Urban and rural green infrastructure: two projects for the metropolitan city of Rome

Carlo Blasi, Laura Zavattero, Giulia Capotorti, Riccardo Copiz, Fausto Manes, Barbara Mollo, Marta María Alós Ortí

Sapienza University of Rome, Italy

Introduction

The Charter of Rome is a turning point for science and policy. Based on former international and European initiatives, such as the Habitats Directive (1992), the European Landscape Convention (2000) and the EU Biodiversity Strategy to 2020, the Charter is a commitment by the scientific community to share with policy decision-makers concrete local implementations, moving from words to action. This means, among other things, assessing the conservation state of each ecosystem with a view to improved land planning and management based on specific rehabilitation measures for natural capital. Green infrastructure (GI) represents one of the most concrete ways to link scientific research, management actions and policies.

The current European GI Strategy (European Commission, 2013) is stimulating national and subnational proposals, planning and implementation of a large number of projects covering urban and peri-urban areas. In Italy, the mapping and assessment of ecosystems and their services (MAES) process, as part of the EU Biodiversity Strategy, deals with the assessment of ecosystem conservation status, the identification of priorities for ecosystem restoration and the promotion of GI according to Target 2 of the EU Biodiversity Strategy to 2020. In implementing the MAES process in Italy and in accordance with the orientations of the Charter of Rome, we demonstrate that in urban areas GI implementation is the best opportunity to make natural, semi-natural and traditional rural systems—still present in urban and peri-urban areas—a driver of well-being and quality of life, securing at the same time the conservation of biodiversity and the provision of ecosystem services (ES). We describe two concrete GI projects for the metropolitan city of Rome explicitly conceived to combine the supply of ES with the restoration of ecosystems and the enhancement of ecological connectivity. According to the specific requirements of a metropolitan city, we defined at an appropriate scale: (i) the criteria for setting biodiversity priorities; (ii) the understanding and geospatial assessment of key demands for ES; and (iii) the opportunity for integrating GI into existing policy and planning tools. These two projects, oriented towards expected benefits in both environmental and socio-economic terms, represent examples of actual inclusion of GI into land planning, encouraging investments into 'green' rather than 'grey' solutions and consequently limiting the pressures that affect environment and human well-being in our cities and their hinterlands.

The Italian MAES process and the definition of a national green infrastructure strategy

Taking into account the model proposed at the EU level (Maes et al., 2013, 2014), the Italian MAES process and the definition of the national GI strategic framework has been divided into a number of steps (Figure 1). The outcomes provide the Ministry of the Environment with a reliable body of information for the concrete implementation of the National Biodiversity Strategy (MATTM, 2010; Capotorti et al., 2015), for the improvement

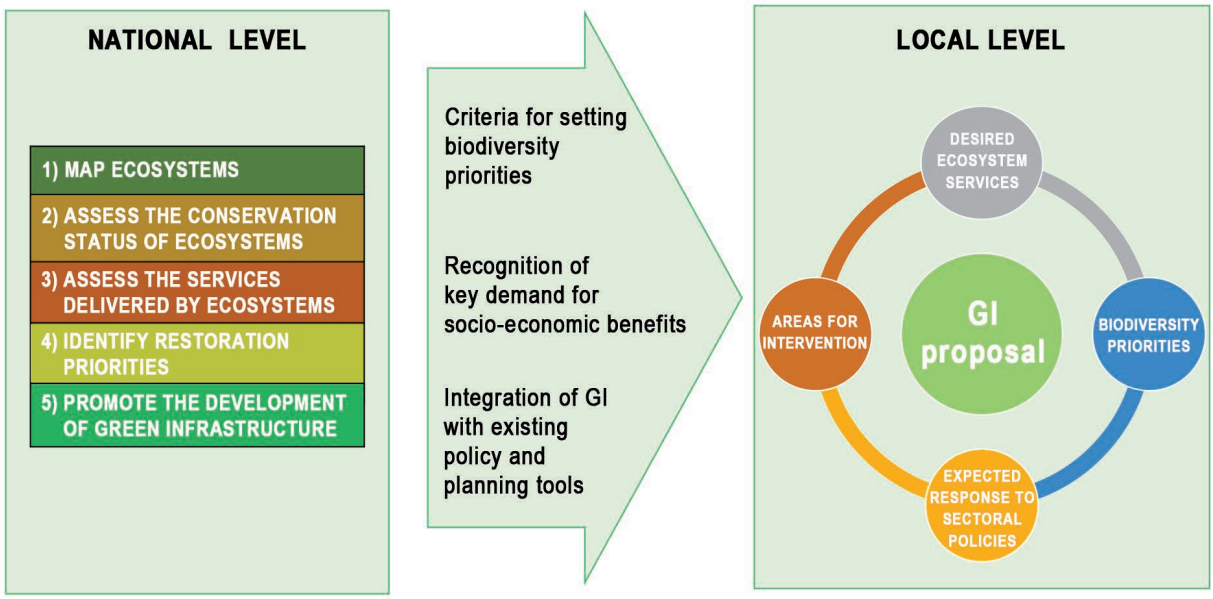


Figure 1

The relationship between the national MAES process and the GI projects.

in biodiversity data collection within the National Biodiversity Network (Martellos et al., 2011; http://biodiversity.europa.eu/countries/italy), for the development of the environmental accounting system (Capotorti et al., 2012) and, finally, for facilitating the cooperation between state administration and regional authorities (ftp://ftp.minambiente.it/pnm/Strategia_Nazionale_Biodiversita/Capitale_Naturale/).

In the international context, the methods adopted and the results achieved in Italy are examples of implementation, at the national level, of the EU Biodiversity Strategy. They also promoted a constructive scientific and technical debate with other EU Member States (http://biodiversity.europa.eu/maes/maescatalogue-of-case-studies). Moreover, the Italian experience provided a fruitful cooperation with the EU institutions, which, in turn, led to the definition of the Charter of Rome on Natural and Cultural Capital (Blasi et al., 2014). Figure 1 shows the connections between the MAES process and the GI projects. The implementation of the MAES process and the definition of the GI strategic framework in Italy involve a multidisciplinary group of scientists including geo-botanists, landscape ecologists, functional ecologists, foresters and zoologists. Vegetation science, in its multiple aspects ranging from plant communities to vegetation series and landscape scale ecosystems (Blasi et al., 2011), is contributing significantly to the MAES process, playing a key role in mapping, in the assessment of ecosystem conservation status, in the identification of priorities for the restoration of ecosystems and in the setting up of an ecological framework to promote GI.

Project definition of green infrastructure

The EU Biodiversity Strategy to 2020 defines GI as 'a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services'. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings (European Commission, 2013). GI consists of 'spatially or functionally connected areas which maintain ecological coherence as an essential

condition for healthy ecosystems', providing, at the same time, added value that attracts investment in natural capital and in the ability of ecosystems to deliver multiple goods and services (European Environment Agency, 2014). In this definition there are three key aspects that are further described:

(a) the connectivity between different structural and functional elements, which may be achieved through different types of connections;

(b) the knowledge of the multifunctionality of ecosystems;

(c) environmental planning and sustainable management.

Connection. Referring to the elements and their connections in a network perspective, the potential components of GI include (Naumann et al., 2011 mod.).

- Protected areas: large areas of healthy and functioning ecosystems with minimal intervention required (e.g. national parks, forest reserves).
- Restoration zones: reforestation zones, increased foraging areas, new areas of habitat for ecosystem services (e.g. peat bogs), conversion of a habitat back into its original form via management actions.
- Sustainable use areas: areas to improve the ecological quality and permeability of landscape; sustainable economic land uses and related restrictions (e.g. relevant to tourism activities) that help in maintaining or restoring healthy ecosystems.
- Green urban features: parks, gardens, grassy verges, green walls, green roofs.
- Natural ecological corridors (hedgerows, wildlife strips), stepping stones, riparian vegetation, etc.
- Artificial connectivity features: features designed specifically to assist species movement (e.g. green bridges, eco-ducts, wildlife passages, etc.), which can result from compensation measures to recreate connectivity that has been lost or compromised as a result of grey infrastructure construction (e.g. a motorway).
- Multifunctional zones: areas in which a balance is reached between various uses such as access, recreation and biodiversity; areas where enhanced public access is promoted, such as green zones adjacent to existing and planned settlements.

Each of these elements can contribute to identifying, at the different spatial scales, the GI in urban, peri-urban and adjacent rural areas, inside and outside networks of protected areas, to reach the objective of improving ecological efficiency and related ecosystem services. Not all green areas are GI, only those, natural or artificial, that are part of an interconnected network (Maes et al., 2016). GI can be designed and promoted at different spatial scales in relation to the environmental requirements, project aims and territorial level considered and the context in which actions take place. At the same time, and in relation to the scale, all these elements can vary from the local (e.g. tree rows, green roofs, small green islands, linear urban parks) to the regional or national dimension (e.g. large forest areas, coastal systems, networks and systems of protected areas).

The two projects for the metropolitan city of Rome addressed in this contribution refer to the local level and are well identified in two different contexts: urban in one case and agri-peri-urban in the other. They contribute significantly to the EU debate on multiscale GI projects (Rocha et al., 2015).

In urban contexts GI provides a large array of benefits, from health (e.g. improved air quality) to places'

attractiveness. If adequately interconnected, green urban features, such as parks, tree-lined streets, bike paths, gardens and green walls, can significantly improve the quality of life, contributing, at the same time, to biodiversity conservation and climate change mitigation (Capotorti et al., 2017).

Multifunctionality. The concept of multifunctionality is strictly related to the provision of multiple ecosystem services. This is what characterises GI implementation, improving the supply of ecosystem services in all dimensions (provisioning, regulating, cultural) and adding, in general, relevant physical, psychological, emotional and socioeconomic benefits: urban–rural connections, food production and consumption connections, appealing places to live and work in, greater sense of community, sense of place, strengthened links with voluntary actions of civil society, education, knowledge, learning, investment, and job and development opportunities. Table 1 reports a selection of benefits provided by GI in urban and in rural contexts. More benefits can be added, such as higher property values, resilience of ecosystem services, land loss and fragmentation reduction and improved soil permeability. This is summarised in Table1, which synthesises the expected benefits from the two GI projects presented in this paper.

The assessment of the multifunctionality of services provided requires the analysis of their demand (Liquete et al., 2015). Maintaining the full functionality of ecosystems and conserving biodiversity always means guaranteeing the provision of different services in space and time. Consequently, the definition and implementation of GI implies the identification of specific requirements, adequately evaluated in each territorial context and at appropriate scale, and the difference between longer range demand, such as food provision, and local demand, such as soil protection (Maes et al., 2013). Therefore the analysis of the demand should always be connected to the identification of a GI, as in the case of the two projects reported here.

Planning and management. The link between knowledge and mapping of ecosystems and their functions and services, planning and the sustainable management of natural resources are the main focus of the Italian MAES process. In fact, the methodology applied corresponds first to the knowledge of the state of ecosystems, their territorial ecological potentials and all the aspects linked to the composition, structure and functions that influence the ecosystem processes and the provision of their services. This is the essential knowledge base on which the two GI projects have been developed.

Two green infrastructure projects for the metropolitan city of Rome

Recently, Italy adopted two laws that include relevant objectives for the development of GI. A first important reference point at national level is the law for the development of public green spaces, which aims at promoting standards for the delivery of ecosystem services (air quality regulation, hydrological risk mitigation, soil protection and enhancement of cultural values) (Gazzetta Ufficiale, 2013). This law states that all municipalities are responsible for the safeguarding of individual trees, tree lines and groups of trees of landscape, naturalistic, monumental, historical and cultural value. In 2014 a second, national law established the Italian ‘metropolitan cities’ with the aim of strategic territorial development through the promotion of an integrated management of services, infrastructures and communication network (Gazzetta Ufficiale, 2014). This law outlines that the strategic territorial plan is the main tool to achieve these goals. As for the metropolitan city of Rome, the guidelines for the strategic plan were recently adopted. They include the promotion of the natural and cultural capital of Rome and the establishment of synergies between GI and urban and rural areas.

Table 1

Benefits provided by GI in urban and rural contexts.

	URBAN GI	RURAL GI
Environmental benefits		
Air quality improvement	X	
Microclimate regulation	X	
Urban temperature regulation	X	
Noise reduction	X	
Soil erosion reduction		X
Water supply management		X
Flood control	X	X
Soil consumption reduction		X
Improved soil permeability	X	X
Carbon stock and sequestration	X	X
Biodiversity-related benefits		
Improved ecosystem connectivity	X	X
Improved ecosystem functionality	X	X
Landscape permeability	X	X
Pollination	X	X
Social benefits		
Improved health and well-being	X	
Job opportunities	X	X
Improved economy (investments, revenues)	X	X
Increase of property value	X	
Flood risk prevention	X	X
Social cohesion	X	
Cultural benefits		
Greater sense of community	X	X
Sense of place and belonging	X	X
Knowledge, learning and educational opportunities	X	X
Improved emotional, aesthetic and recreational experiences	X	X
Increased tourism opportunities	X	X

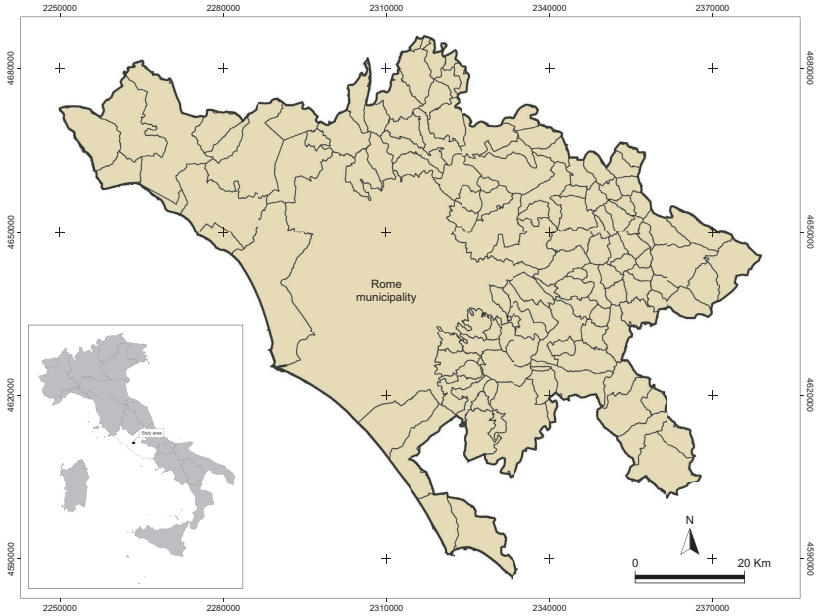


Figure 2

Study area, metropolitan city of Rome, Lazio, Italy.

The planning area

The metropolitan city of Rome (Figure 2) is located in central Italy, close to the Tyrrhenian coast, and occupies 5 352 km², with a population density of 811 people/km² (about 4.3 million people). It corresponds to the administrative province, matching the third level of European NUTs, and it accounts for 121 municipalities, including the capital city of the country, Rome.

The two GI projects presented in this paper are based on the following two planning instruments.

1. Land ecological network (LEN), adopted as a legally binding document of the general provincial territorial plan of Rome (2010) to balance ecological, social and economic interests in the process of spatial planning (Blasi et al., 2008).
2. Ecological network of the municipality, a legally binding document of the new general master plan of Rome (2008). The document regulates all relevant physical and functional transformations in the municipality and includes its environmental components, such as protected areas, public green spaces, urban areas and agricultural lands.

The physical environment of the metropolitan area shows a variety of climatic conditions and physiographic features. The coastal area has a Mediterranean climate, the inland mountain area is temperate and the intermediary hills have a transitional climate, with a short period of summer aridity and heavy precipitation in spring. The litho-morphology ranges from coastal sandy dunes to pre-volcanic sedimentary hills, volcanic plateaus and reliefs, with carbonate pre-Apennine and alluvial plains along the main river network. Such environmental heterogeneity, together with a millennia-long history of human influence, has contributed to shape the variety of spatial configurations of current ecosystems. A large amount of information is available on types and mapping of ecosystems and their condition, represented by vegetation proxies (Table 2). At the metropolitan level, a vegetation map at 1:25 000 scale (http://websit.cittametropolitanaroma.gov.it/BDV2014/Veget_Reale.aspx) includes 48 forest, 37 shrubland, 39 herbaceous and three pioneer ecosystem types. At the city level, a vegetation map at 1:10 000 scale includes 18 forest, 10 shrubland and 24 herbaceous ecosystem types (http://www.urbanistica.comune.roma.it/prg-vigente-g9b.html). More detailed maps, often supporting the management plans, are also available for specific sites, such as protected areas, portions of main river basins and river corridors.

Table 2

Geographic information system (GIS) data available for the metropolitan city of Rome.

ECOSYSTEM MAPPING
GIS data (metropolitan scale/urban scale) 1:25 000/10 000
• Maps of local scale ecoregions
• Maps of biophysical land units
• Maps of vegetation cover and land use
• Maps of vegetation series
• Maps of potential natural vegetation
• Maps of species distribution (vascular flora, mammals, birds, amphibian and reptiles)
• Map of land use and land cover change 1954-1980-2001
ECOSYSTEM CONDITION
GIS data (metropolitan scale/urban scale) 1:50 000/1:25 000/1:10 000/2 × 2 km grid cells
• Maps of naturalness of ecosystem types
• Maps of landscape conservation status (ILC index) of ecoregions and land units
• Maps of structural conservation status of ecoregions (at the local scale)
• Maps of threatened and rare plant species and target vegetation types for conservation
• Map of richness of species with high conservation value (vascular plants, mammals, birds, amphibian and reptiles)
• Maps of habitat types of community interest (Natura 2000)
• Map of positive and negative trajectories of land cover transitions
• Map of sites with outstanding combination of physical, biological and cultural values (core areas for proposal of the Rome Municipality Urban Biosphere Reserve)
• Map of priority areas for the forestation plan of Rome municipality

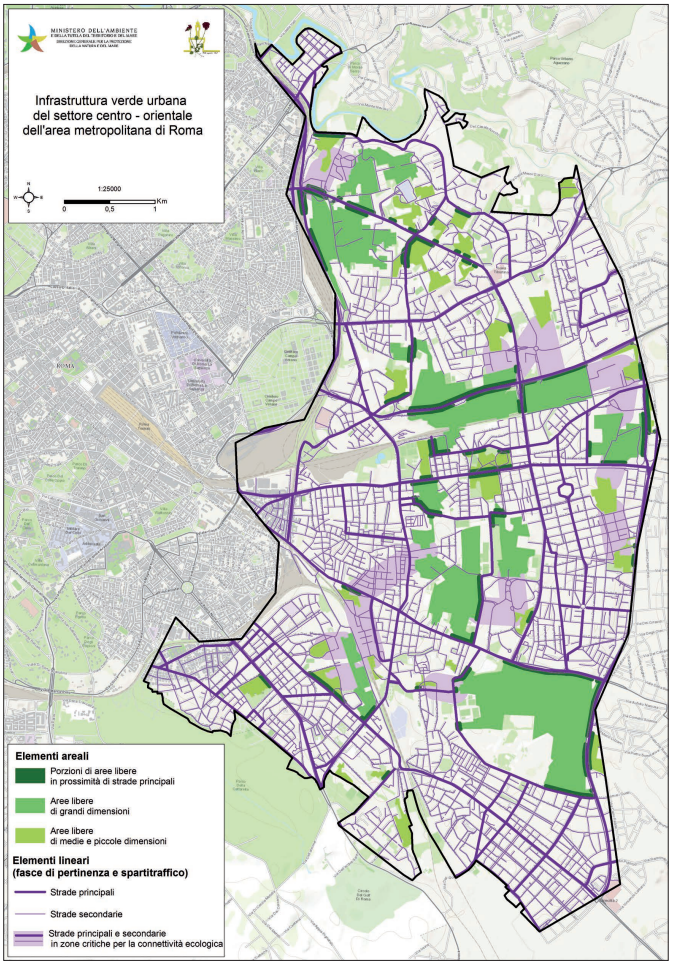
The two projects target two specific areas: the first is an urban GI; the second aims at reinforcing the interconnection between rural and urban GI. As mentioned above, the implementation of the two GI starts from the characterisation of the project areas and the analysis of the demand for ecosystem services that the project aims to improve. Following the EU framework and the accounting principles for the ecosystem services, the project's added value is shown by an indicative evaluation of the expected environmental and socioeconomic benefits.

Figure 3

Area of the GI urban project.

Figure 4

Map of GI in urban context.



Urban GI in the central-eastern sector of the metropolitan city of Rome

In this densely populated urban area, the primary objective of the GI is the improvement of air quality through a reduction in particulate matter (PM) in the atmosphere originated by anthropogenic sources such as industrial and heating plants or motor vehicles. Besides this, the more general need to improve biodiversity and connectivity as stated by the GI strategy has been taken into account. These are in fact two main aspects at the base of the multifunctionality of GI, which includes human health and the quality and resilience of ecosystems.

The project has been designed for a densely populated urban area between the internal road belt and the railroad ring (Figure 3). The choice is motivated by the data and maps on the PM concentration overlapping the low conservation status of ecosystems in non-built-up areas (Frondoni et al., 2011; Capotorti et al., 2013, 2015) and by their connectivity role between the Natural Reserve of the Valle dell'Aniene and the Regional Park of the Appia Antica (Figure 3).

Project outline

The GI is made up of both areal and linear structures present in a densely populated urban fabric (Figure 4). The complex multifunctional analysis identified elements of GI (Table 3), each providing more than one service. Particulate removal is facilitated by local species or forest communities that at the same time support biodiversity conservation and ecological connectivity.

Table 3

GI spot and linear elements and main expected ecosystem services in the metropolitan area of Rome.

URBAN GI IN THE METROPOLITAN AREA OF ROME						
Type of GI element	Description	Legend	Expected ecosystem service provision X = prevailing, X = accessory			
			PM removal by linear sources	PM removal by spot sources	Biodiversity improvement and restoration	Connectivity improvement
Areal elements	Strips near main roads		X	X	X	X
	Larger areas		X	X	X	X
	Small and medium areas		X	X	X	X
Linear elements	Main roads		X	X		
	Secondary roads		X	X		
	Main and secondary roads in key connectivity areas				X	X

In the implementation phase vegetation species coming from different territorial areas were selected with the double criteria of coherence with ecological characteristics of the site (climate, soils, forms) and adaptation to the urban environment (Mirabile et al, 2015).

In designing GI the expected the expected benefits should always be assessed in qualitative, quantitative and, whenever possible, economic terms (see Table 3). Considering that the planned actions mainly relate to rehabilitation rather than conservation, the assessment of expected benefits mainly relates to the added value of new reforestations and road tree lines. The assessment of biodiversity and ecological connectivity enhancement are based on bio-physical indicators and, consequently, are space and quality related. The identified indicators include, for example, the increase in maintained or recovered forest area, the number of trees newly planted, the length of ecological corridors and the metrics on ecological representativity and connectivity at the landscape level. In our specific case the planned elements are:

- 5.5 ha of new forest areas;
- 20 ha of forest strips;
- 12 300 evergreen oak plants;
- 2 500 evergreen and deciduous oaks;
- 120 km of tree rows;
- a sevenfold reduction in isolation (index of non-dimensional proximity);
- halved minimum distance between natural/semi-natural areas.

Concerning particulate removal, the assessment of benefits is made using available indicators processed in different studies on the metropolitan area of Rome (Martuzzi et al., 2006; Manes et al., 2014, 2016) and on international research (Nowak et al., 2006, 2014; McPherson et al., 2007).

The evaluation of the particulate removal and the estimated beneficiaries are:

- approximately 1 t of PM_{10} annually removed;
- 100 kg annual increase in PM_{10} removal;
- 285 000 potential resident beneficiaries;
- approximately 20 t of dust and particulate trapped annually by some 15 000 trees planned in rows and equivalent to EUR 600 000 per year, corresponding to the estimated cost of technological solutions.

The main outcome of this first project is a scientific basis for implementing and developing GI, taking into account well-identified benefits and beneficiaries. This project is also an example of the necessary synergies required between policies, laws, administration, planning and science for the implementation of GI in a densely populated urban area.

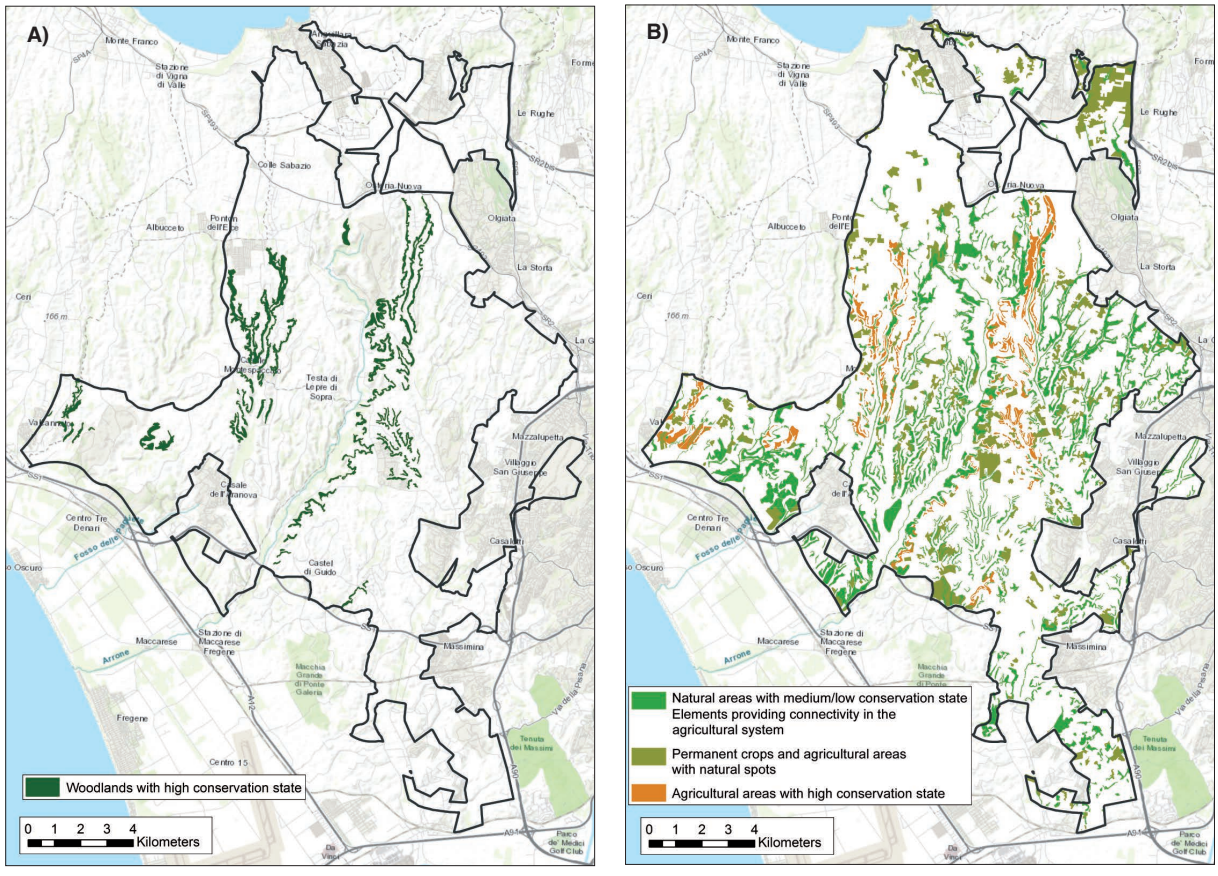
Figure 5

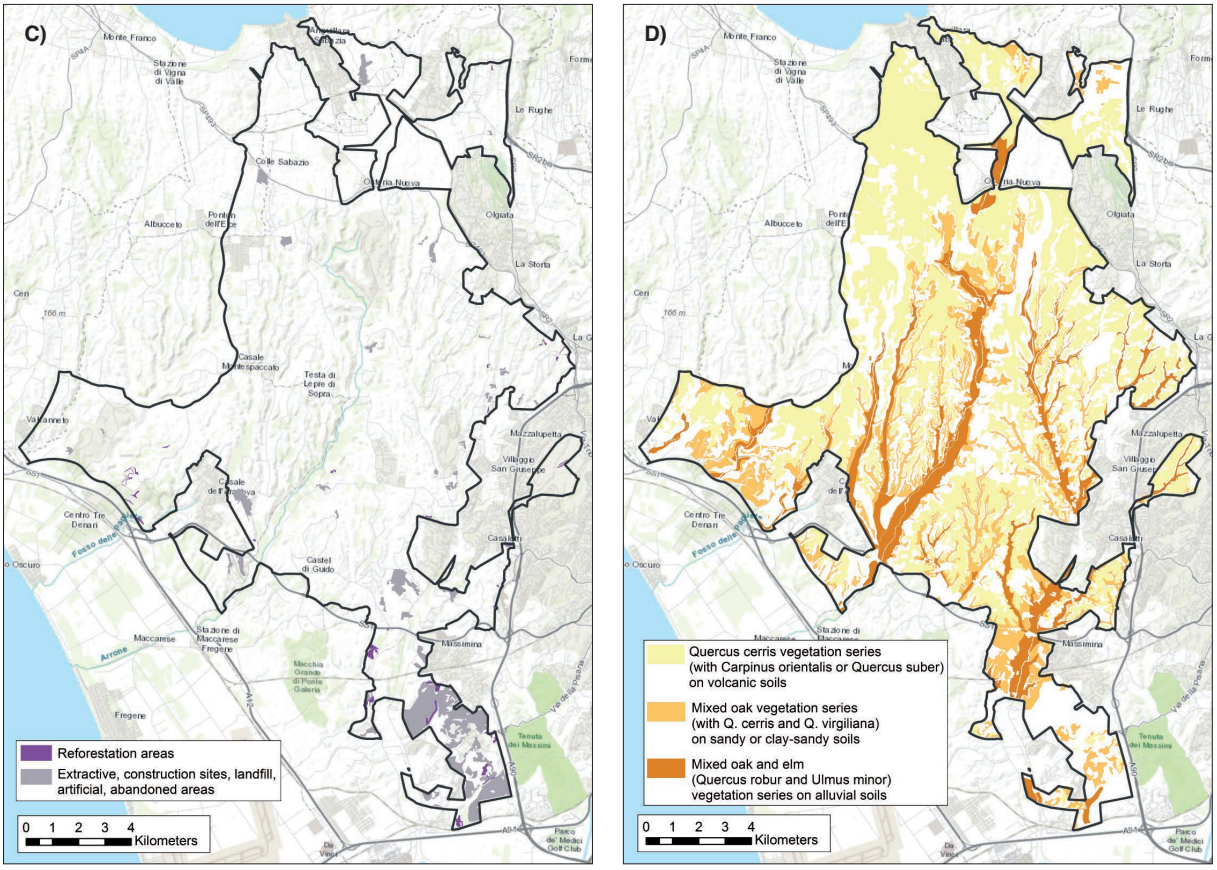
A) Areas for conservation;

B) Elements providing connectivity;

C) Areas for rehabilitation/ restoration (non-agricultural);

D) Areas for rehabilitation/ restoration (agricultural).





Peri-urban GI in the metropolitan area of Rome

Within the metropolitan area of Rome the agricultural system covers about 50 % of the total area. The need to safeguard biodiversity, reduce agricultural soil loss and safeguard the landscape of the *Campagna Romana* (Roman countryside) is acknowledged. This project is located in the northern part of the metropolitan city of Rome, and is managed by two administrations: the province and the municipality. The project elements cover either large areas or spots in relation not only to their conservation status but also to tourism opportunities (see Table 4 and Figure 5). All developments are in line with the rural development programme of the Lazio region for 2014-2020 (http://lazioeuropa.it/files/140723/regione_lazio_psr_feasr_2014_2020_luglio_2014.pdf) see Table 5. The spots are represented by agritourism, farms, tourist information centres and historical monuments. The project (see Figure 6) also considered the improvement of services for agrifood, environmental and tourist enterprises with a view to consolidating rural job opportunities.

Table 4

GI summary table of the elements and expected ecosystem services in the rural metropolitan area of Rome.

RURAL GI IN THE METROPOLITAN AREA OF ROME				
GI components		**Expected ecosystem service provision** X = prevailing, X = accessory		
GI elements	**Description**	**Biodiversity**	**Soil loss reduction**	**Traditional agricultural landscape promotion**
Areas for conservation				
	Woodlands with high conservation status	X	X	X
Landscape elements providing connectivity				
	Natural areas with medium/low conservation status Elements providing connectivity in the agricultural system	X	X	X
	Permanent crops and agricultural areas with natural spots	X	X	X
	Agricultural areas with high conservation status	X	X	X
Rehabilitation areas in non-agricultural land				
	Reforestation areas	X		X
	Extractive, construction sites, landfill, artificial, abandoned areas	X	X	
Rehabilitation areas in agricultural land				
	Quercus cerris vegetation series (with *Carpinus orientalis* or *Quercus suber*) on volcanic soils	X	X	X
	Mixed oak vegetation series (with *Quercus cerris* and *Quercus virgiliana*) on sandy or clay-sandy soils	X	X	
	Mixed oak and elm (*Quercus robur* and *Ulmus minor*) vegetation series on alluvial soils	X	X	
Multifunctional areas				
Spots	Agritourism and farms	X	X	X
	Tourist information points and historical-cultural points			X

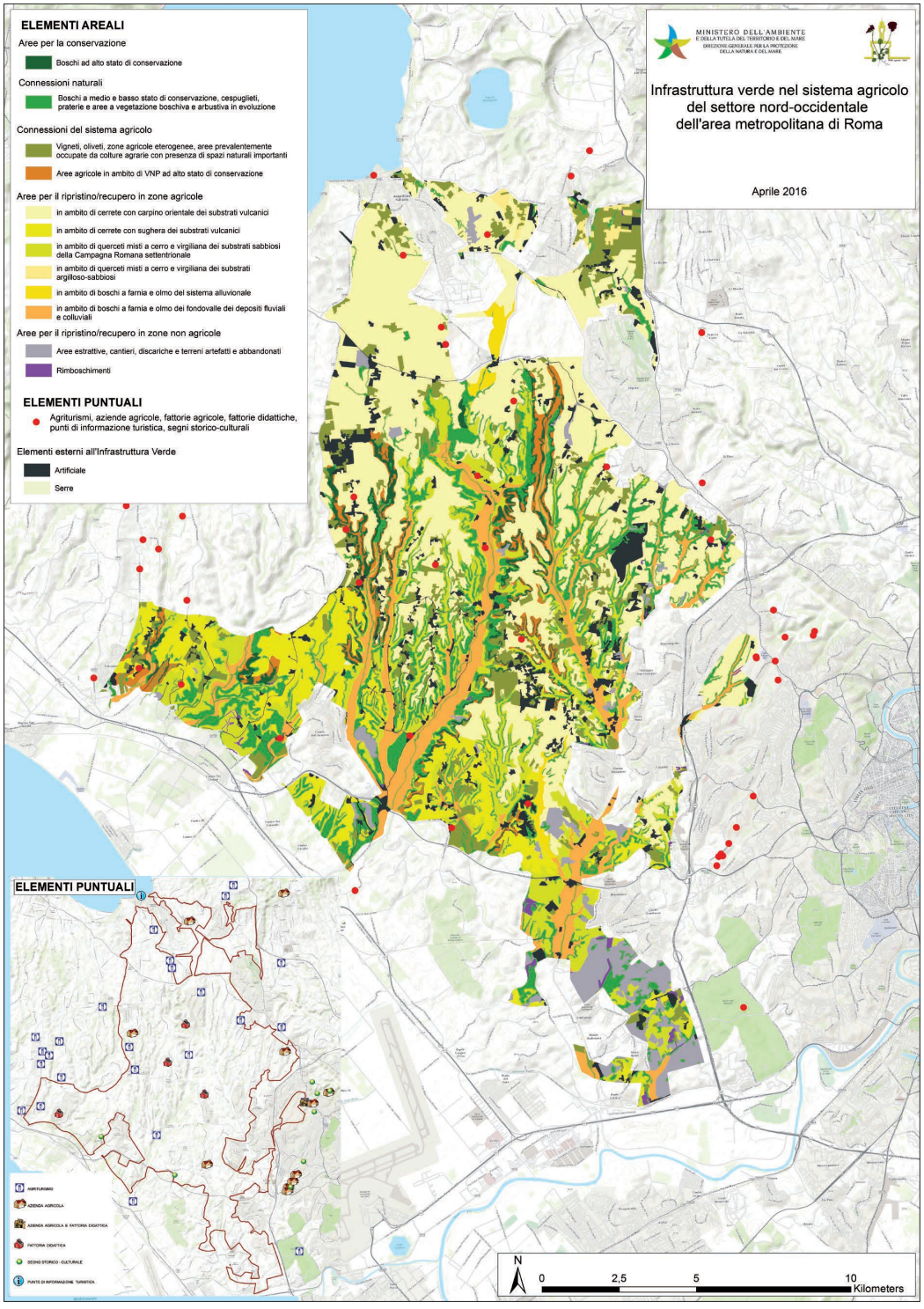


Figure 6

Map of peri-urban GI in the metropolitan area of Rome.

Table 5

Synthesis of demand, aims and benefits of the peri-urban GI project.

Demand for ecosystem services	Increase in biodiversity and coherence with local vegetation
	Reduction of agricultural soil loss
	Promotion of traditional agricultural and landscape system
Areas	23 000 ha in the agricultural sector of the northern *Campagna Romana*
Project aims	Identification of area and spot elements for the assessment of ecosystem conservation status at the local scale and selected measures of the rural development plan
Benefits evaluation	**Environmental benefits:** **1 600 ha of new areas for conservation** **600 ha of new natural connections** **2 000 ha of contrast to the urban sprawl** **10 000 ha for the improvement of the landscape value of agricultural areas in the *Campagna Romana*** **Socio-economic benefits** (supporting the selected measures of the Lazio (regional) rural development programme (https://ec.europa.eu/agriculture/sites/agriculture/files/rural-development-2014-2020/country-files/it/factsheet-lazio_en.pdf) — Measure 214: Agri-environment payments — Measure 216: Non-productive investments — Measure 221: First afforestation of agricultural land — Measure 222: First establishment of agroforestry systems on agricultural land — Measure 223: First afforestation of non-agricultural land

Conclusions

Investing in GI through appropriate valuation of ecosystems and the services they provide is among the European Union's priorities for smart, sustainable and inclusive growth (European Commission, 2010). GI represents a cost-effective alternative to other solutions, making the best use of natural capital and creating local job opportunities as referred to by the Charter of Rome. This is why GI is not only about biodiversity conservation but also about policies and actions in many other sectors: agriculture and rural development, forests, water, climate change, green economy, transport, human well-being and territorial planning (Naumann et al., 2011). There is a priority for agriculture, even in cases of urban GI, concerning job opportunities for young people and the revitalisation of traditional agricultural production and of public goods and services from farming, including cultural services that may support sustainable tourism. In Europe, agricultural and territorial policies provide support instruments to prevent abandonment and land fragmentation and encourage non-productive investment that benefits protection area networks like Natura 2000.

The two projects presented here are based on local planning instruments introduced almost a decade ago as legally binding integrated environmental components in urban and peri-urban areas. Most recent developments relating to the GI concept within EU policies have confirmed the importance of including in territorial planning an

integrated ecosystem approach leading to a network of natural and semi-natural areas designed and managed to deliver ecosystem goods and services. The final aim is to provide solutions for the well-being of the growing urban population, better harmonisation with productive rural areas, spaces for recreation, opportunities for sustainable growth and permanent jobs. These solutions apply to complex and interrelated ecosystems that may positively respond to multifunctional demands whenever their structural, functional and landscape conditions are secured at the same time. Based on the main objectives of GI, the related EU strategy and the key message of the Charter of Rome, the two projects described suggest some relevant objectives and future perspectives for Europe and beyond:

- identify the many interconnections and the multifunctionality of natural and semi-natural systems;
- develop all synergies existing between natural and semi-natural areas, GI, urban and rural areas;
- integrate the GI into planning and territorial development policies;
- improve the basic knowledge of structure and functions underlying the natural and cultural capital within sectors and disciplines ranging from ecology, human and social sciences, and economy, and towards initiatives coherent with the principles of sustainability.

With the current dramatic growing trend in urbanisation in Europe and worldwide, GI represents one of the most challenging and concrete ways to link scientific research, management actions and policies on the one hand and to improve living conditions and urban–rural environmental, economic, social and cultural relations on the other.

Acknowledgments

This work was supported by the Italian Ministry of the Environment and the Protection of Land and Sea (MATTM) Directorate-General for Protection of Nature and Sea.

References

Blasi, C., Attorre, F., Capotorti, G. and Zingari, P. C. (eds) (2014), *Natural and cultural capital—Contributions to the conference held at the botanical garden of Rome, Italy, 24 November 2014*, Ograro, Rome.

Blasi, C., Biondi, E., Izco, J. (2011), '100 years of plant sociology: a celebration', *Plant Biosystems*, Vol. 145 (suppl. 1), pp. 1-3.

Blasi, C., Zavattero, L., Marignani, M., Smiraglia, D., Copiz, R., Rosati, L. and Del Vico, E. (2008), 'The concept of land ecological network and its design using a land unit approach', *Plant Biosystems*, Vol. 142, No 3, pp. 540-549.

Capotorti, G., Alós Ortí, M. M., Anzellotti, I., Azzella, M.M., Copiz, R., Mollo, B. and Zavattero, L. (2015), 'The MAES process in Italy: contribution of vegetation science to implementation of European biodiversity strategy to 2020', *Plant Biosystems*, Vol. 149, pp. 949-953.

Capotorti, G., Del Vico, E., Anzellotti, I. and Celesti-Grapow, L. (2017), 'Combining the conservation of biodiversity with the provision of ecosystem services in urban green infrastructure planning: critical features arising from a

case study in the metropolitan area of Rome', *Sustainability*, Vol. 9, No 1, p. 10 (doi:10.3390/su9010010).

Capotorti, G., Zavattero, L., Anzellotti, I., Burrascano, S., Frondoni, R., Marchetti, M., Marignani, M., Smiraglia, D. and Blasi, C. (2012), 'Do national parks play an active role in conserving the natural capital of Italy?', *Plant Biosystems*, Vol. 146, No 2, pp. 258-265.

Capotorti, G., Del Vico, E., Lattanzi, E., Tilia, A. and Celesti-Grapow, L. (2013), 'Exploring biodiversity in a metropolitan area in the Mediterranean region: the urban and suburban flora of Rome (Italy)', *Plant Biosystems*, Vol. 147, No 1, pp. 174-185.

Capotorti, G., Mollo, B., Zavattero, L., Anzellotti, I. and Celesti-Grapow, L. (2015), 'Setting priorities for urban forest planning—A comprehensive response to ecological and social needs for the metropolitan area of Rome (Italy)', *Sustainability*, Vol. 7, pp. 3958-3976. CICES (2017), http://cices.eu

European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions—Green infrastructure (GI)—Enhancing Europe's natural capital (COM(2013) 249).

European Environment Agency, *Spatial analysis of green infrastructure in Europe*, technical report No 2/2014, Publications Office of the European Union, Luxembourg, 2014.

Frondoni, R., Mollo, B. and Capotorti, G. (2011), 'A landscape analysis of land cover change in the municipality of Rome (Italy): spatio-temporal characteristics and ecological implications of land cover transitions from 1954 to 2001', *Landscape and Urban Planning*, Vol. 100, No 1, pp. 117-128.

Gazzetta Ufficiale (2013), Legge 14 gennaio 2013, n. 10, Norme per lo sviluppo degli spazi verdi urbani, *GU Serie Generale*, n. 27 del 1.2.2013.

Gazzetta Ufficiale (2014), Legge 7 aprile 2014, n. 56, Disposizioni sulle citta' metropolitane, sulle province, sulle unioni e fusioni di comuni, *GU Serie Generale*, n. 81 del 7.4.2014.

Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B. and Zulian, G. (2015), 'Mapping green infrastructure based on ecosystem services and ecological networks: a pan-European case study', *Environmental Science & Policy*, Vol. 54, pp. 268-280.

Maes, J., Teller, A., Erhard, M., Liquete, C., Braat, L., Berry, P. et al. (2013), *Mapping and assessment of ecosystems and their services—An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020—Discussion paper*, Publications Office of the European Union, Luxembourg.

Maes, J., Teller, A., Erhard, M., Murphy, P., Paracchini, M. L., Barredo, J. I. et al. (2014), *Mapping and assessment of ecosystems and their services—Indicators for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020—Second report*, Publications Office of the European Union, Luxembourg.

Maes, J., Zulian, G., Thijssen, M., Castell, C., Baró, F., Ferreira, A. M., Melo, J., Garrett, C. P., David, N., Alzetta, C. et al. (2016), *Mapping and assessment of ecosystems and their services—urban ecosystems*, Publications Office of the European Union, Luxembourg.

Manes, F., Marando, F., Capotorti, G., Blasi, C., Salvatori, E., Fusaro, L., Ciancarella, L., Mircea, M., Marchetti, M., Chirici, G. and Munafò, M. (2016), 'Regulating ecosystem services of forests in ten Italian metropolitan cities:

air quality improvement by PM_{10} and O_3 removal', *Ecological Indicators*, Vol. 67, pp. 425-440.

Manes, F., Silli, V., Salvatori, E., Incerti, G., Galante, G., Fusaro L. and Perrino C. (2014), 'Urban ecosystem services: tree diversity and stability of PM_{10} removal in the metropolitan area of Rome', *Annali di Botanica (Roma),* Vol. 4, pp. 19-26.

Marando, F., Salvatori, E., Fusaro, L., Manes, F. (2016), 'Removal of PM10 by forests as a nature-based solution for air quality improvement in the metropolitan city of Rome', *Forests*, Vol. 7, No 7, p. 150 (doi: 10.3390/f7070150).

Martellos, S., Attorre, F., De Felici, S., Cesaroni, D., Sbordoni, V., Blasi, C. et al. (2011), 'Plant sciences and the Italian national biodiversity network', *Plant Biosystems*, Vol. 145, pp. 758-761.

Martuzzi, M., Mitis, F., Iavarone, I. and Serinelli, M. (2006), *Health impact of PM10 and ozone in 13 Italian cities*, World Health Organisation, Regional Office for Europe, Copenhagen, Denmark.

MATTM (Italian Ministry for the Environment and the Protection of Land and Sea) (2010), *Italian national biodiversity strategy* (available at: http://www.minambiente.it/sites/default/files/archivio/allegati/biodiversita/estratto_strategia_eng.pdf).

McPherson, E. G., Simpson, J. R., Peper, P. J., Gardner, S. L., Vargas, K. E. and Xiao, Q. (2007), *Northeast community tree guide: benefits, costs, and strategic planting*, US Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California (available at: https://www.itreetools.org/streets/resources/Streets_CTG/PSW_GTR202_Northeast).

Mirabile, M., Bianco, P. M., Silli, V., Brini, S., Chiesura, A., Vitullo, M., Ciccarese, L., De Lauretis, R., Gaudioso, D. (2015), *Guidelines of sustainable urban forestry for the municipality of Rome*, ISPRA, Rome, Italy.

Naumann, S., Davis, M., Kaphengst, T., Pieterse, M. and Rayment, M. (2011), *Design, implementation and cost elements of Green Infrastructure projects—Final report*, European Commission, Brussels.

Nowak, D. J., Crane, D. E. and Stevens, J. C. (2006), 'Air pollution removal by urban trees and shrubs in the United States', *Urban Forestry & Urban Greening*, Vol. 4, No 3, pp. 115-123.

Nowak, D. J. (2014), *Urban tree effects on fine particulate matter and human health* (available at: http://www.fs.fed.us/nrs/pubs/jrnl/2014/nrs_2014_nowak_002.pdf).

Rocha, S.M., Zulian, G., Maes, J. and Thijssen, M. (2015), *Mapping and assessment of urban ecosystems and their services*, EUR 27706 EN (doi:10.2788/638737).