Master Plan
for the
Long-term Rehabilitation Programme of the
Egyek-Pusztakócs Marsh System

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1. INTRODUCTION

The rehabilitation of the Egyek-Pusztakócs marsh system is the oldest (1976-) and largest (5000 ha) habitat restoration project in Hungary. This master plan was prepared as the central background document for the long-term rehabilitation programme of the Egyek-Pusztakócs marsh system (referred to as E-Pu system hereafter). The master plan was developed by experts within the Hortobágy National Park Directorate (HNPD). The plan incorporates knowledge accumulated during the decade-long rehabilitation process and aims to provide a set of general guidelines for the entire rehabilitation programme. This knowledge is available in Hungarian in several sources (see Methods) and was used here to develop a practical framework for the long-term rehabilitation programme of the marsh system. The document therefore encompasses the currently (2005) ongoing LIFE-Nature project („Grassland restoration and marsh protection in Egyek-Pusztakócs", project ID: LIFE04NAT/HU/000119) and activities beyond the duration of the LIFE-Nature project. The master plan serves an ecologically sound set of rules for the rehabilitation process based on knowledge accumulated in recent years and on a map of potential habitats.

2. METHODS

2.1. General methods and source documents

The master plan consists of two sections. The first part is a map and short interpretation of potential habitats in the general area of the E-Pu system, and the second part is a set of general rules that serve as a basis for the development and active planning of habitat rehabilitation or reconstruction activities and for the conservation management of the habitats involved.

The potential habitat map was prepared by using written and spatial (map) information from several published sources, HNPD internal materials and personal expert contributions. The following section briefly describes the sources that were essential in compiling the present master plan and the map of potential habitats.

2.1.1. Final Report of the European Environmental Campus (1992)

The Campus was organised by the Environmental Management Workgroup of Debrecen Agricultural University and the Avignon Centre (GECE), with the support of DG XI of the European Community.

- the international team of 18 people surveyed the E-Pu system extensively (geomorphology, vegetation)
- the report (consisting of 68 pages, prepared by 11 project leaders and contributors)
  - gives a basic description of the E-Pu system (climate, hydrology, water balance, soil conditions, vegetation)
  - evaluates the then-completed hydrological reconstruction and provides preliminary plans, technical considerations and cost calculations for further hydrological reconstruction
  - presents data collected on climatic and soil conditions and vegetation on 102 pages of Appendix

- analyzes potential buffer zones around marshes and woodland areas near marshes as potential nesting sites for birds (Annex I species: herons, cranes and birds of prey), identifies the requirements, optimal design and management of buffer zones and woodland areas
- gives potential, schematic habitat maps (one general and one on each of the seven major marshbeds)

2.1.2. Management plan of Hortobágy National Park (1998-2007)

- general description of principles of nature conservation management, position paper and policy parts
- compilation of conservation needs and actions, and description of optimal management practice in the Hortobágy area, general rules
- evaluation of habitat management schemes (e.g. grazing scheme, mowing, rentals, flooding system) and development of criteria for successful management schemes

2.1.3. Sz. Gőri's Ph.D. dissertation (2001)

- review and theoretical foundation for nature management actions and habitat rehabilitation activities
- data on changes in vegetation structure and bird fauna after the hydrological rehabilitation
- demonstration of all experience and evaluation of results from the hydrological rehabilitation of the marshes
- identifying the next important steps concerning the long-term rehabilitation programme

2.1.4. Background document for the Egyek-Pusztakócs landscape-level rehabilitation

programme prepared by B. Kiss, Cs. Aradi and Sz. Gőri (2001)

This document (pp. 60) can be considered as the primary theoretical and practical foundation for the long-term rehabilitation of the E-Pu system, the main parts and contributions are as follow:

- principles of nature conservation management and habitat rehabilitation
- general description of area (geography, soil, hydrology, spatial structure of habitats, landscape values, vegetation: plant assocations, habitats)
- overview of main factors influencing the E-Pu system landscape formation before historic times and review of the history of human influences on the general area
- description of changes following the first phase of the rehabilitation of the marshes (1976-1991), colonisation patterns of plant and bird species, comparison of avian fauna of rehabilitated and other Hortobágy wetlands
- reconstruction of schematic habitat map based on military maps from 1856-66, and landscape-level ecological analysis (military surveys considered: 1783, 1855-66, 1883)
- descriptions of land use changes in the Egyek-Pusztakócs area since 1780s, comparison of conservation status in 1860s (based on maps from the second military survey) and 2001
- devising the major steps of the long-term rehabilitation programme in two steps:

        - first phase: grassland restoration (loess and alkaline/salt steppe grasslands, afforestation) to create buffer zones/ecological corridors on ca. 1530 ha (please see Maps in Section 6.) to decrease arable lands by 50%
        - second phase: restoration of spatial connections to increase the biological permeability among different parts of Hortobágy
            - to protected areas NE of general area (grassland restoration along roads and channels)
            - to marshes and wetlands to S and SE of general area to increase the quality of water supply to more southern marshes/wetlands (water-closing structures), therefore, to be able to mimick Tisza flood dynamics in the landscape to increase habitat diversity on a large spatial scale
- developing detailed plans for
        - water supply system of the marshes (semistatic marshes receiving constant water supply, astatic marshes receiving water according to fluctuations of river Tisza)
        - management to increase habitat diversity
        - management of restored habitats (grazing, mowing, reed-harvesting etc.) in general and on an individual basis
        - the next step (grassland restoration) and long-term rehabilitation (establishing landscape-scale spatial connections to SW, SE and NE directions)

2.1.5. Publication on the Egyek-Pusztakócs landscape-level rehabilitation programme by Cs. Aradi, Sz. Gőri and Sz. Lengyel (2004)

- examination of the Egyek-Pusztakócs area conservation and rehabilitation possibilities through a landscape ecological approach, with the aim of maximising biodiversity
- larger-scale (Tisza river valley) consideration of spatial connections
- overview of the strategic aims of the rehabilitation process in a socio-economic context

The above sources were used in two ways in the creation of the map of potential habitats. First, where the above sources referred to any type of scientific evidence on potential habitats in an area, the map was drawn to reflect these conclusions and we marked the area according to the evidence presented. Second, several of the above documents reached similar conclusions as to the general rules by which habitats were represented in the landscape. These general rules were based on ecological knowledge gained in the decades of research of the Hortobágy region and the general E-Pu system area. For example, it was a reasonable assumption that all areas lying lower than 88 m above sea level were marshes/swamps. We used these general rules to provide an informed estimate of the habitat in areas for which the first type of information (i.e., scientific evidence) was not available.

It is important to emphasise that the potential habitat map indicates a hypothetical status and due to the uncertainties inherent in the reconstruction of past conditions, it should be treated with caution. The potential habitat map is based on current (2005) knowledge, and all information or information expected in the future obviously could not be incorporated. The potential habitat map aims to describe the status of the area concerned in prehistoric times, before human use started to change the area. The plan is general and is not intended to show exact locations of habitats in the pre-historic times, rather, it aims to provide a reasonable estimate of the areal extent and relative spatial system of habitats present at the landscape-scale.

2.2. Interpretation and guidelines

The second part of the master plan is a collection of general statements from the above source documents and general guidelines and rules for the planning of habitat rehabilitation and management activities. Most of these statements and guidelines are either directly copied or reformulated here from the source documents, mostly from document No. 4. ("Background document"). The aim of this part is to summarise the conclusions of the source documents in a form which enables their implementation.

3. RESULTS

3.1. Habitat types and their spatial representation

According to the potential habitat map, marshes, wet meadows, and salt grasslands shared roughly equal areas in the general E-Pu system (24-28%, Table 1.), whereas dry grasslands (16.5%) and alkaline flats (4.4%) occupied smaller surface area. Patches of alkaline marshes and wet meadows were the largest (mean patch size of ca. 30 ha, Table 1.), and salt grasslands and dry (loess) grasslands were represented in smaller patches (23.5 and 11.0%, respectively).

Table 1. Area and proportion of main habitat types most likely to be present in the Egyek-Pusztakócs general area before historic times. Data are from the map of potential habitats (Figure 1.).

Habitat type	Area (ha)	% total area	Mean patch size	N
Dry/loess grassland	822	16.5	11.0	75
Bare alkaline flats	220	4.4	73.3	3
Salt grassland	1384	27.7	23.5	59
Alkaline marsh	1186	23.8	33.0	36
Wet meadow	1379	27.6	30.0	46
Total	4992	100	(Avg.:) 34.1	219

In many areas, characteristic transitional zones between wet and dry habitats were present and functioning (Figure 1., "soft edges"), however, in many other areas, the transitional zones were missing ("hard edges"). The latter was mainly true for areas in the border of the region.

3.2. Lessons learned from the potential habitat map and the source documents

3.2.1. The role of floods in the formation of the Egyek-Pusztakócs marsh system

The map of potential habitats suggested several important factors affecting the structure and composition of the landscape. However, all source documents emphasise that floods of river Tisza played the most important role in forming the landscape in the E-Pu system. According to the flood pulse concept, floods probably affected the area differently in every year. In most years, varying surfaces were covered by varying amount of slowly flooding water. Slowly flooding water did not cause dramatic disturbances, but formed a landscape and vegetation structure tolerant to slow flooding. Such landscapes included many edge-type habitats (ecotons), which have allowed the coexistence of different vegetation types (from dry grasslands to forests and marshes) in the landscape, resulting in a dynamically changing mosaic-structure of habitats and vegetation types.

Flood water spread to the area from two flood gates, one in the NW part of the area, a few hundred meters S of the present-day village of Egyek-Félhalom and another in the NE part of the area, ca. 1 km N of the present-day Meggyes forest. The floods entering the area from the NW flowed through Csattag marsh, from where three arms led to (i) Meggyes marsh to the S, (ii) Kis-Jusztus marsh to the SE and (iii) Bőgő marsh and Fekete-rét marsh to the E. The latter two connections are no longer existing because agricultural use has filled up the ancient waterways. The floods entering the area from the NE have remained mostly confined to the E part of the area, separated from the larger W side by a series of loess plateaus of roughly N-S orientation. The E part of the area was probably drained by a natural riverbed leading to the SE, whereas the W portion of the area was probably drained via Kis-Jusztus marsh to the S.

Before historic times, landscape was constantly changing due to the floodings and the settlement of various sediments, which resulted in a variable landscape consisting of riparian shoals, large alkaline flats rich in microforms and oxbows in deeper riverbeds. The main sediments carried by floods were large-grained blue sand (deposited in peripheral areas mostly in the northern parts, where floods entered the area) and riparian loess or clay in the largest part of the area (deposited usually on higher river shoals), whereas water slowly spreading to flats and marshes deposited fine-grained meadow clay. These effects led to the formation of relatively high (8-10 m) elevational differences. After floods retreated during summer or in dry (no-flood) years, the water balance differed by the grain size of sediments deposited. The water balance became more evaporative for soils of larger grain sizes, and formation of alkaline microforms took place in sandy and loessy areas as well as on alkaline flats. The operation of the above factors led to a landscape rich in elevational differences, unlike in most of the "classic" Hortobágy, where landscapes are invariably flat.

3.2.2. Dry habitat types

The higher grounds (ca. 91 m in northern part, 90 m in southern part) were not or only rarely reached by floods, soil formation resulted in loess-based black ('tchernozjom') soils, which, together with the dry and hot climate, resulted in the appearance of dry grasslands. Most of these higher grounds were probably covered by loess grasslands (main plant association: *Salvio nemorosae-Festucetum rupicolae*, some important genera: *Verbascum*, *Linaria*, *Thymus*, *Dianthus, Phlomis*, *Taeniatherum* spp. etc.). On soils other than loess, local soil conditions determined the dominant vegetation type. Many of the higher grounds are also characterised by high alkalinity, and transitional vegetation types between loess and alkaline grasslands probably occurred in such areas. On alluvial sandy areas on the periphery (NE part of area), sand grassland associations (e.g. *Potentillo arenariae-Festucetum pseudovinae*) were present to a smaller extent. Other types of dry grasslands also may have been present in the area. Such grasslands are also influenced by climate and water balance, e.g. soil humidity decreases dramatically with elevation, and on high loess plateaus (> 91 m), water efflux and evaporation limits the growth of more complex vegetation types (e.g. forests).

The areas slightly below or surrounding loess plateaus (between ca. 89 and 90 m elevation above sea level) were also dry most of the year but were more influenced by salinity due to an evaporative water balance. On such areas, alkaline grasslands occurred probably (main plant association: *Achilleo-Festucetum pseudovinae*). This habitat is and probably was characterised by different varieties of the main plant association.

In very flat areas, flood water spread out and receded only slowly from the area. The small-scale (few cm) differences in elevation in such areas led to different erosion patterns and enabled the formation of microforms, i.e., shoulders, small plateaus, ridges and slopes, with elevation ranging from a few cm to 40-50 cm. These alkaline flats with diverse microforms also showed a highly complex mosaic of plant associations. For example, at the erosion base, at elevations often covered by water from floods, snowmelt or precipitation, *Puccinellietum limosae* are found, whereas *Camphorosmetum annuae* is characteristic in or near bare alkaline surfaces, and *Pholiuro-Plantaginetum tenuiflorae* on the slopes of the microforms. On top of the microforms, usually some variety of alkaline grasslands (*Achilleo-Festucetum*) are to be found.

Most observations suggest that two types of forests may have been present in the area before historic times. First, in areas where actively flowing water was bordered by higher grounds, e.g. near wet meadows and marsh edges, riparian softwood gallery forests *Salicetum albae-fragilis*) were present, representatives of which are also found in some parts of the general E-Pu system area. On slightly higher grounds ancient riverbeds, riparian hardwood gallery forests, e.g. forests dominated by *Quercus*, *Fraxinus* and *Ulmus* spp. may have been present. Second, on drier, higher, but not on the highest loess plateaus, loess steppic forest *Aceri-tatarico Quercetum* or loess shrub *Amygdaletum nanae* may have existed. However, the area of this forest type has probably been limited because on higher grounds, a drier type of water balance may not be suitable for the formation of loess steppic forests.

3.2.3. Wet habitats

In lower-lying areas (between ca. 88 and 89 m), varying degree of water cover for varying duration in the year resulted in large surfaces covered by wet meadows. The area of wet meadows probably fluctuated considerably according to precipitation differences among years. These areas were the transitional zones between grasslands and marshes, with usually gradual change in both directions (edge-effects and ecotone-type habitats). Wet meadows often appeared in tussocks, main plant associations are *Agrostio-Alopecuretum pratensis*, *Agrostio-Eleochariti-Alopecuretum geniculati*, *Agrostio-Beckmannietum*, and *Agrostio-Glycerietum poiformis*.

Low-lying areas (< 88 m) were covered with water during considerable duration throughout the year. Depending on geomorphology, stagnating or slowly moving water occurred in such areas. In areas with no or little natural slope, stagnating waters led to the formation of marshes. In deepest parts, where water cover was present throughout the year, eustatic marshes were present. Eustatic marshes, however, are not characteristic to the area, and could probably be found only in the deepest part of Hagymás marsh. In slightly shallower areas, water cover was present during most of the year. Depending on the nature of water coverage, semistatic or astatic marshes were present in the area.

Semistatic marshes are larger, deeper marshes, including, for example Meggyes marsh and Fekete-rét marsh. These were characterised by constant water supply either from nearby areas or ground water even in years when floods did not reach the E-Pu system. Semistatic marshes dried out only in the driest years and contained mostly reedbeds *Scirpo-Phragmitetum* interspersed with open water surfaces (characterised by species in the following genera: *Nymphaea*, *Salvinia*, *Nymphoides*, *Stratiotes*, *Trapa*, *Utricularia*, *Ceratophyllum*, *Myriophyllum*, *Potamogeton*, *Lemna*, *Hydrocharis* spp. etc.). Semistatic marshes were surrounded by a characteristic pattern of zonation. Reedbeds/open waters were surrounded by various forms of wet meadows, and alkaline grasslands took over with increasing elevation. The transitions, however, depended on shoreline geomorphology. On slightly grading slopes and long, flat shorelines, the transitions were wide and heterogeneous (soft edges), whereas in areas where elevation differences were substantial within a short distance, e.g. where marshes were bordered by loess plateaus, transitions were sharp and sudden.

Astatic marshes are smaller, shallower marshes located in natural depressions. Astatic marshes in small natural depressions usually fill up and dry out several times during the year. Because of the extreme conditions, usually the entire area of astatic marshes can be considered as a transition zone, resulting in a rather species-poor vegetation, consisting mostly of *Bolboschoenetum maritimi continentale*. Due to the small extent and sudden changes in water cover, there is no characteristic zonation surrounding the astatic marshes.

In areas where large volumes of flood water was not held back by more compact soils, or where naturally grading slopes occurred, the interaction between geomorphology and hydrological effects created slowly flowing ‘rivers’ of flood water. The remnants of such ancient riverbeds/waterways can be well recognised on the map of potential habitats as well as in the field. These waterways led water to, through and from the area. When water supply was cut off at the time of the regulation of river Tisza, these waterways probably became similar to oxbow-lakes found currently along river Tisza (as close to a few hundred m from the general E-Pu system area). Later, with the drainage and/or natural drought, these water bodies began to be filled up, changed to marshes and later to wet meadows through succession. Many of the ancient waterways can thus be recognised currently as irregular stripes of wet meadows.

3.3. Summary of the most important human influences on the area

This section provides a more or less chronological description of the most important human influences and presents how these influences modified the landscape in the general E-Pu system area.

On the area of the potential habitat map, 23 kurgans (mounds of earth collected nearby) were built by nomadic tribes as sites of worship or burial sites, which became covered by dry grasslands, and by loess grasslands in several places. Some of these kurgans hold degraded remnants of loess grasslands aimed to be restored in the long-term rehabilitation programme.

Forests were felled in the 16th and 17th centuries, when nearby villages paid their taxes to the Ottoman Turkish empire in the form of wood. Turks mostly used wood for military purposes, e.g. to strengthen fortresses). As a result, very small patches of forests of varying states of naturalness have remained in general area.

Loess grasslands (soils of highest quality) were broken up and used as arable lands after Turks left the area and some of the villages were revitalised by the settlement of peasants from other parts of the country. Most of the current arable lands were used as such as early as in 1856-66 (e.g. arable lands in 1856-66: 3400 ha, in 2001: 3650 ha).

The slowly increasing human population in the area had a progressively larger influence on the area. The most important of this influence was the gradual drying of the area, outlined as follows.

1. Árkus channel was constructed before 1850, draining Hajdú-fenék marsh and the SE part of area.
2. Tisza river regulation took place in the 1860s, eliminating the most important water supply to the general area.
3. The construction of drainage canals for diverting inland water from areas for agriculture started in the early 1900s.
4. An active drainage programme of the marshbeds took place between 1930 and 1950.
5. The Egyek area melioration programme (1970-1980) to improve conditions for agriculture (construction of further drainage ditches) took the last blow to natural water supplies.

The drainage of waters collected by the wet meadows and marshes had two deleterious effects on natural habitats. First, the total surface area covered by wetlands decreased. Second, ecotons (‘positive edges’ or transitional zones between marshes/wet meadows and grasslands) decreased even more, resulting in a less complex shoreline more vulnerable to drainage and chemical pollution.

According to reconstructed habitat maps in the source document in 2.1.4., marshes occupied ca. 1700 ha in 1856-66, and 1140 ha in 2001 (33% loss). The retreat of marshes was followed by the retreat of wet meadows and much of such lands were started to be used for agriculture. During this process, spatial connections between marshes were lost, filled up by farmers, and arable lands began to border marshes. Wet meadows were drained and also used for agriculture, rest of the former wetland area became grasslands (which have increased from 1700 ha in 1856-66 to 2100 ha in 2001).

It is important to mention that marsh-meadow edges have also decreased, and decreased proportionally more than the area, because shorelines became straighter/less complex (e.g. shoreline complexity index decreased by half between 1856-66 and 2001), which contributed to the decrease of habitat diversity.

The intensive agricultural use of the area in the 1960s and 1970s further decreased the natural values, e.g. through physical compaction of the soil by large machinery, through runoff and infiltration of chemicals from arable lands to the marshes due to the loss of wet meadows as potential buffer zones.

4. DISCUSSION

4.1. Conclusions with relevance to the long-term rehabilitation programme

In spite of of human influence on the area, the E-Pu system is special because the habitat types characteristic to Hortobágy and the remnants of the once extensive floodings are concentrated in a relatively small and geomorphologically diverse area. This also explains the high general diversity of the area, even though most of the plant associations are degraded and are less diverse than their counterparts in less affected areas.

One important conclusion from the potential habitat map is that current (European and Hungarian) practice to manage habitats by land parcel numbers or as „a marsh” or a „forest” is ecologically unsound here because then the naturally dynamically changing elements of the landscape structure are held within strict constraints. By doing management based on land parcel numbers, we eliminate the dynamic natural changes, natural extension and retreat of natural systems that are inherently important in the maintenance of the habitat complex. Constrained management also eliminates the transitional zones among natural habitat patches, which are very important in ecological processes as migration routes, corridors for interior-preferring species and potential stages of adaptations.

The aim of the long-term rehabilitation programme, therefore, is to restore the E-Pu system to a stage when all of the habitats are in their respective favourable conservation status and the ecological processes that once formed the landscape are at least partly operational and maintain or enhance the diversity of habitats. Such ecological processes include succession (ideally, all potential stages should be present within a succession series) and natural disturbance regimes, which need to be imitated by an optimal management regime. The imitation of pre-historic disturbance regimes, e.g. by the creation of transitional/buffer zones and ecological corridors, grazing grasslands and marshes, burning of marshes etc., several succession stages can be maintained in the area, therefore, the ecological processes that once formed the natural habitats can be restored to some extent. By achieving these goals, it will be possible to increase the resilience of the landscape to external effects (e.g. global warming).

Based on the above, the general immediate aim is to significantly decrease the area of arable lands, and increase the proportion of marshes, meadows, forests and loess grasslands. The long-term rehabilitation plan devised would provide a new approach to habitat restoration because the plan handles mosaic systems structurally and operationally as one unit, allowing for the dynamic changes that have once formed the landscape among and within the components, and would implement an integrated management of the components.

Based on the above, the most necessary immediate steps in the long-term rehabilitation are as follow.

Ecological corridors need to be restored. For example, spatial connections between Csattag marsh and Meggyes marsh (Ecological corridor 1), Csattag marsh and Kis-Jusztus marsh (Ecological corridor 2) need to be established again by eliminating arable lands, restoring grasslands and/or wet meadows in the natural depressions linking the target marshes.

Buffer zones should be established around rehabilitated marshes. In such zones, plowing should be eliminated in at least a 50 m zone in all arable lands neighbouring wetlands. In areas where plowing is eliminated, grasslands or, depending on the area, wet meadows should be restored that can provide an adequate buffer zone against infiltration from arable lands. The transformation of arable lands to grasslands is also important for the water supply for the marshes, e.g. more runoff water will reach the marshes if they are bordered by grasslands rather than by arable lands.

Most of the marshes/wet meadows that can be restored in the area have already been restored in the first phase of the long-term rehabilitation programme. Due to constraints by land ownership, etc., even after the hydrological rehabilitation, only 10-12% of the areas regularly covered by water (area of wet meadows combined with marshes on the potential habitat map) could be restored. The optimal management of these rehabilitated wetlands is to imitate the natural fluctuation of water levels (flood pulse concept) as far as possible.

It is important to see that arable lands have special importance in maintaining food sources for waterbirds (winter wheat/corn for migrating cranes, geese, ducks), for birds of prey (small mammals, rabbits, pheasants, quail etc. for eagles, falcons, harriers), and for other forest-steppe birds (orthopterans, other insects for rollers, shrikes etc.). Therefore, it is important to maintain such lands on the long term in areas where they contribute to providing food sources for target birds. However, all of these lands should be cultivated extensively, without the use of chemicals and with small machinery.

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6. MAPS

Figure 1. Map of potential habitats in the general Egyek-Pusztakócs area. Area for the Egyek-Pusztakócs LIFE-Nature project is shown in red.

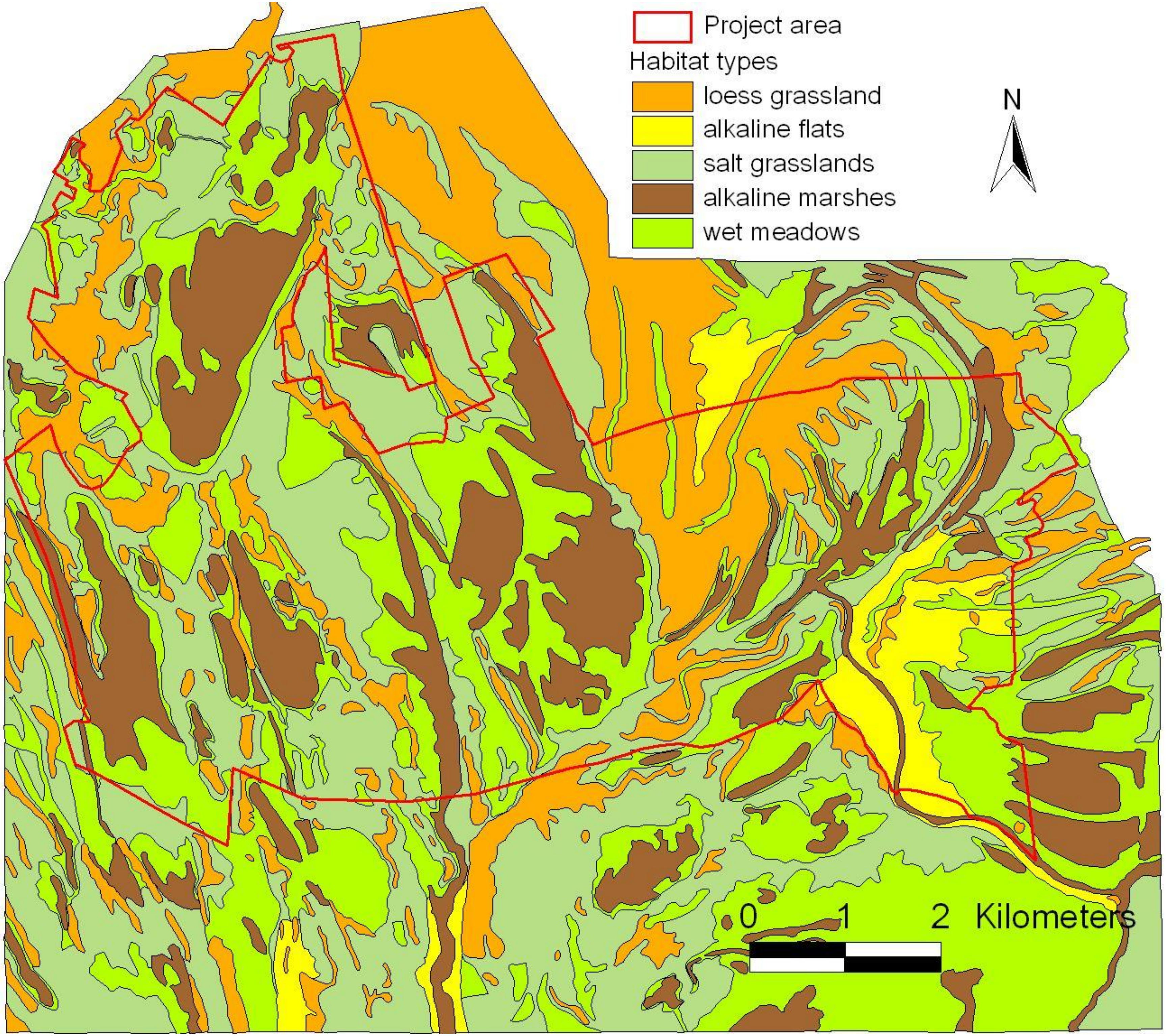

Figure 2. Map of potential habitats in the project area of the Egyek-Pusztakócs LIFE-Nature programme.

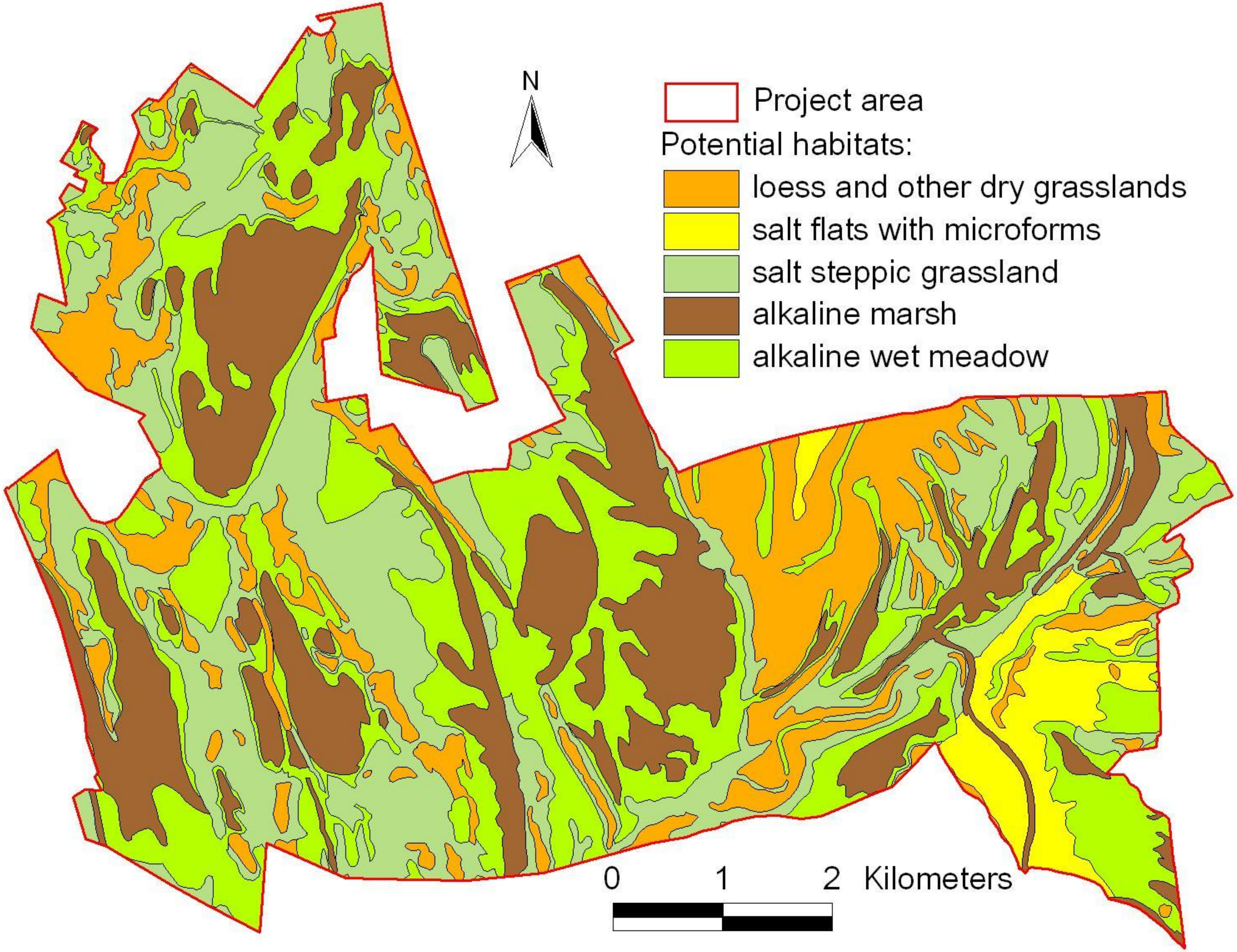

Figure 3. Map of potential habitats in the project area of the Egyek-Pusztakócs LIFE-Nature programme with potential wooded areas.