SZENT ISTVÁN UNIVERSITY
DOCTORAL SCHOOL OF ENVIRONMENTAL SCIENCES

EFFECTS OF NATURAL CONSERVATION MANAGEMENT ON THE VEGETATION OF MOUNTAIN MEADOWS

PhD THESIS

Gergely Pápay

Gödöllő
2020

Name of doctoral school:	Doctoral School of Environmental Sciences
Branch of science:	Environmental sciences
Head of the Doctoral School:	**Dr. Erika Csákiné Michéli** Professor, Head of Institute Szent István University, Faculty of Agricultural and Environmental Sciences Institute of Environmental Sciences Department of Soil Science and Agricultural Chemistry
Supervisor:	**Prof. Károly László Penksza** professor

Prof. Károly László Penksza
Supervisor

Prof. Erika Csákiné Michéli
Head of Doctoral School

Hungary's meadows and pastures are predominantly semi-natural. Though they are among the most diverse habitats of the country, to maintain this there is a need for nature conservation management.
In this work I surveyed three areas, on grasslands in the Mátra. They were the following: Sár-hegy, grasslands near Fallóskút and Parádóhuta, on which management (mainly shrubcutting) is conducted regularly by the Bükk National Park Directorate. I surveyed habitats with different levels of disturbance through botanic and coenological analysing of the vegetation. During the task the survey broadened and I also examined the effects of game browsing in 3 areas.
The project KEOP-3.1.2/2F/09-2009-0007 „Rétek, gyepek, (fás) legelők helyreállítása és kezelése a BNPI Működési területén" [Restoration and management of meadows, grasslands and (wooded) pastures in the Bükk National Park Directorate] is held on the study areas, with rehabilitational aims in the short term, and and nature conversation economical ones in the long term.
Red deer, roe deer and wild boar are natural inhabitants in our medium mountains (Bihari et al. 2007) and it begs the question: are their natural disturbances on mountain grasslands to be identified certainly as injuries or these effects of game can contribute naturally to slowing down the problematic successional processes (Katona et al., 2015). The surveys on effects of game conducted in the forests of Mátra (Fehér et al., 2016) show that on the regional level the role of ungulates is not that big as it is speculated to be based on the experiences (Szmorad et Király, 2014).
Many surveys proved recently that disturbances can increase the stability of the system (Simberloff, 1982), natural disturbances are basic part of the life of the ecological systems (White, 1979; Pickett et al., 1978; Whittaker et al., 1977; Standovár et Primack, 2001). If mowing or pasturing ceases, it can lead to increasing cover of shrub and afforesting (Ölvedi, 2010; Sendžikaite et Pakalnis, 2006; Willems, 1983), so the return of these methods can be a solution on these areas in terms of nature conservation (Ölvedi, 2010; Deák et Tóthmérész 2005, 2007; Stampfli et Zeiter, 1999). Ending the management often harasses the biodiversity of the habitats, it can lead to decrease diversity by increase the cover of some species of wide tolerance (Klimeš et al., 2000; Házi et al., 2090, 2011, 2012; Catorci et al., 2017).

In the last decades it has become evident that increasing level of shrub is a problem at global scale (Archer et al., 1995). It is clear that the increasing level of shrub has a negative effect on grasslands in several ways: besides decreasing biodiversity (Giarrizzo et al. 2015, Tälle et al. 2016), shrub overshadows shorter herbaceous plants (Bergelson, 1990; Facelli et Pickett, 1991) and inhibits their growth mechanically (Wedin and Tilman, 1993). The small grassland patches, species with short life cycle and with shorter lived seeds and species with narrow habitat tolerance are the most vulnerable to increasing the cover of shrubs, even in the extensively managed grasslands. This declining tendency is particularly dangerous for rare and protected species, and it can lead to their local extinction. (Fischer et Stöcklin 1997, Stöcklin et Fischer 1999).

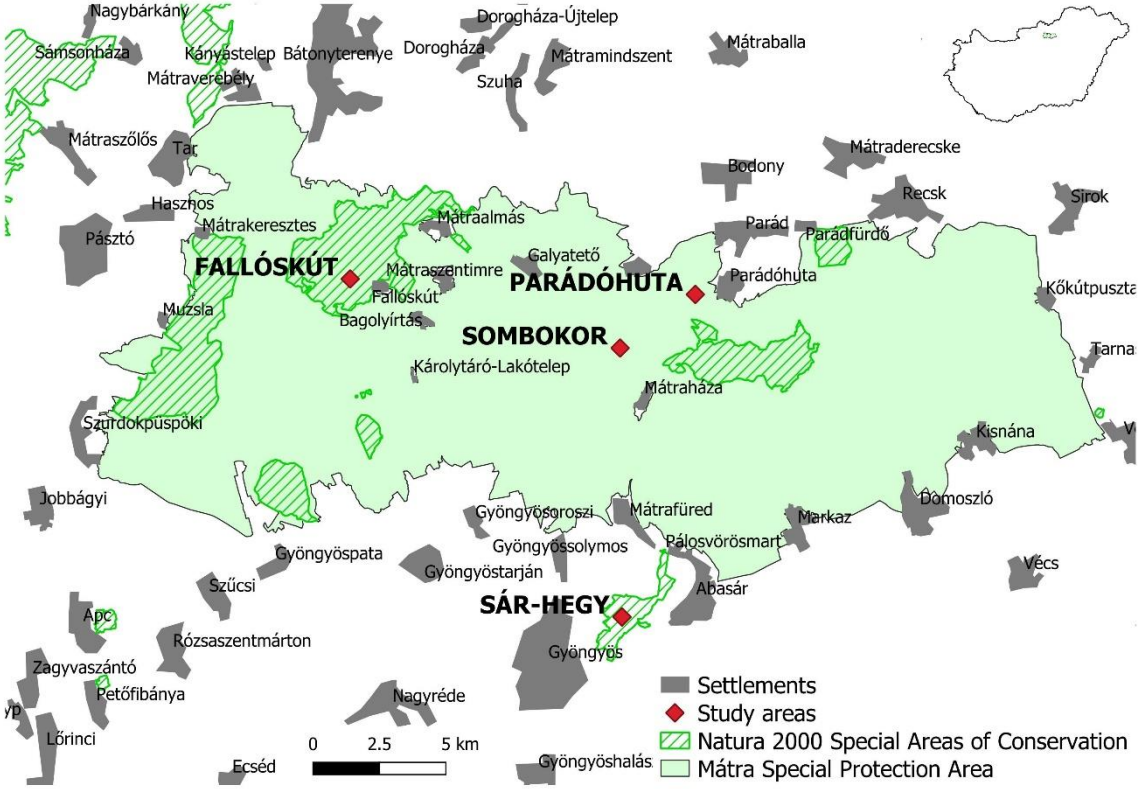
The main goals and questions of this survey were the following:

- Is there a chance to form natural or seminatural grasslands on Central European forest steppes in different forest belts through natural connservation management?
- Analysing and valuating the role of game browsing as a grassland forming issue in changing the dominancy relations between shrub and main grassland species (mainly grasses).

- Can we use an original grassland only browsed by game as control? Can we generalize the vegetation types formed by effects of game? I also wanted to review the issue in domestic and international literature.
- An important goal was to follow the changes in the vegetation through seven years, concerning species composition, cover values, invasive species and increasing cover of shrub.
- I wanted to analyse the changes in vegetation caused by nature conservation management (pasturing, mowing) following shrubcutting or its absence (abandoning).
- I also wanted to survey the importance of the formed grassland in terms of nature conservation and pasture management.
- Can we use the formerly cut and managed (pastured, mowed) areas as control?
- It was an imortant task to survey if mowing or pasturing leads to grasslands of greater value in terms of diversity and species composition. Which nature conservation management method is more effective under present microclimatic conditions and vegetational situations?
- Can we employ oecological indicators when valuing grasslands, mainly at proving disturbance? Which lifeform-spectrum is more informative and usable as indicator value?
- An important goal was to elaborate the possibilities of using coenological and game browsing examining methods parallel.

METHODS

My survey was carried out on different mountain grassland areas of the Mátra (Sárhegy, Fallóskút, Parádóhuta, Sombokor). Three of them (Fallóskút, Parádóhuta, Sár-hegy) are open grasslands enclaved between forest areas on which I surveyed tha changes of vegetation after shrubcutting. The grassland of Sombokor served as control during the survey of game effects.


Nagybárkány
Sámsonháza
Kányástelep
Bátonyterenye
Mátraverebély
Dorogháza-Újtelep
Dorogháza
Szuha
Mátramindszent
Mátraballa
Mátraszőlős
Tar
Bodony
Mátraderecske
Recsk
Sirok
Haszhos
Mátrakeresztes
Mátraalmás
Pásztó
Parád
Parádfürdő
FALLÓSKÚT
Mátraszentimre
Fallóskút
Galyatető
PARÁDÓHUTA
Parádóhuta
Kőkútpuszta
Muzsla
Bagolyirtás
SOMBOKOR
Károlytáró-Lakótelep
Tarna
Mátraháza
Szurdokpüspöki
Kisnána
Jobbágyi
Gyöngyösgroszi
Mátrafüred
Markaz
Domoszló
Gyöngyöspata
Gyöngyössolymos
Pálosvörösmart
Gyöngyöstarján
Vécs
Szűcsi
Abasár
SÁR-HEGY
Apc
Rózsaszentmárton
Gyöngyös
Zagyvaszántó
Petőfibánya
Nagyréde
Lőrinci
0
2.5
5 km
Ecséd
Gyöngyöshalás
Settlements
Study areas
Natura 2000 Special Areas of Conservation
Mátra Special Protection Area

The sample areas on Sár-hegy were the following:
I: Area shrubcut for 9 years, with the subassocation of *Arrhenatherum elatioris* (Br.-Bl. 1919) Scherrer 1925 *typicum* Oberd. 1952 and *Festucetosum sulcatae* Eggler 1958.
II: Control area, which was grassland formerly, pastured of mowed. The characteristic association is *Salvinio-Festucetum sulcatae pannonicum* Zólyomi 1958, where *Festuca valesiaca* is dominant as subassociation or facies former.
III: closed *Populus tremula* forest patch.
IV: closed grassland on the top near Szent Anna lake, mowed since 2000 (*Arrhenatherum elatioris* (Br-Bl. 1919) Scherrer 1925), where *Danthonia decumbens* is facies former.

The areas at Parádóhuta was covered by forests unti the 18th century, which were cut permanently until the 1850s in order to build glasshouses on their place.

I: Mowed systematically until 2013. Mosaic-like, with frequent patches of *Festuco ovinae-Nardetum* Dostál 1933 and *Festucetum rubrae-Cynosuretum* Tx. 1940.
II: Shrubcut area with a typicum patches of *Festucetum rubrae-Cynosuretum* Tx. 1940 and facies of *Helictotricon pubescens.*
III: Shrubcut area, *Festucetum rubrae-Cynosuretum* Tx. 1940, which was divided to more and less intensively foraged parts.

At Fallóskút I surveyed 8 areas:

I: Oak forest cut in 2012, then abandoned grassland, continuous *Molinietum coeruleae* W. Koch 1926.
II: Wetter areas of mowed meadows, where *Molinia* is a facies former in *Festucetum rubrae-Cynosuretum* Tx. 1940, Soó 1957.
III: wetter *Arrhenatherum* subassociation of mountain meadows (*Festucetum rubrae-Cynosuretum* Tx. 1940, Soó 1957 *arrhenatheretosum* Máthé – Kovács 1960).
IV: drier *Festuca* subassociation of mountain meadows (*Festucetum rubrae-Cynosuretum* Tx. 1940e, Soó 1957 *Festucetosum pseudovinae* Máthé – Kovács 1960).
V: shrubcut opening, where patches of *Pulsatillo hungaricae-Festucetum rupicolae* (Soó 1938) Borhidi 1995 appeared.
VI: shrubcut area, where spontaneously growing patches of *Crataegus* and *Prunus spinosa* had been formerly. Management was carried out in 2012.
VII: This area had been *Quercetum petreae-cerris* Soó 1957 originally. Management was carried out in 2012.
VIII: This area had been *Querceo petreae-Carpinetum pannonicum* Soó 1957 originally. Management was carried out in 2012.

Records were made betveen 2013 and 2019, in May-July of every year, using 2×2 m sample plots, according to Braun-Blanquet (1964), giving the cover values of the species. Taxonomy follows Király (2009), Nature Conservation Values were given according to Simon (1988). Data analysis was based on the lifeform system of Raunkiaer (1934) and Pignatti (2005) both. Social Behaviour Types according to Borhidi (1995) were used. During the survey of game browsing we set out 50 sample plots in every area, which gives adequate representativity. Data were recorded along transects representing the characteristic herbaceous vegetation patches every 3-10 m, depending on the size of the grassland (Parádóhuta: 1,5 ha; Fallóskút: 1,6 ha; Sombokor: 0,6 ha), within circles with a radius of 1,13 m. In the same circles coenological records arso were made (Penksza et al.,

2016), in which cover percentages of herbaceous and arboreal species were estimated. The latter results are not discussed here.
Data were analysed in the following way: relative abundance of every species in the complete sapling set were recorded, and the relation of the browsed individuals (the ones browsed on top were recorded also separately). The abundance (rare/common) of the present species playing a role in afforestation and their selective browsing (browsed/spared) were analysed χ^2 test and Bonferroni-test (Byers et al., 1984; Neu et al., 1974). In the case of abundance we supposed consistent distribution, factual supply distribution was compared to that; distribution of browsing among plant species was compared to the division of them in the supply. Selectivity of plants (browsed/spared) was quantified using the index of Jacobs (1974).
To digest the complete data structure, we used different ordination methods during our survey. These methods help to interpret the original multivariate data structures through using variables derivated from original ones. The variables covers the biggest possible proportion of the variancy of the original data structure. During PCA analysis the linear correlations variables (in our case, the species) along a background gradient are analysed. On the contrary, DCA (detrended correspondency analysis) presumes an unimodal answer curve disposing a maximum value. Using DCA, it is possible to picture objects (species) in the same coordinate system during an interactive process. Shannon-diversity was also calculated on every sample plot.

RESULTS

In Hungary, shrubcutting, mowing and grazing are preferred in managing the grasslands (Kalmár 2014, Valkó et al. 2011). But our knowledge is imperfect about the role of autochtonous big-bodied herbivores in maintaining these valuable grasslands by slowing down successional processes. Their effects are interpreted commonly as negative, such as the treading of mouflon in rocky grasslands (Baráth et al., 2013), or the browsing on the valuable plant species (Lenday and Kalapos 2009).
In our survey areas many valuable species appeared, such as *Thlaspi jankae* at Parádóhuta, *Carlina acaulis, Colchicum autumnale* and *Gentiana pneumonanthe* at Fallóskút, *Iris variegata* or *Lilium martagon* at Sombokor; and ungulate game can be a threat to their populations and habitats. In the present work coenological results are not amplified but it appeared that in some cases herbaceous plants are also effected by game (examples are chewed leaves of *Iris*es and inflorescences of *Lilium martagon,* or treaded *Cholhicum*s). But I did not notice significant disturbance on them. The effect of game was bigger and more general on saplings of arboreal species.
The shrub level and its available species play the main role in the diet of our ungulate species (Katona et al., 2013c). On afforesting mountain grassland patches many arboreal species' young sprouts are within reach, which grants steady food source by renewing after browsing. On these small patches game can consume the more protein-rich parts of plants to great extent by regular browsing, though they probably do not feed for a long time at one occasion. According to our results the majority of arboreal plants were intensively browsed without sortment. This could mean that ungulates find better vegetal nutriment than in neighboring forests, where browsing is much more selective and less intensive (Fehér et al., 2016). Since the total biomass of these sprouts is relatively low, the effect of game browsing on it can be significant.

Foraging can also play a crucial role both in maintaining and disandvantagous alteration (over-foraging) of the mountain grasslands. But when domestic animals are missing, the role of indigenous big bodied herbivores becomes more valuable. These ungulates act as ecosystem engineers and maintain dynamic grassland-shrub complexes, where besides effects of climatic changes valuable mountain grassland species appear and settle down in the more open areas (Weigl and Knowles, 2014). Türke et al. (2008) have pointed out that in Szénások the effect of game is not consistent in different habitat patches; it could threat valuable habitats potentially, but complete exclusion can lead to afforestation at the edge of forests and shadowing or closing neighboring grasslands. According to our Mátra surveys, arboreal species appearing in greater amount and browsed to a lesser extent (*Crataegus, Rubus, Euonymus, Rosa*) probably play the main role in afforesting the grasslands, so the removal of these species must be aided with artificial treatment. Other arboreal plants can be rolled back by indigenous big-bodied herbivores on a proper level.
At Parádóhuta, boidiversity dropped at areas which had been cut in 2012 then abandoned. The cover of disturbance-tolerant and competitor species increased slightly, but not drastically. The relative stable state of the vegetation was mainly due to the game, which had „managed" the area by continuous browsing the young sprouts (Penksza et al., 2015, 2016). Similar phenomena were detected on some areas of Fallóskút (VI-VII-VIII).
Area I of Parádóhuta was managed differently in every surveyed year, so we were able to observe effects on the short term. To reconstruct the abandoned grasslands, the most obvious solution is to bring back mowing (Deák and Tóthmérész, 2005, 2007; Stampfli and Zeiter, 1999; Valkó et al., 2009, 2012) or grazing systems (Kovács-Hostyánszki et al., 2013; Tälle et al., 2016; Török et al., 2014, 2016) used in the past. Because of that, nature conservation management has been extended to grasslands, which were diverse in the past but have become poor in species; in this way they can stop and turn back the process of declining biodiversity (Szabó et al., 2007; Penksza et al., 2008, 2015; Házi et al., 2010, 2011; Vida et al., 2008). Mowing is often used as an additional intervention in order to roll back weeds germinating during the first phase of forming grasslands, and to help indigenous grassland specialist species to grow (Vida et al., 2008; Török et al., 2007, 2008, 2011). Mowing as nature conservational management slows down the invading of shrub and afforestation, and helps new species that are typic in the association to germinate. In this way it leads to form more diverse grassland habitats (Huhta et al., 2001). In some cases, the changes in the species pool can be detected in the first year after the management already (Beltman et al., 2003).
The significance of mowing is shown on the permanently mowed area at Sár-hegy, the vegetation was stable during the survey, the cover of the disturbance tolerant species and naturalness-signing ones remained the same. It has been affirmed on the grasslands near Parádóhuta, that arboreal plants' cover increases significantly without proper management. It has been pointed out by Hansson and Fogelfors (2000) during a 15-year experiment, that on grasslands where the main goal is to maintain high biodiversity, systematic mowing (in this case, every 3 years) is needed in order to avoid increasing phanerophyte cover. During a 12-year survey Dzwonko and Loster (2008) have compared the vegetation of a newly cut calcareous grassland with another one with similar makings which had been maintained for years. According to their results, there was no significant difference between the vegetations of the two grasslands; the cover of bush increased significantly. The authors suggest that it could be useful to repeat management in every few years, if possible, before the cover of bush reaches 30%. Baba (2003) also points out the significance af systematic shrubcutting. He compared the vegetation on managed and unmanaged grasslands calcareous grasslands in Poland. Shrubcutting (supported by mowing) has increased the diversity of species, although the author adds that there were significant differences

between restaurated grassland patches and the near-natural ones which had been managed for years. This survey also discuss the effects of too intensive mowing, which declines diversity. In this case, species which are less valuable in terms of nature conservation (for example *Calamagrostis arundinacea* and *Brachypodium pinnatum*) increase their cover. Bonanomi et al (2006b) surveyed the effects of shrubcutting in the short term. Although during the 3-year experiment the management lowered the amount of biomass signifcantly, but biodiversity increased. According to the authors, systematic shrubcutting can be a remedy for nitrogen accumulation too. Pykälä et al. (2005) have conducted surveys in Finland; they pointed out that species diversity declines after ceasing foraging and the increasing cover of shrub lowers it further. Peco et al. (2006) have studied vegetation types called dehesas in Spain, which had been abandoned by traditional farmers during the last few years. The stopping of foraging did not cause many changes in the number of species, but the relation of cover percentages altered greatly: the association-forming herbs declined by appr. 50% on both dryer and wetter deheasas.

Mowing plays a significant role when recostructing abandoned meadows (Deák and Tóthmérész, 2005, 2007; Stampfli and Zeiter, 1999; Valkó et al., 2009, 2012), because it slows down the process of afforestation and by creating habitats for many supporting species it helps grassland biodiversity to stabilize and increase (Huhta et al., 2001).

On the *Populus tremula* patch, which was poor in species already in 2013, disturbance tolerant plants carried on to grow, and by 2017 a nearly continuous shrub had formed. According to the results it had been prooved that continuous management (mowing) stabilizes grasslands' vegetation; on the contrary, ceasing management could lead to growing cover of shrubs and arboreal plants and declinig biodiversity in a few years.

My results clearly showed that systematic nature conservation management and shrubcutting increases species richness of the vegetation. But on areas which had been abandoned recently, I detected declining biodiversity. We can point out that grasslands once utilized, should not be abandoned, because the cover of shrub will increase and invasive species will invade the vegetation, so nature conservation management must be conducted systematically. According to the results, foraging has also a significant positive effect on biodiversity.

NEW SCIENTIFIC RESULTS

I surveyed three different domestic (and characteristic in Central Europe) forest-steppes in the *Quercus* and *Carpinus* belt on the long term (7 years) which were formed by shrubcutting, through yearly sampling and evaluation. My surveys verified that this tima-span is enough for a seminatural grassland to form. As a result of the game browsing, three different vegetation type formed: heavily covered by shrub; dominated by invasive or invasive-like dominant grass species (for the most part, *Calamagrostis epigeios*), and mosaic-like vegetation consisted of shrubs, diverse herbaceous species (grasses, legumes and other dicots).

Along nature conservation management, game browsing was manifested not as an endangering issue, but as a process helping to form and maintain the vegetation. Game browsing caused the increasing of naturalness of grassland vegetation through driving back the shrub. At the same time, grassland species' number has increased, which can be seen as a positove effect in terms of pasture management. The habitat aon Sombokor, which was surveyed in comparing game effects, could be used as control as it was maintained only by game on the long term. I also wrote a review article about the domestic and international literature concerning the effects of shrubcutting and game browsing.

I provided floristic and coenological data from four areas of the Mátra (west and top region of Sár-hegy, Fallóskút, Parádóhuta, Sombokor).
I managed to malaxate and employ classic coenological sampling and inquirying effects of game browsing, simultaneously. This is significant because the parallel surveying of shrub and grass vegetation is nearly unique in domestic and international literature.
It was confirmed that in seven years following shrubcutting changes appear concerning species composition, cover values, invasove species and set back shrub, which can lead to forming natural grasslands.
There has been a possibility to survey the effects of management (mowing, foraging) on the grassland and the solitary effects of game. According to the results, on the surveyed areas it can be stated that abandoning can lead to declining biodiversity and species number. On these vegetations mowing could be the most adequate management method, which was proved mainly by areas of Parádóhuta.
Oecological values can be also used when following the changes and surveying naturalness. The system of Pignatti was used in Hungary (elsewhere than on pasture) for the first time and proved to be an adequate method, it was an useful indicator of the changes.

Publications in the topic of this work

Articles in a periodic

Article in a foreign language, with IF

Gergely Pápay, Ádám Fehér, Gábor Szabó, Zita Zimmermann, Levente Hufnagel, Eszter S.-Falusi, Ildikó Járdi, Dénes Saláta, Károly Penksza, Krisztián Katona (2018): Impact of wild ungulate browsing on mountain grasslands established by shrub removals in zonal (Fagetalia) forest areas, Mátra Mountains, Hungary. Tuexenia 38: (in press)

Article in a foreign language, with IF

G. Pápay, P. Norbert, K. Penksza (2019): The effect of mowing and pasturing on grassland vegetation in Mátra Mauntains (Parádóhuta). Gyepgazdálkodási Közlemények 17(2): pp. 35-40.

Article in Hungarian, without IF

Katona Krisztián; Fehér Ádám; Szemethy László; Saláta Dénes; Pápay Gergely; S.-Falusi Eszter; Kerényi-Nagy Viktor; Szabó Gábor; Wichmann Barnabás; Penksza Károly (2016): Vadrágás szerepe a mátrai hegyvidéki gyepek becserjésedésének lassításában. Gyepgazdálkodási Közlemények 14(2): pp. 29-35., 7 p. (2016)

Pápay Gergely (2016): Cserjeirtás után magára hagyott, legeltetett és kaszált gyepterületek vegetációjának összehasonlító elemzése parádóhutai (Mátra) mintaterületen. Gyepgazdálkodási Közlemények 14(2): pp. 37-48. , 12 p. (2016)

Pápay G., Penksza K., Szabó G., Ibadzane, M., Járdi I., Wichmann B. (2017): Természetvédelmi kezelések hatása hegyi rétek vegetációjára a Gyöngyösi Sár-hegy TT területén. Gyepgazdálkodási Közlemények 15(2). 37-46.

Pápay Gergely; Wichmann Barnabás; Penksza Károly: Parádóhuta melletti cserjeirtott mintaterületen kialakult gyep növényzetének változása vadrágás hatására 2012 és 2019 között. Gyepgazdálkodási Közlemények 17(1): pp. 43-50. , 8 p. (2019).

Conference appearances

In a foreign language (abstracts)

Gergely Pápay, Eszter S.-Falusi, Károly Penksza (2016): Comperative analysis of vegetation on grasslands abandoned, grazed and mowed after shrubcutting in Mátra Mountains in Hungary. In: Guarino R , Bazan G , Barbera G (szerk.): The 60th IAVS Annual Symposium: Vegetation patterns in natural and cultural landscapes – Abstract Book . 374 p.

Károly Penksza, Ádám Fehér, Dénes Saláta, **Gergely Pápay**, Eszter S.-Falusi, Viktor Kerényi-Nagy, Gábor Szabó, Barnabás Wichmann, László Szemethy, Krisztián Katona (2016): Studies on grassland regeneration and game browsing impact after shrub control in Parádóhuta (Mátra Mountains, NE Hungary). In: Guarino R , Bazan G , Barbera G (szerk.) The 60th IAVS Annual Symposium: Vegetation patterns in natural and cultural landscapes – Abstract Book . 374 p.

Pápay Gergely, S.-Falusi Eszter, Penksza Károly, Wichmann Barnabás: Comparative analysis of vegetation on grasslands abandoned, grazed and mowed after shrub cuttings in the Matra Mountains from Hungary. In: Biogeography Of The Carpathians, Cluj-Napoca, 2017: Ecological and evolutionary facets of biodiversity. The Second Interdisciplinary Symposium, 28-30 September 2017, Cluj-Napoca, Romania. 215 p.

Gergely Pápay, Eszter S.-Falusi, Károly Penksza (2017): Comperative analysis of vegetation on grasslands abandoned, grazed and mowed after shrubcutting in Mátra Mountains in Hungary. In: Guarino R , Bazan G , Barbera G (szerk.): The 60th IAVS Annual Symposium: Vegetation patterns in natural and cultural landscapes – Abstract Book . 374 p. (ISBN:9788899934439)

Károly Penksza, Ádám Fehér, Dénes Saláta, **Gergely Pápay**, Eszter S.-Falusi, Viktor Kerényi-Nagy, Gábor Szabó, Barnabás Wichmann, László Szemethy, Krisztián Katona (2017): Studies on grassland regeneration and game browsing impact after shrub control in Parádóhuta (Mátra Mountains, NE Hungary). In: Guarino R, Bazan G , Barbera G (szerk.) The 60th IAVS Annual Symposium: Vegetation patterns in natural and cultural landscapes – Abstract Book . 374 p. (ISBN:9788899934439)

Gergely, Pápay; Eszter, S -Falusi; Barnabás, Wichmann; Károly, Penksza (2017): Comparative analysis of vegetation on grasslands abandoment, grazed and mowed after shrubcatting in Matra Montains in Hungary. STUDIA UNIVERSITATIS BABES-BOLYAI BIOLOGIA Supplement pp. 178-179. , 2 p.

Gergely, Pápay; Ádám, Fehér; Gábor, Szabó; Zita, Zimmermann; Levente, Hufnagel; Eszter, S.-Falusi; Ildikó, Járdi; Dénes, Saláta; László, Szemethy; Péter, Csontos et al. Impact of wild ungulate browsing on the vegetation of restored mountain hay meadows. In: 62nd IAVS Annual Sympodium: Abstracts (2019) p. 183

REFERENCES

Archer, S. R., Schimel, D. S., & Holland E. H. (1995). Mechanisms of shrubland expansion: Land use, climate or CO2? *Climatic Change, 29*, 91–99.

Baba, W. (2003): Changes in the structure and floristic composition of the limestone grasslands after cutting trees and shrubs and mowing. Acta societatis botanicum Poloniae 72(1): 62-69.

Baráth N.-Bartha S.-Házi J.-Wichmann B.-Penksza K. (2013): A dolomitsziklagyepek degradációjának és a muflon (*OVIS musimon*) jelenlétének összefüggései a Budai-hegységben. Vadbiológia 15: 72-85.

Beltman, B.-Van den Broek, T.-Martin, W.-Ten Cate, M.- Güsewell, S. (2003): Impact of mowing regime on species richness and biomass of a limestone hay meadow in Ireland. Bulletin of the Geobotanical Institute ETH 69: 17-30.

Bergelson, J. (1990): Life after death: site pre-emption by the remains of Poa annua. *Ecology, 71,* 2157–2165.

Bihari Z.-Csorba G.-Heltai M. (szerk.) (2007): Magyarország emlőseinek atlasza. Kossuth Kiadó, Budapest

Borhidi, A. (1995): Social behaviour types, the naturalness and relative ecological indicator values of the higher plants in the hungarian flora.- Acta Bot. Hung. 39: 97-181.

Braun-Blanquet, J. (1964): Pflanzensoziologie. Wien-New York

Byers, C. R.-Steinhorst, R. K.-Krausman, P. R. (1984): Clarification of technique for analysis of utilization- availability data. Journal of Wildlife Management 48: 1050- 1053.

Catorci, A.-Piermarteri, K.-Penksza, K.-Házi, J.-Tardella, F. M. (2017): Filtering effect of temporal niche fluctuation and amplitude of environmental variations on the trait-related flowering patterns: lesson from sub-Mediterranean grasslands. Scientific Reports 7: Paper 12034. 14. p.

Deák B.-Tóthmérész B. (2005): Kaszálás hatása a növényzetre a Nyírőlapos (Hortobágy) három növénytársulásában. In: Molnár E. (szerk.): Kutatás, oktatás, értékteremtés. MTA ÖBKI, Vácrátót, pp. 169-180.

Deák B.-Tóthmérész B. (2007): A kaszálás hatása a Hortobágy Nyírőlapos csetkákás társulásában. Természetvédelmi Közlemények 13: 179-186.

Dzwonko, Z.-Loster, S. (2008): Changes in plant species composition in abandoned and restored limestone grasslands – the effects of tree and shrub cutting. Acta societatis botanicorum Poloniae 77(1): 67-75.

Facelli, J. M.-Pickett, S. T. A. (1991): Plant litter: its dynamics and its role in plant community structure. Botanical Review 57, 1- 32.

Fehér Á.-Katona K.-Szemethy L. (2016): Okozhatnak-e a csülkös vadfajok térségi szintű problémákat a Mátra erdőiben? Vadbiológia 18: 17-26.

Fischer, M., & Stöcklin, J. (1997): Local extinctions of plants in remnants of extensively used calcerous grasslands 1950-85. *Conservation Biology, 11,* 727-737.

Giarrizzo, E., Burrascano, S., Zavattero, L., & Blasi, C. (2015): New methodological insights for the assessment of temporal changes in semi-natural dry grasslands plant species composition based on field data from the northern Apennines. *Hacquetia 14,* 19–32.

Hansson, M.-Fogelfors, H. (2000): Management of semi-natural grassland; results from a 15-year old experiment in southern Sweden. J. Veg. Sci. 11, 31-38.

Házi J.-Nagy A.-Szentes Sz.-Tamás J.-Penksza K. (2009): Adatok a siska nádtippan (Calamagrostis epigeios) (L.) Roth. Cönológiai viszonyaihoz Dél-tiszántúli gyepekben. Tájökológiai Lapok 7(2): 1-13.

Házi, J.-Bartha, S.-Szentes, S.-Wichmann, B.-Penksza, K. (2011): Seminatural grassland management by mowing of Calamagrostis epigejos in Hungary. Plant Biosystems 145 (3): 699-707.

Házi, J.-Bartha, S.-Szentes, Sz.-Penksza, K. (2010): Seminatural grassland management by mowing of Calamagrostis epigejos in Hungary. Plant Biosystem 145(3): 699-707.

Házi, J.-Penksza, K.-Bartha, S.-Hufnagel, L.-Tóth, A.-Gyuricza, Cs.-Szentes, Sz. (2012): Cut mowing and grazing Effects with grey cattle on plant species composition in case of Pannon wet grasslands. Applied Ecology and Environmental Research 10(3): 223-231.

Huhta, A. P.-Rautio, P.-Tuomi, J.-Laine, K. (2001): Restorative mowing on an abandoned semi-natural meadow: short-term and predicted long-term effects. Journal of Vegetation Science 12: 677-686.

Jacobs, J. (1974): Quantitative measurement of food selection. A modification of the forage ratio and Ivlev's electivity index. Oecologia 14: 413-417.

Kalmár Zs. (2014): Természetvédelmi célú gyeprekonstrukció rövid távú eredményei dombvidéki löszgyepekben és erdőssztyepréteken. Gyepgazdálkodási Közlemények 2014 (1-2): 29-37.

Katona K.-Bleier N.-Hejel P.-Fehér Á.-Szemethy L. (2013a): Terepi módszertani segédlet a vadonélő patás fajok erdei élőhelyeken megfigyelhető hatásainak méréséhez. Patamat Bt., Vértessomló

Katona K.-Fehér Á.-Szemethy L. (2015): Vadkár-okozók állománycsökkentésétől a növény-növényevő kapcsolatrendszerek többoldalú kezeléséig. Természetvédelmi Közlemények 21: 108-115.

Katona K.-Hejel P.-Szemethy L. (2013b): Terepi módszertani segédlet a vadonélő patás fajok jelenlétére, élőhely- használatára utaló jelek felismeréséhez. Patamat Bt., Vértessomló

Katona K.-Kiss M.-Bleier N.-Székely J.-Nyeste M.-Kovács V.- Terhes A.-Fodor Á.-Olajos T.-Szemethy L. (2013c): Növényevő nagy vadak rágáspreferenciái, mint a táplálkozási igények indikátorai. Vadbiológia 15: 63-71.

Király G. (szerk.) (2009): Új magyar füvészkönyv. Magyarország hajtásos növényei. Határozókulcsok. Aggteleki Nemzeti Park Igazgatóság, Jósvafő

Klimeš, L.-Jongepierova, I.-Jongepier, J. W. (2000): Effect of mowing on a previously abandoned meadow: ten year experiment. Priroda. 17: 7-24.

Kovács-Hostyánszki, A.-Elek, E.-Balázs, K.-Centeri, Cs.-Falusi, E.-Jeanneret, P.-Penksza, K.-Podmaniczky, L.-Szalkovszki, O.-Báldi, A. (2013): Reply to reviewers' comments on MS „Earthworms, spiders and bees as indicators of habitat and management in a low-input farming region - a whole farm approach" Ecological Indicators 33: 111-120.

Kricsfalusy, V. V. (2013): Mountain grasslands of high conservation value in the Eastern Carpathians: syntaxonomy, biodiversity, protection and management. Thaiszia – J. Bot. 23 (1): 67-112.

Lendvay B.-Kalapos T. (2009): A magyarföldi husáng (*Ferula sadleriana*) populációinak állapotfelmérése 2008-ban. Természetvédelmi Közlemények 15: 486-492.

Neu, C. V.-Byers, C. R.-Peek, J. M. (1974): A technique for analysis of utilization-availability data. Journal of Wildlife Management 38(3): 541-545.

Ölvedi T. (2010): A kaszálás vegetációra és magkészletre gyakorolt hatásai. Botanikai Közlemények 97: 159-169.

Peco, B.-Sánchez, A. M.-Azcárate, F. M. (2006): Abandonment in grazing systems: Consequences for vegetation and soil. Agriculture, Ecosystems and Environment 113: 284-294.

Penksza K.-Fehér Á.-Saláta D.-Pápay G.-S.-Falusi E.-Kerényi- Nagy V.-Szabó G.-Wichmann B.-Szemethy L.-Katona K. (2016): Gyepregeneráció és vadhatás vizsgálata cserjeirtás után parádóhutai (Mátra) mintaterületen. Gyepgazdálkodási Közlemények 14(1): 31-41.

Penksza K.-Pápay G.-Házi J.-Tóth A.-Saláta-Falusi E.-Saláta D.- Kerényi-Nagy V.-Wichmann B. (2015): Gyepregeneráció erdőirtással kialakított gyepekben mátrai (Fallóskút) mintaterületeken. Gyepgazdálkodási Közlemények 13(1-2): 31-44.

Penksza K.-Tasi J.-Szentes Sz.-Centeri Cs. (2008): Természetvédelmi célú botanikai, takarmányozástani és talajtani vizsgálatok a Tapolcai és Káli-medence szürkemarha és bivaly legelőin. Gyepgazdálkodási Közlemények 6: 47-53.

Pickett, S. T. A.-Thompson, J. N. (1978): Patch dynamics and the design of nature reserves. Biological Conversation 13: 27-37.

Pignatti, S. (2005): Valori di bioindicazione delle piante vascolari della flora d'Italia. Braun-Blanquetia 39: 1-97.

Pykälä, J.-Luoto, M.-Heikkinen, R. K.-Kontula, T. (2005): Plant species richness and

persistence of rare plants in abandoned semi-natural grasslands in northern Europe. Basic and Applied Ecology 6: 25-33.

Raunkiær (1934): Biological types with reference to the adaption of plants to survive the unfavourable season

Sendžikaite, J.-Pakalnis, R. (2006): Extensive use of sown meadows - A tool forrestoration of botanical diversity. Journal of Environmental Engineering and Landscape Management 14: 149-158.

Simberloff, D. (1982): A succession of paradigms in ecology: essentialism tomaterialism and probablism. In Saarinen, E. (ed.): Conceptual issues in ecology. Reidel (Kluwer), Boston. pp. 63-99.

Simon T. (2000): A magyarországi edényes flóra határozója. Tankönyvkiadó, Budapest

Stampfli, A.-Zeiter, M. (1999): Plant species decline due to abandonment of meadows cannot easily be reversed by mowing. A case study from the southern Alps. Journal of Vegetation Science 10: 151-164.

Standovár T.-Primack R. (2001): A természetvédelmi biológiai alapjai. Nemzeti Tankönyvkiadó, Budapest

Stöcklin, J., & Fischer, M. (1999): Plants with longer-lived seeds havelower local extiction in grassland remnants 1950-85. *Plant Ecology, 143,* 29-37.

Szabó, M.-Kenéz, Á.-Saláta, D.-Szemán, L.-Malatinszky, Á. (2007): Studies on botany and environmental management relations on a wooded pasture between Pénzesgyőr and Hárskút villages. Cereal Research Communications, 35 (2): 1133-1136.

Szmorad F.-Király G. (2014): Az erdők természetvédelmi szempontú kezelése. In: Haraszthy L. (szerk.): Natura 2000 fajok és élőhelyek Magyarországon. Pro Vértes Közalapítvány, Csákvár, 758-760.

Tälle, M.-Deák, B.-Poschlod, P.-Valkó, O.-Westerberg, L.- Milberg, P. (2016): Grazing vs. mowing: a meta-analysis of biodiversity benefits for grassland management. Agriculture, Ecosystems & Environment 15: 200-212.

Török P.-Arany A.-Prommer M.-Valkó O.-Balogh A.-Vida E.- Tóthmérész B.-Matus G. (2007): Újrakezdett kezelés hatása fokozottan védett kékperjés láprét fitomasszájára, faj- és virággazdagságára. Természetvédelmi Közl. 13: 187-198.

Török P.-Deák B.-Vida E.-Lontay L.-Lengyel Sz.-Tóthmérész B. (2008): Tájléptékű gyeprekonstrukció löszös és szikes fűmagkeverékekkel a Hortobágyi Nemzeti Park (Egyek- Pusztakócs) területén. Botanikai Közlemények 95: 115-125.

Török, P.-Kelemen, A.-Valkó, O.-Deák, B.-Lukács, B.- Tóthmérész, B. (2011): Lucerne-dominated fields recover native grass diversity without intensive management actions. Journal of Applied Ecology 48: 257-264.

Török, P.-Valkó, O.-Deák, B.-Kelemen, A.-Tóth, E.-Tóthmérész, B. (2016): Managing for composition or species diversity? – Pastoral and year-round grazing systems in alkali grasslands. Agriculture, Ecosystems & Environment doi: 10.1016/j.agee.2016.01.010

Török, P.-Valkó, O.-Deák, B.-Kelemen, A.-Tóthmérész, B. (2014): Traditional cattle grazing in a mosaic alkali landscape: Effects on grassland biodiversity along a moisture gradient. PLoS ONE 9 (5): e97095.

Türke I. J.-Kun A.-Botta-Dukát Z.-Kézdy P. (2008): A túltartott nagyvadállomány okozta változások természetes növényközösségekben 2002-2007 között. Rosalia 4: 105-142.

Valkó O.-Török P.-Vida E.-Arany I.-Tóthmérész B.-Matus G. (2009): A magkészlet szerepe felhagyott hegyi kaszálórétek helyreállításában. Természetvédelmi Közlemények 15: 147-159.

Valkó, O.-Török, P.-Matus, G.-Tóthmérész, B. (2012): Is regular mowing the most appropriate and cost-effective management maintaining diversity and biomass of target forbs in mountain hay meadows? Flora 207 (4): 303-309.

Valkó, O.-Török, P.-Tóthmérész, B.-Matus, G. (2011): Restoration potential in seed banks of acidic fen and dry-mesophilous meadows: Can restoration be based on local seed banks? Restoration Ecology 19: 9-15.

Vida E.-Török P.-Deák B.-Tóthmérész B. (2008): Gyepek létesítése mezőgazdasági művelés alól kivont területeken: a gyepesítés módszereinek áttekintése. Botanikai Közlemények 95: 101-113.

Wedin, D. A., & Tilman, D. (1993): Competition among grasses along a nitrogen gradient: initial conditions and mechanisms of competition. *Ecological Monographies, 63,* 199–229.

Weigl, P. D.-Knowles, T. W. (2014): Temperate mountain grasslands: a climate-herbivore hypothesis for origins and persistence. Biol. Rev. 89:, 466-476.

White, P. S. (1979): Pattern, process, and natural disturbance in vegetation. The Botanical Review 45(3): 229-299.

Whittaker, R. H.-Levin, S. A. (1977): The role of mosaic phenomena in natural communities. Theoretical Population Biology 12: 117-139.

Willems, J. H. (1983): Species composition and above ground phytomass in chalk grassland: The role of seed rain and seed bank. Vegetatio 52: 171-180.