Comparing regional differentiation of land cover changes in natural and administrative regions of the Czech Republic using multivariate statistics

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Abstract
Direct and indirect factors both influence land cover. One of the most important indirect factors influencing the arrangement and structure of land cover in the Czech Republic in the 20th and 21st centuries was the fall of the communist regime and the subsequent political, legislative, socio-cultural and institutional changes. Through cluster, factor and principal component analysis, it is possible to precisely analyse land cover changes in different spatial scales and in different types of spatial classifications (regional classifications). Various spatial levels and types of spatial classifications show different results, which are often complementary or more precise. All, however, correspond to the growing variability of land cover structures both within the types themselves and among other types. The landscape of the Czech Republic is moving in the direction of greater variability in the structure and composition of land cover classes.

Key words
land cover, regional differentiation, multivariate statistics, Czech Republic

Introduction
As Lambin et al. (2001) states, land use (LU) is a function (f) of pressures, opportunities, policies, vulnerability and social organization. Pressures is f (population of resource users, labour availability, quantity of resources and sensitivity of resources), Opportunities is f (market price, production costs, transportation costs and technology), Policies is f (subsidies, taxes, property rights, infrastructure and governance), Vulnerability is f (exposure to external perturbations, sensitivity and coping capacity), and Social organization is f (resource access, income distribution, household features and urban-rural interactions).

Land cover (LC) and land use are not synonyms. LU expresses the function of space; LC expresses the physiognomic character of the territory; LC is defined using characteristics that are visible on the Earth's surface, and it indirectly reflects other natural conditions (geological bedrock, climate, soil, geomorphology and human subsystems). LC also includes anthropogenic changes to the Earth's surface (e.g., developed land with buildings, land for industrial or logistical use, transportation lines). LC changes constitute the replacement of one cover type by another, and they are measured by a shift from one LC category to another, as is the case of agricultural expansion, deforestation, or changes in urban extent (Lambin, 2006). LC changes are caused by direct and indirect factors that stem from the natural predisposition and limits of the land as well as socioeconomic demands and needs. In turn, these LC changes can change causative factors (Reid et al., 2006; Lambin et al., 2001). Moreover, the broader general legislative, institutional, political and economic framework that keeps the LC dynamics going is also changing.

LC is more frequently used in the natural sciences, in which the physical or chemical properties, quantity and character of the vegetation and NDVI are investigated (Xu et al., 2002). LU is mainly used by social scientists who analyse the methods and changes in which the land is used, and they look for economic, social and other consequences of this use. They also propose modifications and plan and manage the land. LU change at any location may involve either a shift to a different use or an intensification of the existing use (Meyer and Turner, 1994).

LC changes are most frequently analysed on the regional scale (Van Doorn and Bakker, 2007; Seguchi et al, 2007). Authors treat the territory of an entire country less often (Feranec et al., 2007; Krausmann et al., 2003; Bičík and Jeleček, 2005; Balej and Anděl, 2010). These analyses include looking for the driving forces and consequences of LC changes in the socioeconomic context (e.g., Byron and Lesslie, 2008; Babigumira et al., 2008). LC changes are also discussed in connection with global warming and the production (and reduction) of greenhouse gases (Watson et al., 2000). Some authors create prediction models (Haberl et al., 2003; Haber and Fehrenbach, 2004) based on the history of past LU changes, natural features, man-made infrastructure and LU decisions to be used as a tool for community planning (Liu et al, 2007; Maxwell et al., 2000; Stephane and Lambin, 2001). Remotely sensed data are a standard source of information about LC (Peterson and Aunap, 1998; Bastin et al., 2002; Kusimi, 2008; Iovanna and Vance, 2007). With the development of information technology, methods and opportunities for obtaining, processing and interpreting data are also developing (Herold et al., 2006). It is no longer a major difficulty to analyse data for a relatively extensive area.

In the Czech Republic the traditional land use and land cover studies were based on territorial units of municipalities (Bičík and Kabrda, 2008) or of sampling cells in distributed models (Chuman and Romportl, 2010), using the cadastral databases, old maps and aerial images and most recently the CORINE LC database (European Environmental Agency). These approaches are valuable for landscape ecological studies (e.g. for landscape typologies emerging from European Landscape Convention) and for detection of effects of diverse driving forces, but (a) they give only a limited information about regional differentiation of the study area, (b) they do not enable to correlate landscape (natural) parametres with social ones at the mesoregional scale and thus (c) they do not fully enable to include results of LUCC analyses in regional policy and this remains far from appreciating the landscape complexity.

The development of LC structures can be analysed on a broad range of spatial scales (from the local all the way up to the global). The multi-scale approach, in which the results from a single spatial level are supplemented and compared with the results from another spatial level, is rare. Similarly, if the authors are concerned with the internal structure of the regions in a large land unit (e.g., an entire country) based on LC structure, they use the various internal divisions of the country (administrative units or certain natural units). Each of these segmentations can bring different results, however. These results are influenced by which segmentation is selected. We have therefore posed the following questions:

- In what ways has LC changed in the Czech Republic after the fall of communism in 1989? What are the prevailing trends in the development of LC on different scales?
- How has LC structure been differentiated in the different regions of the Czech Republic? Can we find similarities and cluster them into specific types?
- How do the various spatial scales have an impact on the results of cluster analyses based on the LC structures of individual regions?
- How does the selection of a different type of internal segmentation of the territory have an impact on the results of cluster analyses based on the LC structures of individual regions?
- Which advantages and disadvantages are connected with the selection of the spatial level and the type of segmentation of the territory if one aims to find the similarities and differences in LC structure in different parts of the territory?

Data and methods

Since 1990, the CORINE LC database has made it possible to assess the development of LC in most European countries. Due to its coarse scale, but large scope in terms of space, this database is often used for evaluating LC developments from extensive areas of land (e.g., Iovanna and Vance, 2007, Kusimi, 2008). The vector data of LC are interpreted from satellite images from Landsat 5 TM taken between 1989 and 1992, from Landsat 7 ETM (2000) and the most recent images from the Spot satellite (2006) (e.g., Nunes de Lima, 2005; Feranec et al., 2007).

All three geodatabases (1990, 2000 and 2006) are mutually comparable, as they were created according to similar criteria. The minimum mapping unit was set at 25 ha, and the minimum width of mapped linear objects was 100 m. The output was LC maps at a scale of 1:100,000 with 44 LC classes for European countries (Table 1).

Table 1. LC classes monitored in the Czech Republic (in 1990, 2000 and 2006).

1 Artificial surfaces	**3 Forest and semi-natural areas**
11 Urban fabric	*31 Forests*
111 Continuous urban fabric	311 Broad-leaved forests
112 Discontinuous urban fabric	312 Coniferous forests
12 Industrial, commercial and transport units	313 Mixed forests
121 Industrial or commercial units	*32 Scrub and/or herbaceous vegetation associations*
122 Road and rail networks and associated land	321 Natural grasslands
123 Port areas	322 Moors and heathland
124 Airports	324 Transitional woodland-scrub
13 Mine, dump and constructions sites	*33 Open spaces with little or no vegetation*
131 Mineral extraction sites	332 Bare rocks
132 Dump sites	334 Burnt areas
133 Construction sites	
14 Artificial, non-agricultural vegetated areas	
141 Green urban areas	
142 Sport and leisure facilities	
2 Agricultural areas	**4 Wetlands**
21 Arable land	*41 Inland wetlands*
211 Non-irrigated arable land	411 Inland marshes
22 Permanent crops	412 Peat bogs
221 Vineyards	
222 Fruit trees and berry plantations	
23 Pastures and meadows (grasslands)	
231 Pastures and meadows (grassland)	**5 Water bodies**
24 Heterogeneous agricultural areas	*51 Inland waters*
242 Complex cultivation patterns	511 Water courses
243 Land principally occupied by agriculture with significant areas of natural vegetation	512 Water bodies
24 Heterogeneous agricultural areas	
242 Complex cultivation patterns	
243 Land principally occupied by agriculture with significant areas of natural vegetation	

Modern technology and software now make it possible to handle ever more complex tasks and resolve them ever more quickly. We applied the software STATISTICA 9 to examine the set of LC structure geographic data. We used the following statistical functions: principal component analysis (PCA), cluster analysis (CA) and factor analysis (FA). Similar attempts, though none at this scale, can also be found in earlier studies (Byrne et al., 1980; Cakir et al., 2006; Fung and LeDrew, 1987; Richardson and Milne, 1983). The use of PCA in land change studies even dates as far back as 1979 (Lodwick, 1979).

Using FA and PCA, we analysed the LC database in individual years (1990, 2000 and 2006). We analysed the structure of LC classes in two spatial levels and in two types of spatial segmentation, always for the entire Czech Republic. We made our calculation based on standardised data (the share of LC classes in territorial units). There were 11 variables (LC classes). We generalised LC classes that exist in the Czech Republic (Table 1). Due to their insignificant areas, classes 322, 332, 334, 411, 412 and 511 were omitted. We merged similar and relatively small classes in the Artificial surfaces group. We also merged three forest classes.

Due to the results from the application of FA and PCA, we generalised the number of variables for R^2=70% (eigenvalue=5 and cumulative percentage of variance greater than 0.70). As a result, we reduced the variables from the original 11 LC classes to 5 principal components, while losing precision as indicated. With these components, we then described the entire data set. We originally calculated the average Euclidean distance (full connections, AED) between the cases (i.e., territorial units). We clustered the territorial units using the k-means method through hierarchical clustering. We compared the resulting dendrograms and tables of members of the clusters from both methodologies, and on the basis of the composition of the clustering, we decided on potential differences.

To analyse the dynamics of LC changes, we calculated the total LC change index in the years between 1990 and 2000 and between 2000 and 2006:

$$Iclc_i = 1000 * \frac{Area_{i,t2} - Area_{i,t1}}{Area * (t2 - t1)}$$, where

$Area_{i,t2}$ is the area of the ith class in time t2; $Area_{i,t1}$ is the area of the ith class in time t1, i.e., at the start of the period; and Area is the total area of the mesoregion. The total change index is the sum of the absolute values $Iclc_i$ from all LC classes.

Temporal scale: The Czech Republic after the fall of communism

The fall of communism in the Czech Republic (after 1989) caused significant socioeconomic changes as well as changes in the characteristics of human activities in the landscape. The political change led to LC changes in various parts of the Czech Republic in differing ways and intensities (Bičík and Jeleček, 2005). The intensity of the changes following the fall of communism differed on the political, institutional, economic, social and cultural levels. We analyse in which direction and with what level of intensity these changes had an impact on LC in various areas of the Czech Republic. Here, the years 1990, 2000 and 2006 mark various periods in the transformation of the Czech Republic.

The transformation period (1990-2000) was preceded by the period of communism (1948-1989). This period can be designated as the final phase of an industrialized society. The transformation period represents the transition from a centrally-planned economy to a market economy. This transition is marked by price liberalisation, land and property privatisation, the definition of a new legislative and institutional framework, the opening of the economy and liberalisation at the socio-cultural level. The transformation is also reflected in agricultural activities and industrial production.

In the post-transformation period (after 2000), the transformed economy experienced a revival. Services and tourism, especially, began to develop and grow. Mining and raw material-intensive industry declined. Small and mid-sized minor (precision) engineering companies were formed; in some cases, large companies in the car and subcontracting industries were also established. Agricultural (crop and livestock) production (as well as employment in the sector) fell. In 2001, the European Commission confirmed that the Czech Republic had a functioning economy, stating that the country met the Copenhagen criteria.

Communication and information networks experienced intensive development. In terms of the settlement structure, the process of suburbanisation appears as satellite towns with new infrastructure constructed in the hinterlands of large agglomerations, which puts much pressure on land near urban areas.

After the Czech Republic joined the European Union (2004), economic development accelerated (up until the crisis in 2008). In 2005-07, the GDP increased by more than 6% each year. Pressure on the land increased as transportation and technical infrastructure was built. New warehouse spaces, trans-loading facilities and other auxiliary logistics infrastructures arose. This form of construction along transportation lines is often uncontrolled and chaotic. The suburbanization process in the form of urban sprawl is characterised by the establishment of residential compounds and commercial areas. Large shopping and entertainment centres are erected on greenfield sites near major cities. More satellite towns (similar to "edge cities" in the U.S.) that are emerging and growing along the outskirts are also becoming commuting centres, with decreased dependence on the core city (Ouředníček, 2004).

Rapid economic growth is also associated with the development of industrial production in nearly 200 new industrial zones, which were built on greenfield sites. At the same time, derelict industrial and agricultural facilities (brownfields) have remained an unaddressed problem.

Spatial scale: different types of areal units

We analysed the LC changes in four types of territorial segmentation (Balej and Anděl, 2010). According to Haggett (1972), it is necessary to view territorial units and regions with regard to why they are being used in the specific case and how they are defined. Some territorial units are defined based on their similar physiognomic characteristics. Other territorial units are defined the basis of the functions they fulfil and the connections within segments of the region.

We studied LC changes in two types of regions: formal and functional. Formal regions are defined based on similar characteristics. Functional regions are spatial systems based on internal spatial and functional interactions between the core (or node or focus) and its hinterland. The strength of functioning relationships between the core and the hinterland is a criterion for defining these regions. The spatial level is also important. For both types of regions, we used two spatial scales: macroregional and mesoregional. A precondition in this case was the composability of the regions and that a certain number of mesoregions form a macroregion.

Formal macroregions in the Czech Republic are geomorphological sub-provinces (the second-highest order in the Czech Republic in geomorphological regionalization). These contain smaller formal mesoregions that are geomorphological units (Table 2). The key factors for specifying formal macroregions and mesoregions are relief type, morphography, morphostructure and morphogenesis. The areal extent of the regions, defined by the mutual relationships to the superordinate regions, is also a significant criterion. These regions are typified by physiognomic differences from one another (Balatka and Kalvoda 2006).

The functional macroregions are administrative regions (NUTS 3 according to the classification of territorial units in the European Union). The functional mesoregions are the districts of the Czech Republic (NUTS 4, or LAU 1, local administrative units), which are component parts of the regions (Table 2). Functional regions are spatial units that are internally connected by strong socioeconomic ties.

Table 2. Different types of spatial units.

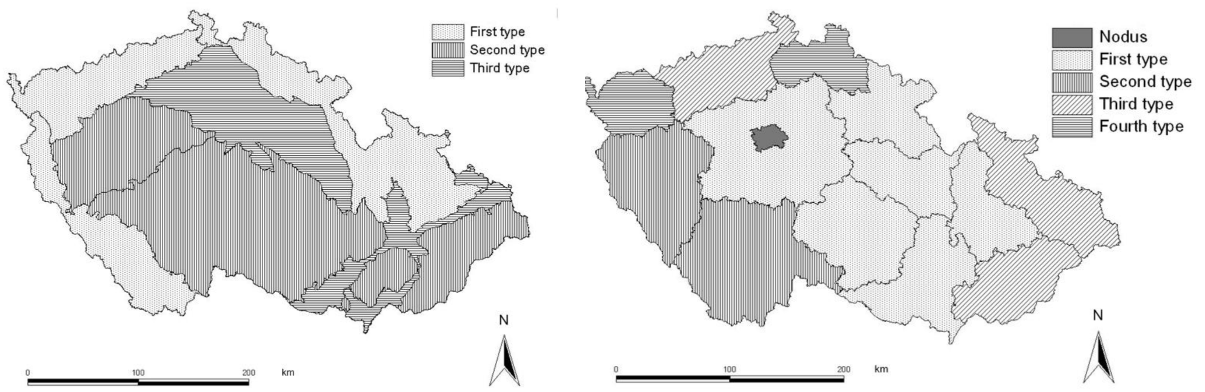
Type of region	**Spatial scale**	**Identification**	**Regions** (Nr.)	**Area** (Avg. in km^2)	**Types** (Nr.)
Formal	macroregional	geomorphological subprovince	10	7 887	3
	mesoregional	geomorphological unit	93	848	10
Functional	macroregional	province	14	5 633	5
	mesoregional	district	76	1 038	7

Typologies of the Czech Republic based on type of region and on spatial scale

According to the LC structure, the typology of a region can be created using a cluster analysis. Amongst clusters, the LC structures differ from one another; within the clusters, the LC structures of the units are similar. A dendrogram and CA demonstrate the "distance" of LC structures amongst all the pairs of regions in 1990, 2000 and 2006. Three types were formed for the formal macroregions, and five types were formed for the functional macroregion. The crucial limit in the average Euclidean distance (AED) amongst clusters was set at 20 AED at the macro level and 10 AED at the meso level.

The first type of formal macroregion predominantly includes mountainous (border-area) macroregions. The second type is hilly and highland macroregions. The third type is lowland and basin macroregions, where LC changes are already minimal. It has been shown that the dynamics of change generally decrease from west to east and with falling elevations (Figure 1).

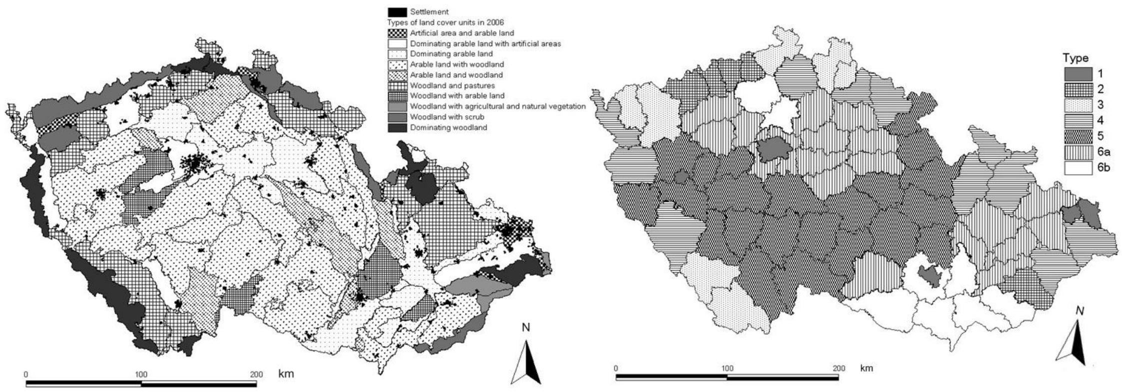
Figure 1. Typology of the formal (left) and functional (right) macroregions based on LC structure.



A more complex division arose for functional macroregions (Figure 1). The first type is relatively homogenous internally. This type has good natural conditions for agriculture (especially land and climate), and in terms of geographical location and accessibility, it also has good conditions for overall economic development. Great stability in development in the LC classes is typical for this type, and it can be designated as an area with growing pressure on land in the hinterlands of Prague and along the main arteries. The second type is highly homogenous due to its exposed geographical location, neighbouring Germany and Austria.

The land, which is less fertile and more suitable for grazing, is predominantly cooperatively owned. The third type is composed of macroregions that have been affected most significantly by the political changes and the transformation from a centrally planned economy to a market economy. The different situation of these macroregions stems from their long-term economic orientation on the energy, mining, steel and chemical industries – i.e., sectors that have negative impacts on the natural and social environment (Balej et al., 2008). The smallest macroregions form the fourth type feature broken, uneven terrain with a high percentage of woodland.

Figure 2. Typology of the formal and functional mesoregions based on LC structure.



For the **formal mesoregions** (93 geomorphological units), 10 types were created at the lower hierarchical level. These types were placed in order so that they would progress from anthropogenic spaces significantly modified by humans to predominantly woodland types (Figure 2). Artificial areas are predominant in the **Artificial area and arable land** type. Other classes have a similar share (arable land, pastures, agricultural and natural vegetation and woodland). These classes are located in smaller territories, especially in basins and troughs. There is high population density and industrial activity in this type. The **Dominant arable land with artificial area** type is in basins, hilly areas and the hinterlands of the city of Prague. This type is dominated by arable land (46%). The distribution of other LC classes is relatively even. The **Dominant arable land** type is land with intensive agricultural activity (average 72% arable land). This type is composed of 13 geomorphological units with high land quality that are concentrated around the valleys of the country's largest rivers. The **Arable land with woodland** type is territory with arable land and a significant distribution of woodland. This is the most widespread type in the Czech Republic (18 geomorphological units). Nearly half of the country's territory falls under this type. The **Arable land and woodland** type is characterised by similar parameters, with nearly even percentages of woodland and arable land. Woodlands are predominant in the other types. The **Woodland with pastures** type is the most widespread and is located in extensive foothill regions along the country's borders. This type is marked by the highest distribution of pastures. In addition to a higher percentage of woodland, **Type G – Woodland with arable land** also has a relatively large distribution of arable land. In this territory, this type is concentrated west of Prague and northeast of Brno, where residents of both major cities travel to visit recreational attractions. The **Woodland with agricultural and natural vegetation** type fills in the mountainous area along the border with Slovakia. Recreational activities are also frequent in the **Woodland with scrub** type, which also has a high distribution of pastures. The mountains along the frontier in northern Bohemia are of this type. The greatest share of woodland is in the **Dominant woodland** type, where the average percentage of woodland cover is 75%.

Functional mesoregions (76 districts) are divided into seven types. Economic, social and geographic factors are different from type to type but are similar within the type (Figure 2). The first two are the most stable and relatively strictly defined types. **1. The Metropolitan type** contains the core regions and the economic and transportation nodes of the Czech Republic. These regions have a high representation of urbanised space (over 16%) and industrial space (over 5%) and a low representation of arable land (under 30%) and woodland. Their development trends aim to continue to strengthen their role as areas of concentration. **The 2nd type** indicates a **structurally impaired area** with similarly high representations of industrial and warehouse space (an average of 8%) and meadows (approximately 15%) but with a low share of arable land. Post-1990, there has been a decrease in arable land, particularly in the first period. The growth in warehouse space (the highest in the Czech Republic) can illustrate the revival of economic activity in these depressed regions. The other types do not represent such sharply defined groups, and some mesoregions are on the borderline between individual clusters. The **3rd and 4th types** are composed predominantly of mountainous, frontier districts. **The 3rd type** includes mostly **industrial** mesoregions. Most districts have higher representations of urbanised and wooded space, while their arable land is lower, with its share dropping dramatically from 1990 to 2000. In contrast, warehouse space increased in 2000-2006. **The 4th type** is distinct for its **peripheral location and extremely high forest cover**, with woodland demonstrating growth trends, especially in the period from 2000 to 2006. **The 5th type, hills and highlands,** is the most extensive in terms of area, and it includes the central hills and highland areas. **The 6th lowland type** includes intensively farmed valley areas. This type is marked by its high representation of arable land and urbanised space and its relative developmental stability. As part of the 6th type, **we can designate sub-type 6b, which has a high share of vineyards**.

Results

In functional macroregions, LC changes are somewhat higher than in formal macroregions. This result is not as demonstrable in the high and low values, but it is apparent in the Iclc averages, including those for LC classes with the greatest share. When comparing both periods (1990/2000 and 2000/2006), we can state that LC changes are not as intensive in the first period as in the second period. This result is shown in all Iclc classes and parameters (avg., max., min.). Furthermore, Table 3 shows that the functional and formal mesoregions differ significantly in Iclc. In contrast to units of an administrative character, units of a natural character are far more conclusive, and they attest more to the LC changes. This phenomenon is not exhibited on the macro level due to the size of the units and, thus, the "blotting out" of their natural characteristics.

The mesoregion types with the greatest LC changes are structurally impaired areas and peripheral frontier areas (Table 4). In LC classes, it applies that for the formal macroregions Arable land and Pastures, the Iclc is 4.20 respectively 3.65. For the same LC classes in functional macroregions, the Iclc is 4.58 and 4.01. It is in these types that the drop in arable land is greatest. Due to their focus on the heavy chemical and energy industries (including large-scale brown coal surface mining), these regions became problematic after 1990. Another typical feature of these areas is the growth of meadows. In contrast, minimal changes in the development of LC classes can be observed in the lowland types of mesoregions with high representations of arable land as well as in vineyard regions and areas with the highest elevations (Table 4).

Table 3. Iclc according to the type of region and to spatial scale in 2006/2000 and 2000/1990.

		LC change index 2006/2000			**LC change index 2000/1990**		
		Avg.	**Max**	**Min**	**Avg.**	**Max**	**Min**
Macroscale	**Formal**	12.2	19.4	3.9	9.4	21.9	2.1
	Functional	13.3	19.3	6.7	10.8	21.9	1.7
Mesoscale	**Formal**	17.1	77.5	2.6	12.8	51.9	0.8
	Functional	14.8	39.7	0	10.5	39.2	0.8

Tab. 4. Iclc in different types of mesoregions (2006/2000 and 2000/1990).

	Type 2006		**LC change index 2006/2000**	**LC change index 2000/1990**
Fucntional mesoscale	1	Metropolitan type	12.7	7.6
	2	Structurally impaired area	29.1	23.9
	3	Industrial	17.7	20.1
	4	Peripheral location and extremely high forest cover	19.2	16.1
	5	Highlands type	8.7	4.6
	6	Valley type	14.8	7.9
	7	Wine-growing	8.6	3.4
Formal mesoscale	A	Artificial area and arable land	26.0	21.7
	B	Dominating arable land with artifical area	20.8	13.2
	C	Dominanting arable land	6.4	2.3
	D	Arable land with woodland	13.6	5.9
	E	Arable land and woodland	17.1	8.5
	F	Woodland and pastures	28.3	25.6
	G	Woodland with arable land	10.1	8.9
	H	Woodland with agricultural and natural vegetation	13.4	10.9
	I	Dominanting woodland	20.0	21.3
	J	Woodland with scrub	15.9	15.5

The LC analysis showed that in the transformation period (1990-2000), there were generally smaller LC changes. The largest changes were in the structurally challenged regions, the industrial areas, and in mountainous regions, which have broken, uneven terrain along the borders with Germany, Austria and, in part, Poland. In the subsequent period, the greatest changes were again in the mountainous and structurally challenged industrial regions but also (newly) in the hilly and foothill regions – i.e., at lower elevations. The change in the total index of changes shows a delay in LC changes in peripheral geographic locations in internal peripheries. These are along the borders of the current regions (of functioning macroregions). The development of the overall Iclc is predicated mainly on the change of LC classes with the greatest share. This is a transition from arable land to pastures and meadows or growth in heterogeneous agricultural areas, artificial surfaces and forest and semi-natural areas.

Table 5. AED according to the type of region and to spatial scale in 1990, 2000 and 2006.

Average Euclidean Distance		**1990**			**2000**			**2006**		
		Avg.	**Max**	**Min**	**Avg.**	**Max**	**Min**	**Avg.**	**Max**	**Min**
Macroscale	**Formal**	27.4	35.7	21.3	31.3	41.3	24.5	32.5	43.4	25.3
	Functional	20.3	26.8	15.1	23.4	32.2	17.3	23.7	32.0	17.5
Mesoscale	**Formal**	39.5	62.6	28.6	43.1	66.6	31.1	43.5	67.8	32.0
	Functional	26.7	54.9	19.4	30.4	55.9	22.1	31.1	57.3	22.5

The decline in arable land and the increase in meadows are apparent in nearly all types. The greatest values are in the border regions with greater representations of area at higher elevations. In the first period, land principally occupied by agriculture with significant areas of natural vegetation changed only slightly; in the second period, the change was far more pronounced. This category increases in the mesoregions of Southern Bohemia, Southern Moravia and Vysočina. Wooded vegetation expanded more intensively in the second period. This area grew most rapidly due to the impact of the wooded revegetation of disposal sites following brown coal mining in northwestern Bohemia.

Tab. 6. AED in different types of mesoregions in 1990 and 2006.

	Type 2006	**Name of the type**	**AED 2006**	**AED 1990**
Fucntional mesoscale	1	Metropolitan type	24.8	24.2
	2	Structurally impaired area	21.3	18.9
	3	Industrial	25.1	22.7
	4	Peripheral location and extremely high forest cover	17.3	17.3
	5	Highlands type	14.2	11.3
	6	Valley type	18.1	17.3
	7	Wine-growing	14.6	13.0
Formal mesoscale	A	Artificial area and arable land	25.4	28.5
	B	Dominating arable land with artifical area	18.5	17.8
	C	Dominanting arable land	13.2	12.7
	D	Arable land with woodland	14.1	11.7
	E	Arable land and woodland	15.7	12.7
	F	Woodland and pastures	16.6	15.3
	G	Woodland with arable land	11.9	10.2
	H	Woodland with agricultural and natural vegetation	9.1	14.9
	I	Dominanting woodland	15.6	17.8
	J	Woodland with scrub	12.4	11.4

In all the years that were monitored, the formal regions are more differentiated according to AED. The natural parameters (geomorphology, morphogenesis, climate condition and soil type) of the formal regions are more homogenous. The variability of LC is more differentiated. In functioning macroregions, these borders are created by socioeconomic or historical ties, and the relationship between LC and natural conditions thus manifests itself far less. The functional regions have LC types that are more similar to one another. The variability of LC has grown in all types of regions and for all values (avg., max., min.) from 1990 to 2006 (Table 5), and it has grown more significantly in functional regions. In formal regions, the growth is less dramatic. Some pairs of regions can be found whose LC structures have become more similar over time.

Greater differentiations amongst spatial units within one type, as well as more dynamic LC changes, are present at the mesoregional level. The development of AED according to individual types of mesoregions (Table 6) confirms that for most types, AED increased from 1990 to 2006, and as a result, the variability within the individual types has also risen. Types with high representations of artificial surfaces feature the greatest variability within types. In contrast, the specific wine-growing and woodland areas with agricultural and natural vegetation types have the lowest variability. These form more extensive, unique areas in the southeast of the Czech Republic.

Discussion and Conclusions

After the development of a market economy in the Czech Republic, production costs (including those for food) started to become more important. This development indirectly specified the areas in the Czech Republic suitable for intensive farming, and it separated these from less suitable areas where costs are higher. The transformation to a market economy put significant pressure on adaptation to natural and new economic (market) conditions.

The more broken the geomorphology, the higher the average elevation and the further west the macroregion or mesoregion is located, the more intense the LC changes. To a significant extent, this phenomenon corresponds to previous developments in Western Europe (Germany and Austria). This phenomenon is also related to the previous subsidies provided for farming in the mountainous and highland areas, where the natural conditions are less suited to agriculture. LC changes have thus entered the Czech Republic from Germany and Austria, and they are spreading farther eastward. The lowlands, basins and ravines have greater stability. The greatest LC change is the shift from arable land to pastures. Again, this change is most intense in topographically broken, uneven areas. The absolute opposite is the case for the growth of artificial areas.

In terms of the structure of LC in general, there is a proven, continuously growing heterogeneity in the Czech regions. At the beginning of the transformation period (before 1989), the uniformity of central planning was strongly evident. After the fall of the communist system, the titles to land were returned to their original owners. Often, however, the new owners were not interested in the land, and they let it lie fallow (waste). Moreover, agricultural crop growing was becoming more and more concentrated in the most fertile areas with the best climate. In connection with the population’s growing demands for quality housing and with the transformation to a post-modern society, satellite towns in the hinterlands of large agglomerations are being constructed (suburbanization), or in some cases, the village way of life is becoming urbanized through the construction of houses and villas (reurbanization). As a result, developed residential space is increasing. Space for industrial and retail operations are also growing, mostly in connection with the development of the transportation infrastructure, that is, along newly constructed highways and motorways.

The results indicate that the mesoregional formal type (formed by physical geographic units) best epitomises the LC structure. In contrast, the functional mesoregional type can find greater application in monitoring trends in the development of the socio-geographic system (social or economic data) and in setting the measures for regional policy and management.

These data are monitored in this type of administratively defined territory. Like rural typology (Perlín, Kučerová, Kučera, 2010), LC structure-based typology can serve as one of the bases for forming development studies, particularly studies of rural areas. With this typology, support tools can be better formulated in relation to the specific aspects of individual parts of the Czech Republic. The results provide an answer to the territorial differentiation of LC changes. The macroregional level can have good predictive power when making international comparisons in the framework of EU countries (Balej, Anděl, 2010).

Compared with formal regions, functional regions are more complex. These regions are developing at a higher rate, and they reflect less natural determination. As the hierarchical level grows, the complexity and rate of development increases and the reflection of natural determination falls (see Figure 6). Differentiation is also apparent between the two monitored periods (1900-2000 and 2000-2006). It is generally the case that the differences in the LC structure that existed in the first period (between pairs of mesoregions) have become more complicated, and new clusters are arising.

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