

The role of habitat and landscape factors in grassland community assembly

Project summary (Final report)

In intensively used agricultural landscapes of Europe remnant fragments of the dry grassland habitats have a high conservation importance. For their effective protection we need to understand mechanisms driving the species and trait composition of isolated grassland communities. In the research project we provided important insights into the processes influencing the biodiversity and functional diversity of dry grasslands embedded in agricultural landscapes. We used a multitaxon (involving both vascular plants and arthropod taxa) and multisite (more than 100 study sites in two biogeographical regions) approach to provide sound and generalisable results. For the research we used isolated grasslands located on ancient burial mounds (called ‘kurgans’) as model ecosystems. As kurgans are important sites unifying the preservation of our cultural, historical and natural heritage, we could also draw attention on the synergy between the protection of conservation values and cultural heritage.

Short summary of publications related to the project

In the frame of the research project altogether 8 core papers were published in WoS journals and 6 in other journals; the PI was the first author in 11 and last author in 2 core papers. The PI published a monograph about Eurasian kurgans, and was the first/last author of three book chapters related to the research topic. During the project period the PI had published further 18 papers that are closely related to the research topic (conservation, management and restoration of grassland habitats). The results of the project had been presented both in international and Hungarian conferences.

Summaries of the core publications

1, Kurgans as safe havens for grassland plant and arthropod species in agricultural landscapes

Based on a large-scale botanical and zoological survey of 138 mounds in Hungary, we compared the management regimes, the presence of threatening factors and the conservation potential of kurgans embedded in non-protected transformed landscapes and in protected areas. We found that mounds could extend the borders of the protected areas by maintaining the populations of grassland specialist plants and arthropods (ants, orthopterans, true bugs and rove beetles) even in transformed landscapes. We revealed that the lack of proper management, the presence of anthropogenic disturbances and the encroachment of woody species are the most considerable threats for the long-term maintenance of biodiversity on kurgans located outside the protected areas.

Publication: *Deák et al. 2020 Biological Conservation [IF2020: 5.990]*

2, Role of grassland fragments in the maintenance of species and phylogenetic diversity

We showed that plant species richness of grassland specialist plants on island-like kurgans were comparable to species richness in extensive grasslands. This was supported by the high environmental heterogeneity which resulted in steep slopes of species accumulation curves

contributing to the high species richness of specialists. We found that mounds preserved the same amount of phylogenetic diversity represented by the branch-lengths as grasslands.

Publication: *Deák et al. 2020 Biodiversity and Conservation [IF2020: 3.549]*

3, Trait composition in patch-like and linear grassland fragments

We revealed that on kurgans acting as habitat islands specialist plant species were characterised by traits (such as self-compatibility, large seed mass and tall stature) otherwise typical to plants inhabiting true-islands. Kurgans and extensive grasslands were characterized by higher functional diversity than verges, which is due to the higher level of environmental heterogeneity compared to the homogeneous environment in verges.

Publication: *Deák et al. 2021 Frontiers in Ecology and Evolution [IF2020: 4.171]*

4, Alternative successional ways on abandoned kurgans related to former land use

We showed that former land use on kurgans might considerably influence vegetation succession patterns in agricultural landscapes. In former croplands, excess phosphorus, while in former *Robinia* plantations, excess nitrogen was present in the soil even four years after the land use change and grassland vegetation was in an early or midsuccessional stage both on the mounds. These results suggested that without proper management/restoration measures recovery of grassland vegetation is slow on mounds formerly used as cropland or black locust plantation.

Publication: *Deák & Valkó et al. (2020): Nature Conservation [IF2020: 2.417]*

5, Effect of historical landscape on current species richness in habitat islands

In our multi-taxa study we assessed the effects of present and historical grassland amount and connectivity on the current species richness of grassland specialist and generalist plants and arthropods in grassland fragments. We found evidence for an unpaid extinction debt in specialist plants, suggesting that they have not come to equilibrium with the grassland amount and connectivity of the present landscape. Our results pointed that unpaid extinction debt should be considered an early warning signal in the case of grassland specialist plants in fragmented grasslands, and active restoration of grassland connectivity is necessary to halt ongoing extinction processes. Specialist arthropod taxa with short generation times and high mobility together with generalist plants and animals adapted to a wide range of habitats were not affected by the landscape-scale decline of grassland habitats.

Publication: *Deák et al. 2021 Biological Conservation [IF2020: 5.990]*

6, Functional composition of ant assemblages in habitat islands

We revealed that despite their small sizes, mounds as permanent and relatively undisturbed landscape elements could provide safe havens for diverse ant assemblages even in transformed

agricultural landscapes. The complex habitat structure of wooded mounds supported high species and functional diversity of ant assemblages. Ant species on wooded mounds had small or medium-sized colonies, enabling the co-existence of more species. We revealed that the effect of landscape composition on ant assemblages was mediated by habitat factors: steep slopes buffered the negative effect of the cropland matrix and enabled higher ant diversity.

Publication: *Deák & Báthori et al. 2021 Scientific Reports [IF2020: 4.379]*

7, Environmental heterogeneity driven biodiversity in habitat islands

In our study we tested the effect of environmental heterogeneity on the overall biodiversity and spatial arrangement of species assemblages in kurgans. We found that small scale topographical heterogeneity provided on the mounds induces the heterogeneity of other environmental heterogeneity components (soil and microclimate), and by that it allows the coexistence of various microsites even within small spatial scales that considerably increases their biodiversity potential.

Publication: *Deák et al. 2021 Science of the Total Environment [IF2020: 7.963]*

8, Monograph about kurgans

The PI published a monograph in English about the conservational role of kurgans in open landscapes of Eurasia and the factors that can support or threaten their existence. Results of the papers published in the frame of this research project are involved as case studies in the book.

Publication: *Deák B. (2020) Nature and Culture: The Role of Ancient Burial Mounds in the Conservation of Eurasian Steppe Vegetation. Tihany, Magyarország: Ökológiai Kutatóközpont, 172 p.*

9, Floristic data from kurgans

We published floristic data collected on 82 kurgans located in the area of the Hortobágy National Park Directorate. Our dataset covers 64 CEU quarter quadrates, and the territory of 45 settlements. We provide data on 39 taxa that are either protected or regionally rare. Our records demonstrate that kurgans have a vital role in maintaining the populations of rare and endangered grassland species even in transformed landscapes.

Publication: *Deák et al. 2019 Kitaibelia*

10, Development of the Eurasian Kurgan Database

As a part of the project the PI initiated an international database capable for collecting and providing open access data on the historical, cultural and conservation values of Eurasian kurgans (<http://openbiomaps.org/projects/kurgan>). The aim of the database is to provide open access data on kurgans for scientific research, governmental bodies and raise the attention of

the wide public towards kurgan protection. Due to the high interest both from the scientific community and civilians we received a huge amount of kurgan data. The database contains almost 4000 data records covering eight countries of continental Eurasia.

Publications: *Deák et al. 2019 Hacquetia*; *Bragina et al. 2019 Steppe Bulletin*; *Deák 2019 Kurgan Database dataset doi: 10.18426/obm.3mbbectm2bmg*

11, Further publications related to kurgans

We published a paper focusing on the biodiversity values of Bulgarian kurgans (*Apostolova et al. 2020 Annual of Sofia University*), we made a detailed field survey of the geomorphology, soil, flora and fauna of the Zsolca mounds acting as habitat islands (*Tóth et al. 2019 Hacquetia*), and further three book chapters related to the conservation and management of historical sites.

Short summary of publications related to the research topic.

We provided a global review on the biodiversity potential of sacred natural sites (*Löki et al. 2019 Global Ecology and Conservation*), we studied the effects of topography on plant biodiversity formed on mound like burrows of ecosystem engineer species (*Valkó et al. 2021 Journal of Arid Environments*), applicability of conservation and management practices in dry grassland habitats (*Valkó & Deák 2021 Current Opinion in Environmental Science & Health*, *Kovácsné Koncz et al. 2020 Applied Vegetation Science*, *Bátori et al. 2020 River Research and Applications*, *Bátori et al. Frontiers in Ecology and Evolution*, *Kiss et al. 2021 Journal of Vegetation Science*, *Labadessa et al. 2020 Tuexenia*, *Balogh et al. 2021 Tuexenia*), restoration possibilities of dry grasslands in human-transformed landscapes (*Valkó et al. 2021 Restoration Ecology*, *Kiss et al. 2021 Restoration Ecology*), the effect of management and attitude of local citizens on urban grasslands (*Fischer et al. 2020 Conservation Letters*, *Lampinen et al. 2021 Basic and Applied Ecology*), the landscape-scale effects of wooded habitats in arid regions (*Tölgyesi et al. 2020 Ecography*).

Conferences

The results of the research project have been presented in international and Hungarian conferences.

International conferences:

- 3rd Community Ecology Conference
- European Geosciences Union General Assembly
- Ecology Across Borders Conference
- Reproductive strategies from genes to societies – Frontiers in animal and plant reproduction research
- 19th European Carabidologists' Meeting
- 3rd International Conference on Island Ecology, Evolution & Conservation
- Eurasian Grassland Conference
- Conference of the European Archaeological Association
- Conference of the Ecological Society of Germany, Austria and Switzerland
- 'Fire in the Earth System' conference

Hungarian conferences:

- Magyar Ökológus Kongresszus
- Aktualitások a természet- és tájvédelem területén - Központban a kunhalmok védelme konferencia
- Táj és Tájat alakító ember - Kunhalmok ölelésében Konferencia
- VIII. Magyar Tájökológiai Konferencia
- 20. Kolozsvári Biológus Napok
- Növényi stratégiák és jellegek szerepe az ökológiai kutatásokban workshop
- Másodlagos és antropogén élőhelyek kutatása Workshop
- Leromlott élőhelyek gyepvetéssel történő helyreállítása workshop

Scientific activities connected to the project

- In the past five years the PI has been serving as a guest editor-in-chief and then a guest editor in the Special Features of the *Tuexenia* journal (the official journal of the Floristic Society of Germany). These Special Features focused on the conservation and restoration of dry grassland habitats in Central-Europe.
- The PI was co-organiser of two Hungarian conferences (in 2020 and 2021) that focused on the conservation, management and protection of kurgans.

Public outreach

- In order to effectively disseminate the knowledge gained from my researches to the scientific community and the whole society the PI maintains scientific blogs in Hungarian (<http://deakvalko.blogspot.com/>) and in English (<https://deakvalko.blogspot.com/>).
- The PI also actively disseminated the results of the research project in the public media and in public forums. During the project he gave several interviews in the radio, in the press and in internet journals. The PI frequently gave talks about the conservation importance of kurgans for the wide public in public forums organised by the Hortobágy and Körös-Maros National Park Directorates. The results of the kurgan studies were represented in lectures in Hungarian universities and also in the ecology seminar of the University of South Bohemia (České Budějovice). The PI was the main organiser of a whole-day-long multidisciplinary event for the wide public (with more than 1000 visitors) about the cultural, historical and conservation values of ancient burial mounds ('Kert a Kőbön', <https://botanikuskert.hu/kert-a-kobon-fesztival/>).

Open science: involvement of the wide society into kurgan protection

- The PI initiated an international database involving kurgan data from whole Eurasia (Eurasian Kurgan Database; <http://openbiomaps.org/projects/kurgan/>). As a part of the project, we provide open access data on kurgans for scientific research, governmental bodies and for the wide public.