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THE USE OF LAND COVER DATA IN ECOSYSTEM SERVICES ASSESSMENT

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WYKORZYSTANIE BAZ POKRYCIA TERENU DO OCENY ŚWIADCZEŃ EKOSYSTEMOWYCH

STRESZCZENIE: Przedmiotem badań była ocena sekwestracji węgla, jako popularnego wskaźnika regulacyjnych świadczeń ekosystemowych, przy użyciu dwóch baz pokrycia terenu – Urban Atlas (UA) i Corine Land Cover (CLC). Badania objęły zachodnią strefę miejską i podmiejską Warszawy z fragmentem Kampinoskiego Park Narodowego (gminy Stare Babice, Izabelin, Łomianki i dzielnice Warszawy – Bemowo, Bielany). Wyniki świadczą, że dane CLC i UA nie są wystarczającym materiałem kartograficznym do oceny świadczeń ekosystemowych w skali lokalnej. Opracowywanie planów przestrzennego zagospodarowania na poziomie gmin lub ich fragmentów, powinno opierać się na badaniach terenowych, których celem będzie weryfikacja danych UA i CLC. Należy również wykorzystywać wskaźniki, które nie bazują bezpośrednio na danych UA i CLC.

SŁOWA KLUCZOWE: świadczenia (usługi) ekosystemowe, pokrycie terenu, Urban Atlas, Corine Land Cover, sekwestracja węgla

Introduction

Scale, time and location of the ecosystems are the main features for mapping and assessment of ecosystem services. In the TEEB Manual for Cities: Ecosystem Services in Urban Management[1] it is written that "one of the challenges is to ensure that communication takes place between the environmental- and planning departments and that information about the ecosystems services is considered as part of the planning process". In Poland, the planning process covers the four main stages of planning studies: national (in scale of 1:500 000-1:1000 000), voivodeship (1:100 000-1:200 000), commune (1:10 000 – 1:25 000), and local (1:1000 – 1:5000). Just like in Natura 2000, the main factor of spatial planning[2] from the perspective of the ecosystems and their services is the spatial planning at the commune and local level. National and regional levels are necessary for consistency of ecosystems, their goods and services protection. Each level, but especially local one, allows assessing the potential influence of spatial planning on the value of the ecosystem services and consequentially the quality of the lives of the residents of specific districts and neighbourhoods. The preservation of the ecosystems and their capacity to provide services seems particularly important for the urban areas, because the majority of the populations lives within them, spends time there, and reaps benefits from the ecosystems located nearby. The inhabitants of big cities are willing to work in their centres, but often want to live in the suburbs to raise their well-being. This produces the urban sprawl effect[3]. This zone is home to particularly endangered ecosystems and their services. Their protection depends on the local spatial development plans. Regardless of its rank, each survey must recognise the natural conditions in form of an eco-physiographic study and projections of impact on the environment, which is regulated by the act concerning spatial planning[4]. The scale of the study is an important, perhaps key factor in the application of the ecosystem services mapped and assessed in the future, which is the intention of the European Commission establishing the guidelines for such studies – MAES (*Mapping and Assessment of Ecosystems and their Services*)[5]. The suggested cartographic starting point for such

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[1] TEEB, *The Economics of Ecosystems and Biodiversity (2011), TEEB Manual for Cities: Ecosystem Services in Urban Management*, www.teeweb.org [20-09-2014], p. 34.

[2] M. Kistowski, M. Pchałek, *Natura 2000 in spatial planning – the role of ecological corridors*, Warsaw 2009, p. 9.

[3] M. Gutry-Korycka (ed.), *Urban sprawl. Warsaw Agglomeration case study*, Warsaw 2005.

[4] The act dated 27th March 2003 concerning spatial planning. Journal of Laws of 2003 No. 80 item 717.

[5] J. Maes et al., *Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020*, Luxembourg 2013.

studies is the Corine Land Cover (CLC)[6]. For urban ecosystems, it is the Urban Atlas (UA)[7], due to its superior resolution.

The objective of this study is to compare the assessed carbon sequestration as the most popular indicator regulating ecosystem services[8] with the application of CLC and UA within the communes inside the urban sprawl zone. Carbon sequestration is defined as change in C storage in aboveground and belowground biomass that result from tree growth during a single growing season[9]. Grass and herbaceous plants take part in C sequestration, but the role is insignificant[10]. Urban and suburban area is not only the source of carbon, but also the area of carbon storage and sequestration. For instance in USA, forests and forest products currently store the equivalent to 10-20% of U.S. fossil fuel emissions. The urban forest role is important in this process also. Urban forests are responsible for 20 percent of total reductions C in California (avoided emission area included)[11].

Data and Methods

The study area included the communes located between Warsaw and the Kampinos National Park. Choosen communes are representive for showing typical urban sprawl area. Each of them represent different pattern of land cover (dominance of built-up area, dominance of agriculture area and forest). Two districts of the city of Warsaw were selected (Bielany and Bemowo), which had a great share of agricultural terrains and were not a part of the main city core[12] back in the 1970s, the Łomianki rural-urban commune, and two rural communes, Izabelin and Stare Babice. The location of communes and their land cover are suitable to assessing and monitoring of land cover changes, spatial and temporally ecosystems changes.

CLC and UA were applied to establish their land cover classes and to calculate the basic landscape metrics for each commune and district: Number of patches (NP) and Patch density – number of patches/ha (PD). The calculations were made in Fragstat 4.2[13], while the GIS analyses were performed in Esri ArcGIS 10.1. The main parameters of CLC and UA: Minimum Mapping Unit (MMU) and

[6] www.eea.europa.eu [20-09-2014].

[7] Ibidem.

[8] M.W. Strohbach, D. Haase, *Above-ground carbon storage by urban trees in Leipzig, Germany: Analysis of patterns in a European city*, "Landscape and Urban Planning" 2012 no. 104, p. 95-104; Z.G. Davies et al., *Mapping an urban ecosystem service: quantifying above-ground carbon storage at a city-wide scale*, "Journal of Applied Ecology" 2011 no. 48, p. 1125-1134.

[9] M. E. Gregory, X. Qingfu, A. Elena, *A new approach to quantify and map carbon stored, sequestered and emissions avoided by urban forests.*, "Landscape and Urban Planning" 2013 no. 120, p. 70-84.

[10] H.K. Jo, G.E. McPherson, *Carbon storage and flux in urban residential greenspace*, "Journal of Environmental Management" 1995 no. 45(2), p. 109-133.

[11] D.C. McKinley et al., *A synthesis of current knowledge on forests and carbon storage in the United States*, "Ecological Applications" 2011 no. 21(6), p. 1902-1924.

[12] M. Gutry-Korycka (ed.), *Urban sprawl. Warsaw Agglomeration case study*, Warsaw 2005.

[13] K. McGarigal, S.A. Cushman, E. Ene, *FRAGSTATS v4: Spatial Pattern Analysis Program for Categorical and Continuous Maps*, Computer software program produced by the authors at the

Table 1

Tree cover for CLC and UA classes, x – category does not appear within the surveyed area [%]

Category	Urban Atlas	tree cover [%]	Corine Land Cover	tree cover [%]
MMU	0.25 ha		25 ha	
Artificial surface	Continuous Urban Fabric (average degree of soil sealing: > 80%)	5	111 Continuous Urban Fabric	X
	Discontinuous Dense Urban Fabric (average degree of soil sealing: 50-80%)	15	112 Discontinuous Urban Fabric	15
	Discontinuous Medium Density Urban Fabric (average degree of soil sealing: 30-50%)	30		
	Industrial, commercial, public, military and private units	5	121 Industrial and commercial units	5
			122 Road and rail networks and associated land	5
	Green urban areas	70	141 Green urban areas	70
	Sports and leisure facilities	10	142 Sport and leisure facilities	10
Forest and semi-natural area	Forests	90	311 broad-leaved forest	90
			312 Coniferous forest	90
			313 Mixed forest	90
			324 Transitional woodland scrub	65
Agricultural area	Agricultural + Semi-natural areas + Wetlands	5	222 Fruit trees and berry plantation	5
			231 Pastures	5
			242 Complex cultivation patterns	10
			243 land principally occupied by agriculture with significant area of natural vegetation	50
Others	Isolated Structures	15		
	Land without current use	10		

Source: own study.

quantity of classes within the artificial surface, agriculture areas, and forests areas, are different (Table 1).

In the next step the annual amount of carbon sequestered per acre per year has been estimated. In this research carbon sequestered has been calculated us-

University of Massachusetts, Amherst 2012, Available at the following web site: www.umass.edu [20-09-2014].

ing the formula of Rowntree and Nowak[14], where multiply percent tree cover by 0.00335. An assessed percentage of tree cover was established for a given class of land cover (Table 1). At least carbon sequestration has been converted into tons C per hectares per year.

Results

The high UA resolution and more allotments for built-up areas provides both rural and urban communes with more individual units (NP) in a given commune/district and higher density per ha (PD), (Table 2). The diverse resolution and method of preparing the material also entailed a diverse interpretation of the tree-covered terrains, which provided different areas for the given classes. From the perspective of the ecosystem services, including the regulating ecosystem services, the presence of forests is a good example. Despite the numerous classes assigned to forest areas (Table 1), CLC ultimately reduces their areas due to the classification of certain areas as green urban areas. This is particularly visible in the Bielany district, where the Bielany Forest is classified as a green urban area, which made the forest area 499.8 ha (Table 2). According to statistical data[15], the forest area in Bielany is 804 ha. The estimated value (939 ha) was provided by the UA study. If the research is used for planning studies for communes and districts, such differences can provide flawed evaluation of the services and benefits provided to humans from urban ecosystems. For carbon sequestration, the forests have greater potential due to the great tree density (our assessment: average of 90%). For green urban areas, these can be parks dominated by lawns and individual trees, but also forest parks. For these reasons, the estimated tree cover percentage value is lower.

The assessed carbon sequestration value for the surveyed areas was similar. There were considerable differences in the estimated carbon sequestration for the city of Łomianki. This results from the diverse qualification of the artificial surface, which is 74% on the CLC map and 61.9% on the UA map, where the CLC has more land cover classes with a specific tree cover percentage assigned (Table 1).

Conclusions

The differences in carbon sequestration result from the various legends in both classification systems, from the various level of generalisation. CLC holds more categories for areas not built up. A flaw of CLC is the appearance of mixed categories (242, 243), the share of which is big in Poland due to the fragmented

[14] R.A. Rowntree, D.J. Nowak, *Quantifying the role of urban forest in removing atmospheric carbon dioxide*, "Journal of Arboriculture" 1991 no. 17(10), p. 269-275.
[15] Statistical Review Warsaw, May 2012.

Table 2

Comparison of units structure and carbon sequestration among 6 study sites

Category	Area (ha)	NP (CLC)	NP (UA)	PD (CLC)	PD (UA)	Carbon tons/ha/year (CLC)	Carbon tons/ha/year (UA)	Forest ha (CLC)	Forest ha (UA)
Bemowo district	2492.2	55	734	2.207	29.452	0.175	0.170	304.1	293.1
Bielany district	3230.6	54	718	1.672	22.225	0.273	0.279	499.8	939.6
Izabelin rural commune	6494.6	98	454	1.509	6.990	0.620	0.624	5325.5	5333.3
Łomianki city	839.4	27	422	3.217	50.274	0.183	0.122	89.0	74.5
Łomianki rural commune	3039.8	54	580	1.776	19.080	0.194	0.233	649.7	822.3
Stare Babice rural commune	6334.9	88	1010	1.389	15.944	0.189	0.200	1413.9	1408.8

Source: own study.

structure of the rural areas. The tree cover percentage may be very diverse for these mixed categories. The tree cover percentage may also be very diverse for the urban green areas (from parks with sparse tree canopies to parks with dense tree cover and urban forests).

The available CLC and UA databases are only useful for comparison. The assessment of the actual carbon storage and carbon sequestration requires detailed tree canopy cover maps derived from orthophotos and the parameterisation of the C volume based on field surveys.

Despite the high resolution, the weak points of Urban Atlas in local surveys were revealed in the analysis of the provision ecosystem services. Ecosystem services provided at urban patch level (house, front garden, squares etc.) cannot be displayed by the Urban Atlas data[16]. Additionally, UA is developed only for cities with population over 100 000, which limits its use (27 cities in Poland).

As the most frequently used indicator of regulating ecosystem services in the Warsaw urban sprawl zone within 6 administration units, the surveys of carbon sequestration established that CLC and UA are not satisfactory cartographic material for the local scale in the assessment of the ecosystem services. The creation of spatial development plans at the level of the communes and their fragments should include field surveys aimed to verify the data obtained from the CLC and UA database and apply the indicators, which are not closely associated with the CLC and UA database. In the case of cities not covered by Urban Atlas, CLC should include verification of the data concerning the forest and semi-natural area.

[16] N. Larondelle, D. Haase, *Urban ecosystem services assessment along a rural–urban gradient: A cross-analysis of European cities,*" Ecological Indicators" 2013 no. 29, p. 179-190.