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LAND COVER CHANGES IN SLOVAKIA IN THE PERIOD 1970-2000

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The paper brings the results of a synoptic analysis and assessment of land cover changes in Slovakia in the period 1970-1990-2000 by application CORINE land cover data layers: CLC70, CLC90 and CLC2000, derived by application of visual interpretation and computer aided visual interpretation of LANDSAT MSS, TM and ETM images. The relationship between the CLC data and the national statistics is also analysed. In the 1970-1990 period, a total 315,600 ha of land cover changed in Slovakia with the most intensive changes observed in the agricultural landscape. The changes that took place in the 1990-2000 decade were less extensive: 207,006 ha of land cover changes (with pronounced changes in forest landscape). Land cover data and the corresponding changes in Slovakia identified under CLC projects are characterized, apart from spatial precision, by compatibility and comparability at the European level.

Key words: CORINE land cover, land cover change, computer aided visual interpretation, statistical data, Slovakia

INTRODUCTION

By participation of the Institute of Geography in the international projects *Phare Topic Link on Land Cover* (Feranec et al. 2000), *CORINE (Coordination of Information on the Environment) Land Cover 1990 (CLC90), Image and CORINE Land Cover 2000 (I&CLC2000)* (Feranec et al. 2005b, Feranec et al. 2007a) and BIOPRESS (Gerard et al. in print) data layers were prepared depict-

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ing the frequency and size of land cover areas in Slovakia for the 1970s and 1990s and for 2000 (+/– one year) at a scale of 1:100 000, by application of Landsat MSS, TM, ETM satellite images. The existence of the CLC70, CLC90 a CLC2000 data layers laid the foundations for regular monitoring and assessment of land cover changes in Slovakia. Satellite images definitely support the regular monitoring and assessment of land cover changes induced by human society at the national level.

Land use and land cover changes are considered the central theme of research concerning the global landscape changes, solution of which contributes to knowledge of the future of our planet (cf. Verburg and Veldkamp 2005). This is also the reason why the objective of our study is connected with the analysis and land cover assessment for the periods of the 1970s, 1990s, and 2000 by application of visual and computer added visual interpretation of satellite images. Both approaches were also applied to derivation of data layers which document the land cover of Europe and its changes in the period of the 1990s and 2000 (+/– one year).

LAND COVER CHANGES IDENTIFICATION – REVIEW OF APPROACHES

One of the basic assets of the data obtained by remote sensing techniques is that they provide information about landscape objects and their changes. The methodological tool ever more frequently used for their gathering in geography is the *multitemporal analysis* (Boresjö 1989) or the analysis *of multitemporal remote sensing data* (Adeniyi 1985).

Treitz and Rogan's (2004) and Rogan and Chen's (2004) studies also provide the comprehensive view of approaches to identification and monitoring of landscape changes based on use of remote sensing data important for cognition of so far existing application of the digital approaches to the quoted changes. These approaches are pendants of visual and computer aided visual interpretation of satellite images developed at the Institute of Geography SAS. Kalensky et al. (2003) study provides an exhaustive survey and comparisons of studies published before 2003 in the field of land cover mapping. The substantial part of the evaluated papers is based on digital approaches to satellite image interpretation. The *Earth Observation for Sustainable Development of Forest* (*EOSD*) Project is worth mentioning here. Its aim is to create a land cover map of the forested parts of Canada, based on image processing. Nine of the 23 classes of the nomenclature characterize the forest landscape (Wulder 2002). The *National Land Cover Database – NLCD 2001* of the USA contains 29 classes of land cover identified by digital interpretation of Landsat 5 and 7 satellite images and other data obtained from thematic maps (Homer et al. 2004).

The issue of identification land cover change by application of remote sensing data has been worked on under various international projects and programmes. Some of them were: *LACOAST* (LAnd cover changes in COASTal zones), the aim of which was to identify land cover changes in the 10 km wide coastal zone of Europe for the period 1975-1990 using the CORINE land cover (CLC) 1990s database and images of Landsat MSS (from the 1970s) (Perdigao and Christensen 2000). The *Phare Topic Link on Land Cover* project was partially focused on identification of land cover changes in Czechia, Hungary, Ro-

mania and Slovakia like in the preceding project for the 1970s-1990s again using the CLC90 database and Landsat MSS images (from the 1970s) (Feranec et al. 2000). The derivation of the CLC2000 data layers of a substantial part of Europe has been described in detail in Feranec et al. (2007).

The aim of the Pan-European *BIOPRESS* project (2003-2005) was the analysis of the effects of land cover change on biodiversity on experimental areas (73 squares 30×30 km and 59 transects 15×2 km) in different biogeographic regions of Europe and areas protected under Natura 2000 for the years 1950, 1990 and 2000. Information on land cover changes were again generated from aerial black and white photographs and from the CLC90 database by the method of computer aided visual interpretation (Gerard et al., in print).

Since the end of 2005, the pilot project GMES *Service Element Land (GSELand)* has been worked on in the context of all-European monitoring activities under the *Global Monitoring for Environment and Security* (*GMES*) programme. Its aim is to prepare land use and land cover mapping by application of satellite images on the all-European level with the minimum unit area 0.25 ha – 5 ha (www.gmes.info). These monitoring activities also cover generation of the all-European CLC2006 layer. The CLC2006 data layer of Slovakia will be finished in summer 2008.

USED DATA AND METHODS

The basic prerequisite for landscape object changes by application of remote sensing data is the existence of change in spectral response of objects that is recordable by the imaging facility. These changes manifest on images by changes of the interpretation sign suggesting conversion or the gradual transition/ modification of one land cover class or its parts into another (Coppin et al. 2004). The example of conversion can be demonstrated for instance, by the change of meadow area into water body area and modification by gradual change – natural overgrowing of the meadow area by forest wood species during the observed period. Identified and assessed land cover changes are regarded as categorical changes.

Even in spite of an extensive use of digital approaches to land cover identification as documented by Coppin et al. (2004), Treitz and Rogan (2004) and Rogan and Chen (2004), the method of visual interpretation of satellite images (Heymann et al. 1994) was used in the process of generating the CLC90 data layer. The method of computer aided visual interpretation of satellite images (Perdigao and Annoni 1997, Steenmans and Perdigao 2001, Büttner et al. 2004, Feranec et al. 2004, Feranec et al. 2007) was used in its update to the state in 2000 (+/– one year) and identification of land cover changes in Europe including Slovakia in the periods 1970-1990 and 1990-2000. These methods were used above all because in identification of heterogeneous land cover classes (example of CLC nomenclature Heymann et al. 1994, Bossard et al. 2000) based on satellite images it must be taken into account that:

- The content of CLC classes is very heterogeneous which means that spectral characteristics of objects which form one class can differ a lot from each other; which does not allow use of image processing for classification of heterogeneous objects into one land cover class only on the basis of a spectral signature or texture,

- Accepting the interpretation sign *association* (Feranec 1999), as the classifying criterion in the framework of the corresponding algorithm of image analysis is difficult,
- Natural conditions modifying spectral characteristics of objects (formed by patterns of land cover) can be very heterogeneous for the same class, which complicates their identification.

The detailed characteristics of visual interpretation methods, computer aided visual interpretation and supervised classification of satellite image data were quoted in studies that are parts of this work (Feranec and Kolář 1988, Feranec et al. 1991 and 1993, Feranec 1999, Feranec et al. 2000, 2007a, 2007b). The study of Bossard et al. (2000), representing the text and graphic part of the computer aided visual interpretation method of satellite images (characteristics of objects and samples that constitute 44 classes of the CLC nomenclature) used in 26 European countries participating in the *I&CLC2000* Project is especially important.

REVIEW OF RESULTS

Studies of Feranec et al. (2000), Feranec and Oťahel' (2001), Feranec et al. (2005a), Feranec et al. (2005b, 2007a), which are parts of this paper, confirm that satellite images have become a valuable data source concerning land cover and its changes accessible both at the supranational and national levels (for instance Slovakia – http://atlas.sazp.sk and http://dataservice.eea). These data derived by single methodology with resolution of the minimal area of 25 ha and the minimal change of 5 ha have laid foundations of the systemic analysis and assessment of land cover and those of links between land use and economic activities with indicators of biodiversity in the whole of Europe. Data obtained by satellite image interpretation can be used with other data to widen or supplement the national statistical data characterizing landscape classes and land use (kinds of parcel) delimited by functional signs and updated every year by conventional methods in a detailed scale.

The benefit of the data obtained by interpretation of satellite images lies in the fact that they represent the real state of the landscape defined by the date when the satellite image was taken (albeit limited by the minimum size of the mapped area). National statistics (NS) describe the legal state of land use (functional areas – parcels). A difference may exist between the legal aspect and the real landscape use (for instance, forest does not have to grow necessarily on forest land so the area of forest land does not have to coincide with the area of real forest growths, etc.). The fact that the data obtained by interpretation of satellite images contain the *attribute of location* compared with data of the national statistics that only relate to administrative units is a significant asset of the method.

The results of the detailed analysis of the relationship between the CLC data and the NS data published in Feranec et al. (2001) show that:

- CLC data require adaptation because they contain more classes (there are 5 and 44 classes at the first and third levels respectively, see Tab. 1, CORINE land cover nomenclature), than in the NS (nine classes, see Tab. 2),

Tab. 1. CORINE land cover nomenclature (Heymann et al. 1994, Bossard et al. 2000)

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

- Even in spite of adaptation, CLC classes 24, 32, 33, 41 and 42 cannot be considered because the NS does not contain analogue classes,
- The contents of CLC classes 11 and 12 and partially also 13 and 14 are close to the NS class *built-up areas* but the CLC nomenclature widens its content (it also covers gardens in rural settlements, infrastructure as part of industrial areas and construction, dumping sites or urban greenery); it means that the total surface area of *built-up* areas in CLC data is distinctly larger (see Tab. 2), although it does not contain settlements with areas smaller than 25 ha, (which were aligned to class 24),
- The arable land data are parts of both the NS and the CLC nomenclature (class 21) containing areas larger than 25 ha; areas of arable land smaller than 25 ha are under class 24; surface of areas in this class (21) in the CLC set is larger because permanent (2-3year) crops are aligned there along

Tab. 2. Comparison of CLC data and national statistics (NS) in Slovakia for the period 1970-1999-2000 (in ha) (Feranec 2006)

National statistics classes	CLC	1970		1990		2000	
		CLC70	NS70***	CLC90	NS90***	CLC2000	NS2000***
Urban fabric	11+12	244 130	110 626	255 597	122 462	259 772	219 340
Arable land	21	1 667 372	1 551 344	1 676 062	1 513 794	1 670 350	1 450 519
Permanent crops (vineyards, fruit trees and hop plantations)	22*	33 767	55 677				
Vineyards	221**			27 777	31 892	25 369	27 705
Fruit trees and hop plantations	222**			13 134	22 696	10 594	19 629
Pastures	23	236 299	850 351	319 923	816 294	300 559	865 222
	24	550 078		425 527		432 838	
Forests	31+32*+324**	2 118 832	1 912 402	2 081 775	1 977 185	2 100 970	2 001 249
	33	12 218		12 025		11 478	
	41	4 346		5 883		4 397	
Water bodies	51	21 890	88 928	21 939	93 931	28 198	93 104
Other areas			259 582		248 977		149 109
Gardens			72 794		77 712		77 619
Other classes CLC	(13+14)* (131+132+133+141+142+321+322)*	16 243		66 041		61 158	
Total		4 905 175	4 901 704	4 905 683	4 904 943	4 905 683	4 903 496

* for 70's; ** for 90's and 2000

*** ČÚGK, SÚGK, ÚGKaK, FSÚ, ČSÚ, SŠÚ, ŠÚ SR (1971, 1991 and 2001)

- The areas of orchards, vineyards and hop gardens are similar in both data sets; their larger total area in the national statistics is due to the circumstance that CLC data only cover the area of *permanent crops* (class 22) larger than 25 ha; the difference in areas of this class for the 1970s is also the consequence of poor resolution of the Landsat 4 MSS images,
- In comparison of the two data sets, the differences between *pastures* are most pronounced because the areas of permanent crops (fodders/grasses) cultivated on arable land as part of the crop rotation are included in the class of *grasslands* under the NS while the areas of grasslands smaller than 25 ha were included in class 24 according to the CLC method criteria; areas of meadows, especially above the upper timber line, are part of class 32 *natural grasslands* in the CLC data,
- Some differences between the NS and CLC data for forest area are caused by errors in satellite image interpretation above all in the case of LANDSAT 4 MSS from the 1970s and probably also by the inclusion of class 324 (it represents abandoned pastures that cannot be classified as forest land) in *forest.*
- The class *gardens* only exists in the NS data.
- The area of *water bodies* in the CLC data is smaller as it only contains areas larger than 25 ha and parts of rivers and canals wider than 100 m; smaller water bodies are associated with class 24,
- CLC nomenclature does not contain the class *other areas* and in turn CLC classes 131, 132, 133, 141, 142, 321, 322, 331, 332, 333, 411, and 412 are not specified in the NS data.

Increased compatibility of both data sets will require increased precision in identification of land cover classes by means of satellite images and the gradual unification of the class contents. It must be emphasized that changes identified by comparison of statistical data from different time horizons do not offer the option to analyse their inner dynamics under various landscape classes which in turn is the chance available under the CLC method.

Land cover changes in Slovakia in the period 1970-2000

The studies Feranec et al. (2000), Feranec and Oťahel' (2001) and Feranec et al. (2005b) bring the detailed results of land cover change analysis for Slovakia during the quoted period. From 1970 to 1990, in the territory of Slovakia 315,640 ha of land cover changed (6.4 % of the total area of the State); in the 1990s and in 2000 (+/– one year) the changes amounted to 207,002 ha of land cover (4.2 % of the total area of the State).

Tab. 2 compares the *statistical* data for Slovakia from 1970, 1987 and 2000 that are closest to the CLC data. Their structure required adaptation particularly merging because it contains more classes (15 classes at the second level and 44 classes at the third level, see Tab. 1). Even in spite of such adjustment, CLC classes 24 *heterogeneous agricultural areas*, 33 *open spaces with little or no vegetation* and 41 *inland wetlands* could not be considered, as the NS does not contain such data. Even the CLC70 data differ from those of CLC90 and

CLC2000, as they were not derived by merging the third level of land cover classes with the second. They were identified directly by the interpreter. It causes the overestimation of their real areas for instance in *forest* (31) and *scrub and/or herbaceous vegetation association* (32).

The above characteristics of NS and CLC classes shows that different approaches to generation of data is the critical cause of the differences:

- Both data sets confirm the increasing trend towards built-up areas,
- Diminution of arable land (21) suggested by NS data was not confirmed unambiguously by the CLC data (the contents of class 21 as defined by CLC is not identical with NS class 21 content; see the explanation in the preceding page); enlargement of arable land area in 1990 identified on the basis of CLC data is connected with the State subsidy policy for agriculture,
- The area of permanent crops (summation of vineyard and orchard classes) slightly increased pursuing the CLC data for 1990 (the real physiognomic state of the landscape did not change – orchards and vineyards were still identified), while they were not filed in NS data in the functional sense of the word; the decrease of areas of permanent crops is evident both in the NS and CLC data for 2000 (the effect of changes in the State agrarian policy),
- Enlargement of pastures has been identified only by NS data; there are different contents ascribed to this class by the two data sets. Consequently, different areas have been identified; grasslands are also included in classes 24 and 32 in the CLC data,
- National statistics confirmed the enlargement of forest for the 1970-1990 period and 2000, the CLC data showed a similar trend but only for the period between 1990 and 2000; the larger area of forest (31) pursuing the CLC data is above all the consequence of its merging with the class *scrub and/or herbaceous vegetation associations* (32); diminution of *forest* in the 1990s as demonstrated by the CLC data was connected with the construction of the Gabčíkovo Water Works and the change of alluvial forest (by deforestation) into construction areas,
- The area of water bodies in the CLC data compared with NS data is smaller because different criteria were applied to delimitation of water bodies; the CLC data show that the area of water bodies enlarged during the study period.

A more detailed view of land cover changes in Slovakia (by means of maps and tables) for the period between 1970 and 1990 identified by the CLC method is given in Feranec et al. (2000) and the monograph Feranec and Oťaheľ (2001) while the period 1990-2000 is dealt with in Feranec et al. (2005b, 2005c).

Tab. 3 suggests that as far as area is concerned, the greatest changes in the period between 1970 and 1990 in Slovakia were those of *heterogeneous agricultural areas* (24) in favour of *arable land* (21) – 371,500 ha and *pastures* (23) – 417,100 ha and vice versa, those of *pastures* in favour of *arable land* – 157,300 ha and *heterogeneous agricultural areas* – 431,900 ha. The identified trend was caused by the State agrarian policy. Changes of this type have been

Tab. 3. Land cover changes in Slovakia in the period between 1970 and 1990 (Feranec et al. 2000)

1970s classes	1990's classes 11	12	13	14	21	22	23	24	31	32	33	41	51	Total 1970s
11	-	130	30	-	10	-	-	130	-	-	-	-	50	120
12	10	-	70	-	10	-	-	10	-	20	-	-	10	120
13	1 260	310	-	0	190	0	90	340	30	140	-	50	630	3 040
14	10	-	-	-	-	-	-	10	-	-	-	10	40	70
21	3 890	1 820	2 550	50	-	6 540	12 770	18 300	360	150	-	40	640	47 110
22	20	-	-	-	1 530	-	20	430	-	-	-	-	-	2 000
23	150	20	20	-	15 750	110	-	43 190	270	2 510	-	-	340	62 550
24	2 070	420	410	120	37 150	2 240	41 710	-	1 470	1 140	-	120	870	87 720
31	60	180	3 120	140	1 410	10	1 010	4 130	-	87 160	10	210	350	97 780
32	-	70	130	50	340	-	280	2 220	5 480	-	990	10	100	9 660
33	-	-	10	-	-	-	-	10	-	660	-	-	90	770
41	20	20	60	-	180	-	140	190	230	330	-	-	350	1 530
51	-	10	390	40	10	-	20	310	380	130	0	1 640	-	2 950
Total 1990s	7 480	2 980	6 960	400	56 580	8 900	56 050	69 270	8 210	92 240	1 010	2 080	3 480	315 640

Tab. 4. Land cover changes in Slovakia in the period 1990 – 2000 (Feranec et al. 2005b)

1990's classes \ 2000's classes	112	121	122	131	132	133	142	211	221	222	231	242	243	311	312	313	321	324	331	333	411	511	512	Total 1990's
112						25							16										28	69
131		6						6							10			65					93	180
132											70							244						314
133	221	214	63					34				12	26					1 524				1 563	2 365	6 022
141	7	23																						30
142																							34	34
211	1 850	544	99	68	56	356	7		882	254	4 623	13 205	1 409	23	10	25		201					134	23 746
221	81	11						2 872			123	10	245											3342
222	58							2 412	44			132	208											2854
231	74	28		19	47	159	49	8 051				3 737	6 624	413	136	189		10 269					229	30 024
242	14	7				51		264			179		314											829
243	738	101		34		175	81	4 360		40	4 574	282		1 808	180	684		4 860					392	18 309
311	27	5		68	28	16	53	6			14		207		61	2 053		13 686				6	20	16 250
312				86	73	26	39	14			64		14	62		522		37 252					72	38 224
313	22			26	36	69	41				16		18	1 013	693			7 094						9 074
321																		1 345						1 345
324	22			6		5	40	34			146		141	35 428	4 719	12 827						6	92	53 466
331																		35		121		102		258
333											61						482							543
334																		30						30
411													119					25					1 450	1 594
511		11																	26	6			308	351
512	7																				112			119
Total 2000's	3 121	996	162	307	240	882	310	18 053	926	294	9 870	17 378	9 340	38 747	5 809	16 300	482	76 630	26	127	112	1 677	5 217	207 006

Tab. 5. Land cover changes in Slovakia in the period 1990-2000: differences in class areas (Feranec et al. 2005b)

CLC classs	Area 1990 (ha)	Area 2000 (ha)	Difference in area (ha)	% of total change
111	1 004	1 004	0	0.0
112	227 152	230 227	3 075	1.9
121	28 119	29 115	997	0.6
122	1 570	1 731	162	0.1
123	268	268	0	0.0
124	2 418	2 418	0	0.0
131	3 468	3 595	127	0.1
132	1 785	1 713	-72	0.0
133	6 127	992	-5 125	3.2
141	1 178	1 148	-30	0.0
142	9 684	9 962	278	0.2
211	1 698 920	1 693 205	-5 715	3.5
221	28 173	25 758	-2 415	1.5
222	13 536	10 976	-2 559	1.6
231	335 679	315 477	-20 202	12.5
242	30 002	46 566	16 564	10.3
243	409 467	400 394	-9 074	5.6
311	1 086 656	1 109 213	22 558	14.0
312	556 594	524 204	-32 390	20.1
313	368 110	375 352	7 242	4.5
321	33 012	32 148	-864	0.5
322	14 397	14 397	0	0.0
324	151 272	174 455	23 183	14.4
331	315	83	-232	0.1
332	7 043	7 043	0	0.0
333	6 325	5 909	-416	0.3
334	30	0	-30	0.0
411	6 141	4 656	-1 485	0.9
412	231	231	0	0.0
511	10 751	12 077	1 326	0.8
512	15 322	20 430	5 108	3.2

identified in the southern part of the Podunajská nížina and Východoslovenská nížina lowlands, but also in central and northern parts of Slovakia. The second most conspicuous change in terms of area has manifested in diminution of *forest* (31) in favour of *transitional woodland* (32) – 871,500 ha. It was caused by logging and various calamities that struck the region of Záhorie, Slovenské rudohorie Mts., Čergov, Ondavská vrchovina and Laborecká vrchovina mountain ranges. Changes of agricultural and forest landscape in favour of *urbanized areas* (11, 12 and 13) on 149,900 ha were identified above all along the urbanization axes that stretch in the valleys of the Váh, Nitra and Hron rivers. Construction of the Gabčíkovo Water Works also enlarged the area of changes in urbanized landscape.

Results published in the papers by Feranec et al. (2005a) and Feranec et al. (2005b) make it possible to identify the basic trends in land cover changes in Slovakia for the 1990-2000 decade. The most important changes in area took place in forest landscape. The original 58,032 ha (see Tab. 4) that changed into *transitional woodland/shrubs* (324, areas after clear-cut and damage – calamities, for instance in mountain ranges of Levočské vrchy, Hnilecké vrchy, Veporské vrchy, Považský Inovec) increased by another 18,600 ha of *transitional woodland/shrubs* with origins in overgrown (abandoned) *pastures* (231, above all in mountainous and submountainous areas), *natural grassland* (321) and *heterogeneous agricultural areas* (243). *Transitional woodland/shrubs* naturally developed into 52,974 ha of *forest*. However, in total *forest* diminished by 2,590 ha (omitting class 324 – Tab. 5). Privatization of forest and market mechanisms were the decisive factors that determined the observed changes of the forest landscape.

Enlargement of heterogeneous agricultural areas by 16,564 ha (mostly at the expense of arable land) is the most frequently identified change in agricultural landscape (above all in the districts of Námestovo, Tvrdošín, Liptovský Mikuláš, Detva, Nitra – Tab. 5). This change is the consequence of privatization and leasing of farmland to private persons accompanied by the return to cultivation of small fields, pastures and permanent crops. However, cultivation of large blocks of farmland still prevailed in Slovakia during the periods evaluated.

Identified changes in the urbanized landscape have manifested in the enlargement of urban fabric, industrial and recreation areas along with communications by 4,500 ha (above all in hinterland of Bratislava and Košice, in the districts of Komárno, Dunajská Streda, Galanta, Levice, and Michalovce). Changes in rural settlements were not as pronounced (the fact that only changes with the minimum area of 5 ha and larger were identified must be borne in mind).

CONCLUSION

Land cover is an important indicator of landscape changes. It is represented by landscape objects, the physical state and physiognomic manifestation of which can be identified visually in the terrain or by means of remote sensing data.

The cadastre registers landscape objects (plots) above all in the context of their functional and legal aspects. NS also observe changes of plots on the re-

gional and national scales applying the aspect of administrative units (districts) but it does not offer their precise location.

In spite of differences between the NS and CLC classes, the data about land cover/land use changes can be interpreted very effectively at the national level. The NS point to changes of plots, functional areas and records their surface area, while the CLC data highlight changes of the real landscape, those of its physical conditions represented by land cover. Many areas in agricultural landscape that were formerly pastures have been abandoned due to the changed government agrarian policy of the State and they have changed into *scrub and/or herbaceous vegetation associations* (identified as class 32 in the CLC data).

In Slovakia, 315,640 ha of land cover changed in the period between 1970 and 1990. The greatest share in this figure is attributable to changes of *heterogeneous agricultural areas* (24) in favour of *arable land* (21) 37,150 ha and pastures (23) 41,710 ha, as well as *pastures* that changed into *arable land* – 15,730 ha and into *heterogeneous agricultural areas* – 43,190 (see Tab. 3). Diminution of *forest* (31) in favour of *scrub and/or herbaceous associations* (32) – 87,150 ha was also important in this period.

During the 1990-2000 decade, a total of 207,006 ha of land cover changed. Among the changes, those of *forest* (31) into *scrub and/or herbaceous vegetation associations* (32) – 58,032 ha, and vice versa their changes (32) in favour of *forest* (31) – 52,174 ha dominated (see Tab. 5). Enlargement of *heterogeneous agricultural areas* at the expense of *arable land* by 16,564 ha (see Tab. 5) dominated in the agricultural landscape.

The land cover data for Slovakia and changes identified under the CLC projects are characterized by spatial correctness and international compatibility including the efficient comparison of landscape changes almost at an all-European scale.

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ZMENY KRAJINNEJ POKRÝVKY SLOVENSKA V OBDOBÍ 1970 - 2000

Zmeny využitia krajiny a krajinnej pokrývky sú považované za ťažiskovú výskumnú tému globálnych zmien krajiny, ktorej riešenie by malo prispieť k poznaniu budúcnosti našej planéty (cf. Verburg a Veldkamp 2005). Cieľom štúdie je preto poskytnúť výsledky prehľadnej analýzy a hodnotenia zmien krajinnej pokrývky Slovenska v období 1970-1990-2000 aplikáciou vizuálnej a počítačom podporovanej vizuálnej interpretácie satelitných snímok. Výsledky prezentované v štúdii boli získané v kontexte participácie Geografického ústavu SAV na riešení medzinárodných projektov: *Phare Topic Link on Land Cover* (Feranec et al. 2000), ďalej *CORINE Land Cover 1990 (CLC90), Image and CORINE Land Cover 2000 (I&CLC2000)* (Feranec et al. 2005b, Feranec et al. 2007a) a *BIOPRESS* (Gerard et al. in print).

Aj napriek rozsiahlemu používaniu digitálnych prístupov na identifikáciu zmien krajinnej pokrývky sa v rámci projektov CLC použili metódy vizuálnej interpretácie a počítačom podporovanej vizuálnej interpretácie satelitných snímok. Dôvodom použitia týchto metód bola najmä výrazná heterogenita obsahu tried CLC, ktorá nedovoľuje ich identifikáciu iba na základe spektrálneho príznaku alebo textúry.

Zo získaných výsledkov vyplýva, že v období 1970-1990 sa na Slovensku zmenilo 315 600 ha krajinnej pokrývky. K tejto rozlohe prispeli najviac zmeny heterogénnych

poľnohospodárskych areálov (24) v prospech ornej pôdy (21) – 37 150 ha a lúk (23) – 41 710 ha, ako aj lúk v prospech ornej pôdy – 15 730 ha a heterogénnych poľnohospodárskych areálov – 43 190 ha (pozri tab. 3). V tomto období boli výrazné aj úbytky lesov (31) v prospech leso-krovín (32) – 87 150 ha.

V desaťročí 1990-2000 sa celkovo zmenilo 207 006 ha krajinnej pokrývky. Z týchto zmien dominovali zmeny lesov (31) na prechodné lesokroviny (32) – 58 032 ha a opačne, ich zmeny (32) v prospech lesov (31) – 52 974 ha (pozri tab. 5). V poľnohospodárskej krajine dominovalo zväčšenie triedy mozaiky polí, lúk a trvalých kultúr (242), najmä na úkor ornej pôdy (211) o 16 564 ha (pozri tab. 5).

Dáta o krajinnej pokrývke Slovenska a jej zmenách, identifikované v rámci projektov CLC, sa vyznačujú okrem priestorovej korektnosti aj výhodou nadnárodnej kompatibility a možnosťou porovnávania zmien krajiny takmer v celoeurópskom kontexte.