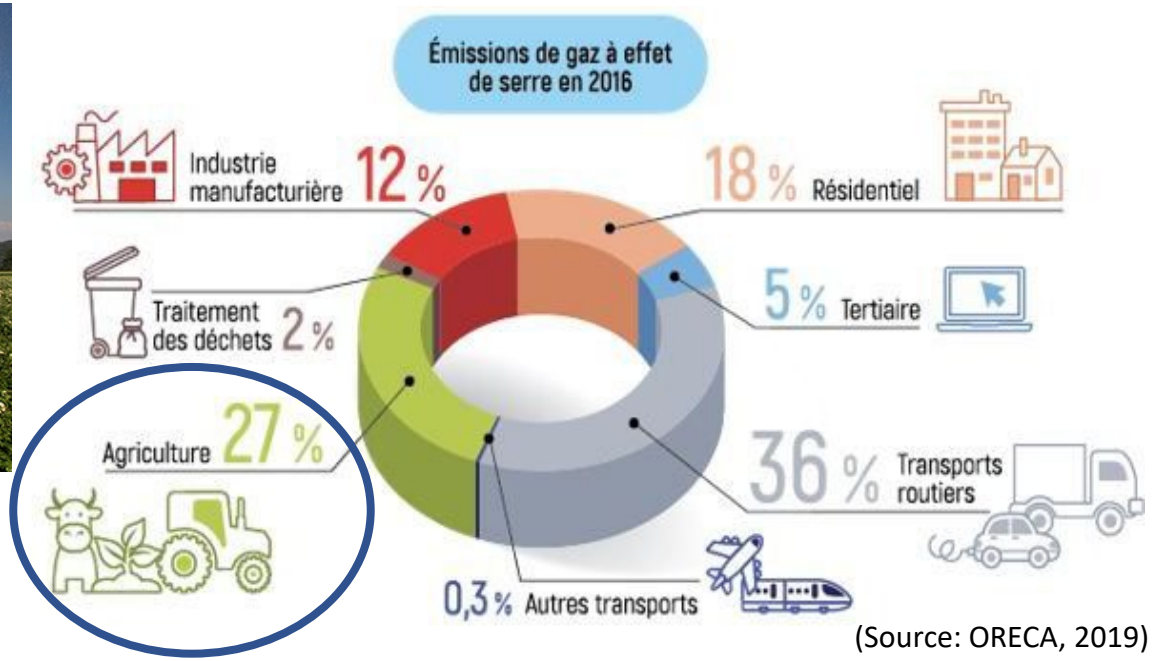
CBGP, Montpellier
18/04/2023

Soil engineers and their tremendous activity in a changing environment

Céline PELOSI, Research Director
INRAE
UMR 1114 EMMAH - Equipe DISCOVE
Centre PACA, Avignon

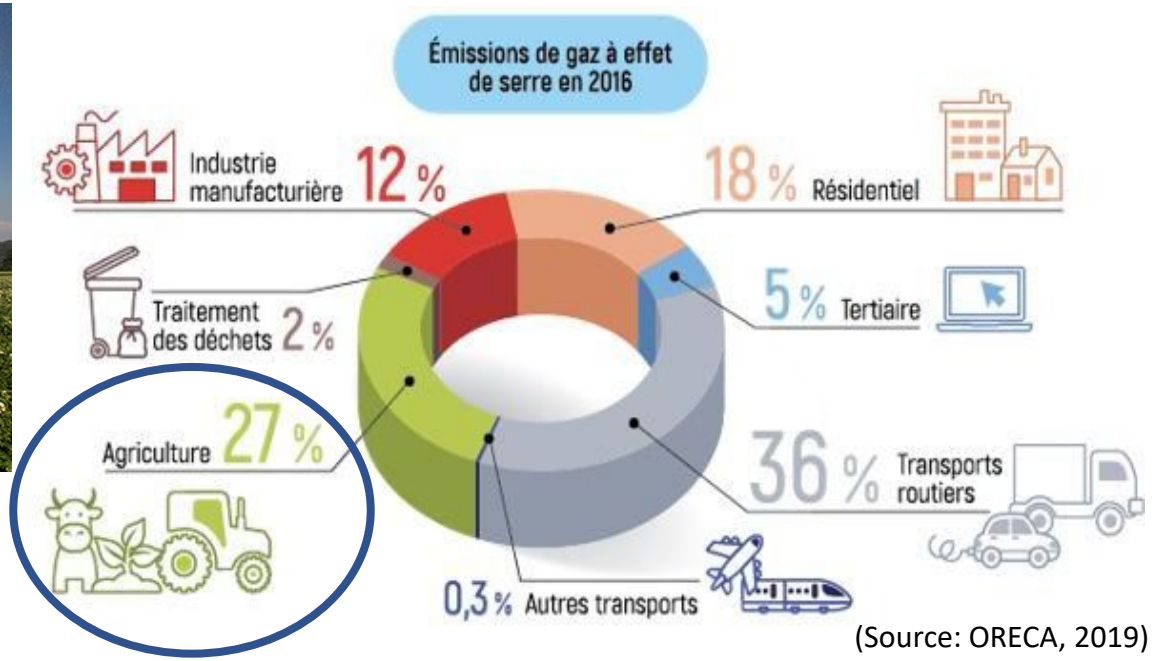
RÉPUBLIQUE FRANÇAISE
Liberté Égalité Fraternité

INRAE



(Source: ORECA, 2019)

Mitigation: reduction of GHG emissions and long-term carbon storage

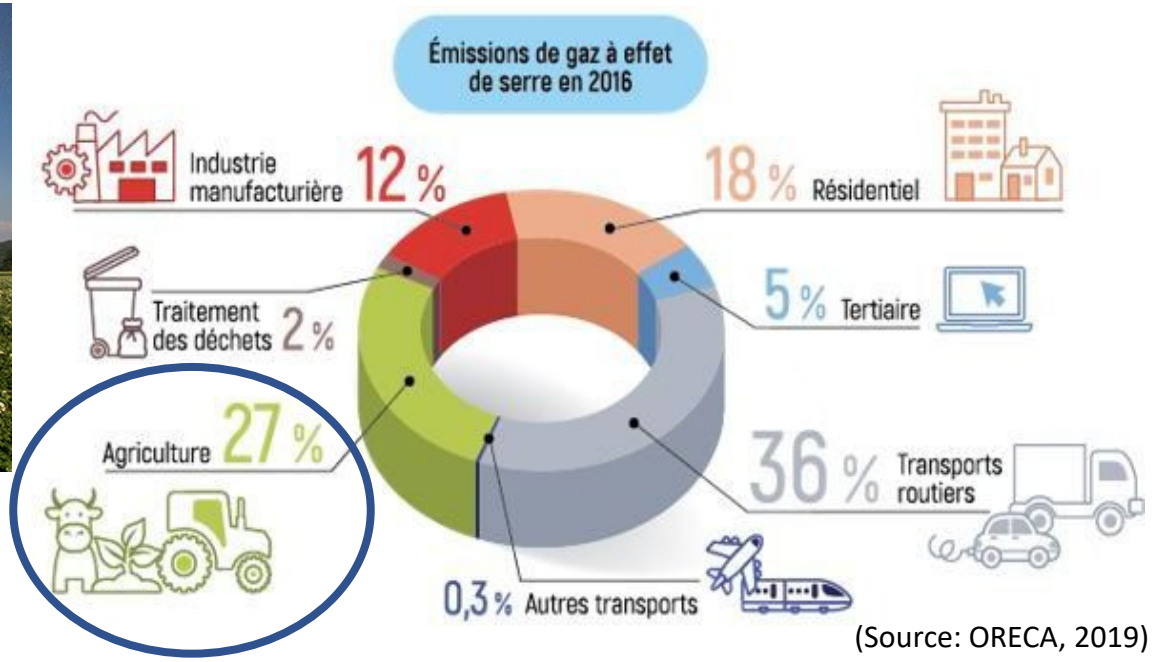


(Source: ORECA, 2019)

Mitigation: reduction of GHG emissions and long-term carbon storage

Design and deploy adaptation strategies:

Limit the vulnerabilities of the systems in the context of current and future climate change



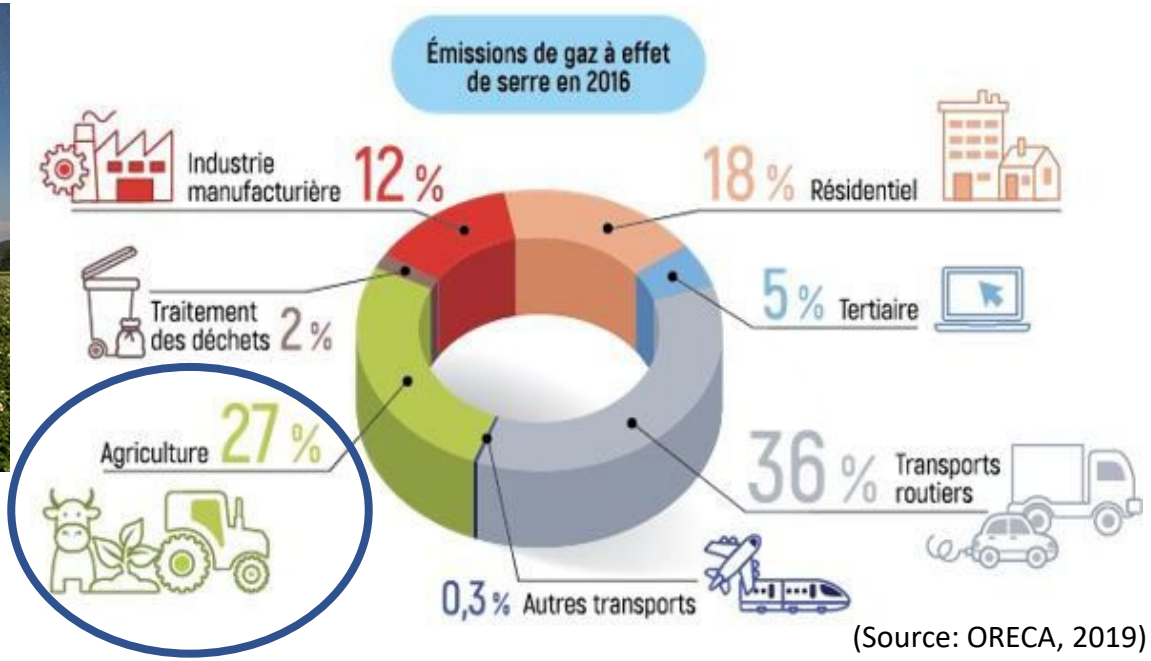
(Source: ORECA, 2019)

Mitigation: reduction of GHG emissions and long-term carbon storage

Design and deploy adaptation strategies:

Limit the vulnerabilities of the systems in the context of current and future climate change

Ex. lever: intra and interspecific plant diversity



(Source: ORECA, 2019)

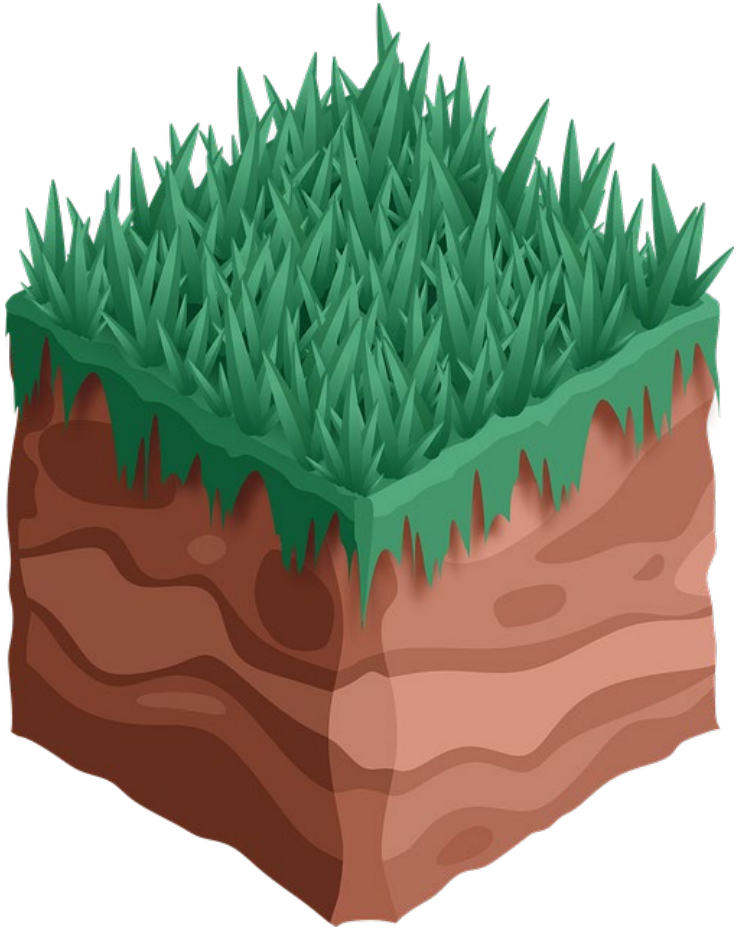
Mitigation: reduction of GHG emissions and long-term carbon storage

Design and deploy adaptation strategies:

Biological soil component

= lever for the adaptation of agricultural systems to climate change

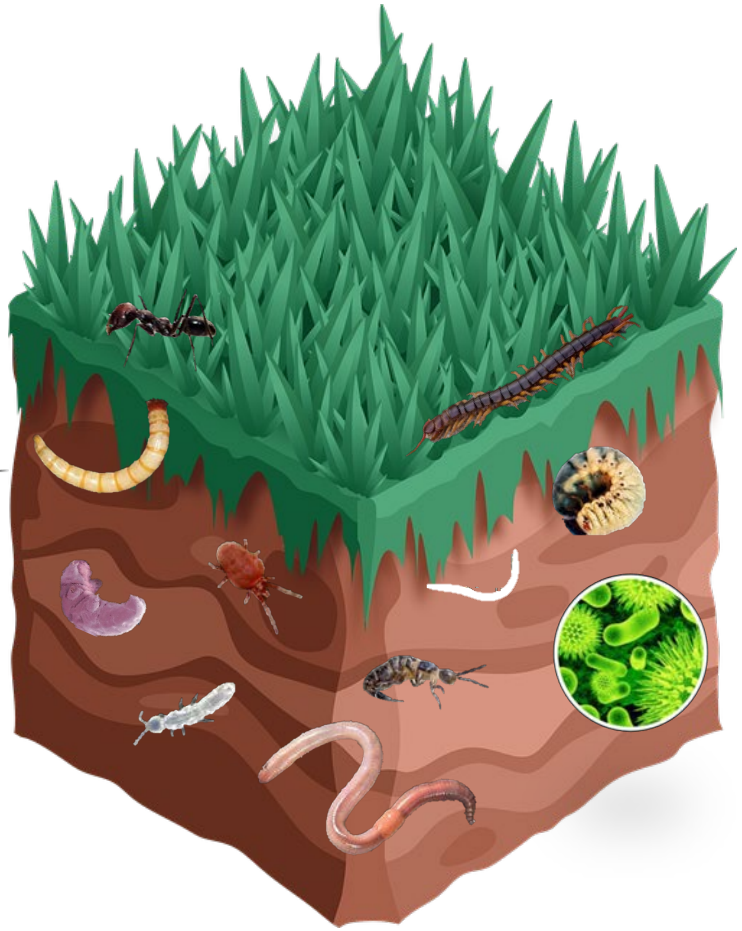
SOIL

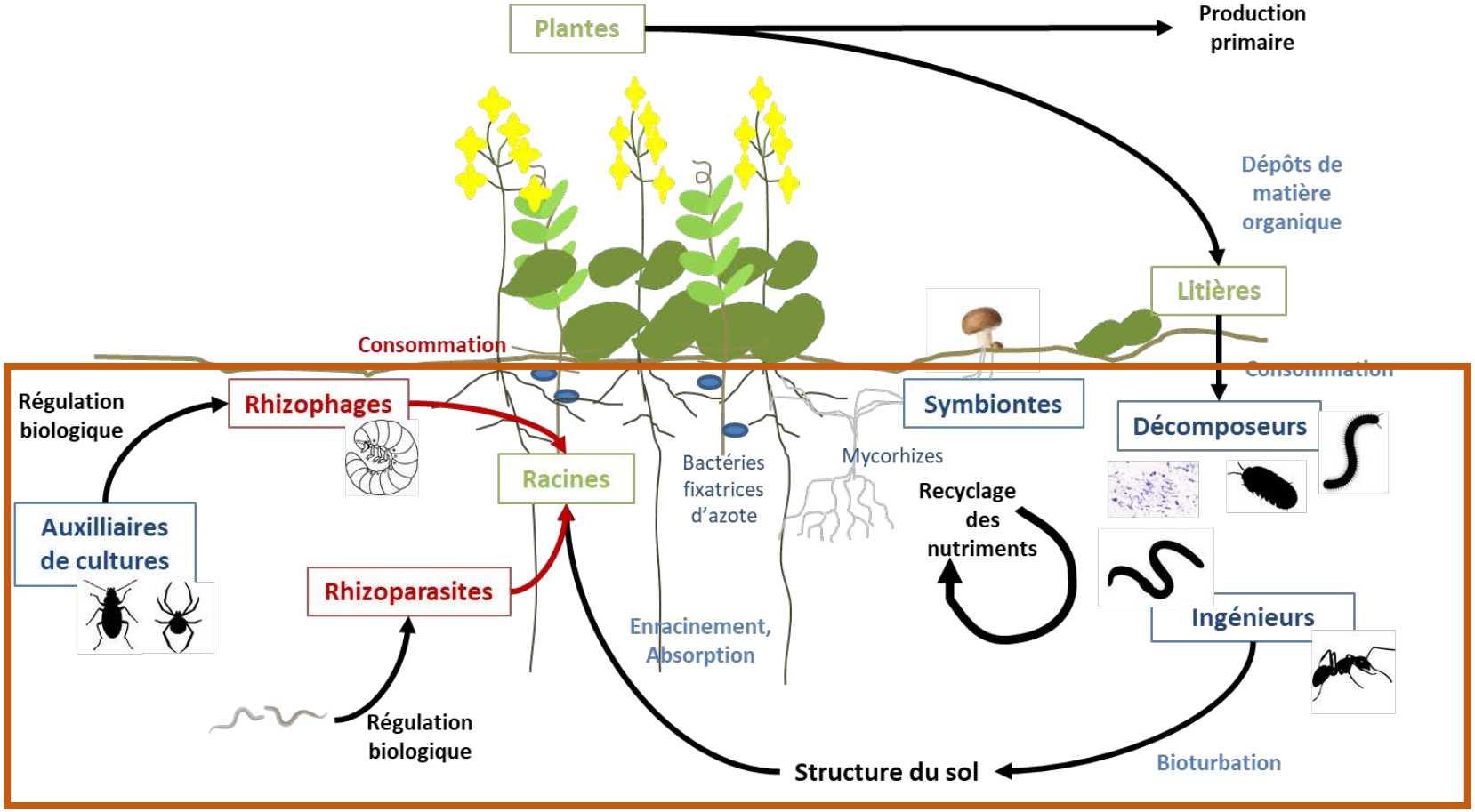


ECOSYSTEM SERVICES

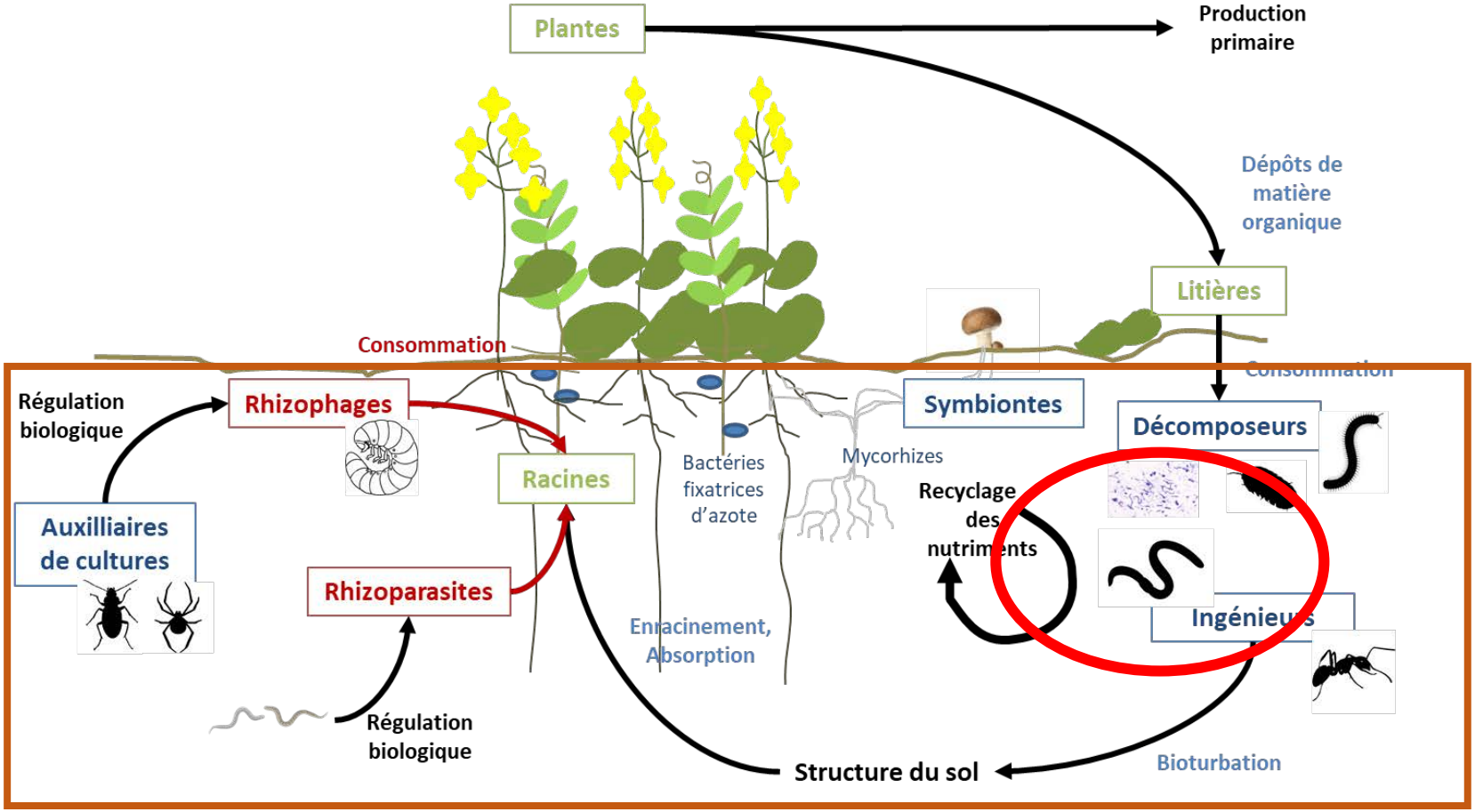
BIODIVERSITY

Maintenance and regulation of ecosystem services

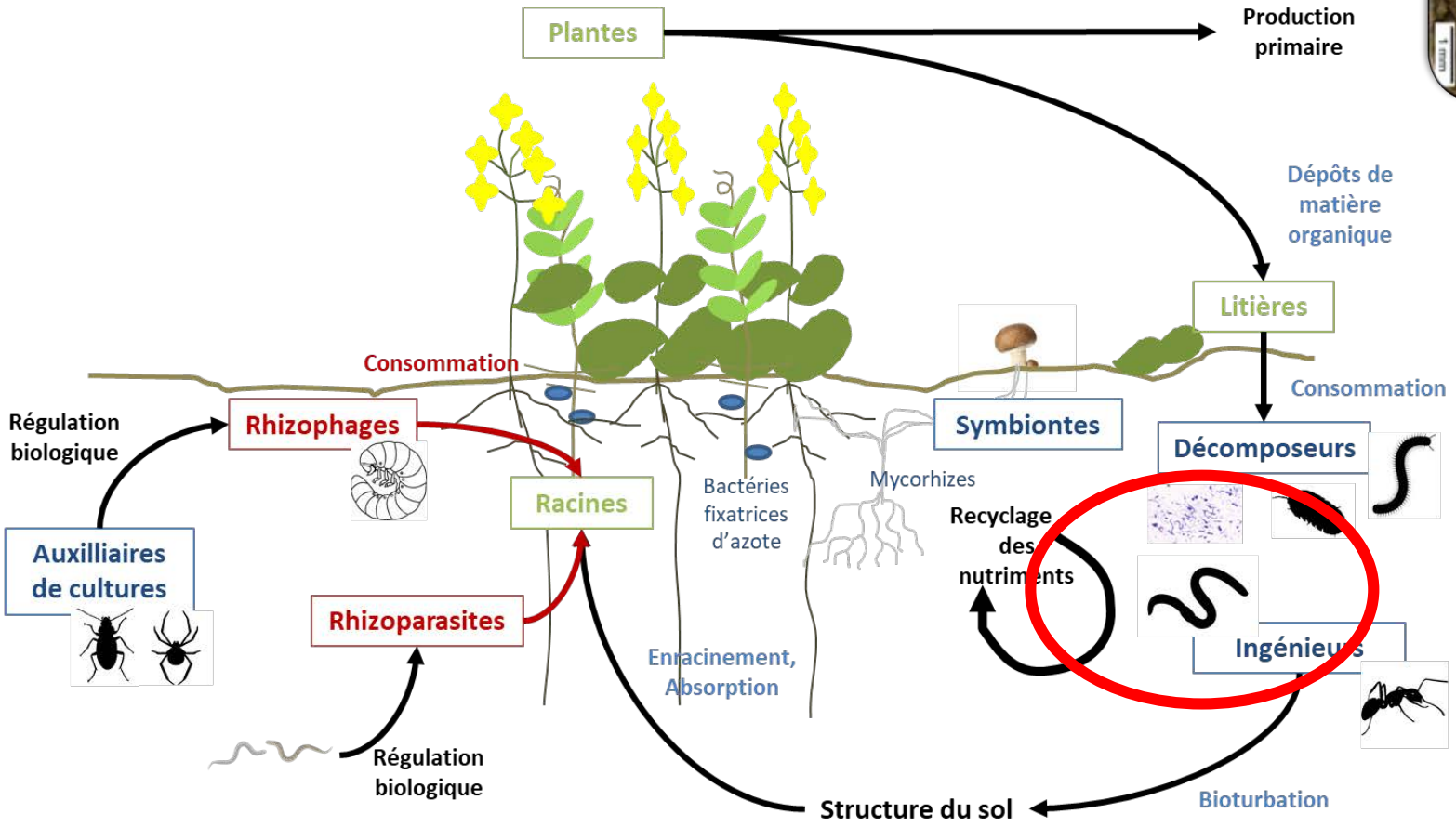




Soil ecologist

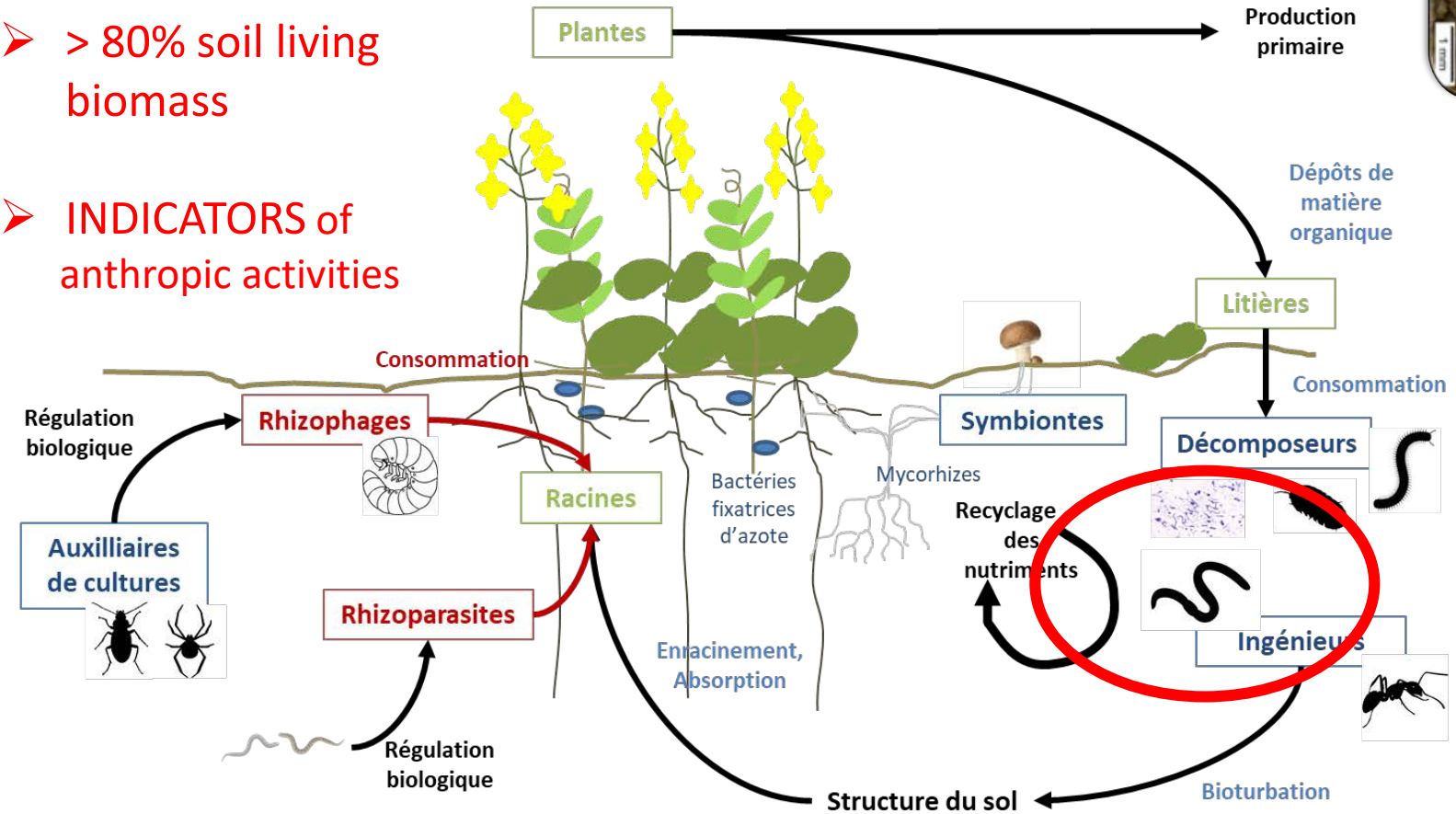

Plantes
Production primaire
Dépôts de matière organique
Litières
Consommation
Consommation
Régulation biologique
Rhizophages
Racines
Bactéries fixatrices d'azote
Symbiontes
Mycorhizes
Décomposeurs
Recyclage des nutriments
Auxilliaires de cultures
Rhizoparasites
Enracinement, Absorption
Ingénieurs
Régulation biologique
Structure du sol
Bioturbation

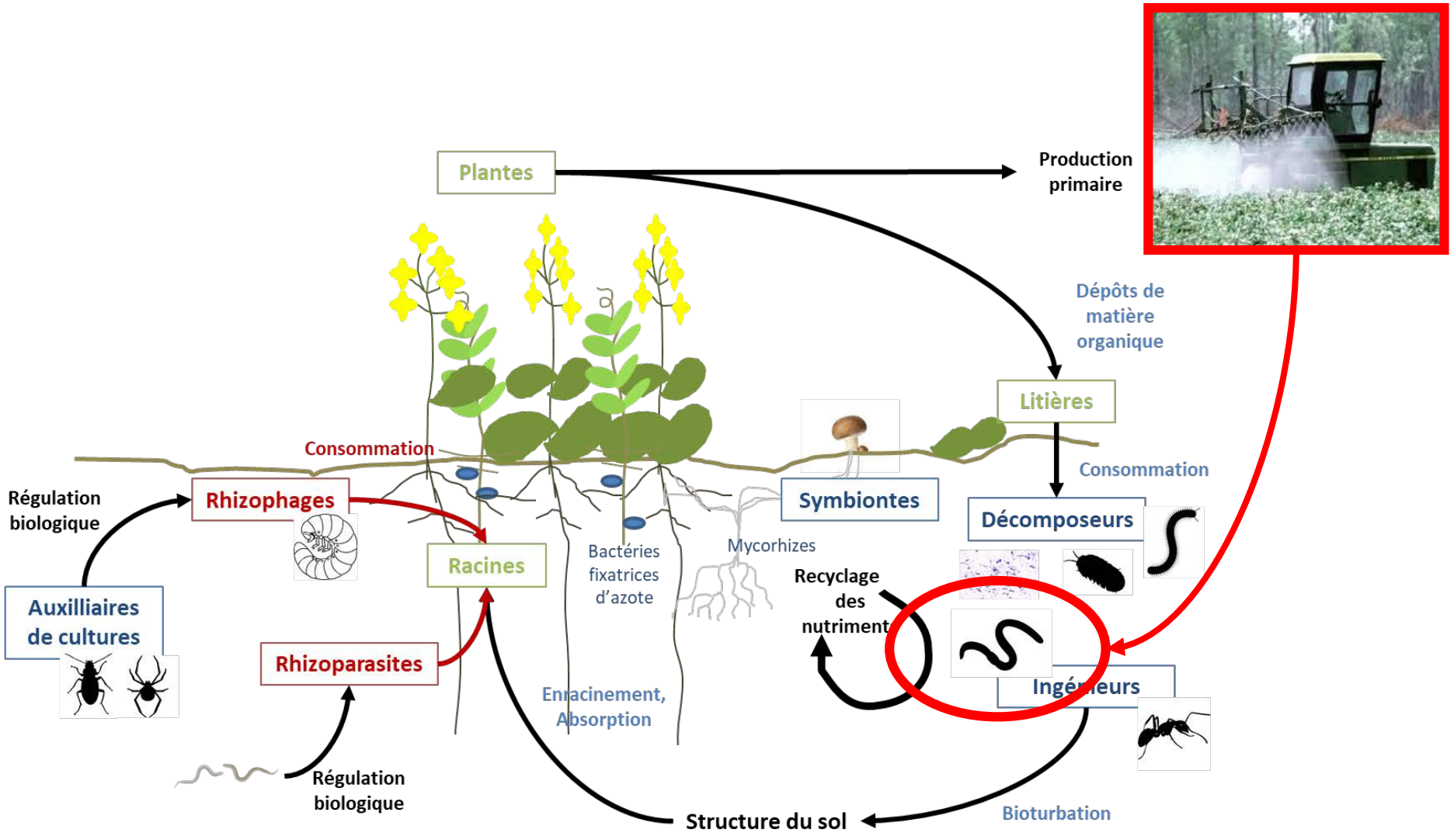
Earthworms and enchytraeids



Earthworms and enchytraeids

- > 80% soil living biomass
- INDICATORS of anthropic activities

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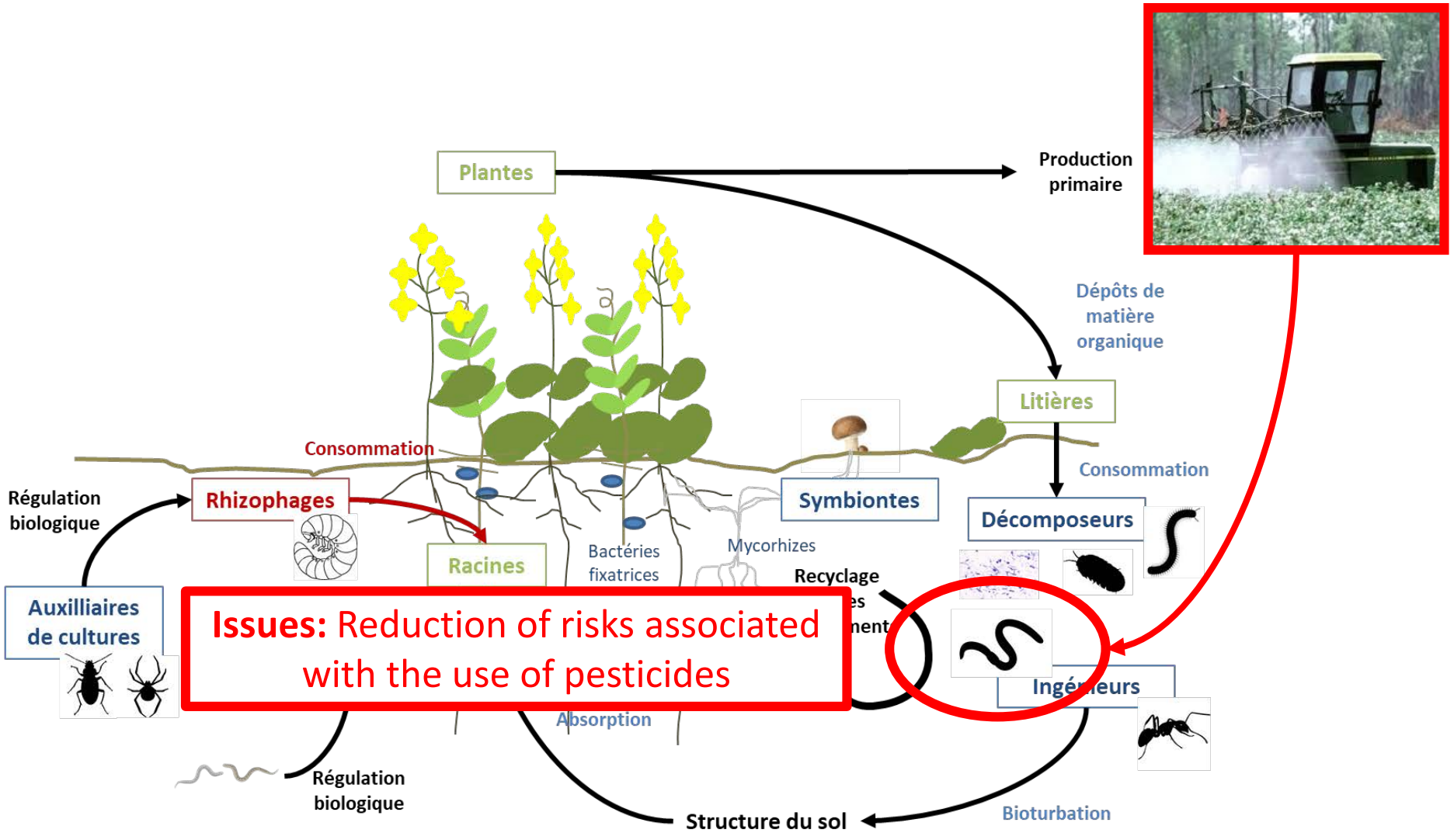
Plantes
Production primaire
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Rhizophages
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Décomposeurs
Racines
Bactéries fixatrices
Mycorhizes
Recyclage
Auxilliaires de cultures
Issues: Reduction of risks associated with the use of pesticides
Ingénieurs
Absorption
Régulation biologique
Structure du sol
Bioturbation

Relevance of earthworm species used in risk assessment

Contents lists available at SciVerse ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Review

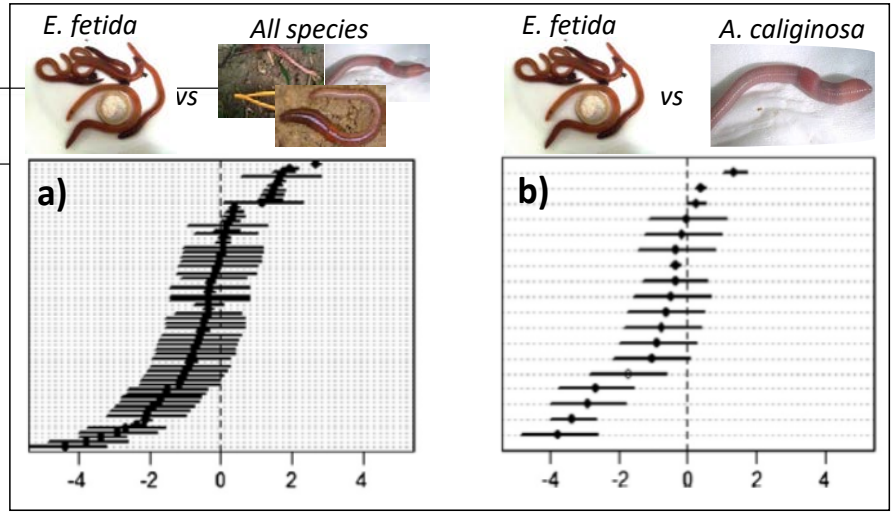
Searching for a more sensitive earthworm species to be used in pesticide homologation tests – A meta-analysis

C. Pelosi [a,*], S. Joimel [b,c], D. Makowski [d,e]

[a] INRA, UR251 PESSAC, F-78026 Versailles cedex, France
[b] Université de Lorraine, Laboratoire Sols et Environnement, UMR 1120 BP 172, F-54505 Vandoeuvre-lès-Nancy cedex, France
[c] INRA, Laboratoire Sols et Environnement, UMR 1120 BP 172, F-54505 Vandoeuvre-lès-Nancy cedex, France
[d] INRA, UMR 211 Agronomie, F-78000 Thiverval Grignon, France
[e] AgroParisTech, UMR 211 Agronomie, F-78000 Thiverval Grignon, France

HIGHLIGHTS

- *Eisenia fetida* is less sensitive to pesticides than species found in cultivated fields.
- Sensitivity of *Lumbricus rubellus* is variable from one study to another.
- *Aporrectodea caliginosa* and *Lumbricus terrestris* are the most sensitive species to pesticides.
- *A. caliginosa* is proposed as model for ecotoxicological and homologation tests.



Log ratio of LC50 (species n vs. *E. fetida*,
a) All species of earthworms
b) *Aporrectodea caliginosa*

Prediction of earthworm abundances based on TFIs

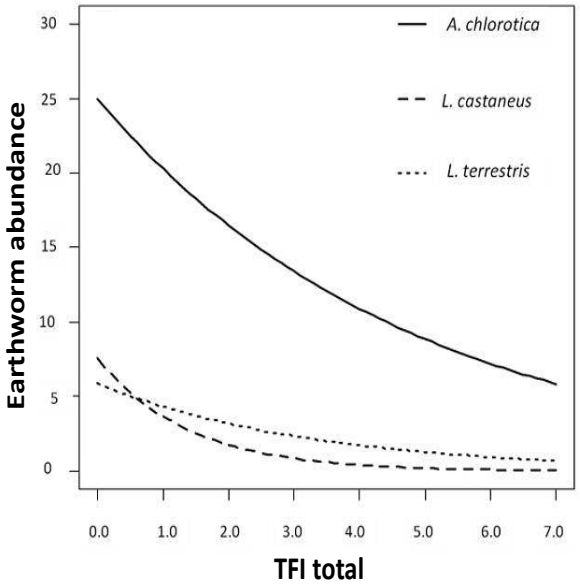
Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Reduction of pesticide use can increase earthworm populations in wheat crops in a European temperate region

C. Pelosi[a,*], L. Toutous[a], F. Chiron[b], F. Dubs[c], M. Hedde[a], A. Muratet[d], J.-F. Ponge[e], S. Salmon[e], D. Makowski[f,g]



TFI	Earthworm species	TFI effects
Total	*L. castaneus*	-0.73 (0.12)
	L. terrestris	-0.31 (0.06)
	A. chlorotica	-0.21 (0.03)

Figure 6. Poisson regressions (on the left, and coefficients corresponding to the « TFI effect », above) of the abundance of three earthworm species in function of TFI total (insecticide + herbicide + fungicide).

Contamination of agricultural landscapes by pesticides

ELSEVIER

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Residues of currently used pesticides in soils and earthworms: A silent threat?

C. Pelosi [a,*], C. Bertrand [b], G. Daniele [c], M. Coeurdassier [d], P. Benoit [e], S. Nélieu [e], F. Lafay [c], V. Bretagnolle [f,g], S. Gaba [g,h], E. Vulliet [c], C. Fritsch [d]

Le Monde
VENDREDI 30 OCTOBRE 2020

Des niveaux alarmants de pesticides dans les sols

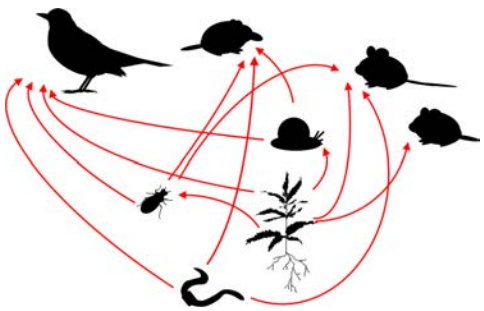
Une étude montre une large contamination de l'environnement, où plusieurs produits s'accumulent

Alors que le Sénat a adopté, mardi 27 octobre, la remise en selle des néonicotinoïdes sur les cultures de betteraves sucrières, une étude française met en agriculture conventionnelle, en agriculture biologique, mais aussi sur des prairies et des haies n'ayant jamais reçu de traitements. *« Dans 40 % des cas, on retrouve plus de dix pesticides différents »*, explique l'écologue Vin- *pensions aussi possible de n'en trouver aucune trace. »*

La réalité s'est révélée aux antipodes. *« Les taux d'imidaclopride que l'on retrouve dans les vers de terre sont faramineux,* estime ainsi l'écologue Vincent Breta- *dans les vers de terre*, confirme l'entomologiste John Tooker, professeur à l'université de Pennsylvanie (Etats-Unis), qui n'a pas participé à cette étude. *Les concentrations relevées dans les vers de terre*

« Pour certains oiseaux qui se nourrissent de vers, les concentrations

Des résultats préliminaires, non encore publiés, suggèrent que la chaîne alimentaire est impactée. *« Nous avons commencé à faire des mesures sur les micromammifères, et celles-ci semblent cohérentes*



Enchytraeids, these poorly known bioindicators

INRA SCIENCE & IMPACT

Département EA

UMR 1402 ECOSYS
Écologie fonctionnelle et écotoxicologie des agroécosystèmes

Centre de Versailles-Grignon

Contact
Celine Pelosi
celine.pelosi@inra.fr

Les enchytréides, des bioindicateurs mal connus

Résumé

Présents dans la plupart des sols du Monde, les enchytréides sont des Annélides Oligochètes, au même titre que les vers de terre. Si l'utilisation de ces derniers comme bioindicateurs de la fertilité du sol et des perturbations anthropiques est relativement bien documentée, les enchytréides sont beaucoup moins connus et étudiés. Pourtant, ils sont considérés comme des indicateurs de stress chimiques dans les écosystèmes terrestres et ont récemment été reconnus comme indicateurs des pratiques agricoles dans les agroécosystèmes.

ELSEVIER

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

journal homepage: www.elsevier.com/locate/ecoenv

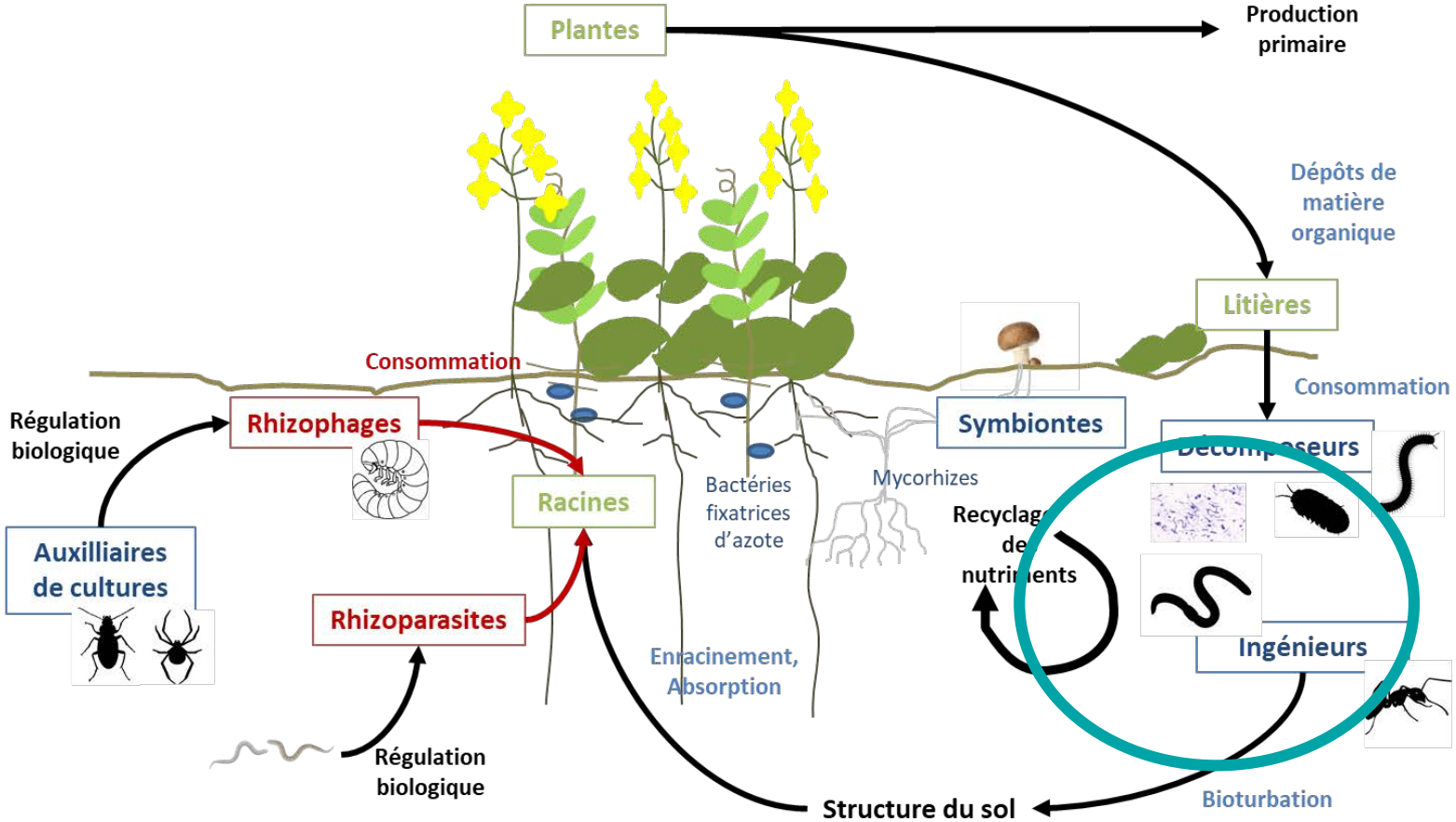
Differences in sensitivity between earthworms and enchytraeids exposed to two commercial fungicides

CrossMark

Sylvain Bart[a,*], Céline Laurent[a], Alexandre R.R. Péry[a], Christian Mougin[a], Céline Pelosi[a]

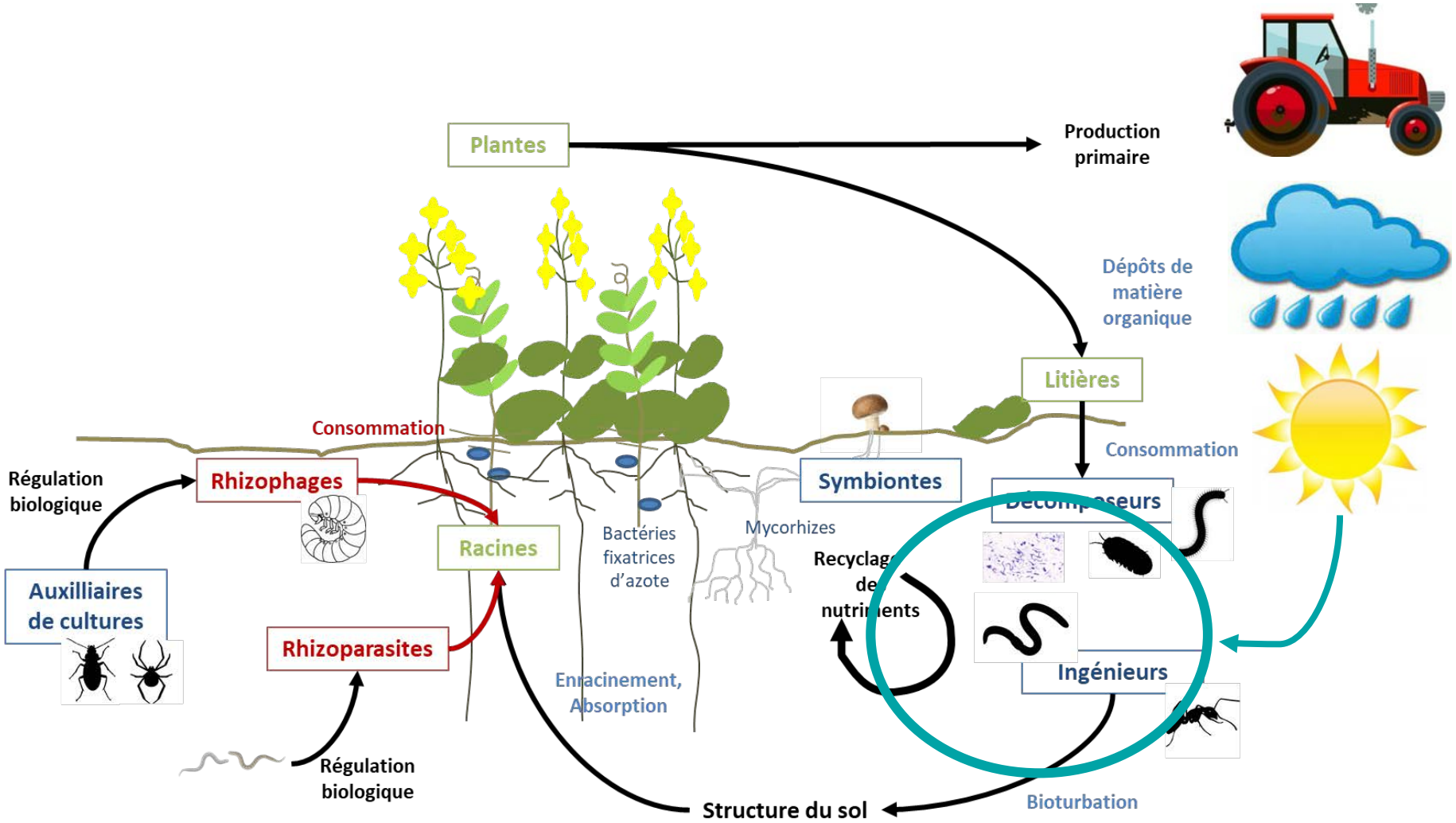
UMR EMMAH (Modelling Agricultural and hydrological systems in the mediterranean environment)

Avignon, 2019



Key actors in soils = LEVERS

UMR EMMAH, 2019



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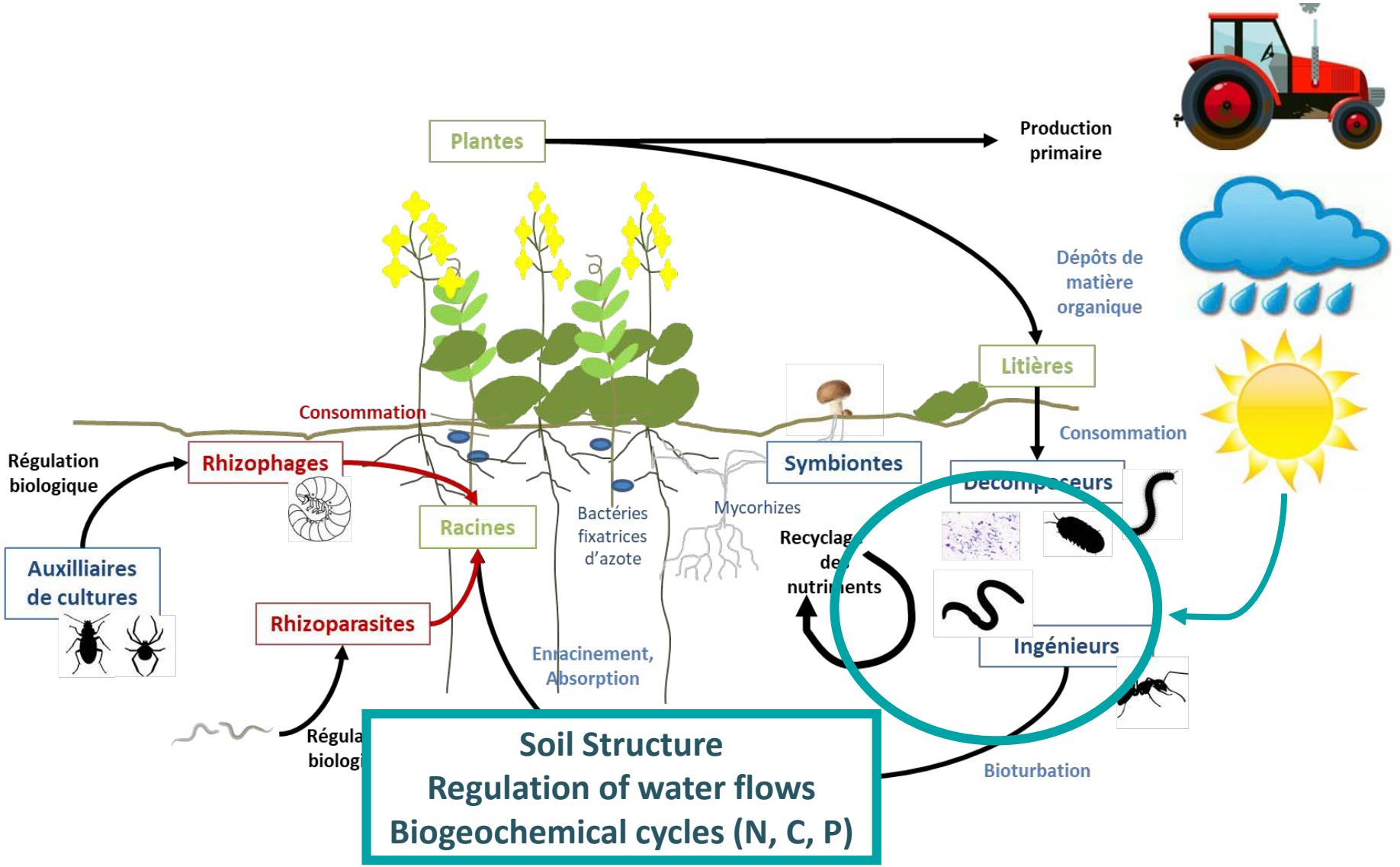
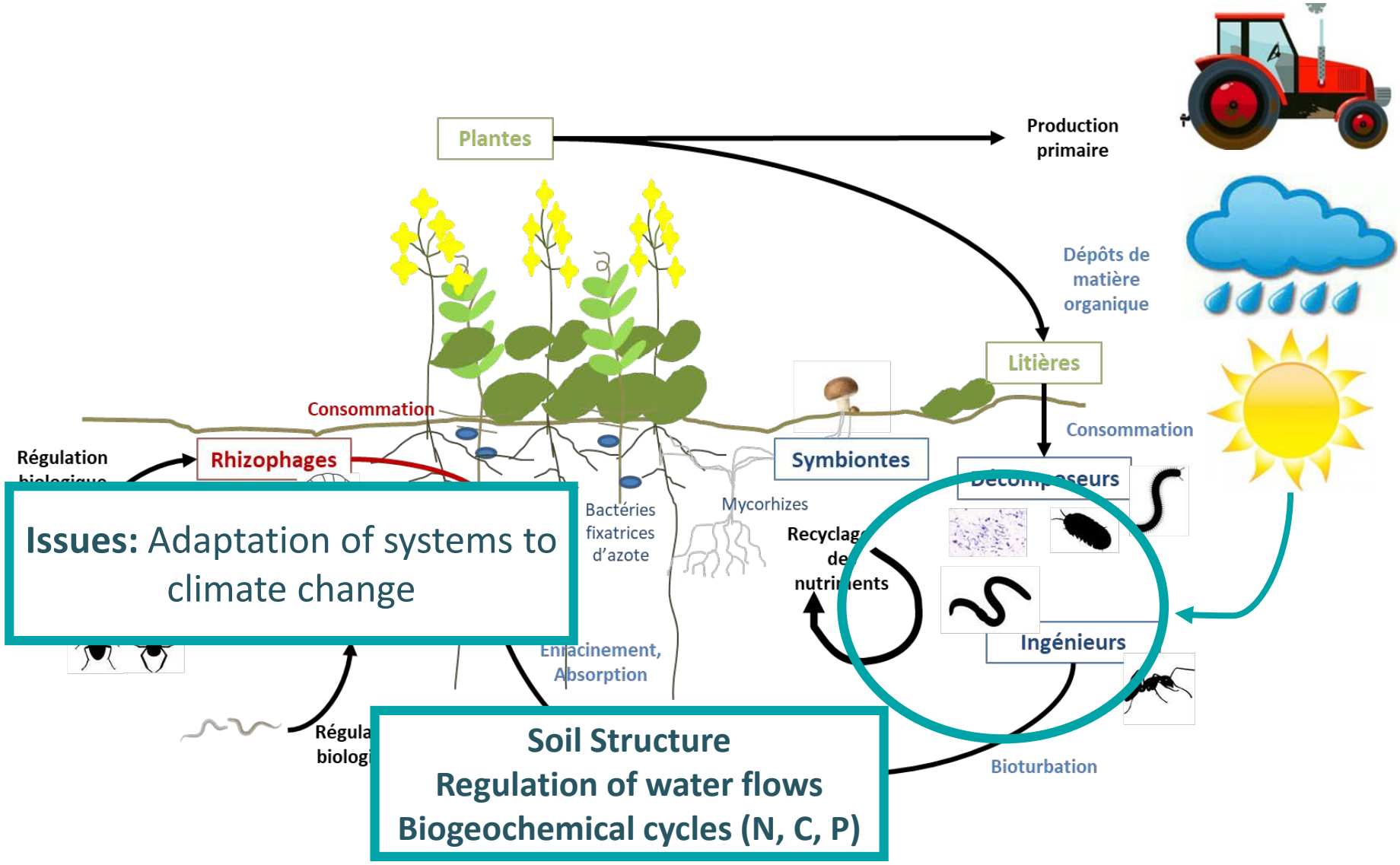
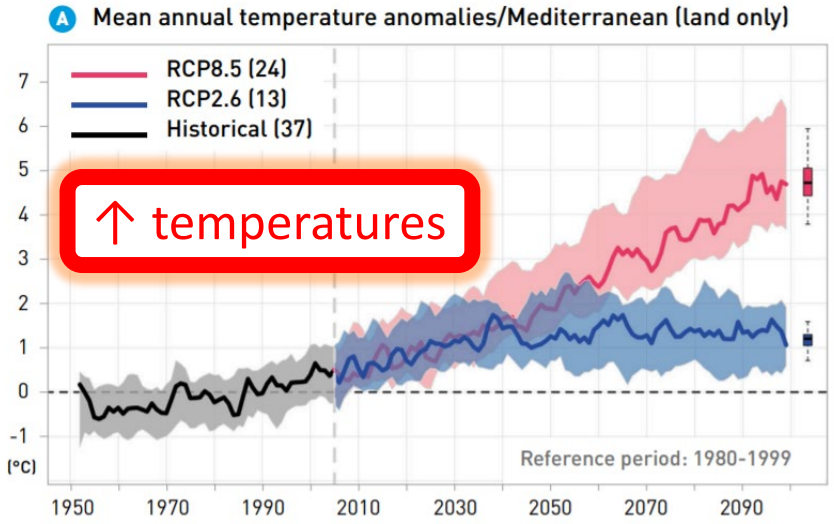
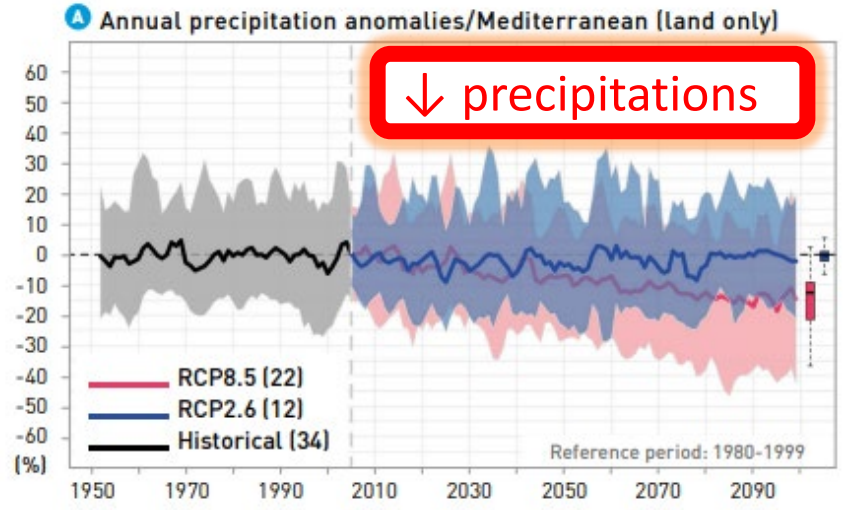


UMR EMMAH, 2019



Mediterranean zone





↑ drought periods

Annual number of consecutive days of drought (< 1 mm/d)

↑ extreme events

Number of days of precipitation > 40 mm

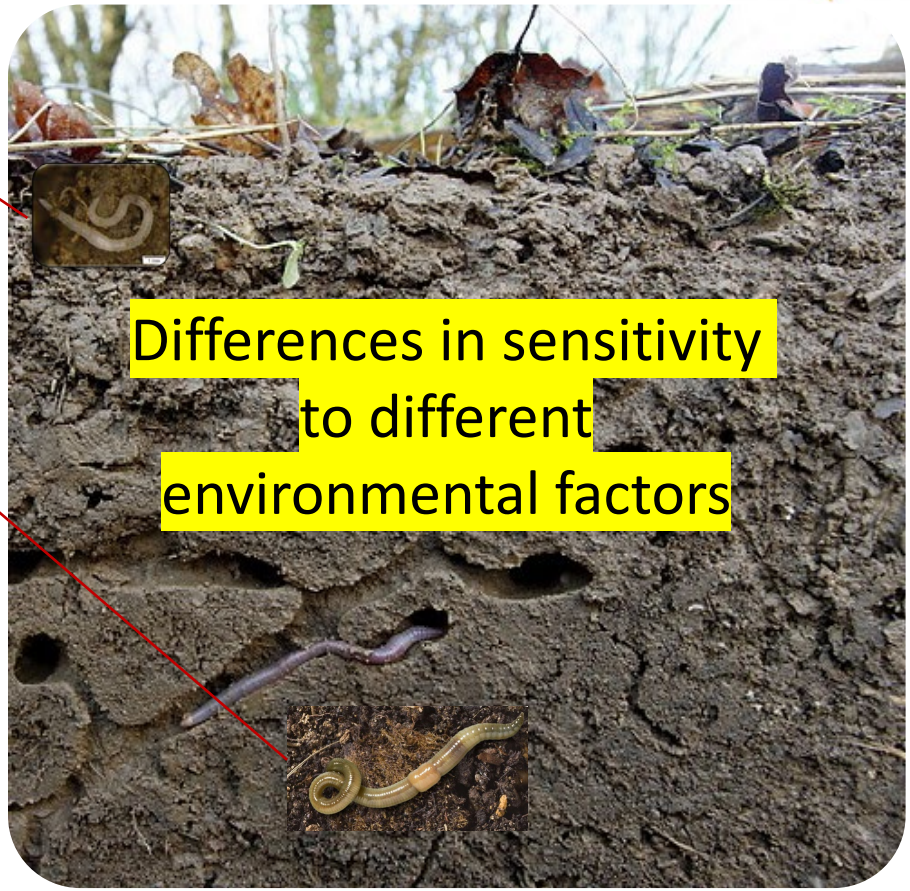
Source: MedECC (2020)

Enchytraeids

Earthworms

Enchytraeids

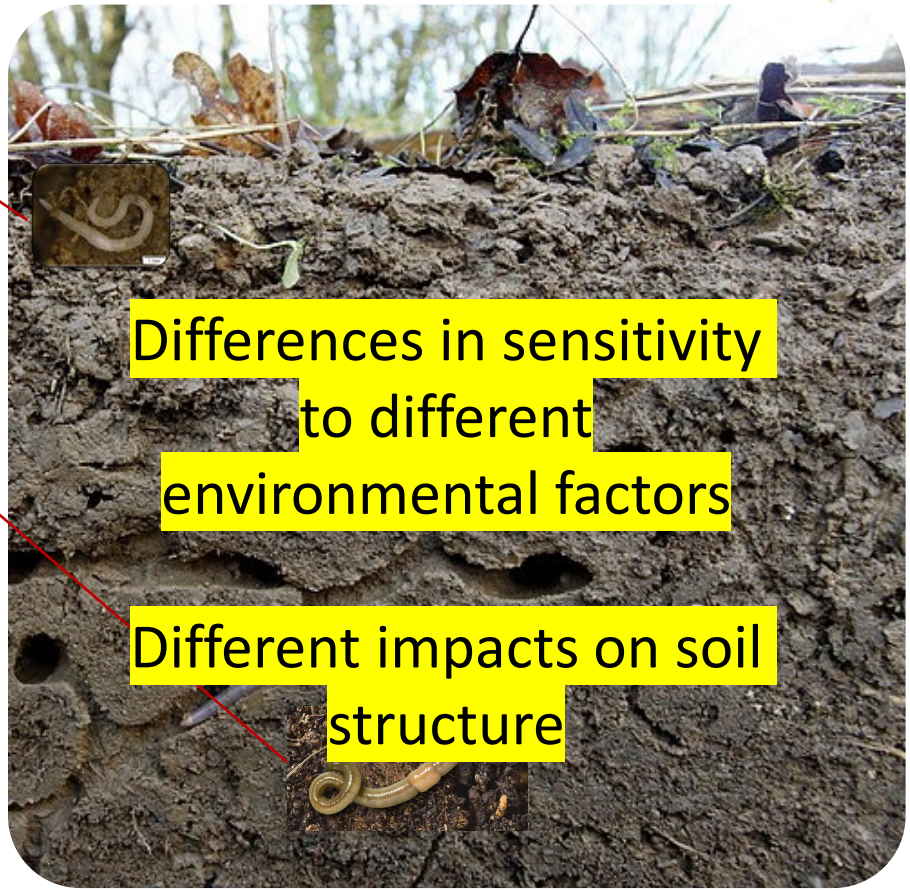
Earthworms

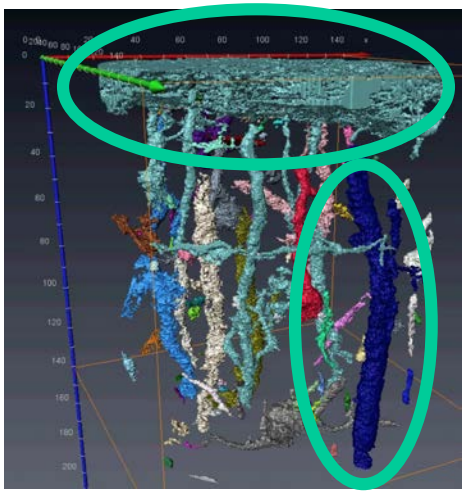


Differences in sensitivity to different environmental factors

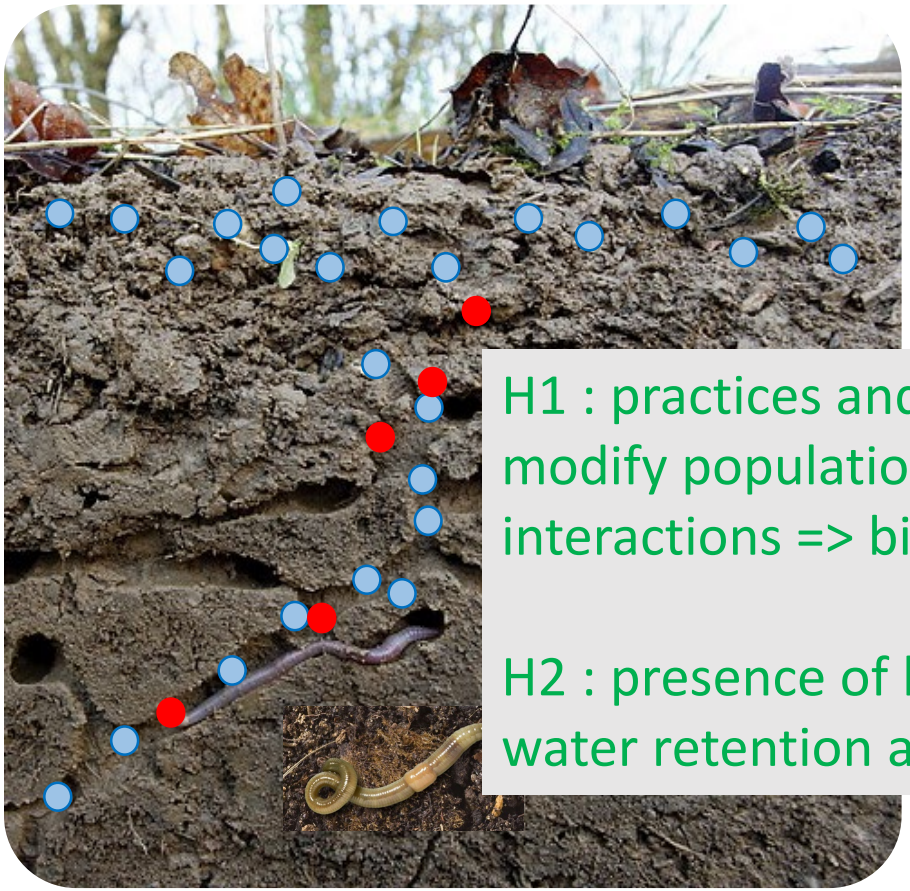
Enchytraeids

Earthworms





Retention and drainage of water and particles



H1 : practices and climatic variables modify population dynamics and interactions => bioturbation

H2 : presence of both taxa promote water retention and drainage

Differences in sensitivity to different environmental factors

C. Serbource
PhD student

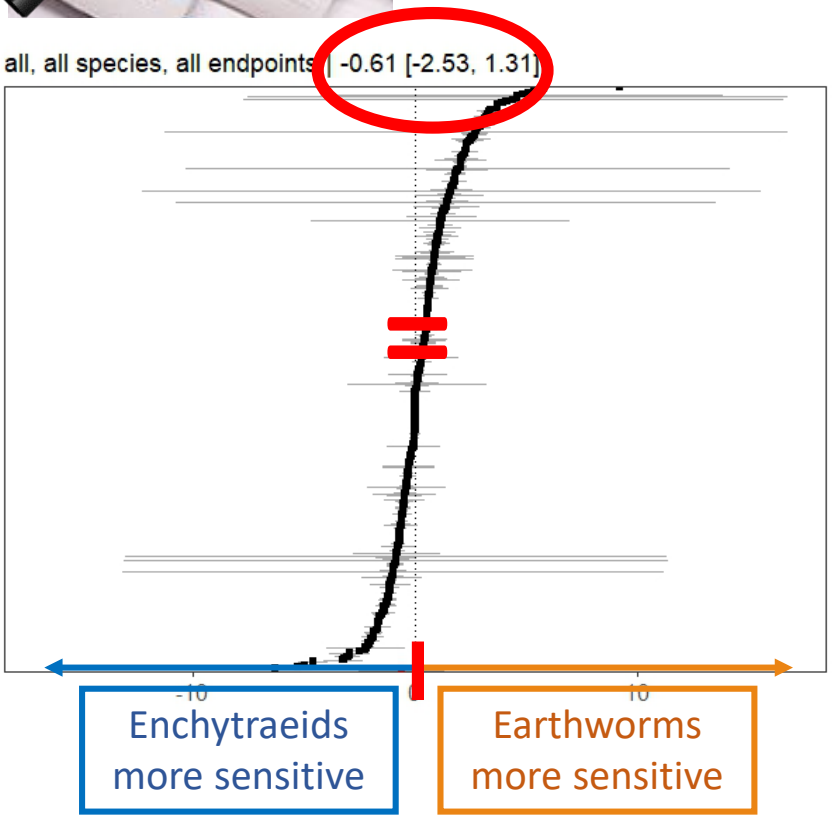
Differences in sensitivity to different environmental factors

C. Serbource
PhD student

Same study, same experimental conditions
Same factor tested on both organisms
Same data measured e.g., mortality, reproduction
At the species level

Differences in sensitivity to different environmental factors

C. Serbource
PhD student

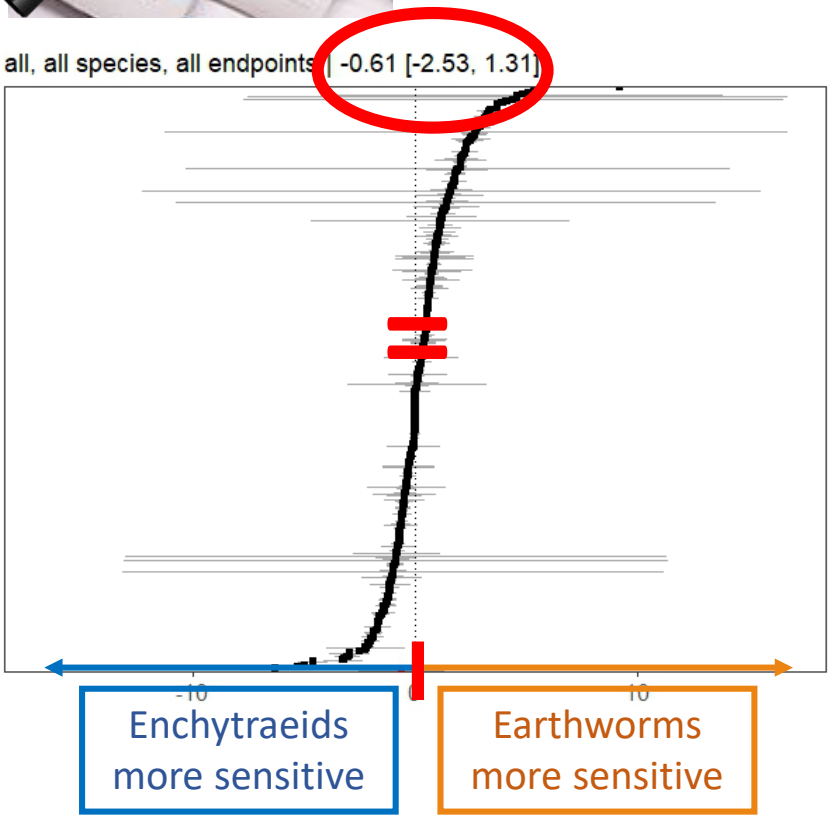


Same study, same experimental conditions
Same factor tested on both organisms
Same data measured e.g., mortality, reproduction
At the species level

Differences in sensitivity to different environmental factors

C. Serbource
PhD student

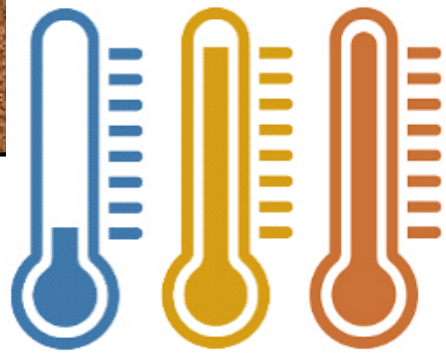
Mainly on chemicals (95%), almost nothing on climatic parameters
Enchytraeids more resistant to extreme conditions e.g., drought (Maraldo & Holmstrup, 2009)



Same study, same experimental conditions
Same factor tested on both organisms
Same data measured e.g., mortality, reproduction
At the species level

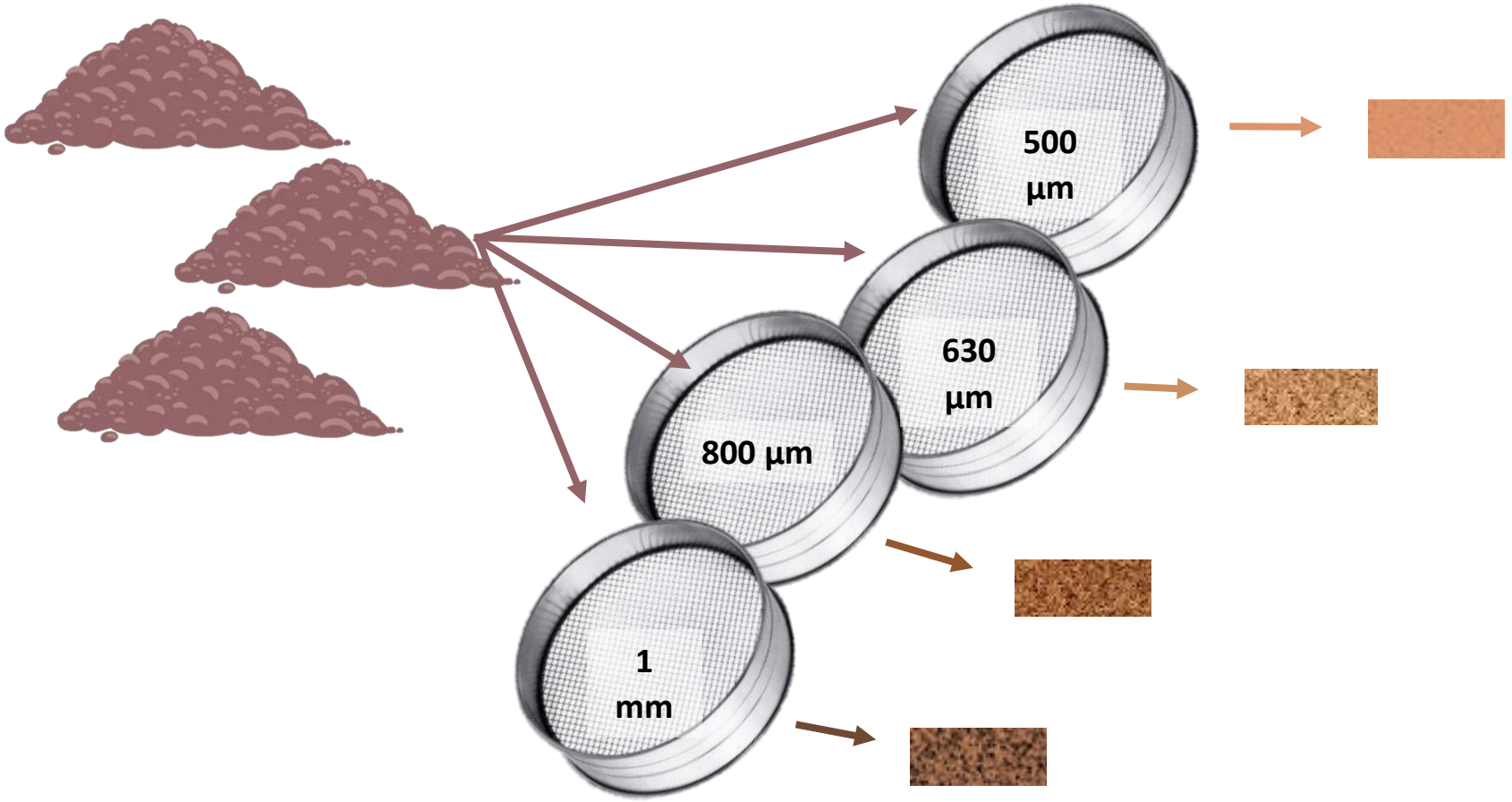
Modification of soil structure

Sensitivity of enchytraeids and earthworms to climatic factors



Different soils

Different grain size



Different bulk density
(compaction)

Enchytraeids/ earthworms / both

without

D= 1,0 & D= 1,2

D= 1,0 & D= 1,2

A few weeks

X-ray tomo or microtomography

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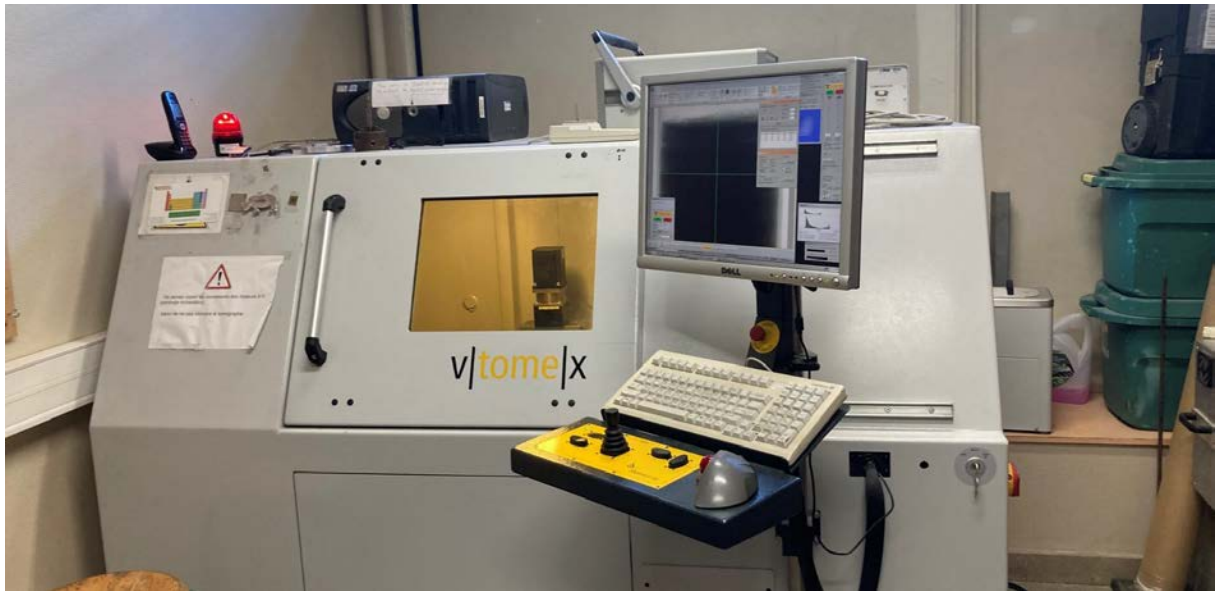

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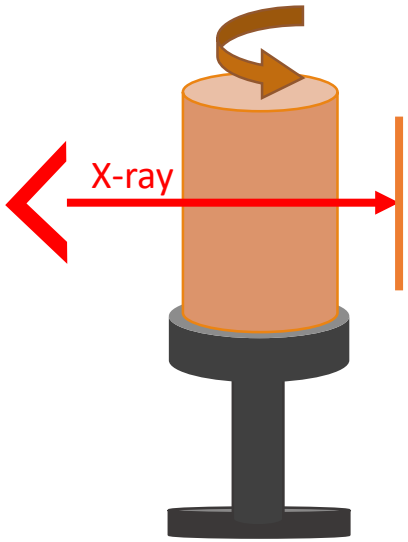


1200 slices per micro-cosmes

1 slice

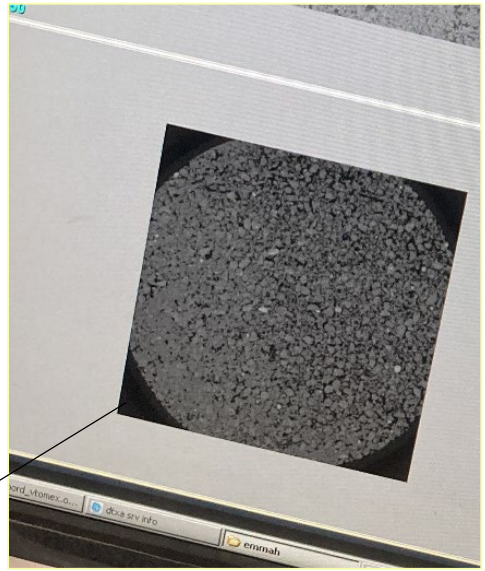
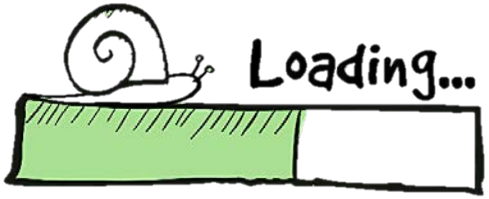
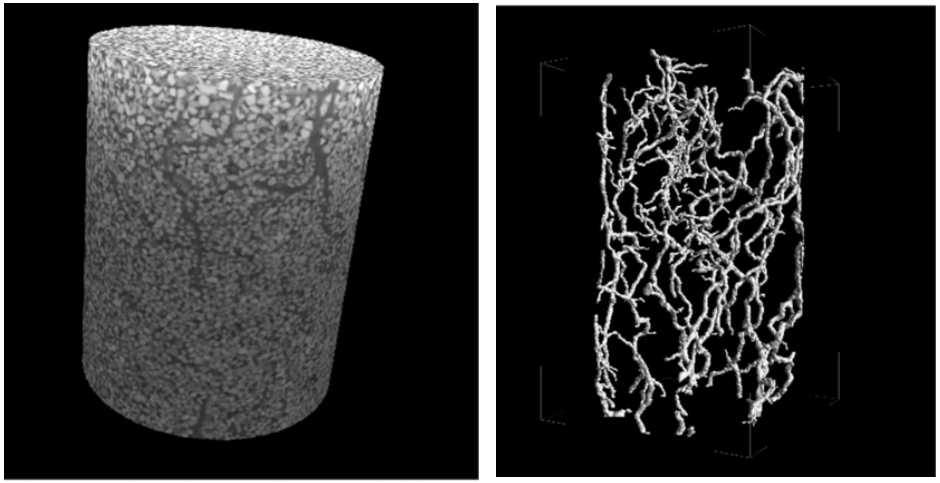


Image processing



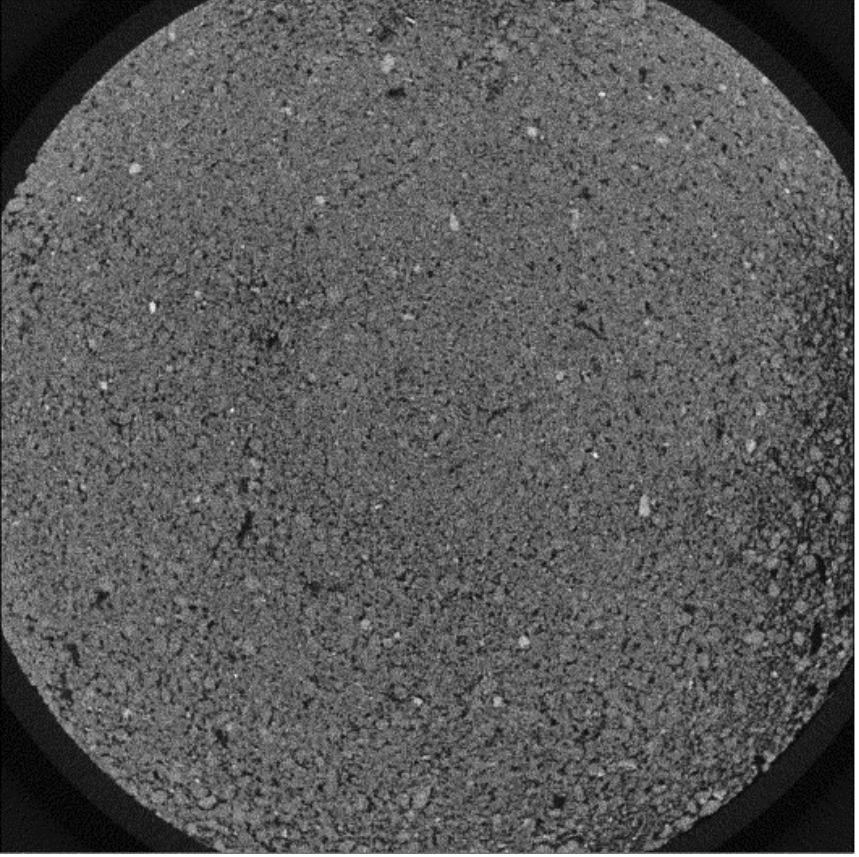
Reconstruction

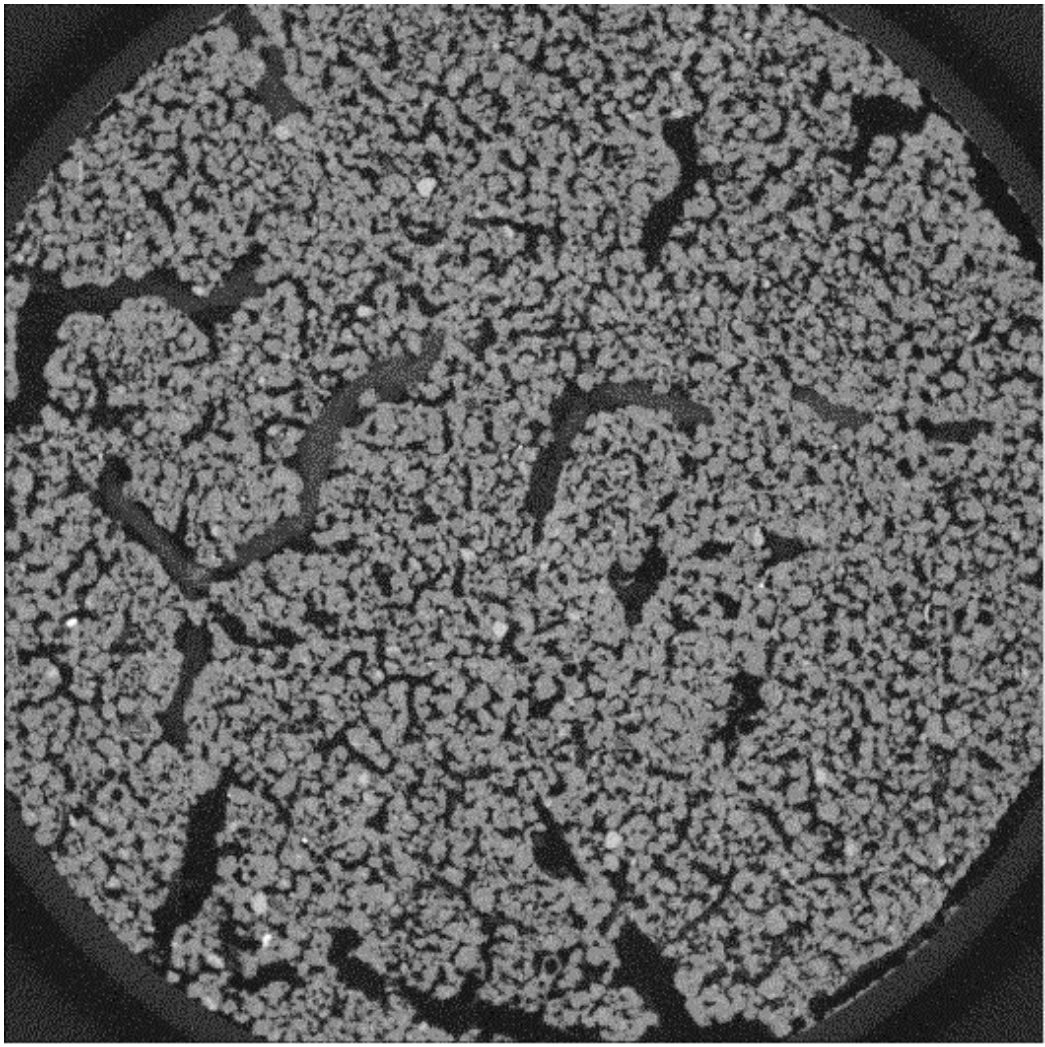


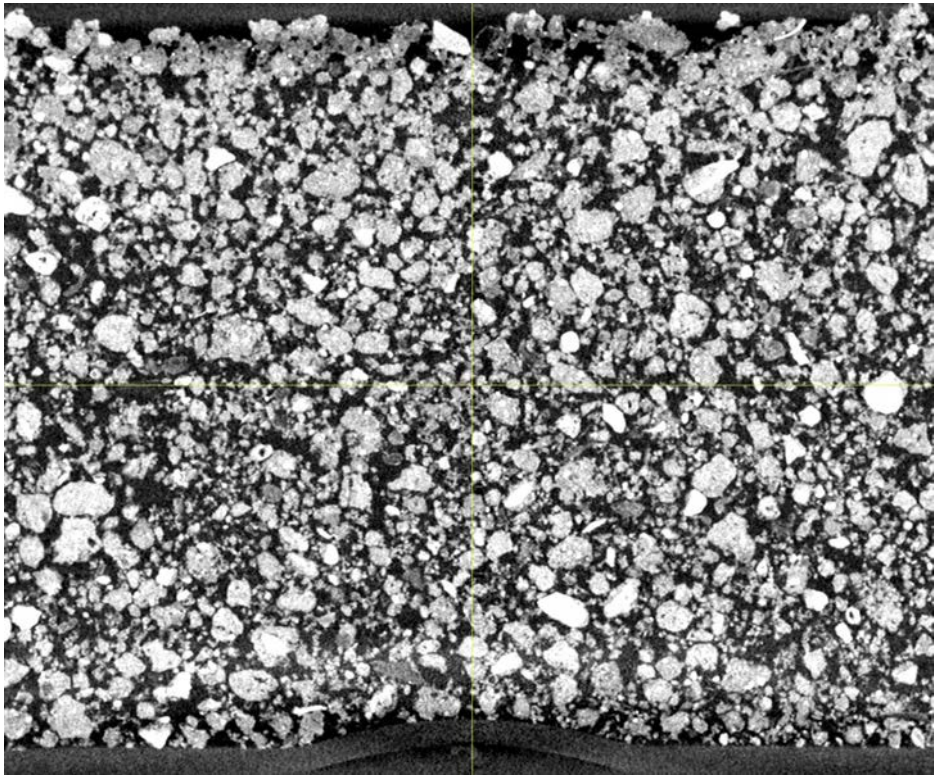
Non-destructive quantification of cereal roots in soil using high-resolution X-ray tomography **R. Flavel et al. 2012**

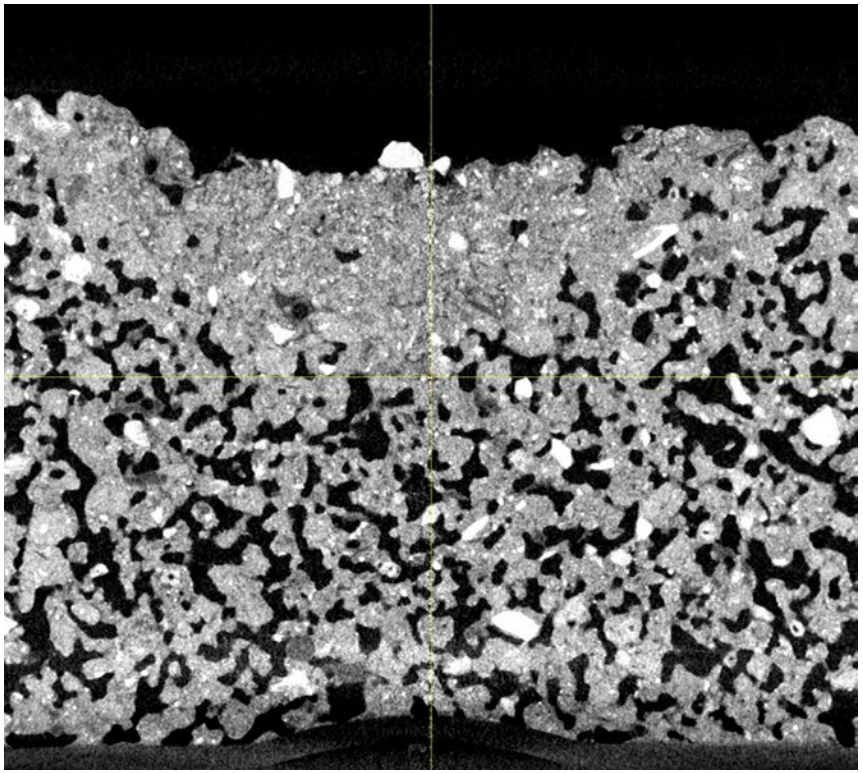
Parameter calculation

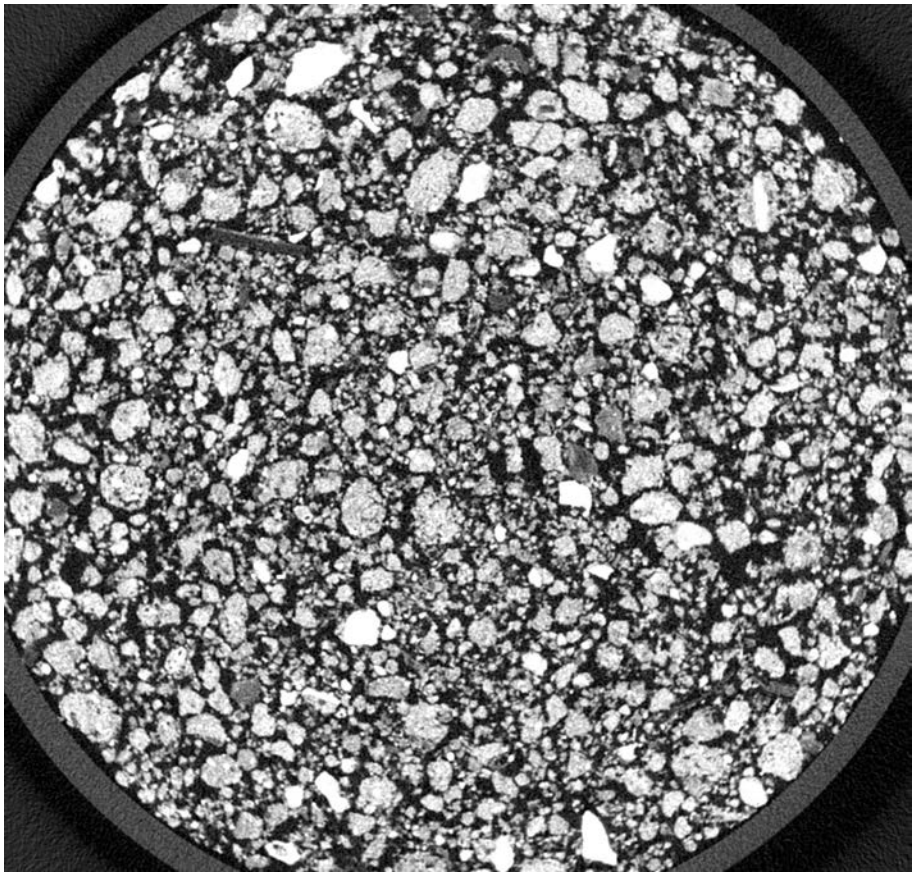
- Total porosity
- Gallery length
- etc.

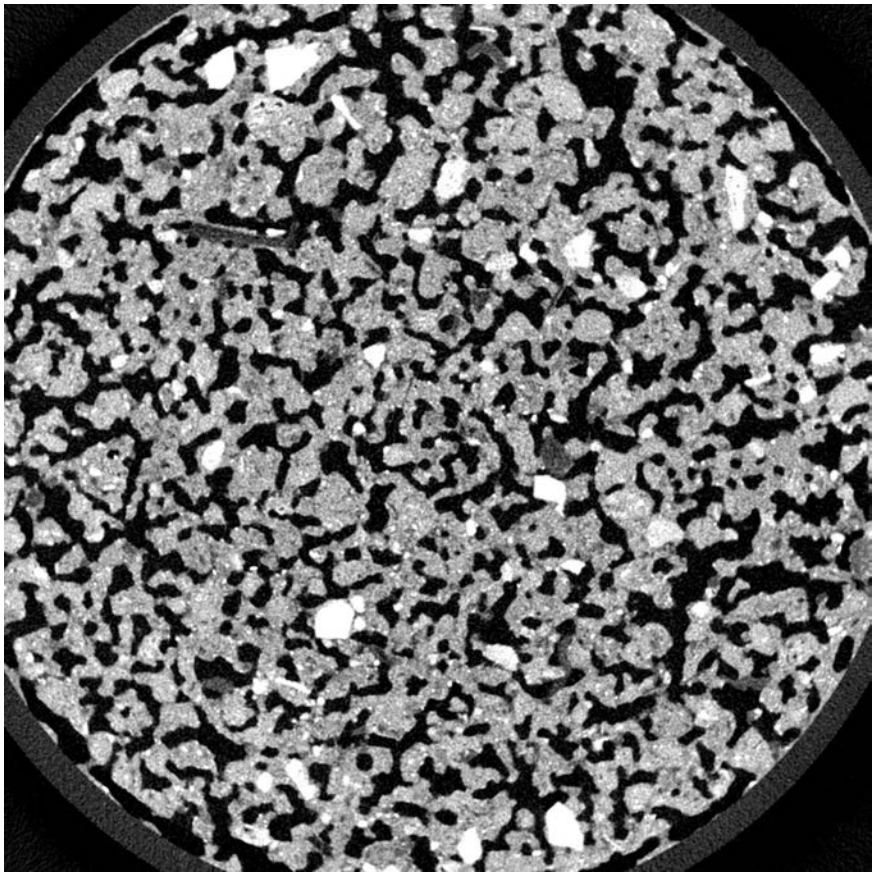




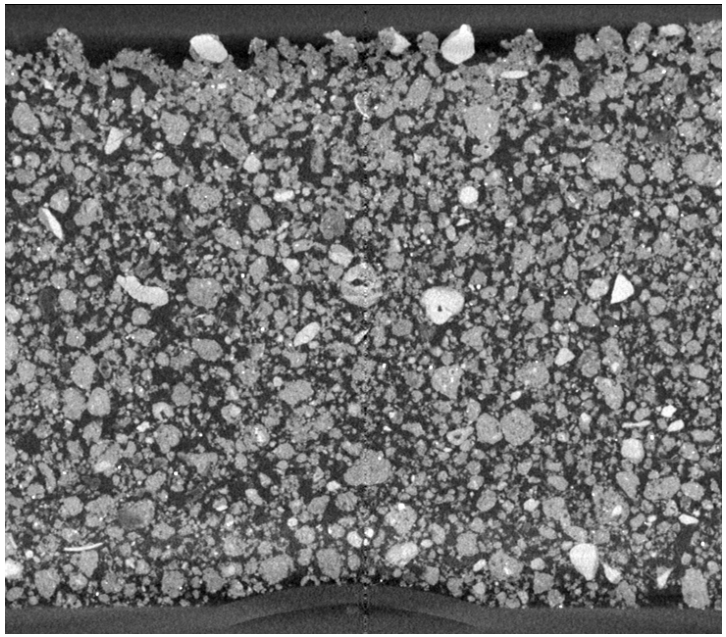




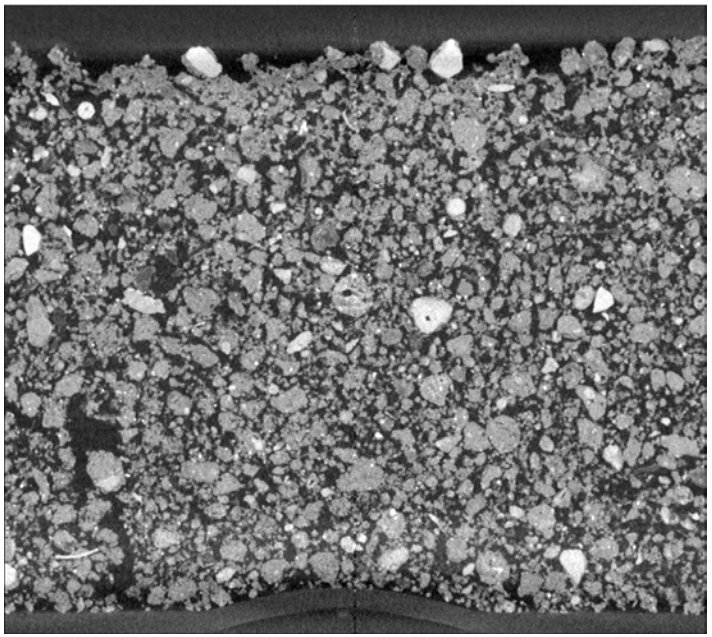


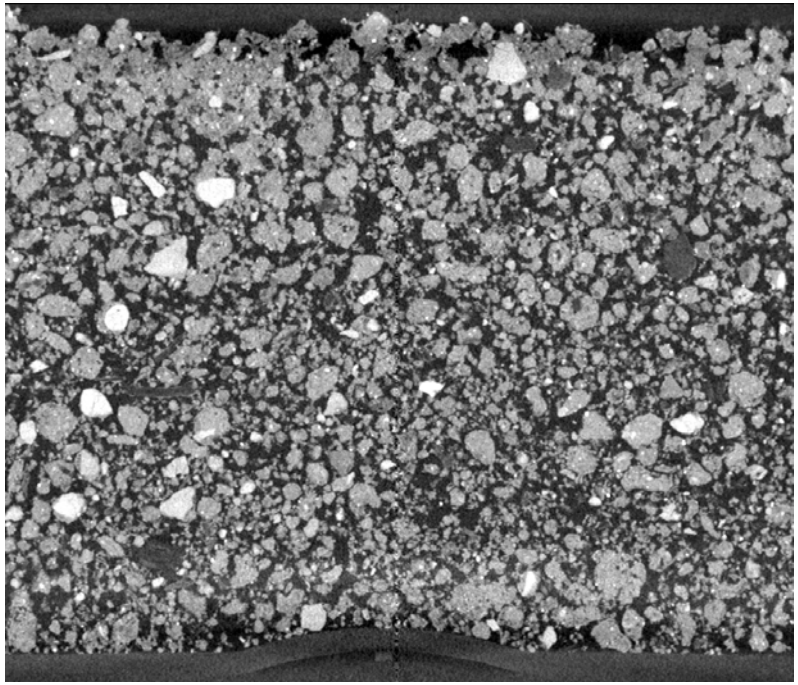


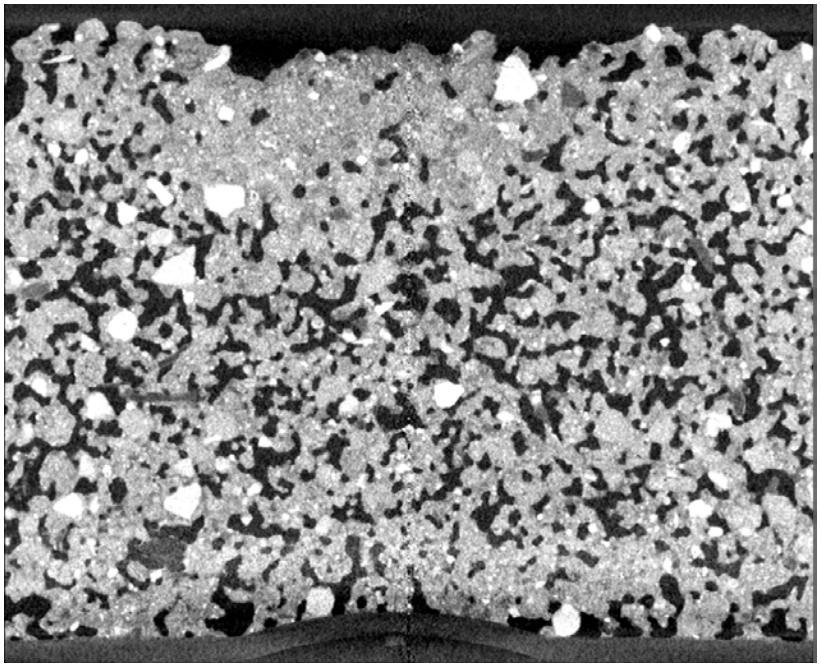
16/12/22

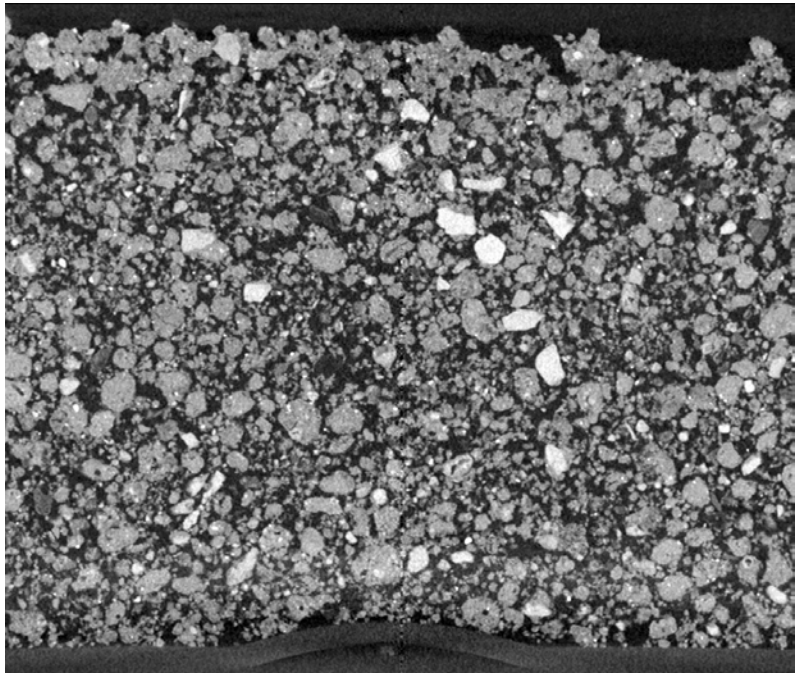


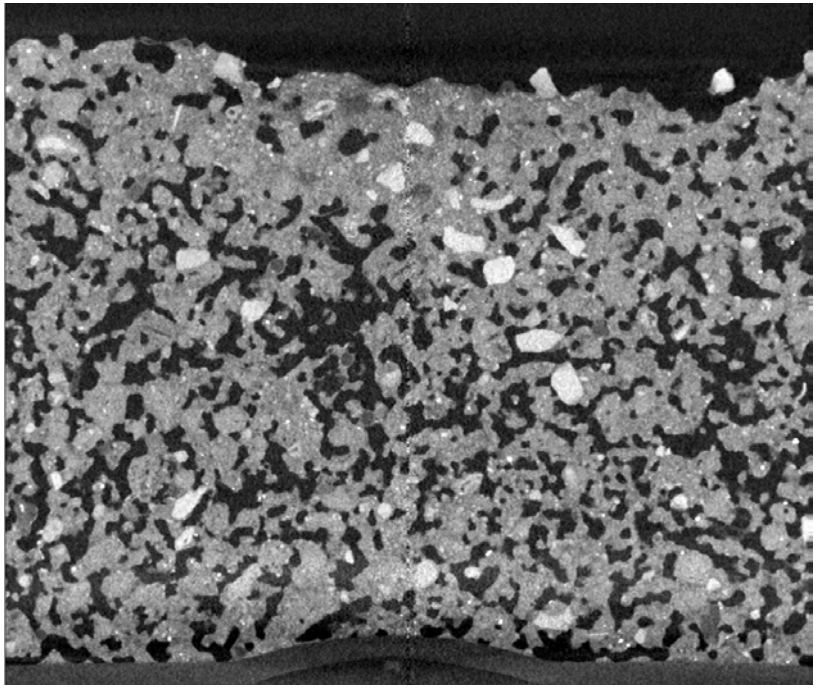
25/01/23





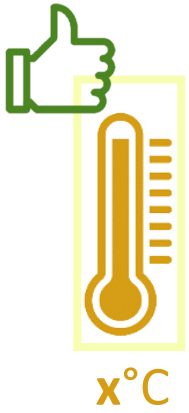






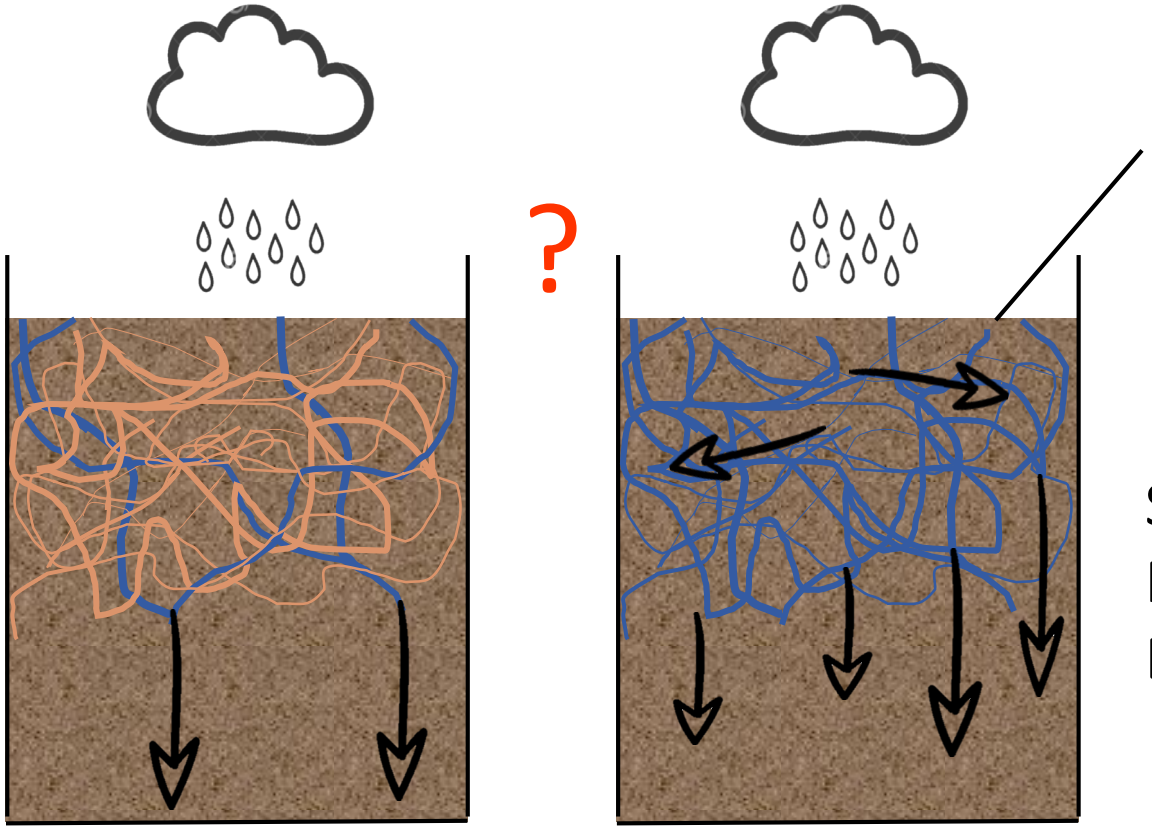
rain

rain



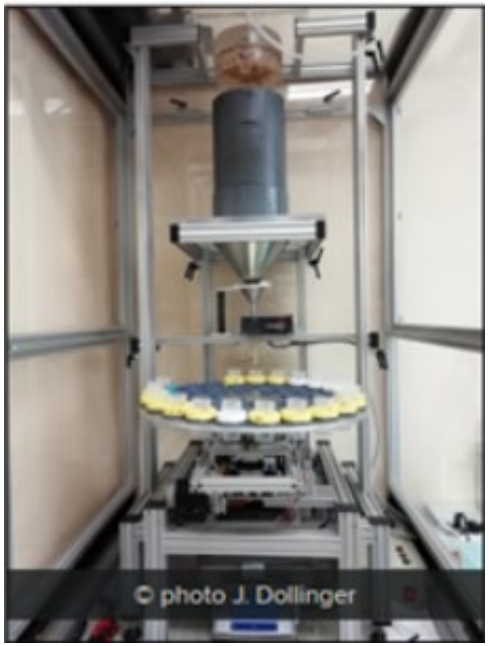
x°C

No animals

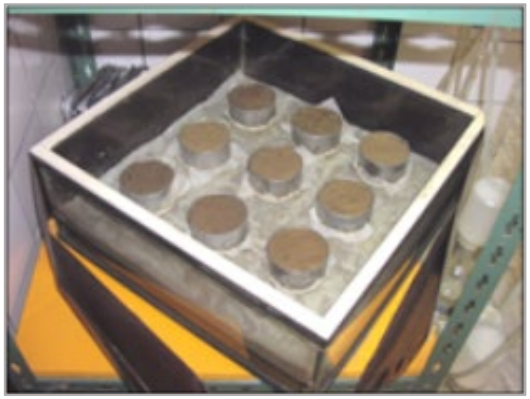


Spongy property?
Faster water infiltration?
Better water retention?

Water infiltration



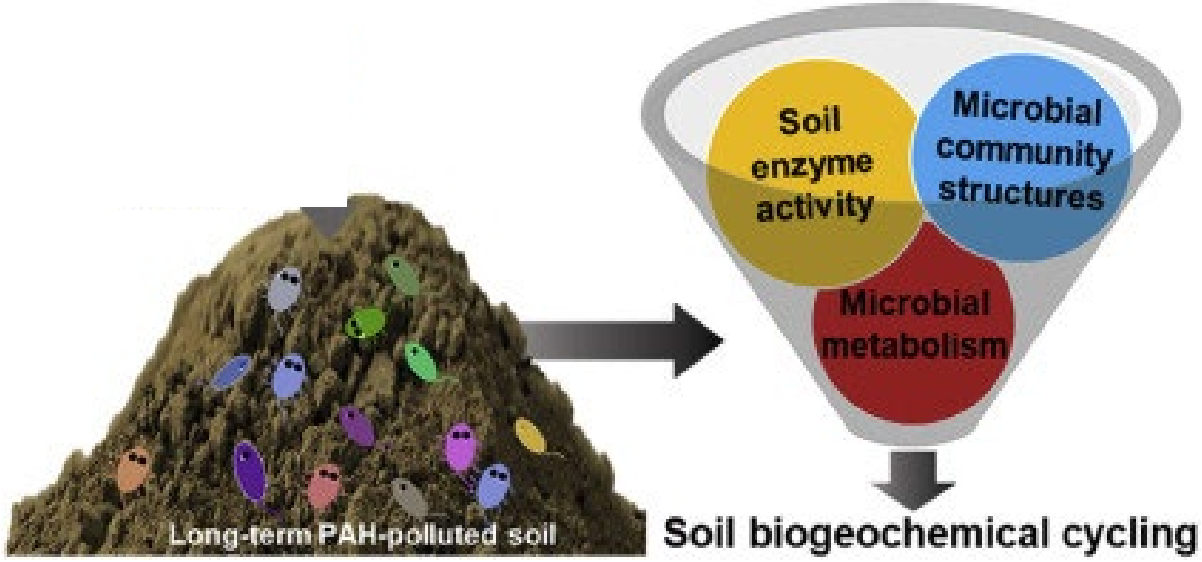
Water retention



Permeability test (infiltration)

Soil enzyme activity

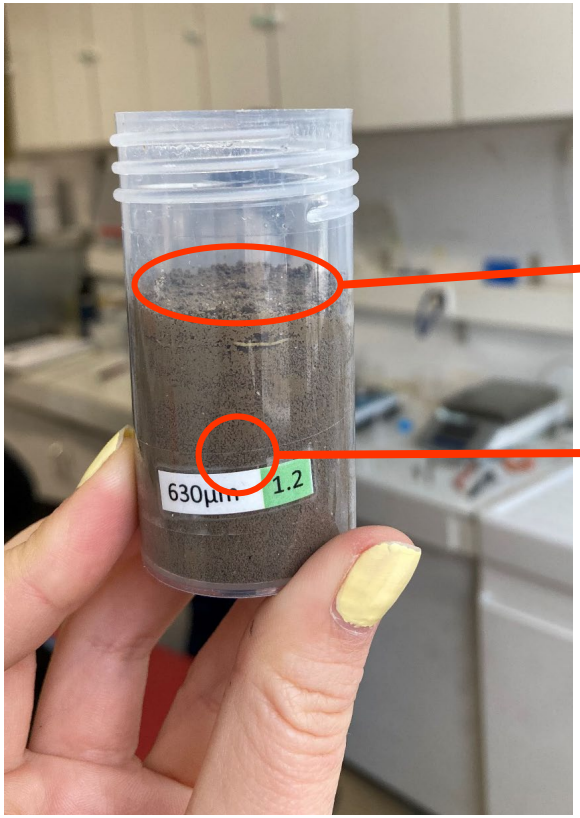
Dejections of (earthworms and enchytraeids)
VS
Bulk soil



Granulométrie grossière

Granulométrie fine

Enzymology (biochemistry)



- Phosphatase (Phosphorous)
- Glucosidase & carboxylesterase (Carbon)
- Urease (Nitrogen)
- Deshydrogenase (living biomass)

In the field: assessment of enchytraeid and earthworms populations under different agricultural practices (to promote them)

ORGANIC MATTER INPUTS

ACT on system functionality

Innovative practices in vineyards

ACT on system functionality

Innovative practices in vineyards

Understand the processes

Increase in nutrient availabilty for plants

Modification in copper (bio)availability

Water infiltration
OM degradation

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Hyp. Better biological functioning
⇒Improved soil functioning
⇒Less vulnerable to climate change

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Generalization
(uses, management, territories)

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Generalization
(uses, management, territories)

L. Petit-dit-Grezeriat
PhD student

Revitalization of vineyard soils by earthworm inoculation and massive inputs of organic matter

Meta-analyse

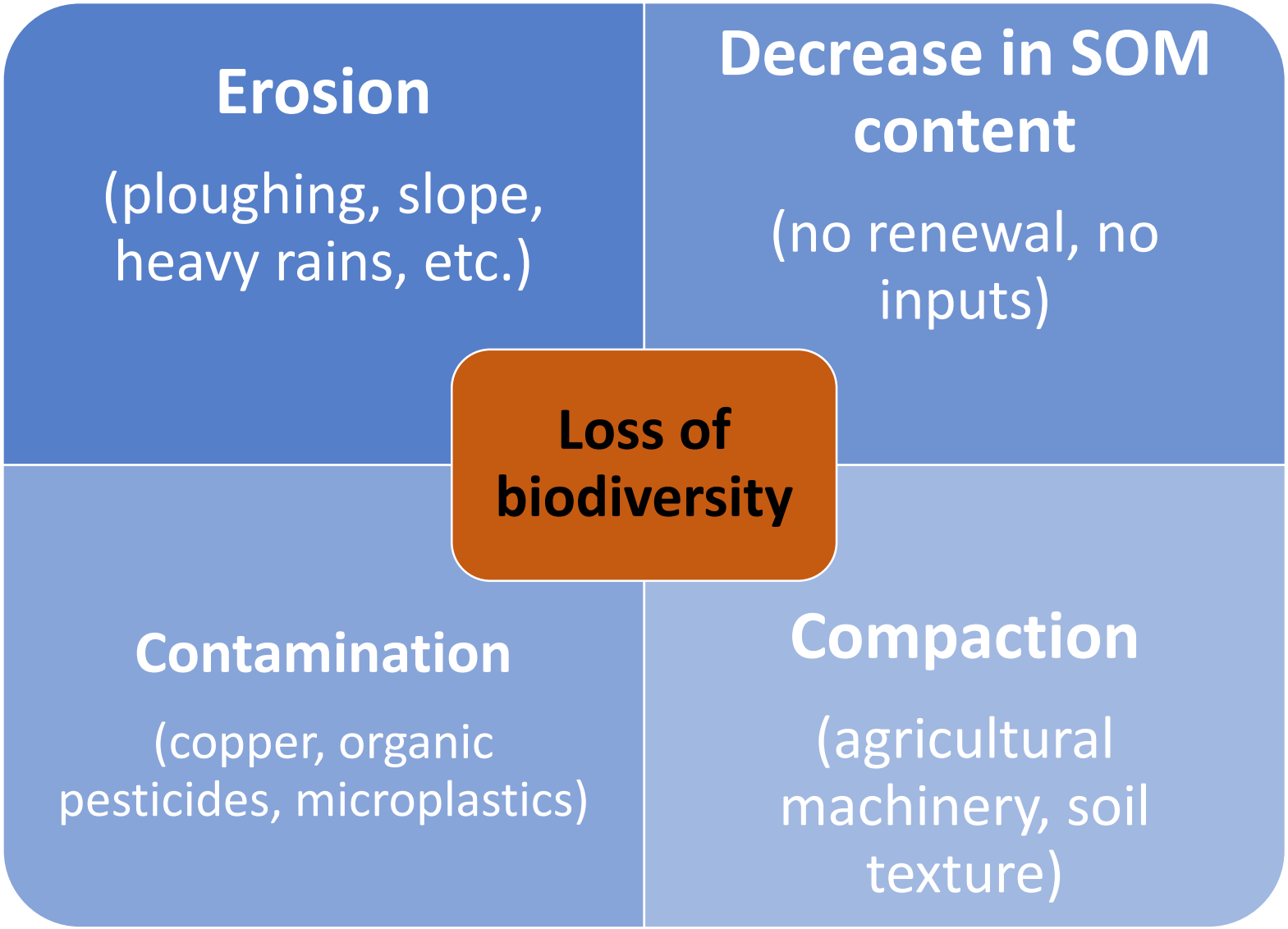
Increase in earthworm abundance and biomass after an earthworm inoculation initiative?

Field study

Survival and dispersion

Laboratory studies

Reproduction of the inoculated species (different combination and OM inputs)


Erosion
(ploughing, slope, heavy rains, etc.)
Decrease in SOM content
(no renewal, no inputs)
Loss of biodiversity
Contamination
(copper, organic pesticides, microplastics)
Compaction
(agricultural machinery, soil texture)

Inoculations in November 2021 at 4 different places (fields)

Species	Abundance
A. nocturna	25
L. terrestris	20
A. chlorotica	40
A. caliginosa	*35*
TOTAL/point	*120 individuals*

T2
Green compost

T1
Fresh refined material (FRM)

T3
Digestate/FRM

Aporrectodea nocturna
(Anécique)

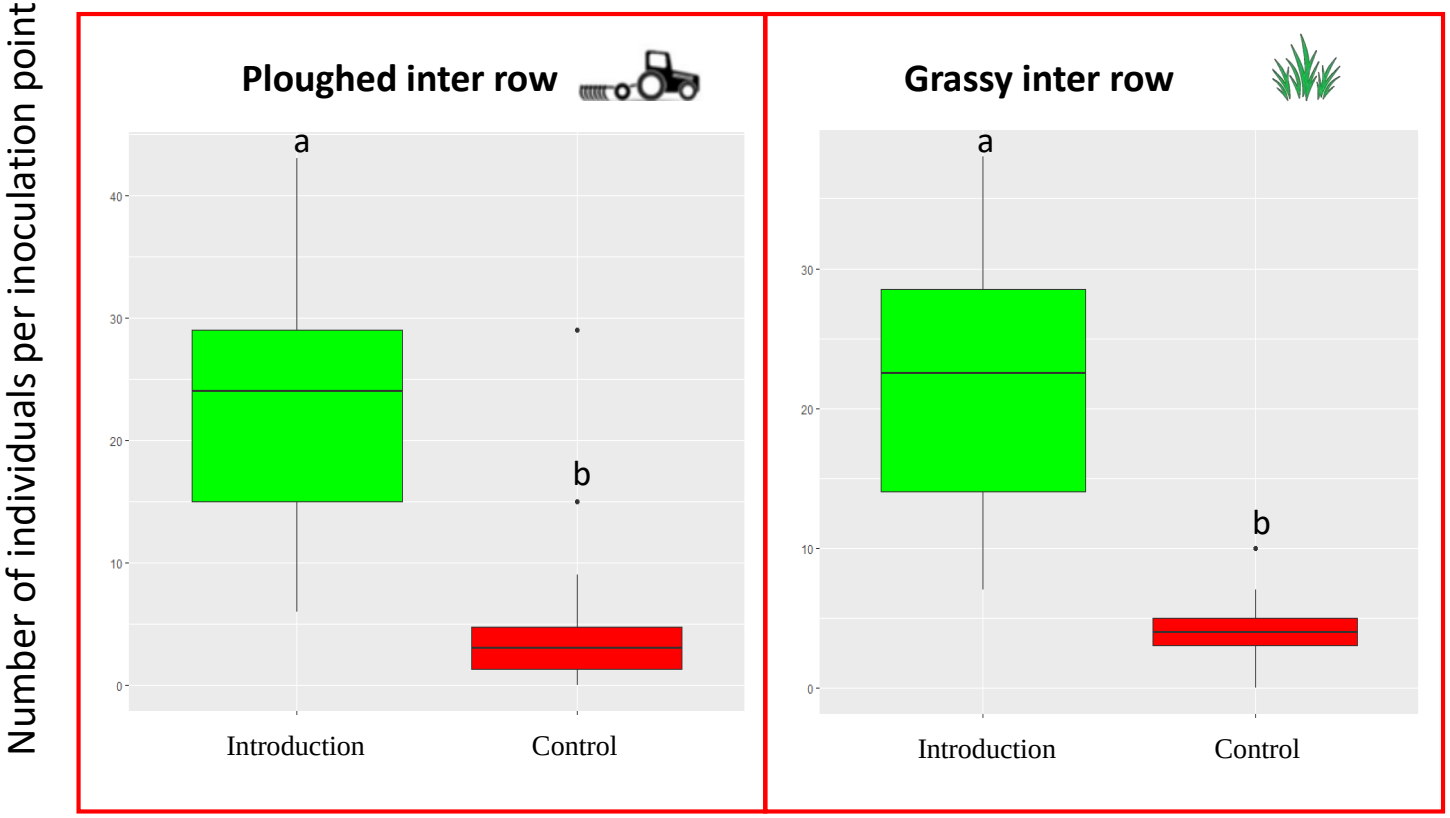
Aporrectodea caliginosa
(Endogé)

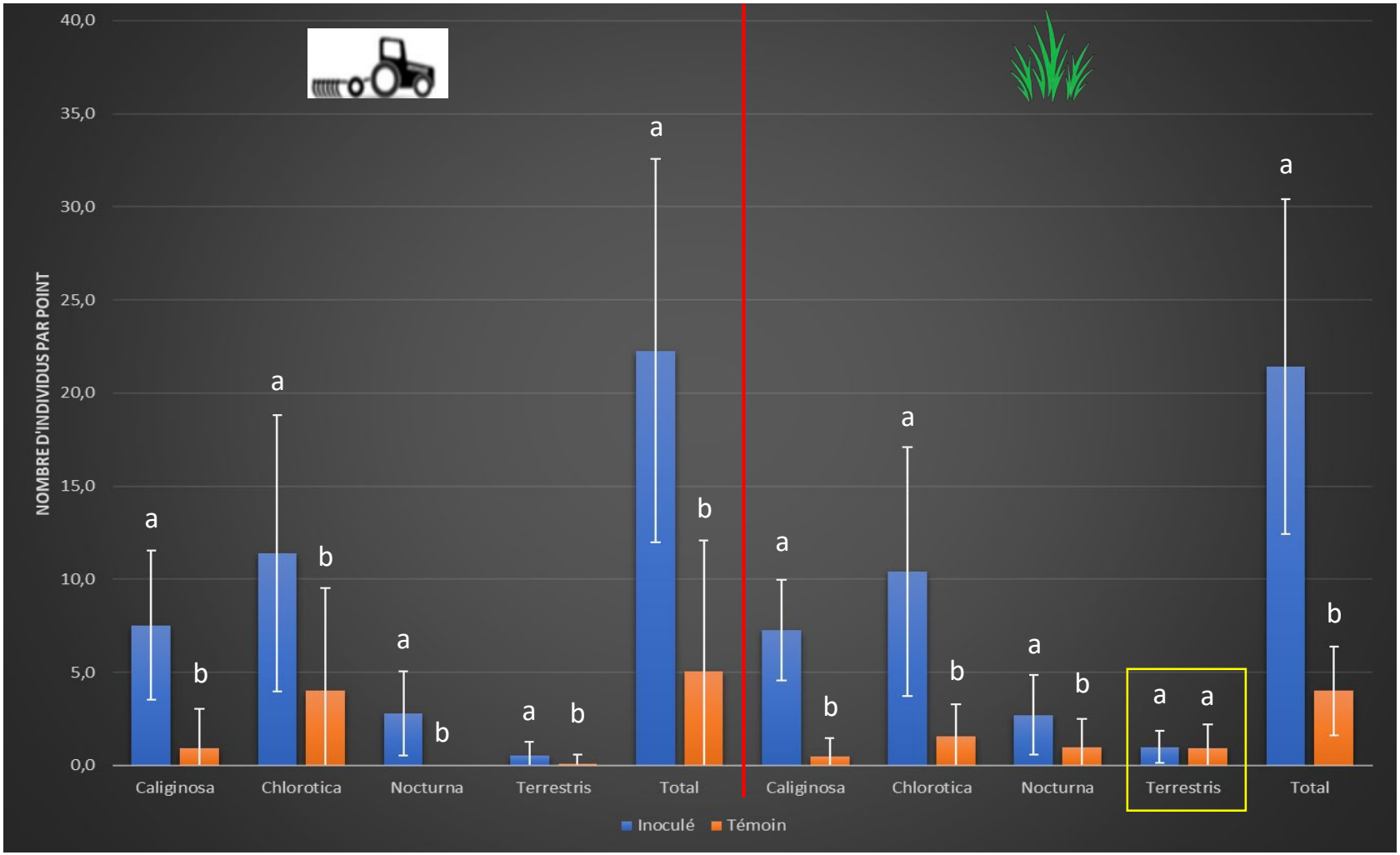
Allolobophora chlorotica
(Endogé)

A few weeks after the inoculation

Earthworm dejections at the soil surface

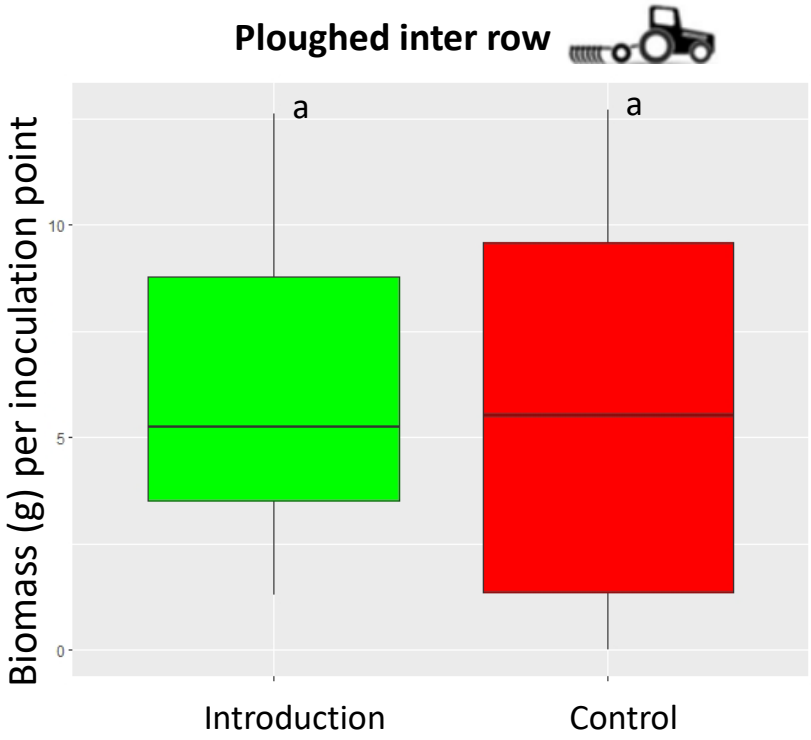
Abundance of the inoculated species 4 months after their introduction (March 2022)

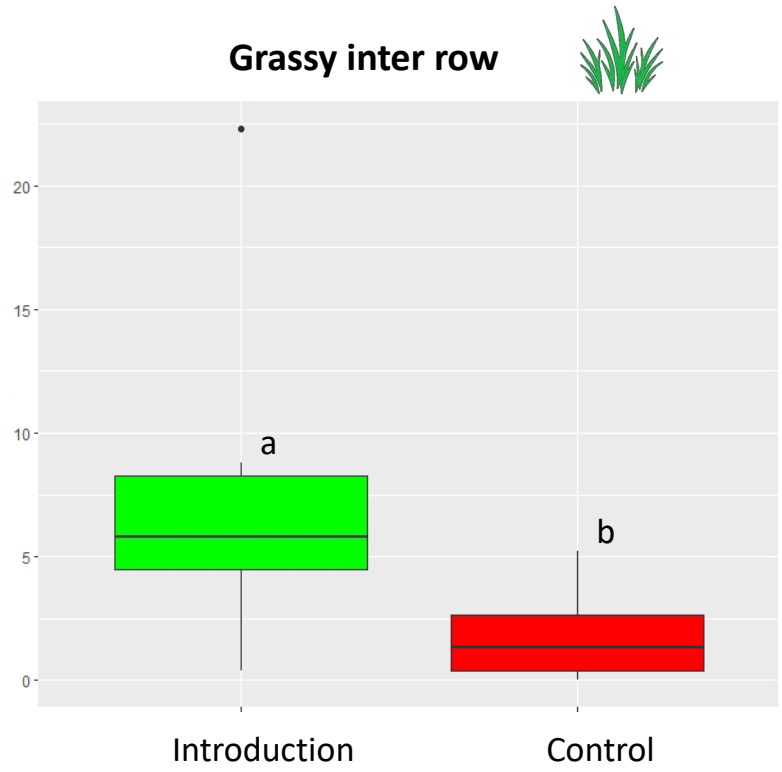


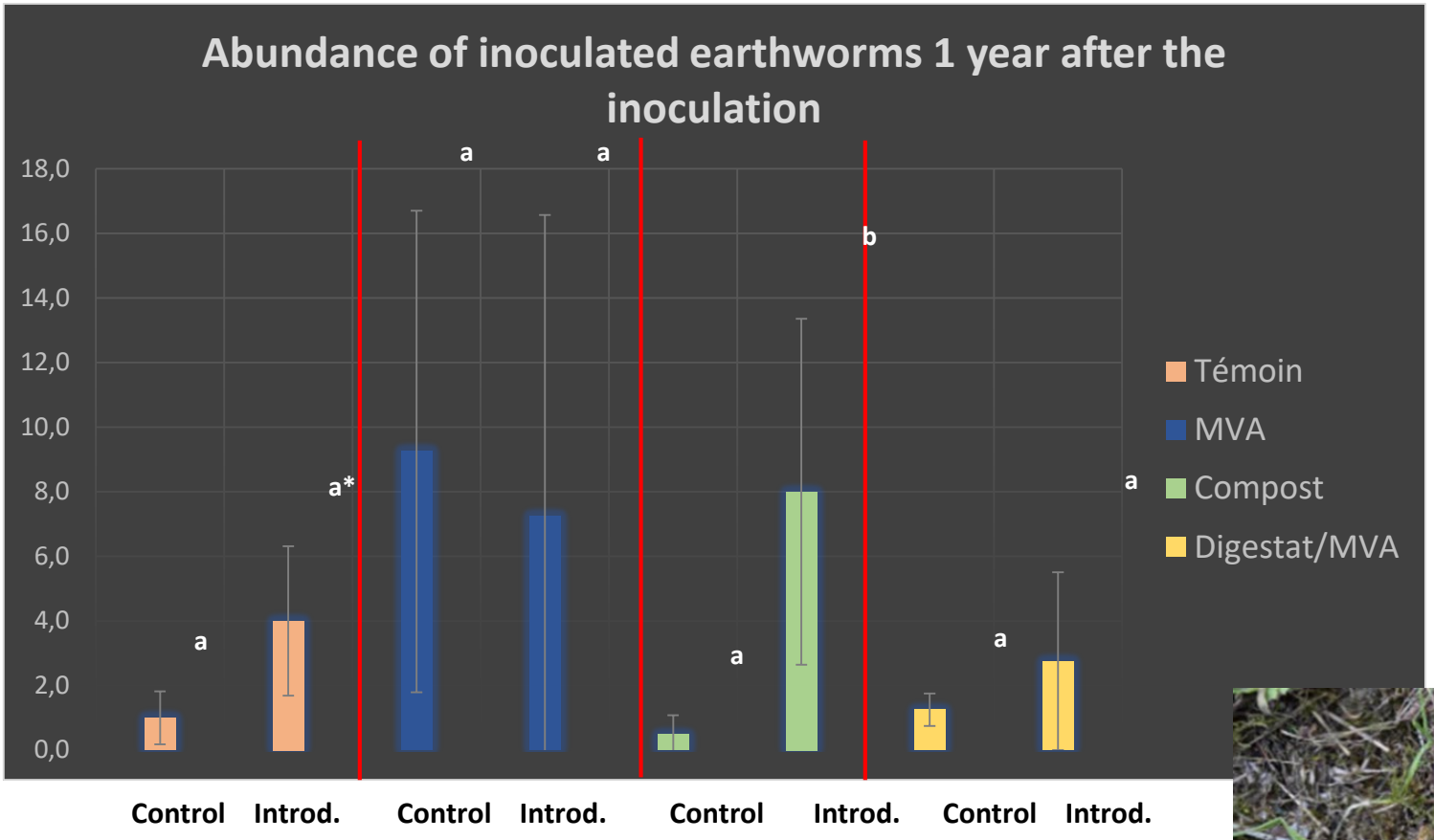

40,0
35,0
30,0
25,0
20,0
15,0
10,0
5,0
0,0
NOMBRE D'INDIVIDUS PAR POINT
a
b
a
b
a
b
a
b
a
b
a
b
a
b
a
b
a
b
a
a
a
b
Caligninosa
Chlorotica
Nocturna
Terrestris
Total
Caligninosa
Chlorotica
Nocturna
Terrestris
Total
Inoculé
Témoin

BIOMASSE

Biomass of the inoculated species 1 year after their introduction (November 2022)

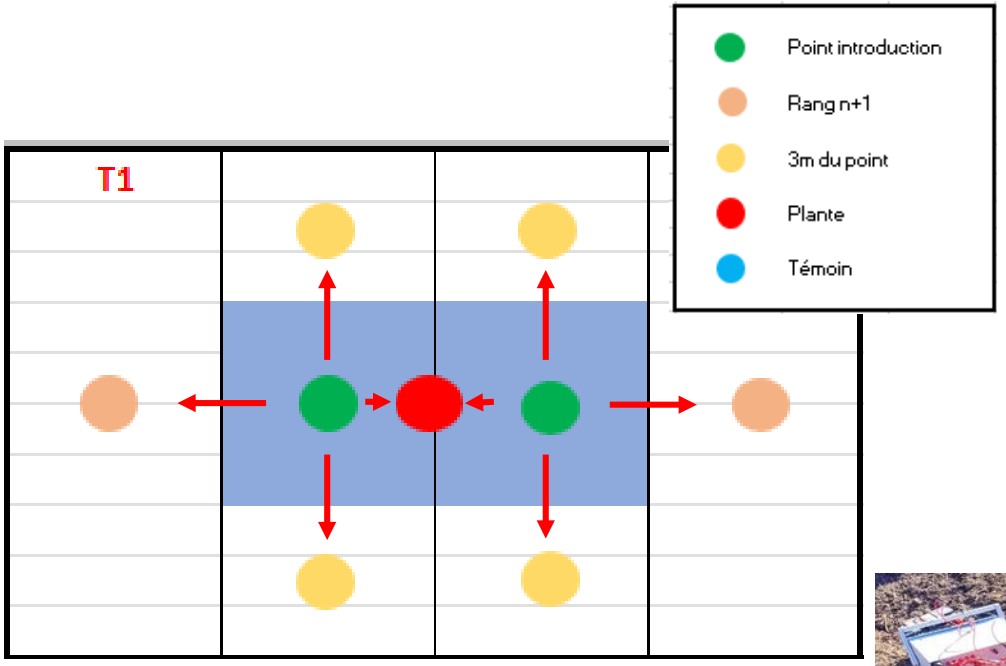






Fresh refined material : better for earthworm establishment (moisture)

Good candidate


T1
Point introduction
Rang n+1
3m du point
Plante
Témoin

Survival satisfactory in the short term (4 months)

Less after 1 year

Efficient species for reintroduction: *Aporrectodea nocturna*.

Low dispersion 1 year after

Reproduction : compost was the best food compared to fresh refined material and no food

Species association better for the endogeic species

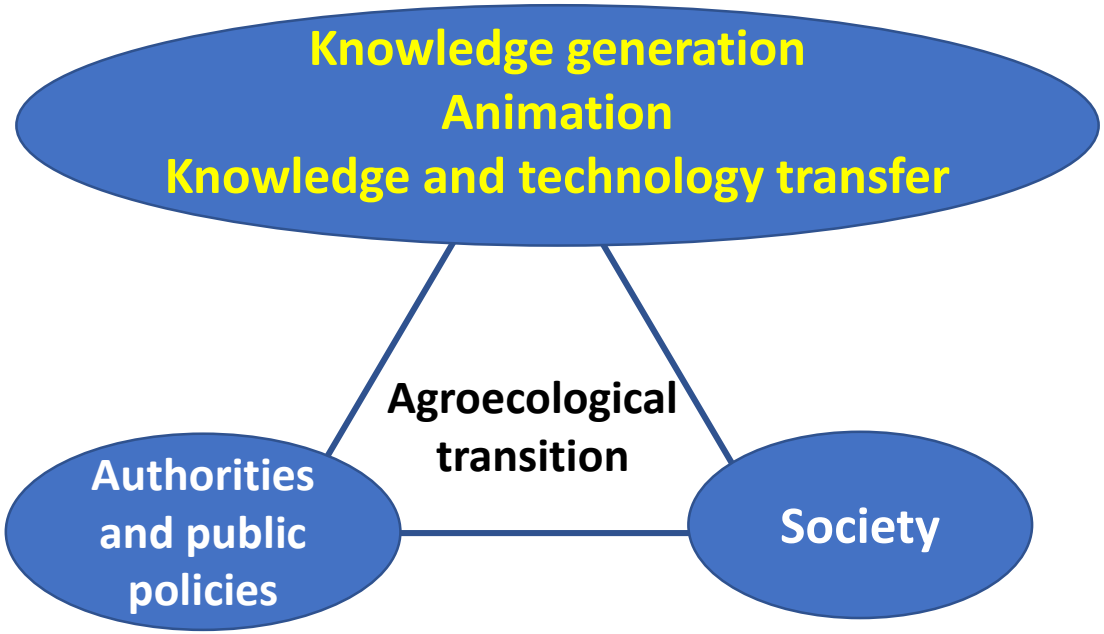
Field study

Survival and dispersion

Laboratory studies

Reproduction of the inoculated species (different combination and OM inputs)

Integration of biology/ecology in understanding and modeling the functioning of (hydro)systems



LEVERS to reduce risks for agroecosystems and improve their resilience to climate change