Analysis of land cover changes in the middle part of Danube–Tisza Interfluve, with special regard to land use anomalies and nature conservation

Summary of Ph.D. thesis

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1. INTRODUCTION, AIMS

Inter- and transdisciplinary study of landscape structure, functioning and change that analyze the natural, environmental and socio-economic factors integratively, is a traditional task of landscape ecology. One of main aim of the research, which was introduced in the dissertation, was the complex landscape analysis with functional, structural and chronological approach of a certain landscape part. It has developed under relatively homogenous socio-economic and landscape historical circumstances, and has a quite integrated character regarding the basic physico-geographical conditions. I carried out a GIS-based analysis of such an area that can be described as a landscape part, which has much more inner heterogeneity in social and natural characteristics, than its integrated landscape ecological character as a whole unit. My examinations focus mainly on land cover and its changes which are assessed with ecological-landscape historical aspect and landscape protection purposes, from the end of 18th century until today.

In order to introduce the outstanding role of natural conditions playing in land cover changes and landscape changes, I have analyzed their emergence in different time periods, as well as the temporal change of their exploitation as landscape potentials. I have determined the natural landscape types and the landscape type characteristics of the study area in order to know the basic physical structures and the attributes of natural landscape functioning, and to reveal their differentiating role playing in landscape development.

I have drawn a parallel between the quantitatively expressed land cover changes and the results from social science, human geography and landscape history research, which describe the land use changes and their causes. I have made conclusions about the quality and importance of socio-economical driving forces by the results, which can be calculated based on the GIS databases and maps displaying the historical and relevant landscape states.

During the research I have been looking for the answer to the question: what kind of pattern is shown by the land cover stability and the temporal variety of land cover in space? I have also examined, which factors influence the structure of these patterns and what are the edifications for the landscape protection and land evaluation. Habitat mapping was carried out in the study area, where I have located natural areas (habitats, habitat aggregations), which have high importance for landscape protection.

Further important ***questions*** may occur in connection with ***land cover*** and its ***stability***:

How did the spread of the scattered farms (traditional landscape elements) ***and new-type residential homesteads change*** in the near past in the certain landscape parts with different conditions (accessible and inaccessible areas regarding the transportation, urban-rural fringe, rural landscape parts)?

Are there any horticultural production areas cultivated continuously as vineyards or orchards in the study area, which ***hold value*** for landscape protection ***due to their cultural significance***?

What are the possible reasons of the transformation of such ***grasslands and wetlands***, which had been stable for a long time, but in the near past they became human transformation-affected?

I have further examined that since when and in what extent did such ***land utilization*** occur ***on the wetlands***, i.e. in the water-affected areas with semi-natural vegetation, which implies disturbance of surface and ***destruction*** or damage of semi-natural vegetation. Because of the limited possibilities of land utilization, which is a result of the water surplus of water-affected areas, and due to the ***deviation*** (difference) ***from the*** historically developed, ***adaptive land use structure***, the cultivation causing soil disturbance and land transformation was considered as a ***land use anomaly***.

Together with the above mentioned aims, it is essential to understand landscape functioning, discover the factors, which influence or determine the landscape structure and landscape change. It is also important to know the direction of landscape development, in order to detect the landscape's values and their endangerment and find out the consequences of changes for landscape protection, which were the final aims of my research.

2. THE STUDY AREA

The study area with a size of 25×25 km has an ordinate square shape, and it is situated in the Danube–Tisza Interfluve, or according to the hierarchic order of Hungary's natural landscapes, in the „Danube–Tisza Sand Ridge" region. From between the microregions constituting this region, it involves certain parts of „Sand Ridge in Kiskunság" and „Loessial Ridge in Kiskunság".

In this area it was easy to catch the differencing factors of landscape development and the characteristics emerging on local scale. The study area, which also involves Kecskemét, seemed to be proper for exploration and presentation of different development ways of the city, its urban fringe and the rural landscape parts. It shows the unequal landscape development well, that the actual landscape ecological condition of study area is characterized by all the landscape types (natural, managed, cultivated, suburban and urban) together deemed the anthropogenic intensity.

According to the landscape typology of (Pécsi et al. 1972) created from the Great Hungarian Plain and the map of landscape types of Hungary the study area consists of „loessial plain with deep groundwater table and chernozem", „sandy region with half-fixed dunes, planted forest and remnants of sandy steppe-meadow", „fixed sandy plain with mosaic-composed sandy steppe-meadow, Robinia- and Populus-forests, vineyards and orchards", „sandy plain with chernozem soil, horticulture and arable use". We can also find „interdune depressions", which can be characterized with high ground water table, fenny meadow soils and sodic meadow soils.

3. METHODS

The historical analysis and the assessment of role of natural conditions were preceded by construction of GIS databases. I used the following map sources directly (as an information record) or indirectly (as an interpreted and edited GIS data file):

- Digital geological map of Hungary (MDFT, M=1:100.000)
- From the series of geological map of Great Hungarian Plain „Kecskemét" and „Dunaújváros–Izsák" parts
- Pécsi's geomorphological map representing Kecskemét's vicinity (1968)
- Kreybig's review soil-knowledge map series
- Genetic soil map of Hungary (MÉM NAK genetic soil map)
- Agrotopographical database of Hungary (AGROTOPO)
- Point- and polygon-based habitat map of Danube–Tisza Interfluve
- Kiskunság National Park Directorate's (KNPI) database of natural areas
- Maps of First–Third Military Survey (interpreted as land cover)
- Bedő's first and second, corrected forest map (1885, 1896) and modified version by Járó (1966)
- Homolka's agriculture map (1895)
- Unified Modern Legion Maps (1940–1944, interpreted as land cover)
- Maps of Military New-Survey (1953–1959) (interpreted as land cover)
- Topographic maps with Gauss–Krüger projection system (M=1:25.000, FÖMI 1989)
- Topographic maps with EOV projection system (M=1:10.000, FÖMI 1992–1996, interpreted as land cover)
- Orthophoto formats of aerial photographs created in 2000, 2005 and 2009
- Periphery and clear vector real estate registry database originated from 2008 (KÜVET, BEVET, interpreted as land cover)

Based on the above mentioned and as land cover interpreted maps, ***I have edited land cover maps of seven different time horizons*** (1783, 1860–1864, 1881–1883, 1930's, 1957–1959, 1992–1996, 2008–2009) concerning the study area with the help of an GIS software (ArcGIS 9.3).

Based on the land cover maps I have evaluated the land cover changes of the study area, using also the literature of settlement history, historical geography, landscape history and other social science. The GIS comparison with the map files representing the natural conditions also helped this process. In the case of the first six time horizons with visual interpretation of map borderlines I have divided land cover types, which compose unified category system comprehending the different time horizons, and for these I have created vector databases. The six land cover types of the study area are: 1. arable land 2. meadow, pasture, grassland with groves 3. natural forest, artificial forest, tree-plantation, closed scrubs 4. vineyard, orchard, garden (kitchen-garden, market-garden, flower-garden, park) 5. settlement, other built-up area (roads, cemetery, landfill) 6. natural water cover 7. artificial still water. I use the 2., 3., and 4. land cover types in order to abbreviation in this form: 2. grasslands and grasslands with groves 3. forests, tree-plantations 4. horticultural areas.

Attribute and geometric data of KÜVET, BEVET real estate registry database were converted according to this unified land cover category system with reclassification and merging. For the better comparison, because of the different scale of source maps, with the use of Töpfer's Radical Law, according to smallest 1:50.000 scale I reduced the number of polygons of those maps which have different scale, to the number which fits to 1:50.000 scale.

I have combined the land cover raster files with a cell size of 100 meters with the 100-meter resolution raster versions of two attributes of AGROTOPO-database (soil texture, soil quality score), which express the quality of production site. (The raster files have been converted from the appropriate vector files.) I have gained the statistically analysed results from the combined files with the „Select By Attributes" function.

For the identification of semi-natural areas and habitat groups I have made a GIS file of the areas covered with natural and semi-natural habitats and habitat-aggregations (of the semi-natural areas) based on habitat classification which I have accomplished at field work. The minimum size of a mapped habitat was 1 hectare. The borderlines were drawn based on the orthophotos from 2005. I have done the field work from 2004 continuously, mostly in the period between 2004 and 2008, partly related to the MÉTA-program. The habitat classification was achieved with the help of Habitat-knowledge Guide 2.0, which was compiled for the MÉTA-program. The habitats were recoded using the later published habitat classification guide. Beside my own habitat classification I have taken into consideration in the region previously completed habitat surveys as a control, too.

Because of the instability of habitat type borders, the temporal variability, the abundance of habitat-complexes and most of all because of the extension of the studied landscape part, I decided to merge the habitats into greater units. I have separated six semi-natural habitat-groups: marshes, wet grasslands and sodic habitats, closed dry grasslands, open sand steppes and scrubs, sand forests, wet scrubs and forests.

For the assessment of land cover stability and temporal variety of land cover I used the vector databases of five time horizons (1881–1883, 1930's, 1957–1959, 1992–1996, 2008–2009). I converted these to raster format with cell sizes of 10, 25, 50, 100 and 200 meters. (Only these five vector databases were appropriate for stability and temporal variety studies due to the accuracy of the original maps). I combined the raster files with different cell sizes by cell size and then I reclassified them. The frequencies (number) of land cover change, i.e. the land cover stability were determined with the help of Microsoft Office Access program according to the data of combined files. It was possible to evaluate the temporal land cover variety with the variety tool from cell statistics toolbox of the GIS software. There was a great number of results and the need of controlling them one by one during the analysis of combined files, which comprehends two or more time horizons. From the different cell-sized combinations with different cell sizes, I examined the 100-m resolution combinations in more detail, which give not too much number (1000–1200) results.

The degree of stability is determined by the frequency of land cover changes, i. e. that how many times did the type of land cover in a given area (in the same cell of raster files) change. In the GIS model used, there is a mathematical maximum of 4 changes between the five time horizons. The temporal land cover variety expresses that how many different land cover types occurred in a given area from a parent time, regardless of the number of changes. Due to my classification, theoretically 7 land cover types may vary in the study area. In accordance with my rating, the degree of land cover variety can be considered low, if only 1–2 land cover types appear in the given area, and high if it is characterized by at least 4–5 land cover types during the times.

The stability and temporal variety result maps were compared with the maps of different attributes (stock of organic matter, soil quality score, soil texture, water exchange characteristics, chemical reaction, depth of topsoil layer) of AGROTOPO-database by visual collation.

I have received the grasslands and wetlands which were stable till the regime change but since then changed by using the „Select By Attributes" function. The results (410 cells) which were received by selection from 100×100 cell-sized, combined database were controlled cell by cell through visual collation with EOTR topographic map and orthophoto form 2009.

During the examination the land use anomalies related to the water-affected areas, in order to reveal them I have compared the land cover map databases in case of five time horizons (1881–1883, 1930's, 1957–1959, 1992–1996, 2008–2009) with the databases of areas with natural water cover with GIS method. I have built the database named as the map of areas with natural water cover by unification („Union" function) of the cells which belong to the sixth type (natural water cover) of the land cover maps originated from the above mentioned time horizons.

The databases of areas with natural water cover were converted, according to the databases of land cover maps, to raster files with cell sizes of 10, 25, 50, 100 and 200 meters. Through the combination of raster files with the same cell sizes, I gained five databases. From these I determined those cells (for each time horizon) with selection by attributes, where natural water cover appears in any time horizon and on the same place, in the examined time horizon another land cover type come up, which is not compatible with the surface water influence or with the historically developed, adaptive land use structure. Such incompatible land cover type is arable land, vineyard, tree plantation, built-up area, or artificial water facilities (e.g. reservoir, fish pond). The cells which were received by selection were controlled one by one. The apparent result cells, which contained real and false results as well, were compared with the original map, with the orthophoto from 2000 and the EOTR topographical map (scale: 1:10.000). Those apparent results (individual cells) were considered as false results, which were independent of the effect of groundwater, and according to orthophoto unanimously dry area, outside the local depressions. 1124 cells of 100- and 200-meter resolution result maps were investigated one by one if it shows a real result, or because of error possibilities, it can be considered as a false result. I have deducted my conclusions evidently only in accordance with real results.

For the analysis of changes in density of scattered homestead network (scattered farms and new-type residential homesteads) I used the following source maps (already available in digital format, or digitized by myself): the map sheets of First, Second and Third Military Survey (1783, 1860–1864, 1881–83), Unified Modern Legion Maps (1940–1944), Military New-Survey (1957–1959), topographic maps with Gauss-Krüger projection system (1989) and orthophotos from 2009. With the visual interpretation of scattered homesteads, which occurs in the seven time horizons, I built up digital point databases with the help of ArcGIS 9.3 program, from which I generated density maps („Point Density” tool). The points of the scattered homesteads were recorded in such an area which is bigger than the study area and was enlarged with that width which is equal to the side length/radius of the neighborhood area. A circle shaped neighborhood area was used.

Expansion of the neighborhood radius allows taking more point into consideration, but the summarized score is divided by bigger area unit, therefore the values of density are changing. Bigger neighborhood radius results in a more generalized raster file, so we can draw only some more general conclusions. The created raster result maps were reclassified with defined interval (50 and 100).

Density map files of the single time horizons were collated using GIS operations. Out of the maps of two succeeding time horizons which were created with the same cell size and neighborhood radius, the values of the earlier were subtracted from the other using the „Minus” tool. The results of this operation became those maps which shows, that where and to what degree did the density of scattered homesteads decrease or increase between the different time horizons.

4. RESULTS

4.1 Main results of the historical analysis

4.1.1. In the period from the end of the 18th century until today, the different natural potentials of natural landscape types (sand dune area, sandy plain, loessial plain, meadow depression, sodic depression) which can be divided by the natural landscape factors sometimes completely determined the structure of land use, and consequently the structure of land cover. Its changes (the landscape development, in other words) have also been determined by these physico-geographical factors. ***In the beginning of 20th century***, because of the favourable condition of sandy soils (immunity to the phylloxera) ***horticultural areas*** (vineyards and lands partly used as vineyards), which size ***increased by four-five times, concentrated clearly on sand dune areas and sandy plains.*** We find them on 93% of the sandy soils of the AGROTOPO-database at this time. According to my data, at the beginning of ***intensive afforestations***, 95% of new afforestations between the middle 1930’s and 1957–59 occurred ***on sandy soils***, against the areal proportion (about 70%) of this soil type. The reason of this is that sand areas were considered less suitable for agricultural cultivation and deflation was considered a source of danger. The thesis above is also supported by the fact that quality of production sites could have played a role in the cultivation abandonments between 1992–1996 and 2009. It can be explained with that compared to the proportion of area of sand, sandy loam and loam physical soil types (69.5%, 22.6% and 7.9%), the proportion of fallows was 82.0%, 16.2% and 1.8% in accordance with these types.

4.1.2. ***Land cover changes*** of the research area were characterized by the following main trends ***since the end of the 18th century***. The share of ***the treeless grasslands and grasslands with groves decreased continuously*** from 80–90% ***by the end of the 1950's*** to 17%, and then ***increased*** to 23.1% because of cultivation abandonments ***by the years after the regime change***. It has ***started to decline again in the recent past***, it was 20% in 2009. The extent of ***forests and tree plantations is steadily increasing***, from a nearly treeless landscape (about 1%) to a significantly forested landscape (about 23%). The ***arable lands*** after the initial 5–10% ***reached their maximum*** (about 56%) ***in the first half of the 20th century, after then*** their rate continuously ***decreased*** to 35%. The proportion of ***horticultural areas*** has also changed from 2–3% to approximately to 18% and then to 12% ***with such a temporal fluctuation***. The extent of ***natural water covers*** was determined by climatic conditions: its rate moved between 1% and 4%. The share of ***built-up areas increased*** continuously from 0.4% to almost 8%.

4.1.3. ***Land cover changes in the recent past*** (between 1992–96 and 2009), which are also probable tendencies for today, are summarized as follows:

- the ***expansion of urban space*** and built-up areas, and the ***spread of*** modern, new-type ***scattered homesteads*** around Kecskemét,
- the ***decrease of*** the number of traditional scattered ***farms***,
- the ***decline in grasslands and arable lands*** due to the agricultural recession, mainly through the increase in subsidized afforestations,
- the areal decline of vineyards, orchards and gardens for similar reasons,
- ***occurrence of grassy fallows*** with smaller proportion on the places of former horticultural areas and arable lands.

4.2. The connection of land cover stability and temporal variety of land cover with the production site characteristics

4.2.1. Based on the comparison with the attribute layers of the AGROTOPO database, the ***stability*** and the temporal variety show a close spatial ***coincidence with the pattern of soils*** with different organic matter content. If two classes are formed on the basis of the soil organic matter content (in

Hungarian: SZK) (in the case of class 1 SZK<100 t/ha, in the case of class 2 SZK>100 t/ha), we can find that in the areas belonging to class 2, one or two land cover types occurred from the end of the 19th century, while in the areas belonging to class 1, three-five land cover types combined or replaced each other. The areas with ***high land cover stability*** and small variety are the ***meadow depressions, sodic depressions and the loessial plains***. The former have been dominated by grasslands (probably regularly or just periodically water-affected grassland) and natural water cover named land cover categories for a long time. While on loessial plains arable land is the dominant and stable land cover type. The areas with ***land cover which is*** quite ***variable*** (unstable) and ***varied*** (diverse in time), are represented by ***sand dune areas and sandy plains*** where sandy soils have usually only very small (<100 t/ha) organic matter content. ***My conclusion*** is that the ***higher the organic matter content*** is, the ***less has the utilization changed over time***. And thus the ***less land cover types have occurred*** in the given location, reflecting the ***close relationship between land use and the natural agroecological potential***.

4.2.2. ***The degree of fertility or natural agroecological potential*** can be further expressed with the so-called soil quality score, which is, according to my results, also closely related to the temporal variety and stability of the land cover. The soil quality score classes (class 1: 0–10 TÉSZ, class 2: 11–80 TÉSZ) based on the TÉSZ attribute of the agrotopographic map file and the areas belonging to the same soil quality score classes show a recognizable spatial ***coincidence with the areas*** which are in nearly or totally ***equally degree varied and stable***. If we compare the areas created according to TÉSZ with the stability and temporal variety maps, we find that high stability and small variety characterize the areas with high and medium soil quality score (class 2). While in areas with low soil quality score (class 1) usually multiple land cover changes and various land cover types occurs in the examined period.

4.2.3. Since the wider region of the research area had decisively agricultural character from the point of view of utilization between 1881–83 and 2009, the degree of agroecological potential influenced both the stability and temporal variety of land use and land cover. Based on the results, if we consider either the soil organic matter content or the soil quality score, we can conclude that ***the natural agroecological potential has acted in this region as a driving force for landscape changes in the last 130–140 years***.

4.2.4. However, I have not found spatial coincidence with the patterns of other soil properties included in the AGROTOPO database (such as physical soil type, water management properties, chemical reaction, depth of topsoil).

4.3. Spatial and temporal development of land use anomalies related to the water-affected areas

4.3.1. According to my results, it can be verified with GIS tools that at the end of the 19th century, ***there were such water-affected areas*** in the region, which were not covered by grassland or natural water cover but ***were utilized as arable lands*** despite the danger of flooding.

4.3.2. By examining the temporal trend, I found that ***ecologically negative landscape transformations*** of the water-affected areas (apart from the outliers caused by climatic and social reasons in the first half of the 20th century), were more and more characteristic of the study area ***from the end of the 19th century, in parallel with the anthropogenization*** of the landscape. The share of the converted areas (built-in, ploughed, afforested, etc.) has grown from around 2% to 5–6% during the examined period. According to this, the occurrences of ***land use anomalies*** in the water-affected areas were not extraordinary in the past, but as time progressed, this tendency strengthened, so today we can find more and more places with their appearance.

4.3.3. ***In the 1930's, land use anomalies*** of the water-affected areas occurred with a very high proportion (around 7.4%), ***in 98%*** of them were results of ***conversion to arable land***. In my opinion, the economic (world economy and local economy crisis) and the climate change-related factors (the extremely dry and droughty period) caused the plowings of water-affected areas by the reinforcement of each other's effects. Therefore complex factors (***integrated effects of socioeconomic and natural causes***) are supposed to play a decisive role in the extraordinary emergence of land use anomalies. At the same time, climate change could influence the land transformation processes also indirectly, through the weakening of the local economy.

4.3.4. In summary, I found that ***in all of the five analyzed time horizons***, from between the ***new land use forms confronting the natural water covers and water-affected grasslands*** (according to the size of the transformed land), ***conversion to arable land*** was the most typical, with 77–78% of the total amount of transformation. ***Utilization as artificial water body, land use for water storage, irrigation, fishing***, etc. purposes (10–11%) and ***building***

in of biotopes (8–9%) took place ***in a much smaller area***. Forest-plantation, afforestation (3%) and utilization as vineyards and orchards (0.5–1%) are not typical in the water-affected areas belonging to the study area, but sometimes they occurred. The outlier proportion of arable farming can be explained by its a priori large spatial share, by the demand for large area for farming, by the less labor input of plowing, and by the smaller risk associated with the asset value, compared to the other new land use types.

4.4. Changes in the density of scattered farms system and network of scattered homesteads

4.4.1. According to the examination of highest density sites and the analysis of the most significant changes, the study area has been characterized by a general ***densification process of scattered homesteads*** already ***from the end of 18th century.***

4.4.2. The former garden areas with vineyard, which now already belong partly to closely built-up clear or to residential area with gardens in periphery, have been densified by scattered homesteads (farms) ***in the three decades before 1957–59.*** Before their transformation, building and integrating into the inner, contiguous city at the end of the 20th century, some settlement parts (e.g. Petőfiváros, Hunyadiváros, Széchenyiváros and Hetényegyháza) came in for a dynamic spread of scattered farms. Máriahegy, Felsőszéktó, Szolnokihegy, Kőrösihegy were among the farm districts where the density changes had the highest value. These ***scattered farm densifications*** are less related to the roads, rather to the ***inner, horticultural areas,*** besides that their position ***closer to the city*** is also outstanding compared to today's trends.

4.4.3. During the next ***three decades until 1989***, besides the former garden-plots, a few ***horticultural areas***, which were not ranked as a garden plot (e.g. two blocks of farms in Katonatelep, those parts of Felsőszéktó and Úrihegy which are situated closer to the road to Hetényegyháza), were ***fast inhabited*** (populated) and ***densely settled*** with scattered homesteads. Outside of the proximate surrounding area of Kecskemét I did not experience significant densification in this period.

4.4.4. Particularly in the proximate surroundings of Kecskemét, to the line of Hetényegyháza-Ballószög-Helvécia, ***centers with high density*** have been formed ***until our days, on the place of former garden plots, vineyards and horticultural areas*** (e.g. farms in Katonatelep, „small gardens near to Halasi road”, Felsőszéktó-Úrihegy, Máriahegy). With smaller neighborhood radius (e.g. r=200 meters), densifications along the busy farm roads and causeways also emerged, among others, in some frequented parts of Kadafalva, Helvécia and Ballószög.

4.4.5. In comparison with the density map of the previous time horizon (1989) it can be concluded that ***the centers of densifications*** of Máriahegy, Úrihegy, Budaihegy and Vacsihegy started to spread to the outer area of Kecskemét ***by 2009***, ***in the north and to the northwest***, as a result of the higher densifications there. The growth of density of places situated further from Kecskemét can be noticed anywhere else, e.g. south from Katonatelep and Hetényegyháza, as well as along the roads of periphery of Kadafalva, Helvécia, Ballószög and Szabó Sándor settlement. The biggest change has affected the part of Úrihegy facing the road to Hetényegyháza where more and more people began to build probably because of the advantages given by the rural way of life and favorable traffic conditions. It is remarkable that in other parts of the study area – because of the not so high density of scattered homesteads – the changes were also not so significant except certain cases, for example the area that is directly adjacent to the in-lot of Jakabszállás, and which have been continuously built in lately by scattered homesteads.

4.5. Evaluation of the change and stability of land cover and some of its components from the perspective of landscape protection

4.5.1. Based on the 100-m resolution raster data layer of ***time horizon of the year 2009, the total area of the grasslands and wetlands*** in the examined area was about ***14 thousand hectares***. According to my calculations, from this only about ***43%*** are grasslands and wetlands with ***stable land cover*** between 1881–83 and 2009. Compared to the whole area of all grassland and wetland in 2009, at the end of the 1950’s still 56%, but in the years of regime change, just about 46% had a stable land cover. This reflects the continuous decrease of those areas (biotopes) which are especially valuable from the point of view of landscape protection and nature conservation.

4.5.2. I highly examined the recent changes of grasslands and wetlands which had stable land cover ***until the 4^th^ time horizon (1992–1996)*** with special attention. Based on the controlled results obtained by selection from the 100×100 m cell-sized, combined raster database, ***5.2% of grasslands and wetlands which were stable*** between 1881–83 and 1992–96, ***have been destroyed*** in the recent past. The ***afforestation and the forest-plantations*** (20–21%), together with the ***conversion to arable lands*** (68–69%) are primarily responsible for the destruction of stable grasslands and wetlands. It has also been happened that they were transformed into vineyards, orchards and gardens with small parks (5%) or into water facilities (reservoir, fishpond, fishery, etc. 2%), or maybe they have fallen victim to building (4%).

4.5.3. According to my results, the following can be stated: ***in the studied landscape part***, there is no such a contiguous, several hectares sized area of horticulture, cultivated traditionally as a vineyard or orchard which would have significant value for landscape protection due to its cultural-historical significance. ***Traditional small-scale field horticulture*** as a cultural-historical value can be found now ***only locally***.

4.5.4. I have found that the measurable ***loss of grasslands*** in our days ***is critical*** from the point of view of landscape protection for several reasons. Because of their ecological significance, their role in open, steppe landscape character, their visual landscape value and also their landscape potentials (ecosystem services), the ***isolation*** and ***fragmentation*** of them and the ***decline in their share*** is very unfavourable.

4.5.5. Based on the relative proportions of the aggregated extent of grasslands and arable lands compared with that of the forests (which was found to be minimum 12-times bigger), the study area during the periods preceding the era of Antrop's 'post-modern landscapes' (pre-World War II) could be always characterized by ***open steppe landscape character***. ***Nowadays***, the above rate is only 2.4-times, which also demonstrates the ***closeness of the landscape scenery***. The decline in the arable land size in the recent past was mainly caused by afforestation with plantation-like tree stocks and with alien species, resulting in exponentially the ***character loss of the open steppe landscape*** and the formation of closer landscape scenery.

4.5.6. The continuous growth of ***built-up areas***, which is characteristic especially in Kecskemét's fringe zone, also ***raise landscape protection problems*** due to the loss of area suitable for agricultural use, and the unfavourable ***change in landscape aesthetic conditions***. The further expansion of urban space and modern, residential scattered homesteads which do not fit in landscape scenery, in particular within a stripe enclosed with circles of 10 and 15 km radius from the city center, will be a threatening factor in the future. In these areas the landscape scenery is still favourable, due to the high proportion of semi-natural areas, to the presence of traditional scattered farms fitting well in the landscape and to the presence of other unique landscape features. At the same time, the lack or at least the small proportion of landscape-alien artificial facilities is also characteristic of these areas threatened by urban sprawl or spreading of residential scattered homesteads.

4.5.7. ***From the point of view of landscape protection, the most valuable*** landscape part of the research area is the region outside the circle of 15 km from the center of Kecskemét, where most of the traditional, archaic and ***scattered farms meaning landscape value*** are situated, and where the highest proportion of ***semi-natural areas with various habitat composition*** and outstanding landscape scenery importance can be found. Besides the highly protected national park units which are in more reassuring situation, we can also find landscape parts with such a worth that can be measured to them (e. g. Köncsögpuszta, Kunpuszta). In my opinion, due to the large extent of ***the zone*** and the great number of its landscape values with incorporal importance, it ***deserves a landscape-scale protection***.

PUBLICATIONS DIRECTLY USED FOR THE DISSERTATION

DÓKA R. 2006a: A vizes élőhelyek és a szántógazdálkodás tájhasználati konfliktusa a Duna-Tisza közén [Land use conflict of wetlands and arable farming in the Danube–Tisza Interfluve]. In Kiss A., Mezősi G., Sümegi Z. (szerk.).: Táj, környezet és társadalom. Ünnepi Tanulmányok Keveiné Bárány Ilona professzor asszony tiszteletére. Szeged SZTE. pp. 155–165.

DÓKA R. 2006b: A homokhátsági tanyák természeti környezeti vonatkozásai [Natural environmental aspects of farms in the Sand Ridge Region]. A falu 31. (2) pp. 43–51.

DÓKA R., ALEKSZA R., KŐHALMI F., KEVEINÉ BÁRÁNY I. 2010: A tájváltozások és a társadalmi-gazdasági viszonyok alakulásának összefüggései a Duna–Tisza köze középső részén. [Connections between landscape changes and alteration of socio-economical circumstances in the middle part of Danube–Tisza Interfluve] In: Szilassi P., Henits L. (szerk): Tájváltozás értékelési módszerei a XXI. században. Tudományos konferencia és műhelymunka tanulmányai, 2010. JATEPress, Szeged (http://www.geo.u-szeged.hu/tajvaltozas) pp. 159–179.

DÓKA R. 2011: Tájhasználati változások, tájértékek és tájvédelem a Duna–Tisza közén [Land use changes, landscape values and landscape protection in the Danube–Tisza Interfluve]. In: Rakonczai J. (szerk.): Környezeti változások és az Alföld. Nagyalföld Alapítvány kötetei 7. Nagyalföld Alapítvány Békéscsaba, pp. 315–325.

DÓKA R., ALEKSZA R. 2011: The temporal variety and variability of land cover from the second half of the 19th century in the region of Kecskemét. Acta Climatologica et Chorologica 44–45. pp. 31–39.

DÓKA R. 2015: Vízjárta területek tájhasználatának anomáliái a Duna–Tisza közi síkvidék középső részén. [Land-use anomalies of water affected areas in the middle part Danube–Tisza Interfluve (Hungary)] Tájökológiai lapok 13. (2) pp. 217–234.

DÓKA R., Iványosi Szabó A. 2015: A természeti földrajzi környezet [The physical geographical environment]. In: Iványosi Szabó A. (szerk.): A Kiskunsági Nemzeti Park Igazgatóság 40 éve. Kiskunsági Nemzeti Park Igazgatóság, Kecskemét pp. 16–30.

KOVÁCS A. D., **DÓKA R.** 2018: Tanyák a tájban – gondolatok a tanyás térségek környezeti összefüggéseiről. [Scattered homesteads in the landscape – thoughts on the environmental context of the regions with scattered homesteads] A Falu 33:(3) pp. 61–72.

DÓKA R., KISS M., BÁRÁNY-KEVEI I. 2019: Land use anomalies on wetlands, in different time horizons – A case study from Hungary.

Carpathian Journal of Earth and Environmental Sciences, August 2019, Vol. 14, No. 2, pp. 287–300.

OTHER PAPERS RELATED TO THE TOPIC OF THE DISSERTATION

MUCSI L., RAKONCZAI J., BALÁZS R., BRENYÓ P., **DÓKA R.,** KOVÁCS F., KOVÁCS A. D., Csatári B. (témavezető, szerk.), KOVÁCS A. D., (szerk.): Tanyakutatás 2005–2006. Kutatási jelentések: 1. füzet. A tanyás térségek környezete (2005) [’Tanya’ research 2005–2006. Research reports: 1. booklet. Environment of regions with ’tanya’ (2005)] Kecskemét: MTA RKK Alföldi Tudományos Intézet. 60 p., (Készült a Duna-Tisza közi Homokhátság vízpótlásáról szóló országgyűlési és kormányhatározatok nyomán, a Magyar Regionális és Területfejlesztési Hivatal Kiemelt Térségi Programok Főosztálya megbízásából.)

DÓKA R. 2008: A termőhelyi adottságok és a tájhasználat térbeli összefüggései a Kiskunsági-homokhátom – tájhasználati konfliktusok térképezése [Spatial connections between site production conditions and the land-use in the Sandy Ridge in Kiskunság – mapping land use conflicts]. In: Csorba P., Fazekas I. (szerk.): Tájkutatás–tájökológia. (A II. Magyar Tájökológiai Konferencia kiadványa, Debrecen 2006.) pp. 117–124.

OTHER PUBLICATIONS

UNYI M., **DÓKA R.** 2015: A Kelemen-széki élőhely-rekonstrukció főbb hidrológiai vonatkozásai [Major hidrological references of habitat reconstruction at Kelemen Lake]. In: Gampel T.–Sziget E. (szerk.): A Magyar Hidrológiai Társaság által rendezett XXXIII. Országos Vándorgyűlés dolgozatai. 16 p.

AWERENESS-RAISING PUBLICATIONS

DÓKA R. 2010: Turjánvidék és az Őrjeg: lápok és mocsarak a Dunamellék és a Homokság ölelésében [Turjánvidék and Őrjeg: Fens and swamps embracing in Dunamellék and Homokság]. Barna Zs., Gilly Zs. (szerk.): Turjánvidék a Kiskunságban. Boróka Füzetek. Kecskemét, KNPI pp. 3–5.

DÓKA R. 2011: A Dunamenti-síkság szikeseinek természeti földrajzi jellemzői [Physical geographical characteristics of sodic areas on the Plain along

Danube]. Gilly Zs. (szerk.): Szikesek a Kiskunságban. Boróka Füzetek. Kecskemét, KNPI pp. 7–14.

BOROS E., **DÓKA R.** 2011: A szikes tavak [Sodic lakes]. Gilly Zs. (szerk.): Szikesek a Kiskunságban. Boróka Füzetek. Kecskemét, KNPI pp. 15–24.

F., PÁL SZABÓ,, A., MÁTÉ,, P., AGÓCS,, **R., DÓKA**,, J., LISZTES,, Á., NÉMETH,, L., TAJTI,, I., SOMODI,, GY., KRNÁCS,, A., IVÁNYOSI SZABÓ,, K., ÁBRAHÁM,, E., RONKÓ SZABÓ 2014: Excursions in the Kiskunság National Park. Zs., Gilly (ed.) Boróka Füzetek. Kecskemét, KNPI 96 p.

DÓKA R. 2015: A Duna–Tisza közi lápok és édesvízi mocsarak főbb jellegzetességei [Major features of fens and swamps in Danube–Tisza Interfluve]. Faggyas Sz. (szerk.): Mocsarak, lápok a Duna-Tisza közén. Boróka Füzetek. Kecskemét, KNPI pp. 3–20.

DÓKA R. 2019 (ed): Települési szintű válogatás a KNPI által nyilvántartott egyedi tájértékekből. (Jelentés a Kiskunsági Nemzeti Park Igazgatóság működési területén, 2010 és 2018 között és az Igazgatóság által koordináltan végzett egyedi tájérték felmérési munkákról.) [Municipal selection from the unique landscape values registered by KNPI. (Report on the surveys of unique landscape values, executed between 2010 and 2018, in the operational area of Kiskunság National Park Directorate and coordinated by the Directorate)] Kézirat, KNPI, Kecskemét 153 p.