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Grasslands of temperate Europe in a changing world – Editorial to the 16th EDGG Special Feature in *Tuexenia*

Grasländer des gemäßigten Europas in einer sich verändernden Welt – Vorwort zum 16. EDGG-Sonderteil in *Tuexenia*

Steffen Boch[1, *], Thomas Becker[2], Balázs Deák[3], Jürgen Dengler[4, 5, 6] & Valentin H. Klaus[7]

[1]WSL Swiss Federal Research Institute, Zürcherstr. 111, 8903 Birmensdorf, Switzerland; [2]Regional and Environmental Sciences/Geobotany, University of Trier, Behringstr. 21, 54296 Trier, Germany; [3]Lendület Seed Ecology Research Group, Institute of Ecology and Botany, Centre for Ecological Research, Alkotmány út 2-4, Vácrátót, 2163, Hungary; [4]Vegetation Ecology Group, Institute of Natural Resource Sciences (IUNR), Zurich University of Applied Sciences (ZHAW), Grüentalstr. 14, 8820 Wädenswil, Switzerland; [5] Plant Ecology, Bayreuth Center for Ecology and Environmental Research (BayCEER), University of Bayreuth, Universitätsstr. 30, 95447 Bayreuth, Germany; [6]Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Puschstr. 4, 04103 Leipzig, Germany; [7]Institute for Agricultural Sciences, ETH Zürich, Universitätstr. 2, 8092 Zürich, Switzerland
**Corresponding author, e-mail: steffen.boch@wsl.ch*

Zusammenfassung

Mitglieder der *Eurasian Dry Grassland Group* (EDGG) und deren Vorgängerorganisationen geben seit 16 Jahren Grasland-Sonderausgaben (*Special Features*) in *Tuexenia* heraus. Das diesjährige *Special Feature* mit dem Titel *Grasländer des gemäßigten Europas in einer sich verändernden Welt* umfasst sieben Artikel, die verschiedene Aspekte der Graslandforschung beleuchten und dabei unterschiedliche Organismengruppen einbeziehen: LLUMIQUINGA et al. untersuchten Langzeiteffekte von Einsaat, Mahd und Kohlenstoffzusatz (Reduktion der Nährstoffverfügbarkeit durch Verschiebung des C/N-Verhältnis) auf den Renaturierungserfolg von pannonischem Sandgrasland auf ehemaligen Äckern. BÓDIS et al. verglichen die kurzfristigen Effekte verschiedener Pflegemaßnahmen (Mahd mit/ohne Abfuhr des Schnittguts sowie Brennen) auf den ökologischen Zustand aufgegebener Pfeifengraswiesen in Westungarn. BALOGH et al. analysierten Verzehrraten und Ernährungspräferenzen von Rindern in artenreichen Steppenwiesen der ungarischen Tiefebene, um eine nachhaltige Grasland- und Viehwirtschaft zu ermöglichen. HEER et al. untersuchten Dichteeffekte der zwei Hemiparasiten *Melampyrum arvense* und *M. nemorosum* auf die Pflanzenartenvielfalt im Grasland der Insel Saaremaa (Estland). KUMMLI et al. führten 25 Jahre nach der Ersterfassung eine Wiedererhebung der Artenzusammensetzung und Diversität und der Vegetation von urbanen Grasländern in Zürich durch. CHARMILLOT et al. (2021) untersuchten die Vegetationsveränderungen von Kalkhalbtrockenrasen des Schweizer Juras in den vergangenen 40 Jahren mittels Wiedererhebungen von bekannten Untersuchungsflächen. ROLEČEK et al. (2021) korrigierten den 2019 in Tuexenia veröffentlichten Höchstwert von 106 Arten (ROLEČEK et al. 2019) in einer siebenbürgischen Steppenwiese (Rumänien), der aufgrund einer fehlerhaften Flächenabgrenzung in einer 10,9 m²-Fläche und nicht wie angegeben in einer 10 m² großen Fläche ermittelt wurde, und meldeten gleichzeitig neue Höchstwerte für den Artenreichtum an Gefäßpflanzen, die jemals in 10 m²-Flächen ermittelt wurden (115 und 110 Arten in zwei benachbarten Flächen).

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1. Introduction

The Eurasian Dry Grassland Group (EDGG; http://www.edgg.org) is a network of researchers and conservationists interested in the biodiversity, ecology, conservation and restoration of Palaearctic natural and semi-natural grasslands (DENGLER et al. 2021). The main aims of the EDGG are to facilitate research and scientific discussions on any aspect of Palaearctic grasslands by organising conferences and field workshops, to support the publication of grassland research, to establish grassland vegetation-plot databases (e.g. GrassPlot; DENGLER et al. 2018, BIURRUN et al. 2019, 2021), and to promote policies and legislation towards the protection, adequate management and restoration of Palaearctic grasslands.

This Special Feature, entitled *Grasslands of temperate Europe in a changing world*, continues a long tradition of grassland-related paper collections in *Tuexenia*. It is part of a series of Special Features organised by the EDGG in various international journals (e.g. BOCH et al. 2020a, VALKÓ et al. 2021), as well as books (e.g. TÖRÖK & DENGLER 2018, BOCH et al. 2020b, DENGLER et al. 2020), that aim to disseminate results of grassland research to scientists and practitioners by highlighting the importance of biodiversity and appropriate land use for ecosystem functioning and human well-being. By releasing these Special Features, EDGG also aims to facilitate the implementation of scientific findings in grassland conservation and policy.

As is the case for *Tuexenia* in general, the EDGG extended the geographic and syntaxonomic scope for the present and upcoming Special Features to consider contributions from the whole nemoral zonobiome (also called temperate midlatitudes) in Europe, including its transitions to neighbouring zonobiomes, such as submediterranean, hemiboreal and forest-steppe zono-ecotones. Thus, the new geographic scope ranges from Galicia in the west to the Urals in the east. However, contributions from the boreal, arctic, mediterranean or continental (steppic) zonobiomes are also potentially considered after prior consultation with the Editors, and if a connection to Central Europe is made. In addition, the syntaxonomic scope of the Special Feature has been broadened and, like EDGG, now considers all types of natural and semi-natural grasslands (mesic, wet, dry, saline, sandy, rocky, alpine), as well as vegetation types dominated by bryophytes, lichens, forbs and dwarf shrubs (e.g. tall forb communities and heathlands).

In this Editorial, we introduce the 7 papers of this year's EDGG Special Feature, written by 49 authors from 4 countries.

2. Grasslands of temperate Europe in a changing world

Grasslands in Europe harbour a high diversity of various taxa (DENGLER et al. 2014, BOCH et al. 2020a, TÖRÖK et al. 2020, BIURRUN et al. 2021) and provide a wide range of crucial ecosystem functions and services (MANNING et al. 2018). It has been shown that maintaining a high level of biodiversity is of key importance to maintain ecosystem multifunctionality (ZAVALETA et al. 2010, DELGADO-BAQUERIZO 2016, SOLIVERES et al. 2016). However, because of land-use and environmental changes, European grasslands showed strong declines in habitat extent and quality over the past decades. In fact, in Europe grasslands are among the most heavily human-impacted habitats. Global change, including land-use changes such as intensification and abandonment, has been found to be one of the most important drivers of losses in native biodiversity, and in ecosystem functions and services, in grasslands (IPBES 2018). The impacts on ecosystem functions and services can be either direct, e.g. by altering the productivity or the disturbance regime of ecosystems, or indirect, by causing changes in community composition and biodiversity loss, which then feed back on the services (ALLAN et al. 2015). In Western Europe, it has been estimated that more than two-thirds of the previously traditionally managed secondary grasslands have experienced intensification of land use. Another large proportion has been destructed or degraded by the conversion to built-up areas or other land-use types such as arable fields (e.g. to grow crops for biogas production; BOCH et al. 2020b, DENGLER et al. 2020). Increased productivity due to nutrient input via atmospheric deposition and fertilisation, combined with high mowing frequencies and stocking densities, has had detrimental effects on grassland biodiversity. These changes have caused cascading negative effects across trophic levels and resulted in a large-scale loss of species richness and altered species assemblages towards homogeneous communities with reduced ecosystem multifunctionality (ROTH et al. 2013, GOSSNER et al. 2016, SOLIVERES et al. 2016, BOCH et al. 2020c, DENGLER et al. 2020, TÖRÖK et al. 2020, BOCH et al. 2021, HUMBERT et al. 2021, KUN et al. 2021, ROTH et al. 2021). Consequently, many grassland habitat types and species are now endangered (DELARZE et al. 2016) and this intensification will probably further decrease the ecological quality of grasslands in the long term (GRAF et al. 2014, APOLLONI et al. 2017, BOCH et al. 2019a, b).

In contrast to the lowlands, where ecologically valuable habitats cover only a small share of the agricultural land because of intensive land use at the landscape scale (e.g. < 4% of the agricultural land in Switzerland; WALTER et al. 2013, MEIER et al. 2021), mountain areas still have a considerably larger share of near-natural areas in which biodiversity can be maintained (GUNTERN et al. 2020, MEIER et al. 2021). However, despite the general perception that grasslands in mountainous regions are still traditionally managed and harbour rich biodiversity, land-use intensification is currently also happening in mountain areas. This development largely mirrors what had happened between 1960 and 1980 in Central European lowland regions (GRAF et al. 2014). Current case studies show that improved, at least partially subsidised infrastructure and land consolidation, including the removal of structural landscape elements valuable for biodiversity, in combination with the use of modern agricultural machinery have improved the accessibility of many areas and facilitated the intensification of grasslands even in remote or steep locations (APOLLONI et al. 2017, BOCH et al. 2020c, GUNTERN et al. 2020). Unfortunately, until now these negative ecological developments in mountain grasslands have received only little attention from stakeholders, policy-makers and the wider public. Overall, these patterns reflect a largely unsustainable land use on the landscape scale.

Another major driver of change in grassland ecosystems is heat and drought stress as part of climate change (SCHILS et al. 2020), which likely affect wet grasslands more than naturally dry grassland habitats (BUSE et al. 2015). Several biodiversity and ecosystem functioning studies have suggested that drought effects in grasslands could (partially) be offset by enhancing plant species richness (CRAVEN et al. 2016, THOMPSON & KAO-KNIFFIN 2016), underlining the need to consider plant diversity an important functional driver and potentially also a form of insurance against climate change in grasslands (GRANGE et al. 2021). However, the transferability of such (often experimental) findings to semi-natural grasslands is still debated (KLAUS et al. 2020). Nonetheless, the urgent need to adapt to climate change puts restoration measures, such as increasing the richness of (native) plant species by seeding, into the spotlight (VALKÓ et al. 2016, FREITAG et al. 2021), not only for ecological but also for agricultural and societal reasons (SCHAUB et al. 2021). However, despite the well-known threats to grasslands (DENGLER et al. 2020, SCHILS et al. 2020) and recent efforts at the national or European level to conserve and restore grasslands and their biodiversity, habitat degradation and destruction is ongoing (SILVA et al. 2008, BAFU 2017, IPBES 2018). European policy-makers have to develop appropriate tools, e.g. promoting spatially and temporally more complex alternative management systems (e.g. VAN KLINK et al. 2017, HUMBERT et al. 2018, KUN et al. 2021), to reverse these negative trends rather than focus on the subsidisation of agricultural productivity. In order to maintain and restore ecosystem multifunctionality and sustainable grassland use, it is essential that European agricultural policy becomes more directed towards increasing sustainabile production and not just maximising agricultural productivity (IPBES 2018, GUBLER et al. 2020).

Over the last two decades, due to the strengthening of scientific networks, grassland researchers have become much better connected throughout Europe, and research activities in grassland ecosystems have improved. This resulted in a deeper understanding of grassland ecosystem functioning and services, which is an important step towards highlighting the importance of the protection and restoration of semi-natural grasslands. However, there are still many aspects of grassland ecology that should be considered in future studies. Such "hot topics" include the relationships between biodiversity, environmental gradients and management options, the importance of past land use for biodiversity and ecosystem functions, and options to increase the efficacy of management and restoration measures. The contributions in this Special Feature aim to fill this gap at least partially.

3. Contributions to the 16th EDGG Special Feature

The contributions in this year's EDGG Special Feature highlight different aspects of grassland research. The articles focus on biodiversity patterns across different study organisms, as well as across spatial and temporal scales, including topics related to grassland restoration, plant–plant or plant–animal interactions, and vegetation resurveys.

LLUMIQUINGA et al. (2021) studied the long-term effects of initial seeding, mowing and carbon amendment on the restoration success of Pannonian sand grasslands on abandoned crop fields. The authors re-investigated two experimental sites that they had established 16 years ago (HALASSY et al. 2016). They assessed whether soil-available nitrogen, vascular plant species richness, total vascular plant cover and the relative cover of target and neophyte species still differ among the experimental treatments. Of the treatments applied, mowing and carbon amendment had positive short-term (HALASSY et al. 2016, 2019) but no long-term effects on the vegetation. However, seeding had a long-term effect that was still visible 16 years after initial application, with higher relative cover of seeded species and lower relative cover of neophyte species. These sown species also spread from the sown plots to the adjacent areas. The results indicate that ploughing combined with seeding of a low-diversity seed mix, followed by initial management (preferably grazing or mowing), can successfully assist the restoration of Pannonian sand grasslands on abandoned crop fields.

BÓDIS et al. (2021) studied short-term effects of conservation management on the vegetation of abandoned fen meadows in western Hungary, which are subjected to litter accumulation and the encroachment of competitive and invasive species. To assess the efficiency of three different treatments, i.e. burning and mowing with or without hay removal, the authors compared several vegetation characteristics one year after the measures with a baseline survey done in the previous year, using a Before-After-Control-Impact design. The authors evaluated the treatment effects on several vegetation characteristics and conservation value indicators, such as Shannon diversity, cover of forbs, a naturalness score and a forage quality score. However, none of the treatments caused a significant change in most of the conservation value indicators. The only change induced by the treatments was a significant decline in litter cover in the plots treated with mowing with hay removal and burning compared with the plots treated with mowing without hay removal and the control plots. The authors conclude that none of the treatments were able to mitigate the most influential threat factor in these fen meadows, which was the dominance of *Molinia caerulea*. To improve the situation, the authors suggest trying to suppress *Molinia* by seeding hemiparasitic taxa such as *Rhinanthus* spp. (TĚŠITEL et al. 2017, HEER et al. 2018, CHAUDRON et al. 2021), which are native species in these fen meadows. However, for this specific habitat type this approach still needs to be tested in future experiments.

BALOGH et al. (2021) investigated consumption rates and dietary preferences of cattle in species-rich mesic grasslands of the Central Hungarian Plain in order to gain knowledge for sustainable management of the sites. Above-ground biomass samples were collected from grazed and ungrazed sites and compared. At grazed sites, biomass was reduced by 65% and flowering success was reduced by 85%. The living mass of forbs and graminoids was similarly reduced, whereas moss biomass and plant litter were not reduced by grazing. Cattle preferred species with a high specific leaf area (SLA) and high N content. Based on their results, the authors classified plants into three preference categories. They conclude that the livestock carrying capacity of an area can be carefully planned based on SLA and nitrogen (N) content measurements. The authors recommend implementing a grazing regime with a spatial and temporal mosaic pattern, to achieve variable grazing pressure and maintain maximal species diversity.

HEER et al. (2018) showed that the hemiparasite *Rhinanthus alectorolophus* affects grassland plant species richness and that this effect depends on the density of *Rhinanthus*. The authors reported an optimum curve, with the highest diversity values occurring at intermediate densities of *Rhinanthus*, most likely because hemiparasitic plants can reduce interspecific competition by parasitising competitive species over-proportionally. However, whether these relationships also hold true for other hemiparasites has remained largely unclear. As a proof of principle, HEER et al. (2021) therefore tested density effects of the hemiparasitic species *Melampyrum arvense* and *M. nemorosum* on the species richness of grasslands on the island of Saaremaa, Estonia. The authors found significant hump-shaped relationships of total vascular plant species richness with the relative cover of *M. arvense* and *M. nemorosum*, with the highest species richness occurring at 13% and 40% cover, respectively. At relatively low densities > 29.7% of *M. arvense* and relatively high densities > 81.8% of *M. nemorosum*, species richness was even lower than in plots without these hemiparasites. The findings support the use of a density-gradient approach when the aim is to explore relationships between hemiparasites and species richness.

KUMMLI et al. (2021) assessed the effects of environmental change on mesic grasslands in the urban context. They resurveyed 30 plots in the city of Zurich (Switzerland), approximately 25 years after the first vegetation survey at these sites. The authors found that only 15% of the original grasslands had disappeared, mostly due to the construction of buildings. Several of the remaining grasslands that had previously been used as pastures were being mown, leading to significant ecological changes, such as less ruderal site conditions and a decrease in the ecological indicator value for nutrients in these communities. However, after 26 years and against their expectations, the authors did not find any decrease in alpha diversity in the remaining 30 grassland plots they reinvestigated in Zurich. The relatively good ecological conditions of these grasslands could be the result of a lower agricultural intensification pressure in the urban compared to the rural environment. Thus, the authors conclude that maintaining urban grasslands have the potential to contribute considerably to the conservation of grassland biodiversity.

CHARMILLOT et al. (2021) studied the vegetation change in meso-xeric calcareous grasslands of the Swiss Jura Mts. by resampling 28 vegetation plots 40 years after the original survey. The investigated grasslands mostly showed a directional change from typical Mesobromion to stands that are now transitional or even belonging to the Arrhenatherion. Mean vascular plant species richness decreased by approx. 11%. Mainly therophytes and low-growing chamaephytes as well as stress-tolerators had decreased, while hemicryptophytes and competitive species had increased. Mean indicator values for nutrients and moisture had increased, as did the community-weighted means of canopy height and seed mass. These developments together are interpreted as signs of (i) eutrophication (e.g. through atmogenic nitrogen input) and (ii) decreased disturbance due to a less intensive/more regular pasture management. While the findings in many respects are in line with other resurvey studies of meso-xeric grasslands, some deviations let the authors call for accounting of regional peculiarities when devising conservation and management strategies.

ROLEČEK et al. (2021) corrected the previously published maximum of 106 species (ROLEČEK et al. 2019), which was recorded in a 10.9 m^2 plot, instead of a 10 m^2 plot as originally indicated, due to erroneous plot delimitation. At the same time the authors report new maxima of vascular plant species richness ever recorded in 10 m^2 plots (115 and 110 species in two adjacent plots). The plots were resurveyed in a meso-xeric grassland in the well-known site Valea Lui Craiu, located in the Fânaţele Clujului grassland complex close to the city of Cluj in Transylvania, Romania, where the former maximum value was also discovered (DENGLER et al. 2012, WILSON et al. 2012).

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ORCIDs

Thomas Becker https://orcid.org/0000-0002-7942-5575
Steffen Boch https://orcid.org/0000-0003-2814-5343
Balázs Deák https://orcid.org/0000-0001-6938-1997
Jürgen Dengler https://orcid.org/0000-0003-3221-660X
Valentin H. Klaus https://orcid.org/0000-0002-7469-6800

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