Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2025, 15(5), 19-21, doi: 10.15421/2025_638

Perspective

Sustainable ecosystem services: Interactions among land management, water conservation and soil fungal communities

Emily R. Carvalho*

Department of Ecology and Environmental Management, University of Lisbon, Portugal

**Corresponding author E-mail: ercarvalho@uboa.pt*

Received: *02 September, 2025, Manuscript No: UJE-26-178649,* ***Editor assigned:*** *05 September, 2025, PreQC No: P-178649,* ***Reviewed:*** *16 September, 2025, QC No: Q-178649,* ***Revised:*** *23 September, 2025, Manuscript No: R-178649,* ***Published:*** *30 September, 2025*

Sustainable ecosystem services are increasingly threatened by land-use change, water scarcity and disruptions to soil microbial communities. Soil fungi, as key mediators of nutrient cycling, plant health and soil structure, play a crucial role in maintaining ecosystem function, particularly under water-limited conditions. Integrating land management strategies with water conservation practices can enhance soil fungal diversity and resilience, thereby sustaining ecosystem services such as carbon sequestration, crop productivity and biodiversity support. This article synthesizes current knowledge on the interactions among land management, water conservation and soil fungal communities, highlighting their implications for ecological sustainability. Drawing from case studies in agricultural, dryland and riparian systems, we propose an integrative framework for managing soils and water to optimize ecosystem services in the context of global environmental change.

Keywords: Soil fungi, Ecosystem services, Land management, Water conservation, Carbon cycling, Dryland productivity, Biodiversity, Sustainable agriculture, Soil health, Ecosystem resilience.

Introduction

Ecosystem services—the benefits humans derive from nature—depend on the health and functionality of soil, water and biodiversity. Land-use change, intensive agriculture and climate-driven water scarcity threaten these services by disrupting soil structure, microbial diversity and hydrological cycles. Soil fungal communities, including mycorrhizal fungi and decomposers, serve as critical regulators of nutrient availability, carbon storage and plant productivity. These fungi enhance plant resilience to drought and other stressors, underpinning the delivery of ecosystem services in both natural and managed landscapes. Sustainable land management and water conservation strategies can strengthen soil fungal networks, maintaining ecosystem productivity and stability. By understanding the interactions between land management practices, water availability and soil fungal diversity, we can design strategies that safeguard ecosystem services under increasing environmental pressures (Rust NA, et al. 2022). This article explores these interactions across scales, emphasizing the integration of ecological knowledge into land and water management for sustainability. Soil fungi contribute to ecosystem function through nutrient cycling, organic matter decomposition and symbiotic associations with plants. Ectomycorrhizal and arbuscular mycorrhizal fungi facilitate nutrient uptake, enhance soil structure and improve plant drought tolerance. Saprotrophic fungi decompose organic matter, releasing nutrients that sustain plant growth. The diversity and functional redundancy within fungal communities buffer ecosystems against disturbances, ensuring the continuity of key ecosystem services.

Description

Fungal communities are highly responsive to land management and water availability. Drought can reduce fungal biomass and activity, but pre-exposure to moderate stress can enhance resistance, creating an ecological “memory” that supports ecosystem resilience. Land-use intensification, including monoculture cropping, tillage and chemical inputs, often diminishes fungal diversity and disrupts these functional roles. Maintaining heterogeneous habitats and organic inputs can preserve fungal networks critical for ecosystem stability. Integrating organic amendments, crop rotations and reduced tillage can enhance soil fungal diversity, structure and nutrient availability. Mycorrhizal fungi in agroecosystems improve crop nutrient acquisition, drought tolerance and carbon allocation to soils (Mommaerts V, et al. 2010). By fostering microbial diversity, these practices maintain productivity while reducing dependency on chemical fertilizers, aligning agricultural outputs with ecosystem sustainability. Ecological restoration of degraded landscapes and reforestation initiatives increase fungal richness and functionality. Restored soils often exhibit enhanced organic matter content and microbial connectivity, supporting plant establishment and carbon sequestration. Landscape-level restoration also benefits pollination networks and hydrological regulation, demonstrating the multi-service benefits of integrated land management.

Urban expansion fragments habitats and alters soil properties, threatening microbial diversity. Green infrastructure, urban wetlands and permeable landscapes can mitigate these effects by preserving soil fungal networks, enhancing water infiltration and supporting biodiversity (Walpole M, et al. 2009). Integrating fungal ecology into urban planning can improve soil fertility, stormwater regulation and ecosystem service delivery in human-dominated landscapes. Water availability is a key determinant of soil fungal community structure and function. Efficient water management—including rainwater harvesting, mulching and controlled irrigation—maintains soil moisture, enhancing fungal activity and diversity. Healthy fungal communities improve soil aggregation, water retention and nutrient cycling, creating feedback loops that stabilize ecosystem services under drought conditions. Mycorrhizal fungi enhance plant access to water and nutrients during dry periods, while saprotrophic fungi decompose organic matter, releasing bound water and nutrients. These microbial interactions mitigate the impacts of water scarcity on plant growth and productivity (Li M, et al. 2021). In dryland ecosystems, fungal-mediated water conservation supports primary production, carbon sequestration and habitat stability.

Combining water conservation strategies with sustainable land management enhances fungal-mediated ecosystem services. Practices such as cover cropping, reduced tillage and wetland restoration optimize soil moisture and microbial activity, supporting carbon cycling, plant productivity and biodiversity. Integrative approaches strengthen ecosystem resilience to climatic variability and anthropogenic pressures. Soil fungi influence carbon fluxes by decomposing organic matter and stabilizing carbon in soil aggregates. Mycorrhizal fungi transfer plant-derived carbon to soil, while saprotrophs regulate decomposition rates. Land-use change and water stress can disrupt these processes, reducing carbon storage (Ihrmark K, et al. 2012). Conserving fungal diversity and maintaining soil organic matter are therefore essential for climate mitigation and ecosystem stability. Soil fungal health indirectly supports pollination by enhancing plant vigor and flower production. Diminished fungal diversity can lead to reduced plant growth, lower flower abundance and decreased pollinator activity. By sustaining microbial networks, integrated land and water management practices promote both productivity and ecosystem services such as pollination and biodiversity maintenance.

Conclusion

Sustainable ecosystem services depend on the intricate interactions among land management, water conservation and soil fungal communities. Soil fungi mediate nutrient cycling, carbon storage and plant productivity, forming a critical link between land-use practices, hydrology and ecosystem resilience. Sustainable agricultural practices, landscape restoration and urban green infrastructure maintain fungal diversity and functionality, while water conservation strategies enhance microbial-mediated services under drought conditions. Integrating microbial ecology with land and water management provides a multiscale approach to sustaining ecosystem services, supporting biodiversity, climate adaptation and human well-being in a changing environment.

Acknowledgement

None.

Conflict of Interest

The authors declare no conflict of interest.

References

Rust, N. A., Stankovics, P., Jarvis, R. M., Morris-Trainor, Z., de Vries, J. R., Ingram, J., Reed, M. S. (2022). Have farmers had enough of experts?. Environmental Management 69 : 31-44.

Mommaerts, V., Jans, K., Smagghe, G. (2010). Impact of *Bacillus thuringiensis* strains on survival, reproduction and foraging behaviour in bumblebees (*Bombus terrestris*). Pest Management Science 66: 520-525.

Walpole, M., Almond, R. E., Besançon, C., Butchart, S. H., Campbell-Lendrum, D., Carr, G. M., Zimsky, M. (2009). Tracking progress toward the 2010 biodiversity target and beyond. Science 325: 1503-1504.

Li, M., Liang, D., Xia, J., Song, J., Cheng, D., Wu, J., Li, Q. (2021). Evaluation of water conservation function of Danjiang River Basin in Qinling Mountains, China based on InVEST model. Journal of Environmental Management 286:112212.

Ihrmark, K., Bödeker, I. T., Cruz-Martinez, K., Friberg, H., Kubartova, A., Schenck, J., Lindahl, B. D. (2012). New primers to amplify the fungal ITS2 region–evaluation by 454-sequencing of artificial and natural communities. FEMS Microbiology Ecology, 82:666-677.

Citation:

Carvalho, ER., (2025). Sustainable ecosystem services: Interactions among land management, water conservation and soil fungal communities. *Ukrainian Journal of Ecology.* 15:19-21.