RESTORING BIODIVERSITY IN A HIGHLY-INTENSIVE TOURISTIC URBAN AREA: A CASE STUDY IN THE CITY OF MATERA (SOUTHERN ITALY)

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Abstract
Cities play a considerable role in landscape protection and global biodiversity conservation. They comprise several habitat types, from remnant patches of native vegetation, urban wastelands, gardens, yards, *etc.*, to highly engineered green infrastructures, such as green walls/roofs and bioswales. Landscape planners are increasingly aware about the need to re-connect, through the urban-rural gradient, the endangered urban biodiversity with the surrounding natural areas. This need is even more urgent in case of urban settlements experiencing a remarkable growth in their population due to a heavy increase of tourism flows. This is the case of the City of Matera (Southern Italy), an UNESCO site currently selected as the European Cultural Capital 2019, which is facing an impressive growth in tourism population and relevant services. Hosting a *Site of Community Importance*, as well as a *Special Protection Area*, this city urgently needs suitable actions aimed to plan and manage its Urban Green Spaces (UGS), *i.e.*, urban green areas finalized to provide ecological, environmental, recreational and economic benefits, restoring its environmental resilience. In this paper, the actual UGS surfaces in Matera have been quantified with multi-source data and GIS tools, and the pattern assessed through specific landscape metrics, implementing a Decision Support System (DSS).

Key words: landscape protection, touristic fruition, biodiversity restoration, ecological infrastructures, Urban Green Spaces

Introduction

In recent years, there has been an increasing depopulation of small urban centers in favor of the growth of cities. This, given the considerable role of cities in landscape protection and biodiversity conservation, entails the need to redesign and rethink urban settlements, taking into account the ecological functions, urban species and habitats (Aronson et al., 2017; Grimm et al., 2008). An analysis of the impact of settlement patterns on landscape protection in areas in which there is a close relationship between rural and urban is therefore fundamental (Statuto et al., 2018/b; Olišarová et al., 2018). Currently, urban and landscape planners are moving towards a more resilient planning approach, in which they try to re-connect built-up territories with rural areas (Statuto et al., 2013), with the aim to restore suitable ecological networks with the surrounding natural environment. The approach that most emerges is based on the concept of *Urban Green Spaces (UGS)*. These UGS - such as native vegetation, urban wastelands, gardens, parks etc. - are finalized to provide ecological, recreational and economic benefits. Their role is fundamental to restore the environmental resilience of urban areas (Alvey A., 2006; Tian et al., 2014). In this context, it is important the awareness about the role of UGS, so as to assess the urban biodiversity pattern, implementing recommendations that can be easily applied to urban planning, design and management practices as well (Brunbjerg et al., 2018). This need is even more urgent in highly-intensive touristic urban areas, in which also important naturalistic and environmental assets are included, as in the case of the selected study area, the City of Matera (Southern Italy). This City is an UNESCO site, currently selected as the European Cultural Capital 2019, which urgently requires suitable actions safeguarding it from an impressively growth of touristic pressure, in the perspective of a sustainable management of its public recreational fruition (Cillis and Statuto, 2018).

Material and methods

The City of Matera (Fig. 1) is well-known for its cave-dwelling area (so-called: "*Sassi*"), a UNESCO World Heritage Site designated since 1993. Beside its historical and cultural aspects, the Matera landscape is made up of important naturalistic elements: the Natural Historic Archaeological Park of "Rock Churches"; a Special Area of Conservation (SAC*)*, as well as a Special Protection Area (SPA), both included in the UE network of protected sites (Natura 2000). In the present paper, only the perimeter defined as "Urban area" by the municipal plan has been taken into consideration (about 803 ha).

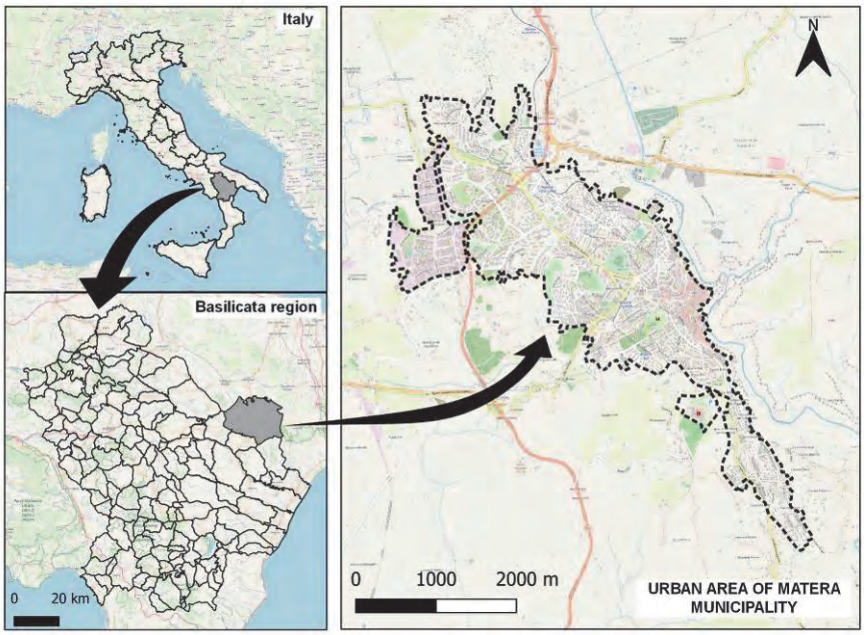

Fig. 1: Study area: the Matera urban settlement

In a first phase of the analysis (Fig. 2), the UGS detected in the study area have been spatialized through techniques of semi-automatic classification of orthophotos (Statuto et al., 2016) and satellite images, so as to evaluate their position and to calculate their relevant surface (expressed in hectares). Hence, to properly quantify and evaluate these UGS, the dataset has been implemented into a Geographical Information System, using QGIS 3.4 and the "GIMP Selection Feature" plugin. This plugin, starting from orthophotos of the year 2017, extrapolates all the polygons of the UGS to an excellent resolution, using the selection of the *green color* of the vegetation, which enables a validation directly in QGIS through a specific check. Then, in order to achieve a greater accuracy, these data have been successively integrated also with the elaboration of satellite images Sentinel-2 of the same year of the orthophoto (May 2017), so as to better classify some UGS (Kopecká et al., 2017) which were more difficult to detect. In this way, also the lawns have been classified, even if at a lower resolution, by an unsupervised classification with K-Means algorithm made with *i.cluster* of GRASS GIS.

The second phase of the analysis involved the implementation of a set of landscape metrics finalized to evaluate the qualities of the ecological network, for purposes of biodiversity restoration and landscape planning (Statuto et al., 2018/a). The generalized UGS raster without any differentiation between different typologies has been considered (Li et al., 2015). Landscape metrics have been calculated at the level of the whole landscape by Fragstats 4.2.1 (McGarigal et al., 2012), expressing the following indexes:
- *Landscape Shape Index* (LSI) provides a simple measure of class aggregation (LSI = 1 when the landscape consists of a single square);
- *Fractal Dimension Index* (FRAC_MN) reflects shape complexity across a range of spatial scales (range is from 1 to 2, with values approaching 1 in case of shapes with very simple perimeters, approaching 2 in case of shapes with highly convoluted perimeters);
- *Euclidean Nearest Neighbor Distance* (ENN_MN) has been used to quantify patch isolation; the values (in meters) approach 0 as the distance to the nearest neighbour decreases, which means that the patches are more close;
- *Shannon's Evenness Index* (SHEI) is a measure of the patch diversity. It ranges from 0 (no diversity) to 1 (when the area distribution among patch types is perfectly even).
Finally, the landscape metric *Connectance Index* has been calculated using the *moving window approach* of the same software (Hagen-Zanker, 2016). This Connectance Index is reported as a percentage (0-100) of the maximum possible interconnection, given the number of patches. The obtained results of this approach have enabled the creation of a raster model.

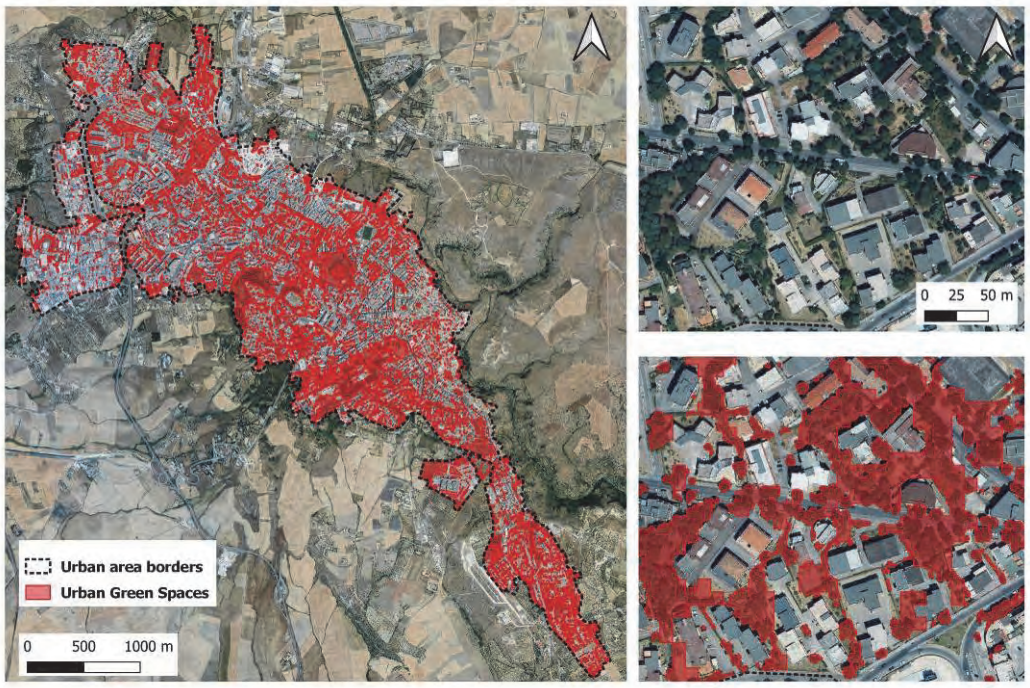

Fig. 2: Urban Green Spaces quantification and spatialization

Results and Discussion

The quantification of the UGS shows that about 150.6 hectares – *i.e.*, about 18.7% of the total urban area - is covered by different types of vegetation (from tree-lined streets to lawns). Moreover, through the simple realization of a UGS concentration map (Fig. 3 - Left), it has been possible to highlight the areas with different spatial density of UGS.

The landscape metrics which have been calculated (Tab. 1) provide information about the theoretical potential of the land regarding the biodiversity, fragmentation and aesthetic aspects (Statuto et al., 2018/a).

Tab. 1: Landscape metrics values

LSI	FRAC_MN	ENN_MN	SHEI
40.81	1.62	7.98	0.69

Some of these metrics can be individually evaluated, while others need a comparative approach. The SHEI, indeed, shows a fairly high value of diversity, almost equal to 0.7, while the FRAC_MN indicator of shape complexity shows a value (1.62) corresponding to a good level of landscape diversity, complexity and richness. On the other hand, the average distance between the nearest neighboring UGS (ENN_MN) is such as they compose a well-structured ecological network of the UGS, their disaggregation level being not high, since the value of LSI is relatively low.

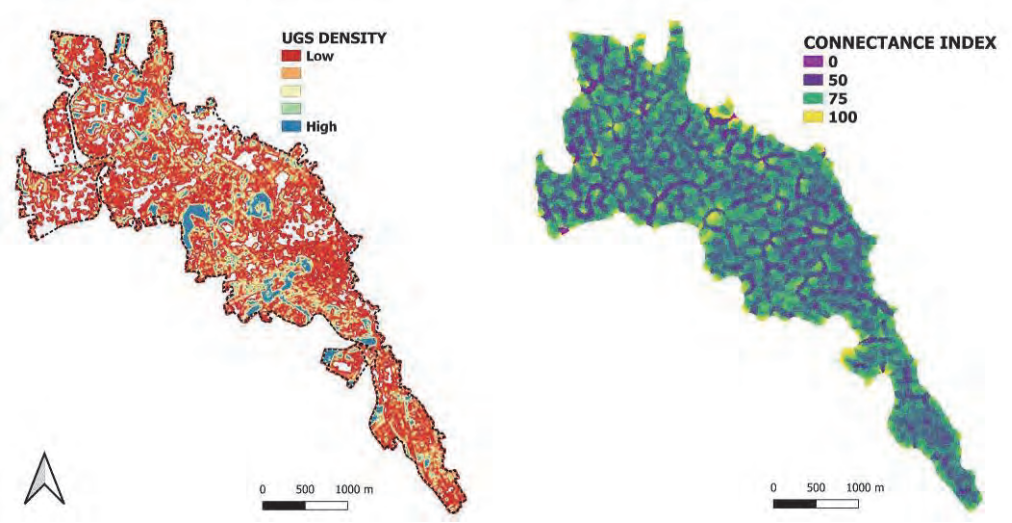

Fig. 3: UGS concentration map (Left) and Connectance index map (Right)

The spatialization of the *Connectance index* (Fig. 3 - Right) enabled to geo-localize the corridors characterised by lower values (Fig. 3 - Right). From a statistical analysis of the raster map of the *Connectance index* (value ranging from 0-100), it emerges that 23.8% of the urban area has a value of less than 50, whereas 61.8% of values is included between 50-75 and, finally, the 14.4% values exceed 75. We can finally conclude from an overall analysis of the Matera UGS that the conditions are already positive, and the improvements of vegetation could be localised in the northern area, of more recent urbanization.

Conclusion

The UGS analysis methodology here proposed has demonstrated that the GIS approach is a fundamental tool to quantify the surface area and to evaluate the spatial and qualitative characteristics. By integrating different tools such as satellite images and landscape metrics, it has been possible to implement a complete survey of the conditions of the ecological network, assessing the state of potential biodiversity in an urban area. The values of the landscape metrics represent the information base, on which it will be possible to plan the future development of the UGS, even through the implementation of a Decision Support System (DSS).

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Souhrn
V této práci byla navržena metodika pro řádné vyčíslení a vyhodnocení městských zelených prostor (UGS) s nástroji GIS. UGS vysoce intenzivní turistické městské oblasti (město Matera - jižní Itálie) byly realizovány technikami poloautomatické klasifikace ortofot a satelitních snímků, aby bylo možné zhodnotit jejich polohu a plochu v hektarech. Pak byla vypočtena množina krajinných metrik pro vyhodnocení vlastností ekologické sítě. Tímto způsobem bylo možné posoudit kvalitu ekologických vazeb mezi městskými a venkovskými oblastmi a naplánovat akce na obnovu biodiverzity a zlepšení ekologické sítě městské oblasti.

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