Greenhouse gas (CO_2, CH_4, N_2O) emissions from soil fauna – what have we learned over the past decade?

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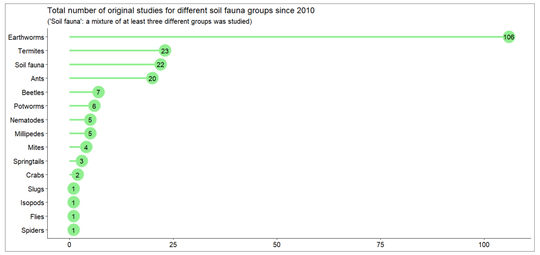
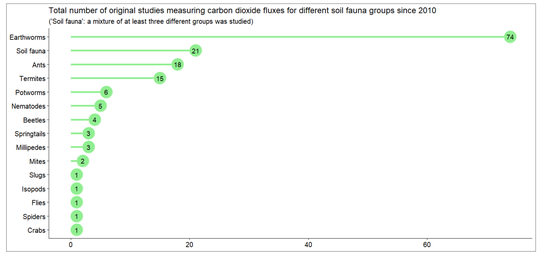
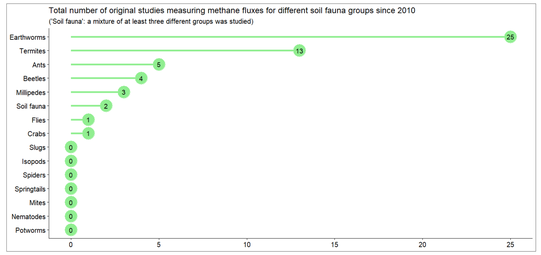
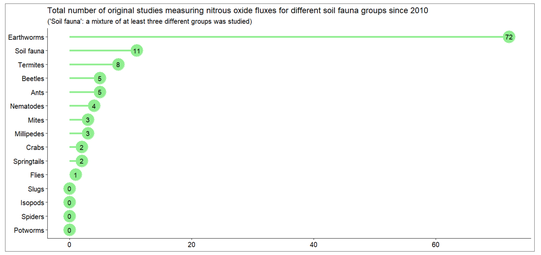








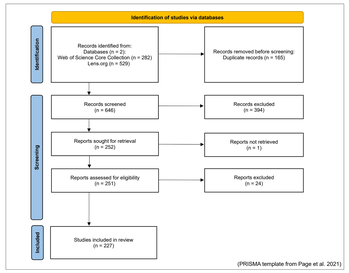
Background & Method

"Changes in species composition and the reorganization of local and regional biological communities have consequences for biophysical and biochemical processes, with implications for climate and regional energy, nutrient and water cycles (Arneth et al., 2020)." (Pörtner et al. 2021)

- In 2014, Schmitz et al. published the paper „Animating the carbon cycle", stating that to improve our quantitative understanding of the carbon cycle, we have to include all organisms, not only focus on plants and microorganisms. However, in the same paper they also stated:

"One group of animals that are potentially important to consider but are not discussed at length here are soil fauna. This is because more science is required [...]."

- How far have we come in acquiring new knowledge on direct GHG emissions from soil fauna and their mediating effects on soil GHG fluxes since then? On 09.01.2024, I conducted a literature search focusing on original studies and review papers published since 2010. Only original studies were included which conducted direct measurements of greenhouse gases. Here, I present preliminary results of this literature search.



Review papers on soil faunal GHGs

- In addition to the original research studies, 20 reviews were identified that addressed direct and indirect effects of soil fauna on GHG fluxes.
- Nine of these reviews looked at soil GHG fluxes from a system perspective and included information on soil fauna, but did not place a sole focus on this group.
- Eleven studies reviewed the available data for specific groups: earthworms (5 studies), pseudoscorpions (1), ants (1), ant nests (1), isopods (1), soil invertebrates (1), and termites (1).
- A first screening identified the following phrases to characterize our current knowledge base.:

...after many years of neglect...

...the net effect remains unknown...

...harness knowledge from trait-based ecology...

...few existing data...

...more detailed studies imperative...

...more data needed on different species and habitats...

...lack of data...

...more field-scale studies needed...

...food webs rarely considered in C flux modelling...

...new quantitative research needed...

...understanding of responses to climate change rudimentary...

...understudied...

...lack of integrative models...

...lack of studies > 1 year...

Examples of unusual GHG flux studies

Conclusions & Outlook

"Climate change and biodiversity loss are two of the most pressing issues of the Anthropocene. While there is recognition in both scientific and policy-making circles that the two are interconnected, in practice they are largely addressed in their own domains. The research community dedicated to investigating the climate system is somewhat, but not completely, distinct from that which studies biodiversity." (Pörtner et al. 2021)

This quote is from the report of the IPBES-IPCC workshop on biodiversity and climate change, the first ever joint collaboration between these two intergovernmental bodies. Although referring to climate change and biodiversity loss in general, it highlights in my opinion the main reason why soil is still in large parts a black box. To illuminate this box with respect to GHG fluxes:

1) Soil flux researchers and soil ecologists should join their knowledge in interdisciplinary research projects.

2) Established methods need to be modified (where possible) and new methods need to be developed to allow non-invasive field monitoring of soil biodiversity (e.g. Görres & Chesmore 2019, Maeder et al. 2022).

3) New soil health indices are needed focusing on soil faunal groups and soil food webs for inclusion in GHG flux models.

Biodiversity loss also affects belowground communities. We might already be losing soil fauna before we are able to understand their role in soil GHG flux dynamics!

References:

Görres & Chesmore (2019): Active sound production of scarab beetle larvae opens up new possibilities for species-specific pest monitoring in soils. Scientific reports 9, 10115, DOI: 10.1038/s41598-019-46121-y ◆ Maeder et al. (2022): Temporal and spatial dynamics in soil acoustics and their relation to soil animal diversity. Plos One 17: e0263618, DOI: 10.1371/journal.pone.0263618

Page et al. (2021): The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372: n71, DOI: 10.1136/bmj.n71 ◆ Pörtner et al. (2021): Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change. IPBES secretariat, Bonn, Germany, DOI: 10.5281/zenodo.4659158

Schmitz et al. (2014): Animating the carbon cycle. Ecosystems 17: 344-359, DOI: 10.1007/s10021-013-9715-7.