

Overview of Changes in Land Use and Land Cover in Eastern Europe

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Abstract This chapter presents an analysis of land cover changes in Eastern Europe between 1990 and 2006, assessed using CORINE (Co-ORDination of INformation on the Environment) Land Cover (CLC) datasets. The plethora of potential land cover change categories were condensed into seven categories of major land use change processes: urbanization, agricultural intensification, agricultural extensification, afforestation, deforestation, construction and management of water bodies, and other changes. The amounts of each change category and their spatial distributions are summarized, and the change categories were also mapped to show the relative amounts of change (per $3 \times 3 \text{ km}^2$) between 1990 and 2000 and between 2000 and 2006. The results showed that while more afforestation than deforestation was observed in the first period, the reverse was true in the second period, when deforestation outpaced afforestation. Urbanization and suburbanization were major processes in Eastern Europe, particularly around existing major cities, and the speed of this process generally increased from the first to the second period. Both the intensification and extensification of agriculture were common

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during both periods, but a larger effect was observed in the first period. Overall, land use changes were highest in central Europe and the Baltic countries and lowest in southeast Europe.

1 Introduction

The collapse of socialism in 1989 caused massive socio-economic and institutional changes (Prishchepov et al. 2013). This event has affected landscapes throughout Russia and Central and East European satellite states. This chapter addresses land cover (LC) changes in Eastern Europe between 1990 and 2006. First, a brief overview of previous studies on LC changes in Eastern Europe is provided here.

The landscape of Eastern Europe has experienced significant changes in grassland cover. Cremene et al. (2005) reported a significant recent reduction in Steppe-like grasslands in Eastern Europe. In Central Eastern Europe, including the Czech Republic, Hungary, Romania and the Slovak Republic, the main types of landscape changes were urbanization/industrialization, intensification of agriculture, extensification of agriculture, afforestation, deforestation, enlargement of areas of extraction (exhaustion) of natural resources, and other anthropogenic changes according to an analysis overlaying CORINE Land Cover (CLC) data with Landsat MSS (Multispectral Scanner) imagery corresponding to the late 1970s and visually observing the differences between CLC1990 and the 1970s imagery (Feranec et al. 2000). However, at the local scale, certain processes dominated. For example, along the Czech Republic-Austria border, afforestation prevailed from 1990 to 2000 (Kupkova et al. 2013). In the Czech Republic, the increase in forest areas is relatively permanent (an increase of 5 % during the 20th century), occurring in areas that are not as well suited for agriculture, i.e., in sub-mountain and mountain areas (Bičík et al. 2010).

While forest degradation, i.e., the partial extraction of timber and other goods from forests, was a common process in East Europe during the post-Soviet period, afforestation was generally widespread throughout the majority of the region since the fall of socialism (Taff et al. 2010). One major reason for afforestation was the abandonment of farmland, which was common throughout Central and Eastern Europe, according to an analysis of 250-m MODIS 8-day NDVI composites (Alcantara et al. 2013). Similarly, high rates of land abandonment were observed in northeastern Europe between 1990 and 2000, according to an analysis of Landsat TM data (Prishchepov et al. 2012). Baumann et al. (2012) used a combination of summer and winter Landsat images to analyze forest changes in European Russia and observed substantial regional variation, with an overall forest loss between 1990 and 1995 and an overall forest gain between 2005 and 2010. However, there were significant differences between countries in Eastern Europe in terms of their abandonment rates after the collapse of the Soviet Union (Prishchepov et al. 2012; Alcantara et al. 2013), indicating a strong influence of state-level institutional factors. Kuemmerle et al. (2006) also observed significant

differences in land use (LU) changes between some countries within the Carpathian Mountains (Poland, Slovakia, and Ukraine). Kuemmerle et al. (2008) observed that drivers of LU changes also considerably varied between neighboring countries in the Carpathian region. Kozak (2003); Kozak et al. (2007a, b) investigated the main trends and drivers of LU/LC changes in the Carpathian Basin; afforestation and a decrease of arable land were the main long-term trends observed in these studies.

In addition to documenting the patterns of LU changes in general, it is particularly important to understand the drivers and consequences of recent LU and LC changes in this region resulting from the massive socio-economic perturbations that occurred after the fall of socialism (Prishchepov et al. 2010; Hostert et al. 2011). Key drivers of changes in LU patterns in former socialist countries included (1) country-specific land policies relating to the legal attitude towards private land ownership, (2) transferability of land, and (3) land allocation/redistribution strategies (Lerman et al. 2004). Macours and Swinnen (2000) investigated the changes in agriculture production and associated causes in Central and Eastern Europe during the transition period and observed that the primary involves deterioration in the terms of agriculture trade, transition uncertainties, and extreme weather events. During the period from 1990 to 2004, the Czech Republic experienced a significant increase in grassland areas, a process deeply influenced by the termination of significant subsidies given by the socialist state, which ended at the beginning of the 1990s (Bičík et al. 2010).

This chapter presents an overview of landscape changes (spatial distribution and intensity) in Eastern European countries based on CLC during the periods from 1990–2000 to 2000–2006 and describes a useful a mapping methodology for presenting landscape changes on a macro-scale.

2 Methodology

We quantified basic input information concerning recent LC changes in Central and Eastern Europe for 17 countries: Albania (AL), Bosnia/Herzegovina (BA), Bulgaria (BG), Croatia (HR), Czech Republic (CZ), Estonia (EE), Hungary (HU), Kosovo (KV), Latvia (LV), Lithuania (LT), Macedonia FYR (MK), Monte Negro (ME), Poland (PL), Romania (RO), Serbia (RS), Slovakia (SK) and Slovenia (SI). We considered two time periods, 1990–2000 and 2000–2006, and analyzed the changes based on the CLC database. The change data layers CLC1990–2000 and 2000–2006 are available at <http://www.eionet.europa.eu/gis/>, and details concerning these data are provided in Nunes de Lima (2005) and Feranec et al. (2007). A summary of the LC classes included in the change databases CLC1990/2000 and 2000/2006 is shown in Table 1.

We derived the main landscape changes for the second level of CLC classes after applying the conversion table (Table 2). This conversion table, i.e., the “matrix of changes”, groups LC changes of the same type. There are $15 \times 14 = 210$ possible combinations of one-to-one changes between the 15 CLC classes at the second level (Feranec et al. 2010).

Table 1 CLC nomenclature (Heymann et al. 1994; Bossard et al. 2000)

<i>1 Artificial surfaces</i>	<i>3 Forest and semi-natural areas</i>
<i>11 Urban fabric</i>	<i>31 Forests</i>
111 Continuous urban fabric	311 Broad-leaved forests
112 Discontinuous urban fabric	312 Coniferous forests
<i>12 Industrial, commercial and transport units</i>	313 Mixed forests
121 Industrial or commercial units	<i>32 Scrub and/or herbaceous vegetation associations</i>
122 Road and rail networks and associated land	321 Natural grasslands
123 Port areas	322 Moors and heathland
124 Airports	323 Sclerophyllous vegetation
<i>13 Mine, dump and constructions sites</i>	324 Transitional woodland-scrub
131 Mineral extraction sites	<i>33 Open spaces with little or no vegetation</i>
132 Dump sites	331 Beaches, dunes, sands
133 Construction sites	332 Bare rocks
<i>14 Artificial, non-agricultural vegetated areas</i>	333 Sparsely vegetated areas
141 Green urban areas	334 Burnt areas
142 Sport and leisure facilities	335 Glaciers and perpetual snow
<i>2 Agricultural areas</i>	<i>4 Wetlands</i>
<i>21 Arable land</i>	<i>41 Inland wetlands</i>
211 Non-irrigated arable land	411 Inland marshes
212 Permanently irrigated land	412 Peat bogs
213 Rice fields	<i>42 Maritime wetlands</i>
<i>22 Permanent crops</i>	421 Salt marshes
221 Vineyards	422 Salines
222 Fruit trees and berry plantations	423 Intertidal flats
223 Olive groves	<i>5 Water bodies</i>
<i>23 Pastures</i>	<i>51 Inland waters</i>
231 Pastures	511 Water courses
<i>24 Heterogeneous agricultural areas</i>	512 Water bodies
241 Annual crops associated with permanent crops	<i>52 Marine waters</i>
242 Complex cultivation patterns	521 Coastal lagoons
243 Land principally occupied by agriculture, with significant areas of natural vegetation	522 Estuaries
244 Agro-forestry areas	523 Sea and ocean

Table 2 Conversion table (Feranec et al. 2010) for all of Eastern and Central Europe

1990 classes	2000 classes															
		11	12	13	14	21	22	23	24	31	32	33	41	42	51	52
	11	0	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	12	7	0	7	7	7	7	7	7	7	7	7	7	7	7	7
	13	7	7	0	7	7	7	7	7	7	7	7	7	7	6	7
	14	7	7	7	0	7	7	7	7	7	7	7	7	7	6	7
	21	1	1	1	1	0	2	3	3	4	4	7	7	7	6	7
	22	1	1	1	1	3	0	3	3	4	4	7	7	7	6	7
	23	1	1	1	1	2	2	0	2	4	4	7	7	7	6	7
	24	1	1	1	1	2	2	3	0	4	4	7	7	7	6	7
	31	1	1	1	1	5	5	5	5	0	5	5	5	7	6	7
	32	1	1	1	1	2	2	2	2	4	0	5	7	7	6	7
	33	1	1	1	1	2	2	2	2	4	4	0	7	7	6	7
	41	1	1	1	1	2	2	2	2	4	4	7	0	7	6	7
	42	1	1	1	1	2	2	2	2	4	4	7	7	0	6	7
	51	1	1	1	1	7	7	7	7	4	4	7	7	7	0	7
	52	1	1	1	1	7	7	7	7	4	4	7	7	7	7	0

1—urbanization (industrialisation), 2—intensification of agriculture, 3—extensification of agriculture, 4—afforestation, 5—deforestation, 6—water bodies construction and management, 7—other changes (recultivation, dump sites, unclassified changes, etc.)

We grouped these 210 potential land use/cover change (LUCC) classes into seven major LU change processes:

- Urbanization: represents changes in agriculture (CLC classes 21, 22 and 23; codes are explained in Table 1), forest lands (classes 31, 32, and 33), wetlands (classes 41 and 42) and water bodies (51 and 52) into urbanized land (the construction of buildings designed for living, education, health care, recreation and sport) and industrialized land (the construction of facilities for production, all forms of transportation and electric power generation).
- Intensification of agriculture: represents the transition of LC types associated with lower intensity use (e.g., from natural areas—classes 32, 33, except forest class 31 and wetland class 4) into higher intensity agricultural use (classes 21 and 22).
- Extensification of agriculture: represents the transition of LC types from a higher intensity agricultural use (classes 21 and 22) to a lower intensity agricultural use (classes 23 and 24).
- Afforestation: represents forest regeneration, i.e., the establishment of forests by planting and/or natural regeneration in other natural areas or agricultural lands (change of classes 21, 22, 23, 24, 33, 41, and 42 into classes 31 and 32).
- Deforestation: involving forestland (class 31) changes into another LC or damaged forest (classes 21, 22, 23, 24, 32, 33 and 41).

- Construction and management of water bodies (abbreviated: Water bodies construction): involving the change of mainly agricultural (classes 21, 22, 23 and 24) and forest land (classes 31 and 32) into water bodies and the consequences of the management of water resources and the water surface area of reservoirs (Haines-Young and Weber 2006).
- Other changes: includes changes resulting from various anthropogenic activities, such as the recultivation of former mining areas, dump sites, unclassified changes, etc. More detailed characteristics of these changes are listed in Feranec et al. (2010).

The size of the changed area is generally too small to present on a map showing all of Central Europe (e.g., the smallest identified change area in the frame of the CLC mapping is 5 ha.). A practical solution for how to “visualize” such small areas of change is the presentation of the intensity/rate using a regular grid pattern. Consistent with Feranec et al. (2010), we used a 3×3 km grid as a compromise between the actual spatial distribution of the seven above-mentioned changes and their presentations on the Central European level at a meaningful scale. To this end, we first defined the mean LUCC value for the region for each of the seven LUCC types. For each LUCC type, the *mean LUCC* value represents the mean percent area of each 3×3 km² square covered by that LUCC type, taken only among 3×3 km² squares in which the LUCC type occurred. For each LUCC type, the mean LUCC value utilized in the map represents a ratio of the area of that LUCC type (in the whole study area) to the summed area of all squares of the 3×3 km grid in which such changes occurred (i.e., the denominator is $9 \text{ km}^2 \times$ the number of squares in which that LUCC type exists). The mean value of each LUCC type in both periods is listed in Table 3.

We mapped each of the seven types of changes in each of the two time periods (between 1990–2000 and 2000–2006) to show how these changes differed. We compared the LUCC types between the two time periods for each square. We assigned each square a red color when the percentage of the changed region remained steady or increased between the two time periods or a blue color when the percentage of the changed region decreased between the two time periods (Figs. 1, 2, 3, 4, 5, 6, and 7) as follows:

Table 3 Mean values of each LUCC type in both periods

	1990–2000 (%)	2000–2006 (%)
Urbanization	1.7	2.0
Intensification	3.5	2.9
Extensification	5.0	3.7
Afforestation	1.7	2.0
Deforestation	3.5	2.5
Water bodies construction	2.2	1.6
Other changes	3.1	2.4

Note these means are defined as the mean percent area of each 3×3 km² square covered by that LUCC type, taken only among 3×3 km² squares in which that LUCC type occurred

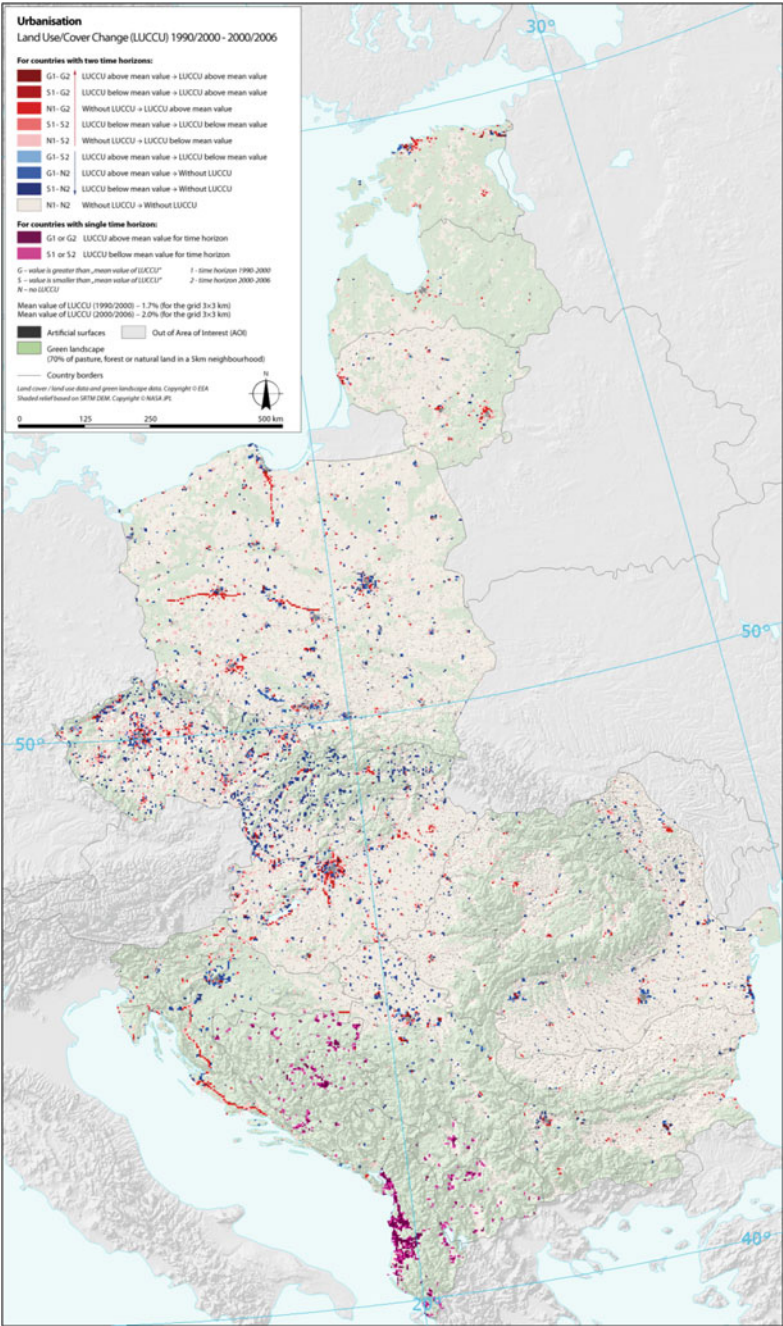


Fig. 1 Spatial distribution of urbanization in Central Europe for the periods 1990–2000 and 2000–2006

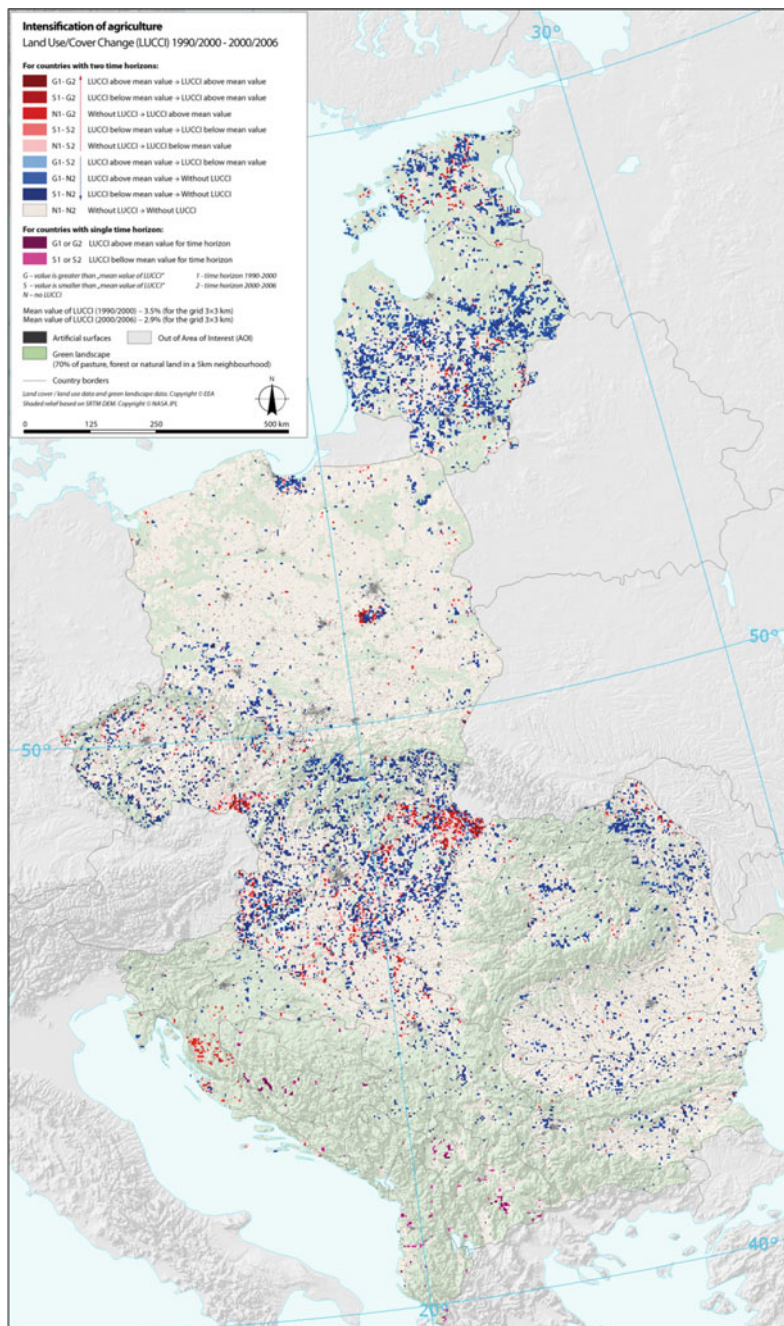


Fig. 2 Spatial distribution of intensification in Central Europe for the periods 1990–2000 and 2000–2006

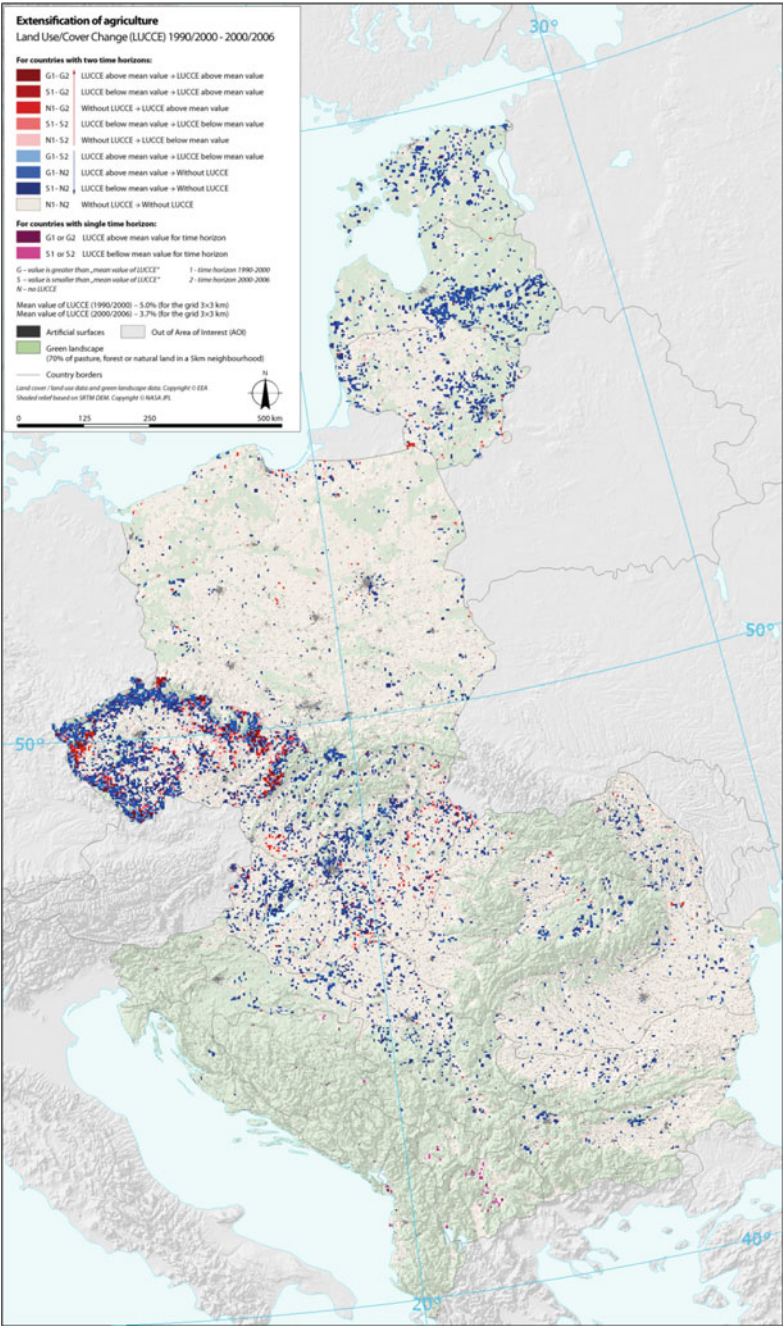


Fig. 3 Spatial distribution of extensification in Central Europe for the periods 1990–2000 and 2000–2006

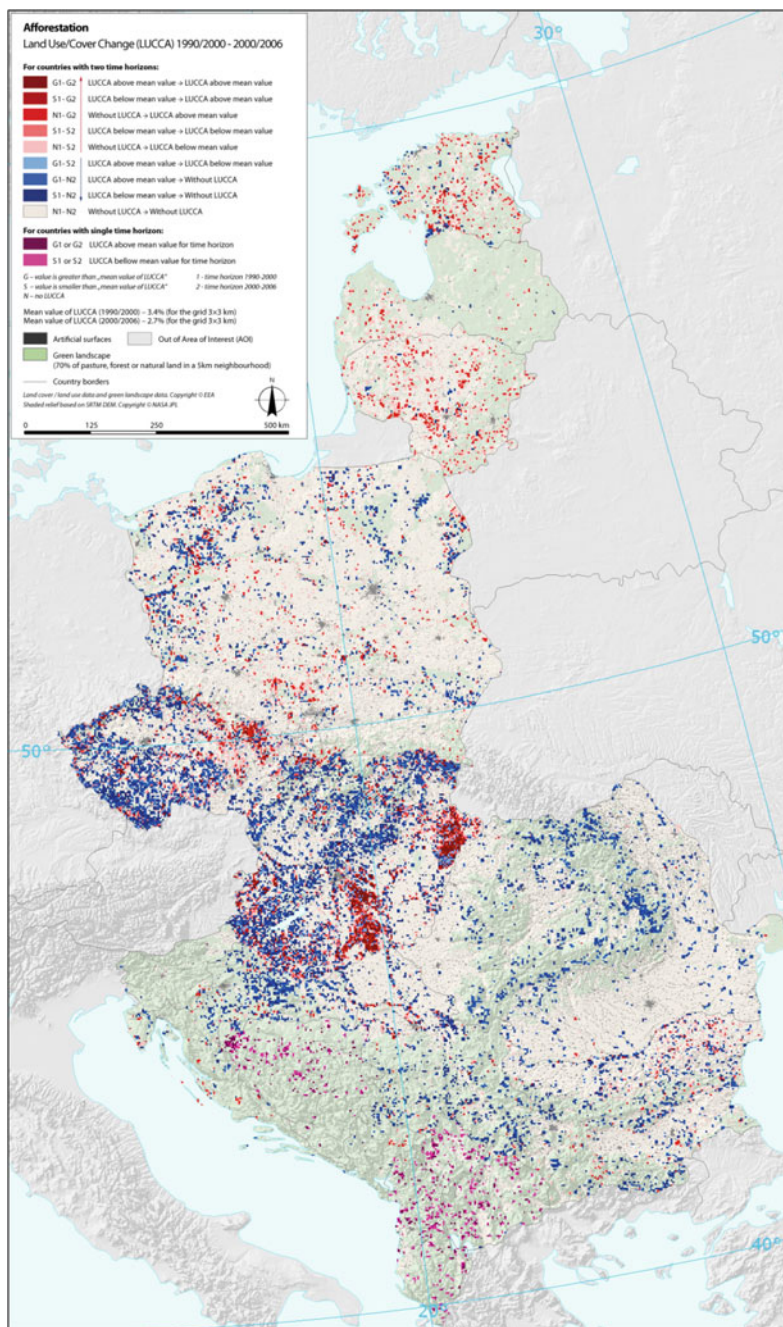


Fig. 4 Spatial distribution of afforestation in Central Europe for the periods 1990–2000 and 2000–2006

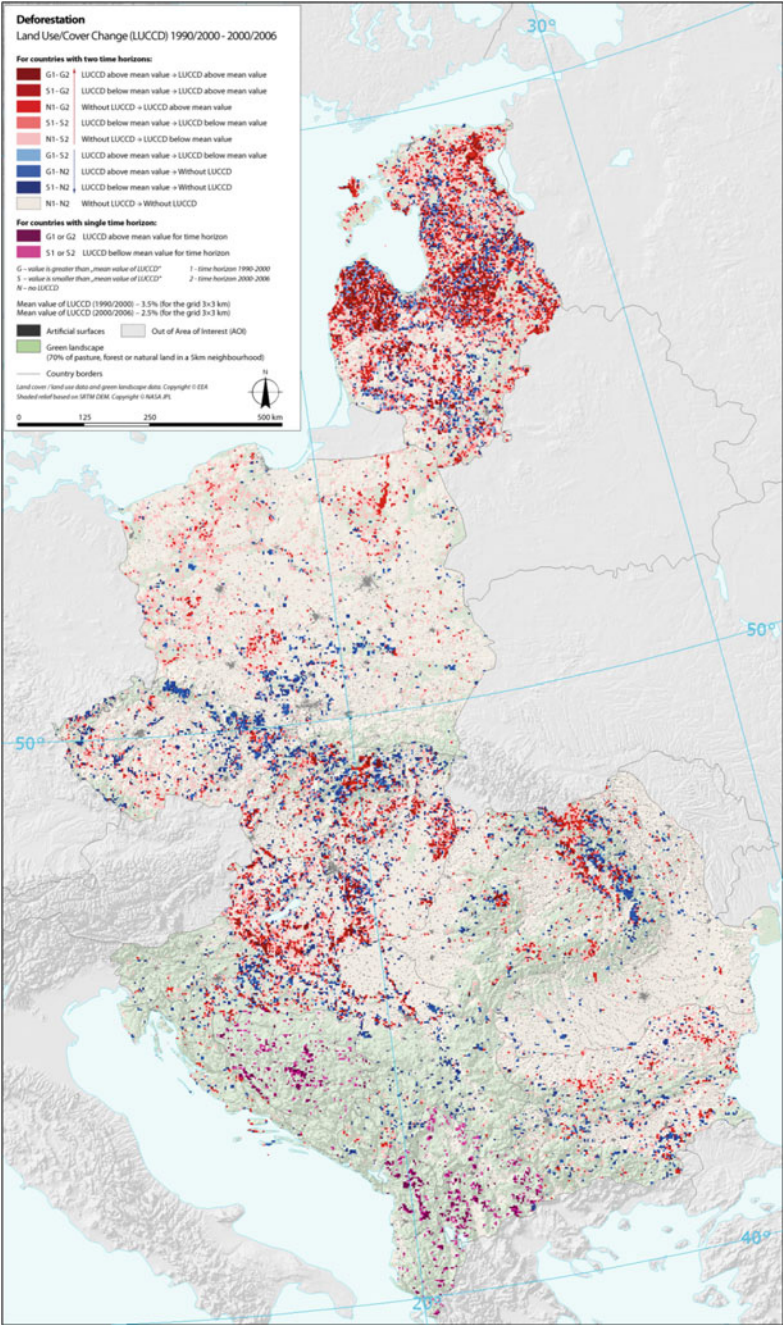


Fig. 5 Spatial distribution of deforestation in Central Europe for the periods 1990–2000 and 2000–2006

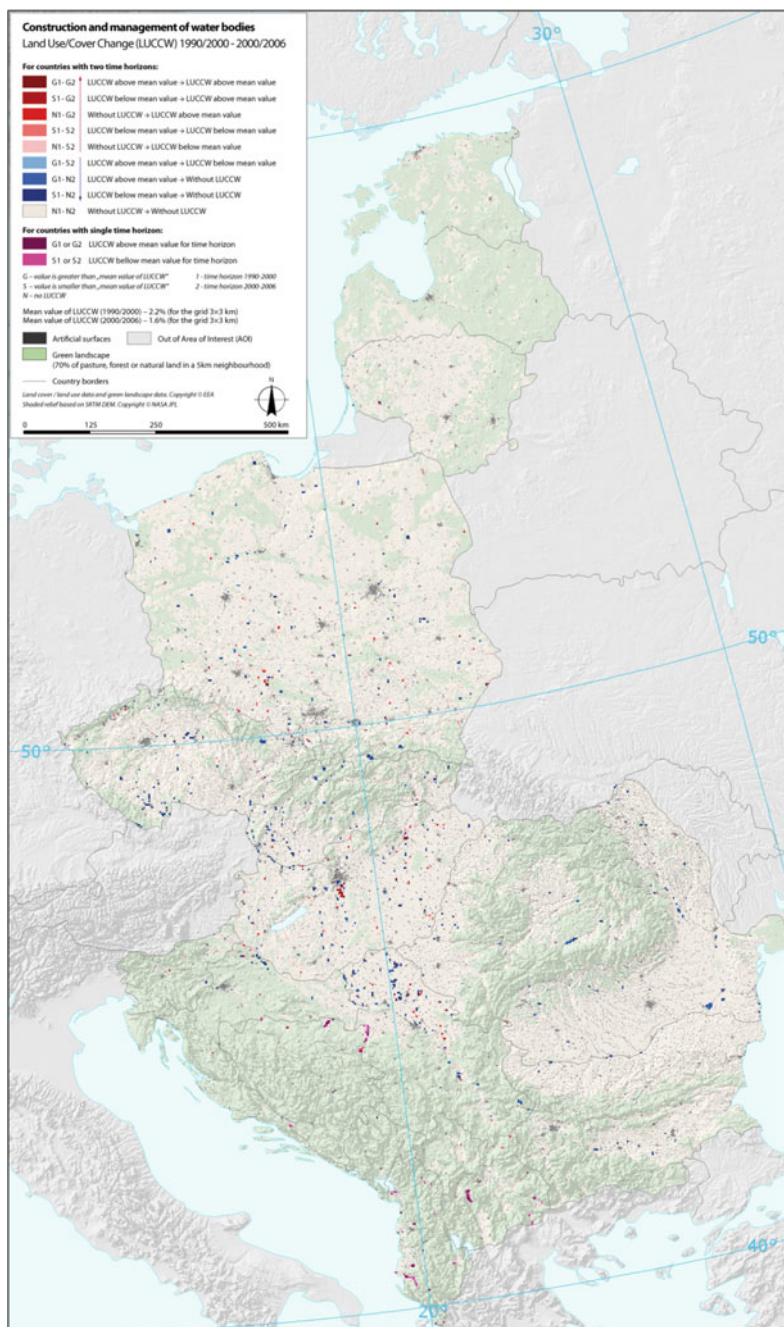


Fig. 6 Spatial distribution of the construction and management of water bodies in Central Europe for the periods 1990–2000 and 2000–2006

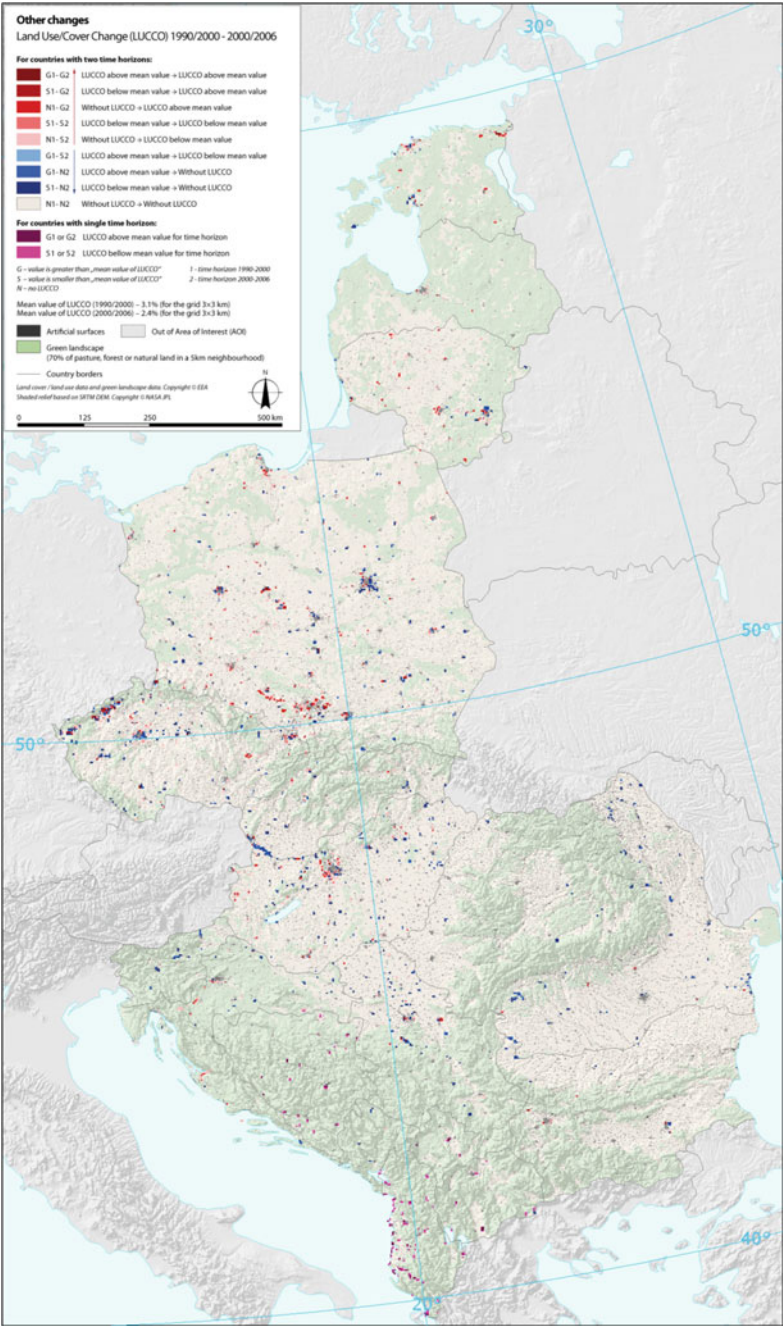


Fig. 7 Spatial distribution of other changes in Central Europe for the periods 1990–2000 and 2000–2006

G1—G2: LUCC above mean value—LUCC above mean value
S1—G2: LUCC below mean value—LUCC above mean value
N1—G2: Without LUCC—LUCC above mean value
S1—S2: LUCC below mean value—LUCC below mean value
N1—S2: Without LUCC—LUCC below mean value
G1—S2: LUCC above mean value—LUCC below mean value
G1—N2: LUCC above mean value—Without LUCC
S1—N2: LUCC below mean value—Without LUCC
N1—N2 Without LUCC—Without LUCC

G—value is greater than the “mean value of LUCC”, **S**—value is smaller than the “mean value of LUCC”, **1**—time horizon 1990–2000, **2**—time horizon 2000–2006, **N**—without LUCC identification (Feranec and Soukup 2013).

For Albania, Bosnia/Herzegovina, Kosovo and Macedonia, LC data are only available for 2000–2006, and we used a dark magenta color (G2) for an above-mean LUCC value and a light magenta color (S2) for below-mean LUCC value.

3 Results

3.1 Urbanization

Urbanization represents the expansion of artificial surfaces, including the construction of residential buildings, industrial areas, road and railway communications, etc. (Table 2). The results presented in Table 4 and Fig. 1 suggest increasing amounts of construction between the two time periods, particularly in the suburban areas of large cities, such as Budapest (Fig. 1), the northern and northeastern parts of Prague, northeastern Tallinn, northern and western Vilnius, western Warsaw, western Bucharest, and northeastern Bratislava. Major cities in the northern, southern and eastern parts of the study area were not as affected by the intensive urban and suburban processes compared with the changes that occurred in the cities in the central region. The construction of motorways dominated the western part of Croatia, central Poland, southwest of Hungary, and north of Slovakia. Additionally, a minor decline in the construction rate in 2000–2006 (relative to 1990–2000) occurred in several parts of Slovakia (Fig. 1), east and southeast of Warsaw, in the surrounding areas of Zagreb, western Prague (where some suburbs were created on abandoned agricultural lands, and the population increased 30–50 % during 2000–2010), west and east of Krakow, north of Serbia, and east of Bucharest (for a detailed analysis of the LU changes in Southern Romania see Kuemmerle et al. 2009b). In places where only the data for the period from 2000 to 2006 are available, urbanization occurred in the northern, central and southern regions of Bosnia/Herzegovina, Kosovo and the northern and south-western parts of Macedonia. A high rate of construction/urbanization occurred in the western part of Albania from 2000 to 2006.

Table 4 LUCC types in Central Europe for the periods 1990–2000 and 2000–2006

	1990–2000			2000–2006		
	Total area (ha)	Mean yearly increase in the period (ha)	Mean yearly change of total LUCC area (%)	Total area (ha)	Mean yearly increase in the period (ha)	Mean yearly change of total LUCC area (%)
Urbanisation	70,377	7037.7	3.2	131,143	21,857.2	9.5
Intensification	381,648	38,164.8	17.4	114,785	19,130.8	8.3
Extensification	486,275	48,627.5	22.1	93,115	15,519.2	6.7
Afforestation	619,346	61,934.6	28.1	344,569	57,428.2	24.9
Deforestation	580,318	58,031.8	26.4	652,129	108,688.2	47.1
Water bodies construction	17,204	1720.4	0.8	10,283	1713.8	0.7
Other changes	41,855	4185.5	1.9	39,715	6619.2	2.9
Total LUCC area	2,197,023	219,702.3	–	1,385,739	230,956.5	–
Total study area	122,375,321	–		134,022,612	–	

Countries where LUCC data available for 1990–2000 period: BG, CZ, EE, HR, HU, LT, LV, ME, PL, RO, RS, SI, SK

Countries where LUCC data available for 2000–2006 period: AL, BA, BG, CZ, EE, HR, HU, KV, LT, LV, ME, MK, PL, RO, RS, SI, SK

In total, from 1990 to 2000, an average of 7037.7 ha (3.2 %) of the total area experiencing LC changes (2,197,023 ha) occurred annually as urbanization (Table 4). During the six-year period between 2000 and 2006, 21,857.2 ha (9.5 %) of the total mean annual changes (230,956.5 ha) corresponded to urbanization. A comparison of the sizes of all types of changes showed that urbanization ranks fifth in the first period and third in the second period.

3.2 Intensification of Agriculture

The intensification of agriculture was widespread from 1990 to 2000; but from 2000 to 2006, it declined in all countries (Fig. 2). We observed a particularly strong decline in the intensification of agriculture in Lithuania, Latvia, Estonia, Slovakia, the Czech Republic and Hungary and a lesser effect in southern Poland, north-eastern Romania, northern Bulgaria and central Serbia. Some degree of intensification of agriculture (changes of arable land into vineyards and orchards) was observed in northeastern and central Hungary, western Croatia and southeastern Czech Republic. A common occurrence of the transfer of agricultural lands into

non-agricultural use was observed in Less Favored Areas (LFA) with poor soils and in the areas surrounding larger towns (for more details see Jelecek et al. 2012).

The share of intensification of agriculture (change of grassland into arable land and arable land into orchards and vineyards, etc.) was 38,164.8 ha (17.4 %), i.e., the fourth most extensive change (Table 4) in the first period. In the second period, the intensification of agriculture declined to 19,130.8 ha (8.3 %). The extent of these changes makes agricultural intensification the 4th most common LC change occurring in both time periods.

3.3 Extensification of Agriculture

The extensification of agriculture was primarily observed in areas the northeast of Croatia; the central regions of Serbia and the central part of Bulgaria; the northern, western and southern regions of the Czech Republic; areas north of Slovakia; areas north and center of Hungary; the eastern region of Lithuania; the southeastern region of Latvia; and the northern and central regions of Estonia. Muller et al. (2009) also documented an increase in agriculture land abandonment in central and northeastern regions of Romania.

The mean annual extent of the extensification of agriculture was 48,627.5 ha, (22.1 % of total changes, i.e., the third most extensive change in the first period; Table 4). This type of change decreased in the second period to 15,519.2 ha per year (6.7 %), representing the 5th most widespread change (Table 4).

3.4 Afforestation

In the first period, the mean annual changes totaled 61,934.6 ha (28.1 %) of afforestation, representing the most extensive change in the first period. Afforestation ranked second in the second period (Table 4), with a mean annual size of 57,428.2 ha (24.9 %; Table 4). The largest afforestation during both time periods was observed in the northeastern and central regions of Hungary, the northeastern region of the Czech Republic, and in Lithuania and Estonia. A lack of afforestation was detected in western, southern and central Czech Republic; central Slovakia; western, northwestern and northern Hungary; central and eastern Romania; central Bulgaria and southeastern Serbia. Below average values of afforestation were also evident in Bosnia/Herzegovina, Kosovo and Macedonia (Fig. 4).

3.5 Deforestation

The most extensive areas of deforestation occurred in Latvia, Estonia and Lithuania; in western, central and northeastern Hungary; the northeastern Romania and northern Slovakia. Less conspicuous signs of deforestation were also detected

in the western, central and northern regions of Poland, northern Bulgaria and northeastern Croatia. A decline in the deforestation rate in 2000–2006 (relative to 1990–2000) was evident in the north, northeastern and eastern regions of the Czech Republic (Fig. 5). A high deforestation rate from 2000 to 2006 occurred in northeastern Albania and central Bosnia-Herzegovina.

Deforestation was the second most common LC change in the 1990s, reaching an average of 58,031.8 ha per year (26.4 %; Table 4). In the second period, deforestation was the biggest land cover change in Eastern Europe, reaching 108,688.2 ha per year (47.1 %; Table 4).

3.6 New Construction of Water Bodies

Changes of agricultural and forest landscapes into water bodies were sporadic, occurring in southern Poland, northeastern Hungary, and northern Serbia (Table 2; Fig. 6).

The increase in water bodies was the least widespread land use change in both time periods, comprising only 1720.4 ha (0.8 %) and 1713.8 ha (0.7 %; Table 4) in the first and second periods, respectively.

3.7 Other Land Use/Cover Changes

The re-cultivation of areas following the extraction of raw materials, landfills, and unclassified changes (Table 2) primarily occurred in northern Estonia, showing the widespread re-cultivation of areas where combustible shale had previously been mined, including southeastern Latvia, southern and southwestern Poland, northeastern Czech Republic (where the former “Black Triangle” mining landscape is being re-cultivated), and in the surrounding areas of Budapest and northwestern Croatia (Fig. 7).

These “other” changes were second-to-last in terms of size. In the first and the second periods, these changes amounted annually to 4185.5 ha (1.9 %) and 6619.2 ha (2.9 %; Table 4), respectively.

4 Conclusions

The area of LUCC that we identified was approximately 21,970 km² in 1990–2000 and approximately 13,860 km² in 2000–2006 among 17 Central European countries, comprising a total area of approximately 1,340,000 km². The greatest changes were afforestation and deforestation, totaling 54.5 % of the total LUCC area in 1990–2000 and 72.0 % of the total LUCC area in 2000–2006 (Table 4).

This study showed that while the areas of afforestation were slightly larger than deforestation in the first period (1990–2000), deforestation far outpaced afforestation in the second period (2000–2006). This finding interestingly contrasts with Taff et al. (2010), who showed that the overall forest area increased in almost all Central and Eastern European countries between 2000 and 2005 using an analysis based on data obtained from national statistics and summarized by the UN-FAO (FAO 2006). This assessment of LU/LC changes, based on CLC data (which is based mostly upon satellite image analyses), questions the validity of national datasets on forest areas, suggesting that differing country definitions of forest land (or possibly the distinction between forest land and standing forest) might significantly affect these analyses. The causes of afforestation in the region likely reflect agriculture abandonment (Taff et al. 2010), while primary causes of deforestation are more numerous. Significant forest disturbances occurred in the Šumava Mountains in Germany and the Czech Republic, reflecting the calamitous outbreak of spruce bark beetle in the Šumava Mountains resulting from windbreak renovations of forest stands (Hais et al. 2008). Land ownership types influenced differences in forest changes in Poland after socialism (state vs. private), according to Kuemmerle et al. (2009a). Landowners occasionally practiced unsustainable clear-cutting on lands in Latvia in the early years (late 1990s and early 2000s) after post-Soviet land restitution (Taff 2005).

Significant changes occurred on the agricultural lands in the study region. Two antagonistic trends, extensification and intensification, were documented. Extensification (primarily over-grassing) was a prominent trend, particularly in Central Europe (the north, western, southwestern and northeastern region of the Czech Republic, and the northwestern region of Slovakia, Fig. 3) and in the Baltic states in the first period (1990–2000). These changes are also shown in Fig. 3. A particularly significant increase in grasslands was observed on arable lands in the Czech Republic in the period since 1990, which is the first period since the middle of the 19th century where grasslands have rapidly increased in the Czech Republic (Bičík et al. 2010). The abandonment of arable land accompanied grassing over during the transition of the agricultural sector in the Czech Republic in the early 2000s. Official government estimations reported that ca. 300 thousand hectares (10 % of the total area of arable land in the Czech Republic) were fallowed in the year 2003 (due to the Agricultural Policy Strategy for the period after accession to the EU 2004–2013). Part of this fallow arable land was re-cultivated after the accession of the Czech Republic into the EU when farmers obtained EU subsidies for agricultural production; however, a significant part of the fallow arable land has successively changed into grasslands or forests. This process particularly occurs in unfavorable areas with low-quality soils (Bičík and Jančák 2003). The intensification of agriculture was a more dominant trend on agricultural land during the period from 2000 to 2006, with a concentration in Central European areas with favorable conditions for arable land, including new vineyards and orchards. Generally both extensification and intensification decreased in area in the second period. Approximately 40 % of the total LUCC area led to agricultural land (either

intensification or extensification) in 1990–2000, and 15 % of the total LUCC area led to agricultural land in 2000–2006.

The intensity of urbanization was three times higher in 2000–2006 than in the first period. Urbanization was concentrated in the largest core population areas (big cities) into which the main flows of investment were aimed. Urbanization was the third most common trend, in terms of area, in the second period with approximately 10 % of the total LUCC area. The smallest LUCC category (construction and management of water bodies) covered only 0.8 and 0.7 % of the total LUCC area in 1990–2000 and 2000–2006, respectively.

Territorial differences in LUCC trends were observed in the study area. Countries in the central part of the study area were affected by more intense changes and a wider spectrum of changes (often antagonistic: intensification and urbanization and land abandonment and afforestation). The second most intensive changes occurred in the Baltic states, particularly on agricultural and forestlands. However, the southern countries (e.g., Bulgaria, Bosnia-Herzegovina, Monte Negro), Slovenia and the central parts of Poland and Romania experienced an overall lower intensity of changes. This phenomenon is likely associated with the different conditions of these countries during the communist period. The Baltic states and former Czechoslovakia were more affected by the collectivization of agriculture, with radical changes on agricultural land. These processes were not introduced with respect to natural and market conditions. Areas with unfavorable conditions were often covered by agricultural land because the agricultural sector was highly subsidized. The Balkan countries and Poland maintained traditional agriculture, based on small private farms. After the collapse of socialism, LU in the Czech Republic, Slovakia and the Baltic states reverted back to more sustainable structures from the point of view of environmental and market factors. Transitional processes evoked intensive changes. Countries in the central region of the study area and the Baltic states joined the EU more quickly than other countries, in the first accession wave in 2004. The economy of these countries had to adopt EU markets and agricultural policies in a short period. These factors were important drivers of changes that increased the polarization between north-central countries and southern regions of the study area.

The observed trends showed a long-term tendency of transition from a local scale of societal organization into a regional, state and most recently, a global scale. Similar structures and trends of LUCC were observed in large regions with specific functions (residential, agricultural, recreation...). Thus, typological regions with specific function(s) and LUCC trends can be delimited in Central Europe.

Thus, the main purpose of the present study was to document major LUCC trends in Central Europe during the periods 1990–2000 and 2000–2006. Further analyses of territorial differentiation and the evaluation of driving forces could be developed based on the obtained results and LUCC maps. A detailed review of smaller LUCC case studies and comparisons of changes and drivers would also be useful for future research.

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