

FUNCTIONAL USE OF THE SUBURBAN LANDSCAPE AFTER 1989 THROUGH THE EXAMPLE OF THE CITY OF OLOMOUC

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Abstract

In 1989, fundamental political and social changes took place in the then Czechoslovakia that were associated with a number of consequences. One of them was the creation of entirely new general conditions for the development of the suburban landscape. Therefore, this paper deals with evaluation of the development of a selected suburban landscape since 1989. For the purposes of our study we have selected two suburban areas of the city of Olomouc (Černovír and Chválkovice). We analysed the transformations of the functional use of the landscape, particularly with regard to the assessment of changes in ecological stability. The changes in functional land use are assessed using the methods of digitising the available aerial photogrammetric images and their subsequent management in a geo-information system. These methods are used to quantify each category of functional use and then to evaluate the dynamics of their changes. In both cases the spatial aspects are also considered. In the next part of the paper, the facts that are found are discussed and interpreted using the identification of so-called driving forces.

Key words: driving forces, landscape structure, ecological stability, aerial photogrammetric image, Olomouc, Czech Republic.

INTRODUCTION

The present paper focuses on one of the basic geographic concepts, by which we mean the landscape. Although in the context of the Czech and Slovak environment, this is a relatively frequent object of geographical research, we would say that the subcategory of landscape with which we work in this paper has not (with the exceptions of Daniel et al. 2010; Šveda and Vigašová 2010; Šveda 2011) received adequate attention so far despite the fact that, in a transitional period, the suburban landscape is one of the fastest-developing areas in terms of its functional use. The main objective of this paper is therefore to evaluate the development of the functional use of the suburban landscape in a period of the transformation of the city of Olomouc. We are

convinced that this paper can contribute to understanding the transformation of the functional use of the suburban landscape in the post-communist environment.

Into the category called suburban landscape we can include local peripheral areas of Olomouc, which have been selected for the purpose of this paper. Considering the size limitations of the paper, the research does not cover all the local suburban neighbourhoods of Olomouc, but only two of them have been selected: the land registry areas of Chválkovice and Černovír, which represent two of the current 26 neighbourhoods of Olomouc (Figure 1). In 1919, these areas became, along with 11 other surrounding villages, administrative parts of the so-called Greater Olomouc (Act 2014/1919 Coll.).

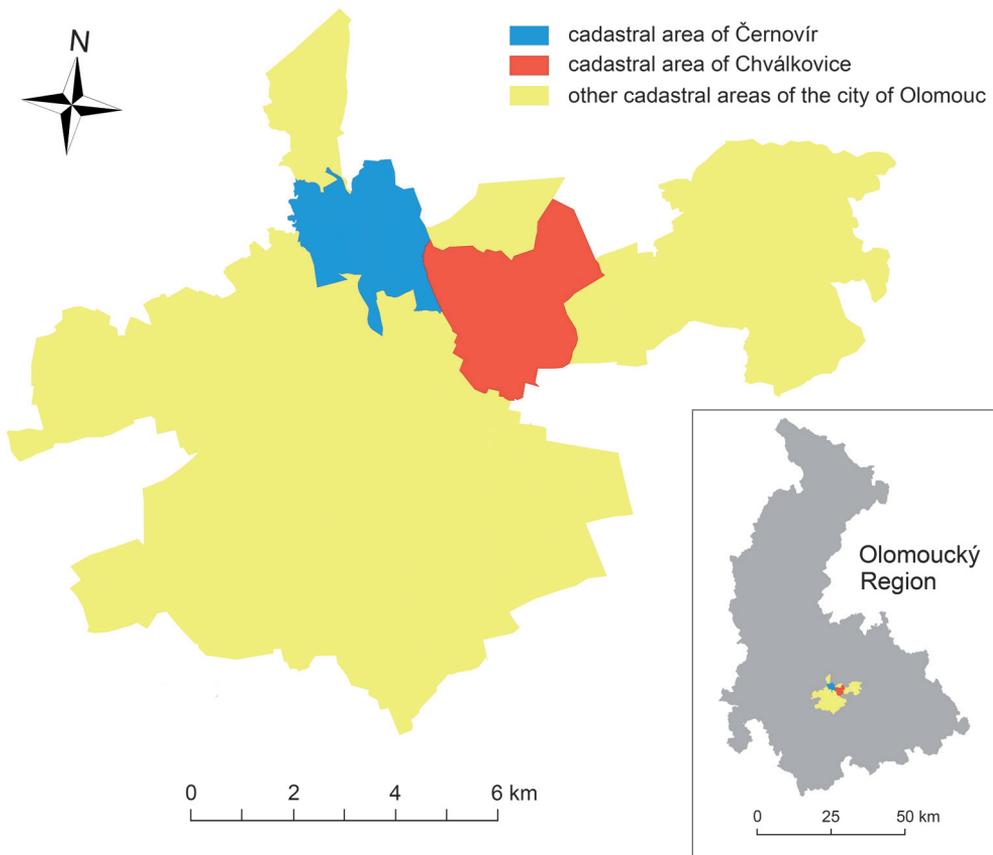


Figure 1 Illustration of the land registry areas of Černovír and Chválkovice in the city of Olomouc and in the Olomoucký Region. Sources: ArcGIS 9.3; CENIA geoportal INSPIRE 2012; own processing

Until then, Černovír and Chválkovice had been independent municipalities since 1850 (Neighbourhood Committee No. 1 2002). The areas in question lie north (Černovír) and northeast (Chválkovice) of the city centre. Although the land registry area of Chválkovice is larger (763.3 ha according to the Czech Territorial Identification Register 2014a) than the land registry area of Černovír (551.7 ha according to the Czech Territorial Identification Register 2014b), in comparison with the land registry areas of all the neighbourhoods of the city of Olomouc, they are relatively similar in area (being the second nearest neighbourhoods to one another in size). Together they cover almost 13% of the total area of the city of Olomouc (a total of 10,333 hectares according to the calculations of CZSO 2014, of which 7.4% is Chválkovice and 5.3% Černovír).

The land registry areas of Chválkovice and Černovír were selected not only because of the aforementioned similarity of the area of the neighbourhoods to be surveyed, but also because of their possessing very similar geomorphological characteristics. The fact that these areas are adjacent to each other also played a role in the selection.

We will try to achieve the main objective of the paper by answering the following questions. First, we are interested in changes in the stability of the functional use of the suburban landscape. Using the phenomenon of the stability of the functional use of the landscape, it will be possible to understand the intensity of the changes in the landscape structure. Second, we ask the question why the function of the suburban landscape has been changing.

The identification of the factors that were present in the background of the changes in the stability of the functional use of the suburban landscape could help to provide a deeper understanding of the process of the transformation of the landscape structure. Third, we are interested in how the development has affected the ecological stability of the landscape. As a fourth research question, we could ask whether the development of the functional use of the landscape of both neighbourhoods has been similar or different. Answering this research question would help to reveal which of the developmental factors are generally effective or rather specific.

At the beginning, the issue being addressed will be theoretically anchored and the methodological basis presented. Next, all the methodological procedures that were used to produce the analytical part of the paper will be briefly described. In the analytical part, the graphic features and comments on them will be used to review and discuss all the significant findings related to the structure of the landscape or areas of interest and their development. Subsequently, we will try to interpret these substantive findings and formulate relevant conclusions using the concept of so-called driving forces.

THEORETICAL AND METHODOLOGICAL BASIS

One of the basic concepts involved in the present study is the landscape. Despite the difficulty of providing a comprehensive definition it can be characterised as a geocomplex formed by nature, as well as other influences, involving certain ground territory (Boltižiar and Olah 2009), which is both the result and the means of anthropogenic impact and interactions with the environment (Kizos et al. 2010). Its essential features are diversity and variability (Kolejka et al. 2013) characterised by its formation over time by the transformation and modification of previously existing systems (Demek et al. 2012). Currently, we can only speak about the so-called cultural landscape, resulting from the gradual transformation of natural landscapes caused to various extents by man (Schein 2010). The suburban landscape, whose functional use is examined in this paper, undoubtedly belongs to this category.

The type of landscape arrangement and its features and components and mutual relationships, which were substantially influenced by both natural and anthropogenic processes (Golešová 2008), is characterised by the *landscape structure*. It involves a diverse set of material elements of the landscape that currently fill the earth's surface (Růžička and Růžičková 1973). It is determined by the interaction of abiotic, biotic, and socio-economic elements and components, realised both by the movement of the ground, energy and information, and a change in the material composition or structure of the latter component or element in response to the transfer (Miklós and Izakovičová 1997:83). The paper focuses on the *secondary landscape structure*, or anthropogenic superstructure of the primary structure formed by a mosaic of forms of use of areas (Kolejka et al. 2013) that cover the earth's surface.

The paper is also closely related to the concepts of *land cover*, *landscape use*, and *land use*. Land cover describes the physical condition of the contemporary landscape represented by both natural and man-modified and man-created objects (Feranec and Otáhel 2001). These objects include all observable spatial objects in the landscape, whether within field research or using data from remote sensing. The concepts of “landscape use” and “land use” (or “use of ground surfaces”) have much in common, but the first term is somewhat broader. Unlike “land use”, which describes the particular form of the utilisation of landscape elements for any human activity or another purpose (Naveh and Lieberman 1994), often followed by quantification of the collected data, “landscape use” characterises the specific manifestation of human activity in space and time within historical, economic, social, and/or cultural terms (Boltižiar and Olah 2009). As a consequence, the analysis of landscape use also brings information about the society and the processes taking place in it. In cases of an overriding focus of the study of landscape use on the function of landscape elements and their categories in time, also including examining the social and natural processes behind the specific changes of the landscape function, we can talk about the so-called “functional landscape use”.

As a result of the variable and dynamic character of the landscape it is clear that there are also changes in the landscape structure, land cover, and land use or ground use. The changes in landscape use reflect the complex interactions of nature and society and the development of the natural environment and human society (Demek et al. 2012). The detailed research into these changes is connected with the study of so called driving forces, i.e. the processes affecting the development trends of the landscape (Marcucci 2000). Within this study, the condition of the landscape is characterised and the ongoing processes and specific reactions to these processes are described. In Europe, a commonly used concept is DPSIR (drivers – pressures – state – impact – responses), which is especially suited to planning for future landscape use (European Environmental Agency 1999). When the transformation of the landscape structure and its functional use are being analysed, the relationships between the elements of the landscape, agents of changes, and the driving forces are analysed. Examination of the driving forces is standardly based on the so called system definition, which formulates the objective of the study and defines the area of research and its extent, the nature of the research, its delimitation in time, and the definition of the landscape features in question – all that with regard to the availability of data. This step is followed by systems analysis, dealing with the landscape change itself and the degree of stability of the physical landscape elements, agents of change, and the driving forces. The system synthesis is the final stage of this process and aims at the connection of the actors and driving forces of causal relationships and the identification of their impact on the elements of the landscape structure (Bürgi et al. 2004). Its goal is to look at the landscape and study it as a whole, not just as a set of elements (Antrop 2000).

Transformations of landscape use are examined in particular with regard to the assessment of changes in the *stability of functional landscape use*, i.e. with regard to the preservation or changes in the form of the functional use of landscape elements between the selected milestones. In this context, the ecological stability of the landscape is equally important and can be simply defined as the ability of an ecosystem to balance the changes caused by external factors and

sustain its natural properties and functions (Czech Ministry of the Interior 1992). Each landscape element is characterised by a certain degree of stability, while the overall ecological stability of the landscape expresses the ratio of all the types of landscape elements present at a given time (Forman and Godron 1993). The ecological stability is a dynamic property of a landscape primarily related to the indicative and regulatory role of biota (Kolejka et al. 2013), and its degree can be described by the coefficient of ecological stability (K_{cs}), which represents the proportion of environmentally relatively stable areas to ecologically relatively unstable areas.

METHODS

With regard to the main objective of this paper, we used a combination of several research methods, with an emphasis on the analysis of aerial photogrammetric images which represent objective, accurate, and non-generalised images of the landscape at the time of their acquisition (Lipský 2007). In comparison with a topographic map, aerial photogrammetric images provide a high information value (Naveh and Lieberman 1994:121) and are able to picture elements that may not be considered important for display on the map, although they play a significant role in the detailed mapping and research of the area (Minár et al. 2001). The aerial photogrammetric images used for the purposes of our research were provided by the Military Geographical and Hydrometeorological Institute in Dobruška. The acquisition of the images was followed by their digitisation using a scanner, content identification, and management in the GIS environment.

Regarding the content identification of the aerial photogrammetric images, the categories of functional landscape use were determined by visual interpretation of their contents. In this case, this extended method requires considerable experience in working with particular types of images in order to avoid certain pitfalls that may influence the quality of interpretation of the information presented in the aerial photogrammetric images (Adams and Gillespie 2006:10). These pitfalls were eliminated both by direct observation in the field and also by the methods discussed by Koleda (2010).

The aerial photogrammetric images were then subjected to georeferencing, a GIS method that enabled their positional shifts to be corrected. Then we created map layers of the landscape structure for 1991 and 2009 that corresponded to the structure of the landscape captured by the aerial photogrammetric images in these years. Using the identity function we projected the transformation of the functional use of the landscape between 1991 and 2009 into a newly created map layer. By this we obtained the required data on changes in the functional use of all the areas of the territory in question.

The process of the determination of the individual categories of functional landscape use was inspired by the methodology of CORINE Land Cover (European Environmental Agency 1995), which is currently the means that is most widely used for the interpretation of landscape conditions in Europe. However, in consideration of the nature and spatial extent of the research area, the following specific categorisation was applied:

- a. forested land – an area with a predominance of contiguous forest and scrubland vegetation;
- b. arable land – areas used for the production of agricultural crops;
- c. permanent grassland – meadow, common meadow, waterlogged meadow – wetlands, meadow surrounded by hedgerows, meadow with scattered vegetation, meadow with river vegetation, pasture, grassland surrounded by hedgerows;
- d. gardens and orchards – vegetable garden, orchard, vegetable garden with fruit trees;
- e. water bodies – watercourse, watercourse surrounded by a row of trees, pond, or lake;
- f. built-up areas – brick residential buildings, public spaces, church, chapel, cemetery, agricultural development, yards, fortification elements;
- g. industrial area – development of an industrial nature, including internal communications and open spaces and premises used for agricultural production;
- h. railways;
- i. roads – paved, unpaved, paved with rows of trees, unpaved with rows of trees, a pathway with a row of trees, a road with a ditch, a road without a ditch, pathway, accommodation road.

In our search for driving forces (see previous section), in other words, the processes behind the significant changes in the structure of the landscape in the areas of interest, we used methods based on studies of archival sources as well as literature of general nature. In the study of the driving forces the most considerable changes in the functional use of the landscape were taken into account, as these changes can mostly be traced in archives or in the literature. Transformations of areas of a smaller size did not need a written record, which indicates the fact that they were not of fundamental importance. For this reason, they were marginalised in this paper.

The ecological stability of the landscape is an indicator that is methodologically tackled by a series of quantitative approaches. In our study we used the coefficient of ecological stability defined by Míchal (1994). This formula was used although we are aware of the fact that it does not consider quality within an independent category. On the other hand, because of the spatial extent of the area, the categories of functional landscape use do not differ too much. The selection of the coefficient was also conditioned by its simplicity and hence clarity.

ANALYSIS OF THE FUNCTIONAL USE OF THE LANDSCAPE IN THE LAND REGISTRY AREAS OF ČERNOVÍR AND CHVÁLKOVICE BETWEEN 1991 AND 2009

Within the period under review, attention was paid first to the analysis of the transformations of the functional use of each land registry area separately – first Černovír, then Chválkovice. The information obtained provides an overview of major changes in the categories of forms of utilisation, assessing their intensity and the stability of functional use and definition of the driving forces that most probably initiated the changes concerned. The final comparison and overall evaluation of the development of the functional use of the land registry areas of Černovír and Chválkovice aims to capture the similar and diverging trends in these adjacent neighbourhoods of the city of Olomouc.

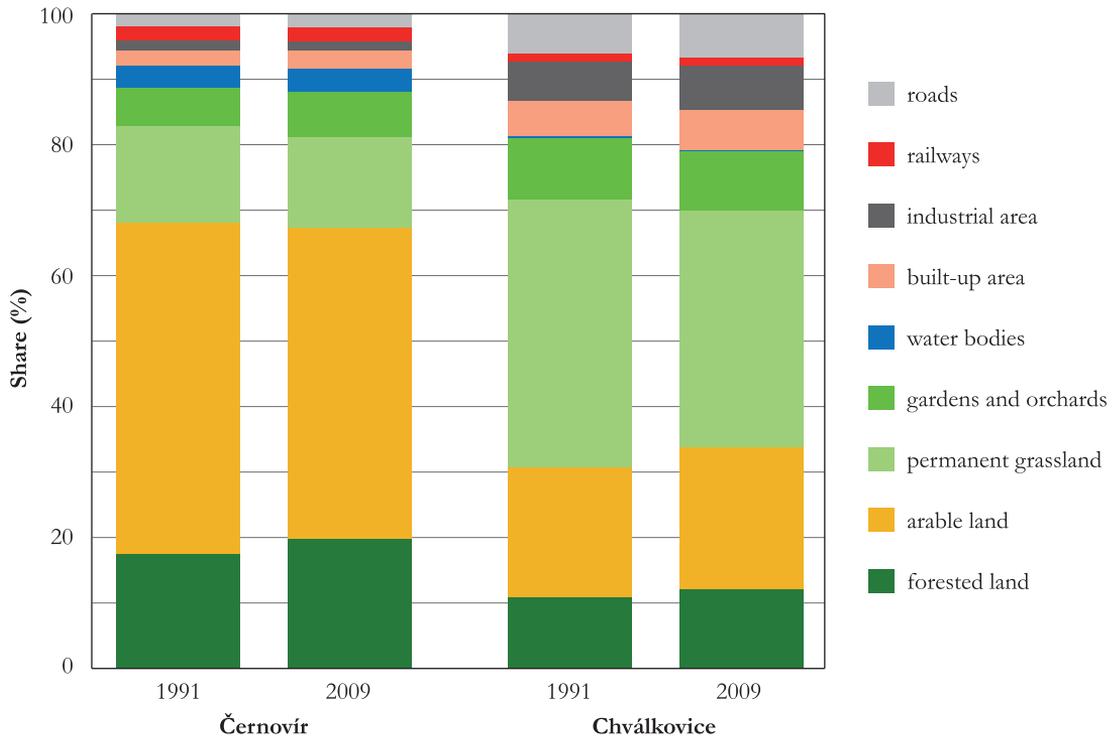


Figure 2 Global share of categories of functional use within the total area of Černovír and Chválkovice in 1991 and 2009. Sources: ArcGIS 9.3; CENIA geoportal INSPIRE 2012; MGaHI Dobruška 2011; own processing.

Černovír between 1991 and 2009

Between 1991 and 2009, in the land registry area of Černovír the total area of the “arable land” category declined, which was a continuation of a trend which had started before the initial analysis. A decrease of approximately 15 ha was caused by a newfound freedom to possess the land at one’s own discretion (in connection with the dissolution of agricultural cooperatives and renewed private property). Many areas of arable land (noticeably in the southwest at the land registry boundary, in the neighbourhood of allotments) were grassed, transformed into gardens, or afforested. On the other hand, in this period we can also notice the emergence of new areas of arable land, e.g. in the area between the old southern borders of the Černovír forest and the newly afforested area of land. During the selected period of time we can also observe the extinction of many smaller areas of arable land located on plots belonging to residential buildings.

This indicates a drop in the need for one’s own agricultural production and a transition to the consumption of products of agricultural mass production. The value of the stability of functional use for this category provides the information that nearly 95% of all the arable land in 2009 had retained its functional use since 1991.

Like the “arable land”, the category of “permanent grassland” also decreased in its area by 5.5 hectares. Although new areas with permanent grassland were established or extended (in the southwest and west of the area) in many places in the land registry area of Černovír, their conversion into elements of another category was intense. The former areas of this category were transformed into “arable land” or “forested land” (especially in the area of the Černovír forest). The rather intense fluctuation within the “permanent grassland” category is also reflected in the lower stability of its functional use (59%).

Table 1 Area of categories of functional use and transformation index in Černovír and Chválkovice in 1991 and 2009. Source: ArcGIS 9.3, CENIA; geoportal INSPIRE, 2012; MGaHI Dobruška 2011; own processing.

Category of a functional landscape use	Černovír			Chválkovice		
	area (ha)		index of change (%)	area (ha)		index of change (%)
	1991	2009		1991	2009	
forested land	97.49	110.10	112.94	48.59	51.90	106.81
arable land	281.72	264.94	94.04	346.15	365.31	105.53
permanent grassland	81.94	76.58	93.46	182.88	155.23	84.88
gardens and orchards	32.81	39.39	120.06	41.92	39.02	93.08
water bodies	18.47	19.29	104.46	1.55	1.31	84.20
built-up area	13.56	14.95	110.19	23.72	26.20	110.45
industrial area	8.56	8.10	94.66	88.43	93.74	106.00
railways	11.91	11.90	99.95	5.50	5.53	100.57
roads	10.74	11.94	111.18	27.22	28.86	106.03

The general tendency of a gradually increasing area of “forested land” that started in 1938 continued in the period 1991-2009 and the increase of nearly 13 ha confirms the significant position of this category in the land registry area of Černovír. It is conditioned mainly by the growth of vegetation in the area of the Černovír forest, the major part of which has a function of a protective zone of water sources discovered in the late 19th century (SOKA Olomouc) and used for the needs of the city of Olomouc up to now, to the north and south, but also by the expansion of forested land in the immediate vicinity of the existing forest (a forest near the Černovír shooting range in the western part of the land registry area) or the groups of trees along the Morava River, or by the emergence of entirely new areas in this category (in the southwest of the land registry area). The stability of the functional utilisation of this category in this period reaches 80%.

A slight increase in the area of “water bodies” (0.8 ha) was associated primarily with the expansion of the lake located in the north of the land registry area, but the development of water bodies and resources was influenced by several significant events. The first was the catastrophic flood in 1997,

when 98.93% of the Černovír area (Caritas Czech Republic 1997) was flooded by the millennial water (Schulz 2009). The flood significantly changed the appearance of the suburb and damaged a large number of houses, but as soon as the flood wave moved over the Černovír fens (considered extinct from the mid-20th century), it turned out that the water regime of the area was fairly well preserved, and that some protected species of flora and fauna still survived here. Since that time, there have been attempts to rescue and restore the fens (Sagittaria 2011). The bed of the Trusovický potok creek in the section before its confluence with the Morava River has been embanked along the newly built road. In an effort to prevent other serious consequences of “high water”, various flood protection measures have been adopted, including, among other things, the construction of an earth dam in Černovír (Schulz 2009). Other floods affected the area in question in 2007 and their consequences (e.g. damages to the structure of the fire station, damaged pavements) were removed by 2009 (Neighbourhood Committee No. 1 2010). The fact that there is not a very large number of range-significant changes in this category is reflected in the relatively high value of the stability of the functional use of its components (93%).

During the period in question there was a further expansion of the allotments for gardening in the area of Černovír, which resulted in an increase in the aggregate area of the “gardens and orchards” category by nearly 7 hectares. In the period 1991-2009, an entirely new allotment called “U Staré Moravy” was created near the land registry boundary between Černovír and Lazce (north-east of the bridge over the Morava River) and in addition, the existing allotments were extended, which is especially evident in the case of the areas “Jezuitská 1” (at the confluence of the Morava River and Částava Canal in the north of the area being studied), “Jezuitská 2” (down the Morava River) and “Tchaj-wan” (south of the Částava Canal). The “Laty” allotment near the railway line in the southeast part of the land registry area was also extended. Gardening and recreation areas also began to appear intensively in the immediate vicinity of continuous residential development, e.g. in the eastward direction towards the Černovír forest – the “Žitná 1, 2, 3, 4” allotments – or at the southernmost tip of the land registry area of Černovír – the “Jablonského 2, 3, 4” allotments (Hrochová 2013). Although the category underwent quite substantial changes, it was not a large-scale transformation, and therefore the stability of the functional use is not low (74%).

In the period after 1989, the administrative arrangement of the city of Olomouc was discussed, as in the 1970s a large number of nearby villages were attached to Olomouc without too much regard for the wishes of their people. For this reason, these municipalities held referenda, which resulted in the independence of some of them (e.g. Samotíšky, a municipality neighbouring with the land registry area of Chválkovice, became independent in 1992). The remaining municipalities and neighbourhoods forming the Olomouc micro-region were significantly affected by the city of Olomouc. They offer opportunities for recreation to its inhabitants, as well as lots for building houses at advantageous prices (Schulz 2009), which is related to the suburbanisation processes which Olomouc encountered in that period (Burian et al. 2010). These events also affected the category of “built-up areas” in Černovír. New residential buildings were erected,

the existing development towards the Černovír forest was extended, and a large number of weekend houses were built in the ever-extending allotments. A new house (No. 296) with a tennis court and access road providing a connection with the main road to Chomoutov was built near the northernmost pond, whose surface area grew between 1991 and 2009. The slight increase in the area of the “built-up areas” category was also caused by the erection of new buildings in the area of the shooting range and the construction of a new building in the area of the existing waterworks and water treatment facilities. During the floods in 1997, 70 houses were damaged and the structure of the bridge over the Morava River was damaged (Kubáňová 2012). In 2000, Olomouc became a regional capital (Schulz 2009) and the scope of operation and interest of this Moravian metropolis was significantly extended. The stability of the functional utilisation of elements in this category was 78% in the period 1991-2009.

In the “roads” category, the total length of the road network in the land registry area of Černovír increased by nearly 5 km (from 23.7 km in 1991 to 28.4 km in 2009). During the period in question, the road accompanying the bed of the Trusovický potok creek on the right bank was renovated over a distance up to about 500 m before its confluence with the Morava River, where it spanned the creek by means of a footbridge and was connected to the road leading to the centre of the Černovír residential development. In 2009, the road was extended up to the confluence of the creek with the Morava River and here it was connected to the communication along this watercourse. On the other hand, a part of the road leading westwards from the “Tchaj-wan” allotment ceased to exist. The damage to the structure of the bridge during the flood in 1997 led to the construction of a new bridge, which was completed in 1999 and slightly changed the course of the road linking Černovír and Lazce at Heydukova street (Kubáňová 2012). The Emma storm, which hit the area in 2008, destroyed the guardrail on the bridge over the busy railway connection between Olomouc and Prague in the Černovír forest, and a subsequent survey found further damage to the structure of the

ČERNOVÍŘ 1991-2009

Formation of FORESTED LAND from category:

-  forested land
-  other categories

Formation of ARABLE LAND from category:

-  arable land
-  other categories

Formation of PERMANENT GRASSLAND from category:

-  permanent grassland
-  other categories

Formation of GARDENS AND ORCHARDS from category:

-  gardens and orchards
-  other categories

Formation of WATER BODIES from category:

-  water bodies
-  other categories

Formation of BUILT-UP AREA from category:

-  built-up area
-  other categories

Formation of INDUSTRIAL AREA from category:

-  industrial area
-  other categories

Formation of RAILWAYS from category:

-  railways
-  other categories

Formation of ROADS from category:

-  roads
-  other categories



Figure 3 Spatial distribution of stable and unstable areas of functional use of the landscape in Černovíř between 1991 and 2009.

Sources: ArcGIS 9.3; CENIA geoportál INSPIRE 2012; MGaHI Dobruška 2011; own processing.

bridge, which excluded car traffic (Neighbourhood Committee No. 1 2010). At present, the overpass has been repaired and can be used by cyclists and hikers as well as motor cars. In addition, a new communication connected to the main road from Lazce through Černovír to Chomoutov improved the accessibility of the Černovír shooting range for residents of Lazce and Černovír. Nevertheless, the road network was maintained in general and the stability of its functional utilisation was quite high (83%). On the other hand, the category of “railways”, including the railway line connecting Olomouc and Zábřeh, did not undergo any changes in the period in question and therefore the stability of its functional use is 100%.

A slight decrease in the “industrial area” category (0.4 ha) was caused by the grassing over of a part of the former industrial area at the southern border of the land registry area of Černovír. Although there were no buildings in this area, it was used mostly for industrial purposes. The political changes and economic transformation after 1989 also affected the former state company Farmakon, at the time one of the most important plants in the Czech Republic with a monopoly of pharmaceutical production. After the Velvet Revolution, it became a state enterprise and in the privatisation process some of the employees established Farmak a.s., which acquired the Olomouc part of the former state enterprise in 1996 (Hovadík 2000). Production started to focus on Western markets and clients who were demanding with regard to the quality of goods, and the number of employees dropped to 406 from 1,100 in 1980 (Burešová 2009). The pollution caused by the manufacturing process became a serious issue in the newly-established democratic society and because of several accidents which occurred in the company, its transfer out of the city was discussed. However, the company’s management undertook to produce less demanding substances and focused on cosmetics, pharmaceuticals, and detergents. The high value of stability of the functional use of the category “industrial area” (88%) is due to the stagnation of industrial development and the preservation of most of the buildings that existed at the beginning of the period in question.

Chválkovice between 1991 and 2009

This local part of the city of Olomouc adjacent to the land registry area of Černovír also underwent tangible changes within the period in question with more or less significant driving forces behind them. In the period 1991-2009, the category of “arable land” maintained its dominant position, which it has occupied since at least 1834 (Harrodová 2015). Although the collective farms gradually ceased to exist after the fall of the Soviet Union, and it could be expected that the total area of arable land would decrease, the opposite is true. The total area of arable land increased in the period 1991-2009 by almost 20 ha. The most striking transformation of the landscape structure in connection with this category can be seen in the east of the residential development of Chválkovice, where relatively large areas of “permanent grasslands” were transformed into arable land. The reacquired freedom to decide about the land was reflected in an increase in the overall “diversity” of the landscape structure of this land registry area. The category of “permanent grasslands” suffered a significant loss of its total area (about 27 ha), although, when the map layers of the initial and final states of deployment of elements in the land registry area of Chválkovice are compared, it is also possible to see the emergence of new areas of permanent grasslands (e.g. around the isolated woodland in the east of the land registry area). The drop was caused mainly by the ploughing of previously grassed areas, which therefore were most often transformed into the “arable land” category. The stability of the functional use of the “arable land” category amounted to 84% (the apparent effect of the total area of the category), while for the “permanent grassland” category, because of the variability of the deployment of its elements, the stability of the functional use was only 64%.

The increase in the area of “forested land” (3.5 ha) was caused mainly by the increasing area of the Černovír forest, but also by an increase in the “density” of the tree cover accompanying the Bystřice river. Completely new areas of forested land then appeared around Chválkovice Fort II (to the west of the main road) – one in its immediate vicinity, and the other at a distance of about 500 m to the

CHVÁLKOVICE 1991-2009

Formation of FORESTED LAND from category:

- forested land
- other categories

Formation of ARABLE LAND from category:

- arable land
- other categories

Formation of PERMANENT GRASSLAND from category:

- permanent grassland
- other categories

Formation of GARDENS AND ORCHARDS from category:

- gardens and orchards
- other categories

Formation of WATER BODIES from category:

- water bodies
- other categories

Formation of BUILT-UP AREA from category:

- built-up area
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Formation of INDUSTRIAL AREA from category:

- industrial area
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Formation of RAILWAYS from category:

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- other categories

Formation of ROADS from category:

- roads
- other categories

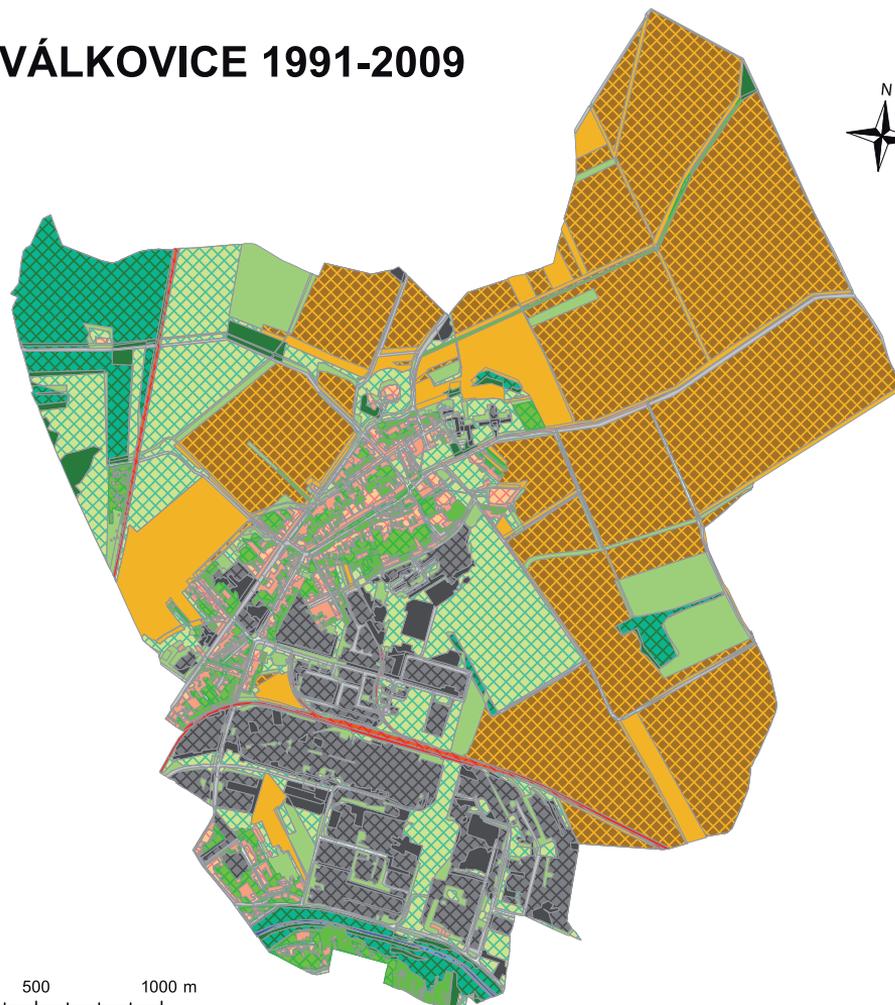


Figure 4 Spatial distribution of stable and unstable areas of the functional landscape use in Chválkovice between 1991 and 2009.

Sources: ArcGIS 9.3.; CENIA geoportal INSPIRE 2012; MGaHI Dobruška 2011; own processing.

west. These changes were reflected in the value of the stability of the functional use of this category, which reached 79%.

The “water bodies” in the land registry area of Chválkovice did not undergo any major changes between 1991 and 2009, even though fairly dramatic events took place in Olomouc in this period. Of course, the most serious event was the flood in 1997, which did not affect Chválkovice as much as the adjacent land registry area of Černovír; 16.88% of Chválkovice was flooded (Caritas Czech Republic 1997). However, in the spring of the previous year, the neighbourhoods of Chválkovice and Týneček were flooded by rapidly melting snow (SDH Chválkovice). A slight decrease in the total area occupied by elements in the “water bodies” category was caused by a slight modification of the river bed of the Bystrice river. The not-very-intense transformation of this category corresponds to 89% stability of its functional use.

The area of the “gardens and orchards” category dropped during the period in question by 1 ha, which was caused by a slight reduction of the “U tratě” allotments (at the eastern edge of the railway line crossing the western side of the land registry area of Chválkovice) and the expansion of residential development towards the areas of industrial production (both to the north and south of the Olomouc–Krnov railway line). New residential buildings were erected on areas formerly used as gardens and orchards. On the other hand, the decline in the area of this category was not radical, because new or revitalised areas of gardens and orchards appeared, especially in the “Bystrovanská” allotment lying on the southern border of the land registry area (Hrochová 2013). The stability of the functional use of this category between 1991 and 2009 reached 76%.

The increase (from 23.7 ha to 26.2 ha) in the “built-up areas” category was mainly caused by the continued expansion of residential complexes into industrial areas (Burian et al. 2010), which was quite a significant process in Chválkovice. During the period in question the elements of this category sprawled noticeably, especially in a southwesterly

direction from Pavlovičky, but also southeast of the Selské náměstí square. The rise in this category was also due to newly built weekend houses in the “Bystrovanská” allotment. The number of houses in Chválkovice increased from 421 in 1991 to 484 in 2008 (CZSO 2008). These changes are also reflected in a not-too-high value of the stability of the functional use of the “built-up area” elements (79%).

The length of “railways” did not change between the years 1991 and 2009 (5.36 km) and the same applies to the category of “roads” (35.5 km both in 1991 and 2009); however, the communication network was slightly transformed by some changes to local roads. The building of new roads or extension of existing ones linking areas of industrial production was balanced by the disappearance of some roads that formerly led through more “open” space (i.e. particularly roads leading between fields). While the stability of the functional use of the category “railways” is almost 100%, the transformation of the road network caused a drop of this value to 81%.

The gradual growth of “industrial area” in the land registry area of Chválkovice, which had already started during the era of socialist industrialisation, also continued in the period in question; however, there was no striking boom in the construction of industrial plants, production halls, or warehouses. The increase of about 5 ha is associated with the expansion of existing companies and a new industrial area (a filling station) expanding into the area in question from the neighbouring land registry area (Týneček). The economic changes after 1989 also affected production companies in Chválkovice. The last Olomouc mill, in Chválkovice, was privatised in 1992 and acquired by Ceram Šenov, but its operations ended in 1996. The Sigma Company submitted a privatisation project in 1991, and the joint stock company ISH Pumps, established in 1997, manufactures irrigation equipment (production located in Chválkovice). Privatisation also took place in other companies; it is worth mentioning the former company Pozemní stavby, which was acquired by Stemex-Bau in 1997. The company Dopravní stavby was divided into three joint-stock companies, DS IEC, Prodos, and Holding, which

merged again in 1997, when the joint stock company Dopravní stavby holding was established; it finally disappeared in 2002 without liquidation, since it was acquired by Skanska, based in Prostějov. The state company Prefa submitted its privatisation project in 1992, and in the same year it was transformed into the joint stock company Beta, which changed to the Prefa H+Z limited company in 1995 (Schulz 2009). One of the most important companies currently residing in the land registry area of Chválkovice is the PRESBETON Nova limited company, which focuses on exports of concrete paving and masonry materials to Austria and Slovakia (Chamber of Commerce of the Olomoucký Region 2010). The expansion of the total area of industrial area was reflected in a lower value for the stability of the functional use of this category (75%).

EVALUATION OF THE FUNCTIONAL LANDSCAPE USE OF ČERNOVÍR AND CHVÁLKOVICE BETWEEN 1991 AND 2009

The consequences of the events in 1989 affected nearly every sphere of the life of the inhabitants of Olomouc, and they affected the economic development and the administrative arrangement of the city especially significantly (referenda in municipalities integrated into Olomouc in the 1970s and the independence of Samotíšky, the land registry area adjacent to Chválkovice). Between 1991 and 2009, we can recognise a substantial number of driving forces that were actively involved in shaping the landscape of the land registry areas of Černovír and Chválkovice.

The fall of communist power and domination in Czechoslovakia was reflected in the evolution of the landscape structure of both land registry areas. The reacquired freedom to possess land at one's own discretion was reflected in a greater "diversity" of deployment of elements of the categories of functional use and in the gradual disruption of the forced integrity of areas dictated in the socialist period. Many areas previously used for agriculture began to be used differently. In the land registry area of Černovír the decline in the area of arable land was caused in most cases by its transformation

into permanent grasslands, forested land, and gardens and orchards. In Chválkovice, however, the development of this category was different, even though the reduction of this area would be expected after the dissolution of the local collective farm. This fact points to the position of arable land and agricultural production in this land registry area still being very strong. Both land registry areas also experienced the expansion of forested land areas, especially in the immediate vicinity of the Černovír forest and along the beds of rivers flowing through their territory.

In the period in question, the recreation areas in Černovír, i.e. the allotments solely, continued to expand. Many existing allotments were enlarged in this land registry area and one completely new allotment called "U Staré Moravy" was established. On the other hand, in Chválkovice this trend gradually faded, and although several weekend houses were built in the period 1991-2009, the overall level of recreational activities in the form of gardening gradually decreased (as evidenced by the current appearance of the "Bystrovanská" allotment, which is described as partially degraded). The newly-built weekend houses contributed to the increase in the built-up areas, which is noticeable in both land registry areas in this period. In Černovír, this increase was mainly due to new buildings in the allotments, but also to the extension of the premises of the waterworks and water treatment plants and a newly built house by the most northerly-lying pond. In Chválkovice, we can observe further penetration of residential buildings into areas of industrial production, which has been an increasingly frequent phenomenon in the city of Olomouc since 1985.

A significant event affecting primarily the development of the land registry area of Černovír, but also Chválkovice, was the flood in 1997, considered to be a millennial water event. It flooded 98% of the territory of Černovír (70 houses were damaged and the structure of the bridge over the Morava River damaged) and 17% of the land registry area of Chválkovice. However, thanks to the flood, it was revealed that the Černovír fens, considered extinct since the 1950s, had a relatively well-preserved water regime and therefore it was possible to revive them.

Table 2 Absolute and relative values of the share of stable and unstable functional landscape use in Černovír and Chválkovice between 1991 and 2009.
Source: ArcGIS 9.3. CENIA; geoportal INSPIRE, 2012; MGaHI Dobruška 2011; own processing.

Formation of category (2009)	Functional use	From category (1991)	Černovír			Chválkovice		
			Area (ha)	Share in category (%)	Share in total area (%)	Area (ha)	Share in category (%)	Share in total area (%)
forested land	stable	forested land	88.47	80.35	15.88	40.74	79.04	5.32
	unstable	other categories	21.64	19.65	3.88	10.80	20.96	1.41
arable land	stable	arable land	251.05	94.75	45.05	305.87	83.96	39.97
	unstable	other categories	13.90	5.25	2.49	58.45	16.04	7.64
permanent grassland	stable	permanent grassland	45.19	59.02	8.11	98.48	63.78	12.87
	unstable	other categories	31.38	40.98	5.63	55.92	36.22	7.31
gardens and orchards	stable	gardens and orchards	29.03	73.69	5.21	29.60	76.00	3.87
	unstable	other categories	10.37	26.31	1.86	9.35	24.00	1.22
water bodies	stable	water bodies	17.94	92.97	3.22	1.17	89.25	0.15
	unstable	other categories	1.36	7.03	0.24	0.14	10.75	0.02
built-up area	stable	built-up area	11.63	77.78	2.09	20.64	78.80	2.70
	unstable	other categories	3.32	22.22	0.60	5.55	21.20	0.73
industrial area	stable	industrial area	7.12	87.86	1.28	70.30	74.99	9.18
	unstable	other categories	0.98	12.14	0.18	23.45	25.01	3.06
railways	stable	railways	11.90	100.0	2.14	6.34	97.24	0.83
	unstable	other categories	0.00	0.00	0.00	0.18	2.76	0.02
roads	stable	roads	9.91	82.97	1.78	23.06	81.31	3.01
	unstable	other categories	2.03	17.03	0.36	5.30	18.69	0.69

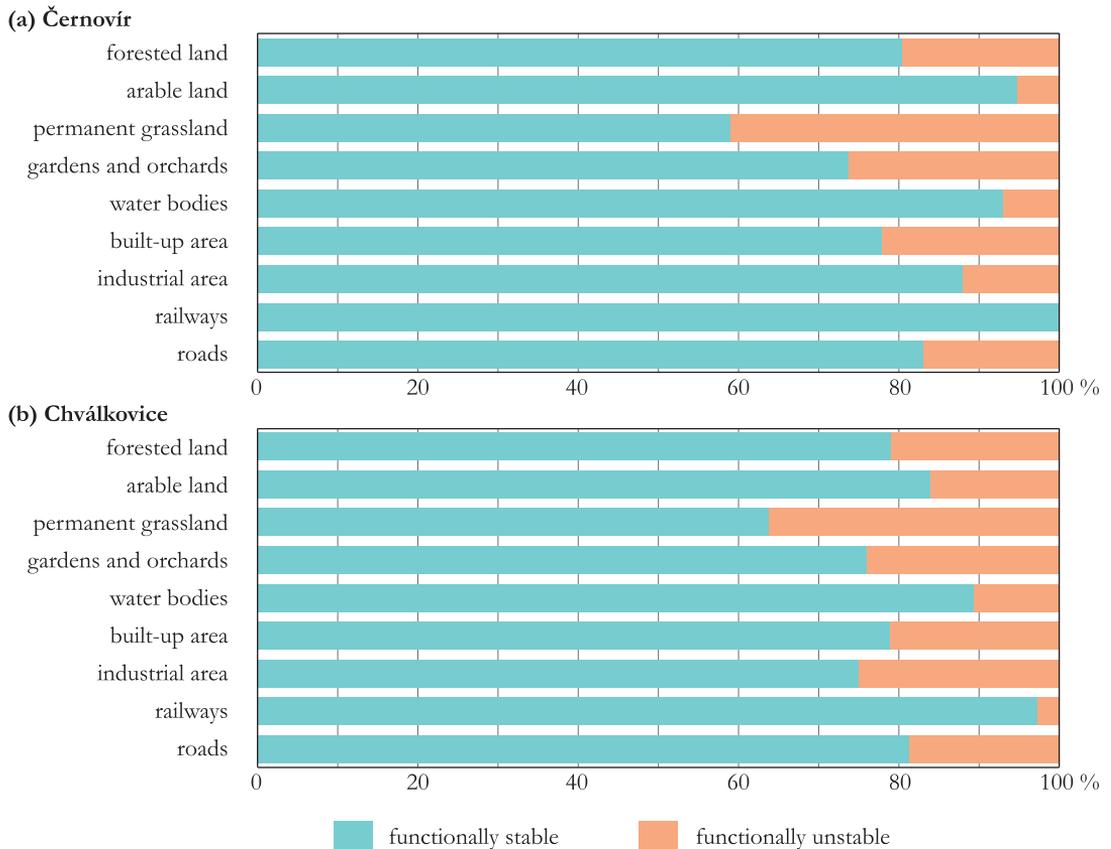


Figure 5 Ratio of stable and unstable areas of functional landscape use in Černovír and Chválkovice between 1991 and 2009. Sources: ArcGIS 9.3.; CENIA geoportál INSPIRE 2012; MGAHI Dobruška 2011; own processing.

As part of the flood control measures an embankment dam was built in Černovír. Another flood hit Černovír in 2007, and its consequences took the next two years to remove.

The changes in the economy brought waves of privatisation of industrial enterprises, which significantly affected plants located in both the areas being studied. The former national company Farmakon was privatised and became the joint-stock company Farmak, with a significantly lower number of employees, and its production gradually switched over to the manufacture of cosmetics, pharmaceuticals, and detergents. The industrial zone in Chválkovice expanded between the years 1991 and 2009, but local companies had to submit privatisation projects. The Chválkovice mill was closed in 1996 and the Sigma Company underwent privatisation in 1991, and from

1997 on kept up its production in Chválkovice under the name ISH Pumps. Pozemní stavby was acquired by Stemex-Bau and Dopravní stavby was transformed into the joint stock company Dopravní stavby holding. At present, one of the major companies operating in the land registry area of Chválkovice is the limited company PRESBETON Nova.

The overall stability of the functional landscape use in this period reached high values in both land registry areas. In Černovír, 45% of the area of which was covered by arable land at the end of the period in question, 85% stability of the functional use of the identified categories was shown. A slightly lower but still very high value of this characteristic (78%) was found in Chválkovice, where the predominant category (also arable land) occupies 40% of the total area of its territory.

ECOLOGICAL STABILITY OF THE LANDSCAPE BETWEEN 1991 AND 2009

The coefficient of ecological stability was obtained using the following formula:

$$K_{es} = S / L$$

where S is the acreage of relatively stable areas (forested land, gardens and orchards, permanent grassland, water bodies) and L is the acreage of relatively unstable areas (arable land, built-up areas, industrial area, roads, railways).

This coefficient is used to create a notion of the resistance of the landscape in the land registry areas under study against interferences which are reflected in the structure of the landscape, and its subsequent ability to recover after a disturbance. In Černovír, the coefficient reached 0.71 in 1991 and 0.79 in 2009. The values of this characteristic in Chválkovice were even lower: 0.56 in 1991 and 0.48 in 2009. In both cases, therefore, it is an area that is intensively used ($0.30 < K_{es} < 1.00$), mainly for agricultural mass production, which causes weakening of the self-regulatory processes and thus significant ecological instability and high requirements for inputs of additional energy. The coefficient of ecological stability of the landscape in Chválkovice, then, even approaches values describing territory exceptionally used with a clear disruption of natural structures ($0.10 < K_{es} < 0.30$) (Míchal 1994). Until the onset of the socialist system of agriculture, the land registry area of Černovír averaged significantly higher ecological stability, but what were at that time radical interventions in the landscape caused the inevitable decline of this characteristic. Then, between 1991 and 2009, a slight increase can be observed in this area, associated with a decrease in the intensity of agricultural mass production and partly with the aim of rescuing the Černovír fens and the associated expansion of areas of forested land. The territory of Chválkovice has undergone a different development in the past, because it has been widely used for agriculture for a long time (Harrodová 2015) and the gradual conversion from an area with agricultural functions into an area of industrial-agricultural character could not have any positive effects on the value

of the coefficient of ecological stability, because the industrial area also falls into the category of relatively unstable areas. In Chválkovice, the industrial area and arable lands are also preserved and the landscape is therefore intensively exploited at present.

CONCLUSIONS

The paper focuses on an evaluation of the development of the functional use of areas of the suburban landscape in the city of Olomouc after 1989. For the purposes of our research, we selected two local neighbourhoods of the city of Olomouc, namely Černovír and Chválkovice, whose landscapes can be typologically described as suburban. In connection with the main goal we tried to find answers to the research questions formulated in the introduction. The responses to the questions are presented below.

With regard to the first research question, we can say that the stability of the functional use of the suburban landscape in the areas of interest was quite high and clearly outweighed the instability. As the landscape is a constantly evolving dynamic system, we also noticed changes in the structure of the functional areas in both neighbourhoods. However, the high values of the shares of stable functional areas in the total area indicate that the intensity of the transformation of the landscape structures was not critical in the areas of interest.

The concept of driving forces was used to explain why the changes in the landscape use occurred. The most important driving force were the social and political turbulences that took place in 1989. The newly acquired freedom to possess the land caused larger quantitative fragmentation of areas of functional use of the landscape in both areas in question. A very important driving force was the flood in 1997, which played an essential role, especially in Černovír. The transformation wave related to the privatisation of industrial companies mainly affected the industrial area category. We perceive the phenomena of suburbanisation, which, by the way, occurred more intensely in other suburban parts of Olomouc (Kladivo and Šimáček 2011), and recreation as the driving forces with the greatest influence on the changes in the built-up areas.

The third research question concerned the ecological stability of the landscape of the areas of interest. The analysis indicated that at the beginning and end of the period in question, Černovír and Chválkovice were areas whose landscape was used very intensively. In Chválkovice, the development tendency slowly transformed the local landscape into an area exploited in an above-average manner, with a clear disruption of natural structures. This is primarily caused by a significant proportion of the arable land category.

In connection with the last research question, we consider the developments of the functional use of the landscape in the neighbourhoods of Olomouc that were explored as similar in the sense of a small dynamic of transformation of the functional use of the landscape. In both cases, therefore, we can talk about territories whose landscape was not significantly transformed by the development in the transition period. On the other hand, the differences between the areas of interest have been identified in the development tendencies of some subcategories. Here we mean primarily the category of arable land, as well as the categories of water bodies, gardens and orchards, and industrial area.

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Résumé

Funkční využití příměstské krajiny po roce 1989 na příkladu města Olomouce

Předkládaná studie se zaměřuje na analýzu funkčního využití krajiny dvou místních částí města Olomouce, Černovíra a Chválkovic, a na evaluaci hlavních hybných sil, které stály v pozadí konkrétních proměn zaznamenaných mezi lety 1991 a 2009. Cílem této analýzy je zhodnocení vývoje funkčního využití příměstské krajiny v postkomunistickém období na příkladu města Olomouce a studium procesu konkrétních proměn v krajině struktury zkoumané oblasti. Důraz je přitom kladen na zjištění stability funkčního využití a ekologické stability krajiny tohoto území, evaluaci diferencí a paralel v rámci vývoje obou katastrálních území a celkové dynamiky krajiny po zásadních historických událostech v roce 1989. Studii je usilováno o přispění k dosavadnímu poznání transformace funkčního využití příměstské krajiny na konkrétním příkladu doplněném o vypovídající grafické prvky.

Teoretické vymezení problematiky bylo nejprve následováno analýzou leteckých měřických snímků, založenou na jejich digitalizaci, identifikaci obsahu (tzn. vizuálním rozpoznání konkrétních prvků vymezených kategorií funkčního využití krajiny) a managementu v prostředí GIS. Zde byl proveden georeferencing snímků, vytvořeny mapové vrstvy a nakonec došlo k promítnutí proměny funkčního využití krajiny mezi léty 1991 a 2009 do nově vytvořené mapové vrstvy (aplikací funkce identity). Proces stanovení kategorií funkčního využití byl inspirován v Evropě často užívanou metodikou CORINE Land Cover a po zvážení specifík oblasti pak došlo k vymezení celkem 9 tříd identifikovaných prvků. Vytvořené mapové vrstvy jsou přímou součástí příspěvku a společně s daty z nich získanými prezentují informace o stabilitě/nestabilitě funkčního využití krajiny Černovíra a Chválkovic v rámci studovaného časového úseku. Zjištěné údaje byly doplněny poznatky vyplývajícími ze studia hybných sil, což přispělo k získání uceleného pohledu na vývojový proces proměny funkčního využití v transformačním období. V neposlední řadě byla také zjišťována ekologická stabilita krajiny těchto oblastí a její vývoj, a to užitím Míchalova koeficientu ekologické stability.

Zjevně nejvýraznější hybnou silou ovlivňující vývojový trend příměstské krajiny města Olomouce byly sociální a politické turbulence proběhnuvší v r. 1989, které se odrazily zejména v intenzivnější fragmentaci ploch funkčního využití krajiny v obou studovaných místních částech. Ta pak byla konkrétně zapříčiněna nově nabytou svobodou nakládat s pozemky dle uvážení vlastníků. Velmi důležitou hybnou silou se pak staly povodně v roce 1997, které sehrály roli především v Černovíře. Transformační vlna privatizace průmyslových podniků byla silou ovlivňující především kategorii průmyslový areál. Změny zastavěných ploch měly na svědomí fenomény suburbanizace (která však daleko intenzivněji probíhala zejména v jiných místních částech Olomouce) a rekreace. Zjištěné hodnoty koeficientu ekologické stability v roce 1991 a 2009 poukázaly na skutečnosti, že jak v případě Černovíra tak i Chválkovic lze hovořit o území, jehož krajina byla intenzivně využívána, ve Chválkovicích pak dokonce vývojový trend přibližuje místní krajinu k území nadprůměrně využívanému se zřetelným narušením přírodních struktur. Na této skutečnosti se výrazným způsobem podílí dominantní zastoupení orné půdy v oblasti.

Dynamika proměn funkčního využití ploch ve zkoumaných místních částech Olomouce nebyla tedy po roce 1989 příliš intenzivní, což vypovídá i o méně výrazné celkové transformaci krajiny Černovíra a Chválkovic. Diference mezi zájmovými územími byly zjištěny v trendech vývoje některých dílčích kategorií, a to především v rámci kategorie orná půda, vodní plochy, zahrady a sady a průmyslový areál.

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