Soil Carbon in the Ecological Transition

IFP Energies nouvelles INRAE

International symposium
24 - 26 January 2024

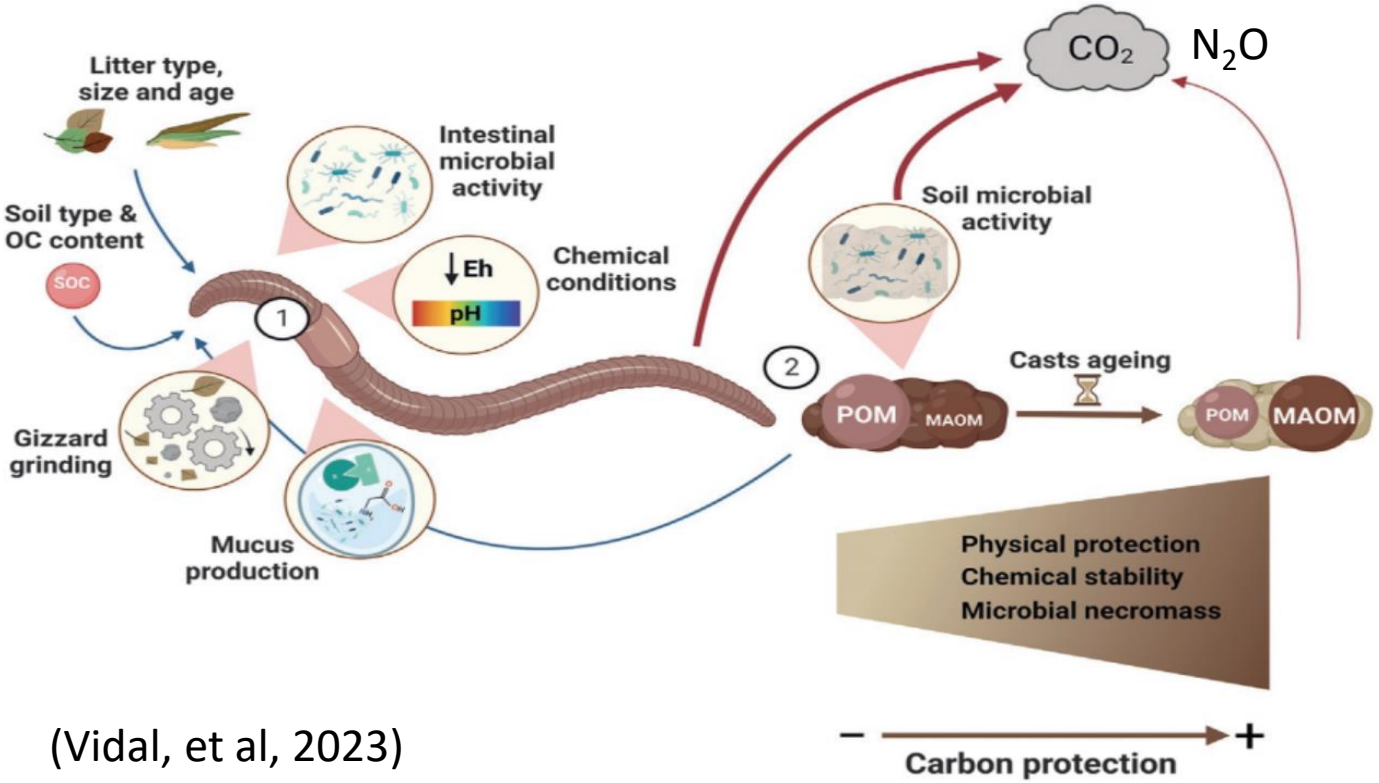
Land use determines the composition and stability of organic carbon in earthworm casts under tropical conditions

Chao Song [a,b], Nicolas Bottinelli [a, c, *], Tien-Minh Tran, Francisco Ruiz, Gabin Colombini , Yacouba Zi, Pascal Jouquet, Cornelia Rumpel [a, *]

a. IRD, CNRS, Sorbonne Université, Univ Paris Est Creteil, INRAe, Institute of Ecology and Environmental Sciences (iEES-Paris), F-75005, Paris, France
b. Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences, Shijiazhuang 050061, China
c. Department of Soil Sciences, Soils and Fertilizers Research Institute (SFRI), Hanoi, Viet Nam

1 Introduction

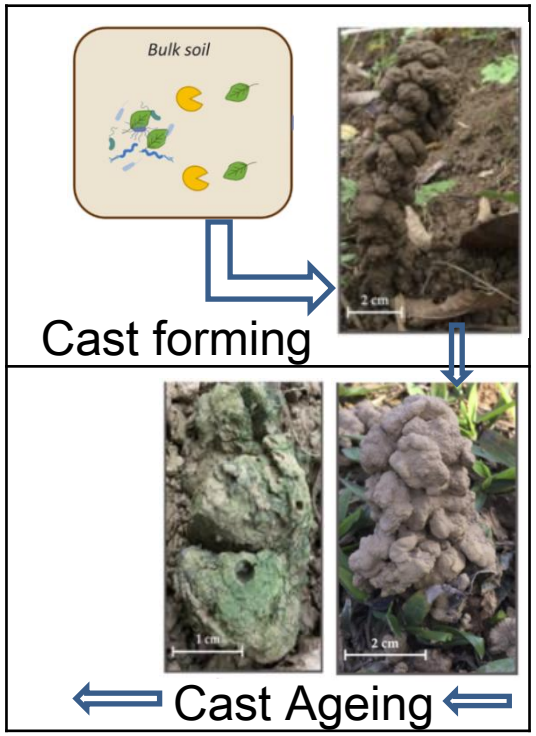
- Earthworms-----important drivers of SOC turnover
- However, their critical role in achieving carbon neutrality is still controversial: OC decomposition *vs.* OC stabilization

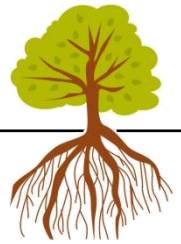


(Vidal, et al, 2023)

1 Introduction

Knowledge gap: the stability of cast OM and its sensitivity to surrounding environment in contrasting land use systems, e.g. **woodland** *vs.* **meadow**



		**Ref.**
Root, SOC, Water regimes (Micro)biological activity,…… **Different**		(Lavelle et al., 2022; Sun et al., 2020)
		(Assouline and Mualem, 1997; Li et al., 2019; Yan et al., 2021)
X		(Kochiieru et al., 2020)

1 Introduction

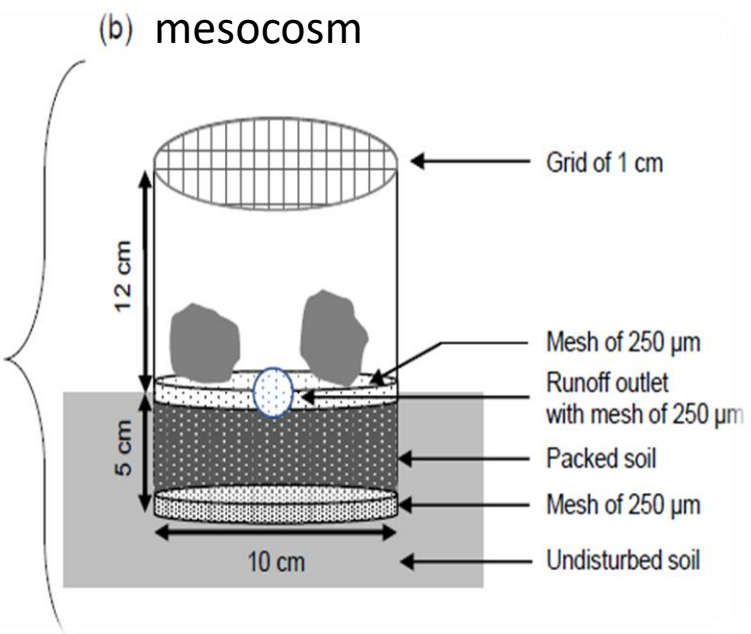
- **Objective:** to assess the effect of land use on
  - the dynamics of POM and MAOM occluded in casts and reference soils during field exposure
  - the chemical changes during their ageing.

2 Experiment design and methods

A **400-day field exposure experiment:** in a tropical woodland and meadow of northern Vietnam.

Land use	pH (KCl)	SOC	Clay	Sand
Woodland	3.9	2.5%	50%	17%
Meadow	3.8	3.7%	58%	16%

Soil type: Acrisol
Earthworm: Anecic species
Amynthas adexilis (*A. khami*)



Soil

Cast

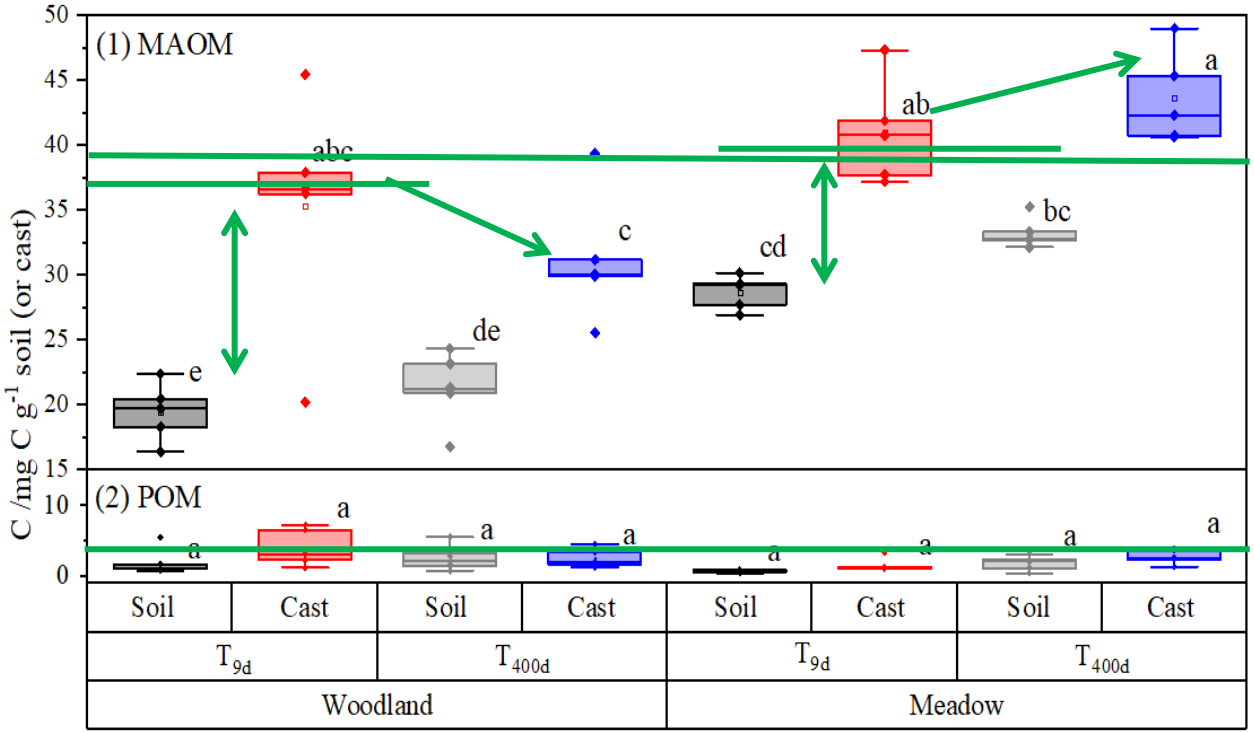
2 Experiment design and methods

- **Sampling:** 9 days (T_{9d}) and 400 days (T_{400d}) after field exposure

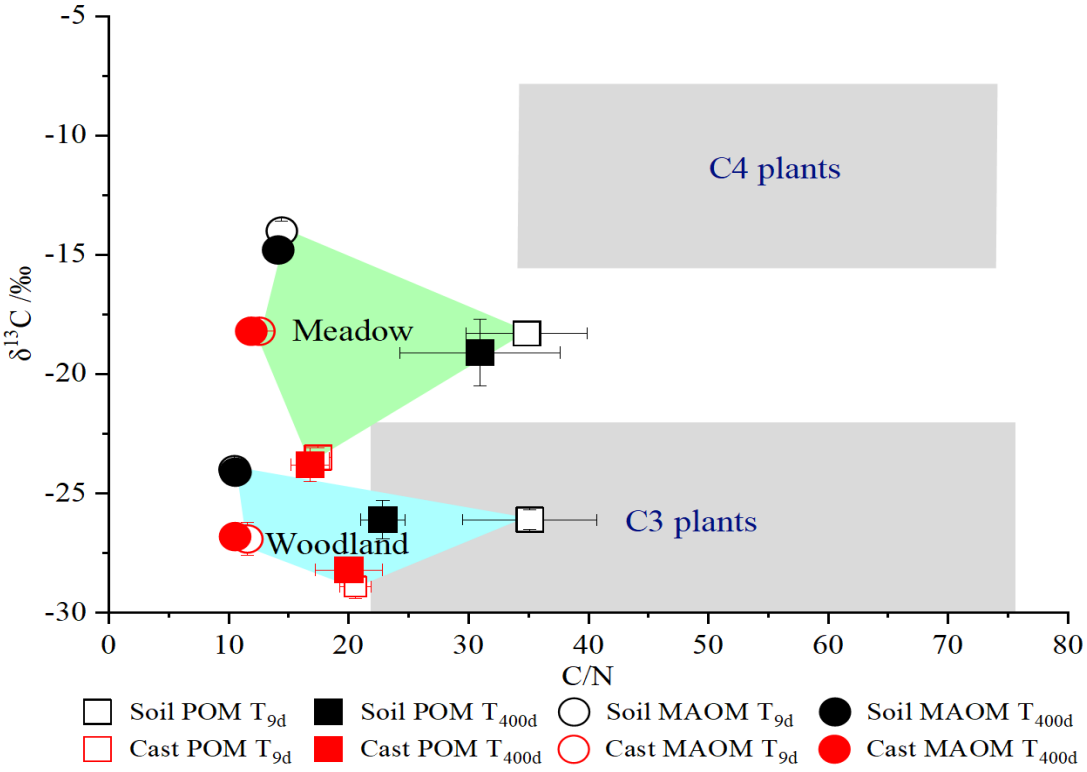
Sample treatment or tests	Parameters	Methods	For studying:
Density fractionation	POM and MAOM	Na-polytungstate with density of 1.6 g cm^{-3}	The stability of cast OM; protecting mechanisms
Elemental composition	C and N content	dry combustion	The quantity of Cast OC, C/N
Carbon isotope	$\delta^{13}C$	Micromass® Isoprime Isotope ratio mass spectrometer	The feeding material of the earthworms
Chemical composition	Mid-infrared signature	FTIR-ATR	The quality of Cast OC

3.1 Earthworm-induced OC enrichment (*C quantity*)

- Casts C: >90% of MAOM C (*vs.* 60% for temperate ECs)
- A significant MAOM C enrichment in their casts (1.4~1.8 fold)
- MAOM-C: meadow> in woodland
- Trends with time: decreased in woodland but increased in meadow



3.2 Difference in sources and dynamics of cast POM and MAOM-----C Isotope composition



C isotopic composition is **depending on land uses**

$\delta^{13}C$:

- woodland < meadow
- cast < soil

- MAOM: more positive $\delta^{13}C$ & lower C/N than POM, indicating **both cast fractions have their different sources**

POM--primarily from plant materials (including undigested plant debris and fresh roots)

MAOM---predominately microbial-derived origin

3.3 The OC functional groups of POM and MAOM determined with FTIR-ATR *(C quality)*

- Significant differences between fractions
- Similar between cast and soil, between T_{9d} and T_{400d}, and between land uses

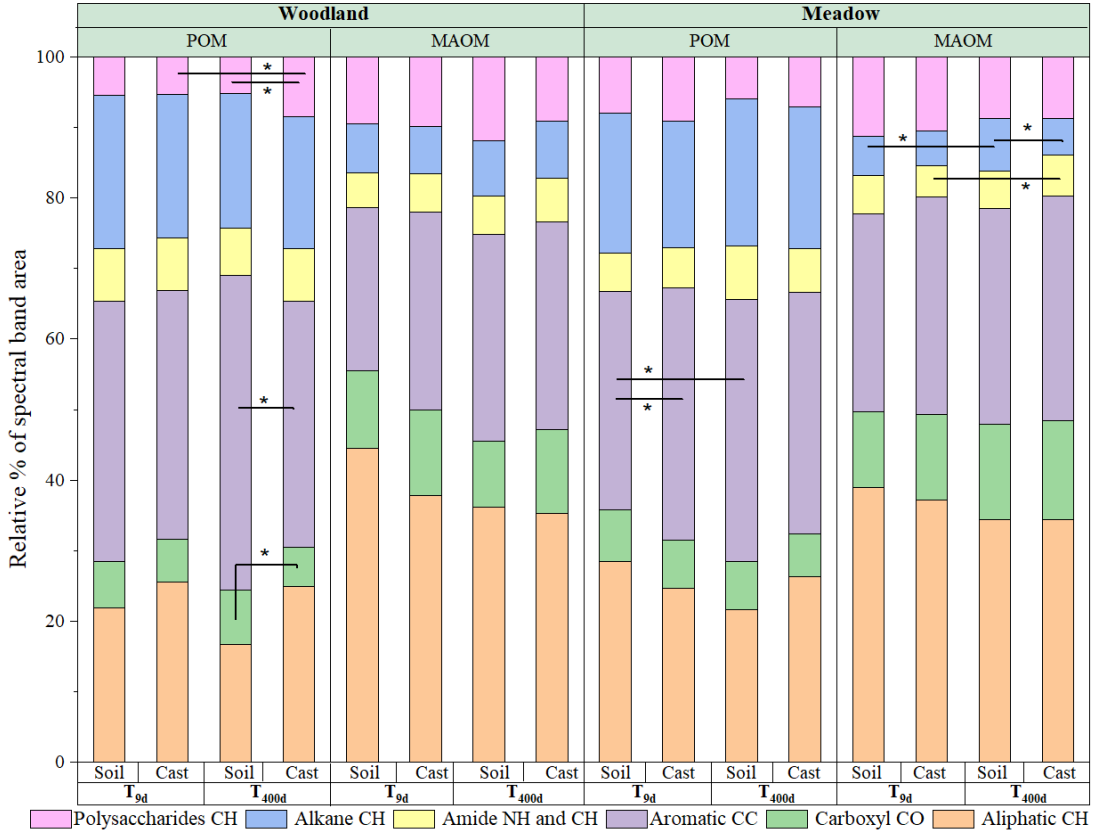
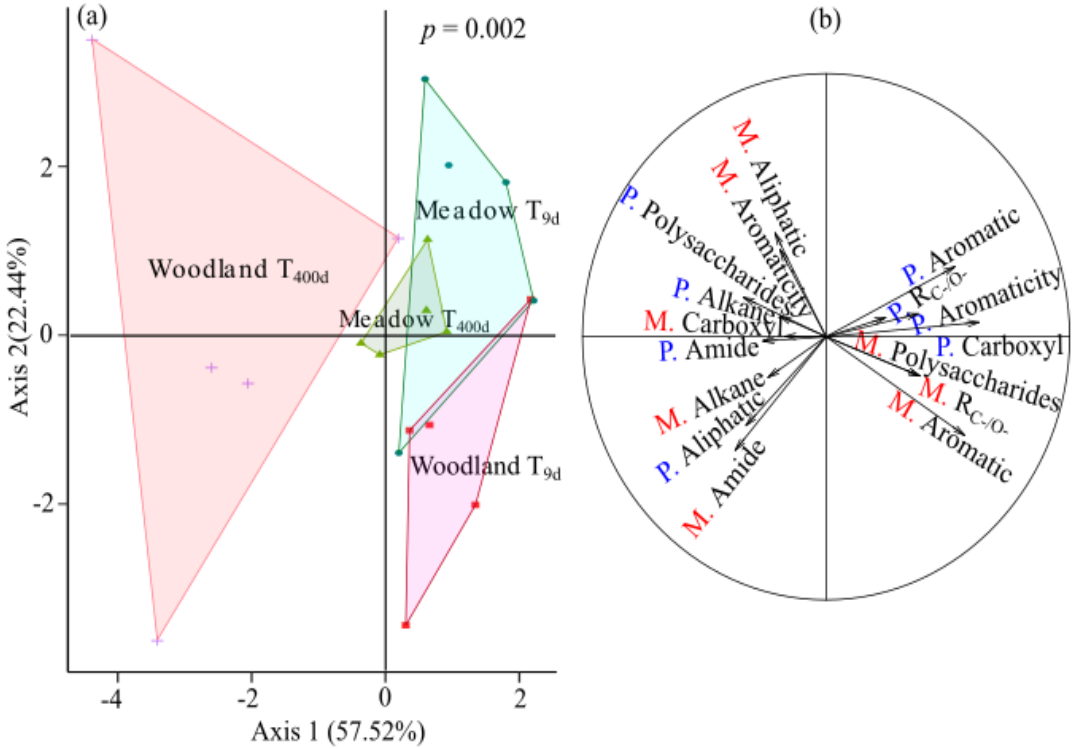


Fig.: Relative proportions (%) of spectral band areas refer to their contribution to the total spectra.

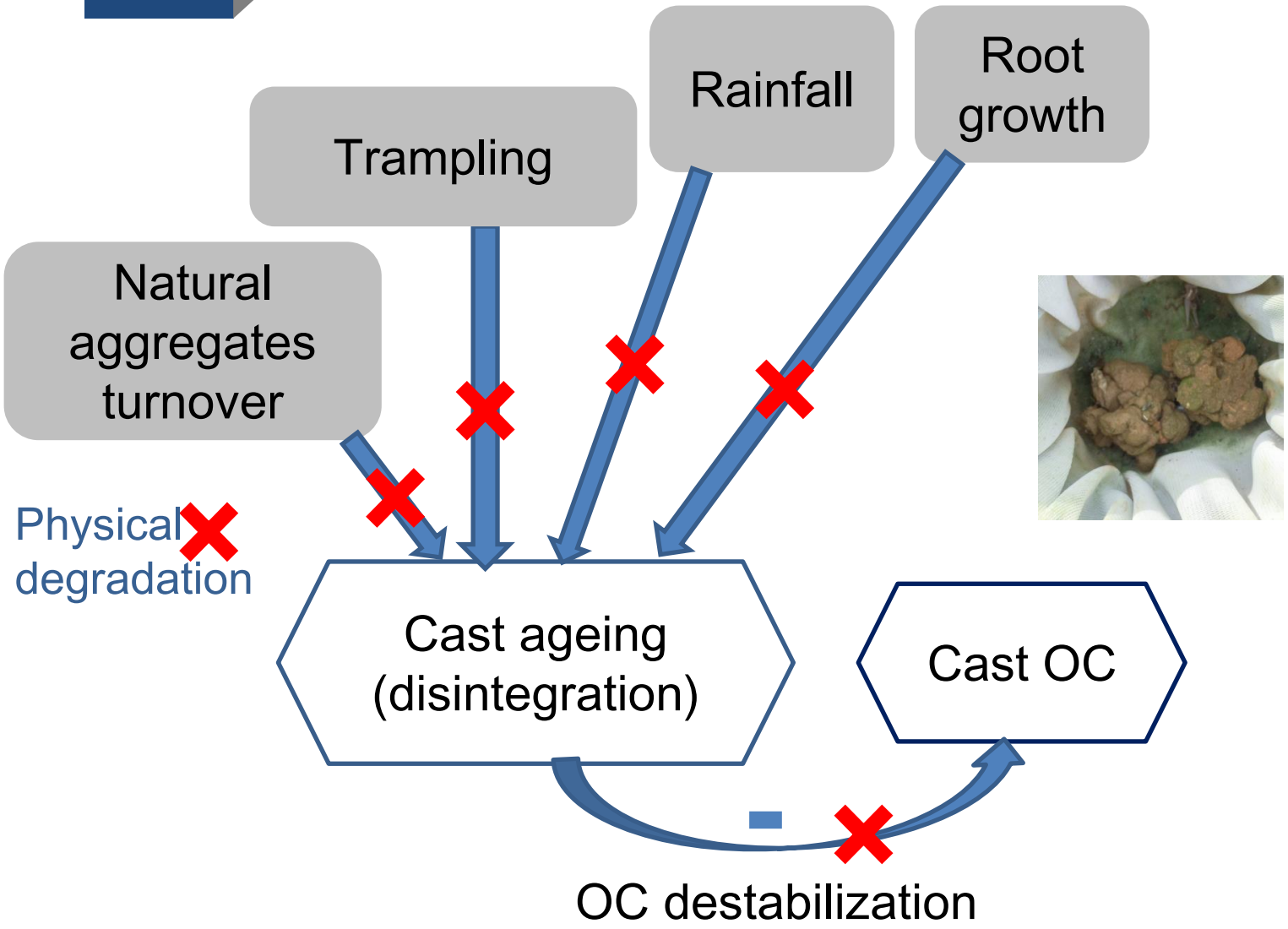
3.3 The OC functional groups of POM and MAOM determined with FTIR-ATR *(C quality)*

- Significant differences between land uses
- temporal changes for the woodland system, but no significant changes for the meadow system

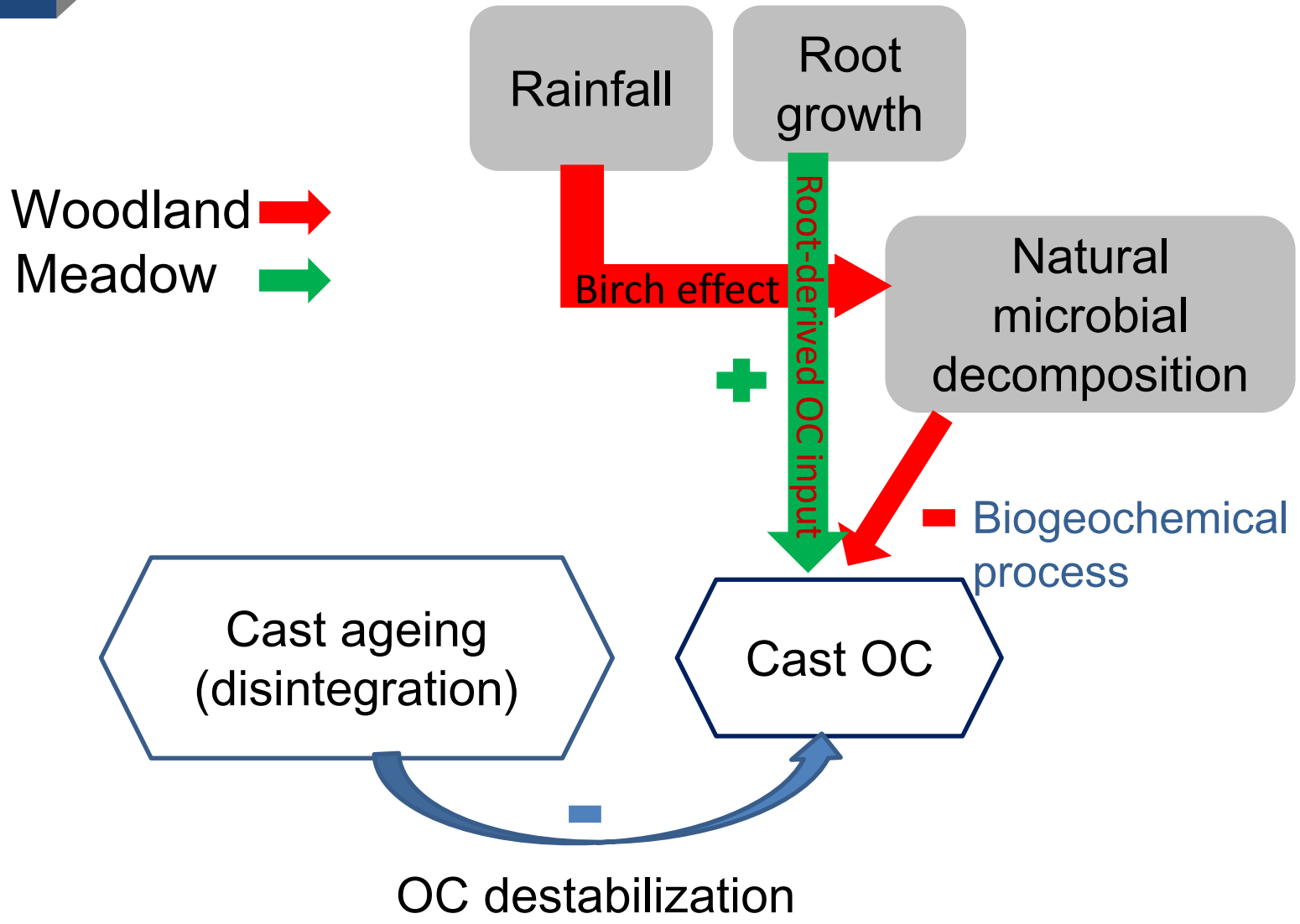


BCA plot for observing specific earthworm-induced variations in functional group content (subtraction)

3.4 Land use dependency of the turnover and fate of cast OC during ageing: Controlling factors



3.4 Land use dependency of the turnover and fate of cast OC during ageing: Controlling factors



3.4 Land use dependency of the turnover and fate of cast OC during ageing: Controlling factors

- POM under Meadow at T_{9d}

POM under Meadow at T_{400d}

- New roots originate from ingested seeds and/or weed plants searching for nutrients (Clause et al., 2015; Decaëns et al., 2003; Forey et al., 2011).

4 Conclusions and future work

Conclusions

- Earthworms induce SOC storage as MAOM rather than occluded POM
- Land use influences composition of earthworm induced SOC in fractions
- Occluded POM in earthworm casts is susceptible to loss on an annual timescale
- Land use influences persistence of earthworm induced SOC in MAOM fractions

Future work

- Fe, Al-associated OM in cast

5 Acknowledgement----Funding

This project was financially supported by CNRS/INSU (VINAWORM) research program under the framework of the EC2CO program. The results contribute to the ANR project U2 Worm (ANR-20-CE01-0015- 01). C. S. was supported by China Scholarship Council (CSC) Grant #202004180033 and Natural Science Foundation of China (NSFC) grant #41877398. We also thank IRD, SFI and M-TROPICS observatory for access to the experimental site.

Any questions?

Thank you for your attention

More details:
Song, C., et al., Soil Biology and Biochemistry, 2024

Email: Cornelia Rumpel (cornelia.rumpel@inrae.fr)
Nicolas Bottinelli (nicolas.bottinelli@ird.fr)
Chao Song (songchao@mail.cgs.gov.cn)