Land Use/Cover Changes in Selected Regions in the World
Volume VII

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Land Use/Cover Changes Commission of International Geographical Union (IGU-LUCC) has been re-established in 1996. Its first international meeting was held in the city of Brisbane, Australia, in 1997. One of the most active commission’s members was Professor Yukio Himiyama from Japan, who was also the head of the commission. Thanks to his initiative and organizational skills he managed to publish the first volume of a land use atlas, called "Land Use/Cover Changes in Selected Regions in the World" (2001). The atlas introduced selected papers focusing on land use and cover changes in different countries. Volume II was published a year later and further two Volumes (III, IV) were issued in 2005. A lack of financial support and initiators hindered efforts to publish new volumes for some time. In 2010, an aggregate edition of atlases Vol. I–IV was published under Professor Himiyama’s supervision, because of a remarkable interest among land use researchers in such a book. Volume V was published in Prague at Charles University in 2010. Professor Himiyama presented the following Volume VI on the occasion of IGU congress in Köln (Germany) in 2012.

What is so specific about these atlases? Above all, they summarize land use and cover changes papers from different countries, studied with various methods. Thus, the atlases enable international contacts and publicity of research results as well as they show new and original methods and approaches in land use research. They also provide an essential possibility of publication in larger format; papers usually cannot be printed in such an extent in scientific journals. The atlases offer an equal extent of text and graphics, and there is also a possibility to publish full-colour maps and figures. Coloured maps facilitate better perception of various analysed land-use categories, their development and other features.

Volume VII includes eleven papers altogether (ten from Czechia and one from Slovakia); however, the first seven papers make a whole with general introduction plus six case studies from Czechia. In order to obtain atlases Volume VI and Volume VII, editors should be contacted on their email addresses.

We believe that it will be possible to continue publishing these atlases in the future too. The next atlas (Vol. VIII) should be concerned again on the LUCC from different countries over the world.

Ivan Bičík
Head of the IGU-LUCC Commission

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Changes of Land Use Structure in Czechia: From Local Patterns to a More Complex Regional Organization

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1. Introduction

The territory of present-day Czechia was covered by forests by about 80% until the turn of the 1st and 2nd millennia AD (Lipský, 1999). The population increase, though for a long time modest only, has been mostly responsible for deforestation. The extent of agricultural land reached its maximum at the end of the 19th century (in that time it covered more than 60% of the whole territory). For centuries, agricultural land was seen as the most important natural source and as a key to well-being. National economy and the whole society, however, began to change on the eve of industrialization in the late 18th century. Mather (2002) understands this change as a crucial one in most European countries as far as land use structure is concerned. On the Czech territory forests grew by 5% during the 20th century and nowadays cover ca. 34% of the whole territory. Agricultural land (especially arable land) has undergone even more important changes, having been decreasing in the course of more than 100 years; in the period of 1948–1965 this decrease was a marked one (Jeleček, 1985). Only part of the former agricultural land was invaded by forests – the urban sprawl proved to be a more important phenomenon. The increase of built-up areas and the so-called remaining areas (non-productive land, mining areas, cemeteries, urban parks, military areas, 1st zones of national parks etc.) both in total extent as well as in relative terms can be seen as the most important land use/land cover change during the past 200 years.

The industrial revolution had started fundamental economic and social changes that accelerated over the time (Purš, 1973). Settlement structure and agriculture were influenced, too. Ongoing urbanization brought many urban features into the originally rural countryside. What came to existence was an urbanized society that began to influence greatly the remaining rural areas. Farmers who had originally been the chief “users” of the landscape became regionally specialized, the intensity of agriculture varied. Subsistence agriculture did not dominate any longer. New agricultural techniques that influenced specialization of individual farms depended on the size, location, and also on the differential rent (Jeleček, 1985). With the advance of modern long-distance transportation lines – railways and later roads – it became easier to transport agricultural products from fertile regions to the areas of demand. That is, cheap products could reach distant markets, sometimes crossing national or even continental boundaries.

All the above processes led to fundamental changes in land use and landscape itself. The extensive database created at the Department of Social Geography and Regional Development, Charles University, Prague allowed to document and assess long-term changes of land use patterns. Eight basic land use categories in some 9,000 territorial units were examined in the years 1845, 1948, 1990, and 2000. These years coincide with crucial economic and political changes on the Czech territory (for more, see www.lucc.ic.cz). A number of books and articles that evaluate long-term land use changes and that use the above database have been published over the past twenty years (Bičík, Jeleček, Štěpánček, 2001; Bičík, Götz, 1998; Bičík, Jeleček, 2009; Bičík, Kupková, Štych, 2011; Bičík, Kupková, 2012).

Data relating to the years 1896 and 2010 have been added to the database recently and will be examined soon.

2. Long-term land use and land cover changes

Revelle (1984) examined global changes of the use of different natural formations as well as changing patterns of agricultural and arable land. He showed how the increase of agricultural and arable land in the course of the 19th century was concentrated into the economically more developed regions; on the other hand in the less developed areas the same process was delayed by at least 50–100 years. In Europe, agriculture still much influences the rural landscape as a whole including its biodiversity. Two important processes should be taken into account: intensification that occurs mostly in fertile lowlands versus less intensive development typical of higher altitudes with less favourable natural conditions. Thus, in most European countries including Czechia land use/land cover changes differ a lot by region. Lipský (2010) argues that the use of rural landscape is becoming more unequal both on local and regional levels. At the local level patches of abandoned arable and agricultural land emerge and these are again being inhabited by a number of species; a new “wilderness” comes into existence (Lipský, 2010). On the other hand the current agricultural subsidies channelled to less favoured areas have a similar effect as subsidies under the centrally-planned economy had: in land use terms the existing structure (relatively high share of agricultural and arable land) is being conserved also in regions with less favourable natural conditions (Jančák, Bičík, 2006). Thus, the use of landscape moves towards large regional units with similar land use structure. In Czechia this process is especially distinctive due to a strong concentration of agricultural businesses that had started already 50 years ago and that to a certain extent still goes on.

In the pre-industrial society each community had to be self-sufficient – as a result, in order to survive all land use categories were needed. Hauler (1953) shows that at late as at the beginning of the 20th century there still were patches of arable land at an altitude of 900 metres or higher. The ongoing modernization, however, brought different functions influenced by more (less) intensive use of the land. Urbanization had great effects, too – consequently local land use patterns became much more differentiated than earlier. New functions appeared in the rural landscapes and new regions with similar land use/land cover structure came into existence. These regions, however, are much bigger than the older subsistence units (formerly often consisting...
Fig. 1 — Major Land Use Changes in Czechia in the period 1948–2000.

Fig. 2 — Main landscape processed in period 1845–1948 (application of Gabrovce, Kladnik, 1997).
Note: Increase of forest areas (afforestation) / permanent grassland (grassing) / arable land + permanent cultures (intensification) / built-up + remaining areas (urbanization) reached in all increasing categories more than 75% (high) / 50% (moderate) / 25% (low).
of one single village or a small region) and show similar patterns when examined by Basic Territorial Units (BTU). When compared to each other, however, such typological regions may differ greatly (Bičík, Kupková, Štych, 2012).

### 3. Data and Methods Used

The data that we use to demonstrate land use/land cover changes are of two types. First, there are data based on field mapping that include the areal extent of each land use category by territorial units (to ensure comparability, eight categories are identified). Second, data based on detailed mapping are used: two cadastral maps are superposed on each other and as a result all detailed changes can be analyzed including changes between (among) different land use categories. Altogether, 8,903 comparable basic territorial units were examined, data refer to the years 1845, 1948, 1990, and 2000 and the database can be accessed at www.lucc.ic.cz. There are eight land use categories: arable land, permanent cultures, meadows, pastures (forming together agricultural land), forest, water, built-up and remaining areas (the last three categories combined form so called other areas).

In order to show basic trends also a simplified land use structure is used (agricultural land, forest areas, other areas – see Table 1). This database has been described in detail in a number of recent publications. It forms a unique source of information on land use changes. Our aim is to define main functions of the Czech territory. Industry, housing, leisure, environmental protection, agriculture, conservation, and recreation are all land use categories that can be examined for all periods available.

The above description of the land use changes as well as the attached maps allow us to highlight general trends. Relatively large regions with similar land use patterns are being formed, depending on new functions/trends dictated by modernizing trends within society. Economic and social functions and trends, however, change over the time and consequently land use structure is being changed, too. This is likely to happen also in the future – each change of function will probably bring some land use changes. Our aim is to define main functions of the Czech landscape in the early 21st century and their reflection in changing land use patterns. Several case studies have been carried out in order to show typical land use/land cover changes that happened between 1845 and 1948. It includes changes of agricultural land as well as of forest, water, built-up and remaining areas.

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### 4. Case studies: Selection of Appropriate Regions

Reliable data (www.lucc.ic.cz) are available for the last 170 years, i.e. for the period when fundamental changes of agricultural production and landscape use took place on the Czech territory. The changing character of society as a whole, not just the needs of local communities, became the main driving force that brought new trends and functions into the landscape, consequently influencing also the land use patterns.

The necessary amount of agricultural products had long been secured by increasing the extent of arable land; later, however, a more intensive agricultural production concentrated into the most favourable areas prevailed. Thus, the landscape that originally served mostly the needs of agriculture became functionally more varied – a process that lasted practically during the whole 20th century and that continues also nowadays (with a short exception after the agrarian reform in the 1920s). Figure 3 shows that BTUs with arable land increase prevail; on the contrary, Figure 4 reflects the opposite (1st half of the 20th century). Figure 5 reflects substantial losses of arable land that had happened particularly under Communism (some 18% less in 1990 when compared with 1948) and that continued under the re-established democratic regime (1990–2000). This series of maps shows important changes of single one land use category, i.e. that of arable land. Similarly, changing patterns of all land use categories can be examined for all periods available.

Figure 2 shows synthesis of all land use categories between 1845 and 1948. It includes changes of agricultural land as well as of forest, water, built-up and remaining areas.

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Fig. 3 – Changes of arable land 1845–1896 (100 = territorial extent in 1845).

Fig. 4 – Changes of arable land 1896–1948 (100 = territorial extent in 1896).
A) Urbanized areas featuring a constant increase of built-up and remaining areas. Agricultural land and forest areas form just a tiny minority, decreasing in terms of size over the time.

B) Hinterland of main/middle-sized cities and towns. The original agricultural function is being transformed towards housing, retail, transportation and logistics. Chaotic suburban development is typical. Agricultural land is being invaded by built-up and remaining areas with largely negative environmental consequences.

C) Cultural landscape of lowlands and low-lying gently rolling regions. Arable land dominates, with patches of intensively used permanent cultures (orchards); on the contrary, forests, meadows and pastures are rare. A small increase in built-up and remaining areas is observed around local urban centres.

D) Uplands below 650 m a.s.l. with average natural conditions. Land use structure remains more or less stable, with a lot of agricultural use, some housing and in places also with recreational areas.

E) Highlands and elevated regions showing long-lasting losses of agricultural land, especially arable land. Former fields have been typically converted into meadows and pastures, some also to forests.

F) Mountainous areas with specific functions. These can be divided into three subtypes:
   a) The western frontier along the former iron curtain. Under Communism (1948–1989) the land was managed exclusively by state-owned farms and by the military, access was limited. Privatization of state-owned farms after 1989 caused decrease of agricultural production; meadows and pastures became dominant.

b) Heavily depopulated regions like Krušně hory or Jeseníky. Depopulation was due to the displacement of German speaking inhabitants after World War II; many people also simply moved out to more attractive locations.

c) Holiday areas like Krkonoše, Jizerské hory, Orlické hory.

g) Military training areas (both former and operational ones) like Brdy, Ralsko or Doupov. Permanent settlements are minimal as are economic activities; patches of high-quality environment exist.

H) National parks and other protected areas where commercial exploitation is limited by law. Land use structure is stable with high share of forests, meadows, and pastures.

I) Regions with marked out-migration and a lot of leisure/recreational facilities (southern part of Central Bohemia, the Beskides, etc.). No intensive agriculture over the past 25 years, advent of biological farming.

J) Mining areas where much of the agricultural land was taken by open-pit mines. Large scale landscape degradation had taken place. Some degraded areas were reclaimed over the past 20 years. In some places exists "new wilderness".

The above typological regions are examined by comparing detailed maps from selected case studies areas. The first map reflects the situation between 1826 and 1843, the second map dates back to the early years of the 21st century. Just a selection of case studies is presented here.

5. Case studies

In all case studies the same methods have been adopted. The evaluation of land use/landscape changes is based on the comparison of cadastral maps (mid-19th century) with current aerial photographs and maps generated in the GIS environment (scale 1:5,000). Each plot has been vectorized to get the information on land use in respective years. Afterwards, GIS tools (overlay) were used to reveal the changes (in general and in details, too) and their localization.

It became necessary to ensure compatibility of all land use categories. Thus, such a classification that would correspond to all examined categories in all years has been adopted.

### Table 2 – Case studies: selected overview

<table>
<thead>
<tr>
<th>Kežířské – Kleintaxen</th>
<th>Abertamy, Hřebčín</th>
<th>Rudná</th>
<th>Živohošť, Kleničná, Blažím</th>
<th>Hrubá Vrbka, Malá Vrbka, Kutlov</th>
<th>Kobyli</th>
</tr>
</thead>
<tbody>
<tr>
<td>position within Czechia</td>
<td>depopulated frontier near the Austrian border</td>
<td>depopulated frontier near the former East German border</td>
<td>Greater Prague (central Bohemian agglomeration)</td>
<td>south of Prague at the side of Vltava river</td>
<td>south east Moravia near the Slovakian border</td>
</tr>
<tr>
<td>typological region</td>
<td>F(a)</td>
<td>F(b)</td>
<td>B</td>
<td>I</td>
<td>L-E</td>
</tr>
<tr>
<td>land use/cover change</td>
<td>increase of forest areas, meadows, pastures no arable land</td>
<td>increase of forest areas, meadows, pastures no arable land</td>
<td>increase of residential and retail areas, more transport lines decrease of agricultural land</td>
<td>increase of water and remaining areas decrease of arable land</td>
<td>stable land use structure, slight increase of built-up areas decrease of arable land</td>
</tr>
<tr>
<td>natural conditions</td>
<td>altitude 500 m a.s.l. high precipitations low quality soils</td>
<td>altitude 700 m a.s.l. cold environment shallow, low quality soils</td>
<td>altitude 380 m a.s.l. high share of arable land fertile soils including loess</td>
<td>altitude 350–400 m a.s.l. rocky shores medium fertile soils</td>
<td>altitude 300 m a.s.l. + high share of forest areas fertile soils, environmentally valuable meadows</td>
</tr>
<tr>
<td>population changes</td>
<td>displacement of Germans iron curtain depopulation</td>
<td>displacement of Germans uranium mines depopulation</td>
<td>marked population increase close links with Prague</td>
<td>population decrease many second homes</td>
<td>no major changes rich social life</td>
</tr>
<tr>
<td>function</td>
<td>remote, peripheral location high quality environment</td>
<td>peripheral location permanent housing, holiday area</td>
<td>core area permanent housing, services area</td>
<td>inner periphery second housing, holiday area</td>
<td>peripheral location agriculture, permanent housing, UNESCO Biosphere Reserve, special types of recreation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>semi-peripheral location agriculture, permanent housing, wine tourism</td>
</tr>
</tbody>
</table>

Note: Kleintaxen, in the past Klein-Taxen.
Fig. 5 – Changes of arable land 1845–2000 (100 = territorial extent in 1845).

Fig. 6 – Localization of case study areas.
Source: AcČR 500.
classification used complies with the cadastral map system based on the decree No. 190/1996 (Act No. 265/1992).

The existing land use structure has been determined using ortophotomaps and field research in the areas of case studies. Field research was carried out during spring and summer time mostly. The State Map (1:5,000) was used during the mapping. Table 3 shows the basic land use categories.

Proper classification of plots often proved to be difficult during the field research. That is why also aerial photographs have been used, ensuring the accuracy regarding exact position of the examined plots. Four square meters was set as the minimal plot size; smaller patches of land were not digitized.

In order to transform Basic Maps and Cadastral Maps, the Topol programme has been used. It includes most Czech map series and also position of each sheet. In the case of the 1:5,000 maps such a type of transformation was precise enough as basic coordinates of all sheets were available. With Cadastral Maps, however, the situation was more complicated. Each cadastral unit is divided into a number of sheets – as a result, some sheets cover just a small, marginal part of that cadastral unit and consequently exact coordinates are not available. In order to ensure an exact transformation, more points with precise coordinates must be identified. Thus so-called “identical points” both on the Cadastral Maps and on the transformed Basic Map (ortophotomap) were searched for. Cadastral boundaries, major junctions, dikes or important buildings (churches) often served as these identical points. Subsequently the Cadastral Maps were transformed into the S-JTSK Coordinate System using the ArcGIS programme. All plots were vectorized in the ArcGIS environment and the resulting databases were thoroughly controlled.

As a next step, territorial extent of the examined land use categories in respective years was calculated. Land use changes were identified using the overlay method. In such a way the total size of plots with any land use change was detected as well as changes in all land use categories including exact localization. The resulting tables and maps bear a lot of valuable information including the size of plots with/without land use changes (in hectares). Land use changes are precisely characterized – it is recorded which land use category had existed on the respective place at the beginning and what kind of change later happened.

Table 3 – Case Studies – Land Use Classification

<table>
<thead>
<tr>
<th>Land use categories</th>
<th>1. Arable land (AL)</th>
<th>2. Permanent cultures (PC)</th>
<th>3. Permanent grassland (PG), i.e. meadows and pastures</th>
<th>4. Forest areas (FA)</th>
<th>5. Water areas (WA)</th>
<th>6. Built-up areas (BA)</th>
<th>7. Remaining areas (RA)</th>
</tr>
</thead>
</table>


References

(including references mentioned in case studies – pp. 13–48)


Zelená kniha (2010). Rozvojová politika EU pro udržitelný rozvoj a růst podporující začlenění. Zvýšení dopadu rozvojové politiky EU.

1. Geographical situation

This evaluated microregion is composed of Czech abolished village Košťálkov and Austrian village Kleintaxen located some 400 m on both sides of Czech-Austrian border line (see Figure 1). The case-study area is located on the southeast border of Jindřichův Hradec District, in an area known as “Bohemian Canada” (Česká Kanada in Czech). This area is characterized by its harsh climatic conditions and an elevation that, for the most part, is between 500 and 700 m above sea level.

Košťálkov Municipality existed until 1953, when it was dissolved in order to create the fortified border zone. The army destroyed all of the buildings in the village as well as in two smaller settlements. In this area, only one smaller municipality, Staré Město pod Landštejnem, along the local significant state highway, was preserved. It now administers the territory of Košťálkov. The neighbouring municipality of Kleintaxen, just over the state border, is located in the northern reaches of Lower Austria. The natural centre for these municipalities is the Austrian town of Kautzen and the district capital is Waidhofen an der Thaya (20 km away).

This case study area was selected because of its position on the Czech-Austrian border. With this selection we hoped to document characteristic landscape changes in areas, in which the iron curtain was – after the displacement of the Czech Germans and until 1953 – incrementally constructed and fortified. We added the Austrian municipality of Kleintaxen into this comparison, as a means of more clearly demonstrating differences in land use, particularly differences related to political-economic changes in this type of borderland territory in Czechia, during the latter half of the 20th century.

2. Natural environment

Košťálkov is located in an area known as Bohemian Canada, due to the relatively harsh natural and climatic conditions of the hilly landscape with its large proportion of forest cover and the large number of ponds on mountain streams. The municipality itself was situated at an elevation of 540 to 550 m a.s.l. The entire area is oriented towards the southeast. Košťálkov was sheltered from the west by the mountain ridge, which is the source area of the creek that flowed through the village. Further to the east the valley floor slopes down to meet the Pstruhovec stream with an elevation of roughly 520 m a.s.l. The slope of the former fields ranges from zero to seven degrees which, according to current soil ecological units, would be considered from flat to gently sloped. The village of Kleintaxen has an elevation of approximately 550 m a.s.l.

The local climate is determined by the relatively high elevation (510 to 670 m a.s.l.) and by a highly varied terrain. The average temperature in July ranges from 15 to 17 °C, whereas average temperatures in January are around –3 °C. On average, there are more than 20 rainy days, with more than 10 mm of rain, each year. During the season, there are, on average, 70 to 90 days with snowfall. Temperature average is ca 4–5 °C and amount of precipitation ca 800 mm per year.

The monotonous geological substratum of crystalline acid granitic plutonic rocks is the base of a relatively homogeneous land cover with a dominance of acid light-grained cambisols which give way to their glutinous subtypes or directly to stagnosols at lower parts of the relief. The soils on gentle and gradual slopes are locally stony and their fertility is average or below average in general. The site of the abandoned village Košťálkov is probably a typical microrelief with the remains of walls, synanthropic vegetation and a sequence of hardwood plant associations. The traditional use is based on potato and forage crops growing as well as shepherding. The present-day agricultural use is of extensive character. The originally agricultural land was partly afforested and it includes large areas of scattered grassland. In the western part of the area, there is a continuous spruce stand.

As these data indicate, the area presents rather unfavourable conditions for agriculture. Winters here present harsh climatic conditions and summers are humid and cool. Winter conditions last for approximately 100 days each year. The area is unique, first and foremost, because of its landscape. The region has a very high portion of forest cover interspersed with a large number of ponds; it is unique in its varied terrain. For this reason, the Bohemian Canada Nature Park, with an area of 283 km², was designated in 1994.

3. Social and economic conditions

The landscape is thickly forested and did not see human settlement until the late middle ages. The first written record of
the municipality of Košťálkov (at that time, known in German as Gottschallings) is from 1487, when it belonged to the Landštejn/Landstein estate. Small stream, which originates in the nearby forest, flowed through the municipality and was used to create a small fish pond in the upper part of the village. Historically, the municipality included two additional hamlets. Municipality existed until 1953, when it was dissolved in order to create the border zone. In addition to Košťálkov, the army also destroyed other smaller municipalities here along the border, forcing the Czech inhabitants – who had only moved into the area changing (in significantly smaller numbers) after the Czech Germans had been removed from the land in 1945 – to move once again; this time deeper into the country’s interior. This fate was shared by other now no-longer-existing municipalities in the area, including Rajčéřov, Romava, Staré Hutě, Kuní, Dětříž, Pernárec and Košlák (Chromý, 2003).

From 1953 until 1989, the zone of engineered defences (in the distance from several hundred meters to several kilometres from the real border), which served to secure the western border of communist Czechoslovakia, separated the national border from Czechia’s inland. This part of the landscape was accessible only to military personnel, designated by the Ministry of the Interior to defend the border, and was practically, entirely void of any economic utilization. Even in the interior in the vicinity of these engineered defences (barbed wire fences, at times even equipped with live electric current, a ploughed strip of land approximately seven meters wide, various alarm and communication equipment lining a signal path for the army, etc.) a strict ban on any economic use of the land was enforced. This ban applied not only to individual, private farmers (at this time, only a few hundred such farmers existed in all of Czechoslovakia), but also to agricultural co-ops. Only state, or rather military, owned and operated farms and forests (forest enterprises) that were entirely subject to the state and therefore easy to control, were permitted to conduct business in this area.

The deserted village Košťálkov was one of the largest municipalities in the area around Staré Město pod Landštejnem. The oldest available data – from 1842 – regarding the number of inhabitants report a population of 291 people. Up until the end of the nineteenth century, the village’s population steadily grew, to 320 inhabitants in 1880, and 356 in 1895. All later censuses show declining numbers of inhabitants influenced by peripherality of this locality and process of urbanization (see Table 1). The 1930 census records 246 inhabitants, practically all of which were of German nationality. After the borderlands were separated and annexed, pursuant to the Munich Agreement, and the Protectorate of Bohemia and Moravia was created, Košťálkov belonged to the German Empire. Among other things, this meant that the border between Košťálkov and Kleintaxen disappeared. In effect, this supported the tendency for the municipality’s inhabitants to travel more frequently to Lower Austria and less frequently to Bohemia for products and services, for national and social reasons. The prevalence of the German speaking inhabitants also manifested itself in the results of elections between 1920 and
1930. DSDAP (the German Social Democratic Worker’s Party) prevailed in elections in all of the years, in which elections to the national assembly were held (1920, 1925 and 1929). SDP (the Sudeten German Party), founded in 1933 by K. Henlein and supported by A. Hitler, won the next two elections, in 1935 and 1939.

In 1945, 280 inhabitants lived in Košťálkov. During the period from August 1945 until 1947, nearly all of the German inhabitants living in Czechoslovakia were forced to move (as in Poland, Hungary, Romania and other European countries), on the basis of decisions made by the victorious powers at the Potsdam Conference on 2 August 1945. In the case-study area, the displacement of inhabitants was primarily carried out during the so-called “wild transfer” period, which occurred directly after the end of the war and which was accompanied by a number of excesses. German inhabitants were thrown out of their homes, their property was looted both by Soviet soldiers and by newly arriving Czech inhabitants – the so-called gold-diggers – intentionally coming here from the inland. Košťálkov, however, was not a very attractive target for Czech immigrants from the inland moving to the borderland. In 1947, the village had only 129 inhabitants which later declined to only a few dozen people. Not long afterwards the municipality was designated for desertion, on the basis of a 1951 decree from the Ministry of the Interior concerning the creation of a border zone. Already in 1948, the Ministry of the Interior ordered the removal of all inhabitants from the nearby municipalities of Romava and Staré Hutě. Some of these people moved to Košťálkov, only to be forced to relocate again, two years later.

Data on the number of houses in Košťálkov show a gradual increase up until World War II. The municipality had in 1895 58 houses, by 1939 the number had increased to 73. At present, Košťálkov is nonexistent. In its immediate vicinity, however, across the Austrian border with practically identical natural and situational conditions, we find the small settlement of Kleintaxen, which is now a very small village, with roughly 25 inhabitants and 37 buildings (both residential and agricultural) – see Figure 2.

Traditional economic sectors in the area included agriculture, forestry and weaving. Industrial production has never been located here. In 1929, the trades practiced in Košťálkov were characteristic of community subsistence for a small agricultural village: wheeler, smith, shoemaker and miller. Sources from 1909 report that the village had a two-room schoolhouse, a newstand, a German volunteer fire-fighter group, a manor estate, a mill, two inns, a mixed goods store and a small chapel. At present, the area draws a rather large number of tourists, in spite the fact that there is no village here. Bicycle trail no. 1007A, which continues on to Kleintaxen and Großtaxen in Austria, crosses through the territory of the former municipality. A rest area for cyclists has been built in the area of the municipality. Two reconstructed crosses at their original locations are the only standing remains of the former municipality. In addition to these, the foundations and ruins of portions of the former buildings are visible in some places (see a model of the former village – Figure 3). A number of wild fruit trees can also be found at the site of the deserted village. In 2006, the border roadway connecting Košťálkov and Kleintaxen was repaired and – in a ceremony involving local inhabitants of Kleintaxen, former residents of Košťálkov and government representatives from both countries – the border crossing was officially reopened. Initially the border crossing was designated only for pedestrian and bicycle traffic, but now it improves the mutual accessibility of two peripheral areas in neighbouring countries for passenger vehicles and motorcycles as well.

4. Long-term land use changes

Košťálkov is situated close to the Czech-Austrian border, on the area administered by the town hall of Staré Město. The displacement of German population and later of Czech resettlers after 1953 brought about a momentous change in land use. This decided on the fate of not only Košťálkov, but also of a number of settlements to the south of Staré Město. The selection of the locality for a detailed analysis of land use was primarily influenced by this turning point in the modern history of settlement and in the use of this particular area (see Figures 4, 5 and Table 2).

Until the early 1990s, rather poor, stony soils, at which cultivation was often difficult, were managed in a relatively intensive
Fig. 5 – Land use in the case study area in the years 1823 and 2003
Source: Czech Office for Surveying, Mapping and Cadastre; authors field survey (2003)
way by a state-owned farm, as everywhere near the border, with the state’s generous subsidies. As a result, there was an extensive ploughed-up area as well as primarily dairy production of stabilized cattle. The privatization of agriculture after 1990 and the end of the former system of agricultural subsidies brought about major changes in farming ways. Only a small quantity of arable land has remained in the area as most of it has been transformed into meadows and pastures or was left fallow without any transfer into the category of pastures and meadows in the cadastral register. At present, this permanent grassland is being grazed at a much smaller scale by meat cattle, only stabled in winter. Recently, a part of the pastures has even been used for newly introduced bison breeding from North America as the animals easily endure the harsh winter conditions of this part of Česká Kanada (“Czech Canada”), while near the area, a different owner breeds European bisons.

These specific types of breeding are mainly motivated by an effort at an economically more efficient utilization of the existing conditions for agricultural economy as the price of meat of the exotic animals is about three times higher than that of beef. The described transformations of the functions of landscape in the Košťálkov territory have also had a major impact on the structure of land use, sharply contrasting with landscape changes in the neighboring cadastral unit of Kleintaxen beyond the state border in Austria. In the study area, there were also substantial changes in the sense that at the time of the Communist agricultural large-scale production, the former narrow, long strips of land (until now typical of the neighboring Kleintaxen) were replaced with consolidated large plots, whereby balks disappeared. At present, this consolidation of the former split subdivision into larger strips constitutes one of the major environmental problems (high soil erosion, waterlogging at low altitudes, wash-out of nutrients from higher parts of land, etc.).

5. Perspectives, problems and risks of future development

Obviously, the displacement of Czech Germans in 1945–1946 and the abandonment of the Košťálkov village, resettled by the Czech population after 1953, over the construction of iron curtain on the Austrian-Czech border influenced not only the loss of the residential function, but also, to a large extent, of the productive agricultural function. This is why the index of change in the area was high, having reached 59.08% in 1823–2003. This means that a change in the category has occurred, compiled on the basis of a comparison of two map layers at almost one half of the territory of the studied cadastral unit. A comparison of maps of two time horizons has revealed a substantial decline in agricultural land (arable, permanent grassland as well as permanent cultures) and there was roughly the same increase in forest areas (almost to the triple of that from 1823).

In the given years, a similar situation could be seen in other regions alongside Czechia’s western border. What matters is that until 1989 neither any private farms nor agricultural cooperatives could farm close to the iron curtain, only state-owned farms (or military-owned farms and forests). In this area, it was the Nová Bystřice state farm and Staré Město pod Landštejnem farm. At present, the farmed area is owned by private companies.

With its current function, the territory constitutes a meadow and woodland landscape with a very low level of influence of current society on its changes. There is a domination of environmental and recreational functions, with a limited scope of economic utilization of a minor part of the area. We consider it highly interesting to compare the erstwhile and present-day structures of land of Košťálkov with the neighboring locality in Austria. Despite the same natural conditions, a rather significant proportion of arable land was maintained on the Austrian side, while the traditional land disintegration into small strips of land with various owners and sowed crops was conserved there. Naturally, this has a major impact on the territory’s environmental quality. Given the peripheral location of the model area towards both Czech and Austrian nodes, the prospects give some guarantees of the preservation of present-day structure of land use or only minor changes in the future. In fact, there was an undoubtedly very interesting attempt from the turn of the century when a foreign investor prepared a project of a large recreational center for the neighboring cadastral unit Rajchérov in an environmentally priceless area (the capacity of about 3,000 persons!), which promised a fairly high number of jobs in an area plagued with unemployment. Due to the opposition by the general public and primarily the disagreement with the project voiced by the Environment Ministry, the investor’s interest moved elsewhere. A complex of tens of recreational houses, primarily for foreign buyers, was established near Nová Bystřice in the area of another abandoned locality. It can use both the facilities provided by the small town of Nová Bystřice and ten golf courses on both the Czech and Austrian sides of the border. Thanks to the solution, the area of Košťálkov and the neighboring Rajchérov could be left in an undisturbed, significantly secondary natural state.
1. Geographical situation

Abertamy and Hřebečná (also known in German, before 1945, as Abertham, Hengstererben or Hengst) are two settlements with their own respective cadastral units that comprise Aber- tamy Municipality. This case study area is located at a relatively high elevation (650–900 m a.s.l.) and is composed primarily of peneplains of the peak areas of the Krušné hory Mountains (also known as the Ore Mountains) that, at present, have a high concentration of forest and permanent grassland cover (see Figures 1 and 2). Within Czechia, the region has a markedly peripheral position. The territory has no railway connection; however, a one-track non-electrified track leads through the neighbouring cadastral units. The only local highway (I/25) traverses the neighbouring cadastral units of Jáchymov and Boží Dar, connecting the local centre – the town of Ostrov – with Germany (in the direction of Chemnitz). Within the Perník Municipality, two second-class roadways intersect one another – one leading from Oldřichov to Jáchymov and the other from Horní Blatná to Ostrov. The nearest larger town that serves as a municipality with extended competencies, in which the model territory is included, is the town of Ostrov (with ca 17,500 inhabitants in 2011) in the distance of some 12 km (but 400 m lower!). The main centre for the area is Karlovy Vary, the seat of the regional government, which can be reached by car at a distance of less than 30 km.

2. Natural environment

The entire area lies within the Krušné hory Mountains and, consequently, elevations range from 600 m a.s.l. to 1,115 m a.s.l. The nearby municipality of Boží Dar is, with an elevation of 1,020 m, the highest municipality in Czechia. In terms of geology, the western part of the area is primarily composed of Palaeozoic foliated and metamorphic rocks (phyl- lites and mica schist) and granite is the most significant rock of the eastern portion. A concentrated body of Tertiary volcanic rocks is located along the border of the Hřebečná cadastral unit (and in other locations outside the case study area). A number of characteristic divisions can be found here. Soils consist primarily of podzols, though humus and cambisols are also found in the area, i.e. soils not well-suited to intensive agricultural production. The area is home to a number of peat bogs, some of which are subject to state nature conservation efforts.

The area is drained by the Labe (Elbe) River into the North Sea. A lower order divide between the drainage basins of the Ohře River (in Czechia) and the Mulde River (in Saxony, Germany) is located in the vicinity of the case study area. Myslivny Reservoir, with a surface area of approximately 3 ha, is located in the study area. The 12 km long Blatenský Canal from the 1740s is a particularly interesting historic water project. It serves both to drain surface water and water pumped out of mining operations as well as a means of rinsing and separating mined ore and powering the mining machinery utilized in the deep shafts. Primarily silver, tin and iron were mined here. Due to its generally high elevation, the area is divided among cold and very cold climate zones, in which long-term average annual temperatures range from 3 to 5 °C. Climate is relatively wet and snow is regular almost three months.

The case study area is home to a number of protected areas, the most significant of which is the Božídarské rašeliniště National Nature Preserve (nearly 930 ha), where the thickest layers of peat measure up to 3.8 metres. Due to its relatively high elevation, high relative humidity and frequent strong winds, this national nature preserve has a very harsh climate and is home to specimens of Scandinavian flora. Other significant natural sites include the Rýžovna nature preserve (20 ha), a mountain ridge composed of volcanic rocks with typical basalt jointing and Oceán nature preserve (42 ha), a preserved mountain peat bog.

3. Social and economic conditions

The oldest written record concerning Abertamy comes from 1529. In 1579, Abertamy was designated a royal mining town, due to the silver and tin ore found in the area. Evidently in 1545, two underground mines were established. The settlement of Hřebečná was founded at these mines. The main period of mining in Hřebečná was during the second half of the sixteenth century, at which time this mining district was, in terms of the volume of tin ore (Cassiterite) production, the most significant in the Krušné hory Mountains (probably 3,000 to 3,500 tons). In 1589, it was said that the Abertamy ore vein produced about 25 tons of silver. The greater part of this extracted metal was

Case Study Areas Abertamy, Hřebečná: Change of Land Use Patterns 1842–2007

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Fig. 1 – Case study area Abertamy, Hřebečná
Source of map: ArcČR 500
apparently used to make the famous Jáchymov tolers, the most valuable silver coins of the late middle ages.

With the beginning of the seventeenth century, silver mining began to decline in importance. More significant finds in nearby Jáchymov had been, during the sixteenth century, the primary producer of silver ore within the Czech Lands, taking the place of previously dominant Kutná Hora. During the Thirty Years’ War, however, mining in the area lost much of its former importance. Only mining for tin ore continued, because tin was used in making kitchen and mass ornaments and vessels. The eighteenth century saw a short renewal of interest in mining, which continued on occasion under the direction of various owners until the end of the nineteenth century. From 1756 to 1856, only about 0.5 ton of silver was mined, along with small amounts of lead (1.4 tons), cobalt (6.2 tons) and bismuth ores.

The poverty of the area’s residents and the harsh climatic conditions, particularly in winter, have led to a rather high frequency of goat husbandry. In 1850, a factory was established in Abertamy to produce gloves from goat leather. These gloves were exported to locations throughout the world. The gloves were expanded upon this tradition, creating a state-run enterprise out of several previously small, family firms with German owners. As a result of the transformation and foreign competition, this factory was closed down after 1990.

The problem preventing increased mining activities and production was the limited depth, to which miners could reach, due to problems concerning the removal of water from the tunnels. While mining silver, miners encountered a black, shiny rock (uraninite), the occurrence of which signified the end of a silver vein. It was not until Marie Skłodowska Curie’s research, at the beginning of the twentieth century, that a number of rare elements were discovered in the Jáchymov uraninite. The importance of Hřebečná and Abertamy, therefore, gradually decreased and they were entirely abandoned after uranium began to be mined in the Jáchymov area in 1945. The study area became part of a strictly controlled zone. Most of the mining structures in Hřebečná were destroyed. And so, because of uranium, mining activities, for the third time, brought renewed interest in the case study area and in the greater Jáchymov region. The renewed mining of ore left its mark on the entire area, including Abertamy and Hřebečná. New mines were opened, new settlements and homes for miners and for prison guards were established around. A significant portion of the mining work was performed by labour camps, consisting primarily of political prisoners of the communist regime. Practically all of the uranium ore was exported to the USSR for further use. Less than 20 years of mining, after World War II, were enough to transform the ground under Abertamy into a labyrinth of tunnels. From 1946 to 1965, in their quest for uranium for the Soviet Union, miners dug more than 53 kilometres of tunnels, shafts and chimneys, within the cadastral unit of Abertamy alone. An additional 17 kilometres of mine tunnels are hidden to the east of the municipality. The Abertamy deposit was, at that time, one of the richest in Czechoslovakia.

The case study area is, therefore, an area of recent colonization, primarily due to the recovery of metal ores (silver, tin, iron, etc.). The miners that settled the area, the majority of which came from Saxony, were very dependent on supplying their own food. Consequently, settling the area introduced long-term
pressure on the surrounding forests, which after being cleared – primarily for mining purposes – provided land for cultivating basic food products or, in other cases, served as pasture for raising livestock, especially goats and sheep. The wood was, naturally, used in the construction of homes and stables, for heating and other purposes. The area had 3,310 inhabitants in 1869 (see Table 1). By the beginning of the twentieth century, this number had increased to 4,293 inhabitants, most of which claimed German nationality. In 1938, the area was annexed by the German Reich. With the annulment of the Munich Agreement, the territory was returned to Czechoslovakia and it was decided that the German residents would be removed from the area. During 1945 and 1946, approximately three million Germans were displaced from Czechoslovakia. Of the 1,158 people living in Hřebečná at that time, 905 (78%) were displaced. The neighbouring settlement Rýžovna ceased to exist completely (see Figure 6). Due to insufficient, subsequent resettlement of the area with Czech immigrants, from the country’s internal regions and, in part, from foreign countries, there was a significant decline in the number of permanent inhabitants living in the case study area (only 2,261 in 1950). Another reason behind this change was the gradual decline in economic activities in the borderland, including agricultural activities. Remaining inhabitants of the area often relocated to make a better life in the more developed internal regions of the country, particularly in industrial cities.

During the period of rapid expansion of uranium mining after 1950, approximately 2,261 inhabitants lived there, in addition to several thousand prisoners. The closing of the mines and their subsequent destruction devastated the local landscape. The number of inhabitants continued to fall and, in 2001, only 1,197 inhabitants lived in the area.

In 2001 (the most recently taken population census), nearly half of all the economically active individuals commuted to workplaces outside the case study area. It is safe to assume that the increasing role of recreational activities, during the past decade, shall at least partially compensate for lost jobs in industry. In light of local natural conditions, recreational activities present solid opportunities for further development. Winter recreation, in particular, has become a rather prosperous sector of the local economy, followed by a slightly less significant summer tourist season.

The significance of recreational activities in this area is evident in the fact that a 2005 special housing census recorded 132 cottages (originally rural houses) and cabins (newly constructed recreational structures) and 262 houses for permanent living. The decline in permanent inhabitants resulted in a portion of the buildings being remodelled for the owners’ families use or to become tourist lodging places (see Table 2). A number of guest houses have been constructed in recent years.

4. Long-term changes in land use

In the past, agriculture played an important role in the utilization of the local land, even though the conditions for farming were not favourable at all. However, agriculture was an important and irreplaceable activity for the survival of the population; agricultural land covered 60% of the monitored land and arable land 16% of the area. From the Figure 3 depicting land structure in the years 1842–2007, significant changes can be observed in the use of land of Albertamy and Hřebečná. The most important trend is the decrease in the area of agricultural land and total disappearance of arable land. In the first half of the 19th century, arable land was mainly utilised through the three-field system. The soil was not very fertile and fertilizers scarce, so part of the land was always left fallow, which slowly restored the fertility of the soil within a few years. However, in the light of socio-economic changes, this region’s arable land could not compete with more fertile lands from regions situated in lower altitudes. On the other hand, the area of permanent cultures increased. It originally fulfilled the role of subsistence of certain foods, nowadays these areas are mostly green areas in the gardens of family

![Table 1 – Number of inhabitants in the case study area from 1869 to 2001](source: Růžková, Škrabal, 2006)

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<td>1,108</td>
<td>1,224</td>
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Source: Růžková, Škrabal, 2006

![Table 2 – Number of permanently inhabited houses in the case study area from 1869 to 2001](source: Růžková, Škrabal, 2006)

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Source: Růžková, Škrabal, 2006

![Fig. 3 – Land use structure of the case study area](source: Czech Office for Surveying, Mapping and Cadastre, authors field survey (2007))
Fig. 4 – Land use in the case study area in the years 1842 and 2007
Source: Czech Office for Surveying, Mapping and Cadastre; authors field survey (2007)
houses, often with a maintained lawn and decorative bushes. Under the category of agricultural land, permanent grassland experienced an expansion. It increased by almost 60%, mostly at the expense of the gradually abandoned arable land (see Figure 4 and also Figure 5). Least hospitable patches of agricultural land eventually turned into forests, which increased their size by more than 100 ha.

This happened either by planned forestation or by spontaneous displacement of the forest into free agricultural landscape. The displacement of Czech Germans in 1945 also had a big impact on the fall in intensity of land use. The overview of land use structure in years 1842–2007 is shown in the Table 3.

The local landscape kept the picturesque look of highlands with a mosaic of woodland and grassland, which has a positive influence on the development of tourism both in the summer and winter periods. Tourism is becoming one of the most important sources of income for the local population and attractive landscape in the clean environment slowly acquires a non-productive function of providing leisure for its visitors.

5. Perspectives, problems and risks of future development

Peneplains of the top in the Krušné hory Mountains represent a relatively specific area. This is mainly because it is an area situated in high altitudes with rough natural conditions and its so called big and outer medieval colonisation by settlers invited from Germany (Annaberg) was connected to two waves of silver and tin extraction.

In the middle of the last century, the local area was deeply affected by the boom in the extraction of uranium, a situation similar to the whole region of Jáchymov and the deposits in the adjacent Saxony (East Germany). The landscape was strongly

<table>
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<th>∑ = 857.52 ha</th>
<th>Arable land</th>
<th>Permanent cultures</th>
<th>Permanent grassland</th>
<th>Forest areas</th>
<th>Water areas</th>
<th>Built-up areas</th>
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<tr>
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<td>211.46</td>
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<td>3.42</td>
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<td>0.02</td>
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<td>2.16</td>
</tr>
<tr>
<td>Built-up areas</td>
<td>0.00</td>
<td>0.86</td>
<td>1.53</td>
<td>0.26</td>
<td>0.02</td>
<td>1.50</td>
<td>0.54</td>
<td>4.71</td>
</tr>
<tr>
<td>Remaining areas</td>
<td>0.00</td>
<td>1.90</td>
<td>14.54</td>
<td>5.67</td>
<td>0.33</td>
<td>0.39</td>
<td>7.46</td>
<td>22.44</td>
</tr>
<tr>
<td>Total</td>
<td>0.00</td>
<td>26.40</td>
<td>325.12</td>
<td>241.26</td>
<td>6.17</td>
<td>7.43</td>
<td>30.57</td>
<td>519.69</td>
</tr>
</tbody>
</table>

Note: Changes of land use (in hectares) from categories in rows to categories in columns. Example: 284.02 hectares of arable land (1842) has been transferred to permanent grassland in 2007.

Total area (in ha) of observed locality(-ies) in 1942 and 2007.

From the size in 1842 in the same category “survived” till 2007.

Total amount of hectares newly in arable land (etc.) in 2007 from categories in rows.

Source: Czech Office for Surveying, Mapping and Cadastre; authors field survey (2007)
affected by the mining (pings, mining spoils, quarries, remnants of buildings, drainage canals etc.).

As a result of the colonisation, the forests around the settlements were cut down and the freed land was partly used for subsistence agriculture. The displacement of Czech Germans in years 1946–47 and the extraction of uranium in the following two decades led to a further devastation of the land. The extreme impacts of human activity created a relatively strongly damaged environment.

Uranium mines and other mines were mostly closed in the 1960s, so the overall state of the landscape was able to improve by gradual regeneration and renewal. Grassland and spontaneously spreading forests slowly returned to the former agricultural land. Thanks to a sharp reduction of the pollution both on the German and Czech sides after 1990 (desulphurization of coal power plants, filtering of the emissions from factories of heavy chemistry located on both sides of the border in centres below mountains) the region slowly regained its natural character. This turn of events enabled the new development of recreational, environmental and water-management functions (see Figures 7, 8). In the future we can count on a further increase of forest areas at the expense of unused permanent grassland. An increase in the size of built-up and remaining areas, connected to the potential development of recreational functions and tourism in the heavily populated foothills both on the German side (Saxony) and the Czech side (the mining and industrial region at the Krušné hory foothills) should also be expected. A certain advantage is the very low density of population, so in comparison with the other regions in Krušné hory / Erzgebirge (especially on the German side), where bigger towns with better infrastructure can be found, we can expect a further development of tourism connected with nordic skiing, trekking and cycling in this model area. In light of the presented evidence, we can classify the function of the area around Abertamy as a recreational and residential function, without significant risks.}

Fig. 7 – This landscape was used for intensive mining for four centuries in the past, which caused deforestation. Recreational and residential functions are most important nowadays. Photo by I. Bičík.

Fig. 8 – Jáchymov is located at the foot of Klínovec (1,244 m a.s.l.) which is the highest point of Krušné hory Mountains. In the Middle Ages silver, tin and other valuable raw materials were mined in Jáchymov. This is why higher parts of the slopes around the town were subject to deforestation. Currently, these deforested areas form a significant natural potential for recreational use. Leisure time activities prevail at the moment, being complemented by traditional residential and productional functions. There are spa establishments in the town using radioactive water. Photo by I. Bičík.
1. Geographical situation

The municipal area of Rudná stretches over 820 hectares. Rudná as an administrative unit came into existence in 1951 when two previously independent municipalities, Dušníky and Hořelice, merged. Historically, Hořelice was first mentioned in 1051, while Dušníky only in the 13th century. The current name of the municipality reflects the iron ore deposits found in the vicinity (ruda = ore).

In our research which is focused on different types of landscape utilization Rudná represents a suburban locality, strongly affected by suburban processes. The municipality is situated on the doorstep of Prague, being part of the Central Bohemian urban agglomeration (see Figure 1). The centre of capital is just 15 kilometres away. Consequently, there has been a lot of development over the past years and this process is likely to continue.

Rudná is very well accessible since the D5 motorway (connecting Prague with Southern Germany / Bavaria) skirts the northern part of the town. Thus, commuting from Rudná to Prague is just a matter of minutes. The local road No. 605, which had originally served as the main road connecting Prague and Pilsen, cuts through the municipality in a southwest-northeast direction. Currently, this road carries a lot of traffic including public buses. The geographical situation of Rudná, being generally a favourable one (close to the capital, good transport links), however, also brings several negative effects: heavy truck traffic is an example. Since the time when the motorway was opened, suburban processes have accelerated. This involves a lot of construction – mostly new family houses, but also giant warehouses that are situated in the southwestern part of the cadastre unit (see Figures 2, 3, 6).

The land around Rudná has high quality soils – that is why in the past farming was important here. Houses used to be surrounded by acres of fields and most locals worked as farmers. Because of the close vicinity of the capital, agricultural surpluses were sold on the lucrative Prague market. The discovery of iron ore in the neighbouring village Nučice and the coal mining boom in Kladno (15 kilometres far) in mid-19th century brought significant changes. The limestone quarry in nearby Tachlovice began to operate in the same time. Limestone was used for melting of iron ore and also for construction. In order to secure transportation of all this material, a new railway, called Kladensko-nučická dráha, was built. Iron ore and limestone were transported into the furnaces in Kladno. Since the mid-19th century up until the 1950s, people were typically employed in mining in combination with a small-scale agricultural production grown on leased land. In the course of the last few decades, the influence of Prague has prevailed totally and Rudná became a typical suburban locality.

2. Natural environment

Rudná lies 380 metres above sea level on an elevated treeless plateau called Pražská plošina (Prague Plateau). The area around Rudná is largely flat. The Plateau has an undulating and hilly relief rising up to the 435 m a.s.l. The case study area has an average yearly temperature of around 8 °C; thus, the climate can be denoted as warm to mild. Average precipitation amounts to about 500 mm per year. Among the most common soil types are black and brown soils, and cambisols. Black and brown soils are very fertile and well suited for growing sugar beet, maize, wheat, barley, etc.

The Radotínský potok brook, which is a left tributary to the Berounka River, cuts across the municipality. Hence the entire area is part of the Berounka (Vltava) catchment. The area has a high share of arable land and virtually no forests.

3. Social and economic conditions

The population density of the Praha-západ District equals about 210 inhabitants per sqkm (2010), i.e. it is roughly 50% higher than the average population density of Czechia. The corresponding figure for the Rudná municipal area is 536 inhabitants per sqkm. Since the first census in 1869 the population has risen, with some fluctuations, from 1,014 inhabitants up to 4,494 (2010), see Table 1. Recently, suburbanization became more intensive and especially new family houses mushroomed almost everywhere. Rudná became attractive first of all for young families (adults...
aged typically between 30 and 40 years) with children, who sought housing in a better environment but still in the vicinity of Prague. This process has completely changed the size and structure of the local population. A rapid population growth had started in the last years of the 20th century and accelerated after 2000. In that time the local population began to rise in a natural way (due to a high birth rate) and also due to immigration. Changes in the population structure are also apparent when one compares the amount of young people aged 0–14 years (794) and the number of elderly people over 65 (569). The population age index equals 1.3. Population increase logically also brought a significant increase in the amount of houses. A housing boom began already in the 19th century and accelerated after WWII, when the predominantly agricultural function of the municipality has been transformed into an agricultural-residential one, with many people commuting daily to Prague or Kladno. In 1950 there were just 729 houses, whereas nowadays almost 1,100 (see Table 1).

The ongoing suburbanisation also triggered an extensive construction of warehouses. Advantageous location, cheap land, and a “relaxed” protection of the land after 1990 are to be considered the most relevant factors in this development. Currently, Rudná has a strong residential-service function; agriculture is no more important. Many residents commute on a day-to-day basis especially to Prague: according to the 2001 census 79% of all commuters in Rudná, i.e. 768 people, had a job in Prague. Moreover, further 220 residents regularly travel outside Rudná to attend high schools or universities. On the other hand, the construction of warehouses and service centres in 1990s brought new jobs into the municipality – as a result many people now commute also vice versa, i.e. to Rudná. According to the census, in 2001 there were more than 2,000 such persons. This rather intensive two-way work-related traffic documents a new function within the Prague / Central Bohemian urban agglomeration: many local residents, mostly middle- and upper-middle class people, have well-paid jobs in Prague, whereas commuters from Prague (169 in 2010), Beroun (220), Kladno (136), and nearby villages can find jobs in trade, industry, transportation, and telecommunication companies located near the motorway.

Fig. 2 – Contemporary aerial photograph of the case study area
Source: http://geoportal.gov.cz

Fig. 3 – As Rudná is located very close to Prague, many new warehouses and service centers were established here. There has been a lot of development in the whole territory since 2000. Photo by J. Příšek.
4. Long-term land use changes

Figures 4, 5 and Table 2 show the intensity of land use / landscape changes during the analyzed period. Intensive land use changes have been recorded in Rudná. Originally it had been primarily an agricultural area, but later favourable geographical location and extraction of raw materials transformed part of the arable land into built-up and remaining areas. In the past arable land was fragmented into great many small plots whereas at present rather large fields are typical. This radical change was caused by collectivization in the 1950s; in the same time a big cooperative farm was established here. Though after 1990 many original owners had reclaimed the land stolen by the Communists, only few (re)started farming – much of this private land was leased to big agricultural companies. Fields in the immediate vicinity of the village are under a strong pressure of developers who look for places suitable for new housing projects.

From the environmental standpoint the current state is worse than previously – large fields (some exceeding 100 hectares) are prone to erosion, biodiversity has been reduced significantly. Due to poor and vaguely enforced regulations, part of the high quality land with good soils had been built over and large residential areas and commercial developments originated. In 1840 arable land covered some 90% of the municipal area; at present it still dominates, but the share shrank to just 50%.

The early phase of suburbanization after 1990 was boosted by favourable geographical location near the major highway connecting Prague with Pilsen and Germany. As residential housing as well as commercial development was experiencing a real boom, land use structure began to change rapidly. At the moment, built-up land covers more than 5% of the municipal area (in 1840 it was just 0.3%). The so called remaining areas – in this very case mostly roads and plots with solid surface like parking lots – account for 14%. The boom of residential housing also caused an important increase in permanent cultures, mostly gardens (from 1.2% to 17%).

Forests keep to play just a minor role. Only a few patches of poor agricultural land were afforested. Though meadows and pastures also increased in size (from 4.7% to 9.1%), their importance also remains low. Meadows and pastures, however, are no longer found along water streams where they functioned as an anti-erosion elements, but rather tend to concentrate close to the houses having more of an aesthetic function. Such a change has negative effects on the landscape stability. Wetlands along the creeks have been drained and often turned into arable land. This artificial drainage combined with a rapid spread of solid surfaces in the course of the past two decades makes the water discharge much faster.

Two contradictory processes can be observed as regards landscape changes in Rudná over the past 60 years. To a large extent, different approaches towards land protection under different regimes are responsible for that. The agrarian policy under communism encouraged self-sufficiency, i.e. arable land was highly valued. As a result, wet meadows and pastures were

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**Table 1 – Number of inhabitants and permanently inhabited houses in the case study area from 1869 to 2001**

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</tr>
</thead>
<tbody>
<tr>
<td>Inhabitants</td>
<td>1,014</td>
<td>1,175</td>
<td>1,497</td>
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<td>2,837</td>
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<td>2,974</td>
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<td>Houses</td>
<td>123</td>
<td>141</td>
<td>156</td>
<td>221</td>
<td>321</td>
<td>385</td>
<td>558</td>
<td>729</td>
<td>757</td>
<td>786</td>
<td>816</td>
<td>895</td>
<td>1,052</td>
</tr>
</tbody>
</table>

Source: Růžková, Škrabal, 2006

**Table 2 – Land use changes 1840–2005 (ha)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Total (ha)</th>
<th>Arable land</th>
<th>Permanent cultures</th>
<th>Permanent grassland</th>
<th>Forest areas</th>
<th>Water areas</th>
<th>Built-up areas</th>
<th>Remaining areas</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total 1840-2005</td>
<td>952.48</td>
<td>484.23</td>
<td>136.89</td>
<td>79.16</td>
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<td>0.94</td>
<td>41.76</td>
<td>106.03</td>
<td>372.04</td>
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<td>Arable land</td>
<td>484.23</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td>Permanent cultures</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent grassland</td>
<td>79.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest areas</td>
<td>7.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water areas</td>
<td>0.94</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Built-up areas</td>
<td>41.76</td>
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<td></td>
<td></td>
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<tr>
<td>Remaining areas</td>
<td>106.03</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Changes of land use (in hectares) from categories in rows to categories in columns. Example: 79.16 hectares of arable land (1840) has been transferred to permanent grassland in 2005.

Source: Czech Office for Surveying, Mapping and Cadastre, authors field survey (2005)
Fig. 5 – Land use in the case study area in the years 1840 and 2005.
Source: Czech Office for Surveying, Mapping and Cadastre; authors field survey (Jan Jelének and Přemysl Štych, 2005).
often drained (also in the case study area) in order to be later converted into arable land. Consequently, many anti-erosion elements in the landscape that had helped to prevent floods ceased to exist. The strict protection of arable land, however, was eased after 1990, and large expanses of high quality arable land were taken by developers just within months. Ironically, meadows and pastures with important ecological functions had been drained first and replaced by low quality arable land – just a few years later, however, large quantities of high quality arable land disappeared to make place for housing, warehouses, and new transportation lines.

5. Perspectives, problems and risks of future development

Rudná as a part of the Central Bohemian urban agglomeration has undergone fundamental changes over the past 20–50 years. The municipality is likely to be influenced by a favourable geographical location, just on the doorstep of Prague, also in the near future. At the moment there are residential areas as well as services and some industry; important transportation lines criss-cross the area. Rudná is part of Středočeský kraj (Central Bohemian Region), i.e. the municipality is eligible for European Union funds (GDP per capita in Central Bohemia is still below 75% of the EU average). This fact may further accelerate the pressure on agricultural land which may become an easy prey for developers, let it be housing, industry, warehouses, or transportation lines. The D5 motorway links Prague and Central Bohemia with Germany, which is the most important Czech trade partner. Consequently it is likely that within 10–15 years some agricultural land will be converted into non-agricultural use; these changes, however, will probably be dictated from the national level rather than by local authorities (see Figure 7).

Much of the agricultural land around Rudná is of high quality and for this reason non-agricultural activities should primarily take place in areas with the least quality soils. As most of the land is under the plough now and there is a lack of environmentally valuable areas (forests, meadows, pastures, water bodies), the latter should be increased, possibly to the detriment of the worst agricultural land. In practical terms, however, it is likely that the pressure of property developers will remain high which may rather result in an increase of built-up land and remaining areas. Whether this will happen or not will largely be in the hands of municipal authorities. ■

Fig. 6 – Residential suburbanization (in addition to the commercial one represented by warehouses) caused considerable loss of agricultural and arable land especially during last twenty years. Photo by J. Píštěk.

Fig. 7 – Solar power plants, built during the last four years, have led to significant land use changes in many Czech municipalities. Photo by J. Píštěk.
1. Geographical situation

The researched recreational area comprises three settlements Živohošť, Křeničná and Blažim and is part of a rather distinctly formed natural region of Střední Povltaví (see Figure 1). The Střední Povltaví area can be delimited to the deep cutting valley of the Vltava River from Týn nad Vltavou to the confluence of the Vltava and Sázava Rivers. The studied region is located in southern part of the Central Bohemian (Středočeský) region on the border between Benešov (20 km distance) and Příbram (25 km) districts. Metropolitan center Prague is to the north, at the distance of ca. 60 km. This region has only one regional highway (II/114) and many local ways.

The reason for the selection of the area was the desire to delineate a region characteristic of the Vltava Valley, which is primarily associated with the sphere of recreation, and also to analytically separate local changes in land use from the immediate influence of neighbouring urban centres. Nevertheless, these cities, dominated by Prague, presently strongly determine the main, and still growing, recreational function of the area, characterised by a large share of housing objects dedicated to this function, cottages and lodges and their facilities.

2. Natural environment

The Střední Povltaví area lies within both Central Bohemian and Southern Bohemian regions and is part of the morphological complex of České středohoří highlands. The relief is divided by the deep-cutting Vltava Valley with lateral valleys of tributary streams, which flow into the river through narrow gorges from surrounding high grounds with 450–600 m a.s.l. on average. In the winter period, the bottom of the Vltava valley and the surrounding banks are sometimes affected by temperature inversion.

Granite and granodiorite are the most common rock types to be found here. In some places, the 100–150 m a.s.l. deep Vltava Valley turns into reservoir lakes, the width of which varies between 300–1,000 meters, and their depth occasionally exceeds 50 m. Average temperature is 7–8 °C and the amount of precipitation ca. 500 mm/year.

Mainly because of the high segmentation of the terrain, less fertile, shallow and rocky soils are the norm here, but some places at around 300–400 m a.s.l. offer rather fertile brown soils. In its natural state, the Střední Povltaví area had been widely forested, before a gradual agricultural colonisation started in the 13th century. At that time, the Vltava River served as a key transport route for fuel and construction wood. This eventually led to a deforestation of the landscape and its transformation into agricultural land. With the use of rafts, wood was transported to Prague, to the mining sites near Příbram, or to the surrounding area for general constructions. Continuous forest remained only on steeper slopes and hilltops. Together with fluctuating water levels on the Vltava, the segmented relief with a significant share of forest areas divided into smaller units lead to a considerable natural diversity of the analysed area. The valley of Vltava and those of some of its tributaries are significant bio-corridors of regional and supra-regional significance.

3. Social and economic conditions

The origin of human settlement in the Střední Povltaví area goes back to pre-historic times. The Celts, who settled here later, were the first to wash gold here. In the 16th century gold mining and subsequent population influx reached their peak. The Thirty Years’ War and a following 1713 plague epidemic had significant adverse effects on the population. Economically, the region has long relied on subsistence three-field system agriculture on mostly shallow and in some places rocky soils and cattle herding. Agriculture combined with forest utilisation was supplemented by small handicraft production. General industrialisation on Bohemia in the 19th century had little effect on this area. It was impeded by lack of resources, fuel and regional level communications, construction of which would have been too costly. The area retained a clearly peripheral character all the way to WWII. Emigration to industrial centres (Prague, Příbram) caused a depopulation of the area and an aging of the remaining population. From the perspective of socio-economic activity, this area is categorised as ‘Inner Periphery’.

Between years 1942–1945, almost the entire population of the right bank of this microregion (Střední Povltaví) was evicted and the space was used to create an SS training ground with several small sized concentration camps. The end of the war then saw this area completely depopulated and rather desolate. This situation, however, enabled the emergence of recreational housing.
Recreation was not an entirely new concept here, small cottage settlement had been appearing even prior to the war.

Like the rest of the country, the Vltava valley and surrounding areas were also included in the forced collectivisation of small family farms in the 1950s. Several collective farms, with mediocre economic results, emerged in their stead. In years 1955–1970, these large farms managed to stabilise the population working in the agricultural sector. After 1970s the affiliation of farmer families with the soil which became part of the collective had diminished, which further enhanced the process of emigration. Formerly dominant functions of agriculture and forestry gradually gave way to more varied forms of land use, mostly those developing the area’s potential for recreation. The potential was utilised both by the owners of individual recreational facilities and by visitors enjoying public recreational services (campsites, mass lodges). After the important water constructions had been completed in the first half of the 1950s, low population density and good accessibility from Prague made this area a popular choice for the mass construction of cottages. These were mostly situated outside the traditional settlements, often in naturally precious locations, usually by small water streams or newly emerged reservoirs (see Figure 2).

Currently, agricultural cultivation is heavily influenced by the property restitution process, ongoing since 1990, which seeks to return land and property to original owners or their descendants. Only few of the new owners started to utilise the land themselves, usually they rent the arable land to farming companies or independent farmers. Simultaneously, some land and property has been sold to new, enthusiastic owners, which has led to visible revitalisation in some settlements. Newly introduced ‘bio’ technologies, along with frequent landscape revitalisation programs coming from the government, have moved the local agricultural productive function more towards the newly supported environmental function. Střední Povltaví is and has been a place lacking jobs. Industrial factories appeared in the vicinity after 1945 (Sedlčanské strojírny machine works, Povltavská mlékarna dairy, ore refinery in Příbram and so on), but this also usually caused migration to these close centres. So the Střední Povltaví area continued to lose population and it currently still suffers from depopulation. Lack of jobs and tendency towards depopulation have, however, made positive contributions towards limiting environmental degradation, so the area could retain its character of clean, charming and attractive environment.

If we take a look at the development of population and housing in the selected municipalities Živohošť, Blažim and Křeničná, we can readily observe a significant decline of population and permanent residences after WWII (see Tables 1, 2). A radical decline in permanent residences after 1961 is mostly due to their being sold for recreational purposes. The amount of houses, which found themselves on the floodplains of the Slapy water reservoir (where Živohošť lies) was certainly much smaller than of those that were sold for other functional purposes. The 2001 census, which was rather thorough even in its findings on recreational objects, gives us the following statistics on Živohošť (only): 67 inhabited flats in family houses, ca. 25 flats were used only occasionally for recreational purposes. On top of that, there were some hundreds cottages, used usually only in the summer season. It is quite clear that the recreational function

Fig. 2 – Contemporary aerial photograph of the case study area. Stará and Nová Živohošť are located on both sides of Slapy reservoir on Vltava river (right bottom is Mastník stream) Source: http://geoportal.gov.cz
dominates over both residential and agricultural functions. The official statistics on the permanent residence are therefore only partially representative of the settlement and population in this area. Because of such a high proportion of recreational housing, the total present population on summer weekends is conceivably several times bigger. According to Fialová (2001) the average number of beds in a single recreational property is 5. If we take into consideration all individual recreation housing facilities (recorded in 2001), hotel and pension capacity and a realistic estimate of one-day visitors (who do not require a place to sleep), the actual number of residents can reach 2,000 persons during the summer season.

4. Long-term changes in land use

When looking at the localization of landscape changes that have taken place in this model area, we can state that the most intensive ones occurred on the banks of the reservoir and in its close vicinity (Živohošť and Křeničná cadastre units) – see Figure 4. The changes have resulted from a modified function that was “allotted” to the area by general social needs. This is primarily a change of the former agricultural and forestry function into a recreational function whose importance was gradually growing, having acquired a strong dominance at present. However, due to the unfavorable character of the surface (a rocky riverbank), the area of the cadastre unit Blažim has essentially maintained its traditional agricultural and residential function.

The analyzed model region has a relatively high proportion of stable areas, which means those whose categories of use did not change in the course of the period under observation (see Table 3). In the cadastre unit Blažim, this even relates to roughly 73% of the area. The main reason is non-existence of flat flood plains at the Vltava’s banks in the case of this cadastre unit and a fairly big distance from the river. As a result, no major transfer of arable land and meadows and pastures to recreational areas (gardens, built-up and remaining areas) has occurred in Blažim, unlike the cadastre units of Živohošť and Křeničná. Due to this, the landscape in the cadastre unit has more or less retained its original character and a concentric structure of land use around the village (fields are situated closest to the village, while woodland is mainly preserved at the fringes of the cadastre unit). The most visible change in the cadastre unit Blažim is a decline in the area of meadows and pastures and arable land to the benefit of forest areas. Unlike other parts of the model area, in the Blažim cadastre unit there is hardly any expansion of built-up areas on account of the peripheral character of the region and little, if any, attractiveness for recreational use. This is mainly due to the big distance from the river and poor access to comfortable swimming caused by the rocky bank of the swollen Vltava River. After the Slapy Water Reservoir was filled with water, a significant increase in water area occurred in the region to the detriment of arable land and meadows and pastures (at present, water areas account for over 11% of the total area). The lake inundated about 60 ha of the original area of the Živohošť cadastre unit, giving an impetus to a rapid construction of recreational infrastructure and “second housing” facilities (cottages). As no big settlement has ever been situated in the model area, the growth in the built-up areas, gardens and remaining areas was only concentrated along the banks of the artificial lake. Thanks to this, the character of the rest of the area has remained all but unchanged. Woodland still maintains its considerable extent, making up roughly one half of the examined area.

As already mentioned, there was a significant decline in arable land and meadows and pastures. The former decreased its proportion in the total area from the original 35% down to 26% by 2001 and the latter from 8% down to 3% (see Figure 3). On the whole area under observation, there was a transformation of

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### Table 1 – Number of inhabitants in the case study area from 1869 to 2001

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<td>128</td>
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</table>

Source: Růžková, Škrabal, 2006

### Table 2 – Number of permanently inhabited houses in the case study area from 1869 to 2001

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</tbody>
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Source: Růžková, Škrabal, 2006
34

Fig. 4 – Land use in the case study area in the years 1840 and 2005
Source: Czech Office for Surveying, Mapping and Cadastre; authors field survey (2005)
landscape microstructure of agricultural land (mosaic character of landscape). Due to the socialization of agriculture, accompanied with consolidation of arable land and elimination of other elements stabilizing the environmental function, vast tracts of agricultural land were created. Besides, local landscape suffers from another negative aspect: the loss of “landscape memory”. Due to the rise of the surface of the Vltava River, the inhabitants living close to the river were forced to move out. Before the reservoir was filled with water, tens of buildings were destroyed and the landscape that was being shaped for centuries was inundated (see Figure 5). This caused a considerable modification of the natural character and emigration of a large part of local inhabitants, who had roots in the local landscape and a strong emotional attachment to it. Only contemporaries remember the picturesque character of the Vltava’s original valley that used to attract water sportsmen and inspired many prominent artists.

5. Perspectives, problems and risks of future development

In the first place, it must be suggested that the massive investment in the form of the construction of the Slapy Water Reservoir influenced the development of land structure in the flood area of the water reservoir. Its length of almost 40 km and, in places, width of around 1 km changed the former agricultural and forestry function of the area under observation into the present-day, strongly multifunctional character with an emphasis on recreational, agricultural and residential use of the landscape. The overall trends of changes in land use in the microregion are only slightly more significant than those typical of the whole of Czechia. The general trends correspond with a decline in arable land and meadows and pastures along with a gradual expansion of forest areas. There is some bipolarity in the region as the area alongside the lake is intensively used in the summer when the inflow of visitors culminates, while remote localities and steep banks have retained their traditional nature, reflecting the character of peripheral areas.

As far as the development of land use structure of Střední Povltaví until 2020 is concerned, given the current overall trends one can assume a further reduction of the extent of arable land (and the extent of agricultural land in general), especially in the regions with its lower quality (this also relates to the model area). Hence the assumption that if present-day functions of the analyzed area are preserved, recreational functions can further expand. This is coupled with a major risk, especially in the relatively narrow belt of a non-rocky lake shore of the Slapy Water Reservoir. A further burden of the area caused by an increasing number of users may significantly endanger the quality of recreational functions. As a result, the future of the recreational use of the area should not lie in the expansion of recreational area, but, rather, in an increase in the residential function and improvement in the quality of recreational infrastructure. If the Slapy Water Reservoir is hypothetically used for treatment of drinking water, it is obvious that recreational activities on its banks will have to be substantially reduced, while land use structure will be subsequently altered to the benefit of grassland and woodland. From this viewpoint, the alternative of the use of these water resources to provide water for Prague in the future seems to be rather unlikely due to the large-scale and still expanding recreational function of the area.
1. Geographical situation

The case study area of Slovácké Kopanice is composed of three settlements Hrubá Vrbka, Malá Vrbka and Kuželov; it is situated in the district of Hodonín in the South Moravian Region, in close proximity to the border between Czechia and Slovakia (see Figure 1). It is clear that the position of this case study area is highly peripheral; it is, however, a place with very old traditions and customs, where connections with the Slovaks living on the other side of the border have always been intensive. The area covers approximately 2,800 hectares. Hrubá Vrbka (1,318 hectares), which lies close to Kuželov, is the biggest municipality here. Kuželov extends over 1,020 hectares and features mostly rolling, intensively cultivated landscapes. Malá Vrbka is the smallest settlement within the case study area with 444 hectares.

All three municipalities have a history that spans 600 years since the first written reference. Hrubá Vrbka is the oldest one, mentioned already in 1384; Malá Vrbka was reportedly founded in 1401, and Kuželov in 1406. The eastern limits of Hrubá Vrbka and Kuželov also constitute the border between Czechia and Slovakia. The area is considered a remote periphery, due in part to the fact that no significant traffic routes pass through it. Only one local road runs through the area and ends at Malá Vrbka. The hilly area beyond is only accessible using unpaved tracks and forest paths. Communication lines of higher rank are found in Velká nad Velickou (seat of municipal office; crow flight distance some 8 km, but about 20 kilometres on the road due to hilly terrain). A second class road passes through as well as the railway line which connects eastern Moravia (Veselí nad Moravou) with western Slovakia (Nové Mesto nad Váhom) across the border. Hodonín, seat of district authorities, is located 26 kilometres away (crow flight), or 34 kilometres by road. Somewhat closer lies the administrative centre of the neighbouring district, Uherské Hradiště. This town should be considered a regional centre of the wider region – Moravské Slovácko. The distance between Uherské Hradiště and Brno, the regional capital, is 75 kilometres (crow flight), or ca. 90 kilometres by the fastest road route.

2. Natural environment

The altitude of the analysed area varies between 250 and 583 metres a.s.l. The lowest and highest points are both part of the Hrubá Vrbka municipality. Larger expanses of forests are situated to the east, along the border with Slovakia. The border ridge is also the highest one (583 m). In the northern part of the Hrubá Vrbka cadastre unit, the lowest point within the area is found; this part is also relatively densely built-up. Slopes are generally gentle with gradients usually less than 9°; only the southern slopes near the border reach up to 20°.

The geological bedrock of the analysed area is mostly composed of Cenozoic rocks, formed during the Alpine orogeny, usually sandstones and schist, and is part of the outer flysch Carpathian belt. Soils are rather uniform here. Most of the agriculturally utilised land belongs to the black soil type, which is the most fertile soil type found in the country. The area offers mostly favourable conditions for agricultural production. Only valleys and surrounding areas are covered by flood-plain soils; the cambisols occur in higher altitudes near the border.

The case study area includes a number of small streams which are left tributaries to the Morava River. The entire area is drained into the Black Sea via the Danube.

Czech climate in general is temperate with both maritime and continental influences. Compared to the rest of the country, the Moravian plains, including the Hodonín district, are relatively dry and warm. According to Quitt’s climatic classification (1971), the case study area belongs to the category which is characterised by long, warm and dry summers, warm springs and autumns, and short, relatively warm and dry to very dry winters. The entire area is located at the foothills of Bílé Karpaty Mountains, that have been designated a protected landscape area (Chráněná krajinná oblast – CHKO in short). Large floriferous meadows with scattered trees, as well as mosaic of gardens, fields, and orchards are typical of the mountains (see Figure 2). Rare plant species are found here, too. The protected area was declared on November 3rd, 1980, with an area of 715 sqkm. In 1996 Bílé Karpaty was given the status of UNESCO Biosphere Reserve. Of the three municipalities, Malá Vrbka lies within the protected area as a whole, whereas Hrubá Vrbka and Kuželov only partially. Generally speaking, natural conditions are very favourable for agricultural activities – a fact that is reflected in the land use structure. Outside the built-up areas, much of the land is utilised as arable land, meadows or pastures and only a
small share of the area is covered by forests (mostly deciduous or mixed forests – beech, oak, hornbeam, birch, spruce).

3. Social and economic conditions

Hrubá Vrbka, which is historically the oldest village, contains a protected zone of traditional houses that retained the original layout of a typical hamlet characteristic of Horňácko in 18th and 19th centuries. The case study area, same as the whole Horňácko area, used to have a very diverse religious structure – Catholics, Protestants, Jews, and even Orthodox Christians lived here. In Malá Vrbka houses are grouped along the stream; the village has a bell tower in the centre. Several houses have kept their traditional character. There is no through road in Malá Vrbka; beyond the village the floriferous Vojšice meadows are situated, offering a great variety of plant species. The variety of plants that grow here ranks high even on the national scale. Since 2000, demonstrations of traditional grass-cutting techniques are held here, in order to promote the protection of biodiversity and to show the traditional forms of subsistence (see Figure 3). The village is also noted for weaving and traditional music band. Kuželov boasts the Holland-type windmill, the only one of its type in Moravia, a significant landmark, situated at the top of a hill near the village (see Figure 6). It was built in 1842 as a municipal mill. It ceased to operate in 1964; one year earlier it had been given status of listed monument. The mill and the surrounding estate have been open to public since 1977. There are exhibitions focused on traditional style of living in Horňácko, agricultural equipment and tools from the turn of the 19th and 20th century.

Ethnic composition, age index, socioeconomic structure and other demographic indicators have undergone fundamental changes during the last 50 years. Population changes have been similar in all villages (see Table 1). Since 1869, when the first reliable census had been conducted, the population kept growing until the beginning of the 1920s. It can be observed that in this area the general trends of the demographic revolution took place a quarter of a century later than in the rest of the country. The population had then been declining, although at a much slower rate than in other rural areas, especially in Bohemia, until 2010. It is clear that as a result of ongoing urbanization part of the local population left the area; however, relatively high birth rate helped to keep the population decline at slow pace. There are several reasons for this: the area belongs among the most religious regions in the whole country, many inhabitants still stick to traditional way of life including folk customs that have survived to an extent unknown in other parts of the country.

The number of dwellings has been changing in a different manner over the time (see Table 2). In Hrubá and Malá Vrbka it has been increasing until 1950 (in case of Kuželov until 1930) and now the number of houses is more or less stabilised. Such a process is common in most rural areas in Czechia, but the local increase of houses has been very high: in Hrubá and Malá Vrbka by 80 and 50%, respectively. This fact documents a substantial increase in living standards over the past 150 years as the average number of inhabitants per one house has declined.
The ethnic composition of any area depends on several factors, one of which is also the distance from borders. In the 2001 census people could claim Czech, Slovak, or Moravian nationality (alongside other state nationalities, of course). It seems that Kuželov exhibits the greatest degree of diversity; in reality the differences are rather small as the dividing line between “Czechs” and “Moravians” is a loose one.

Also the age structure is comparable across the case study area. There are slightly fewer inhabitants in the age category 0–14 years than those above 65 (13.5% vs. 15.5%). The share of elderly residents (over 65) ranges between 16% and 18%. The average age in the analysed area is around 40 years. These indicators document that the situation is better here than in other rural areas throughout the country, and that the process of aging has been slowed down somewhat.

According to 2008 data, most inhabitants are employed in the secondary sector. Typically people commute to nearby industrial towns, since only one industrial business (Radiana-Kovo in Hrubá Vrbka) manufacturing steel pipes, is located within the case study area. Much of the land has been ploughed, which proves a high intensity of agricultural activity. One cooperative operates here as do several private farmers. Growing vegetable is common, too. Therefore, while the population is mostly employed in the industry, the area itself has a strongly agrarian character.

More than 60% of the economically active population commute outside of the area. Unemployment remains low in the region; in 2008 the unemployment rate was just 5%. Although the case study area is part of the traditional region Horňácko, tourism is rather insignificant here. Horňácko has its own dialect, customs, folk arts, crafts, traditional music, dances, and especially architecture. Horňácko belongs among the most significant and best preserved ethnographic regions in Czechia.

### Table 1 – Number of inhabitants in the case study area from 1869 to 2001

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<td>1,687</td>
<td>1,551</td>
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Source: Růžková, Škrabal, 2006

### Table 2 – Number of permanently inhabited houses in the case study area from 1869 to 2001

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<td>427</td>
<td>467</td>
<td>477</td>
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Source: Růžková, Škrabal, 2006

4. Long-term land use changes

Comparison of land use data of 1827 and 2005 shows major changes that influenced the landscape in Hrubá Vrbka, Malá Vrbka, and Kuželov (see Figures 4, 5 and Table 3).

The changes of landscape utilization are mostly similar to those recorded in other peripheral regions adjoining the border. There has been a decline of agricultural land; on the other hand, forest areas increased gradually. Also built-up and remaining areas increased in terms of size. Important changes can be observed as regards the agricultural land. Maps and tables show that a great deal of meadows and pastures disappeared – this process reflects the declining importance of traditional farming based on grazing and breeding cattle and sheep. Meadows
Fig. 5 – Land use in the case study area in the years 1827 and 2005.
Source: Czech Office for Surveying, Mapping and Cadastre; authors field survey (2005).
and pastures were losing economic importance and gradually turned to arable land or forest areas. New fields usually came into existence along the streams or in areas where originally meadows and pastures had been surrounded by smaller patches of arable land – in this way larger fields originated. This process also affected the land fragmentation which used to be much higher in the past – on average, plots are significantly bigger now. As a result, the landscape is more prone to erosion and became ecologically vulnerable.

The land use pattern in general is less complicated now than it used to be: boundaries between different land use categories in total became shorter, thus reducing the biodiversity. As most meadows and pastures along the streams disappeared, water retention has been reduced, too, consequently increasing the risk of floods. Nowadays, meadows and pastures cover just 25% of the area (in 1827 it was more than 40%). On the contrary, arable land increased by 120 hectares. Such an increase, rather surprising in a peripheral area, reflects the high importance of agriculture in the region.

The expansion of forest areas is a positive phenomenon. At present forests cover more than 23% of the area, mostly being located in the south, near the Slovakian border. Deeper investigation also shows interesting shifts between forest areas and agricultural land as well as within the agricultural land itself. As an example, 338 hectares of meadows and pastures have been changed into arable land – in this way larger fields originated. This process also affected the land fragmentation which used to be much higher in the past – on average, plots are significantly bigger now. As a result, the landscape is more prone to erosion and became ecologically vulnerable.

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1. Geographical situation

Kobylí is a rather large village and municipality in Southern Moravia, situated in the north-eastern part of Břeclav District, not far from the border with Hodonín District (see Figure 1). The distance from Břeclav town is ca. 25 kilometres; Hustopeče, which serves as a local service centre, is merely 10 kilometres far. Kobylí is part of the South Moravian Region; Brno, the regional capital, is some 40 kilometres far. The distance from well-known wine centre Velké Pavlovice is only 5 kilometres.

The municipality occupies a favourable location in a wide, shallow basin of the Trkmanka creek, bordered by northwest and southeast slopes. Kobylí also forms a Basic Territorial Unit (BTU) which has been more or less stable over the years in terms of size (changes did not exceed 1%). The difference in altitude between the central part of the village (225 m a.s.l.) and the surrounding hills is about 100 metres. Kobylí as well as the nearby villages Velké Pavlovice, Němčičky, Bořetice, and Vrbice, is member of “Sdružení obcí Modré hory” (Blue Mountains Association). Activities of the Association are mostly focused on viticulture and horticulture.

Kobylí enjoys a favourable location as regards transportation lines which has always been a key economic factor. The main axis, the railway line connecting Zaječí (on the trunk line Brno–Bratislava) with Čejč and Hodonín opened in 1897. Mostly agricultural products (especially sugar beet) were transported by the trains; sugar mills in Velké Pavlovice and Čejč were among the destinations. Similar “sugar railways” came into existence also in Bohemia, above all in the Elbe and Ohře Plains between 1880 and 1910. However, since the collapse of sugar industry after 1990 sugar has no more been transported on railways and passenger traffic mostly switched to buses and cars – consequently, many such local railway lines closed down. There is also the regional road No. 422, constructed in the years 1874–1877, running parallel to the railway. This road connects with the major motorway D2 (Brno–Bratislava) near Velké Pavlovice.

The cadastral unit of Kobylí covers 2,114.6 hectares, average altitude being 240 metres. The village is among important centres of wine and fruit production and enjoys high quality soils; the average price of agricultural land is 9.28 CZK per sqm (only for expression of natural quality, average in Czechia is ca. 3.80 CZK per sqm).

2. Natural environment

Kobylí is located in Western Carpathians, in the transitive zone between the Dyjsko-svratecký Basin and Dolnomoravský Basin, more precisely between the uplands Ždánický les (up to 438 m a.s.l.) in the west and Kyjovská pahorkatina (417 m a.s.l.) in the east. The area is among the most fertile Czech regions.

Local rocks are mostly markedly weathered, containing some calcium. Thick layers of loess are typical. The Dyjsko-svratecký Basin and Dolnomoravský Basin are separated by folded sediments dating back to Jurassic and Lower Tertiary periods, often containing calcium and marl, part of the Outer Carpathian Flysch Belt. Soils of this locality are very rich and productive and intensively used for agriculture for thousands years. This region has one of the most productive soils in all Czechia.

The village itself is located in the shallow basin of Trkmanka stream, between wine and fruit growing settlements Bořetice and Brumovice (see Figure 2). Until mid-19th century, part of the basin was filled by large bodies of water, remnants of a vast lake dating from the last Ice Age. Kobylí Lake in the north covered some 360 hectares in early 19th century. Cadastral sources depict the lake as a “body of water without reed”; however, it is likely that due to erosion and silting the lake was shallow, filled by water plants along the shores. The lake had been gradually shrinking and in 1876 was artificially dried up. Trkmanka, the local creek/river (length 42.3 kilometres, catchment area 359 km², average discharge 0.54 m³/s) forms the main water axis now. It has been fully canalized and receives a lot of water drained from the adjoining plots.

Kobylí enjoys a favourable climate, being located in one of the warmest Czech regions. The sun shines some 1,900 hours per year (i.e., each sqm receives about 4,100 kJ), average temperature reaches 8.5–9 °C. Average temperature during the growing season (April–September) is about 15 °C, average precipitation 490 mm per year (Velké Pavlovice). Due to the character of the landscape temperature inversions sometimes occur.
3. Social and economic conditions

Kobyli is first mentioned in the records in 1269; the name is derived from local horse breed (kobyla = mare). Archaeological finds, however, proved that the area had been settled as early as in the Neolithic Age. Kobyli Lake is mentioned in 1464. For centuries, fishing was highly important here – in the Middle Ages fish could be consumed also during the fast and the economic importance of fishing in general was much higher than today. This fact is evidenced also by the local coat of arms of 1671 which includes harpooned fish and wine grapes. Protestant communities of Anabaptists (Hutterites) arrived from Tyrol and Carinthia into the area in mid-16th century and brought more advanced agricultural technologies which helped to improve the local economy (Anabaptists were expelled from Moravia in 1622).

Population and economy was much devastated during the Thirty Years’ War on the territory of the present-day Czechia. Agricultural population decreased; in Kobyli, some 80% of estates became abandoned. In that time landowners [nobility, church] moved surviving peasants from less favourable locations (often founded during colonization) to more fertile areas with better access to the markets. This process probably helped Kobyli, which has very fertile soils, to recover quickly.

Kobyli Lake was dried up in the second half of the 19th century. This fact much influenced the booming agricultural production in the area – new large area of arable land became available, managed by the Pavlovice estate located in the southern part of the former lake. Since 1864 the estate was owned by Mr. Latzel who also owned the sugar mill in Velké Pavlovice – consequently, mostly sugar beet was grown there. In that time sugar production was very important in the fertile lowlands and became one of the economic bases of the emerging Czech nationalistic upper class that entered the political scene on the territory of Austro-Hungarian Empire.

In the early 19th century Kobyli was part of the Velké Pavlovice estate (Hodonín domain). However, as Hodonín was relatively distant, the estate was managed more or less independently, including eight neighbouring villages. The Habsburg imperial family was the last owner (1762–1921).

The increase of non-agricultural population, advance of industrial revolution and ongoing urbanization led to the agricultural revolution. Typically, arable land expanded in terms of size in Kobyli, step by step covering areas of former fallow land, meadows and pastures. On the other hand, vineyards long remained more or less stable (approximately 50 hectares) – a wine boom came only after 1948.

During the whole 19th century Kobyli remained dependent on agriculture, industry was unimportant. The crisis in the 1890s initiated the so called technical-scientific revolution in agriculture; consequently, differential rent II became more important (Jeleček, 2002). Intensification measures required more money, hence investments into less fertile land became no more commercially viable.

The crisis also influenced population patterns. At the turn of the 19th/20th centuries people began to emigrate from the countryside to towns, especially to Brno and Vienna, also to the U.S.A. (Franc, 2000, p. 87; Dlouhý, 2004). Farmers gradually switched...
to the so-called free farming, more advanced machinery and fertilizers were introduced, waterlogged plots became drained, etc. Thus, the agricultural land became used in a more intensive way: in land use terms this means decrease of arable land, meadows, and pastures, slow increase of forest and other areas (Bičík, Jeleček, Štěpánek, 2001). Specifically in wine growing areas (including Kobylí) an important increase of vineyards and orchards has been recorded since 1960s. This process had even accelerated just before Czech Republic became an EU member (2004) – see Figures 3 and 4.

Viticulture in Bohemia and Moravia was much affected by the “phylloxera plague” in 1909 which spread quickly and damaged almost all vineyards. Renewal of vineyards and effective protection against the insects was made possible only through more resistant grape vine imported from the U.S.A. Apart from phylloxera, also some other new pests appeared – as a result, insecticides became widely used.

The agrarian reform in Czechoslovakia, carried out in the 1920s, did not bring major improvements to small farmers. In the case of Kobylí, 141 small farmers were given 125 hectares of land in total. 456 hectares of land were managed as a state estate (nationalized Habsburg property) until 1951. As a result, the estate had a better access to modern technology including agricultural machines, fertilizers, and electricity.

Collectivization was enforced in agriculture soon after World War II. Franc (2000) brings important figures regarding the structure of agricultural businesses in Kobylí just before collectivization started (1946). Almost everywhere a great majority of farms owned just small patches of land. In the case of Kobylí, some 99% of farms were smaller than 20 hectares, managing 83.5% of the cultivated land. The rest (16.5%) was owned by the single estate. Almost half of the farms had less than 2 hectares available, cultivating in total just one fifth of the agricultural land. Moreover, the estate in Kobylí owned majority of the local forests.

Most former socialist cooperatives and state-owned farms survived the period of transformation after 1989 – return towards the fragmented structure as it had existed until 1948 was impossible in economic terms. Thus, at present relatively large businesses form the base of Czech agriculture, which is a rather favourable situation compared to some other countries.

Collectivization started soon after Communists had seized the power in 1948 and followed Soviet models. The socialist-style cooperative in Kobylí (JZD) was founded in 1950 and collectivization was “successfully” finished by 1963. The Kobylí cooperative had some 530 employees and managed 1,035 hectares of land: 907 hectares of arable land (i.e. ca. 60%), and just 77 hectares of vineyards. Small patches of privately managed land covered in total about 200 hectares; these were mostly vineyards, each family was allowed to have 1,000 square metres at maximum. Production from these small plots was a sort of subsistence farming.

In 1974 the cooperative in Kobylí merged with cooperative in the neighbouring village Vrbice to form a new cooperative called Družba Kobylí. Soon after 1989 major changes occurred in Czech agriculture. The existing large cooperatives and state-owned farms were transformed into market oriented companies (private companies, joint-stock companies), but most businesses remained relatively large in terms of size. The original owners whose land had been confiscated by the Communists could reclaim the property – most of them, however, rented the regained land out to the existing cooperatives or transformed companies. Only a few new private farms came into existence (see Jančák, Bičík, 2005).

Historically, the agricultural structure in Kobylí regarding organization and land tenure has not undergone major changes over the time: there has always been one big estate (private, socialist, joint-stock) on one hand and a number of small scale farmers on the other hand. In 1991 the cooperative was again split between Kobylí and Vrbice. As some land was reclaimed by the original owners (or descendants) the cooperative land shrank a bit. In 1998 the cooperative property was transferred to the daughter company Patria and consequently Kobylí cooperative ceased to exist.

At present Patria is by far the biggest agricultural business in Kobylí with ca. 260 employees. The annual production of grapes amounts to 1,400 tones; apricot production is among the

Table 1 – Number of inhabitants and permanently inhabited houses in the case study area from 1869 to 2001

<table>
<thead>
<tr>
<th>Year</th>
<th>Inhabitants</th>
<th>Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1869</td>
<td>1,560</td>
<td>338</td>
</tr>
<tr>
<td>1880</td>
<td>1,810</td>
<td>366</td>
</tr>
<tr>
<td>1890</td>
<td>1,697</td>
<td>376</td>
</tr>
<tr>
<td>1900</td>
<td>1,801</td>
<td>391</td>
</tr>
<tr>
<td>1910</td>
<td>1,855</td>
<td>404</td>
</tr>
<tr>
<td>1921</td>
<td>2,082</td>
<td>417</td>
</tr>
<tr>
<td>1930</td>
<td>2,208</td>
<td>527</td>
</tr>
<tr>
<td>1950</td>
<td>2,174</td>
<td>598</td>
</tr>
<tr>
<td>1961</td>
<td>2,388</td>
<td>618</td>
</tr>
<tr>
<td>1970</td>
<td>2,266</td>
<td>610</td>
</tr>
<tr>
<td>1980</td>
<td>2,220</td>
<td>624</td>
</tr>
<tr>
<td>1991</td>
<td>2,103</td>
<td>712</td>
</tr>
<tr>
<td>2001</td>
<td>2,092</td>
<td>731</td>
</tr>
</tbody>
</table>

Source: Růžková, Škrabal, 2006

![Fig. 3](image3.png) Vineyards established before joining Czechia into EU are located on the southwest slopes between Kobylí and Bořetice. Photo by L. Jeleček.

![Fig. 4](image4.png) Wide valley of Trkmanka stream: on the left are old vineyards of small owners, on the right are terraces of abandoned old vineyards. Photo by L. Jeleček.
Fig. 5 – Land use in the case study area in the years 1827 and 2001
Source: Czech Office for Surveying, Mapping and Cadastre; authors field survey (2001)
biggest in the whole country (grown on 162 hectares). Animal husbandry focuses on dairy farming, pork and beef.

Small-scale plastic industry producing pools, pipes, containers, etc. developed in Kobylí already before 1990. Production was managed by the cooperative and this tradition goes on also nowadays.

Population changes over the time to a certain extent also indicate the changing importance of given area. Rather large, compact villages are typical of the southern part of Moravia. Houses are often grouped along the main road with fields radiating out from the village. Table 1 shows how the number of inhabitants and houses in Kobylí changed since 1869.

2,117 inhabitants lived in Kobylí in 2012 which is an increase of almost 30% compared to 1869 (1,560 inhabitants only). Such an increase is not uncommon in many large villages and towns throughout the fertile plains in Southern Moravia, but it differs from population changes in villages located in less fertile regions – these tend to lose population since late 19th century.

The population of Kobylí decreased between 1869 and 1880. The village has been losing permanent inhabitants also since 1960s, with the exception of the period 2001–2010. Similar changes have been recorded in the Břeclav District as well as in the whole Czechia. Though Kobylí was not directly affected by the displacement of Germans after 1945 (most villagers were Czechs), some locals left the village in that time for the formerly German speaking areas to resettle the borderland. Within the Břeclav District, however, some 20% of the population was expelled. At present the ethnic structure is a compact one with more than 98% of inhabitants claiming Czech (or “Moravian”) nationality.

Though Kobylí is located relatively near the Austrian border, the post-1945 German exodus did not have any major impact. The formerly German speaking belt flanking the border was relatively narrow here – the fertile lands of South Moravia had been settled by Slavic people already before the German colonization started in the 13th century.

### Table 2 – Land use changes 1827–2001 (ha)

<table>
<thead>
<tr>
<th>Category</th>
<th>1827</th>
<th>2001</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable land</td>
<td>438.8</td>
<td>538.0</td>
<td>637.6</td>
</tr>
<tr>
<td>Permanent cultures</td>
<td>10.2</td>
<td>17.0</td>
<td>27.2</td>
</tr>
<tr>
<td>Permanent grassland</td>
<td>134.4</td>
<td>99.4</td>
<td>233.8</td>
</tr>
<tr>
<td>Forest areas</td>
<td>0.0</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Water areas</td>
<td>322.9</td>
<td>188.4</td>
<td>511.3</td>
</tr>
<tr>
<td>Built-up areas</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Remaining areas</td>
<td>4.0</td>
<td>4.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Total</td>
<td>571.7</td>
<td>668.5</td>
<td>1,239.2</td>
</tr>
</tbody>
</table>

Note: Changes of land use (in hectares) from categories in rows to categories in columns. Example: 4.5 hectares of arable land (1827) has been transferred to permanent grassland in 2001.

**Source:** Czech Office for Surveying, Mapping and Cadastre, authors field survey (2001)

4. **Long-term land use changes**

Historical changes and current state of land use structure have been influenced by the mutual interaction of natural and societal driving forces. In the case of Břeclav District among the most important societal driving forces were industrial and agricultural revolutions (2nd half of the 19th century), the so called technical-scientific revolution in the 20th century, displacement of German speaking population, communist regime, re-establishing of market-oriented economy and also the influence of EU Common Agricultural Policy that was evident already before the accession to EU in 2004 (Bičík, Jeleček, 2009).

On the national level, the most important land use changes historically occurred in infertile mountainous regions. Large losses of arable land since 1945 in the hilly regions along the Slovakian border and areas formerly settled by German speaking population along the “iron curtain”. Wine- and fruit growing regions that produce a high “added value” have undergone major changes since 1970s: typically vineyards, orchards, and gardens expanded at the expense of arable land, meadows and pastures. At first look these land use changes may resemble those that occurred in less fertile regions; the reasons, however, were entirely different. In terms of size, there are seven times more vineyards in Kobylí now compared to 1845 (313 hectares instead of 42); orchards grew even 17 times (250 vs. 15 hectares)! These land use categories experienced an important increase at the expense of other types of agricultural land. In this very case the general rule normally valid in most fertile regions – i.e. the more fertile land and the better position towards the markets, the less important land use changes – can not be applied (see Figures 5 and 6).

More vineyards, however, also means higher environmental risks – especially vineyards located on steep slopes are prone to erosion. The expansion of vineyards (increase by 129 hectares between 2000 and 2010, i.e. more than between 1948 and 1990, just 117 hectares) was made possible by the EU approval. The
The Treaty of Accession included the article that allowed increase of vineyards by 2% in total. The Czech Act No. 321/2004 and corresponding decrees provide details where and how new vineyards can originate. There were 19,633 hectares of vineyards in Czechia in 2010 of which 17,338 hectares bore grapes (Zelená kniha, 2010, p. 102). The land tenure, however, is highly uneven: 72% of vineyards belong to winegrowers that own more than one hectare of land, but these owners account for just 5% of all winegrowers (Zelená kniha, 2010, p. 102). Thus, there is just a small group of relatively big producers on one hand; on the other hand great many small winegrowers work only part time in agriculture and much of their production is consumed by themselves or their relatives and friends (see Figure 7).

Much of the vineyards expansion falls into the 2nd half of the 20th century, with the exception of the transformation period (1990–2010). In terms of size, vineyards increased most between 2000 and 2010 (plus 71%; in the same period arable land decreased by 25%, orchards increased by 31%). These changes prove the decreasing importance of grain production and that of arable land in general. As an example, in 1845 in Kobyli arable land accounted for 74% of all agricultural land; in 1896 and 1948 respectively this share was 88%, in 1990 69%, and in 2010 just 58%. Since 2000 wheat, corn, and rapeseed have been grown almost exclusively on the land, with corresponding economic and ecological consequences. The structure of export/import has changed significantly on the national level: at present Czechia imports mostly products with high added value like meat, milk, or cheese; on the other hand grain is being exported.

Data on land use structure related to 1845, 1896, 1948, 1990, 2000, and 2010 as well as Table 2 shows interesting trends that may superficially seem to be similar, but have quite different reasons.

1) Previous research carried out in the end of the 20th century proved that during 1880s and 1890s the land use structure remained more or less stable (Jeleček, 1985, 1995; Bičík, Štěpánek, 2000). This stagnation was mostly influenced by macroeconomic situation and societal driving forces that required high investments in land improvements in order to secure enough food for non-agricultural population. Differential rent II became more important, i.e. fertile land attracted more and more agricultural businesses.

2) A similar trend is observed in the period 1990–2000. The reasons, however, were quite different – first of all there were political, economic, and social changes during the transformation period.

5. Perspectives, problems and risks of future development

Any major changes in land use structure in the foreseeable future are likely to be influenced rather by external factors. These may include changes of Common Agricultural Policy (CAP) or balancing agricultural subsidies between old and new EU-members; these subsidies are most likely to decrease. World prices of agricultural products may also play an important role, as well as GATT agreements or different types of market protections. If changes of agrarian policy become necessary as a result of external pressure, there may again be a higher demand for arable land. It is difficult to estimate the perspectives of wine business as at the moment it covers only half of the domestic consumption. Land use changes, however, always manifest themselves with a certain delay behind the external driving forces. Thus, land use structure in Kobyli is likely to remain relatively stable at least during the next ten years.

Contemporary land use structure as long-term development of land use in this locality corresponds to other lowlands regions of Czechia with good natural condition. High intensity of plant production is very typical, specialization on vines, fruits and vegetables is remarkable as reflected in Figures 2, 3 and 4.

Fig. 7 — Many new wine cellars came to existence in Southeast Moravia where the best soils are found (2008). These investments can be considered proof of success of traditional small family-owned wine businesses. Photo by I. Bičík.
II

Land Use Changes in Northwestern Part of Czechia: the Effects of Displacement of German Inhabitants

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Introduction

In connection with the displacement of the German population, we have documented land use changes in various types of landscapes along the Czech-German border in four model areas. These areas are marked by their partly differing development, varying German percentages of the population in the interwar period, and especially by their varying geographic conditions for economic development. All of these areas are part of the northwestern Sudetes, which was an area with a high German population in the interwar period (a total of over 90% of the population) and, as a result, an area where the displacement of the German population after the end of World War II had a major impact (the Sudetenland). The Czech-Saxon border of the Sudetes runs along the natural barrier of the Ore Mountains, continuing further westward in the Smrčina range. This is one of the oldest borders in Europe, but since the Middle Ages it has been the site of important cultural and business interaction – as seen in the external colonisation of Czech lands by religious orders [e.g. the Cistercians of Waldsassen] and settlers. As a result, since as early as the High Middle Ages the basic spatial and functional structure of the cultural landscape has been defined in the northwestern Sudetes. The special features of the Sudetes are reflected in the different character of the landscape, unique folk art and architecture, the way in which the landscape was economically utilised and other areas. As a result, the “Sudeten landscape model” is sometimes mentioned in association with the past development of the area.

The questions we posed in our article are as follows:

- How did the differing starting conditions (German percentage of the population, economic activity and links to the German side of the border) manifest themselves in the subsequent development of land use in the model areas?
- Which landscape elements were most affected by the displacement of the German population, and why? Which were renewed, changed, which were resumed? How did this manifest itself in land use changes (and) at the present time?
- What are the outlooks in terms of collaborating, reviving or resuming the historical form and function of the pre-war landscape?

Case studies

We found the land use changes in four areas (Figure 1) which differ in terms of their historical development, geographical location, economic activity and German percentages of the population in the pre-war period. These four areas represent the diversity of the landscape in the northwestern Sudetes, where land use changes were different due to their varying geographical conditions (Table 1).

Type A Highland periphery (Verneřice district) is located in the eastern part of the Bohemian Uplands, beyond the main road leading to Germany. Economic growth is not as dynamic as in the territory located immediately near the Bohemian-Saxon border. Following the administrative reform in the 1860s, its type became the “periphery” of the Ústí Region. Its location on the border of the region and its large distance from the regional capital had a negative impact on the development of this type. The territory is not suitable for intensive farming. The earlier rapid settlement (latter half of the 19th century) was connected with the development of textile industry and brown coal mining. The population reached a record high in the 1880s. Regressive development ensued after the establishment of the Czechoslovak Republic. This regression peaked when the German population, which until then was a clearly dominant majority, was expelled after the end of World War II. In the years from 1930 till 1950, the number of residents dropped by 70%. The original industrial function changed to the present mixed / indistinct.

Type B Borderland semi-periphery (Petrovice district) is located in the eastern Ore Mountains along the border with Germany (Saxony). After World War II, the area was dominated by its strongly peripheral geographical location and economic development was limited. When the borders opened in 1990, the geographical location improved substantially. Plateaus with a high share of woodland alternating with farmed meadows are predominant. Before World War II, over 90% of the population was German and population losses due to the displacement were greatest. In the years from 1930 till 1950, the number of residents dropped by 70%. The economic function of the area also changed significantly. From its mixed function (agro-industrial) in the pre-war period (small industry, animal production, trade), its function changed to recreation. Economic development in type B was dynamic, mainly in the first phases of industrialisation (in direct relation to development in Saxon cities). This was followed by stagnant economic and demographic development and marked regressive trends after World War II.

Type C Coal basin (Bílina district) has a useful geographical location below the Ore Mountains on a regional development corridor. The deforested, even land is located about 200 metres above sea level. As a result of extensive surface mining, the northern and eastern part of the territory is highly devastated. Before World War II, over 70% of the population was German and population losses were not as marked [30%]. The economic function is stably focused on brown coal mining and industry related to this. Territory of this type found itself under heavy anthropogenic pressure in the latter half of the 20th century. The gradual transformation of the land has affected its natural functions as well as its socio-economic and cultural functions.

Type D Agriculture area (Třebenice district) is a region featuring a predominantly flat, lowland relief. There is little woodland and it is intensively farmed. Fields alternate with
Fig. 1 – Case studies in the northwestern section of Czechia

Fig. 2 – Abandoned settlement in northwestern part of Czechia
Table 1 – Basic attributes of case studies in periods: industrial (until 1947) → totalitarian (1948–1989) → post-industrial (1990 till nowadays).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Highland periphery</th>
<th>Borderland semiperiphery</th>
<th>Coal basin</th>
<th>Agriculture area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Case study</td>
<td>Varnsdorf</td>
<td>Petrovice</td>
<td>Bílina</td>
<td>Trebenice</td>
</tr>
<tr>
<td>Geo location</td>
<td>semiperiphery</td>
<td>border</td>
<td>exposed</td>
<td>semiperiphery</td>
</tr>
<tr>
<td>Altitude (in m)</td>
<td>highland, 400-600</td>
<td>mountains, 500-750</td>
<td>basin, 195-215</td>
<td>lawlands, 170-260</td>
</tr>
<tr>
<td>Maximum of inhab. (year)</td>
<td>1850</td>
<td>1880</td>
<td>1930</td>
<td>1910</td>
</tr>
<tr>
<td>Decrease of inhab. (between 1930-1950) (%)</td>
<td>70%</td>
<td>70%</td>
<td>30%</td>
<td>25%</td>
</tr>
<tr>
<td>Proportion of German inhab. (in 1950) (%)</td>
<td>90%</td>
<td>90%</td>
<td>70%</td>
<td>25%</td>
</tr>
<tr>
<td>Past human activity</td>
<td>industrial</td>
<td>mixed</td>
<td>industrial</td>
<td>agricultural</td>
</tr>
<tr>
<td>Present human activity</td>
<td>mixed</td>
<td>tourism</td>
<td>industrial</td>
<td>agricultural</td>
</tr>
</tbody>
</table>

Table 2 – Land use data sources – aerial photographs

<table>
<thead>
<tr>
<th>Case study</th>
<th>Years (number of photographs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrovice</td>
<td>1953 (11) 1982 (6) 1996 (7) 2003</td>
</tr>
<tr>
<td>Bílina</td>
<td>1938 (5)     1987 (3)</td>
</tr>
</tbody>
</table>

Fig. 3 – Population of case studies in 1930–2010
Fig. 4 – Type A Highland periphery (Verneřice) – land use changes

Fig. 5 – Type B Borderland semi-periphery (Petrovice) – land use changes
second post-war censuses in 1921 and 1930, proposed distinguishing the respondent's ethnic origin by using native language and, in addition, taking a survey of nationality as a matter of personal conviction. The government selected the definition of nationality as membership in an ethnic group which is characterised by the native language. In contrast, after World War II the second method was selected – the declaration of nationality as “personal national conviction”. It is generally surmised that at the local municipal scale, residents were likely to report they belonged to the local majority (Häufler, 1976). Evidence can also be provided in a number of neighbouring municipalities. The towns and villages in the model district of Trebenice are one example. The small village of Chrášťany was “Czech”, while neighbouring Čizkovicke was exclusively “German”. It can be surmised that the national structure here was not sharply divided by the boundary of the municipality, but was more diverse (more even distribution of both ethnic groups).

Development after 1945

We observed an evaluation of developments in land use changes in three time intervals distinguished by specific characteristics in the Sudetes area (Table 3):

The final phase of an industrialized society (until 1947) is distinguished by the development of the secondary sector and considerable dynamics. Socio-geographic factors play a stronger role in regional development than natural conditions. The extensive urbanisation process, associated with a high degree of spatial mobility, gains ground. For the northwestern Sudetes, the conclusion of this period represents a break in its development and an interruption in the continuity of development up to now. As a result of the displacement of the German population, some peripheral areas remain unsettled. This resulted in widespread disruption of the community structure, the destruction of homes, and the disappearance of numerous historical and artistic landmarks.

The period of a totalitarian communist state (1948–1989) can also be generally understood as a certain phase of an industrial society. It was marked by a departure away from the natural trajectory of development in advanced European countries, where the characteristics of a post-industrial society had started to appear (Hampf, 1998). Impacts associated with the displacement of the German population intensify, as the “new” settlers’ identification with the landscape is weakened. In the foothills of the Ore Mountains, large-scale brown coal surface mining and associated heavy industry (especially the energy and chemical industries) experience development. Large-scale farming becomes stronger. There is a sustained drop in geodiversity. The period reaches a climax with the environmental crisis, associated with maximum pressure on the environment.

In our conditions, the first phases of the post-industrial society are connected with the economic transformation and the advancement of the market economy. The settlement system becomes integrated. Depopulation development trends in large core areas become stronger, to the detriment of space in the hinterlands of these areas. The opening of the borders and cross-border cooperation lead to development in once peripheral areas along the border with Germany. For many, travel and tourism (the “recreation industry”) represents the main vehicle of the area’s economic and social rehabilitation. A renaissance of traditional, multi-functional use of the landscape takes place.

Results – land use changes and transformations in landscape function

According to the types monitored, land use changes and transformations in landscape function differed in northwestern Bohemia.

Type A Highland periphery (Verněřice district). The settlement of the area is connected to German colonisation in the late 13th and early 14th centuries, and the area’s dynamic development with the development of textile industry and brown coal mining in the latter half of the 19th century. The discovery of brown coal deposits strengthened economic development from the mid-19th century. Since the mid-19th century, though, the Verněřice district has economically become less important, mainly due to the area’s poor accessibility. In the post-war period, the main emphasis was placed on developing agricultural production (cooperative farms). The development of recreational functions in the form of holiday homes and cottages prevented smaller municipalities from completely disappearing. In the transformation period, small-scale private economic activities are again developing both in industry and agriculture (cattle raising). Tourism remains at the same level. Private, individual tourism in the form of holiday homes and cottages continued to be predominant.

Table 3 – Three different periods in northwestern part of Czechia and their causes and effects on landscape

<table>
<thead>
<tr>
<th>Period</th>
<th>Driving forces</th>
<th>Landscape changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>Strong economic and cultural/historical ties to Germany</td>
<td>Cultivated and farmed landscape with a mosaic of small fields, meadows and pastures</td>
</tr>
<tr>
<td></td>
<td>Development of minor industry, especially in the border area</td>
<td>Diverse landscape in terms of ethnic groups, customs and cultural history, featuring a unique architectural character</td>
</tr>
<tr>
<td></td>
<td>World wars</td>
<td>Centre of settlement and economic activity in the border area</td>
</tr>
<tr>
<td></td>
<td>Beneš decrees</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Displacement of Sudeten Germans</td>
<td></td>
</tr>
<tr>
<td>Totalitarian</td>
<td>Resettled border area</td>
<td>Decrease in the quality of landscape character in the built up areas of the municipalities and in the rural areas</td>
</tr>
<tr>
<td></td>
<td>Collectivisation and central planning</td>
<td>Many farms, small buildings of cultural and historical importance in the landscape disappear</td>
</tr>
<tr>
<td></td>
<td>Centre of economic activities shifted to the basin area</td>
<td>Historical traditions, cultural events and customs are interrupted</td>
</tr>
<tr>
<td></td>
<td>Development of large-scale brown coal surface mining and related industry</td>
<td>Succession on the deserted lands</td>
</tr>
<tr>
<td></td>
<td>Economic cross-border ties interrupted and directed along the border</td>
<td>Land consolidation (speeding up the drainage of water from the landscape, erosion)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disruption of the relationship to the land and property</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Devastation of natural environment (acidification of land and water, degradation of woodlands, marginalisation of land along the border)</td>
</tr>
<tr>
<td>Post-industrial</td>
<td>Economic transformation</td>
<td>Renewal of human activity in the landscape</td>
</tr>
<tr>
<td></td>
<td>Market economy</td>
<td>Renaissance of traditional landscape use - small-scale economic activity</td>
</tr>
<tr>
<td></td>
<td>Privatisation of land and property</td>
<td>Reduction of dominant functions – mining, energy, chemical industry – redevelopment of complementary functions (tourism, alternative forms of agriculture) along the border</td>
</tr>
<tr>
<td></td>
<td>Accession to the European Union</td>
<td>Renewal of cultural and historical elements in the landscape, traditions, customs and cross-cultural ties</td>
</tr>
<tr>
<td></td>
<td>Schengen Area</td>
<td>Formation of suburban territories and renewal of rural activities with the arrival of a new middle-aged generation</td>
</tr>
</tbody>
</table>

53
Fig. 6 – Type C Coal basin (Bílina) – land use changes

Fig. 7 – Type D Agriculture area (Třebenice) – land use changes
The distribution of land cover structure is highly influenced by the linear distribution of artificial areas along small streams. In a village with a population between 500 and 1,000 residents, arable land plots run perpendicular with meadows and pastures. LC changes show a simplification of the landscape mosaic. More extensive stretches of arable land, meadows and pastures are gradually created. These LC changes continue with varying intensity throughout the entire period. In the last year right up to the present, the representation of meadows and pastures and woodland is increasing. The share of arable land has fallen up to the present time.

Type B Borderland semi-periphery (Petrovice district). The thickly wooded mountaneous area around Petrovice was settled in the 12th century in connection with mining. The greatest transformation in the character of the landscape relates to the events following the end of World War II, when the area remained under-settled for a sustained period following the displacement of the German population. The number of residents plummeted to just a quarter, and the settlement structure was markedly transformed. During the totalitarian regime, political influences associated with waves of collectivisation and a “new” rural organisation were also strongly asserted. What were once small fields and meadows were united into basic cooperative farms (JZD), and in some cases were also used for large-scale cattle farming. For the Petrovice district, the 1990s constituted the end of job opportunities at the collective farms or in small-scale industrial companies – but it was a catalyst for business development, particularly in the area of tourism and travel services.

As is the case of Type A, the LC structure is highly influenced by the linear distribution of artificial areas along small streams. Stretches of arable land, meadows and pastures run perpendicular to these. An analysis of LC changes shows that first the LC structure was simplified by consolidating the lands, and later all of the arable land turned into meadows and pastures. At present there is almost no arable land in this type. Another major LC change is the gradual transformation of deserted areas into scrub and, in the final phase, woodland.

Type C Coal basin (Bílina district). The Bílina district represents an area where the function of the landscape totally changed in the course of development – from what was originally purely agricultural (one of the most fertile areas in Bohemia) to an industrial-agricultural and then an urban and devastated landscape. Following up on earlier local mining, large-scale surface mining was introduced in the 1960s that created enormous anthropogenic shapes in the relief (mine pits, disposal sites). In the 1970s, three municipalities ceased to exist; before World War II, over 4,000 residents lived in the small towns. A similar situation occurred to the southeast of Bílina, where the Radovesice disposal site was established. In the 1970s, earth was brought in to the site of older mines here. The enormous mound buried the municipality of Radovesice, which had over 1,400 residents shortly after the end of World War II. Modern structures and the transformation of the landscape in the past decades have entirely changed the landscape character.

This type is distinctive for its very significant LC structure change. Originally a harmonious mosaic composition in the western half and a homogeneous eastern half (scrub), devastation resulting from brown coal surface mining has diametrically transformed the structure. By 1987, artificial areas became the dominant class with preserved woodland in the eastern edges and pockets of arable land in the westernmost salient. Artificial areas contain the linear town of Bílina in the centre, large-scale brown coal surface mine to the west, and a reclaimed space to the southeast where woodland alternates with scrub.

Type D Agriculture area (Třebenice district). The landscape character and function of the Třebenice district was affected most by the waves of collectivisation in the latter half of the 20th century, during totalitarianism. What until then were small plots of arable land cultivated by private farmers were consolidated by government decree into extensive tracts of land, significantly changing the face of the landscape. Many boundaries, groves, woodland along watercourses and paths, lone trees and specific alluvial communities practically disappeared from the landscape. In most cases, characteristic agricultural folk architecture, church buildings and minor compositional landscape elements were destroyed.

In the Agriculture area, there was a drastic reduction in the mosaic structure of the landscape as a result of agricultural collectivisation and land consolidation. Bands of woodland and meadows and pastures along the watercourses disappeared from the landscape. The landscape is dominated by extensive stretches of arable land. Following stagnation in the development of land cover structure (in the interval from 1962 till 1994), LC changes can currently be observed and aim to renew the original bands of woodland along the streams.

Discussion and conclusions

The most dynamic changes took place in the northwestern Sudetes after the end of World War II, which is a trend that corresponds in part to general regularities in land use development in Bohemia (Bičík and Jeleček, 2005). Compared with land use changes in the central part of Czechia, in addition to changes to the economic use of the landscape, the settlement structure was significantly transformed. In most territories, the agricultural function of the landscape was lost. This was due to the departure of farmers. This was the site of a drastic experiment in which the original residents were replaced with new arrivals. Yet they did not know local traditions or the territory’s potential for economic activity, and did not even have personal ties to the land. In most cases these were young people (families) who sensed an opportunity for getting easy access to satisfying their basic needs. They did not have an established relationship to the new property and the land obtained. They did not know how to care for the land, how to develop economic activity and forge business relationships.

The experiment was a confrontation of the historical landscape with residents who did not know the landscape or its development. Resident farmers were replaced with resident consumers. As a result, the Sudetes landscape is a sort of memento: It shows what could happen to a far greater extent if the trajectory of landscape development is severely disrupted and its function significantly changed.

The Sudeten landscape was disrupted, its immunity weakened and it did not have enough strength to stand up to everything with which it was confronted. Fixed points in the landscape, hollow ways, thousands of stone statues, wayside shrines, chapels and landmark trees disappeared (Balej et al., 2010). As a result of collectivisation, the charming landscape was transformed into anonymous fields and overgrown bushes and meadows.

How should it develop and which direction should the landscape of northwestern Bohemia take? There are several segments of change: Use the current settlement structure and clearly differentiate it from the open, unbuilt landscape; emphasise the natural dominant features of the settlements; use the network of historical paths and cultural artefacts in the landscape.
**Petrovice** (Rájec): total change of landscape function, abandonment of the landscape, marginal area remained for natural process of succession, and formation of a “new wilderness”.

**Třebenice** (with Koštál hill): at left: 1905 – finely-grained mosaic of agricultural landscape, small fields divided by access footways edged with wood balks. In 2003 coarse-grained agricultural landscape with abandoned orchards and fruits.

**Bílina** (Jeníčov Újezd in Czech, Lang-Ugest in German): population was almost 2000 inhabitants in 1930. In 1975, it disappeared as a result of opening of a large-scale coal-mine Maxim Gorkij.

**Verneřice**, medium–coarse-grained landscape with meadows and arable land in 1947 was changed to large-scale grained landscape nowadays.

*Fig. 8* – Changes of landscape types of sample areas in the last 100 years
The highland periphery allows for developing hiking, cycling and small-scale local traditional economic activities and producing typical lace products. To cultivate the borderland semi-periphery, alternative forms of agricultural activity, agrotourism and ecotourism can be considered; for regulated summer and winter hiking, this type is absolutely ideal. The coal basin is a territory in which it is necessary to look for the optimal layout and character of new landscape elements (water, woodland, agricultural reclamation of the mined area). Alternating landscape functions (production and environmental) in the area has shown to be the best option. In an agriculture area, the effects of collectivisation on the landscape – which are speeding up erosion and water drainage – must be corrected. It is important to recognise that climate changes can lead to more extreme hydrometeorological situations (drought, heavy rain). It is therefore important to be prepared for these by reconstructing small landscape elements (renewing natural pools, marshes, groves, boundaries, revitalising small streams, etc.).

Acknowledgment

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References


III

Integrated Landscape Assessment of Cezava Region

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1. Introduction

Intensified utilization of the landscape represents one of the main drivers of global environmental change. Intensive landscape exploitation usually decreases biological diversity and triggers processes like soil depletion and consolidation, erosion, eutrophication, water regime disturbance etc. (Opdam et al., 2006). These disruptions of the landscape functions and services affect ecological stability of the landscape in terms of its resilience and resistance ability (de Groot, 2006; Jongman et al., 2004; Lipský, 2000). However, the landscape qualities are essential for local ecological and environmental conditions as for the creation of the local culture. Besides, the landscape functions and services determine delivery of substantial benefits to human society (MA, 2005). Availability of these benefits with great ecological, socio-cultural and economic value (de Groot, 2006) requires a management maintaining the landscape capacity to provide them.

To demonstrate how intensive land use and quality of the environment interact and how the interactions influence landscape functions and services, this study introduces integrated landscape analysis of the Czech agricultural region Cezava. Firstly, the research analyzes long-term land use changes. In a second step, it assesses an impact of these changes on environmental conditions of the study area. Then, by the ecosystem services analysis, the study describes remediation capacity of existing and proposed ecological networks in the study region.

Study Area

The region Cezava was chosen as a study area due to its specific natural conditions and its agricultural character, which make it possible to explore the impacts of unidirectional management and their influence on the provision of ecosystem services. The region is situated in Czechia, in South Moravia, about 15 km to the south of Brno city. It consists of 15 municipalities, which cover a total area of more than 15,000 ha (Map 1).

The Cezava region belongs to Western Carpathian Mountains province (Demek and Mackovčín, 2006). The highest elevation point is the hill Výhon reaching 356 m. The territory of the interest crosses the Litava River (formerly Cezava), representing dominant watercourse. The subsurface of the study area is created by unconsolidated sediments of marine Neogene covered by terrace gravel sands originated in Pleistocene. Both types of sediments overlay thin layers of loess. Alluvia, affected by fluctuating groundwater level, are covered by fluvisols stemming from carbonate sediments. In lower marginal areas of uplands, fluvisols are replaced by luvisols and partly by pararendzinas. Black soils occurring in the river basin of Litava are agriculturally utilized (Havlíček and Navrátilová, 2005).

Climate of the area is very favourable and it is one of the warmest regions in the country (Cezava belongs to Pannonian region). Being to one of the most fertile regions in Czechia, soil production potential influences the land price. Official land price of the agricultural land is based on the system of pedo-ecological units (PEU; in Czech: "Bonitovaná půdně ekologická jednotka – BPEJ") and represents hypothetical price but reflecting real market conditions. Every unit has a unique five-digit code according to climate (first digit in the code), soil type (second and third digit in the code), relief evaluation (fourth digit in the code) and soil profile depth (fifth digit in the code). The code identifies homogeneous land units and specifies their production potential. As the Table 1 indicates, official land price per cadastrum units in the study area ranges from 8.47 CZK/m² up to 13.61 CZK/m². Comparing prices of Cezava with minimal (0.7 CZK/m²) and maximal (14.81 CZK/m²) national land price values, they demonstrate high production potential of soil in the study area.

Cezava has been agriculturally exploited area since historical times. Crucial transformation and simplification of landscape structure happened in more recent history in 1950s. Figure 1 and Figure 2 depict the landscape structure transformation. In favour of production intensification land was consolidated into large-scale fields and so-called belt parcels disappeared from the landscape.

Currently, Cezava faces after-effects of unidirectional land use. Arable land has reached 75% of land cover at the expense of other ecosystem types. The area also encompasses few natural landscape elements – nature protected areas and Natura 2000 sites covering about 0.9% of the region. Small in size, they are not expected to compensate the impact of intensive agriculture.

2. Methods

The methodology combines land use change analysis with ecosystem services analysis in order to carry out an integrated assessment of ecological stability of the study area.
Figure 1 – Aerial photo of Moutnice (1949) – small scale land use ("belt parcels")
Source: VGHMÚ Dobruška, © MO ČR/HÚVG

Figure 2 – Aerial photo of Moutnice (2000) – large scale land use (big plots of arable land after collectivisation)
Source: VGHMÚ Dobruška, © MO ČR/HÚVG
2.1 Land Use Analysis

The land use analysis exploits the LUCC Czechia Database as a data resource. The data from the database reflect the macrostructure of the landscape. Therefore, the analysis primarily focuses on general information about changes in land use and their trends, rather than on a spatial configuration within land use categories. For more information on character of data see e.g. Břížka et al. (2000) or the website http://lucc.ic.cz/lucc_data/.

The data were analysed in a way to provide the trend of the change for selected land use categories – agricultural land, forest, water, built-up and remaining areas. In addition, the category of agricultural land was observed into more detail. Time horizon 1845 represents an initial state with which the situation in 2000 is compared.

2.2 Landscape Stability Assessment

Commonly used ecological stability coefficient \( C_{es} \) illustrates the level of ecological stability of the study area. The coefficient compares the proportion of relatively stable areas (forests, streams, etc.) with the proportion of relatively unstable areas (e.g. fields, urban areas):

\[
C_{es} = \frac{A_S}{A_U},
\]

where \( A_S \) is the area of ecologically relatively stable plots and \( A_U \) the area of ecologically unstable plots (Lipský, 2000).

To further analyse environmental conditions in the study area, the study focuses on wind and water soil erosion and provides soil erosion maps. In the last step, the ecological network was analyzed. To assess the structure and functionality of existing ecological network, the plans originated in 1990s were studied. The plans are documents of territorial planning which guide line landscape development and urbanization (Building Code 50/1976 Coll.). Founded knowledge was broadened by information from the study of Havlíček and Navrátilová (2005). The ecosystem services concept helped to investigate ecological network effectiveness present in the study area. Thus, potential effect of newly planned ecological network based on the restoration plan of Havlíček and Navrátilová (2005) was assessed.

2.3 Ecosystem Services Analysis

The ecosystem services analysis represents a tool for an assessment of the benefits people obtain from ecosystems (MA, 2005). The methodology used for the services categorization in this study follows de Groot’s (2006) approach. De Groot grouped functions and associated services in four main categories: regulation, habitat, production and information functions. Categories are defined in the following way: Regulation functions/services are essential for maintaining the conditions for life on the Earth (e.g. maintenance of clean air, water and soil, prevention of soil erosion and biological control services). Habitat functions/services relate to the spatial conditions needed to maintain biodiversity and evolutionary processes. Natural ecosystems provide refuges and reproduction habitat to species. Production functions/services (by producing biomass) supply humans with many resources ranging from food and raw materials to energy resources and genetic material. Information functions/services contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience. From the range of services potentially provided by ecosystems, those which are relevant for the ecological network were selected (Table 2). Three ecosystem types included in the assessment were permanent grassland, forests and water bodies. Undoubtedly, not solely these ecosystems provide services. However, a complex provision of services by ecosystems present in the study area was a subject of another study.

### Table 2 – Overview of the ecological network structure across municipalities in Cezava region (2009)

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Number of network components</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bičík</td>
<td>18</td>
<td>P</td>
</tr>
<tr>
<td>Kobylice</td>
<td>3</td>
<td>?</td>
</tr>
<tr>
<td>Melín</td>
<td>12</td>
<td>?</td>
</tr>
<tr>
<td>Macešnice</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Nesvačilka</td>
<td>1</td>
<td>?</td>
</tr>
<tr>
<td>Nikolice</td>
<td>1</td>
<td>?</td>
</tr>
<tr>
<td>Otmarov</td>
<td>0</td>
<td>?</td>
</tr>
<tr>
<td>Otvice</td>
<td>1</td>
<td>?</td>
</tr>
<tr>
<td>Šenkvice</td>
<td>5</td>
<td>?</td>
</tr>
<tr>
<td>Větice</td>
<td>5</td>
<td>?</td>
</tr>
<tr>
<td>Újezd u Brna</td>
<td>8</td>
<td>?</td>
</tr>
<tr>
<td>Žatčany</td>
<td>0</td>
<td>?</td>
</tr>
<tr>
<td>Židlochovice</td>
<td>13</td>
<td>3</td>
</tr>
</tbody>
</table>

P – proposed, F – functional, ? – information not available

3. Results and Discussion

3.1 Changes in Land Use

In the observed time period the study area follows the national trend of the changes in land use (Břížka et al., 2000). The area of agricultural land and water areas dropped while forest, built-up and remaining areas increased (Graph 1). Despite the reduction of the total agricultural land area, the share of arable land raised (Map 3). Agricultural collectivization in 1950s eliminated a number of meadows and pastures (Graph 2, Map 5) as well as alleys, solitaires, shrublands or balks from the landscape. Thus, the landscape structure was importantly simplified.

3.2 Impact of Intensive Land Use on the Environment

Unidirectional land use and intensive agriculture are the main common causes for environmental issues such as increased soil erosion (Map 6 and Map 7), water pollution and biodiversity loss (Havlíček and Navrátilová, 2005). The currently applied management creates a landscape with a limited ability to balance disruptive influences. These findings are supported also by outcomes from the landscape stability assessment based on an ecological stability coefficient \( C_{es} \). Map 8 shows that 12 out of 15 municipalities belong to the category of territories with maximal disruption of natural structures and no balanced landscapes occur within the area (Stable Cadastro, 2008). However, \( C_{es} \) is considered as only complementary indicator to other data because of a rough and limited informational value (Machar, 2009).

3.3 Stabilizing Capacity of the Ecological Network

In order to support ecological stability of Cezava region, the concept of ecological networks was involved in the research as a


A tool for landscape optimization. The idea of ecological networks (ENs) was developed in urban planning at the beginning of the 20th century. It is understood that size, shape and connectivity are essential factors for functioning and functionality of habitats and ecosystems. However, habitats and ecosystems over Europe are becoming smaller, more fragmented and isolated (Lawrence, 2007). Bennett (2004) defines the ecological network as a “coherent system of natural and/or semi-natural landscape elements that is configured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources”. Current ideas about ecological networks have developed into various concepts and conservation strategies in different countries. Czech ecological networks focus on two key purposes. They aim to stabilize the whole landscape by a functional zoning of landscape elements into areas, which compensate zones of intensive land use and to facilitate species dispersal and survival in the landscape. Core areas (biocentres) are interconnected by linear structures – biocorridors. Additional components of the Czech ecological networks are interactive elements. They are landscape segments, which support functioning of ecosystems in the cultural landscape, e.g. alleys.

An ecological network has already been introduced in the study area, however only partially in view of the initial proposal (Table 2). Incomplete network structure results in low connectedness. Therefore, network functionality is expected to be affected.

Havlíček and Navrátilová (2005) consider national and regional biocentres present in Cezava region as partly functional and only partly efficient or not efficient. Incomplete ecological network does not compensate intensive land use and biodiversity of the study area remains low (Havlíček and Navrátilová, 2005; Voříšek et al., 2008).

On the other hand, despite functional problems, establishment of the ecological network delivered benefits implying from the network adoption as mapping and protection of nature biotopes (Konvička et al., 2005). Structural elements of the network represent relics of nature in agricultural landscape. By their determination, many habitats were protected against transformation to arable land or built-up area. Thus, (semi)natural ecosystems remaining in the landscape further provide several services.

Even though the services provision is not limited to the ecosystems of ecological network only, this study addresses the capacity of these. Provision of ecosystem services supported by the ecological network is illustrated by Table 3.

The analysis revealed that ecological network supports and provides a number of ecosystem services despite its fragments only have been implemented in the landscape. As the study area still faces environmental problems, partial implementation of the network could be seen as an unused opportunity in the effort of landscape optimization.

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**Table 3 – Analysis of services provided by the ecological network in the study area**

<table>
<thead>
<tr>
<th>Identification of main services</th>
<th>Permanent grassland</th>
<th>Quantification of services provided by ecosystems</th>
<th>Forests</th>
<th>Water bodies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulation Services</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate regulation</td>
<td>CO₂ fixation</td>
<td>Fixation capacity depends on precipitation and species composition (Patrick et al., 2007; 0.52 t of carbon/ha/yr) (Vleeshouwers and Verhagen, 2002)</td>
<td>7 CO₂ tonnes/ha/year (Pešoutová, 2007)</td>
<td>Not estimated</td>
</tr>
<tr>
<td>Temperature and humidity regulation</td>
<td>Not estimated; support the service</td>
<td>A single large tree can transpire 450 l of water per day. This consumes 1,000 MJ of heat energy to drive the evaporation process. Thus, summer air temperature is lowered (Bolund and Hunhammar, 1999).</td>
<td>Not estimated; support the service</td>
<td></td>
</tr>
<tr>
<td>Air quality</td>
<td>Reduction of air pollution</td>
<td>Fixation of particulates</td>
<td>Mixed forest: 15 t/ha/year spruce forest: 30-45 t/ha/year (Bolund and Hunhammar, 1999)</td>
<td>Not estimated; support the service</td>
</tr>
<tr>
<td>Emission control</td>
<td>Protection against wind and water erosion</td>
<td>Emission reduced</td>
<td>Emission reduced</td>
<td>Emission reduced</td>
</tr>
<tr>
<td>Soil formation</td>
<td>Organic matter rests in the soil</td>
<td>Organic matter rests in the soil</td>
<td>Not relevant</td>
<td>Not relevant</td>
</tr>
<tr>
<td>Flood protection</td>
<td>Not estimated; support the service</td>
<td>9-18 times lower run off (Havlíček and Navrátilová, 2005)</td>
<td>90% regulated streams (flood risk reduction) (Havlíček and Navrátilová, 2005)</td>
<td></td>
</tr>
<tr>
<td>Pollination</td>
<td>Support the service</td>
<td>Support the service</td>
<td>Not relevant</td>
<td>Not relevant</td>
</tr>
<tr>
<td>Biological control</td>
<td>Support the service</td>
<td>Support the service</td>
<td>Not relevant</td>
<td>Not relevant</td>
</tr>
<tr>
<td><strong>Habitat Services</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Habitats and refuges</td>
<td>Habitats for endangered xeromorphic species</td>
<td>Refuges of wildlife Limitations on provision of the service by changed natural species composition</td>
<td>10% of original capacity to provide the service (corresponds to non-regulated streams)</td>
<td></td>
</tr>
<tr>
<td><strong>Production Services</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food provision</td>
<td>Not relevant</td>
<td>56 kg of deer meat/ha of forest (Pešoutová, 2007)</td>
<td>Forest fruits, mushrooms, herbs, game</td>
<td>Fish</td>
</tr>
<tr>
<td>Raw materials provision</td>
<td>Fodder, hay, other organic matter</td>
<td>13.5 m³ of timber/ha of forest (Pešoutová, 2007)</td>
<td>Source of mineral water “Šaratica” (two localities of collection)</td>
<td></td>
</tr>
<tr>
<td>Ornamental species</td>
<td>Not estimated</td>
<td>Sculls, leather, attires</td>
<td>Not estimated</td>
<td>Not estimated</td>
</tr>
<tr>
<td><strong>Information Services</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Historical heritage</td>
<td>Slavkov Battlefield (location of Battle of Austerlitz)</td>
<td>Not relevant</td>
<td>Source of mineral water “Šaratica”</td>
<td></td>
</tr>
<tr>
<td>Tourism and recreation</td>
<td>Biking trails</td>
<td>87 visitors/year/ha (Ministry of Agriculture, 2009)</td>
<td>Fishing</td>
<td></td>
</tr>
<tr>
<td>Mental restoration</td>
<td>Limited capacity to provide the service</td>
<td>Great capacity to provide the service (Kaplan and Kaplan, 1990)</td>
<td>Limited capacity to provide the service</td>
<td></td>
</tr>
</tbody>
</table>
1 — maximal disruption of natural structures
2 — obvious disruption of natural structures
3 — intensive utilization (mainly agricultural)
4 — balanced landscapes

0 2 km

Cezava region

Map 8 — Ecological stability of the landscape in the Cezava region based on the coefficient of ecological stability $C_{EC}$ (Stable Cadastre, 2008)

Map 6 — Vulnerability of the study area to wind erosion (Havlíček and Navrátilová, 2005)

Map 7 — Vulnerability of the study area to water erosion (Havlíček and Navrátilová, 2005 and Janeček et al., 2007)
3.4 Landscape Stability Optimization

In response to limitations of existing ecological network and overall low ecological stability of Cezava, the study suggests to increase a number of rehabilitation measures in the area. A number of ecosystem services in the landscape needs to be enlarged at the expense of arable land. Taking into account natural characteristics of the study area, three main types of suitable arrangements are the enhancement of the area of permanent grassland, reintroduction of water bodies (e.g. ponds) in the landscape and forestation by native species. All these ecosystem types represent stabilizing components for the landscape. According to the land use analysis, permanent grassland have dropped to 6%, water areas have been reduced to 31% and forest areas have doubled size since 1845. When following the proportions of reduction since 19th century up today, areas of permanent grassland and water areas should be increased the most. However, other factors like the current land use (mainly increase of urban areas and infrastructure) or economical and social conditions need to be respected.

The suggestion how to increase/decrease proportions of particular ecosystems was introduced by the Restoration plan worked out by Havlíček and Navrátilová (2005). They suggest to reduce the area of agricultural land by 20% and increase the area of permanent grassland (by 13%), forests (by 8%) and water bodies (by 2%) and to develop an ecological network (Table 4).

The following paragraph discusses potential effect of the Restoration plan (Havlíček and Navrátilová, 2005) on the ecosystem services provision. Regulation, habitat and cultural services are expected to be improved. Because of data constraints, the quantification of improvement was not feasible except for few services. For example, forests would be enlarged by 720 ha. Thus, annual CO2 fixation by forests could be increased by about 5,000 t. In addition, there should be approximately 40,000 kg more of deer meat, 97,200 m³ more of timber and about 60,000 more visitors in forests every year. Food provision is a service which is going to decline with the reduction of the area of arable land. By arable land reduction of 20%, average annual crops yield would drop by about 28,200 t (taking into account average yield 9.4 t/ha). Nevertheless, this reduction in food provision should not influence food availability, because of the ongoing agricultural overproduction in Czechia (Ministry of Agriculture, 2009).

4. Conclusion

The study analyzed the influence of intensive agricultural land use in Cezava region on the quality of the environment and assessed the effect of optimization measures. Intensive agriculture in Cezava triggered several environmental problems such as soil erosion, water pollution and biodiversity loss (Havlíček and Navrátilová, 2005). The landscape stability is negatively affected as well. Thus, the provision of regulation, habitat and cultural services are limited. As the services are substantial for human well-being (MA, 2005), the effect of optimization measures on them was examined. The results of the integrated landscape assessment suggest enlargement of the scale of landscape optimization measures in a way appropriate to the intensive agricultural use. Consequently, regulation, habitat and cultural services are expected to be improved. The provision service would be reduced, nevertheless with no negative effect on food availability.

From the methodological point of view the study reveals the potential of the approach, which combines long-term land use changes and the concept of ecosystem services, for the integrated assessment of landscape restoration. However, uncertainties introduced in the research need to be considered. The outputs of ecosystem services analysis are often limited by quantitative data and knowledge scarcity. Complex processes in the ecosystems are not completely understood so far as well as synergies and interdependencies in the systems. This can importantly influence the reliability of results.

From a practical point of view, financial costs are a key factor influencing the establishment of new ecological network and supporting rehabilitation measures. The proposal of the ecological network, water management, reforestation and grassing overreach 60 million EUR (the exchange rate of CZK and EUR used here refers to the average annual exchange rate in 2005, as the restoration plan was submitted in 2005) (Pešoutová, 2007). Relevant ministries for the potential financial support are Ministry of the Environment, Ministry of Agriculture, Ministry of Regional Development and Ministry of Culture (e.g. for the Landscape Heritage Zones). The reintroduction of the ecostabilizing elements in the landscape is also motivated by several subsidizing programs, e.g. European Agricultural Fund for Rural Development (EAFRD), Natural Environment Care Program (Program péče o přírodní prostředí), Landscape Care Program (Program péče o krajinu) and others. These programs offer the agricultural enterprises and farmers to participate in the maintenance and renovation of rural landscape.

Financial expenditures on landscape optimization measures should not be seen solely as costs but preferably as investments. From a long-term perspective it is probable that implemented measures could avoid or reduce costs of erosion control, water treatments or air clearance. Further, they may significantly support other regulating, habitat and cultural landscape services and thus contribute to improvement of ecological stability of the study area. To support this, further analysis (e.g. cost-benefit analysis) is necessary.

In addition, landscape rehabilitation is a process with social impact. Therefore, key stakeholders from natural, social and economical fields potentially affected by the implementation of the restoration plan should be involved in the decision making process. The rational decision making is desirable in the planning process, otherwise the method is less effective (Opdam et al., 2006). In this process, the concept of ecosystem services could help as it bridges natural and social science. Identification of numerous benefits to diverse stakeholder groups may introduce "common language" and thus facilitate communication during negotiations.

<table>
<thead>
<tr>
<th>Ecosystems</th>
<th>Current proportion (ha)</th>
<th>Suggested proportion (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable land</td>
<td>11,432.00</td>
<td>+2,001.00</td>
</tr>
<tr>
<td>Permanent grassland</td>
<td>114.00</td>
<td>+721.00</td>
</tr>
<tr>
<td>Forests</td>
<td>747.00</td>
<td>+279.00</td>
</tr>
<tr>
<td>Water bodies</td>
<td>40.00</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 – Comparison of current and suggested proportions of ecosystems in the study area (according to the Restoration plan of Havlíček and Navrátilová, 2005)
Acknowledgement

The study is based on my thesis research, which was part of my study in Environmental Sciences at the Environmental Systems Analysis Group (ESA), Wageningen University, the Netherlands. The LUCC Czechia database, utilized during the research, was supported by the Grant Agency of the Czech Republic, GAČR 205/09/0995 “Regional differentiation and possible risks of land use as a reflection of functional changes of landscape in Czechia 1990–2010”. The research was also supported by Grant Agency of Charles University in Prague, research grant number 353911, and by project CzechGlobe – Centre for Global Climate Change Impacts Studies, Reg. No. CZ.1.05/1.1.00/02.0073.

References


Trend of Changes in Czechia’s and Slovakia’s Artificial Surfaces (1990–2006) Represented on a Map

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²GISAT s. r. o., Prague, Czechia
Introduction

Under the pan-European CORINE Land Cover (CLC) 1990, CLC 2000 and CLC 2006 projects land cover changes which demonstrate spatial distribution of the effect of human activities on landscape were identified. The change in favour of artificial surfaces is considered as one of the most important. Information about changes in extension of artificial surfaces obtained through CLC projects is also accessible for Slovakia and Czechia. Graphic outputs – areas of changed land cover classes in favour of artificial surfaces are presentable by means of thematic maps (Feranec and Nováček, 2007).

Projects devoted to the subject, such as ESA GSE projects – the Soil Service for the Provision of Advanced Geoinformation on Environmental Pressure and State (SoilSAGE) project; the Global Monitoring for Environment and Security (GMES) Urban Services (GUS) project or the GMES Service Element (GSE) Land Monitoring project as well as the JRC the Monitoring Urban Dynamics (MURBANDY) project; the Monitoring Land Use-Cover Change Dynamics (MOLAND) project (Burghardt et al., 2004) also confirm that the question of expanding soil sealed areas is gaining an increased attention. The GMES Fast Track Service Precursor on Land Monitoring (Kopecky and Kahabka, 2009) project deserves a special mention as it established a soil sealing survey at 100 × 100 m resolution covering 38 European states (27 EU Members States and 11 neighbouring states) divided into five classes: 0–29%, 30–49%, 50–79%, 80–99%, 100%. The fact that soil sealing/impermeable areas is one of the subjects implemented in the form of High Resolution Layers (HRL) under the GMES Initial Operation (GIO) (http://ec.europa.eu/enterprise/newsroom/cf/itemdetail.cfm?item_id=5343&lang=en) confirms the need for fresh information about soil sealing (Feranec and Soukup, in print).

As map is among the most suitable means to document changes in artificial surfaces, one possible way of map compilation in the pan-European context is demonstrated in the study Feranec and Soukup (in print). The study is based on use of CLC data that are widely accessible for map presentation of the changing artificial surfaces in Europe. The term “artificial surfaces” (bearing “1” in CLC classes, see Tab. 1) denotes artificial, impermeable surfaces also referred to as “soil sealed”. In our studies (Feranec et al., 2010; Feranec and Soukup in print), characteristics of changes in artificial surfaces, including soil sealing, are integrated into a common term of “land cover flow urbanization” (LCFU). Different intensities of LCFUs make it possible to record and represent their occurrence on an area of 5 ha and larger on a map at a small scale.

The aim of the study is to demonstrate the trend of LCFU changes focusing on spatial pattern and intensity in Slovakia and Czechia in the years 1990–2000 and 2000–2006 by means of maps.

Approach and methods

All data concerning spatial distribution and the areas of CLC1990, CLC2000, along with the CLC2006 classes and their changes are available at http://terrestrial.eionet.eu.int CLC nomenclature (Heymann et al., 1994; Bossard et al., 2000; see Tab. 1). Identified LC changes that were associated with the process of artificial surfaces formation, which is considered part of urbanization (change of agricultural areas, forest and semi-natural areas into artificial areas) and are referred to as the LC flow urbanization (LCFU) were selected. The LCFU – a flow which represents the change of agricultural (classes 21, 22 and 23) and forest land (classes 31, 32 and 33), wetlands (classes 41 and 42) and water bodies (51 and 52) into urbanized land (the construction of buildings designated for living, education, health care, recreation and sport) as well as industrialized land (construction of facilities for the production, all forms of transport and electric power generation) is discussed in Feranec et al. (2010). Specific changed areas of artificial surfaces are mostly too small (e.g. the smallest identified change area in the frame of the CLC mapping is 5 ha) to be presented on a map either on the national or on the European level. A practical solution how to “visualize” such small areas of change is the presentation of their intensity through a regular grid pattern. Following the study by Feranec et al. (2010), the 3 × 3 km grid has been used as a compromise between the actual spatial distribution of changes concerning processes of urbanisation, intensification of agriculture, extensification of agriculture, afforestation, deforestation, construction of water bodies and their presentation on the European level at an accessible scale. The mean LCFU value presented on maps of Czechia and Slovakia was calculated by summing up all areas within the 1 × 1 km squares that are characterised by this specific LCF, divided by the number of 1 × 1 km squares where such changes took place – the mean value of LCFU 1990–2000 was 12.9% and LCFU 2000–2006 was 10.2%.

The obtained value of LCFU change in the square was compared with the mean change value of the particular LCFU and it was assigned red colour hues if the percentage of the changed parts was greater than the mean change value, or hues of blue if the percentage of the changed parts was smaller than the mean change value (see Fig. 1) as follows:

G1–G2: LCFU above mean value – LCFU above mean value
S1–G2: LCFU below mean value – LCFU above mean value
N1–G2: Without LCFU – LCFU above mean value
S1–S2: LCFU below mean value – LCFU below mean value
N1–S2: Without LCFU – LCFU below mean value
G1–S2: LCFU above mean value – LCFU below mean value
G1–N2: LCFU above mean value – Without LCFU
S1–N2: LCFU below mean value – Without LCFU
N1–N2: Without LCFU – Without LCFU

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Trend of Changes in Czechia’s and Slovakia’s Artificial Surfaces (1990–2006) Represented on a Map

G1–G2: LCFU above mean value – LCFU above mean value
S1–G2: LCFU below mean value – LCFU above mean value
N1–G2: Without LCFU – LCFU above mean value
S1–S2: LCFU below mean value – LCFU below mean value
N1–S2: Without LCFU – LCFU below mean value
G1–S2: LCFU above mean value – LCFU below mean value
G1–N2: LCFU above mean value – Without LCFU
S1–N2: LCFU below mean value – Without LCFU
N1–N2: Without LCFU – Without LCFU
Fig. 1 – Changes of LCU (artificial surfaces) in Czechia and Slovakia in 1990-2000-2006.
Table 1 – CLC nomenclature

<table>
<thead>
<tr>
<th>Artificial surfaces</th>
<th>Forest and semi-natural areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Urban fabric</td>
<td>37 Forests</td>
</tr>
<tr>
<td>111 Continuous urban fabric</td>
<td>311 Broad-leaved forests</td>
</tr>
<tr>
<td>112 Discontinuous urban fabric</td>
<td>312 Coniferous forests</td>
</tr>
<tr>
<td>12 Industrial and commercial transport units</td>
<td>313 Mixed forests</td>
</tr>
<tr>
<td>121 Industrial or commercial units</td>
<td>32 Shrub and/or herbaceous vegetation associations</td>
</tr>
<tr>
<td>122 Road and rail networks and associated land</td>
<td>321 Natural grassland</td>
</tr>
<tr>
<td>123 Port areas</td>
<td>322 Moors and heathland</td>
</tr>
<tr>
<td>124 Airports</td>
<td>323 Sclerophyllous vegetation</td>
</tr>
<tr>
<td>13 Mine, dump and construction sites</td>
<td>324 Transitional woodland-shrub</td>
</tr>
<tr>
<td>131 Mineral extraction sites</td>
<td>33 Open spaces with little or no vegetation</td>
</tr>
<tr>
<td>132 Dump sites</td>
<td>331 Beaches, dunes, sands</td>
</tr>
<tr>
<td>133 Construction sites</td>
<td>332 Bare rocks</td>
</tr>
<tr>
<td>14 Artificial, non-agricultural vegetated areas</td>
<td>333 Sparserly vegetated areas</td>
</tr>
<tr>
<td>141 Green urban areas</td>
<td>334 Burnt areas</td>
</tr>
<tr>
<td>142 Sport and leisure facilities</td>
<td>335 Glaciers and perpetual snow</td>
</tr>
<tr>
<td>2 Agricultural areas</td>
<td>4 Wetlands</td>
</tr>
<tr>
<td>21 Arable land</td>
<td>41 Inland wetlands</td>
</tr>
<tr>
<td>211 Non-irrigated arable land</td>
<td>411 Inland marshes</td>
</tr>
<tr>
<td>212 Permanently irrigated land</td>
<td>412 Peat bogs</td>
</tr>
<tr>
<td>213 Rice fields</td>
<td>42 Maritime wetlands</td>
</tr>
<tr>
<td>22 Permanent crops</td>
<td>421 Salt marshes</td>
</tr>
<tr>
<td>221 Vineyards</td>
<td>422 Salines</td>
</tr>
<tr>
<td>222 Fruit trees and berry plantations</td>
<td>423 Intertidal flats</td>
</tr>
<tr>
<td>223 Olive groves</td>
<td>5 Water bodies</td>
</tr>
<tr>
<td>23 Pastures</td>
<td>51 Inland waters</td>
</tr>
<tr>
<td>231 Pastures</td>
<td>511 Water courses</td>
</tr>
<tr>
<td>24 Heterogenous agricultural areas</td>
<td>512 Water bodies</td>
</tr>
<tr>
<td>241 Annual crops associated with permanent crops</td>
<td>52 Marine waters</td>
</tr>
<tr>
<td>242 Complex cultivation pattern</td>
<td>521 Coastal lagoons</td>
</tr>
<tr>
<td>243 Land principally occupied by agriculture, with significant areas of natural vegetation</td>
<td>522 Estuaries</td>
</tr>
<tr>
<td>244 Agro-forestry areas</td>
<td>523 Sea and ocean</td>
</tr>
</tbody>
</table>

Source: Heymann et al. (1994), Bossard et al. (2000)

Results

The approach of colour differentiation used in the map (see Fig. 1) makes it possible to perceive two basic LCFU trends in Slovakia and Czechia in 1996–2000 and 2000–2006 periods:

G1–G2, S1–G2, N1–G2, S1–S2 (red colour hues) – enlargement or standstill of the LCFU – changes characterized by the change of the LCFU rate that expanded during the second time horizon (2000–2006), or was the same in both time horizons (but did not diminish; see Fig. 1). This type of changes covers:

– Western, northern and eastern peripheries of Prague (residential construction), environs of Liberec (residential and construction areas), Ústí nad Labem (industrial & road construction), Most, Chomutov, Karlovy Vary and Plzeň (with stable share of residential, commercial construction), Hradec Králové (dominated by the construction of the new WSWM communication to Prague) and Pardubice, České Budějovice and Brno (again dominated by residential constructions), Hranice (presumably construction of a communication) and Ostrava (dominated by industrial and commercial area sprawl) in Czechia (see Fig. 1).

– Eastern and north-eastern environs of Bratislava, central and upper Považie and eastern parts of Liptovská and Popradská Basins (where LCFU increased due to construction of the motorway, centres of logistic and residential quarters); environs of Trnava and Žilina (newly artificial surfaces of KIA and Peugeot-Citroën car factories); upper Považie, eastern part of the Liptovská and Popradská Basins (construction sites changed in favour of road and rail networks and associated land – 122 and discontinuous urban fabric – 112); in Slovakia as a whole with distinct dominance of its western part (enlargement of 112 areas) in Slovakia (see Fig. 1).

G1–S2, G1–N2, S1–N2 (light blue to dark blue hues) – decrease of the LCFU rate – decrease in the period of 2000–2006 compared to the period 1990–2000. The symptoms of the decreased LCFU rate (see Fig. 1) are most distinguishable:

– In the southern and north-western periphery of Prague, southern environs of Chomutov and Karlovy Vary and almost all around Olomouc in Czechia (see Fig. 1).

– Especially in the western and south-western parts of Záhorie, south-east of Bratislava, central Považie, upper Ponitrie, between Zvolen and Banská Bystrica, in the eastern part of the country, environs of Prešov, Košice and Humenné in Slovakia (see Fig. 1).

Tab. 2 brings the summarizing statistical picture of the LCFU increasing trend in Czechia and Slovakia in 1990–2006. It reveals a rather distinct increase of artificial surfaces in two periods 1990–2000 – in ten years (by 11,239 ha, annual average 1,124 ha) and in 2000–2006 – in six years (13,256 ha, annual average 2,209 ha) in Czechia where the average annual changes of LCFU almost doubled compared to the first increase (by 96.5%, equaling to 1,085 ha a year). It should be noted that the pan-European trend corresponded to only 16.4% of annual LCFU change in the second period.

LCFU in Slovakia increased by 5,338 ha (annual average 534 ha) in 1990–2000. In the second, 2000–2006 period, the
LCFU increased only by 3,300 ha (annual average 550 ha), which compared to the previous period was only 16 ha (3%) a year. This average LCFU trend of increase in Slovakia was distinctly below the European annual average of 16.4% (see Tab. 2).

Conclusions

Mean annual increase of LCFU for the two study periods in Czechia was pronounced (96.5%). On the contrary, it was almost balanced (3%) in Slovakia.

Average annual increase of LCFU (96.5%) in Czechia dwarfed the European trend (16.4%) almost six times. Average annual increase of LCFU in Slovakia (3%) represented only one fifth of the pan-European trend (16.4%) in compared periods.

The applied means of expression for the map at small scale, which was the difference in colour hue fulfils two functions, that of identification and that of classification which made it possible to discern the basic trends of LCFU expansion in Czechia and Slovakia in the period in question (although Kraak and Ormeling, 1996 assert that colour hues only stand for qualitative differences between objects).

Map presentation of the changed LCFU, their spatial distribution and their intensity may represent a valuable source for the identification and assessment of factors causing landscape changes, not only from the research but also the applied points of view. Apart from enriching thematic cartography, it has certainly proved to be useful in environmental planning.

Acknowledgement

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References


The Utilisation of Relative Development Index in the Assessment of Land Use in Czechia 1845–2000

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The Utilisation of Relative Development Index in the Assessment of Land Use in Czechia 1845–2000

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1. Introduction

1.1 Research on land use in literature

Recently, similarly as in past quarter of century, the analysis of land use changes has received a new impetus and is being developed further. We can witness an increase in the number of completed important international projects dealing with nature–society interactions in the long-term perspective at the macro-regional level or even in global setting. Very inspiring for the study of long-term land use changes are the publications of Turner II, Meyer (1994) and Douglas, Huggett, Robinson (eds 1997, again 2002). Both publications present considerations from the entire range of geographical and other disciplines and examine global changes of the environment and the role of human society in these changes (Global Change).

At more general level, it is necessary to recall the idea of Hampl (1998), who differentiated three basic phases of nature – society interactions, dominated either by the determination or the competition or the cooperation. They correspond to different stages in the evolution of human society, where a gradual release of the society from external determinations by natural conditions and evolution of new sorts of internal (social) or external (socially geographical) organization is under way.

During the 1980s the mapping of land use, which was usually focused on the situation of agriculture, got a new impulse in the form of topics dealing with the interaction of nature and society in time that shifted traditional land use to a new concept, as a means of expressing the changes of this interaction in time. A detailed mapping of large areas of the Earth’s surface became possible, quickly and repeatedly, thanks to the development of remote sensors. The development of land use mapping using new resources made it possible to compare more effectively the state of the land cover at different time periods. Some examples of these types of studies – more recent where the remote sensing and GIS methods are interconnected, published for example by Wastenson et al. (1981), Seger (1994), Hyltén, Uggla (2000) and others. In Czechia these studies include Šíma and Tollinger (1996), Feranec and Ofařeh (2000), Lipský (1999), Kupková (2001) and many others. Derek et al. (2001) states that geography is characterized primarily by the interest of its individual disciplines studying landscape elements in two main sub-complexes – physical and human. Their mutual interconnection is weak and there are only a few topics where they converge. However, the issue of environment in a broader sense, including, among others, land use, is one of them.

The key academic terms that appear in relation to the development of modern technologies are “land cover” and “land use”. Of crucial importance is that society, depending on its level of development assigns specific functions to various elements of the landscape and these are subject to change over time. This then creates pressure on the transformation of land cover and land use. Human society has become one of the decisive factors of landscape change in large areas of the world and certainly the most significant factor, when compared to natural forces, in changes occurring over short-term periods of time. Himiyama (2002) sees the relationship between socio-economic changes, environmental changes (expressed by using land cover) and land use changes as an interconnected triangle of mutual relationships working in both ways.

The term land use went through long development from its introduction to science by Stamp (1948). First of all the content of this term has been expanded. Currently, British and American geography includes in this term not only the classification of the types of land use but also its ownership, problems connected with the transformation of the function of a region, development of certain regional units, environmental protection, and perhaps also other activities connected to land and its use. On the contrary, the term “land survey” as Derek et al. (2001, p. 432) characterizes it is much closer to our understanding of the term land use. He characterizes land survey (the evidence of the use and ownership of land) as “observing and cartographical presentation of land use mapping” ... and “as strictly descriptive practices that were preferred by geographers for a long time in the initial phase of land use development and the subsequent planning of urban and rural regions”.

Land use changes have been analysed by research on all spatial levels after 2000 by looking for the driving forces that cause these changes. A little bit later, the DPSIR concept appears (Smeets, Weterings, 1999; Feranec, Ofařeh, 2000 and others). This concept denotes social and economic development – primarily the growing population and its consumption of resources – as the main driving force creating pressure on the surrounding environment. Because of this, the state of the environment changes either gradually or intermittently, which leads to impacts on human health as well as on the Earth’s ecosystems. These impacts may evoke, usually in developed societies, a response which may lead to the regulation or even to the elimination of the forces causing these changes.

1.2 Assessment of land use in Czechia

In the past 20 years, our efforts have been focused on the analysis of a very valuable and detailed map (scale 1:2,880) and table materials from the Land Registry archives. The oldest data, which originally include over 50 categories of land use reach back to 1826–1834. Also available is data from years 1948, 1990 and 2000 (with fewer categories). This data covers two of Hampl’s phases: competition and cooperation. We have published a variety of articles, maps and comparisons of regional differentiation of land use in Czechia, also in regard to other countries (Bíčík, Jeleček, Štôpánek, 2001; Bíčík, Kupková, 2001;
The research into long-term changes of LU in Czechia and especially the search for their common driving forces is based on statistical and cartographic analysis of the written materials compiled by the Land Registry office. This method has one great advantage when compared with others (e.g. remote sensing). It enables us to work with a longer time-frame (about 170 years), which can differentiate according to the character and intensity of the human driving forces. This method of historical (dynamic) land use study has a scope of 13,000 cadastre units of Czechia. The data has been adjusted so that the structure of land use (8 categories) and size of individual units were comparable throughout the entire observed time horizon. This adjustment then produced 8,903 comparable units ("sravnitelné územní jednotky" in Czech, basic territorial units, further BTU), 65% of which are composed of one cadastre unit, in other cases, two or three (or more) cadastre units had to be combined to ensure spatial comparability. This resulting database then allowed us to work with relatively accurate and most importantly comparable numerical information. (We analyse the summary data for BTU, without having to look at changes of spatial distribution of categories within individual units.)

A second great advantage of working with historical land use data is the possibility to compare the differences of land use structure in each BTU in two or more time-frames. This enabled an analysis of changes occurring from one time-frame to another and the observation of these differences in terms of land use development and the extent of individual categories.

This method does, of course, have certain disadvantages, as well, since is does not allow for a satisfactory analysis of the changes of the extent of individual categories within BTU. This becomes especially poignant when attempting a geo-ecological analysis of small-scale areas. It does also, however, represent a first level of generalisation on the structural changes of the distribution of land in the chosen categories, which illuminates general trends across larger administratively or naturally defined areas.

The data on land use according to the cadastral database do fortunately often relate to important historical developments of Czech 19th and 20th century history. An overview of the summary changes between selected categories in Czechia is compiled in Table 1.

Data from 1845 are heavily bound with the upcoming bourgeois revolution of 1848/9, which paved the way for capitalist market economy, the industrial revolution, released agriculture from the yoke of serfdom and enabled the progress towards a democratic and civic state. Time distances between the surveys are 155 years (1845–2000) and 10 years (1990–2000) respectively. Between the years 1845 and 1990, Czechia was affected by a number of historical events of political and economic significance (the birth of independent Czechoslovakia 1918, the Munich dictate, the displacement of Czech Germans and the ascension of the communist party after 1945), which influenced the economy and had a profound effect on the use of land. The most important of these was 1948, when the communist party seized power and started a radical transformation of industry and connected land use. The period between 1990 and 2000 then represents a decade of far reaching changes, including the return of land ownership and a capital transformation of agriculture (which is the economic sector most influencing the structure of land use), as well as other parts of the industry. It is also a period preceding the country’s accession to the EU, after a prolonged and sometimes problematic negotiation process, which also influenced Czech agriculture (Jančák, Götz, 1996; Bičík, Jančák, 2005).

The following article is focused on an analysis of the state of development of land in Czechia, based on a special index, called the Relative Development Index. This index has not been used in our publications until now. With the use of the index, we would like to confirm the following hypotheses:

**Hypothesis 1:** The development of the socioeconomic sphere leads to a concentration of activity in lower altitudes, despite these offering the best conditions for agriculture. The outcome is a rather intensive appropriation of arable land and the agricultural land stock and their transformation into built-up areas and so-called remaining areas.

**Hypothesis 2:** The development of transport/interconnection enables regional differentiation of agriculture effectiveness. Utilisation of arable land of limited quality becomes unsustainable and the land moves to the categories of permanent grassland and forest areas.

**Hypothesis 3:** The displacement of Czech Germans in 1945–47 accentuated the differentiation of land use in Czechia. Most of these areas, which had been settled by this group prior to their displacement, now show a significant degree of decline of intensive economic activity and a transformation of land into permanent grassland and forest areas than the country’s interior.

### 2. Methodology

The utilised development index enables us to assess the changes in the extent of land in each category. The development index is relativised in relation to the development in a hierarchically superior entity (in our case the development of the given category in the whole of Czechia) in the following way:

\[
RV_{uA-B} = \frac{P_{uB} \times C_{iA}}{P_u \times C_{iB}}
\]

\[
(P_u) is the share of the category at the beginning of the observed period and \(P_u\) at its end for a given BTU, and \(C_{iA}\) is the share of the category at the beginning of the observed period and \(C_{iB}\) at its end for a given superior unit – e.g. Czechia).

The indicator does not have any units. If the value of the index is equal to 1, then the same relative change occurred in the BTU and in the whole of Czechia. If the value exceeds 1 and the given category increased in the country, then the selected BTU experienced an even stronger increase; if the category declined in the country, it declined less, or perhaps even increased in the BTU. If the value of the index is below 1 and the whole country experienced an increase in the category, then the share of the

### Table 1 – Development of the structure of land use in Czechia between 1845 and 2010 – the share of individual categories in %

<table>
<thead>
<tr>
<th>Year</th>
<th>Forest areas</th>
<th>Permanent grassland areas</th>
<th>Arable land cultures</th>
<th>Permanent cultures</th>
<th>Other areas</th>
<th>Built-up areas</th>
<th>Remaining areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1845</td>
<td>28.8</td>
<td>17.6</td>
<td>48.2</td>
<td>1.1</td>
<td>4.3</td>
<td>0.6</td>
<td>2.8</td>
</tr>
<tr>
<td>1882</td>
<td>28.9</td>
<td>14.2</td>
<td>51.7</td>
<td>1.5</td>
<td>3.7</td>
<td>0.7</td>
<td>2.5</td>
</tr>
<tr>
<td>1896</td>
<td>28.9</td>
<td>14.2</td>
<td>51.4</td>
<td>1.5</td>
<td>3.8</td>
<td>0.7</td>
<td>2.6</td>
</tr>
<tr>
<td>1929</td>
<td>30.0</td>
<td>13.3</td>
<td>50.6</td>
<td>1.5</td>
<td>4.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1948</td>
<td>30.2</td>
<td>12.9</td>
<td>49.1</td>
<td>1.9</td>
<td>5.1</td>
<td>1.1</td>
<td>3.4</td>
</tr>
<tr>
<td>1970</td>
<td>31.0</td>
<td>11.8</td>
<td>42.1</td>
<td>2.7</td>
<td>10.4</td>
<td>1.4</td>
<td>8.3</td>
</tr>
<tr>
<td>1990</td>
<td>33.3</td>
<td>10.5</td>
<td>41.9</td>
<td>2.9</td>
<td>12.3</td>
<td>1.6</td>
<td>8.6</td>
</tr>
<tr>
<td>1995</td>
<td>33.3</td>
<td>11.3</td>
<td>40.0</td>
<td>–</td>
<td>12.4</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2000</td>
<td>33.4</td>
<td>12.0</td>
<td>39.3</td>
<td>3.0</td>
<td>12.3</td>
<td>1.6</td>
<td>8.6</td>
</tr>
<tr>
<td>2010</td>
<td>33.7</td>
<td>12.5</td>
<td>38.1</td>
<td>3.1</td>
<td>12.6</td>
<td>1.7</td>
<td>8.9</td>
</tr>
</tbody>
</table>

Adjusted by Jeleček (1995)
category increased less, or even declined, in the selected BTU, if Czechia experienced a decline in the category, then the share of the category declined even more in the BTU.

Even the Relative Development Index can be zero, or display very high values; however, the presence of extremes is limited by this "gelatinisation". The factual development, however, that is, if there was an actual increase/decline of the share and extent of land covered by the specified category, cannot be successfully discerned from the Relative Development Index.

This index represents a common statistical method used to assess regional differentiation of a large number of units in terms of their changes compared to a superior whole (region, drainage basin, state etc.). A development of the selected phenomenon (in this instance land use according to specified categories) in a larger area usually displays varied tendencies, different, sometimes even contradictory trends of development in its individual parts. This is exactly the case when it comes to the use of land, where several categories reveal very different tendencies in terms of their extent of coverage across the individual units composing the whole.

A characteristic feature, which relates not only to Czechia, is that the smaller the units chosen for analysis, the greater the regional differentiation displayed. Land units of a higher order then show less differentiation than their predecessors, because of the aforementioned contradictory trends across categories.

In this article, we decided to focus primarily on three categories of land use in the time frames of differing length, 1845–2000 and 1990–2000. The choice of these two time frames is inspired by the desire to compare long-term trends with those seen in the first ten years of economic transformation process. Of the land use categories, we selected those which seemed to be most significant in the majority of the BTUs – arable land – the changes of which have been dynamic in the last two centuries and have accelerated after WWII, built-up areas and remaining areas. On a state level, arable land continues to shrink in size since the end of the 19th century. The dynamics of the increase of built-up areas is a key indicator of socioeconomic development of areal units, even though the extent of land marked as developed continuously to rise in virtually all BTUs. The third observed category is remaining areas, which, albeit internally quite heterogeneous, constitutes the most significant category in most BTUs in terms of the development index.

Individual categories are defined in the following way:

1) Arable land (AL)
   a) lots with permanent use for cultivation of different plants as grains, tubers, feed plants, technical plants, vegetables and other garden plants usually in specifically sown formations
   b) lots which are temporarily grassed (some years feed plants or arable land temporarily used as meadows)
   c) greenhouses, hot-beds, Japan houses built on arable land

2) Built-up areas (BA)
   a) lots with buildings (without greenhouses)
   b) courts as a part of inhabited, industrial or farm buildings as its integral parts

3) Remaining areas (RA) – all lots without order of agricultural or above named areas of nonagricultural use
   a) stores and workshop areas (especially lots without fences or fenced by buildings), lots for construction if they are now out of agricultural use and can be used for other activity (stores areas etc.)
   b) lots for transport/streets, soft fields but stable ways, squares, roads, highways and railroad bodies (or for telecommunication purposes / radio, TV, mobile phones, etc.)
   c) built-up areas for health services, sports and recreation (swimming pools, open air sport grounds, hippodromes etc.) and recreational areas surrounding hotels and boarding houses (areas for ball games, sun bathing etc.)
   d) preserved areas or other reservations defined by laws, areas of cultural heritage if these areas are not agricultural or forest lands
   e) parks, public gardens, private decorative gardens
   f) mines and of mine care zones (peat, sand, stone, ore mines, areas devastated by mining)
   g) deposits for rests from mining, areas for handling of goods, raw materials, hard cover areas for move of farms animals etc.
   h) cemeteries
   i) lots without opportunities for agricultural use (gorges, stone dams and fences), land with sand or stones without trees or shrubs, watered areas, areas out of use, areas of avalanche paths etc.

3. Results
3.1 Arable land

An important indicator in the use of the Relative Development Index is the land share of the given category at the three points in time observed for the whole of Czechia. In 1845, arable land constituted 48.2% of the total land share of Czechia, in 1990 this share dropped to 41.0%, in 2000 it was 39.3% and in the last year for which information is available, 2010, the share declined further to 38.1%.

The diagram of the relative development of the share of land covered by arable land in 1845–2000 points to major differences in the development of arable land share across the 8,903 BTUs. A logical and obvious outcome is the decline of the share of AL in the main centres of socioeconomic development (cores), such as Prague, Ostrava, Brno, Plzeň or Zlín, where the industrial base kept developing over the entire observed period, as well as other places, which experienced significant growth after WWII (eg. basins at the foot of the Krušné hory mountains).

Another type of area with a significant loss of AL are borderlands whose population diminished after the war, and which have a minimum of industry and unfavourable conditions for agriculture (Šumperkso, Bruntálsko, Šumava).

Significant losses of arable land are concentrated in the northern half of Czechia, where the displacement of Czech Germans had profound consequences. Industry (textile, glassmaking – eg. Liberecko, Podkrkonoš, at the foothills of the Orlické hory mountains) located in this area attracted sufficient workforce into the cities, but less the countryside. This is why the decline of traditional behaviour patterns of local inhabitants (factory employment in the morning, work at the farm in the afternoon) translated into a loss of arable land and later to an overall loss of land used for agriculture (meadows and pastures).

The aforementioned shrinking of the arable land in those areas exceeds for many BTUs the average situation of the observed whole 50 times. Of interest is the increase of the share of AL (clear from other results produced from our database), especially in the most fertile areas, which experienced long-term efforts to adjust water flows, dry up marshlands and drain ponds, mostly along the rivers Labe and Vltava. These trends have been pointed out in detailed studies by Bíček et al. (2010).

In the first decade of the economic transformation 1990–2000, the changes in the share of arable land were not particularly...
Fig. 1 – The Relative Development Index (in %) – arable land – period 1845–2000
Source: LUCC Czechia (www.lucc.ic.cz)

Fig. 2 – The Relative Development Index (in %) – arable land – period 1990–2000
Source: LUCC Czechia (www.lucc.ic.cz)
significant, yet the decline continued. The areas with significant losses (see Figure 2) are again concentrated in the borderland mountainous and foothill regions suffering from depopulation and the associated deterioration of the age, social and educational population structure. Most BTUs with the greatest loss of arable land in this period are located at the inner foothills of the border mountains of the southwest and northwest of Bohemia. The transformation decade has of course brought about much less profound decline in the share of arable land then the previously examined period of 155 years.

Increase in the share of arable land occurred in only 36.5% of BTUs between 1990–2000. This implies that almost two thirds of the units saw a loss of arable land!

The most significant areas with an increase of the extent of arable land in this decade of economic transformation are the Moravian valleys and the fertile Polábi in Bohemia. Considering the overall decline of AL of almost 2%, the index rating of 103–106 (Figure 2) only signifies a smaller decline when compared to the rest of Czechia. Of interest could be the highest category (index value 106 and higher), which is however territorially rather dispersed. A possible reason for this could be the ongoing restorations, when a return of agricultural land to individual owners could have caused an increase of the extent of arable land.

3.2 Built-up areas

Czechia as a whole underwent an increase of the extent of built-up areas. In 1845, this category had a share of only 0.59% of the total. By 1990 this had gone up to 1.59% and 1.65% in 2000. It is also important to stress that the increase in the extent of built-up areas is a feature shared by the majority of all BTUs. To some extent, built-up areas are an indicator of the intensity of development of socioeconomic activities, which is documented by a cartogram representing a long-term trend in the years 1845–2000 (Figure 3).

The most notable concentration of BTUs with an above-average growth of the built-up areas coverage, when compared to the situation of all of Czechia, is in Prague and its surrounding areas. A similar situation can be observed, although on a smaller scale, with other major urban centres of Bohemia and Moravia, with the exception of České Budějovice and Jičín. Other regions with a significant increase of built-up areas are eastern Bohemia and a belt of settlements between Ostrava and Opava, near the border with Poland. Southwest of Ostrava, by the western foothills of the Carpathians, lays a somewhat less significant belt of BTUs with an above-average increase of built-up areas share. In the case of Ostravsko, the cause is probably the after-war “socialist” industrialisation. Also, a less pronounced line of above-average growth has been recorded in the Podkrušnohorský area, beneath the Krušné hory mountains. Some BTUs in this region, however, have experienced a decline in built-up areas. This is a result of open-cast coal mining and an associated destruction of tens of settlements in this formerly fertile and densely populated area.

A feature characteristic of both observed time-frames is that the share of built-up areas declines only in very exceptional circumstances. Except for the aforementioned case of Podkrušnohorský coal basin, it relates mostly to areas of settlements depopulated in the borderland with Germany and Austria (the displacement of the Germans and the creation of the “iron curtain”). Decline also infrequently occurs in some areas, which have undergone significant changes in their functions (military training grounds, construction of reservoirs and reservoir lakes etc.). Somewhat surprising is the discovery that most of Moravia experiences a much slower increase in the share of built-up areas, compared to the rest of Czechia, despite a long-term population trend is significantly more positive here than in Bohemia. A logical outcome is that about 70% of all BTUs show below-average increase, since most of the development is concentrated in the main urban centres.

It is possible to assert that areas of greatest increase in the share of built-up areas in the 1990–2000 period (Figure 4) very much resemble those which have been identified in the 1845–2000 period.

Considering the rather short time scale of the observed period, the most significant increases in built-up areas are connected to residential and commercial suburbanisation of Prague and other large cities (Brno, Plzeň). Another important area of BTUs with a trend of growth is the connecting line between Ostravsko and Bílina in southern Moravia. Remaining notable increases usually belong to several BTUs concentrated around regional urban centres (Hradec Králové, Pardubice, Olomouc).

It is fair to say that a certain resemblance exists between the regional concentrations of built-up areas increase in both of the observed periods. This documents the relative stability of the settlement structure formation and its hierarchical ordering (Hampf, 2005 and others). This supports the surmise that the period after 1990 saw a greater degree of development especially in the already most significant centres, as opposed to the totalitarian period (1948–1990), which supported new development in smaller, district level cities (71) and other central settlements as prescribed by the planning system based on the idea of a network of central settlements.

3.3 Remaining areas

Remaining areas are certainly the most progressively growing category of land use from a long-term perspective. It is probably also influenced by the character of this category, since it is an umbrella term for a variety of different functions (see Chapter on methodology). The cartogram of 1845–2000 (Figure 5) clearly identifies two different types of areas. The first are locations with a high degree of concentration of socio-economic potential, especially agglomerations of Prague, Brno, Ostrava and to a lesser degree some of the smaller cities. The line of Podkrušnohoří also falls into this category, albeit because it belongs, thanks to the coal mining and extensive industrial and residential sprawl, to some of the most disadvantaged areas of Europe. This area also experienced interference caused by the changing of traffic routes, water flows and the destruction of tens of settlements.

Another important factor in the observation of remaining areas are administrative changes, which affected this category in the long-term, as well as in the last included decade of 1990–2000. It concerns land included into/excluded from other functional complexes, such as military training grounds or first national park zones and this administrative change translated into the extent of remaining areas in the concerned cadastral units. (The areas are marked on the map.)

For the 1990–2000 period, it can be stated that the application of the relative index has not produced any clear regional differentiation from the national average (Figure 6). It is evident that remaining areas have increased in size especially due to construction facilities in the hinterlands of regional centres. The cartogram reveals three developmental axes stretching from Prague to the southwest (Příbram, Plzeň, Bavaria), northwest (Ústí nad Labem) and inland towards Brno–Mikulov.

If we are to compare long-term trends regarding remaining areas with those from the last decade of the 20th century, it can
Fig. 3 – The Relative Development Index (in %) – built-up areas – period 1845-2000
Source: LUCC Czechia (www.lucc.ic.cz)

Fig. 4 – The Relative Development Index (in %) – built-up areas – period 1990-2000
Source: LUCC Czechia (www.lucc.ic.cz)
be safely stated that the discovered trends continued in a similar, albeit less profound manner in years 1990–2000. A case with significant effect was the administrative shift of the forests of the first protection level of the Šumava national park into the category of “remaining areas”.

An important factor in the increase of the share of remaining areas, which has a regionally very dispersed character in the 1990–2000 period, were the undergoing restitutions and privatisations, which returned land previously concentrated in the hands of the state to about 3.5 million owners and several thousand managers as part of the privatisation process (state forms, breeding grounds, manufacturing factories of industrial and forestry production). This process also necessarily included a reorganisation according to categories, which could have lead to a more accurate registration and a shift of a larger portion of land into the category of remaining areas.

The spatial analysis is further supported by Table 1 (see page 7), which sums up the types of changes in the land macrostructure. It summarizes the increases and declines of three main categories: agricultural land (arable land, permanent cultures, meadows, pastures), forest areas and other areas (comprising water, built-up and remaining areas) “+” signifies a stagnation or increase in the extent of land under that category, “−” the signifies a decline. The first column refers to agricultural land, column two to forest areas and column three to other areas. The table clearly demonstrates the different types of changes in the macrostructure as occurring in the observed time-frames. Most significant changes in a given period are marked in red. The “other” category, in this instance, includes the previously observed categories of built-up and remaining areas. The share of water zones remained virtually the same over the observed period, so any documented changes must have occurred within the two other sub-categories. The table reveals a radical increase in the share of other areas in the 1948–1990 period, when more than 99% of the country’s administrative units experienced an increase. Only 74% of these exhibited an increase between the years 1845–1948 and in the last documented decade only 57.5%.

It becomes clear that an overall increase in the share of other areas is typical of all the observed periods, although with a varying intensity.

4. Conclusion

Based on the analysis of the long-term changes in land use (1845–2000) and comparison with development during Czechia’s transformation period (1990–2000), we can make several significant conclusions.

A greater degree of development of the socioeconomic sphere has caused a concentration of most activities (production, services, housing, population) into areas with lower altitudes. The consequence is a rather intensive appropriation of arable land and an increase in the size of built-up and remaining areas in the main centres of socioeconomic activity and their surrounding areas. These long-term trends have also been confirmed during the observed ten-year period of economic transformation (1990–2000).

A range of Czech as well as foreign publications point to phases of the development of the settlement structure, or urbanisation, the latest of which show a selective character of the development of the entire settlement structure (Hampl, 1998). These trends are confirmed by our analysis of the changes of the share of arable land, built-up and remaining areas through the Relative Development index.

Rings of arable land appropriation and an increase in the size of built-up and remaining areas have appeared around main population centres, and lines of the same phenomenon have appeared around communication axes.

All of the disclosed cartograms confirm these trends; as a result, we can assert that the first hypothesis has been confirmed. In other words, population increase (both through population change and migration) is accompanied by a change in land use function in these areas. This change of function of land primarily affects the structure of cities and their surrounding areas (decline in arable land, increase in built-up and remaining areas). It can be stated that not even 42 years of central planning (1948–1990) and the politics of redistribution had a significant impact on these trends. We could perhaps concede that they have succeeded in slowing down some of these trends typical of the development of landscape in a modern society.

An example of such slowing effect can be socialist subsidies for farming in naturally disadvantageous regions. These have stabilised the share of arable land even in places where it was not profitable in a regional as well as in a national level. On the other hand, not even a strict law established for the protection of agricultural land stock (which includes arable land) could halt a significant increase in the share of built-up and remaining areas on the grounds of most core agglomerations of Czechia.

Developments of the 1990–2000 period clearly show that the loss of subsidies was one of the major factors causing a swift decline of the share of arable land in areas with less suitable natural conditions (especially mountainous regions, but also foothills, land with a high gradient and those with limited accessibility). This trend unifies in terms of structural development tens of BTUs in the aforementioned regions. This creates regions which experience a loss of arable land in inner foothills of border mountains in the long-term time-frame and even more profoundly in the 1990–2000 period. The transformation of landscape went through two phases here – first, unused arable land turns into permanent grassland, partially into forest areas. Later, a part of the grassland also turns into forest areas. This process takes place primarily in areas previously depopulated because of the displacement of Czech Germans and the subsequent creation of the iron curtain. It reappears again, although this time not for political reasons because of the end of subsidies, between 1990–2000 in the inner foothills of border mountains, which causes a disproportionate increase in the extent of permanent grassland, since these areas have previously been covered by an unsustainably large coverage of arable land with meagre yield. Our database provides us with the ability to ascertain that almost half of all BTUs experienced an increase in the share of permanent grassland in this period, because of the abandonment of arable land! The chief reason for this was economic-preservation of arable land in these areas had become economically unsustainable after the loss of subsidies.

The second hypothesis (the influence of transport accessibility/interconnectedness on land use) is also relevant and is connected to effectiveness and the utilisation of differential rent I (Jeleček, 1981). Actually, Ungerman (1983) has already demonstrated in his research the inefficiency of investing into land with lower fertility, in which the investment brings much smaller returns than in more fertile areas. That is the reason why adequate railroad infrastructure (19th/20th century) accelerated the process of abandonment of infertile arable land, especially in higher altitudes and steep slopes or other disadvantaged locations. With this knowledge in mind, we must contend that the third hypothesis (the influence of the displacement of Czech Germans on land use changes) holds true, the process of
Fig. 5 – The Relative Development Index (in %) – remaining areas – period 1845–2000
Source: LUCC Czechia (www.lucc.ic.cz)

Fig. 6 – The Relative Development Index (in %) – remaining areas – period 1990–2000
Source: LUCC Czechia (www.lucc.ic.cz)
depopulation of smaller settlements in mountainous areas and abandonment of associated arable land began much earlier, some time towards the end of the 19th century. It was, however, rather gradual and selective. The displacement of Czech Germans and the creation of the iron curtain after 1948 did much to enhance this originally primarily economic process.

References