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MANAGEMENT of Natura 2000 habitats

* Pannonic sand steppes

6260

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Pannonic sand steppe in Kiskunság National Park, Hungary. Photo: Daniel Dítě

62 - Semi-natural dry grasslands and scrubland facies

EUNIS Classification:

E1.2E
Pannonic sand steppes

* Priority habitat

Summary

Pannonian sand steppes are characterised by open sand grassland communities usually dominated by tussock-forming, narrow leaved grass *Festuca vaginata* and *Stipa borysthenica*. Closed sand steppes are characteristic with vegetation cover higher than 50%. These habitats are typified by *Festuca wagneri* and *Festuca rupicola*. The habitat communities usually occur on base-rich sands and are richer in species than those occurring on acidic sands. Pannonic sand steppes are endemic habitats of Pannonic biogeographical region, with the centre of their distribution in Hungary, but being found also in Lower Austria, Slovakia, Romania, Bulgaria and Serbia.

Pannonic sand steppes could be maintained without management if the ecological conditions which allowed shifting dunes and their mosaic of open communities to exist in the first place, including uncontrolled wind erosion, were allowed to be present. Since most of the dune systems were stabilized during last centuries, management is needed to maintain sand steppes and their associated species richness. Grasslands on sandy soils are relatively fragile and can only stand extensive grazing, which is traditional use of the sand grasslands.

The major threats for Pannonic sand steppes are changes in traditional land use, especially the decrease in the number of grazing sheep and goats. The intensification of certain agricultural and forestry practices has also contributed to large-scale losses. In Hungary, 1 sheep per ha staying for 2 days in year is recommended for the maintenance of open and closed grasslands on sand.

On the areas where afforestation through succession is a problem, mixed sheep-goat herds can be used. Controlling the number of livestock used is very important, especially in dry years, to avoid overgrazing and trampling. Using of large and herded flocks can be dangerous. Where the maintenance or rehabilitation of shifting dunes is important, deliberate overgrazing, mostly by goats, should be used. On the sand plains, herded or rotational grazing of low number of cattle should be used. Small parts of the grassland should be left out on a rotational basis as refuges. In dry years, grazing should be discontinued.

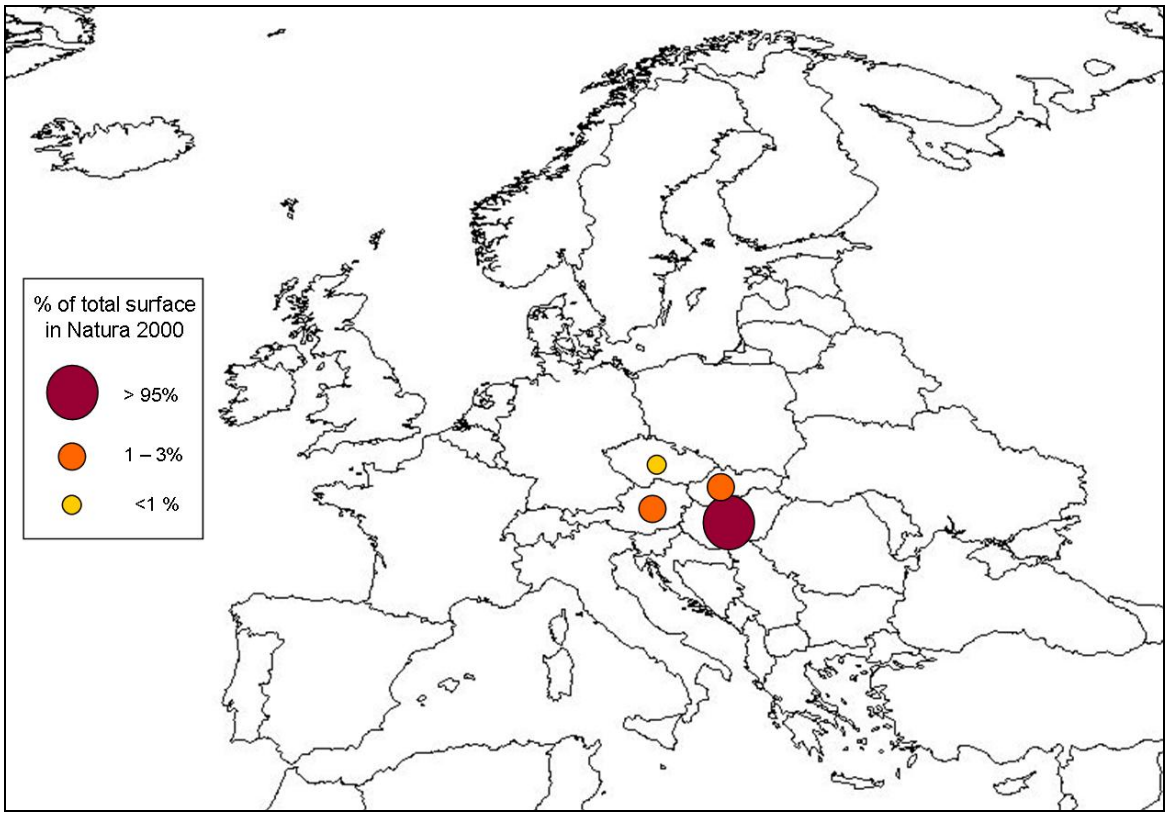
An extreme threat to the habitat is spreading of invasive plant species. The most serious threat to these grasslands after abandonment is the invasion of the allochthonous, strongly aggressive tree *Robinia pseudacacia* (black locust). Other invasive alien species are herb *Asclepias syriaca* (common milkweed), tree species *Ailanthus altissima* (tree of heaven) and shrub *Prunus serotina* (American cherry). Different methods and experiences for suppression of alien and expansive species are described in this document.

1. Description of habitat and related species

Pannonic sand steppes are characterised by open sand grassland communities usually dominated by tussock-forming, narrow leaved grasses *Festuca vaginata* and *Stipa borysthenica*. Closed sand steppes are typical, with a vegetation cover of over 50%. These habitats are typified by *Festuca wagneri* and *Festuca rupicola*. The habitat communities usually occur on base-rich sands and are richer in species than those occurring on acidic sands.

Distribution

Pannonic sand steppes are endemic habitats of the Pannonian biogeographical region, located in Hungary, but extending into Lower Austria, Slovakia, Romania and Bulgaria. In terms of non-EU countries, the habitat also extends into Serbia.



Percentage distribution of the total surface of Pannonic sand steppes in Natura 2000

Pannonic sand steppes 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	71	18,627	97.42
Continental	2	493	2.58
Countries	**Nº of sites**	**Estimated surface in Natura 2000 (ha)**	**% of total surface in Natura 2000**
Hungary	63	18,354	96.00
Slovakia	6	242	1.26
Austria	2	493	2.58
Czech Republic	2	31	0.16
TOTAL	**73**	**19,120**	**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

The vegetation of sand steppes is dominated by medium or tall perennial, tuft-forming grasses or suffrutescent plants that have a woody base and often have semi-woody stems with lacunar ground cover, together with their associated annual communities developed on mobile or fixed sands in the Pannonian basin. It includes similar communities in the West Pontic basin (EC 2007).

Pannonian open sand steppes typically have highly specialized animal and plant species, dominated by Pannonian and Continental steppe species, some of which are endemic. Grasslands occur in a mosaic with bare ground surfaces, and vegetation covers no more than 50-60% of the area, which dries out in mid or late summer. The seasons are marked: during spring and autumn, with better water supply, some annual plants appear (Fekete *et al.* 1997). Open sand grassland communities are dominated by tussock-forming, narrow leaved grasses *Festuca vaginata* and *Stipa borysthenica*.

Closed sand steppes are characterised by a vegetation cover of more than 50%. These habitats are typified by *Festuca wagneri* and *Festuca rupicola*, *Chrysopogon gryllus*, *Stipa capillata*, *Poa angustifolia*, *Bothriochloa ischaemum* (Bölöni *et al.* 2003). The number of endemic species is lower (Molnár Zs. pers. comm.). According to current knowledge, closed sand steppe grasslands are unlikely to develop from open sand steppes with *Festuca vaginata*, due to adverse water saturation and climatic conditions which prevent humus accumulation (and soil development) in open sand steppes. Closed sand steppes are considered to be grasslands of sandy forest clearings or the result of the drying out of certain moist meadow types (Kelemen 1997).

Main subtypes identified

Due to the characteristic geomorphology and different climatic and floristic effects, unique types of vegetation have developed in the Pannonian biogeographical region.

Festucetum vaginatae is endemic to the Carpathian basin, growing in semiarid climatic conditions on calcareous sand soil with a low humus content. *Festuca vaginata*, and *Stipa borysthenica* are dominant, with *Stipa capillata* found on slightly more humic and fixed soils. Open habitats between grass tussocks are sometimes occupied by lichens (*Cladonia convoluta*, *Cl. magyarica*, *Cl. furcata*, *Parmelia pokornyi*), and xerophytic mosses (such as *Tortula muralis*). A majority of the species present are specialists, found only in these habitats, which make the open sand steppe grasslands unmistakeably different from other grasslands. Other important species include *Fumana procumbens*, *Euphorbia segueriana*, *Dianthus serotinus*, *Alkanna tinctoria*, *Syrenia cana*, and *Gypsophila fastigiata*. In some locations, *Ephedra distachya* and *Colchicum arenarium* can also be found. *Koeleria glauca* occurs in larger patches. This species, with good germinability, produces many seeds and hence is used for the regeneration of grassland areas. More frequent annuals include *Polygonum arenarium*, *Kochia laniflora*, *Salsola kali*, *Plantago arenaria*, *Arenaria serpyllifolia*, *Erophila verna*. The number of species is, however, not high; rather it is the diversity of life forms that is significant. Apart from perennials and annuals, bulbous or tuberous, semi-brush plants are also present (Fekete *et al.* 1997).

It occurs mainly in Hungary, where it extends into the Alföld region and occupying huge areas in Kiskunság (Demeter & Veen 2001), but being present also in Lower Austria, western Romania, northern Serbia (Mucina *et al.* 1993) and in southern Slovakia (Stanová in Valachovič *et al.* 1995).

Festucetum wagneri. This community is found in several parts of the Danube–Tisza interfluve in Hungary. They are usually associated with *Festuca vaginata* grasslands but occur on slightly more fixed, better soils. They are slightly more closed-cover grasslands than the *Festucetum vaginatae* community and their species composition is closer to that of steppe meadows. Important species include: *Iris arenaria*, *Achillea ochroleuca*, *Peucedanum arenarium*, *Linaria genistifolia*, and *Phleum phleoides*, as well as many common species with *Festucetum vaginatae* and steppe meadows affiliates such as *Jurinea mollis*, *Pulsatilla pratensis*, and *Aster linosyris* (Fekete *et al.* 1997).

Diantho serotini-Festucetum vaginatae occurs at the north-western limits of the *Festucion vaginatae* alliance, and transforms towards *Corynephorion canescentis*. They occur on base-poor acidic sands. Its habitats are dominated by *Festuca vaginata* subsp. *dominii, Corynephorus canescens*, and in places by *Stipa borysthenica*. The occurrence of mosses – *Ceratodon purpureus,* and *Polytricum piliferum*, and lichens of the *Cladonia* genus, is common (Stanová in Valachovič *et al.* 1995). In the Czech Republic these communities are restricted to a few sites in southern Moravia (Chytrý 2007, Chytrý *et al.* 2001). In Slovakia, a community has developed on sands in the Borská lowland area, but this is classified under the 2340* Pannonic inland dunes habitat (Stanová & Valachovič 2002). In Austria, the community is restricted to the area along the river Morava.

Festuco-Corynephoretum is an open steppe grassland on acidic sands, present in Hungary in the Nyírség, Kisalföld, and Belső-Somogy regions, as well as along the northern part of Danube – Tisza interfluve. In Romania, the community belongs to the 2340* Pannonic inland dunes habitat (Gafta & Mountford 2008). The annual *Corynephorus canescens* as well as *Festuca vaginata* do not produce closed growth grasslands. Typical species include *Jasione montana*, *Hypochoeris radicata*, *Vulpia myuros*, *Dianthus arenarius* subsp. *borussicus*, *Galium parisiense*, *Filago vulgaris*, *F. minima*, as well as *Agrostis capillaris*, *Rumex acetosella*, *Poa bulbosa*, *Carex stenophylla*, and *Potentilla arenaria*. Acidophilous mosses and lichens can also be very frequent. Many varieties of the community are found in the Belső-Somogy region, which can occur either on more stabilised moist soils or can be a transition to meadows or forest habitats (Fekete *et al.* 1997).

Astragalo austriacae-Festucetum rupicolae are closed sand steppe grasslands. This rare plant community occurs in small patches on sand steppe forest clearings and forest edges. The soil's humus content is greater than in the case of open sand steppe grasslands (Kelemen 1997). Dominant species include *Festuca wagneri* (on soils with smaller humus content), *Festuca rupicola*, *Chrysopogon gryllus*, *Stipa capillata*, *Poa angustifolia*, and sometimes *Carex humilis*. In more open and dry growths *Stipa borysthenica*, *Koeleria cristata*, and *Festuca vaginata* are frequent. The presence of *Bothriochloa ischaemum*, *Calamagrostis epigeios*, and *Cynodon dactylon* indicates disturbance. More frequent flowering plants (dicotyledons) include *Veronica spicata* (*Pseudolysimachion spicatum*), *Potentilla arenaria*, *Dianthus pontederae* (*D. giganteiformis* subsp. *pontederae*), *Silene otites*, *Salvia pratensis*, *Filipendula vulgaris*, *Plantago media*, *Erysimum diffusum*, *Asperula cynanchica*, *Teucrium chamaedrys*, *Galium verum*, *Iris humilis*, *Achillea pannonica*. Other typical but rare species are: *Achillea ochroleuca*, *Trifolium montanum*, *Peucedanum arenarium*, *Colchicum arenarium*, *Iris variegata*, *Anthericum liliago*, *Astragalus dasyanthus*, *A. excapus*, *A. asper*, and *Adonis vernalis*. On calcium poor (acidic) sands in the Nyírség region of Hungary, an ecologically equivalent type of closed sand steppe grassland Pulsatillo hungaricae-Festucetum rupicolae, with a presence of *Pulsatilla pratensis* subsp. *hungarica*, *P. patens*, *Iris aphylla* subsp. *hungarica* can be found. *Veronica pallens* (a south Siberian element) is an important continental relic. Closed sand steppes on former oak forest sites are often species rich. In such places *Trifolium alpestre*, *Senecio integrifolius*, *Geranium sanguineum*, and *Anemone sylvestris* can be found (Bölöni *et al.* 2003).

Potentillo arenariae-Festucetum pseudovinae are sandy pastures that developed as the result of centuries of using sand steppes for grazing. The resulting closed sand steppe grassland is species rich, but also contains weeds and disturbance-tolerant species. The vegetation shows large spatial heterogeneity, and the level of degradation and species dominance varies between patches. The most important dominant species include *Festuca pseudovina*, *Cynodon dactylon*, *Achillea pannonica*, *Poa angustifolia*, *Galium verum*, *Carex liparicarpos*, and *Potentilla arenaria*. Other typical species include *Eryngium campestre*, *Ononis spinosa, Stipa capillata, Salsola kali.* Acid sands (e.g. in the Nyírség region of Hungary) often saw the development of sandy pastures, instead of *Molinia* meadows, or *Festuca pratensis* meadows. Typical

species include *Festuca pseudovina*, *Potentilla arenaria*, *Pulsatilla pratensis* ssp. *hungarica*, *Pulsatilla patens*, *Pulsatilla grandis*, and *Iris arenaria* (Kelemen 1997). These communities can also be found in western Romania (Gafta & Mountford 2008).

Cynodonti-Festucetum pseudovinae is a dry sandy pasture community, which develops on grazed pannonic sand steppes with more fixed soils. It is a short closed-growth grassland, with spaces between *Festuca pseudovina* tussocks occupied by *Cynodon dactylon*, hemicryptophytic dry grassland perennials, or psamophytic annuals. More vulnerable species have disappeared as a result of grazing, while prickly or poisonous species survive and are spreading. Except for the growth-forming species mentioned already, other frequent species include *Poa bulbosa*, *Koeleria cristata*, *Bromus mollis*, *Carex stenophylla* and *C. supina*, *Potentilla arenaria*, *Rumex acetosella*, *Kochia laniflora*, *Polycnemum arvense*, *Scleranthus annuus*, *Herniaria glabra*, *Minuartia viscosa*, and *Cerastium semidecandrum*. Noteworthy species include *Eryngium campestre*, *Euphorbia cyparissias*, and *Pulsatilla hungarica* (Borhidi & Sánta 1999).

Species that depend on the habitat

Dianthus diutinus is a plant species endemic to the Carpathian basin in Hungary, occurring on open sand grasslands (*Festucetum vaginatae*), forming mosaics with poplar-juniper habitats on the Danube-Tisza interfluve, and is considered to be extremely rare. As a result, it is a priority species of Community interest. Natural habitats in their original state are rare due to the effects of fragmentation and isolation resulting mainly from forestry activities. There are less than 10 known sites at present, and many of them can be characterised as having poor habitat quality for *Dianthus diutinus* (LIFE06 NAT/H/000104).

Pannonic sand steppes are characterised by specific insect fauna. Grasshoppers, crickets, and katydids (*Orthoptera*) are among the most significant. The subendemic pannonic species *Acrida hungarica* is probably the most typical, and occurs in original xerophytic vegetation, reaching the northern border of its geographical distribution in Slovakia. Other significant psammophilous species in these habitats include *Acrotylus insubricus*, *A. longipes*, *Myrmeleotettix antennatus*, *Calliptamus barbarus*, *Stenobothrus fisheri*, *Euchorthipus declivus*, etc. (Kalivodová *et al.* 2002). Further noteworthy insect groups include wasps (*Vespidae, Hymenoptera*) and beetles (*Coleoptera*). The latter group includes the native psammophilous subspecies *Cicindela hybrida magyarica* (Kelemen 1997) and the continental *Carabus hungaricus* (Molnár pers. comm.).

In terms of vertebrates, reptiles and specifically lizards are noteworthy. In Hungary, *Lacerta agilis* (sand lizard), *Lacerta viridis* (green lizard), and *Podarcis taurica* (Balkan wall lizard) reach especially high densities on sand grassland habitats in comparison with other European locations (Kelemen 1997).

In terms of birds, both *Burhinus oedicnemus* (stone curlew) and *Anthus campestris* (tawny pipit) nest on sand steppes. Many other bird species such as *Coracias garrulus* (European roller), *Upupa epops* (hoopoe), *Lanius minor* (lesser grey shrike), and *Lanius collurio* (red-backed shrike) feed on sand steppes (Kelemen 1997).

Pannonic sand steppes are also an important habitat for mammals. *Spermophilus citellus* (suslik) and *Spalax leucodon* (lesser mole rat) prefer grasslands with more stabilised soils. *Mustella eversmanni* (steppe polecat) is also fixed to sand and salt steppes (Kelemen 1997, Borhidi & Sánta 1999).

Related habitats

In dry sandy areas, open semi-desert habitats are mixed with steppe-like sand grasslands as well as with poplar-juniper woodlands. In the interdune depressions at the border between sand regions and floodplains, wetland communities such as *Molinia* grasslands, alder and ash fen woodlands, and alkaline fens are characteristic. Alkali vegetation found on higher floodplain areas, sometimes in the vicinity of sand dunes, is a very typical Pannonian vegetation formation (Kovács-Láng *et al.* 1999).

*2340 Pannonian inland dunes are open dune pioneer grasslands on siliceous substrates, dune lichen communities, and pioneer swards with many therophytes. These pioneer grasslands occur in mosaics with different sand habitats, as well as with Pannonian sand steppes which occur on siliceous substrate.

*6120 Xeric sand calcareous grasslands are pioneer communities on calcareous to neutral sands, dominated by annual species, which usually occur in mosaic with Pannonian sand steppes *6260.

*6250 Pannonian loess steppe grasslands are dry communities of *Festucion valesiacae,* typically dominated by fescue grasses, herbs, and annual species, which may occur in a patchwork with Pannonian sand steppes.

*91N0 Pannonian inland sand dune thicket (*Junipero-Populetum albae*) is a xerophilous mosaic of open scrub or open woodlands with *Juniperus communis* and *Populus* species, and open or closed sand steppe grasslands on sands in the Pannonian area. Both habitat types are endemic to the Pannonian region.

*1530 Salt steppes and salt marshes may occur in mosaic with sand dunes and are located below sand dunes, in depressions or flat areas.

*6410 *Molinia* meadows on calcareous, peaty or clayey-silt soils (*Molinion caeruleae*) are located in interdune depressions influenced by underground water. When there is a drastic drop in the groundwater table, the interdune depressions with the peat forming *Molinio-Salicetum rosmarinifoliae* communities gradually dry out and species of sand steppe grasslands occupy the space and homogenise the vegetation (Fekete *et al*. 1997).

Ecological services and benefits of the habitat

The conservation value of open sand steppe grasslands is linked to a number of unique endemic plant species such as *Dianthus diutinus, Pulsatilla hungarica, Linum hirsutum* subsp. *glabrescens, Tragopogon floccosus, Gypsophyla fastigata* subsp. *arenaria, Dianthus serotinus, Colchicum arenarium,* and *Iris arenaria*. Some endemic species are typical for Pannonian loess steppe grasslands, but may also occur on sand dune grasslands. Examples include *Pulsatilla zimmermannii, Minuartia glaucina, Onosma arenaria*, and *Onosma pseudoarenaria* subsp. *tuberculata*. Apart from these, the communities also contain significant numbers of nationally rare species in all the countries where this type of habitat occurs.

In Hungary, the Kiskunság National Park is the area with the best-preserved sand steppes on sand dunes. This is a region of outstanding natural beauty which, combined with old shepherd traditions and horse-drawn carriages and horse shows, makes the area very attractive for tourists.

Trends

Sand steppes and shifting sand areas are considered to be one of the most endangered habitats in Central Europe. While at the beginning of the 20th century, sands were still widespread, by now they have been reduced dramatically through stabilizing measures, intensive agricultural and forestry use, as well as by mass tourism.

According to new data from Hungary, 94% of 18th century open sand grasslands and about 99 % of closed sand grasslands have disappeared (Biró *et al.* 2008). The most prominent sand areas in the country are: the Duna-Tisza köze sand ridge, Nyírség, Kisalföld, Belső-Somogy, Tengelic, and Jászág (Molnár 2003). Although this vegetation type is still widespread in other sandy regions in Hungary, most habitats have become degraded, especially species-rich steppe grasslands (Margóczi 1993). It is estimated that the area of closed sand steppe grasslands in Hungary may temporarily have increased following deforestation over the last several centuries. However, following the spread of ploughing down to arable land, it has shrunk dramatically. Recently, their area has again been increasing due to the draining of fen meadows, however the newly developing types are significantly different (with respect to species composition and dominance) from the original closed sand steppes on sand dune, which these days survive only as fragments (Bölöni *et al.*2003).

Of the sand dunes, which formerly covered large areas of eastern Lower Austria, only small patches remain today. Sand dunes are some of the most valuable habitats in the cultural landscape, as this is where many highly specialized animal and plant species find their last refuge (Wiesbauer 2007). Pannonian sand steppes are located on the eastern Marchfeld and in the Neusiedler See area, with a total estimated area of about 100 ha (Wiesbauer 2003).

In Slovakia, Pannonian sand steppes on the Danubian plain and in the east Slovak lowlands are fragmented and very rare. On the Danubian plain, locations can be found near Čenkov, Hurbanovo (Abov), Imeľ, Nesvady, Chotín, Virt (the Mašan reserve), Marcelová, and the sand dunes in the vicinity of Galanta (Stanová in Valachovič *et al.* 1995, Eliáš jun. & Sádovský 2005).

In Bulgaria, sand steppes, located in the vicinity of the village of Archar in the Vidin district of north-western Bulgaria, are very rare (Tzonev, pers. comm.).

Species diversity is decreasing due to a lack of management. Habitats are being invaded by more competitive herbs, grasses, shrubs and trees. The degradation of grasslands has also resulted in a significant loss of biodiversity. In the past all sand grasslands used to be grazed. Today, most of the sand dunes have not been grazed for the past 40-50 years, while others are frequently overgrazed.

Threats

The main threats for Pannonian sand steppes are changes in traditional land use. This is especially visible in the decreasing number of grazing sheep and goats. The intensification of certain agricultural and forestry practices has also contributed to large-scale losses. An extreme threat to the habitat is the spread of invasive plant species.

Abandonment

Lack of grazing is causing grasslands to become more closed and moss cover to increase (Molnár 2003). The abandonment of sand dunes is causing increased biomass production, litter accumulation and the establishment of shrubs and trees, especially poplars. Increased litter production may affect the original species composition in this community, since it leads to humus accumulation, which stimulates the spread of generalists and may cause the local extinction of some open sand grassland species (Onodi *et al.* 2006).

Weedy abandoned fields are very common in situations that would otherwise be suitable for open sandy *Festucetum vaginatae* grasslands (Török *et al.* 2000).

Overgrazing

In the past, the diverse habitats in the Kiskunság National Park were maintained by grazing by domestic animals. There used to be small farms scattered over the area, each with 2 to 5 cattle and 10 to 40 sheep that grazed the area surrounding the farm. This resulted in a high, but even grazing pressure. Now, flocks contain 500-800 sheep under one shepherd and do more trampling than grazing. Large flocks do not necessarily have the most positive effects and can lead to the undesirable spread of aggressive or alien plant species and erosion on the dunes (Kelemen 2000).

In the case of dry sandy pastures of *Cynodonti-Festucetum pseudovinae*, overgrazing results in a decrease of perennial species in favour of annuals and increased nitrogen supply, while trampling disturbance supports invasion by weeds such as *Chenopodium* sp. and *Amaranthus* sp. or even aggressive non-native species (Borhidi & Sánta 1999).

Following abandonment of grazing, sandy pastures can develop into a certain type of open or closed sand steppe, but only when these communities are present nearby and can serve as a source of genes for re-colonisation (Kelemen 1997).

Afforestation

Plantations have fixed vast sandy areas in Hungary, thus relieving the impact of sand storms, which used to cause serious damage and hardship to the local population, and which used to be known as yellow rain. The containment of wind blown sand became a crucial question by the 19th century. Many tree and shrub species, both native and exotic, were tested and during the second half of the 19th century

afforestation successes were achieved by using black locust. Between 1950 and 1980, forestry companies afforested sandy areas, which were not suitable for agricultural production with *Pinus nigra* (Corsican pine) and *Pinus sylvestris* (Scots pine). However, sand afforestation continued even after this aim had been achieved, that is after the sand stopped shifting. Planting on sand hills causes serious damage from both the economic and nature conservation points of view (Molnár 2003). The same process also took place in Slovakia and Lower Austria.

Invasion of non-native species

Invasion by alien species is one of the greatest biological threats to biodiversity, second only to habitat destruction (Scalera & Zaghi 2004).

The most serious threat to these grasslands after abandonment is the invasion of the allochtonous, strongly aggressive tree *Robinia pseudacacia* (black locust). Intensive vegetative spread (and enhanced germination after fire) makes this species a superior competitor in secondary succession, compared to the native clonal species *Populus alba.* Nitrogen fixation and rapidly decomposing litter make *Robinia* habitats rich in nutrients where only a very limited number of species can survive (Matus *et al.* 2003). Other invasive alien species include the herb *Asclepias syriaca* (common milkweed), the tree species *Ailanthus altissima* (tree of heaven) and the shrub *Prunus serotina* (American cherry). Sand dunes in the Cenkov Nature Reserve in Slovakia face enormous problems due to the invasion of *Ailanthus altissima* and *Celtis occidentalis* (Ulrych pers. comm.) and there is no practical experience in reducing their spread. *Populus canadensis* is another expansive species found in the habitat. Foresters planted *Pinus sylvestris,* which is not native to the habitat and have had a very negative impact on basic sands because of acidification.

Ailanthus altissima is a very aggressive plant, a prolific seed producer (up to 350,000 seeds in a year) that grows rapidly, and can overwhelm native vegetation. It also produces toxins that prevent the establishment of other plant species. The root system is aggressive enough to cause damage to sewers and foundations (GISD 2008). While the spread of *Ailanthus altissima* is slower than that of *Robinia pseudoacacia*, the impact of both is similar. Almost no other species can survive beneath the canopy of this clonally spreading tree (Udvardy 2004).

Common milkweed, *Asclepias syriaca*, is the most aggressively invasive herb species found on sand steppes. By means of prolific seed production and intense vegetative spread, it quickly invades abandoned fields and disturbed grasslands on sand. Grazing of sand grasslands can also encourage invasion by *A. syriaca*. The species strongly hinders secondary succession and the regeneration of disturbed sand steppes (Bagi 2004).

Cenchrus incertus is a widespread invasive grass found on sand steppes in Hungary, but its nature conservation significance is low. The most characteristic feature of the species is the thorns around the inflorescence of the plant that can cause injuries to livestock and people. As an annual pioneer species it first invades open sand surfaces, and then disappears during the first few years of succession. Nevertheless, on heavily grazed open sand steppes repeated disturbance stabilizes its populations. The presence of *C. incertus* renders the utilisation of the landscape for typical sandy grassland purposes, grazing and animal husbandry more difficult. Another problem can be the proliferation of the species on paths and dirt tracks, causing an inconvenience to tourists and visitors (Szigetvári 2006). *Calamagrostis epigejos* is another invasive grass species, while invasive herbs include: *Ambrosia artemisifolia, Conzya canadensis, Oenothera spp., Tragus racemosus* and *Cannabis sativa*. In Slovakia *Solidago canadenis* and *Iva xantifolia* can also be found. In areas of Hungary seeing an invasion of alien species following disturbance by heavy machinery, *Ambrosia artemisifolia, Asclepias syriaca* and *Cenchrus incertus* can make a comeback fairly quickly.

Various illegal off-road activities represent another major contemporary threat. Every protected area has already been affected by different levels (1-5 %) surface disturbance.

Mining

Illegal quarrying by native Roma communities, who sell the sand in Sofia for use in construction, represents the main threat to sandy habitats in the Danube region of Bulgaria (Tzonev, pers. comm.).

Climate change effects

Most Pannonic sand steppe habitats in the Kiskunság region are strongly influenced by temporary climate variations, since this area belongs to an arid region of Europe. The year-by-year fluctuation of precipitation may influence the composition of vegetation by forcing or restricting the vegetative growth of certain species, but it rarely alters the vegetation types (Körmöczi 1989, 1991). Effects of longer climatic fluctuations, such as several years of serious precipitation deficit, however, could result in more dramatic changes in the vegetation structure, sometimes even causing the loss of well-defined vegetation types.

2. Conservation management

General recommendations

Pannonic sand steppes could be maintained without management if the ecological conditions which allowed shifting dunes, including uncontrolled wind erosion, were allowed to be present. Since most of the dune systems in the Pannonian area were stabilised over the previous centuries, management is needed to maintain sand steppes and their associated species variety. Sand dunes have been stabilised to such an extent that, without appropriate management, natural succession leads to the formation of scrub and woodland (in locations where the humus content of the soil is larger than in open sand steppe grasslands) or at least invasion by expansive grasses and alien species.

Grasslands in the region are semi-natural habitats where biological diversity is maintained alongside human activities. Grasslands on sandy soils are relatively fragile and can only be managed by extensive grazing. Light sandy soils place significant limitations on profitability and crop yields, as well as on machinery use.

Non-intervention can be applied in locations where the objective is to allow natural succession (eg. *Festucetum vaginatae* communities). Active management is required at least periodically (about every 5 years) to stop the spread of alien species and to prevent afforestation (Kelemen & Warner 1996). It is very difficult and costly to attempt the suppression of these species. The only meaningful solution is to re-establish the traditional use of the land. A significant proportion of sand grasslands are managed by conservation grazing, or less frequently, by mowing.

Regeneration of sand steppes largely depends on continuous positive management (on-going disturbance), and its mode and frequency, but also on the absence of non-native invasive species, and the presence (within a reasonable distance) of natural sand steppes, which serve as a source of seedlings for re-colonisation. Regeneration potential is usually high in former sand steppe areas when there is no intensive grazing and trampling, burning or close mowing (Bölöni *et al*. 2003).

Several LIFE projects in Hungary and Austria have focused on the protection of sand dunes and their mix of species. In Austria, many extensive maintenance measures were taken within the framework of a LIFE project. In order to contain the spread of forest into an area of ecologically valuable sand grassland, undesirable woody plants were removed. In addition, the topsoil was removed in small areas to enable the establishment of larger pioneer areas. Repeated maintenance measures such as small scale and differentiated grass cutting and extensive grazing thinned out the site and contributed to the optimal development of sand grassland (Wiesbauer 2007).

The Life Nature Project "Habitat Management of the Pannonian Grasslands in Hungary" is attempting to find a solution to the complex task of grassland management. Pannonian sand steppes are one of the habitat types being focused on.

Active management

Grazing

Grazing is a traditional use of sand grasslands. Onodi *et al*. 2006 found that moderate grazing is a management option for maintaining the vegetation structure and plant diversity of open sand grasslands.

The open steppe community *Festucetum vaginatae* does not need grazing. This is a novel idea in "best management". The reason is very simple. All alien species need some light disturbance to enable colonisation of "untouched" habitats. The other problem is that a grazed area is never uniform. It is always partly overgrazed near buildings (corral) and in places where the animals start their grazing. An area is

partly well managed (in the middle of the area) and partly under-grazed. The overgrazed areas are always the starting point for colonisation by alien species.

On closed dunes it is mostly sheep that are used, while on plains it is cattle. For the maintenance of open and closed grasslands on sand, 1 sheep per ha for 2 days a year is recommended (Kelemen & Warner 1996).

In areas where afforestation through succession is a problem, mixed sheep/goat herds can be used. Control over the number of livestock used is very important, especially in dry years, to avoid overgrazing and trampling. Using large herded flocks can be dangerous.

Where the maintenance or rehabilitation of shifting dunes is important, deliberate overgrazing, mostly by goats, should be used.

Herded or rotational grazing by smaller numbers of cattle should be used on sand plains. Small areas of the grassland should be excluded on a rotational basis as refuges. In dry years, grazing should be avoided (Kelemen & Warner 1996).

An experiment was undertaken in the Kiskunság National Park to test the best method for rehabilitating shifting dunes using small separate flocks of sheep and goats, and mixed animal flocks. The following results were reached (Kelemen 2000):

1. Biomass production in open sand grasslands is too low for Hungarian Grey Cattle.
2. Sheep tend to graze in depressions and mainly eat grass.
3. Goats tend to graze more on the slopes, and consume poplar suckers as well as juniper.
4. Mixed sheep/goat herds are better than pure sheep or goat herds. Sheep tend to move more slowly and graze more efficiently while goats cover larger areas and have a heavy impact on the vegetative growth of poplars.

Sand dune areas contain a large variety of plant communities. Therefore, it was necessary to develop a new method for grazing some areas, especially to re-establish mobile dunes. This method consists of small enclosures of 1 ha with easily removable electric fences placed around the affected area. The "working" animals are goats, 10/ha, and Racka sheep, 3/ha. High grazing pressure for a short period of time, repeated if necessary, eliminates not only young poplars but also grass species, and re-establishes mobile dunes. This method prevents encroachment by poplars, while at the same time preventing the grazing of more sensitive vegetation in the depressions. (Kelemen 2000).

Breed characteristics and economic aspects (Kelemen 2000)

Racka sheep are very tough. They can be kept in nomadic conditions and can survive on very low quality fodder. The breed is ideally suited for nature conservation management.

Tsigai (Cigaja) sheep originated in Southeast Europe, where they are raised for meat and milk. The sheep are very tough, and can be kept profitably. Lambs grow fast. A decrease in the quality of fodder leads to some loss of condition in the animals.

Goats are very resistant and can be kept in nomadic conditions. They survive well in unfavourable conditions, as they are an opportunistic feeder. Goats can be profitable, as there is a good market for organically-grown kids.

Mowing

Mowing is nearly impossible on open sand steppes; it is more typical for closed steppes. It is practised on small areas in depressions between dunes, or locally. Mechanised mowing is possible only in flat sandy areas where the vegetation is tall enough to cut (eg. communities of *Astragalo-Festucetum rupicolae* or *Potentillo arenariae-Festucetum pseudovinae*). Mowing should not commence before the 1st of July, in order to protect ground-nesting birds, and to allow the plants to produce seeds. Mowing can be carried

out once a year, except during very dry years, when it should be avoided. The machinery should cut the vegetation a minimum of 10 cm above the soil surface to protect tussock formation by dominant grass species. A minimum of 15 % of the area should be left uncut to provide winter cover for insect fauna. The unmown area can be rotated from year to year.

Nowadays, mechanised mowing on dunes is not feasible or economically viable. Steeper slopes and areas containing rare species should not be mowed with machinery, due to erosion problems. Mowing should not commence before the 1st of July. Mowing can be carried out once a year, except during very dry years, when it should be avoided (Kelemen & Warner 1996).

Mowing is important for the control of shrub invasion, and can lower the availability of nitrogen in the soil. However, it is not effective enough for the restoration of sand grasslands, because the transformation of the vegetation can be blocked by the initial dominance of clonal plant species (e.g. *Cynodon dactylon*). Frequent mowing can damage the target species. The timing of mowing should be changed from year to year according to the degree of weed reproduction, which raises difficulties with management planning (Török *et al* 2003).

In Austria, mowing is recommended after flowering of *Gypsophila paniculata*. It is recommended that only one third of the sand dune area is mown annually and that the unmown area be rotated about the site. More frequent mowing is recommended on areas where trees and shrubs were removed. Biomass should be removed after a few days, to enable the development of caterpillars (LIFE 98 NAT/A/5418).

Eradication and control of invasive species

Suppression of *Robinia pseudoacacia* plantations and rehabilitation of sand grasslands is necessary, at least within protected areas. Trees should be cut during late summer or early autumn (second half of August, beginning of September), so that the shoots freeze and die during winter. This method is more efficient when freshly cut stumps are coated with herbicide, for example a 50 % solution of Glyphosate. New shoots should be cut in July of the following year. The surviving shoots should be grazed or where this is not possible, treated with chemicals (Kelemen & Warner 1996). Seedling establishment in clear-cut *Robinia* stands can be difficult due to the presence of strong competitors such as *Conyza canadensis* or *Calamagrostis epigeios.* As the upper most soil layer contains the densest and most species-rich seed banks, top soil removal is not advisable. Burning should also be avoided as it intensifies the vegetative and generative spread of *Robinia* (Matus 2003).

Hungarian nature conservationists have developed a very simple and efficient method for eliminating *Robinia*. It involves drilling a 4-7 cm deep hole, with an 8 mm diameter, into the tree. The direction of the borehole has to point not to the centre of the tree but must run nearly parallel with the bark at a 10° angle to the xylem. The hole must be completely filled with herbicide (Glyphosat), and then has to be sealed with lime putty. The number of holes depends on the size of the tree. There has to be one hole for every 10 centimetres of the trunk's circumference. The best time for employing this method is the second half of August and September, when most of the liquids go down to the root system. This method kills not only the tree itself but completely stops the regeneration of the root system as well.

Sand dunes in Slovakia face enormous problems from the proliferation of *Robinia pseudoacacia*. Very small area was cleared in the Čenkov and Chotin area about 10 years ago, but at present there is significant regeneration. If there is no systematic approach to the eradication of invasive species, such ad hoc measures have no positive effect on the protection of the habitat.

Ring-barking is another successful method, which may also be used for the suppression of *Pinus sylvestris*. The best time for ring-barking is the growing period – in spring and at the beginning of summer. Important factors are the depth and width of the cut. When the tree is bigger and heavier, cuts have to be deeper and wider, and around the trunk's entire circumference, down to the xylem. The cut should be at a height of between 30 and 130 cm. When the tree is bigger, several rings can be cut. Combining ring-barking with the use of an herbicide is also recommended (Gojdičová pers. comm.). Suppression of pine species should be done by mechanical means. Where that is possible without causing erosion, the trees should be removed from the area.

Ring-barking is not appropriate for *Ailanthus altissima* and *Robinia pseudoacacia,* as it causes intensified vegetative regeneration.

Mechanical suppression of *Asclepias syriaca* and *Ailanthus altissima* is not satisfactory - the use of chemicals for several years is required. Mechanical defence does not lead to significant results against *Asclepias syriaca*. Since *A. syriaca* has very few natural enemies, and because it is poisonous, grazing animals will not eat it, and the only effective means of control is chemical. Since *Asclepias syriaca* possesses a strong, underground rhizome system, mechanical control is not effective.

Proliferation usually begins in degraded areas, and often results in 10 ha patches in abandoned arable fields, vineyards, young plantations, and even in slightly degraded semi-natural sand grasslands. Its eradication is theoretically possible by mowing three times a year, but it is very demanding work. Using mowing machinery is also harmful for the vegetation of the soft sandy habitat; cutting by hand combined with chemical treatment is the only acceptable method (LIFE06 NAT/H/000104).

When using chemicals, systemic products should be used in order to destroy not only the surface, but also the underground sections of the plant. The chemical should not be able to seep out of the root and rhizome system into the surrounding soil. Extraordinary care should be taken during the treatment of *Asclepias*, in order to avoid other plants from being affected by the chemical (when using it in semi-natural habitat), especially *Dianthus diutinus* (LIFE06 NAT/H/000104).

When using chemicals, each plant has to be coated by hand using brushes or a sponge. Glyphosate is a quite effective herbicide against *Asclepias*, but treatment has to be repeated a minimum of three times a year. If the coverage is over 50 %, careful use of a sprayer is also possible.

5 goats per ha for 4 weeks is optimal for the suppression of *Populus* shoots. Animals should be contained using mobile electric fencing (Kelemen 2000).

Sometimes, the removal of invasive species may be complicated by legal constraints. An Austrian LIFE Nature project "Pannonian Sand dunes" (LIFE98 NAT/A/5418) had as its objective the management of the last remaining dunes in Austria, which were "constrained" by pines planted by the forestry administration during various reforestation campaigns, as well as by alien plants, such as *Ailanthus altissima* (tree of heaven) and *Robinia pseudoacacia* (false acacia), which invaded the dunes. National forestry laws were the main constraints to the project, forbidding the removal of exotic trees, especially those planted during the twentieth century as part of reforestation programs (Scalera & Zaghi 2004). There is a similar situation in Hungary. The elimination of a forest (even alien tree plantation) requires the establishment of a new one of the same size in a different location, or requires the payment of large sums of money to the government, depending on the type of tree, even when the area is protected and state owned, and the eradication is a part of a LIFE project.

Sound feasibility studies should always be carried out before any eradication program. This approach avoids project failure due to the impossibility of removing certain species, both for ecological and financial reasons. Feasibility studies should take into account the efficiency of the interventions, the possible effects on native species and ecosystems, and the potential risk of re-invasion (Scalera & Zaghi 2004).

Rehabilitation of shifting dunes and creation open patches

The objective of shifting dune management is the maintenance of the mosaic of different successional stages and the maintenance of shifting dunes. Grazing by sheep and goats on an area fenced off using an easily removable electrical fence, similar to practices used in the Kiskunság National Park, should be undertaken. For the rehabilitation of shifting dunes the use of 10 goats and 5 Racka sheep per ha for 4 weeks per year is optimal, and should be carried out for several years. Sheep are not essential, and using 12-15 goats should suffice (Kelemen 2000).

In Slovakia, sand dunes used to be traditionally grazed by the Mangalica breed of hairy pig (Ulrych pers. comm.), which had a positive impact through the creation of open patches.

The experimental removal of soil to create open patches for the establishment of pioneer stages of sand dune communities has been tested in Austria (LIFE 98 NAT/A/5418).

In Slovakia, in the small protected area Líščie diery near Nesvady, the vegetation cover of sand dunes was disturbed by the use of quad bikes. Annual sand species, which until then had been rare in that area, such as *Syrenia cana*, started to occur in the first year following disturbance. While initially not present at the site, *Corispermum nitidum* could be observed following disturbance. On the other hand, the removal of vegetation cover of another reserve, Chotínske piesky, by bulldozer resulted in some rare psammophytic species, such as *Polygonum arenarium*, appearing, as well as annual weed species, such as *Stenactis annua, Ambrozia artemisifolia* and *Amaranthus retroflexus* etc. (Eliáš jun., pers. comm).

Festuca wagneri and other dominant closed sand steppe grasses usually tolerate grazing or mowing once a year quite well. Burning provides optimal disturbance only if it is applied over several years or decades. Opening of the grassland's vegetation cover can result in the proliferation of weeds on small patches, although it does not necessarily result in permanent damage. In cases of strong disturbance (such as frequent burning), the grassland is disrupted, the presence of characteristic species decreases, and disturbance-tolerant species start to spread. Permanent disturbance can result in species-poor types, and *Festuca* disappearing and being replaced by generalist grasses and weeds (Bölöni *et al.* 2003).

Other relevant measures

Secondary succession on fallow land in the sandy regions of Hungary

Under the right conditions, abandoned fields on sandy soils may spontaneously develop into a kind of "secondary sand steppe", if left without any intervention. In Hungary thousands of hectares of arable fields have been abandoned over the past two decades, and the trend could well continue. Some of these fields are no longer cultivated because they have been incorporated into protected areas, but many were abandoned for economic reasons. Sandy soils comprise of a large proportion of low productivity areas of Hungary, especially in the central region of the country. The potential vegetation on these soils is endemic *Festucetum vaginatae* community. Secondary successions on sandy soils in Hungary appear to be unique, because the specialist species of the open sand grassland could become quickly established within 10 years. There is no need for active restoration practices. Most of the weeds disappear within a decade (Csecserits & Rédei 2001).

Grasslands developing on old fields are sensitive to disturbance, and their regeneration relies more on seed dispersal than on the seed bank. The seed bank's potential for the restoration of sand grasslands on abandoned fields is low. The seed bank is important in that care must be taken to avoid soil disturbance that would arrest or reverse secondary succession by favouring the emergence of early succession species. Nevertheless, the surrounding vegetation is usually the best propagule source for restoration. Many grassland species are mobile and remnants of the open sand grassland community are present in the area. The species richness of these remnant patches and their proximity to abandoned land together determine the species richness of developing grasslands and hence, the importance of seeding or planting certain species in order to improve species richness of spontaneously developing grasslands (Halassy 2004).

Monitoring

Remote sensing was initially used primarily for resource mapping, but satellite images of the same area, taken several years apart but at the same point in the growing season, may indicate changes in the susceptibility of a sand steppe to changes. Some of the other indicators which can be determined through remote sensing techniques are:

- Livestock density: a larger number of cattle means intense grazing and indicates a cause of degradation
- Deforestation
- Livestock movement patterns
- Falling groundwater levels
- Shrub encroachment and species change

The monitoring methods used in the sand areas of the Danube-Tisza region have been developed by Mezösi & Szatmári (1998). The analysis was based on GIS and remote sensing methods. Taking Landsat and SPOT images, the soil wetness index (SWI) was calculated. The SWI relates to canopy and soil moisture. The driest areas (SWI <6%) are exposed to wind erosion to a greater extent. Overlapping physical parameter maps with SWI maps and land use maps found high correlations between land use and SWI indexes.

Ex-situ protection

Protection of psammophytic species ex-situ on artificial sand dunes is carried out by the Botanical gardens of the Commenius University in Bratislava, and the Agricultural University in Nitra, in Slovakia. In Nitra, the following species of Pannonian sand steppes are cultivated: *Dianthus serotinus, Corispermum nitidum, Tribulus terrestris, Alcana tinctoria, Festuca vaginata, Kochia laniflora, Minuartia glaucina, Syrenia cana, Fumana procumbens, Gypsophila paniculata* and *Ephedra distachya*. *Stipa borysthenica, Iris arenaria, Colchicum arenarium, Gypsophila arenaria* and *Alyssum tortuosum* will be collected and added to the collection in 2008 (Eliáš jun., pers. comm).

Special requirements driven by relevant species

The main objective of the LIFE Nature project "Conservation of the Pannonian species *Dianthus diutinus"*, which started in late 2006 and is managed by the Kiskunság National Park, is to stabilise 85% of the presently known habitats of species *Dianthus diutinus*. The project aims to create and establish a semi-natural habitat network with the help of the enlargement and unification of the present habitats at the three most important sites for the plant species (Bodoglár, Bócsa and Csévharaszt). These sites will remain free from, or be only minimally affected by, forestry activity, as the species requires open sand grasslands.

Grazing is considered to be prerequisite for securing favourable habitat conditions for many noteworthy animal species belonging to Pannonian sand steppes. Kelemen (1997) claims that insufficient grazing pressure leads to a reduction in biodiversity. Grazing creates mosaic grassland with vegetated and bare ground patches. The bare ground is essential for many species such as the ant-lion (*Myrmeleonidae*), psammophilous *Cicindela* spp. beetles, and birds *Burhinus oedicnemus* (stone curlew) and *Anthus campestris* (tawny pipit). In their case, moderate grazing pressure or slight overgrazing is favourable (normal grazing pressure is ½ livestock unit/hectare or 4 but preferably 2 sheep/ha on closed sandy grassland). *Burhinus oedicnemus* (stone curlew) can be vulnerable to livestock pressure during the nesting season, which is from May to July (Kelemen 1997). Báldi *et al.* (2005) claim that *Anthus campestris* (tawny pipit) species had mixed preference towards intensively or extensively managed grassland sand steppes in Hungary. Kelemen (1997) indicates that both grazing abandonment and conversion to intensive agriculture can threaten the species.

Spermophilus citellus (suslik) prefer short grazed but continual vegetation cover, and avoids taller grasslands. A rich presence of insects attracted by animal excrement, or those naturally occurring on grassland (such as grasshoppers and crickets), represents an important food source for many birds such as *Upupa epops* (hoopoe) or *Coracias garrulus* (European roller). Hence, using herbicides, e.g. for the eradication of invasive plants, should be excluded (e.g. Bohuš in Polák and Saxa, 2005).

Cost estimates and potential sources of EU financing

Cost for eradication of alien species

Using chemicals is very costly. For example, when undertaking chemical suppression of *Asclepias syriaca*, one cannot use sprayers. Each plant has to be treated individually with a brush or a sponge. Glyphosate is a quite effective herbicide against *Asclepias*, but treatments have to be repeated a minimum of three times a year. In Hungary, the cost was 700 Euro/ha/year (50 % being the cost of the herbicide, 50 % the labour costs) when the cover of *Asclepias* varied between 5-50 %.

Removal of invasive species may face legal constraints. National forestry laws are generally the main constraints, forbidding the removal of exotic trees, especially those planted during the twentieth century as part of reforestation programs. For example, eliminating a forest in Hungary (even a plantation of alien trees), requires planting a new one of the same size in a different location. Another example is the requirement to pay large fines to the government, depending on the type of tree (eg. 1500 Euro/ha for *Robinia*, 1350 Euro/ha for a *Pinus* plantation), even if the area is protected and state owned, and the eradication is a part of a LIFE project.

In the Kiskunság National Park, closed sand steppes are partly managed by the National Park Administration and party by local farmers on a contractual basis. NP Administration rent land to farmers for a low fee, but in return, farmers have to graze the sand steppes using only half the amount of animals per ha that would be normal outside protected areas or Natura 2000 sites.

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

Agri-environmental support for sandy areas in Hungary is carried out through area-based horizontal and Natura 2000 support schemes (Hungarian Ministry of Agriculture and Rural Development 2007), which are open to all eligible areas in the country.

Land use prescriptions for Natura 2000 grasslands and the grassland management scheme measures partly or fully overlap each other. To avoid double funding, the agri-environment payments of a farmer already in receipt of Natura 2000 support are reduced accordingly.

There is only one cost-intensive obligation as part of the requirements placed by the horizontal grassland management scheme, which also appears in the Natura 2000 land use prescription package for grasslands. Consequently, the producer shall receive agri-environmental support, besides the compensatory payment through the Natura 2000 area, decreased by the amount received through the latter (31 euro/ha).

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

Schemes		Agri-environmental payments €/ha		Natura payment €/ha	AE + Natura payment €/ha
		Non Natura area	Natura area		
Horizontal Schemes				38	
Extensive grassland management	Grazing	100	69		107
	Mowing	56	25		63
Organic grassland management	Grazing	107	76		114
	Mowing	63	32		70
Conversion of arable land into grassland management schemes – 2nd year					
Environmental land use change	Mixed	143	105		143
Nature conservation land use change scheme	Mixed	170/175	132/137		170/175

Potential sources of EU financing

EU funds for Natura 2000 in the period 2007-2013 should come from different existing Community financial instruments aiming to enhance rural, regional, and marine development in the EU. The integrated use of these resources will allow the financing of various management actions for areas with habitats listed in the Habitats Directive and included in the Natura 2000 network. Each Member State has identified the issues that are of most concern locally and has prioritized EU funds in order to address these issues. National and regional programs, which have been prepared by Member States on the basis of the EU Regulations, determine the concrete funding possibilities for Natura 2000.

Among the diversity of sources for EU funding, the following funds might primarily be of interest for the management of pannonic sand steppes:

- The European Fund for Rural Development (EARDF): This program has a potential to cover many management activities that might be relevant for this habitat type, although the measures have to be covered in the National Strategy and related Rural Development Plans (RDPs) in order to be eligible on a national basis. However, costs for most management actions for conserving pannonic sand steppes are mostly eligible for agri-environmental subsidies within this program.
- 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 mostly need to be integrated into a broader development context, and for ERDF also related to productive investments (e.g. infrastructure). However, the Interreg approach is more flexible, but this 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 emphasize practical non-recurring management actions (at least 25 % of the budget). When clearly justified, compensation payments for restrictions in commercial land-use are eligible under 'Nature'. Recurring management is not eligible under LIFE+.

For more information on what management measures are eligible for financial support under various EU funds, it is recommended to consult the "Financing Natura 2000 Guidance Handbook" (Torkler 2007), available at: http://ec.europa.eu/environment/nature/natura2000/financing/index_en.htm. Furthermore, a web tool (based on that handbook) to determine the possible funding for Natura 2000 sites is available at: http://financing-natura2000.moccu.com/pub/index.html.

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The Life Nature Project "Sand dunes in Niederösterreich" http://www.sandduene.at/ (Project No. LIFE98 NAT/A/5418)

The Life Nature Project "Conservation of the Pannonic endemic *Dianthus diutinus*" (Project No. LIFE06NAT/H/000104) http://www.tartosszegfu.hu/