Final report

Testing environmental and landscape factors as drivers of diversity in dry grassland fragments

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Aims of the project, main research topics

Due to the large scale changes in land use practices there has been a dramatic decline in the area of grassland habitats in whole Eurasia. The loss of habitats results in the fragmentation, isolation of formerly extended grasslands, and also affected the populations of grassland specialist species. Biodiversity harboured by the remaining grasslands and grassland fragments are considerably affected both by the local environmental and landscape factors. In spite of their often small size remnant grassland habitats considerably contribute to the maintenance of the landscape-scale biodiversity, provide several ecosystem services for the society such as pest control, pollination, water retention, and are also important elements of the landscape's aesthetic values. In our project we aimed at revealing the mechanisms affecting biodiversity of grassland habitats embedded in anthropogenous landscapes and also to provide a theoretical background for their protection. Based on our results we provided scientifically sound solutions for the conservation and restoration of such systems.

We studied the conservational importance of grassland fragments preserved by historical sites (ancient burial mounds, the so called 'kurgans') in the frame of an international cooperation. We performed a large-scale field campaign in which we sampled 168 kurgans in Hungary. By this large-scale dataset covering the major part of the Great Hungarian Plain we studied the effects of local biotic and abiotic factors and the landscape composition on the biodiversity and trait composition of grassland habitat islands. I also demonstrated the role of Central-Asian kurgans in conserving steppe diversity based on the results of our expedition in Kazakhstan. We estimated the biodiversity potential of the urban green infrastructure, revealing the mechanisms that maintain the biodiversity of semi-natural open habitats in urban environments. We evaluated the restoration measures that can be applied for enhancing grassland biodiversity of historical sites, and based on our results we also provided a practical 'know how' for that. We studied the effects of ecosystem engineering animals in maintaining grassland biodiversity of agricultural landscapes. As a summary of the studies involved into this project I published a monograph about the role of kurgans in conserving biodiversity.

Key results of the project

Role of kurgans in maintaining biodiversity in Eurasian steppes.

We published a synthesis paper about the distribution, vegetation and threatening factors of Eurasian kurgans covered by grassland vegetation (Deák et al. 2016 *Biodiversity & Conservation*). The paper is a result of an international cooperation (with the involvement of Polish, Ukrainian, Bulgarian, Russian and Kazakh co-authors) which was initiated for

drawing attention on the importance of kurgans in conserving biodiversity of human-transformed landscapes across the whole steppe and forest steppe biomes. As a conclusion of the reviewed literature and the evidence-based studies involved in our paper we provided feasible solutions for the protection of the kurgans and also for integrating them into the agri-environmental schemes. Since the publication of the paper (November 2016) according to the Google Scholar it received 48 citations.

Local factors driven biodiversity in grassland habitat islands

We revealed the effects of local habitat factors such as habitat area, slope, recent disturbance, past destruction and the level of woody encroachment on the species richness and cover of grassland specialists and problem species (competitor weedy species) of small grassland islands harboured by kurgans (Deák et al. 2016 *Biological Conservation*). We found that micro-topographical heterogeneity can counterbalance the negative consequences of the small habitat area of habitat islands, and revealed that special habitat conditions provided by kurgans can suppress the negative effects of the cessation of management. Thus, kurgans can act as refuges for grassland vegetation even in heavily transformed landscapes.

Micro-topography driven heterogeneity in steppic landscapes

Based on the data collected during our research expedition in Kazakhstan, we evaluated the effects of micro-habitat diversity, changes in grazing intensity and their interaction on the steppe vegetation harboured by kurgans (Deák et al. 2017 *Plant Ecology & Diversity*). We proved that even in extended pristine steppic landscapes kurgans characterised by a high environmental heterogeneity can considerably increase landscape-level species diversity. However, inadequate level of grazing has a detrimental effect on the biodiversity potential of these structures.

Effects of local and landscape filters in sorting species pool of grassland specialist species

By using a trait-based approach we revealed the effects of habitat filters (woody encroachment, slope inclination and human disturbance) and landscape filters (local and regional isolation) on the metapopulations dynamics of grassland specialist species preserved in small habitat islands (Deák et al. 2018 *Landscape Ecology*). We found that whilst clonality and persistent seed bank can support persistence of grassland specialist plants in highly isolated grassland fragments, good disperser species are suppressed in such situation due to the indirect dispersal mechanisms of anemochory and the lack of animal dispersal vectors.

Role of ecosystem engineer animal species in maintaining biodiversity

We revealed that a moderate soil disturbance by burrowing animals can provide temporal establishment gaps for grassland species in habitat islands; therefore, they can sustain a disturbance-tolerant subset of grassland specialist species (Godó et al. 2018 *Ecology and Evolution*).

Restoration of grassland vegetation on historical sites

We evaluated the restoration efficiency of seed sowing, planting greenhouse-grown plants and transplanting plant individuals from threatened populations onto burial mounds. Our project demonstrated that by the revitalisation of the vegetation on historical monuments, cultural ecosystem services can also be restored (Valkó et al. 2018 *Nature Conservation*).

Effects of landscape factors on the populations of two endangered bird species.
To reveal additional aspects of the landscape context in shaping the species composition of open habitats I took part in two projects exploring factors affecting populations of endangered bird species. In the study of Végvári et al. (2016; *Land Degradation & Development*) we studied the effect of landscape composition on the lekking behaviour of an iconic steppic bird, the Great Bustard (*Otis tarda*). We also studied the effect of landscape heterogeneity and composition on the occurrence of the red-listed European Roller (*Coracias garrulus*) (Kiss et al. 2016; *Journal for Nature Conservation*).

Application of remote sensing in mapping grassland structure
In our paper published in the *Ecological Indicators* we studied the applicability of digital surface models in habitat mapping of complex grassland habitats (Alexander et al. 2016). We also developed a methodology based on airborne laser scanning for the mapping of conservation status and biodiversity in complex alkali landscapes (Zlinszky et al. 2016 *ISPRS*). We also provided methodological solutions for using hyperspectral data in the classification of diverse open habitats, mostly driven by heterogeneous habitat conditions (Burai et al. 2016, *Tájökológiai Lapok*).

Other studies
We studied the factors responsible for driving diversity patterns of forest-steppe vegetation (Bátori et al. 2018 *Biodiversity & Conservation*, Tölgyesi et al. 2018 *Plant Ecology and Diversity*), the role of green space network in maintaining urban biodiversity (Deák et al. 2016 *Tuexenia*; Hüse et al. 2016 *Land Use Policy*), scale-dependent effects of grazing in grasslands characterised by a high environmental heterogeneity (Godó et al. 2017; *Tuexenia*), and performed two meta-analyses to evaluate the effects of grazing and mowing on the conservation of grassland habitats (Tälle et al. 2018 *Biodiversity & Conservation,* Tälle et al. 2016 *Agriculture, Ecosystems & Environments*).

Dissemination of project results

Papers
We published in total 29 papers, including 27 in impact-factored journals. The total impact factor of the papers related to the project is 79,091. Out of the impacted papers, I am first author in 8, last author in 2. I also published a monograph. The complete list of publications can be found on the NKFI and MTMT servers. All publications have been uploaded into a public database (MTAK REAL).

Monograph summarising the results of the OTKA project
In order to draw scientific and public attention on the importance of sacred natural sites (such as the kurgans) in conserving our natural and cultural heritage I summarised the results of the OTKA project in a monograph (Deák et al 2018). The monograph provides a detailed overview on the history, conservational and cultural role of Eurasian kurgans. The results of the papers supported by the OTKA project are involved in the book as case studies.

Conferences

I presented the results of the studies supported by the OTKA research grant in 36 presentations in international and 46 presentations in Hungarian conferences. The results were presented in the following meetings:

International conferences
- 10th European Conference on Ecological Restoration (Freising, Germany; 2016 August 21-26.)
- 13th Eurasian Dry Grassland Conference (Sighisoara, Romania; 2016 September 20-25.)
- Biological diversity of Asian steppes (Kostanay, Kazahstan; 2017 April 24-27)
- 1st International Conference on Community Ecology (Budapest, Hungary; 2017 September 28-29)
- 39th New Phytologist Symposium (Exeter, UK; 2017 June 26-30)
- 60th Annual Symposium of the International Association for Vegetation Science (Palermo, Italy; 2017 June 20-24)
- 14th Eurasian Dry Grassland Conference (Riga, Estonia; 2017 July 4-11)
- European Geosciences Union General Assembly 2017 (Wien, 2017 April 24-28)
- 18th Kolozsvári Biológus Napok (Kolozsvár, Romania; 2017 March 31-April 1);
- BES-GFÖ-NECOV-EEF Joint Annual Meeting (Ghent, Belium; 2017 December 11-14.)
- 48th Annual Meeting of the Ecological Society of Germany, Austria and Switzerland (Vienna, Austria;2018 September 10-15.)
- Annual Symposium of the International Association for Vegetation Science' (Bozeman, MT, USA; 2018 July 22-27.)
- European Congress for Conservation Biology (Jyväskylä, Finnland; 2018 June 12-15.)

Hungarian conferences
- XI. Aktuális Flóra- és Vegetációkutatás a Kárpát-medencében (Budapest, 2016. February 12-14.)
- NATURA 2000 területek természetvédelmi vizsgálatai, élőhelykezelési, fenntartási tapasztalatai - Fenntartható fejlődés a Kárpát-medencében III. (Gödöllő, 2016. March 17.)
- VII. Magyar Tájökológiai Konferencia (Szeged, 2017 May 25-27.)
- 11. Magyar Ökológus Kongresszus (Nyíregyháza, Hungary; 2018 August 28-30.)
- XIX. Kolozsvári Biológus Napok (Kolozsvár, Romania; 2018 April 13-15.)
- XII. Aktuális Flóra- és Vegetációkutatás a Kárpát-medencében Konferencia (Debrecen, Hungary; 2018 February 23-25.)
- XI. Magyar Természetvédelmi Biológiai Konferencia' (Eger, Hungary; 2017 November 2-5. Nov.)
- 6. Kvantitív Ökológiai Szimpózium' (Budapest, Hungary; 2017 October 13.)

Other results, grants and awards during the project period
- In the first year of my OTKA grant I was a guest editor of the Eurasian Dry Grassland Group Special Feature in the Journal *Tuexenia*, which is the international, impacted journal of the German Floristic Association. The main topic of the Special Feature is closely related to the topic of my OTKA research grant: effects of habitat and landscape factors on grassland habitats.
- From 2017 I have been serving as the chief of the guest editors of the grassland Special Features (the related two editorial papers: Deák et al. 2017 *Tuexenia*, Deák et al. 2018*Tuexenia*). The main topic of the Special Features is closely related to the topic of my

OTKA research grant: effect of habitat and landscape factors, management and restoration efforts on grassland diversity.
- I was awarded for the grant of the New National Excellence Program of the Ministry of Human Capacities (ÚNKP-17-4-III-DE-160).
- I was awarded for the grant of the New National Excellence Program of the Ministry of Human Capacities (Bolyai +;ÚNKP-18-4-DE-9).
- I received the support of the Book and Journal Publication Grant of the Hungarian Academy of Science (MTA Könyv- és Folyóirat-kiadás támogatási pályázat) and I received the funding for publishing the book'Nature and history – The role of the kurgans in conserving steppe vegetation' [Természet és történelem - A kurgánok szerepe a sztyeppi vegetáció megőrzésében].
- One of my PhD students (Bernadett Hüse) successfully defended her PhD.
- My student Szilvia Radócz was awarded by the best poster presentation prize in the 13th Eurasian Dry Grassland Conference, 2nd prize in the OTDK Conference and by the Stephen W. Kuffler Award.
- I habilitated at the University of Debrecen. The topics involved in my habilitation thesis (effects of micro-topography, landscape composition and management on dry grassland communities) were highly related to the topics involved into my OTKA research. Title of the thesis: "Mikrotopográfia, táji környezet és kezelés hatása szikes növényközösségek szerveződésére" /Effects of landscape composition and management regime on the species composition and structure of alkali grasslands/.
- I submitted my DSc thesis which encompass many of the studies related to the present OTKA grant (the role of kurgans as habitat islands in the maintenance of metapopulations dynamics and biodiversity of fragmented landscapes). Title of the thesis: "Termőhelyi változatosság, táji környezet és tájhasználat szerepe gyepi növényközösségek élőhelyi mintázatainak és fajkészletének kialakításában." /The role of habitat heterogeneity, landscape composition and land use in maintaining the structure and biodiversity of dry grasslands/

Published studies supported by the project

Alexander, C., Deák, B., Heilmeier H. (2016): Micro-topography driven vegetation patterns in open mosaic landscapes. *Ecological Indicators* 60: 906-920. [IF2016: 3.898]

Bátori, Z., Erdős, L., Kelemen, A., Deák, B., Valkó, O., Gallé, R., Bragina, T. M., Kiss, P.J., Kröel-Dulay, G., Tölgyesi, C. (2018): Diversity patterns in sandy forest-steppes – a comparative study from the western and central Palaearctic. *Biodiversity and Conservation* 27: 1011-1030. [IF2017: 2.828]

Burai, P., Lénárt, Cs., Valkó O., Bekő, L., Szabó, Zs, Deák B. (2016): Fátlan vegetációtípusok azonosítása légi hiperspektrális távérzékelési módszerrel. *Tájökológiai Lapok* 14: 1-12.

Deák B., Valkó O., Török P., Tóthmérész B. (2016): Factors threatening grassland specialist plants - A multi-proxy study on the vegetation of isolated grasslands. *Biological Conservation* 204: 255-262. [IF2016: 4.002]

Deák, B., Hüse, B., Tóthmérész, B. (2016): Grassland vegetation in urban habitats – Testing ecological theories. *Tuexenia* 36: 379-393. [IF2016: 1.325]

Deák, B., Tóthmérész, B., Valkó, O., Sudnik-Wójcikowska, B., Bragina, T.-M., Moysiyenko, I., Apostolova, I., Bykov, N., Dembicz, I., Török, P. (2016): Cultural monuments and nature conservation: The role of kurgans in maintaining steppe vegetation. *Biodiversity & Conservation* 25: 2473-2490. [IF2016: 2.265]

Deák, B., Tölgyesi, Cs., Kelemen, A., Bátori, Z., Gallé, R., Bragina, T.M., Abil, Y.A., Valkó, O. (2017): Vegetation of steppic cultural heritage sites in Kazakhstan – Effects of micro-habitats and grazing intensity. *Plant Ecology and Diversity* 10: 509-520. [IF2017: 1.205]

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Deák, B (2018): Természet és történelem - A kurgánok szerepe a sztyeppi vegetáció megőrzésében. Budapest, Magyarország: Ökológiai Mezőgazdasági Kutatóintézet 150 p. ISBN: 9786158105613

Godó L., Valkó O., Tóthmérész B., Török P., Kelemen A., Deák B. (2017): Scale-dependent effects of grazing on the species richness of alkaline and sand grasslands. *Tuexenia* 37: 229–246. [IF2017: 1.125]

Godó, L., Tóthmérész, B., Valkó, O., Tóth, K., Radócz, S., Kiss, R., Kelemen, A., Török, P., Švamberková, E., Deák, B. (2018): Ecosystem engineering by foxes is mediated by isolation in grassland fragments. *Ecology and Evolution* 8: 7044-7054. [IF2017: 2.340]

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