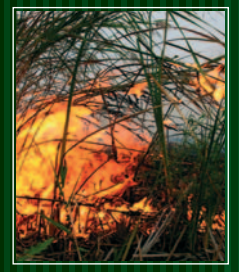

Grassland restoration and marsh protection in Egyek–Pusztakócs

Written by: Szabolcs Lengyel, László Lontay, Csaba Aradi, Szilvia Gőri, István Kapocsi and Attila Molnár

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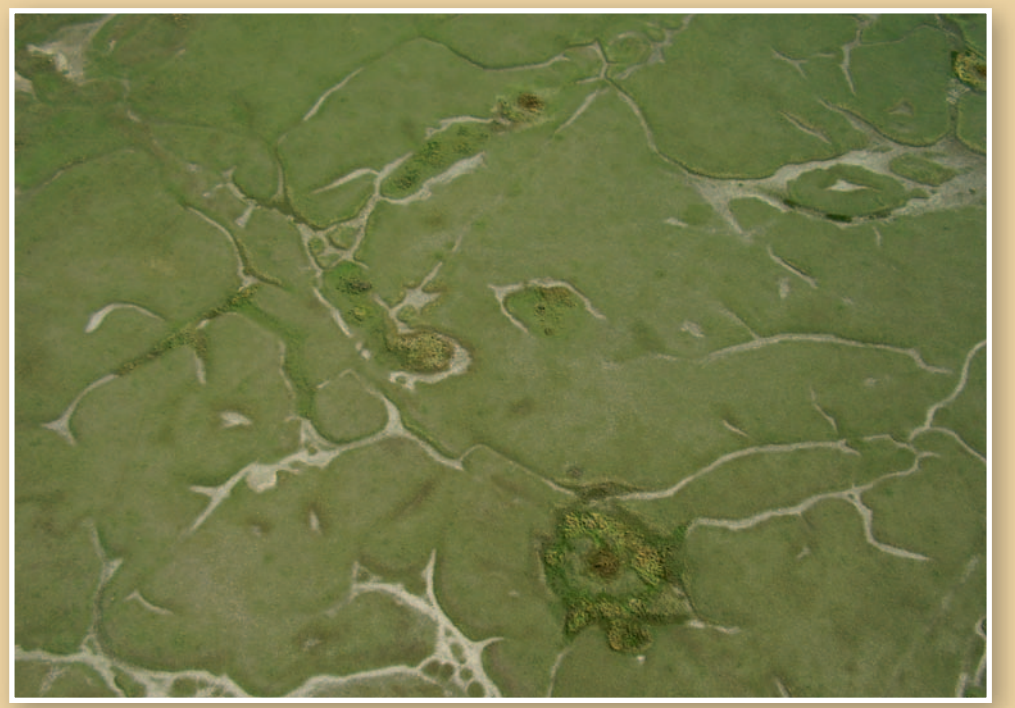

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FOREWORD

The loss and degradation of natural habitats have greatly accelerated throughout Europe in the 20th century. Agricultural intensification, industrial pollution and the apparently endless sprawl of cities and villages have resulted in the retreat, and occasionally, the loss, of native species and habitats. Since its foundation in 1973, Hortobágy National Park has aimed to restore and rehabilitate the Great Plain landscapes that had been transformed for centuries by human activities. As a result, the first habitat rehabilitation programmes in Hungary were started in the Hortobágy region. By its vast area and great success, the landscape-level rehabilitation programme of the Egyek–Pusztakócs marsh system emerges of all such restorations. The first phase of this programme (1976–1997) involved the rehabilitation of the marshes and meadows after the hydrological reconstruction of the water supply system. The second phase of the long-term landscape rehabilitation focuses on the restoration of grasslands and on the management and protection of the already revitalised marshes. The present publication describes the second phase, which was financially supported at 67% by the LIFE-Nature programme of the European Union between 2004 and 2008, but it also provides an insight into the most significant results of the first phase with a brief overview of the background of the second phase.

The Egyek—Pusztakócs habitat rehabilitation programme, founded on several decades of restoration and management experience, is the oldest and largest habitat restoration programme in Hungary and very likely in Europe. The project successfully contributed to the restoration and future preservation of a substantial portion of the unique biodiversity of Hungary. There are only very few cases in any person's life when one can do so much in such a short time against the degradation and loss of natural values. We therefore proudly present our results, share our experiences and present the problems found to generate ideas for further solutions. Please let us recommend our publication for your reading enjoyment.

Sincerely,

The authors:
dr. Szabolcs Lengyel, project manager
László Lontay, project coordinator
dr. Csaba Aradi, chief conservation advisor
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1. INTRODUCTION: THE EGYEK–PUSZTAKÓCS MARSH SYSTEM

One of the largest grassland prairies in Europe, Hortobágy, was once a mosaic of open floodplains, marshes, loess and alkali steppes and grasslands, and forests. Hortobágy is an erosion base formed on the alluvial fan of the ancient Sajó and Hernád rivers that has been eroding continuously since the last glaciation. The Hortobágy landscape was primarily formed by the floods and riverbed-translocations of river Tisza, the grazing and trampling pressure of large herbivores and the fires that occasionally scorched the land. Recent geomorphological studies showed that alkali soils, indicative of extensive grasslands, were present in the area in the Pleistocene (20–16 thousand years ago), which suggests that the area had been a forest-steppe consisting of alkali and loess grasslands and wooded areas before historical times. Since the beginning of historical times, human activities, including the felling of wooded areas, the regulation of river Tisza and elimination of floods, have transformed the area into a grassland steppe interspersed with marshes and used mainly for grazing.

The Egyek–Pusztakócs marsh system is located in the western part of Hortobágy, on its border with the Nagykunság region, in the ancient floodplain of river Tisza and south of the village of Egyek (source: Google Maps).

1.1. A geographical description of the marsh system

The 4073-ha. "Egyek–Pusztakócs marshes" unit of Hortobágy National Park belongs to Tiszafüred (Jász-Nagykun-Szolnok county), and Egyek and Hortobágy (Hajdú-Bihar county) municipalities. The entire area of the marsh system has been part of Hortobágy National Park since its foundation (January 1, 1973). As part of the National Park, the marsh system has been inscribed on the UNESCO World Heritage list in the "Cultural landscape" category since 1999. The entire area of the marsh system is included on the annex of the Ramsar Convention on wetlands of international importance and is part of the Natura 2000 network based on both the Habitats and the Bird Directives.

The geology of the Egyek-Pusztakócs area is determined by Pleistocene and Holocene sediments and loess-silt that had accumulated on the alluvial fan of the ancient Sajó and Hernád rivers. The sediments were later covered by sandy loess deposited by the floods of river Tisza. The soils of the marsh system are usually alkali and of low productivity, and belong to meadow solonetz and other alkali solonetz soil types. Higher plateaus, which used to be ancient riverbanks and were rarely flooded, are covered by loess-based, sandy-clayey meadow tchernozjom.

The marsh system topographically is a high floodplain lowland extending between 87 and 98 m above sea level. Characteristic topographic forms are the loessy sand-covered higher plateaus running mostly from N–NW to S–SE, the marshes which formed in ancient riverbeds and flood waterways that had regularly received large amounts of water from the floods of river Tisza. The marsh system, therefore, differs from the classic, table-flat surfaces of the Hortobágy region. The variable, mosaic-like landscape concentrates the most characteristic habitat types of the greater Hortobágy in a small area: "in between plateaus ending steep here or rolling gently there, marshes are smoothened, and tussock meadows forming colourful mosaics with wet alkali plant associations, checkered loess grassland fragments, salt-covered white, bare alkali surfaces and variable alkali microforms change into each other with hardly recognisable boundaries, laced with smaller forests here and there" (Rakonczay [ed.] 2004).

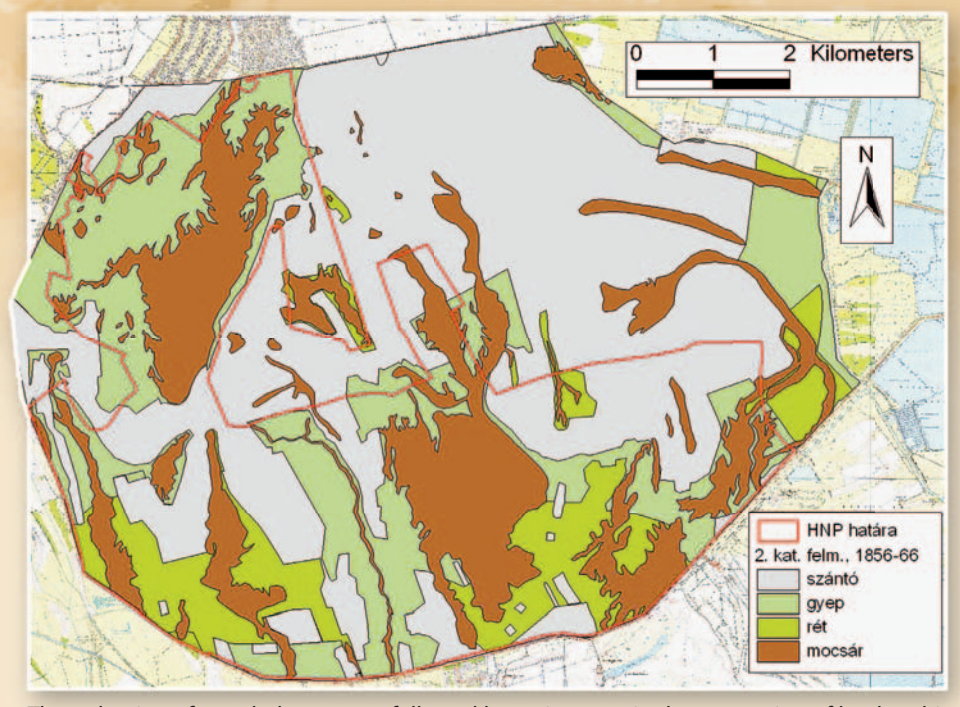
Today the marsh system is characterised by a mosaic-like landscape structure, the most important elements of which are the ancient riverbeds running mostly from N to S (marshes, in darker colours on aerial photograph), the loess-covered higher grounds between the marshes (lighter colours, usually arable lands), the meadows in the edges of marshes, the alkali grasslands and pastures, and the small pockets of woodlands, treelines and dry loess grassland fragments (source: Google Earth).

The climate of the marsh system belongs to the temperate warm, dry type. The mean annual temperature is 9.8°C and the frost-free period is from April 10–12 to October 16–18. The annual number of sunny hours is c. 1950. Precipitation ranges between 520 and 550 mm, and is distributed erratically in most years, resulting in a relative water deficit of the landscape.

The marsh system has no natural streams or rivers. The eight large, once hydrologically interconnected marshes used to transport river Tisza floodwaters from the north towards the Kunkápolnás marshes further to the south. There are no stable standing waters, although the deepest (c. 2 m) parts of the marshbeds are covered with water throughout the year. Seasonally flooded, marshy meadows are found all over the marsh system. The ground water table is located at depths of 2 to 4 m, but can be closer to the surface in wet years. The dissolved salt content of the ground water is high (> 2 mg/l), and is dominated by sodium and chlorides and sulphates.

1.2. A short history of the marsh system

The first major human influence on the area was the felling of the forests present on oxbow-banks and less alkali loess plateaus. According to records from the Middle Ages, neighbouring villages paid their taxes to the Turks in wood, which caused the destruction of once extensive gallery forests and forest-steppe oak woodlands.



The reduction of wooded areas was followed by an increase in the proportion of lands cultivated as arable land. The maps of the second military survey (1856-66) show that as early as the middle of the 19th century, all of the higher loess plateaus had been broken up and were regularly cultivated.

The marsh system that used to be regularly flooded by river Tisza has been drained gradually since the early 19th century. Records exist on the active sludge-removal from Árkusér, the canal draining the eastern marshes, from the first third of the 19th century. The regulation of river Tisza by the 1860s terminated the most important source of water supply to the marsh system. The construction of the system to drain inland waters, started in the 1900s and accelerated between 1930 and 1950, has drained most marshes, led to the sinking of the ground water table and to the emergence of a general water deficit in the habitats. Canal constructions in the frame of the Egyek area melioration programme (c. 1980) have led to a near-fatal drought and an almost irreversible degradation of the marsh system.

As a result of river regulation, flood control and drainage works, the sources of natural water supply have all but vanished. By the 1980s, Tarhos, Bőgő, Csattag and Meggyes marshes have completely dried up. The drying was mainly caused by the changes in the natural water drainage systems and was only exacerbated by the extremely long low-precipitation period between the late 1970s and early 1990s. Most of the natural water catch-

ment of the marshes were ploughed and the connections between the marshes were terminated by filling up, active improving of the soil and ploughing of the former natural depressions that had connected the marshes.

Parallel to the drying of the area, more and more grasslands and meadows were broken up by ploughing and the proportion of arable lands has gradually increased. Besides the areal reduction of wetland habitats, characteristic edge habitats and zonal transitions (e.g. dry grassland—wet meadow—tussock meadow—marsh) have disappeared. In many areas, patches of homogeneous habitats separated by sharp, sudden, non-transitional edges have appeared.

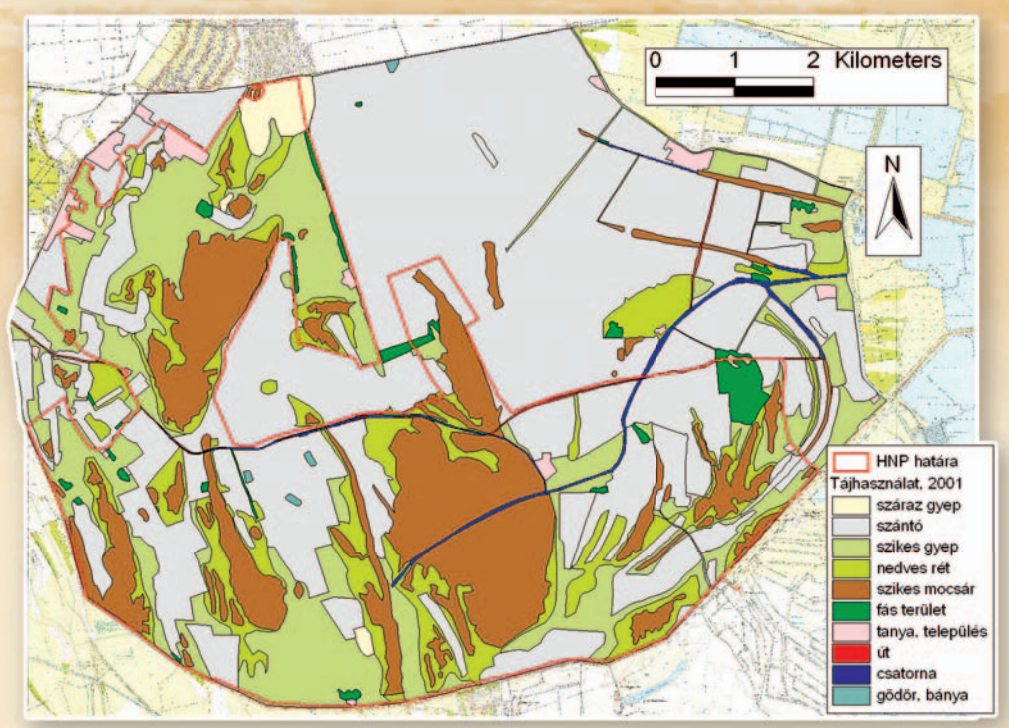
The areal proportion of arable lands reached its maximum (35% of the soon-to-be-protected area) by the late 1960s, whereas marshes had retreated to 6% of the total land surface.

1.3. Rehabilitation of the marshes (1976–1997)

With its strongly degraded 4000-ha.-plus area in the early 1970s, the Egyek–Pusztakócs marsh system was a classic example of habitats in dire need of restoration. It is not coincidental that the first large-scale, landscape-level habitat restoration programme in Hungary has been started here in 1976. The aim of the rehabilitation was to construct and operate a water supply system that could mimic the floodings that had been characteristic to the area before river regulation and to achieve a hydrological reconstruction and revitalisation of the marshes. The construction of the water supply system was started with Fekete-rét (1976) and continued with Kis-Jusztus, Bőgő and Meggyes marshes, and was completed in 1997 Hagymás and Csattag marshes. The canal system has brought the water of river Tisza once again to the marshes.

1.4. Results of marsh rehabilitation (1997–2001)

The habitat-level changes following the hydrological reconstruction have indicated the regeneration and revitalisation of marsh habitats. In a few years, the areal extent of marshes has approached the level estimated before human activities had started to transform the area.

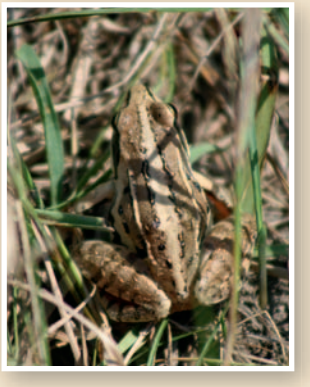


The hydrological reconstruction has caused the rapid regeneration of the marshes, with their areal extent increasing to 26–28% (habitat map from 2001).

Today most of the marshes are covered by reedbeds (*Scirpo-Phragmitetum*), interspersed with stands of Broad-leaved and Narrow-leaved Bulrush (*Typha angustifolia* and *T. latifolia*), Softstem Bulrush (*Schoenoplectus tabernaemontani*) és Common Clubrush (*S. lacustris*). The recolonisation of the once extensive submersed vegetation (Eurasian Milfoil *Myriophyllum spicatum*, Pondweed *Potamogeton* spp., Hornwort *Ceratophyllum* spp.) has been extremely fast and increasingly larger areas are covered by White Waterlily (*Nymphaea alba*), Yellow Waterlily (*Nuphar lutea*), Yellow Floating-heart (*Nymphoides peltata*), Water Chestnut (*Trapa natans*) and Floating Fern (*Salvinia natans*).

The marshes are abound in fishes. The most important fish species are Crucian Carp (*Carassius* spp.), Tench (*Tinca tinca*), European Weather Loach (*Misgurnus fossilis*), Bitterling (*Rhodeus sericeus amarus*), Spined Loach (*Cobitis taenia*), Common Carp (*Cyprinus carpio*), abundant predators are Catfish (*Silurus glanis*) and Northern Pike (*Esox lucius*). Reptiles include the rare Dice Snake (*Natrix tessellata*), whereas the Grass Snake (*Natrix natrix*) and European Pond Turtle (*Emys orbicularis*) are abundant. Among mammals, the Eurasian Otter (*Lutra lutra*) is worthy of mentioning, which lives in great numbers in the canals and nearby fishponds.

Hagymás-lapos is the most diverse marsh and is home to the the largest Hortobágy stand of Yellow Irises (*Iris pseudacorus*).



Some amphibians, such as the Marsh Frog (*Rana arvalis*) and the Fire-bellied Toad (*Bombina bombina*) reach high densities in the marshes.

The success of hydrological reconstruction was indicated by very rapid changes in the bird fauna. In the years after the reconstructions, rare, valuable species of birds such as the Pied Avocet (*Recurvirostra avosetta*), Black-winged Stilt (*Himantopus himantopus*) and Mediterranean Gull (*Larus melanocephalus*) appeared in unexpected numbers in the marsh system. The initial recolonisation was followed by a decelerating stabilisation process, during which bird assemblages became more characteristic to stagnant waters and species less typical in Hortobágy marshes disappeared.

Among reed-nesting birds, the populations of Bluethroat (*Luscinia svecica*) and Moustached Warbler (*Acrocephalus melanopogon*) are worth mentioning. Rare, valuable nesting species are the Ferruginous Duck (*Aythya nyroca*), Red-necked and Black-necked Grebes (*Podiceps grisegena* and *P. nigricollis*), Little Grebe (*Tachybaptus ruficollis*). Several

The marshes provide significant nesting sites to egrets and herons (e.g. Great Egret *Egretta alba*, Purple Heron *Ardea purpurea* (upper left), Little Bittern *Ixobrychus minutus*, Bittern *Botaurus stellaris*), Spoonbill *Platalea leucorodia* (upper right), and gulls and terns (Common Black-headed Gull *Larus ridibundus*, Common Tern *Sterna hirundo*, Whiskered Tern *Chlidonias hybrida*, Black Tern *C. niger*, White-winged Tern *C. leucopterus*).

duck species have strong nesting or migrating populations in the area. In the fall, Greater White-fronted Geese (*Anser albifrons*) form large flocks, in which occasionally Lesser White-fronted Geese (*Anser erythropus*) mix. The great flocks of ducks and geese attract several rare birds of prey (e.g. White-tailed Eagle *Haliaeetus albicilla*, Saker Falcon *Falco cherrug*).

Areas with shallower water are often covered by extensive stands of Maritime Bulrush (*Bolboschoenus maritimus*), whereas tussock meadows neighbouring the marshes contain interesting mosaics of stands of Floating Sweet-grass (*Glyceria fluitans*), Reed Sweet-grass (*G. maxima*) and European Slough Grass (*Beckmannia eruciformis*).

Marshes are also important for Cranes (*Grus grus*) that use the area both for staging in the fall and spring and oversummering in increasing numbers.

2. THE SECOND PHASE OF LANDSCAPE REHABILITATION: THE LIFE-PROGRAMME (2004–2008)

2.1. The biota of dry habitat types

In the Egyek–Pusztakócs marsh system, the habitat types and plant associations most characteristic to the Hortobágy are concentrated in a relatively small area and show transitions towards the habitats characteristic to the river Tisza corridor and the Nagykunság region. The Egyek–Pusztakócs landscape is highly varied by the meadows forming mosaics with wet alkali associations and drier alkali microforms, bare alkali surfaces, loess grassland fragments and small wooded areas. This diversity of habitats makes the marsh system especially suitable for restoration, because restoration and management can lead to favourable changes in the conservation status of numerous species, communities and habitats.

The varied microtopography of the edges of Fekete-rét, Tarhos-lapos and Csattag-lapos, covered with alkali grasslands, wet alkali associations, bare alkali surfaces and tiny loess grassland fragments remind us of the classic Hortobágy steppes.

Lone old poplars (left) and riparian patches of some wooded areas (right) are witnesses to a floodplain past.

Wet meadows neighbouring the marshes are surrounded by varied mosaics of wet alkali associations, alkali grasslands interspersed with bare alkali surfaces. The vegetation of alkali grasslands matches that of classic Hortobágy alkali steppes. The main types are the mugwort alkali steppe (*Artemisio santonici-Festucetum pseudovinae*), sneezwort alkali steppe (*Achilleo setaceae-Festucetum pseudovinae*), the alkali step-grade association (*Matricario-Plantaginetum tenuiflorae*), whereas water-affected types (e.g. saltmarsh-grass wet alkali association *Puccinellietum limosae* and bare alkali surfaces *Camphorosmetum annuae*) are less common.

The highest dry plateaus were once covered by extensive loess grasslands. The more species-rich type of this vegetation is the loess steppic grassland (*Salvio nemorosae-Festucetum rupicolae*), whereas loess pastures (*Cynodonti-Poetum angustifoliae*) are present in more disturbed (grazed) areas.

A loess grassland with Hair-like Feather-grass (*Stipa capillata*) in early spring (left) and a loess pasture in late summer (right).

Loess steppic grasslands formed on meadow tchernozjom, the soils of highest productivity in the area. It is not coincidental that these grasslands were the first to be broken up by ploughing. Habitat maps based on the second military survey (1856–66) witness that almost all the higher plateaus had been cultivated as arable lands as early as the middle of the 19th century. Loess steppic grasslands are one of the most damaged habitat types not only in the Hortobágy region but also in the Hungarian Great Plains.

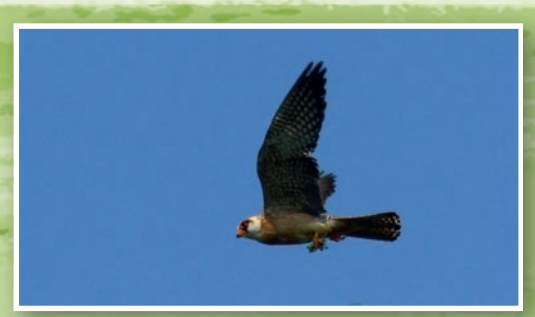
Dry habitat types of the marsh system host a rich bird fauna. The Skylark (*Alauda arvensis*) is the most common nesting bird in grasslands. An interesting species on fallows and bare croplands is the Tawny Pipit (*Anthus campestris*). Agricultural areas are the centres for nesting for Quail (*Coturnix coturnix*), Lapwings (*Vanellus vanellus*) and are occasionally visited by the Eurasian Dotterel (*Charadrius morinellus*) on their fall migration. Observations of Great Bustards (*Otis tarda*) on both grasslands and arable lands have become more frequent in recent years. This species used to be more common in the area, and it even had a stable lekking site east of Fekete-rét until the 1960s.

Characteristic plants of loess steppic grasslands are the Wild Sage and Austrian Sage (*Salvia nemorosa* and *S. austriaca* left) and Hungarian Pink (*Dianthus pontederae* right).

Grasslands are important feeding sites for Rollers (*Coracias garrulus*) and Lesser Grey Shrikes (*Lanius minor*) nesting in wooded areas, and for Bee-eaters (*Merops apiaster*) nesting in loess walls in the northern and southern edges of the marsh system.

On marsh edges and meadows, the Yellow Wagtail (*Motacilla flava*) is the most abundant nesting bird.

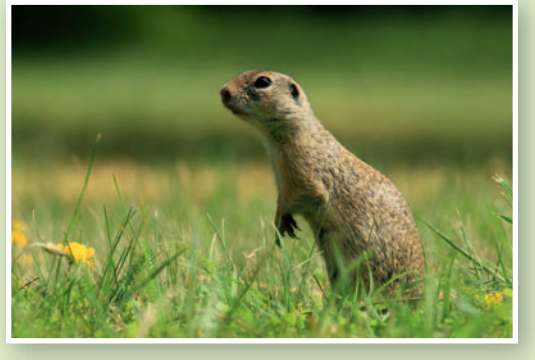
The greatest values of dry habitat types, however, are birds of prey. Northern Harriers (*Circus aeroginosus*) are common everywhere in the marsh system. Other important breeding raptors include the Montagu's Harrier (*Circus pygargus*), the Short-eared Owl (*Asio flammeus*) and the White-tailed Eagle (*Haliaeetus albicilla*). The marsh system is frequently visited for feeding by the Long-legged Buzzard (*Buteo rufinus*), the Imperial Eagle (*Aquila heliaca*), the Short-toed Eagle (*Circaetus gallicus*) and the Saker Falcon (*Falco cherrug*).



The largest (50–80 pairs) and the recently most stable colony of Red-footed Falcons (*Falco vespertinus*) in Hungary is found in the marsh system, and Kestrels (*Falco tinnunculus*) breed in similar numbers scattered in the area.

Among mammals, the Siberian Ferret (*Mustela eversmanni*) is worth mentioning. The European Badger (*Meles meles*) and Red Fox (*Vulpes vulpes*) excavate their burrows on higher points of kurgans and loess plateaus. Brown Hares (*Lepus europaeus*) are increasing and large groups of Roe Deer (*Capreolus capreolus*) can be observed on grasslands and agricultural lands. Agricultural lands and grasslands are also home to a diverse fauna of small mammals (Common Vole *Microtus arvalis*, European Pine Vole *Microtus subterraneus*, European Water Vole *Arvicola amphibius*, Striped Field Mouse *Apodemus agrarius*, Yellow-necked Mouse *Apodemus flavicollis*, Wood Mouse *Apodemus sylvaticus*, Harvest Mouse *Micromys minutus*, Steppe Mouse *Mus spicilegus*, Bicolored Shrew *Crocidura leucodon*, Common Shrew *Sorex araneus*, Pygmy Shrew *S. minutus*).

The most important mammal of dry habitats is the Souslik (*Spermophilus citellus*), the population of which has fluctuated between 150 and 500 individuals until the late 1990s.



Steppe Mice and their mounds can be found in many locations of the marsh system.

2.2. Threats

Despite the favourable changes in the conservation status of marshes after the hydrological reconstruction, the status of dry habitat types (meadows, alkali and loess grasslands) did not improve. The proportion of arable lands remained high (31%), whereas the proportion of dry alkali and loess grasslands remained low (26%) compared to the proportions estimated before human activities had started to transform the area (arable lands: 0%, grasslands: 45–48%).

At the beginning of the LIFE-Nature project, we identified the following major threats: high proportion of arable lands, fragmentation of grasslands by arable lands, agricultural intensification and chemical use, goose-farming, lack of optimal conservation management (grazing) of grasslands and homogenisation of habitats.

Arable lands cover most of the former grassland areas in the marsh system. The proportion of arable lands was high as early as in the middle of the 19th century, but reached its maximum extent by 1969. The breaking up and ploughing of the higher plateaus that had not regularly been reached by floods, and the cultivation of areas that had later become available gradually with the drainage of the marshes have almost completely destructed dry grassland habitats. Natural or seminatural grasslands have persisted only in hardly accessible locations such as the edges of marshes, between ploughed fields and in small areas.

Arable lands (shown in grey on the habitat map of 2001) cause the fragmentation and the loss of spatial connectivity of grasslands. The northern, southwestern and eastern grasslands are highly isolated from each other.

An ancient marshbed and meadow zone ploughed in the northern part of Kis-Jusztus marsh in 2001.

Agricultural intensification, i.e., the uncontrolled use of chemicals (pesticides, herbicides and fertilisers), threatens grasslands and rehabilitated marshes. The chemicals used in intensive agriculture can damage natural grasslands and marshes by surface runoff or infiltration. This effect is especially critical in areas where arable lands border the protected habitats.

Chemicals used in intensive agriculture (herbicides, pesticides, fertilisers) reach lower-lying grasslands, meadows and marshes by surface runoff or underground infiltration, causing an increased production of organic matter (eutrophication), the disappearance of rare and sensitive species, and degradation of the entire habitat.

In the Villongó area that borders the marsh system from the southeast and is included in the Natura 2000 network of protected habitats, goose-farming was present in two larger farms. Because goose-farming severely damages grasslands in several ways, it is essential to eliminate goose-farming and transform the farms into livestock grazing, which is more favourable from a conservation point of view.

By their grazing, trampling and feces, domestic geese cause the acidification and increasing compactness of the soil, the destruction of the natural flora and the dominance of weeds of rapid reproduction.

Subfossil records attest that Hortobágy grasslands had probably been grazed and trampled by large herbivores (bison *Bison* spp., aurochs *Bos primigenus*) well before humans entered the region. From the Bronze Age, grazing gradually shifted to livestock farming (sheep, horses, cattle). Grazing, therefore, has been highly important in the formation of Hortobágy grasslands and is fundamentally important as an optimal way of management in maintaining a good conservation status of the natural or semi-natural grasslands. In 2001, extensive tracts of grasslands were not grazed, whereas in other parts, grazing pressure did not reach optimal levels, and still in some other parts, grazing was concentrated, leading to overgrazing. The lack or inbalances of grazing have caused the accumulation of dead plant matter (litter), the homogenisation of the vegetation, disappearance of rare species and a general degradation of the habitats.

Grazing is the optimal way of conservation management to maintain the good conservation status of Hortobágy grasslands.

Older aerial photographs, maps and reports show that the Egyek–Pusztakócs marshes were once a highly complex mosaic of different habitat types (e.g. drier "islands", open mudflats, stands of cattails and bulrushes, reedbeds, open water surfaces etc.). In some wetlands of the marsh system, a strong homogenisation of the vegetation has started likely due to the invariable amount of water supplied to the marshes every year and the effects of reed-harvesting that became more intensive after rehabilitation. The homogenisation process causes the retreat, thinning and disappearance of the species characteristic to the declining habitat types, which leads to a general degradation of the area.

As a result of constant water supply and reed harvesting, considerable tracts of the larger marshes have been overtaken by homogeneous, species-poor assemblages of reedbeds (*Phragmitetum australis*) and many wet meadows have been dominated by the Meadow Foxtail (*Alopecurus pratensis*).

2.3. Project objectives

The Egyek—Pusztakócs landscape-level habitat rehabilitation is one of Hungary's largest habitat restoration programme, involving seven large marshes, their adjoining meadows, grasslands and arable lands on a total of 5000 ha. Based on the threats remaining after the first phase of landscape rehabilitation (hydrological reconstruction), the general objectives of the second phase were to restore grasslands and to protect and manage the marshes already rehabilitated. Specific aims were the following:

- to establish ecological corridors to connect fragmented grasslands by grassland restoration on arable lands and by extensive (chemical-free) cultivation of arable lands,
- to establish buffer zones to protect rehabilitated marshes by grassland restoration or afforestation on arable lands,
- to eliminate goose-farming and transform farms to sheep or cattle-farming,
- to extend and balance grazing as the optimal way of grassland management,
- to increase the diversity of habitat types in homogeneous marshes by grazing and fire management,
- to provide feeding areas to birds of prey, waterbirds and shorebirds by extensive cultivation of arable lands.

2.4. Activities of the LIFE-programme

2.4.1. Land purchase

The aim of this action was to purchase lands used for goose-farming and to purchase arable lands and grasslands that are involved in ecological corridors and buffer zones and that are not yet owned and managed by Hortobágy National Park. We designated c. 400 ha. arable lands and grasslands for purchase. During the implementation of the project, after an information campaign to land owners, we purchased all but 10 ha. of the designated lands or a total of 390 ha. On all arable lands purchased, we started the restoration of grasslands. On purchased grasslands that had been used for goose-farming, we transformed farming to grazing by sheep or cattle.

We planned the purchase and restoration of 90 hectares of arable lands to establish grassland corridors between marshes and buffer zones near marshes on the eastern shore of Csattag-marsh (shown in brown in the upper left part of space image) and on the northern shore of Feketerét marsh (brown in lower right corner).

2.4.2. Grassland restoration

The most important conservation action of the second phase of the landscape rehabilitation was to restore grasslands on arable lands. In this project, we started grassland restoration on an unprecedented 760 hectares of land. Our approach was to sow only the seeds of a few foundation species after the suitable preparation of the soil and to let ecological processes (succession) take care of the rest of restoration.

Seeds for the restoration were obtained mostly by harvesting in nearby, target-state grasslands (mostly *Festuca* spp., c. 12 tonnes in the four years of the project), whereas a smaller amount was purchased from commercial sources.

Soil preparation was conducted by deep-ploughing once and disk-harrowing twice.

We sowed 20–25 kg of seed mixture per hectare of prepared land, using a modified fertiliser-spreader.

On higher loess plateaus that had probably been covered by loess steppic grasslands before broken up by ploughing, we sowed a mixture consisting of seeds of *Festuca rupicola*, *Poa angustifolia* and *Bromus inermis* in proportions of 2:1:1, whereas in lower-lying areas where conditions were more likely to favour alkali grasslands, we sowed a mixture consisting of seeds of *Festuca pseudovina* and *Poa angustifolia* in proportions of 2:1. The harvested seeds were cleaned by sieving and the mixtures of the required proportions were prepared in large quantities.

Sowing was conducted in late September and early October each year between 2005 and 2008. This period was generally followed by a rainy period, which was highly favourable for the initial germination and growth of the sown seeds.

The spring and summer following the fall restoration, the restored lands were covered by rapidly growing weeds. The sea of weeds formed spectacular fields in many places.

To efficiently control the further spread and growth of weeds, we mowed the lands before the major blooming period of the weedy species (in mid-June).

After mowing, it was somewhat surprising to see that the sown grass species have already formed closed swards in several places. These observations suggested that the dense weed cover had a favourable effect on the sown grasses by providing highly suitable microclimatic conditions (shade, high water vapor content) for the germination and growth of the sown grass species.

By the second year following grassland restoration, the dominance of the sown grasses exceeded the cover of weeds (the area on the left side of the picture was sown using the loess seed micture, whereas the area on the right side was sown by the alkali seed mixture).

After grazing and mowing started in the second or the third year, a vegetation characteristic in typical species to the target grasslands has developed in both alkali (lower left) and loess grassland restorations. Weeds did not completely disappear but had low cover relative to the higher cover of the sown grasses. By the third year, numerous species typical in target natural grasslands have appeared spontaneously in the newly restored grasslands (e.g. *Achillea collina*, *Cruciata pedemontana*, *Dianthus pontederae*, *Scorsonera cana*, *Koeleria cristata*, *Melandrium viscosum*).

Animal assemblages have changed considerably parallel with the changes in the vegetation. Arable lands and first-year restored grasslands were characterised by the dominance of generalist species, whereas the number of species typical in natural grasslands (e.g. *Amara fulvipes*, *Gampsocleis glabra*, *Gnaphosa rufula*, *Chorosoma schillingi*) increased considerably by year 2. There was a marked change in species composition between year 2 and 3, resulting in an influx of many species typical in target grasslands.

Point counts of birds showed that species that are typical of alkali grasslands but which were also present on arable lands (e.g. Skylark *Alauda arvensis*, Yellow Wagtail *Motacilla flava*) have greatly increased in density. The restored grasslands have also provided feeding areas for many species of conservation value (e.g. Red-footed Falcon *Falco vespertinus*, Buzzard *Buteo buteo*, Whiskered Tern *Chlidonias hybridus*, Bee-eater *Merops apiaster*, Lesser Grey Shrike *Lanius minor*, Roller *Coracias garrulus*). In summary, we have observed unexpectedly rapid favourable changes both in vegetation and in animal assemblages in the first years following grassland restoration.

Whiskered Terns (*Chlidonias hybridus*, left) showed great preference for feeding above restored grasslands.

The approximate costs of our method of grassland restoration are shown in table below. The costs of obtaining seeds can be reduced to one-third by harvesting seeds from natural grasslands of good conservation status, although harvesting, especially its timing, requires great expertise. The costs of mowing can also be reduced if farmers can utilise the plant material mowed (only as litter in the case of weedy grasslands). On average, grassland restoration using the method described above cost between 450–500 € per hectare.

Work phase	Activity	Approximate cost (incl. VAT)*
Obtaining seeds	Harvesting	100 €/ha (average, 100 kg/ha.)
	Purchasing	12 €/kg (average, depends on species)
Land preparation	Heavy disk ploughing	60 €/ha.
	Disk ploughing	60 €/ha.
	Disk harrowing	30 €/ha.
Sowing	Sowing (25 kg/ha.)	20 €/ha.
	Disk harrowing	30 €/ha.
Mowing	Machine mowing	48 €/ha.
	Baling	5 €/ha.

* using an exchange rate at 250 HUF/EUR

2.4.3. Afforestation

The marsh system lies 5 km from river Tisza and the floods of Tisza once were of primary importance in the formation of the Egyek–Pusztakócs landscape. It is easy to envision that the riparian gallery forests typical along river Tisza were probably present in the area before historical times. Written records from the middle ages suggest that nearby villages paid their taxes to the Ottoman Turks in wood, therefore, the areal decrease of wooded areas can be dated at the time of the Turkish occupancy of Hungary (1541–1686).

In order to restore some of the former wooded areas, we planned afforestation on former oxbow-banks that once had likely been covered by gallery forests (in the eastern part of the area, areas in green on map to the right) and in buffer zones where arable lands reached directly to the marshes and which have been deemed suitable for afforestation (in the western part, areas in green on map to the left).

Afforestation was conducted after suitable soil preparation by sowing acorns of English Oak (*Quercus robur*) on former oxbow-banks (left) and by planting seedlings of White Willow (*Salix alba*) and White Poplar (*Populus alba*) on marsh edges (right) in the fall of 2006.

Our attempts at afforestation, however, were unsuccessful. Most acorns were dug out by Wild Boars (*Sus scrofa*). Moreover, a high proportion of the planted seedlings did not bring new shoots and soon died likely due to the soil conditions (high alkalinity) that may have had changed during the centuries since the time when forests last prospered in the area. The few seedlings that did bring shoots were damaged by Roe Deer (*Capreolus capreolus*). Because the replacement of acorns and seedlings in a smaller area was also unsuccessful and because fences could not be constructed due to its prohibitively high (unplanned) costs, afforestation was abandoned. In the areas where afforestation had been planned (80 ha.), grassland restoration using the above-described methods was carried out in 2008.

Failure of afforestation: in the fall and winter, acorn plantations were seriously damaged by Wild Boars (*Sus scrofa*), which are present in high densities in the area. Wild Boars methodically searched for, dug out and destroyed 95% of the acorns sown.

2.4.4. Grazing of native and restored grasslands

Grazing is the optimal way of management on Hortobágy grasslands. We carried out two activities to ensure an optimal level of grazing for non-grazed or under-grazed grasslands in the project area. First, we contacted local farmers in the villages of Egyek, Egyek–Félhalom, Tiszafüred–Kócsújfalu and Nagyiván and offered them incentives for grazing such as discounted renting prices and assistance with applications for funding to agri-environmental programmes. As a result, the number of grazing livestock increased and grazing could be extended to undergrazed or non-grazed areas.

As a result of cooperation with farmers, considerable developments have been carried out with regards to infrastructure and livestock numbers. Several farmers that had not dealt with animal husbandry before invested in purchasing farms and land. An example for such new business directions is the Nagy-Jusztus farm pictured above, which was bought by Nagyiván Agricultural Llc., renovated by the company and successfully extended using funding from the rural development agri-environmental programme in Hungary. Other farmers built additional infrastructure and increased their livestock. As a consequence, grazing could be extended completely to the native grasslands surrounding Csattag marsh (total of c. 400 ha. newly grazed grasslands), and grazing has been extended to the restored grasslands (150 ha. restored in 2005) in year 3.

After the termination of goose farming in the Vil-longó area, sheep-farming has been started in the larger farm (shown above) in 2005 (c. 600 sheep on c. 150 ha. in 2008), and cattle grazing has been started in the area of the smaller farm in 2006 (c. 100 cattle on c. 200 ha. in 2008). As a result of this activity, a regeneration of grasslands damaged by geese has started in the areas surrounding the farms.

Second, to ensure grazing in specific areas and habitats such as marshes and marsh edges, we purchased 50 Hungarian grey cattle. We established the infrastructural conditions for grazing of this livestock in the southwestern part of Fekete-rét marsh.

A 2-ha. fold surrounded by electric fence equipped with solar panels, a drinking well and a trough, a shepherd's home etc. were built in the southwestern part of Fekete-rét marsh.

Grey cattle purchased in the project were used to allocate grazing to marsh edges and non-grazed grasslands first in the southern and later in the northern part of Fekete-rét marsh.

In 2006, grazing pressure was increased by the addition of grey cattle from one of the large herds of the Hortobágy Nature Conservation and Gene Preservation Public Benefit Company. As a result, a total of 180 grey cattle were roaming in an area of about 150 ha. grasslands and 250 ha. marshland. In 2007 and 2008, one of the local farmers offered to bring in a herd of 180 mixed cattle (Hungarian grey and speckled breeds). This positive development allowed us to allocate grazing by the project cattle to the northern edge of Fekete-rét marsh, where grazing was also necessary to open up homogenised reedbeds.

As a result of these activities, we extended the grazing system to a total of about 2000 ha. or the overwhelming majority of the grasslands of the marsh system. Native and restored grasslands and marsh edges are now regularly grazed by c. 600 cattle (Hungarian grey and speckled), whereas grasslands are grazed by c. 2500 sheep. Grasslands restored between 2005 and 2008 are now involved in the grazing system depending on their condition, but usually in year 3 after restoration. The involvement of local farmers and their becoming financially interested in grazing in the area will likely ensure the long-term, sustainable maintenance of grazing as the optimal way of conservation management in the area of the Egyek–Pusztakócs marsh system.

To study the effect of grazing on vegetation, we built exclosures that effectively kept out grazing livestock and served as controls to the grazing treatment. The same exclosure is shown in 2007 (above) and in 2009 (below). In the absence of grazing, i.e., within the exclosures, the originally diverse, classic dry-wet alkali transition has dissipated and the number of plant species decreased considerably due to the accumulation of dead plant material. Reed has become stronger in the non-grazed exclosure, whereas it retreated in the grazed area.

2.4.5. Opening up of reedbeds using grazing and fire management

We planned two conservation management actions to open up homogeneous reedbeds to increase the diversity of habitats. Grazing by grey cattle in the southern part of Fekete-rét marsh aimed primarily to open up homogenised reedbeds.

Grey cattle are especially suitable for grazing in marsh edges because they highly prefer grazing freshly grown spring reed in waters as deep as 1 m. We have observed bands of 30–40 cattle several times to wade into the marsh and to spend the entire day grazing, wandering and resting in the marsh. We estimated that c. 200 ha. in the southern part of Fekete-rét marsh was regularly trampled and grazed by grey cattle.

Grazing has proved to be effective in reducing the homogenisation of the marsh habitats. Grey cattle have created small openings at the edges and larger cleared areas within the reedbeds by their trampling and grazing in several areas. These openings were visited by individuals of many bird species (herons, egrets, ducks, greylag geese), and there were several openings in which either Whiskered Terns (*Chlidonias hybrida*) or Common Black-headed Gulls (*Larus ridibundus*) founded nesting colonies.

The aim of fire management also was to open up reedbeds. We scheduled burning to the late summer, for the time of reed blooming, when the rhizome of the plant is in a nutrient-poor state as most nutrients are up in the inflorescence (flower) of the plant. Burning at this time is expected to be successful in getting the rhizome rid of its nutrients, and this effect, coupled with an early spring flooding, may be successful in killing the rhizome and containing reed.

After acquiring the necessary permits and clearing the area to be burned, burning was conducted on 120 ha. of Fekete-rét marsh in August 2007, when reed was still green and blooming.

The results of fire management were spectacular: homogeneous reedbeds in the southern part of Fekete-rét marsh were taken over mostly by associations dominated by *Typha* species, and by *Schoenoplectus*-dominated associations and open water surfaces to a smaller extent. Besides reed (*Phragmites communis*), other marshland species have appeared with smaller or larger cover (e.g. *Bolboschoenus maritimus*, *Rumex palustris*, *Typha angustifolia*). As a general result, the cover of reedbeds decreased, and the number of species colonising the burned areas has increased considerably.

2.4.6. Extensive cultivation of arable lands

The marsh system has always been famous for its bird species. Observations have showed, however, that although many species regularly occurs in the area, many do not colonise the marsh system as a breeding species. The bird species in question are protected or strictly protected species in Hungary and are listed on Annex I of the Birds Directive of the EU, primarily birds of prey (e.g. Imperial Eagle *Aquila heliaca*, White-tailed Eagle *Haliaeetus albicilla*, Long-legged Buzzard *Buteo rufinus*, Saker Falcon *Falco cherrug*), but they also include species that require large undisturbed tracts of complex habitats including fallow or arable land (e.g. Great Bustard *Otis tarda*). The chances of (re)colonisation of these species may be enhanced by increasing their food base that consists mainly of small mammals, e.g. by extensively cultivating several crops in small areas close to the potential nesting sites. Extensive (chemical-free) croplands can also provide favourable feeding sites for other protected, strictly protected or Annex I birds (e.g. waterbirds: ducks, geese; shorebirds: sandpipers, plovers; cranes), which visit the area on migration. To benefit all these species, we have cultivated 170 ha. arable lands extensively, without any use of chemicals, to enhance the populations of small mammals and to provide a food base for raptors (small mammals as prey) and for waterbirds (fresh plant growth during fall migration).

The main block of extensive croplands was located west from Meggyes-forest, a nesting site for several raptor species. On these lands, alfalfa, corn, sorghum, millet, sunflower, winter rye, pea, wheat and barley, were grown in 100-m-wide stripes. In the remaining area, we determined the crops to be sown every year based on a traditional crop rotation scheme.

The extensive croplands greatly aid the reintroduction programme for the Grey Partridge (*Perdix perdix*), that has been ongoing in the marsh system since 2004.

In the area of the extensive croplands, the population of rabbits (*Lepus europaeus*) has increased considerably.

The effect of extensive cultivation was studied by comparing the small mammal fauna of extensive and intensively cultivated croplands that were neighbouring the extensive lands from outside the protected area. Small mammals reached significantly higher species richness and density one year after the start of extensive cultivation than in intensively cultivated lands with similar crops. The highest difference was between corn fields, mostly due to the very high proportion of Steppe Mice (*Mus spicilegus*), whereas the difference was smaller in the case of wheat. The most important crop for small mammals and thus, for raptors, however, was alfalfa, in which the total density of small mammals was very high (540 individuals/ha.).

2.4.7. Monitoring activities

The monitoring of the flora and fauna of natural grasslands that are the targets of restoration is essential to evaluate the success of restoration. To this end, we conducted a baseline assessment of the flora and fauna in the areas near Csattag marsh, which included extensively used loess and alkali grasslands, meadows and marshes in an average conservation status. We detected a total of 472 species, the majority of which were arthropods (210 species) or plants (196 species). Although the species richness of arthropods is generally lower in Hortobágy than in other natural areas of the Great Plains because few species are able to tolerate the climatic extremes and frequent changes in conditions (e.g. unfavourable periods during both summer and winter, high variation in temperature and periods of flooding), the studied groups were found to be unexpectedly species-rich.

Within arthropods, spiders (Araneae, 84 species, e.g. *Pisaura mirabilis*) and carabid beetles (Carabidae, 67 species) were the most species-rich, whereas crickets and grasshoppers (Orthoptera, 31 species) and leafhoppers (Auchenosrrhyncha) and heteropterans (Heteroptera) were less speciose. Data from point counts collected as part of the baseline assessment showed that the grasslands are regularly used by 66 bird species for nesting, feeding or other life activities.

We designated permanent sampling sites and two plots (exclosures) at each site to monitor the results of grassland restoration. Exclosures served as controls where no grazing or mowing occurred to provide a reference to grazed or mowed sites. In botanical studies, we conducted phytosociological surveys and phytomass-sampling inside and outside the permanent plots.

To observe the changes following fire management carried out to reduce the homogenisation of marshes, we conducted phytosociological surveys in 2×2-m plots before and one year after the controlled burning on randomly selected points in Fekete-rét marsh. Finally, the effect of extensive cultivation of arable lands was studied by surveying and comparing the small mammal fauna of extensively cultivated lands and nearby intensively cultivated lands (outside the project area but bordering the extensive lands).

In zoological studies, we surveyed the most important arthropod groups (herbivores: orthopterans, leafhoppers and heteropterans; predators: spiders, carabid beetles) using sweep-netting (left) and pitfall traps (right) six times per year. The zoological study also included the standardised counting of birds at permanent counting points twice every year.

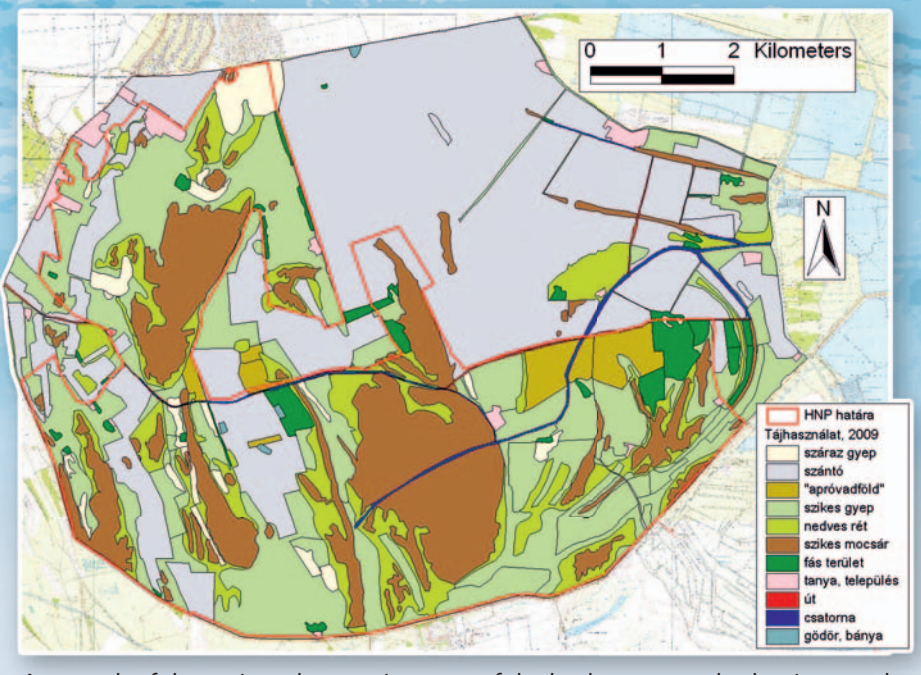
3. RESULTS AND FUTURE OF THE LIFE-PROJECT

3.1. Conservation status in 2009: A summary of the results

As a result of the second phase of the landscape-level habitat rehabilitation programme, most of the natural or semi-natural terrestrial habitat types reached a better conservation status, i.e., their status, quality, spatial connectivity and chances for long-term persistence have been greatly improved. The results suggested that grassland restoration was successful beyond our expectations. Monitoring results showed that the species composition of restored grasslands progressed towards that of the restoration targets (natural loess and alkali grasslands), and in the case of alkali restorations, it even reached the targets in only three years.

The fragmentation of grasslands has been substantially reduced, the chemical load from agricultural cultivation of arable lands has decreased considerably and continuous human disturbance has terminated in most areas. Directly deleterious effects on grasslands such as goose-farming has been eliminated, and grazing as the optimal way of grassland management has been extended to a large part of the terrestrial habitat types. The methods used for the opening up of homogeneous reedbeds (grazing, fire management) were successful, and the diversity of habitat types in Fekete-rét marsh has increased.

To enable the further favourable development of restored grasslands, it will become essential in the future to ensure the removal of the dead plant matter (litter) that is accumulating in great quantities and to enhance the colonisation of rare dicotyledonous plant species. Restored grasslands thus need to be managed primarily by grazing or by mowing where grazing is not feasible. Grazing is the preferred option because, besides removing dead litter, grazing livestock can also efficiently enhance the colonisation of rare dicotyledonous plants by bringing in plant propagula (seeds) on their body or by their feces. Grazing can also lead to a further increase in the diversity of the insect fauna and can lead to the colonisation of rare alkali nesting birds. In the rental contracts with farmers, therefore, Hortobágy National Park gives detailed instructions on the arrangements required from farmers regarding grazing and mowing activities. The monitoring of the effect of grassland restoration and the effects of grazing and mowing using field experiments will be continued from other sources.



As a result of the project, the mosaic nature of the landscape complex has increased since 2001, spatial connections between marshes and grasslands have been established and human disturbance has been greatly reduced. The areal proportions of habitat types better match those estimated for prehistoric times. The favourable changes in habitats will also be beneficial for populations of numerous protected or strictly protected species and Natura 2000 species found in the marsh system.

3.2. What will happen after the LIFE-programme?

Key to all conservation actions is sustainability into the future, for which local stakeholders, especially farmers, have to be involved by making them directly interested in maintaining the restorations and conservation management. The most relevant activity in sustaining the important results of the LIFE-programme is grazing, which is the optimal way of managing Hortobágy grasslands. To this end, we have involved several farmers and farming companies into the new grazing system. By cooperating with these farmers by favourable renting contracts and other means (e.g. supporting their applications to agri-environmental schemes), we achieved that several of them invested considerable resources into developing or extending the infrastructure for grazing and into increasing the number of grazing livestock. As a result of these efforts, farmers have become financially interested in maintaining the grazing system and eventually in providing the optimal way of managing grasslands on the long-term.

To further study the effects of restoration and management actions, we will continue and extend the monitoring system established in the LIFE-programme. The project partner, University of Debrecen, in cooperation with experts from HNPD, will continue to study the favourable changes initiated by restoration and management in the LIFE-programme in the Egyek–Pusztakócs marsh system using a research grant from the Hungarian Scientific Research Fund.

4. NATURE CONSERVATION IN THE EUROPEAN UNION AND THE LIFE-PROGRAMME

The nature conservation policy of the European Union is founded on two directives, the Birds and the Habitats Directives. The aim of the Birds Directive, adopted in 1979 (79/409/EGK), is to protect all bird species that naturally occur in the area of the member states. Annex I of the Directive lists those species for which member states are required by law to designate and protect Special Protection Areas.

The aim of the Habitats Directive, adopted in 1992 (43/92/EGK) is to preserve all plant species and all animal species other than birds, and in general, biological diversity, that naturally occurs in the area of the member states. Annex I of the Habitats Directive lists the natural habitat types of community importance, and Annex II lists threatened, vulnerable or rare plant and non-bird animal species of community importance. The Habitats Directive requires the member states to designate and protect Special Areas for Conservation. Special Protection Areas and Special Areas for Conservation together form the Natura 2000 network, which is the continuous ecological network of natural habitats of community importance and areas designated for the protection of plants and animals of community importance.

Two habitat types found in the Egyek–Pusztakócs marsh system and in Hortobágy are designated as "priority" habitat types in Annex I of the Habitats Directive: Pannonian alkali steppes (Natura 2000 code: 1530) and Pannonian loess steppic grasslands. The fundamental aim of grassland restoration carried out in the LIFE-programme was to restore an drehabilitate these two highly important habitat types.

The LIFE-programme (L'Instrument Financier pour l'Environnement) is a financial system that was formed in 1992 to financially support the environmental policies of the European Union. The LIFE-Nature programme is a component of the LIFE-programme, and it primarily aims to aid the execution of the two nature conservation directives and to protect the Natura 2000 network. The LIFE-Nature programme financially supports projects that enhance the preservation or restoration of the favourable conservation status of habitats and wild species of fauna and flora of European importance. The LIFE-Nature foundation provides 50% of the costs for conservation projects. In exceptional cases, this proportion can reach up to 75% in cases when the project targets either habitats listed as "priority" habitat types in the Habitats Directive or bird species directly threatened by extinction. Further information on the Natura 2000 network can be found at http://ec.europa.eu/ environment/nature/index_en.htm and on the LIFE-programme at http://ec.europa.eu/ environment/life/home.htm.