Received: 10 June 2022 | Accepted: 14 June 2022
DOI: 10.1111/1365-2656.13765

Journal of Animal Ecology BRITISH ECOLOGICAL SOCIETY

RESEARCH HIGHLIGHT

The global impact of management on soil nematode abundances

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Handling Editor: Jennifer Gill

Abstract

Research Highlight: Li, X., Liu, T., Li, H., Geisen, S., Hu, F., & Liu, M. (2022). Management effects on soil nematode abundance differ among functional groups and land-use types at a global scale. *Journal of Animal Ecology*, https://doi.org/10.1111/1365-2656.13744. Despite the well-documented decline of aboveground species abundances as a result of land-use intensification, there has been little attention on the effects of human activities on belowground species abundances. Li et al. analyse nematode data, the most abundant animal on the planet, from across the globe to determine whether their abundances vary between managed and unmanaged habitats. The authors show that, unlike aboveground biodiversity, nematode abundance is higher in managed than unmanaged primary and secondary habitats. Furthermore, responses to land management vary between trophic groups and they do not appear to follow the general hypothesis that higher trophic levels are more vulnerable to human activity than those further down the food chain, except in urban habitats. Finally, Li et al. show that the relationships between environmental predictors and species abundance were weakened (and sometimes reversed) in managed habitats. Together, their results reveal how land-use management is impacting the trophic composition of soil nematode communities and their relationships with the environment, which has implications for ecosystem functioning.

KEYWORDS
human activity, land use, land-use intensity, management, nematodes, species abundance, trophic group

Globally, species across multiple taxonomic groups have suffered local reductions in abundance due to land-use change and intensification (Newbold et al., 2015; Seibold et al., 2019), with large potential impacts on ecosystem functioning (Allan et al., 2015). The majority of these studies have focussed on aboveground biodiversity, whilst the belowground realm has often been ignored. There have been multiple calls, however, to open up the 'black box' of belowground biodiversity patterns and identify the threats these species face (Phillips et al., 2017; White et al., 2020).

Li et al. (2022) delve into this black box by providing insight into the effects of land-use intensity on the most abundant type of animal on Earth; nematodes (Bardgett & van der Putten, 2014; van den Hoogen et al., 2019). Nematode abundances are already known to vary between biomes (van den Hoogen et al., 2019) and vegetation types (Song et al., 2017), and land-use effects on abundance have been studied at a local scale (Li et al., 2020; Pothula et al., 2019). Li et al. (2022), however, advance our knowledge of nematode spatial ecology by unpicking the impacts of human activity on global patterns of nematode abundances. They show that, unlike their aboveground counterparts, nematode abundance is higher in managed primary and secondary habitats than in unmanaged ones, and remains unchanged in pasture, cropland and urban habitats (Table 1; Figure 1a).

Nematode distributions are strongly influenced by soil characteristics (Raymond et al., 2013), which are thought to be the

TABLE 1 Li et al. (2022) investigated the difference in nematode abundance between managed and unmanaged habitats. They show that, in some instances, abundances were higher in managed than unmanaged areas (green arrows), but often there was no difference in abundances between the two land-use intensities (grey boxes), both when all nematodes were considered or when split into trophic groups. Only fungivorous nematodes in pasture and predators in urban areas showed lower abundances in managed compared to unmanaged habitats (red arrows)

Habitat Type	Total	Bacterivores	Fungivores	Herbivores	Omnivores	Predators
Primary	↑			↑		
Secondary	↑	↑		↑		
Pasture			↓			
Cropland						
Urban		↑	↑			↓

most important drivers of nematode abundance globally (Nielsen et al., 2014; van den Hoogen et al., 2019). Given the impact of land use on soil quality and structure (Neal et al., 2020), we might, therefore, expect to observe changes in nematode abundance between land-use types and land-use intensity.

In addition to understanding how total abundances of taxonomic groups vary under different land uses, it is important to determine how abundance changes within different functional or trophic groups are affected. Higher trophic level species are believed to be more vulnerable to anthropogenic pressures than those lower down (Barnes et al., 2014; Purvis et al., 2000). For example, a global analysis of multiple taxonomic groups showed that carnivores are disproportionately negatively affected by human land use compared to the abundances of animals within other trophic groups (Newbold et al., 2020). Furthermore, land-use intensification can cause multitrophic homogenisation of both belowground and aboveground biodiversity (Gossner et al., 2016) and the effect of different soil characteristics on nematode abundance varies between trophic groups (Nielsen et al., 2014). Changes in the trophic structure of communities can have huge impacts on ecosystem functioning and are particularly important to consider for nematodes due to their pivotal roles in the soil food web and carbon and nutrient cycles (Hunt & Wall, 2002; van den Hoogen et al., 2019).

Li et al. (2022) show that abundance differences between managed and unmanaged habitats vary between trophic groups (Table 1), which can impact the functional composition of nematode communities. For example, anthropogenic influences in terms of management and urbanisation appear particularly beneficial to already numerically dominant bacterivores and herbivores, whilst the negative effects of management were observed in omnivores and predators in urban regions. These changes will alter the soil food web and may impact ecosystem functioning (Setälä, 2002), although the degree to which these changes will occur depend on soil community stability mechanisms (Hunt & Wall, 2002). For example, Kostin et al. (2021) showed that soil microbial biomass stability was in fact higher in intensively managed meadows than other less-intensive agricultural land-use types.

Li et al. (2022) suggest that the increase in abundance of bacterivores and herbivores in human modified habitats may be a result of the increased nutrient addition that accompanies human activities, for exampl fertiliser addition or the use of cover crops, which promote plant growth, and in turn benefit microbes and microbivores. This corresponds with previous findings that the proportion of the nematode community consisting of bacterivores increases with agricultural management intensity (Yeates, 1999). They also use this mechanism to explain why the hypothesis that higher trophic levels are more negatively affected by management was only observed in urban areas; the positive impact of an increase in abundance of their prey (bacterivores and fungivores) may outweigh the negative impact of human activities.

Climate can also be an important driver of nematode abundance (Song et al., 2017). Management, however, appears to augment this relationship with the positive effect of precipitation and the negative effect of mean temperature both weakened

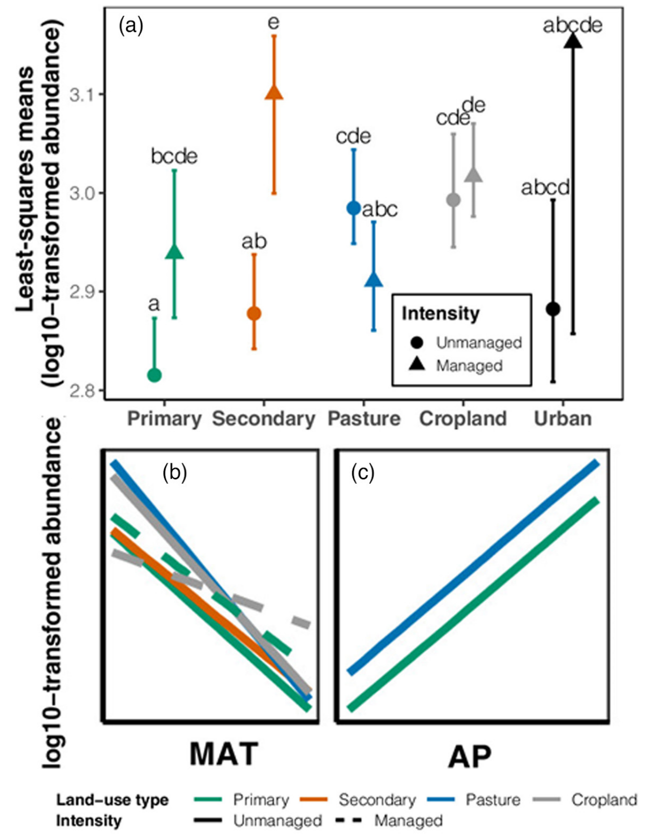

FIGURE 1 Management and land-use impacts on total nematode abundance and the relationship between abundance and climatic factors: (a) The least means from mixed effect models of total nematode abundance from unmanaged (circles) and managed (triangles) habitats. Significant relationships between total nematode abundance and (b) mean annual temperature (MAT) and (c) annual precipitation showing that management (dashed lines) weakened the relationships in managed habitats (Figure adapted from Li et al., 2022).

in managed compared to unmanaged habitats (Li et al., 2022; Figure 1b,c). This matches results previously found at more local scales (Li et al., 2020; Vazquez et al., 2019). This interaction between climate and land-use intensity can make the impact of future climate change difficult to predict. Land use may reduce the resilience of species to climate change and vice versa (Schulte to Bühne et al., 2021).

Given the important role of nematodes, as well as other soil fauna, in ecosystem functioning, understanding how management and anthropogenic activity influence their abundance is a vital knowledge gap that needs addressing. The results of Li et al. (2022) challenge the general consensus that the intensive management of habitats leads to declines in species abundances, particularly of those at higher trophic levels. In fact, human activity can increase nematode abundance for many trophic groups. This is a striking result as not only does it contrast with global scale analyses of aboveground diversity (e.g. Newbold et al., 2015) but also may have serious consequences for soils and their functioning across large spatial scales through trophic restructuring (Setälä, 2002). Combined with a weakened effect of climate and soil organic carbon on abundance under human-modified habitats, this by no means suggests that intensive management is beneficial for belowground biodiversity as species abundances become less regulated by environmental filtering and the natural balance of the soil ecosystem is perturbed.

CONFLICT OF INTEREST

The author has no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

Data have not been archived because this article does not use data.

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How to cite this article: White, H. J. (2022). The global impact of management on soil nematode abundances. *Journal of Animal Ecology*, *91*, 1736–1739. https://doi.org/10.1111/1365-2656.13765