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LAND COVER CHANGES ALONG THE IRON CURTAIN 1990–2006

KUPKOVÁ, L., BIČÍK, I., NAJMAN, J. (2013): Land Cover Changes along the Iron Curtain 1990–2006. Geografie, 118, No. 2, pp. 95–115. – The article analyses land cover changes along the Iron Curtain in the period 1990–2006. CORINE land cover state and land cover change datasets are used to evaluate differences in land cover structure in 1990 and in land cover changes between the eastern (from former German Democratic Republic to Hungary) and western (former Federal Republic of Germany and Austria) border sections along the Iron Curtain. The results confirm different representation of individual land cover categories on the eastern and western sides. Different intensity of changes at the eastern and western border sections has been confirmed, too. More intense land cover changes were detected in the "East" after 1990. The highest intensity of changes was recorded at the Czech border sections where rather strong process of afforestation took place, together with retreat of intensive agriculture (changes on more than 8% of the area between 1990 and 2000). On the contrary, the Austrian border section was the most stable area (changes only on 0.13% of the area).
KEY WORDS: land cover – change – Iron Curtain – 1990–2006.

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1. Introduction

Land use, land cover, and their changes depend on a whole array of environmental, socio-economic, and political factors. Areas near the state border have quite often specific functions (Chromý 2000) and peripheral location may lead to special forms of landscape management. The latter sometimes results in a specific land use / land cover patterns.

Although, as Rašín (2010) states, a sound and internationally conceived analysis of land change in Central Europe does not exist, the Czech borderland has recently been a frequent subject of geographical research. The areas of research interest (regarding the space as well as the subject matter), however, vary a lot.

Several studies that deal with the borderland in a general context of post-transformational development, regional development or differentiation have been published (Hampl 2000; Jeřábek 2000; Jeřábek, Dokoupil, Havlíček et al. 2004; Kolejka et al. 2005; Kolejka, Marek, 2006). Quite frequent are also analyses showing that changes in the borderland differ from the changes in the interior of Czechia, mostly as a result of the Germans exodus after 1945. These

studies deal with the socio-geographical aspect (Chromý 2000, Kuldová 2005) as well as with the space function and land use (Štěpánek 1992, 2002; Bičík, Štěpánek 1994; Bičík, Kabrda 2007; Rašín, Chromý 2010). Bičík, Kabrda (2007) and Breuer et al. (2010) analysed the land use changes in the Czech borderland and the driving forces that led to these changes. Their contribution represents a complex view of the land use structural changes in the Czech borderland; their primary focus is on the changes in the categories of arable land, forest areas, and built-up areas. As the authors emphasize, the changes found were not caused strictly by the different political factors but, to a certain extent, also by the less favourable natural conditions of the border regions.

The Iron Curtain, its function, its fall and influence on the landscape form a special chapter in the border research. Such publications often deal with the economic effects of the fall of the Iron Curtain; for example, effects on the job market in the border regions (Moritz, Gröger 2007) or on the rural development (Breuer et al. 2007) were studied. There are also plenty of publications that rather belong to popular or documentary literature (Jílek, Jílková et al. 2006; Antikomplex et al. 2006).

The existence of the former Iron Curtain can also be viewed in a positive way as it contributed – though unintentionally – to nature conservation. As Engels et al. (2004, p. 1) write: "Nature was the only winner in the issue of the construction of the inhuman border between the East and the West."

When it comes to studies concerning changes on both sides of the Iron Curtain, for example Kušová, Bartoš (2000) or Rašín, Chromý (2010) dealt with the region along the Czech-Austrian border. A detailed study focused specifically on the region of Valticko and Vitorazsko has been carried out by Rašín (2010).

Practically all of the above mentioned publications that examine the Iron Curtain effects deal only with the Czech territory. What is missing is a publication focusing on the Iron Curtain as a whole, analysing the differences between areas located east and west of the former heavily guarded border.

In the case of land use/land cover changes, this limited focus can be attributed to the data sets that the authors primarily used in their studies. Concerning the analyses of the function of space and land use, statistical data from the cadastral registers was primarily used for the analyses of the borderland in the above-mentioned studies. Some authors also utilized the Land Use / Land Cover Change Database (LUCC Czechia) based on statistical data: Štěpánek (1992) for the first time used this data for evaluation of the borderland; Bičík, Štěpánek (1994) examined land use changes in the Sudetenland in the post-war period, and Bičík, Kabrda (2007) analysed in detail the Czech borderland in the period 1845–2000.

In the above-mentioned study, Rašín (2010) used, in addition to statistical data, also historical cartographic sources and orthophotographs for the evaluation of the current condition of the landscape. Carefully selected remote sensing data allows to evaluate conditions and changes of the landscape over the past decades in extensive regions that also include cross-border areas. This is demonstrated in some publications like Kuemmerle et al. (2005), or Milanova, Telnova (2008).

Looking for remote sensing data sources suitable for long term land cover evaluation on the European level, the CORINE Land Cover program

(COoRdination of INformation on the Environment) outputs can be used with an advantage. The CORINE Land Cover project outputs are based on satellite data from the Landsat and Spot (European Environment Agency – Data and maps 2010). CORINE data was used, for example, for the evaluation of land cover in Slovakia, in the Netherlands, and in Bulgaria (Feranec et al. 2007, 2009; Feranec, Oťaheľ, Nováček 2010). Büttner et al. (2004) deal with the state and mapping of land cover in Hungary based on the CORINE data, too.

As the CORINE Land Cover data is available for three different years (1990, 2000, and 2006) for most of Europe, it can also be used for studies of land cover changes along the Iron Curtain after the fall of Communism in Central/Eastern Europe. Our intention therefore is to use the CORINE Land Cover state and change data with the following goals:

(1) To compare the share of different land cover categories in 1990 on the eastern and western parts of the former Iron Curtain.

(2) To evaluate land cover changes after the fall of the Iron Curtain in the period 1990–2000–2006 on both sides of the entire former Iron Curtain, and to assess the impacts of the Iron Curtain removal on land cover.

Detailed attention will be devoted to land cover changes in the border areas of Czechia and its western neighbours, i.e. Austria and the former Federal Republic of Germany (so called Western Germany).

As the former Comecon countries had centrally planned economic systems that also included high level of self-sufficiency, there was a big pressure for intensive agriculture (Bičík, Jančák 2005). Consequently, land use and land cover were strongly affected. This situation has changed dramatically with the re-introduction of market economy, private property restitution, and renewed land market after 1989. We may therefore expect that:

(1) Shares of individual land cover categories in 1990 would significantly differ on both sides of the former Iron Curtain.

(2) Land cover changes after the fall of the Iron Curtain (in the period 1990–2000–2006) would be more intensive on the eastern side.

2. Area of Interest

The Iron Curtain created a considerable barrier within the whole Europe and it separated the population on both sides for almost 50 years. The Iron Curtain was a strictly guarded border between the democratic states in the West and the East that was governed by Communist regimes. The protection of the border also included measures that influenced fundamentally the lives of the people on both sides of the border.

Military buildings and installations as well as extensive military training areas influenced the landscape so dramatically that their traces are still noticeable in the landscape. Entire settlements have been cleared and much of the cultural landscape that had been created here over centuries, having become typical for the Czech borderland, was destroyed (Antikomplex et al. 2006). On the other hand, the "expulsion" of human presence from large parts of the borderland improved conditions for nature conservation in the close proximity of the border. These environmentally important regions were and still are

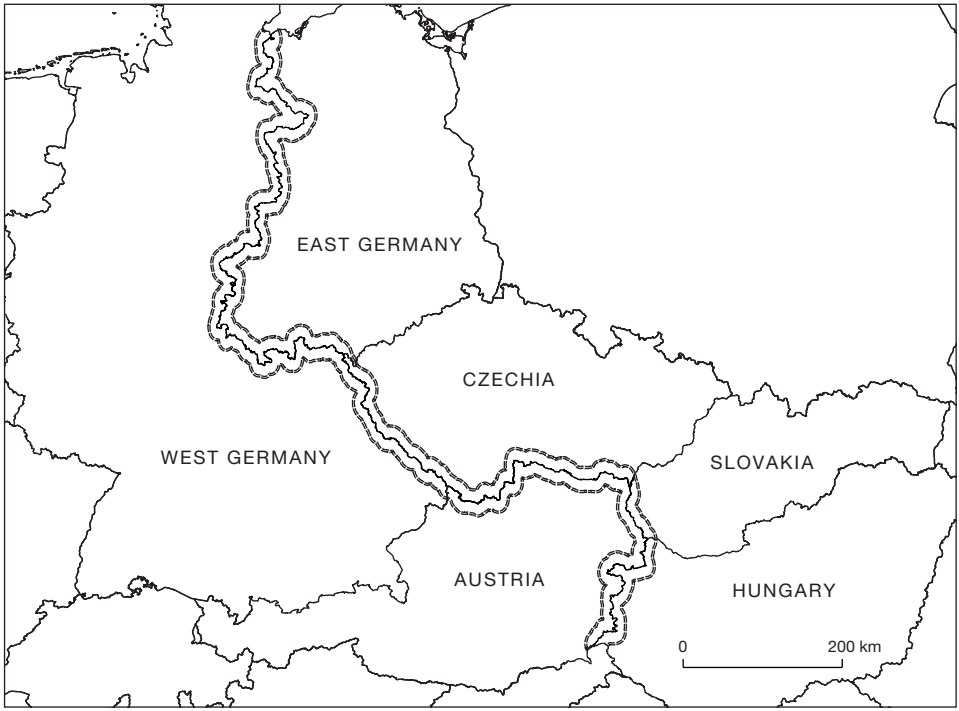

Fig. 1 – Area of interest with the fifteen kilometres wide border zone on the eastern and western sides of the border

of great interest: many nature reserves and even national parks have been established here since the fall of the Iron Curtain.

The research area (see Fig. 1) was defined as a 15 kilometres wide zone on both sides of the state border. It covers almost all nation states along the former Iron Curtain. We labelled the borderland belt in the states east of the Iron Curtain as the "East" and the borderland belt in the states west of the Iron Curtain as the "West". Thus, the "East" covers former East Germany (the German Democratic Republic), Czechia, Slovakia, and Hungary. The "West" covers former West Germany (the Federal Republic of Germany) and Austria.

The distance of 15 kilometres on both sides of the border was determined in order to indicate the processes in the landscape that have been directly influenced by the Iron Curtain effect. The total length of such a border line is approximately 2,600 kilometres.

3. Data and Methods of Analysis

The CORINE Land Cover (CLC) was the main database used for the analysis of the land cover in the defined area. The CORINE program originated in 1985 and its objective was to create a unified system, using shared methodology that would provide information on the environment on the EU territory. The

Tab. 1 – CORINE Nomenclature Used for the Analysis

Code	Land Cover Category
11	Urban fabric
12	Industrial, commercial and transport units
13	Mine, dump and construction sites
14	Artificial, non-agricultural vegetated areas
21	Arable lawnd
22	Permanent crops
23	Pastures
24	Heterogeneous agricultural areas
31	Forests
32	Scrub and/or herbaceous vegetation
324	Transitional woodland-shrub
33	Open spaces with little or no vegetation
41	Inland wetlands
51	Inland waters

Source: Bossard, Feranec, Oťaheľ 2000

European Commission initiated this project. The land cover data are created individually in each country and subsequently integrated in a unified seamless CORINE Land Cover Database. The entire project is currently coordinated by the European Environment Agency. The dataset is based mainly on the LANDSAT satellite images with a 25 meter spatial resolution (Feranec, Nováček 2009).

Raster dataset was used for evaluation of land cover state in 1990 – Corine Land Cover 1990 raster data – version 13 (02/2010). Different vector layers were used to evaluate changes in the periods 1990–2000 and 2000–2006 – layers Corine Land Cover Changes 1990–2000 – version 16 (04/2012) and Corine Land Cover Changes 2000–2006 – version 16 (04/2012). The minimal mapping unit is 25 hectares (static data), and 5 hectares (change layers) respectively.

The Corine nomenclature has three levels. The first level contains five classes, the second level has 15 classes out of which 13 occur in the area of interest, and finally the third level has 44 classes, out of which 28 occur in the area of interest.

The second level of the CORINE nomenclature was used for our analysis (see Table 1). However, the third level category 324 – transitional woodland-shrub – was evaluated separately as this category has undergone interesting and significant changes on both sides of the Iron Curtain during the researched periods.

Detailed definitions of the categories are published in the CORINE Land Cover Technical Guide (Bossard, Feranec, Oťaheľ 2000). Some definitions are also included in the further text if important for understanding of the results.

The data was processed in the ESRI ArcGIS 9.3 environment. The CORINE raster layer for 1990 was converted to vector format. Vector static (1990) and change (1990–2000 and 2000–2006) layers were clipped by the polygons of particular border sections (buffer in the distance of 15 kilometres from the border). In the analysis we used two overall border sections – "WEST" (the

total area of all border sections to the west of the border) and "EAST" (the total area of all border sections to the east of the border), plus four partial sections: (1) The former Federal Republic of Germany (West Germany) – border section with Czechia; (2) Austria – border section with Czechia; (3) Czechia – border section with Austria; and (4) Czechia – border section with the former Federal Republic of Germany (West Germany). Static tables for 1990 and change tables for the periods 1990–2000 and 2000–2006 were created. Percentage changes of individual land cover categories were calculated. Index of change (IC) that summarizes percentage of all types of changes in particular spatial unit for the comparison of the land cover changes intensity in individual sections of the Iron Curtain in the periods 1990–2000 and 2000–2006 was used (Bičík et al. 1996):

$$IC = \frac{\sum_{i=1}^{n} |A_{1i} - A_{2i}|}{2 \times E} \times 100 \text{ , where}$$

A_{1i} – the areal extent of ith land use category in the first year,
A_{2i} – the areal extent of ith land use category in the last year,
E – total area extent of examined territory.

4. Results

4.1. Land Cover Changes along the Entire Iron Curtain 1990–2000–2006

Table 2 shows the differences in the share of the land cover categories in the "East" (former East Germany, Czechia, Slovakia, and Hungary) and in the "West" (former West Germany and Austria) in 1990 and the major changes in the periods of 1990–2000 and 1990–2006.

The differences in the share of individual land cover categories in 1990 between the "East" and the "West" are significant in some categories (arable land, heterogeneous agricultural areas) and notable also in the case of transitional woodland-shrub and permanent crops. Trends, however, are opposite in the case of mine, dump and construction sites, forests, transitional woodland-shrub and permanent crops in the second period (2000–2006) – see Table 2.

In the case of arable land a certain decrease along the entire Iron Curtain in both periods (1990–2000 as well as 2000–2006) can be observed. The difference in the share of arable land "East" versus "West" decreased over the time as there have been higher losses of arable land during the both periods in the "East". Among the main driving forces behind this process in the "East" were most likely lower agricultural subsidies as well as large scale restitution of property that took place after 1990.

The difference decreased in the period 1990–2000–2006 in the case of heterogeneous agricultural areas. This category includes two subcategories in our area of interest: (1) complex cultivation patterns and (2) land principally occupied by agriculture, with significant areas of natural vegetation. This category together with some other land cover categories (arable land, transitional

Tab. 2 – Land Cover Along the Iron Curtain in 1990 and Land Cover Changes 1990–2000–2006

Land Cover Category	Category share 1990 in %			Decrease/Increase in Area of Category (%) 1990–2000			Decrease/Increase in Area of Category (%) 1990–2006		
	TA	East	West	TA	East	West	TA	East	West
Urban fabric	3.50	3.12	3.87	3.63	4.47	2.97	4.85	5.41	4.44
Industrial, commercial and transport units	0.31	0.43	0.19	25.69	28.14	20.78	31.53	33.50	27.81
Mine, dump and construction sites	0.20	0.27	0.13	–22.78	–42.68	18.96	–14.70	–33.94	25.63
Artificial, non-agricultural vegetated areas	0.15	0.18	0.12	14.81	3.37	32.14	28.74	11.01	55.74
Arable land	40.44	43.40	37.67	–3.80	–6.45	–0.82	–4.48	–7.55	–1.03
Permanent crops	1.16	0.66	1.65	–0.85	–2.49	–0.20	3.15	11.93	–0.29
Pastures	8.06	8.19	7.95	16.10	30.95	1.17	17.37	33.69	0.96
Heterogeneous agricultural areas	8.14	4.83	11.37	–0.65	–1.83	–0.12	–0.77	–2.05	–0.21
Forests	34.98	34.71	35.18	0.91	2.26	–0.39	0.78	2.12	–0.51
Scrub and/or herbaceous vegetation	0.42	0.54	0.30	–3.47	–2.63	–4.94	–6.52	–7.29	–5.19
Transitional woodland-shrub	1.08	1.91	0.27	–22.68	–34.45	59.00	–15.44	–27.99	71.83
Open spaces with little or no vegetation	0.01	0.01	0.00	0.00	0.00	0.00	–59.55	–70.90	–46.98
Inland wetlands	0.55	0.68	0.43	–0.66	–0.89	–0.31	1.43	2.35	0.00
Inland waters	0.97	1.08	0.86	6.56	10.53	1.73	7.74	11.93	2.64

Note: TA – total area of the Iron Curtain (15 km buffer zone on both sides of the border)
Source: based on Corine Land Cover data

woodland-shrub) can illustrate different landscape patterns in the west and east sides of the Iron Curtain.

According to CORINE Land Cover Technical Guide (Bossard, Feranec, Oťaheľ 2000) the transitional woodland-shrub includes also bushy or herbaceous vegetation with scattered trees and can represent either woodland degradation or forest regeneration areas. The Corine Land Cover Change data provides us with a detailed information about the types of changes. Therefore we can conclude that the decrease in the "East" was caused almost exclusively by transformation of transitional woodland-shrub into forests (99% of the decreased area in both periods). On the other hand, the increase of transitional woodland-shrub in the "West" was in most cases detected in the areas of former forests (about 98% in the both periods).

The fact that land became used in a less intensive way in the "East" is illustrated by the increase of pastures. Their extent had been similar in the "East" and "West" in 1990; until 2000, however, pastures expanded significantly in the "East" and the increase continued up to 2006. From this perspective, the shift towards a less intensive agriculture is much more pronounced in the "East" than on the "West".

The trend showing a less intensive use of the landscape in the "East" is also supported by the changes of forest cover. While in the "East" forests have expanded by more than 2% (about 15,000 ha) between 1990 and 2006, in the "West" there has been a slight decrease (about 4,000 ha) over the same period.

Also very interesting is the increase of permanent crops in the "East" in the period 2000–2006. This category covers (1) vineyards and (2) fruit trees and berry plantations. As for spatial distribution, permanent crops increased only in Czechia (i.e. in Moravia – mostly vineyards), a little bit in Slovakia, and also in Hungary (mostly areas of fruit trees and berry plantations). Such changes may have been influenced by the accession to the EU (2004) and by national subsidies.

Most of the above mentioned trends (except the category of heterogeneous agricultural areas) support the idea that land cover/land use as a whole has moved towards a less intensive use. An increase of environmentally friendly land cover categories has been recorded in the "East", for example in Czechia, since 1990 (Bičík, Kupková 2012). Scrub and/or herbaceous vegetation seem to be an exception. A closer look at the change databases and at the structure of changes, however, reveals that the latter category has been mostly replaced by transitional woodland shrub and forests (1990–2000) and by inland wetlands (2000–2006) respectively. Thus, the decrease of scrub and/or herbaceous vegetation seems to be a natural one and it supports the theory of environmentally favourable changes in the "East".

On the other hand the changes in the "East" include a relatively significant increase of urban fabric and industrial, commercial and transport units. These changes reflect an increased human activity in the territory after the fall of the Iron Curtain as large tracts of the land along the border, formerly off-limits to the general public, became accessible to people as well as to business.

It is obvious that free movement across the border has also influenced the "West". The fall of the Iron Curtain resulted in new housing projects, leisure time centres as well as in infrastructural development in the 15 kilometres wide

belt along the border. An increase of artificial, non-agricultural vegetated areas has been recorded on both sides. This includes two subcategories: (1) green urban areas and (2) sport and leisure facilities. A higher increase has been recorded in both periods in the "West", exclusively due to expansion of sport and leisure facilities. Similar changes occurred in the "East", too, generated also by increase of sport and leisure facilities (almost 100% in both periods).

The increase of water areas recorded in the "East" can be attributed to the construction of the Gabčíkovo Reservoir on the Danube River.

4.2. Comparison of the Intensity of Land Cover Changes in Different Sections of the Iron Curtain 1990–2000–2006

The differences of land cover changes over the time that took place along the border can be characterized (quantified) using the index of change (Bičík et al. 1996). Table 3 shows the values of this index for different border sections in the "East" as well as in the "West" for both periods.

The analysis shows that there were significant differences between eastern and western border sections especially in the period 1990–2000 as regards the intensity of land cover change that is reflected by the Index of change (see Tab. 3).

The greatest stability, represented by low values of the Index of change, has been recorded in Austria. The values of the Index of change in the Austrian section show that only minor land cover changes occurred over the whole period 1990–2000–2006.

Regarding the intensity of changes, the West German borderland ranked slightly above average in comparison with the whole western section in the both periods. However, West German figures are still much lower than those in the eastern section (in Czechia). The changes here were mainly driven by natural processes and also by the increase of space taken by housing development and other human activities. A certain decrease of the intensity of change in this part of the borderland may be expected in the future.

In the Czech border sections a significantly higher intensity of change in the both periods has been registered in comparison with western border sections. The greatest intensity of changes was recorded in the period 1990–2000.

Tab. 3 – Index of Change during the Periods 1990–2000 and 2000–2006 for Different Border Sections East and West of the Iron Curtain

Area	Index of change (%)			
	1990–2000		2000–2006	
Border section	East	West	East	West
Iron curtain	3.96	0.52	0.61	0.16
Czechia – West Germany	8.42	1.43	1.34	0.25
Czechia – Austria	8.19	0.13	1.48	0.13

Source: based on Corine Land Cover data

Agricultural policies after the year 1990, together with ongoing property restitutions, have probably contributed to more intense changes in comparison to western border sections. Until 1990, only state farms were allowed near the Iron Curtain. Later on, i. e. under the new conditions of market economy, these farms were privatised and frequently fell into great problems. It can be stated that the fall of the Iron Curtain led to the most significant land cover changes in the Czech borderland.

Observing the Index of change, especially that of the period 1990–2000, one can say that the fall of the Iron Curtain was a real trigger for intensive changes along the former Iron Curtain. The only exception is Austria where the land cover/use management proved to be very stable and resistant even to such an important change like the fall of the Iron Curtain.

4.3. Land Cover Changes in the Czech-West German Borderland

The Czech-German borderland is situated in higher altitudes than other sections of the Iron Curtain which has a great influence on land cover and land use. Our research shows that the share of arable land in these remote areas was extremely low compared to the whole area along the Iron Curtain in 1990 (see Table 4). The extent of arable land has been constantly decreasing on the Czech territory since the end of the 19th century (Bičík, Jeleček, Štěpánek 2001). The decrease of arable land on the Czech side of the border was moreover accentuated by the expulsion of Czech Germans (1945–1947; Bičík, Jeleček, Štěpánek 2001).

In 1990 arable land covered just tiny portions of the borderland: 21% on the Czech side and 12% on the German side respectively. On the eastern (Czech) side arable land shrank by 33% over the period of 1990–2000. Over the whole period (1990–2006) the decrease was even bigger: 38.8%. This decrease was caused primarily by lower intensity of farming in areas with poor natural conditions as the "socialist" agricultural subsidies were no longer available. Establishing of the Šumava National Park (1991) also played a role. Shrinking of arable land and increase of pastures went hand in hand – 96% of new pastures in the whole period appeared on former arable land. The increase of pastures in this section is significantly more important than in other areas along the entire Iron Curtain (compare Table 2 and Table 5). A strong influence of natural conditions on the land cover is evident also on the German side. The share of arable land was extremely low in 1990 there; on the other hand, much of the area in the German borderland was covered by forests and pastures already in 1990. Thus, neither arable land nor pastures have undergone significant changes on the German side after the fall of the Iron Curtain.

On the contrary there was a high increase of built-up areas on the German side, by almost 8% between 1990 and 2006. Industrial, commercial and transport units as well as artificial, non-agricultural vegetated areas increased significantly in the western border section in this period, too. Though its share was very low in 1990, the general increase of all these human-influenced land cover categories brings evidences that the fall of the Iron Curtain was followed

Tab. 4 – Land Cover in the Czech-West German Borderland (Federal Republic of Germany) in 1990 and Land Cover Changes 1990–2000–2006

Land Cover Category	Category share 1990 (%)		Decrease/ Increase in Area of Category (%) 1990–2000		Decrease/ Increase in Area of Category (%) 1990–2006	
	East	West	East	West	East	West
Urban fabric	1.41	2.41	0.96	4.62	0.96	7.66
Industrial, commercial and transport units	0.26	0.05	14.06	46.42	16.82	66.97
Mine, dump and construction sites	0.08	0.06	–34.26	32.06	26.38	–3.30
Artificial, non-agricultural vegetated areas	0.22	0.01	0.82	183.46	14.49	249.66
Arable land	21.31	11.89	–33.37	0.01	–38.29	0.14
Permanent crops	0.06	0.00	0.00	0.00	0.00	0.00
Pastures	8.36	19.11	84.93	–0.51	96.41	–0.89
Heterogeneous agricultural areas	7.46	12.15	–0.44	–0.81	–0.52	–0.97
Forests	52.80	53.84	2.79	–1.90	3.42	–2.08
Scrub and/or herbaceous vegetation	1.20	0.03	–5.96	0.00	–32.55	0.00
Transitional woodland-shrub	5.44	0.38	–25.45	274.33	–25.45	301.77
Inland wetlands	0.93	0.00	–0.22	0.00	–0.22	0.00
Inland waters	0.46	0.07	0.00	0.00	0.00	2.42

Note: East = border section in Czechia; West = border section in former West Germany
Source: based on Corine Land Cover data

by an influx of development and industrial infrastructure into the regions near the border.

Also interesting are changes regarding mines, dumps, and construction sites in the Czech border section. The category decreased in the period 1990–2000. On the contrary, this land cover category has increased over the period of 2000–2006 due to new construction sites. Again, this is an evidence of a more intensive human presence in the borderland.

Quite interesting are also changes regarding forests and transitional woodland-shrub categories in the both periods. The forest cover was extremely high in 1990 on both sides of the border, very much above the share of forests in the whole area of interest. On the Czech side the share of transitional woodland-shrub category was also very high. In spite of the "bark beetle calamity" forests kept to expand on the Czech side of the border over the whole time period. The decrease of forests in the German part is – according to our database – the result of gradual deforestation that also allowed the transitional woodland-shrub to increase.

The differences in agricultural land cover structure between Czech and German parts in 1990 (share of arable land, pastures, heterogeneous agricultural areas) prove that the land was managed in very different ways on both sides of the border before 1990. The post-1990 changes on the Czech side (increase of pastures and forests, decrease of arable land) reflect again the shift towards a less intensive land use (including afforestation) on the eastern side of the border.

4.4. Land Cover Changes in the Czech-Austrian Borderland

The differences between Czech and Austrian border sections in 1990 were mainly in the share of heterogeneous agricultural areas, arable land and permanent crops (see Table 5). The land cover/landscape structure on the Austrian side was characterized by a very high share (25%) of heterogeneous agricultural areas (much higher than the average of the entire Iron Curtain and the average of the western side of the Iron Curtain), by a significantly higher share of permanent crops and by a lower share of arable land in comparison with the entire Iron Curtain and with the Czech section of the border (compare with the Table 2).

92% of heterogeneous agricultural areas on the Austrian side in 1990 fell into the third level of the Corine nomenclature classified as Complex cultivation patterns. According to the CORINE Land Cover Technical Guide (Bossard, Feranec, Oťaheľ 2000), Complex cultivation patterns are defined like "Juxtaposition of small parcels of diverse annual crops, pasture and/or permanent crops" (p. 61). This fact reflects very well the difference in the landscape patterns on the both sides of the border. The fragmented landscape on the Austrian side

Tab. 5 – Land Cover in the Czech-Austrian Borderland in 1990 and Land Cover Changes 1990–2000–2006

Land Cover Category	Category share 1990 (%)		Decrease/ Increase in Area of Category (%) 1990–2000		Decrease/ Increase in Area of Category (%) 1990–2006	
	East	West	East	West	East	West
Urban fabric	2.65	3.28	0.90	0.42	1.33	0.61
Industrial, commercial and transport units	0.36	0.01	3.11	0.00	3.75	9.51
Mine, dump and construction sites	0.13	0.00	–39.52	0.00	–20.98	+
Artificial, non-agricultural vegetated areas	0.14	0.00	0.00	+	21.79	+
Arable land	43.06	31.96	–12.87	–0.01	–15.97	–0.06
Permanent crops	1.47	3.10	5.04	–0.06	36.06	–0.27
Pastures	4.18	3.47	127.43	–0.77	146.03	–1.15
Heterogeneous agricultural areas	6.88	25.16	1.98	–0.08	1.93	–0.20
Forests	34.41	32.86	5.83	–0.20	5.74	–0.36
Scrub and/or herbaceous vegetation	0.40	0.01	–2.60	69.67	–1.62	39.70
Transitional woodland-shrub	2.85	0.04	–69.56	127.55	–67.63	217.82
Inland wetlands	0.48	0.05	3.17	0.00	2.19	0.00
Inland waters	2.98	0.05	*–0.35*	*0.00*	*0.01*	*0.00*

Notes: 1. East = border section in Czechia; West = border section in Austria. 2. It is not possible to calculate relative change in the case of artificial, non-agricultural vegetated areas for the Austrian border section because the initial area in 1990 was 0. Sign "+" signalizes that the share of this category increased in the both periods (the share on total area in 2000 was 0.05% and in 2006 it was 0.08%).
Source: based on Corine Land Cover data.

differed much from the large fields on the Czech side formed in the course of collectivization. However, our analysis shows (see Table 5) that heterogeneous agricultural areas have increased significantly on the Czech side and that the landscape structure began to change in this way. When analysing the third level of the Corine nomenclature one can see that the increase was primarily due to complex cultivation patterns (63%) that replaced mostly arable land.

Decrease of arable land (by almost 13%) and a very high increase of pastures (by 127%) have been recorded on the Czech side during the first decade. These trends continued till 2006 and correspond with general decrease of arable land in most other Czech regions. Fields were often being replaced by grassland – process that was repeatedly confirmed by other analyses based, for example, on the cadastral evidence (Bičík, Kabrda 2007). The above mentioned change in agricultural subsidies played an important role on the Czech side, too. Agricultural production had been subsidised by the state over decades; after 1990, however, the funds became unavailable and agriculture had to undergo radical changes. On the Austrian side, the situation in agriculture was much more stable and only minute changes of agricultural land use have been recorded.

Another interesting result that can be registered when analyzing agricultural land categories is a certain increase of permanent crops, especially during the second period 2000–2006 on the Czech side of the border. The rate of this increase is much higher than that recorded on the level of the whole Iron Curtain or on the level of the whole eastern part of the Iron Curtain. Analysis of the structure of permanent crops change in the third level of the Corine nomenclature shows that 92% of the increase in the period 1990–2000 and 100% of the increase in 2000–2006 was caused by a shift from arable land towards vineyards in the South Moravia. The tradition of viticulture in this region has been strengthened also due to the European Union and national subsidies.

As for forests and transitional woodland shrub the trends are the same like in the case of the whole western and eastern part of the Iron Curtain and like in the case of Czech-Austrian borderland.

The urban fabric (1), industrial, commercial and transport units (2), as well as mines, dumps and construction sites (3) are all land cover categories much influenced by humans. It can be concluded that in 1990 the proportion of such areas in the Czech border section was lower than in the whole eastern border section. Also on the Austrian side of the border these areas were less frequent than it was the case of the western border section as a whole (compare Tables 2 and 5). Areal changes over the periods 1990–2000–2006 were rather modest which is a sort of evidence that housing development, industrial and construction activities in this part of the Iron Curtain were not widespread here after the fall of Iron Curtain. On the other hand, areas for sport and leisure activities (subcategory of artificial, non-agricultural vegetated areas) increased in the Czech-Austrian borderland, corresponding to general trends in the entire area of interest.

5. Discussion and Conclusions

5.1. State and Changes of Land Cover Categories

The analysis of land cover changes near the Iron Curtain provides answers to the hypotheses determined in the introduction. The first hypothesis presumes different proportions of different land cover categories on the eastern and western sides of the border in 1990. The analysis proves that there are three land cover categories with significant differences.

These are above all two agricultural categories – arable land and heterogeneous agricultural areas. Significant differences were recorded between the whole eastern section and western section but also in the case of Czech-West German vs. Czech-Austrian borderland. While the share of arable land was in all cases much higher on the eastern side of the Iron Curtain, the share of heterogenenous agricultural areas was in all cases significantly higher on the western part of the border. This fact reflects different agricultural management that resulted into entirely different landscape patterns. The efforts to make agricultural production more effective in the East had started already in the 1950s as part of the collectivization and led to drastic landscape changes. The centrally planned socialist economic system of the second half of the 20th century included also massive agricultural subsidies which created a high pressure to implement intensive agricultural methods also in areas with poor natural conditions including the mountainous regions along the border. Such a situation lasted until 1990. Though subsidies were widespread also on the western side of the Iron Curtain, the agricultural production basically followed the basic market rules and, as a result, farming in the West more or less respected the natural conditions and sustainable development.

Transitional woodland-shrub is the third land cover category that showed significantly different shares of the total area in 1990 on both sides of the border. Its proportion was higher in the "East" as a whole and also was higher in the two Czech border sections than in all corresponding western sections. Also changes over the time are interesting. Transitional woodland-shrub increased in all western sections (the whole "West", West Germany, and Austria) in both periods and decreased in all eastern sections also in both periods. As this type of land cover is closely linked to forests it is clear that its increase would bring a decrease of forest cover and vice versa. And though forests gradually replaced also other land cover categories and were replaced by other categories, not just by transitional woodland-shrub, the results of forest analysis have a clear conclusion. The forest cover increased in all analyzed eastern sections and decreased (mostly just slightly) in all analyzed western sections. On these grounds we can conclude that in the period 1990–2006 afforestation was a general trend in the "East" while in the "West" slight deforestation was more common.

Further interesting results dealing with different land cover categories show an increase of complex cultivation patterns and permanent crops (that mostly replaced arable land). These are some specific examples of land cover changes that were recorded in the Czech border section with Austria (in Moravia).

Increase of permanent cultures in the period 2000–2006 has been indicated in the whole eastern section of the border. As for complex cultivation pattern the same trend has been recorded also in some other post-Communist countries like Slovakia as for example Feranec et al. (2009) found out. Feranec et al. (2009) concluded that among the important driving forces behind these changes were land ownership changes. As for permanent crops (in this very case especially vineyards), there was a sort of a boom in South Moravia after the accession to the EU. In the case of Slovakia Feranec et al. (2010) shows that the official EU recognition of the vineyards was important, too.

Changes of artificial, non-agricultural vegetated areas over the time proved to be quite interesting, too. This land cover category expanded in the border regions after the fall of Iron Curtain and it reflects increase of leisure time and social activities in this region. Artificial, non-agricultural vegetated areas increased in all border sections up to 2006. In absolute terms such an increase much depends also on the population density (Najman 2008) – similarly like in the case of other categories closely linked to human settlement and activities (urban fabric, industrial, commercial and transport units and mine, dump and construction sites categories). In general we can say that these land cover categories increased in almost all sections and reflect an increase of human activities in the border regions after the fall of Iron Curtain.

Though the share of remaining land cover categories – water areas, wetlands and scrub and/or herbaceous vegetation – is rather low, they are important for landscape stability and sustainability. Especially the decrease of the scrub and/or herbaceous vegetation in eastern and also in western sections (with the exception of Austrian border section) is a sort of a warning.

5.2. Intensity and Types of Changes

It had been assumed that there would be more intensive changes on the eastern side of the former Iron Curtain rather than in the "West" – and this hypothesis was confirmed in full. It makes a great difference that can be documented by the percentage of all types of changes in particular spatial unit (expressed by index of change).

Especially high, above-average values of the index of change (compared to the whole eastern section) were recorded in both Czech border sections between 1990 and 2000. Changes were indicated on more than 8% of the total area. High values have also been recorded in the period 2000–2006. Changes in agricultural policy as well as ongoing process of property restitution were perhaps behind these changes that were more intensive in the Czech borderland than in the "East" as a whole and also more intensive than in the corresponding western sections.

On the other hand, the land cover structure in the Austrian border section showed a high degree of stability. The land cover structure has probably reached a state that corresponds to local natural conditions and social structure; large typological regions with similar land cover structure have been indicated here. Little changes in land ownership certainly contribute to the general stability, too. As the Austrian agriculture has not undergone any major changes after

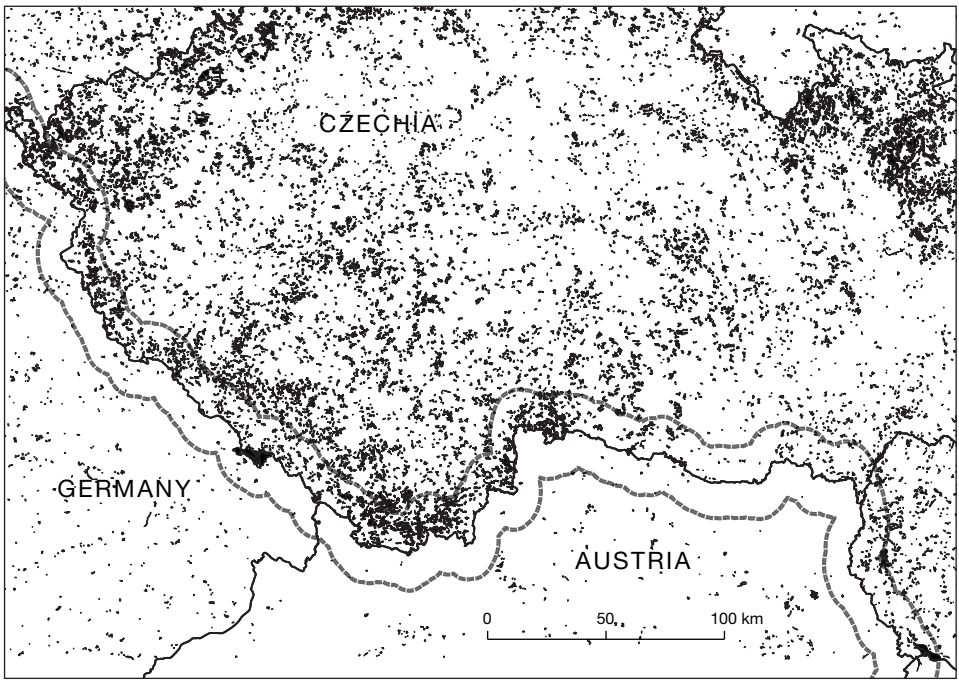

Fig. 2 – Land Cover Changes between 1990 and 2000. Areas that experienced land cover change are marked in black. Source: based on Corine Land Cover data.

1990, the land remained to be used as agricultural land. Only minimal changes in the Austrian borderland can be expected in the future; these may include a slight decrease of arable land influenced by general overproduction and high costs for the production in less favourite natural conditions.

When compared to the Austrian borderland and also to the whole western section of the former Iron Curtain, the West German borderland shows a relatively high intensity of changes, especially during the first period. Here, the land cover changes were influenced above all by natural conditions (mainly higher altitude) and to a certain extent also by development (housing, technical infrastructure). Such changes, however, were less intensive during the second period (2000–2006) and it can be anticipated that the intensity of changes will perhaps decrease in the future, too.

The great differences regarding the number and total size of areas that have undergone land cover changes between the Czech borderland on one side and Austrian and West German borderland on the other side can also be illustrated in maps – see Figures 2 and 3. The density and size of the areas that underwent changes on the Czech side contrast especially with the Austrian borderland where no major changes were detected. Comparison of Figure 2 and Figure 3 shows the differences in the land cover change intensity between the first (1990–2000) and second (2000–2006) periods. Though the second period is shorter it can be concluded that the scope and intensity of changes in the second period are somewhat lower.

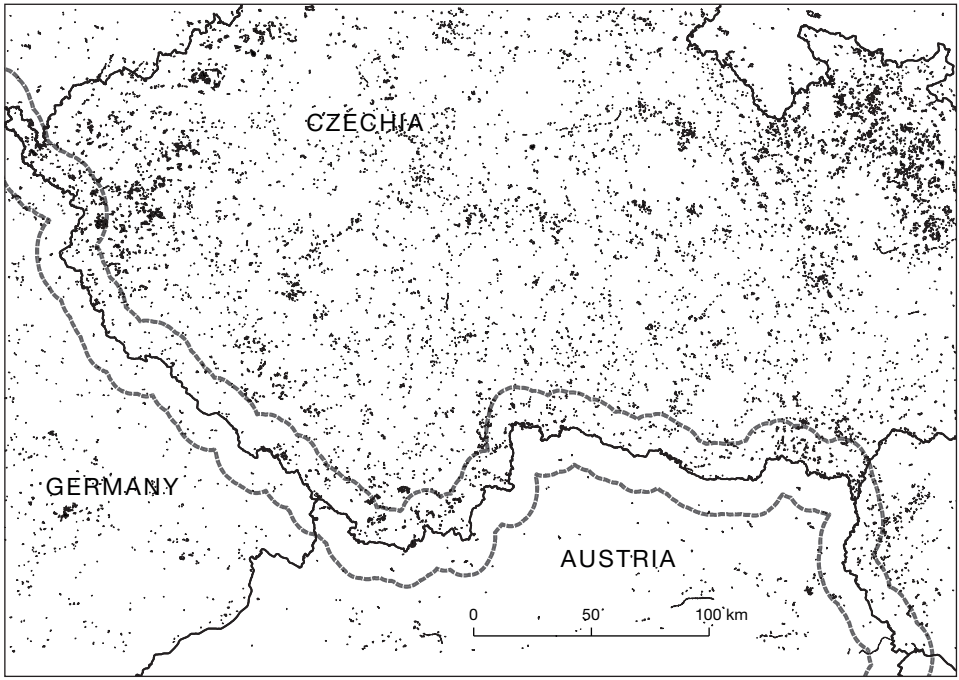

Fig. 3 – Land Cover Changes between 2000 and 2006. Areas that experienced land cover change are marked in black. Source: based on Corine Land Cover data.

Different intensity of land cover change in the eastern and western border sections was accompanied by different dominant types of changes (i.e. the most extensive types of changes by categories).

All eastern sections in both periods show the same dominant types of changes. First, the shift from arable land to pastures is obvious. The second most dominant change was that from transitional woodland-shrub to forest (with one exception). Altogether it proves that the areas east of the former Iron Curtain moved towards a less intensive agricultural use including some afforestation over the period 1990–2006. The only exception was the border in South Moravia in the second period; in this case the second dominant change was shift from arable land to vineyards. This type of change illustrates a regionally specific process of agricultural intensification.

All western sections showed the same first dominant type of change; unlike the "East", however, in the "West" this prevailing change was the shift from forests to transitional woodland-shrub. But the scope of these changes was not as big as in the "East". Moreover the second dominant types of change were different in each section and time period. It is obvious that except the relative slight process of deforestation and some of the above mentioned general tendencies (for example the increase of artificial, non agricultural vegetated areas, or increase of discontinuous urban fabric) the land cover changes at the western side have been reflecting regional circumstances. As a result, nothing like a dominant land cover change can be determined in the western sections. It

can be assumed that there will not be any major changes in the near future as the intensity of changes has been decreasing during the two observed periods.

As for the future trends in the eastern part one can expect a continued decrease of arable land as well as a certain increase of environmentally favourable land cover categories like pastures/meadows and forests. One exception may be the border sections that are located in fertile areas and where farming may be profitable and sustainable in the long run.

A question arises here, whether the current changes that create path to large typological regions with similar land cover/land use structure is in agreement with the proclamation of the multifunctional landscape policy (see also "landscape convergence" – according to Breuer et al. 2010).

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Shrnutí

ZMĚNY KRAJINNÉHO POKRYVU PODÉL ŽELEZNÉ OPONY V LETECH 1990–2006

V posledních letech vzniklo poměrně velké množství prací, které se věnují analýze pohraničí Česka a srovnání vývoje s pohraničím v okolních státech, zejména po pádu železné opony. Studie se zaměřují na různé aspekty, ať již ekonomické, sociální nebo ekologické spojené s využíváním krajiny. Většina studií, které se zaměřují právě na hodnocení rozdílů ve využití krajiny a krajinném pokryvu mezi státy, které oddělovala železná opona, se zaměřuje pouze na malý úsek železné opony. Dosud chybí studie, která by se zabývala železnou oponou jako celkem a téměř všemi státy, které opona oddělovala. Souvisí to do značné míry i s dostupností datových zdrojů, které je možné pro analýzu využít. Ideální pro analýzy krajiny v takto rozsáhlém prostoru jsou data dálkového průzkumu Země. S výhodou je proto možné využít již připravená klasifikovaná data krajinného pokryvu *(land cover)*, která byla zpracována v rámci programu CORINE Land Cover *(COoRdination of INformation on the Environment)*, který započal již v roce 1985 a jehož cílem bylo vytvořit jednotný klasifikační systém a metodu, které by poskytovaly informace o využití krajiny států EU. Databáze CORINE land cover je budována s využitím dat dálkového průzkumu Země (především senzoru Landsat) podle jednotné metodiky a legendy, je vytvářena individuálně v každém státu a integrována do jednotné bezešvé databáze. Celý projekt je momentálně koordinován Evropskou agenturou pro životní prostředí (European Environment Agency – EEA) a vytvořená data je možné stáhnout z jejich stránek (http://www.eea.europa.eu/data-and-maps). Momentálně jsou k dispozici data pro roky 1990, 2000 a 2006 a změnové vrstvy pro období 1990–2000 a 2000–2006.

Tato data byla využita s cílem provést hodnocení stavu krajinného pokryvu *(land cover)* v roce 1990 a jeho změn podél bývalé železné opony v letech 1990–2000–2006 a porovnat vybrané hraniční úseky na východ a na západ od železné opony. Analyzováno bylo území ve vzdálenosti 15 km na obou stranách železné opony. Na straně východu bylo analyzováno území zahrnující bývalou Německou demokratickou republiku, Česko, Slovensko a Maďarsko a na straně západu území bývalé Spolkové republiky Německo a Rakouska. Podrobněji jsme se věnovali hodnocení stavu a vývoje na území Česka a jeho sousedů – bývalé SRN a Rakouska. Předpokládali jsme, že podíl jednotlivých kategorií krajinného pokryvu *(land cover)* v roce 1990 se bude výrazně odlišovat na obou stranách bývalé železné opony a že mezi státy na východ a na západ od železné opony došlo k rozdílnému vývoji (intenzita, převažující procesy změn) v období 1990–2000–2006.

Výsledky potvrdily rozdílné zastoupení jednotlivých kategorií land cover v roce 1990 v území na východ a na západ od železné opony i jejich rozdílné změny v období 1990–2006. Zatímco centrálně řízená ekonomika a dotační systém před rokem 1989 vytvořily tlak využívat na východ od železné opony půdu pro zemědělství i v nepříznivých podmínkách, na západ od železné opony se uplatnila tržní politika, intenzivní zemědělství zde bylo i přes vysoké dotace neudržitelné, byl krajinný pokryv rozmanitější a využití krajiny více odpovídalo přírodním podmínkám. Analýza také potvrdila rozdílnou intenzitu změn v jednotlivých sledovaných hraničních úsecích a intenzivnější změny land cover po roce 1990 na východ od železné opony. V období 1990–2000 došlo na východ od železné opony ke změně na 3,96 % sledovaného území, na západ od železné opony došlo ke změně pouze na 0,52 % sledovaného území. V období 2000–2006 to potom bylo na straně východu na 0,61 % území a na straně západu na 0,16 % území. Nejrozsáhlejší byly změny zaznamenané v českých hraničních úsecích, kde došlo k poměrně rozsáhlým procesům extenzifikace zemědělství a zalesňování a ke změnám v období 1990–2000 na více než 8 % území. To kontrastuje s hraničním úsekem v Rakousku, který byl v průběhu celého sledovaného období velmi stabilní (změny v obou časových obdobích se uskutečnily pouze na 0,13 % území).

Obr. 1 – Zájmové území s 15 km širokou hraniční zónou na východní a západní straně hranice.
Obr. 2 – Změny krajinného pokryvu v období 1990–2000. Plochy, které se změnily, jsou označeny černou barvou. Zdroj: autoři s využitím dat Corine Land Cover.
Obr. 3 – Změny krajinného pokryvu v období 2000–2006. Plochy, které se změnily, jsou označeny černou barvou. Zdroj: autoři s využitím dat Corine Land Cover.

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