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Editorial: Regeneration mechanisms and tradeoffs of ecosystem function after drastic environmental changes

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Editorial on the Research Topic
Regeneration mechanisms and tradeoffs of ecosystem function after drastic environmental changes

Introduction

Numerous factors, including large-scale natural disasters, extreme climate events, and human disturbances, can cause abrupt environmental changes over a short term. These changes can result in the deterioration or even loss of ecosystem functions, which are characterized by a large scale, wide distribution, and difficult recovery (Heinze et al., 2024; Shuai et al., 2024; Wu et al., 2024). After drastic environmental changes, the original ecosystem structure may even collapse leading to systemic decays. Ecosystems may be restored through (re-)colonization of species with the now lost function, or through functional trade-offs and reorganizations in the current species pool to adapt to the new environment and establish a new equilibrium state between organisms and the environment, which may include human-induced regenerative efforts. Along this process, the regeneration and adaptation mechanisms used may be functionally diverse and may differ from those in a gradually changing environment (Di et al., 2023). In an ecosystem with a limited number of available niches, species can either migrate, perish or compete for available the available niches. In the competitive process, trade-off mechanisms will regulate the species composition, species quantity, morphological characteristics, and physiological processes of plants, animals, and microorganisms. Ecosystems, which have a limited amount of resources, contain a number of functionalities, and there is a demonstrated link between the community assemblage of species and the functional trade-offs in any ecosystem (Prabhakara and Kuehn, 2023; William et al., 2024). Therefore, studying the mechanisms and ecological strategies of the recovery in ecosystem functions and the underlaying trade-offs can help in predicting the co-succession of organisms and under significant stochastic disturbances, but also their ecological risk responses.

Restoration and trade-offs of bioecological functions under the environmental change

Plants are primary producers and provide some basic functions of all ecosystems (Isbell et al., 2011). They are suggested as primary models as indicators of ecosystem function-restoration after drastic environmental changes (Feng et al., 2023; Fontaine et al., 2023). In restoration projects, the plant community is vital in overcoming abiotic and biotic barriers that can exist in a degraded habitat (Gomez-Aparicio, 2010; Kiehl et al., 2010) and might enhance ecosystem function. For example, Tang et al. emphasized the important roles a native plant (*Coriaria nepalensis*) plays in the natural restoration of abandoned lead-zinc (Pb–Zn) mines, underlying the "care effect" function it had in helping other understory plant species to re-settle. They also contributed to soil stabilization, i.e., soil fertility, and functions by regulating the structure of soil microbial communities. Similarly, Yang et al. provided an example for the important role of plant inter-root microbial communities had in promoting plant growth and heavy metal uptake. They reported that the native *Oxyria sinensis* was able to tolerate the environmental alterations following heavy metal contamination and helped increase the amount of soil carbon sequestration, but also enhancing nutrient accumulation. These studies emphasized the critical role of adaptations selected plant species rely on in the restoration of ecosystem functions after major disturbances.

In addition to plants, animals and microorganisms also play important roles in changing ecosystem functions. Andersen et al. emphasized the impact of a keystone species on the invertebrate community of an ecosystem. They emphasized that beavers *Castor* spp. enhance invertebrate biodiversity and change the community composition by modifying the environment and creating environmental heterogeneity. These findings exemplifies that keystone species can cause environmental change and form new patterns of ecosystem function through active behavior. Zou et al. reported that grazing disturbance by livestock led to significant changes in microbial antibiotic resistance genes (ARGs) present in bacteria, a presence which might negatively affect their health-associated functions. For example, grazing disturbance increases the diversity, mobility, and pathogenicity of ARGs in the environment, resulting in an increase in antibiotic-resistant microbes in environment, thus posing a potential threat to wildlife health and survival.

In summary, dramatic environmental events alter the abiotic conditions which have a large effect of the biotic system and the system functionality. The novel conditions following the change will give some species a competitive advantage while others will struggle. Some organisms can adapt to environmental changes following a major, acute disturbance, which in turn facilitate other species, thereby driving ecosystem-function recovery. More research on this topic will definitely enhance our understanding of this dynamic, albeit very important field.

Evolution of ecosystem-functions in the context of dramatic environmental changes

In addition to broadcasting how disturbance result in changed species communities and functionalities, as well as how some species facilitate others following disturbance, this Research Topic also reported on changes in ecosystem functions after drastic environmental changes. Yuan et al. reported on desertification and soil erosion following a combination of climate change and human induced change and found that ecological engineering through vegetation restoration may increase the water-holding, wind-sand-fixing capacity of the ecosystem. Further, they found that increased ecological engineering constructions enhanced the capacity for biodiversity. They reported that large-scale ecological reconstruction projects in the Loess Plateau-area have achieved remarkable results and contributed towards the restoration of local ecosystem-functions. Ji et al. investigated the severe impacts of hypoxia on aquatic ecosystems. They reported high grade of organismal decay in in water bodies in hypoxia state. Although these incidents caused reduced pollutant-release, it further deteriorated general water quality. In general, hypoxia in water bodies is closely related to important ecological functions, such as water temperature hierarchy patterns, nutrient status, sediment contamination, algal blooms and reservoir morphology, thus being at the forefront local effects induced by major disturbances in aquatic ecosystems.

Opinion

This anthology describes the changes in ecosystem components and functions after drastic environmental changes from the perspectives of plants, animals, microorganisms and ecosystem-function management. It also provides management recommendations for enhancing ecosystem-function restoration trials on the basis of these changes. These studies improve our knowledge on the evolution of ecosystem functions following stochastic changes in environmental conditions through observations, experiments and reviews. In addition, two studies discussed the important role played by of animal–microorganisms and plant–microorganisms interactions in the dynamics of ecosystem-functions. Conclusions drawn suggests that some ecological functions are realized through interactions across taxa, and highlight the importance keystone species or species groups may play in catalyzing such processes.

Author contributions

DK: Data curation, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. LD: Methodology, Writing – original draft, Writing – review & editing. LA: Writing – original draft, Writing – review & editing. AS: Writing – original draft, Writing – review & editing.

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