INTEGRATED RESEARCH IN CONSERVATION ECOLOGY TO PROTECT GRASSLAND BIODIVERSITY: THE EFFECT OF RESTORATION AND MANAGEMENT ON ECOSYSTEM SERVICES

FINAL TECHNICAL REPORT OF OTKA NNF GRANT NO. 85562 (May 31, 2012)

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1. PROJECT OBJECTIVES AND WORK DONE

The implemented research continued most tasks described in the original proposal of OTKA NNF 78887 from where they were left off at the end of that grant (March 31, 2011, please see **Table 1** for an overview). Some tasks were discontinued due to completion (WP1 Task 2), untimeliness (WP2 Task 1, performed only once in three years) or lack of funding resulting from the reduced budget of OTKA NNF 85562 (WP1 Task 3).

In addition, we extended our studies to include three taxonomic groups that are important in providing ecosystem services: bees, amphibians and small mammals. We collected data to evaluate the effect of grassland restoration and habitat management on the diversity of these taxa and to assess how ecosystem services evolve after habitat restoration and management.

Table 1. An overview of project progress in the reporting period (April 2011 - March 2012).

WP	Task	Short description	Activity status	Related publications *
WP1	Task 1	Continued monitoring of grassland restoration, synthesis of early results	Field surveys and lab studies completed as planned, all data from 2011 available. Field surveys in 2012 started.	(**Deák et al. 2011**; **Henle et al. in press**; **Lengyel et al. 2012b**; **Török et al. 2012a**; **Török et al. 2012b**); *Lengyel et al. 2011*
WP2	Task 2	Study of changes in landscapes	Habitat maps completed for 2010, updated to show target-state natural grasslands for further analysis.	(**Lengyel et al. 2012b**; Mérő & Bocz in press; Rácz et al. 2011; Szabó in press); *Lengyel et al. 2011*
	Task 3	Habitat diversity and species diversity	All data available, time-series analyses are ongoing	(Lengyel et al. 2012a; Varga et al. in prep.)
WP3	Task 1	Grazing experiment	Data are now available from three years at each experimental plot. In addition, data from 2011 are available for bees, amphibians and mammals.	*Valkó et al. 2012*
	Task 2	Mowing experiment		(Mérő & Bocz in press; Török et al. 2012a)

* Articles in ISI-journals are highlighted in Bold and presentations at international conferences are in Italics (for full references, please see below).

2. PUBLICATIONS IN THE REPORTING PERIOD

In the one-year continuation of the original OTKA NNF grant, we published five papers directly related to the research topic in ISI-listed journals (total IF: 7.457) and three non-topical papers with the acknowledgment of OTKA NNF support (total IF: 9.158), one conference paper, and three papers in Hungarian journals. **The total number of papers in ISI-listed journals is eight and total IF is 16.615**. One doctoral dissertation was defended with half of its content arising from the OTKA NNF research. Three undergraduate works participated in a national competition for undergraduates (two won prizes). Six MS theses and one BS thesis were written based on the data collected. Finally, we presented three talks (one invited) and one poster at international conferences and eight talks (one invited) and two posters at national conferences.

2.1. Topical papers in ISI-listed journals (new publications for 85562 period, 2011-2012)

1. Lengyel Sz, Varga K, Kosztyi B, Lontay L, Déri E, Török P, Tóthmérész B. 2012. Grassland restoration to conserve landscape-level biodiversity: a synthesis of early results from a large-scale project. ***Applied Vegetation Science*** 15: 264-276. [**IF: 1,802**]
2. Török P, Miglécz T, Valkó O, Kelemen A, Tóth K, Lengyel Sz, Tóthmérész B. 2012. Fast restoration of grassland vegetation by a combination of seed mixture sowing and low-diversity hay transfer. ***Ecological Engineering*** 44: 133-138. [**IF: 2,203**]
3. Török P, Miglécz T, Valkó O, Kelemen A, Deák B, Lengyel Sz, Tóthmérész B. 2012. Recovery of native grass biodiversity by sowing on former croplands: Is weed suppression a feasible goal for grassland restoration? ***Journal for Nature Conservation*** 20: 41-48. [**IF: 1,545**]
4. Deák B, Valkó O, Kelemen A, Török P, Miglécz T, Ölvedi T, Lengyel Sz, Tóthmérész B. 2011. Litter and graminoid biomass accummulation suppresses weedy forbs in grassland restoration. ***Plant Biosystems*** 145: 730-737. [**IF: 0,829**]
5. Henle K, Mester B, Lengyel Sz, Puky M. In press. A review of a rare type of anomaly in amphibians, tail duplication and bifurcation, with description of three new cases in European species (*Triturus dobrogicus*, *T. carnifex*, and *Hyla arborea*). ***Journal of Herpetology***. [**IF: 1,078**]

2.2. Topical manuscripts under revision in ISI-listed journals

1. Rácz IA, Déri E, Kisfali M, Batiz Z, Szabó Gy, Lengyel Sz. In review. Changes in Orthopteran assemblages after grassland restoration. Submitted to Biodiversity and Conservation.

2.3. Non-topical papers in ISI-listed journals with acknowledgment of OTKA-NNF support

1. Bálint M, Málnás K, Nowak C, Geismar J, Váncsa É, Polyák L, Lengyel Sz, Haase P. 2012. Species history masks the effects of human-induced range loss - unexpected genetic diversity in the endangered giant mayfly *Palingenia longicauda*. ***PLoS ONE*** 7: e31872. [**IF: 4,411**]
2. Keil P, Schweiger O, Kühn I, Kunin WE, Kuussaari M, Settele J, Henle K, Brotons L, Pe'er G, Lengyel Sz, Moustakas A, Steinicke H, Storch D. In press. Patterns of beta diversity in Europe: partitioning the effects of climate, land-cover and distance across scales. ***Journal of Biogeography***. [**IF: 4,273**]
3. Lengyel Sz, Tar J, Rózsa L. In press. Flock size measures of migrating Lesser White-fronted Geese *Anser erythropus*. ***Acta Zoologica Academiae Scientiarum Hungaricae***. [**IF: 0,474**]

2.4. Conference paper

1. Lengyel Sz, Szabó Gy, Kosztyi B, Mester B, Mérő TO, Török P, Horváth R, Magura T, Rácz IA, Tóthmérész B. 2012. Variability in the responses of animal groups to grassland restoration. Dry Grasslands of Europe: Grazing and Ecosystem Services. ***Proceedings of the 9th European Dry Grassland Meeting***, Prespa, Greece, 2012. 05. 19-23.

2.5. Papers in Hungarian journals

1. Szabó Gy. In press. Az egyek-pusztakócsi gyeprekonstrukció hatása vadméhekre (Hymenoptera: Apoidea) [The effect of the Egyek-Pusztakócs grassland restoration on wild bees]. ***Természetvédelmi Közlemények***.

2. Mérő TO, Bocz R. In press. A gyeprekonstrukció hatása a kisemlős együttesekre Egyek-Pusztakócson (Hortobágy) [The effect of grassland restoration on small mammal assemblages in Egyek-Pusztakócs]. ***Természetvédelmi Közlemények***.
3. Rácz IA, Déri E, Kisfali M, Batiz Z, Tóthmérész B, Lengyel Sz. 2011. Gyeprekonstrukció a múlt tükrében. ***Calandrella*** 14: 139-143.

2.6. Doctoral dissertation

1. Valkó O. 2012. Grassland recovery using spontaneous succession and technical reclamation: analysis of restoration success in several grassland types. ***PhD dissertation***, University of Debrecen. Pp. 86.

2.7. Student papers

1. Bocz R. 2012. A gyeprekonstrukció hatása a kisemlős együttesekre Egyek-Pusztakócson (Hortobágy) [The effect of grassland restoration on small mammal assemblages in Egyek-Pusztakócs, Hortobágy]. ***OFKDK-dolgozat***, Országos Felsőoktatási Környezettudományi Diákköri Konferencia, **II. helyezés**. (National Student Conference for Environmental Studies, second place).
2. Mester B, Szalai M. 2011. Természetvédelmi kezelések hatása a Fekete-rét (Hortobágy) herpetofaunájára [The effect of conservation management on the herpetofauna of Fekete-rét, Hortobágy]. ***OTDK-dolgozat***, Országos Tudományos Diákköri Konferencia, **I. helyezés**. (National Scientific Conference for Students, first place).
3. Cozma N. 2011. Kiskunsági szikes vízterek vízi- és vízfelszíni poloska (Heteroptera: Nepomorpha és Gerromorpha) fajegyütteseinek rövid- és hosszútávú vizsgálata [Short and long-term study of species assemblages of aquatic and semiaquatic water bugs of Kiskunság alkali waters]. OTDK-dolgozat (National Scientific Conference for Students).

2.8. MS theses, University of Debrecen

1. Bocz Renáta. 2012. A gyeprekonstrukció hatása kisemlős együttesekre [Effect of grassland restoration on small mammal assemblages].
2. Nagy Zsuzsanna. 2012. Az extenzíven és intenzíven művelt szántók kisemlős együtteseinek összehasonlítása [Comparison of small mammal assemblages of extensive and intensive croplands].
3. Szénási Imre. 2012. A balmazújvárosi Nagy-szik élőhely-rehabilitációjának hatásai 2009-2011 között [Impact of habitat restoration in the Balmazújváros Nagy-szik between 2009 and 2011].
4. Cozma Nastasia. 2011. Kiskunsági szikes vízterek vízi- és vízfelszíni poloska (Heteroptera: Nepomorpha és Gerromorpha) fajegyütteseinek rövid- és hosszútávú vizsgálata [Short and long-term study of species assemblages of aquatic and semiaquatic water bugs of Kiskunság alkali waters].
5. Mester Béla. 2011. Az Egyek-Pusztakócsi mocsárrendszer (Hortobágyi NP) területén zajló természetvédelmi kezelések herpetofaunára gyakorolt hatásainak vizsgálata, különös tekintettel a Fekete-rét kétéltűfaunájára [Study of the effects of conservation management in the Egyek-Pusztakócs marsh system (Hortobágy NP) on the herpetofauna, with special consideration to the amphibian fauna of Fekete-rét marsh].
6. Szalai Mónika. 2011. Legeltetés és égetés kétéltűfaunára gyakorolt hatásai az Egyek-Pusztakócsi mocsarak (Hortobágy) területén [The effects of grazing and burning on the amphibian fauna in the area of the Egyek-Pusztakócs marshes, Hortobágy].

2.9. BS thesis, University of Debrecen

1. Szepesváry Csaba. 2012. Természetes és rekonstruált gyepek Orthoptera együttesei. [Orthoptera assemblages of natural and restored grasslands.]

2.10. Conference presentations (presenter underlined)

1. Valkó O, Török P, Deák B, Kelemen A, Lengyel Sz, Tóthmérész B. 2012. The effects of grazing on species composition of grasslands along a moisture gradient. Talk, ***9th European Dry Grassland Meeting***, Prespa, Greece.
2. Lengyel Sz, Szabó G, Kosztyi B, Mester B, Mérő TO, Török P, Horváth R, Magura T, Rácz IA, Tóthmérész B. 2012. Variability in responses of animal groups to grassland restoration. Poster, ***9th European Dry Grassland Meeting***, Prespa, Greece.
3. Mester B, Szalai M, Puky M, Lengyel Sz. 2012. Természetvédelmi kezelések hatása a Fekete-rét (Hortobágy) herpetofaunájára (The effect of conservation management on the herpetofauna of Fekete-rét marsh, Hortobágy). Talk, ***Third Herpetological Symposium***, Hungarian Natural History Museum, Budapest, Hungary.
4. Bálint M, Málnás K, Nowak C, Geismar J, Váncsa E, Polyák L, Lengyel Sz, Haase P. 2012. Species history masks the effects of human-induced range loss - unexpected genetic diversity in the endangered giant mayfly *Palingenia longicauda*. Talk, „Utilization of genetic approaches for effective conservation of endangered species" ***Regional Workshop of project ConGRESS (Conservation Genetic Resources for Effective Species Survival)***, Debrecen.
5. Lengyel Sz. 2011. A biodiverzitás megőrzésének fontossága – természetvédelmi kutatási projektek tervezése (The importance of biodiversity conservation: designing research projects in conservation). ***Meghívott előadás***, ***Natura 2000 Ismeretterjesztő Konferencia***, Vinca Minor Egyesület, Csomád-Bálványos Gondnokság, Sepsiszentgyörgy, Románia. (Invited talk, Natura 2000 Awareness-raising Conference, Sfantu Gheorghe, Romania)
6. Lengyel Sz. 2011. Természetvédemi célú kutatási projektek tervezése (The design of nature conservation research projects). ***Meghívott előadás***, ***A Bükki Nemzeti Park Igazgatóság természeti értékeinek kutatása I. "Az Ipoly-vízgyűjtő vizes élőhelyeinek komplex felmérése, közösségi jegyzékeinek kidolgozása" c. Inter-reg projekt záró konferenciája***, Felsőtárkány. (Invited talk, "Research on the Natural Values of Bükk National Park", Inter-reg project closing conference, Felsőtárkány, Hungary)
7. Lengyel Sz. 2011. Gyeprekonstrukció hatása a biológiai sokféleségre Egyek-Pusztakócson (Hortobágy). (The effect of grassland restoration on biological diversity in Egyek-Pusztakócs. Talk, ***"University of Debrecen, Grassland Research Centre: Plans and Opportunities" symposium***, Debrecen, Hungary.
8. Lengyel Sz, Török P, Horváth R, Tóthmérész B. 2011. Gyeprekonstrukció hatásai a biológiai sokféleségre Egyek-Pusztakócson (The effects of grassland restoration on biological diversity in Egyek-Pusztakócs). Talk, ***7th Hungarian Conference of Conservation Biology***, Debrecen.
9. Szabó Gy, Lengyel Sz. 2011. Az egyek-pusztakócsi gyeprekonstrukció hatása a fullánkos vadméhekre (Aculeata) (The effect of the Egyek-Pusztakócs grassland restoration on Aculeata wild bees). Talk, ***7th Hungarian Conference of Conservation Biology***, Debrecen.
10. Mester B, Szalai M, Lengyel Sz, Puky M. 2011. Természetvédelmi kezelések (égetés, legeltetés) herpetofaunára gyakorolt hatásainak vizsgálata, különös tekintettel a Fekete-rét kétéltűfaunájára (Study of the effects of conservation management on the herpetofauna, with

special consideration to amphibians). Talk, ***7th Hungarian Conference of Conservation Biology***, Debrecen.

11. Rácz AI, Déri E, Kisfali M, Batiz Z, Tóthmérész B, Lengyel Sz. 2011. Gyeprekonstrukció a múlt tükrében - az egyenesszárnyú (Orthoptera) együttesek hosszú és rövid távú változásai hortobágyi gyeptársulásokban (Grassland restoration in the mirror of the past - long-term and short-term changes of Orthoptera assemblages in Hortobágy grasslands). Talk, ***7th Hungarian Conference of Conservation Biology***, Debrecen.
12. Valkó O, Deák B, Török P, Kelemen A, Miglécz T, Ölvedi T, Tóth K, Lengyel Sz, Tóthmérész B. 2011. Az Egyek-Pusztakócsi LIFE-program botanikai eredményei (Botanical results of the Egyek-Pusztakócs LIFE programme). Talk, ***7th Hungarian Conference of Conservation Biology***, Debrecen.
13. Rácz AI, Déri E, Kisfali M, Batiz Z, Tóthmérész B, Lengyel Sz. 2011. Az egyenesszárnyú (Orthoptera) együttesek hosszú és rövid távú változásai hortobágyi gyeptársulásokban - különös tekintettel az egyek-pusztakócsi gyeprekonstrukcióra (Long-term and short-term changes in Orthoptera assemblages in Hortobágy grasslands, with special consideration to the Egyek-Pusztakócs grassland restoration). Poster, ***7th Hungarian Conference of Conservation Biology***, Debrecen.
14. Valkó O, Török P, Kelemen A, Miglécz T, Tóth K, Deák B, Lengyel Sz, Tóthmérész B. 2011. Alkalmazható-e szántóterületek gyepesítése a gyomok visszaszorítására? (Can grassland restoration on croplands be used to suppress weeds?). Poster, ***7th Hungarian Conference of Conservation Biology***, Debrecen.

3. SUMMARY OF RESULTS

3.1. Early results of grassland restoration: synthesis

An overview of the largest (760-ha) active grassland restoration project in Europe and a synthesis of its botanical results of the first three years was published in *Applied Vegetation Science* (Lengyel et al. 2012b). For this study, we used data on the vegetation in restored and target grasslands and on factors influencing restoration success, collected in a space-for-time substitution design in 2009. We recorded 100 species of flowering plants, of which 37 species were non-weed, ‘target’ species. Annual weeds dominated 1-yr-old fields but had decreased dramatically by the third year due to a developing perennial grass cover. Former alfalfa fields had proportionally fewer weeds than former cereal and sunflower fields. The diversity of common species and the cover of target species increased from 1- to 4-yr-old restored fields. Alkali-restored fields had more heterogeneous vegetation and more species than loess-restored fields. Distance to the target vegetation did not directly affect vegetation variables. There was significant spatial variability in vegetation development, possibly suggesting several local pathways of succession. Grassland restoration was generally successful in accelerating secondary succession towards alkali steppes and loess grasslands. However, further management is necessary to counter the homogenizing effects of litter accumulation,to reduce perennial weeds and to enhance the colonization of target species. Our project provided useful practical insights into grassland restoration and in applying restoration at a number of sites within a larger area to conserve biodiversity at the landscape scale.

3.2. The role of native grass cover and litter accumulation in the suppression of weeds

In two other studies, we analyzed the role of native grass cover (Török et al. 2012a) and accumulated litter (Deák et al. 2011) in suppressing weeds. We found that the rapidly forming cover of the sown grasses effectively suppressed short-lived weeds and their germination except in the first year (Török et al. 2012a). However, the effectiveness of seed sowing followed by mowing in weed suppression can be different on sites with different history or seed mixture. Rapidly establishing perennial weeds, such as *Agropyron* species were only detected in former alfalfa fields; *Cirsium arvense* was found in former cereal and sunflower fields but not in former alfalfa fields. We also found that the rate of weed suppression and success was influenced by the seed mixtures used. In several alkali restorations the high proportion of perennial weeds was detected in year 3. In loess restorations, much lower scores were typical because the loess seed mixture contained seeds of a clonally spreading tall grass, *Bromus inermis,* which could compete more effectively with clonally spreading weeds, than could short grass species. Our findings indicate that post-restoration management requires carefully designed actions that are fine-tuned to address specific threats at the site level.

In the second study (Deák et al. 2011), we examined the effect of litter and graminoid biomass on species richness and biomass of early colonising forbs in former alfalfa fields sown with seed mixtures containing seeds of native grass species. Litter and biomass of graminoids increased significantly during the study, and correlated negatively with the biomass and species richness of forbs. Mean scores of litter and graminoid biomass were two to three times higher in sown fields than in native grasslands. Our results suggested that the accumulation of litter and graminoid biomass is beneficial in the suppression of weedy forbs, but in the long run it might also hamper the immigration of target species.

3.3. Seed sowing and hay transfer

In 2008, we also initiated an experiment in which the effectiveness of a combination of two restoration methods (hay transfer, seed sowing) was evaluated (Török et al. 2012b). The joint application of these methods is rarely used, although it has the potential to gain a predictable and directed vegetation development with effective early weed suppression. We tested the following hypotheses: (i) lower weed cover and biomass is expected in vegetation recovered by the joint method of sowing and hay transfer than by seed sowing only. (ii) With sowing and additional hay transfer a higher rate of establishment of *Festuca* species is expected than with sowing only. Our results supported both hypotheses. We found that the additional application of hay significantly accelerated the development of perennial grassland vegetation and provided a higher weed suppression rate in the first year and onwards in most plots than seed sowing only. A higher establishment rate was detected both in the cover and the biomass of perennial grasses including *Festuca* species in all plots with hay addition than with sowing only. Our results suggest that a combination of hay transfer and low diversity sowing may provide a cost-effective alternative to the more costly high-density sowing and if proper sources for high-diversity hay are available, it may replace high-diversity seed mixtures.

3.4. Effect of grassland restoration on species richness and abundance of animal groups

In a conference paper (Lengyel et al. 2012a), we summarized the responses of species richness and abundance in seven animal groups (orthopterans, bees, carabid beetles, spiders, amphibians, birds, mammals) of ecological and conservation importance (**Fig. 1, 2**). Species richness did not vary but abundance increased with time in orthopterans. Carabid species richness and abundance, and spider and bird abundance decreased after a peak in Year 1 after restoration. Both species richness and abundance of amphibians increased after Year 2. There were no significant changes in species richness and abundance of bees and small mammals and in the species richness of spiders and birds. Our results demonstrate that the responses to grassland restoration can greatly vary among animal taxa. Trends in several arthropod taxa could be explained by vegetation changes, whereas vertebrates showed fluctuations due to factors other than restoration per se. The analyses were extended for a full assessment of responses in species diversity and composition in Orthoptera. One paper from this assessment was published in a Hungarian journal (Rácz et al. 2011) and an English manuscript is currently under evaluation (Rácz et al. in review).

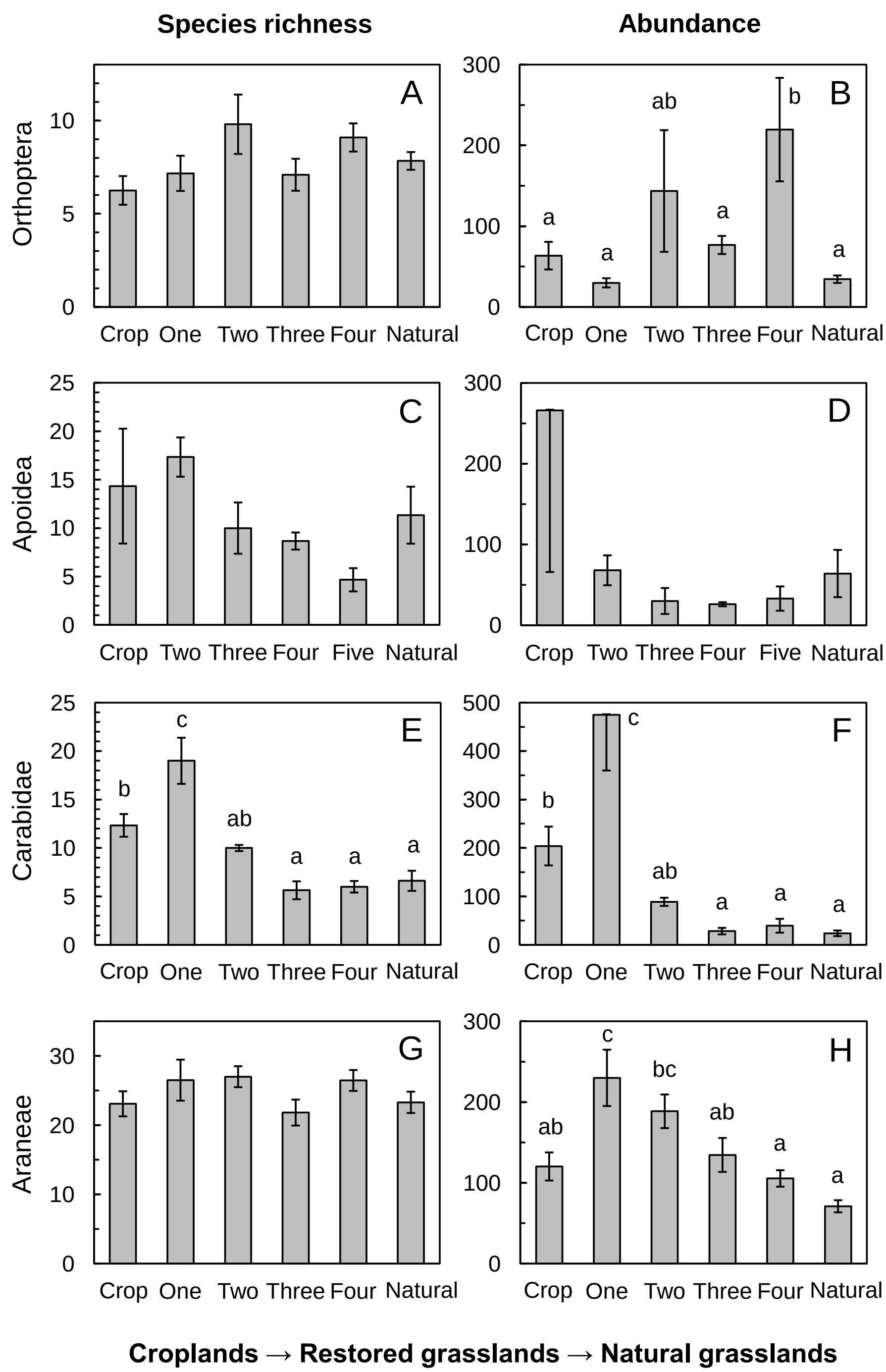

Figure 1. Mean ± S.E. of total species richness (left column) and abundance (right column) of four invertebrate groups in croplands, grassland restorations of four different ages and natural grasslands in the Egyek-Pusztakócs marsh system (Hortobágy National Park, E-Hungary). Different lowercase letters indicate statistical significance between groups (Tukey's HSD test, $p < 0.05$). A,B - bees, C,D - bees, E,F - carabid ground beetles, G,H - spiders.

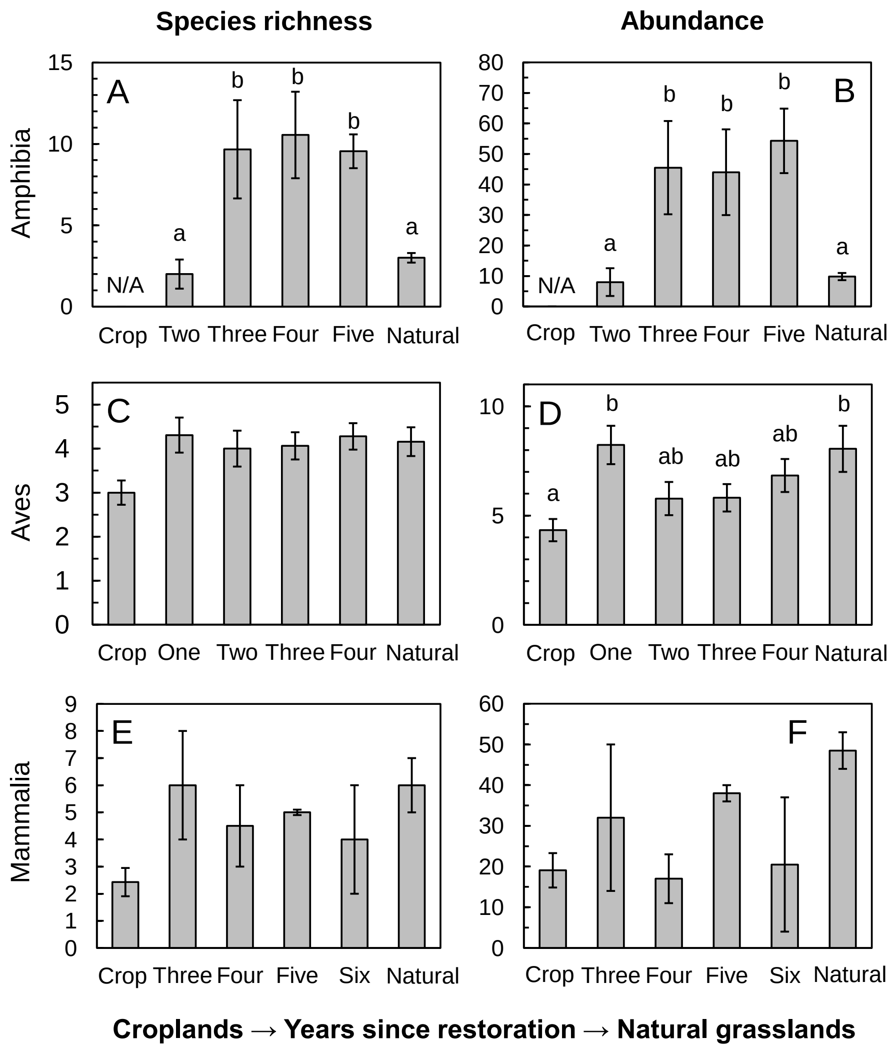

Figure 2. Mean ± S.E. of total species richness (left column) and abundance (right column) of three vertebrate groups in croplands, grassland restorations of four different ages and natural grasslands in the Egyek-Pusztakócs marsh system (Hortobágy National Park, E-Hungary). Different lowercase letters indicate statistically significant differences between groups (Tukey's HSD test, $p < 0.05$). A,B - amphibians, C,D - birds, E,F - small mammals.

3.5. New studies: bees, amphibians, small mammals

In an extension of the original proposal, we assessed the diversity of three taxonomic groups (bees, amphibians, small mammals) that are important in providing ecosystem services in grassland habitats. To survey bees, we compared the bee assemblages in croplands, restored grasslands and target-state natural grasslands (Szabó in press). Our results showed that in the first year following restoration, flower-rich fields of weedy plant species held the highest number of bee species and individuals. With the progress of years, when weedy forbs gradually decreased in cover and plant species characteristic to the target-state natural grasslands increased in cover (see above), the bee assemblages became gradually poorer, consisting of only those species that are characteristic to the target alkali and loess grasslands, and with the disappearance of the transient, generalist species (**Fig. 1, 3a**). The species composition of five-year-old restorations overlapped completely with that of loess and alkali natural grasslands (**Fig. 3b**). We concluded that to maintain species-rich bee assemblages, early-phase restorations are more favourable, whereas to maintain the specialist bee assemblages of natural grasslands, later phases of restorations are more favourable.

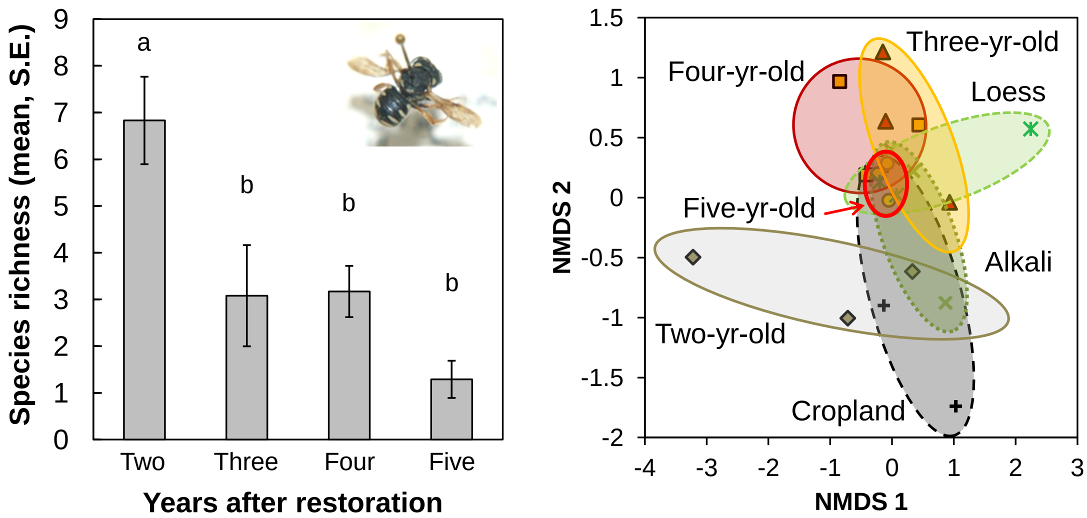

Figure 3. Changes in species richness on restored fields (left) and changes in species composition from croplands through restored fields of different ages to target-state loess and alkali grasslands (right). Different lowercase letters indicate statistically significant differences between groups (ANOVA followed by Tukey's HSD test, $p < 0.05$) (left). Results from a non-metric multidimensional scaling ordination based on presence-absence data (right).

The species richness and abundance of amphibians, however, were higher on restored grasslands than on natural grasslands and in older than in younger restorations (**Fig. 2**). In pitfall traps installed to sample ground-dwelling arthropods, we found extremely large numbers of newts (*Triturus dobrogicus*, *Lissotriton vulgaris*) in September and October of the very wet year of 2010. The number of newts increased gradually with the age of the restored grasslands (Mester et al., in prep.). In the course of fieldwork, we also found an individual with tail duplication, a developmental abnormality that is very rare in newts. We published this observation, along with other observations and a review of this type of abnormality in *Journal of Herpetology* (Henle et al. in press).

We evaluated the changes of small mammal assemblages (voles, mice, shrews) by live-trapping in the spring and the fall of 2011 (Mérő & Bocz in press). Interestingly, neither the species richness nor the abundance of small mammals were influenced by the restoration as there were no significant differences among croplands, restored fields and natural grasslands. However, post-restoration management appeared to fundamentally determine small mammals because the less a grassland was disturbed by management, the more small mammal species and individuals we found **Fig. 4**). This was because grazing and mowing late in the season resulted in very low vegetation by the autumn sampling period, which increased the vulnerability of small mammals to aerial predators (birds). In areas mowed earlier in the season, small mammal abundance was higher, and it was highest in non-managed restored fields that had a high vegetation cover. These results suggested that small mammals rapidly colonize all available habitats after their winter bottleneck period regardless of the habitat type (cropland/restored field/grassland) but that populations can show large increases especially in non-managed or early mowed areas.

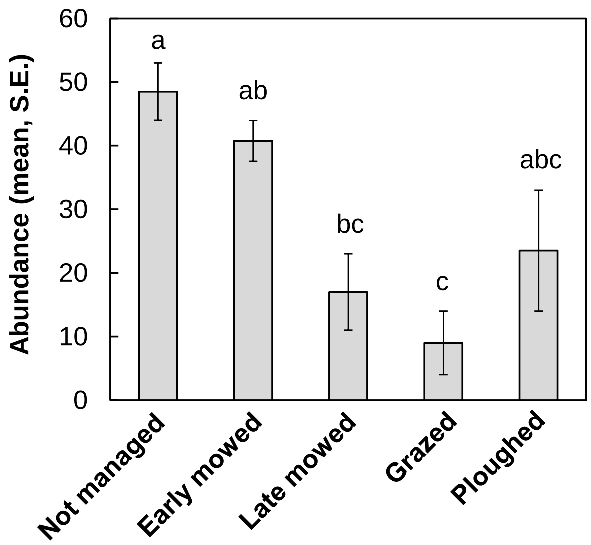

Figure 4. Abundance of small mammals on differently managed grasslands and on croplands ('ploughed'). Early mowing was in June/July, late mowing was in July/August, and sampling of small mammals by live trapping was carried out in September.

3.6. Accessory activities

As corollary research activities, we participated in two international and one national scientific collaborations related to the topic of the original proposal. First, we participated in a collaborative study of the population genetics of the long-tailed mayfly (*Palingenia longicauda*), which is a result of a long-term corollary project at our research group (Bálint et al. 2012). Second, we participated in studying patterns in beta diversity in Europe (Keil et al. in press), the methodological approach of which will be important in later phases of the research programme. Finally, we published a paper on conservation measures and group sizes in a threatened bird species (Lengyel et al. in press).

4. References cited in the text

Bálint, M., K. Málnás, C. Nowak, J. Geismar, É. Váncsa, L. Polyák, S. Lengyel, and P. Haase. 2012. Species history masks the effects of human-induced range loss - unexpected genetic diversity in the endangered giant mayfly *Palingenia longicauda*. PLoS ONE **7**:e31872.

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