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***Chapter 6***

# CONSERVATION AND MANAGEMENT OF ALKALI GRASSLAND BIODIVERSITY IN CENTRAL-EUROPE

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## ABSTRACT

Grasslands are vital landscape elements in Europe; the 180 million hectares of grasslands have a crucial role in maintaining the landscape level biodiversity. Alkali grasslands are typical in Central- and Eastern Europe, with large areas in the Carpathian-basin. These types of grasslands were not the most favorable targets of arable farming, but large areas affected by mineral fertilization, drainage, soil melioration and/or commercial seeding in the last 60 years. In our paper we present important vegetation characteristics, species composition and management of five grassland types from the open annual alkali pioneer swards to tall grasses dominated wet alkali meadows. In general, alkali grasslands are usually characterized by short (*Festuca pseudovina*, *F. rupicola*, *Poa angustifolia*) or tall grasses (*Alopecurus pratensis, Elymus repens*). They harbor several steppe endemics (e.g. *Plantago schwarzenbergiana*, *Cirsium brachycephalum, Limonium gmelinii* ssp. *hungarica*, *Puccinellia limosa* and *P. peisonis*) and halophyte species (*Salicornia prostrata, Salsola soda, Suaeda pannonica, S. maritima*),

adapted to high salt contents of soil. According to the uneven pattern of soil salt and water, alkali grasslands are spatially very diverse. Maintaining alkali grasslands the extensive grazing mostly by cattle and sheep is essential. Nowadays, in large areas of alkali grasslands former grazing are ceased or replaced with mowing. This resulted in a change of species composition, decreased richness and/or litter accumulation. Alkali grasslands are refugees of alkali steppe vegetation; thus, restoration and preservation of their biodiversity have a high conservation priority in Habitats Directive of the EU (Pannonic salt steppes and salt marshes, 1530).

**Keywords**: alkali grassland types; salt; grazing; mowing; grassland recovery.

## 1. INTRODUCTION

Conservation of grassland biodiversity is of top priority in conservation policy of Europe and elsewhere (Nösberger and Rodriguez 1996). Grasslands are vital elements of traditional landscape and of crucial importance for biodiversity conservation (Wallis De Vries et al. 2002). Grasslands also provide important ecosystem services for recreation, sport and tourism (Isselstein et al. 2005). Natural grasslands are in constant decline in many parts of Europe. This considerable decline is mostly caused by the conversion of grasslands into croplands and tree plantations (Hald and Vinther 2000, Poschlod and WallisDeVries 2002). In western part of Europe this process was very intensive in countries with intensive agriculture (Kiehl et al. 2010). In native grassland fragments a rapid decline of former species richness resulted in by ceased or altered traditional management by grazing and mowing (Valkó et al. 2011), by agricultural intensification in a form of improved use of fertilizers, pesticides, and by commercial seeding (Bakker and Berendse 1999). Thus, the conservation and restoration of grasslands became a high priority action worldwide.

In Eastern and Central Europe in the former socialist era many grasslands were ploughed up, and the use of fertilizers was also increased; however, extent grasslands in areas with low potential of crop-production were maintained by low intensity farming. After the collapse of the state own agricultural cooperatives the socio-economical changes associated with cheap import and insufficient funds of the new land-owners were resulted in a decrease of 50-70% of former livestock numbers in this region and a large scale abandonment of semi natural pastures and mown grasslands (Isselstein et al. 2005). The total extension of grasslands was decreased by 14% caused mainly by ceased former management between 1989 and 2007 in Hungary.

Among the remnant grassland fragments of near natural state, alkali grasslands are one of the best preserved grassland habitats in Europe. These types of grasslands are utilized as pastures, because their poor soil quality and fluctuating water regime unsuitable for intensive agriculture and forestry. Due to these facts, their unique flora and fauna is well preserved till now. In Habitats Directive which is a cornerstone of Europe's nature conservation policy alkali habitats have an important role. These types of habitats of Carpathian basin were included into Natura 2000 network as "Pannonic salt steppes and salt marshes (1530)" registered as priority habitat type of the EU. In the present paper we aimed at to discuss the most important alkali grassland types, their traditional management, current conservation status, and restoration possibilities.

## 2. SOIL CONDITIONS AND CLIMATE

Continental alkali grasslands are influenced by the high soil salt content and dynamic changes of water regime. These types of grasslands are generally located in soils with high levels of groundwater and at least moderate salt concentration ($Na_2CO_3$, NaCl, rarely $K_2CO_3$ and KCl) and a high pH (8-10) under a continental climate. The soil salt content is originated from eroded debris transported by groundwater from volcanic mountains and sodium, calcium and magnesium content of the bedrock (predominantly loess). Due to the intensive evaporation caused by often extreme, dry and warm summer periods, the groundwater which is near to the soil surface and have high salt content transports the salt to the upper soil layers where its accumulates.

Types of alkali soils and grasslands are generally determined by the vertical position of salt accumulation zone and groundwater level. The least productive types are where the groundwater level is high and the salt accumulation zone is at or near to the soil surface. Characteristic alkali soil types are solonchak and various types of solonetz. *Solonchak* soils frequently have a considerable sand soil fraction and are characterized by high mean groundwater levels where the salt accumulation zone is near located to the soil surface. The humus content is generally low. There is generally no definite geometric soil structure. *Solonetz* soils are well structured and can be characterized with deeper groundwater tables and salt accumulation zones than solonchak soils. The steppic types are characterized by high humus content. The upper soil layer can be very hard (when dry) or soapy (when wet).

Alkali soils develop by natural or a human induced way (Molnár and Borhidi 2003). Naturally developed alkali soils are present in the Carpathian-basin since

the Pleistocene with considerable extent (Bárczi et al. 2006). Secondary alkali soils are formed after drainage or river regulation works, which was typical from the 19th century (river regulations) till the end of the socialist era (irrigation in marshes and fens) in the Carpathian basin. The lowered water levels and desiccation of habitats induced secondary salt accumulation in higher soil layers especially in former wet non-alkali meadows, marshes or even in fens (Molnár and Borhidi 2003).

# 3. GRASSLAND TYPES

## 3.1. General Characteristics

Alkali grasslands are typical in regions with at least moderately continental climate, extent stands located from Middle-Asia (e.g. Siberia and Mongolia) to Middle- and Eastern-Europe (Ukraine, Romania, Hungary), but very sporadic in Western Europe. The largest native occurrence of alkali grasslands to the west is located in the Carpathian-basin (mostly in Hungary and Romania, but some minor grassland patches are present in Austria and in the Czech Republic).

The dominant species of most alkali grassland types are widely distributed grass species with a wide range of humidity and salt tolerance (*Agrostis stolonifera*, *Alopecurus pratensis*, *Beckmannia eruciformis, Elymus repens, Festuca pseudovina* and *F. rupicola*). Alkali grasslands harbor several grassland species characteristic to Eurasian continental steppes and several endemics to the Carpathian basin. Several alkali grassland types harbor the same common grassland species; thus their classification is based not only on differential species and species composition but on the relative proportion of dominant species. On habitats with extremely high salt contents and rapid changes in water availability sparse halophytes dominated vegetation is typical. These types of grasslands are classified in "Annual alkali pioneer swards of steppes and lakes" when several short lived herbs are characteristic, and in "Dense and tall *Puccinellia* swards" if *Puccinellia* spp. are present with a relatively high abundance. The relatively dry, short-grass alkali grassland types are "*Artemisia* alkali steppes" and "*Achillea* alkali steppes" on meadow solonetz or solonchak. Both types are characterized by the same short grasses, but the latter one generally harbors several non alkali species (species characteristic to loess grasslands). Tall grasses dominated species poor meadows on alkali soils are classified into the "Alkali meadows" type. The "Tall herb alkali meadows and meadow steppes" harbor the same tall grass species as the former type, but are generally situated on higher elevations with

higher richness of forbs characteristic for loess grasslands, alkali steppes and alkali meadows. In the followings we present these types of alkali grasslands in the Carpathian basin, in accordance with the classification of Molnár et al. (2008).

Extent homogeneous stands of a single alkali grassland type can be rarely found; various type of grasslands form generally a heterogeneous mosaic structure in accordance with the uneven pattern of soil salt contents, relief and water availability.

In a landscape characterized by alkali grasslands near to the highest elevated plateaus and point bars with loess vegetation generally stands of *Achillea* alkali steppes are situated. Near to *Achillea* alkali steppes but at lower elevations on soils with higher salt content (solonetz or solonchak) typically *Artemisia* alkali steppe vegetation is located (Molnár and Botta-Dukát 1998; Török et al. 2011a). At the lowest elevations alkali meadows, and in the deepest depressions alkali marshes are situated.

Figure 1. Open pioneer alkali grassland with *Salicornia prostrate.*

## 3.2. Annual Alkali Pioneer Swards of Steppes and Lakes

These types of habitats are typical on salt lake beds and several micro-formations of alkali landscape characterized by extremely high salt accumulation at or near to the soil surface, low soil fertility and high groundwater level even in summertime. Annual alkali pioneer swards of steppes and lakes have a low

vegetation cover and harbor a high number of endemic (*Puccinellia peisonis, Suaeda pannonica, S. salinaria*) and common halophyte species (*Camphorosma annua*, *Lepidium cartilagineum*, *Matricaria recutita*, *Plantago maritima*, *Salicornia prostrata*, *Spergularia maritima*, *Suaeda maritima;* Fig. 1.).

### 3.3. Dense and Tall *Puccinellia* Swards

They are generally wet and species poor alkali habitats with high concentration of accumulated salt in the upper soil layers. Their stands are covered with shallow water in the spring. The vegetation cover usually exceeds 50% in springtime, but in dry years and/or seasons this cover can decrease to a few percent. Stands are more typically located in solonchak soils where the extension of continuous stands reaches several hectares. Most characteristic are the endemic *Puccinellia* species (*Puccinellia limosa, P. pannonica, P. peisonis*), and the commonly widespread *P. distans,* however the vegetation composition changes very dynamically in time. In wet years several *Juncus* species and *Alopecurus pratensis* can reach considerable cover. In dry years short-lived forbs like *Artemisia santonicum, C. annua, Cerastium dubium, M. recutita, Pholiurus pannonicus, Plantago. maritima* and *P. tenuiflora* become frequent. *Puccinellia* swards are generally used as pastures grazed by cattle.

### 3.4. *Artemisia* Alkali Steppes

*Artemisia* alkali steppes are characterized by short grasses (mainly *F. pseudovina*) and two subspecies of *A. santonicum* (*A. santonicum* ssp. *santonicum* and *patens;* the latter is an endemic subspecies) regularly used as pastures. These grassland types are generally covered by shallow water (a few mm) in springtime. Polygonal soil splits may appear on the soil surface in the dry summer. *Bupleurum tenuissimum, C. dubium, Gypsophila muralis, Limonium gmelinii* ssp. *hungarica, Lotus tenuis, Podospermum canum, Ranunculus pedatus* and several *Trifolium* species. are frequent species of alkali steppes. Salt tolerant species like *Aster tripolium ssp. pannonicum, Atriplex littoralis, L. cartilagineum, P. maritima, Suaeda* spp., are widespread.

*Artemisia* alkali steppes have several endemic species like *A. tripolium* ssp. *pannonicum, L. gmelinii* ssp. *hungarica, Suaeda* spp., *Puccinellia* spp. and *Plantago schwarzenbergiana* which is present in disturbed stands. If suitable water conditions are met (e.g. in springtime) and overgrazing occur several short-

lived species (*Erophila verna, Hordeum hystrix, M. recutita* and *Polygonum aviculare*) are present. In wet years in open patches several species characteristic to annual alkali pioneer swards (*Myosurus minimus, P. limosa, Scleranthus anuus*) occur.

## 3.5. *Achillea* Alkali Steppes on Meadow Solonetz

*Achillea* alkali steppes are closed, short-grass steppes on solonetz soils with a moderate salt contents (meadow and chernozem solonetz), characterized by short grasses (*F. pseudovina*, *F. rupicola, Koeleria cristata*, *Poa angustifolia* and in heavily grazed stands *Cynodon dactylon*, Fig. 2). Considerable stands of *Achillea* steppes were originated due to secondary salt accumulation. Several species characteristic also for loess grasslands are common (*Dianthus pontederae, Filipendula vulgaris, Silene viscosa, Salvia austriaca*). Because of the relatively low soil salt concentration only a few salt specialist are characteristic in these grasslands. *Achillea* steppes are rich in forb species, the most frequent species are *Achillea collina, A. setacea, B. tenuissimum, C. dubium, G. muralis, Inula britannica, Plantago lanceolata, P. canum, Ornithogalum kochii*. Several *Trifolium* species are also present (*Trifolium angulatum, T. fragiferum, T. retusum, T. striatum, T. strictum*). These types of grasslands are traditionally used as pastures grazed by cattle or sheep. In overgrazed stands grazing tolerant species can appear (*Carduus nutans*, *C. dactylon, Eryngium campestre, Ononis spinosa*).

## 3.6. Alkali Meadows

Alkali meadows are tall grasslands dominated by tall grasses like *A. pratensis, A. stolonifera, B. eruciformis, E. repens* and *Glyceria fluitans*. This type of alkali grassland is generally covered by shallow water from early spring till midsummer. There are usually two herb layers. In the upper herb layer with the tall grasses several tall forbs are characteristic (e.g. *Lycopus europaeus*, *Lythrum salicaria, L. virgatum* and *Rumex stenophyllus*). In the second herb layer small forbs (*Cerastium dubium, Galium palustre, I. britannica, Leonurus marrubiastrum, Lotus tenuis, Lysimachia nummularia, Mentha aquatica, Mentha pulegium, Oenanthe silaifolia, Ranunculus lateriflorus, R. repens, R. sardous*) short sedges (*Carex distans, Carex melanostachya*) and rushes (*Juncus compressus, Juncus gerardii*) are present. Two endemic species *Rorippa sylvestris*

ssp. *kerneri* and *Cirsium brachycephalum* are typical in most stands. These grasslands are traditionally extensively grazed or used as hay meadows.

Figure 2. *Achillea* alkali steppes in July in the Hortobágy Puszta, Hungary.

## 3.7. Tall Herb Alkali Meadows and Meadow Steppes

Originally these grasslands are typical in the clearings of alkali steppe oak woodlands (Bölöni et al. 2008, Molnár et al. 2008). The vegetation of these tall alkali grasslands are characterized by several tall grasses and herbs. In springtime they are usually wet, and they get dry till late summer. Characteristic species are tall grasses as *A. pratensis* and *E. repens* and several tall forbs like *A. sedifolius*, *Rumex pseudonatronatus* and *Peucedanum officinale*. Several species of loess steppes (*F. vulgaris, Fragaria viridis, Galium verum, Peucedanum alsaticum, Stellaria graminea*) and several salt tolerant species (*Artemisia pontica, A. santonicum* and *L. gmellinii* ssp. *hungarica*) occur. This habitat type is rare and of high conservation value in the Carpathian basin and traditionally managed by low intensity cattle grazing.

# 4. MANAGEMENT AND THREATS

## 4.1. Traditional Management

Alkali grasslands were maintained by the large wild herbivores from the Pleistocene till the early Holocene (Bárczi et al. 2006). Parallel to the increase of the human presence in the Carpathian-basin these herbivores have disappeared. Their role was taken over by domestic grazers like cattle, sheep and horse. Nomadic herding in alkali habitats was present from the middle ages till the end of the Second World War.

*Artemisia* and *Achillea* alkali steppes, *Puccinellia* swards and annual alkali swards of steppes were generally used as pastures for sheep. Cattle grazing is typical on all alkali grassland types but annual pioneer swards. It is more frequent on *Achillea* and *Artemisia* alkali steppes and alkali meadows.. The wet grasslands and marshes were also grazed by Hungarian Grey cattle and Water Buffalo. The optimal stocking density was one large livestock (cattle, horse or buffalo) or 4-7 sheep per hectare. Traditionally only a negligible part of meadows were mown for producing some additional winter forage.

The most suitable time for mowing was at the beginning of flowering of the frequent grass species, usually in May. In some years the mowing time could have an overlap with the breeding time of several protected bird species, or in wet years the soil surface can be covered by water. Thus; in practice, mowing of nature conservation areas is only permitted from the middle of June, but only with mowing machinery equipped with an instrument warning nesting birds (e.g. chains attached to the front of the mower).

## 4.2. Current Management and Threats

From the middle of the 20$^{th}$ century onwards the number of livestock decreased rapidly because of the economic and political changes after the Second World War. At the early years of the socialist era several attempts were made to improve the poor fertility of pastures by draining water, melioration, use of fertilizers, commercial seeding and by application of pesticides. The former use by nomadic herding was in several places replaced by intensive animal farming where the livestock was kept in stables. An additional effect of the established animal framing systems was, the increased rate of linear infrastructures (e.g. roads and canals) was necessary to transport additional forage and take away animal dung.

To provide forage for stabled livestock most of the formerly grazed alkali meadows were transformed to hay meadows. The mowing by mowing machinery resulted in a more homogeneous vegetation structure than grazing and this change in land use altered the species composition of the meadows (Török et al. 2011b). The former patch dynamics were destroyed and several species adapted to grazing induced patchiness (e.g. characteristic short-lived endemics adapted to regular trampling and grazing) became rare.

It was also typical, that in several pastures livestock grazing was replaced by grazing of domestic geese. Ten thousands of domestic geese were fenced in a relatively small area which caused a dramatic decrease in the cover of grassland species and increase that of weeds in the subjected grasslands. Thus, goose grazing is not allowed in protected Natura 2000 sites, nowadays.

After large state-run agricultural co-operatives have collapsed and lands were often privatized after 1990 the cessation of former management became typical. By the cessation of management by grazing and mowing the species number, heterogeneity and number of microhabitats (formed by regular disturbance by grazing and mowing) was decreased. Abundance of frequent grassland species e.g. *A. pratensis, A. stolonifera, E. repens* in meadows, *Festuca* and *Artemisia* species in short-grasslands, and amount of accumulated litter was increased. These changes resulted in a decrease of plant species richness found also in other type of grasslands (Valkó et al. 2011). The formed homogenous grassland stands with high litter accumulation became also improper for birds (e.g. for *Charadrius alexandrinus*, *Glareola pratincola*, *Tringa tetanus, Vanellus vanellus*) preferring open grassland patches for nesting. The developed thick litter layer can prohibit the reintroduction of grazing and can increase the probability of spontaneous fires. However, it is important to stress that in lack of grazing (or mowing) no spontaneous tree and shrub invasion can be foreseen, because of the improper arboreal vegetation.

The increase of several invasive species was recently detected caused by unfavorable changes in hydrological and management status of alkali grasslands. Non-native invaders in dry alkali grasslands are *Elaeagnus angustifolia* and *Hordeum jubatum*. In abandoned wet alkali meadows and marshes the spread of the alien *Amorpha fruticosa* was detected. Three other non-native tree species *Acer negundo, Ailanthus altissima* and *Fraxinus pennsylvanica* are typical invaders in riparian forests and near to water streams. Thus, their spread to wet abandoned hay meadows with low soil salt contents can be foreseen.

## 5. CONSERVATION REMARKS

Several recent attempts were made to restore and conserve alkali grassland biodiversity in the Carpathian basin. In one of the largest alkali habitat complex in the Hortobágy Puszta several large scale habitat restoration projects were started from 2002 onwards, funded by the EU. To restore the historical water regime of water drained marshes and grasslands the key action was to eliminate irrigation systems (dikes and channels). In the project "Restoration of pannonic steppes, marshes of Hortobágy National Park" (LIFE02NAT/H/008634) 560 km draining channel was eliminated between 2002 and 2005 and further 400 km will be eliminated in the near future.

The largest known alkali grassland restoration in Europe was in Egyek-Pusztakócs, Hortobágy National Park, Hungary. In this project co-financed by the LIFE Nature programme and the EU (LIFE04NAT/HU/000119), altogether 665 ha of alkali grassland was restored in 2004-2008 period using low diversity seed mixtures of local provenance (for details see Török et al. 2010). To restore Important Bird Areas in alkali landscapes in the projects "Habitat management of Hortobágy eco-region for bird protection" (LIFE02 NAT/H/008638), "Sodic lake habitat restoration" (LIFENAT07 /H/000324), and "Conservation of *Otis tarda* in Hungary" (LIFE04 NAT/HU/000109) restoration of alkali steppe and wetland habitats were planned to provide feeding and breeding habitats for endangered bird species (e.g. *Chlidonias leucopterus*, *Grus grus*, *Otis tarda*). These aims are fulfilled with complex habitat restoration measures including rewetting actions, grassland recovery by sowing of low diversity seed mixtures (over 350 ha in the Kiskunsági National Park and in the Hortobágyi National Park) and reintroduction of former management by extensive grazing. Due to these efforts the nesting populations of the protected bird species were increased significantly (e.g. these increase was more than 16% for *Otis tarda* populations).

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