Act Sci Soc 34 (2011): 97–109

The Role of Humans in the Development, Survival and Conservation of Semi-dry Grasslands in Central-Europe

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Abstract The paper makes an attempt to approach grasslands with a holistic view: as parts of nature and simultaneously as the scene of different activities of humans. The paper gives a short review on the history and the actual state of grasslands with special focus on Hungarian semi-dry grasslands. It emphasizes the major role of humans even in the formation, the development, the maintenance and conservation of European grasslands. Land use history of European semi-dry grasslands is sketched and the importance of traditional management in the existence of highly valued diverse grasslands is pointed out. The negative effects of recent anthropogenic factors threatening the existence and diversity of semi-dry grasslands in Europe in Hungary are estimated and conservation actions taken to prevent further deterioration are mentioned. The paper comes to the conclusion that maintenance of high-diversity semi-dry grasslands is only possible with the re-introduction of traditional farming systems at landscape scale.

Keywords land use history, traditional farming, management, maintenance

The role of grasslands in the European landscape

Grasslands play a vital role in the structure and functioning of the overall landscape. They also contribute to effects on agronomic, social, environmental and economic activities at national, regional and catchment scales (Lemaire et al. 2005). Grasslands are integral parts of the semi-natural landscape of central Europe and they are of major importance for biodiversity in agricultural landscapes (Wallies De Vries et al. 2002, Klimek et al. 2007). They are in the focus of nature conservation (e.g. the EU Habitats Directive and Natura2000 network) because of their high species richness and the occurrence of many rare or endangered species (Riecken et al. 1994; Borhidi & Sánta 1999; Chytrý et al. 2001; Stanová & Valachovič 2002). Semi-dry grasslands

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of central Europe are recognized by the European Community as endangered habitat types, and "Sub-Pannonic steppic grasslands"(6240) as Natural Habitat Types of Community Interest according to Annex I of the Habitats Directive (92/43/EEC).

Permanent grasslands play a major, but not always well recognized or understood role for society (production, employment), the environment, and biodiversity. The grasslands are key habitats for many species: herbs, grazing animals such as deer and rodents, butterflies and reptiles, and many bird species. Dry grasslands contain some specialist species, for example orchids and butterflies, which can survive only in dry well-lit conditions (European Commission 1999). Grasslands, especially those visibly rich in species (flowering plants, insects, and raptors) have high recreation value as well. Grasslands have long been an important feature for landscape painting and the appreciation of the countryside. Grasslands such as steppes are the homes of ancestors to several of the now most widespread crops, garden bulbs, several species and medicinal plants. Permanent grasslands are therefore gradually becoming an important issue of concern in global, European, European Community and national decision-making, although to a widely varying extent (European Commission 1999).

Grasslands inhabited by rich vegetation inspire the spectators in many different ways. Some bystanders are mesmerized by its colorfulness; others are intrigued by the vivid living space and the swarm of niches competing with and depending on each other. Moreover, one could be enthused by the sight of the open space, the boundless perspectives or it can be an unbearable encumbrance as well, and provide a depressing sense of overwhelming. Thus a number of artworks are indeed arising from a plain related experience, memory or thought. Grasslands and steppes are obvious object of artists, poets, writers, painters, etc. They are representing metaphorical as well as aesthetical values as they appear on a garden variety of artifacts. On the other hand, the plains are in fact the stage of both individual and community life. They provide the actual terrain for celebration, cultivation, skirmish, punishment, prayer, decision making just to highlight the most important social activities. For example, one may marry his or her love of life on grassland, and nourish a whole family from the same ground, and finally burry beloved ones on this area. Therefore the least we can state is the dual importance of grasslands; as a natural habitat for countless species, and a central place of social interactions. Both of which are deeply embedded in the very fabric of a highly complex and sophisticated network of organic and social life. It is therefore imperative to preserve these natural phenomena for the sake of endangered species and of communities.

Temperate grasslands occur naturally in the middle latitudes in regions where the seasonal climate favours the dominance of perennial grasses. In Eurasia steppes cover some 250 million ha of rolling plains that extend as a broad belt across the continent from Hungary to Manchuria (Archibald 1995, Fig. 1.). The grasslands of Eurasia form a more or less treeless corridor across the continent in which various regional associations are broadly differentiated according to latitude and altitude. The forest steppe component which corresponds with the tall-grass prairies of North America (Archibald 1995) forms a more or less continuous belt in the northern part of the Eurasian steppe region, followed by the real steppe belt and the semi-desert belt southwards. The forest steppe belt reaches its westernmost and northernmost limit in the Carpathian Basin, ranging up to the Vienna Basin and South-Moravia (Borhidi 1961, Zólyomi & Fekete 1994).

Figure 1. Area covered by forest steppe vegetation in Eurasia

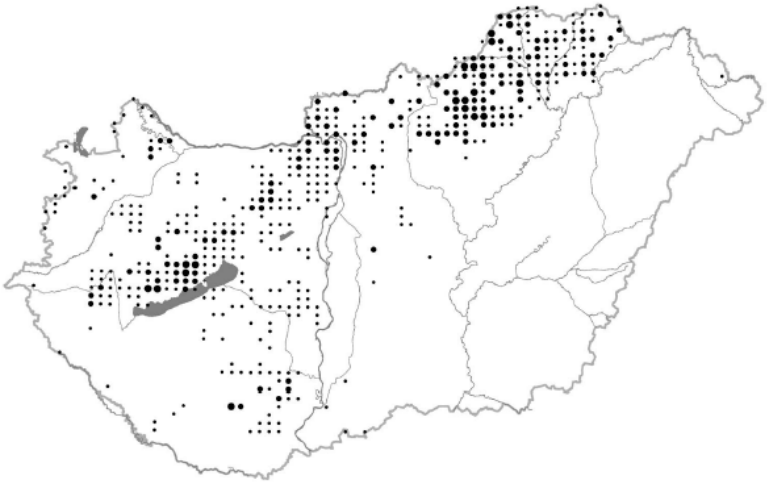
Source: WWF

Mostly secondary steppic grasslands occur also elsewhere in Europe with larger extent (especially in south Germany, Switzerland, France, Spain, in the British Isles, Estonia and south-Sweden). They are usually called as calcareous grasslands, since in these wetter and more humid parts of Europe dry and semi-dry grasslands usually develop on shallow, rocky soils. Although, they are not part of the Eurasian forest steppe formation, species composition, ecology, traditional land use and recent conservation problems of these calcareous grasslands are very similar and comparable those of the dry and semi-dry grasslands of the Carpathian Basin. The overall area of grasslands in Europe is hard to estimate since there are no comprehensive studies for this (European Commission 1999). In semiarid areas of Hungary, semi-dry grasslands are considered to be parts of the Eurasian forest steppe vegetation as remnants of former mosaic landscape of steppes, dry oak forests and shrublands (Zólyomi & Fekete 1994). Although most of the semi-dry grasslands today represent an intermediate stage of secondary succession after deforestation or of regeneration after the abandonment of vineyards or small-size ploughlands, they are characterized by remarkably high species richness (Virágh et al. 2008). Semi-dry grasslands have preserved numerous elements of the former oak woodlands, thus having a great nature conservation value (Fekete et al. 1998, Virágh et al. 2008, Horváth 2009) and being parts of the Hungarian Natura2000 network.

In Hungary the actual semi-natural vegetation of the whole country was surveyed and estimated in the frames of the MÉTA project between 2004 and 2007 (Molnár et al. 2007). The survey was based on the list of semi-natural habitats of Hungary (Bölöni et al. 2007). Calcifrequent semi-dry grasslands correspond to the MÉTA habitat type 'H4 – *Bromus erectus-Brachypodium pinnatum* xero-mesic grasslands, dry tall herb communities and forest steppe meadows' (Molnár et al. 2008a).

According to the MÉTA survey, the actual extension of semi-dry grasslands in Hungary is 12.000 ha, the two-third of that can be found in the Északi-középhegység (8.000 ha). Semi-dry grasslands occur in several places, however with much smaller area (2.700 ha) in the Dunántúli-középhegység, and sporadically in the eastern part of Dunántúli-dombság (700 ha), northern part of Nyugat-Dunántúl (280 ha), and in the western part of Alföld (Mezőföld, 300 ha). Semi-dry grasslands can also be found in small amount in Kisalföld, in the western part of Dunántúli-dombság, and in the northern part of the Duna–Tisza köze (Molnár et al. 2008a).

Figure 2. Distribution map of semi-dry grasslands in Hungary. Small dots indicate small amount of vegetation (0.1 –17 ha), medium dots mean medium amount of vegetation (17.1 –140 ha) and large dots mean large amount of vegetation (more than 140 ha) in the quadrate of approximately 3500 ha.



Source: Molnár et al. 2008a

Development of semi-dry grasslands in Central Europe and in Hungary

It is widely known that the evolution of grasslands run parallel with the evolution of large herbivores all over the globe. With the appearance of *Homo sapiens* being able to use tools and to alter its environment considerably, humans played more and more important role in the transformation of nature. Physiological studies on the unconscious habitat preferences of humans have shown that humans tend to visualize, draw or name landscapes with mosaic vegetation of patches of small forests or trees and grasslands as the place where they would live with pleasure. These desired landscapes to live can be considered as wooded savannah – or in European aspect–forest steppe landscapes, which corresponds well with the theory that *Homo sapiens* has been evolved in the vegetation belt of the wooded savannah. This might indicate that all of us share a vision of the lost Paradise, and in this Paradise grassland and forest patches form a mosaic with each other. This is the type of landscape human beings try to bring into existence, wherever they live. Up to the limits of environmental conditions, people create clearings and pastures in the landscapes originally formed only by deep forests and they plant trees or patches of forests to places which lack woody vegetation. The indistinct and many times not conscious aim is to make a wooded savannah–forest steppe habitat to live in.

There are always dynamic processes in the landscapes formed by mosaics. In case of an untouched forest steppe vegetation the grassland part would shrink if climate gets cooler and wetter and extend in the longer dry and warm periods. The fluctuation of population sizes of large native herbivores would also alter the proportions of steppe and woodland. However, these would be natural processes. Since human reached the governor role on Earth and has got out from the rules of nature due to its technical development, the importance of natural processes has been dra-

matically decreased (Vitousek et al. 1997). Long ago, since the beginning of agriculture people can totally alter landscapes of vast areas with their activities.

It is widely accepted that nearly all central European calcareous grasslands developed after Neolithic times from human land use practices, like burning, sheep and cattle grazing, or hay making over the course of thousand years (Pott 1995, Wallis De Vries et al. 2002, Baumann 2006). However, suitable habitats for calcareous grasslands in the natural landscape of central Europe might have existed since the last ice age, but were scarce, small and isolated (Poschlod & Wallis De Vries 2002). Many authors assume that calcareous grasslands may have existed before man settled down (Poschlod & Wallis De Vries 2002). Nevertheless, most of the current semi-dry grasslands of Central Europe are considered to be secondary being developed due to human impact, after cutting and thinning the original (mostly dry and semi-dry oak and oak-hornbeam) forests for grazing or hay making (Pott 1995, Willems 2001, Poschlod & Wallis De Vries 2002). However, their history is quite diverse as they originate from different time periods since the Neolithic age and they underwent diverse land use history as well (Poschlod & Wallis De Vries 2002).

It seems rather obvious that the history of European human culture and the history of calcareous grassland are bound together. Although, their origins are yet to be defined someplace else due to extent issues. Our point is that men and grasslands have been and are developing jointly, and provide mutual influence to one another. So, the task of grassland preservation is not feasible solely by forming national parks. To keep grasslands and steppes alive and flourish they should be permanently maintained and nourished. Thus the separation of human influence from these areas might even destroy these delicate habitats. We need to aim at the symbiotic relationship between humans and grasslands in order to maintain both of their existence.

The centuries or sometimes thousands of years of traditional management not only stabilized these grassland patches but enabled them to become enriched with light-demanding steppe species while the original species of forests and forest fringes could be maintained as well. In other cases, under favorable environmental conditions and landscape context, species-rich semi-dry grasslands could develop on abandoned fields, orchards or vineyards. Although it seems that nearly all of the calcareous grasslands of north-western Europe have been cultivated (i.e. ploughed) for some time during the 19th century (Wallis De Vries et al. 2002, Dutoit et al. 2003), this is most probably not the case for the Hungarian semi-dry grasslands. At least some small patches of grasslands on the steepest slopes of hills and of narrow valleys on the thick loess bedrock of the Mezőföld areas and on the foothills of the Északi- and Dunántúli-középhegység are thought to be ever free from ploughing (Horváth 2002, Illyés & Bölöni 2007). Those are the only areas that can and ought to be preserved just the way they are by associate them to the nearest nation park.

Historical management of semi-dry grasslands

Traditional management is beneficial for nature since it has been running similarly for centuries and thus entities of nature can adapt to it (Berkes et al. 2000, Molnar et al. 2008, 2009). The main difference between traditional and modern management is that the existence of people who do traditional management depends entirely on nature. Traditional farmers get nearly everything what they need for their lives directly from nature. Since traditional farmers live from nature they do care for nature, they protect and enhance it. Traditional farmers need to have knowledge – conscious or uncon-

scious – on the whole complexity of nature; especially on production cycles (Berkes et al. 2000, Molnar et al. 2008, 2009). Independent from the fact whether they had knowledge on the bio-geochemical processes and energy flows of nature, their activities are usually not harmful for the functioning of nature. They use a long-term approach in getting the values from nature: they take as much as they need and do not take much more. They give back to nature as many as they can, which is clearly reflected on the fact the whole farming system is based on circles of production. One example for thinking in cycles is the fertilization of cut arable land in the autumn by cattle grazing, which has multiple benefits, since cattle feed from the weeds have come out since the time of harvest, the weeds are prevented to ripen seeds and thus proliferate and the soil is fertilized by the dungs of livestock. A traditionally farming community is a part of nature. Traditional management is sustainable since it is in harmony with the caring capacity of the environment, in times when nature gives more; people live better, while in bad times people suffer.

The less our lives depend directly on nature – i.e. on traditional farming – the further we get from nature. In the developed societies of the modern world where 80% of the population lives in cities the direct linkage to nature has been already lost for the majority of the population. The direct link to nature as the basis of life has become rather indirect; the care for nature of the conscientious farmer has shifted to the anxiety of conservationists. The formerly sustainable farming has become unsustainable, since we take more than we necessary need. Thank to technical development, humans got out from the control of nature. People found out that – in the short run – the production of nature can be increased artificially. The alarm of overused nature warned us to rethink the theory and practice of sustainable development. Due to our recently gained academic knowledge on the relations of bio-geochemical processes of production and on the functioning of ecosystems we know (Anton et al. 2010) that we are responsible for the protection of nature, we need to restore species richness, wild plants and animals. However, most of us have stopped to live directly from nature. Today we usually enjoy only the recreational and aesthetic values of nature. It is highly unsustainable this way, since we run costly restoration activities in order to keep nature in a state suitable for recreation.

In historic dimensions, traditionally managed grasslands have been extensively used by mowing and grazing and have hardly received artificial fertilizer (Klimek et al. 2007). Maintenance of permanent grasslands was formerly done through haymaking and grazing in integrated labour-intensive systems. Maintenance at present tends to be either through grass cutting or grazing, and the intensity of cutting and grazing (over- or under-cutting or grazing) is a major issue for survival of specific grassland types. Cattle farming with full or partial stabling and concentration of cattle geographically have caused considerable problems for the continuation of many grazing schemes for nature protection. Decrease or disappearance of old grazing regimes (mountain dairy meadows) and of transhumance (seasonal migrations of grazing flock) has led to the abandonment and disappearance of large grasslands (European Comission 1999). It happened at different times in different landscapes, however, severe decline occurred mainly in the 20th century due to the abandonment of grazing and traditional farming systems. For example, in the Northern Franconian Albs around 95% of semi-dry grasslands disappeared between 1860 and 1993; while in Hanila, the largest alvar site in Estonia, 70% of open grasslands disappeared from 1951 to 1994-96 due to absence of grazing (Baumann 2006). Many authors argue that the native, but aggressively spreading grass species started to colonize stands and thus suppress the forb species after the abandonment

of grazing, which in the long run lead to the decrease in species richness (Bobbink & Willems 1987, Hurst & John 1999, Willems 2001). These changes occurred in accordance with the transformation of human population. By this transformation we mean the migration of great extent into cities, and abandoning of a number of rural ways of life. The urbanization and the industrial revolution have conjointly devastated the surviving chances of grasslands by sucking human resources out, and by colonizing a fair amount of its terrains. Simultaneously, however, have conceded some territory–like old vineyards, and orchards etc–for grassland vegetation to overtake but this reformation was indeed disproportional. As a result, the traditional management of grasslands almost has gone extinct, but for the very least has lost its attractiveness, and it was dishonored by the advocates of industrial progression. This attitude has a distinct impact on the constriction of grasslands to further have rendered them raw land resources of future industrial parks.

Traditional management of Hungarian semi-dry grasslands was similar to the ones in Western Europe; however, transhumance shepherding was ceased in Hungary due to the Treaty of Trianon (peace agreement signed in 1920, at the end of World War I). In the mountainous parts of Europe transhumance lasted even till the 1960-ies in some regions (Poschlod & Wallis De Vries 2002). According to the discussions with elderly people, the abrupt change and then a collapse of the traditional farming system started around the 1960-ies in Hungary when the collectivization was initialized. Many of the former pastures became abandoned, while others became overused due to the concentrated livestock. The number of sheep reached a peek around the middle 80-ies with 3000 thousand individuals and started to decrease heavily only in the middle 90-ies to 1000 thousand (Hungarian Central Statistical Office). Many small-sized vineyards and orchards were abandoned at the same time since the owners had no energy to cultivate them besides the full-time work in the kolhoz. In these former orchards and vineyards species-rich semi-dry grasslands have developed in many places; while, simultaneously the original grasslands might have disappeared due to the spread of trees and shrubs (Illyés & Bölöni 2007, Illyés et al. 2007b).

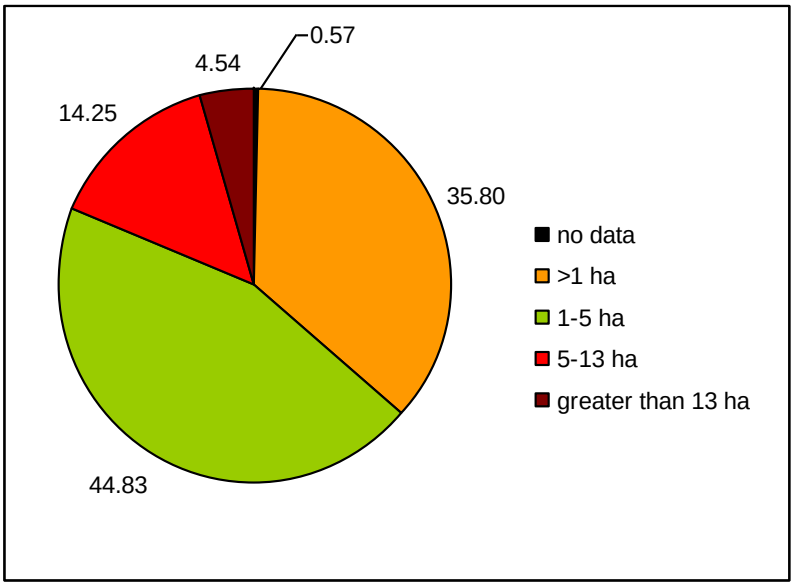
Threats to European and Hungarian semi-dry grasslands

Habitat loss is the primary environmental cause of biodiversity decline at local, regional and global scales also in case of grasslands (Dirzo & Raven 2003). It is recognized as a serious threat to high numbers of rare and declining plant species in Europe (Söderström et al. 2001). Over the past century, grasslands and other semi-natural plant communities in temperate Europe have suffered dramatic decline in their area due to land-use changes, and thereby once widespread vegetation types became highly vulnerable (Louto et al. 2003). In particular, calcareous grasslands decreased dramatically in area all over Europe (Baumann 2006). For example, in England the Agricultural Act of 1947 caused drastic agricultural development and thus long established grasslands were converted to arable fields to maximize cereal production (Baumann 2006).

Intensification and abandonment of traditional agricultural practices have drastically altered farmland landscapes in Europe and thus semi-natural grasslands became increasingly fragmented (Söderström et al. 2001). The situation of semi-dry grasslands in Hungary is the same as in other parts of Europe; most of the stands are fragmented and are threatened by different factors such as shrub encroachment or low intensity management (Illyés & Bölöni 2007, Illyés et al. 2007b, Virágh et al. 2006,

2008, Molnár et al. 2008b). Proportion of patches smaller than 5 ha is strikingly high, it reaches 80% according to the MÉTA database (Fig 3.).

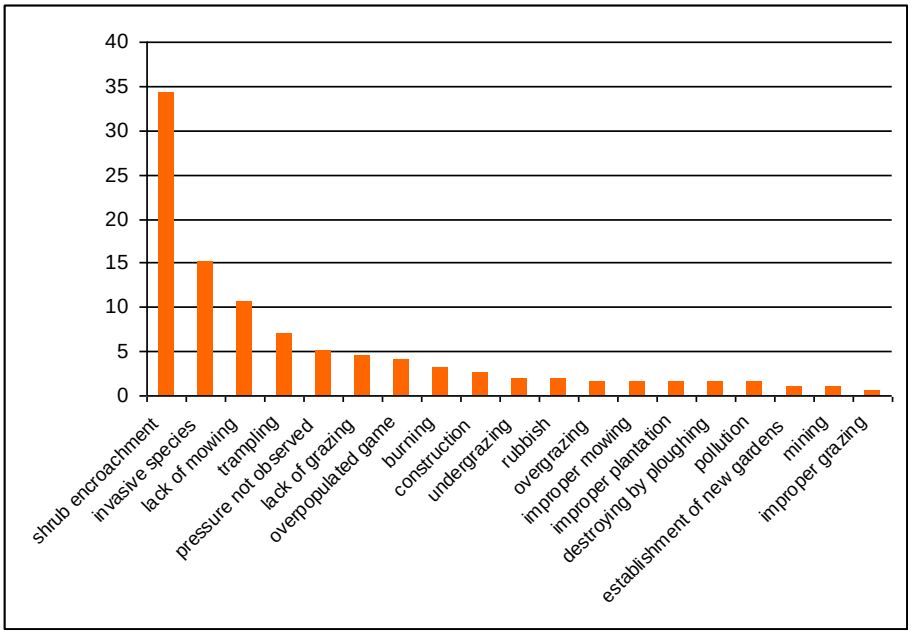
Figure 3. Distribution of patch-size categories of semi-dry grasslands according to the MÉTA database of (semi-)natural vegetation of Hungary



Fragmentation, habitat loss and change or abandonment of the traditional land use practice threaten the most the European grasslands (Dirzo & Raven 2003, Baumann 2006, Helm et al. 2006, Klimek et al. 2007); however, there are no available data on the frequency of these threats or on the proportion or of the area they affect. During the MÉTA survey of (semi-)natural vegetation of Hungary (Molnár et al. 2007) threats on the particular habitat types were documented as well. According to this survey nearly 90% of semi-dry grassland is threatened by at least one factor (Illyés & Bölöni 2007, Seregélyes et al. 2008). Main threats of Hungarian semi-dry grasslands are summarized in Fig. 4.

By taking a closer look at threat factors according to Fig. 4. The first and the most significant of them is the scrub encroachment it has just as much influence as the combined impact of all other factors below trampling. The top 4 factors actually outnumber anything else on the chart moreover the first and the second factor have proven to have the most significant influence on grasslands. This implies the importance and necessity of human interference in case of preserving grasslands and steppes. Since the lack of traditional grassland management is results a quick change in vegetation due to aggressive invasive species are gaining more and more ground. Thus the rapid shrinking of grasslands is eventually a result of natural processes, however, the very course of events were probably triggered by the lack of human intervention. Namely humans are indeed responsible for the recent change in landscape regarding the steppes and grasslands but the liability is shared with those of leading factors of Fig. 4.

Figure 4. Percentage shares of all semi-dry grassland threatened by different factors according to the MÉTA database of (semi-)natural vegetation of Hungary



Data compiled from Molnár et al. 2008b

Management for conservation

Conservation of semi-dry grasslands is a priority issue at European level because of their high species richness and the occurrence of many rare or endangered species (Riecken et al. 1994; Borhidi & Sánta 1999; Chytrý et al. 2001; Stanová & Valachovič 2002). This is also reflected by the fact that semi-dry grasslands are priority habitats in the EU Habitats Directive and Natura 2000 network.

In western Europe the management of grasslands for conservation purposes started long ago (Baumann 2006). Most probably the first and still running conservation management was established in the south Netherlands over 30 years now in order to halt the spreading of the agressive *Brachypodium pinnatum* (Willems 2001). Different kinds of mowing regimes were introduced and tested in order to find the best solution for decreasing the cover of an aggressively spreading grass species and maintaining or even increasing the number of species (Bobbink & Willems 1987, Willems 2001). Since the sites are too small and isolated, grazing is recently not feasible in south Netherlands, however, that was the traditional management of the area (Willems 2001). In other places grazing, mowing or the combination of these two are used for the maintenance of semi-dry grasslands (e.g. Hurst & John 1999, Dutoit et al. 2003, Barbaro et al. 2004, Mitchley & Xofis 2005, Klimek et al. 2007). In western Europe it was recognized decades ago that for effective conservation of semi-dry grasslands planned management is needed, the aim of which is exclusively the maintenance of the state of the grassland and not economical benefit (Dutoit et al. 2003, Barbaro et al. 2004, Mitchley & Xofis 2005, Klimek et al. 2007).

Conservational management of semi-dry grasslands in Hungary according to my knowledge is sporadical and affects only very small areas. In most cases the management is run by the supervisorship of the particular National Park (the whole territory of Hungary, even the non-protected ones is assigned to one of the national park authorities). Yet the recent management regimes or techniques could be rather effective from practical point of view, a severe problem is that nearly all of them lack scientific basis, monitoring and in many cases even documentation. In most cases these management activities are linked to the management of some rare and protected species, while the effects on the grassland community have only secondary importance. Another problem is that it is very hard to get even a very small bit of information on these managements.

Grassland ecosystems have to be managed with multi-purpose objectives corresponding to the different functions assigned to grassland: environment, biodiversity, landscape ecology, and agricultural production with socio-economic outputs (Lemaire et al. 2005). Without management, the quality of semi-dry grassland habitats decreases rapidly and there is no way to get the lost values back. Proper habitat management run exclusively for conservation purposes, however, is expensive and in many cases difficult to perform. Re-establishment of traditional forms of land-use instead would be a far more economical – and at the same time ecological – solution. The proper strategy would amalgamate rural developmental strategies, ecologically sustainable agriculture and nature conservation (Sutherland 2002, Kleijn & Sutherland 2003, Haslett et al. 2010). For instance, by supporting eco-tourism or ecologically sustainable husbandry run by families of smaller communities, simultaneous use of semi-dry grasslands for economical and ecological purposes would be feasible. Nevertheless, to reach this goal, collaboration of higher political circles as well as local decision makers, farmers and people from nature conservation is essential.

References

Anton, C., Young, J., Harrison, P.A., Musche, M., Bela, Gy., Feld, C.K, Harrington, R., Haslett, J.R., Pataki, Gy., Rounsevell, M.D.A., Skourtos, M., Sousa, J.P., Sykes, M.T. (2010): Research needs for incorporating the ecosystem service approach into EU biodiversity conservation policy. *Biodiversity Conservation* 19:2979–2994.

Archibald, O.W. (1995): *Ecology of world vegetation.* Chapman & Hall, London.

Barbaro, L., Rossi, J.P., Vetillard, F., Nezan, J. & Jactel, H. (2007): The spatial distribution of birds and carabid beetles in pine plantation forests: the role of landscape composition and structure. *Journal of Biogeography* 34: 652-664.

Baumann, A. (2006): On the vegetation history of calcareous grasslands in the Franconian Jura (Germany) since the Bronze Age. *Dissertaciones Botanicae* 404., J. Cramer, Berlin, Stuttgart.

Berkes, F., Johan, C. and Carl, F. (2000): Rediscovery of traditional ecological knowledge as adaptive management. – *Ecological Applications* 10: 1251–1262.

Bobbink, R. & Willems, J.H. (1987): Increasing dominance of Brachypodium pinnatum (L.) Beuv. in chalk grasslands: a theat to a species-rich ecosystem. – *Biological Conservation* 40: 301-314.

Bölöni, J., Molnár, Zs., Illyés, E. & Kun, A. (2007): A new habitat classification and manual for standardized habitat mapping. – *Annali di Botanica* 7: 105-126.

Borhidi, A. (1961): Klimadiagramme und Klimazonale Karte Ungarns. – Acta. Univ. Sci. Budapestiensis de Rolando Eötvös, Sect. Biol. 4: 21-50.

Borhidi, A. & Sánta, A. (1999): *Vörös Könyv Magyarország növénytársulásairól* [Red data book of Hungarian Plant communities]. – Természetbúvár Alapítvány Kiadó, Budapest.

Chytrý, M. (ed.) (2007): Vegetace České republiky 1. Travinná a keříčková vegetace [Vegetation of the Czech Republic. 1. Grasslands and dry vegetation]. – Academia, Praha.

Dirzo, R. & Raven, P.H. (2003): Global state of biodiversity and loss. – *Annual Review of Environmental Resources* 28: 137-167.

Dutoit, Th., Buisson, E., Roche, Ph., & Alard, D.(2003): Land use history and botanical changes in the calcareous hillsides of Upper-Normandy (north-western France): new implications for their conservation management. – *Biological Conservation* 115: 1-19.

European Commission (1999): *Agriculture, environment, rural development. Facts and Figures.*

Fekete, G., Virágh, K., Aszalós, R. & Orlóci, L. (1998): Landscape and coenological differentiation of Brachypodium pinnatum grasslands in Hungary. – *Coenoses* 13: 39-53.

Haslett, J.R., Berry, P. M., Bela, Gy., Jongman, R.H.G., Pataki, Gy., Samways, M.J. and Zobel, M. (2010): Changing conservation strategies in Europe: a framework integrating ecosystem services and dynamics. – *Biodiversity and Conservation* 19 (10): 2963–2977.

Helm, A., Hanski, I., & Pärtel, M. (2006): Slow response of plant species richness to habitat loss and fragmentation. – **Ecology Letters** 9: 72-77.

Horváth, A. (2002): *A mezőföldi löszvegetáció términtázati szerveződése* [Spatial organisation of loess vegetation of the Mezőföld]. – Scientia Kiadó, Budapest.

Horváth, A. (2009): Validation of description of the xeromesophilous loess grassland association, Euphorbio pannonicae-Brachypodietum pinnati. – *Acta Botanica Hungarica* 51 (3-4).

Hurst, A. & John, E. (1999): The biotic and abiotic changes associated with Brachypodium pinnatum in chalk grassland in south-east England. – *Biological Conservation* 88: 75-84.

Illyés, E. & Bölöni, J. (eds.) (2007): *Lejtősztyepek, löszgyepek és erdőssztyeprétek Magyarországon* [Slope steppes, loess steppes and forest steppe meadows in Hungary]. – Budapest.

Illyés, E., Molnár, Cs., Garadnai, J. & Botta-Dukát, Z. (2007b): Északi-középhegységi erdőssztyeprétek természetvédelmi állapotának felmérése – esettanulmány [Survey and evaluation of the threats of forest steppe meadows in the North Hungarian Range – a case study]. – *Természetvédelmi Közlemények* 13: 163-172.

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

Klimek, S., Kemmermann, R.G.A., Hofmann, M. & Isselstein, J. (2007): Plant species richness and composition in managed grasslands: The relative importance of field management and environmental factors. – *Biological Conservation* 134: 559 – 570.

Lemaire, G., Wilkins, R., Hodgson, J. (2005): Challenges for grassland science: managing research priorities. – *Agriculture, Ecosystems and Environment* 108: 99-108.

Louto, M., Rekolainen, S., Aakkula, J. & Pykälä, J. (2003): Loss of plant species richness and habitat connectivity in grassland s associated with agricultural change in Finland. – *Ambio* 32: 447-452.

Mitchley, J. & Xofis, P. (2005): Landscape structure and management regime as indicators of calcareous grassland habitat condition and species diversity. – *Journal of Nature Conservation* 13:171-183.

Molnár, Zs., Bartha, S., Seregélyes, T., Illyés, E., Botta-Dukát, Z., Tímár, G., Horváth, F., Révész, A., Kun, A., Bölöni, J,. Biró, M., Bodonczi, L., Deák, J.Á., Fogarasi, P., Horváth, A., Isépy, I.., Karas, L., Kecskés, F., Molnár, Cs., Ortmann-né Ajkai, A. & Rév, Sz. (2007): A grid-based, satellite-image supported, multi-attributed vegetation mapping method (MÉTA). – *Folia Geobotanica* 42: 225–247.

Molnár, Zs., Biró, M., Bölöni, J. & Horváth, F. (2008a): Distribution of the (semi-) natural habitats in Hungary I. Marshes and grasslands. – *Acta Botanica Hungarica* 50 (Suppl.): 59-106.

Molnár, Zs., Bölöni, J. & Horváth, F. (2008b): Threatening factors encountered: actual endangerment of the Hungarian (semi-)natural habitats. – *Acta Botanica Hungarica* 50 (Suppl.): 119-217.

Molnár, Zs., Bartha, S. and Babai, D. (2008): Traditional ecological knowledge as a concept and data source for historical ecology, vegetation science and conservation biology: a Hungarian perspective. – In: Szabó, P. and Hédl, R. (eds.): *Human Nature: Studies in Historical Ecology and Environmental History.* Institute of Botany of the ASCR, Brno, pp. 14–27.

Molnár, Zs., Bartha, S. and Babai, D. (2009): A népi növényzetismeret és az etnogobotanikai, ökológiai antropológiai megközelítés szerepe napjaink vegetáció- és tájkutatásában. [Role of ethnogeobotanical and ethnoecological knowledge in vegatation and landscape ecology]. – *Botanikai Közlemények* 96: 95–116.

Mumford, L. (1986): *A gép mítosza*, Európa Könyvkiadó, Debrecen.

Poschlod, P. & Wallis De Vries, M.F. (2002): The historical and -socio-economic perspective of calcareous grasslands –lessons from the distant and recent past. – *Biol. Conserv.* 104, p. 361–376.

Pott, R. (1995): The origin of grassland plant species and grassland communities in Central Europe. – *Fitosociologia* 29: 7-23.

Riecken, U., Ries, U. & Ssymank, A. (1994): *Rote Liste der gefährdeten Biotoptypen der Bundesrepublik Deutschland.* Schriftenr. – Kilda Verlag, Greven.

Seregélyes, T., Molnár, Zs., Bartha, S. & Csomós, Á. (2008): Regeneration potential of the Hungarian (semi-)natural habitats. – *Acta Botanica Hungarica* 50(Suppl.): 229-248.

Sutherland, W. J. (2002): Conservation biology: Openness in management. – *Nature* 418: 834–835.

Söderström, B., Svenssen, B., Vessby, K. & Glimskär, A. (2001): Plants, insects and birds in semi-natural pastures in relation to local habitat and lanscape factors. – *Diversity and Conservation* 10: 1839-1863.

Stanová, V. & Valachovič, M. (eds.) (2002): Katalóg biotopov Slovenska [Habitat Catalogue of Slovakia]. – DAPHNE, Bratislava.

Virágh, K., Horváth, A., Bartha, S. & Somodi, I. (2006): Kompozíciós diverzitás és términtázati rendezettség a szálkaperjés erdőssztyepprét természetközeli és zavart állományaiban [Compositional diversity and spatial pattern organisation in the natural and degraded stands of Brachypodium pinnatum dominated forest steppe meadows]. – In: Molnár E. (ed.), *Kutatás, oktatás, értékteremtés* [Research, education, accomplishing values]. MTA ÖBKI, Vácrátót, pp. 89-110.

Virágh, K., Horváth, A., Bartha, S. & Somodi, I. (2008): A multiscale methodological approach for monitoring the effectiveness of grassland management. – Community Ecology 9: 237-246.

Vitousek, P.M., Mooney, H.A., Lubchenco, J. and Melillo, J. M. (1997): Human domination of Earth's ecosystems. – *Science* 277: 494–499.

Wallis De Vries, M.F., Poschlod, P. & Willems, J.H. (2002): Challenges for the conservation of calcareous grasslands in northwestern Europe: integrating the requirements of flora and fauna. – *Biological Conservation* 104: 265-273.

Willems, J.H. (2001): Problems, approaches and results in restoration of Dutch calcareous grasslands during the last 30 years. – Restoration Ecology 9: 147-254.

Zólyomi, B. & Fekete, G. (1994): The Pannonian loess steppe: differentiation in space and time. – *Abstracta Botanica* 18: 29-41.