

Csecserits, Anikó

Impact of establishment, spreading, and management of invasive plant species in semi-natural and regenerating habitats (2018-2023), FK-NKFIH 128465

Final report

Project aims

The aim of the present proposal was to study the long-term spread of invasive plant species, to study the effect of these species on ecosystems and to study the effectiveness of mechanical management of a perennial invasive herb. We established a field experiment, where we can compare non-invaded plots with invaded and invaded, but managed plots and study the changes in several ecosystem attributes (Task 1). In order to study the establishment, spread and effect of invasive alien species regionally we repeated a large-scale survey of primary and secondary grasslands (Task 2.) Besides these we continued small-scale long-term monitoring of secondary grasslands, thus we can follow both the population changes of invasive species and the efficiency of single herbicide treatment of invasive species in long-term. Our focal invasive species was the common milkweed (*Asclepias syriaca*; from here on: *Asclepias*), however, we studied also generally the presence and spread of other alien species, too.

The hypotheses of the research were the following: 1) The effect of an invasive plant species is density-dependent and can be detected on different levels: on plant species, plant communities and ecosystem properties. 2) The effect of invasive species can be explained and is mediated by changes in abiotic environment like soil attributes (e.g. nutrient content) or light conditions. 3) The spreading of an invasive species results in the decrease of indigenous species abundance, changes in composition and functional diversity. 4) Decreasing the abundance of invasive species by management results in the increase (spreading) of other, probably indigenous species, altering the species composition, functional diversity and ecosystem properties.

We test the 1-4 hypotheses by manipulating the population density of invasive species in a plant community (Task 1) and by collecting observational data from a) long-term, large scale studies (Task 2) and b) monitoring nature conservation management aiming at reducing invasive species (Task 3)

Personal and material conditions

There was budget for the full-time employment of the PI, but the project did not allow other full or part-time research employment. Two senior researchers, Melinda Halassy and Katalin Sztár, worked on the planning, data sampling, and analysis of results. A PhD student, Boglárka Berki, joined the project. Her main PhD topic was connected to the field experiment dealing with the effects of *Asclepias* (Task 1). However, she also participated in Tasks 2 and 3, both during the fieldwork, data processing, and analysis.

Besides these, during the preparation stage, field samplings and data recording, several students and young researchers joined the project: Ágnes Árvai, Anna Fruzsina Nagy, András Mártonffy, Adrienn Gyalus, Edina Csákvári and Amina Lkhagvasuren. Lkhagvasuren wrote her MSc thesis at ELTE University about Task 2, about the changes in invasion level, especially changes of *Asclepias* abundance at a landscape scale in grasslands and old fields (Lkhagvasuren 2023). At the end of the project, Sebastian Ospina helped us in Tasks 1 and 2. He wrote his MSc Thesis about the spreading pattern of new invasive species in Kiskunság (Ospina 2023). In 2023, Ádám Ruprecht joined the project, and he will use in his MSc Thesis the data of Task 3.

We took the help of labour assistance, especially for the work of Task 1.

We purchased the most recent aerial photos together with the digital terrain models for the 5 km × 5 km landscape windows for Fülöpháza in order to select the sampling sites for Task 1. The largest purchase of the project was the order of soil sample analysis at the start and after three years of field experiments (Task 1). Contrary to the plans, we did not purchase soil temperature or water content measuring equipment because of the difficulties of purchase, and the more expensive price offer.

The Centre for Ecological Research provided all other facilities. We got all the necessary permissions for vegetation and soil surveys in the protected areas.

Field sampling

We completed all field samplings of all planned Tasks. In Task 1, we selected ten old-fields, where we established, repeatedly managed, and monitored the field experiment of *Asclepias* management from May of 2019 till September of 2023. *Asclepias* management was done twice a year: one cutting at the end of June and one cutting at the end of July; and plots were sampled twice a year: once in June, before the management, and once in September, after the management. As we plan the pursuit of management and monitoring, we confirmed the signs of the field experiment during the last survey.

We conducted the revisiting and resurvey of the grasslands and old fields planned in Task 2 during the first three field seasons. We visited 242 sites, but we could resample only 161 plots, as some of the sites were used again as arable land or became inaccessible. We conducted the planned resampling of Task 3 in old-fields of Fülöpháza twice: in 2020 and in 2023. The resampling of 2023 was conducted with the help of a MSc student, Ádám Ruprecht, and the topic of his thesis will be not only the long-term changes of old-fields but also the effect of the extreme drought of 2022.

We have asked for a prolongation of the project due to the difficulties connected to the COVID-19 epidemic. This prolongation helped us to continue the field experiment of Task 1, which has already become a long-term experiment with particular results.

Main results

Task 1. Field experiment on *Asclepias syriaca*

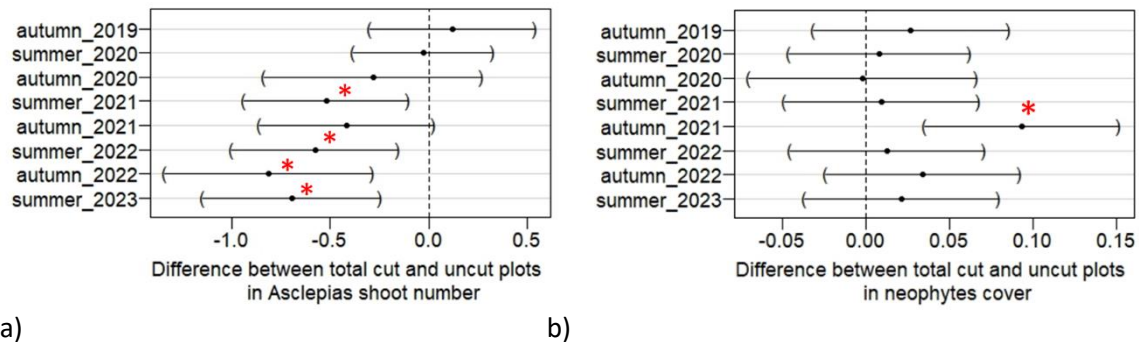
We conducted a field experiment started in May 2019 on the selected ten old fields, so this was the fifth year of the treatment. To our knowledge, there is no such documented, long-term experiment related to *Asclepias*. Moreover, there is a lack of long-term experiments or monitoring connected to invasive species, especially to perennial invasive species in the world, thus our experiment fills a knowledge gap on this topic. We plan to continue this in collaboration with two other projects [2, 5].

We studied the effect of *Asclepias* on the abiotic conditions, plant individuals, and plant communities. At the start of the experiment, we could compare the invaded and non-invaded communities. We found that there was no difference in the main soil attributes between the invaded and non-invaded communities (Berki et al. 2023). However, there was a difference in light conditions: in invaded communities, during the summer, there was less light on the soil surface, which can have an effect on the other plant species. Moreover, there were more sandy specialists in non-invaded plots than in invaded plots.

As a consequence of treatment, both the cover, shoot number, and pod number of *Asclepias* decreased, although only after a few years of treatment (Fig 1a). After three years of management, there was an increase in the cover of other neophyte species in the managed plots (Berki et al., 2023, Fig 1b), which can be a sign of secondary invasion. However the increase of neophyte cover was not present afterwards in 2022 and 2023, either because of the extreme drought of 2022 or the increase of other perennial species in managed plots. After five years of treatment, we found an increase in the cover of sand specialist species. Our results suggest that perennial clonal species need long-term mechanical management in order to reach a decrease in their cover and changes in the cover of

specialist species. As there is a need to speed up the process of repelling the invasive species and reestablishment of native species, the introduction of native species should be used (Halassy et al. 2019, Kövendi-Jakó et al. 2019), however, it needs to be tested in the future [3].

A more detailed analysis of the experiment will be part of the PhD thesis of Boglárka Berki (PhD student at ELTE). We plan to continue the management in order to gain an unprecedented long-term result about the management of perennial invasive herb species, which will be possible in the frame of the project collaboration [4].



a) b)
Figure 1: Effect of cutting on the shoot number of *Asclepias* (a) and neophytes cover (b) compared to the uncut plots. If the confidence intervals do not cross the zero line, the effect is considered significant. The points indicate the mean difference, while the whiskers show the 95% family-wise confidence intervals.

Task 2 – Large-scale pattern and effect of invasion

We conducted the field survey of the large-scale repeated monitoring. With the resurvey, we could follow the successional changes in primary and secondary grasslands (i.e. old-fields). We found that the studied primary grasslands remained the same habitats, and land use changes occurred only in old fields: 64% of young, 45% of medium and 10 % of old old-fields were ploughed again (Csecserits et al. 2022).

According to the resurvey, there was no difference in the cover of perennial species among the old old fields and grasslands. The cover of woody species increased both in old fields and closed grasslands, however with big dispersion indicating various patterns (Lkhagvasuren 2022, Csecserits et al. 2022). Generally, the vegetation of old-fields is very similar to primary grasslands in some characteristics (species number, perennial cover), but still, old-fields are separate habitats (i.e. higher level of invasion, higher level of habitat generalist species). Their presence in the landscape enhances habitat diversity, thus old-fields are important parts of the green infrastructure (Török et al. 2021, Sztár et al. 2021, [1]). The remaining difference between primary grasslands and old-fields indicate the importance of primary (i.e. permanent habitat for centuries), which was founded in the case of forests (Rédei et al. 2020) and other habitat complex (Kertész et al. 2020), too.

The level of invasion decreased only in open grasslands between the two surveys, and it was the highest in young and medium-aged old-fields (Lkhagvasuren 2022, Csecserits et al. 2022, Fig 2.). One of the most frequent annual alien species was the ragweed (*Ambrosia artemisiifolia*). Its cover was higher on old-fields than in primary grasslands in both surveys. However, the cover of ragweed decreased significantly between the two surveys both in primary grasslands and in old-fields. This is probably because of the increasing cover and competitive effect of perennial and woody species.

The most important invasive perennial species, the *Asclepias* has a higher cover on old-fields than in primary grasslands. The cover of this species increased only on young old fields between the two surveys, in primary grassland or elder old-fields its cover did not changed. These patterns indicate that there is a permanent presence of invasive species, especially that of *Asclepias*. During the process of

spontaneous succession, without changes in land use this species remains a permanent part of the vegetation. Comparing the old-fields with active restoration sites indicate the effectiveness of active seed propagation (Kövendi-Jakó et al 2019, Halassy et al. 2019).

The MSc thesis of Amina Lkhagvasuren was written on the basis of Task 2. Continuing the theme of invasion, there were two other MSc theses written by Sebastian Ospina and Avinanda Chakraborty, dealing with the distribution pattern of the region ((Ospina 2023) and trait composition of new non-native species (Chakraborty 2023). We plan to continue the study of the spreading and trait characteristics of newly naturalizing alien plant species in the frame of the project [4]. Moreover, we are preparing a manuscript about the changes in trait compositions of grasslands and old fields.

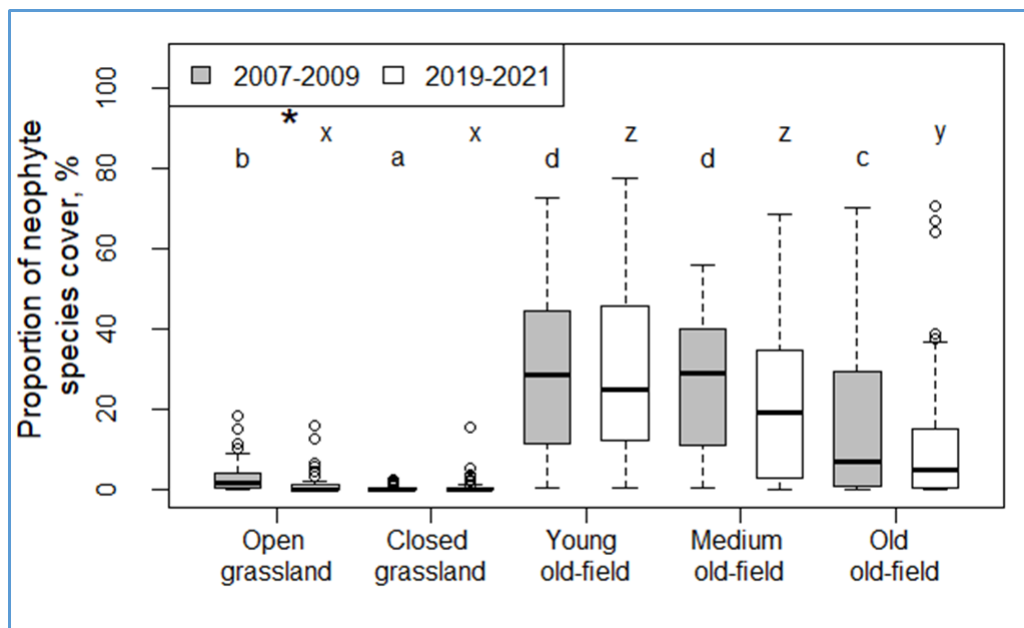


Figure 2: The proportion of neophyte species cover at the studied habitats in the two survey periods. „a, b, c”: indicate significant differences between habitats in the **1. Survey**; „x, y, z”: indicate significant differences between habitats in the **2. Survey**; *: indicate significant differences between the two surveys at a given **habitat**.

Task 3. Small-scale and long-term changes of invasion and effect of one-time herbicide management

This long-term and small-scale study examined the vegetation dynamics of abandoned agricultural fields with permanent plots near the village of Fülöpháza. We found that the cover of native plant specialists increased in young old-fields, but did not change in elder old-fields between 2000 and 2020. The cover of *Asclepias* has increased since the start of the study (2000), but only on approx. half of the studied fields. A chemical treatment in 2014-2015 resulted in a temporary decrease in the cover of *Asclepias* in the following year, but, in some of the fields, it could regain its previous cover within five years (Fig 3.). In 2020, after five years of treatment, there was already no significant difference in the cover of *Asclepias* between the herbicide-treated and non-treated plots. In the meantime, the cover of specialist species did not increase on the treated fields, so no significant regeneration of the native plant community took place (Csecserits et al. 2020, 2021).

We conclude, that the management of an invasive species, in this case the *Asclepias* is not enough in itself to restore the native communities, but should be combined with other treatments (e.g. grazing, seed sowing), that promote the establishment of native species.

This monitoring is a part of the Kiskun-LTER project, thus we plan a regular resampling every third year. The latest resampling took place in 2023 and the analysis of the results will be the topic of the MSc thesis of Ádám Ruprecht (ELTE).

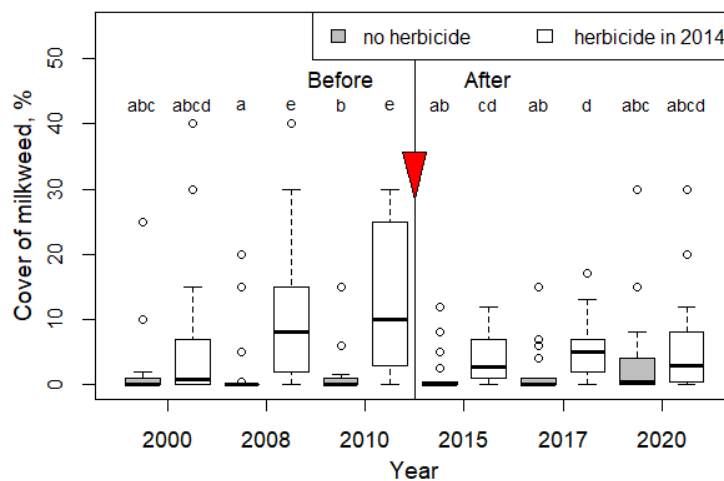


Figure 3. Changes in the *Asclepias* cover the small-scale study between 2000 and 2020. The red arrow indicates the time of single herbicide treatment of *Asclepias*. Different letters indicate significant differences.

Synthetic results of the project and implications for practice

In our project we studied the impact of establishment, spreading and management of invasive plant species. We focused mostly on the clonal perennial plant species, *Asclepias*, but we studied also the changes in the level of invasion and establishment of other alien species, e.g. *Opuntia humifusa*.

Concerning the impact of the presence of *Asclepias*, we did not find any significant effect on soil attributes but found in the light conditions on the soil surface. Probably, this effect could be one reason for the lower cover of sand specialists in the invaded stands of old-fields. According to the regional resurvey, we found no signs of the intensive spreading of *Asclepias* either in elder old-fields or in primary grasslands, there was an increase in cover of *Asclepias* only on young old-fields. Even in the small-scale study, we found that *Asclepias* could establish only a part (approximately half) of the abandoned fields and this pattern remained after almost two decades.

Concerning the management, we found that after five years of mechanical removal, the shoot numbers and cover of *Asclepias* decreased, but there was hardly any recovery of native specialist species. Besides these, we found that after a single herbicide treatment, the cover of *Asclepias* decreased but did not disappear, even it remained at the same level. Moreover in non-treated plots, the cover of *Asclepias* increased. At the same time, the cover of specialist species did increase.

According to a recent model (MacDougall & Turkington, 2005) there could be two types of invasive species: drivers, which generate themselves changes in the ecosystem and native species composition, and passengers, which alien species just follow the possibilities generated by environmental changes. Of course, these two types represent the endpoints of a continuous scale and each species can be and have different effects under different environmental conditions. Moreover, there are also transition species, the so-called “backseat drivers” (Bauer 2012), which do not initiate the changes in native species composition but follow it and afterwards have indirect effects on it. Based on our studies we conclude that *Asclepias* can be closer to the “passenger”-end of the scale, or more a “back-seat” driver as it shows no intensive spreading in a stable land use system (i.e. elder old-fields) and their single or short-term removal was not followed by the intensive recovery of habitat specialist plant species. Thus the simple removal of this alien species is not enough for achieving the recovery of native communities.

Based on our study we conclude, that old fields are unique habitats even with the presence of alien species. In order to enhance the proportion of native specialist species and lower the amount of

perennial invasive herbs, long-term management is needed, and not only the removal of the invasive herb but also the promotion of the establishment of native species e.g. by grazing, mowing and/or seeding.

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- Ospina, Sebastian Rodriguez (2023) Local dispersal pattern of *Opuntia Humifusa*, A New Alien Plant In Kunbaracs, Hungary. MSc thesis. ELTE, Supervisor: Anikó Csecserits and Tibor Kalapos
- Rédei, T., Csecserits, A., Lhotsky, B., Barabás, S., Kröel-Dulay, G., Ónodi, G., & Botta-Dukát, Z. (2020). Plantation forests cannot support the richness of forest specialist plants in the forest-steppe zone. *Forest Ecology and Management*, 461, 117964.
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- [1] Development of the Hungarian Green Infrastructure (KEHOP-4.3.0-VEKOP-15-2016-00001, KEHOP-4.3.0-VEKOP-15-2021-00002). Project leader: Katalin Török
- [2] The application of filter-based assembly models in the restoration of sand grasslands (2018-2023) NKFI FK 127996. Project leader: Melinda Halassy
- [3] Seed-based restoration to prevent the establishment and spread of invasive species (2022-2026) NKFI K13860. Project leader: Melinda Halassy
- [4] Egészségbiztonság Nemzeti Laboratórium – Invázióbiológiai Divízió és Járványökológiai Divízió (2022-2026, RRF-2.3.1-21-2022-00006) Project leader: Garamszegi László Zsolt, Földvári Gábor
- [5] Jelleg-alapú társulászerveződés vizsgálatok: a forráshasznosítás jellegek bevonása teljesebb képet ad? (2021-2025) NKFI K 138674, Project leader: Zoltán Botta-Dukát

Other activities connected to the project (Supervising, teaching and collaborations)

1) Students and thesis written related to the project

BSc

Nagy, Anna Fruzsina (2022) Az Amerikában honos medvetalpaktusz (*Opuntia*) nemzetség európai és hazai előfordulása és a hazai állomány magjainak csírázóképesége. BSc Thesis ELTE, Supervisor: Anikó Csecserits and Tibor Kalapos

MSc

Lkhagvasuren, Aminaa (2022) Variation in the level of plant invasion through time and habitats in Kiskunság (Hungary). MSc thesis. ELTE, Supervisor: Anikó Csecserits and Tibor Kalapos

Ospina, Sebastian Rodriguez (2023) Local dispersal pattern of *Opuntia Humifusa*, A New Alien Plant In Kunbaracs, Hungary. MSc thesis. ELTE, Supervisor: Anikó Csecserits and Tibor Kalapos

Chakraborty, Avinanda (2023) Comparison of the traits between newly naturalized and invasive plant species in Hungary. MSc thesis. ELTE, Supervisor: Anikó Csecserits and Tibor Kalapos *PhD*

Joined students:

Berki, Boglárka ELTE, Doctoral School of Biology Ecology, Conservation Biology and Systematics Programme (2020/09-2024/08), PhD thesis expected in 2024, Supervisor: Anikó Csecserits and Tibor Kalapos

Ruprecht, Ádám, MSc Student, Thesis expected in 2024, Supervisor: Anikó Csecserits and Tibor Kalapos

2) University courses and seminars - ÖB seminars

Csecserits, A., Berki, B., Csákvári, E., Halassy, M., Rédei, T., Sztár, K. & Botta-Dukát, Z. Will milkweed (*Asclepias syriaca*) be with us forever?—insights from a long-term monitoring and a short-term removal experiment. ÖBI Seminar 2020.10.01. Vácrátót, Hungary.

Csecserits, A., Boglárka, Berki, Edina, Csákvári; Adrienn Gyalus; Melinda, Halassy; Attila, Lengyel; András, Mártonfy; Anna Fruzsina Nagy; Tamás, Rédei; Sebastian Ospina; Katalin, Sztár & Zoltán, Botta-Dukát: (Dis)similarity between alien and native plant species and its role at the stages of invasion process ÖBI Seminar 01 Dec 2022, Vácrátót, Hungary.

Special course “Invasion Ecology” at the ELTE for MSc and PhD students in 2021/2022 and 2022/2023, in the autumn semesters, given by the PI, partly based on the knowledge gained during this project.

3) Collaborations with other projects

[1] Development of the Hungarian Green Infrastructure (KEHOP-4.3.0-VEKOP-15-2016-00001, KEHOP-4.3.0-VEKOP-15-2021-00002). Project leader: Katalin Török

[2] The application of filter-based assembly models in the restoration of sand grasslands (2018-2023) NKFI FK 127996. Project leader: Melinda Halassy

[3] Seed-based restoration to prevent the establishment and spread of invasive species (2022-2026) NKFI K13860. Project leader: Melinda Halassy

[4] Egészségbiztonság Nemzeti Laboratórium – Invázióbiológiai Divízió és Járványökológiai Divízió (2022-2026, RRF-2.3.1-21-2022-00006) Project leader: Garamszegi László Zsolt, Földvári Gábor

[5] Jelleg-alapú társulá szerveződés vizsgálatok: a forráshasznosítás jellegek bevonása teljesebb képet ad? (2021-2025) NKFI K 138674, Project leader: Zoltán Botta-Dukát

Appendix 1

All publications connected to the project and to the PI, grouped by types

We published 5 papers on the project topic and 2(+5) related publications with the grant number indicated, 7 Hungarian papers to inform local managers and 28 (14 oral, 14 poster) conference presentations.

Publications on project results in English

- 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
- 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

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

- Rédei, T., Csecserits, A., Lhotsky, B., Barabás, S., Kröel-Dulay, G., Ónodi, G., & Botta-Dukát, Z. (2020). Plantation forests cannot support the richness of forest specialist plants in the forest-steppe zone. *Forest Ecology and Management*, 461, 117964.
- Kertész, M., Ónodi, G., Botta-Dukát, Z., Lhotsky, B., Barabás, S., Bölöni, J., ... & Rédei, T. (2020). Different impacts of moderate human land use on the plant biodiversity of the characteristic Pannonian habitat complexes. *Flora*, 151591.
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- 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
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- Berki, B., Csákvári, E., Gyalus, A., Halassy, M., Csecserits, A.: Impact of *Asclepias syriaca* on the vegetation composition of primary and secondary sand grasslands. International Association for Vegetation Science, 64h Annual Symposium – Hybrid, June 27th - July 1st, 2022, Spain, Madrid. (poster)
- Botta-Dukát, Z., Gyalus, A., Kabai, M., Lhotsky, B., Csecserits, A.: Correlation between specific leaf area (SLA) and leaf dry matter content (LDMC) across scales. International Association for Vegetation Science, 64h Annual Symposium – Hybrid, June 27th - July 1st, 2022, Spain, Madrid. (poster)
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- Csecserits A., Berki Boglárka, Csákvári Edina, Halassy Melinda, Mártonffy András, Szitár Katalin, Botta-Dukát Zoltán: Kivel él együtt egy inváziós faj: hasonló vagy eltérő növényi jellegekkel rendelkező fajokkal? 7. Kvantitatív Ökológiai Szimpózium, 2022 04. 26., Vácrátót. (oral)
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