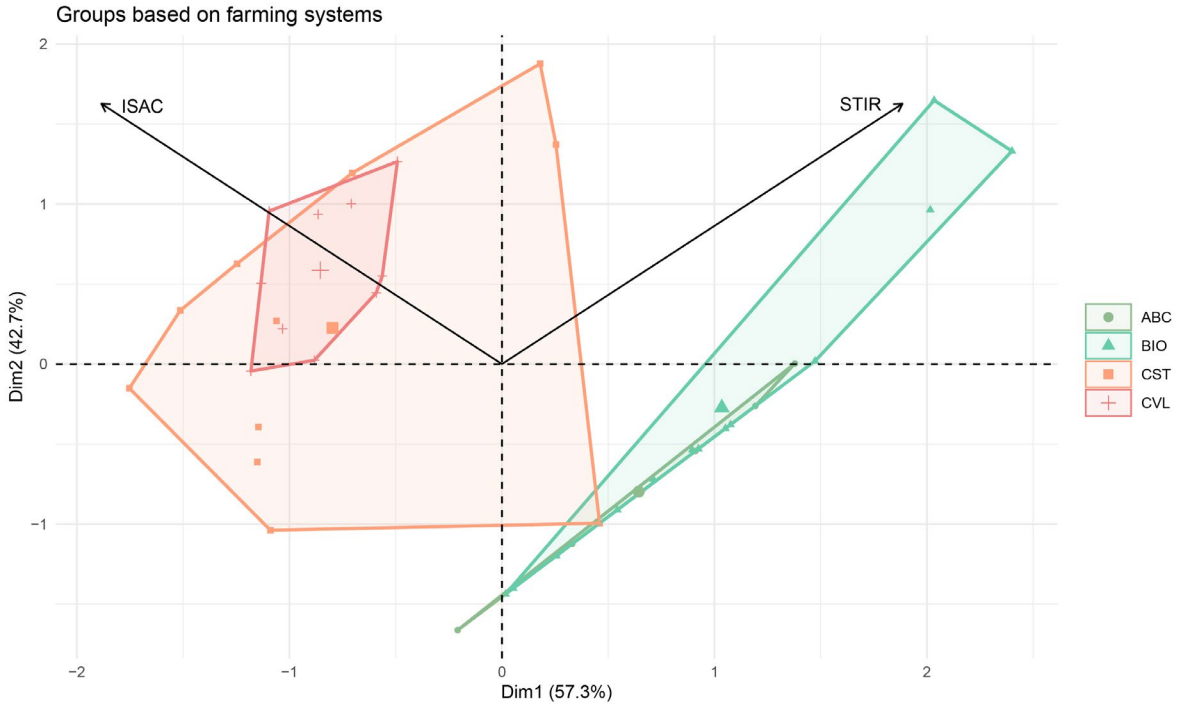
→ **High practices diversity within farming systems**

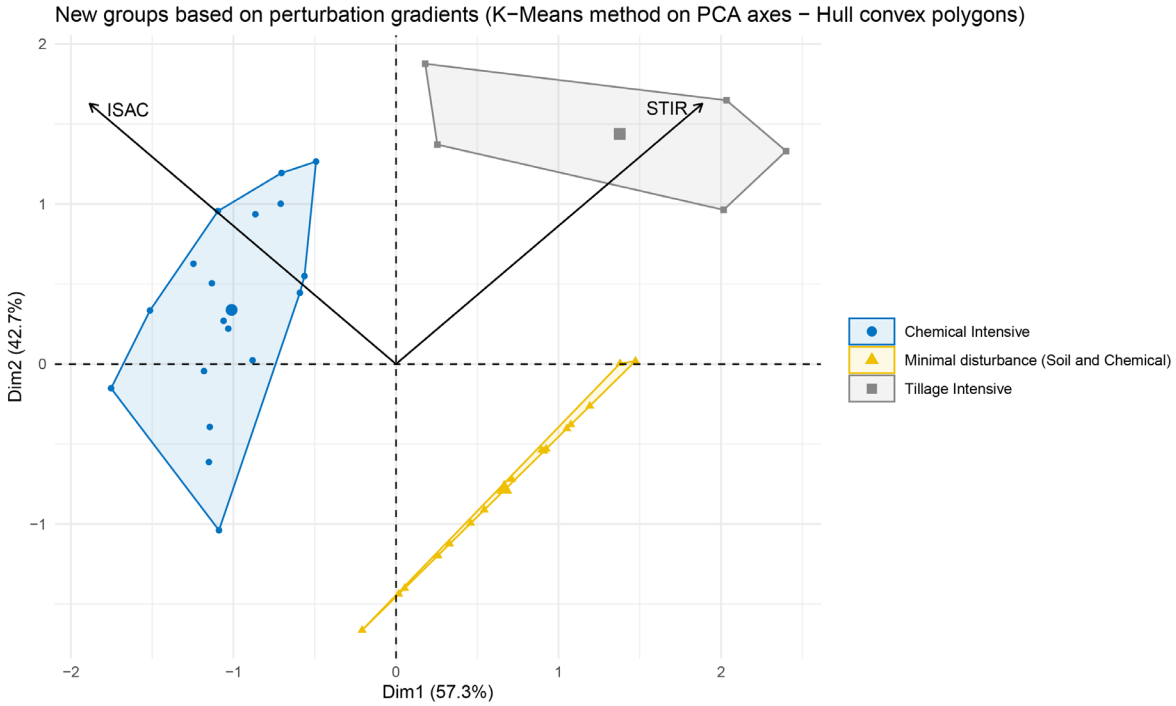
Key question:
how to better capture the impact of practices?

Preliminary Results

Disturbance Gradients

Clustering on disturbance gradients (PCA + k-means)





Farming system groups: strong **overlap**

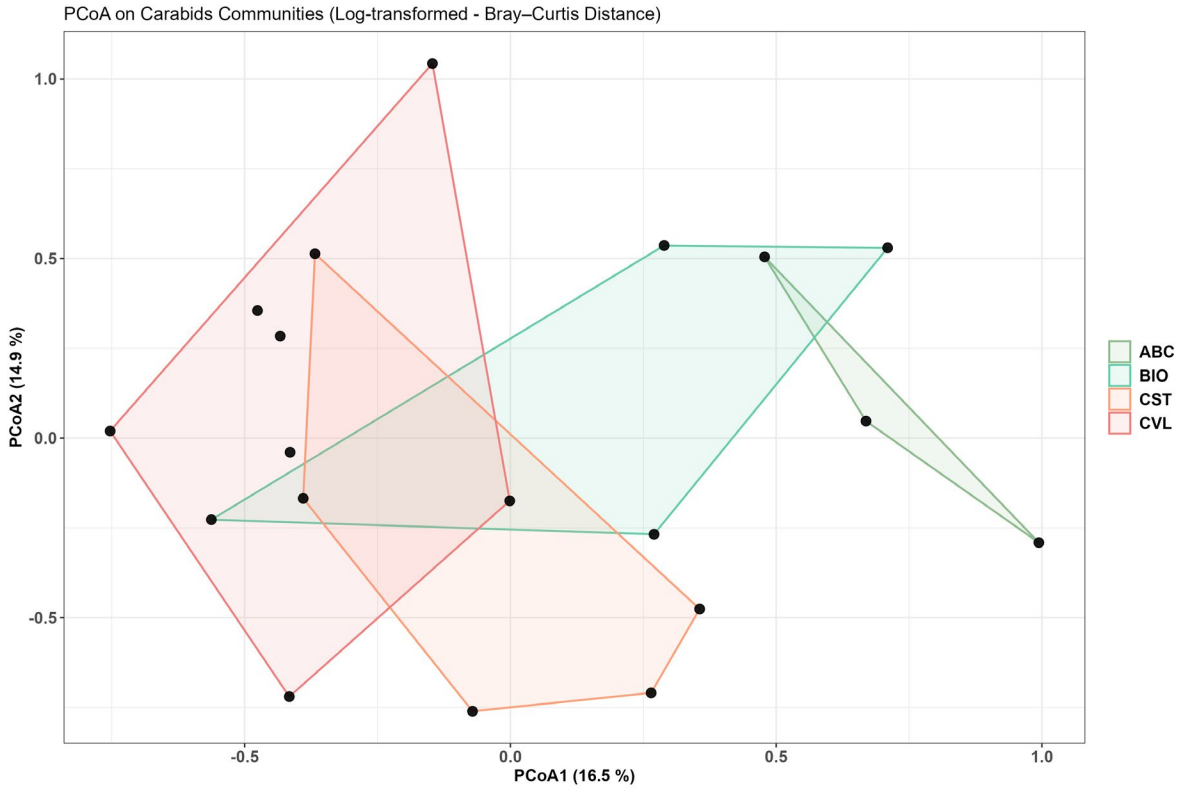
Gradient-based clustering: 3 **distinct profiles**

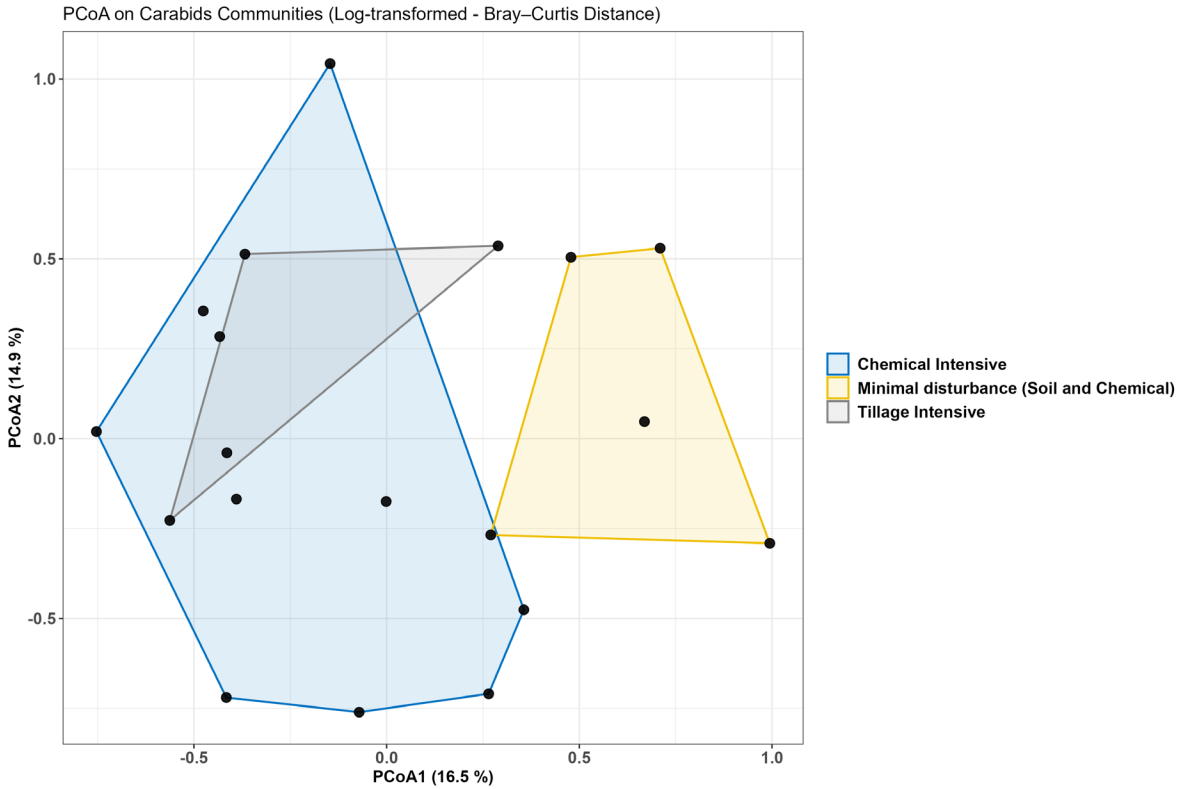
→ Broad farming system categories mask differences in disturbance regimes. Gradient-based clustering provides a clearer differentiation

Preliminary Results

Disturbance Gradients – Example on Carabid community

PCoA of carabid community composition (log-abundance; Bray–Curtis distance)





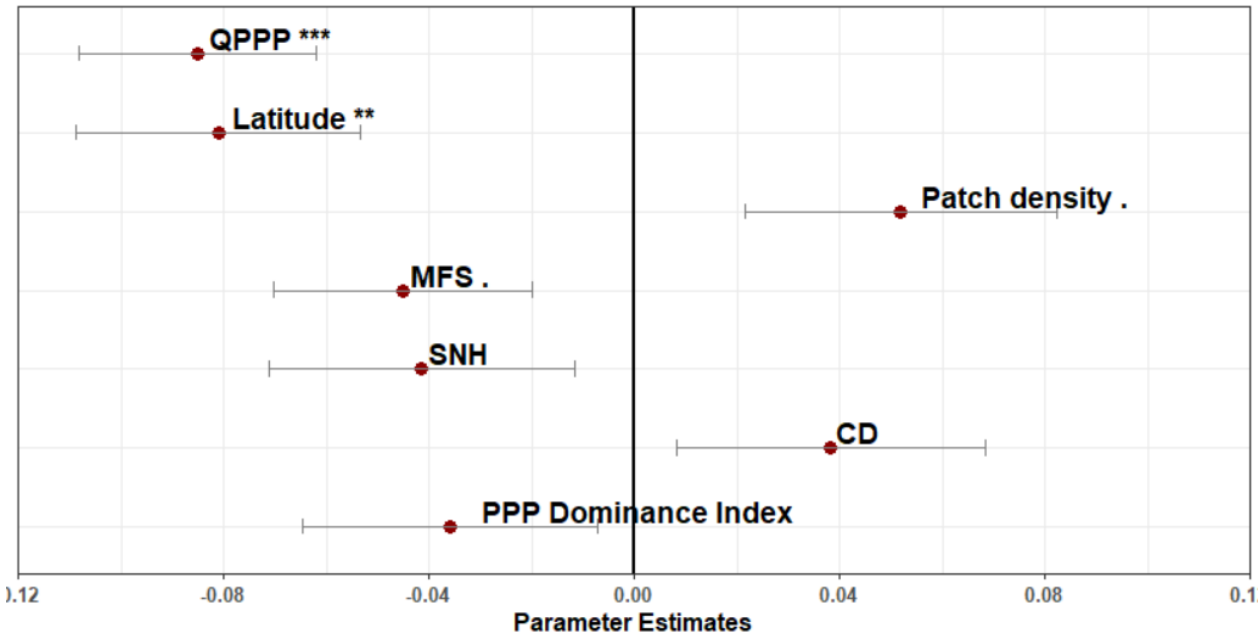
Farming system groups: **overlapping but gradient**

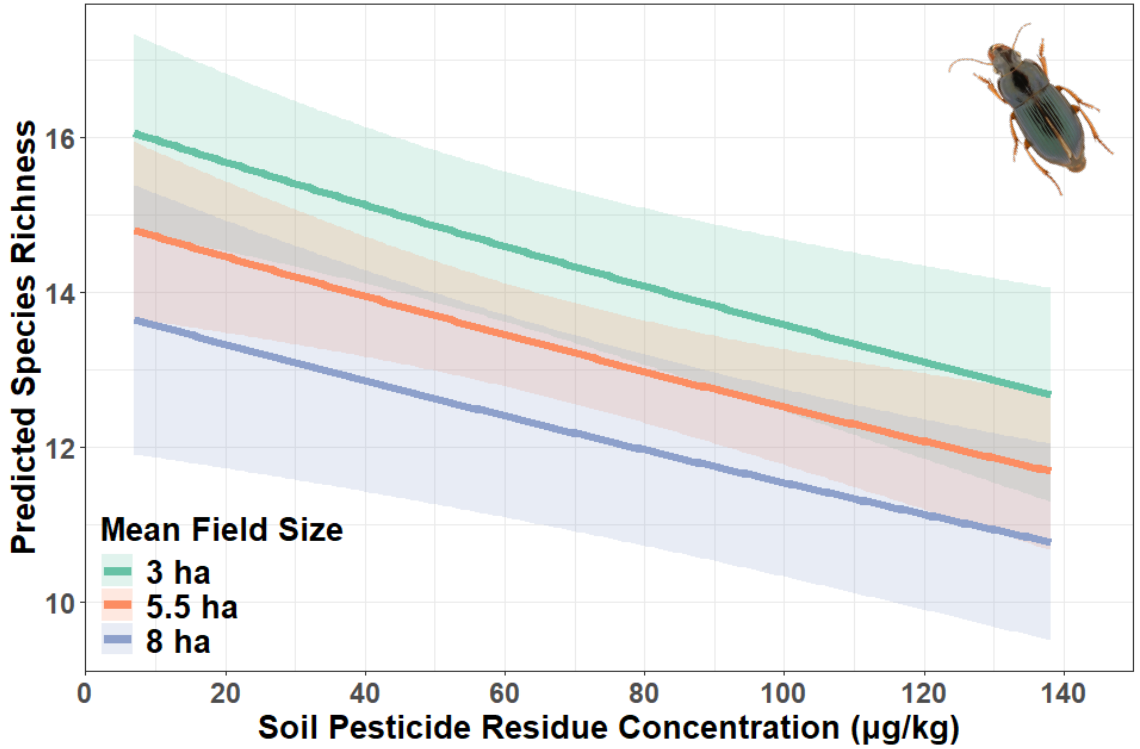
Gradient-based: **distinct profiles**

→ Gradient-based grouping is informative for community analysis

Preliminary results

Pesticide use reduces carabid species richness

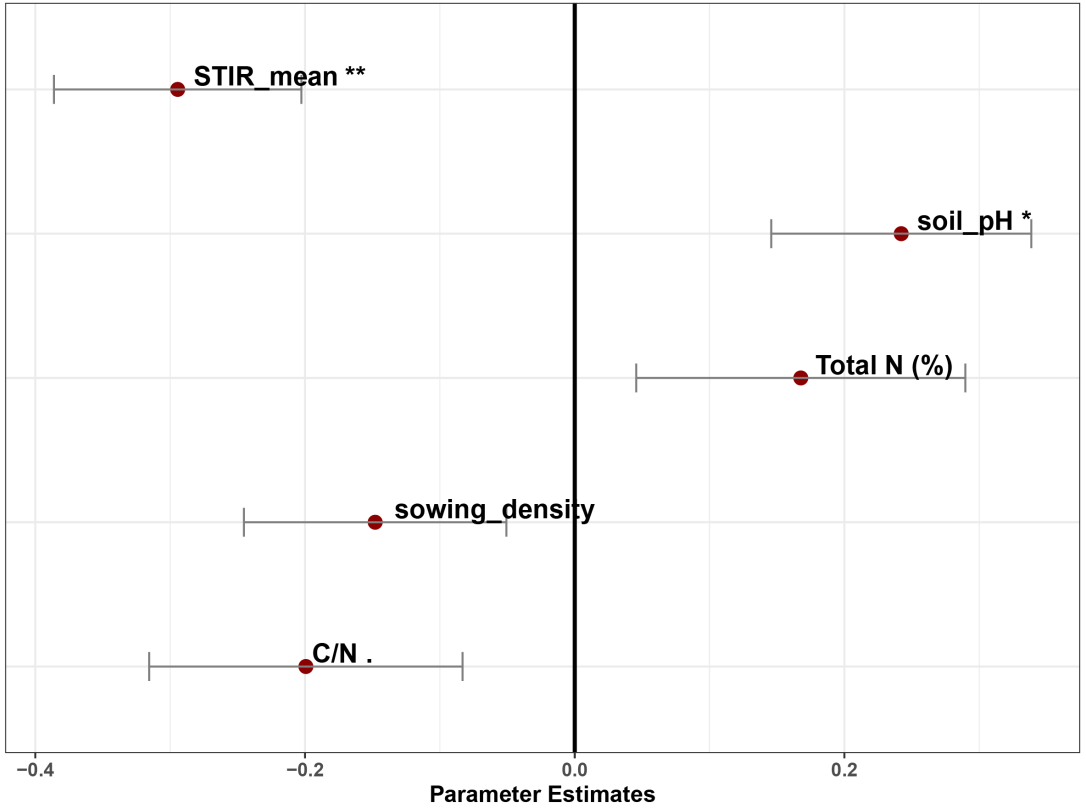


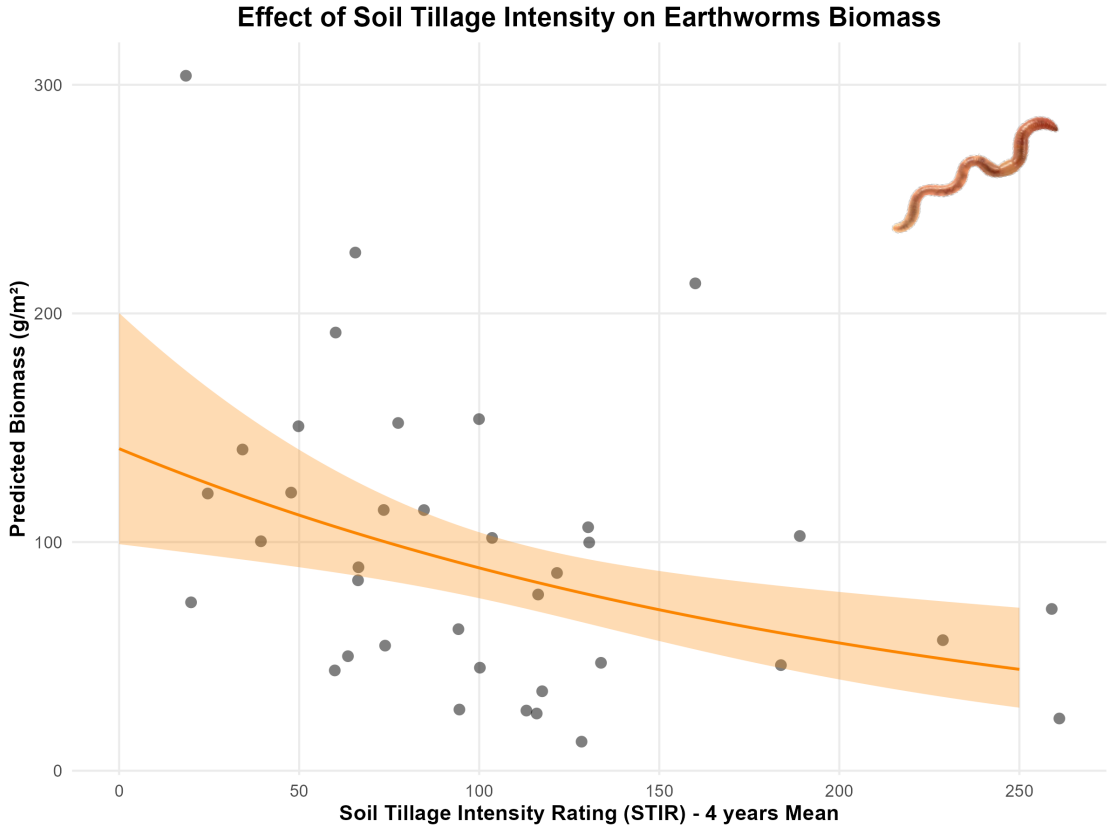


GLMM on carabid Specie Richness per Site (Poisson distribution, n = 2)

Preliminary results

Soil tillage intensity reduces earthworm biomass





GLMM on earthworm Biomass per Site (Gamma distribution, n = 40)

Conclusion

- **Disturbance gradients capture management better than broad farming-system categories**.
- **Communities respond to these gradients**. Gradient-based groups show clearer separation in carabid community composition (PCoA) than system labels.
- **Biodiversity effects are group-specific:**
  - **Carabid species richness declines with pesticide use.**
  - **Earthworm biomass declines with tillage intensity**; pesticide indicators showed no detectable short-term effect on earthworms in our sample.

→ **Take-home message**: Moving from broad farming systems to quantitative disturbance gradients provides a stronger basis to guide biodiversity-friendly cereal farming in Wallonia.

Perspectives

Disturbance gradients analysis:

- Increase gradient sample size → more interviews
- Add descriptors for gradient construction (soil coverage, fertilisation, …)

Multitrophic diversity:

- Unravel variables effects on multitrophic diversity (Sirami *et al*., 2019)
- Piecewise-SEM including carabids, earthworms, soil microorganisms, pollinators and weed communities (Barnes *et al*., 2017 & Carbonne *et al*., 2022)

Barnes, A. D. *et al.* (2017). *Direct and cascading impacts of tropical land-use change on multi-trophic biodiversity*. *1*(10), 1511–1519. https://doi.org/10.1038/s41559-017-0275-7
Carbonne, B. *et al.* (2022). Direct and indirect effects of landscape and field management intensity on carabids through trophic resources and weeds. *Journal of Applied Ecology*, *59*(1), 176–187. https://doi.org/10.1111/1365-2664.14043
Sirami, C. *et al.* (2019). Increasing crop heterogeneity enhances multitrophic diversity across agricultural regions. *Proceedings of the National Academy of Sciences*, *116*(33), 16442–16447. https://doi.org/10.1073/pnas.1906419116

Avec le soutien de la Wallonie

Biodiversity Ecosystems Landscapes

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ENVIRONMENT - BIOINDUSTRIES - AGRICULTURE

Questions?

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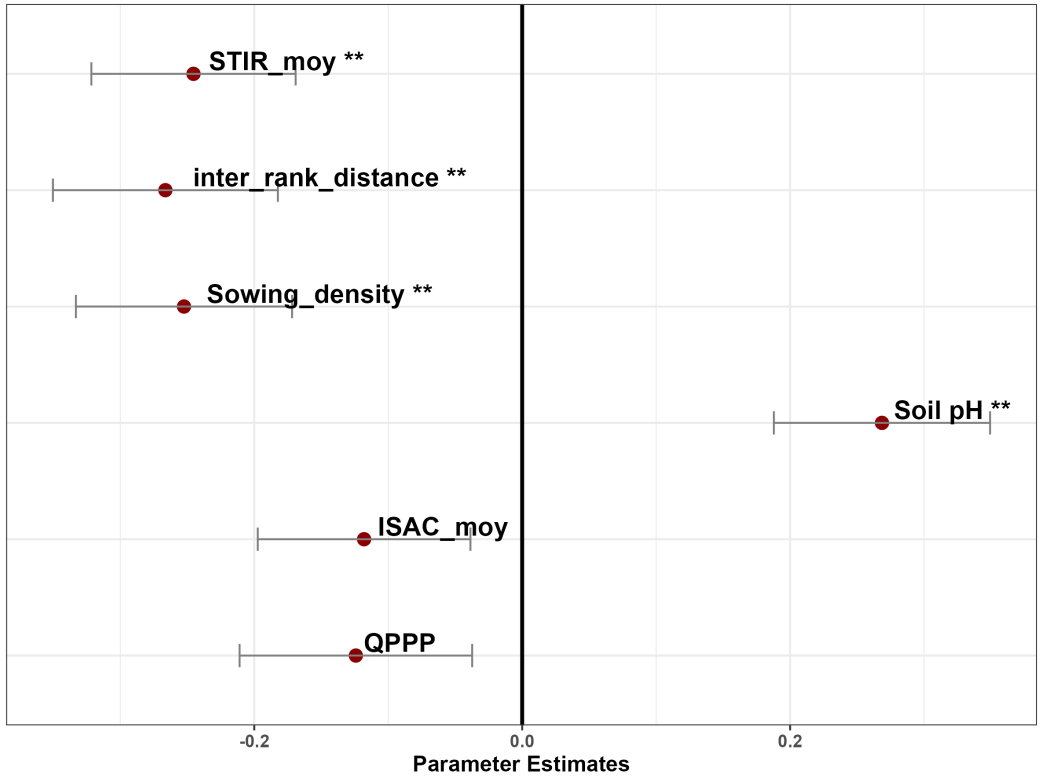
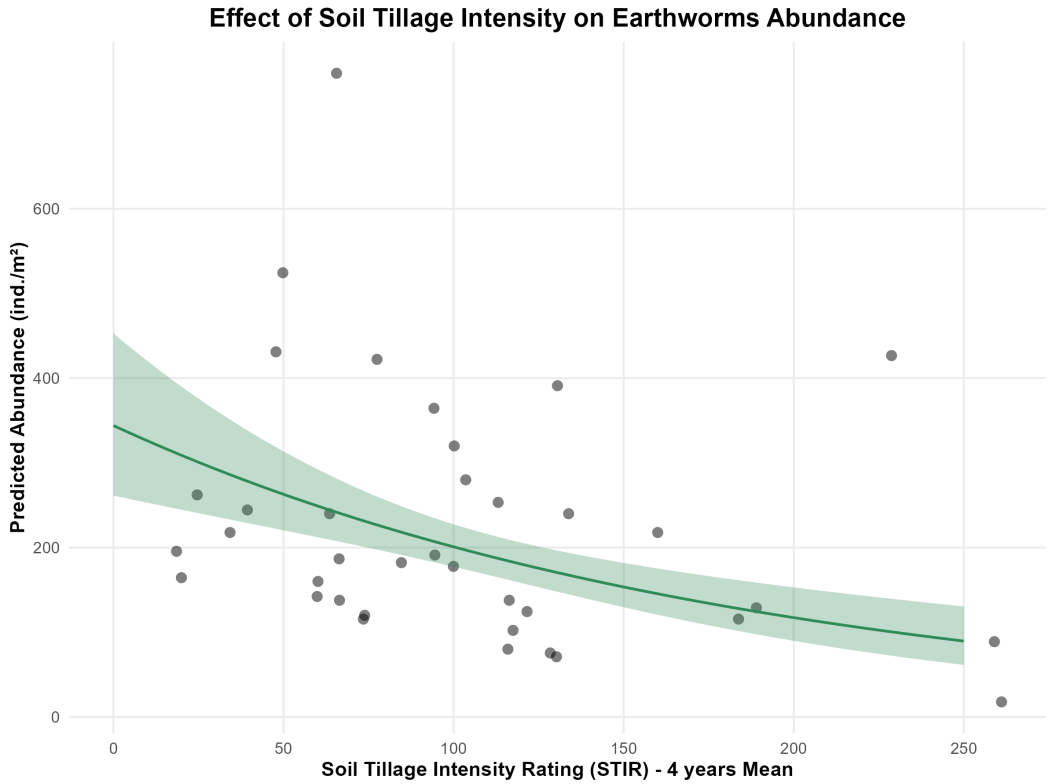
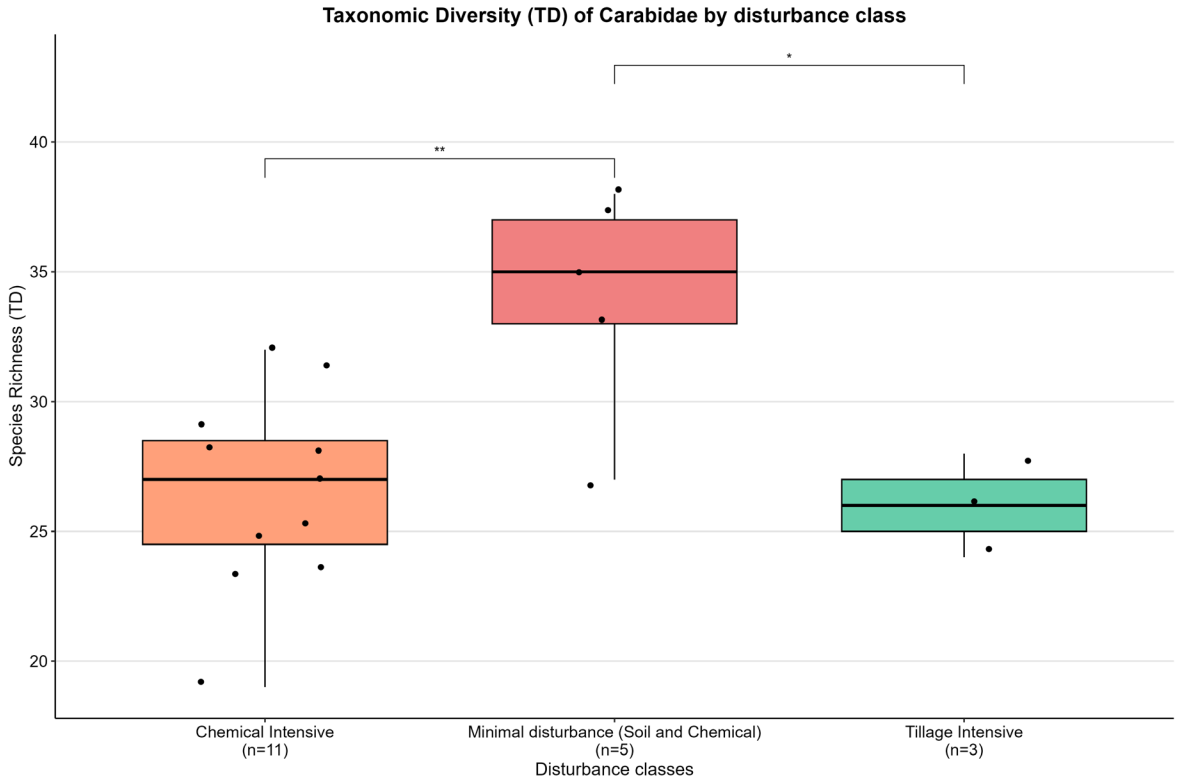
Appendix

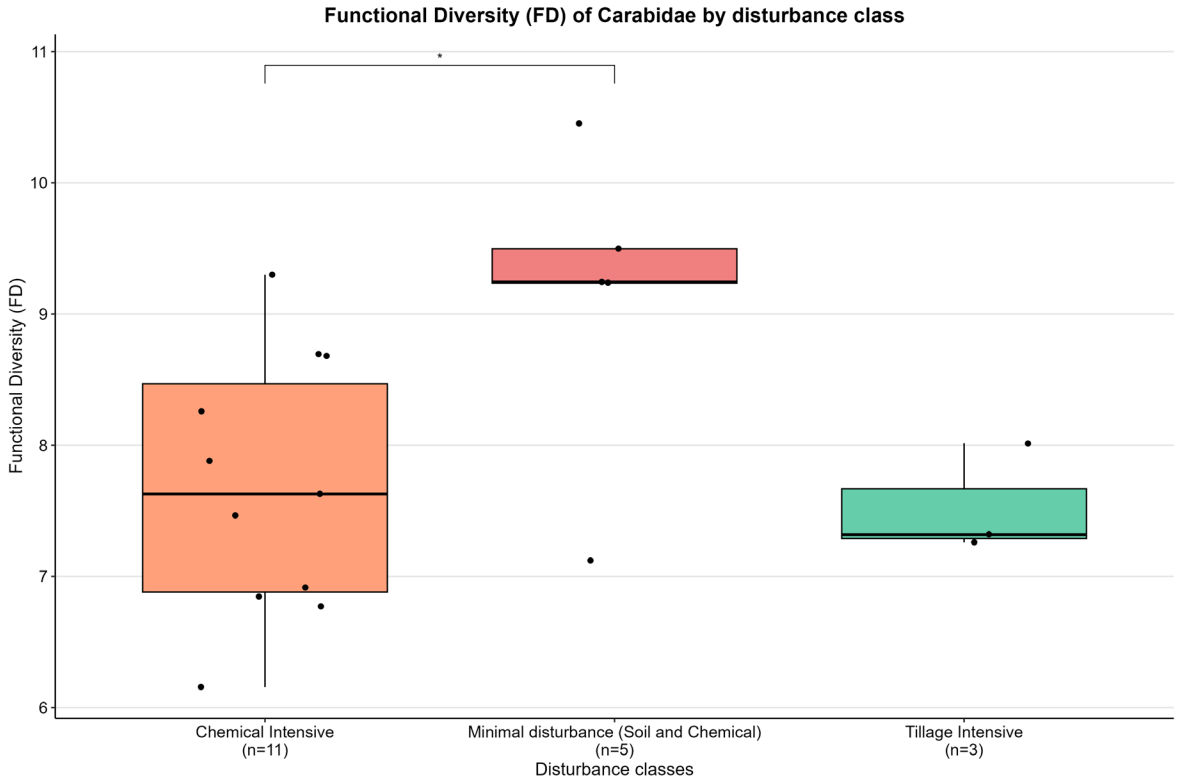
Earthworms Abundance



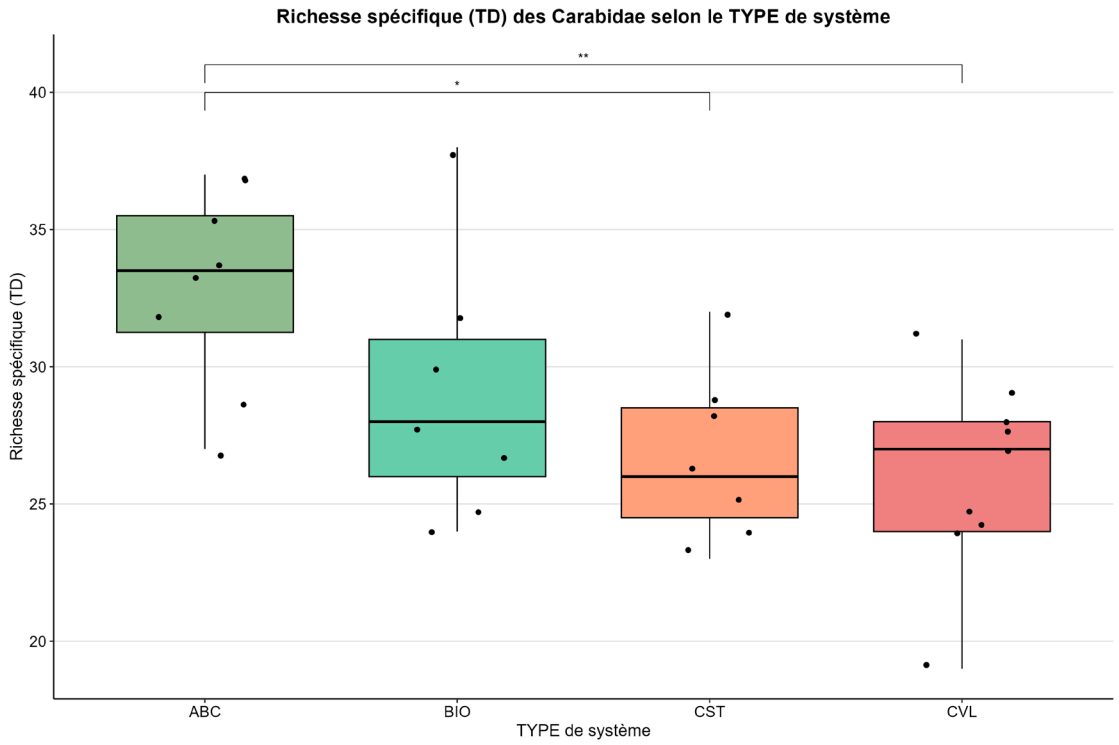


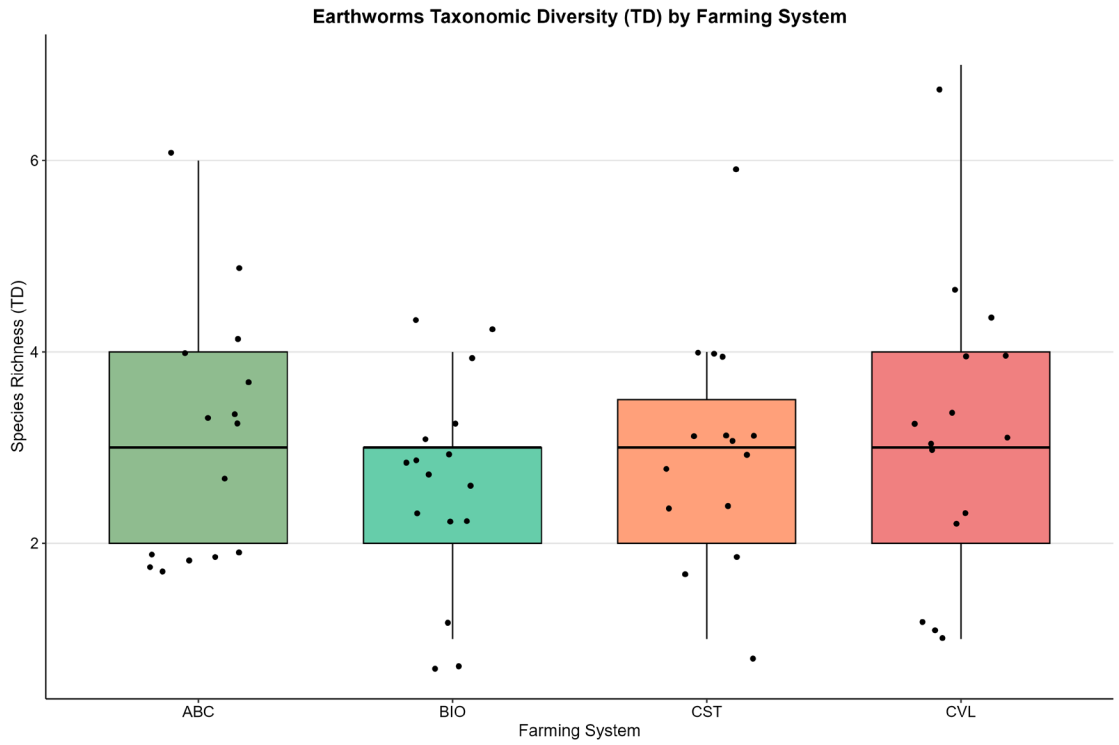
Appendix


Taxonomic Diversity (TD) of Carabidae by disturbance class
Species Richness (TD)
40
35
30
25
20
*
**
Chemical Intensive
(n=11)
Minimal disturbance (Soil and Chemical)
(n=5)
Tillage Intensive
(n=3)
Disturbance classes


Functional Diversity (FD) of Carabidae by disturbance class
Functional Diversity (FD)
11
10
9
8
7
6
*
Chemical Intensive
(n=11)
Minimal disturbance (Soil and Chemical)
(n=5)
Tillage Intensive
(n=3)
Disturbance classes

Appendix


Richesse spécifique (TD) des Carabidae selon le TYPE de système
**
*
40
35
30
25
20
Richesse spécifique (TD)
ABC
BIO
CST
CVL
TYPE de système


Earthworms Taxonomic Diversity (TD) by Farming System
6
4
2
Species Richness (TD)
ABC
BIO
CST
CVL
Farming System