



# Green space networks as natural infrastructures in PERI-URBAN areas

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## Abstract

Focusing on the analysis of green spaces of urban and peri-urban borders, this paper puts into practice a methodology designed for the analysis of green areas and peri-urban spaces as green infrastructures, but from a multifunctional and integrating perspective, as it is stated in the European Strategy for Green Infrastructures and the 2030 Agenda for Sustainable Development goals. The deadline for implementing European legislation in this area means that strategic plans are being developed at local and regional level. In Spain there are municipal and regional strategies already developed and implemented but the national strategy has not yet been approved. To this end, the development of monitoring and evaluation tools such as the one presented in this article, can help not only in local decision-making, but also in the establishment of common criteria to help assess its future evolution.

This research analyses the large peri-urban parks located in the southwest of the Community of Madrid (Spain). The evaluation is carried out from a local to a regional scale applying multifunctionality criteria to the planning, design, execution, maintenance and resilience phases. From the point of view of landscape structures, the findings of this study reflect a high environmental and social services delivery value, which makes it possible to understand the need to create networks to integrate the peri-urban spaces into the city and to attend to and understand the needs of all actors involved: citizens, political leaders, municipal technicians and private companies, providing them a common vision that improves the future of these spaces.

This makes them core areas from which to design strategic plans for natural infrastructure and improvement of biodiversity in the urban area, being, likewise, an example that can be extrapolated and applied to large cities whose urban areas are adjoined and where peri-urban parks can be the starting point for designing supramunicipal strategies for open spaces.

Based on these results we can conclude that south-west Madrid provides the ideal conditions for implementing a supra-municipal strategy for green infrastructures which, starting with its large forest parks, showcases the periurban areas which connect them with the urban green network. The Móstoles Green Network and Bosquesur are two strategic projects which, together with the forest parks, constitute a working framework based on which the Supra-municipal Strategy for Open Spaces in South-west Madrid can be devised.

**Keywords** Peri-urban green spaces · Green infrastructures · Sustainability · Evaluation tool

## Introduction

The relationship of city dwellers to their environment requires their reconciliation with the peri-urban area, making way for nature in the city, without boundaries, fences, hedges, physical or administrative limits, perceiving it as an opportunity and

improvement to our quality of life (Narain 2017). Those diverging perceptions must be taken into account through urban development strategies to create a socially just and sustainable city planning in the face of global environmental changes (Riechers et al. 2018). The advantages that this urban development model offers are increasingly clear, an ecological reading of the city not only offers more pleasant spaces but also unquestionable evidence of improved health for its inhabitants (Calaza 2016). This paradigm shift requires a joint effort by the government and social stakeholders in promoting citizen participation and, along with it, the benefits that involving citizens in decision-making brings (Mueller et al. 2018), in order to raise awareness and drive home the positive aspects of nature's presence in the city for citizens and in the management of public services alike.

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In this respect, the development of Green Infrastructure Strategies offers a new framework for action, which will enable us to have sustainable cities in the future (Gavrilidis et al. 2017). In the one hand due to the ecological principles, of respect and integration of natural processes in the urban environment. On the other due to their large-multiscale vision, in terms of territory and time (European Commission 2014). Many authors acknowledge the cross-cutting risks and trade-offs related to the complexity and dynamism of urban peripheries, which may eventually lead planning to unsustainable or unlivable outcomes. Integration among different scales and sectors emerges as a requirement for effective sustainable planning (Geneletti et al. 2017).

Green Infrastructure Strategies are an implementation tool for connecting the urban areas with their natural environments: network of green areas in the city, parks and gardens, community gardens and small green spaces in the city. Currently, the European Commission directs its lines of action towards the design of Green Infrastructure Strategies as a planning tool. The studies, designs and actions must be based on the principles of sustainability, multiscalarity and multifunctionality, and meet the requirements indicated by said Commission for the characterization of the elements as Green Infrastructures. This vision is part of the objectives of the 2030 Agenda of the United Nations for Sustainable Development: “Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning” (United Nations 2015). The green infrastructure plays an essential role in fulfilling these aims, since a multiscale perspective and the achievement of economic, social and environmental objectives are intrinsic to this approach.

From an ecological perspective, peri-urban parks function as bridging areas between urban and peri-urban spaces, characterized by the presence of agricultural uses, dispersed settlements, spaces without specific use and an extensive network of roads and cattle routes (Friedmann 2016). These spaces have in common the strong fragmentation caused by increasingly larger and more complex infrastructures, the exploitation of natural resources or the interactions of natural and human systems of the city and its own development and growth (Calabuig 2013). But they are also spaces that cushion the effects of the impact of the urban environment on the natural environment; they are reservoir areas of nature that can be added to the urban environment if the multifunctional approach of the landscape is incorporated to the planning processes of new urban developments (Hedblom and Andersson 2017). From a design point of view, it is essential that these spaces recover their value, so that projects incorporate elements of ecology, agriculture and extensive use, conservation and generation of native vegetation, especially living hedges, and use them as spaces for sustainable leisure or recreation (Directorate General for Agriculture and Rural Development 2005).

Numerous studies affirm that the most important asset of green areas is the generation of intangible services, (Haines-Young and Potschin 2018), specifically the improvement of the quality of life of citizens and their contribution to social welfare (Calaza 2015). Specifically, the characteristics of design, location and surface of the peri-urban parks make them the most representative natural spaces of the city, which means a great opportunity for the initiation or didactic approach of the citizens to nature (Otto and Pensini 2017). For this reason many town councils locate information and environmental education points in them, where they work on raising awareness in areas such as the interpretation and conservation of natural resources and landscape (Feszterova and Jomova 2015; Nasibulina 2015), consolidation of reuse and recycling habits (McKenzie et al. 2014) or urban agroecology.

The improvement of the quality and services of the peri-urban parks has positive consequences in their perception by the citizens, but also when it comes to attracting activities that generate economic resources, in so far as they favor, either directly or indirectly, business initiatives for high-quality, environmentally-friendly, sustainable tourism, business activities for sustainable leisure, refreshments, etc. All these things imply the economic revaluation of these spaces and, without a doubt, favor the feeling of belonging to them and, along with it, a wish to look after and maintain them. In this respect, any landscaping project, irrespective of its function, size or location, must protect, improve and regenerate the benefits and services provided by healthy ecosystems (U.S. Green Building Council 2015). The CICES classification (Common International Classification of Ecosystem Services) developed by the European Environmental Agency (Haines-Young and Potschin 2018) classifies ecosystem services in three categories: procurement, related to the supply of material goods, food-stuffs, energy, etc. regulation and maintenance of the environment, and culture, which includes intangible services.

Currently, municipal management of the urban green belt is excessively focused on economic, ornamental and surface area criteria, a work method which will require a change of mentality on every level in the context of the new framework for developing Green Infrastructure strategies (ASEJA, FEMP, AEPJP, 2019), featuring a comprehensive, systematized assessment to establish the possible environmental, social and economic impacts which affect them, associated with changes in design, construction and maintenance practices (Hansen et al. 2017). This evaluation should be an iterative and constant process which helps to improve the quality of the existing spaces and to improve design practices by establishing quality standards (Anguluri and Narayanan 2017). Finally, it should emphasize the role that green spaces play in improving the quality of life of city dwellers, their contribution towards mitigating climate change as part of Green Infrastructure (Design Trust for Public Space and the City of New York 2010).

Finally, as an application of the guidelines stated both in the European Strategy for Green Infrastructure (European Parliament 2013) and in the 2030 Agenda for Sustainable Development (United Nations 2015), Spain is close to publish the State Strategy for Green Infrastructure and Ecological Connectivity and Restoration. For its implementation, all the professionals involved (managers, planners and designers) will need operational tools to help them in decision-making at local and regional level, as well as provide them with multidisciplinary approaches between administrations.

This article analyzes the potential of the design of green infrastructure plans based on the analysis of peri-urban landscapes and, more specifically, the large peri-urban parks, since these constitute the closest natural space to citizens and play an important role in generating ecosystem services with local communities, as established by the FAO Urban Forest classification (Salbitano et al. 2017). This analysis must be carried out using multifunctional methodologies in which all phases of planning, design, execution and maintenance of these parks are reviewed from an ecological, social and economic perspective.

The aim of this research is to put into practice an overall evaluation tool to analyze the green periurban areas and use this strategy to establish new criteria in the Technical Specifications of public tenders for design management and maintenance phases of new green infrastructure projects. To this end, the case study presented in this paper seeks to respond to the questions compromising the future of our cities, by looking at the role granted to the urban and peri-urban green belt not from a theoretical perspective but based on the reality of large peri-urban green areas, in this case, in South-west Madrid:

- How can a network of green infrastructures be generated from the peri-urban space?
- What do the large peri-urban parks contribute to the urban green space network?
- How to revert current maintenance problems from design criteria? What kind of spaces, designs and management models generate the necessary resources for the public authorities so that they may remain in the future?

It consists of a set of cities that make up the southern belt of Madrid, whose urban development has been taking over the natural spaces that existed reducing them to mere interstitial spaces that, today, from the perspective introduced by the design of green infrastructure strategies, acquire great value as areas of urban-natural connection and biodiversity source spaces from which to develop urban biodiversity strategies in large cities.

## Methodology

The methodology applied in the present research (Verdú Vázquez et al. 2017), proposes a work method based on the

integration of green spaces characterization and evaluation methods and supra-municipal strategy planning and evaluation tools. This is a working method in which a synthesis is made of different existing methodologies and programmes that are suitable for a comprehensive diagnosis, from the administrative phase through to the execution and maintenance of green areas and peri-urban natural space projects. It also allows its potential as a Green Infrastructure to be assessed within the framework of Open Space Strategies. The objectives and actions to be developed in each case may be collected in the form of studies or guidelines for action by the administrations.

The analyzed bibliography is based on the characterization of the urban green grid defined in the green planning of the city (Falcón 2007) and the peri-urban space (Arenas Cabello et al. 2012). These studies provide evaluation criteria and management recommendations aimed especially at public administrations. In Spain, the study on Green Infrastructure recently published and developed by the Asociación Española de Parques y Jardines Públicos (AEPJP 2017) focuses on specific management criteria such as ratios per inhabitant, analysis of management models, budget allocations or human resources.

On the other hand, for the overall evaluation of the projects, the methodology presented in this paper takes as reference the systems of evaluation and certification of green areas in England: the Green Flag Award (Greenhalgh 2006) and the USA Sustainable Sites Initiatives (U.S. Green Building Council 2015), based on the diagnosis and evaluation of green areas from technical criteria of quality, universality and resilience.

As a result, a matrix is obtained which enables an overall, multifunctional and multi-scale diagnosis, enhancing the project itself and its potential as a Green Infrastructure within the framework of supra-municipal Strategies (Dige 2015) (Mayor of London 2009).

The new methodology has been applied in south-west Madrid, as an example that can be extrapolated to other large cities where urban growth exerts a strong pressure on the peri-urban space, which is reduced to a fabric of interstitial spaces in which the presence of large peri-urban parks and the conservation of peri-urban agriculture models are key to the generation of ecosystem services. The selected projects are located around the cities of Móstoles, Alcorcón, Leganés and Fuenlabrada and have in common the same operating pattern:

- They are the largest peri-urban green spaces in Madrid, with a strong link to areas of high natural or landscape value, such as the Regional Park of the Middle Course of the Guadarrama River and Southeast Regional Park.
- Naming them forest parks gives them a significant role in the green infrastructure and, as such, in the creation of urban forests (Calaza et al. 2018), particularly in the case



of Bosquesur and the Móstoles Green Network. The FAO Urban Forest classification gives peri-urban forests the greatest importance for biodiversity and landscapes (Salbitano et al. 2017)

- In all of the projects, *water is a key element*, be it due to the recovery of hydrological networks, to endorheic basins or to the creation of artificial lakes.
- They have a *strategic location* in relation to linear infrastructures which generate fragmentation processes.
- They are *recreational areas* with a strong component of public use that is highly concentrated in terms of space but without any commitment from the authorities to implement an active participation program.

These spaces are: “El Soto” Nature Park (Móstoles), the green artery of “Las Presillas” and “Arroyo Butarque” parks (Alcorcón-Leganés) and the “Polvoranca” Park (Leganés). Meanwhile, in 2013, the city of Móstoles embarked on a sustainability strategy with regard to the urban green belt: the Green Network (Department of Town Planning and the Environment. Móstoles Council 2014), which is included in this study alongside the Bosquesur forest park project (Sanjuanbenito 2005), the objective of which is the recovery of the Mediterranean ecosystem in the peri-urban area of South-west Madrid (Fig. 1). The previously mentioned methodology will be applied to these green areas, in order to assess their appropriateness for adapting to sustainability principles and their function, rather than as a

provision, as an infrastructure, as bridging areas in a landscape planning process within the framework of a strategy of open spaces.

After defining the *physical, social and cultural context* in which the selected projects fall, a review of the *administrative background* in which these projects were created was performed in order to contextualize the circumstances which warrant the investment in new green spaces and the strategies which generate their design. Linking large green spaces with their environment: size, shape, ecological processes, memory of the place, town planning, population, etc., must be key to the design process, to generating dynamics within them to reflect these elements. For this reason, special attention is paid to the *meaning that these large green spaces acquire in their environment*, analyzed by means of a sequence of historical images provided by the Territorial Information System of the Madrid Institute of Statistics (<http://www.madrid.org/nomecalles/>), as well as images from museums and municipal historical archives.

The third part focuses upon *landscaping*, trying to answer questions such as: ‘Does the design create shapes, meanings and uses in line with the needs?’, ‘What is the capacity of the model implemented to assume social changes which determine tastes, the type of use required for this space, the political changes which define future lines of action, or the ecological changes inherent in natural systems?’ This evaluation was carried out using the original design plans, historical photographs and in situ in the parks being studied, the results obtained being recorded in the evaluation matrix and photographic archives.

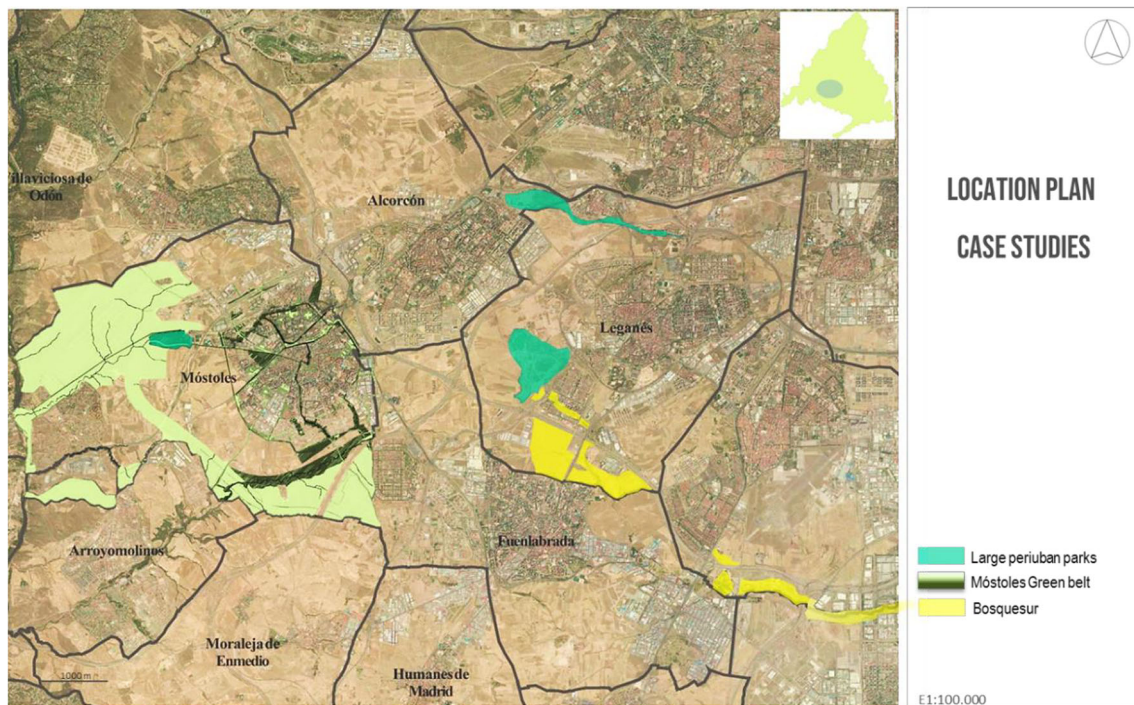


Fig. 1 Location of the green spaces included in the case study. Prepared by the authors and <http://idem.madrid.org/?v=ambiental>



Finally, compliance with *sustainability and resilience criteria* is evaluated by using criteria such as their link with landscape planning tools, whether they incorporate monitoring and quality assessment tools and their suitability as Green Infrastructures in the context of supra-municipal planning strategies.

## Study area

The large peri-urban parks studied make up a green belt around the large cities of south-west Madrid. They have a direct connection with the Regional Network of Natural Protected Spaces included in the Natura 2000 Network and with strategic projects designed for the peri-urban area in this territory such as Bosquesur (Sanjuanbenito 2005) or the Fuenlabrada Agricultural Park (Yacamán Ochoa 2014).

The “El Soto” Nature Park is located to the west of Móstoles, between the city and the Regional Park of the Middle Course of the Guadarrama River (Fig. 2). It was constructed in 1984 and is the city’s largest green space (44 Ha). It may be classified as a peri-urban green area due to its location and type of use, but its use by the masses means that it is close to the concept of a “forest park” (Sanjuanbenito 2005), with extensive areas of tree plantations on the existing agricultural land. It connects with the aforementioned Regional Park via the Arroyo El Soto stream and this artery, currently a ‘green track’ is one of the main arteries underpinning the Móstoles

Green Network project (Department of Town Planning and the Environment. Móstoles Council 2014).

The green artery of Las Presillas and Arroyo Butarque (Fig. 3) follows the Butarque stream through the cities of Alcorcón and Leganés. It constitutes an example of how ecological boundaries can be created for administrative reasons in continuous natural spaces, caused by a differential treatment of the peri-urban park concept in each town. As such, focusing upon a common landscape element, the linear axis of the Arroyo Butarque stream, its design, maintenance and public use program is very different depending on the town in which it is located.

Meanwhile, Polvoranca Park (Fig. 4) is the largest peri-urban green space in the south of the metropolitan area of Madrid, spanning 150 ha around seasonal lakes, in a cereal-growing area where a seasonal stream runs through it and constitutes, just out of the park, the beginning of the plots forming Bosquesur, a supra-municipal project that aims to recover the Mediterranean ecosystem in the peri-urban space of the Southwest Madrid.

## Results

The results of the *analysis of the context* (Table 1) in which these projects are located reflect that all of them are located in fragile natural spaces as a consequence of the development of the large cities in South-west Madrid: streams with rising

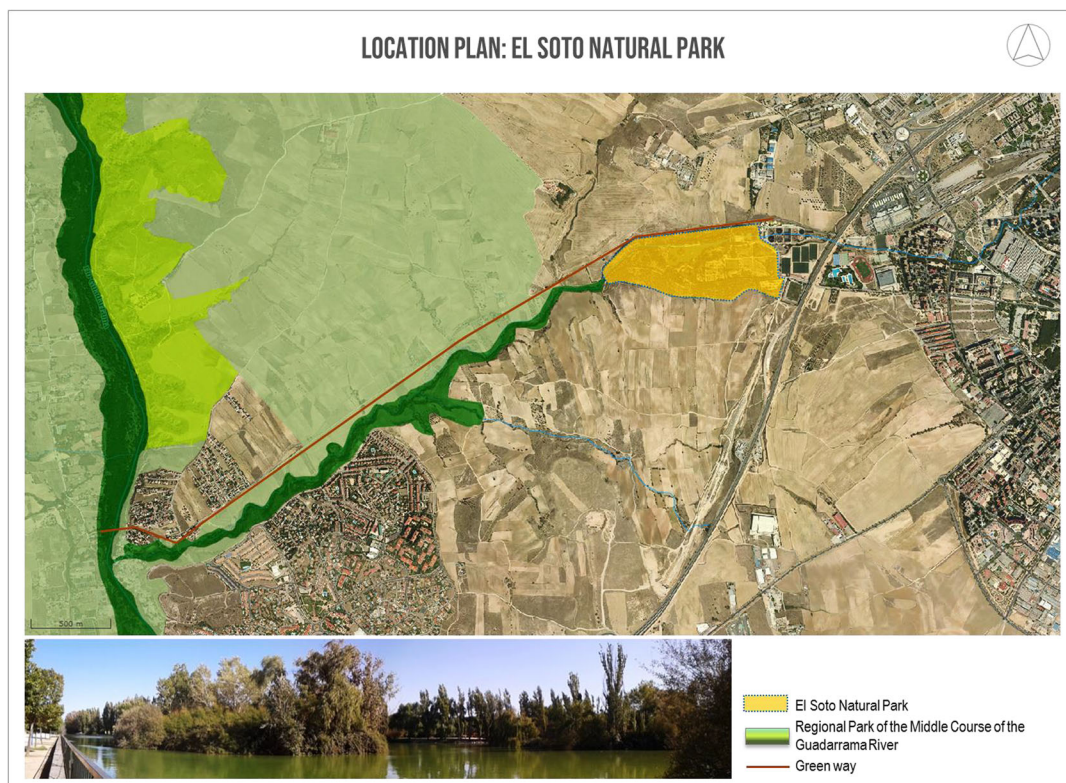
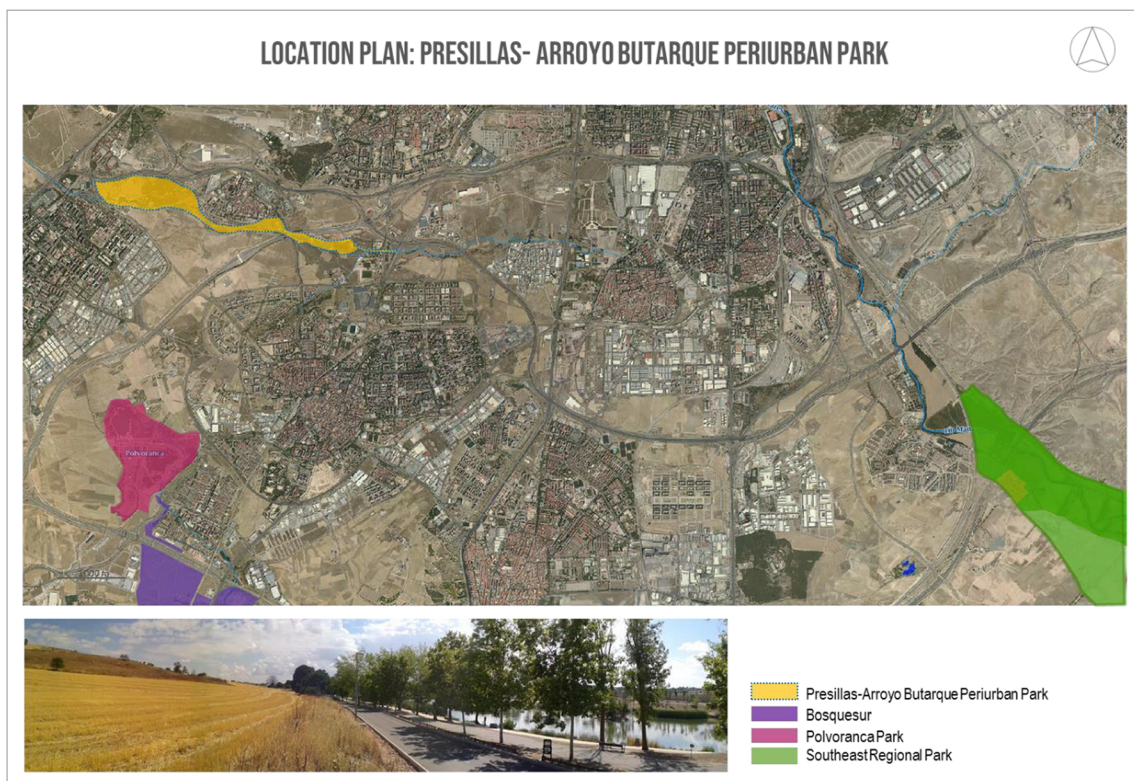
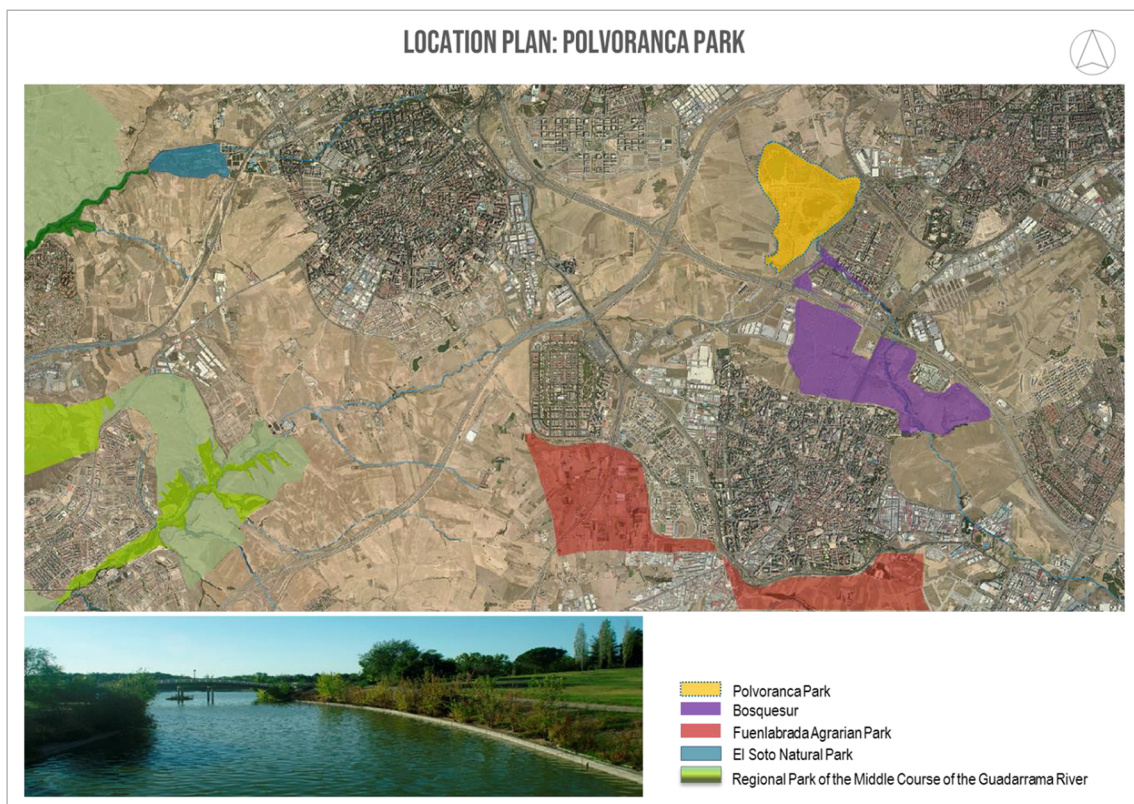


Fig. 2 El Soto Nature Park context. Prepared by the authors and <http://idem.madrid.org/?v=ambiental>





**Fig. 3** Green artery of Las Presillas and Arroyo Butarque context. Prepared by the authors and <http://idem.madrid.org/?v=ambiental>



**Fig. 4** Polvoranca Park context. Prepared by the authors and <http://idem.madrid.org/?v=ambiental>

**Table 1** Context and governance evaluation matrix. Prepared by the authors

CONTEXT	EL SOTO NP	LAS PRESILLAS_ARROYO BUTARQUE	POLVORANCA	BOSQUESUR	GREEN NETWORK	
<i>Creation date</i>	1984	2009/2011	2004 and 2009	1992	2007	2013
<i>Ownership</i>	Private	Private, expropriated	Public and private	Private	Public and private	Public and private
<i>Area</i>	44 ha	57.50 ha	18 ha	150 ha	561 ha	Municipal area project
<i>Connection with the environment</i>	Physically with the environment: none. Public use: adequate in private vehicle	Physically with the environment: total. Public use: very limited	Physically with the environment: Irregular; Public use: optimum	Physically with the environment: irregular. Public use: adequate except from Alcorcón	Physically with the environment: very high. Public use: adequate	Physically with the environment: very high. Public use: very high
<i>Average accessibility</i>	2 km	1.5 km	0.5 km	0.8-2 km	1.5 km	0-2 km
<i>Prior land use</i>	Non-irrigated crops, allotments and groves	Meadows, abandoned dry land, Presillas stream	Stream and industrial or residential land	Endorheic basins and farming	Various: Farming, dumps, industrial, construction, etc.	Residential, farming, tertiary, industrial, natural spaces
<i>Conservation function or habitat/species recovery</i>	El Soto stream	Presillas stream	Butarque stream	Lake ecosystem	Culebro stream and Canto Echado ravine	Guadarrama river
<i>Recovers degraded areas</i>	NO	Yes, stream bed	Yes, stream bed and adjacent areas	NO	Yes, uncontrolled rubbish dumps	Las Sabinas settlement
<i>Generates projects in developed areas</i>	NO	NO	Yes, connection with green belt in La Fortuna	NO	YES	YES
<i>Connection with better nature networks: ecological or green</i>	YES	NO	NO	YES (Bosquesur)	YES	YES
<b>GOVERNANCE</b>						
<i>Administrative execution procedure</i>	Direct commission	Public tender	Public tender	Ideas contest	Public tender	Designed by town planning department
<i>Participatory processes involving local agents and users</i>	NO	NO	NO	NO	NO	In aspects without implications
<i>Management</i>	Local public authority with privatized services	Local public authority with privatized services	Local public authority with privatized services	Local public authority with privatized services	Local public authority with privatized services	Undefined

volumes due to the contribution of waste water from treatment plants, residual spaces of low landscape quality, disused agricultural areas, rubbish dumps, areas which are isolated between a web of infrastructures, etc. The recovery of these spaces already entails their revaluation, as well as a significant change in how they are perceived by citizens.

Regarding the physical connection, creating opportunities to connect these spaces physically and functionally both with each other and with urban areas by means of an Open Spaces Strategy, is a solid base on which to design Green Infrastructures. All of the projects reflect the effort to facilitate visitor access, mainly through bridges or roads,



but the existence of large linear infrastructures such as highways or motorways, restricts their design, especially on foot or by bicycle. In all cases, these are access points in which mobility criteria have prevailed over those of landscape integration, missing a great opportunity to create ecological connections.

Regarding the functional connection, the analysis of the location and total area of the large green parks analyzed also supports this argument by relating them to the concept of the “green lung”, reserved for green spaces assigned to leisure and nature activities for inhabitants of big cities. These are peri-urban green areas in which there is an evolution towards integration concepts, ecological connectivity and the incorporation of environmental education, but with the same common shortcomings in the treatment of all of them as services, without long-term planned designs. Since they are green spaces in peri-urban areas, the physical disconnection with the environment, with perimeter fences around them all, will condition the visual connection with the environment and the free movement of species.

Regarding the analysis of governance, the projects were awarded by public tender, except El Soto Nature Park, which was a direct award. Currently, the management is public with private adjudication of maintenance. It is only possible to talk about moving closer towards *citizen participation* in the Móstoles Green Network project, where a round table was organized with local agents, entrepreneurs and political groups, in addition to carrying out surveys and workshops in the city’s different green spaces, as well as at the district councils.

Establishing good governance practices is key to carrying out projects which, although local in nature, fall within national frameworks. As such, multi-disciplinary working groups and wide-scale planning are required. The difficulties in relation to cooperation between local authorities in managing these green areas result in incoherent situations which compromise the adequate fulfilment of projects with common objectives and their landscape integration.

Opting for ecological city planning implies a tendency towards creating Green Infrastructure networks and is a procedure on a supra-municipal scale, related to the social, natural and political environment. To achieve this, it is necessary for everyone to make an effort: designers, authorities, politicians and citizens, in changing perspective and opting for innovation.

### Reading based on landscape structures

At the heart of the designs is the incorporation of landscape structures with structuring elements such as the hydrological network as a structuring element and the preservation of plant formations or some pre-existing roads that follow

the natural topography (Figs. 5 and Table 2). These images make it possible to compare the adequacy of the design to the previous structures of the landscape, specifically to the topography, maintenance of stacional streams and conservation of the existing plant masses. With the exception of the Móstoles Green Network, which is based on a more inclusive concept, the cases studied have been created around a common element, the seasonal streams and the opportunity to improve their quality and functionality. However, there are also serious shortcomings, such as the previous analysis of the quality and adaptation of land uses in order to establish the program and zoning of uses. This lack of evaluation of the designs with respect to the physical and climatic environment conditions their maintenance, causing the loss of the necessary balance between functionality, durability and enjoyment to facilitate their long-term sustainability.

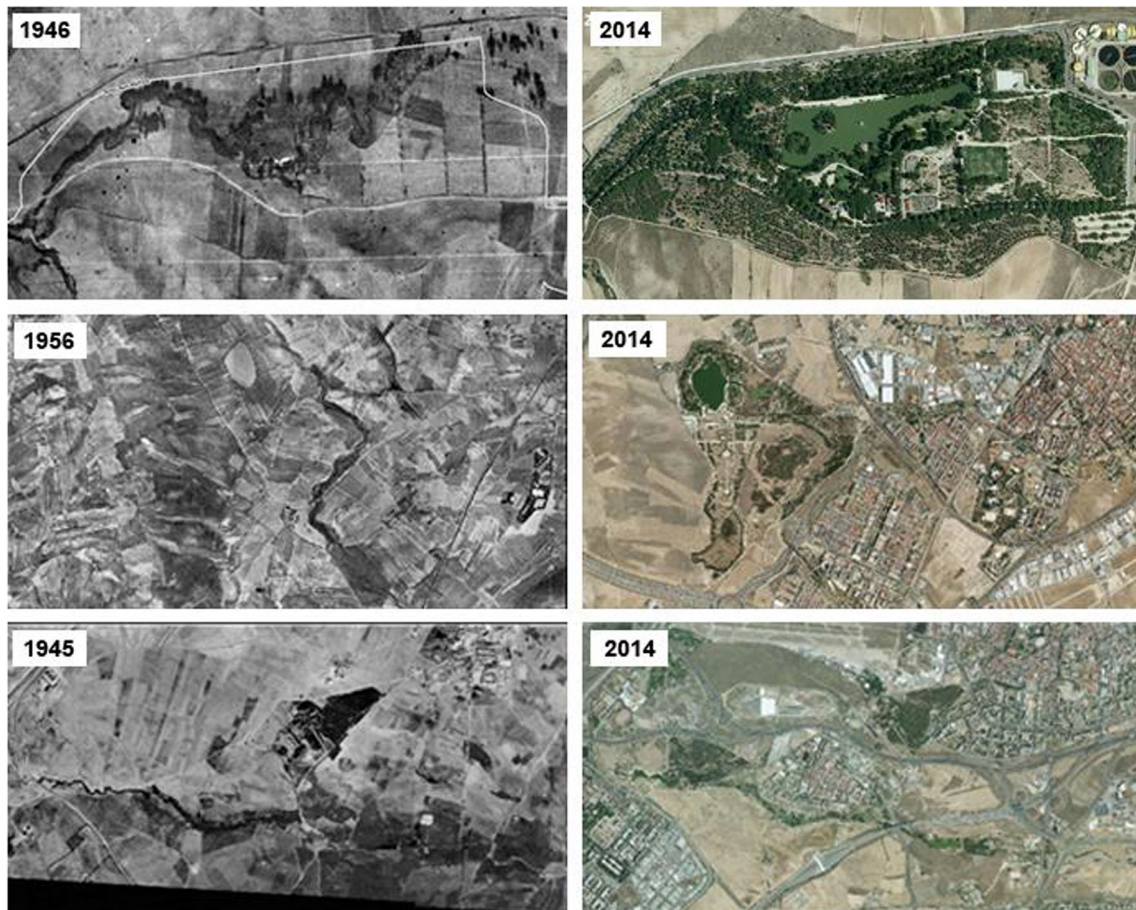
A project effort is necessary, in terms of design and creativity so that the ecological processes meet social needs as part of a changing joint dynamic in natural and social spaces. Landscape-based planning requires time which does not always coincide with policy management timings, as such, it is necessary to understand it as strategic city planning. Landscaping provides the vision, the technical knowledge, the creative unity and the pragmatism required for this and the strategy which should be looked at is one for a Green Infrastructure which proposes actions in accordance with political commitments and responses to current and future challenges (Landscape Institute 2013).

### Design

The design analysis shown in Table 3 includes the following aspects: visual quality, management of the water cycle, soil and plant elements, integration of the construction elements and design of the public use program.

The peri-urban parks analyzed present common *design elements* (Figs. 6, 7 and 8), being dominated by meadows with few wooded areas around the sheets of water, tree-lined river banks, in some cases with shrubby vegetation and extensive natural meadows with plantations of tree species which are often unsuitable as is reflected by their state of development and plant health. Their *aesthetic or functional link* with the nearby space is reduced to the selection of river corridors as a concept of design, which does not manage to have continuity in the surrounding landscape. As a result, we have a program of unconnected uses and naturalization attempts without spatial organization or landscape complexity that is explained in detail below.

The projects evaluated do not reflect a clear *integration of soil, water and vegetation*, instead one of the elements dominates the design, particularly water as an ornamental element or forest masses. In spite of efforts in soil-vegetation



**Fig. 5** Changes in the landscape context in El Soto Nature Park (up), Green artery of Las Presillas and Arroyo Butarque (middle) and Polvoranca Park (down). Prepared by the authors and <http://www.madrid.org/nomecalles/Inicio.icm>

**Table 2** Evaluation matrix of a reading based on landscape structures. Prepared by the authors

READING BASED ON LANDSCAPE STRUCTURES	EL SOTO NP	LAS PRESILLAS_ARROYO BUTARQUE		POLVORANCA	BOSQUESUR	GREEN NETWORK
<i>Design team</i>	Forestry Engineering	José Luis Muñoz (municipal expert)	Territory and Engineering Studies Society (2004), Francisco Javier González Martín (architect)	López Chollet Dalmau (architects)	TECNOMA	Móstoles Council town planning experts
<i>Link with urban planning instruments</i>	Town Planning General Plan and Strategic Plan	Town Planning General Plan	Town Planning General Plan	Town Planning General Plan	Town Planning General Plan	Town Planning General Plan and Strategic Plan
<i>Design based on reading of landscape structures</i>	Only topography	Yes, but without a defined concept	Only topography	YES	NO (The same plan is repeated irrespective of the environment)	NO
<i>Location of soil and plant protection areas</i>	NO	NO	NO	YES	YES (Forms part of project)	NO
<i>Evaluation of previous design</i>	NO	NO	NO	NO	NO	YES (internally)

**Table 3** Design evaluation matrix. Prepared by the authors

DESIGN	EL SOTO NP	LAS PRESILLAS_ARROYO BUTARQUE	POLVORANCA	BOSQUESUR	GREEN NETWORK	
<i>Visual quality</i>	Consistency in treatment of vegetation strata, deterioration of wooded areas. Very low in stream. Interrupted view of landscape.	Inadequate treatment of visuals and landscape values.	Adequate treatment of visuals, zoning of design according to public use.	Adequate treatment of landscapes and visual axes, landscape integrated in environment; improve shrubbed areas.	High in Canto Echado and Butarque stream area. Consistency in treatment of vegetation strata and areas of public use.	Specific actions to improve the visual axes and to integrate and improve visual quality in the urban area are being considered.
<i>Critical points</i>	Quality and bed of El Soto stream, quality of lake, program, forestry management.	Absence of program and process. Water management.	Water and lake management.	Reconcile public use program with ecological design processes.	Excessive repetition in planting patterns and public use areas. Absence of program.	Link with all local areas involved and joint implementation of program.
<i>Potential</i>	Option of multifunctional water cycle management, link with citizens, integration with ecological and green networks.	Option of phased integrated design.	Connectivity with the environment and physical continuity of the river corridor.	Phased design, regional management and environmental education program from the start.	Based on connectivity and recovery of the Mediterranean ecosystem.	Starting point for a Green Infrastructure network.
DESIGN: WATER CYCLE MANAGEMENT						
<i>Local rainfall management</i>	NO	YES, but without maintenance	YES (dams at connection with Presillas, lake and reception of rainwater)	YES (closed water cycle)	NO	NO
<i>Reduction in water consumption</i>	NO	YES (species selection and local watering throughout)	NO	YES, (cyclical water management system, the aim is for it to be a closed cycle)	YES (species selection)	NO
<i>Rain water control facilities</i>	NO	YES	YES	YES	NO	NO
<i>Water ecosystem recovery</i>	NO	NO	NO	YES (connection of lakes with Arroyo Culebro and continual flow to this riverbed)	YES (Arroyo Culebro)	YES (Guadarrama river)
DESIGN: SOIL AND PLANT ELEMENT MANAGEMENT						
<i>Soil management plan</i>	NO	NO	NO	NO	NO	NO
<i>Invasive species control</i>	YES (according to regional law)	YES (according to regional law)	YES (according to regional law)	YES (according to regional law)	YES (according to regional law)	NO
<i>Use of native species</i>	NOT A PRIORITY	NOT A PRIORITY	NOT A PRIORITY	YES	YES	NO
<i>Conservation and recovery of previous plant communities</i>	NO	NO	YES (right margin)	YES	NO	NO



**Table 3** (continued)

DESIGN	EL SOTO NP	LAS PRESILLAS_ARROYO BUTARQUE	POLVORANCA	BOSQUESUR	GREEN NETWORK	
<i>Visual quality</i>	Consistency in treatment of vegetation strata, deterioration of wooded areas. Very low in stream. Interrupted view of landscape.	Inadequate treatment of visuals and landscape values.	Adequate treatment of visuals, zoning of design according to public use.	Adequate treatment of landscapes and visual axes, landscape integrated in environment; improve shrubbed areas.	High in Canto Echado and Butarque stream area. Consistency in treatment of vegetation strata and areas of public use.	Specific actions to improve the visual axes and to integrate and improve visual quality in the urban area are being considered.
<i>Reduction of island effect</i>	YES	YES	YES	YES	YES	YES
<i>Compositional complexity</i>	IRREGULAR: high in shrub formations, low in wooded and herbaceous areas	LOW	LOW	AVERAGE (lacks the diversity of the shrub and herbaceous strata)	AVERAGE (lacks the diversity of the shrub and herbaceous strata)	LOW
DESIGN: MATERIALS						
<i>Landform-integrated and flexible designs</i>	YES (excluding actions when creating the lake)	YES (excluding actions when creating lake systems)	YES (excluding actions when creating the lake)	YES (excluding actions when creating the artificial lake)	YES	NO
<i>Recovered, reused and recycled materials</i>	NO	YES	NO	NO	NO	NO
<i>Materials in accordance with established regulations and certifications</i>	YES	Not in every case	YES	YES	YES	YES
<i>Local materials</i>	Not a priority	Not a priority	Not a priority	Not a priority	Not a priority	Not a priority
DESIGN: WELLBEING AND SOCIAL IDENTITY						
<i>Recognition of regional and local identity and history</i>	NO (Pending incorporation of historical reference)	NO	YES	YES (by the CEA(Environmental Studies Center))	NO	NO
<i>Protection and valuation of historical and natural heritage</i>	NO (archaeological points of interest excluded)	NO	NO	YES (by the CEA(Environmental Studies Center), not in the design which excludes the recovery of the village of Polvoranca)	YES	YES
<i>Promotion of balanced public use</i>	NO (Management tends to focus on public use)	NO	NO	YES	NO	YES
<i>Promotion of physical and mental health</i>	YES (Exercise circuits and inclusion in healthy living programs)	NO	YES (Social Services programs)	YES (in the design itself)	YES (from the CEA(Environmental Studies Center))	YES (from the department of sport)
<i>Contribution to social integration</i>	YES (Leisure, integration and volunteer activities, but no specific programs)	NO	YES	YES (from the CEA(Environmental Studies Center))	YES (from the CEA(Environmental Studies Center))	NO
<i>Promotion of agricultural and horticultural use</i>	NO (Proposal for creation of	NO	NO	NO (Proposal for creation of	NO (Proposal for creation of	NO

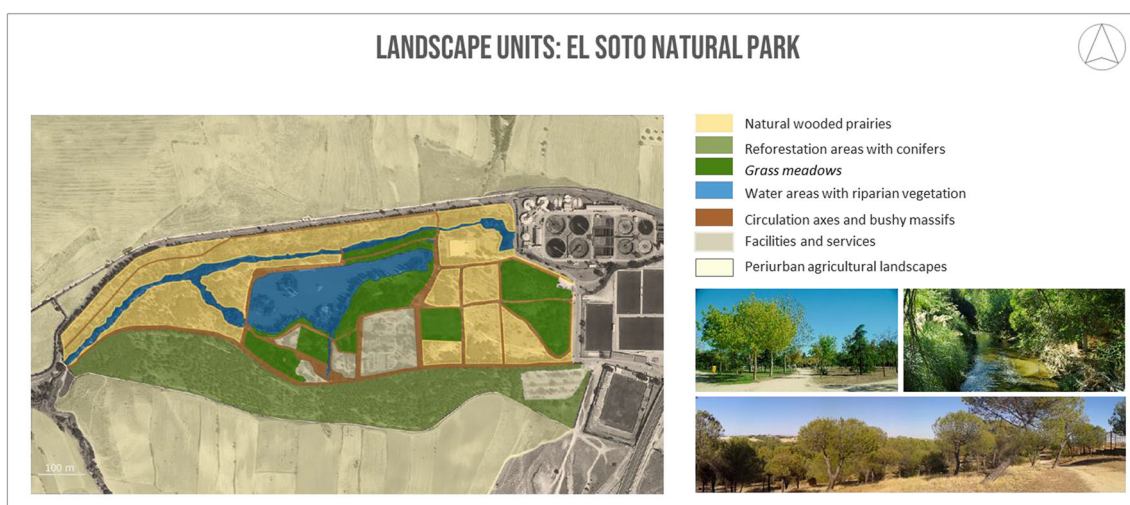
**Table 3** (continued)

DESIGN	EL SOTO NP	LAS PRESILLAS_ARROYO BUTARQUE		POLVORANCA	BOSQUESUR	GREEN NETWORK
<i>Visual quality</i>	Consistency in treatment of vegetation strata, deterioration of wooded areas. Very low in stream. Interrupted view of landscape.	Inadequate treatment of visuals and landscape values.	Adequate treatment of visuals, zoning of design according to public use.	Adequate treatment of landscapes and visual axes, landscape integrated in environment; improve shrubbed areas.	High in Canto Echado and Butarque stream area. Consistency in treatment of vegetation strata and areas of public use.	Specific actions to improve the visual axes and to integrate and improve visual quality in the urban area are being considered.
<i>Promotion of clean energy use</i>	allotments not implemented) NO	NO	NO	allotments not implemented) YES (by the CEA(Environmental Studies Center))	allotments not implemented) YES (by the CEA(Environmental Studies Center))	NO
<i>Contribution to local economy</i>	NO	NO	NO	NO	NO	YES
DESIGN: CONSTRUCTION						
<i>Pollution control during construction</i>	In accordance with specifications	In accordance with specifications	In accordance with specifications	In accordance with specifications	In accordance with specifications	NO
<i>Retention of usable topsoil</i>	In accordance with specifications	In accordance with specifications	In accordance with specifications	In accordance with specifications	In accordance with specifications	NO

adaptation by means of the selection of native species, especially in Povoranca Park and Bosquesur, the design lacks the compositional complexity that generates heterogeneity and contributes to the improvement of biodiversity, since these functions were not considered as priorities from the design phase. Adequate soil management during the design and construction phases and the use of suitable soils when developing

the vegetation would significantly reduce the economic investment and maintenance effort subsequently required.

The *selection and treatment of project materials* is an aspect that needs comprehensive improvement since aside from the certification required, the use of materials which contribute towards mitigating climate change is not a priority in any of the projects, be it to improve the filtering of rain



**Fig. 6** Landscape units in El Soto Nature Park. Prepared by the authors and <http://idem.madrid.org/?v=ambiental>



Fig. 7 Landscape units in Green artery of Las Presillas and Arroyo Butarque. Prepared by the authors and <http://idem.madrid.org/?v=ambiental>

water or to use flexible, recycled or reused materials which, due to their origin, contribute towards reducing the carbon footprint. This situation is widespread and could be reversed were governments to incorporate in their project tender documentation for the execution and maintenance of green areas that contracted companies must comply with circular economy criteria.

Regarding their role in the promotion of social welfare, these are highly valued areas such as leisure and sports areas because of their proximity to residential areas and the direct contact with nature that they provide for citizens. However,

the limitations in the design of a program for public use are reflected in the scarce diversification of leisure opportunities for groups such as adolescents, young people and people with special needs, or in the concentration and, therefore, high pressure around singular points such as bodies of water or wooded leisure areas.

The existence of Nature Learning Centers in these parks contributes towards boosting the program and encourages citizen participation, but they are also essential in raising awareness about the need to conserve and care for these spaces.

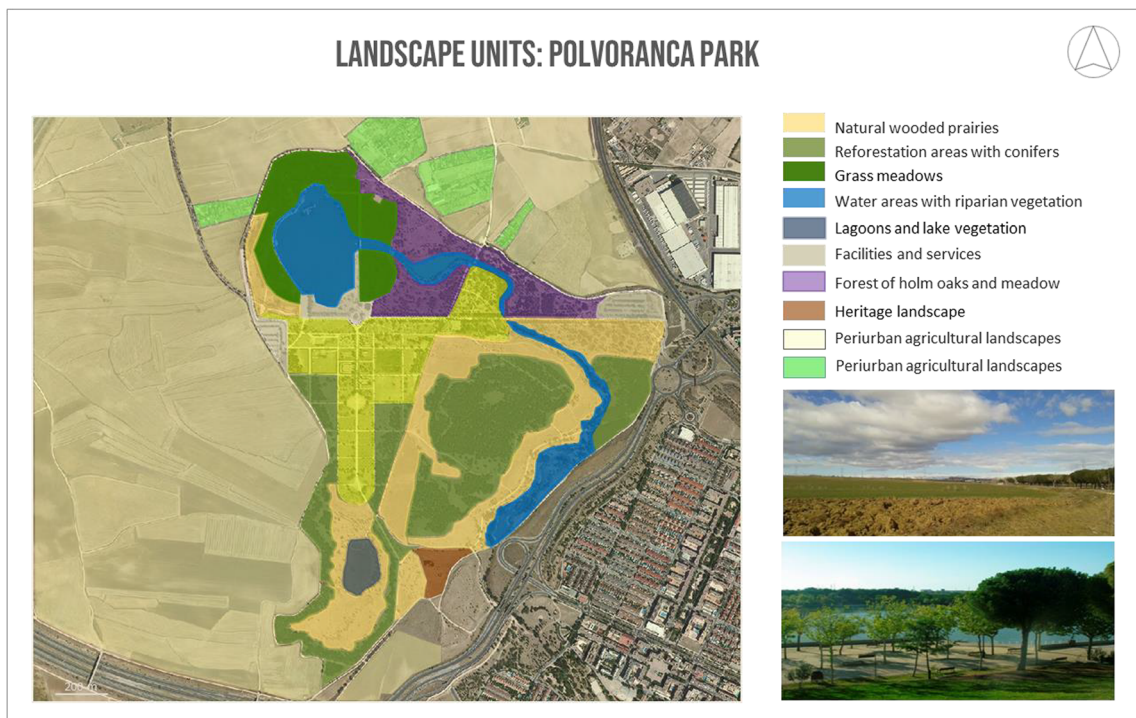


Fig. 8 Landscape units in Green artery of Polvoranca Park. Prepared by the authors and <http://idem.madrid.org/?v=ambiental>



Public use in these spaces is linked to the generation of large amounts of waste, a product of days out and coexistence, which makes a plan to raise awareness about this issue and its selective collection necessary, as stated above. Environmental education centers should be the driving elements of citizen participation in decision-making about the future of these green spaces.

### Maintenance

The low integration of maintenance criteria such as those shown in Table 4 during the design phase causes great problems to assume the costs of these interventions. Specifically, it is in the areas with more adaptive designs where the effects of the lack of staff and investment are less noticeable. It is necessary a thorough and economically quantified research into the resilience that green spaces with less intensive maintenance are demonstrating during this period of general economic crisis and more specifically of downturn in the gardening sector.

It is precisely at this moment that local administrations are investing in the recovery of their green heritage, when they have the opportunity to design sustainable green areas which require less intervention, have reduced annual costs and which require less investment. Incorporating the maintenance perspective in the design process will increase the chances of these spaces being more interesting and longer lasting.

However, this change of paradigm in gardening entails the need to train professionals at all levels, who are familiar with the natural processes required in order to plan and execute maintenance tasks incorporating aesthetic, technical and ecological factors. Maintenance activities in green spaces require a considerable financial investment by local councils: labor, supplies, facility maintenance and civil works, pruning, waste management and water consumption are the areas to evaluate financially during the design of sustainable green spaces. This change in model must not have a negative effect on the staffing levels, rather it should promote their gardening

expertise and improve their conditions and social status as professionals responsible for the quality of green spaces.

The production and collection of waste is another of the weaknesses of peri-urban green spaces. A large amount of waste is generated in these areas as a consequence of both public use and maintenance work. The waste generated during maintenance work is taken to composting plants at plant waste disposal sites but that produced by public use requires a significant collection effort, as well as awareness campaigns and the design of selective collection schemes for the access points. Otherwise, we are faced by a significant contradiction: having green peri-urban spaces in order to improve the quality of life of citizens who themselves represent a critical point in terms of waste generation. This aspect exceeds physical limits, the perimeter fences around our green spaces, it being common for waste to accumulate in neighboring natural and agricultural areas.

Despite the existence of a long tradition in raising awareness on this subject, efforts must continue so that users understand the importance of a correct civic and environmental conduct when using peri-urban areas, both when it comes to correct waste collection and in terms of not feeding the fauna present in these spaces, especially in water habitats. In this sense, is fundamental the promotion of programs to improve urban biodiversity in the Centers of Environmental Education, as a means of publicizing the importance of urban wildlife to citizens.

### Sustainability and resilience: Monitoring, innovation and good practices

The assessment carried out is summarized in Table 5, which sets out the needs identified for inclusion in the design objectives and actions for a future Open Spaces Strategy that, starting with the peri-urban parks studied, includes a multi-functional analysis of the peri-urban space incorporating singular projects designed using resilience criteria, and connecting with the city through its network of green areas.

**Table 4** Maintenance evaluation matrix. Prepared by the authors

MAINTENANCE	EL SOTO NP	LAS PRESILLAS_ARROYO BUTARQUE		POLVORANCA	BOSQUESUR	GREEN NETWORK
<i>Maintenance plan</i>	YES	NOT SPECIFICALLY	NOT SPECIFICALLY	YES	YES	NO
<i>Reduction of irrigation water consumption</i>	NO (progressive incorporation of watering in natural grassland)	YES	NO	YES	YES	NO
<i>Plant health management plan minimizing the use of chemical agents</i>	YES (QMC of contracting entity)	NO	NO	NO	NO	NO
<i>Reduced fire risk</i>	YES	YES	YES	YES	YES	NO



Table 5 (continued)

SUSTAINABILITY AND RESILIENCE: Monitoring, innovation and good practices	EL SOTO NP	LAS PRESILLAS_ARROYO BUTARQUE	POLVORANCA	BOSQUESUR	GREEN NETWORK
<b>ECONOMIC</b>					
<i>Generates productivity</i>					
<i>Economic revaluation of land and property</i>					Land reserve
<i>Showcases ecosystem services</i>					
<i>Promotes tourism and local produce</i>	Linked to environmental classroom		Linked to CEAs (Environmental Centers)		
<i>Contributes towards urban regeneration</i>		Attached to urban area		Attached to urban area	Great potential

First, it is necessary to incorporate the assessment of the projects and the possibility of starting to implement phased programs, linked to the reading of the landscape, which may also imply more flexible public use programs as the project progresses. Also, in these spaces, plans will have to be drawn up, in the short term, for landscapes that were created decades ago, being creative and producing logical action plans, carefully monitoring financial resources, after first carrying out an assessment of the green belt and urban and peri-urban areas, from the small plots to the large-scale spaces in each city, prioritizing right from the project phase with a forward-looking approach.

The future of these spaces is perceived in this study as members of a larger network of green areas in which they play a key role due to both their maturity as projects and spaces which are already integrated in society, their size and:

- The ecological connectivity with supra-municipal networks in the case of El Soto Nature Park, that connects through a greenway with the Protected Natural Areas network.
- To be included in the city's planning strategies, such as El Soto Nature Park in Móstoles Green Network, including aspects of mobility and landscape quality in urban areas.
- Both Móstoles Green Network and Bosquesur project must be the seed of a new conception of green planning in the Southwest Madrid.
- Being projects which contemplate multifunctionality, with a variety of uses and a reading of landscape structures, such as Polvoranca
- Working on a supra-municipal scale with the objective of showcasing the heavily fragmented peri-urban spaces in Bosquesur.

The presence of these established green peri-urban areas may constitute places in which awareness is raised with regard to the need to apply management models which are more respectful with biological diversity, generating a critical social mass which enables the extension of these models to the green belt of urban areas.

## Conclusions

According to the United Nations 2030 Agenda for Sustainable Development, citizens must have universal access to green areas and the connection between urban and peri-urban areas must be encouraged. The research described in this paper shows the important contribution of periurban green zones for the fulfillment of this double objective since environmental, social and economic values converge in them and also supra-territorial strategies can be defined from them. In this



way, one of the essential principles of Urban Ecology, connectivity as a foundation of resilience, is fostered.

The role of these areas as green corridors is essential to the provision of ecosystem services related to regulation and maintenance, in this case particularly those related to the regulation of the water cycle. However, there are significant design shortcomings which make it hard to establish different maintenance criteria which are more sustainable on an economic and environmental level. The importance of dual-layered design: meadows and wooded areas, also imposes a model for public use which shows little variety.

The difficulties of joint management between local administrations in the management of these green areas result in incoherent situations that condition the adequate achievement of projects with common objectives and their landscape integration. Establishing good governance practices is essential when carrying out projects that, although local in nature, are framed at territorial scales. The commitment to ecological planning in the city implies supporting this work from a supramunicipal perspective in relation to the social, natural and political environment. This requires an effort by all the actors involved: designers, administration, politicians and citizens, in a change of vision and an alternative for innovation. In this way, the weaknesses identified and issues associated with maintaining peri-urban green areas evaluated make them spaces offering great laboratory potential for launching programs featuring dynamic designs and ecological maintenance, and citizen participation that helps to define a program of public use in line with its conservation or aimed at the incorporation of green entrepreneurship initiatives.

The results of the research reflect the essential role of periurban parks in the generation of ecosystem services as an intangible value which contributes towards improving citizens' quality of life: doing sport in the fresh air, closer contact with nature in the city, their role in raising environmental awareness and providing environmental education through a network of environmental classrooms or involvement in urban agriculture. The current COVID-19 health crisis is forcing us to be creative in these areas, to come up with proposals which diversify public use of our parks, avoiding population concentration around certain areas or specific points, the same applying to managers and those responsible for planning the cleaning and maintenance of the green infrastructure.

This research puts into practice an overall evaluation tool to analyze the aforementioned areas, starting with the incorporation of new criteria in the Technical Specifications of public tenders for both the design phase and subsequent management and maintenance phases. From the point of view of landscape structures, the findings of this study makes it possible to understand the need to create networks, to integrate the periurban spaces into the city and to attend to and understand the needs of all actors and sectors involved, providing them a common vision that improves the future of these spaces. These results

can be extrapolated and applied to large cities whose urban areas are adjoined and where peri-urban parks can be the starting point for designing supramunicipal strategies for open spaces.

In each case, their multifunctional value gives them a key role not only in the Sustainable Strategic Planning of the cities in which they are located, but also at the supra-municipal level.

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