SZENT ISTVÁN UNIVERSITY

Vegetation dinamic and coenological examination of secondary dry grasslands in fallow lands in Western Cserhát

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Background and objectives

The geomorphological and geographical features of Hungary are particularly suitable for agriculture usage. A large part of our country is typical agricultural -landscape, including a substantial part of the cultivated area of fruit cultivation and viticulture as well. Territorial composition of the culture, regional proportion of socio-economic changes and natural disasters can have a significant impact on both cultivated, abandoned areas and uncultivated land, thereby alter their land ratio (Beck 2005).

Besides our country is characterized by the abandonment of cultivated areas. In these areas, on set asides, abandoned vineyards may secondary succession can start, resulting species rich plant communities in favorable cases. These communities can be similar to the original vegetations in aspects of species composition and structure, with high nature conservation value (Barath 1963).

Parallel to the long term scaling human landuse can be occured such vegetation dynamical changes, which results can be important in the aspects of ecological and nature conservation as well. The reorganized vegetation units, associations of internal dynamics of the results of exploration work in semi-natural grasslands can help in preservation and improvement.

Because the loess covered areas was priority for agriculture, due to the evolved csernozjom-soils had extremly high fertility, there is little chance to preserve the remained extensive patches of original vegetation.

Breaking the best soils started in the earliest times in the late neoliticum.
So there areas became almost entirely cultivated. Previously loess vegetation were found in bands between private farms, but after the agricultural collectivisation these areas disappeared too. For even then remained small, non-cultivated grass fragments, sensibles, ditches are often changed to narrow strips of secondtary grasslands and can be often degradated as well.

For this reason these grasslands and grassland fragments have high conservation value. These special habitats are keepers of valuable relict and endemic plant species as well. Therefore, the protection and preservation of these grassland patches and fragments is an important task. It is also very important to elaborate a suitable nature conservation management as well.

The main threatening factors of grasslands are fragmentation, cultivation practices, changes in cultivation, overexploitation, land improvement, overgrazing, and construction of linear facilities, waste disposal and mining.

The breaking of grasslands, planting forests, creation of vineyards and orchardsor flooding of areas could mean total destruction of habitat. During these processes the remaining spots can totally separated, resulting elemination of possibility gene flow that can lead to genetic degradation.

Human interventions also contributed significantly to create and maintain our grasslands, including loess grasslands since most of the vegetation could not be found in its original place. Developement of current grasslands human activity and agriculture had major role and these are is the reason why is it so important to regulate nature conservation management.

To the maintance of grasslands, regular and moderate grazing and mowing contributed. In absence of mowing increase of weed, shrub, woody species amount can occurs. In addition to mowing, bush clearing should be applied. Proper management can prevent overgrowth of invasive plant species. Appropriate amount of grazing animal can ensure the continuous and low interference, which is necessary for the maintenance of treeless condition and high species diversity.

In parallel with disappearance and degradation of natural grasslands, attention of botanists increasingly turned to regeneration process. Therefore, I choose my subject field in which these processes could studied. Secondary dry grasslands which formed after the abandonement of vineyards provide an excellent opportunity for examine regeneration processes and to monitore secondary succession.

Agricultural cultivation, establishment of arable lands, croplands, vineyards or orchards cause a large-scale intervention in natural systems. In this case, it is not only a topical wound healing process but succession process resumes on a large-scale free surface.

For centuries secondary successional grasslands developing on abandoned fields were utilized by grazing and hay making (Poschlod and Wallis de Vries 2002; Ruprecht 2005). Traditional grazing and hay making contributed to the propagulum transport between grasslands and promoted local seedling establishment. The traditional management of abandoned fields enhanced and utilized the spontaneous succession and maintained the landscape scale regeneration potential of the vegetation and the sustainability of the ecosystem services. Recent changes involve intensification and abandonment of landuse and these processes are often accompanied by diversity loss in semi-natural habitats (Ryser *et al.* 1995; Fiala *et al.* 2003; Bartha 2007; Virágh *et al.* 2008). Grassland biodiversity is especially threatened by the collaps of extensive animal husbandry (Poschlod and Wallis de Vries 2002; Lindborg 2006). Decreasing species richness due to the aggressive expansion of grasses into grasslands has been reported from various parts of Europe (Rebele 1996; Sedláková and Fiala 2001; Huhta *et al.* 2001). *Calamagrostis epigeios* (L.) Roth (see below *C. epigeios*), is a tall perennial clonal grass (Prach and Pyšek 1994) one of the typical example of plant species spreading successfully to areas where former human management has been abandoned (Prach and Pyšek 2001).

C. epigeios has a broad range of distribution in Europe. It occurs in natural grasslands (Somodi *et al* 2008), in forests (Zhukovskaya and Ulanova 2006; Csontos 2010), in river floodplains (Fiala 2001; Gergely *et al*. 2001) and in ruderal assemblages (Prach 1987, Bartha 1992, Baasch *et al*. 2010a). It also appears in successional habitats developing after forest clearings or after the abandonment of agricultural fields (Csecserits and Rédei 2001; Bartha *et al.* 2010). This species can survive in dry, nutrient-poor stressed environment, however, it is most successful in open, nutrient-rich, mesic habitats (Rebele 2000). *C. epigeios* is able to form monodominant patches and able to reduce species richness considerably (Somodi *et al.* 2008).

Because of its rapid and aggressive expansion, *C. epigeios* recently become a problematic species for nature conservation aspect. Related problems were reported from central Europe (Rebele and Lehmann 2001; Sedláková and Fiala 2001; Holub 2002; Házi and

Bartha 2002; Luoto *et al*. 2003; Stranská 2008; Somodi *et al.* 2008), from western Europe (ten Harkel and van der Meulen 1995), and also from north America (Aiken *et al.* 1989).

Frequent mowing was suggested as a potential management measure for repressing tall herbs or clonal grasses and for maintaining or improving grassland biodiversity (Huhta *et al.* 2001; Deák *et al.* 2007). Successful control of *C. epigeios* by mowing was reported from the first five years of vegetation succession on a species poor ruderal landfill site from Germany by Rebele and Lehmann (2001). However, we have no experiences from other habitats especially from secondary grasslands.

General aims

The aim of this study was to find out how mowing treatment affects *Calamagrostis epigeios* and other species which co-occur in *C. epigeios* patches in secondary grassland developing in abandoned vineyards in a rural landscape.

1. My first aim was to explore species composition of the investigated abandoned vineyards? What are the dominant plant species? How changable the species composition and species dominance relations in the study sites during studied period?

2. How can one native invador race such as *Calamagrostis epigeios* influence sward composition?

3. Is frequent mowing an effective management tool for controlling the spread of *C. epigios* in secondary mid-successional grasslands?

4. In oreder to significantly reduce the cover of *C. epigeios* how many mowing years are necessary?

5. How can influence regular mowing the main matrix species? How can it influence the development of abandoned vineyards vegetation in agro-environmental landscape?

6. What kind of roles have regular mowing on diversity of sward?

7. There was also an important aim to investigate, how can be vegetation of study area and target plant community similar? Near by the study area ther is a target community such as *Euphorbio pannonicae-Brachypodietum pinnati* Horváth 2010, and *Salvio nemorosae-Festucetum rupicolae* Zólyomi ex Soó 1964.

8. What kind of interaction can be observed between active land management and long-term spontaneous succession at longer time-scales during the study period?

Materials and methods

Study site

My study area is situated in Északi-középhegység, in the western part of the Cserhát mountains. Kosdi-hillside and Csővár hills are the nearest geological landscape elements (Marosi and Somogyi 1991). The total area covered by a variable thickness of loess, which was formed during the ice age. From this loess blanket paralell ridges emerged such as Bükkös hill (190 m above sea level) and Somló hill (202 m).

Investigation areas situated on the north-east slopes of Somló hill, where the examined surface was 7 hectar. In case of Bükkös hill the north facing slopes was 3.3 hectar and the west facing slopes was a 15 hectar large area.

Center coordinates are as follows:
Somló hill: 47° 47’ 43,09” N, 19°14’ 23,37” E
Bükkös hill, North: 47° 45’ 58,87” N, 19°12’ 51,57” E
Bükkös hill, West: 47° 45’ 38,23” N, 19°12’ 47,53” E

From administrative point of view the two hills belongs to Vác, Vácduka and Penc settlements. From vegetation geographical point of view belongs to Pannonicum, Matricum and Neogradense floristical districts.

Methods of the landscape historical analysis and vegetation mapping

To the landscape historical analysis, I have used literature sources and different maps of the I-III. Military Surveys. The area was available to me in 1951, 1965, 1980, 2005, 2009. aerial photographs were used.

For preparation of vegetation maps two different methods were used. For the first map method made by Tibor Seregélyes (1997) were followed (Seregélyes and Csomós 1995) and was drew by hand. For the second map – vegetation map from 2009 – Arc Wiev 3.1. program was applied. Blind field map was prepared and after fieldwork data of vegetation patches were uploaded by this program also.

The age of investigated fallow lands

According to the available aerial photograps I can made the following statement about the age of investigated fallow lands: north area of Bükkös hill have not cultivated for at least 47 years, so it was classified into 45-50 years old fallow land group. West slopes of Bükkös hill and Somló hill have not cultivated for at least 32 years, so it was classified into 30-35 years old fallow land group.

Coenological survey

The experimental area is covered by a mosaic of shrubs (*Cornus sanguinea*, *Ligustrum vulgare*, *Crateagus monogyna, Rosa canina, Rubus caesius*, *Clematis vitalba*) and mid-successional grassland patches. The most abundant patch-forming grasses are *Arrhenatherum elatius, Festuca rupicola, Brachypodium pinnatum, Calamagrostis epigeios, Bothriochloa ischaemum*. The most abundant mid-successional herbs are *Dorycnium herbaceum, Inula ensifolia*, *Agrimonia eupatoria* and *Thymus praecox.* In close vicinity (within 2 km) there are remnant fragments of the original meadow-steppe (*Euphorbio pannonicae-Brachypodietum pinnati* Horváth 2010) and dry steppes (*Salvio nemorosae-Festucetum rupicolae* Zólyomi ex Soó 1964) which can be considered as a target for the regeneration succession. We have carried out stratified random sampling. The shrub- and *Robinia pseudoacacia* dominated patches were omitted, and patches with low cover the *C. epigeios* (less than 60%) were disregarded as well. The remaining *C. epigeios* dominated patches were very abundant in the beginning of the study. The diameter of these monodominant patches was larger than 25 m. We established each study site eight pairs of 3 × 3 m permanent plots, positioned randomly along the slope and arranged in a split-plots design (Jones and Nachtschein 2009) of mown and control plots. The field experiment was conducted from 2001 to 2011, with mowing twice a year in June and in September of all years. Vegetation data were monitored in 2 × 2 m permanent quadrats placed in the middle of each 3 × 3 m plot, i.e. there was 1 m buffer zones between the paired (mown and control) quadrats. Cover of each vascular species was estimated visually. The average minimal distance between the split-plots was 26 meters, the maximal distance was 50 meters.

For recordings Braun-Blanquet (1964) methods were applied –2×2 m quadrates were performed – coverage values specified in percentages for each species. Names of species follow Simon (2000) nomenclature.

Biomass examinations.

In case of Bükkös hill and Somló hill areas biomass investigation were taken as well. Paralel with coenological recordings, a 2×2 m2 grassland part were cut by trimmer leaving 4cm high stubble in order to model effect of sheep. Sampling was taken from the middle 1×1 m2 part. Trimming waste was sorted according to important groups of grazing. Coverage values of each grass forming was calculated from total coverage percentage per mass ration of each grass forming, ie. *C. epigeios*, other grasses, other dicots, unpalatable thorny species and litter.

Data analysis

Total cover, species richness and the Shannon-diversity (Pielou 1975) was calculated. The effects of mowing were tested using repeated – measure analyses of variance (ANOVA). For *post-hoc* test the Tukey Honestly Significant Difference (HSD) with corrections (adjusted p-values for the multiple tests) was used. Data were analyzed by the R-statistical program (R Development Core Team 2009).

Our experiment was performed in transitional vegetation with ongoing secondary succession. By mowing we aim to promote the regeneration of this grassland to a target community (*Euphorbio pannonicae-Brachypodietum pinnati*) (Horváth 2010). Therefore, the success of the restoration measure should be evaluated not only by species richness and diversity but by evaluating the changing species composition. For this purpose we classified the species into two groups:

1 – T: target species

2 – N: non target species

We grouped species with similar preference to different (1, early; 2, mid-; and 3, late-) successional stages. Classification was based on our country-scale survey of old-field succession (Bartha *et al*. 2010), and on the Borhidi's social behaviour index (an Hungarian adaptation of Grime's system (Grime *et al.* 1988)).

The first group, T**:** *target species*: are mainly dry grassland generalist species *(Hieracium spp., Galium verum, Inula ensifolia),* including also some specialists and rare species *(Jurinea mollis, Carex halleriana, Centaurea sadleriana)* and matrix species (*Bromus erectus, Brachypodium pinnatum* and *Festuca rupicola*). The second group, N: *non target species*: are disturbance tolerant ruderal species, generalist and typical to early successional stages (e.g., *Carduus spp., Gallium mollugo, Picris hieraciodes, Vicia cracca*). In this group are ruderal competitor and competitor species, they are also generalists, typical to mid-successional stages (e.g., *Agrimonia eupatoria, Securigeria varia, Falcaria vulgaris, Lathyrus tuberosus, Plantago media*).

Results

Landscape history of the investigation area

The area was originally covered by the forest component of the Pannonian forest-steppe zone. According to old military maps (First Military Survey 1785) and other historical sources (Torma 1991), the area has been inhabited since the Bronze Age, and been mostly used as vineyards since the XVII century. Since centuries this hilly landscape was a mosaic of small vineyards, orchards and croplands with scattered patches of woods and steppes. Loess steppe fragments appeared on hilltops and ridges and wet meadows in the valleys. Actual land use has often changed due to wars and changing economic conditions. Therefore abandoned fields and the related secondary succession have a long history in the area and the species adapted to different successional stages are also part of the regional species pool.

The landscape history of the area determinated by the vicinity of Danube, since has been inhabited for prehistoric times. Large Neolithic, Copper Age, and Árpád Age colonies were found on its filed. Ruins of soil castle from the Bronze Age was found on the top of the Bükkös Hill, while at the bottom of Somló hill similar findings have been found in the same age (Torma 1991).

Maps of First Military Survey indicate vineyard on the west facing slopes of Bükkös hill in 1785. Somló hill was forested at that time. Second Military Survey indicate vineyard and orchard in both cases of hill. Rows of trees accompanied with the stream. This was surveyed in 1842 in Vác. During Third Military Survey the map did not change significantly. The opposing Kis hill, Bok hill that was close to the village, Menyecske hill, Szank hill (these were all at the border of Penc) was covered by vineyards.

Results of vegetation mapping

Vegetation of Somló hill

The experimental area in Somló hill is 7 hectares and was a vineyard abandoned 30-35 years ago. It has north-eastern exposition (slope 14 degree) and it is covered by a mosaic of shrubs (*Cornus sanguinea, Ligustrum vulgare, Crateagus monogyna, Rubus caesius, Clematis vitalba, Genista tinctoria*) and mid-successional grassland patches. The most abundant patch-forming grasses are *Calamagrostis epigeios, Brachypodium pinnatum, Arrhenatherum elatius, Festuca rupicola, Stipa tirsa*. The most abundant mid-successional herbs are *Dorycnium herbaceum, Inula ensifolia, Fragaria viridis, Coronilla varia, Centaurea spinosa, Leontodon hispidus. One of the most frequent species is Agrimonia eupatoria.* In close vicinity (within 2 km) there are remnant fragments of the original meadow-steppe (*Euphorbio pannonicae-Brachypodietum pinnati* Horváth 2010) and dry steppes (*Salvio nemorosae-Festucetum rupicolae* Zólyomi ex Soó 1964) which can be considered as a target for the regeneration succession.

Vegetation of Bükkös hill

On the north facing slopes of Bükkös hill the permanent vegetation types not changed or only in small amount during examination period. These individual patches were dominated by *Arrhenatherum elatius, C. epigeios* or *Cytisus austriacus.*

However, the *Inula ensifolia* and *Festuca rupicola* dominated patched are often transformed into *C. epigeios* dominated type. Equilibrium was shifted toward moisture demanding species, amount of *Cytisus austriacus*, *Brachypodium pinnatum* and *Dorycnium herbaceum* increased.

Permanet *Bothriochloa ischaemum* vegetation type was observed on the west facing slopes which very rarely replaced by *Prunus spinosa* or *Dorycnium herbaceum.* In this area it is also well known that *C. epigeios* and *Bromus erectus* can sucessfully transform *Inula ensifolia* and *Festuca rupicola* dominated patches, however in one case Festuca *rupicola* replaced *C. epigeios*.

Results of coenological investigation

Mowing twice a year was effective to decrease the cover of *C. epigeios*. The results of the repeated–measure analyses of variance showed that the treatment significantly affected the cover of *C. epigeios*. At the beginning of the experiment, *C. epigeios* was dominant in all plots with ca. 60% coverage. The average cover was 67 % in the mown plots, and 69% in the control plots in the Somló hill. In the Bükkös hill north facing slopes this value was 62% and 63%, in the north facing slopes 72% and 71% respectively.

Due to mowing, its coverage decreased significantly after 2 years. When compared to the starting year, a significant decrease of *C. epigeios* was detected also in the control plots. However, this spontaneous decrease appeared much later, after 6 or 7 years, or in one territory ther was no significat change. *C. epigeios* cover varied greatly between the replicates, especially in the case of the control plots. Significant differences between mown and control plots was detectable first in the 2nd year in Bükkös hill north slopes, and in the 3th years of the experiment in other two territory. This reduction can be observed in landscape scale as well.

Repeated–measure ANOVA showed that species richness was significantly affected by mowing. Comparing the species richness between mown and control plots, significant differences were detected in Somló hill in the 5^{th} and only the 10^{th} years in case of other territory. Comparing species richness of a particular year to the starting year of the experiment (2001), the first significant difference appeared after 5 years, and this difference was maintained during the subsequent years.

There was no significant difference in the Shannon-diversity of the mown and control plots during the 11 years. Comparing Shannon-diversity of a particular year to the starting year of the experiment (2001), the first significant difference appeared after 2, 4 or 9 years, according to the different places.

General decrease was found in the cover of *C. epigeios* and a general increase in the cover of *Brachypodium pinnatum* in Somló hill and *Festuca rupicola in* Bükkös hill during the 11-year study. The trend was similar between treatments, however, the speed of changes were considerable affected by mowing. In mown plots *Brachypodium pinnatum* become dominant by the 5^{th} year, and *C. epigeios* become subordinate after 6 years. In control plots, *Brachypodium* become dominant 3 years later, only in the 8^{th} year, and *C. epigeios* remained the 2^{nd} most important species. Beside the maintained cover of *C. epigeios*, “Non target species”~~-~~remained also more important in the control plots. Overall comparison of the relative importance of species groups shows similar pattern. Relative cover of target species increased considerably in the mown plots (from 24% to 41%), while their contribution sightly decreased in control plots (from 23 % to 21 %). The results of Nonmetrical Multidimensional Scaling show that mown and control plots were similar at the beginning of the study. Mown plots changed more during the period of the experiment~~s~~ following divergent trajectories, while control plots remained more similar to the initial species composition.

Table 1. The most important significant differences between mown and control plots during study period

<table>
<tr><th rowspan="2">Results</th><th colspan="3">First significant differences compared to 2001 (year)</th><th colspan="3">First significant difference between mown and control plots (year)</th></tr>
<tr><th>decreasing C. epigeios cover</th><th>increasing numeber of species</th><th>increasing Shannon diversity</th><th>decreasing C. epigeios cover</th><th>increasing numeber of species</th><th>increasing Shannon diversity</th></tr>
<tr><td>SOMLÓ MOWN</td><td>2</td><td>5</td><td>4</td><td rowspan="2">3</td><td rowspan="2">5</td><td rowspan="2">0</td></tr>
<tr><td>SOMLÓ CONTROL</td><td>7</td><td>8</td><td>8</td></tr>
<tr><td>BÜKKÖS NORH MOWN</td><td>2</td><td>5</td><td>9</td><td rowspan="2">3</td><td rowspan="2">10</td><td rowspan="2">0</td></tr>
<tr><td>BÜKKÖS NORH CONTROL</td><td>6</td><td>9</td><td>9</td></tr>
<tr><td>BÜKKÖS WEST MOWN</td><td>2</td><td>5</td><td>2</td><td rowspan="2">2</td><td rowspan="2">10</td><td rowspan="2">0</td></tr>
<tr><td>BÜKKÖS WEST CONTROL</td><td>0</td><td>8</td><td>3</td></tr>
</table>

Discussion

In our experiment, mowing twice a year was effective to decrease the cover of *C. epigeios*. However, the significant decrease appeared only in the 3rd year. A similar 2-year lag between the start of the mowing and the decrease of *C. epigeios* was reported by Rebele and Lehmann (2001) from a different habitat. The slow decrease can be attributed to the nutrient reserves accumulated in the rhizomes of this species (Fiala *et al*. 2003, Klimes and Klimesova 2002, Kavanova and Gloser 2005). *C. epigeios* lost high amount of its biomass due to the frequent cutting (Klimes and Klimesova 2002). Still it takes several years to exhaust its stored nutrients. *C. epigeios* is known to colonize in the early stage of succession (Prach 1987, Bartha 1992, Bartha *et al*. 2004, Baasch *et al*. 2010b). Therefore, we expect that *C. epigeios* should have been present at least for 30 years in our site and it might develop considerable nutrients reserves. Our results suggest that mowing twice a year is probably enough for exhausting the storage organs and to produce negative nutrient budget for this species.

Most studies found that mowing increased species richness in abandoned grasslands (Bobbink and Willems 1991; Fenner and Palmer 1998; Deák and Tóthmérész 2007, Klimesova *et al*. 2008). In our study, mowing also increased species richness and diversity in secondary mid-successional grasslands. However, the response to the treatment was slow, significant difference in species richness appeared after 5 years of mowing, and the increase in diversity appeared only after 2 or 4 or 9 years. *C. epigeios* is a tall grass with high amount of standing dead material and with thick litter layer. It also has high amount of belowground biomass. Therefore, it can be expected that it has strong competitive effects on other species. In a detailed study of the fine-scale species turnover in dense *C. epigeios* stands, decreased rate of local immigrations of other species was found, while the rate of local extinctions was the same as in the neighbouring *Festuca rupicola* grassland (Somodi *et al*. 2008). Therefore, it can be hypothized that the negative effect of *C. epigeios* on diversity is based on the limitation of the establishment of other species. Mowing decreased the cover of *C. epigeios* and also the amount of the *C. epigeios* litter, i.e mowing probably “switched off” the establishment limitation and it opened a “successional window” (Johnstone 1986; Bartha *et al*. 2003, Dostalek and Frantik 2008) for colonizing species.

Our results show that after removing the limiting factors for species establishments, it tooks 5 additional years until significant number of new species was able to establish.

This result is in accordance with other studies reporting slow response of the vegetation composition to restoration measures (Stampfli and Zeiter 1999; Rebele 2000; Hellström *et al.* 2006). In most cases, the possible reason for the slow vegetation response is propagulum limitation. In our case, the local species pool was relatively rich and most of the potential immigrant species were already present in the close neighborhood of the *C. epigeios* patches. Although, these species were present a few meters far from the experimental plots, it takes several years for them to disperge to the plots. The slow rate of diversity increase found in our study underlines the importance of fine-scale within-stand dispersal limitation and other fine-scale spatial constraints determining the rate and direction of vegetation dynamics (Bartha *et al.* 2004).

In our experiment, the some of the significant differences between mown and control plots appeared after 2-3 years in case cover of *C. epigeios*, and 5-10 years if we consider the increasing number of species, i.e a shorter study would conclude that mowing was ineffective for increasing species richness in these successional grasslands. Our results suggest that restoration experiments should be designed for at least 8-10 years to get realistic results in this type of successional communities. Another advantage of long-term permanent plot experiments is that they enable us to study the interaction between restoration treatments and the spontaneous dynamics of the vegetation. According to our knowledge all previous studies reported about the spread of *C. epigeios* (Aiken *et al*. 1989; ten Harkel and van der Meulen 1995; Rebele and Lehmann 2001; Sedláková and Fiala 2001; Holub 2002, Házi and Bartha 2002; Luoto *et al.* 2003, Stranská 2004, Somodi *et al.* 2008, Szirmai 2008), and no published study has found the reverse trend. In our experiment, we found a significant decrease of the cover of *C. epigeios* also in the control plots. Mowing resulted in a decrease of *C. epigeios* after 2 years while spontaneous decrease appeared after 6-7 years.

Studies analysing repeated vegetation maps found either nearly linear increase in the area of patches dominated by *C. epigeios* (Somodi *et al*. 2010) or no trend with fluctuation between 7 and 20% (Baasch *et al*. 2010a). In a large-scale survey of secondary grasslands developing on oldfields and on abandoned vineyard in Hungary (Bartha *et al.* 2010), we found that *C. epigeios* is abundant in the young successional stages but it is missing or less frequent in late successional grasslands. This result might imply that *C. epigeios* disappears spontaneously in secondary succession. However, this conclusion should be taken with cautions because the survey mentioned was based on the space for time substitution (Pickett 1989). Using space for time substitution, we assumed that all stands had the same history and the same landscape context. Contrary to this assumption, conditions changed considerably and the abandonment of grazing and mowing become typical in the recent decades (Poschlod and Wallis de Vries 2002; Lindborg 2006) parallel with the eutrophization of the environment (Dalton and Brand-Hardy 2003). In these changed environments, the *C. epigeios* might get an advantage, it spreads and it has prolonged dominance.

Split-plot design potentially allows species to colonize the control plot from the neighbouring mown plots in our long-term study. To test for this potential artefact, we have sampled some of the buffer zones between the mown and control plots. However, these buffer zones were more similar to the control plots, i.e. the spontaneous decrease of *C. epigeios* in the control should be explained by other factors.

Therefore, our study provides direct evidence that *Calamagrostis epigeios* can spontaneously decrease in secondary grassland succession. It needs further study to understand the mechanism of these changes. In the control plots, where the cover of *C. epigeios* spontaneously decreased, the species richness and the diversity also increased. It can be explained by the slow process and lag affects found also in the mown plots. In the control plots, significant decrease of *C. epigeios* was detected after 6-7 years. Assuming similar rate of colonization as it happened to the mown plots, we should wait another 2 years to detect an increase of species richness in this control plots.

While mowing is an effective method to reduce the aggressive tall grasses and tall herbs, it may have negative effect to other tall and broadleaved species that are components of the target community (Fenner and Palmer 1998; Bartha 2007). Further disadvantage of mowing is that it is expensive and hard to organize. Therefore on a long term it is important to think about alternative restoration measures and conservation management. Prescribed burning cannot be an alternative because it increases the dominance of the *C. epigeios* (Hille and Goldammer 2007; Marozas *et al.* 2007). Therefore, we suggest that after a (ca. 8-year-long) period of mowing grazing should be reintroduced to the area (Dostalek and Frantik 2008). Most of the people consider *C. epigeios* as a dangerous invader, but this is not necessary true. In the early stage of the regeneration process it can have positive effects (for example by controlling soil erosion), and our results also suggest that its negative effects on diversity are not permanent.

Considering of our specific questions, we conclude that frequent mowing is an effective management tool for controlling the spread of *C. epigeios* in secondary mid-successional grasslands. By mowing twice a year it takes approximately 2 years to reduce the cover of *C. epigeios* and 2 ,4 or 9 years to increase diversity. Our long-term study provided an unexpected result, i.e. the spontaneous decrease of *C. epigeios* in the control plots at much slower rates. Our results suggest that *C. epigeios* can disappear spontaneously in secondary grassland succession after ca. 40-50 years. Therefore, at longer time-scale, spontaneous succession should be considered as a basis for active land management (Prach *et al.* 2001).

New scientific results:

1. I have prepared the vegetation maps for Bükkös and Somló hills. I have examined vegetation changes between 1997 and 2009.

2. I have demonstrated that regular mowing twice in a year is an efficient tool for controling aggressively spreading *Calamagrostis epigeios*. Mowing is an effective method to reduce the aggressive tall grassland species.

3. I have confirmed, that regular mowing, significantly and positively affects the number of species and diversity.

4. Changes which occur as an effect of mowing happened prolonged. They occured at different times. The significant decreasing of cover of *C. epigeios* was 2 years after the first treatment, the significant increasing of number of species after 5 years, and the significantly increasing of Shannon-diversity is 2; 4 or 9 years after the first mowing.

5. I have demostrated untreated and spontaneous regression of *Calamagrostis epigeios,* that differ from literature and pratical results.

6. I have provided data for the time scale of the secondary succession. Regression of *Calamagrostis epigeios* occured 6-7 years, increasment of species number occured 8-9 years, while increase of diversity occured 3, 8, 9 years later from the beginning of experiment, respectively.

7. There are few reference in the national and international literature, where we can find few hint of long term - longer period than a decade – monitoring and treatment. Similarly, few data available from dangerous invasive species suppressing by regular mowing.

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