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The application of filter-based assembly models in the restoration of sand grasslands (2018-2023)

NKFI FK 127996

Final report

Project aims

The aim of the present project was to integrate and scale up the local knowledge gained on sand grassland restoration in Hungary within the framework of filter-based assembly models in order to help the elaboration of a future national restoration strategy. We re-sampled previous restoration experiments (expansion in time), and local results were completed with landscape scale factors that might influence the outcome of restoration measures (expansion in space). We hypothesized that (1) regeneration potential was higher in landscapes with less intensive land use; (2) the dispersal filter represented a stronger constraint in landscapes with more intensive land use; (3) niche availability constraints were less important than dispersal limitation in oligotrophic systems; (4) the biotic filter became more relevant as the vegetation closes and in landscapes with high invasive pressure; (5) restoration success increased if targets are within the range of potential natural vegetation (PNV) types.

Personal and material conditions

The position of the researcher to be recruited has been filled with Edina Csákvári, whose main task was analyzing the regeneration capability of sand grasslands. In addition, a foreign Ph.D. student, Bruna Paolinelli Reis, at the ELTE Doctoral School of Biology, was involved in the project co-supervised by the principal investigator to analyze the long-term effect of restoration practices and landscape constraints in the restoration success of Pannonian grasslands. Another Ph.D. student, Nóra Sáradi, at the Doctoral School of Environmental Sciences, Szent István University, Gödöllő, from September 2019 analyzed the role of invasive species in the restoration of Pannonic sand steppes. Márton Vörös, at the ELTE Doctoral School of Biology, worked on the topic of restoration targets and multiple potential natural vegetation (MPNV). Four MSc students were also involved in the project. Zeynab Seyidova, at the ELTE Environmental Sciences, worked on Exp2, Belén Yesenia Llumiquinga, at the ELTE Environmental Sciences, on Exp3, Cseperke Anna Csonka on Exp5, and Emese Krpán on long-term impact of drought.

A laptop for the recruited researcher, an external data storage, and a camera for field documentation were purchased in the first year. We acquired the following background data for the studied locations: administrative and landscape regions, habitat maps, soil maps and data (Agrotopo), meteorological data (FORESEE, Kiskun LTER), map of invasive species (Fülöpháza). We obtained regeneration estimation for sand grassland habitats (G1, H5b, M5) and invasive pressure for all locations of sandy habitat and the natural capital data (NCI) for the same locations within Hungary from the MÉTA database, plus MPNV model predictions and background environmental data at the MÉTA hexagon level. We purchased the most recent aerial photos together with the digital terrain models for the 5 km ×5 km landscape windows for Fülöpháza, Izsák, Bugac (2019), and Nyíregyháza (2017). We also purchased a desktop PC, a CHC LT700H field tablet, and a Stemi 305 trino

Axiocam208 stereo microscope. All other facilities were provided by the Centre for Ecological Research.

We planned to resample five restoration experiments in this project. In the final design, one experiment was replaced by another, namely, the Exp. 4. Control of *Asclepias syriaca* in the restoration of fallow land (Szitár & Török 2008) was replaced by an experimental reintroduction site (Kövendi-Jakó et al. 2021).

We got all the necessary permissions for vegetation and soil surveys in protected areas.

Field sampling

We successfully completed the re-sampling of five experiments following the original sampling protocols to obtain long-term data. All sites and plots were marked for long-term monitoring together with GPS data recorded and photo documentation.

We have sampled the main habitat types (primary grassland, secondary grassland, plantation, arable land, and native forest) within the 500 m radius landscape buffer around each experimental site. Plus, we performed a detailed census for invasive alien species along 8× 100 m transects around each site. We also made some field visits to estimate restoration success related to shrub control in the Kiskunság National Park related to the MPNV-restoration target selection topic. We won a grant (ELKH SA-66/2021) to do some additional samplings in other seed introduction experiments carried out by other experts within the Kiskunság National Park, where we estimated the success of restoration interventions compared to control and the composition of the surrounding landscape.

Main results

Regeneration potential

We investigated the spatial regeneration trajectories of open and closed steppe and Poplar-juniper sand dune forests and thickets based on local, neighboring, and old-field regeneration capacity estimates of the Hungarian Habitat Mapping Database (MÉTA) for the whole country. The most vulnerable type of vegetation was closed grasslands, where spontaneous recovery was the most limited (Csákvári et al. 2019). We estimated the impact of environmental factors (naturalness, abiotic factors, and land cover) in determining the regeneration success. Our results confirm that better restoration results can be achieved in the vicinity of larger (semi-)natural areas, but the specific site conditions must also be taken into account during prioritization, e.g., seasonality of the local precipitation and the sand content of the soil (Csákvári et al. 2021). We used this knowledge together with analyzing spatial regeneration trajectories (the comparison between regeneration locally, at neighboring sites, and on abandoned old-fields) to prioritize restoration efforts for these vegetation types (Csákvári et al. 2022). Country-wide GIS-based spatial regeneration maps of sandy habitats were finalized and published. The final results were built in a decision-supporting system that can localize and determine the extent of priority areas for sand grassland restoration based on Multiple Potential Natural Vegetation models and abiotic and biotic conditions. The decision support system was tested for the Danube-Tisza Interfluve.

Dispersal filter

We have found that the dispersal is a strong filter for the spontaneous recovery of sand grasslands on degraded land. Without introducing target species, restoration efforts (e.g., mowing or carbon amendment only) might fail to achieve long-term success, depending on the availability of propagules of target and invasive species in the landscape (Halassy et al. 2019, 2021, Reis et al. 2021). Tree plantations of non-native species were found to be the main source of invasion, and secondary grasslands developed after cropland abandonment could be both sources of target and invasive species (Reis et al. 2022). Distance to primary grasslands or the estimated amount of target propagules did not have any significant impact on restoration progress, but the higher abundance of invasive species in the 500 m landscape buffer and the proximity to tree plantations had a significant negative effect (Reis et al. 2022). Within a shorter distance (100 m) from the restoration sites, invasive pressure affected the abundance of perennial invasive species interacting with time, but no distance-related effect on invasion was found (Sáradi et al. under review). The fact that seeding was found to be the best method for restoring sand grassland (Llumiquinga et al. 2021, Reis et al. 2022, 2023) also shows that dispersal has a key role to play in the assembly processes in the studied system. We delineated and tested possible seed transfer zones for restoration purposes (Cevallos et al. 2020, 2021).

Abiotic filter

We found that abiotic environmental conditions also play an important role in the regeneration of sand grasslands. With climate change, increasing temperatures and more frequent summer droughts can be expected that can severely affect restoration efforts. Drought in the year of sowing can result in weak seedling establishment (Kövendi-Jakó et al. 2021). Droughts also lead to shifts in vegetation composition during long-term vegetation development, indirectly promoting the dominance of invasive species over target species, because invasive plants seem to better recover after drought events (Krpán 2023). Soil properties remained similar in the long term. The manipulation of soil available nitrogen by carbon amendment was of limited importance for the restoration success, resulting in lower cover of vascular plants and cryptogams compared to control, but no differences were found for target or invasive alien species (Halassy et al. 2021) or species of different nitrogen requirements (Seyidova 2020).

Biotic filter

Long-term vegetation development trajectories show that restoration sites approach reference conditions, but do not reach full success in 10–25 years. This is due to the fact that although the cover of target species increases with time, the cover of invasive species can also increase depending on the studied restorative treatments and the landscape context. This is primarily due to an increase in the cover of perennial invasive species (mostly *Asclepias syriaca*), while the cover of annual invasive species (dominantly *Ambrosia artemisiifolia, Conyza canadensis*) generally decrease with time (Sáradi et al. under review). Restorative methods that keep the vegetation open, like carbon amendment and, even more so, mowing, create windows for colonization, but the new sites can be occupied by invasive species if they are present in the landscape (Halassy et al. 2019, 2021, Reis et al 2021). Introducing target species reduces the availability of recruitment niches and besides increasing target cover, increases the resistance of restoration to invasion (Llumiquinga et al. 2021, Reis et al. 2022, 2023). The introduction of native species can be implemented through the transfer

of commercially available species, species collected in the wild or hay with varying success in terms of vegetation cover and diversity (Kövendi-Jakó et al. 2019) or planting in the case of woody species (Halassy et al. 2020). Seeds from ex situ seed banks can also be used for the establishment of sand grassland species, as they maintain their viability in the short term as an adaptation to the local arid environment (Kövendi-Jakó et al. 2021).

Restoration target

We collected restoration interventions at a national level between 2002 and 2016 and evaluated the achievements regarding Aichi Target 15 (Török et al. 2019). We used this dataset with some additional new projects to investigate the relationship between the necessary post-treatment intensity of grasslands restored by shrub removal and the range of potential local native vegetation types according to the Multiple Potential Natural Vegetation (MPNV) model's predictions. We confirmed the utility of MPNV in defining sites that have low potential for grasslands, while high potential for forests and thus are likely to require continuous management and thus continuous human and financial efforts after grassland restoration. We propose MPNV to be used to set local restoration targets and estimate associated maintenance needs, and to identify self-sustainable restoration targets in general. The related manuscript (Vörös et al.) is under review in Restoration Ecology (D1 journal).

Implications for practice

Based on our results, we propose large-scale grassland restoration on abandoned agricultural fields as a cost-effective and sustainable restoration target, where present in the range of potential natural vegetation, instead of industrial tree plantations and afforestation with non-native species.

Multiple potential natural vegetation models can help to focus the spatial prioritization of grassland restoration over forest restoration at the national scale by detecting areas with high grassland and low forest potentiality where restoration of open habitats is more feasible and sustainable. It can also be used to set local restoration targets and estimate maintenance needs.

Regeneration potential estimates (or the environmental factors that correlate well with regeneration capacity) help optimize the spatial allocation of restorative interventions. The type of suggested restoration interventions can be also prioritized based on the spatial regeneration trajectories.

Priority should be given to locations with good regeneration capacity where passive restoration can be used. The presence of large remnants of (semi-) native vegetation indicates better regeneration and lower restoration (intervention) intensity, while the presence and proximity of non-native tree plantations are threats to recovery and should be either avoided or managed with high-intensity interventions.

In fragmented landscapes, the best method for restoring sand grasslands is the introduction of target species that boosts the establishment of target species and controls non-native invasion. Sowing commercially available species, harvested species, including seeds stored in an ex situ seed bank, hay transfer, or planting are equally well suited for this purpose. The creation of small species introduction units, also referred to as “establishment windows” from where the species can spread to the whole site can be applied as a cheaper solution for large-scale restoration. It is recommended to use multi-year, scheduled seeding to reduce the negative impacts of particularly dry years.

Where existing vegetation limits the restoration of sand grassland, low-intensity mowing or grazing should be applied, especially to control woody encroachment – involving non-native species, e.g., *Robinia pseudoacacia* – and to open up space for colonization. The new spaces can be occupied also by invasive species; therefore, we suggest applying mowing (grazing) in combination with other treatments, e.g., the introduction of target species or targeted control of invasive species.

Carbon amendment can be used right after the abandonment of arable cultivation to temporarily reduce soil available nitrogen and keep the vegetation open in order to supplement seeding, but only on the small scale and especially when N fertilizers were previously applied causing high nutrient levels in the soil. Once the vegetation established, applications should be ceased.

Restorative treatments can have the highest influence on the success of sand grassland restoration, exceeding the impact of landscape factors and time. Targeting the dispersal, abiotic, and biotic filters in parallel would improve the effectiveness of restoration.

Publications

We published 14 (6 D1) papers on the project topic and 6 (3 D1) related publications with the grant number indicated and 6 Hungarian papers to inform local managers and 38 (30 oral) conference presentations.

Publications on project results in English

2023

Reis, B. P., Kövendi-Jakó, A., Csákvári, E., Szitár, K., Török, K., Sáradi, N., ... & Halassy, M. (2023). Early sowing is more effective in the long-term for restoring sandy grassland than six years of mowing or carbon amendment. Ecological Engineering, 186, 106824. https://authors.elsevier.com/sd/article/S0925857422002853 IF: 4.379 Q1

2022

Csákvári, E., Molnár, Z., & Halassy, M. (2022). Estimates of regeneration potential in the Pannonian sand region help prioritize ecological restoration interventions. Communications biology, 5(1), 1-11. https://www.nature.com/articles/s42003-022-04047-8 IF(2021): 6.268 D1

Reis, B. P., Szitár, K., Kövendi-Jakó, A., Török, K., Sáradi, N., Csákvári, E., & Halassy, M. (2022). The long-term effect of initial restoration intervention, landscape composition, and time on the progress of Pannonic sand grassland restoration. Landscape and Ecological Engineering, 18: 429–440. https://doi.org/10.1007/s11355-022-00512-y IF(2021): 2.147 Q2

2021

Cevallos, D., Szitar, K., Halassy, M., Kövendi-Jakó, A., & Török, K. (2021). Does seed trait variability support preliminary seed transfer zones for Hungary? Applied Ecology and Environmental Research, 19(5), 4129-4149. http://dx.doi.org/10.15666/aeer/1905_41294149 IF(2021): 0.858 Q3

Csákvári, E., Bede-Fazekas, Á., Horváth, F., Molnár, Z., & Halassy, M. (2021). Do environmental predictors affect the regeneration capacity of sandy habitats? A country-wide survey from Hungary. Global Ecology and Conservation, 27, e01547. https://doi.org/10.1016/j.gecco.2021.e01547 IF(2021): 4,159 Q1

Halassy, M., Kövendi-Jakó, A., Reis, B., Szitár, K., Seyidova, Z., & Török, K. (2021) N immobilization treatment revisited: a retarded and temporary effect unfolded in old field restoration. Applied Vegetation Science, 24:e12555. https://doi.org/10.1111/avsc.12555 IF (2021): 3.73 Q1

Kövendi-Jakó, A., Szitár, K., Halassy, M., Halász, K., Mojzes, A., & Török, K. 2021. Effect of seed storing duration and sowing year on the seedling establishment of grassland species in xeric environments. Restoration Ecology Vol. 29, No. S1, e13209 https://doi.org/10.1111/rec.13209 IF(2021): 4.181 D1

Llumiquinga, Y. B., Reis, B. P., Sáradi, N., Török, K., Szitár, K., & Halassy, M. (2021). Long-term results of initial seeding, mowing and carbon amendment of the restoration of Pannonian sand grassland on old-fields. Tuexenia, 41, 361-379. https://www.tuexenia.de/publications/tuexenia/Tuexenia_2021_NS_041_0361-0379.pdf IF(2021): 1.116 Q3

Reis, B. P., Kövendi-Jakó, A., Szitár, K., Török, K., & Halassy, M. 2021. Long-term effect of mowing on the restoration of Pannonian sand grassland to replace invasive black locust plantation. Restoration Ecology Vol. 29, No. S1, e13152 https://doi.org/10.1111/rec.13152 IF(2021): 4.181 D1

2020

Cevallos, D., Bede-Fazekas, Á., Tanács, E., Szitár, K., Halassy, M., Kövendi-Jakó, A., & Török, K. (2020). Seed transfer zones based on environmental variables better reflect variability in vegetation than administrative units: evidence from Hungary. Restoration Ecology 28, 911–918. https://doi.org/10.1111/rec.13150 IF(2020): 3.25 D1

Halassy, M., Csecserits, A., Kovacsics-Vári, G., Kövendi-Jakó, A., Reis, B. P., & Török, K. (2020). First year woody survival supports feasibility of forest-steppe reconstruction as an alternative to landscaping in industrial areas. Ecological Engineering, 158, 106050. https://doi.org/10.1016/j.ecoleng.2020.106050 IF (2020): 3.924 Q1

2019

Halassy, M., Botta-Dukát,Z., Csecserits, A., Szitár, K., Török, K. 2019. Trait-based approach confirms the importance of propagule limitation and assembly rules in old-field restoration. Restoration Ecology 27:840-849. https://doi.org/10.1111/rec.12929 IF(2019): 2.894 D1

Kövendi-Jakó, A., Halassy, M., Csecserits, A., Hülber, K., Szitár, K., Wrbka, T., Török, K. 2019. Three years of vegetation development worth 30 years of secondary succession in urban-industrial grassland restoration Applied Vegetation Science 22(1),138-149. (2019) https://doi.org/10.1111/avsc.12410 IF (2019): 2.820 Q1

Török, K., Horváth, F., Kövendi-Jakó, A., Halassy, M., Bölöni, J., Szitár, K. 2019. Meeting Aichi Target 15: Efforts and further needs of ecological restoration in Hungary, Biological Conservation, Volume 235, Pages 128-135. https://doi.org/10.1016/j.biocon.2019.04.020 IF(2019): 4.711 D1

Co-authorships on other topics (with grant number indicated) in English

2023

Berki, B., Botta-Dukát, Z., Csákvári, E., Gyalus, A., Halassy, M., Mártonffy, A., ... & Csecserits, A. 2023.Short-term effects of the control of the invasive plant Asclepias syriaca: secondary invasion of other neophytes instead of the recovery of native species. Applied Vegetation Science, e12707. https://doi.org/10.1111/avsc.12707 IF(2022): 3.252 Q1

2022

Szitár, K., Deák, B., Halassy, M., Steffen, C., & Batáry, P. (2022). Combination of organic farming and flower strips in agricultural landscapes–A feasible method to maximise functional diversity of plant traits related to pollination. Global Ecology and Conservation, 38, e02229. https://doi.org/10.1016/j.gecco.2022.e02229 IF(2021): 4,159 Q1

2021

Csákvári, E., Halassy, M., Enyedi, A., Gyulai, F., & Berke, J. (2021). Is Einkorn Wheat (Triticum monococcum L.) a Better Choice than Winter Wheat (Triticum aestivum L.)? Wheat Quality Estimation for Sustainable Agriculture Using Vision-Based Digital Image Analysis. Sustainability, 13(21), 12005. https://doi.org/10.3390/su132112005 IF(2021): 4.166 Q2

Csecserits, A., Halassy, M., Lhotsky, B., Rédei, T., Somay, L., & Botta-Dukát, Z. (2021). Changing assembly rules during secondary succession: evidence for non-random patterns. Basic and Applied Ecology, 52, 46-56. https://doi.org/10.1016/j.baae.2021.02.009 IF(2021): 3.579 D1

2020

Pilotto, F., Kühn, I., Adrian, R., Alber, R., Alignier, A., Andrews, C., ... & Haase, P. (2020). Meta-analysis of multidecadal biodiversity trends in Europe. Nat. Commun., 11, 3486. https://doi.org/10.1038/s41467-020-17171-y IF(2020): 13.038 D1

2019

Reis, B. P., Martins, S. V., Fernandes Filho, E. I., Sarcinelli, T. S., Gleriani, J. M., Marcatti, G. E., ... & Halassy, M. 2019. Management recommendation generation for areas under forest restoration process through images obtained by UAV and LiDAR. Remote Sensing, 11(13), 1508. https://doi.org/10.3390/rs11131508 IF (2019): 4.509 D1

Conference presentations in English

2022

Csonka, Cs. A.; Török, K., Halassy, M. 2022. Costs and benefits of grassland reconstruction as an alternative to landscaping in industrial areas. 6th European Congress of Conservation Biology. August 22–26, 2022, Prague, Czech Republic (oral)

Reis, B.P., Szitár, K., Kövendi-Jakó, A., Török, K., Sáradi, N., Csákvári E., Halassy, M. 2022. The long-term effect of restoration practices and landscape composition on the success of sand grasslands restoration. 13th SERE Conference, 3-9 Sept 2022, Alicante, Spain. Abstracts Book. p.172. (oral)

Csákvári, E., Molnár, Zs., Halassy, M. 2022. Application of regeneration potential trajectories to prioritize ecological restoration interventions in the Hungarian sand regions. 13th SERE Conference, 3-9 Sept 2022, Alicante, Spain. Abstracts Book. p.176. (oral)

Halassy, M., Csonka, Cs. A., Török, K. 2022. Costs and benefits of grassland reconstruction in an industrial area. 13th SERE Conference, 3-9 Sept 2022, Alicante, Spain. Abstracts Book. p.178. (oral)

Vörös, M., Halassy, M., Gyalus, A., Schmotzer, A., Deák, B., Valkó, O., Bede-Fazekas, Á., Crecco L., Somodi, I. (2022). Post-treatment intensity of restored grasslands depends on the potential natural vegetation distribution of the location. International PhD Meeting in Botany 2022. 22-25th September, Poroszló, Hungary (oral).

Reis, B. P., Török, K., Nune,s A., Branquinho, C. & Halassy, M. (2022). Ecological restoration within eLTER community: the results of a questionnaire. Oral presentation in the ILTER Scientific Conference 2022. 12-14th October, Novi Sad, Serbia. (oral online) pp. 24. https://api.biosens.rs/wp-content/uploads/2022/08/ILTER-abstract-book-2.pdf

2021

Csákvári, E., Horváth, F., Molnár, Zs., Halassy, M. 2021. The connection between environmental predictors and regeneration capacity of sandy habitats in Hungary. 6th FORUM CARPATICUM, 21st June to 25th June, 2021, Brno, Czech Republic. Book of Abstracts p. 102. (poster)

Csonka, A.Cs., Török, K. Halassy, M. 2021. Costs and benefits of grassland reconstruction as an alternative to landscaping in industrial areas – a case study from Hungary. International Expert Workshop "Economic Aspects of Nature Restoration", 13 – 16 October 2021, Isle of Vilm, Germany. (oral)

Halassy, M., Reis, B.P., Török, K. 2021. The long-term effect of restoration interventions and the impact of landscape context on the restoration of Pannonic sand grasslands. 9th World Conference on Ecological Restoration, JUNE 21-24 | 2021. Program and Abstracts Book p. 371. (oral)

Halassy, M., Török, K. 2021. Long-term monitoring and evaluation of restoration experiments in Kiskun LTER, Hungary. 12th European Conference on Ecological Restoration SERE2021, September 7 and 10 2021, online. Abstracts Book. p. 216. (oral)

Reis, B.P., Kövendi-Jakó, A., Szitár, K., Török, K., Halassy, M. 2021. Restoration of sand grasslands to replace invasive black locust plantation: effects of long-term mowing. 12th European Conference on Ecological Restoration SERE2021, September 7 and 10 2021, online. Absctracts Book. p. 79. (oral)

2020

Csákvári, E., Bede-Fazekas, Á., Horváth, F., Molnár, Zs., Halassy, M. 2020. The connection between environmental predictors and regeneration capacity of sandy habitats in Hungary. 6th Student Conference on Conservation Science, 25 – 29 August 2020, Tihany, Hungary, Book of Abstracts, p. 12. (oral)

Reis, B.P. 2020. Restoration of sand grasslands to replace invasive Robinia pseudo-acacia plantation: effects of long-term mowing. 6th Student Conference on Conservation Science, 25 – 29 August 2020, Tihany, Hungary, Book of Abstracts, p. 24. (oral)

Sáradi, N., Reis, B. P. , Szitár, K., Csákvári, E., Török, K., Halassy, M. (2020): The appearance and spread of invasive species during the restoration of Pannonic sand steppes. 6th Student Conference on Conservation Science, 25 – 29 August 2020, Tihany, Hungary, Book of Abstracts, p. 26. (oral)

2019

Halassy, M., Csecserits, A., Kovacsics-Vári, G., Kövendi-Jakó, A., Török, K. 2019. Forest steppe reconstruction as an alternative to landscaping in industrial areas. 15th EEF, Lisbon, Portugal, 29 July-2 Aug 2019, Book of abstracts. p. 420. (oral)

Kövendi-Jakó, A., Halassy, M., Csecserits, A., Szitár, K., Halász, K., Török, K. 2019. Restoration of native grasslands at urban-industrial sites - a great opportunity for biodiversity conservation. IAVS 62nd Annual Symposium, Bremen, Germany, 14-19 July 2019 (oral)

Reis, B.P., Kövendi-Jakó, A., Szitár, K., Török, K., Halassy, M. 2019. Long-term effect of management to replace invasive tree plantations with Pannonian sand grassland. 15th EEF, Lisbon, Portugal, 29 July-2 Aug 2019, Book of abstracts. p. 421. (oral)

Somodi, I., Konrád, K. D., Bede-Fazekas, Á. 2019. Grassland restoration – how can multiple potential natural vegetation (MPNV) estimations contribute? 16th Eurasian Grassland Conference, 2019-05-29, Graz, Austria, Abstract, p. 46. (oral)

2018

Halassy, M., Reis, B.P., Kövendi-Jakó, A., Török, K. 2018. Long-term effect of climate on the restoration success of Pannonian sand grassland, SERE 2018, SERE 2018, 9-13 Sept 2018, Reykjavík, Iceland, Abstract Book, p. 30. (oral)

Reis, B.P., Kövendi-Jakó, A., Szitár, K., Török, K., Halassy, M. 2018. Long-term effect of management on the restoration success of Pannonian sand steppe on previous Robinia pseudo-acacia plantation. 8th Meeting of PhD students in Plant Ecology and Botany, 26-28 October 2018, Telč, Czech Republic. (oral)

Reis, B.P., Kövendi-Jakó, A., Szitár, K., Török, K., Halassy, M. 2018. Long-term effect of mowing on the restoration success of Pannonian sand steppe at clear-cut Robinia pseudo-acacia plantation. Student Conference in Conservation Science (SCCS) Europe, 4 - 8 September 2018, Tihany (Lake Balaton), Hungary. (oral)

Török, K. Bölöni, J., Horváth, F., Kövendi-Jakó, A., Halassy, M., Szitár, K. 2018. Meeting Aichi Target 15: Efforts and further needs of ecological restoration in Hungary. SERE 2018, 9-13 Sept 2018, Reykjavík, Iceland, Abstract Book, p. 11. (oral)

Posters in English

Csákvári et al. 2021. The connection between environmental predictors and regeneration capacity of sandy habitats in Hungary. 6th FORUM CARPATICUM – Linking the Environmental, Political

and Societal Aspects for Carpathian Sustainability. 21-25 June 2021, Brno, Czech Republic. Book of Abstracts p. 102. (poster)

Kövendi-Jakó, A., Szitár, K., Halász, K., Mojzes, A., Halassy, M., Török, K. 2018. Seed banks as sources for reintroduction of species: a case study in the Pannonian ecoregion. SERE 2018, 9-13 Sept 2018, Reykjavík, Iceland, Abstract Book, p. 109. (poster)

Reis, P.R., Kövendi-Jakó, A., Szitár, K., Török, K., Halassy, M. 2019. Long-term effect of mowing on the restoration success of Pannonic sand steppe at clear-cut Robinia pseudo-acacia plantation. IAVS 62nd Annual Symposium, Bremen, Germany, 14-19 July 2019 (poster)

Sáradi, N., Reis, B.P., Llumiquinga, Y.B., Szitár, K., Csákvári, E., Kövendi-Jakó, A., Török, K., Halassy, M. 2021. Long-term changes in the abundance of invasive alien plant species during the restoration of Pannonic sand steppes. 9th World Conference on Ecological Restoration, JUNE 21-24 | 2021. Program and Abstracts Book p. 651. (poster)

Sáradi, N., Reis, B.P., Szitár, K., Török, K., Csákvári E., Halassy, M. 2022. Impact of landscape-scale invasion level on sand grassland restoration. 13th SERE Conference, 3-9 Sept 2022, Alicante, Spain. Abstracts Book. p. 309. (poster)

Hungarian publications

Csákvári, E., Horváth, F., Molnár, Zs., Halassy, M. 2019. Homoki élőhelyek regenerációs képességének országos szintű vizsgálata. In: Fazekas István, Lázár István (eds). Tájak működése és szerkezete. Debrecen, pp 231-236.

Csecserits, A., Halassy, M., Rédei, T., Szitár, K., & Botta-Dukát, Z. (2020). A selyemkóró (Asclepias syriaca L.) tömegességének változásai homoki parlagokon szukcesszió és természetvédelmi kezelés hatására. Természetvédelmi Közlemények, 26, 1-15. https://doi.org/10.20332/tvk-jnatconserv.2020.26.1

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Conference presentations in Hungarian

Csákvári, E., Halassy, M. 2022. Prioritizing habitat restoration methods based on regeneration potential of Pannonian sand grasslands. TDK Talent Day, 25 February 2022, MATE, Gödöllő, Hungary (oral)

Csákvári, E., Bede-Fazekas, Á., Horváth, F., Molnár, Zs., Halassy, M. 2021. Assessment of the regeneration potential of Pannonian sand habitats in the landscape environment. 21st Biology Days in Cluj-Napoca. Cluj-Napoca 16 - 17 April 2021. Book of Abstracts, p. 20. (oral)

Gyalus, A., Halassy, M., Vörös, M., Somodi, I. 2021. The need for shrub removal for maintaining grasslands and the potential of natural vegetation. 21st Biology Days in Cluj-Napoca. Cluj-Napoca 16 - 17 April 2021. Book of Abstracts, p. 29. (oral)

Halassy, M., Szitár, K., Török, K. 2019. Seeding, mowing and carbon amendment in old-field restoration. Restoration of degraded habitats by sowing grassland, 7 March 2019, KNP, Hungary (oral)

Kövendi-Jakó, A., Csecserits, A., Halassy, M., Szitár, K., Hülber, K., Wrbka, T., Török, K. 2019. The use of seeding and haying in large-scale sand grassland restoration. Restoration of degraded habitats by sowing grassland, 7 March 2019, KNP, Hungary (oral)

Kövendi-Jakó, A., Szitár, K., Halász, K., Mojzes, A., Halassy, M., Török, K. 2019. The role of seed storage in dry grassland restoration 20th Kolozsvár Biological Days, 12-14 April 2019, Cluj-Napoca, Rumania (oral)

Sáradi, N., Llumiquinga, Y.B., Reis, B.P., Török, K., Szitár, K., Csákvári, E., Halassy, M. 2021. Long-term effects of initial seeding, mowing and carbon source application in the restoration of abandoned fields of sand grassland. 21st Biology Days in Cluj-Napoca. 16 - 17 April 2021. Cluj-Napoca, Rumania. Book of Abstracts, p. 53. (oral)

Vörös., M., Halassy, M., Gyalus, A., Schmotzer, A., Deák,B., Valkó, O., Bede-Fazekas, Á., Crecco, L., Somodi, I. 2022. Relationship between post-treatment intensity of grassland restored by shrub clearance and the distribution of potential natural vegetation. 7th Symposium on Quantitative Ecology, 26 April 2022, Vácrátót, Hungary (oral)

Posters in Hungarian

Halassy, M., Csecserits, A., Csonka, Cs., Kövendi-Jakó, A., Török, K. 2022. Grassing with native species - a more sustainable landscaping option? XIII Hungarian Conference on Conservation Biology. "Climate change: trends, threats and solutions" 28-31 August 2022, Pécs, Hungary (poster)

Reis, B.P., Szitár, K., Kövendi-Jakó, A., Török, K., Sáradi, N., Csákvári, E., Halassy, M. 2021. The impact of intervention type, surrounding landscape and time on the restoration success of sand grasslands. 12th Hungarian Ecology Congress, 24-26 August 2021, Vác, Hungary, Abstract Book, p. 190. (poster)

Vörös, M., Somodi, I., Halassy, M. How can the success of restoration be measured? 12th Hungarian Ecology Congress, 24-26 August 2021, Vác, Hungary, Abstract Book, p. 218. (poster)

Other activities

Seminar/webinar lectures

Halassy M. 2021. State of Ecological Restoration in Hungary. SERE Webinar series, 10.03.2021. online

Halassy, M. 2021. The long-term effect of restoration interventions and the impact of landscape context on the restoration of Pannonic sand grasslands. ÖBI Seminar 28 Jan 2021, Vácrátót, Hungary. online

Reis B.P., Kövendi-Jakó A., Szitár K., Török K., Halassy M. 2019. Long-term effect of mowing on the restoration of Pannonian sand grassland to replace invasive black locust plantation. Öbi Seminar, 7 November 2019, Vácrátót, Hungary.

Halassy, M. 2018. The application of filter-based assembly models in the restoration of sand grasslands (2018-2022) Öbi Seminar, 4 Oct 2018, Vácrátót, Hungary.

Workshops organized

Somodi I., Vörös M., Halassy M. "Hogyan mérhető a restauráció sikeressége?/How to measure the success of restoration?" XIII. Actual Flora and Vegetation Research in the Carpathian Basin conference, 11-14 November 2021.

Halassy, M. What can we learn from eLTER on long-term monitoring and evaluation of restoration interventions? 12th European Conference on Ecological Restoration, August 31 and September 4 2021, Alicante, Spain (online)

Students related to the project

MSc

Krpán Emese (2023) Effect of drought on the restoration of open sand grasslands based on long-term observations. MSc thesis. UMEA, Sweden

Cseperke Csonka (2022) Cost-benefit analysis of ecological restoration in the LEGO factory in Nyírség. MSc thesis. ELTE

Zeynab Seyidova (2020) Long-term evaluation of Pannonian sand grassland restoration on fallow land with soil N immobilization. MSc thesis. ELTE

Belén Yesenia Llumiquinga (2020) Long-term impact of seeding, mowing and carbon amendment in the restoration of Pannonian sand grassland on fallow land. MSc thesis. ELTE

PhD

Bruna Paolinelli Reis (2021) The long-term effect of restoration practices and landscape composition in the restoration success of Pannonian grasslands. PhD thesis. ELTE, Doctoral School of Biology Ecology, Conservation Biology and Systematics Programme (summa cum laude)

Nóra Sáradi. The role of invasive species in the restoration of Pannonian sand steppes. SZIE Doctoral School of Environmental Sciences. (2019/09-2023/08) Thesis expected in2024

Márton Vörös. Applicability of a multiple potential natural vegetation model in the selection of ecological restoration targets. ELTE Doctoral School of Biology. (2020/09-2024/08) Thesis expected in 2025

Grants awarded in relation to the project

2022-2023 The effect of landscape factors on grasslands restoration (ELKH SA-66/2021)

Collaborations

Development of the Hungarian Green Infrastructure (KEHOP-4.3.0-VEKOP-15-2016-00001, KEHOP-4.3.0-VEKOP-15-2021-00002).

eLTER H2020 projects (H2020-INFRAIA-2019-1, 871126 and 871128)

Visiting scientist, Lorenzo Crecco, Italy (Erasmus program).

Actions taken for practitioners

To help develop best practice in restoration in Hungary, we have had the Society for Ecological Restoration's (Gann et al. 2019) International Principles and Standards for the Practice of Ecological Restoration translated into Hungarian for open access publication.

We prepared regeneration capacity maps of sandy habitats (open sand steppes, closed sand steppes and aspen-shrub sand steppe and thickets) for Hungary, published them in Hungarian (Csákvári et al. 2019).

Based on our results, we have created a decision support system that can locate and determine the extent of priority areas for sand grassland restoration in the Danube-Tisza Interfluve.

We made these information available through our website: https://www.restoration-ecology.hu