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Editorial: The role of soil mesofauna as indicators of sustainable ecosystem management plans

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Editorial on the Research Topic
The role of soil mesofauna as indicators of sustainable ecosystem management plans

Soil is comprised of a diversity of organisms, from plants to microorganisms (e.g. bacteria and fungi) and soil fauna (micro-, meso- and, macrofauna), which collectively are the basis of many ecosystem services that deliver benefits, directly and indirectly, to human well-being. The biodiversity of soil biota supports ecosystem services that are essential for sustainable agricultural production by participating in organic matter decomposition, nutrient and water cycling, global carbon dynamics, and suppression of soil-borne diseases and pests.

In this context, soil fauna plays an important role in maintaining soil quality and health and in providing the above-mentioned ecosystem services. They also contribute to soil structure and consequently to the alteration of hydrology, resource availability, regulation, and pest suppression. Understanding the intricate relationships between soil fauna and carbon sequestration, in addition to their direct and indirect impacts on greenhouse gas emissions, is critical for elucidating soil organic matter dynamics within the framework of global carbon cycle models. Some authors have observed that higher soil fauna abundance and diversity facilitate litter carbon release, leading to more complete denitrification and reduced N_2O emissions (Lubbers et al., 2020). However, carbon dynamics in terrestrial ecosystems are often affected by plant resource allocation strategies (Liu and Li, 2020; Elbasiouny et al., 2022; Jevon and Lang, 2022), which in turn can change depending on the belowground properties of terrestrial ecosystems (e.g. nutrients, mycorrhizal symbiosis, and soil herbivores). In some cases soil fauna can act as a stressor, and even if plants can theoretically alter biomass allocation in response to stressors like herbivore foraging, in terrestrial ecosystems they are often subject to multiple stressors acting in tandem. Wang et al. observed that some plants, like cherry tomato, possess the ability to adjust biomass allocation and nutrient distribution among various organs in response to alterations in soil composition, symbiotic associations with mycorrhizal fungi, and root foraging. Thus, soil fauna can establish complex ecological relationships in the soil that, by affecting plants, indirectly impact carbon fixation and elemental cycling in terrestrial ecosystems.

However, soil fauna does not only influence soil properties, but is also affected by them. Indeed, trees could play the role of keystone species, influencing microclimate and soil biogeochemistry, and thus modulating soil fauna community structure and impacting directly and indirectly the related ecosystem functions. Many factors can contribute to threatening keystone-species tree survival, for example soil disturbance and climate change, which can contribute to tree susceptibility to forest pathogens (Jung et al., 2000). Through changes in soil properties and food availability, tree pathogens could induce changes in the soil community, affecting foundation tree species and leading to cascading effects on ecosystems (Strujik et al.).

Today, soil fauna, especially arthropod biodiversity, is increasingly threatened by a number of natural and anthropogenic factors, such as climate and land-use change, and agricultural intensification. In particular, some arthropod groups have been shown to be highly sensitive to changes in soil quality, so they are particularly affected by changes in soil microhabitat, often related to management practices that lead to alterations in soil physical and chemical properties. An example is land-use change for large-scale agricultural expansion, which can result in agricultural management that can have detrimental effects on soil health and ecosystem functioning by negatively impacting the mesofauna community. In addition, when assessing the impact of intensive soil management on soil health it is even more important to consider various factors, including climate, soil composition, and land-use practices (Cherubin et al., 2021). Vanolli et al. observed that, even though land-use change can lead to a decline in the richness and abundance of soil mesofaunal communities, soil texture emerges as a critical factor influencing the restructuring of these communities in response to land-use changes; in addition, conservation practices and proper management are essential to mitigate the negative effects of land-use change. The authors emphasized that the specific functional traits of mesofaunal organisms, along with their habitat preferences and food sources, influence their response to land-use alterations, and thus not only land management but also local soil conditions and mesofaunal habits should be considered to safeguard soil health and ecosystem functioning in agricultural landscapes.

Urbanization, unsustainable agricultural practices, and inappropriate forest planting and management are emerging as important drivers of species decline. In addition, it has been observed that taken together, both climate change and land use intensification can reduce the biomass of soil arthropods.

Since the activities and interactions involving soil organisms are intimately tied to multiple ecosystem processes critical to both ecological integrity and societal welfare, arthropods should be considered in land management assessments to improve sustainable land management practices and restoration projects. Soil fauna could be used as a valid indicator of soil quality and health, not only through the study of its community structure and the habits of its components, but also through the application of arthropod-based indices (e.g. QBS-ar; Parisi, 2001). Indeed, Fusco et al. observed how the QBS-ar index could be a good method to evaluate alterations in soil quality following significant events such as wildfires, and could be useful over time to assess whether beneficial events such as reforestation efforts have succeeded in restoring the soil to good health. In essence, the QBS-ar index is proving to be a valuable tool for measuring the dynamics of soil quality and assessing the efficacy of management interventions in promoting the recovery and restoration of soil microarthropod communities following perturbations. Its application facilitates informed decision-making processes aimed at enhancing ecosystem resilience and fostering sustainable land management practices. In conclusion, soil arthropods can play the dual role of supporters and indicators of soil quality conditions. Investigating the drivers that affect the dynamics of soil communities and establishing well-informed site management plans will be essential to maintaining soil arthropod biodiversity (and the ecosystem services they provide) and therefore contributing to alleviating the effects of climate change. Monitoring changes in soil arthropod populations can provide valuable information on the health of the soil ecosystem.

Author contributions

SR: Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization. HG: Writing – review & editing. LOF: Writing – review & editing, Supervision, Conceptualization.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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