Relationship between the diversity and mowing in cleared grassland areas in the Börzsöny mountains

Zsófia Fehér
MATE Department of Botany, Gödöllő
feherzsofia@invitel.hu

SUMMARY

Nowadays, mowing has an increasing role in the management of semi-natural and nature conservation areas. Semi-dry grasslands have been formed on cleared areas of forest in the Pannon mountains, which would be reclaimed by forest without use of the areas by humans.

In our work we analysed cleared grasslands. The questions we aimed to answer were the following: (i) What kind of vegetation changes were caused by different land use types? (ii) Is mowing a proper method for grassland management and nature protection in the studied system? (iii) Do the species composition and the diversity vary within two years when conditions of precipitation are different?

In four sampling areas situted in Börzsöny mountains (North-Hungary), we registered the plant species and their cover values in ten quadrats per sampling area. We performed a site assessment in April, June and October, 2013-2014. We analysed the data by using cluster and ordination processes and we compared the sampling areas on the basis of the humidity preference and Shannon's index of diversity.

From nature conservation's point of view, it is favourable that the cover of Potentilla alba occurring in the area was high. It is a specialist plant species with low stress resistance. However, due to tourism, it occured less frequently in the area and Bromus erectus became dominant instead. The species whose cover was more extensive in areas not affected by tourism – for example Alopecurus pratensis, Galium verum, Carex praecox, Trisetum flavescens – occurred less frequently in areas affected by tourism. On the short run, species did not completely disappear due to the changing conditions but their abundance decreased, as has been already supported by other surveys.

The ordination analysis showed that the composition of species considerably differed with the portions of land cultivated in different ways. The change of the cover values was apparent not only in the case of the dominant species but of also in case of species with smaller cover. The decrease of diversity, the change of plant cover, the decrease of number of sensitive species as a result of tourism are typical phenomena all over the world.

The Shannon's diversity records showed that due to human presence and trampling the diversity declined. It was considerably lower in the year with less rain. In the year with more rain the diversity of species was considerably higher, however, the difference in between the surveyed areas was large. All these examples draw attention to the important role of environmental factors alongside the human factors. The water reserve also influences the productivity of grasslands and water has primary importance in the structure of plant communities.

According to the survey, in the two areas not affected by tourism, in the rainier year the difference between the humidity preference of the species of the dry and the less dry patches became similar. On these areas, there were more species with higher humidity preferences in the rainier year, however, this tendency could not be observed in the rainier year on areas affected by tourism. The areas affected by tourism may react in a less flexible manner to the change in precipitation conditions.

Based on our analysis, we can conclude that the surveyed semi-dry grasslands are extremely rich in species and therefore proper grassland management plans are needed. To preserve grasslands of high natural value, the impacts of the environmental factors should also be considered in addition to becoming acquainted with the history and the present conditions of landscape use.

Keywords: *mowing, tourism, forest, diversity*

ÖSSZEFOGLALÁS

A közelmúltban a védett természeti, természetközeli területeken igencsak megnőtt a kaszálás jelentősége. A kárpát-medencei erdők helyén keletkezett félszáraz gyepek újra beerdősülhetnek emberi beavatkozás hiányában.

Munkám során cserjeirtott gyepeket vizsgáltam. Fő kérdéseim a következők voltak: milyen változásokat okozott a területhasználat megváltozása? Mennyire hasznos a kaszálás a gyepgazdálkodásban és a természetvédelemben? Megváltozik-e két év alatt a fajösszetétel és a diverzitás, ha a csapadékviszonyok változnak?

Négy mintaterületen, 4×10 kvadrátban mértem fel a fajok borítását 2013 és 2014 áprilisában, júniusában és októberében. Az adatelemzés során klaszteranalízist és ordinációs eljárásokat alkalmaztam, valamint összehasonlítottam a kvadrátok fajösszetételét nedvességigény és Shannon-diverzitás alapján.

Természetvédelmi szempontból jelentős adat az alacsony stressztűrő képességű Potentilla alba nagy borítása. Azonban a turizmus miatt a faj visszaszorul, és a Bromus erectus válik dominánssá. Azok a fajok, melyeknek a borítása a turizmus által kevéssé érintett területeken nagyobb (pl. Alopecurus pratensis, Galium verum, Carex praecox, Trisetum flavescens), a zavart területeken visszaszorulnak. Összhangban más kutatásokkal, a fajok a változó körülményekre először nem eltűnéssel, hanem dominancia-csökkenéssel reagálnak.

Az ordinációs analízis szerint a különféle módon hasznosított területek fajösszetétele jelentősen különbözik egymástól. A turizmus által érintett gyepterületeken a jellemző fajok borítási értéke alacsony. A kisebb mennyiségben jelen lévő fajok borítása szintén változik. A diverzitás csökkenése, a növényborítás változásai, az érzékeny fajok számának turizmus által okozott csökkenése az egész világon megfigyelhető jelenségek.

A Shannon-diverzitás az emberi jelenlét és taposás következtében csökkent. Különösen igaz ez a csapadékszegényebb évekre. Az esősebb években a diverzitás nagyobb volt, bár a különbség a vizsgált területek között jelentős. E példák ráirányítják a figyelmet a környezeti tényezők fontosságára az emberi tényezők mellett. A vízkészlet a gyepek produktivitását is befolyásolja, a növényközösségek szerkezetének alakításában a víznek elsődleges szerepe van.

Eredményeim alapján a két, turizmus által nem érintett területen az esősebb évben a szárazabb és nedvesebb részek fajainak nedvességigény-értékei hasonlóvá váltak. Ebben az évben több, nagyobb nedvességigényű faj jelent meg ezeken a területeken, ellentétben a turizmus által érintett részekkel. Az utóbbi területek valószínűleg kevésbé rugalmasan reagálnak a változó csapadékviszonyokra.

Eredményeim alapján elmondható, hogy a vizsgált félszáraz gyepek igen fajgazdagok, ezért megőrzésükhöz és fenntartásukhoz megfelelő kezelési tervekre van szükség, hogy megőrizzük ezeket az értékes gyepeket, figyelembe kell vennünk a környezeti hatásokat, és a tájhasználat múltbeli és jelenlegi módozatait.

Kulcsszavak: *kaszálás, turizmus, erdősülés, fajdiverzitás*

INTRODUCTION

Area s of natural grasslands have considerably decreased in Europe in the past decades (Luick, 1998; Dullinger et al., 2003; Sebastià et al., 2008; Penksza et al., 2010, 2013, 2020; Kiss és Penksza, 2018; Catorci et al., 2017; Házi et al., 2011, 2012; Szentes et al., 2011; Zimmermann et al., 2011), while priority has been given to grassland management using nature conservation and ecological criteria (Nagy, 2008; Habel et al., 2013). The reason that the conservation of grasslands is highly important is their important role in maintaining and preserving the diversity (Houghton et al., 2001; Habel et al., 2013; Saláta 2009, 2017; Saláta et al., 2011, 2012, 2013).

Natural and semi-natural grasslands are also endangered by the loss of habitats and by industrial and recreational activities (Drewitt, 2007). Due to changing land use, traditionally managed grasslands are rarely seen (Kaligarič et al., 2006; Komarek, 2007a, b; Valkó et al., 2018). This is an unfortunate fact as regular mowing and foraging are the primary tools of maintaining these areas. These methods are of high importance in terms of nature conservation management, by affecting the successional processes (Penksza et al., 2008; Komarek, 2008; Horváth és Komarek, 2016; Török et al., 2011, 2018; Szentes et al., 2009; Pápay et al., 2019c; Valkó et al., 2012; Kelemen et al., 2014).

Natural disturbances are part of the ecological systems, and the majority of meadows and hayfields of high nature conservation value can only be preserved through management (Whittaker and Levin, 1977). By means of nature conservation treatments, the number of grassland species can be increased and various accompanying species can be introduced (Besnyői et al., 2012; Baráth et al., 2012; Penksza et al., 2009a, b, c; Stroh et al., 2002; Szabó et al., 2010, 2011, 2017a, b; Labadessa et al., 2020).

Besides, due to the removal of the accumulated litter, colonization patches are created for numerous accompanying dicotyledonous species (Bissels et al., 2006; Deák et al., 2012; Tälle et al., 2016). The extensive grassland management, the preservation of nature conservation areas and the flora and fauna are also supported by the Natura 2000 network through the supporting system of the European Union (Klejn and Sutherland, 2003).

One of the most important danger threatening mountain grasslands is the increasing cover of shrubs (Pápay and Uj 2012; Penksza et al., 2015; Pápay, 2016), which is a problem that exists also on a global scale (Pápay et al., 2018). This situation calls for management, such as extensive grazing, pasturing (Járdi et al., 2017; Zimmermann et al., 2018) and shrub cutting (Pápay et al., 2017). However, in some cases, ungulate browsing can provide help in this task by setting back the growth of new sprouts (Katona et al., 2016; Penksza et al., 2016; Pápay et al., 2019c, 2020).

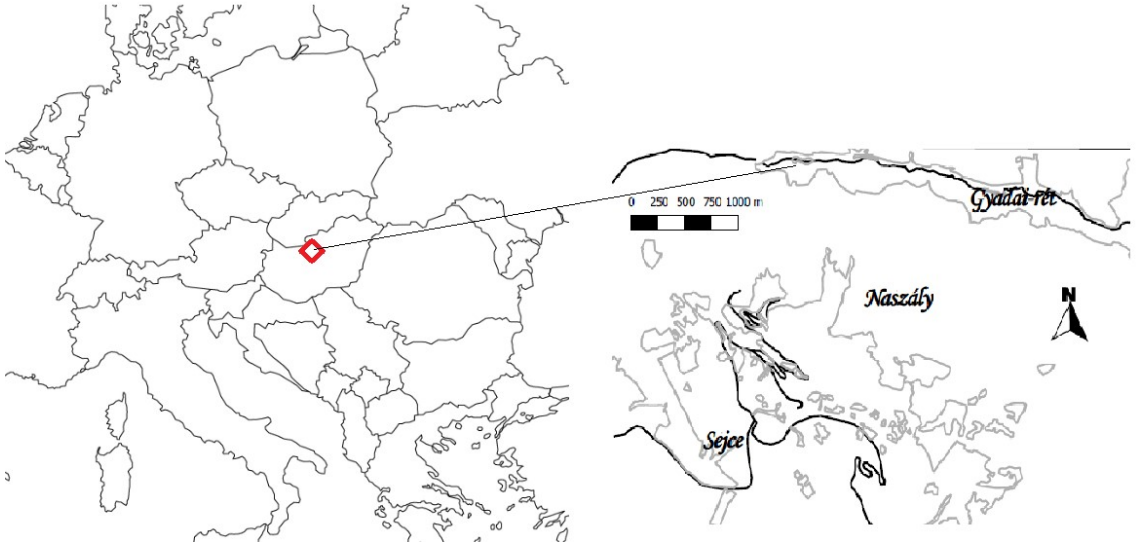
MATERIALS AND METHODS

The surveyed area

The surveyed area is situated in the Carpathian basin, in the Northern region of Hungary, within the countryside Mount Börzsöny in the small region of Kosd hills (*Figure 1*) (Dövényi, 2010). The area was once characterised by *Aceri tatarici-Quercetum roboris*, *Quercetalia cerris* (in patches), and *Salvio nemorosae-Festucetum rupicolae* (in smaller patches). The meadow Gyadai is situated at the Northern end of Mount Naszály forming a part of the Kosd hills in the valley of the stream Lósi, this is where our surveys were carried out.

The meadow Gyadai was created by cutting down the forest areas around the stream Lósi. The largest plant communities of the meadow Gyadai are the *Pastinaco-Arrhenatheretum* and *Alopecuro-Arrhenatheretum* meadows, the forest steppes and the semi-dry cleared grasslands. The meadow „Gyadai" is characterized by remnant trees, which provide shade for animals on hot days. The meadow Gyadai also accommodates some plant species of *Carici pilosae-Carpinetum* (Rév et al., 2008; Kertész, 1988). The meadow is preserved by human activities, otherwise the entire area might be reclaimed by forest.

Figure 1: **Geographic situation of the surveyed area**



1. ábra: A vizsgált terület földrajzi elhelyezkedése

The Sampling Method

Before defining the sampling areas on the meadow „Gyadai", we made repeated visits to the site during a period of five years (3-4 times each year), during which we assigned 4 parts of the grassland that were mown regularly. We paid special attention to the areas where pressure of tourism was greater, owing to organised activities.

We used military and topographic maps as well as aerial photos to follow the changes in the history of the areas, and we also analysed detailed descriptions, written by local historical sources (Pintér and Tímár, 2010). Based on these sources we realized that along the stream, on the meadow Gyadai, there was only a narrow zone of grassland (at the end of the 18th century), which had been extended by the mid 19th century. After that period only minor changes of land use were carried out in the meadow. From the 1990s, little patches of farmland could be seen in the area.

On the meadow Gyadai we assigned four sampling areas based on the records, the documents and maps and the experiences gained at the site. The four sampling areas are characterized as mown grasslands, however due to the increasing number of visitors, the areas are more or less affected, or they may deviate from each other in the history of the landscape or in the water management parameters. The areas were mowed twice a year (in mid-July and August). Random sampling was performed using quadrat assignment preceding the on-site sampling. The sampling points were assigned based on a rectangular grid projected on the area, which were slightly altered by on-site corrections to avoid the quadrats falling on roads, bushes, wild boar diggings, or mud flows. Due to the random sampling it may have occurred that a quadrat had been assigned on slightly disturbed patches. We assigned a total of 40 quadrats of 2×2m for the coenological sampling so that 10 quadrats were assigned to each portion of the area. The quadrats with sampling codes 1-10 were assigned at a distance of approximately 2 km (at the maximum possible distance) from the nearby tourist information centre. Access to the area is difficult due to forest and bush patches. It cannot be accessed by car through the nearby forest, because the local forest management company has banned access to the forest road. We assigned the quadrats 11-20 in the area next to the above described area. In this case, however, we assumed that this area may be a drier mown grassland. Quadrats 21-30 are located in the grassland near to the village Katalinpuszta, which is a popular tourist destination. At weekends thousands of people visit the area. In 2-3 weeks, during the main plant reproduction and growth period programs are organized where 50-100 people take part, or school children play games. If there are no organised activities, people use this portion of the mown grassland for picnic. We assigned quadrats 31-40 to be located at the edge of the grassland, which is next to the tourist information centre. Due to its marginal conditions, this part of the grassland is not visited by tourists. The tourist route is from the tourist information centre through the forest and is next to this part of the grassland at the edge of the forest (where the slope is rising). This route is bordered by the grassland along a relatively narrow zone. The forest surrounds the narrow part of the meadow there.

It is assumed that there was a forest area in this part of the grassland 230 years ago. The sampling points were visited three times in both surveying years. The sampling activities were carried out in the same weeks and months (April, June and October) of 2013 and 2014. We localized the quadrats at the site by using a Garmin Dakota 20, GPS, and during further samplings we searched the fixed sample quadrats with a GPS. During sampling we recorded the time, exposure, the altitude, and the names of species following the nomenclature by Király (2009) and Király et al. (2011), and we estimated the

percentage cover of occurring vascular plant species. We identified the phytocoenosis according to the literature published by Borhidi (2003).

Data Analysis

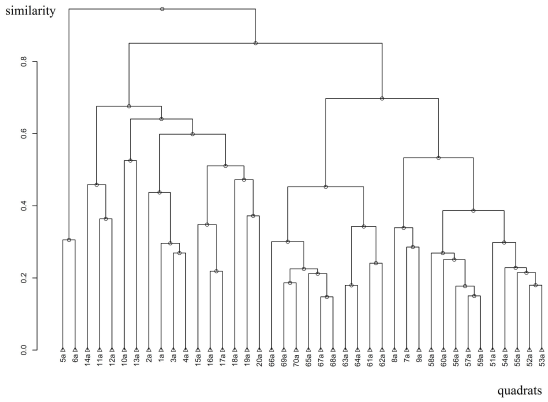
The data recorded in the four different sampling points were analysed for their humidity preferences (Horváth et al., 1995). We calculated the Shannon diversity indices for all the quadrats of the entire database, covering all sampling dates. We calculated the averages of the diversity indexes for each portion of area as per the date and year of sampling. Based on the average quadrat records of the portions of areas assessed on the largest covers of the relevant quadrats, we defined the dominant plant species also for each portion of the area. We regarded those species whose estimated cover exceeded 8% as per the averaged quadrats as dominant. In order to present the similarities and differences between the sampling points, we used the cluster analysis generated by the Bray-Curtis matrix, and the ordination process. We conducted all analyses using the program R 3.02. For the purposes of data management and application, we combined the data of each species recorded in fixed quadrats, and if one of the species was found simultaneously in several various sampling quadrats during one year, we considered the highest cover value for the calculations. We used this method of simplification instead of the averaging method, because using the averaging method, the determinant dissimilarities and the higher average cover values of the portions of areas might have disappeared. Further, this method was the best one to conform with our sampling method.

RESULTS

Based on the dendrogram of 2013, the area located at the edge of the grassland (31-40) was strongly separated within the mown grasslands (*Figure 2*).

By comparing the dendrogram with the sampling cover values, it is evident that *Potentilla alba* is primary and highly dominant in the abovementioned portion of the grassland. Besides, the covers of *Bromus erectus, Festuca rupicola* and *Trisetum flavescens* were considerable. The sampling quadrats (21-30) represented a well isolated group of species with connections to each other at low levels whose locations were often visited by tourists. In this portion of the grassland, the primary dominant plant species was *Bromus erectus* whose cover was very extensive, and the secondary-dominant species were *Festuca rupicola* and *Filipendula vulgaris*. We deemed dominant plant species to be the one whose cover exceeded 8% estimated by an on-site assessment (*Table 1*).

Figure 2: **Dendrogram of the sampling quadrats – 2013**



Legend: 1-10 wetter mown meadow in the direction of Ősagárd; 11-20 drier mown meadow in the direction of Ősagárd; 21-30 mown and tourist visited meadow; 31-40 mown meadow, which used to be forest; a: 2013(1)

2. ábra: A kvadrátok 2013-as eredményeinek klasszifikációja
1-10: nedvesebb kaszált rét Ősagárdnál; 11-20: szárazabb kaszált rét Ősagárdnál; 21-30: kaszált és látogatott gyep; 31:40: kaszált gyep, korábban erdő(1)

Table 1

The dominant species with the largest covers in the quadrats of the surveyed areas (2013)

K1		K2		K3		K4	
Plant species	**Cover (%)**	**Plant species**	**Cover (%)**	**Plant species**	**Cover (%)**	**Plant species**	**Cover (%)**
Bromus erectus	16.9	*Festuca valesiaca*	16.1	*Bromus erectus*	46.8	*Potentilla alba*	30.5
Galium verum	9.4	*Festuca rupicola*	13	*Festuca rupicola*	8.2	*Bromus erectus*	16.6
Festuca valesiaca	9.3	*Galium verum*	12.1	*Filipendula vulgaris*	8.1	*Trisetum flavescens*	12
-	-	*Alopecurus pratensis*	9.7	-	-	*Festuca rupicola*	11.2

1. táblázat: A domináns fajok borításai a vizsgált területek kvadrátjaiban (2013)

The quadrats of the two mown grasslands next to Ősagárd were connected to each other at a higher level, and these areas were not completely isolated from each other. Each of the two portions of grassland were diverse, and the number of the plant species found in these two portions of grassland was much higher than in the two other portions of the mown grassland. It is worth mentioning that there were five dominant species: *Bromus erectus, Galium verum, Festuca valesiaca, Festuca rupicola,* and *Alopecurus pratensis*. 5 and 6 quadrats were different

from the others. These quadrats are highly covered by *Calamagrostis epigeios*.

On the mown grassland, the area was also isolated in the second year (*Figure 3*), which is located at the edge of the grassland (31-40). That portion of the grassland was highly covered by *Potentilla alba* and *Bromus erectus*. The presence of *Trisetum flavescens* was also considerable (*Table 2*).

The sampling quadrats 21-30 represented a well isolated group of species with connections to each other at low levels whose locations were often visited by tourists. In this portion of the grassland, the cover of the dominant species (*Bromus erectus* and *Festuca rupicola*) was considerably high in 2014. There was a higher level connection between the quadrats of the two mown grasslands next to Ősagárd, and based on the dendogram these portions of the area were not clearly isolated from each other. These two portions of grassland are heterogeneous compared to the two other mown portions of the grassland. Similarities between the individual quadrats occurred only at high connection levels. Similar to the previous year, quadrats 5 and 6 were different from the other sampling quadrats, and they were encroached by *Calamagrostis epigeios.*

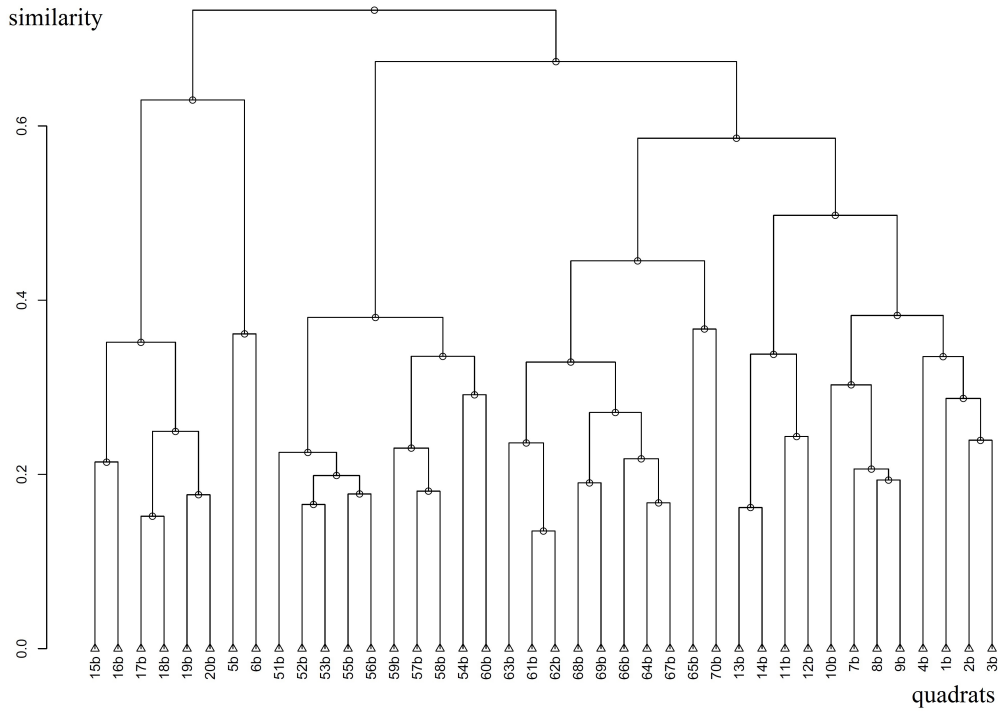
Table 2

The dominant species with the largest covers in the quadrats of the surveyed areas (2014)

K1		K2		K3		K4	
Plant species	**Cover (%)**	**Plant species**	**Cover (%)**	**Plant species**	**Cover (%)**	**Plant species**	**Cover (%)**
Bromus erectus	22	*Trifolium campestre*	25	*Bromus erectus*	41	*Potentilla alba*	30.5
Trisetum flavescens	8.9	*Carex praecox*	14	*Festuca rupicola*	12.3	*Bromus erectus*	16.6
Potentilla alba	8.6	*Trifolium alpestre*	12.7	-	-	*Trisetum flavescens*	12
Arrhenatherum elatius	8.4	*Trisetum flavescens*	12.5	-	-	*Festuca rupicola*	11.2
-	-	*Festuca valesiaca*	12.1	-	-	*Arrhenatherum elatius*	9.2

2. táblázat: A domináns fajok borításai a vizsgált területek kvadrátjaiban (2014)

Figure 3: **Dendrogram of the sampling quadrats – 2014**



Legend: 1-10 wetter mown meadow in the direction of Ősagárd; 11-20 drier mown meadow in the direction of Ősagárd; 21-30 mown and tourist visited meadow 31-40 mown meadow, which used to be forest; b: 2014(1)

3. ábra: A mintakvadrátok 2014-es eredményeinek klasszifikációja

1-10: nedvesebb kaszált rét Ősagárdnál; 11-20: szárazabb kaszált rét Ősagárdnál; 21-30: kaszált és látogatott gyep; 31-40: kaszált gyep, korábban erdő(1)

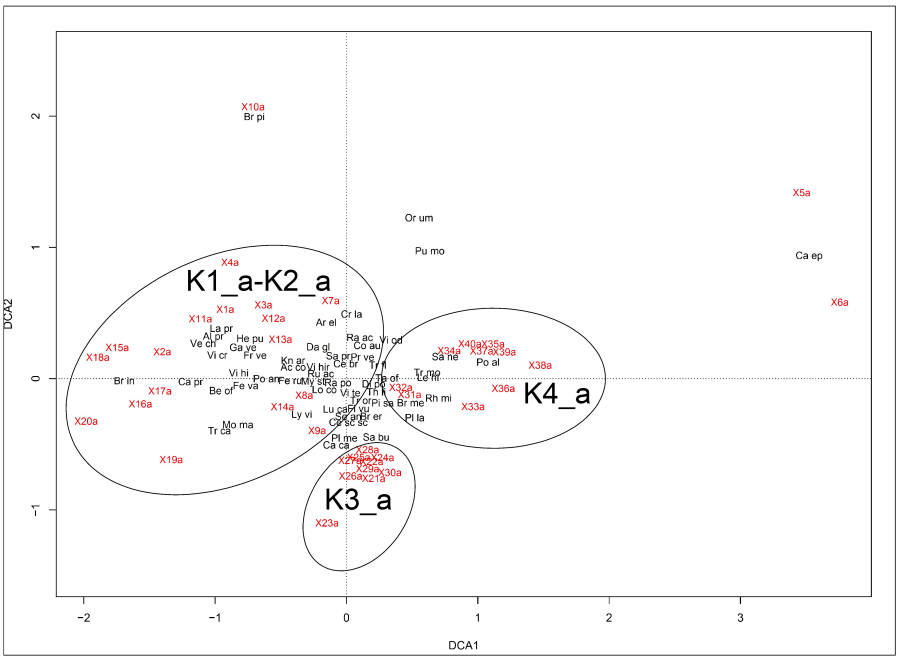
Based on the DCA of the mown grasslands (*Figure 4*), the following can be established concerning the analysed portions of grassland (K1_a=1a-10a, K2_a=11a-20a, K3_a=21a-30a, K4_a=31a-40a):

Three groups of the mown grasslands could be isolated (with ellipses). One of these contained the quadrats of the mown area that is located at the beginning of the meadow (31a-40a). The quadrats of the mown grassland shown on the figure as affected by tourism also formed an isolated group including all quadrats of the portion of the grassland (21a-30a.) The third ellipse consisted of the two mown grasslands next to Ősagárd, which two portions of grassland were not clearly isolated from each other (K1_a, K2_a). These two areas were more heterogeneous than the other two mown grasslands. The three quadrats of area K1_a (5a, 6a, 10a) were found outside the isolated areas, and deviated considerably from those areas.

Based on the ordination analysis, some species of the mown grasslands next to Ősagárd (K1_a, K2_a), which characterize the isolated area are the following: *Bromus inermis, Carex praecox, Betonica officinalis, Trifolium campestre, Moenchia mantica, Cruciata laevipes, Arrhenatherum elatius, Dactylis glomerata, Knautia arvensis, Helictotrichon pubescens, Vicia cracca, Lathyrus pratensis, Vicia hirsuta, Poa angustifolia, Festuca valesiaca.* Some species of the mown grasslands located at the beginning of the meadow (K4_a), which characterize the isolated area: *Potentilla alba, Trifolium montanum, Rhinanthus minor, Plantago lanceolata, Briza media, Salvia nemorosa, Leontodon hispidus*.

The species isolated in the mown grassland (K3_a) affected by tourism are not shown in the DCA. In accordance with the DCA, the presence of *Calamagrostis epigeios* promotes the isolation of the quadrats 5a, 6a, while the presence of *Brachypodium pinnatum* promotes the isolation of the quadrat 10a.

Figure 4: **Results of the DCA of mown grasslands in 2013**



Legend: Ac co: Achillea collina, Al pr: Alopecurus pratensis, Ar el: Arrhenatherum elatius, Be of: Betonica officinalis, Br pi: Brachypodium pinnatum, Br me: Briza media, Br er: Bromus erectus, Br in: Bromus inermis, Ca ep: Calamagrostis epigeios, Ca ca: Carex caryophyllea, Ca pr: Carex praecox, Ce sc sc: Centaurea scabiosa subsp. scabiosa, Ce br: Cerastium brachypetalum, Co au: Colchicum autumnale, Cr la: Cruciata laevipes, Da gl: Dactylis glomerata, Di po: Dianthus pontederae, Fe ru: Festuca rupicola, Fe va: Festuca valesiaca, Fi vu: Filipendula vulgaris, Fr ve: Fragaria vesca, Ga ve: Galium verum, He pu: Helictotrichon pubescens, Kn ar: Knautia arvensis, La pr: Lathyrus pratensis, Le hi: Leontodon hispidus, Lo co: Lotus corniculatus, Lu ca: Luzula campestris, Ly vi: Lychnis viscaria, Mo ma: Moenchia mantica, My st: Myosotis stricta, Or um: Ornithogalum umbellatum, Pi sa: Pimpinella saxifraga, Pl la: Plantago lanceolata, Pl me: Plantago media, Po an: Poa angustifolia, Po al: Potentilla alba, Pr ve: Primula veris, Pu mo: Pulmonaria mollissima, Ra ac: Ranunculus acris, Ra po: Ranunculus polyanthemos, Rh mi: Rhinanthus minor, Ru ac: Rumex acetosa, Sa ne: Salvia nemorosa, Sa pr: Salvia pratensis, Sa bu: Saxifraga bulbifera, Se an: Seseli annuum, Ta of: Taraxacum officinale, Th li: Thesium linophyllon, Tr or: Tragopogon orientalis, Tr ca: Trifolium campestre, Tr mo: Trifolium montanum, Tr fl: Trisetum flavescens, Ve ch: Veronica chamaedrys, Vi cr: Vicia cracca, Vi hi: Vicia hirsuta, Vi te: Vicia tenuifolia, Vi hir: Viola hirta, Vi od: Viola odorata K1_a: 1-10 wetter mown meadow in the direction of Ősagárd; K2_a: 11-20 drier mown meadow in the direction of Ősagárd; K3_a 21-30 mown and tourist visited meadow; K4_a: 31-40 mown meadow, which used to be forest, a: 2013

4. ábra: A kaszált gyepek 2013-as eredményeinek DCA elemzése

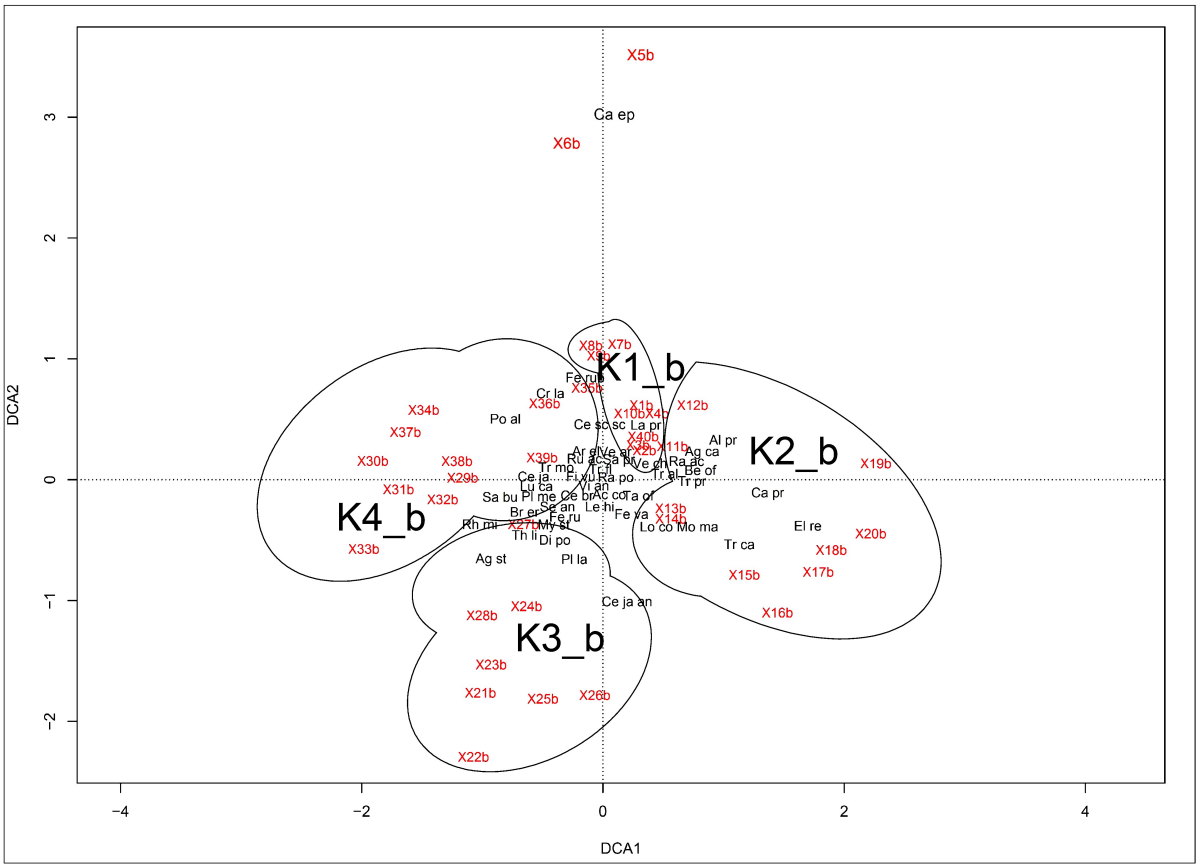
K1_a: 1-10 nedvesebb kaszált gyep Ősagárnál; K2_a: 11-20 szárazabb kaszált ygep Ősagárdnál; K3_a 21-30 kaszált, látogatott gyep; K4_a: 31-40 kaszált gyep, korábban erdő. a: 2013

Based on the DCA of the mown grasslands with samplings in 2014 (*Figure 5*), the following is established concerning the analysed portions of grassland (K1_b=1b-10b, K2_b=11b-20b, K3_b=21b-30b, K4_b=31b-40b):

Four groups of the mown grassland could be isolated (with irregular forms), however, this isolation was not entirely clear as minimum 1-2 quadrats occurred in an isolated group in which they were not expected. An area could be isolated, where the quadrats of the mown area located at the beginning of the meadow were found (31b-40b). The figure shows that the quadrats of the mown grassland affected by tourism also formed a separate group, which included the quadrats 21b-28b of the portion. The third group consisted of the mown grassland far from Ősagárd, which includds all quadrats of the portion (11b-20b). The fourth portion (1a-4a, 7a-10a) consisted of the quadrats of the mown area next to Ősagárd. Two quadrats of this area (5b,6b) were found outside the isolated groups and deviated considerably from those.

Based on the ordination analysis, some species of the mown grasslands far from Ősagárd which characterized the isolated area are the following (K2_b): *Alopecurus pratensis*, *Carex praecox*, *Elymus repens*, *Trifolium campestre*. The species that characterized the mown grassland next to Ősagárd is *Lathyrus pratensis*.

Figure 5: **Results of the DCA of mown grasslands in 2014**



Ac co: Achillea collina, Ag ca: Agrostis capillaris, Ag st: Agrostis stolonifera, Al pr: Alopecurus pratensis, Ar el: Arrhenatherum elatius, Be of: Betonica officinalis, Br er: Bromus erectus, Ca ep: Calamagrostis epigeios, Ca pr: Carex praecox, Ce ja: Centaurea jacea, Ce ja an: Centaurea jacea subsp. angustifolia, Ce sc sc: Centaurea scabiosa subsp. scabiosa, Ce br: Cerastium brachypetalum, Cr la: Cruciata laevipes, Di po: Dianthus pontederae, El re: Elymus repens, Fe rub: Festuca rubra, Fe ru: Festuca rupicola, Fe va: Festuca valesiaca, Fi vu: Filipendula vulgaris, La pr: Lathyrus pratensis, Le hi: Leontodon hispidus, Lo co: Lotus corniculatus, Lu ca: Luzula campestris, Mo ma: Moenchia mantica, My st: Myosotis stricta, Pl la: Plantago lanceolata, Pl me: Plantago media, Po al: Potentilla alba, Ra ac: Ranunculus acris, Ra po: Ranunculus polyanthemos, Rh mi: Rhinanthus minor, Ru ac: Rumex acetosa, Sa pr: Salvia pratensis, Sa bu: Saxifraga bulbifera, Se an: Seseli annuum, Ta of: Taraxacum officinale, Th li: Thesium linophyllon, Tr al: Trifolium alpestre, Tr ca: Trifolium campestre, Tr mo: Trifolium montanum, Tr pr: Trifolium pratense, Tr fl: Trisetum flavescens, Ve ar: Veronica arvensis, Ve ch: Veronica chamaedrys, Vi an: Vicia angustifolia; K1_b: 1-10 wetter mown meadow in the direction of Ősagárd; K2_b: 11-20 drier mown meadow in the direction of Ősagárd; K3_b 21-30 mown and tourist visited meadow; K4_b: 31-40 mown meadow, which used to be forest, b: 2014

5. ábra: A kaszált gyepek 2014-es eredményeinek DCA elemzése

K1_b: 1-10 nedvesebb kaszált gyep Ősagárnál; K2_b: 11-20 szárazabb kaszált ygep Ősagárdnál; K3_b 21-30 kaszált, látogatott gyep; K4_b: 31-40 kaszált gyep, korábban erdő. b: 2014

On the grassland effected by tourism (K3_b), there was more extensive cover of *Agrostis stolonifera, Plantago lanceolata, Thesium linophyllon, Centaurea jacea* subsp. *angustifolia*. In the mown grassland located at the edge of the meadow (K4_b), the following species occurred at higher rates: *Potentilla alba, Trifolium montanum, Saxifraga bulbifera, Rhinanthus minor, Plantago media, Luzula campestris, Festuca pratensis*. In accordance with the DCA, the isolation of quadrats 5b and 6b is caused by *Calamagrostis epigeios.*

CONCLUSIONS

From a nature conservation point of view, it is favourable that the cover of *Potentilla alba* occurring in the area is high. It is a specialist plant species with low stress resistance (Pavlů et al., 2011). However, due to tourism, it occurs even less in the area and instead, *Bromus erectus* becomes dominant. It might be also due to tourism that *Bromus erectus* not only displaces previous species, but also decreases the cover of grassland specialist species. The plant species whose covers are more extensive in areas not effected by tourism – for example *Alopecurus pratensis, Galium verum, Carex praecox, Trisetum flavescens* – occur less frequently in areas effected by tourism. The species reacts first to the changed conditions not with disappearence but with a the change in relation to dominance, as has been already supported by other studies (Podani, 1997; Deák et al., 2018).

The ordination analysis shows that the species composition considerably differs with the portions of land managed in different ways. In the portion of grassland affected by tourism, the number of species characterising the individual area is low, which is more characteristic in years with less rain, when the diversity of species is reduced. The change of the cover values affects not only the occurrence of the dominant species but also the subordinate ones. The decrease of diversity, the change of plant cover, the decrease of number of sensitive species as a result of tourism are registered all over the world (Le et al., 2014; Grabherr, 1982).

The Shannon diversity records show that due to human presence and trampling the diversity of the species is reduced. The diversity of species is considerably low in years with less rain. In years with more rain the diversity of species is considerably higher, however, the difference in diversity between the surveyed areas is much increased. All these examples draw attention to the important role of environmental factors alongside the human factors (Stampfli, 1995; Catorci et al., 2011, 2017). The water reserve also influences the productivity of grasslands and water has primary importance in the structure of plant communities (Barcsák, 1989; Penksza et al., 2015, 2016; Pápay et al., 2019a, b, c).

According to the survey, on the two areas not affected by tourism, in the rainier year the difference between the humidity preference of the plant species occurred on the dry areas and the less dry areas became similar. In the rainier year, the differences increased between two portions of grassland with similar humidity preferences but different land use. On areas not affected by tourism, there were more species with higher humidity preferences occurred in rainier year, however, this tendency could not be observed in the rainier year on areas affected by tourism. The areas affected by tourism may react less flexibly to the change in rain conditions.

It can be said based on our analysis, that the surveyed semi-dry grasslands in the Pannon mountains are extremely rich in species and therefore proper grassland management plans should be designed. To preserve grasslands of high natural value, the impacts of the environmental factors should also be considered in addition to becoming acquainted with the history and present conditions of the landscape use (Halász et al., 2018; Bartholy et al., 2012; Catorci et al., 2011; Gustavsson et al., 2007; Galvánek and Lepš, 2009).

REFERENCES

Baráth N.-Bartha S.-Házi J.-Wichmann B.-Penksza K. (2012): Vegetációváltozások a vadkizárás és a túltartott nagyvadállomány hatására a Budai-hegység dolomitsziklagyepeiben. AWETH 8: 3-18.

Barcsák Z. (1989): Gyeptermesztés és hasznosítás. [Grass cultivation and utilization] Gödöllő

Bartholy, J.-Pongrácz, R.-Nagy, J.-Pierczka, I.-Hufnagel, L. (2012): Regional climate change impacts on wild animals' living territory in central Europe – Applied Ecology and Environmental Research 10(2):107-120.

Besnyői V.-Szerdahelyi T.-Bartha S.-Penksza K. (2012): Kaszálás felhagyásának kezdeti hatása nyugat-magyarországi üde gyepek fajkompozíciójára. Gyepgazdálkodási Közlemények 10(1-2): 13-20.

Bissels, S.-Donath, T. W.-Hölzel, N.-Otte, A. (2006): Effects of different mowing regimes on seedling recruitment in alluvial grasslands. Basic and Applied Ecology 7: 433-442.

Borhidi A. (2003): Magyarország növénytársulásai. [The phytocoenoses of Hungary] Akadémiai Kiadó, Budapest

Catorci, A.-Cesaretti, S.-Gatti, R.- Ottaviani, G. (2011): Abiotic and biotic changes due to spread of Brachypodium genuense (DC.) Roem.& Schult. In Sub-Mediterranean meadows. Community Ecology 12: 117-125.

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.-Valkó O.-Schmotzer A.-Kapocsi I.-Tóthmérész B.-Török P. (2012): Gyepek égetésének természetvédelmi megítélése – probléma vagy gyepkezelési alternatíva? [Grassland burning in Hungary – is it a problem or a promising conservation measure?] Tájökológiai Lapok 10(2): 287-303.

Deák, B.-Valkó, O.-Török, P.-Kelemen, A.-Bede, Á.-Csathó, A. I.-Tóthmérész, B. (2018): Landscape and habitat filters jointly drive richness and abundance of grassland specialist plants in terrestrial habitat islands. Landscape Ecology 33: 1117-1132.

Dövényi Z. (szerk.) (2010): Magyarország kistájainak katasztere. [Cadastre of the small regions of Hungary.] MTA FKI. Budapest

Drewitt, A. L. (2007): Birds and recreational disturbance. Ibis, 149: 1-2.

Dullinger, S.-Dirnböck, T.-Grabherr, G. (2003): Patterns of Shrub Invasion into High Mountain Grasslands of the Northern Calcareous Alps, Austria. Arctic, Antarctic, and Alpine Research 35(4): 434-441.

Galvánek, D.-Lepš, J. (2009): How do management and restoration needs of mountain grasslands depend on moisture regime? Experimental study from north-western Slovakia (Western Carpathians). Applied Vegetation Science 12: 273-282.

Grabherr, G. (1982): The impact of trampling by tourists on a high altitudinal grassland in the Tyrolean Alps, Austria. Vegetatio Volume 48(3): 209-217.

Gustavsson, E.-Lennartsson, T.-Emanuelsson, M. (2007): Land use more than 200 years ago explains current grassland plant diversity in a Swedish agricultural landscape. Biological Conservation 138: 47-59.

Habel, J. C.-Dengler, J.-Janišova, M.-Török, P.-Wellstein, C.-Wiezik, M. (2013): European grassland ecosystems:threatened hotspots of biodiversity. Biodiversity and conservation 22: 2131-2138.

Halász, A.-Tasi, J.-Bajnok, M.-Szabó, F.-Orosz, Sz. (2018): Climate sensitivity of Hungarian grasslands. In: Horan, B.-Hennessy, D.-O'Donovan, M.-Kennedy, E.-McCarthy, B.-Finn, J A.-O'Brien, B. (szerk.) Sustainable meat and milk production from grasslands: Proceedings of the 27th General Meeting of the European Grassland Federation, Wageningen Academic Publishers pp. 598-600.

Házi, J.-Bartha, S.-Szentes, Sz.-Wichmann, B.-Penksza, K. (2011): Seminatural grassland management by mowing of Calamagrostis epigejos in Hungary. Plant Biosystems 145: 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 Enviromental Research 10: 223-231.

Horváth J.-Komarek L. (2016): A világ mezőgazdaságának fejlődési tendenciái. SZTE-MGK, Hódmezővásárhely. 270 p.

Horváth F.-Dobolyi Z. K.-Morschhauser T.-Lőkös L.-Karas L.-Szerdahelyi T. (1995): Flóra adatbázis 1.2. Taxonlista és attribútum állomány. MTA ÖBKI. Vácrátót

Houghton, J. T.-Ding, Y.-Griggs, D. J.-Noguer, M.-Van Der Linden, P. J.-Dai, X.-Maskell, K.-Johnson, C. A. (szerk.) (2001): Climate Change 2001:The Scientific Basis. Cambridge University Press, Cambridge, UK

Járdi I.-Pápay G.-Fekete Gy.-S-Falusi E. (2017): Marhalegelők vegetációjának vizsgálata az Ipoly-völgy homoki gyepeiben. Gyepgazdálkodási közlemények 15(2): 9-21.

Kaligarič, M.-Culiberg, M.-Kramberger, B. (2006): Recent vegetation history of the north Adriatic grasslands: expansion and decay o fan antropogenic habitat. Folia Geobotanica 41: 241-258.

Katona K.-Fehér Á.-Szemethy L.-Saláta D.-Pápay G.-S-Falusi E.-Kerényi-Nagy V.-Szabó G.-Wichmann B.-Penksza K. (2016): Vadrágás szerepe a mátrai hegyvidéki gyepek becserjésedésének lassításában. Gyepgazdálkodási Közlemények 14(2): 29-35.

Kelemen, A.-Török, P.-Valkó, O.-Deák, B.-Miglécz, T.-Tóth, K.-Ölvedi, T.-Tóthmérész, B. (2014): Sustaining recovered grasslands in not likely without proper management:vegetation changes and large-scale evidences after cessation of mowing. Biodiversity & Conservation. 23: 741-751. doi: 10.1007/s10531-014-0631-8.

Kertész Á. (1988): A Dunakanyar-hegyvidék természeti környezetpotenciáljának mezőgazdasági és idegenforgalmi szempontú értékelése. [Evaluation of the potential environmental improvement of the mountains along Dunakanyar from agricultural and touristic aspects.] MTA Földrajztudományi Kutatóintézet. Budapest

Király G. (szerk.) (2009): Új magyar füvészkönyv Magyarország hajtásos növényei. Határozókulcsok [New Hungarian Herbal Invasive plants in Hungary. Identificatin keys.] Aggteleki Nemzeti Park Igazgatóság. Jósvafő

Király G.-Virók V.-Molnár V. A. (szerk.) (2011): Új magyar füvészkönyv Magyarország hajtásos növényei. Ábrák [New Hungarian Herbal Invasive plants in Hungary. Figures] Aggteleki Nemzeti Park Igazgatóság. Jósvafő

Kiss T.-Penksza K. (2018): A legeltetés hosszú távú hatása kiskunsági füves pusztákon. Természetvédelmi Közlemények 24: 104-113.

Kleijn, D.-Sutherland, W. J. (2003): How effective are European agri-environment schemes in conserving and promoting biodiversity? Journal of Applied Ecology 40: 947-969.

Komarek L. (2007a): A földhasznosítás rendszerváltozás utáni módosulásai a Dél-Alföldön. In: Kovács Cs.-Pál V. (szerk.) A társadalmi földrajz világai: [Becsei József professzor 70. születésnapjára] Szeged, Magyarország: pp. 325-332.

Komarek, L. (2007b): The structural changes in the agriculture of the South Great Plain since the regime change. In: Kovács, Cs. (szerk.): From villages to cyberspace: In commemoration of the 65th birthday of Rezső Mészáros, Academician: Falvaktól a kibertérig: Ünnepi kötet Mészáros Rezső akadémikus 65. születésnapjára, Szeged, pp. 329-339.

Komarek L. (2008): A Dél-Alföld agrárszerkezetének sajátosságai. Csongrád Megyei Agrár Információs Szolgáltató és Oktatásszervező Kht., Szeged. 143 p.

Labadessa, R.-Deák, B.-Valkó, O. (2020): No need for grazing exclusion – Sheep grazing supports the recovery of grasslands even from the early successional stages. Tuexenia 40: 429-443.

Le, C.-Ikazaki, K.-Siriguleng Kadono, A.-Kosaki, T. (2014): Grassland degradation caused by tourism activities inHulunbuir, Inner Mongolia, China. IOP Conf. Series: Earth and Environmental Science 18 012137

Luick, R. (1998): Ecological and socio-economic implications of livestock-keeping systems on extensive grasslands in south-western Germany – Journal of Applied Ecology 35: 979-982.

Nagy G. (2008): A gyephasználati lehetőségek sokoldalúsága. [Diverse use of grassland.] Gyepgazdálkodási Közlemények 6: 5-7.

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

Pápay G.-Uj B. (2012): Természetvédelmi élőhelykezelés hatása a gyöngyösi Sár-hegy gyepterületeinek vegetációjára. Gyepgazdálkodási közlemények, 2012(1-2): 39-48.

Pápay G.-Marks I.-Járdi I.-S-Falusi E. (2017): Természetvédelmi kezelések hatása gyepterületek vegetációjára a Gyöngyösi Sár-hegy TT mintaterületein. Gyepgazdálkodási Közlemények 15(2): 37-46.

Pápay, G.-Járdi, I.-Szabó, G.-Penksza, K. (2018): Shrub cutting as a habitat transforming factor: a review. International Journal of Latest Engineering and Management Research 4(1).

Pápay G.-Szabó G.-Szőke P.-Zimmermann Z.-Fűrész A.-Péter N.-Penksza K. (2019a): Természetes és telepített homoki gyepek vegetációja és biomassza-vizsgálatai kisalföldi mintaterületeken. Gyepgazdálkodási Közlemények 17(1): 35-42.

Pápay, G.-Michéli, E.-S.-Falusi, E.-Barczi, A.-Fuchs, M. (2019b): Botanical and soil studies in sandy vegetation of North Hungarian Great Plain. 18th Alps-Adria Scientific Workshop Abstract Book 124-125. pp.

Pápay G.-Wichmann B.-Penksza K. (2019c): Parádóhuta melletti cserjeirtott mintaterületen kialakult gyep növényzetének változása vadrágás hatására 2012 és 2019 között. Gyepgazdálkodási Közlemények 17(1): 43-50.

Pápay, G.-Kiss, O.-Fehér, Á.-Szabó, G.-Zimmermann, Z.-Hufnagel, L.-S.-Falusi, E.-Járdi, I.-Saláta, D.-Szemethy, L.-Penksza, K.-Katona, K. (2020): Impact of shrub cover and wild ungulate browsing on the vegetation of restored mountain hay meadows. Tuexenia 40: 445-457.

Pavlů, L.-Pavlů, V.-Gaislera, J.-Hejcman, M.-Mikulka, J. (2011): Effect of long-term cutting versus abandonment on the vegetation of a mountain hay meadow (*Polygono-Trisetion*) in Central Europe. Flora 206, 1020-1029.

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.

Penksza K.-Tasi J.-Szabó G.-Zimmermann Z.-Szentes Sz. (2009a): Természetvédelmi célú botanikai és takarmányozástani vizsgálatok adatai Káli-medencei juhlegelőhöz. Gyepgazdálkodási Közlemények 7: 51-58.

Penksza K.-Szentes Sz.-Centeri Cs.-Tasi J. (2009b): Juhlegelő természetvédelmi célú botanikai, takarmányozástani és talajtani vizsgálata a Káli-medencében. Animal welfare, etológia és tartástechnológia 5(1): 49-62.

Penksza, K.-Szentes, Sz.-Házi, J.-Tasi, J.-Bartha, S.-Malatinszky, Á. (2009c): Grassland management and nature conservation in natural grasslands of the Balaton Uplands National Park, Hungary. Grassland Science in Europe. Alternative Function of Grassland. International Occasional Symposium European Grassland Federation. Brno Czech Republik 7-9. September 2009. pp. 512-515.

Penksza K.-Szentes S.-Loksa G.-Dannhauser C.-Házi J. (2010): A legeltetés hatása a gyepekre és természetvédelmi vonatkozásai a Tapolcai- és a Káli-medencében. Természetvédelmi Közlemények 16: 25-49.

Penksza K.-Házi J.-Tóth A.-Wichmann B.-Pajor F.-Gyuricza Cs.-Póti P.-Szentes Sz. (2013): Eltérő hasznosítású szürkemarha legelő szezonális táplálóanyag tartalom alakulás, fajdiverzitás változása és ennek hatása a biomassza mennyiségére és összetételére nedves pannon gyepekben. Növénytermelés 62(1): 73-94.

Penksza K.-Pápay G.-Házi J.-Tóth A.-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.-Fehér Á.-Saláta D.-Pápay G.-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.-Csík, A.-Filep, A. F.-Saláta, D.-Pápay, G.-Kovács, L.-Varga, K.-Pauk, J.-Lantos, Cs.-Lisztes-Szabó, Zs. (2020): Possibilities of Speciation in the Central Sandy Steppe, Woody Steppe Area of the Carpathian Basin through the Example of Festuca Taxa. FORESTS 11: 1325-1327.

Pintér B.-Tímár G. (szerk.) (2010): A Naszály természetrajza. DINPI Budapest

Podani J. (1997): Bevezetés a többváltozós biológiai adatfeltárás rejtelmeibe. Scientia Kiadó. Budapest

Rév Sz.-Marticsek J.-Fülöp Gy. (2008): Természetvédelmi szempontú gyephasznosítás. Duna-Ipoly Nemzeti Park Igazgatóság. Budapest

Saláta D. (2009): Legelőerdők egykor és ma. Erdészettörténeti Közlemények 79. 1-80.

Saláta D. (2017): Az Északi-középhegység fás legelőinek tipológiája és természetvédelmi vonatkozásai. PhD értekezés. SZIE Környezettudományi Doktori Iskola. Gödöllő. 9-16.

Saláta D.-Wichmann B.-Házi J.-Falusi E.-Penksza K. (2011): Botanikai összehasonlító vizsgálat a cserépfalui és az erdőbényei fás legelőn. AWETH 7(3): 234-262.

Saláta D. S.-Falusi E.-Wichmann B.-Házi J.-Penksza K. (2012): Faj- és vegetáció-összetétel elemzése eltérő legeltetési terhelés alatt a cserépfalui és az erdőbényei fáslegelők különböző növényzeti típusaiban. Botanikai Közlemények 99(1-2): 143-159

Saláta D.-Varga A.-Penksza K.-Malatinszky Á.-Szalai T. (2013): Agrárerdészeti rendszerek és alkalmazási lehetőségeik a hazai ökológiai gazdálkodásban. AWETH 9(3). 315-320.

Sebastià, M. T.-de Bello, F.-Puig, L.-Taull, M. (2008): Grazing as a factor structuring grasslands in the Pyrenees. Applied Vegetation Science 11: 215-222.

Stampfli, A. (1995): Species composition and standing crop variation in an unfertilized meadow and its relationship to climatic variability during six years. Folia Geobotanica Phytotaxonomica 30: 117-130.

Stroh, M.-Storm, C.-Zehm, A.-Schwabe, A. (2002): Restorative grazing as a tool for directed succession with diaspore inoculation: the model of sand ecosystems. Phytocoenologia 32: 595-625.

Szabó G.-Zimmermann Z.-Szentes Sz.-Sutyinszki Zs.-Penksza K. (2010/11): Természetvédelmi és gyepgazdálkodási vizsgálatok a Dinnyési-fertő gyepeiben. Gyepgazdálkodási Közlemények, 8(2): 31-38.

Szabó G.-Zimmermann Z.-Bartha S.-Szentes Sz.-Sutyinszki Zs.-Penksza K. (2011): Botanikai, természetvédelmi és gyepgazdálkodási vizsgálatok Balaton-felvidéki szarvasmarhalegelőkön. Tájökológiai Lapok 9(2): 431-440.

Szabó G.-Zimmermann Z.-Csontos P.-Wichmann B.-Szentes Sz.-Barczi A.-Pápay G.-Járdi I.-Penksza K. (2017a): Nyílt homoki gyepek cönológiai és talajtani vizsgálata a Duna-Tisza közén. Gyepgazdálkodási Közlemények 15(2): 47-56.

Szabó, G.-Zimmermann, Z.-Catorci, A.-Csontos, P.-Wichmann, B.-Szentes, Sz.-Barczi, A.-Penksza, K. (2017b): Comparative study on grasslands dominated by Festuca vaginata and F. pseudovaginata in the Carpathian Basin. Tuexenia 37: 415-429.

Szentes Sz.-Tasi J.-Wichmann B.-Penksza K. (2009): Botanikai és gyepgazdálkodási vizsgálatok 2008. évi eredményei a badacsonytördemici szürkemarha legelőn. Gyepgazdálkodási Közlemények 7: 73-78.

Szentes, Sz.-Dannhauser, C.-Coetzee, R.-Penksza, K. (2011): Biomass productivity, nutrition content and botanical investigation of Hungarian Grey cattle pasture in Tapolca basin. AWETH 7(2): 180-198.

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

Török, P.-Penksza, K.-Tóth, E.-Kelemen, A.-Sonkoly, J.-Tóthmérész, B. (2018): Vegetation type and grazing intensity jointly shape grazing on grassland biodiversity. Ecology and Evolution 8: 10326-10335. doi/full/10.1002/ece3.4508

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.-Venn, S.-Zmihoski, M.-Biurrun, I.-Labadessa, R.-Loos, J. (2018): The challenge of abandonment for the sustainable management of Palaearctic natural and semi-natural grasslands. Hacquetia 17(1): 5-16.

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

Zimmermann Z.-Szabó G.-Bartha S.-Szentes Sz.-Penksza K. (2011): Juhlegeltetés hatásainak természetvédelmi célú vizsgálata legelt és művelésből kivont gyepek növényzetére. AWETH 7(3): 234-262.

Zimmermann Z.-Pápay G.-Szendrei F. B. (2018): Szarvasmarha legelőként és kaszálóként történő hasznosított Tura melletti üde gyepek összehasonlító cönológiai elemzése. Gyepgazdálkodási Közlemények 16(1): 49-63.