

## THE EFFECT OF ARIDIFICATION ON DRY AND WET HABITATS OF ILLANCS MICROREGION, SW GREAT HUNGARIAN PLAIN, HUNGARY

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### Abstract

By the beginning of the 21<sup>st</sup> century, investigations aiming landscape history and landscape changes became especially important in the environmental research. The decreasing number of natural areas called the attention of the world to the rapid changes in the landscape caused by human activities and climate change. Certain places are facing with increased problems caused by the sensitiveness of landscapes. In Hungary, in the Danube–Tisza Interfluve a continuous groundwater-table sinking process was observed, as a result of anthropogenic effects of the last century and the consequences of climate change. On the highest part of this mesoregion (e. g. Illancs microregion), the decrease of the groundwater-level has reached 7 metres compared with the 1970s which affected significantly the nature and the local inhabitants as well. This study aimed to investigate the effect of this aridification process on dry and wet habitats of Illancs microregion. It reveals the ongoing processes in the landscape, referring to the previously affecting factors. In case of dry habitats, fragmentation and invasive species play important role as threatening factors. Wet habitats are significantly decreasing, shift of the vegetation zones can be observed. The stands are degraded, their steppification is dominant and can be observed only in the deepest parts of the depressions.

*Keywords:* landscape changes, aridification, dry habitats, wet habitats, water-shortage

### 1. Introduction

European landscapes were highly affected by human activities in the 20<sup>th</sup> century. Due to industrialisation, extension of settlements and intensive agriculture, many natural areas were degraded or disappeared. By recognising the importance of the decrease of biodiversity, several international cooperations were born in order to protect habitats and species (e. g. Birds Directive and Habitat Directive in connection with Natura 2000 network, Ramsar Convention on wetlands). Investigations aiming landscape history and landscape changes have come to the front in scientific research by the beginning of the 21<sup>st</sup> century (Küstler, 1999; Rackham, 2000; Biró, 2006; Molnár, 1997, 2007), as understanding the ongoing processes in the landscape and realising the possible and effective management for nature conservation require this type of knowledge too.

The Hungarian vegetation heritage was examined comprehensively by MÉTA mapping between 2003 and 2006 (Molnár et al. 2007). This survey estimates the

total amount of natural, semi-natural and degraded natural vegetation to 1.800.000 hectares covering only 19.4% of the country. 17.3% of this is seriously degraded, 46.8% is moderate degraded, 32.6 % is semi-natural and 3.3% is natural area (Bölöni et al. 2008). The further degradation and disappearance of natural habitats can be caused by more threatening factors nowadays. The most serious ones are the spread of invasive species, the degradation effect of overkept games, the non-sustainable practice of silviculture and the drainage of wetlands (Molnár et al. 2008). The increasing number of years with drought (Pálfai, 2000) also contributes to the degradation.

As a result of the human activities in the last century (forestation, melioration, extended settlements, increased drinking-water consumption and need for irrigation water) and the consequences of climate change, a continuous groundwater-table sinking process can be observed in the Danube–Tisza Interfluve (Pálfai, 1994; Kuti et al. 2002; Rakonczai and Bódis, 2002; VITUKI 2005). On the highest part of the Sand Ridge, the groundwater-level has decreased by 7 metres in 2003 (which was a dry year) compared to the 1970s. In an area of around 10,000 km<sup>2</sup>, the water shortage has reached 4.8 billion m<sup>3</sup> which is equal to the amount of the total annual Hungarian water-use (Rakonczai, 2007). According to model calculations, water shortage can be explained much more by natural causes (precipitation shortage, climate change) in the highest part of the Danube–Tisza Interfluve (Szanyi and Kovács, 2009).

Because of the special geographical features of the landscape, the Danube–Tisza Interfluve is a popular research field for soil and earth science, hydrology and physical geography considering its additional water-shortage problem. Among its landscape historical research the vegetation reconstruction based on historical maps and regional-scale analysis created by Bíró (2003, 2006) is remarkable. Our research area, the Illancs microregion (Fig. 1a) is an area highly affected by the mesoregional groundwater-table sinking process. This area was previously underresearched, but nowadays several ecological, landscape ecological and geobotanical studies were born (Horváth, 2004; Bíró, 2006; Pándi, 2006; Csecserits et al. 2010). Majority of its natural habitats became cultivated or degraded as a result of the intensive silviculture and agriculture in the 20<sup>th</sup> century. This paper aims to investigate the state and the changes of dry sandy and wet habitats of this microregion and their landscape-historical relations in two protected natural areas and in two former wet habitats dominated sample areas.

## **2. Sample area and methods**

Illancs microregion is located in the southwest part of the Danube–Tisza Interfluve (Fig. 1b) which contains the highest point of this mesoregion (Ólom-hegy 172 m).

The borders of this microregion are not similarly defined (Fig. 1a). Its western border is the Kecel–Baja bluff along the line of Sükösd–Nemesnádudvar–Hajós–Császártöltés settlements. Its eastern border is determined between Császártöltés and Jánoshalma by Marosi and Somogyi (1990a), Mezösi (1989), while Keresztesi (1989), Marosi and Somogyi (1990b) draw it between Kecel and Kunfehértó settlements. Others (Bíró et al. 2007) consider the microchore similar to the latter, but without the Kéles-halmi Sandlands. Its curvy southern border is also drawn differently in the previously mentioned references. The surface is mainly covered by sand, but loess and their mixed varieties also occur in smaller extent and in different depth and thickness under the surface as well (Fig. 2). Among the aeolian sand-forms parabolic dunes, hummock dunes, residual ridges and deflation hollows are the most common. Nowadays, planted forests are the dominant habitat-types (locust and pine trees), natural vegetation occurs fragmentedly in smaller extension. Its natural habitats are open sand grasslands and closed sand steppes (Pándi 2008). The ratio of invasive species is high, *Asclepias syriaca* is the most frequent.

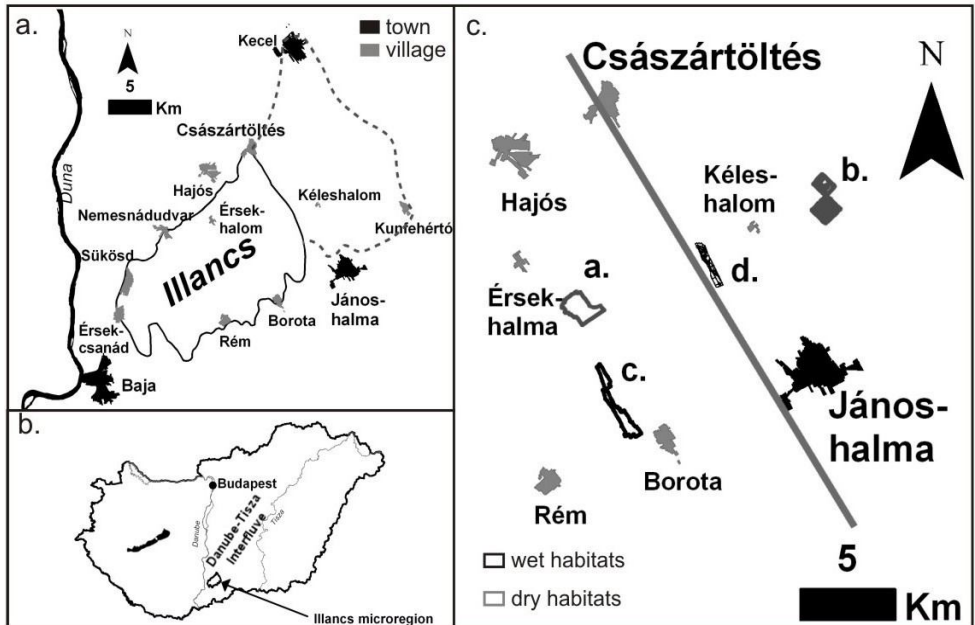


Fig. 1. a. Settlements of Illancs microregion and the different microregion-borders; b. Location of the Illancs microregion; c. Location of the sample areas. The line represents the disputed eastern border of the microregion. (a. Hajósi Homokpuszta NR; b. Kélesalmi Homokbuckák NR; c. former wet habitats dominated blow-out near Borota; d. Lake Kélesi).

We studied 2 protected areas covered mainly by open sand grasslands (Hajósi Homokpuszta Nature Reserve, Kélesalmi Homokbuckák Nature Reserve), and two, former wetter habitats dominated deflation hollows (one meadow located west from Borota, the other at Lake Kélesi near Kéles-halom) (Fig. 1c). The protected

meadows, where open sand grasslands dominate, were analysed because significant decrease and fragmentation of natural areas were observed in the microregion. These areas are still representing the former natural vegetation of the area and their infection with *Asclepias syriaca* is not significant. Moreover, Kéles-halmi Homokbuckák NR is located in the disputed part of the microregion defined with different borders, therefore the comparison of these protected areas can contribute to the determination of the proper border. Wet habitats were chosen around the examined dry habitats for analysis. The borders of the dry habitats dominated meadows are equal to the official protected areas, while the borders of the wet habitats dominated sample areas are determined according to the landuse. The land-cover changes were analysed by topographical maps of the 1950s (MNH 1955) and actual ortophotos (FÖMI 2005). The habitat mapping was based on the categories of the Hungarian National Habitat Classification System (Bölöni et al. 2007) using ortophotos (FÖMI 2005). We present the state of the sample areas on the base of the habitat pattern and species composition with special regard to the consequences of water-shortage. The study of the above mentioned two sand-dune areas with complex view – considering e.g. both geomorphology and vegetation – is important as they have a key role in determining the northeastern microregion-border (between Illancs and Kiskunságian Sandlands). For the geomorphological analysis, digital elevation models of the sample areas were created based on the contours of the topographical maps from the 1980s. To determine the mesoforms, slope and aspect values were analysed. For the data evaluation ArcMap 9.3 software was used.

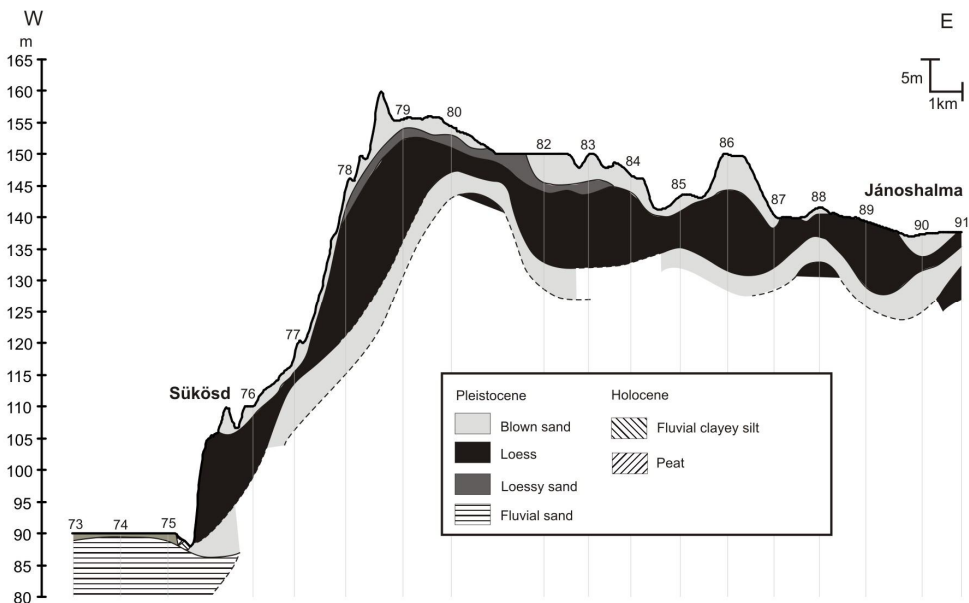


Fig. 2. Cross section of Illancs microregion. Edited by L. Kuti and Zs. Ladányi based on data from the Geological Institute of Hungary

### 3. Results

#### 3.1. Dry habitats

The first difference between the two sample areas is that the Hajósi Homokpuszta NR has steppe while the Kéles-halmi Homokbuckák NR has rather forest-steppe physiognomy (Fig. 3). It can be explained by their different historical land-use. Both protected areas have open sand grassland matrix, into which poplar-juniper steppe woodlands are incorporated in Kéleshalom while in Hajósi Homokpuszta NR it is substituted by *Crataegus monogyna* dominated dry shrubs. This fact alone can't explain the border of microregions as there is no data on *Juniperus communis* in this region which would be older than 250 years. Therefore, it isn't known exactly, if there were sand dunes with *Juniperus communis* in the Danube–Tisza Interfluve before the 19th century at all (Molnár, 2003).

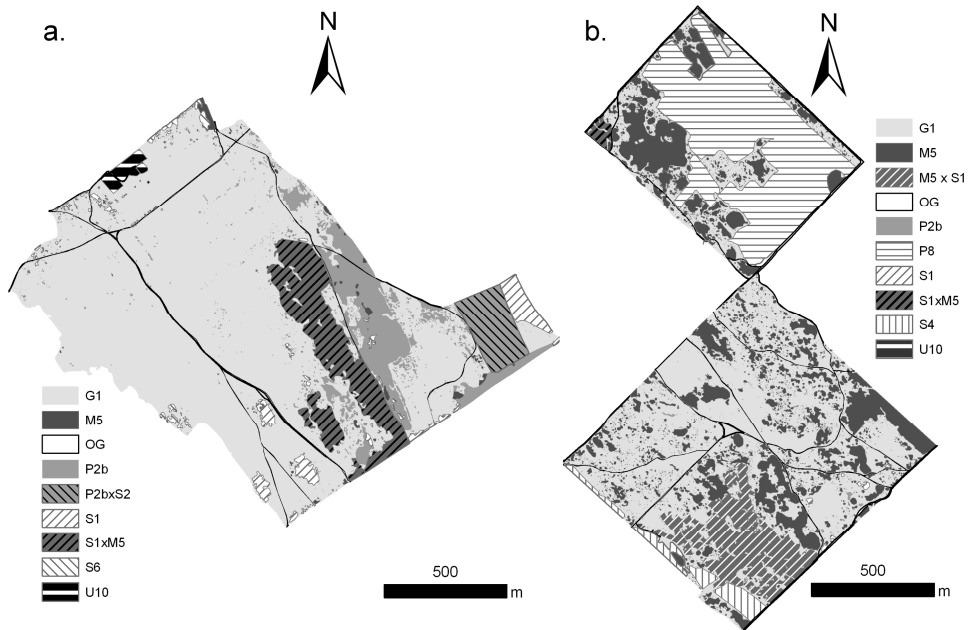


Fig. 3. a., Habitat map of Hajósi Homokpuszta Nature Reserve; b. Habitat map of Kéleshalmi Homokbuckák Nature Reserve (key according to A–NÉR (Bölöni et al. 2007)) G1: Open sand grassland, M5: Poplar-juniper steppe woodland, OG: Trodden weed community, P2b: Dry shrub, P2BxS2: Mixture of dry shrub and cultivated poplar forest, S1: Locust-tree forest, S1xM5: Transition between locust tree and poplar steppe woodland M5xS1: Locust-tree infected Poplar-juniper steppe woodland. P8: Cut-off area, S4: Planted pine forest S6: Invasive tree-species dominated spontaneous forest, U10: Hamlet

Both sample areas are remains of the former natural vegetation between planted forests (locust and pine trees). The particle size of sand is different on the leeward-windward slopes and in the blow-outs (Molnár, 2003), which can be observed in

the closeness and species composition of grasslands. The steep slopes and the upper parts of dunes are characterised by *Festuca vaginata*, *Stipa borysthenica*. On their windward sides *Fumana procumbens* subtype occurs while on leeward sides more closed grasslands with *Stipa capillata* dominate. The speciality of Hajósi Homokpuszta NR is the *Festuca wagneri* dominated sand steppe which is a transition between open sand grasslands and closed sand steppes (TIR 2010). The species composition shows this too: open sand grassland species (*Stipa borysthenica*, *Alkanna tinctoria*, *Festuca vaginata* etc.), closed sand steppe species (*Chrysopogon gryllus*, *Galium verum*, *Salvia pratensis* etc.) or common species of both types (*Stipa capillata*, *Potentilla arenaria* etc.) also occur. On both sample areas significant amount of *Crataegus monogyna* occurs (Figure 4.). Current process on these grasslands is the intensive spread of *Crataegus monogyna*, especially in Hajósi Homokpuszta NR which can be explained by its steppe physiognomy and its partial abandonment too, which needs an active grassland management of nature conservation.

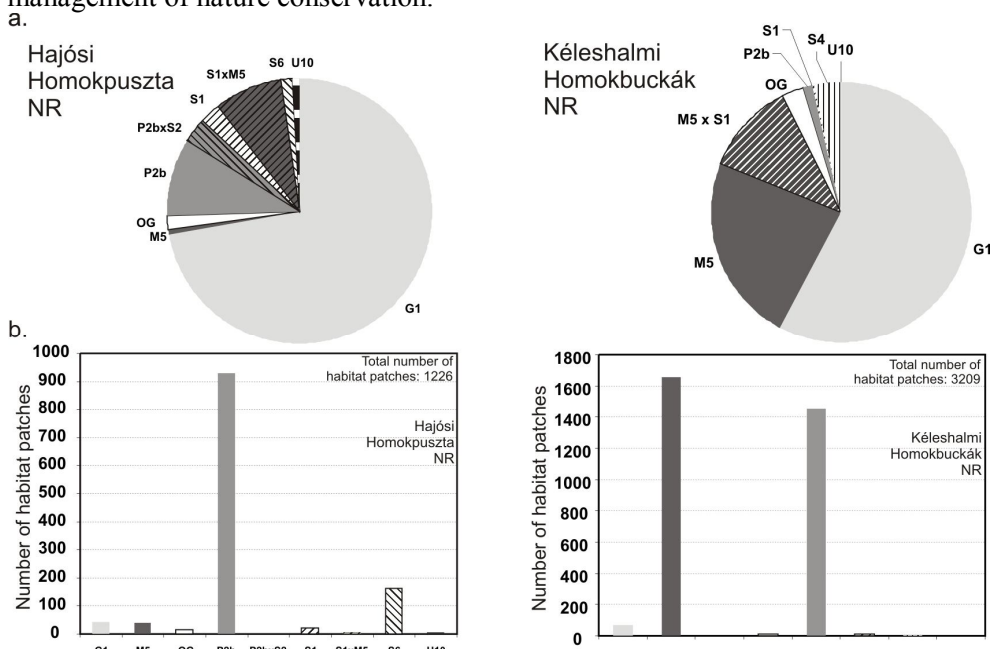


Fig. 4. a. Areal share of habitat patches of the sample areas, b. Number of habitat patches (due to a huge fire event in the north part of Kéleshalmi Homokbuckák NR forests were damaged and cut out (P8), only the south part was analysed)

These grasslands have also protected and strictly protected species like *Dianthus serotinus*, *Alkanna tinctoria*, *Stipa borysthenica*, *Iris arenaria*, *Adonis vernalis*, *Crocus reticulatus*, *Onosma arenaria*, *Tragopogon floccosus*, *Corispermum nitidum* etc. Both protected areas became partially cultivated during the 20<sup>th</sup> century which affected the landscape pattern (Figure 5.). The north-eastern part of Hajósi Homokpuszta NR gave place to a small vineyard. The strait lines of

*Crataegus monogyna* (Fig. 3a, 5a.) on the place of the former boundary and the lack of the classical sand dunes (Figure 6/a.) still refer to it in the landscape. The Kéleshalmi Homokbuckák NR became partially cultivated in this period too. On the topographical maps of the 1950s (MNH 1955), 2 hamlets with arable lands, vineyards and orchards can be identified (Fig. 5b.). The human landscape transformation is also shown by the surface-planations which were made in order to make the dunes cultivable (Fig. 6b). The northern part of this sample area was afforested in the end of the 20<sup>th</sup> century, but because of a fire in the beginning of the 2000s, the forest was cut out. After the abandonment of this plot invasive species (mostly *Asclepias syriaca*) have spread on this disturbed place.

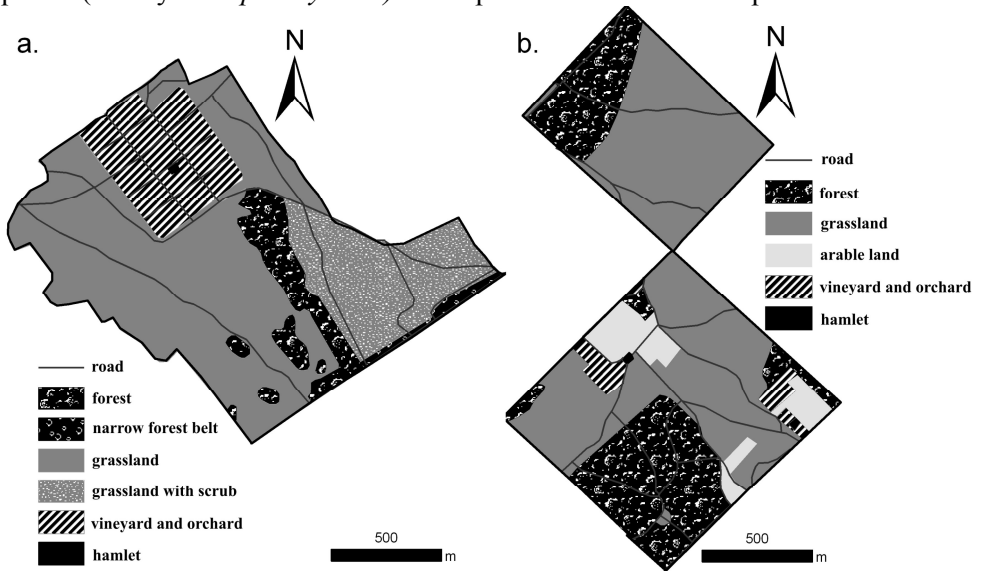


Fig. 5. Land-cover of sample areas in the 1950–1960s (MNH 1955) on the sample areas (a. Hajósi Homokpuszta NR; b. Kéleshalmi Homokbuckák NR)

The sample areas are located almost at the same elevation above sea level, and the relief differences are similar as well (14–15 m). Among the positive eolian forms parabolic dunes and residual ridges are determining (Fig. 6). Their crest lines are around 200 metres in average. The slope of leeward sides of the dunes in Hajósi Homokpuszta NR do not exceed 15°, while in Kéleshalmi Homokbuckák NR this angle on average is larger, but is maximum 22°. The dunes in both sample areas are not higher than 10 metres, while the dunes in Fülöpháza (40–50 km northeast) have an average height of 10–15 metres (Kiss and Tornyánszky, 2006). According to the above mentioned data, the size of mesoforms in Hajósi Homokbukák NR differs slightly from the Kéleshalmian ones.

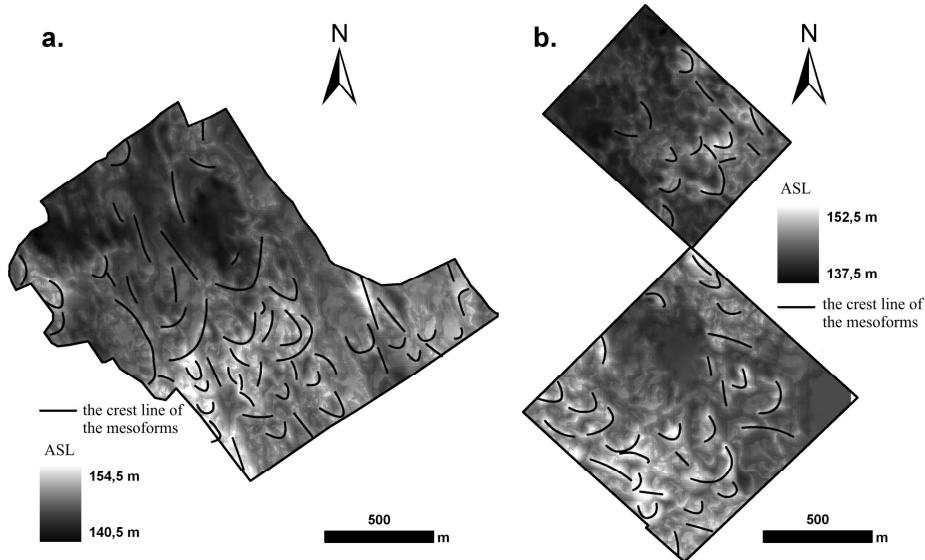


Fig. 6. Relief model of the examined sample areas on the basis of topographical maps from the 1980s (a. Hajósi Homokpuszta NR; b. Kéleshalmi Homokbuckák NR)

### 3.2 Wet habitats

Fens and marshes belonged to the natural habitats of the dune zones in the deflation hollows too. The depressions between dune-fields were characterised by wet habitats like *Molinia* fens (Bíró, 2006). As a result of meliorization began in the 1940s and the precipitation shortage (as a consequence of climate change), their extension decreased significantly. Such habitats could be found in the depressions along the southern border of Illancs according to historical maps (HIM 1764–1787, HIM 1806–1869, HIM 1872–1884, MNH 1955) until the 1970s.

The sample area west from Borota (Fig. 7a.) was presumably characterised by fen and saline habitats before the meliorization. Fens remained mainly in the northern part of the sample area, mostly as drying-out *Molinia* fens and fen tall-herb communities. The groundwater-table decrease is shown by the spread of *Crataegus monogyna* on *Molinia* fen, which is typical species of dry steppes. In the middle of the area a shift of vegetation zones can be observed: sand steppe grasslands took the place of *Molinia* fen in the deflation hollows, whereas *Molinia* fen moved to the channel crossing the sample area. Saline habitats are represented in their dried-out, steppified varieties, mostly in the south part of the sample area. These are characterised by *Agrostis stolonifera* and *Festuca arundinacea* – this latter species refers to sand burial –, but their ratio is exceeded by *Dactylis glomerata* and *Festuca pseudovina* showing the result of steppification. Other sand steppe grassland species also occur like *Ononis spinosa*, *Achillea collina*. *Achillea*



*asplenifolia* and *Juncus gerardi* represents the remains of saline meadows. Marks of leaching process are demonstrated by the higher ratio of *Agropyron repens* and *Poa angustifolia*. In all the other parts of the examined area, the previous wet habitats have totally transformed to sand steppe grasslands. Due to grazing with sheep, the invasion of *Asclepias syriaca* is not significant.

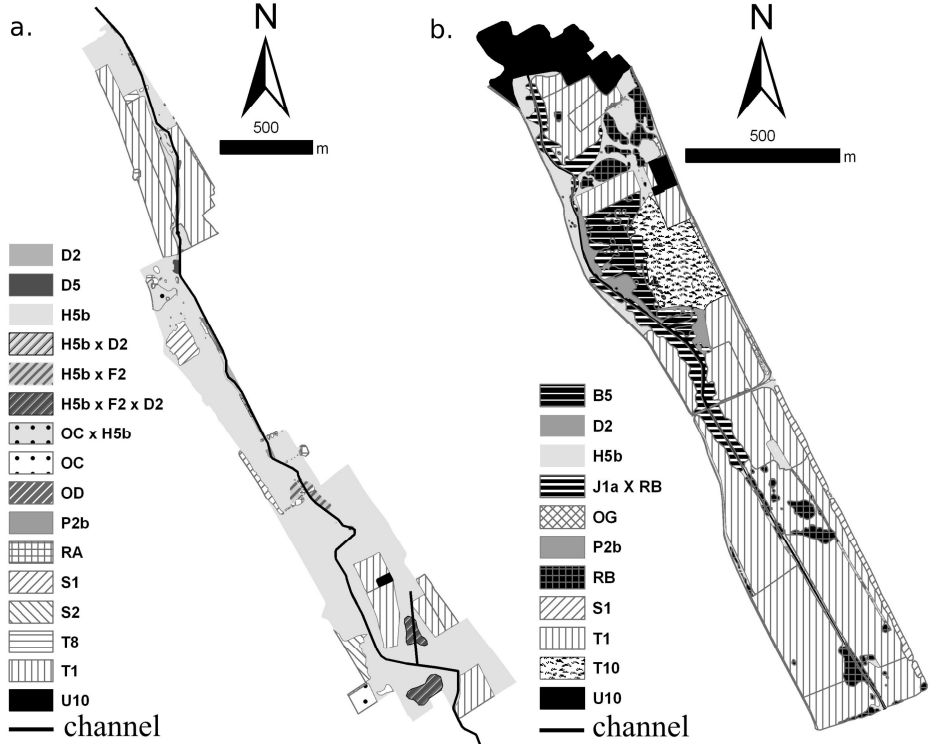


Fig. 7. Habitat maps of the sample areas former determined by wetter habitats a. Sample area west from Borota; b. Blow-out near Kéleshalom with the Lake Kélesi. Habitat categories (key according to A–NÉR (Bölöni et al. 2007)): D2: Molinia fen, D5 Fen tall-herb community, H5b: Sand steppe grassland, H5bxD2: Former Molinia fen became a sand steppe grassland, H5bxF2: Former saline meadow became a sand steppe grassland, H5bxF2xD2: Former transition between Molinia fen and saline meadow became a sand steppe grassland, OCxH5b: Highly weedy sand steppe grassland, OC: Weedy dry grassland, OD: Soft-stem invasive vegetation, P2b: Dry shrub, RA: Tree-groups of native species, S1: Locust-tree forest, S2: Cultivated poplar forest, T8: Small-scale vineyard and orchard, T1: Large-scale arable land, U10: hamlet, B5: Sedgefield, H5bxOC Weedy sand steppe grassland, J1axRA: Group of fen-shrubs and native trees, OG: Trodden weed community

The sample area around the Lake Kélesi (Fig. 7b) became almost totally cultivated in the last decades, so only the deepest parts preserved the former wet habitats. Tall herb communities, Molinia fens and *Salix cinerea* fen-shrubs represent nowadays the former wet habitats. The territory is maintained by the groundwater-flows coming from the surrounding dune zones, which helped the drying-out and steppification remains of wet habitats to survive. Characteristical wetland species are here the *Salix cinerea*, the *Molinia hungarica*, the *Populus alba*, the *Typha*

*angustifolia* and the *Mentha aquatica*. On the edges of the blow-out sand steppe grasslands occur, but this habitat-type occupies the former cultivated regenerating meadows too.

#### 4. Summary

Natural and anthropogenic processes of the 20<sup>th</sup> century highly affected the natural and semi-natural habitats in the microregion. In case of dry habitats mainly land-use changes and their consequences – like afforestation, fragmentation – caused significant alterations. The grasslands incorporated into planted forests are threatened by the spread of dry shrubs on non-managed places and by the invasion of *Asclepias syriaca* on disturbed places. The ratio of natural grasslands is really small and they are characterised by less invasive species. The two examined protected areas covered by sand grasslands don't show enough difference in geomorphology and species composition to be sorted into different microregions. On the examined wet habitats, the shift of vegetation zones is dominating. The remains of fen and saline habitats can be identified, but only in the deepest parts of blow-outs. Only their dried-out, steppificated varieties are represented, many times they are totally transformed into sand steppe grasslands. Sluice in the channel occurs just in the northern part of sample area west from Borota, which is permanently closed that has contributed to the preservation of *Molinia* fens in the channel. This fact shows the importance of water retention in this landscape. The actual land-use has a big role in the formation of landscape too. Near to the sample area in Borota hardly any *Asclepias syriaca* occurs on a fallow, which is clearly the positive effect of grazing with sheep. However a lot of stringing plants occur (*Carduus nutans*, *Ononis spinosa*) in sand steppe grasslands, so their naturalness is medium. Sand steppe grasslands with more natural species-composition on the edges of the blow-outs support the regeneration of abandoned arable lands and of the drying-out wet meadows.

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