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Monitoring vegetation and land use quality along the rural–urban gradient in a Mediterranean region

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A B S T R A C T

This paper illustrates a methodology to quantify vegetation quality and its possible degradation in a large 'shrinking' Mediterranean city. Vegetation quality was estimated at three years (1960, 1990, 2006) in the Nuts-3 prefecture of Rome, central Italy (5355 km^2) through the analysis of comparable land cover maps. The aims of this work are to assess how 'compact growth' and 'sprawl' impact on vegetation quality, and to monitor the territorial disparities observed in the vegetation quality as caused by urbanization and land use polarization. Built-up areas covered 3.3% and 12.9% of the investigated area in 1960 and 2006, respectively, with a dispersed to compact urban surface ratio passing from 1.2 to 1.9. Vegetation quality increased slightly during the investigated period with a diverging trend between urban and rural areas. As a consequence, territorial disparities in the same variable grew due to low-density urban diffusion in lowlands and depopulation with land abandonment and natural forestation in mountain areas.

Introduction

Urbanization is a process of settlement diffusion that involves different factors that gradually end up changing spatial structures and creating new landscape patterns (Antrop, 2004). Urbanization reflects cultural and sociological challenges caused by the transformation of rural life styles into urban-like ones, inducing changes in the way man uses his environment and in the ecological functioning of the landscape (Alberti, 2005; Antrop, 2000, 2006; Conway & Lathrop, 2005; Johnson, 2001; McDonnell et al., 1997; Pickett et al., 2001).

Urbanization acts in different ways according to the geographical and geopolitical position of the region, and thus it should be approached considering the specific territorial and historical context in which particular urban forms shape cities (Antrop, 2005; Bruegmann, 2005; Richardson & Chang-Hee, 2004). Landscapes created by the transformation of the countryside around urban centres are referred to as 'periurban' landscapes and are characterized by a wide variety of land uses, which is expressed in a highly-fragmented morphology (Antrop, 2004). In periurban regions new elements and structures are superimposed upon the traditional landscape, that tends to become functionally homogeneous although with a high structural heterogeneity. This process of landscape 'homologation' was largely due to the polarization in areas with different land uses caused by urban expansion (e.g. Salvati & Sabbi, 2011).

Urban sprawl is regarded as a relatively recent process in Europe, especially in southern Europe (see Gargiulo Morelli & Salvati, 2010 and references therein). Traditionally, Mediterranean cities experienced a rapid compact growth till 1990s (Leontidou, 1990). After this period, a low-density expansion was observed especially in large urban areas (Chorianopoulos, Pagonis, Koukoulas, & Drymoniti, 2010). The recent Mediterranean patterns of urban development impose to rethink the impact of 'dense' and 'dispersed' growth on landscape transformations. This dichotomy has sometimes related the opposition between diffused 'green cities' and high-density, compact cities (Jim, 2004) to the choice between urban desirability and suburban livability (Neuman, 2005). From the environmental point of view, trade-offs have been pointed out between outer land preservation and environmental quality within dense and diffused cities (Allen, 2003; Bolound & Hunhammar, 1999; Garcia & Riera, 2003).

Sprawl-driven landscape changes have caused the depletion of heritage values and land resources (Antrop, 2000, 2004; Chorianopoulos et al., 2010; Economidou, 1993). The loss of arable lands, olive groves, vineyards, and annual crop is the most visible

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landscape transformation in the Mediterranean urban areas (Salvati, Sabbi, Gargiulo, Rontos, & Benaki, 2009). In this region little is known of how small, semi-natural landscape elements are evolving, how patterns are created, and how the ecological functioning of the landscape is affected (Marull, Pino, Tello, & Cordobilla, 2009). Also, little is known about the magnitude of these changes and about how they are controlled or not (Falcucci, Maiorano, & Boitani, 2007).

Since vegetation cover is one of the most sensitive factor to landscape deterioration in the Mediterranean basin (Kosmas, Danalatos, & Gerontidis, 2000; Pettorelli et al., 2005; Simeonakis, Calvo-Cases, & Arnau-Rosalen, 2007), this paper focuses on vegetation quality and its potential degradation. Vegetation and land use quality is an attribute of the landscape heavily affected by exurban development (Kosmas, Gerontidis, & Marathianou, 2000; Paul & Tonts, 2005). It was hypothesized that the two last phases of the Mediterranean urban expansion (i.e. 'compact growth' and 'sprawl') impact differently on the vegetation quality of periurban regions homogenizing rural landscapes and stressing the polarization in areas with high and low land quality (e.g. Salvati & Sabbi, 2011).

Based on a survey of land cover changes covering a period of 46 years (1960–2006), vegetation quality was quantified over a large Mediterranean urban region (Rome, central Italy) that experienced high rates of population growth between the 1960s and the 1980s. Since the 1990s Rome has began to face a change towards a more dispersed and horizontal rather than vertical growth to the detriment of farmland, forests, and wetlands (Munafò, Norero, Sabbi, & Salvati, 2010). Therefore, the aim of this paper is to evaluate the impact of 'compact growth' and 'sprawl' on the vegetation quality along the urban-to-rural gradient in Rome. Information derived from the analysis of these dynamics may contribute to inform strategies for the containment of urban sprawl and the mitigation of land degradation (Barrow, 1994).

Methods

Study area

The study area is the prefecture of Rome (121 municipalities with a surface area of 5355 km^2). The municipality of Rome is the biggest one (1285 km^2) and it was further divided into 19 local districts with a size similar to the remaining municipalities of the prefecture. The investigated area was therefore partitioned into a total of 139 spatial units. The region is characterized by a complex topography consisting of 30% lowlands, 50% uplands and 20% mountains (Fig. 1). Climate is typically Mediterranean with hot and dry summers and mild-wet winters. Average annual temperature is nearly 15 °C and average annual rainfalls range between 600 mm and 1200 mm depending on the elevation. Although urban areas occupy an important (and increasing) part of the region, the majority of the prefecture's area still consists of forests, pastures, and cropland. Despite degraded by summer fires and the considerable human pressure caused by the closeness to Rome, the Mediterranean forest vegetation was preserved in some coastal and upland forests.

Cartographical data

Data were obtained from the elaboration of three land cover maps (see Salvati & Sabbi, 2011): (i) the CORINE-like 'Land Cover Map of Italy' produced by the National Research Council and the Italian Touring Club in 1960 (LCM60), and (iii) two CORINE land cover maps respectively dated 1990 (CLC90) and 2006 (CLC06). The CLC project was aimed at providing land cover maps at various times for the entire Europe and was coordinated by the European Environment Agency (EEA). The CLC inventory was based on satellite images as the primary information source. The choice of scale (1:100.000), minimum mapping unit (25 ha) and minimum width of linear elements (100 m) for CLC mapping represents a trade-off between production costs and land cover information details (Salvati & Bajocco, 2011). The standard CLC nomenclature includes 44 land cover classes grouped into a three-level hierarchy. The five main (level-one) categories are: (CLC1) urban areas, (CLC2) agricultural areas, (CLC3) forests and semi-natural areas, (CLC4) wetlands, and (CLC5) water bodies.

Assessment of vegetation and land use quality

Vegetation quality information were derived from the available land cover maps (see Section 2.2) according to the indicator of vegetation quality developed in the framework of the Medalus II project (Kosmas, Kirkby, & Geeson, 1999) with the aim of assessing sensitive areas to land degradation. This procedure was applied to a number of study sites in Portugal, Spain, Italy, and Greece to quantify vegetation quality and potential land degradation. The procedure is capable to integrate variables from different data sources and its outputs were validated on the ground (Brandt, 2005; Kosmas, Tsara, Moustakas, & Karavitis, 2003).

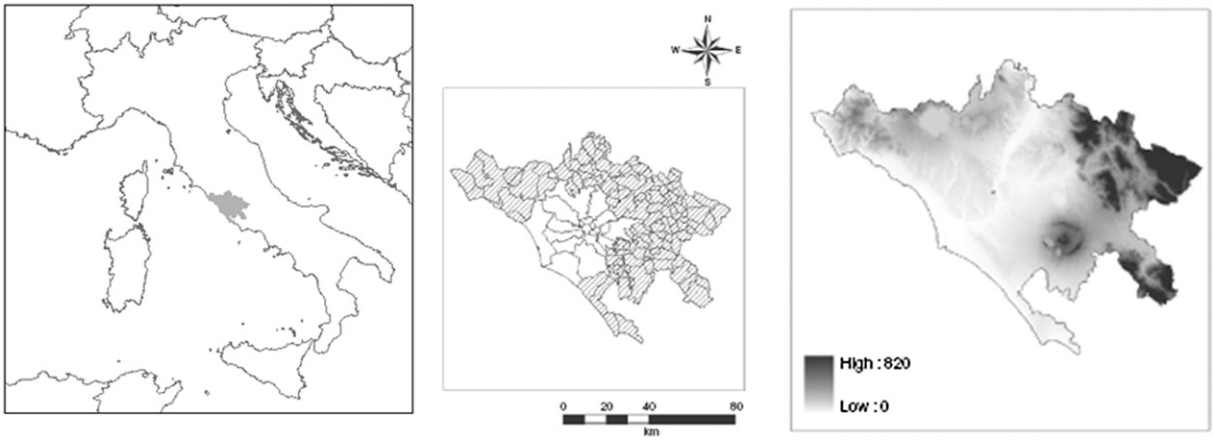

Fig. 1. The investigated area (prefecture of Rome, central Italy); (left) the location of the study area in Italy; (middle) the political division of the area in suburban municipalities (dark) and urban districts (white); (c) the elevation range.