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EDITORIAL

Plant Communities in Changing Environment

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Abstract
Changing environment markedly shapes plant diversity and vegetation across all spatial scales. It leads to innumerable local, regional and sometimes global changes in plant communities. Here, we present eleven full-text research articles of the Special Issue "Plant communities in changing environment", which focuses on the evaluation of plant diversity and vegetation changes in different plant communities. We conclude that the results of all research studies show that plants, habitat and functional diversity are strongly conditioned in space and time by various factors, including climate, water regime, snow conditions, and human activities. These changes are also among most significant potential threats for plant diversity.

Keywords Changing environment · Classification · Conservation · Diversity · Ecology · Management · Plant communities

Introduction

The Earth's climate is rapidly changing, due to human activities and this has profound implications for the plant communities. As temperatures rise, ecosystems are experiencing shifts in precipitation patterns, altered nutrient availability, and increased frequency of extreme weather events. These changes pose significant challenges to the survival and functioning of plant communities, which are the foundation of terrestrial ecosystems. Human activities have mainly caused rapid and large-scale environmental changes in recent years (Speißer et al. 2022; Zhang et al. 2023). In fact, plant communities are not immune to ecological shifts and global change factors, e.g. abandonment of traditional management, eutrophication, warming, nitrification, pollution, etc. (Halada et al. 2009; Polst et al. 2022). One of the results of environmental changes is the loss of biodiversity, which is very important for maintaining the structure and function of ecosystems (Zhang et al. 2023). Consequently, plant diversity remains one of the central topics in many studies (Bobbink et al. 1998; Biurrun et al. 2021; Hrivnák et al. 2022; Speißer et al. 2022). Also, the diversity and distribution of plant functional traits (Díaz et al. 2009; Bruelheide et al. 2018) and life forms (Midolo et al. 2024) has a broad appeal in the research of plant communities.

Climatic factors (including extreme events and seasonality), disturbance frequency and intensity, and disturbance history are suggested as key factors to be considered in global comparisons of vegetation responses to land use and in predictive models of ecosystem dynamics. Rural landscapes, especially in Central Europe, have undergone significant land-use changes since the 1950′s, including a prolonged period of abandonment (Hegedüšová and Senko 2011; Harásek et al. 2023; Janišová et al. 2023) and the

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habitat fragmentation (Klinkovská et al. 2023). Moreover, the abandonment of traditional management also leads to grassland encroachment by trees and shrubs (Palaj and Kollár 2021; Sanjuán et al. 2018; Valkó et al. 2018) as well as the spread of non-native and invasive species (Hejda et al. 2009; Crawford and Rudgers 2012; Delimat and Kiełtyk 2019; Axmanová et al. 2021; Hejda et al. 2021; Hegedüšová Vantarová et al. 2023; Májeková et al. 2023). Invasive species constitute one of the most significant threats to biodiversity and have an impact on many ecosystems worldwide (Keller et al. 2011; Dawson and Schrama 2016; Pyšek et al. 2020; Ikinci 2022; Kochjarová et al. 2023; Shevera 2024).

As we strive to mitigate and adapt to climate change, it is crucial to consider the resilience and adaptive capacity of plant communities. Understanding how different species respond to changing conditions and identifying key functional traits can inform conservation and restoration efforts.

In this special issue, we aim to explore the latest advancements in our understanding of plant communities in a changing environment. We will examine and present the key findings and challenges in this field. By synthesizing this knowledge, we hope to contribute to developing effective strategies for conserving and managing plant communities in the face of ongoing environmental crisis.

Contributions of the Special Issue

Landscape management has undergone significant changes, including grazing cessation, which led to considerable changes in floristic composition (Gavrichkova et al. 2022). Palaj et al. (2023) pointed out that in the Western Carpathian high mountains, there is a decrease in cover of some diagnostic species of *Nardetea strictae* class, especially *Nardus stricta*, and at the same time, an increase in competitively strong species with their high biomass productivity. Evident is a shift in floristic composition indicating a transformation of the vegetation of *Nardion strictae* to other communities, mainly from the *Loiseleurio-Vaccinietea* class. Moreover, climate change has a similar effect on the spread of dwarf shrubs as the cessation of grazing (Pauli et al. 2012). Janišová et al. (2023) pointed out that grazing intensity significantly affects species richness of xeric and mesic grasslands on calcareous bedrock at small spatial scales. In contrast, habitat conditions play a more crucial role at larger scales. Grazing is considered to be the optimal and crucial management to prevent the dominance of competing species (Kiehl 2008; Janišová et al. 2023). However, controlling grazing intensity, flexible rules for grazing, mowing and subsidy eligibility are important for the preservation and protection of semi-natural grasslands. Janišová et al. (2023) confirmed that the grassland vegetation in the Hainburger Berge Mts has a high conservation status, relating to both species diversity and the presence of endangered species.

Classification of vegetation is an essential tool to describe, understand, predict and manage biodiversity (De Cáceres et al. 2015). It summarizes the spatial and temporal variation of vegetation with respect to multiple purposes, e.g. to define units for ecological research or management and conservation strategies (Dengler et al. 2013). Klinovská and Roleček (2023) provided new vegetation-plot data from South Moravia (Czech Republic) and developed a new classification of thermophilous fringe vegetation based on differences in overall species composition. Thermophilous fringe and tall herb vegetation reflects the ecological and geographical features, e.g. edaphic factors, diversity of main vegetation, peculiarities of community dynamics, regional species pool and regional climatic influence (Tzonev et al. 2019). The classification prepared by Klinovská and Roleček (2023) divided studied vegetation of *Geranion sanguinei* to four vegetation types and three subtypes; *Potentilla alba-Laserpitium latifolium*, *Potentilla argentea-Geranium sanguineum*, *Vincetoxicum hirundinaria-Origanum vulgare*, *Geranium sanguineum-Peucedanum cervaria*, variant *Inula insifolia*, *Geranium sanguineum-Peucedanum cervaria*, variant *Cytisus nigricans*, *Geranium sanguineum-Peucedanum cervaria*, variant *Dictamnus albus*. It can serve as a model for future revisions of the national syntaxonomic classification scheme of fringe and tall-herb vegetation in the Czech Republic.

Relict vegetation of water-splashed petrifying rocks with calcareous tufa formation dominated by *Adiantum capillus-veneris* and wetland bryophytes of the class *Adiantetea* was investigated in Georgia, a Caucasus biodiversity hotspot (Novák et al. 2023). The authors used a more comprehensive data set of similar communities reported from Europe and its surroundings to compare newly recorded vegetation types and previously described associations of the *Adiantetea* class. They also designated a new association *Saxifrago cymbalariae-Adiantetum capilli-veneris* defined by the characteristic species of the Colchic-Caucasian territory together with dominant bryophyte *Palustriella commutata*. Due to the occurrence of relict and endemic species and the limited extension of Georgian communities of water-splashed petrifying rocks with *Adiantum capillus-veneris*, these communities deserve conservation attention.

Wetland ecosystems are particularly vulnerable to invasions worldwide (Zedler et al. 2004; Rasran 2021), hence it is crucial to study the occurrence of non-native aquatic macrophytes (Brundu 2014). Shevera et al. (2024) presented the history and current distribution of *Typha laxmannii* in Ukraine. For the first time, *T. laxmannii* was recorded in 1902 in the south of Ukraine. Nowadays, it is distributed

almost throughout Ukraine, and it forms three variants of the association *Typhetum laxmannii* and occurs in other twenty-six associations. However, the syntaxonomic position of the alliance *Typhion laxmannii* is still controversial. On the other hand, the authors confirmed a significant width of its ecological amplitude and confinedness mainly to eutrophic, slightly saline ecotopes. The obtained results point to the role of non-native species in the synanthropization of vegetation and their use in the creation of management plans for water bodies and protected areas with regard to methods of restraining expansion and limiting invasions of alien species.

Vávra et al. (2023) reported seven records in Checkia of the new alien macrophyte *Wolffia globosa* native to Southeast Asia (Landolt 1986). In Czechia, it occurs in the associations of water macrophytes *Potametum denso-nodosi*, *Nymphaeo albae-Nupharetum luteae*, *Lemno-Spirodeletum polyrhizae* and *Hydrocharitetum morsus-ranae*. The authors pointed out that species has a great ability to spread. However, possible pathways for the introduction of *W. globosa* to Czechia are unknown.

In forest ecosystems, the threats caused by invasive non-native species include loss of diversity, species competition, hybridization and transmission of diseases (Langmaier and Lapin 2020). In Europe, *Quercus rubra* has been cultivated since the seventeenth century as an ornamental as well as a useful tree (Nicolescu et al. 2020). Nevertheless, woody plants are not usually regarded as significant invasive alien species (Richardson and Rejmánek 2011; Hegedüšová Vantarová et al. 2023). However, Májeková et al. (2023) confirmed that planted alien *Quercus rubra* forest stands in Central Europe influence the diversity and cover of the herb layer. Moreover, the dense canopy of *Q. rubra* and the large cover of litter consisting mainly of fallen old red oak leaves affected the species richness of the undergrowth.

Mediterranean islands are important biodiversity hotspots with high endemicity. Its plant diversity has been strongly influenced by specific historical, biogeographical and ecological conditions. However, due to several environmental threats many narrow endemics might face unpredictable consequences (Médail 2017). One of these species is *Delphinium pentagynum* subsp. *formenteranum*, an endangered species restricted to the island of Formentera (Balearic Islands). Flowering, pollination, and germination strongly influence the plant life cycle and can be considered crucial (Chiang et al. 2009). This was also confirmed by Llorens et al. (2023) who studied floral traits, flowering phenology, seed viability and germination of *Delphinium pentagynum* subsp. *formenteranum*.

Bryophytes are good indicators of habitat conditions worldwide (Stefańska-Krzaczek et al. 2022). Mežaka et al. (2023) aimed to increase the knowledge about EU Habitat directive bryophyte species distribution and conservation in Latvia. The results showed that EU Habitat Directive bryophyte species conservation in the long-term is unclear. Authors recommend initiating large-scale protected bryophyte monitoring programs and population studies that could contribute to plant community and global climate change research. Another interesting contribution on bryophytes is the article by Širka et al. (2023) on bryophytes in the classification and ecology of calcareous beech forests in Central Slovakia. In most previous studies, bryophytes had often been omitted (Mucina et al. 2016). Therefore, the role of bryophytes in the differentiation of plant communities was unclear. The results of the author´s analyses revealed no noticeable differences in bryophyte species richness between vegetation units. Bryophyte species composition in studied beech forests is mostly influenced by moisture availability and the cover of bare rocks. The authors pointed out that the majority of bryophytes of forest understorey grow on other substrates besides soil, especially on rocks, and living and dead wood. The main message for readers is a recommendation to sample all substrates and microhabitats involving soil, rock, dead wood and tree trunks to obtain a complete picture of species composition and diversity of forest plant communities.

The last contribution of the special issue is devoted to the *Silene aucheriana* populations of different geographical and climate conditions in Iran (Safaeishakib et al. 2023). The prediction of how species will respond to climate change requires a synthesis drawing from population genetics, geography, palaeontology and ecology (Schierenbeck 2017). To identify the taxa most sensitive to anthropogenic changes, an understanding of the distribution of genetic variation in the landscape and the life history or ecological parameters that influence this variation is important (Brandvain et al. 2014). The results confirmed that genetic divergence is present amongst populations, which is most likely caused by their climatic conditions. The investigation of genetic diversity should provide basic information about their current status in Iran.

Special issues on this topic can provide valuable insights and advance our understanding of the causes and consequences of changing environment on plant communities.

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