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Original article

The dynamics and conservation of forest ecosystems in Bucharest Metropolitan Area

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ABSTRACT

Over the recent years, metropolitan regions dealt with the growing problems of urban growth, land use/land cover changes, landscape fragmentation, deforestation and loss of natural vegetation. By its position in the Romanian Plain (southern Romania), Bucharest Metropolitan Area faced significant land transformations over the past centuries due its favourable natural, socio-political and economic conditions which shaped the pre-requisites for intensive/extensive agriculture, urbanization and industrialization. The paper is aiming to provide an insight on the temporal and spatial evolution of forest ecosystems based on several statistical and spatial data issued from historical documents and cartographical materials covering the past over two hundred years: 1790–1912 (empirical approach); 1912–1990 and 1990–2014 (spatial and statistical analysis). The outcomes revealed significant forest withdrawal over the analysed intervals in relation to the main triggering driving factors (e.g. historical, political, economic). Moreover, the study is completed with valuable information on the biogeographical and ecosystem classification of forests in the study-area, as well as the conservation of forest ecosystems though natural protected areas.

1. Introduction

The future and dynamics of earth ecosystems is increasingly dependent on the patterns of the main environmental changes (e.g. urban growth) as they fragment, isolate, and degrade natural habitats (Alberti, 2005), thus causing significant structural changes to European forestry (Konijnendijk, 2003). As a result, particularly in metropolitan areas, the urban development is rapidly transforming landscapes, strongly altering biodiversity and ecosystem functioning from local to global scales (Buyantuyev and Wu, 2009). Forests and green areas surrounding cities have been considered key components of urban ecosystems (Salvati et al., 2016). Metropolitan areas, too, face the growing problems of urban growth, hence triggering land use/land cover changes, landscape fragmentation, land degradation, habitat loss, loss of natural vegetation and a general decline in the extent of wetlands and wildlife habitats (Alberti, 2005; Dumitraşcu et al., 2010; Knorn et al., 2012).

In general, the literature on the dynamics of urban green space is mainly related to densification processes with a particular focus on the Asian and Australian cities than the European and North American ones. The identified patterns generally point to: the rapid losses and fragmentation of urban green space (Asian developing countries); the decrease of urban green space mainly related to the infill development (e.g. Australia, Europe); increase of urban green space due to the increase of urban area, but loss of undeveloped open areas at the city edge as (e.g. rapidly growing Chinese cities, Europe); increase of urban green space due to strategic plans to enhance urban green space (e.g. Singapore and China) (Haaland and van den Bosch, 2015). In Europe, studies have revealed an overall increase of urban green areas in Western European cities (between 2000 and 2006), while Eastern Europe cities faced a decline (Kabisch and Haase, 2013). The severe socio-economic changes after 1990 (e.g. population shrinkage, industrial decline) heavily affected land use/cover, and green space was no exception. As a consequence, in some cities from the South-Eastern and Central European countries (e.g. Hungary, Romania, Bulgaria) less than 40% of the total population lives within a 500-m distance from a 2-ha-minimum urban green space (UGS), while more than two thirds of population living in Scandinavian countries or some western EU countries (e.g. Germany, Austria) have access to green spaces within 500-m distance (Kabisch et al., 2016). The social and economic transitions of the urban dynamics in Central and South-East European cities followed almost the same pathways through urban policy with some differences mainly related their connection with the Western Europe on European transport corridors (Mihai et al., 2015). In Romania, the fall of communist regime brought about significant changes related to land management, industrial reconversion, restitution of private lands and

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urban planning which have led to a decrease in the urban green spaces (Badiu et al., 2016). Over the last century, in Bucharest Metropolitan Area significant human-related impacts have changed the natural ecosystems, forests often been replaced with secondary meadow associations (natural pastures and hay-fields), xerophyllous species tending to expand over the next vegetation belts. As a result, some vegetation types have reduced in size and almost disappeared, while others changed their floristic structure and composition, favouring aridization processes in the context of climate change (Muică and Dumitraşcu, 2001). Before 1948, in Romania, 28% of forests were owned by the state, 23% were in private possession or in the possession of local communities, religious or educational institutions and about 50% were forms of communal ownership, so called public property (Ioras and Abrudan, 2006; Griffiths et al., 2012). During the communist period (1948–1989) Romania's forests were almost entirely owned by the state. After the fall of communism (1990-to date) forest restitution was implemented through several laws aimed at returning the woodland to former owners or their successors. As a consequence, the resulted socio-economic and political changes gave a start to significant spatial transformations, through land use/land cover changes, including cropland abandonment and changes in the forest cover, exerting high pressure on natural ecosystems (Grigorescu et al., 2015). In the lowlands the largest share of oak forests, steppe and sylvo-steppe vegetation have been replaced by croplands (Popovici et al., 2013).

Under the growing impacts of urban growth, there has been an increasing concern on environmental quality in urban areas and the ecological benefits sustained by urban green spaces (Flores et al., 1998). Within cities, forests can mitigate most of the environmental impacts of urban development by moderating climate, reducing building energy-use and atmospheric carbon dioxide (CO2), improving air quality, lowering rainfall runoff and flooding, and reducing noise levels (Nowak and Dwyer, 2007). In the aftermath, substantial urban forest literature mainly examined the role green infrastructure play in improving the quality of the urban environment, i.e. air pollution (Yang et al., 2005; Nowak et al., 2006; Escobedo et al., 2008, 2015; Janhäll, 2015), ecosystem health (Tzoulas et al., 2007), human health (Frumkin, 2002; Wolch et al., 2014; Jennings and Gaither, 2015), climate change adaptation (Byrne et al., 2015; Matthews et al., 2015), as well as on planning and management of urban green space (Ugolini et al., 2015; Haaland and van den Bosch, 2015; Jim and Chan, 2016). An increasingly number of studies are focusing on the services that urban forest ecosystems provide to urban ecosystems (Nowak and Dwyer, 2007; Jim and Chen, 2009; Escobedo et al., 2011; Haase et al., 2014; Jennings and Gaither, 2015; Larson et al., 2016). Generally, considering that various studies have suggested that people should be willing to pay more to live near forests (Mansfield et al., 2005), green infrastructure may also be seen as an attractive feature in the process of urban sprawl, ergo positively influencing the housing market dynamics (Payton et al., 2008; Saphores and Li, 2012; Escobedo et al., 2015). Nevertheless, there are insufficient studies providing a broad analysis of the dynamics of forests within urban-rural interface and metropolitan areas through qualitative (type of ecosystems, floristic composition) and quantitative (spatial and temporal dynamics) approaches. A few studies addressed the impact of land use/cover changes on green spaces (Li et al., 2014; Sanesi et al., 2016; Salvati et al., 2016) and the linkages between urban sprawl and urban/suburban green spaces (Salvati and Ferrara, 2013; Sperandelli et al., 2013).

Studies undertaken in Romania revealed that transformations of the forest ecosystems have been caused by several processes in relation to the environmental particularities of the analysed regions: forest restitution and land ownership, deforestation (Griffiths et al., 2012; Knorn et al., 2012; Popovici et al., 2013); multi-temporal spatial analysis and conservation of forests (Pătru-Stupariu et al., 2013; Dumitraşcu et al., 2014a); clear-cutting, degradation through extreme weather events and pollution (Peptenatu et al., 2013; Prăvălie et al., 2014); fragmentation and illegal logging especially after the retrocession of forest land on the privately-owned terrains, natural (due to regeneration on deforested terrains, abandoned farmland and pastures) and artificial afforestation (planting after logging, calamities or establishment of a new forest on degraded lands) (Popovici et al., 2013); lack/poor professional management, financing, and scientific support in protected areas (Iojă et al., 2010; Knorn et al., 2012) etc. All of these involved loss of essential ecosystem services (e.g. wood and non-wood products, biodiversity), change of ecosystem functioning and species extinctions by way of habitat loss (Kuemmerle et al., 2009), introduction and spread of invasive species (Dumitraşcu et al., 2014b), substitution of forests with semi-natural or modified land use/land cover categories (e.g. shrubs, secondary pastures, transitional woodland-scrub), land degradation through erosion and intensification of extreme weather phenomena, aridization processes (Peptenatu et al., 2013; Popovici et al., 2013; Pravalie et al., 2014) etc. However, there is a need to investigate the long-term dynamics and structure of forests in metropolitan areas in order to understand urban transition and urban growth (Salvati et al., 2015). Thus, the current paper is seeking to provide an insight on the temporal and spatial evolution of forest ecosystems in a territory affected by the growing problems of urban growth and provide valuable information on the biogeographical and ecosystem classification of forests, as well as the conservation of forest ecosystems.

2. Material and methods

The study aims at providing an insight on the temporal and spatial evolution of forest ecosystems in one of the most dynamic urban-rural systems in south-eastern Europe, i.e. Bucharest Metropolitan Area. The analysis relied on a wide range of statistical and spatial data issued from historical documents and cartographical materials covering more than two hundred years: 1790–1912 (empirical approach restricted to analytical visual inquiry); 1912–2014 (spatial and statistical analysis). Thus, the historical records on forest dynamics was completed by the territorial analysis made through the interrogation of multi-temporal geospatial and statistical data detected for two main time-intervals (1912–1990 and 1990–2014).

The first interval (1912–1990) provides an historical overview of the forest dynamics in relation to the main land reforms, while the second (1990–2014) offers an insight of the transition period to the market economy as well as the pre- and post-accession to the European Union when significant land use/land cover changes related to the intensification (intense use of land through major investments in the means of production and labour force) and extensification (conversion of additional land to be cultivated) of agriculture, deforestation and urban sprawl-related processes (mainly suburbanization) occurred (Grigorescu et al., 2015). The statistical analysis of the spatial and temporal dynamics of forest-covered areas was performed using the Geographical Information Systems (GIS) based on the querying of initial geospatial data resulted for selected years: 1912 (A), 1988/1990 (B) and 2014 (C) from the raster data vectorisation of the cartographic materials and satellite images (Table 1). The scale of the cartographic sources used is considered appropriate for the size of the study-area so as the resolution of the satellite images. The interpretation and analysis of the LANDSAT satellite images was conducted using visual interpretation and digital image processing.

As a result, the authors computed the ***Forest Dynamics*** indicator (ha) measured as the difference between the forest-covered area computed for the last and first year for the period under review, at LAU2 level (Local Administrative Unit 2 – the lowest administrative division equivalent to communes, municipalities and cities): ***FD*** = *B-A or C-B*. Herewith, in order to highlight the proportion of forest-covered areas over the analysed years, the ***Annual Share of Forest Cover (%)***, was calculated for each year as the relationship between the analysed year and the summing up of all three years involved (T): ***ASF*** = (*the analysed year * 100)/T*. For the current status of the forest cover in Bucharest Metropolitan Area, the current study was completed with the