A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfilment of the Degree of Master of Science

Protecting green spaces: Identifying areas for protection in Felsőrákos meadows (Budapest, Hungary) through habitat mapping

Lea VÉGH

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Lea VÉGH

CENTRAL EUROPEAN UNIVERSITY

ABSTRACT OF THESIS submitted by:
Lea VÉGH
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The importance of urban green areas is increasingly recognised by international organizations as part of the sustainable development concept. Due to the growing tendency of urbanization, by 2050 around 70% of the human population is expected to live in cities. Urban green areas, such as parks, riversides, and meadows significantly contribute to the quality of living conditions. These aspects are examined in the case of the Felsőrákos meadows at Rákos stream (Felső-rákosi rétek – Budapest, Hungary), which is one of the largest green area on the Pest side of the city. These fields originally belonged to the floodplain of the Rákos stream, but after the stream became regulated they lost their annual water cover and were used for hay production and grazing. In recent years the area became neglected and spontaneous renaturalization took place. The present study identifies the different habitat types of the area and their naturalness through field observation and aerial photography. The location of protected plants, invasive species and illegal landfills is also surveyed. Based on the findings, recommendations are made for the designation of protected areas in the Felsőrákos meadows to restore and preserve the natural conditions and prevent harmful activities in the area. The study is intended to provide assistance to municipal decision makers in developing their future concept of the environment of Rákos stream.

Keywords: urban green areas, ecosystem services, habitat mapping, conservation

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List of abbreviations

ÁNÉR	General National Habitat Classification System
CBA	cost-benefit analysis
UGA	urban green area
UHI	urban heat island effect
WFD	water framework directive
WTP	willingness to pay

Habitats:

Ab1	Euhydrophyte vegetation of rivers and channels with flowing water
B1a	Eu-and mesotrophic reed and Typha beds
B5	Non-tussock tall-sledge beds
D2	Molinia meadows
D34	Mesotrophic wet meadows
E1	Arrhenatherum hay meadows
H5a	Closed steppes on loess
OB	Uncharacteristic mesic grasslands
OC	Uncharacteristic dry grasslands
OD	Stands of invasive forbs
OF	Ruderal tall-herb vegetation
P2a	Wet and mesic pioneer scrub
P2b	Dry and semi-dry pioneer scrub
RA	Scattered native trees or narrow tree lines
RB	Uncharacteristic or pioneer softwood forests and plantations
RDb	Non-native deciduous forests and plantations mixed with native trees
P3	New afforestations
S1	Robinia pseudoacacia plantations
S2	Populus x euramericana plantations
S6	Spontaneous stands of non-native trees
S7	Scattered trees or narrow tree lines of non-native trees
T3	Vegetable and flower plantations, greenhouses
T6	Extensive arable lands
T9	Gardens
T11	Nurseries, Salix viminalis plantations
U8m	Streams-artificial
U9d	Standing waters- pool
U10	Farms

1. Introduction

The importance of urban green areas (UGA) became well recognized in the past decade. The concept of sustainable development and sustainable cities put forward other values than only industrial and economic development, and emphasized the need of ecosystem services for the cities, or more exactly, within the cities. UGAs provide many benefits to the urban population: they generate cooler microclimates around themselves (Landsberg 1981), and are often part of the windtunnels which vent citycenters (Alföldi and Kovács 2008), hence they reduce smog. They also decrease the concentration of dust particles in the air, further enhancing air quality (Bolund and Hunhammar 1999). Urban parks and forests have better water retention abilities than roads and buildings, therefore they lessen the impact of heavy rains, so reducing the risk of channel pluggage and back flow (Zhang *et al.* 2012). They provide green space for pastime activities, or just a relaxing environment for children and adults alike, their health improving effects are proven by studies (Takano *et al.* 2012). Last but not least they are home to several plant and animal species, and usually create connections between the inner areas and the surrounding environment of the city . All of the above mentioned subjects and many others, which the study do not have time to discuss in full detail, belong to the ecosystem services group, and the benefits they create indirectly are more than enough to justify the presence of UGAs in the cities.

However, UGAs are often threatened by industrial developments or estate projects, as selling them would bring a lot of money to the city or municipial authorities (Tombácz 2002). These options are even more appealing, if the area is neglected. The presence of invasive species and illegal landfills not only diminish the aesthetics of the area, but also exude absence of safety. Local people may lose contact with the area and do not value its adventages until it is already sold and built in.

This may be the case with one of Budapest's biggest urban green areas, the Felsőrákos meadows (Figure 1). Felsőrákos meadows fulfill almost every role listed above, or more exactly, has the capacity to fulfill every one of them. The importance of the area has not gone unnoticed by decisionmakers, however the needs of the meadows only received a low priority in the past, therefore the area reflects a neglected feeling, and has become a place of illegal and environmental degrading activities. In its present state it cannot satisfy the needs of the majority, although many inhabitants still visit the better quality parts, and actively enjoy the hidden opportunities.

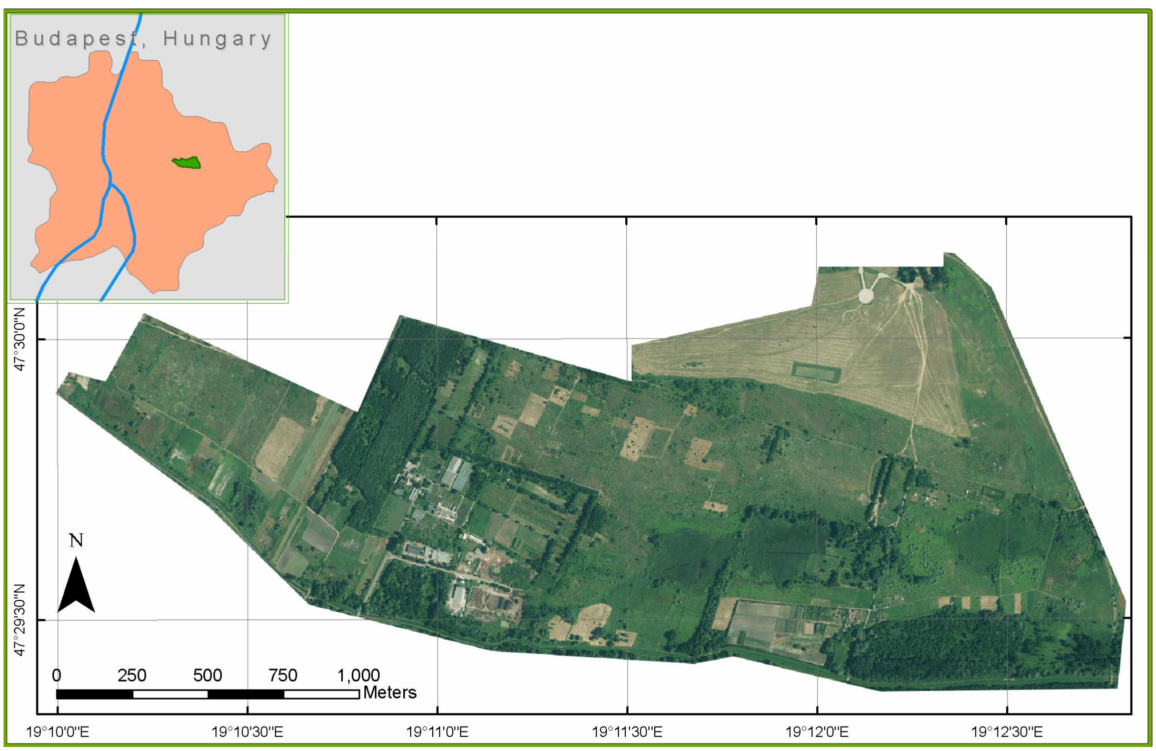

Figure 1 Aerial photograph of the study area, Felsőrákos meadows
From the southern side the Rákos stream border the study area
Source: Institute of Geodesy, Cartography and Remote Sensing

This study examines the situation from the ecological aspect of Felsőrákos meadows, and identifies incentives which would help to place the area under protection and save it from build-in investments. The up-to-date nature of the study is supported by the recent competition of the 10th district, which aimed to find the best renaturalization and park scheme for the future, and by the local community movements which aim to save the area from building projects. Another factor is that no detailed habitat map of the area was made in the past 10 years. Therefore a current map will show the present conditions, such as where are good quality habitats and patches of protected- or, on the contrary, invasive species. It will also help to see the changes compared to the past: to decide whether the area is improving or decreasing in terms of ecosystem health.

Therefore, the **aim** of the study is to identify areas worth protection in Felsőrákos meadows with the help of a new habitat map, and recommend future maintenance plans for the study area. The detailed **objectives** are:

1. Identify the different habitats of the area
2. Identify protected and invasive species found in the area
3. Survey the approximate quantity and quality of illegal dumping sites in the area
4. Explore ownership data of the area
5. Make recommendations for the future.

Completing these objectives, the study will find the answer to the question: which areas should be placed under protection in the future and what kind of maintenance plan is needed to enhance the ecosystem services of the Felsőrákos meadows.

These goals will be reached by field observations complemented with remote sensing techniques. Vegetation and human impacts will be surveyed during walks in the area, and habitats will be identified according to the General National Habitat Classification System of Hungary (ÁNÉR, Bölöni *et al.* 2011). Aerial photographs of the Felsőrákos meadows will be used to deduct assumptions about the history and characteristics of the area.

The study argues that there are good quality areas in Felsőrákos meadows, whose protection and renaturalization would improve the living conditions of both the inhabitants and wildlife. The results will be submitted to the relevant municipalities and organizations to provide support in their decisions concerning the Felsőrákos meadows.

2. History and importance of urban green areas

In the following chapter the recent and past literature will be discussed about urban green areas and their ecosystem services. Starting with a more general overview, and focusing on Budapest in the end, all the major services will be described, stating their importance in sustainable city planning. Afterwards past research on the Felsőrákos meadows will be reviewed, along with the opinion of municipalities and local inhabitants.

2.1 Urbanisation and city parks

The world population is becoming more and more urbanised. In the past 20 years there has been a one billion increase in the number of people who live in cities, and by 2050, 70% of the world population (estimated to be nine billion at that time) is projected to live in urban environments (UN 2012). Big cities, such as the capital of Hungary, are more attractive due to their rich social and economic life, but at the same time, the majority of people value higher and higher a healthy environment for their homes (Tyrvänien *et al.* 2007). Due to this reason the agglomerization area is increasing, creating longer distances to cover during the daily commute to work, which requires energy and has a bigger CO_2 emission (Metz 2010). Big, modern cities are not functioning sustainably at present (Tombácz 2002). Therefore, it is essential to create liveable cities appealing for people. One of the most important factors for this is the proximity and extension of urban green areas, such as city parks or playgrounds (Berényi *et al.* 2008; Tombácz 2002; Elkin *et al.* 1991).

In Europe and America the 18-19th century was the golden age of founding big city parks, such as Hyde Park in London, Central Park in New York, Népliget in Hungary (Sherer 2006; Balázs n.d.). Not surprisingly, this was also the age of increasing urbanization and the foundation of big metropolises. These parks were supposed to replace the sense of nature in cities and be accessible by poor and rich alike, thus also promoting equality among their visitors (Sherer 2006). During the 20th century, the role of city parks decreased and they often were associated with poor safety (Lyytimäki *et al.* 2008) and limitation of good investments (Sherer 2006). Big estates and industrial constructions took over some of their areas due to the growing pressure to cater for cities' needs. In these past decades however, urban green areas (UGAs) have come back into the spotlight, and there are a number of studies which urge the incorporation of urban green planning (Yli-Pelkonen and Niemelä 2005; Niemelä 1999; Elkin *et al.* 1991) in the creation of sustainable cities.

Other researchers, however point out that public green areas have negative effects beside the positive ones. Lyytimäki *et al.* (2008) highlight that green areas may be pollen sources, negatively impacting allergic people, and Dunn (2010) mentions snake bites, pathogens and other factors as potential threats of parks. These so called *disservices* are in sharp contrast with the opinion of Bolund and Hunhammar (1999) and Chiesura (2004), who argue that the positive effects of urban green areas are still neglected, and should be given more attention.

2.2 Ecosystem services of urban green areas

2.2.1 Provision of general well-being

Green areas within the city, beside providing aesthetic pleasure and recreation for inhabitants, also play a serious role in the regulation of the physical characteristics of the city. They reduce air pollution by filtering out the dangerous particles from traffic exhaust gases or other types of pollutants (Bolund and Hunhammar 1999) and the vegetation cover is also capable of stopping or lessening the impacts of dust-storms (De Ridder *et al.* 2004; Kuttler and Strassburger 1999; Elkin *et al*. 1991). The walls of houses and roads increase the temperature within towns, a phenomenon called *urban heat island effect* (UHI, Landsberg 1981) which often makes life miserable during hot sunny days. However, parks are capable of decreasing the run-off time of water in cities and this helps to generate a cooler microclimate in the area (Zhang *et al.* 2012; Oliveira *et al.* 2011; Hamada and Ohta 2010; De Ridder *et al.* 2004; Gómez *et al.* 2004; Elkin *et al*. 1991). In addition, well-structured green areas enhance the ventillation capacity of cities providing wind tunnels to neighbouring areas (Alföldi and Kovács 2008; Deák 2002). In contrast to this, some research emphasizes the positive effects of UHI: Unger (1999) observed that there are more ’beergarden’ days within the city than in rural areas, thus inhabitants may prefer warmer conditions in towns to chill out with a drink.

The perception of urban green areas (UGAs) by the inhabitants is mostly positive: studies show that green areas improve the satisfaction of inhabitants and strengthen social bonds in the community (Arnberger and Eder 2012; Seeland *et al.* 2009; Berényi *et al.* 2008). Although not every inhabitant agrees on the degree of naturality required within an area, almost every participant in a Finnish study named the quality of nearby green areas as one of the important factors of why they like to live in their homes (Tyrväinen *et al.* 2007). In addition, Arnberger and Eder (2012) showed that green spaces increase the level of inhabitant attachment to their closer community, although their preference in terms of the level of wilderness is varied. Other studies examine the relationship between citizens' health and their access to UGAs, and found that there is a positive correlation in the longevity of people and proximity of green areas (Takano *et al.* 2002; de Vries *et al.* 2003).

2.2.2 Ecological role of city parks

Urban green areas (UGAs) also act as suitable habitat patches for wildlife, and play the role of ecological corridors connecting natural areas. However, opinions vary in this latter aspect: according to Beier and Noss (1998) there are not enough and well designed studies to prove the positive effects of corridors, although they agree that UGAs probably are beneficial. Moreover, Hobbs (1992) and Simberloff *et al.* (1992) argue that there is not sufficient evidence which would indicate the money and efforts spend on connecting natural areas. In contrast, other researchers state that even if UGAs do not play a significant role as ecological corridors, their positive effect on biodiversity conservation is unquestionable (Yli-Pelkonen and Niemelä 2005; Breuste 2004; Niemelä 1999). Often UGAs contain rare habitats or species, explains Niemelä (1999), which are worthy of protection in themselves. She also explains, that high diversity of UGAs is a key element of their resilience, which in the anthropogenic, highly disturbed environment, is necessary for their survival. The fragmentation of city parks, and their elevated temperature due to the urban heat island effect, may even have a beneficial role on certain species distribution and well-being (Gilbert 1989), which stands in contrast to the general belief that UGAs are in every case only degraded habitats. Snep *et al.* (2006) further support this argument by stating that butterflies, bats or birds can easily move between fragmented green areas, thus not suffering from the negative effects of fragmentation.

2.2.3 Valuation of urban green areas

These days more and more design plans take into consideration the benefits of UGAs in city planning. Yli-Pelkonen and Kohl (2005) argue that the opinion of local people should be considered since they have valuable personal knowledge about the areas close to their homes. This idea is also supported by Tóth (2002) in the case of Budapest. He argues that green spaces have to be preserved, and local people have to be involved in every stage of this process. This approach may be beneficial, but has to be treated with care. The valuation of urban green areas is extremely difficult, as usual cost-benefit analysis (CBA) cannot take into account all relevant information. Local knowledge may help to add non-monetary value aspects to the CBA, but if people are asked to put a price on the maintenance of urban green areas, they are likely to have lower willingness-to-pay (WTP, Munda 1996). Contingent valuation or contingent ranking may be better options to ask for public opinion (Bateman *et al.* 2006; Tyrväinen and Väänänen 1998). People around the Felsőrákos meadows behave the same way: they appreciate the benefits of the UGA, but, apart from a few exception, still undervalue it in monetary terms.

2.3 Urban green areas in Budapest: the Rákos stream and its surroundings

In the past less attention has been paid to green areas within Budapest than has been required (Alföldi and Kovács 2008), although historically one of the first public parks in the world, the City Park, was established in Budapest, and later on other green parks, such as the Népliget, were also created (Balázs n.d.; Főkert n.d.). A regulation from 1978 stated that every citizen of Budapest should have 7-10 m^2 green area/person within the boundaries of Budapest (Faurest 2008). Although this goal is approximated year by year, there are big differences in the proportions within districts (Tombácz 2002), and some formerly pleasant parks have become neglected and dirty (Balazs n.d.).

The study area of the present study, the Felsőrákos meadows (Figure 1), are under the authority of the 10th, and 16th district, and besides providing quality recreational possibilities in some parts, it also hosts numerous illegal dumping sites, which lessens its former role. Due to its oblong shape, it may provide free time activities to inhabitants from farther parts of the city (Deák 2002), especially if the planned bicycle route will be built along the stream, connecting it into the circulation of Budapest (Hegedűs pers. comm.).

The study aims to attract attention to the ecosystem services provided by the Felsőrákos meadows, and suggest ways to maintain them and increase their quality. The area is one of the biggest green areas of Budapest, and positioned on the Pest side, where hardly any other natural areas can be found, which also increases its potential. It regulates the nearby areas' microclimate, gives a cooling effect during the summer, and even in its present, neglected state people often visit it for running, dog walking, cycling and other leisure activities (Deák 2002).

2.4 History of the Rákos stream

The Rákos stream is 44 km long and its source is in the hills of Gödöllő (Oross 2002). It is one of the longest left side tributaries of the Danube in Pest county, it has 185 km^2 watershed (Fodor 2003), and has played an important role in the life of local people over the centuries, providing power for mills and threat of floods at the same time.

The name of the stream (Rákos, rák= crab) originates from the fact that its spring was so clean that many crabs were observed in the water (Oross 2002). The river was well known for its purity and rich fish, eels and turtles (Oross 2002), but nowadays its quality is bad or neutral, especially within the territorial boundaries of Budapest (Deák 2002; Fodor 2003). The stream follows the general characteristics of the nearby small rivers, i.e. it flows from north to south in its upper part, then turns into west, and continues to flow in a slight north-west direction until it joins the Danube at Vizafogó. Approximately 22 km of the stream flows within Budapest (Deák 2002, Desics *et al.* 2000).

The history of the Rákos was studied by Oross (2002), who describes the stream as one which nourished several little ponds and wetlands, and accommodated a lot of mills along its course, and provided ice during winters. The adjacent fields were not suitable for agricultural cultivation as the stream often flooded the area, but they were used for grazing and hay production. From 1277 until 1540, 35 parliamentary sessions were held on the Felsőrákos meadows (Oross 2002), so the fields played an important role in Hungarian history as well. According to Oross, the first regulating works were done in the 18th century on the Rákos within Pest boundaries, and at the beginning of the 20th century the whole stream bed within Budapest got regulated and covered by concrete blocks to prevent erosion and floods in the area. He reports that the water of the stream was used for artificial fisheries, to fill up the lake of the city park and to provide irrigation for the nearby areas.

2.4 Ecological role of the Felsőrákos meadows

Not only humans, but animals and plants also benefit from the existence of the Rákos stream and surrounding meadows. Although the stream is entirely regulated within Budapest (Oross 2002), several of its little tributaries managed to maintain some smaller wetlands and ponds in the area (Deák 2002). These wetlands were the scene of the discovery of the Hungarian meadow viper (*Vipera ursinii rakosiensis*) in 1893 by Ottó Hermann, the famous Hungarian ecologist (Conservation of the hungarian meadow viper n.d.), and even today hides some highly protected and rare species in the less disturbed meadows.

Birds, reptiles, anurans and some larger mammals (fox, deer, etc.) inhabit the area regularly. Due to the high N_2 content of the stream itself, and its fully concrete covered sides, the aquatic life is not so diverse (Törő 2002), but the smaller lakes accommodate pond turtles and different frogs and toads, and on the stream ducks can be also seen.

The area is home to some protected and rare wetland species, and also characteristic species of Molinia meadows was found in the area by the volunteers of MME[1] (Berényi 2007; Bajor 2006) This organization also carried out some maintenace work in the area, cutting out shrubs and excess reed for allowing the wetland species to fully develop (Berényi 2007). In Hungary, every fen is ex lege protected (Hungarian Law about the protection of environment 1996. LIII. 23.§ (2)), and according to the 2002 fen cataster of Hungary, two areas around the Rákos stream, not far away from the Felsőrákos meadows, are recognized as fens, therefore they should enjoy automatic protection (Bajor 2006). However this regulation is little known, and as there are no signs showing which area is protected, the majority of local people do not know what to protect, or that they should protect some meadows in the area.

To prevent the unintented degradation of valuable wetland habitats, this study will identify areas worthy for protection, and submit its findings to the relevant authorities and organizations. This will help to call attention to the present problems of the Felsőrákos meadows, and hopefully generate further actions.

[1] Magyar Madártani és Természetvédelmi Egyesület [Hungarian Bird and Environment Protecting Organization]

2.5 Major problems

2.5.1 Degradation

Sadly, the Rákos stream became famous for the negative effects of the regulation works along the river. The stream bed was cut straight and covered by concrete blocks, which completely erased the diverse environment of the bed and seriously restricted the number of species capable of adapting to this new milieu (Deák 2002; Törő 2002). Several upstream towns have flushed their waste water without any treatment to the stream up to recent times, and industrial pollution has also not avoided it (Törő 2002). Due to these circumstances, the quality of the water has declined rapidly, and although the negative effects were observed soon, no treatment was applied to moderate them.

The meadows became drier after the regulation works which caused the disappearance of several wetlands (Oross 2002, Deák 2002). In their place often invasive plants raised their heads, such as *Solidago canadensis* or *Asclepias syriaca* (Deák 2002). The natural trees of the area have been cut out almost completely. In their place artificial forests have been planted, which also caused serious habitat disruption.

2.5.2 Illegal activities

Besides the general degradation of the area, other, more stressful anthropogenic effects threaten the Felsőrákos meadows. At several places within the study area, there are illegal landfills, mostly consisting of used car parts, tyres and other equipment, but excessive green waste is not rare either (Desics *et al.* 2000). The municipalities have not taken the necessary steps to eliminate this sad proof of negligence, which may be explained by the remoteness of the area.

Another serious problem is the illegal cable burning at some spots in the Felsőrákos meadows, already described by Deák (2002). The cables contain valuable copper, which is paid by the scrap yard, but to get to the copper, the outer seal cover has to be removed. One obvious and easy way to do it is to simply burn it down from the copper. At some places the soil is entirely covered by ash and damaged by the frequent heat effects. To make matters worse, these cables are most probably stolen, and burning the seal has adverse health effects.

2.6 Past research on the Rákos-stream

In 2002-2003 the Environmental Management and Law Association (EMLA) funded several research projects in connection with the Rákos-stream. Within their program the history of the stream was explored, and the state of the stream and surrounding areas were surveyed. Deák (2002) made a detailed habitat map of the whole watershed of the Rákos stream, and made some corrections concerning the borders of the water basin. His work will be used as a comparison to the present habitat map, to detect the differences and changes over this ten year period.

Törő (2002) made a macroinvertebrate survey along the whole length of the stream and also measured the quality of water at several points. His study shows that the quality of the Rákos within the study area is categorized as bad or moderately polluted. His work is based on the River InVertebrate Prediction and Classification System (RIVPACS), and emphasizes the negative effects of the concrete blocks in the stream bed. Another report from the Budapest Sewage Works Ltd. (2009) also supports his findings, it classified the water of the stream highly polluted in the whole territory of Budapest.

The aim of the research funded by EMLA was to create a long term monitoring project for the Rákos stream, but due to the lack of funding and interest their efforts could not continue after 2002. This study, however, may follow their steps and give an update about the recent state of the Felsőrákos meadows, which may be used later by municipal decision makers. Especially the comparison between Deák's habitat map and the present one will help to show the changes in the area.

2.7 Future plans with the Rákos-stream and the area

2.7.1 Municipality

Fortunately, the representatives of the 10th district all think it is extremely important to preserve the Felsőrákos meadows as a green area, although there are different opinions as to what is the best way to do it (10th district pers. comm.). They plan to create a bicycle route along the stream to connect the outer parts of Budapest into the city circulation (Hegedűs pers. comm.). Along this route they plan to create a narrow park zone, with few artificial objects. They also announced a competition of design plans at the Corvinus University (Hegedűs pers. comm.) for this purpose. In addition, they plan to establish a memorial park at Királydomb (King's hill, Figure 23-point **E**), as according to historical evidence, the parliamentary sessions and kings choosing took place at that part of the area (Hegedűs pers. comm.; Oross 2002).

As for the 16th district, they could not provide information about the future of the Mátyásföld airfield, which was the first airport to receive international flights in 1920 in Hungary, but its role has decreased over the years. After 2000, it did not receive more flights, and became a place for model flyers. The municipality has not decided yet its fate, although they have already received petitions to pronounce it a protected area and exclude it from industrial or housing development schemes, based on its fauna and flora (Daróczy pers. comm.).

2.7.2 Local residents

At the municipal meeting of the 10th district (16 February 2012) several inhabitants were present to express their opinion about the future of Felsőrákos meadows. They all agreed that they do not want any highway or suburban railway system across or along the study area, as it would create serious pollution (noise, traffic, etc.) and reduce the quality of their living conditions. Such plans were featured in the development plan of Budapest, although the representatives stressed the point that these are only plans and it is not decided whether they will be implemented. The local residents generally agreed that they want to improve the accessibility of Felsőrákos meadows and at the same time preserve its natural features to provide space for leisure activities.

It seems that although the Felsőrákos meadows are in a bad shape, they were still able to stir up the local community for united action. As it was previously stated, urban green areas have the capacity to increase the attachment of inhabitants to their wider home. This would result in greater participation in community activities, such as voluntary waste collection or excursions. Felsőrákos meadows is in an excellent position to strengthen these attachments, via providing recreational areas, (relatively) pristine nature for hikings and at the same time preserve its natural values. This study aims to help reaching these goals, via providing a present survey of the area, noting its strengths and weaknesses to improve.

3. Methodology

In the following section a detailed description is given about the techniques and software used during the work. To begin with, the method applied for the characterization and identification of the habitats will be discussed, followed by a section explaining how the quality of the habitats were delineated. Afterwards the limitations of the chosen methodology and the efforts to minimize them will be described. Finally, the sofware package used for the evaluation and editing tasks is introduced.

3.1 Habitat mapping

The study combines the advantages of ground mapping with those of remote sensing. As the study area is small, less than 3.1 km^2, ground mapping is achievable, but as certain areas are hard to access, aerial photograph can be used to complement field observations. The appearance of the habitat types are different in aerial photos, hence conclusions can be drawn about inaccessible areas. Paine (2003) described for example that wetter areas of the grassland have a darker green color than drier meadows around. Also large, monotone areas (e.g. agriculture fields) can be identified in the aerial photo, thus assumptions of vegetation cover can be made based on ground mapping (Budd 1991).

A colored ortophoto was obtained from the hungarian Institute of Geodesy, Cartography and Remote Sensing for the study area. This picture of the Felsőrákos meadows from 2010 (most recent) provides more practical help than the forestry maps which were used by Deák (2002) for his habitat map. Although forestry maps include the proportion of different forest tree species, this feature is not useful in the study area, where natural or semi-natural forests only occur in a limited area. Additionally, two historical aerial photographs (from 1950 [id: 1950/55I/039] and 1987 [id: 1987-315/8773]) were obtained from the MoD Mapping Non-profit Limited Company, to compare the past and present state of the area. These dates were chosen for two reasons: first, photos have to be taken approximetaly 30 and 60 years ago to allow the detection of relevant changes in vegetation cover of the area, and secondly the availability of good quality photographs from the Mod Mapping Non-profit Limited Company's archive limited the choices.

Ground mapping was carried out according to Bullock (2006): after receiving the aerial photograph, the study area was divided into smaller units based on well distinguishable vegetation types (e.g. grassland, forest). These units were surveyed during May and June 2012, and according to the observed plant species and environment, their habitat type(s) was identified. For making international comparisons easier, Natura 2000 names are also displayed next to the hungarian habitat definitions.

For the habitat identification, the latest General National Habitat Classification System (ÁNÉR, Bölöni *et al.* 2011) was used, which provides the most detailed habitat descriptions of Hungary up to now (Bölöni *et al.* 2011). Although the Corine Land Cover system may be used as an alternative to this system, it is more anthropocentric, does not contain so much information about natural habitats as the ÁNÉR system. As the aim of the study is to make recommendations for the locally protected areas location and extent, the wildlife centered ÁNÉR is more appropiate for this purpose. The ÁNÉR system provides a minimum area requirement for the different habitat types separately. This, and the fact that the ÁNÉR habitat identification depends not only on the presence or absence of certain characteristic plant species and their composition with other species, but also on the type of environment where they are found (e.g. quality of neighbouring areas, soil type, general impression, etc.), makes the usual sample quadrat system (for surveying plant populations) irrelevant. As the aim of the fieldwork was to identify the habitats and define their boundaries, and not to measure species distribution across the whole area, the quadrat sampling was not used. Not only would they have not been conducive in defining borders (Hellawell 1991), but they could not have coped with the anthropogenic influences: quadrats would have been unnecessarily on an artificially planted oak forest or a ploughland. Therefore a virtual collector's curve (Colvell and Coddington 1994) were used for sampling vegetation: when no more new species were discovered in the given area, the species richness and distribution was considered well surveyed.

3.2 Naturality index

Two separate indeces were considered for this study, to measure the natural quality of different habitats. The first is associated with the ÁNÉR habitat system (Bölöni *et al.* 2011) which divides habitats into five categories, where category No.1 is the most degraded and No.5 means excellent natural state. Bölöni *et al.* (2011) provide individual descriptions of the different states to all ÁNÉR categories. The second method, a simpler index, is sponsored by the MÉTA program (Vegetation Heritage of Hungary, naturalness key), which differentiates five different habitat types only (woodland, shrubbery, grasslands, marsh-water side and ’other’ habitats). It distributes the habitats into three category (low, middle, high quality) based on a simple questionaire.

For the present study, the more complicated ÁNÉR naturality index is chosen, as it provides more categories, 5 instead of only three, thus it allows a more sensitive classification. Also it is specially designed to categorize ÁNÉR habitats, whereas the MÉTA program applied a more coarse differentiation.

3.3 Limitations of the used mapping technologies

As the research was conducted in May and June, decisions were drawn according to the observations made during this period. The study contains no information about the state of the area in other parts of the year, although monthly variations have a significant influence on the observed species (Budd 1991). Plants, whose germination or reproductive period falls outside May and June, were in many cases difficult or impossible to identify. For example this was the case with *Molinia* spp., whose presence are significant in the identification of *Molinia* meadows. Fortunately, most plants which were important for the habitat classification were easily recognisable, and in difficult cases the composition of other plant species and the observed traits of the environment provided help for the habitat classification.

Both the historical and present aerial photographs were subject to the same limitations: the pictures were taken on a particular day of the year, therefore analyses and comparisons based on them have to take into account the variations caused by seasonal or anthropogenic effects. This was made through qualitative data analyses.

As the study area is an urban green area, the presence of human activities could also not be eliminated. Certain proportions of the research area were fenced and privately owned, therefore field observations were ruled out in their case. Different maintenance practices also made life more complicated: certain areas were cut for hay production, and freshly cut areas were impossible to classify on their own. On these occasions, assumptions were made based on the similarities observed in the aerial photograph and on the adjacent habitat types. As the study was intended to be a survey, its options to minimize this factor were limited (e.g. visiting the area periodically to follow changes), which may affect its accuracy.

3.4 GIS program

During the field work the navigation and the localization of the different borders and points were made by a Garmin GPS device. At the end of each day in the field the GPS data was transferred to computer with ArcGIS software packages. The ArcGIS programs provide an excellent work place to turn the points and lines into an easily understandable, and manageable habitat map. The version used were ArcMap and ArcCatalog 9.3.1. All datasets were generated during the study, except the river network and official borders of Budapest. Rivers and lakes centerlines were downloaded from NaturalEarth data portal (www.naturalearth.com), while the official boundaries of Budapest were obtained from the Global Administrative Areas website (www.gadm.org).

4. Characterization of the habitats of Felsőrákos meadows

In the following section the findings of the study is described. First, a short historical overview is given, with the help of aerial photographs from 1950 and 1987, to give a basic idea about the recent changes to the vegetation compared to the historical wetland-hayland status (Oross 2002). As a substitute to aerial photography, the habitat map of Deák (2002) is used to depict changes between 1987 and 2002. Afterwards, the habitat map of the present study is presented, and a more detailed discussion about the different habitat types. The chapter is finished with discussing protected and invasive species situation together with illegal landfill sites in Felsőrákos meadows.

4.1 Changes to the fields of Felsőrákos over time

The original vegetation type in the study area was expansive wetlands, marshes and wet meadows, which lasted until the stream became controlled in the late 19th-, early 20th century (Oross 2002). To get acquainted with the changes since that period, two historical aerial photographs were analyzed from 1950 and 1987. Additionally, the habitat map of Deák (2002) was used to follow-up changes between 1987 and 2002.

4.1.1 Felsőrákos in 1950

The aerial photograph from 1950 was taken on 13 October, therefore the vegetation was already in its off-peak stage. The photo was handed over on photopaper, as an electronic version is not available from that period. In the photograph (Figure 2) the most characteristic feature is the presence of the many arable small parcels. At that time the surrounding settlements were just annexed to Budapest in 1950 (Ute 2005), therefore small scale subsistence farming was widespread in the area. Wetlands were dried up and used wherever possible, and only small patches of marshland remained close to the stream or its side-canal (point **E**). Trees were largely absent from the area, although planted trees can be discovered around the leech beds (point **C**). Leeches were raised for medical purposes at the time. The airfield of Mátyásföld (point **G**) was a vast grassland at that time: its area was almost the double of its present size.

Figure 2 Historical aerial photograph from 1950
The counterline borders the present study area; **A:** Rákos stream, **B:** sub-canal, **C:** leech beds, **D:** small parcels, **E:** wetlands, **F:** airfield
Source: Mod Mapping Non-profit Limited Company, 1950/55I/039

4.1.2 Felsőrákos in 1987

The aerial photo from 1987 was made on 28 April, therefore the vegetation cover had not reached its peak. As both photos were made at times of off-peak vegetation their comparibility is good. The '87 photo (Figure 3) was obtained in electronic format. Unfortunately, a small proportion of the study area was not included in this photo, but this did not hinder the general analysis. Compared to the 1950s state, the small parcels were replaced by long, uniform arable lands (point **D**). This is due to the fact that from 1950 farmers were forced to enter big farmer's co-operatives, thus decreasing the prevalence of subsistence farming in the area. These big co-ops only used good quality areas, therefore wetlands, inappropiate for large scale farming, regained their strength in some areas (points **E**), as the canals became neglected (point **B**) and water remained in the soil. Trees are much more abundant in the area, an artificial forest was planted (point **F**), and also semi-natural forest patches started to spring up next to the stream (point **I**). In the center of the study area the main site of the Budapest Horticulture Co. Ltd. was already established (point **H**), incorporating a large proportion of once arable lands.

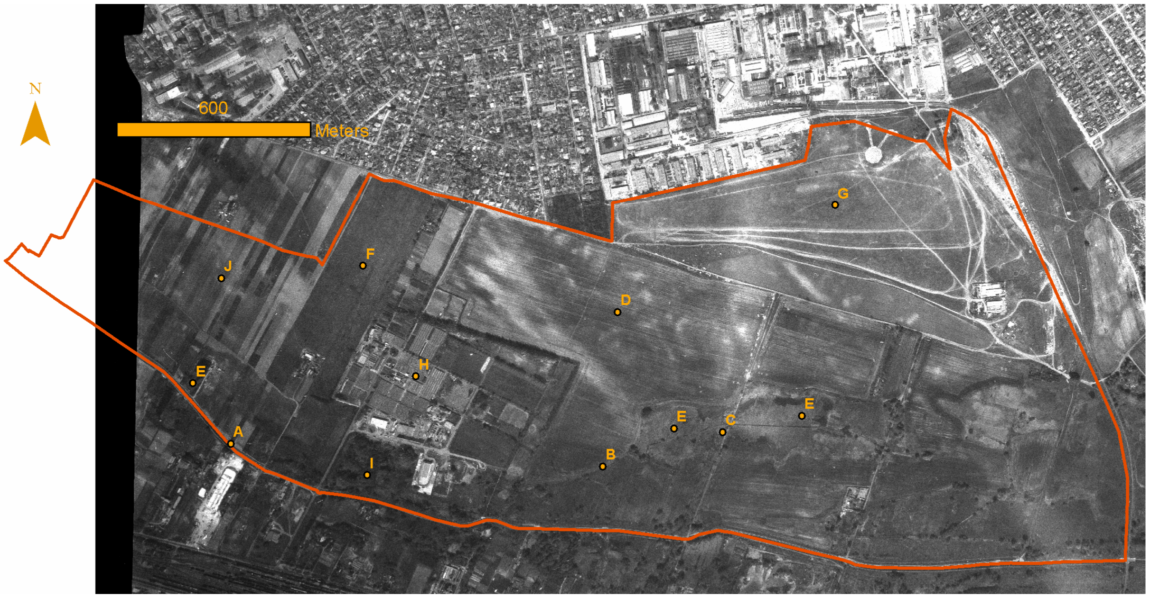

Figure 3 Historical aerial photo from 1987
The counterline borders the study area; **A:** Rákos stream, **B:** disappearing sub-canal, **C:** leech beds overgrown with trees, **D:** big parcels, **E:** wetlands, **F:** tree plantation, **G:** airfield, **H:** Budapest Horticulture co. Ltd., **I:** shrubland – forest, **J:** remaining small parcels
Source: Mod Mapping Non-profit Limited Company, 1987-315/8773

4.1.3 Habitat map from 2002 by Deák

At first glance at Deák's habitat map of the area (Figure 4) it becomes apparent that the great majority of the area is no longer cultivated (point **C**). Although the land was re-distributed to the people after 1990, when the soviet troops were redrawn from the country, the fields were left alone for spontaneous renaturalization. Wetlands and marshes were widespread along the old side-canal and the stream (points **D**), and also fens with *Molinia* spp. were observed (point **F**). A more detailed comparison is given later (Chapter 5) between the habitat map of 2002 and the habitat map of the present study, where changes in quality of the environment is discussed.

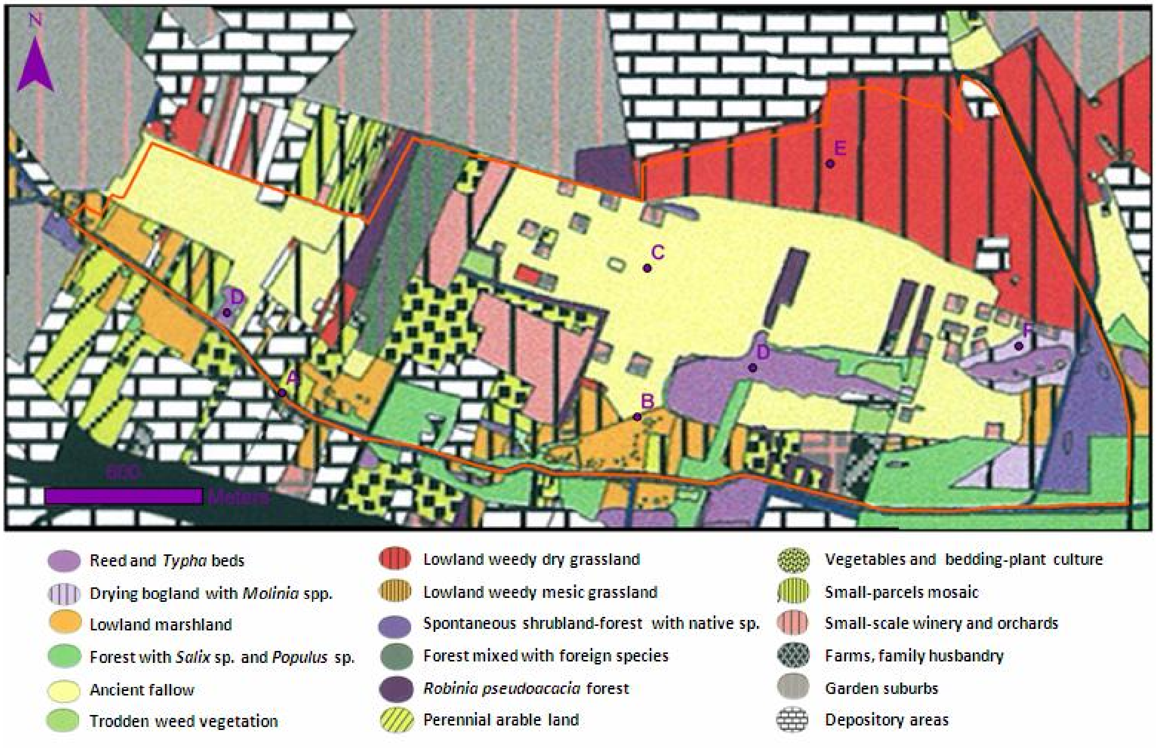

Figure 4 Amended habitat map of Deák (2002)
The counterline borders the present study area; **A:** Rákos stream, **B:** line of the sub-canal, **C:** neglected fields, **D:** wetlands, **E:** airfield, **F:** meadow with *Molinia* spp.

4.2 Present habitat map of the Felsőrákos meadows

The final habitat map is folded into the study on a separate paper in the printed version, and attached as an appendix (Appendix 1) to the electronic format. This solution was chosen to avoid the disadvantages of interpreting small figures, where subtle differences in color and line would not be distinguishable. In this chapter only the general characteristics of the map and individual habitats is described, and the final conclusion about future maintenance practices is drawn in the next chapter. After the general characterization, different subchapters introduce some plants which require special attention: protected and invasive species observed in the area are discussed separately, as well as the most pending illegal activities discovered in Felsőrákos.

4.2.1 General characterization of the habitat map of Felsőrákos

Appendix 1 shows two result map, one of them is the habitat map of Felsőrákos meadows, the other, smaller map, displays the areas which are considered worthy for protection as the result of the study. This section discusses the habitat map.

During the field observation, most of the area was heavily influenced by signs of human presence. Almost the whole study area is surrounded by suburbs, and although most of the small parcel owners do not use their fields, signs of present and past usage were often observed. Due to this reason, the naturality index of the different habitats scarcely got a better score than 3. The most abundant values are 1 (very low naturalness) and 3 (middle level naturalness). None of the observed habitats received 5 (very high naturalness) on their naturality index, which also indicates the general disturbance of the area. Those parts of the habitats which score 4 (high naturalness) in the naturality index, are generally difficult to approach due to the surrounding vegetation and historically did not have good qualities for cultivation, therefore they were not in use in 1950 nor 1987.

Those areas which are actively used by humans for industrial or self-supporting purposes (arable lands, farms, gardens) are not given a naturality index, as they are now fully anthropogenic areas. They occupy a great proportion of the study area, but compared with past conditions, where almost all the uncharacteristic dry grassland (OC) and *Arrhenatherum* hay meadows (E1) were cultivated lands, they play a lesser role in the area. The presence of OC-closed stepp on loess (H5a) mosaics suggests that spontaneous renaturalization has slowly been occurring in the area, and more natural habitats will take the place of once cultivated lands. Although spontaneous forests are very rare in the study area, most of the grasslands are abundant with scattered mesic or dry shrubland patches (P2a, P2b) or single stands, which provide small scale transition areas in their proximity, enhancing the species diversity.

Unfortunately, these shrublands often include non-native species as well, as the majority of the forests also consist of planted, non-native trees. The most abundant is *Robinia pseudoacacia*, which can be found across the whole study area, but is closely followed by *Celtis occidentalis* and *Elaeagnus angustifolia.* These two species are not only present in artificial, planted forms, but also form spontaneous groups and stands across the landscape. After them comes *Acer negundo*, which seems to spread across the fields on its own, in contrast to *Populus x euramericana* species, which although is also very frequent, is mostly found in plantations, while in natural conditions *Populus alba* or *P. x canescens* are more common.

Among the herbaceous invasive plants *Solidago canadensis* and *Asclepias syriaca* are the most successful invasive species, they are found in every habitat type in Felsőrákos meadows, and also occupy a considerable area themselves. As in the habitat map of Deák (2002), their presence is not much emphasized, it can therefore be understood that they became widespread in the past ten years. In general, *S. canadensis* is characteristic to the wet grasslands, while *A. syriaca* is found more often in drier conditions.

The most common natural habitat types are mesotrophic wet meadows (D34), uncharacteristic mesic and dry grasslands (OB, OC), closed steppes on loess (H5a) and mesotrophic reed and *Typha* beds. The rarest, and the area with the best naturality index (4), are the *Molinia* meadows (D2), which were also named in the Deák map (2002). Based on the aerial photographs and Deák's habitat map it can be said that this D2 area has not been cultivated for at least 60 years, which contributed to the good preservation of the area.

4.2.2 U8m- Streams-artificial and Ab- Euhydrophyte vegetation of rivers and channels with flowing water (Natura 2000: none)

Figure 5 Habitats U8m-Ab

The only permanent water habitat in the area is the Rákos stream (Figure 5), which occasionally has some side-canals in spring or during heavy raining. Although during the fieldwork the sub-canals were dry, their positions were easily distinguishable. The side of the Rákos stream is fully covered with concrete blocks for its whole length in the study area. It was intended to stop the erosion of the stream-sides, but according to Deák (2002), this measure was not necessary, as natural erosion was very low intensity. There is also usually one row of blocks on both sides outside the water. These rows can be flat concrete blocks, and border the stream like half meter wide pavements, or meet the water not at right angles, but with a slope of 30-45 degrees. This latter construction is one step closer to the natural state, therefore it got 2 on the naturality index, while the flat block parts received 1. At some sections of the stream, especially in the proximity of bridges, the whole bank of the stream is covered with concrete blocks, leaving no space for natural vegetation at all. The banks of the stream are only a few meters wide and descend to the stream in a 30-45 degree slope. Its vegetation is uncharacteristic OB with negligible naturalness.

Within the stream, very uncharacteristic and uniform hydrophyte vegetation was observed, which together with the artificial bed resulted only in a naturality score of 2. According the Budapest Sewage Work Ltd. (2009), the water of the stream is classified heavily polluted in the whole territory of Budapest. According to them, the main problem is the eutrophication of the water, which together with the fact that there is no shadow at the water surface due to the regulation works, greatly enhance the dispersion of seaweed. Presumably the eutrophication originates from the waste of fisheries close to the border of Budapest, and from illegal dumpings (Rácz pers. comm.).

4.2.3 B1a- Eu-and mesotrophic reed and Typha beds (Natura 2000: none); U9d-Standing waters- pool (Natura 2000: none)

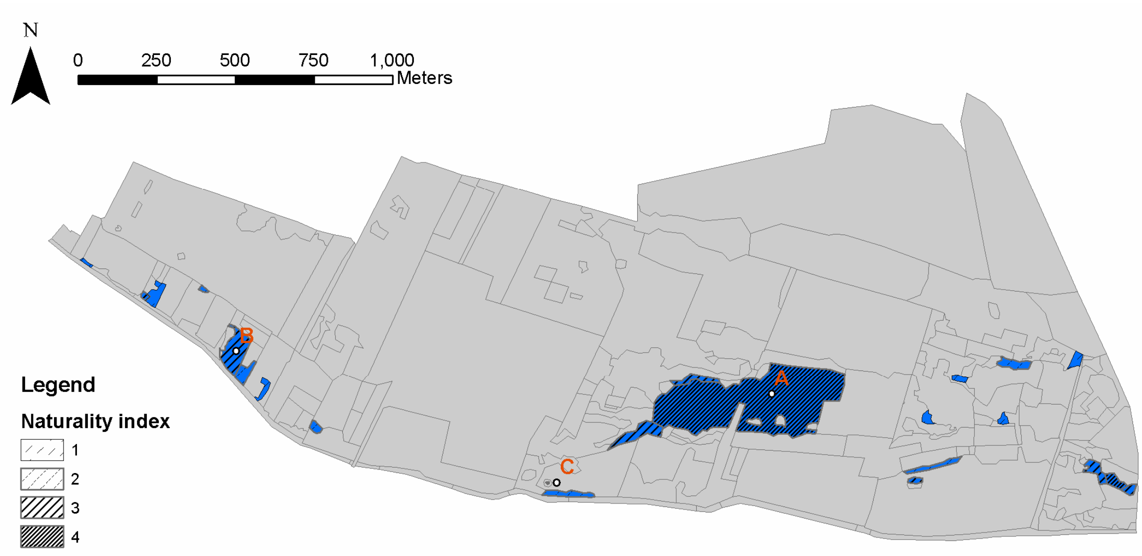

Figure 6 Habitats B1a and U9d

Spontaneous *Phragmites australis* stands are found everywhere in the moister areas, indicating the high soil water level (Figure 6). However, the minimum observation threshold is 25m^2 (Bölöni *et al.* 2011) for the reed and *Typha* bed habitat (B1a), therefore some of the *P. australis* stands are just colouring species in other habitat types and do not form a separate habitat patch. Also most *Phragmites* stands do not stand in water, forming only lower quality habitats. There are two larger standing water bodies in the area, indicated by **A** and **B** in Figure 6. **A** is a large shallow lake, almost fully covered with homogenous *Phragmites* spp., rooted in the soil. Due to its large area and the presence of the lake, the habitat remained in a generally healthy state, and the area was also spared from cultivation as the historical aerial photos support. Due to these facts, it received a naturality index of 4. As discussed in more detail in the next chapter, this area is considered worthy of protection. The other shallow lake at **B** is more like a larger pool, and its vegetation is more disturbed as well. It is covered with *Phragmites* spp. most of the year, but during the fieldwork its banks were also observed in a burnt down state. It received a naturality index score of 3, as the reeds stand both in water and in drier soil. The other scattered groups of reed stands were found in drier areas, therefore they are more mixed with weeds, especially with *Solidago canadensis*, so their naturality index is only 2.

A small pool is located at point **C**, which probably dries out entirely by the end of the summer. It is circled by *Salix* and *Poplar* spp., and has an uncharacteristic hydrophyte population (mostly *Lemna minor*). Across the study area, other pools are also found, but their sizes are not significant, although they provide micro-diversity to the habitats.

4.2.4 B5- Non-tussock tall-sledge beds (Natura 2000: none)

Figure 7 Habitat B5

Carex spp. are abundant through the whole area but they rarely form a habitat on their own. The exception is found around the large swallow lake in the middle of the area, where taller and stronger sledges are present more densely (Figure 7). Characteristic species are *Carex acutiformis*, *C. vulpina* and *C. riparia*. Accompanying coloring species are *Iris pseudacorus,* or less frequently *Iris sibirica*, both of them protected in Hungary. Other marshland species were also found, such as *Symphytum officiniale*, *Sanguisorba officinalis, Ranunculus* sp., which all indicate the good quality of the habitat. Therefore the patches received 3 or 4 on the naturality index. Based on the historical photographs, the area of the B5 habitat was not much disturbed during past decades, as its soil was probably not good enough for cultivation. Also Bölöni *et al*. (2011) explain that the regeneration potential of this habitat type is good, which explains its good naturalness.

4.2.5 D2- Molinia meadows (Natura 2000: 6410 Molinia meadows on calcareous, peaty or clayey-silt-laden soils)

Figure 8 Habitat D2

This habitat type gave the most natural feeling during fieldwork, and later on analyses of the species and environment also strengthened this assumption. The area (Figure 8) is tussocky, mesic and the vegetation is vigorous and strong. Although the detection of the habitat determining species, the *Molinia* spp. were difficult, as they only reach their peak stage during late July-August, they were successfully identified in a satisfactory quantity through the area. Other accompanying species found in the area are: *Iris sibirica*, *Sanguisorba officinalis*, *Galium borale*, and other marshland species (Table 1). Protected *Iris* spp. were also found in great numbers, a definite sign of the need for future protection. The area is surrounded by weedy reeds and *S. canadensis* on the north and west side, but to the east and south more natural meadows and mesic shrublands border it. Reaching the area on foot from most sites was very problematic, a factor which contributes to the relatively undisturbed nature of the area. Although at the margins signs of disturbance are observable, and also some more common species were found, like *C. epigeios*, in general the habitat quality is very good, it received 4 on the naturality index. With proper treatment the bordering fields could be renaturalized to *Molinia* and mesic meadows within 5-10 years, as the regeneration potential of D2 is good (Bölöni *et al.* 2011).

Table 1 Observed species at D2 (non-complete list)
: characteristic sp. to the habitat : lower quality sp. : non-characteristic sp.

Euphorbia villosa	*Festuca arundinacea*
Galium borale	*Galium aparine*
Iris sibirica	*Galium verum*
Molinia spp.	*Lysimachia vulgaris*
Sanguisorba officinalis	*Ranunculus* spp.
Arrhenatherum elatius	*Symphytum officinale*
Achillea asplenifolia	*Apera spica-venti*
Carex vulpina	*Calamagrostis epigeios*
Eupatorium cannabinum	*Potentilla argentea*

4.2.6 D34- Mesotrophic wet meadows (Natura 2000: 6440 Alluvial meadows of river valleys of the Cnidion dubii) and its mosaics

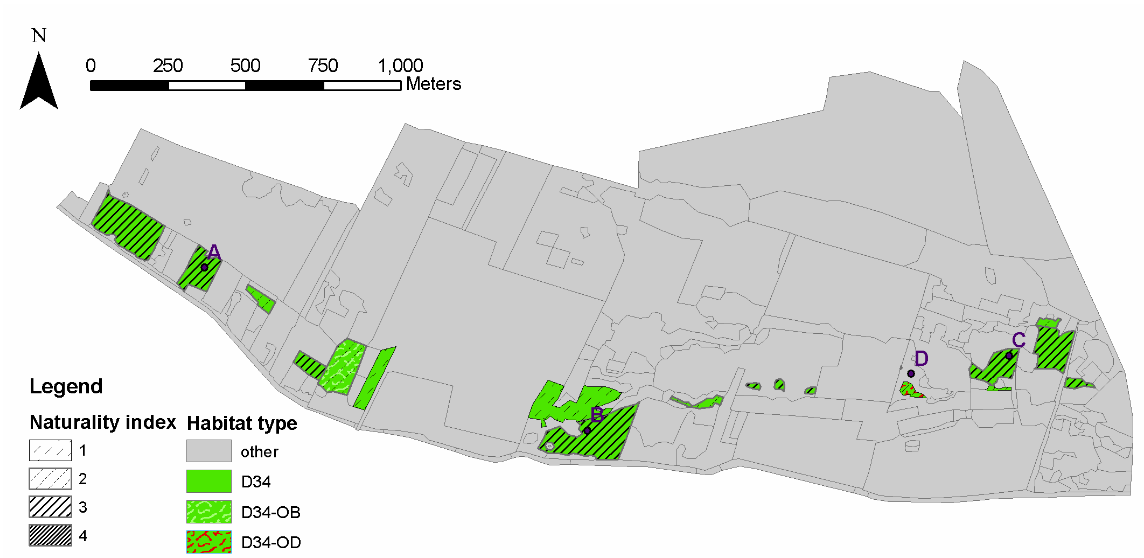

Figure 9 Habitat D34 and its mosaics

Mesotrophic wet meadows is a widespread habitat type across the Felsőrákos meadows (Figure 9). Its naturality index is mostly 3, but sometimes got lesser values, especially if it formed a mosaic with uncharacteristic mesic grassland (D34-OD) or with stands of invasive forbs (D34-OD). At the south-west part of Felsőrákos (within 800m from point **A,** Figure 9), some of the meadows are used for hay production. Reaping, if not overdone, is beneficial for this habitat, as it helps to maintain its good quality and decrease the number of invasive species. However, in some parts the maintenance practice resulted in uncharacterization, whereas the OB mosaics, or simple OB habitats were present instead of D34. The time period of the study was not enough to decide whether these OB patches are currently renaturalizing to D34 or degrading from it. Around point **A** many characteristic species were found, such as *Alopecurus pratensis, Poa pratensis, Galium palustre* (Table 2), and also some scattered *Molinia* stands were discovered (not sufficient quantity and quality however to qualify as D2). However, the meadow gave a general impression of uniformity, with predominant species spread over the area, and also the number of non-characteristic species were high, therefore the area only received 3 or 2 on the naturality index.

Around point **B** the meadows show greater diversity, and also the surrounding landscape is more diverse with scatterred tree groups and small pools. This area was also reaped at the end of June, which, based on the ortophoto from 2010, has been standard practice for years now. As the naturalness of the area only got a score of 3, probably the time and method of the reaping should be further developed if the aim is to reach a good D34 habitat. As the regeneration ability of D34 is good with proper treatment (Bölöni *et al.* 2011), this goal is not unachievable. Several characteristic species were observed, such as *Festuca arundinacea, Betonica officinalis or Inula britannica* (Table 2), along with the already described species of point **A**.

The D34 meadows at point **C** border the previously described D2 habitat, acting as a protecting zone around it. They contain *Carex acutiformis, C. vulpina, Inula britannica* and also some stands of *Molinia* sp. in addition to the already mentioned species. As their other borders face OD fields full of *S. canadensis*, they also show more signs of disturbance at their outer parts. However their situation is not so bad as the D34-OD mosaic at point **D**. There, although some characteristic species of D34 are still recognizable, the natural vegetation starts to be overthrown with the invasive *S.*

canadensis. These fields are not reaped anymore, which contributes to the success of OD habitat. With proper maintenance plans the process could be easily reversed fortunately.

Table 2 Observed species at D34 and its mosaics (non-complete list)
: characteristic sp. to the habitat : lower quality sp. : non-characteristic sp.

Alopecurus pratensis	*Sanguisorba officinalis*
Carex acutiformis	*Symphytum officinale*
Dactylis glomerata	*Achillea* spp.
Festuca arundinacea	*Allium scorodoprasum*
Galium palustre	*Trifolium* spp.
Inula britannica	*Bromus* spp.
Iris spp.	*Calamagrostis epigeios*
Lychnis flos-cuculi	*Poa angustifolia*
Ranunculus spp.	*Tragopogon* spp.

4.2.7 E1- Arrhenatherum hay meadows (Natura 2000: 6510 Lowland hay meadows)

Figure 10 Habitat E1

The *Arrhenatherum elatius* meadows (E1, Figure 10) are found in the north-west side of the study area. At the time of the fieldwork, the meadows were not cut for hay production and grew in their natural fashion. But according to the aerial photograph (Figure 1) some parts of this habitat were subject to reaping in the previous years. Reaping helps to maintain the good quality of this habitat type, and as the observed naturality index score was only 2, it may suggest that a more organized reaping schedule would help to reach higher naturalness, like in the previous case. The low naturality index of the area is explained by the fact that although characteristic species were observed, such as *Arrhenatherum elatius, Dactylis glomerata, Rumex acetosa*, numerous degradation indicating species were also found (Table 3). The meadow also hosts a number of common species (Table 3), and in some parts resembles an uncharacteristic dry meadow (OC) more than its habitat type. Scattered stands of *S. canadensis* and *A. syriaca* were also found in the area. In addition, the shrubs and trees observed in the area also contained approximately 40% invasive species, such as *Robinia pseudoacacia, Elaeagnus angustifolia, Acer negundo*, along with the native *Rosa canina.* The historical aerial photographs show that the land of the E1 habitat was used for cultivation in the past, however in the habitat map of Deák (2002) it was already abandoned. These factors indicate that the habitat type of these meadows is currently changing and could be improved or degraded depending of the treatment they receive.

Table 3 Observed species in the E1 habitat (non-complete list)
: characteristic sp. to the habitat : lower quality sp. : non-characteristic sp.

Arrhenatherum elatius	*Anchusa officinalis*
Dactylis glomerata	*Echium vulgare*
Rumex acetosa	*Erysimum diffusum*
Achillea millefolium	*Gypsophila paniculata*
Centaurea jacea	*Limonium tataricum*
Galium verum	*Poa angustifolia*
Hypericum perforatum	*Silene alba*
Tragopogon spp.	*Silene vulgaris*
Trifolium spp.	*Stenactis annua*

4.2.8 H5a- Closed steppes on loess (Natura 2000: 6240 Sub-pannonic steppic grasslands) and its mosaic

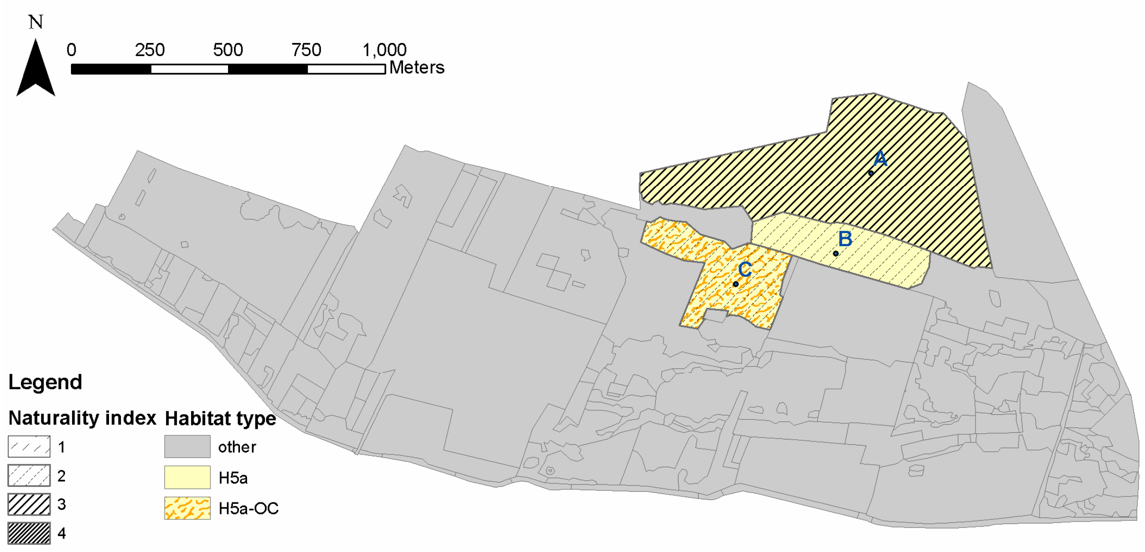

Figure 11 Habitats of H5a and H5a-OC mosaic

In the whole area of the previous airfield middle quality closed steppes (H5a) were found, although not on loess, but on mixed soil (point **A**, Figure 11). The area is currently not used by the municipality, but the local inhabitants exploit the advantages of the field, using it for model-planes- and kite-flying, walking and bicycling. These types of disturbance and the occasional reapings are enough to keep the H5a habitat in a relatively good condition, with a score of 3 on the naturality index. Among the characteristic species observed were *Salvia* spp., *Koeleria cristata*, *Anchusa officinalis* and *Stipa* spp. (Table 4). However most of the *Salvia* spp. were found in big clumps, which indicates a lower quality habitat, and also other disturbance indicating plants, such as *Eryngium campestre* are widespread. Although the present study do not cover animal species, it is worth mentioning that beside the protected *Stipa* spp. the airfield is home to a gopher population, as the many holes and tunnels attest it, which are also protected in Hungary.

According to Daróczy (pers. comm.), there are other two protected plant species in the area, which already lead to a petition to protect the field (process not completed).

At point B, the quality of the habitat decreases (2 on the naturality index), more tall herbs are present, although characteristic species are still easily observable, such as *Tencrium chamaedrys, Astralagus onobrychis* or *Silaum silaus* (Table 4). These fields are situated on a slight southward slope, and were used for agricultural production in the past (see section 4.1), but nowadays they are neglected, and spontaneous groups of shrubs and trees of *Rosa canina*, *Robinia pseudoacacia, Elaeagnus angustifolia, Celtis occidentalis* grow on them. However, the meadow creates a connection towards the closed steppes-uncharacteristic dry meadows mosaic (H5a-OC, point **C**), which is beneficial from the point of view of renaturalization and species reinforcement. In the mosaic meadows, more common species were observed in addition to the fewer H5a plants, such as *Echyum vulgare, Verbascum speciosum,* or *Convolvulus arvensis*.

Table 4 Observed species in the H5a habitat and its mosaic (non-complete list)
: characteristic sp. to the habitat : lower quality sp. : non-characteristic sp.

Anchusa officinalis	*Festuca* spp.
Astralagus onobrychis	*Galium verum*
Koeleria cristata	*Rumex acetosa*
Salvia spp.	*Thymus* spp.
Silaum silaus	*Convolvulus arvensis*
Stipa spp.	*Echyum vulgare*
Tencrium chamaedrys	*Linum austriacum*
Eryngium campestre	*Poa* spp.
Euphorbia cyparrisias	*Verbascum speciosum*

4.2.9 OB- Uncharacteristic mesic grasslands (Natura 2000: none) and its mosaics

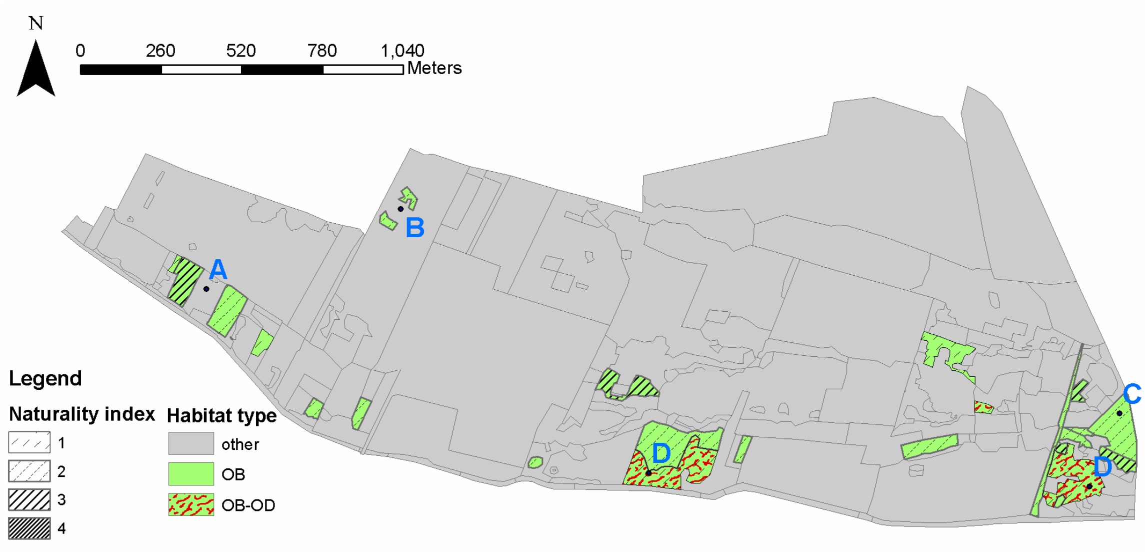

Figure 12 Habitat OB and its mosaics

The uncharacteristic mesic grasslands occurred mostly in the neighborhood of mesotrophic wet meadows (D34, Figure 9), as they are sheltering them from external impacts. They were found across the whole study area (Figure 12), their quality ranging from 1-3 on the naturality index. Among its characteristic species are *Calamagrostis epigeios*, *Plantago lanceolata*, *Cirsium canum* but they also contain some species from the D34 habitat, most often *Symphytum officinale* or *Sanguisorba officinalis* (Table 5). This is especially true for the OB meadows around point **A**, where identifying the differences between a lower quality D34 and higher quality OB was extremely difficult, and it is most probable that the structure of the meadows change from year to year. Around point B two little clearings with mainly *C. epigeios* were found, which were surrounded by a planted forest and more common species, such as *Urtica dioica* or *Chelidonium majus*. At point **C** some of the area was fenced around, but based on the aerial photograph and field observation its structure was assessed as the same as those of the surrounding area.

Some OB meadows (point **D**) received very low naturality index, only a score of 1 or 2, which is explained by the presence of invasive species, namely *Solidago canadensis* most of the time. Some of the OB habitats even formed mosaics with stands of invasive forbs (OD); in every case they received a score of 1 for their quality. Upon renaturalization of the OB habitat, better quality types, such D34, D2 habitats would evolve in their place; the practices needed for this are discussed in section 4.2.5 and 4.2.6 respectively.

Table 5 Observed species in the OB habitat and its mosaic (non-complete list)
: characteristic sp. to the habitat : lower quality sp. : non-characteristic sp.

Calamagrostis epigeios	*Arrhenatherum elatius*
Dactylis glomerata	*Juncus* sp.
Elymus repens	*Mentha longifolia*
Galium palustre	*Poa angustifolia*
Inula britannica	*Cirsium canum*
Plantago lanceolata	*Erysimum diffusum*
Ranunculus spp.	*Saponaria officinalis*
Sanguisorba officinalis	*Solidago canadensis*
Symphytum officinale	*Stenactis annua*

4.2.10 OC- Uncharacteristic dry grasslands (Natura 2000: none) and its mosaics

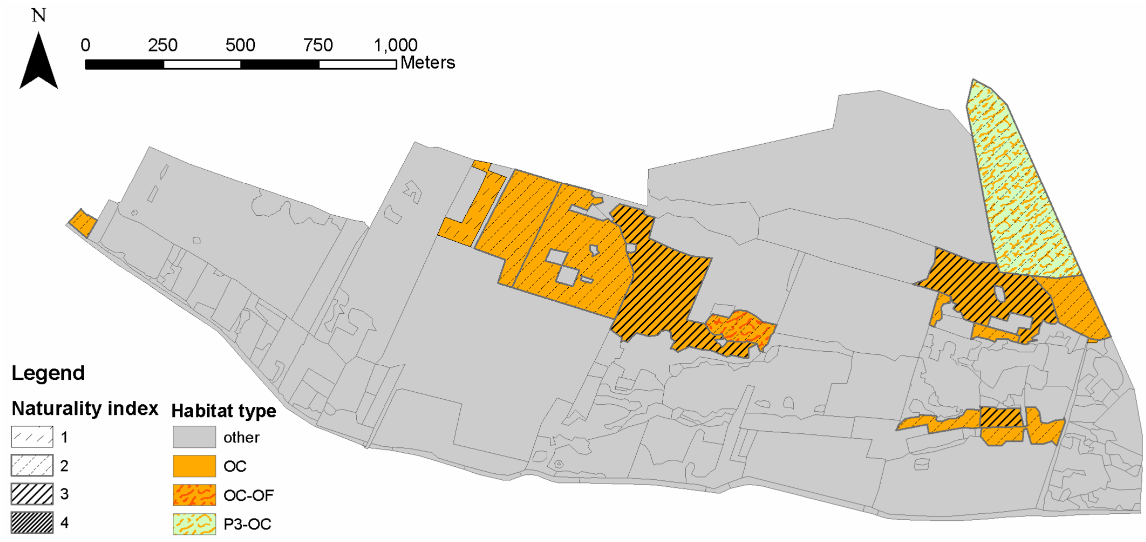

Figure 13 Habitat OC and its mosaics

Uncharacteristic dry grasslands (OC) were common in the northern part of Felsőrákos meadows, far away from the stream and wet meadows (Figure 13). Most of the area defined as OC today was used in the past for cultivation, but got neglected later on. However, some parts of the OC habitat are still used for hay production and also the signs of future gardens and already established weekend gardens were observed. Most of the meadows are scattered with *Rosa canina, Crataegus monogyna* and abandoned fruit trees from the native-, and *Celtis occidentalis, Robinia pseudoacacia* from the invasive shrubs and trees. Although the habitat type is described as uncharacteristic, a relatively large diversity of species live together in the area, such as *Achillea collina*, *Silene alba,* or *Melica transsilvanica* (Table 6). Stands of invasive species were also observed, mostly *Asclepias syriaca*, as the drier conditions are not favoured by *S. canadensis.* Of the wildlife, deer, rabbits, butterflies and numerous birds were met during the field observations. Most of the area got a naturality index of 2 or 3, depending on their structure, and whether protected species, such as *Stipa* spp. were observed. The only exceptions are the mosaics of invasive tall herb forbs (OD), where the *A. syriaca* and *S. canadensis* became too widespread. As was the case of the previous habitat type (OB), if the quality of the area increases, it would develop into a new, more natural habitat type, therefore talking about the OC regeneration potential does not make sense.

In the case of the new afforestation (P3) mosaic (Figure 13), very young, only 30-50 cm high *Quercus* saplings have been planted in parallel rows. The lines are sometimes gappy, and generally the area is allowed to grow as it likes. The habitat is not dominated by one or two species, but is not very diverse either, therefore it received a naturality index of 2.

Table 6 Observed species in the OC habitat and its mosaic (non-complete list)
: characteristic sp. to habitat : lower quality sp. : non-characteristic sp.

Achillea collina	*Cirsium canum*
Calamagrostis epigeios	*Melica transsilvanica*
Convolvulus arvensis	*Rumex patienta*
Echium vulgare	*Thymus* spp.
Eryngium campestre	*Artemisia* spp.
Euphorbia cyparissias	*Tragopogon* spp.
Silene alba	*Vicia cracca*
Poa angustifolia	*Potentilla argentea*
Anchusa officinalis	*Asclepias syriaca*

4.2.11 OD- Stands of invasive forbs (Natura 2000: none); OF- Ruderal tall-herb vegetation (Natura 2000: none)

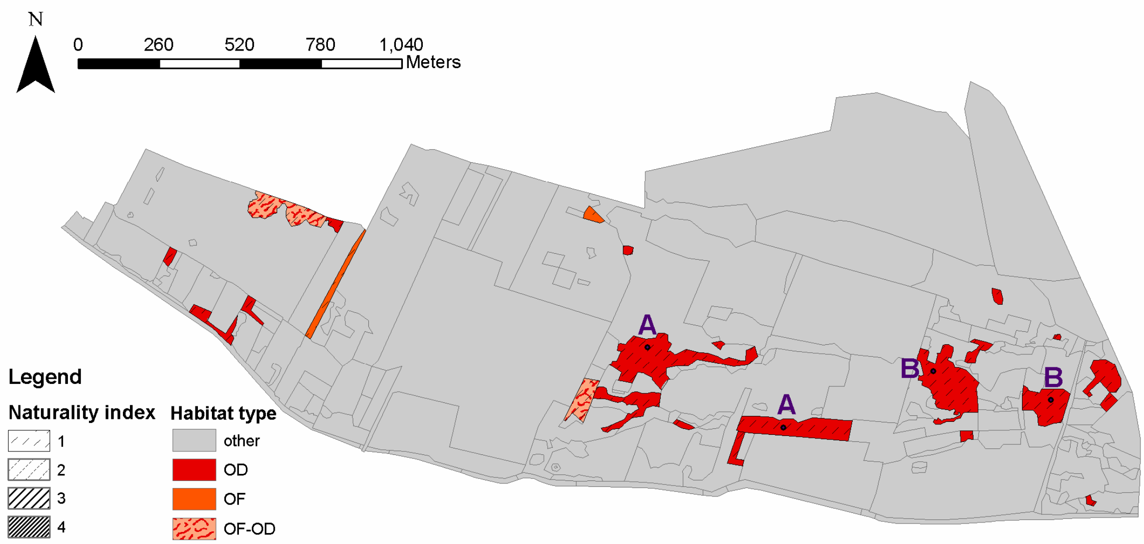

Figure 14 Habitats of OD, OF and their mosaics

Far the most common invasive plants in the study area are *Solidago canadensis* and *Asclepias syriaca* among the herbaceous plants, while among the woods and shrubs *Acer negundo*, *Celtis occidentalis* and *Robinia pseudoacacia* are the winners of this none too appreciative title. As the soil of Felsőrákos meadows is generally moister, *S. canadensis* outnumbers even the *A. syriaca* at most sites, the latter only gains strength at the drier areas. At points **A** (Figure 14) literally there were no other plants to be seen at first sight than *S. Canadensis*, and only closer examination revealed the suffering undercover vegetation. At points **B** in addition to the *S. canadensis*, scattered trees of *Elaeagnus angustifolia* colours the scene. The habitat map only shows those areas where the invasive spp. were more than 50% present (OD, Figure 14). In section 4.4, another map is shown where smaller stands are also displayed.

In the case of ruderal tall vegetation (OF), no characteristic species were observed, but a mix of general species, such as *Rumex patienta* or *Verbascum speciosum*. Both the OD and OF habitats received a score of 1 on their naturality index. Reaping and more careful maintenance would be needed for the development of more natural habitats in their place. Possible methods are discussed in the next chapter.

4.2.12 P2a- Wet and mesic pioneer scrub (Natura 2000: none); P2b- Dry and semi-dry pioneer scrub (Natura 2000: none)

Figure 15 Habitats of P2a and P2b

As mentioned earlier, most of the study area is covered by meadows; forests and shrublands only occupy a very small area of the whole. Of the shrublands, two types were observed during the fieldwork: wet and mesic pioneer scrub (P2a, Figure 15) and dry and semi-dry pioneer scrub (P2b, Figure 15). The P2a habitat is mostly scattered on the west side of Felsőrákos meadows, and consists of scrub *Salix* spp., *Frangula alnus, Sambucus nigra*, which are usually so thick that they are impossible to penetrate. Occasionally *Rosa canina* and *Crataegus monogyna* were also observed, but they are more characteristic of the P2b shrubland. Most of the P2a got a naturality index of 2, as they are often dominated by *S. nigra*, but at the border of the D2 habitat (Figure 8) there is a very dense *Salix* spp. patch, which received a naturality index of 4 due to its healthy state and good quality environment. A number of stands of *Salix* spp. were observed in the proximity of P2a habitats, which indicates that thanks to the high soil-water level the regeneration ability of the habitat is good (Bölöni *et al.* 2011).

In the case of the P2b shrubland, the dominating species are *Rosa canina, Crataegus monogyna*, feral fruit trees, *Syringa vulgaris* and 40-50% invasive species, such as *Robinia pseudoacacia* and *Alianthus* spp., therefore it only received 2 on the naturality index. On the last days of the field work, the upper half of the area was taken into the hands of official gardeners, and a large proportion of the shrubs was cleared. The time limit of this study does not allow the observation of the future developments of the area, therefore it has kept its P2a identification, but hopefully at the end of the intervention the proportion of invasive species will decrease. This habitat type, just like the previous P2a has a good regeneration capacity, especially in abandoned fields. As the neighboring OC habitats already contain some scattered bushes, it is very likely that without anthropogenic influence the P2b habitat would spread further.

4.2.13 RA- Scattered native trees or narrow tree lines (Natura 2000: none); RB-Uncharacteristic or pioneer softwood forests and plantations (Natura 2000: none)

Figure 16 Habitats of RA and RB

Scattered across the meadows small groups of older trees are to be found (RA, Figure 16), which consist mostly of *Populus* spp. (hybrid and natural species mixed) and in a smaller percentage invasive plants. At point **A**, the north part of the habitat contains wild fruit trees, *Acer platanoides*, while the long line of trees is formed from *Populus* spp. and *Robinia pseudoacacia*, planted approximately 30 years ago. As it contains almost 40% *R. pseudoacacia*, it only received a score of 2 on the naturality index. At point **B** mostly *Populus* spp. are found, marking the border between the shallow lake and the pasture of the horse riding school in the area. This tree line has better quality and richer understorey vegetation, therefore it received 3 on the naturality index. The other tree groups are mostly formed by *Populus* spp. and *Salix* spp., and as the other trees in the habitat, are usually older than 20-30 years. This habitat type is usually connected with human presence, therefore it has no official regeneration potential (Bölöni *et al.* 2011), although with time it can reach a highly natural state.

In the study area three bigger forest patches were found, one of them formed by uncharacteristic softwood forest plantation (RB, Figure 16). The forest structure is built up in the following way: next to the stream there is one row of *Quercus petraea*, after it comes and old plantation of hybrid *Populus* spp., and from approximately halfway to the north *Alnus glutinosa* trees take over the habitat. The naturality of the forest also moves along its structure, the most noticeable tree line is that of *Q. petraea*, but afterwards the poplar plantation already shows a higher quality, with fallen trees and richer understorey vegetation. As for the northern part of the forest, where *A. glutinosa* were found, the forest vegetation is sometimes so thick that it was impossible to get through it. At the east part some trees of *Acer negundo* were also found. Overall, the forest gave a good impression of naturalness, therefore it received 3 on the naturality index. Smaller clearings also contribute to the diversity of the habitat, although their species composition is usually dominated by *Carex* spp. or *Phragmites* spp. If the forest is left alone in the future, its structure may become even more similar to that of a natural one.

4.2.14 RDb- Non-native deciduous forests and plantations mixed with native trees (Natura 2000: none)

Figure 17 Habitat of RDb

The other two forest patches are formed by non-native deciduous trees mixed with native trees in forests or plantations (RDb, Figure 17). Based on the historical aerial photographs, this habitat type has become fully developed over the past 30 years. At point **A** is a plantation of *Quercus petraea* and *Quercus rubra*, with some *Robinia pesudoacacia* trees. The southern part of the plantation is rich in understorey vegetation and gives the impression of a proper forest, while the northern part of the plantation is younger and poorer in vegetation. This younger part and the west part of the habitat are formed mostly by *Q. rubra*, while the more natural south-east part by *Q. petraea*. Taking into account every circumstance, the naturality index of the plantation received 2.

At point **B** a more natural, spontaneous looking forest has grown up, with dense understorey vegetation and relatively good diversity. The dominating tree species are

Salix spp., hybrid *Populus* spp. and *Fraxinus* spp., although one or two *Platanus acerifolia* were also encountered. The forest is rich in dead branches and fallen trees and overall has good quality, its naturality index score became 3. This patch was found to be the most natural forest in the study area beside the *Alnus* sp. part of the RB habitat (section 4.2.13). As it contains almost no invasive species, just the original vegetation type, characteristic of pre-controlled times. Its regeneration ability is considered good.

At point **C** the main tree species observed was *Platanus acerifolia* in the middle of the tree rows, surrounded by *Populus* spp., *Robinia pseudoacacia* and some wild fruit trees. The presence of *Platanus* sp. is not characteristic to the Felsőrákos meadows, their occurrence in this case is due to the leech breeding beds, for which shady, more elegant trees were required in the area. The old plantation type of the forest is still observable, and also the trees are younger than in the previous forest habitats. Therefore it only received a naturality index of 2. As invasive species are present in a bigger proportion, the renaturalization ability of this patch is considered not so good.

4.2.15 S1- Robinia pseudoacacia plantations; S2- Populus x euramericana plantations; S6- Spontaneous stands of non-native trees; S7- Scattered trees or narrow tree lines of non-native trees (Natura 2000: none of them)

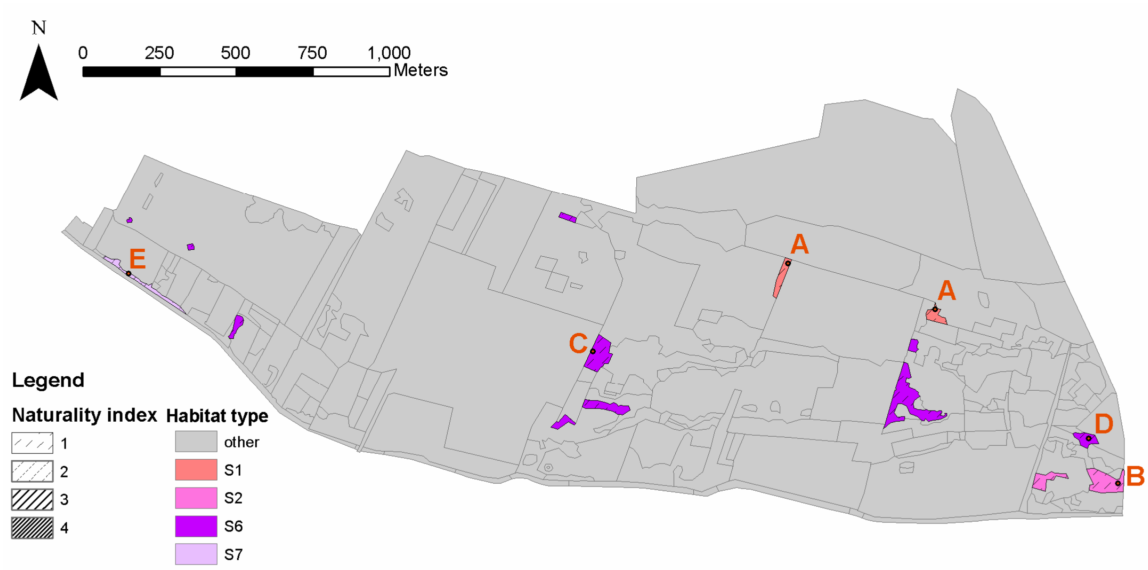

Figure 18 Habitats of S1, S2, S6 and S7

Although the Felsőrákos meadows are mostly subject to invasive forbs of grasslands, a great number of non-native trees are also scattered across the area, often standing alone, not reaching the limit of habitat formation, therefore are not displayed as separate habitat patches in Figure 18. Among these scattered trees mostly *Robinia pseudoacacia*, *Elaeagnus angustifolia* and *Celtis occidentalis* were found. The hybrid *Populus* spp. and the *Acer negundo* stands usually reached the habitat observation limit. At points **A**, planted *R. pseudoacacia* (S1) were found with poor and uncharacteristic understorey vegetation. At point **B** there are tall *Populus* spp. in regular rows (S2), with *S. canadensis* dominating in their shadows. At point **C** a spontaneous *R. pseudoacacia* patch (S6) was observed, whose saplings probably originated from the planted *R. pseudoacacia* row, bordering the Horticulture Ltd. (not displayed in Figure 18). At other S6 habitats the hybrid *Populus* spp. and *E. angustifolia* form the majority, but for example at point **D** only the latter were found, showing the species potential to overtake the bush *Salix* spp. in moister environments. At point **E** a more or less degraded planted tree row, consisting mostly of *Acer negundo*, was observable, although some of its members were already chopped down and the trunks were entwined with *Parthenocissus tricuspidata*. The naturality index of all of these habitats is naturally 1, as the species are completely foreign in Hungary, and their renaturalization is extremely difficult without serious intervention.

4.2.16 T3- Vegetable and flower plantations, greenhouses; T6- Extensive arable lands; T9- Gardens; T11- Nurseries, Salix viminalis plantations; U10- Farms

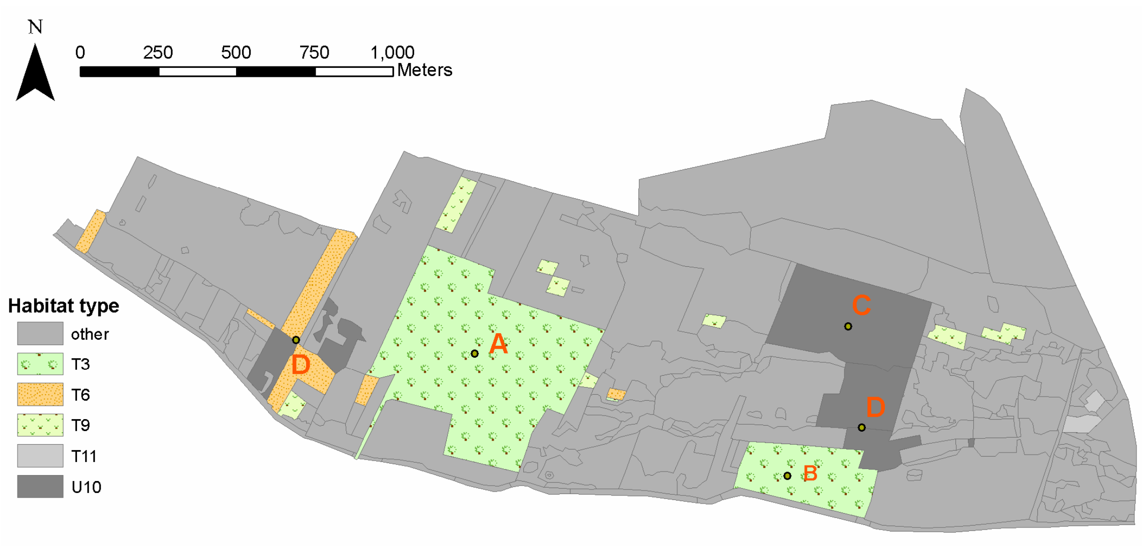

Figure 19 Habitats of T3, T6, T9, T11 and U10

The last group of habitats consists of the anthropogenic habitats in the study area, such as vegetables, flower plantations and greenhouses on a bigger scale (T3), small cultivated parcels (T6), small weekend gardens (T9), nurseries (T11) and family farms (U10), which are displayed in Figure 19. There are two big plantations in the middle of the area, one of them is the Budapest Horticulture co. Ltd. (**A**), the other (**B**) belongs to an unknown owner, maybe from the neighboring farms. Both of them contain various plants, vegetables and flowers. A horse riding school is situated at point **C**, most of the farm area is open pasture, where the horses graze. This pasture probably is an uncharacteristic OC habitat, assuming from its surroundings and aerial photographs. The horses graze regularly at the surrounding non-fenced area as well, and probably contribute to keep low the number of invasive species. At points **D** individual houses and farms are located with permanent inhabitants, while the scattered T9 gardens are used for occasional pastime activities. In contrast to the conditions 30-60 years ago, only a small number of cultivated lands were observable in the study area, which were plowed mechanically. As all of these habitats are fully anthropogenic, it would not make sense to estimate their naturality index or regeneration potential, so they were not analyzed from this point of view.

4.3 Protected species in Felsőrákos meadows

The naturality index of different habitats is sometimes unable to reflect every aspect of the quality of a given area. Although the presence of protected species counts in the assessment of naturalness, it is worth knowing where exactly these species are to be found. In Figure 20 the locations of the two most common protected species of the study area, the *Iris* spp. and *Stipa* spp. are displayed with graduated symbols. As can be seen, these species can be found by amateurs all across the area. As the Felsőrákos meadows are an urban green area, they provide a unique possibility for city people to observe these plants in their more or less natural environment. The meadows could be a place for school excursions from the nearby area, offering a valuable educational experience to smaller children. Evidently, for this, the habitat of the species has to remain in good condition and represent a safe environment for children.

Figure 20 Locations of *Iris* spp. and *Stipa* spp.
The bigger symbols signify greater abundance

4.4 Invasive species in Felsőrákos meadows

From the point of view of future habitat conservation, it is also useful to know where the stands of invasive species outside of the OD areas are. There is no question that OD habitats should be treated properly to prevent the spread of foreign species, but it is also very important to clean out the quality degrading elements of other habitats as well. In Figure 21 the bigger patches of the two herbaceous invasive plants, the *Solidago canadensis* and *Asclepias syriaca* are displayed for this purpose. Both of these species originate from North-America (Simon and Seregélyes 2004), the *S. canadensis* were used as a bedding-plant, while the *A. syriaca* were believed to be a good alternative for cotton production. As both plants can spread with the help of their roots, it is very difficult to get rid of them once they appear in an area.

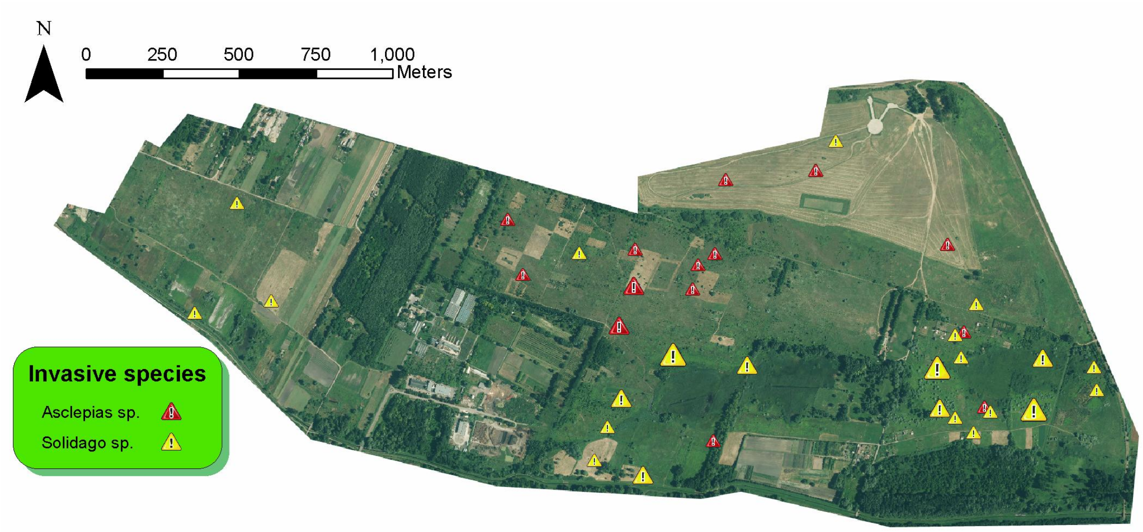

Figure 21 Location of the invasive *Asclepias* and *Solidago* sp.
The bigger symbols signify greater abundance

4.5 Illegal activities in the Felsőrákos meadows

The Felsőrákos meadows can only be a place for school excursions to watch protected species and enjoy nature within the city, if it provides a clean and safe environment to visitors. Unfortunately, during the fieldwork it became clear that the area is home to many illegal dumping sites, and at some points the soil is entirely burnt out, possibly as a result of regular cable burnings. A non-complete map of these activities is shown in Figure 22. As new trash heaps may appear from one day to another, as was experienced during the fieldwork, it is very hard to find every illegal dumping site within the area, also because at places, where the vegetation is dense, the garbage is often overgrown.

The present study did not have the time and means to track down every single illegal dumping site, but tried to survey the general state of the area. The trash consisted mainly of building materials (bricks, stones, cement, etc.), car pieces and accessories, electronic waste (computers, television sets), green waste (manure, garden waste), and general household waste. The waste is not only bad for aesthetic reasons; it is often dangerous to the environment as well.

It is impossible to put an end to the illegal waste dumping practices without the understanding and help of local inhabitants. Even then it is very hard to guard such a big area from external lawbreakers, as it is close to the city and easily accessible by car. The organization of voluntary annual clean-ups, such as the popular *Te szedd*[1] in Hungary, would help to decrease the amount of waste, but due to the amount and nature of trash, professional clean-up with the necessary equipment would be needed first.

In the case of illegal burning sites, two main sites have been identified (Figure 22). Although apart from a few wires no definitive evidence was found during the fieldwork about the nature of the activity, according to local knowledge these sites are used for burning down the outer seal of the precious copper wires. The bare wires are then sold to the scrap yard, often providing valuable income for poor or homeless people. This activity was already described by Deák (2002) and since then the situation has not changed. This problem cannot be solved purely by guarding the area, as regular patrolling would simply result in burners moving to another spot. Better possibilities should be provided as sources of income to this poorer group of people, and they should be

[1] Voluntary waste collection every (half) year, where infrastructure is provided by sponsors

integrated to the society. Solving this situation is far beyond the power of this study and is discussed only theoretically in the next chapter.

Figure 22 Illegal activities in Felsőrákos meadows

5. Discussion and recommendations

The aim of the study was to give recommendations for future maintenance plans of Felsőrákos meadows, one of the largest urban green areas (UGAs) in Budapest. The present study mostly concentrated on the ecological aspects, but also took into consideration the well-being of the inhabitants and illegal activities on site. In fact, all of these viewpoints relate to each other, and are necessary for the major goal: to create a liveable environment for both people and wildlife. Without the presence of good quality UGAs, city dwellers will inevitably suffer from the lack of ecosystem services provided by them: mitigation of the urban heat island effect, clean air, relaxing environment, place for recreational activities, just to name a few. However it is not enough to preserve UGAs, as they have to be preserved in good quality and kept clean and safe from illegal activities, such as dumping, human waste or cable burning.

Banning people from the area is not a solution, although: Felsőrákos meadows may become a better place, but another area would be chosen by lawbreakers and suffer the negative effects. Therefore it is absolutely necessary not just to treat the surface of the problems, but also the root of them: providing alternative possibilities for the poorer layer. Advocating a cheaper and more organized waste collection system within the city, creating more job opportunities and involving citizens in the life of the community and district should be a way to achieve change in people's behaviour, to make them feel that it is in their interest to protect the remaining green areas. The present work call attention to the values of Felsőrákos meadows and to the issues which threaten them, thus makes the first steps towards these goals. The findings will help the governing bodies, organisations and inhabitants to make appropiate decisions regarding the future of the area.

Comparison – 10 years ago vs. now

Through analyzing the changes between the present habitat map and the one made by Deák in 2002, the tendency in the changes of Felsőrákos meadows is discussed. This study shows that although most of the habitat types identified corresponds with their state ten years ago, due to the advance of invasive species some areas became seriously degraded.

The present state of the Felsőrákos meadows is under less human influence than 30 or 60 years ago, when the fields were used for agricultural production. However, the drier northern parts have not been able to regenerate their original habitat type, so they are mostly characterized as uncharacteristic OC habitats. These meadows were displayed as ancient fallows in Deák's map, which means that they were abandoned for at least ten years. With the exception of the E1 habitat in the north-west part of the study area (Figure 10), these years were not enough for the area to transform into a good quality habitat. Even the E1 habitat does not receive high naturality score on the index The moister areas more or less remained in the same habitat type as they were ten years ago, but some of them became overtaken by *Solidago canadensis*. This invasive species was found in big patches across Felsőrákos meadows, often forming their own OD habitat type. Ten years ago they were mentioned as weeds in the mesic meadows, but were not noted in big quantities. Beside them, the drier areas hosted plenty of scattered stands of *Asclepias syriaca*, which also did not get much attention in Deák's analysis.

In the case of arboreal vegetation, Deák mentioned three species which cause serious problems in the catchment of the Rákos stream: *Acer negundo, Fraxinus pennsylvanica*, and *Elaeagnus angustifolia* in decreasing abundance order. In Felsőrákos two of these, *A. negundo* and *E. angustifolia* are also a serious threat, but *Robinia pseudoacacia* and *Celtis occidentalis* are similarly common non-native tree species. As these species form spontaneous stands very successfully, they are very hard to overcome. Hybrid *Populus* spp. seemed to be easier to control, and their RB habitat patch also blended better into the natural patterns with its rich understorey vegetation and fallen branches and trees.

Areas for protection

From the point of view of conservation, four areas and one habitat type are considered worthy of protection (Appendix 1: small inset map; Figure 23). Three areas would serve for conservation purposes and one for conservation and recreational purposes alike. Additionally, the revitalization of the Rákos stream is also recommended. As the Felsőrákos meadows and the Rákos stream have a strong connection, trying to enhance their naturalness separately would not result in the best outcome (Törő 2002). The first site for conservation is the D2 habitat (point **A**, Figure 23) and its surrounding D34- P2a meadows and shrubs, the second is the D34 meadows close to the stream at point **B,** and the third is the B1a habitat at point **C**. These areas were chosen based on their present state and quality, but although they recreate the ancient conditions with great possibility, it cannot be stated exclusively that the original vegetation of Felsőrákos meadows were the same in these places hundreds years ago. However, the goal of conservation can hardly be to perfectly match the earlier conditions in a given area, as predicting which succesion stage would have been reached by now is very unlikely (Bratton 1992; Hayward 2009). However, maintaining healthy, characteristic habitats to the Felsőrákos meadows is an appropiate and accessible aim, and the selected areas are perfect for this purpose.

Figure 23 Areas recommended for conservation

Habitat conservation – point A, B and C

The D2 habitat and its surroundings (point **A**) received very good naturality scores although the soil was drier than in optimum conditions (which may be due also to the weather which was exceptionally dry the whole summer). Moreover, the area was rich in protected and rare species characteristic of the habitats and also did not contain illegal dumping sites. If the water with proper treatment is retained in the area, it would result in an even better quality habitat, and also reach the status of ex lege protection as fen and marshland (Hungarian Law about the protection of environment 1996. LIII. 23.§ (2)). A major threat source, however, is the advancing invasive species circle around it, which without action has the capability to get abundant within the D2 and D34 habitats. Retaining the water in the soil would help to solve this problem, as *Solidago canadensis* does not like the high water level: it only thrives in a middle-moist environment. Based on the cataster map, which the employers of the Institute of Geodesy, Cartography and Remote Sensing kindly provided for internal use, the area of the D2 habitat is part of one big parcel, therefore it would not cause difficulties to identify the owner of the area, and buy the land for protection.

Similar reasons lie behind the protection of the meadows around point **B**, and the B1a habitat in the shallow lake at point **C**. For the meadows, similar treatment, retaining the water, would be also the right solution, as in the case of the D2 habitat. The already existing shallow lake at the B1a habitat could create a connection between the two wetland sites (**A** and **B**), and could absorb the excess water in times of serious flood. However, according to the cataster map, the area around point **B** is divided into many small parcels, and searching for the individual owners may provide a hard task. The situation is better at point **C** which area is covered by five parcels, therefore finding the owners would be easier.

Recommendations – A, B and C

By allowing the water to get back into these two areas, another problem would be solved at the same time: the high water level at the time of floods in the Rákos stream. By creating floodplains in the area, the increased amount of water would naturally flow into the meadows, providing supplies to the habitats, and decreasing the water pressure in downstream areas (Rácz pers. comm.) According to Rácz Tibor, the Felsőrákos meadows is the only place where such plans could be carried out within Budapest. Both upstream and downstream the neighbourhood of the stream is built in, there is not enough space, whereas in the case of Felsőrákos, the old sub-canals could be utilized too, after cleaning and restoring them.

In relation to this, the revitalization of the Rákos stream itself would also enhance the quality of the surrounding meadows and slow down the speed of floods, this way giving a chance to the marshlands to absorb the excess water. As presently the stream is flowing straight in a concrete bed, the shadow cover is negligible, and the quality of water is not good, almost any kind of change would have a positive effect on the connection between the stream and its surroundings. As the water of the stream is considered heavily polluted (Budapest Sewage Works Ltd. 2009), it does not fit into the European Water Framework Directive (WFD, Fodor 2003). This policy requires member countries to keep their natural water in good ecological state. Applying for EU funds for the accomplishment of WFD would be a good opportunity to cover the expenses of the renaturalization.

During the revitalization one possible solution would be to liquidate the existing bed cover and replace it with woven mesh gabion boxes and mattreses, while at the same time changing the straight flow of the stream, providing it with natural bends (Rácz pers. comm.). The gabion technology would prevent the erosion of the banks, and at the same time allow the vegetation to grow through the mesh and form a natural streamside vegetation. Creating bends and allowing the vegetation to grow through the mesh would provide shadowy areas which give shelter to the fauna and help to decrease the dominance of seaweed (Rácz pers. comm.). This process should be attached to the construction of a bicycle track (section 2.7.1) alongside the stream to avoid unnecessary second, third intrusions to the area and to harmonize the expected outcomes.

Areas for recreation – point D, E and forests

The old airfield (**D**) can play an important role both in conservation and recreational activities. Preserving it in its current state would create a suitable habitat for the already discussed plant and animal species, and at the same time serve the needs of local inhabitants, providing place for kite-flying, running, walking, horse riding, to name a few. Although there are no detailed plans up to now as to the fate of the area (Daróczy pers. comm.), the Budapest development Plan (Ute 2005) recognises the airfield together with the rest of the study area as an important cooling channel for the city, and also the importance of a drinking water source at the east side of the airfield, which requires special attention. The problem is that due to the good location and extent of the area, it may be a suitable site for future investments, therefore the 16th district municipality, the owner of the area, may decide to sell it and abandon its maintenance.

Finally, all the forest type habitats are considered important in Felsőrákos meadows, as they increase the diversity of the area, provide shelter for the bigger animals and help to filter the dust particles from the wind. They also provide aesthetics and shadow for the walkers and riders which is an important aspect, as the area is planned to be involved more in the life of the surrounding communities, providing green space and leisure activities. Although most of the forests are planted, this does not mean that they are unable to provide a natural feeling to the wanderer, and over the years their structure could be enhanced in such a way that more natural trees and vegetation will take the lead. In relation to the revitalization of the stream and planned bicycle route, they have the potential to evolve into a pleasant excursion place for schools and individuals alike. The ownership of these areas is divided between one to three shareholders, therefore it would be not difficult to buy them and turn them into this direction.

Also the planned memorial park at the west side of the E1 habitat (**E**, Figure 23; Hegedűs pers. comm.) would create a good opportunity for recreational actitivities. It could be combined with the popular community garden scheme, by converting some parts of the E1 habitat into gardens. Wild flowers and herbs could also be utilized from the remaining E1 area. As this habitat type is not rare within Hungary, its partial loss for engaging the citizens in sustainable community actions (gardening) would be acceptable and beneficial.

Conclusion

As Felsőrákos meadows is an urban green area, its main purpose is to serve the needs of the citizens. However, a much better quality is achievable, if not only the needs of the people, but the aspects of ecological conservation are taken into consideration. With the different levels of protection in Felsőrákos, everybody would be able to find his/her niche: those who prefer parks could bike along the stream, those who prefer wilderness could venture into the forest. Educational paths could be constructed in the more protected areas to allow schoolchildren and adults alike to observe the protected wetland habitats without destroying them. The positive ecosystem services, which were discussed in Chapter 2, would be fully capitalized instead of their present neglected state.

However, further studies are required to fully discover every aspects of the Felsőrákos meadows. A suitable monitoring program should be established to follow the seasonal changes in the area, and determine the range of extreme environmental conditions from year to year. More detailed analysis of the quality of the water in the stream is also needed, and the revitalization plans have to be made with older flow and flood data in mind. After the reconstruction of the stream bed and other maintenance actions, the monitoring program has to be continued to follow up subsequent changes in the area, and make corrections where needed.

The study succesfully identified those areas in the Felsőrákos meadows which would require a certain level of protection to fulfill their role as an urban green area and provide good habitats to species. Apart from the revitalization of the stream, which would be very expensive, the positive development of the area would not have high costs, especially if local inhabitants would be involved in the planning and encouraged to help through voluntary actions. Felsőrákos meadows has a great potential to increase the effectiveness of ecosystem services to the city and maintain its natural biodiversity at the same time. Its future, however, depends on the actions of municipal decision makers and local dwellers as well. This study is aimed to provide help for these stakeholders, to create a more sustainable Budapest together.

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Personal Communications

Daróczy, M. Assistant of the 16th district Municipality, Budapest. E-mail correspondence. 10 July 2012.

Hegedűs, V. Assistant of the 10th district Municipality, Budapest. E-mail correspondence. 2 May 2012.

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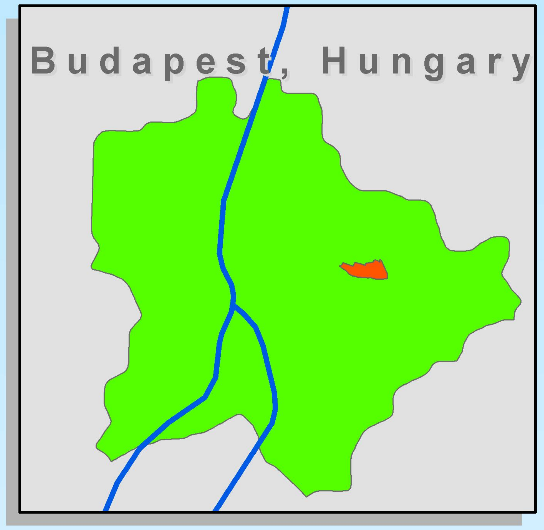
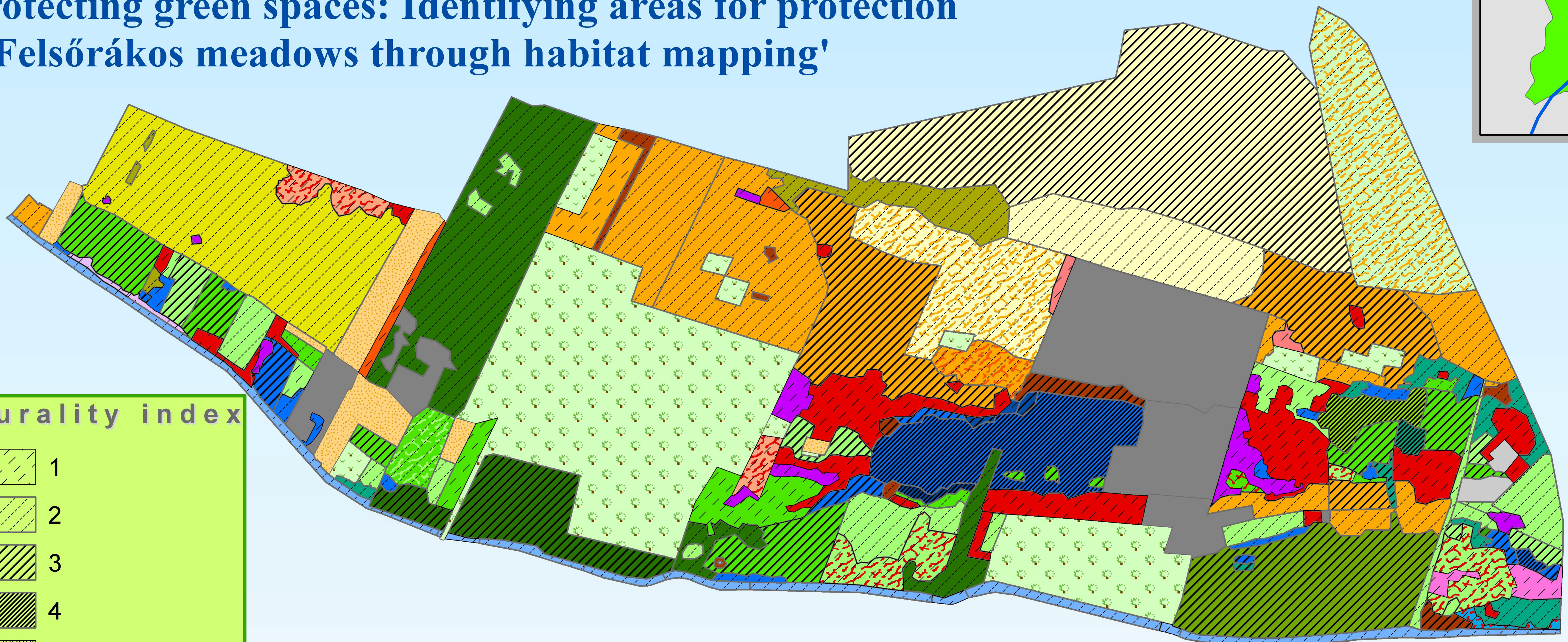
Habitat map of Felsőrákos meadows

Appendix 1 for 'Protecting green spaces: Identifying areas for protection in Felsőrákos meadows through habitat mapping'





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anthropogenic

Legend

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Recommendation for designating protected areas

Areas for conservation
Habitat protection
Forests

Made by Lea Végh, 11 July 2012, Supported by the Central European University