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CORINE LAND COVER MAP OF EUROPE

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Abstract: The paper demonstrates compilation of land cover map of Europe making use of the CORINE land cover (CLC) data and subsequent printing of the map by computer technology at the scale ca 1:5 000 000. The topographic base in azimuth equivalent projection consists of: state borders, capitals, selected roads, a part of river network, which is not covered by the CLC data and the shaded terrain. The thematic overlay contains CLC data from 2006 on the first hierarchic levels and selected classes on the third level (broad-leaved, coniferous and mixed forests). The map was printed by the hybrid digital printer equipped with the piezoelectric inkjet printing heads with four levels of grey scale and a variable size of the print drop from 14 to 42 picolitres. Existence of such map makes possible simultaneous perception of the land cover picture of the different parts of Europe.

Keywords: CORINE, land cover data, topographic base, thematic map, hybrid digital printer, Europe

Introduction

Present computer technologies, particularly the Geographical Information Systems (GIS) make it possible to collect various statistical characteristics concerning landscape objects both in numerical and graphical forms. Maps are such outputs. Kraak and Ormeling (1996) listed the types of data most frequently applied in map-making:

– Data obtained by terrestrial survey;

– Data obtained by photogrammetric survey;

– Data obtained by satellite images (sources of the corresponding thematic information applicable to mapping via analogue and digital interpretation techniques);

– Data of the Global Positioning System (GPS), which improve the accuracy of existing georeferencing methods or can be used in field surveys;

– Data obtained by digitizing or scanning of analogue maps (by vector or raster approach);

– Existing state boundary files, for instance those concerning the borders of administrative units, communications etc.;

– Socio-economic statistical files provided by national statistical services;

– Environmental data files – one of them is the CORINE database (Coordination of Information on the Environment) (Heymann et al., 1994).

The study Pravda et al. (1998) describes examples for application of the CORINE land cover (CLC) in thematic map making (Tab. 1). The table shows that the published CLC maps only characterize land cover (LC) of some European countries or their parts. So far no CLC map of Europe has been made and published.

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The main reason why the preparation of the *Land Cover Map of Europe* at scale 1:5 000 000 (this scale was appropriate for dimensions of posters used at the 26th International Cartographic Conference ICA in Dresden, 25-30 August 2013) is here commented and demonstrated is connected with the existence of the CLC2006 database at scale 1:100 000 for 38 European countries (except for Greece where the data available are from 2000). Reality concerning the occurrence of LC class areas characterised according to a single nomenclature is recorded via this database. Representation of CLC classes in Europe on a single map may provide information about their occurrence and simultaneously offer the option to observe spatial relationships between them.

Table 1. Some characteristics of issued CLC maps (Feranec and Pravda, 1999; Pravda et al., 1998).

Map	Issued (year)	Scale	Numbers of colours	Numbers of screens	Minimal area in map (mm^2)
1. Grand-Duche de Luxembourg	1990	1:100.000	24	-	16
2. Mapa d´usos del sòl de Catalunya	1990	1:250.000	20	-	0.5
3. Mapa CORINE Land Cover de Catalunya	1993	1:250.000	42	8	1
4. Mapa CORINE Land Cover de Catalunya (lleg. europea)	1993	1:250.000	42/56	6/16	1
5. Land Cover Forms. Map sheet M-34-133-C (Šurany)	1994	1:50.000	24	24	2
6. CORINE Land Cover. Map Sheet C7-Dublin and C8-Cork	1995	1:500.000	44	-	0.5
7. CORINE – Land Cover Liege-Namur-Leuwen	1995	1:100.000	24	5	25
8. Land use. In Atlas of Poland	1996	1:1.500.000	13	-	0.1
9. Mapa CORINE Land Cover de la Mediterrània Occidental	1996	1:500.000	42	-	1
10. Mapa d'usos del sòl de Catalunya	1996	1:250.000	21	-	0.5
11. Slovakia – CORINE – Land Cover Tourist Map	1996	1:500.000	30	13	2
12. Slovakia – CORINE – Land Cover Map	1996	1:500.000	30	21	2
13. CORINE Land Cover France	1997	1:1.000.000	44	-	0.5
14. Land Cover. Territory: Zvolen-Detva-Krupina	1998	1:100.000	19	19	2

Bibliography of maps in Table 1

/1/ *Grand-Duche de Luxembourg*. (1990). Programme CORINE, Project Land Cover. 1:100.000. Résultat préliminaire. Ministére de l'Aménagement du Territoire et de l'Environnement, Luxembourg.

/2/ *Mapa d´usos del sòl de Catalunya*. (1990). 1:250.000. 2. ed. Institut Cartográfic de Catalunya, Barcelona.

/3/ *Mapa CORINE Land Cover de Catalunya*. (1993). 1:250.000. Institut Cartográfic de Catalunya, Barcelona.

/4/ *Mapa CORINE Land Cover de Catalunya*. (1993). 1:250.000. Ampliacio de la llegenda europea. Institut Cartográfic de Catalunya, Barcelona.

/5/ *Land Cover Forms. Area of the map sheet M-34-133-C (Šurany)*. (1994). 1:50.000. Geografický ústav SAV, Bratislava.

/6/ *CORINE Land Cover. Map Sheet C7-Dublin and C8-Cork*. (1995). 1:500.000. European Commission, Bruxelles.

/7/ *CORINE – Land Cover Liege-Namur-Leuwen*. (1995). 1:100.000. Institut Géographique National, Bruxelles.

/8/ *Atlas Republic of Poland. Land use*. (1996). 1:1.500.000. Główny geodeta kraju, Instytut geografii i przestrzennego zagospodarowania, Polskie przedsiebiorstwo wydawnictw kartograficznych im. E. Romera, Warszawa.

/9/ *Mapa CORINE Land Cover de la Mediterrània Occidental*. (1996). 1:500.000. Institut Cartográfic de Catalunya, Barcelona.

/10/ *Mapa d'usos del sòl de Catalunya*. (1996). 1:250.000. 3. ed. Institut Cartográfic de Catalunya, Barcelona.

/11/ *Slovakia – CORINE – Land Cover Tourist Map*. (1996). 1:500.000. Geodetický a kartografický ústav, Geografický ústav SAV, Bratislava.

/12/ *Slovakia – CORINE – Land Cover Map*. (1996). Appendix to the Geographia Slovaca 11/1996. 1:500.000. Geografický ústav SAV, Bratislava.

/13/ *CORINE Land Cover France*. (1997). 1:1.000.000. Institut Français de l'Environnement, Orléans, Cartography de Schutter, Anvers.

/14/ *Land Cover. Territory: Zvolen-Detva-Krupina*. (1998). 1:100.000. Geografický ústav SAV, Bratislava.

The *Land Cover Map of Europe* can be effectively accomplished if there is available a harmonized European Spatial Data Infrastructure (SDI). As only partial initiatives and programmes for the preparation of such infrastructures exist so far (Hopfstock, 2012), it was decided to use spatial pan-European data accessible to authors of this paper. The aim is to demonstrate the LC Europe map making based on CLC data and the topographic data used for compilation of thematic European maps at synoptic scales at the European Environment Agency (EEA) and its printing by computer technology.

1. Methods and data

Derivation of LC Europe database became the integral part of the CORINE Programme in 1985 initiated by the European Commission with the aim to create a consistent and compatible database about the environment of the EU Member states. The first CLC1999 project ran under auspices of the European Commission in 1995; the second CLC2000 Project was auspiced by the EEA and the Joint Research Centre (JRC) of the European Commission in 2000, and the third CLC2006 Project became part of the Global Monitoring for Environment and Security (GMES) Project – first-track service on land monitoring (Büttner et al., 2004; EEA-ETC/LUCI, 2007; Feranec et al., 2007; Steenmans and Perdigao, 2001). At present the CLC2012 Project runs in the context of the GMES Initial Operation (GIO) land framework (currently, CLC2012 is been produced under the umbrella of Copernicus, the GMES successor) (Feranec et al., 2012).

Areas of CLC2006 classes were identified via computer aided visual interpretation of satellite images SPOT-4 and/or IRS LISS III (for two dates in 2006 ±1 year) with the geometrical accuracy of images ≤ 25 m, the least size of identified area of 25 ha, and thematic accuracy of identified CLC classes was ≥ 85% (Heymann, 1994).

Part of the thematic content are areas of CLC2006 classes of the first hierarchic level and selected classes of the third level (44 classes of the CLC nomenclature are aggregated and generalized into 8 classes) (Heymann, 1994):

1. Artificial surfaces (all classes 1),
2. Agricultural areas (all classes 2),
3. Broad-leaved forest (311),
4. Coniferous forest (312),
5. Mixed forest (313),

6. Shrub and/or herbaceous vegetation and open space (321, 322, 323, 324, 331, 332, 333, 334 and 335),
7. Wetlands (all classes 4),
8. Water bodies (all classes 5) and the river network from the topographic source.

The thematic content was modified – classes of the first hierarchic level of nomenclature were assigned three classes of its third level, part "Forest and semi-natural areas" – 311, 312 and 313. The map with the proposed content emphasizes classes of the European forest landscapes. The content of map legend prepared based on CLC data though, can be adapted to the purpose for which the map will be issued.

1.1 Topographic base

The topographic source of the thematic *LC map* are the following layers:

– borders with lettering of states (copyrighted by the EEA[1]),
– European capitals with lettering (copyrighted by the EEA[1]),
– selected roads (Road data (highways) copyrighted by the Open Street Map (OSM)).
– waters – they complement the river network which was not identified by satellite images (pursuing the criteria of the CLC project, rivers or their parts wider than 100 m, water bodies larger than 25 ha were identified) (copyrighted by the EEA[1]).

Shaded terrain derived from GTOPO30 dataset. GTOPO30 is a global digital elevation model (DEM) with a horizontal grid spacing of 30 arc seconds (approximately 1 kilometer). GTOPO30 was derived from several raster and vector sources of topographic information. Completed in late 1996, it was developed through a collaborative effort led by the U.S. Geological Survey's Center for Earth Resources Observation and Science (EROS). For the map purposes, version of GTOPO30 data processed and distributed by the EEA for presentation purposes has been used.

1.2 Integration of the topographic base with generalized CLC data

For the final map compilation, CLC data were combined with selected layers (see part 1.1.) and shaded terrain of Europe. The CLC data, nowadays obtained under the European GMES service (Global Monitoring for Environment and Security), arise from primarily digital seamless vector layer covering 38 countries of Europe. Regarding the resolution and size of the original vector layer and the subsequent need of generalization, a derived raster layer with resolution 100 × 100 m distributed by the EEA was used for the purpose of this map. The CLC data were integrated with state borders, state lettering, capitals with lettering, selected roads and water bodies. Shaded terrain uses elevation data derived from GTOPO30 dataset.

1.3 Software

ESRI ArcGIS (c) software has been used for the map generation. Adobe Photoshop (c) software has been used for map finalization and final high resolution print-ready files generation.

1.4 Printing of the map on the hybrid digital printer

Copy of the map was printed on the hybrid digital printer equipped with the piezoelectric inkjet printing heads with four levels of shade of grey and a variable size of the print drop from 14 to 42 picolitres. The printer works in the system mixing CMYK colours hardenable by UV radiation with the Light Cyan and Light Magenta inks added. The used inks are optimised for printing of firm slab and flexible roll material with high resistance to external effects.

[1] GIS EEA map data and templates - downloadable EEA map templates and small scale vector data available at http://www.eionet.europa.eu/gis/. Data and templates are provided under EEA standard re-use policy i.e. unless otherwise indicated, re-use of content on the EEA website for commercial or non-commercial purposes is permitted free of charge, provided that the source is acknowledged (http://www.eea.europa.eu/legal/copyright).
Copyright holder: European Environment Agency (EEA).

2. Results

The CLC2006 data represented by Table 2 and Figure 1 provide the topical view of the European LC.

Artificial surfaces (class 1) including the areas of urban fabric; industrial, commercial and transport units; mine, dump and construction sites and artificial, non-agricultural vegetated areas with total area of 21,494,919 ha (3.18%) (see Tab. 2).

Agricultural areas (class 2), all CLC classes 2 (Heymann, 1994) cover 244,177,622 ha in 38 countries and represent 36.12% (see Tab. 2). Areas of this class are most numerous in lowland and hilly landscape.

Forests of Europe include the areas of classes 3, 4 and 5, *Broad-leaved* (311) occupy 54,932,363 ha, *Coniferous* (312) 74,115,710 ha and *Mixed* (313) 34,200,846 ha (see Tab. 2) are at the second position in terms of area 163,248,919 ha (24.15% of 38 countries' area). They occur in mountain ranges, but also in lowland and hilly landscapes.

Shrub and/or herbaceous vegetation and open space (class 6), which covers e.g. natural grasslands, transitional woodland/shrubs, moors and heathland, sclerophylous vegetation, beaches, dunes, sand plains, bare rocks, sparsely vegetated areas, etc. occupy the area 115,249,777 ha (17.05%). This area occurs in the range from high mountains to the sea or ocean coasts (see Tab. 2 and Fig. 1).

The two last classes include *Wetlands* (class 7) occupying 13,501,840 ha (2%) and *Water bodies* (class 8) with the surface of 14,851,271 ha (2.2%) (see Tab. 2 and Fig. 1).

Table 2. Statistical characteristics of the CLC2006 classes in pan-European context

CLC classes [1] (1st, 2nd and 3rd levels)	CLC2006 [2]	
	Total area (in ha)	Share (in %)
1. Artificial surfaces (all classes 1)	21,494,919	3.18
2. Agricultural areas (all classes 2)	244,177,622	36.12
3. Broad-leaved forest (311)	54,932,363	8.13
4. Coniferous forest (312)	74,115,710	10.96
5. Mixed forest (313)	34,200,846	5.06
6. Shrub and/or herbaceous vegetation and open space (321, 322, 323, 324, 331, 332, 333, 334 and 335)	115,249,777	17.05
7. Wetlands (all classes 4)	13,501,840	2.00
8. Water bodies (all classes 5) [3]	14,851,271	2.20
Total	572,524,348	100.00

[1] CLC nomenclature see (Heymann, 1994)

[2] Excluding Greece, not available for CLC2006. It was substituted by CLC2000 data in final map.

[3] Sea and Ocean is excluded as there is large 523 buffer around CLC datasets and it would completely hide inland water share.

Conclusion

The map demonstrated one of possible ways for the production of thematic maps of landscape in the pan-European context by application of the vector CLC database. The map also provides the basic information about occurrence and area of LC classes and their mutual interactions at a concise scale of 1:5 000 000, which may facilitate an overall comprehension of the current European landscape structure.

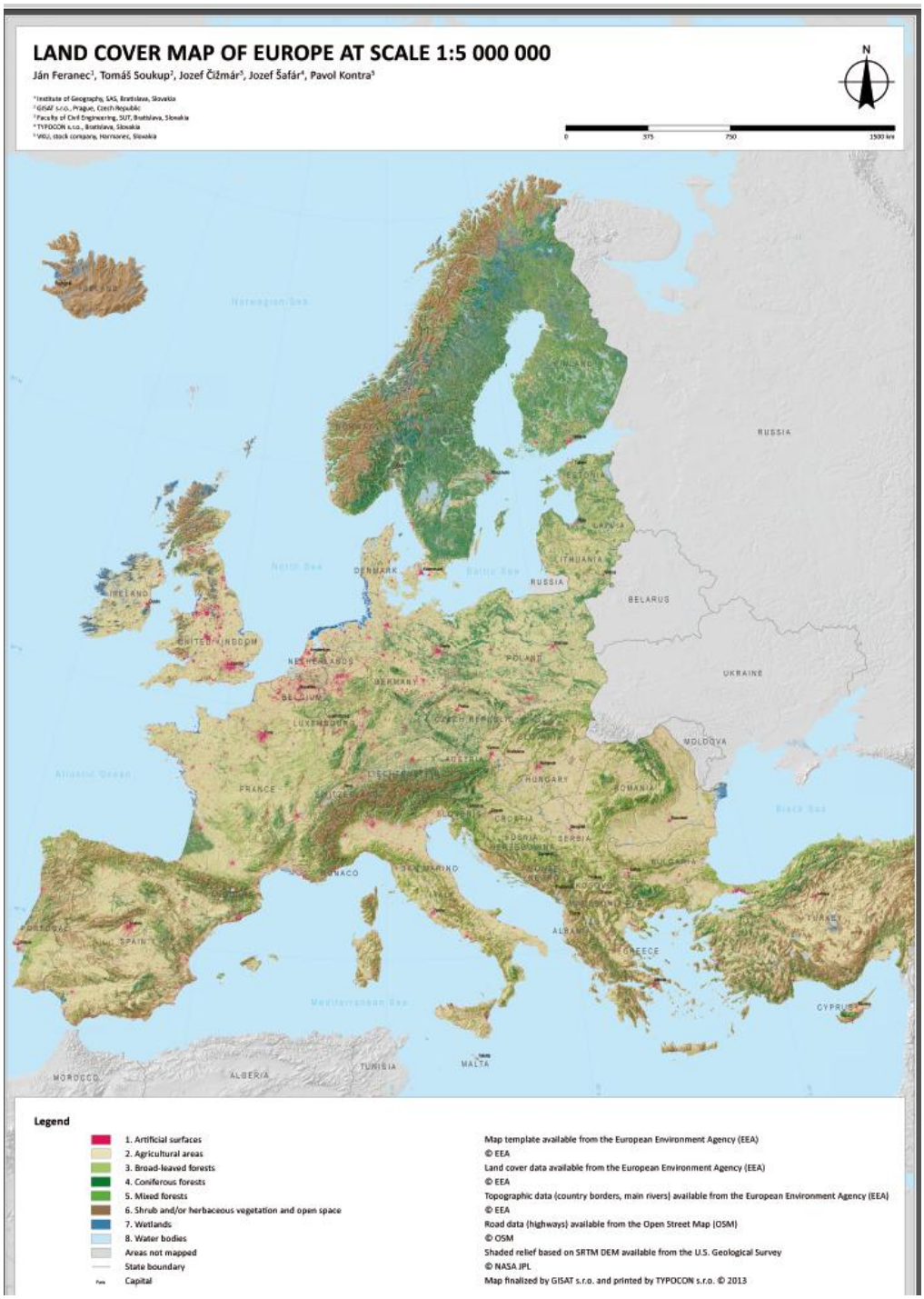

Figure 1. Land cover map of Europe (state in 2006) – the whole map is accessible at: **http://services.gisat.cz/clcmap/mapzoom.html**

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References

BÜTTNER, G., FERANEC, J., JAFFRAIN, G., MARI, L., MAUCHA, G., SOUKUP, T. (2004). The CORINE land cover 2000 project. In Reuter, R. (ed.) *EARSeL eProceedings*, 3 (3), Paris (EARSeL), pp. 331-346.

EEA-ETC/LUCI (2007). *CLC2006 technical guidelines: Technical Report, 17.* Office for Official Publication of the European Communities, Luxembourg. [online]. [cit. 2015-05-11]. Dostupné na: <http://www.eea.europa.eu/publications/technical_report_2007_17>

FERANEC, J., PRAVDA, J. (1999). Applications cartographiques à partir de la base de données CORINE Land Cover en République de Slovaquie. *Bulletin du Comité Français de Cartographie*, 161, pp. 69-74.

FERANEC, J., HAZEU, G., CHRISTENSEN, S., JAFFRAIN, G. (2007). CORINE land-cover change detection in Europe (case studies of the Netherlands and Slovakia). *Land Use Policy*, 24, 1, pp. 234-247.

FERANEC ,J., SOUKUP, T., HAZEU, G., JAFFRAIN, G. (2012). Land cover and its change in Europe: 1990-2006. In Giri, Ch. (ed.) *Remote sensing af land use and land cover: principles and applications*. Boca Raton (CRC Press, Taylor & Francis Group), pp. 285-301.

HEYMANN, Y., STEENMANS, CH., CROISILLE, G., BOSSARD, M. (1994). *CORINE Land Cover. Technical Guide*. Office for Official Publication of the European Communities, Luxembourg.

HOPFSTOCK, A. (2012). A pragmatic approach to the production of a European reference map. In Jobst, M. (ed.) *Service-oriented mapping 2012*. Wien (Jobstmedia Management, Verlag), pp. 95-104.

KRAAK, M. J., ORMELING, F. J. (1996). *Cartography: Visualization of Spatial data*. Dorchester (Longman).

PRAVDA, J., FERANEC, J., OŤAHEĽ, J., HUSAR, K. (1998). Kartografická aplikácia bázy údajov CORINE land cover v mierke 1:100 000 (cartographic application of CORINE Land Cover Database at scale 1:100 000). *Geograficky časopis*, 50, 1, pp. 21-33.

STEENMANS, CH., PERDIGAO, V. (2001). Update of the CORINE Land Cover Database. In Groom, G. and Reed, T. (eds.) *Strategic Landscape Monitoring for the Nordic Countries*. Copenhagen (Nordic Council of Ministers), pp. 101-107.

R e s u m é

Mapa krajinnej pokrývky Európy

Generovanie informácií o priestorových charakteristikách objektov krajiny je často spojené s využívaním počítačových báz údajov. Súčasné počítačové technológie, reprezentované najmä geografickými informačnými systémami (GIS), dovoľujú získať rôzne štatistické charakteristiky o objektoch krajiny v číselnej, ale aj grafickej podobe. Jedným z takýchto výstupov sú aj mapy. Cieľom príspevku je dokumentovať tvorbu mapy krajinnej pokrývky Európy na báze údajov CORINE land cover (CLC) a jej tlač počítačovou technológiou. Zároveň zdôrazňujeme, že charakteristiky o krajinnej pokrývke Európy možno optimálne prezentovať prostredníctvom mapy, ktorá umožňuje sledovať výskyt, ako aj vzťahy medzi jej jednotlivými triedami. Táto mapa, reprezentujúca interpretovanú časť obsahu satelitných snímok, sprostredkuje informácie o súčasnej priestorovej diferenciácii objektov krajiny v celoeurópskom kontexte.

Topografický podklad mapy v azimutálnom ekvivalentnom zobrazení tvoria: zemepisná sieť s hustotou 5°, brehová čiara, riečna sieť, ktorá nie je čiastočne obsiahnutá aj v báze údajov CLC, hranice štátov s ich hlavnými a vybranými mestami a komunikácie (železnice, cesty). Mapa je v mierke ca1:5 000 000.

Súčasťou tematického obsahu sú areály triedy CLC z roku 2006 prvej hierarchickej úrovne a vybrané triedy z tretej úrovne (44 tried legendy CLC je agregovaných a generalizovaných do 8 tried:

1. Artificial surfaces (urbanizované a technizované areály; všetky triedy 1),
2. Agricultural areas (poľnohospodárske areály; všetky triedy 2),
3. Broad-leaved forest (listnaté lesy; 311),
4. Coniferous forest (ihličnaté lesy; 312),

5. Mixed forest (zmiešané lesy; 313),
6. Shrub and/or herbaceous vegetation and open space (kroviny alebo trávne areály; 321, 322, 323, 324, 331, 332, 333, 334 and 335),
7. Wetlands (zamokrené areály; všetky triedy 4),
8. Water bodies (vody; všetky triedy 5) a riečna sieť z topografického podkladu.

Triedy CLC a ďalšie prvky mapy sú odlíšené farebne takto: 1 – červená, 2 – béžová, 3 –svetlozelená, 4 – tmavozelená, 5 – strednezelená, 6 – hnedá, 7 – tmavomodrá, 8 – svetlomodrá, sivá – územie bez údajov CLC, tmavosivá – popis štátov a ich hranice, čierna – hlavné mestá, sivá rastrovaná – tieňovaný reliéf.

Mapa bola prezentovaná na paneli počas 26. medzinárodnej kartografickej konferencie v Drážďanoch (v auguste 2013). Jej tlač sa realizovala na hybridnej digitálnej tlačiarni vybavenej technológiou piezoelektrických inkjetových tlačových hláv so štyrmi úrovňami škály šedej a s variabilnou veľkosťou tlačovej kvapky v rozmedzí od 14 do 42 pikolitrov. Tlačiareň pracuje v systéme miešania UV žiarením vytvrditeľných farieb CMYK doplnených o inky LightCyan a LightMagenta. Použité inky sú optimalizované pre potlač pevných doskových aj flexibilných rolových materiálov s vysokou odolnosťou na pôsobenie vonkajších vplyvov.

Mapa dokumentuje jednu z možností tvorby tematických máp o krajine v celoeurópskom kontexte aplikáciou vektorovej bázy údajov CLC. Zároveň poskytuje základné informácie o výskyte a rozlohe tried krajinnej pokrývky, ako aj o ich vzájomných vzťahoch v prehľadnej mierke 1:5 000 000, ktoré pomôžu lepšie pochopiť štruktúru súčasnej krajiny Európy.

Digitálna verzia mapy je dostupná na: **http://services.gisat.cz/clcmap/mapzoom.html**

Obr. 1 Mapa krajinnej pokrývky Európy (stav v roku 2006) – v elektronickej verzii je mapa dostupná na: http://services.gisat.cz/clcmap/mapzoom.html

Tab. 1 Vybrané charakteristiky vydaných máp CLC

Tab. 2 Štatistické charakteristiky tried CLC2006 v celoeurópskom kontexte

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