TeMA

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Land Use, Mobility and Environment

This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.

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EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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LANDSCAPE PLANNING AND ECOLOGICAL NETWORKS

PART A

A RURAL SYSTEM IN NUORO, SARDINIA

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ABSTRACT

Urban-rural landscape planning research is nowadays focusing on strategies and tools that support practitioners in designing integrated spaces starting from the analysis of local areas, where human and natural pressures interfere. A prominent framework is provided by the ecological networks, whose design regards the combination of a set of green areas or patches (the nodes) interconnected through environmental corridors (the edges). Ecological networks are useful for biodiversity protection and enhancement, as they are able to counteract fragmentation, and to create or strengthen relations and exchanges among otherwise isolated elements. Biodiversity evolution, indeed, depends on the quantity and quality of spatial cohesion of natural areas. In this paper, we aim at designing an ecological network for the periurban area on the town of Nuoro in central Sardinia. The narrative unfolds in two parts. Part A is presented in this paper and includes its methodological premises, i.e. biodiversity conservation and ecological network analysis and design, and the introductory elements of a spatial analysis on a pilot ecological network of one hundred patches. We locate patches by focusing on the ecosystems supported by the target vegetal species holm oak (*Quercus ilex*) and cultivated or wild olive (*Olea europaea* var. *sativa*, *O. europaea* var. *sylverstis*). These are very common plants species in the municipality and some animal species are active as seed dispersal. The reminder, i.e. Part B, of the essay is presented in an homonymous paper that focuses on the illustration of the network analysis conceived as a monitoring system and, in future perspective, as a planning support system.

KEYWORDS

Rural-urban landscape, ecological networks, target species, dispersal distance

1 INTRODUCTION

The development of human settlements has often caused severe interferences with local ecosystems that have resulted in loss of biodiversity. In this respect, uncontrolled pace of building activity and erosion of public spaces and green areas are major determinants. Nowadays planners are faced with urban landscapes often in need of policies directed to the conservation of biodiversity. A prominent strategy able to satisfactorily meet these needs is the construction and management of ecological networks, i.e. a system of punctual green areas interlaced through material (corridors) or immaterial connections. In a number of cases municipalities have successfully adopted that strategy to counteract biodiversity decrease through the reintroduction of certain vegetal and animal target species in peri-urban and urban landscapes. The analysis of the structure and behaviour of ecological networks is often based on graph theory, a discipline that has recently been renewed due to the developments of complex network analysis and to the availability of large data sets and computational power and tools.

The aim of this paper is to study the ecological network of the town of Nuoro, Sardinia and to build a network based analysis that may act as a monitoring tools and ultimately a planning support system. The argument is presented in two papers titled with the extensions "Part A" and "Part B". This paper unfolds as follows. In the second and third sections, we present our main concerns and methodologies regarding biodiversity conservation strategies and ecological network analysis, management, and planning. In the fourth section, we apply a complex network analysis to the characterization of an ecological network for Nuoro, Sardinia. For the remainder of the essay, we refer to paper Part B.

2 BIODIVERSITY AND ECOLOGICAL NETWORKS

For much of the 20th century biodiversity conservation, understood in its classical meaning as "the variety of life found in a place" (Encyclopædia Britannica, 2014), has found in the establishment of natural protected areas an effective tool (Boardman, 1981). However, over the past forty years, the validity of the concept of protected area is in crisis due to the excess of the conventional "conservation islands" (MacArthur & Wilson, 1967; Boardman, 1981; Farhing & Merriam, 1985; Romano, 2000, Rodrigues et al., 2004; Hoekstra et al., 2005). Moreover, a general acknowledgment of the negative effects on biodiversity caused by the landscape fragmentation has been registered (Soulé, 1986; Forman, 1995; Stanners et al. 1995 Forman, 1998; Cook, 2002; Bouwma et al., 2003; Jongman, 2004; Wiegand et al, 2005). At the same time, the emergence of theories on metapopulation (Levins, 1969), polarization of the landscape (Rodoman, 1974) and source-sink (Pulliam, 1988) have pioneered the conservation biology and the concept of landscape connectivity as tool to improve the vitality of the population and the species richness (Noss & Coperrider, 1994; Meffe & Carroll, 1997; Beier & Noss, 1998; Gilbert-Norton et al., 2010).

Thus, the concept of "ecological network" as a conservation network for the recovery and the maintenance of ecological connectivity and environmental continuity were introduced in the scientific debate (Levins, 1969; Noss, 1987; Simberloff, 1988; Dawson, 1994; Jongman, 1995; Forman, 1995).

The validity of scientific theory and the arguments behind this conservation strategy has been widely debated by scholars (Wilson & Willis, 1975; Diamond, 1975; Noss, 1987; Simberloff & Cox, 1987; Simberloff, 1988; Shafer, 1990; Hobbs, 1992, Simberloff et al., 1992; Dawson, 1994; Coperrider & Noss, 1994; Troumbis & Jongman, 1995; Beier & Noss, 1998; Haddad et al., 2000; Crooks & Sanjayan, 2006). In particular, the effectiveness of ecological networks, as tools able to maintain and improve landscapes and habitats spatially integrated, is increasingly accepted as an appropriate approach for the improvement of the ecological quality of natural ecosystems and for the biodiversity protection (Beier and Noss, 1998; Haddad et al., 2000; Van Rooij et al., 2003; Verboom & Pouwels, 2004; Smith, 2004; Damschen et al., 2006; Crooks and Sanjayan, 2006; Gilbert Norton et al., 2010). More recently, ecological networks tools are playing a central role landscape in planning (Opdam et al., 2006; Steiner, 2008), also taking into account an ecological and functional integration approach (Fichera et al., 2010; 2013).

Although identified in different ways, also depending on the reference spatial scale and priority goals, the constituent elements of an ecological network are: i) core areas, ii) corridors, and iii) buffer zones (Jongman, 1995; Bennett, 2004). Core areas are zones of high natural value for the conservation of habitats, species and landscapes. Although the criteria for their identification are not homogeneous, such areas may be divided into two main types (Biro et al., 2006): institutional natural protected areas (Boitani et al., 2003; Boitani et al., 2007); areas with particular characteristics (in terms of vegetation, size and spatial configuration etc.) suitable for the survival of certain species (Lambeck, 1997; Jetz et al., 2003; Watts et al., 2010). Corridors are physical connections between core areas so as to ensure the ecosystems self-regulation by allowing the movement of species. The corridors can be distinguished on the basis of: i) structure: continuous or discontinuous (stepping stones); ii) function (Foppen et al., 2000); and iii) characteristics that led to their identification (naturalness, biopermeability, etc.). Buffer zones are areas around the core areas or around the connecting elements, designed to protect network elements from exogenous disturbance originating from neighboring areas (Jongman, 2004; Oliver et al, 2008).

In their implementation, ecological networks can be classified according to three basic approaches (Fichera et al., 2013): i) physiographic approaches, centered on maintenance and strengthening of the spatial structure of the different existing ecosystems; ii) functional approaches, oriented to the management of ecological processes (than the regeneration of vital habitats for the target species that represent the local biodiversity); and iii) planning approaches, centered on a multifunctional planning perspective: ecological, recreational, aesthetic, etc.

These classical criteria are recently being integrated in the concept of green infrastructure (EEA, 2011), a complex and wide-ranging approach where ecological networks, as well as ensuring environmental features and the maintenance of biodiversity, are configured as guidelines for a proper ecological landscape planning.

3 ECOLOGICAL NETWORKS IN LANDSCAPE PLANNING

The construction and development of ecological networks (ENs) is one of the prominent strategies able to counteract the decrease of biodiversity level in contemporary landscapes (Hagen et al, 2012). According to Jongman et al (2004), ENs developed at different institutional levels have gained an increasing importance as possible common action in landscape planning towards nature conservation also in the context of European integration. Jongman et al (2004) report on EN projects managed in a number of European countries, from Portugal to Russia.

An EN consists of a system including a set of ecological punctual elements, often known as patches, (conceived as nodes) interlaced through a set of linear components, usually referred to as corridors (modeled as edges). The analysis of ENs can thus be referred to graph based modeling techniques that in the last decade have been extensively proposed under the terms complex network analysis (CNA). CNA applications are based on the wider availability in the last 15 years of large dataset and higher processing power. These techniques assist the analyst in the characterization of complex systems in many realms: biology, engineering, sociology, genomics, environmental planning, and others (for a review, see Barabasi and Albert, 2002). While many systems can be modeled by referring just to their topology, i.e. the purely logical relation between the nodes, ENs should be inspected by invoking the class of spatial networks. These networks include elements that present a clear and determinant reference to geographical space: in our case, nodes and edges consist of patches and corridors which display a certain location, extension, width, length, and shape (Dale and Fortin, 2010). The application of spatial networks to modeling ENs is still in its infancy and constitutes a promising field of application. Many studies (Adriansen et al, 2003; Bunn, Urban, and Keitt, 2000; Fall et al, 2007; Fortuna et al, 2006; Minor and Urban, 2007 and 2008; Pascual-Horta and Saura, 2006; Urban and Keitt, 2001; Urban et al, 2009) present similar approaches, as they include, inter alia: i) identification of the elements; ii) landscape connectivity analysis. Advanced spatial analysis is usually adopted to recognize and map ecological patches and corridors through the use of GIS tools including ad hoc routines tailored for network analysis and available in many software programs (Boyd and Foody, 2011; Gurrutxaga, Lozano and del Barrio, 2010; Marulli and Mallarach, 2005; Vuilleumier and Prélaz-Droux, 2002). Landscape connectivity analysis consists of the characterization of the EN, with a focus for establishing whether two given patches are connected or not. In this respect, meta-population, i.e. the study and identification of typical vegetal and animal target species, is of paramount importance (see, inter alia, Cartensen et al. 2012; Cartensen and Olsen, 2009; Hepcan et al, 2009; Kissling et al, 2012). Each species is defined by, inter alia, describing its general behaviour and, in particular, the attitude towards displacement. In this context, a very frequently adopted index is the dispersal distance, measuring the maximum length a certain target species is able to cover. In this sense, two patches are connected if they are located within the dispersal distance of target species, which are typical for the specific EN.

4 CASE STUDY: AN ECOLOGICAL NETWORK FOR NUORO

In this section, we apply a complex network analysis as a tool for the analysis and design of an ecological network for the town of Nuoro (henceforth, ENN), in central Sardinia, Italy. The argument unfolds in subsections as follows. In the first one, we introduce the main characteristics of the town of Nuoro. In the second, we focus on the choice of the target species and argue on the seed dispersal distances. In the third subsection, we report on the data elaborated and software adopted for modeling and analyzing the ENN.

4.1 GENERAL CONTEXT

The context of this application is Nuoro, which is a medium size (36,000 inhabitants in 2012, Istat www.tuttitalia.it) town located in central Sardinia. The history of the town reports on strong relationships between population and landscape, characterized, generally, by ecosystems belonging to the Mediterranean maquis and, typically, by fairly high altitude sites (maximum 955 m above sea level), such as the Ortobene urban mountain. The interplay between urban settlement and landscape is characterized by the absence of a clear boundary delimitating urban and rural settings. In this case, peri-urban areas play an important role in biodiversity management, because they are able to reconnect external environments to internal zones encapsulated in the urban fabric. The design and management of an ecological network would provide the municipality with a powerful tool for increasing the biodiversity level through connectivity policies. On the other side, urban and regional land use plans designed and approved by the municipal administration of Nuoro imply transformations which affect positively or negatively the ecological network. In this case, a coordination is required, as many examples of municipal ecological network indicate (Jongman et al, 2004).

4.2 TARGET SPECIES AND DISPERSAL DISTANCE

Olive (*Olea europaea* L.) and Holm oak (*Quercus ilex* L.) are two of the most characteristic plant species of peri-urban landscape of the town of Nuoro. Thus, they can be selected as vegetal target species for the EN of Nuoro. Olive is a peculiar component of the agricultural landscape by means of the cultivated variety (*O. europaea* var. *sativa*). Orchards are more or less traditional in the planting and managing system and the case of abandoned cultivations is present. Dissemination from cultivated plants may produce feral seedlings but also the wild variety (*O. europaea* var. *sylvestris*) is widely present in the peri-urban natural areas and may be active in the natural colonization of abandoned areas (Mulas, 1999; 2012; Mulas et al., 2002). Following the evolution of the vegetation cover, the affirmations of olive seedling generate the shrub or tree form of the species as component of the Mediterranean maquis (Mulas et al., 2001; 2005). Holm oak is the main component of most developed forests widely growing in the hills around the urban area of Nuoro. Moreover, the pure Holm oak forest is the climax natural vegetation cover of the Nuoro land hills (Mulas et al., 2004a). Olive and Holm oak frequently establish a natural equilibrium (Mulas et al., 2003). Olive is a colonizing species of burned or degraded soils by means of wild or feral seedlings. Seed spreading is highly efficient thanks to many birds or small mammalians (Mulas et al, 2003; 2004b). Seedlings slowly developed as bushes showing a fundamental function of soil protection and enhancing vegetation cover evolution. Olive bushes or trees also play a role in the affirmation of the subsequent colonization of Holm oak. This species, in fact, needs the shade of other bushes or trees and that is the case of the mature Mediterranean maquis. Because of the seed larger size and tender texture, the seedling spreading of Holm oak is less efficient than Olive. However, after colonization, Holm oak is very competitive with respect to other plant species and a significant reduction of biodiversity may be easily measurable in mature forests (Mulas et al., 2003).

ZONE	PATCH CLASSIFICATION	OLIVE (*OLEA EUROPAEA*)	HOLM OAK (*QUERCUS ILEX*)
Peri-urban	1) Natural area or rangeland	Absent	Absent
	2) Olive orchard	Dominant as cultivated or abandoned tree	Absent
	3) Natural area or rangeland	Present as initial colonization by seedlings	Absent
	4) Natural area or rangeland	Affirmed as shrub component of maquis	Absent
	5) Natural area or rangeland	Affirmed as shrub and tree	Present as initial colonization by seedlings
	6) Pure or mixed forest	Absent	Present or dominant as mature tree
Urban	7) Abandoned area	Present or potentially colonizable area	Absent
	8) Natural area/green area	Affirmed as shrub component of maquis or urban green	Absent or present as young plants
	9) Natural area/green area	Absent	Present or dominant as mature tree
	10) Corridors	Street trees, way borders and other forms of natural communications.	Street trees, way borders and other forms of natural communications.

Tab. 1 Possible classification of land plots to support the patches and corridors establishment

Both Olive and Holm oak are widely used in the urban and peri-urban green areas both artificial (gardens and street trees) or natural (abandoned orchards, parks, and unused areas). Thereafter, the choice of those two species allows the classification of urban and peri-urban areas based on the potential colonization, presence and evolution of them. The land analysis may be also structured as ecological network by definition of patches, natural corridors and relative connections, thus measuring the possibility of relationship between urban and peri-urban areas in terms of plant species colonization and evolution. Consequently, the functionality of peri-urban areas with respect to plant cover evolution and as potential receptors of plant colonization from urban sources may be evaluated.

With the aim to analyze this potential network system and to elaborate a corresponding functional model a first definition of potential patches and corridors was designed and presented in Table 1. This is a minimal systematic key of land description proposed for the first step of the soil cover classification.

The most active seed dispersal vector of the Holm oak seeds is the European jay (*Garrulus glandarius*) (Gomez, 2003; Pons and Pausas, 2007). The average dispersal distance of the bird is 250 m, with a recorded maximum of 1000 m (Table 2). Less effective as seed dispersers are the rodents, with some different species like woodmouse (*Apodemus sylvaticus*) and garden dormouse (*Eliomys quercinus*) (Gomez et al., 2008). Rodents are also active in the seed dispersal of Olea europaea but the maximum dispersal distance of these vectors is of few meters. More efficient as olive seed disperser are many frugivorous birds, like Common Starling (*Sturnus vulgaris*), Song Thrush (*Turdus philomenos*), Blackcap (*Sylvia atricapilla*), Sardinian Warbler (*Sylvia melanocephala*) (Rey et al., 2000; Alcantara and Rey, 2003). The most probable maximum distance of seed dispersal by these birds is of 100 m because they swallowed olive fruits whole, regurgitating the stones 20-50 min later (Bass et al., 2006). Wild big mammalians and livestock, like pigs, sheep, goats and cattle, feed both Holm oak and Olive seeds. However, these vectors efficiently disperse only olive seeds. In addition, the European fox (*Vulpus vulpus*) may be a possible disperser of olive seeds for a maximum distance of 50 km (Bass et al., 2006).

VECTOR SPECIES	OLIVE (*OLEA EUROPAEA*)	HOLM OAK (*QUERCUS ILEX*)
Jay (*Garrulus glandarius*)	Unknown	1000 m
Common Starling (*Sturnus vulgaris*); Song Thrush (*Turdus philomenos*); Blackcap (*Sylvia atricapilla*); Sardinian Warbler (*Sylvia melanocephala*);	100 m	Unknown
Rodents: woodmouse (*Apodemus sylvaticus*); garden dormouse (*Eliomys quercinus*)	7.5 m	7.5 m
Sheep (*Ovis aries*), goat (*Capra aegagrus hircus*), cattle (*Bos taurus*), pig (*Sus scrofa*)	2000 m	Unknown
Fox (*Vulpus vulpus*)	50 km	Unknown

Tab. 2 Maximum seed dispersal distance of the most active animal vectors

Because of this knowledge, we can suppose that the two plant species have multiple possibilities to be efficiently dispersed in the peri-urban area, where big mammalians are mostly active, and a reasonably restricted viability in the urban zone. The highest spreading possibility are for Olive species that in spite of the minor dispersal distance (maximum 100 m) is favoured by the high population of active frugivorous birds. On the contrary, the Holm oak showed a potential wider spreading area (maximum 1000 m range) but a decidedly lower population of animal vectors and a strongest dependence from ecological corridors.

3.3 DATA AND SOFTWARE USED

The construction of the ecological network of Nuoro has implied the identification and classification of patches in a pilot area of the town. Geographical information has been drawn from the aerophotogrammetric map of the municipality of Nuoro and verified through photo-interpretation and further field survey. We refer to the ortophoto of Nuoro geo-referenced with Gauss-Boaga coordinates and released in 2006 by the Autonomous Region of Sardinia (ARS). In addition, we have considered the information contained in the Sardinian Forestry Plan, District level, regarding the town of Nuoro. Land use planning information has been extracted from the municipal master plan (official Italian name and acronym: Piano Urbanistico Comunale, PUC) of the town of Nuoro. In Table 3, metadata of the information processed is reported.

DESCRIPTION	FORMAT	SCALE	RESOLUTION	YEAR	SOURCE
Aerophotogrammetric map of Nuoro	AutoCad drawing (*.dwg)	1:10000	—	1998	ARS
Orthophoto	*.Geotiff	—	0.50mx0.50m	2006	ARS WMS free service
Piano Forestale Ambientale Regionale	*.pdf	—	—	2007	ARS
PUC of Nuoro	*.shp	—	—	1980	Province of Nuoro

Tab. 3 Metadata of the information processed for building the ecological network of Nuoro.

Geographic information has been processed through CAD proprietary software (Autodesk AutoCad) and GIS open source software (QGIS). Spatial network visualization and analysis has been performed through the open source software Ghephi (Bastian, 2009).

The narrative of this paper continues in the other homonymous paper "Part B".

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