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NATURA 2000

MANAGEMENT of Natura 2000 habitats
* Pannonic salt steppes and salt marshes
1530

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The European Commission (DG ENV B2) commissioned the Management of Natura 2000 habitats. 1530 *Pannonic salt steppes and salt marshes.

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Suaeda pannonica is indicator of highest salt concentration on Pannonic salt steppes. Böddi-szék, Dunatetétlen, Hungary. Photo: Daniel Dítě

15 – Salt and gypsum inland steppes

EUNIS Classification:
E6.21 Pannonic salt steppes and saltmarshes;
E6.23 Central Eurasian solonchak grassland dominated by [Crypsis]

* Priority habitat

Summary

Pannonic salt steppes and salt marshes are highly influenced by pannonic climate with extreme temperatures and aridity in summer. The enrichment of salt in the soil is due to high evaporation of ground water during summer. There is characteristic zonation of vegetation, based on inland flooding regime, with dominant salt-tolerant grasses and herbs that tolerate or even demand salt concentrations in the soil water. Compared with other salt lakes and marshes of the world, the alkaline lakes of the Carpathian Basin are characterised by lower salt content but higher alkalinity. Alkali habitats have certainly been present in the Carpathian Basin since the last Ice Age. Pannonic salt steppes and salt marshes occur only in a few countries of the European Union. The highest area of total surface and centre of distribution of this habitat type is in Hungary, with edges of its distribution in Lower Austria, southern Slovakia, Romania and Bulgaria. Due to limited geographical distribution, they belong to the most threatened European communities.

Alkali plant communities are relatively species poor. The species combinations, however, are specific but very diverse; therefore the classification of alkali plant communities is rather complicated. The vegetation pattern is closely related to the relief determined by salt content, salt quality, and the depth of soil layer with higher salt concentration. The mosaic-like structure of different habitats supports an exceptionally rich fauna and flora, with several endemic species.

Many Pannonic salt steppes and salt marshes were totally destroyed for agricultural purposes. Ploughing for agriculture is still a major threat. Those remained are threatened by agriculture – impact of eutrophication and lack of management as well as by water management – lowering of water table connected with river regulations and building of canals have very negative impact on those ecosystems.

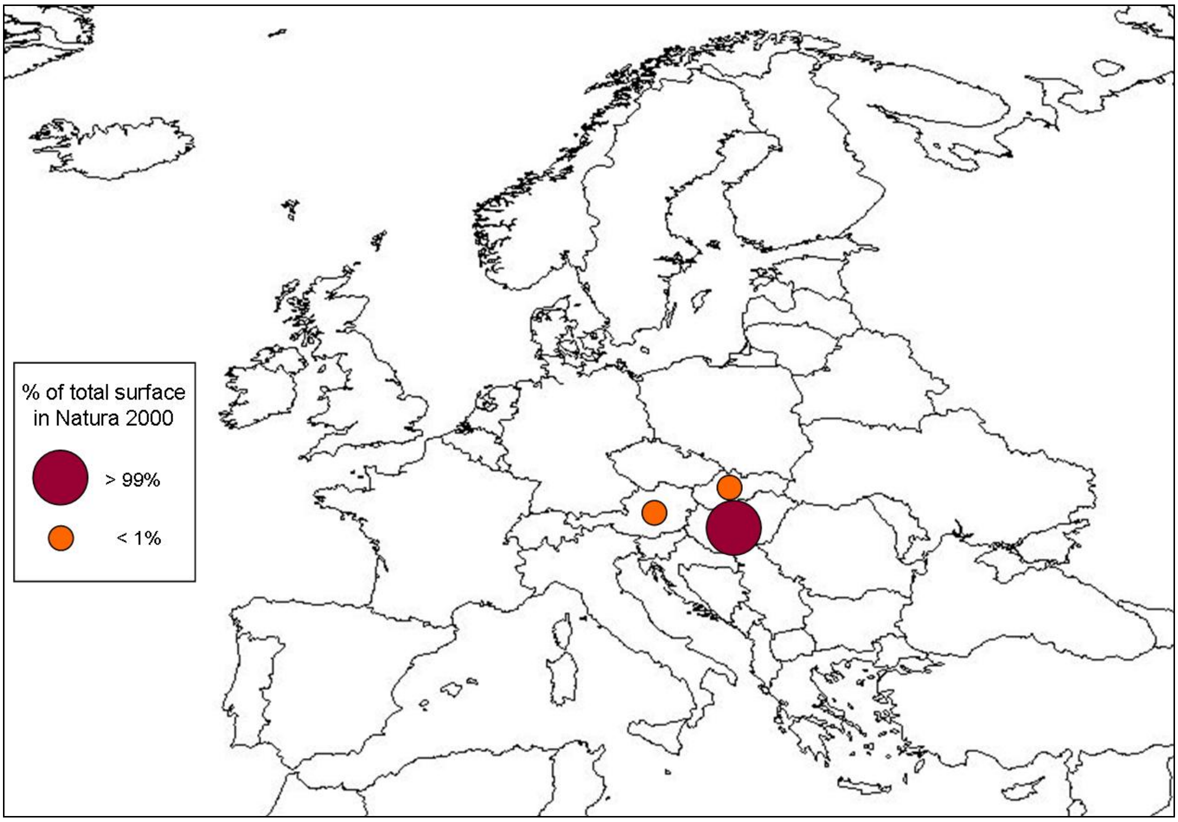
Primary alkali steppes don't need any active management. Most of the salt steppes in the region represent semi-natural habitats where biological diversity is maintained in conjunction with human activities. Grasslands are relatively fragile and can only stand extensive grazing. The indigenous animal species play an important ecological role in the conservation of the salt steppes and salt marshes habitats. When grazing on the appropriate habitat types, they provide optimal maintenance of the vegetation, and thus contribute to the recovery of habitats. Hungarian grey cattle (variety of *Bos taurus primigenius*) is adopted for grazing of salt steppes, as well as racka sheep (*Ovis strepsiceros hortobágyensis*). Number of grazing animals has decreased dramatically and distribution between grazing species has changed also. On the area of the Hortobágy and Kiskunság National Parks, special care is devoted to the original breeds of domestic animals in order to maintain the national gene reserves. Traditional grazing systems are being restored to recreate salt steppe grasslands in Fertő-Neusiedler Lake in Austria.

1. Description of habitat and related species

Salt steppes and salt marshes are highly influenced by a Pannonian climate with its extreme temperatures and arid summers. The enrichment of salt in the soil is due to high evaporation of groundwater during summer. There is a characteristic zoning of vegetation, based on the flooding regime, with dominant salt-tolerant grasses and herbs that withstand or even demand salt concentrations in the groundwater.

Distribution

Pannonian salt steppes and salt marshes occur only in a few countries of the European Union, mainly in the Pannonian bio-geographical region. The largest surface area and the centre of distribution of this habitat type are in Hungary, with the edges of its distribution in Lower Austria, southern Slovakia, Romania and Bulgaria.



Percentage distribution of the total surface of Pannonic salt steppes and salt marshes in Natura 2000

Pannonic salt steppes and salt marshes in Natura 2000 sites

The following data have been extracted from the Natura 2000 Network database, elaborated by the European Commission with data updated on December 2006. The surface was estimated on the basis of the habitat cover indicated for each protected site and should be considered only as indicative of the habitat surface included in Natura 2000.

Biogeographical region	Nº of sites	Estimated surface in Natura 2000 (ha)	% of total surface in Natura 2000
Pannonic	97	208,730	99.80
Continental	4	422	0.20
Countries	Nº of sites	Estimated surface in Natura 2000 (ha)	% of total surface in Natura 2000
Hungary	94	208,720	99.79
Austria	4	422	0.20
Slovakia	3	10	0.01
TOTAL	**101**	**209,152**	**100**

Note: Data for Romania and Bulgaria are not included in the table, because the standard data forms for those countries are not yet available. But the habitat type is found in both countries (Doniță et al. 2005, Kavrakova et al. 2005).

Main habitat features, ecology and variability

Pannonian and Ponto-Sarmatic salt steppes, salt pans (shallow saline lakes), salt marshes and shallow salt lakes are highly influenced by the Pannonian climate with its extreme temperatures and arid summers. The enrichment of salt in the soil is due to intense evaporation of groundwater during the summer. These habitats are mostly of a natural origin and partly influenced by grazing and drainage. The halophytic vegetation consists of plant communities on dry saltpans and steppes, wet salt meadows and the annual plant communities of periodically flooded salt lakes, with their typical zoning (EC 2007).

Salt steppes and their associated salt-tolerant herbaceous communities are the western representatives of the continental alkaline vegetation in the Pontic region. Compared with other salt lakes and marshes in the world, the alkali lakes of the Carpathian Basin are characterised by a lower salt content, but with a higher alkalinity (Boros 2003). In Hungary, short grasslands are called saline puszta.

Many of the plants growing in salt soils are halophytes – plants that tolerate or even demand significant salt concentrations in the soil water. Depending on their tolerance and salt demands, obligate and facultative halophytes are distinguished. Only some of them are obligate halophytes, requiring a high amount of salt to survive. Those that have the best adaptation strategy are succulents (*Suaeda* spp., *Salicornia prostrata, Spergularia maritima, Lepidium cartilagineum, Chenopodium glaucum, Ch. chenopodioides*) and plants with a higher ability to keep water inside of its pore space such as some xerophytic grasses and other monocotyles, including *Puccinelia* spp., *Crypsis aculeata* and *Bolboschoenus maritimus* (Mucina 2003).

Important plant species occurring in this habitat are: *Artemisia santonicum*, *Artemisia pontica, Suaeda corniculata*, *S. pannonica*, *Lepidium crassifolium*, *Puccinellia peisonis*, *Puccinellia limosa, Aster tripolium*, *Salicornia prostata*, *Camphorosma annua*, *Plantago tenuiflora*, *Juncus gerardii*, *Plantago maritima, Cyperus pannonicus*, *Pholiurus pannonicus*, *Festuca pseudovina, Achillea collina, Scorzonera cana, S. parviflora, Petrosimonia triandra, Peucedanum officinale, Halocnemum strobilaceum, Frankenia hirsuta, Aeluropus littoralis, Limonium meyeri, Limonium gmelinii, Nitraria shoberi, Carex distans, C. divisa, Taraxacum bessarabicum, Beckmannia eruciformis, Zingeria pisidica, Trifolium fragiferum, Cynodon dactylon, Ranunculus sardous, Agropyron elongatum, Halimione verrucifera* (syn *Obione verrucifera*), *Lepidium latifolium, Leuzea altaica* (syn *L. salina*), *Iris halofila, Triglochin maritima, Hordeum hystrix, Aster sedifolius. Scorzonera austriaca* var. *mucronata, Festuca arundinacea* ssp. *orientalis* (EC 2007). In Bulgaria, the endemic *Limonium bulgaricum* and other plants as *Scorzonera laciniata, Camphorosma monspeliaca* can be found in this habitat (Kavrakova *et al.* 2005). Other important species are *Crypsis acuelata, Heleochola schoenoides, Chenopodium chenopoiodes, Puccinellia distans, Carex stenophylla, Ranunculus pedatus, Salsola soda, Schoenoplectus tabernaemontani, Trifolium angulatum, Plantago schwarzenbergiana.*

Ecological conditions

The vegetation of salt steppes and salt marshes is determined by two main factors: water and the amount of salt in the soil and water. Changes in salt concentrations in the soil can lead to the disappearance or even the extinction of certain plant species.

The formation and evolution of lowland alkali areas shows considerable variation in both space and time. This is well reflected in the present diverse morphology of alkaline areas - a result of the mutual effects of pedological, climatological and hydrogeological conditions. The reasons for the alkalinisation in the lowlands of the Carpathian Basin are as follows (Boros 2003):

1. The availability of the necessary quantities and quality of salt, provided either by the eroded debris from the surrounding volcanic and limestone hills and mountains, or by the sodium, calcium and magnesium accumulated in loess and drifting sand areas.
2. The basin being almost completely enclosed by higher land so that any accumulated water will remain there.
3. The presence of impermeable layers which have evolved from fine-grained, solid alluvial deposits accumulated over the millennia.
4. A continental climate in which wet winters and springs are followed by warm, dry summers. Extreme changes between wet and dry seasons are typical, creating both floods and regular droughts.

An important characteristic is a fluctuation in the water level. The dissolved salt content of the groundwater accumulates from vast areas, and moves continuously towards low lying alkali lakebeds. During wet springs, groundwater pressure is high. During dry, arid summers the water table may sink considerably, superficial lowland water bodies shrink, and the water that remains eventually collects in the deepest closed basins. The salts reach high concentrations within this reduced water volume. The intense evaporation also draws up salty groundwater from deeper strata. During the driest season, lakebeds completely dry out and the salt crystallises out on the surface (Boros 2003).

Soils in this habitat are hydromorphic, meaning that they are strongly influenced by water evaporation, and the salt dynamics of groundwater is the most important factor in their formation. Alkaline soils evolve where dissolved salts, primarily those of sodium, play a leading role. Clay minerals that swell in humid conditions create a columnar structure in solonetz soils, whereas solonchak soils are typically unstructured (Boros 2003).

Most of the alkali habitats (but mainly those in solonetzic soils) have a special, fine scale geomorphology caused by water and partly by wind erosion. This micro-topographical pattern is highly correlated with the vegetation pattern. The conservation of this geomorphology is a crucial task (Molnár Zs., pers. comm.). In terms of origin, there are two principal types (Molnár & Borhidi 2003):

- Primary alkaline steppes are characterised by specific and species-rich vegetation. *Artemisia* steppes are dominant. These areas had alkali vegetation before the impact of human drainage activities, and their water regime has remained constant over the past 150 years.
- Secondary alkaline steppes are steppes with partly alkaline soils, formed from practically non-alkaline meadow and marsh floodplain habitats. These had been regularly flooded by rivers, but their vegetation has been transformed as a result of river regulation and flood control. *Achillea* steppes are usually dominant.
- The transitional type comprises of drained primary alkaline steppes. Water management resulted in a drop in the groundwater table by app. 10-20 cm, causing the leaching of salts and changes in plant communities.

Only about 20% of the salt habitats are of a natural, ancient origin. The rest are secondary, and originated mainly as a result of river regulation activities at the end of the 19th century (Liamine eds. 2007).

Variability

Alkaline plant communities are relatively species poor. The species combinations are specific but very diverse, so that the classification of alkaline plant communities is rather complicated. The vegetation pattern is closely related to the salt content, the type of salts, and the depth of the soil layer with a higher salt concentration (Molnár & Borhidi 2003).

Alkaline vegetation in the Pannonian belt can be classified into three main syntaxonomic units, which differ in physiognomy as well as in floristic and life-form composition (Molnár & Borhidi 2003):

- *Thero-Salicornietea strictae* Tüxen *in* Tüxen *et* Oberdorfer 1958 includes habitats of annual succulent halophytes of the genera *Salicornia* and *Suaeda* in both maritime and inland salt marshes. They usually occupy those places within the salt-marsh plains that have the highest salt concentrations. In the case of inland marshes, the soils are flooded or at least remain wet during spring, and dry out during the summer (Chytrý 2007). Due to the extreme environmental conditions, these communities are naturally species poor, often consisting of a single or very few species.

- *Crypsidetea aculeatae* Vicherek 1973 is the open vegetation framework for the seasonally dried out beds of alkali lakes, formed mostly by helo-halophyte grasses and sedges. This class includes species-poor habitats of annual graminoids supported by saline habitats. As the water level in these lakes drops during the summer, the wet saline soil on the exposed bottom is colonised by *Crypsis aculeata, Cyperus pannonicus, Heleochloa schoenoides* and other species. In late summer and early autumn, the soil can dry out considerably. In late winter and spring the site is flooded again. The vegetation in the following year regenerates from the seed bank after new exposure of the bottom (Chytrý 2007).

- *Festuco-Puccinellietea* Soó ex Vicherek 1973 is a class created for continental alkali steppes and meadows. Vegetation cover is closed and communities are relatively species-rich, and dominated by hemicryptophytes. This class includes low-lying perennial grasslands on inland saline soils, influenced by trampling or grazing. They are found on slightly less saline soils and drier sites (salts are thus only in the deeper soil horizons) than the annual halophytic vegetation of previous classes. In the local microtopography of well-developed, zoned saline communities, these perennial grasslands are usually confined to slightly elevated habitats (Chytrý 2007).

All these vegetation classes are well established in Hungary, with about 50 plant communities identified (see more detailed classification in Molnár & Borhidi 2003).

In Slovakia (Stanová & Valachovič 2002), remnants of *Crypsidetea aculeatae* and *Thero-Salicornietea strictae* can be found in the *1530 unit. Saline grasslands of *Festuco-Puccinellietea* have been classified as Inland salt meadows *1340.

In the Czech republic, (Chytrý *et al* 2001), communities of Pannonian salt steppes and salt marshes are not mentioned within the national Catalogue of Habitats, and only saline grasslands of *Festuco-Puccinellietea* were classified as Inland salt meadows *1340. In a currently published overview of grassland vegetation (Chytrý 2007), the occurrence of a few remnants of *Crypsidetea aculeatae* has been reported in southern Moravia. *Thero-Salicornietea strictae* is extinct within the Czech Republic and the last evidence of such community had disappeared by the 1970s.

In Austria, communities of *Crypsidetea aculeatae* and *Festuco-Puccinellietea* are recorded and described by Mucina (2003).

In Romania, salt steppes occur in the Pannonian and Western Pontic areas, with a great variety of plant communities (Gafta & Mountford 2008).

In Bulgaria, *Festuco-Puccinellietea* and *Thero-Salicornietea strictae* are classified under the *1530 unit. Some communities of *Festuco-Puccinellietea* (mostly dominated by *Elymus elongatus*, but with a very limited distribution) were classified under Inland salt meadows *1340 (Tzonev, pers. comm.).

In Hungary, a habitat list following the modified version of the National Habitat Classification System was prepared based on Landscape Ecological Vegetation Mapping (MÉTA), which includes a habitat map of the whole country and attributes collected in the field for particular habitats. Halophytic habitats were subdivided into the following types (http://www.novenyzetiterkep.hu/meta/en/index.shtml):

<u>F1a Artemisia salt steppes.</u> Dominated by *Festuca pseudovina* and *Artemisia santonicum* and *Limonium gmelinii* as co-dominants. It is a short-grass community, rich in halophytic species.

<u>F1b Achillea salt steppes on solonetz meadows.</u> It is a short grassland with relatively closed vegetation cover, dominated by *Festuca pseudovina*. Other important growth-promoting species are *Bromus mollis*, *Carex stenophylla*, *Koeleria cristata* and *Poa bulbosa*, and in patches *Agropyron repens* and *Alopecurus pratensis*. Constant and sub-constant species include *Achillea collina, A. setacea*, *Cerastium dubium*, *Inula britannica*, *Plantago lanceolata*, *Podospermum canum* and in sporadic patches *Gypsophila muralis*,

Hieracium pilosella agg. etc. The grassland area is covered to a large extent by *Trifolium angulatum*, *T. fragiferum*, *T. strictum*, *T. retusum* and *T. striatum*.

F2 Salt meadows are periodically water-covered lowland meadows (generally on salt steppes or in the vicinity of salt marshes) in which *Carex distans*, *Beckmannia eruciformis*, *Alopecurus pratensis*, *Agrostis stolonifera* and *Carex melanostachya* represent the dominant monocotyledon species, which are accompanied by the typical dicotyledon halophyte species.

F3 Tall herb salt meadows and salt meadow steppes are meadows which consist of halophytic, meadow and steppe species, with tall herb physiognomy, wet in spring and dry during the summer. Most common species include *Aster punctatus*, *Artemisia pontica*, *Peucedanum officinale* and *Aster linosyris*.

F4 Dense and tall *Puccinellia* swards are lowland meadows with strongly alkali (salty) soils, dominated by *Puccinellia* species, and periodically (especially in the spring) covered by water, or salt swards with sparse vegetation.

F5 Annual salt pioneer swards of steppes and lakes are halophytic vegetation developing after the drying-out of salty lakes and in depressions on alkali steppes which are covered by water during most of the vegetative season. They consist mainly of annual plant species. The dominant species are: *Camphorosma annua, Suaeda spp., Crypsis aculeata, Pholiorus pannonicus, Chenopodium spp., Spergularia marginata, Salicornia.*

A detailed description of its species composition, ecological factors and conservation management can be found in Fekete *et al.* 1997, and Borhidi & Sánta 1999.

Species that depend on the habitat

Pannonian salt steppes and salt marshes have a rich fauna. Seasonal pools on salt meadows and salt lakes host typical macro-plankton. Some representatives are crustaceans which appear in particular in shallow salty waters in early spring, such as *Brachinecta orientalis* and *Branchinecta ferox* (Boros 2003).

Salt lakes and marshes represent important resting and roosting sites for many birds, for example, *Branta ruficollis* (red-breasted goose) and *Anser erythropus* (lesser white-fronted goose). Both suffer from an unfavourable conservation status within Europe (BirdLife International 2004) and have a preference for alkali habitats (Boros 2003). Another remarkable aspect of alkali lakes is that they hold an isolated Central European population of typically coastal species, such as *Recurvirostra avosetta* (avocet), *Charadrius alexandrinus* (Kentish plover) and *Himantopus himantopus* (black-winged stilt). Seasonally wet salt meadows host, among others, *Limosa limosa* (black-tailed godwit) and *Tringa totanus* (common redshank) (Boros 2003).

Salt steppes with saltpans and *Puccinellia* swards are habitats for *Glareola pratincola* (collared pratincole), *Burhinus oedicnemus* (stone-curlew) and *Calandrella brachydactyla* (short-toed lark), while *Glareola nordmanni* (black-winged pratincole) is just an occasional breeder. In Hungary, the breeding of *Acrocephalus paludicola* (Eastern European aquatic warbler) is confined to the alkali marshes and wet meadows of Hortobágy (Boros 2003).

From a conservation viewpoint, the population of *Otis tarda* (great bustard) is highly important; the salt steppe habitats of Hungary host more than 1,000 individuals of this vulnerable bird species.

Among mammals, the most significant species are *Mustella eversmanni* (steppe polecat) and the glacial relic *Sicista subtilis trizona* (southern birch mouse) (Kelemen 1997).

Related habitats

There is typical zoning in relation to related habitats. Loess or sand steppes are typical above the alkali zone; below the alkali zone marshes are typical.

*1340 Inland salt meadows. Non-coastal natural salt basins are made up of different habitat types, consisting of areas seeping saline water. As we described above, there are 3 main classes of halophytic vegetation, which in Hungary are classified under habitat *1530 Pannonian salt marshes. Saline grasslands of *Festuco-Puccinellietea* were classified under habitat *1340 Inland salt meadows in Bulgaria, Slovakia and the Czech Republic.

*6260 Pannonic sand steppes. Pannonic sand steppes are characterised by open sand grassland communities usually dominated by the tussock-forming, narrow leaved grasses *Festuca vaginata* and *Stipa borysthenica*. These communities usually occur in base-rich sands and are richer in species composition than those occurring on acidic sands. Sand steppes occur in mosaic with salt steppes in the Pannonian region.

6410 M*olinia* meadows on calcareous, peat or clay-silt soils (*Molinion caeruleae*) are located in inter-dune depressions influenced by underground water within salt marshes.

Phragmitetea australis R. Tx. & Preising 1942 (reed beds) and *Bolboschoenetalia maritimi* Hejny 1967 form a part of the alkali habitat system and occur in conjunction with them. Salt marshes occur on soils with a high concentration of salt, covered by saline water during most of the vegetation period. The vegetation is predominantly *Bolboschoenus maritimus, Phragmites australis, Scoenoplectus tabernaemontani, Eleocharis uniglumis and Scirpus litoralis.*

Ecological services and benefits of the habitat

Although alkaline grasslands can seem monotonous and relatively species-poor, locally they have substantial ecological diversity on a landscape scale. The mosaic-like structure of different habitats supports an exceptionally rich fauna and flora. Several endemic plant species, such as *Suaeda pannonica, Salicornia prostrate, Puccinellia peisonis, P. salinaria, Limonium gmelinii* ssp. *hungarica, Limonium bulgaricum, Plantago schwarzenbergiana*, occur in these habitats. The insect fauna includes endemic species specialized for salt habitats: e.g. *Saragossa porosa kenderiensis*, *Catopta thrips* (Habitats Directive, Annex II species), *Calosoma auropunctatum, Dorcadion cervae, Poecilus kekesiensis, Coleophora species* and *Stenodes coenosana*. A special highlight of tall herb salt meadows is *Gortyna borelii lunata* (fisher's estuarine moth), a species strongly tied to the plant species *Peucedanum officinale* and listed in Annex II of the Habitats Directive (Boros 2003).

The great flocks of migrating birds in spring and autumn (cranes, wild geese, grebes, shorebirds, etc.) are an unforgettable sight.

The Hungarian Puszta with its millennia-old alkaline landscape is an outstanding example of a cultural landscape shaped by a pastoral human society. The Hungarian Puszta, the distant relative of the prairies, pampa and steppes, is one of the most popular tourist destinations in Europe and a must-see in any tour of the country.

Hortobágy is the largest coherent occurrence of an alkali habitat type in Europe. The Puszta in Hortobágy is of important natural and historical-cultural value, which has been recognised as a UNESCO World Heritage site since 1999. In 1973 it was declared the first national park in Hungary. With its white alkaline Puszta extending to the horizon, its richness of species, its flora and fauna, its special composition, the pastoral traditions, and ancient Hungarian domestic animals, most visitors to Hungary want to visit the park (Bodnár 2004). Visitors are permitted to enter most parts of the park other than strictly protected conservation areas.

The region between the rivers Danube and Tisza is one of the most characteristic geographical regions in Hungary. The Kiskunság National Park was established in 1975, protecting the second largest alkaline puszta in Hungary and offering similar tourist attractions to Hortobágy.

Lake Fertő-Neusiedler See is a true steppe lake and represents the westernmost steppe lake in Eurasia, shared by Hungary and Austria. Marshes, a vast reed belt and saline grasslands surround this shallow, alkaline lake. On the deposital cone of the ancient Danube, there are still approximately 80 shallow saline ponds, mostly in Austria, but this geo-morphological unit also continues into Hungary at Fertőújlak. The whole area has been a nature and landscape protection area since 1965, and the protection area has been classified as a reserve under the Ramsar Convention since 1983. The Fertő-Neusiedler Lake is a MAB Biosphere Reserve. In Austria, the Neusiedler See-Seewinkel National Park (1993) is within the Ramsar area. The southern (Hungarian) end of the proposed site has been a landscape protection area since 1977 and part of the Fertő-Hanság National Park since 1992.

Trends

Alkaline habitats have been present in the Carpathian Basin since the last Ice Age. Primary alkaline steppes have not formed in deforested land. This habitat type has been grazed since the Pleistocene, endemic animal breeds only being replaced by domestic animals over the past few thousand years (Sümegi *et al.* 1998). Up to the mid-19th century, nomadic lifestyles and extensive animal farming were the main form of human impact on the steppes. The river inundated the steppes of the Tisza River valley, and the marshes had plenty of water. Extensive alkaline habitats were also present in the Danube River valley. Grasslands and marshes were grazed according to century-old traditions. 150,000 ha of semi-natural alkali habitat exist in Hungary. Nevertheless, alkaline grasslands were damaged or destroyed over the past 150 years by ploughing, land improvement or drainage (Molnár & Borhidi 2003).

The habitat also occurred in large parts of Slovakia, especially the lowland areas of southern Slovakia. About 8,300 ha of saline biotopes existed in south-western Slovakia up to the middle of the 20th, but after reclamation and land use changes the total area has been reduced to around 500 ha in 20 locations (Sádovský *et al.* 2004). The largest area of saline soils is in the Danube lowlands between the towns of Komárno and Štúrovo on one side and the town of Nitra on the other. The second area of saline soils is in the East Slovakian lowlands, neighbouring the villages of Malčice, Zemplínske Kopčany, Malé Raškovce and Veľké Raškovce (Eliáš jun. *et al.* 2008). A recent study of halophytic habitats suggests that the reclamation of the land (e.g. by ploughing, drying of wet saline soils, planting of *Populus* forests) has caused a strong reduction of pioneer halophytic vegetation (*Camphorosmetum annuae*) in Slovakia. These activities (and especially drainage) have decreased soil salinity, which has resulted in the near-extinction of saline vegetation such as *Camphorosma annua*. The destruction of existing habitats seems to be irreversible and rapid under present conditions. Continuous land reclamation and weak or absent management of protected areas has affected the occurrence of halophytic vegetation (Dítě *et al.* 2008).

Salt steppes in Austria are limited to northern Burgenland (in the area of Neusiedler See – Seewinkel) and to the east of Lower Austria (Zwingendorf and Baumgarten/March). The rapid decrease of these habitats is due to land improvement during the 19th and 20th centuries. More than 80% of the salt locations in Burgenland and in Lower Austria were destroyed or seriously damaged. With the drop in the numbers of open land locations and the changes in habitat make-up, many characteristic animal and plant species belonging to the Pannonian salt steppes region have become rare, and thus the number of endangered species found here has risen dramatically (Wiesbauer 2007).

Salt steppes are especially widespread in Northern Bulgaria - mostly in the Danube Lowlands and the Studena River valley. The most representative are the salt terrains of South-Eastern Bulgaria – the Burgas, Sliven, Stara Zagora, and Iambol districts (the villages of Bikovo, Atolovo, Trapoklovo, Blatec, Dragodanovo, Zhelyu voivoda etc. and the towns of Nova Zagora and Radnevo). In Bulgaria, a lot of attention is paid to the study of the distribution, vegetation and ecology of those habitats. A GIS model of the distribution of the habitat in Bulgaria has been produced, and some occurrences have been checked in the field (Tzonev, pers. comm.).

Romania has proposed 21 sites of Community Interest with a total area 525 ha for preliminary protection of Pannonic salt steppes (Barbos, pers. comm.), mostly located in the Pannonian (western) and Western Pontic (north eastern) areas of the country.

Threats

Many Pannonic salt steppes and salt marshes were totally destroyed for agricultural purposes. Ploughing for agriculture is still a major threat. Surviving areas are also threatened by other effects of agriculture – the impact of eutrophication and a lack of management, the lowering of the water table connected with river regulation and the construction of canals all have a very negative impact on those ecosystems. Due to their limited geographical distribution, they are thus some of the most threatened European communities.

Drainage and lowering of the groundwater level

A major threat is drainage, which lowers the groundwater level, combined with over-fertilisation in order to increase agricultural productivity. This process began with large-scale river regulation during the 19th century and continued with drainage projects during the 20th century. Now, the majority of lowland wetlands, including a large number of alkaline lakes, salt marshes and temporary wetlands, have been irretrievably destroyed.

However, as a consequence of the relatively recent regulation of the waterways and the resultant lack of regular floods, secondary alkaline grasslands have extended. A great proportion of the plant and bird communities of the saline puszta require large tracts of shallow periodic waters, most of which were drained by the channel system. The groundwater level has thus been lowered by river regulation as well as by direct drainage works. The lowering of the water table leads to a gradual loss of salinity as the salts are slowly washed back into the soil, leading to the disappearance of salt-tolerant plant communities. The process has a noxious effect on both insects and birds living in the area (Ecsedi *et al.* 2006).

One of the consequences of salt leaching from the soil is that *Artemisia* steppes turn into characterless *Achillea* steppes, and *Camphorosma* patches into *Artemisia* steppes (Molnár Zs., pers. comm.).

In some cases, where soil salinity was low, the transition of pioneer halophytic communities into communities of *Isoëto-Nanojuncetea* has been observed in Slovakia (e.g. on the dry bed of a small lake at Ďulov dvor near Komárno). This change is probably irreversible and results in the community's full extinction (Eliáš jun. *et al.* 2008). The same pattern has been recorded in degraded saline lakes in Southern Moravia (Chytrý 2007).

Eutrophication and ruderalization

Arable fields and other agricultural areas often surround wetlands. The main source of pollution tends to be fertilizers and herbicides from farms, which cause the eutrophication of alkaline waters and a change in the plant communities.

After heavy disturbance (ploughing, fertilization), the species composition and the vegetation and geomorphological mosaic become more homogenous, nutrient levels remain high and as a result weedy patches often persist for a long time (Demeter & Veen 2001).

Direct contact with intensely managed fields and lower soil salinity (caused by drainage) encourages the presence of weedy plant species such as *Amaranthus retroflexus*, *Atriplex sagittata, A. tatarica*, *Echinochloa crus-galli, Lepidium ruderale, Polygonum rurivagum* (Eliáš jun. *et al.* 2008) and supports the colonization of the soil by *Phragmites australis*, *Bolboschoenus maritimus* and *Typha* spp., which are able to create vegetation cover within a few months (Chytrý 2007). Weedy halophytic vegetation can also be found on secondary habitats, which were created on former salt marshes that have been ploughed, but are still wet and slightly saline.

Abandonment of traditional management

Traditional forms of land use, such as grazing by domestic livestock, have been practiced in this region for more than two millennia. The traditional management system practised on the puszta was based on calving/lambing in late winter/early spring. The sheep were let out to pasture in early April, and the cattle in mid-late April. The animals were tended by herders, who lived on the puszta throughout the grazing period. The bulls were out with the cows until early September. During this period each herder tended a herd of 50 cows plus calves. After the bulls were removed, the herds were joined together, and 4 herders would tend 1,000 cows. The cattle would normally graze the same area for 2 days, before being moved to a different location. In some areas, sheep would follow the cattle, cleaning up the more heterogeneous pasture left by cattle (HNPD 1997).

In the last few decades, this traditional indigenous grazing system has been damaged, especially by the increased presence of species of agricultural value. In some regions, the domestic goose, often kept in flocks of 5-10 thousand, has further advanced the destructive process. With their grazing and droppings, they have destroyed the indigenous salt vegetation (LIFE02NAT/HU/8638)

The number of grazing animals on the puszta has decreased dramatically and the distribution between grazing species has changed as well, partly as a result of political changes in 1990, and partly to changing market demands. The management systems have changed as well – since the late 1970s, the vast majority of sheep have been farmed intensively for the production of young lambs, and the majority of cows have been kept in the vicinity of villages to allow milking twice a day. The overall result is that the number of livestock grazing the central parts of the puszta has been greatly reduced (HNPD 1997).

Traditional management of saline grasslands in Slovakia involved summer mowing followed by autumn grazing. Lack of management, which is the case for almost all protected sites, is causing an accumulation of biomass and has had a negative impact on some very rare species, which are here at the northern limit of their distribution, for example *Limonium gmelinii* ssp. *hungarica.*

Overgrazing

High stocking rates during dry summers usually result in overgrazing. Alkaline habitats are not as sensitive to overgrazing as non-alkaline grasslands, since specialist species tolerate overgrazing well (Molnár & Borhidi 2003). Overgrazing brings with it other threats related to the transporting of livestock, the proliferation of weeds, dung heaps, rubbish deposits, trampling and a threat to ground nesting birds (Kelemen & Warner 1996).

When a short grass steppe is overgrazed, mosses, lichens, annual species and thistles become dominant, but natural dominants can also often tolerate heavy grazing (Demeter & Veen 2001). Degradation of *Artemisia* salt steppes is mainly caused by excessive grazing. In such cases, the following species start to spread: *Bromus mollis, Hordeum hystrix, Poa bulbosa, Erophila verna*, and various mosses and lichens such as *Ceratodon purpureus, Tortula ruralis, Cladonia magyarica, Cl. convoluta,* and *Cl. furcata* (Fekete *et al.* 1997).

In Bulgaria, overgrazing represents the main threat alongside changes in the water regime and new construction. The main effects of overgrazing include negative changes in the species composition of communities, a decreased vegetation cover, and an increase of nitrophilous and ruderal plant species (Tzonev, pers. comm.).

Undergrazing

There is less agreement on the impact of undergrazing. According to Molnár & Borhidi (2003), it may result in the accumulation of some species, while the vegetation structure remains more or less constant. Kelemen & Warner (1996) found that undergrazing might cause substantial changes to pastures, since many important communities and species need short grasslands.

These days, the number of grazing animals has decreased to such an extent, that a major part of the Hungarian Great Plain is not grazed at all. Mowing has become necessary in some areas to hinder leaf litter accumulation and for the sake of nesting bird species (Molnár & Borhidi 2003).

Invasions

There are only a few invasive species present in alkaline landscapes - *Phragmites australis*, *Elaeagnus angustifolia, Hordeum jubatum and Amorpha fruticosa*.

Phragmites australis is an invasive species in several alkaline locations. A good example is Fertő-Neusiedler See. Historical and experimental evidence suggests that regardless of the invasion pattern, establishment is much more likely at sites where rhizomes are buried in well-drained, low salinity marsh areas. Any human activity that buries large rhizomes, increases drainage, or lowers salinity increases the chances of establishing invasive clones (Bart *et al*. 2006).

Elaeagnus angustifolia is commonly found growing along floodplains, riverbanks, stream courses, marshes and irrigation ditches. Its establishment and reproduction is primarily by seed, although some vegetative propagation also occurs. At three years of age, plants begin to flower and bear fruit. Seeds ingested by birds and small mammals are dispersed through their droppings. *E. angustifolia* is tolerant to considerable salinity and alkalinity. However, it prefers sites with low to moderate concentrations (100-3,500 ppm) of soluble salts (Global Invasive Species Database, 2005), and occurs mainly on loess grasslands (with deeper saline soil layers) embedded in alkaline steppes (Molnár Zs., pers. comm.).

Hordeum jubatum has recently started invading the saline habitats of Eastern Hungary (Simon 1992). The species is able to spread quickly on salt marshes, salt steppes and salt meadows. It tends to become a co-dominant or subordinate species in these communities.

Amorpha fruticosa has a limited ability to spread in less saline meadows, dry grasslands and marshes, and especially in the silt dredged from canals, typically following temporary watercourses and the renewal of soil surfaces (Szigetvári & Tóth 2004).

Mowing

Threats linked to mowing can include: unsuitable timing (usually too early), changing the soil structure, and a lack of mowing. Mowing carried out at the agronomically optimal time is not appropriate for of the protection of ground nesting birds. As these are usually particularly threatened species, the timing of mowing needs to be adapted accordingly (for further information see section on special requirements determined by species below).

Changes in the soil structure are usually caused by heavy mowing machinery used on grassland that is not completely dry. This compresses the soil in parallel stripes and creates a bumpy surface.

When mowing is neglected for several years, most meadow types experience an accumulation of dead biomass. An interesting fact is that the proliferation of weeds is on the contrary not so drastic and the process starts slowly. On most meadow types even a 5-10 year omission of mowing does not cause significant problems (Kelemen 1997). On the other hand, there are sites where there has been an absence of management for more than 20 years, and are very degraded as a result of the accumulation of biomass (Molnár A., pers. comm.).

Hunting

The use of vehicles on wet surfaces, which occurs during wild boar hunts, causes compression and disturbance of the soil surface. This can be irreversible. Using bait to attract game to certain places usually causes the proliferation of weed species on such sites.

The feeding and release of game may create problems on botanically important sites. This is especially noticeable on forest steppe clearings, where large numbers of pheasants are released with large volumes of grain. These can also lead to the proliferation of weeds and damage to sensitive plant communities (Kelemen 1997).

Climate change effects

Climate change has serious effects on the water level in salt marshes and steppes. Climatic changes can be a primary reason behind invasions of alien and native species (EC 2000).

2. Conservation management

General recommendations

Based on paleoecological data (Sümegi *et al.* 1998), most alkaline habitats have been stable since the late Pleistocene era, or at least landscapes currently containing alkaline vegetation have had alkaline habitats since then. It is believed that primary alkaline steppes do not need any active management, which has been evidenced from some untouched pastures and unmanaged military areas (Kelemen & Warner 1996). Deeper salt marshes and soda lakes are practically infertile and unused (Molnár A., pers. comm.).

Most of the grasslands in the region represent semi-natural habitats where biological diversity is maintained in conjunction with human activity. Their existence depends on specific types of management. Grasslands in salty areas are relatively fragile and cannot stand intensive grazing (Liamine eds. 2007).

Indigenous animal species play an important ecological role in the conservation of salt steppe and salt marsh habitats. Grazing on appropriate habitat types constitutes optimal maintenance of the vegetation, and thus contributes to the recovery of habitats: Marshland - water buffalo; marshy meadows - Mangalica pig; salty meadows - Hungarian grey cattle (a variety of *Bos taurus primigenius*); alkali puszta and bare *Artemisia* steppe - Racka sheep (*Ovis strepsiceros hortobágyensis*); scrub - goat (LIFE02NAT/HU/8638). In the Hortobágy and Kiskunság National Parks, special care is devoted to the original breeds of domestic animals in order to maintain national gene reserves.

Salt steppes and salt marshes are usually used for grazing – mostly with sheep and less frequently with cattle. Horse-grazing has been reduced to a fraction of its former level, and traditional pig breeding has almost disappeared (Kelemen & Warner 1996). .

Salt grassland communities are less susceptible to disturbance and they regenerate easier than other types because of the high competitive capacity of the natural vegetation in saline soil conditions (Kelemen & Warner 1996, Demeter & Veen eds. 2001).

Active management

Grazing

Traditionally, puszta has been grazed with indigenous Hungarian breeds of cattle, horses and sheep. These traditional landraces play an important ecological role in the conservation of the salt steppe and salt marsh habitats. When grazing on appropriate habitat types, they provide optimal maintenance of the vegetation and provide good conditions for associated species.

Herd animals are usually used for grazing pastures on Hungarian alkaline grasslands, mostly sheep, less so cattle, though that differs from place to place. For example, on the salt steppe of northern Kiskunság the number of cattle is much higher than sheep. The choice of grazing animal partly depends on the owner of the land, and partly on the agricultural subsidy system (Vajda, pers. comm.).

The number of livestock is greatly influenced by the precipitation in the previous and current year; the timing of grazing and the number of grazing animals has to be carefully evaluated each year. In drier years there is practically no vegetation available for grazing after the end of June, and when there is an early spring, grazing may commence weeks before the usual time (the beginning of April). The maximum livestock level on solonetz soils is 1 cattle beast (or horse or water buffalo) or 5-6 sheep per ha. On solonchak soils usually half this number is chosen (Kelemen & Warner 1996).

The number of grazing animals is highly dependent on the management objectives. If the goal is to create an overgrazed area, for *Glareola prationcola* or *Charadrius alexandrinus*, the number can be higher. It can also be higher on wet meadows dominated by *Puccinellia* or *Agrostis* (Vajda, pers. comm.). In the Kiskunság National Park, the grazing period usually starts on April the 1st and lasts until the end of

November. Here, grazing historically continued throughout the entire year. Nowadays, winter grazing is not prohibited, but neither is it encouraged.

There seems to be a variety of opinions regarding the grazing capacity of the puszta. However, there is no doubt that any grazing system should be introduced with a very flexible approach to stocking rates. Meteorological data indicates that large annual variations in grass production will continue, and the availability of extra areas that can be grazed in dry years and mown in normal wet years, will be an important factor in ensuring the success of any grazing system aimed at medium to high livestock rates (HNPD 1997).

Geese grazing in a small flocks (up to 300) can be tolerated in areas that were traditionally grazed, since a removal of the geese can lead to the rapid proliferation of weeds.

The grazing behaviour of cattle depends on the weather. On hot days with insect harassment, the cattle graze in a tight formation, whereas on cool days the cattle graze in a very loose formation, spread out over the puszta.

A part of the Hortobágy National Park (2,400 ha) is set aside for the grazing of 100 or more Przewalski horses. The introduction of these horses started in 1997 as part of a European Breeding Programme. The horses are bred in the area and they are to be reintroduced to Mongolia (HNPD 1997).

Traditional grazing systems are being restored to recreate salt steppe grasslands at the Fertő-Neusiedler See, using native Hungarian Grey Cattle, water buffalo, Racka sheep, Przewalski horses and Mangalica pigs. At the beginning of the 1980s the last remnants of abandoned salt grasslands were protected by targeted conservation grazing. In 1987 conservation grazing using cattle and later Przewalski horses, Hungarian Grey Cattle and white donkeys was started. In the first years after the reintroduction of grazing its impact on grasslands was not very obvious, but later the appearance of rare halophytic species such as *Cyperus pannonicus, Salicornia prostrata*, *Plantago tenuiflora* (threatened by extinction) and *Bupleurum tenuissimum* was observed. Distribution of seeds by grazing animals is beneficial to annual species (Zulka *et al.* 2006).

In the Baumgarten an der March region, alkaline salt steppes are a very rare occurrence alongside wet grasslands. The plant species *Aster canus, Peucedanum officinale, Artemisia santonicum* and *Bupleurum tenuissimum* are botanical rarities. In 1990 the area was in a bad condition – the surrounding area was used for intensive agriculture and the location was not managed and had become partly overgrown with shrubs. In the summer of 1996, grazing by Galloway cattle started. Galloways are very hardy animals and can remain outside for the whole year. They are not very heavy, which is very important on wet pastures, and do not require high quality fodder. Their impact on rare plants is not clear. Compared to the Neusiedler See project, this experiment was not scientifically monitored and controlled, and only had occasional visits. Grazing which is not regularly monitored and has no clear conservational goal may not have a positive impact on salt steppes. Here are some findings and recommendations:

1. Not all halophytic species benefit from grazing, eg. *Aster canus* and *Peucedanum officinale* should be protected from grazing by fencing.
2. Grazing is beneficial only when the number of animals is controlled.
3. Galloways do not graze on all available vegetation – some shrubs remained, which need to be removed as a separate operation.
4. Lack of management is a secondary problem on this particular site; the primary issue is a lack of groundwater due to abstraction (Zulka *et al.* 2006).

Mowing

Mowing has a restricted role on salt grasslands. Cutting by machine is widespread on larger meadows, although some small ones are still cut by hand. After haymaking the aftermath was traditionally grazed. Mowing is important not only for the harvesting of hay, but also for the elimination of weeds from the pastures.

The use of machinery should be restricted to completely dry soils. The cut vegetation is usually dried on the meadow, and it has to be transported as soon as possible. On the nesting grounds of important birds, mowing should not commence before the 20th of June, and on *Puccinelietum* communities before the 15th of July.

The cutting of hay has also been greatly reduced partly as a consequence of reduced stock numbers, and partly as a result of the increase in the cost of the operation. The limitations on haymaking introduced through grazing contracts with the Hortobágy National Park Directorate are strict. Neither artificial fertilisers nor manure are allowed, and in some areas the meadows cannot be cut until the 1st of July. This means that relatively small amounts of hay are produced per hectare. Due to the late cutting date, the hay has low digestibility and it is best used for maintenance feeding supplemented with concentrates to increase energy and protein intake. On rare occasions it is possible to harvest a second crop of hay in late summer (HNPD 1997).

Mowing can be carried out annually, except in very dry years, when it should be avoided. The vegetation should be cut a minimum of 10 cm above the soil surface to protect the tussock formation of the dominant grass species. A minimum of 15% of the area should be left unmown to provide places for overwintering insect fauna. The unmown area can be rotated around the site over a number of years.
The date chosen for mowing depends not only on the type of grassland, but also on the nesting of bird communities. For example, in the nesting area of the great bustard, the earliest time for moving is the 1st of July (Vajda, pers. comm.).

Hydrological rehabilitation

The restoration of the hydrological regime in a salt marsh is not an easy task and in many cases, especially when salt marshes are of a small scale, the damage done is irreversible.

In Hungary, dams and ditches on salt grasslands represent serious problems, since they change the natural hydrological regime. If they do not influence areas outside the grassland or important activities (like transport infrastructure), they should be rehabilitated (infilled or levelled). When this is not possible, sluices and earth-dams should be made at appropriate locations to retain the water (Kelemen & Warner 1996).

On the Hortobágy steppes, irrigation systems were constructed for high yielding grasslands and rice fields during the 1950-60s. A majority of them were never used, but the abandoned channels and ditches have fragmented the native grasslands and formed an obstacle to the natural flow path of surface waters. Those natural processes, which naturally maintained the ecological network of alkaline dry grasslands and marshes became blocked, and the natural hydrology of wetlands suffered a complete transformation, leading to the loss of biological diversity in the area. A LIFE project (LIFE04NAT/HU/8634) aimed to restore Pannonian salt steppes and marshes to a favourable conservational state and to ensure their long term survival in the Hortobágy - the largest coherent occurrence of this habitat type in Europe. The Hortobágy National Park covers 82,000 ha, of which 10,000 ha was directly affected by the project activities:

- removal of unused ditches and canals, through 500 km of canal filling and embankment levelling building of water management structures to retain precipitation in the marshes
- monitoring

As a result of the project, the fragmentation of grasslands was halted, and natural connections between dry grasslands and wetlands were re-established. Natural processes maintaining the habitat diversity of alkaline steppes were initiated, looking towards long term conservation. The natural pattern of surface water flow was re-established, and the natural hydrology of marshes restored (Gõri 2007). The LIFE project in Eastern Hortobágy, which was damaged by canalization, removed nearly 300 water control structures from the puszta, which were later recycled as road bases for local villages and towns. Over 100 kilometres of channels and banks were eliminated with heavy equipment, resulting in the rainwater forming shallow pools. The elimination of channels increased the extent of shallow-water habitats from 37 ha to 295 ha. Most of the damaged dried out habitats have transformed into valuable saline meadow and marshland vegetation. Rare aquatic (*Lemnetea*) and mudflat (*Nanocyperion*) plant communities appeared in the area, with one species endemic to the Carpathian Basin, namely the Hungarian Elatine (*Elatine hungarica*). Original vegetation almost totally re-colonized the backfilled channels by the following year, which was also due to the presence of native breeds of domestic animals grazing there (Ecsedi *et al*. 2006).

Suppression of expansive species

Phragmites australis may be expansive on salt communities. This can be repressed by cutting (between beginning of July and mid-October) or by grazing, for example, by Racka sheep, grey cattle or water buffalo (Kelemen & Warner 1996). It is also important to note that invasion-facilitating activities do not have to occur over large spatial or temporal scales. Human activities can be one off events, and be highly localized. Thus, the importance of small-scale events cannot be underestimated nor discounted from attempts at predicting whether human activities will facilitate the invasion. Finally, early intervention is crucial to prevent large-scale invasion by *Phragmites*, because to the best of our knowledge, it is early establishment that relies heaviest on human alterations (Bart *et al.* 2006).

The alien tree species *Eleagnus angustifolia* can be suppressed by the same methods as common reed while it is young, but later, cutting and even the application of chemical treatments (i.e. Garlon F4 is necessary (Kelemen & Warner 1996). Old *Eleagnus* trees can be uprooted with special machinery. This method is acceptable in protected areas, because the root system of the trees is very small. Once the trees have been removed, and the soil has been levelled, the area can be mowed or grazed (Vajda, pers. com).

Regular grazing, mowing or stalk cutting can suppress the alien shrub *Amorpha fruticosa*. Older habitats or individuals should be cut, followed by the grazing or mowing of the re-sprouting stems. Application of chemicals can also be effective. Garlon 4E proved to be the most effective in field experiments (Szigetvári & Tóth 2004).

Burning

The effect of burning is not yet fully understood. It is possible that it may be used in the future as a management method, as it is believed that fire had a role in the past in maintaining salt grasslands. In the Hortobágy National Park, accidental burning of puszta areas has occurred from time to time. The subsequent development of the vegetation was monitored and it was noted that over a period of 3-5 years, the vegetation largely re-establishes itself to what it was before, so it is not considered to be a feasible management tool (HNPD 1997).

Recovery management

Creation of new habitat

On degraded grasslands, the creation of wetlands is recommended, as these are usually found in a mosaic with the salt grasslands. So-called “pasture ponds” can be established through grazing, for example, by Grey cattle or buffalo, on areas where common reed or *Bolboschoenus maritimus* has encroached. Creation of natron lakes is possible in small depressions where the bed of the lake can be deepened to be close to the impermeable clay strata and where water is able to collect. Shallow wetlands can be developed where water can be retained – although they need to be mown regularly (Kelemen & Warner 1996).

Local disturbances

Local disturbance of the topsoil layer is needed for the protection of halophytic species, which are weak competitors. This includes *Spergularia marina, Heleochloa schoenoides, Crypsis aculeata* etc. It can be done manually with hand tools or with light agricultural machinery. Trampling by cattle is also useful.

Rehabilitation of salt grasslands

Sowing a seed mixture of lucerne and native grasses can rehabilitate ploughed areas. After 2–3 years of moving, a change to grazing is needed (Kelemen & Warner 1996). In the LIFE project 'Restoration of Pannonian steppes and marshes in the Hortobágy National park', *Festuca pseudovina,* the main native grass, was sown to start natural re-colonisation processes (Gõri 2007). Another LIFE project, 'Grassland restoration and marsh protection in Egyek-Pusztakócs', supports the creation of *Festuca pseudovina* (alkaline), and *Festuca rupicola* (loess) grasslands.

Other relevant measures

Monitoring

In order to evaluate the results of management initiatives carried out, a monitoring programme should be established. Generally, the monitoring system and the parameters to be monitored should be simple. The following focus areas are recommended:

- Target bird species – rangers should carry out annual censuses, using a standardised approach.
- Monitoring grazing animals – herd size and number of days grazing different parts of the puszta should be recorded in order to get an indication of the puszta's actual capacity.
- Monitoring of vegetation and flora – to see the impact of a grazing regime and/or different management techniques.

Special requirements driven by relevant species

Mowing of salt meadows at the agronomically-opitmum time can destroy most ground nesting bird nests. Thus in the Kiskunság National Park mowing starts on July the 1st or even July the 15th in the nesting areas of *Otis tarda* (great bustard). Other threatened species include *Circus pygargus* (Montagu's harrier), *Crex crex* (corncrake), *Asio flammeus* (short-eared owl) and *Acrocephalus paludicola* (aquatic warbler). Perhaps less threatened by mowing are *Porzana pusilla* (Baillon's crake) and *Chlidonias leucopterus* (white-winged black tern), as these prefer meadows flooded for a longer period of time, with deeper water. The mowing of *Puccinellia* swards and salt meadows surrounding salt lakes often disturbs rare nesting birds, such as *Recurvirostra avosetta* (avocet), *Charadrius alexandrinus* (kentish plover) and *Himantopus himantopus* (black-winged stilt) (Kelemen 1997).

Some grazing restrictions might be needed during the birds' breeding season. The most important roosting and breeding places should be excluded from grazing. It is important to identify such places at earliest time and at least on some of them to prevent any intervention, especially in the case of *Charadrius alexandrinus* (kentish plover), *Limosa limosa* (black-tailed godwit), *Burhinus oedicnemus* (stone-curlew), *Glareola pratincola* (collared pratincole), *Glareola nordmanni* (black-winged pratincole) and *Calandrella brachydactyla* (short-toed lark) (Kelemen 1997). With regard to *Otis tarda*, grazing usually starts after June the 15th (Vajda, pers. comm.).

Creating patches of overgrazed and trampled plots can be favourable for certain species. The crossing of wet soil by cattle and repeated overgrazing can create this. Such terrain attracts certain rare bird species, such as *Charadrius alexandrinus* or *Glareola pratincola*, for nesting, but it also represents a primary habitat for *Dociostaurus maroccanus* (Moroccan locust) (Kelemen 1997). The creation of large overgrazed areas should, however be avoided. For example, overgrazed areas in the Kiskunság National Park in Hungary represent 1% of the total grazed area (Vajda, pers. comm.).

Cost estimates and potential sources of EU financing

Restoration activities

In the Kiskunság National Park, the most important restoration activity is the creation of grasslands on arable land. The cost of machinery work is €160 /ha. The cost of seeds is €350 /ha for *Festuca pseudovina* and €580 /ha for *Agrostis alba* (Vajda, pers. comm.).

The LIFE project 'Habitat management of Hortobágy eco-region for bird protection' supported the removal of shrubs from 400-500 ha of degraded steppe in the National Park. For tree removal, one member of staff was employed for four years, working approximately half the normal work time. The cost was €48,000.

Establishing a farming system was considered essential for the long-term management of the project area. Plans included the purchase of traditional livestock breeds (such as Hungarian grey and flecked cattle, mangalica pigs, racka sheep and goats), and the erection of electric fences. Land was to be leased to cultivate winter fodder so that animals could be kept on site all year round to maintain a high grazing pressure (vital for obtaining the right vegetation structure for the avifauna). The cost of the electric fence was €64,000 and the price of 1,041 domestic animals was €416,000.

The cost of removing nearly 300 water control structures and of eliminating over 100 km of channels and banks using heavy equipment, resulting in the formation of rain-fed shallow pools on about 200 ha of the puszta was €680,000 (Ecsedi, pers. comm.).

The Hortobágy National Park administration has to pay the Tisza river water management authorities approximately €40,000 to irrigate some large alkaline marshes, with a maximum 10 million cubic meters of water. The pumping of water is done locally to a total cost of €10,000. During very dry years, the cost reaches €50,000 for an area of 50-70 square kilometres. During wet years, and after heavy snow, the water management authority puts the water into the Hortobágy marshes, to prevent villages and towns around the lower Hortobágy river from being flooded. The maximum water amount was 50 million cubic meters (Molnár A., pers. comm.).

Support of Natura 2000 Areas and the Agri-Environmental Support Schemes in Hungary

In Hungary (Hungarian Ministry of Agriculture and Rural Development, 2007), the agri-environmental support system is carried out through area-based schemes, but certain agri-environmental schemes can be received for the whole of the country, i.e. the payments are horizontal. Different area-based (zonal) schemes were worked out: schemes for nature conservation, soil and water protection.

The land use prescriptions for Natura 2000 grasslands and the grassland management scheme under the agri-environmental measure partly or fully overlap. The producer can therefore in theory be supported twice for fulfilling the same requirements. In order to avoid such overcompensation, where Natura 2000 support is received, the amount of agri-environment support payable for the same area is decreased by the relevant amount.

Agri-environmental support schemes in Hungary work very well, especially for great bustard grassland management. The main restrictions include (Vajda, pers. comm.):

- The use of herbicides is strictly forbidden
- There can be no drainage or irrigation
- Mechanical agricultural work cannot be carried out during breeding season (1st May-1st July)
- Harvesting and mowing have to proceed from the middle of the fields outwards
- When nests are found, immediate contact with nature conservation staff must be made
- The use of chains to alarm wild animals is compulsory during harvest

Table 1. The agri-environmental and natura support schemes in Hungary (Hungarian Ministry of Agriculture and Rural Development, 2007)

<table>
<tr><th rowspan="2">Schemes</th><th colspan="3">Agri-environmental payments €/ha</th><th rowspan="2">Natura payment €/ha</th><th rowspan="2">AE + Natura payment €/ha</th></tr>
<tr><th></th><th>Non Natura area</th><th>Natura area</th></tr>
<tr><td colspan="4">Horizontal Schemes</td><td rowspan="13">38</td><td></td></tr>
<tr><td rowspan="2">Extensive grassland management</td><td>Grazing</td><td>100</td><td>69</td><td>107</td></tr>
<tr><td>Mowing</td><td>56</td><td>25</td><td>63</td></tr>
<tr><td rowspan="2">Organic grassland management</td><td>Grazing</td><td>107</td><td>76</td><td>114</td></tr>
<tr><td>Mowing</td><td>63</td><td>32</td><td>70</td></tr>
<tr><td colspan="4">Zonal Schemes</td><td></td></tr>
<tr><td rowspan="2">Grassland management for Great Bustards habitat development</td><td>Grazing</td><td>114</td><td>76</td><td>114</td></tr>
<tr><td>Mowing</td><td>116</td><td>78</td><td>116</td></tr>
<tr><td rowspan="2">Grassland management for habitat development</td><td>Grazing</td><td>105</td><td>67</td><td>105</td></tr>
<tr><td>Mowing</td><td>121</td><td>83</td><td>121</td></tr>
<tr><td colspan="4">Conversion of arable land into grassland management schemes – 2nd year</td><td></td></tr>
<tr><td>Environmental land use change</td><td>Mixed</td><td>143</td><td>105</td><td>143</td></tr>
<tr><td>Nature conservation land use change scheme</td><td>Mixed</td><td>170/175</td><td>132/137</td><td>170/175</td></tr>
</table>

Potential sources of EU financing

Among the diverse sources for EU funding, the following funds might primarily be of interest for the management of Pannonic salt steppes:

- The European Fund for Rural Development (EARDF): This program has a potential to cover several management activities that might be relevant for this habitat, although the measures have to be covered in the National Strategy and related measures Rural Development plans (RDPs) in order to be eligible on a national basis. However, costs for garzing of the pannonic sat steppes are mostly eligible for agri-environmental subsidies within this program. To some extent, necessary infra-structure, such as fences and shelters may also be eligible under this program. – LEADER projects may be designed to include management of sites in the Natura 2000 network.

- The European Regional Development Fund (ERDF), The Cohesion Fund and Interreg: These funds might be relevant in single cases although activities related to Natura 2000 sites need to be integrated in a broader development context, and for ERDF also be related to productive investments (e.g. infrastructure). The Interreg approach is more flexible, but needs a European objective and partnership. Different geographical levels are defined and all of them have their specific rules, eligibility criteria and objectives.

- The Financial Instrument for the Environment (LIFE+): The 'Nature' component of LIFE+ supports best practice and demonstration projects contributing to the implementation of the Birds and Habitats Directives, but only exceptionally outside Natura 2000 sites. The 'Biodiversity' component is for demonstration and innovation projects, contributing to the objectives of the Commission Communication 'Halting the loss of biodiversity by 2010 – and beyond'. Both the 'Nature' and 'Biodiversity' components emphasise concrete non-recurring management actions (at least 25 % of the budget) and, when needed, compensation payments for restrictions in commercial land-use are eligible under 'Nature'. Recurring management is not eligible under LIFE+.

To identify to what extent management measures required for a specific site are eligible for financial support from various EU funds, further consultation of the "Financing Natura 2000 Guidance Handbook" (Torkler 2007) is recommended:
http://ec.europa.eu/environment/nature/natura2000/financing/index_en.htm

Furthermore an IT-tool is available on the EC web site:
(http://ec.europa.eu/environment/nature/natura2000/financing/index_en.htm

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