Sensitivity of green spaces to the process of urban planning. Three case studies of Madrid (Spain)

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ABSTRACT

This paper, based on spatial analysis and planning instruments review, presents some of the problems in green spaces planning in Madrid (Spain) throughout the 20th century. Three paradigmatic cases are studied. A profile of each system is presented, describing the background of the urban project, the planning evolution and the characteristics of the current situation. Urban Green Spaces (UGS) provisions of each zone were analyzed and compared. The work focused on the neighborhood level to better understand the critical factors behind the success or failure of UGS planning to determine what system is the most resilient to planning and management changes. The results show that the green structure of the three zones was defined in their respective master plans, but planning was not respected in any of the three cases studied. It appears that the most important factor affecting UGS systems is the building pressure on the territory planned. Guaranteeing the public access and use of such spaces is a very effective planning measure, as well as taking into account natural areas existing, such as forest areas and rivers. This is a strength of planning that helps authorities to design relevant UGS planning, which can then be effectively applied.

1. Introduction

Over recent decades, the percentage of people living in cities has increased, which has led to urban sprawl. In accordance with the 2014 revisions of the World Urbanization Prospects (United Nations, 2014), the proportion of the world's population that is expected to live in urban areas by 2050 is 66% compared with the 54% in 2014. Thus, managing urban areas has become one of the most important development challenges of the 21st century (Department of Economic and Social Affairs of the United Nations, 2014). However, the influence of UGS on human health and its wellbeing is well known (Kondo, Fluehr, McKeon, & Branas, 2018; Tzoulas et al., 2007), including on pregnant women and the child's positive brain development (Dadvand et al., 2017) or in the maintenance of the wellbeing of the elderly (Tilley, Neale, Patuano, & Cinderby, 2017). Hence, it is important to take into account the existence, conservation and maintenance of UGS in urban planning.

Urban sprawl is one of the factors that has damaged the suitable development of UGS. Several studies have addressed this question, as well as other problems involving UGS (Erickson, 2004; Taylor, Paine, & FitzGibbon, 1995; Yokohari, Takeuchi, Watanabe, & Yokota, 2000).

The great influence of sociodemographic processes on the growth and planning of cities has been studied by various authors. Specifically, many Asian cities have experienced phenomenal urban expansion (Jim, 2004) or Mediterranean cities in a different order of magnitude (Garcia, Garcia, & Atkinson, 2008; Madureira, Andresen, & Monteiro, 2011). This is a phenomenon strongly related to the migration of the population (Sperandelli, Dupas, & Dias Pons, 2013). Further, Lin, Meyers, and Barnett (2015) found that urban consolidation has a negative influence on the amount of space available for tree cover. Thus, urban growth creates a strong pressure on urban green space and causes its fragmentation. A "dramatic drop in capita green space provision in cities with greater population densities" is observed and documented in Fuller and Gaston (2009). According to these authors, green space coverage differs enormously among cities, yet little is known about the correlates of geography of this variation in European cities. Other examples of decline in UGS areas can be found in the city of Porto (Madureira et al., 2011) or in Singapore (Tan, Wang, & Sia, 2013).

These urban transformations have created further problems, with some authors mentioning the fragmentation of UGS as a crucial issue. In Asian mega-cities, urban fringe areas are made of a mixture of urban

and rural land uses, creating a segmented landscape (Yokohari et al., 2000). The literature on UGS dynamics has revealed the loss, isolation and fragmentation of UGS in some countries. On the other hand, Van Herzele and Wiedemann (2003) studied the poor accessibility of UGS in Kortrijk (Belgium) and revealed that many inhabitants of the city do not enjoy even one single green space due to urban barriers. Similarly, according to Lee and Hong (2013), a high level of spatial disparity prevents some inhabitants from accessing large parks. This trend has appeared particularly in Asian developed countries (Haaland & Van den Bosch, 2015).

In addition, financial constraints also play a role. In a Canadian study, they caused cutbacks of the UGS budget (Taylor et al., 1995). Erickson (2004) confirmed this problem: the greenways plan was quite stalled because there were administrative and financial constraints. In Sao Paulo, a speculative retention provoked the non-use of vacant lands (Sperandelli et al., 2013). In other words, frenetic rush towards economic growth sometimes slows UGS development.

Above all, a significant number of studies have pointed out a gap between an urban master plan and the UGS that is actually carried out. For instance, the Central Tokyo Plan was poorly implemented, while the circular green corridor that was planned totally disappeared in 1969 (Yokohari et al., 2000). In Beijing, the greenbelt areas that were designed in the Master Plan are completely different from the reality (Li, Wang, Paulussen, & Liu, 2005). This gap can be expounded on by several reasons. First, there is a lack of documentation on UGS planning and management. Bentsen, Lindholst, and Konijnendijk (2010) claimed that the theme "governance" received poor attention in the area of UGS until 2010. Even though some cities have a master plan, to Landry and Pu (2010), there is a "lack of empirical evaluations of the environmental impact of growth management policies". According to Schilling and Logan (2008), UGS decline is due to the "lack of models of how existing and foreseeable future population levels influence urban systems". Thus, some policies implemented to restrict urban sprawl provoked the opposite effect: the large urban perimeter created by the Sao Paulo Municipality encouraged urban sprawl because the perimeter was too large (Sperandelli et al., 2013).

Haaland and Van den Bosch (2015) also highlighted the fact that there is a lack of strategic green space planning, which includes both quantitative and qualitative criteria. Besides, changes in management policies (Garcia et al., 2008), delays for implementing strategies, and long periods taken for the elaboration of documents can also lead to weak plans or the non-existence of a coherent strategy (Madureira et al., 2011).

Further, some master plans are quite chaotic or abstract according to various authors. Kühn (2003) declared that greenbelt and green heart were abstract ideas of planners barely practicable in specific locations. According to Hilal, Joly, Roy, and Vuidel (2018), authorities generally only focus on UGS for which they are responsible and do not take into account residential landscapes. In other cases, they have deficiencies (Yokohari et al., 2000), as the absence of protected areas (Barbati, Corona, Salvati, & Gasparella, 2013; Erickson, 2004; Jim & Chan, 2016; Li et al., 2005) or even the absence of a master plan, as in Colombo, Sri Lanka (Senanayake, Welivitiya, & Nadeeka, 2013). Sometimes, the absence of a plan is a characteristic of urban planning; for example, Niţă et al. (2018) show a case of a Romanian administration where there is a low level of strategic planning.

The "urban green infrastructure planning" has emerged as a way of conceptualizing connected green space in urbanized environments (Davies & Lafortezza, 2017) and facilitates the integration of UGS as one more element of urban planning. This idea is found among the Sustainable Development Goals (United Nations, 2013; United Nations, 2016). One of these global Sustainable Development Goals responds to research that shows public and green space disappearing in unplanned cities. At the same time, existing public space in planned cities is being commercialized, exacerbating socioeconomic fragmentation (UN-Habitat, 2013; UN-Habitat, 2016).

All these problems are crucial for the development of UGS. Especially, the failure to fulfill the designed master plan seems to be a global issue. Thus, knowing what UGS design factors help to improve the master plan or even to fix UGS endowment issues once the plan has been breached, becomes an important subject. Some authors worked on this focus (Jim & Chan, 2016; Niţă et al., 2018; Xing, Yanfang, Liu, Wei, & Mao, 2018), but at a general territorial level. Yet, studying UGS systems at this level of design does not reveal all the problems of such systems and does not give an exhaustive vision of the issues emerging in the area of UGS. There are authors who encourage UGS design and planning at a very detailed level. Madureira and Andresen (2014) stressed the importance of "locally defined visions of green infrastructure that are both 'strategic-based' and 'place-based'". Jim and Chan (2016) suggested that studying institutional and spatial constraints could be better than using per-capita UGS provisions at the detail level.

Haaland and Van den Bosch (2015) address the need to study urban green spaces at the neighborhood scale. These authors gave several reasons, as this scale is the most important for residents and the neighborhood unit is "homogeneous in terms of housing and development". Baycan-Levent and Nijkamp (2009) highlighted the importance of developing local standards for UGS planning to meet local needs. Tan et al. (2013) stated that the spatial distribution of vegetation is more relevant than the amount of urban vegetation to design a city with a high level of vegetation perceived. Thus, these aspects show the importance of studying UGS at the neighborhood level.

This paper presents three case studies of UGS systems located in Madrid, Spain. It aims at analyzing and comparing UGS provisions of each zone, focusing on the neighborhood level to understand the critical factors behind the success or the failure of UGS planning and management, determine what system is the most resilient to planning and management changes and eventually, to find what the elements are characterizing it.

2. Materials and methods

2.1. Selected case studies

The study cases selected correspond to three singular moments of Madrid's urbanism (Fig. 1).

The first case corresponds to Madrid's first urban planning, approved in 1860 (De Castro. Plan Castro, 1860). The second belongs to the "Partial plan of the city of Aluche Park" (Plan parcial de la ciudad Parque Aluche, COPLACO, 1964), which was one of the first cases in Madrid of urban development from partial plans. These partial plans were used after the Spanish Civil War (1936–1939) in the second half of the 20th century. The third corresponds to the named "city of Tres Cantos". Due to the development plans that promoted the massive arrival of the rural population in big cities, a program of Urgent Urban Development Actions (Decreto-Ley 7/ 1970, n.d.) was made to alleviate the serious housing deficit in the most important Spanish cities. From this program, the new city of "Tres Cantos" was built at the end of the dictatorship of Francisco Franco Bahamonde, and was finished being developed at the end of the 20th century. This city has been an independent municipality since 1991. During the development of this "city", there was a serious world economic crisis (oil crisis, 1973) that radically changed the initial criteria and was reinterpreted with the new keys to democracy in Spain in 1978 (Garcia Escalona, 2010).

The three cases considered correspond to times of great increase in the population of Madrid (INE, 2019), with developments of predominant residential use.

The comparison of the selected cases will establish that the UGS are elements of the design and urban planning that have a great vulnerability to changes in the master plans. This vulnerability is independent of the urban design, of the planning instrument and of the related criteria with the green spaces used in Madrid over the last 150 years. It will also help to determine what features of green spaces make them more resilient to these changes.
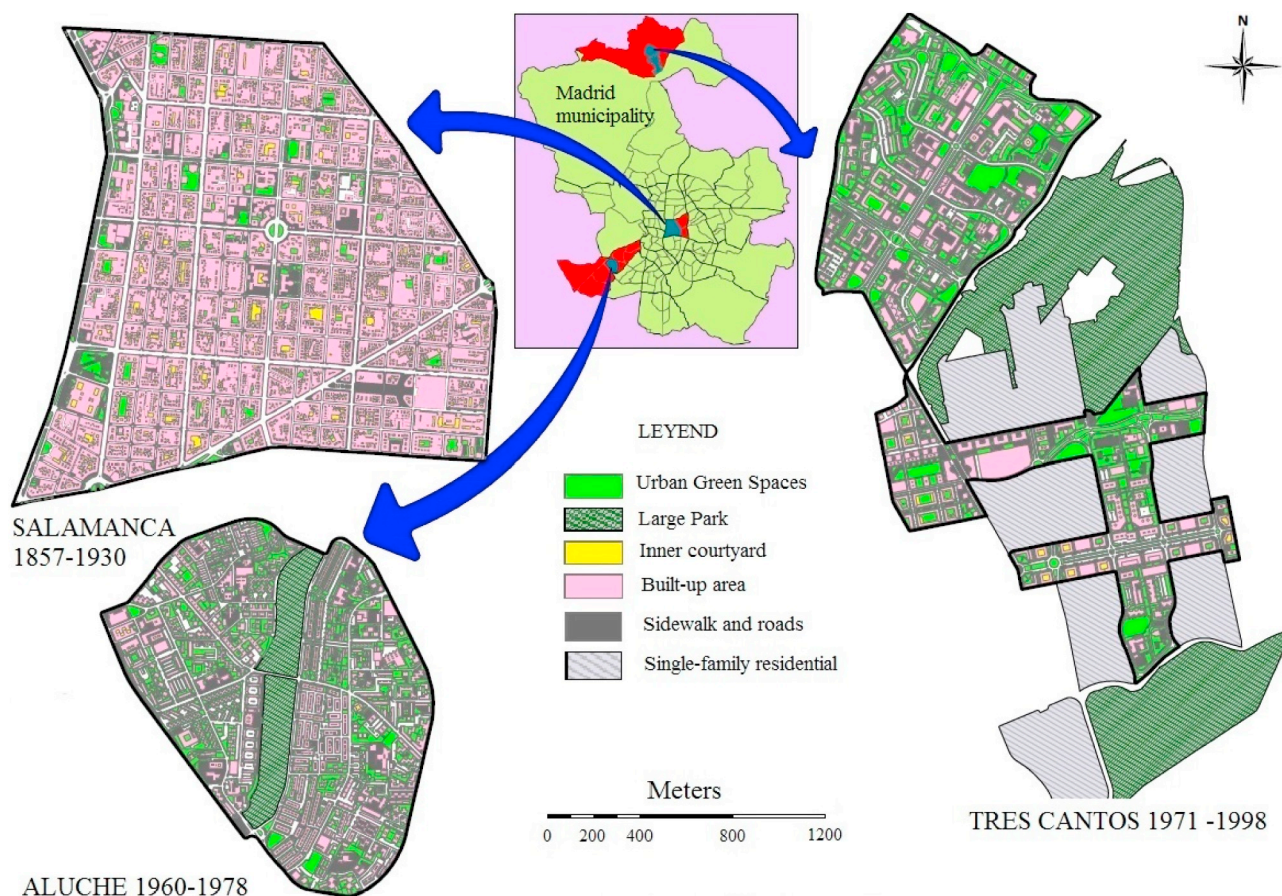
Fig. 1. Study cases. Period and land occupation.

2.2. Analyzed features

1. Urban project proposed
2. Planning evolution
3. Characteristics of the current situation
   3.1 Housing density (per ha, and per built-up ha)
   3.2 Population
   3.3 Urban morphology
   3.4 Characteristics of UGS
       3.4.1 <u>Property regime</u>
       3.4.2 <u>Quantity</u>: UGS area per capita and per housing
       3.4.3 <u>Quality</u>: accessibility, maintenance and functionality

Each of the elements for each study case have been analyzed. The method followed for "urban project proposed" and "planning evolution" has been the revision and analysis of planning documents, both primary (general and partial plans) and secondary. The "characteristics of the current situation" have been obtained through digitization and calculation from different databases. To assess the UGSs quality an index (Quality AMF; Eq. (1)) based on three aspects, "accessibility" (AC), "maintenance" (MA), and "functionality" (FU) was designed and implemented.

$$Quality\ AMF = AC + MA + FU \tag{1}$$

Each of the aspects was evaluated based on four criteria (Table A in supplementary material) and for each criterion six levels of achievement or cases were defined based on typical scenarios in our cities (Tables B, C, D in supplementary material). The criteria were weighted from 4 to 1 according to their influence on the quality of the UGS. Then, an achievement level was selected in each criterion and a value of 4 to 1 was assigned. In each aspect the numbers assigned to the same level

were added. The contribution of each aspect (i.e. AC, MA and FU) to the AMF quality index was defined as the number of the level with the highest value (see example in Table A in supplementary material). The three aspects AC, MA and FU ranged from 0 to 5 and the AMF quality index from 1 to 15. This is because in this study the UGS with AC = 0 were not considered as green spaces. In this study, accessibility has been considered as the easy, safe and quick pedestrian access to a green space that provides some functionality typical of those spaces besides a decorative one. For example: the accessibility score of a narrow green surface serving as a median to a two-lane traffic lane has been considered as zero. In the same sense, the score of a UGS completely fenced or used as parking has been considered as zero. For consistency purposes, the entire fieldwork of UGS was carried out during the spring of 2008 by a single trained person. To estimate the average quality of the UGSs in a neighborhood the weighted average based on UGS surface was calculated for each aspect.

2.3. Green spaces studied

In this work, green spaces are divided into two categories, namely general green spaces and large parks. General green spaces refer to small green spaces incorporated into the urban fabric. However, large parks have a wide area and can be relatively independent from the urban fabric. We consider a surface of 5 ha as the limit above which a green space is considered to be a large park.

2.4. Data collection

Population and housing data, such as the number of inhabitants, housing, cars and the level of income, was collected in Ayuntamiento de Madrid's (Council City of Madrid, CCM) website (www.munimadrid.es).
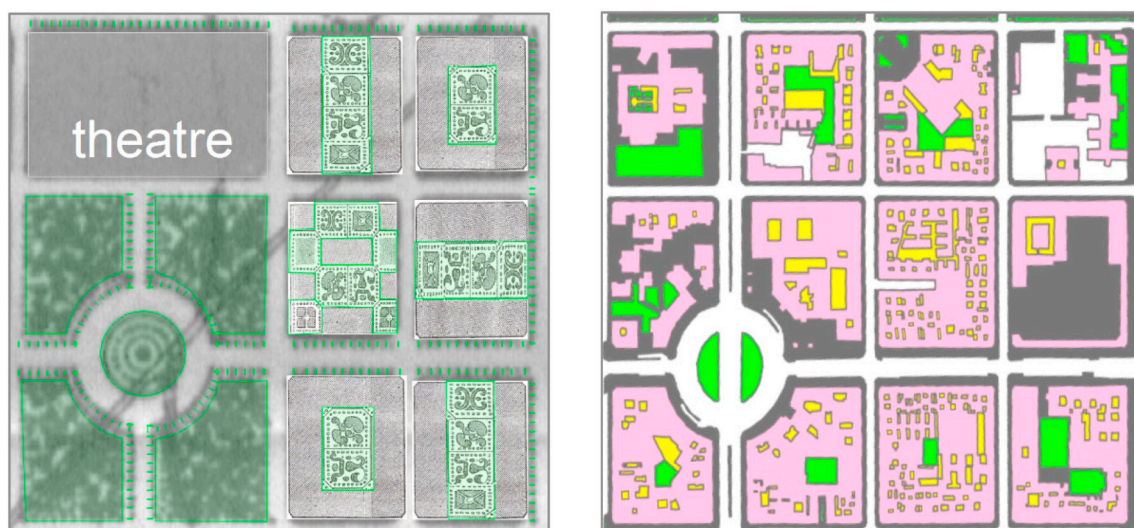
Fig. 2. Salamanca. Proposed planning vs. neighborhood nowadays.
Source: Prepared by the authors from De Castro, 1860, facsimile edition1978.

The table for both districts/neighborhoods can be found in CCM (2001). For the neighborhood of Aluche (in the Latina district), data tables were found in CCM, 2008a and 2008b. As well, for the Salamanca district, refer to the data tables in CCM (2008c and 2008d). For the case of Tres Cantos, one part of the data was found on the website for the Council of Tres Cantos (www.trescantos.es) and the other part in the Department of Statistics of the Tres Cantos Council.

To compare the original master plans and the real green space provision of the three case studies, documents were consulted at the library of the Department of Environment, Housing and Territorial Planning of the Madrid Regional Government (Consejería de Medio Ambiente, Vivienda y Ordenación del territorio, Comunidad de Madrid), in the municipal library of Tres Cantos and in the Town Hall, as well as the specialized library, "Biblioteca Regional Joaquín Leguina". Urban plans were consulted in the Department of Architecture of the Secretariat for Urban Planning.

2.5. Data digitizing

To obtain the area of the UGS existing in each of the three zones studied, DWG (native format AutoCAD ®) based-information was chosen. For the cases of Salamanca and Aluche, maps were found on the Madrid Townhall website (in www.madrid.org/cartografía). For Tres Cantos, maps drawn by the draftsman Ignacio Giménez were found. Then, a selection and correction process was initiated, and the AutoCAD 2008 version was used. A legend was created to title information layers and information layers related to UGS were selected. These layers were homogenized to obtain surface data by manually outlining polygons. The outlines were compared to reality by using satellite tracking and several location errors were corrected. Thereafter, these layers were exported in GIS format and data analysis was done with ArcGIS version 9.3.

3. Results

3.1. Salamanca

3.1.1. Urban project proposed

Nowadays, Salamanca is one of the twenty-one districts of Madrid and is close to the center of the city. In 1857, the engineer Carlos Maria de Castro González designed the Salamanca district as an assembly of closed blocks (De Castro, 1860). These city blocks were bounded by intersecting streets on each side and each closed block was composed of a "*patio*" (courtyard). Each patio had a surface of at least one-sixth of

the plot surface. Special buildings could have three floors and a maximum height of 20 m. The average surface of a "*manzana*" (square) was 80 × 120 m² or 80 × 150 m². Thus, Salamanca was designed as an orthogonal grid with an important presence of gardens and green areas. The Plan of Castro proposed a population density of 196 inhabitants/ha and it multiplied the urban area of Madrid by three (Plan Castro, 2010; Plan Castro, 2018). The vast majority of green spaces were uniformly distributed in the district and aimed at beautifying it. These spaces contained courtyards or gardens and had dimensions of 30 × 90 m², 80 × 120 m² or 200 × 250 m². Those green spaces took the place of several manzanas (squares). De Castro proposed 2,600,000 m² of public green space that represented 17% of the total urban area (García, 2006). Private gardens located at the core of closed blocks increased the green space area and were used as a play site for children or an area for relaxing. The total green space area represented 51.4% of the total urban area (García, 2006).

3.1.2. Planning evolution

In 1860, the "Anteproyecto de Ensanche de Madrid" created by De Castro was approved by Royal Decree (Fig. 2). However, the demographic and immigration situation created a great pressure of urban development, which affected the approved plan.

The Royal Decree of 1864 involved a significant decrease of the green spaces designed by Castro. In that decree, one-third of the green spaces were removed to create roads and almost all of the privately owned green spaces were removed. Additionally, it was authorized to build up to 85% of the plot, whereas initially, it was 50% (Plan Castro, el Ensanche de Madrid, 2018). Furthermore, in the regulation for the Implementation of Law of Populations of June 29, 1864, buildings were allowed up to five storeys plus the attic, instead of the three storeys originally anticipated. This meant that the housing density was almost doubled. Later, in 1873, the Madrid City Council agreements again amended the plan by reducing lane width and removing the gardens designed on privately owned parcels (Plan Castro, 150 años, 2010). The large green spaces designed by Castro at the end of the Paseo de la Castellana was termed *"Parque Urbanizado"* in the Núñez Granés (1910), so that it was an area hosting single-family homes with a garden. In other words, this public park was removed.

3.1.3. Characteristics of the current situation
3.1.3.1. Population. Salamanca is a very compact district made of closed blocks (165.04 ha of built-up area, 83,746 inhabitants and 48,069 housing units) (Table 1). However, it could welcome even more

Table 1
Inhabitants and housing by neighborhoods.
Source: Prepared by the authors on the basis Madrid and Tres Cantos council databases, on January, 122,010, and GIS measurements.

	Salamanca	Aluche	Tres cantos
N° inhabitants	83.746	50.142	27.125
N° housing	48.069	20.316	10.481
Population density (inhabitant/ha)	285,27	365,30	158,64
Density housing (housing/ha)	163,74	148,01	61,3
Inhabitant/housing	1,74	2,47	2,59

inhabitants due to its socio-economic context, given the fact that the average occupation is 1,74 inhabitants per housing.

The district is affected by an aging population (Table 2), so the rate of physical inactivity is very high. At the same time, it is facing a population decline due to a low birth rate.

The indicators of economic development are good (the socio-economic level and purchasing power of this district are high) and the level of health is one of the best in Madrid (Anuario estadístico, 2008a).

3.1.3.2. Urban morphology. This district is made of residential and collective housing in closed blocks (manzanas) and the building height is the same everywhere. Although the concept of "urban density" is subject to debate (Zapatero Santos, 2017), the values obtained in this district (Fig. 3) show that the study area is a homogeneous zone, highly congested and with difficulties to build new developments.

The road network is composed of an orthogonal grid system where ways are prioritized. The high proportion of roads is due to the greater use of cars and particularly motorcycles. However, roads were created to the detriment of green spaces and pedestrians.

Hence, great boulevards were removed and lane width decreased. Parking is regulated but the district lacks parking space on the street, while one-third of the total urban area is dedicated to pedestrian ways. However, pedestrian traffic is limited due to the compact forms of the district and the lack of suitable pedestrian ways. The proportion of the built-up area is really high and the free space distribution is completely unbalanced. Further, the built area occupies more than half the space (56.2%) and the roads are the main component of free space. Most of the free space is not dedicated to pedestrians, but to traffic. Thus, UGS represent a tiny surface (4.3%) in this urban area (Fig. 4).

3.1.4. Characteristics of UGS
3.1.4.1. Property regime. The 77% of the UGS area is privately owned. Many built zones have no private UGS and depend on public UGS. Thus, the inhabitants of this district are completely dependent on the Retiro Park, even though the distance between them and the park is higher than 500 m and they are separated by a seven-lane street without pedestrian crossings (Fig. 5).

3.1.4.2. Quantity. Presently, the UGS area per capita is 1.53 m^2, while the UGS area per housing is 2.66 m^2 (Fig. 6).

The UGS represent 4.3% of the total urban area, 9.9% of the free space and the free space area represents 43.8% of the total urban area (Fig. 4). The size of the UGS is also a key determinant, as the vast

Table 2
Distribution of the population. Percentage by age range and neighborhood.
Source: Prepared by the authors on the basis Madrid and Tres Cantos council databases, on January, 122,010 and October, 242,009 respectively.

	0–15	16–30	31–45	46–60	60–75	> 75
Salamanca	10.93	16.55	24.34	20.27	15.16	12.75
Aluche	10.05	18.69	24.40	16.55	21.32	9.00
Tres cantos	20.84	20.09	25.21	23.03	7.61	3.21
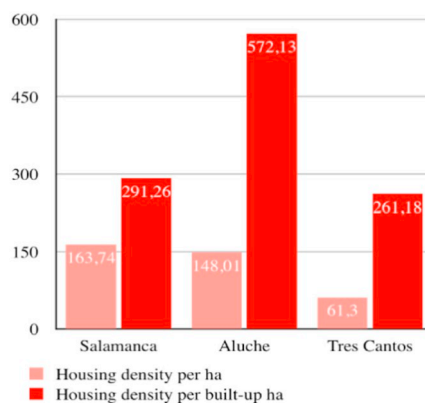
Fig. 3. Housing density.
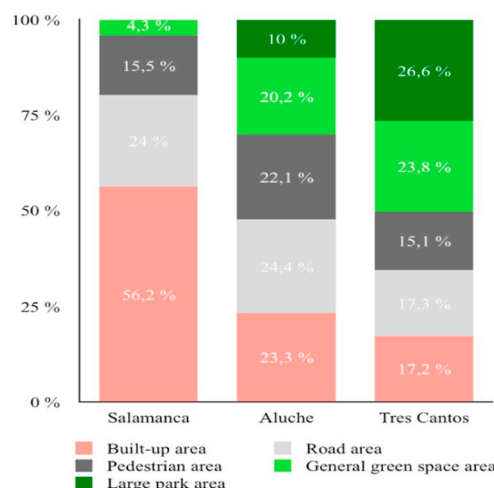
Fig. 4. Occupancy rate relative to total urban area.

majority of the UGS is small: the area of most of the UGS is lower than 500 m^2 (92% of Salamanca UGS, Fig. 11). Only six UGS have an area of between 0.25 and 0.5 ha and they are private lands; no UGS has an area higher than 0.5 ha.

Thus, UGS quantity is tiny and lower than UGS international standards (WHO, 2012), and the initial provision of the master plan. The Retiro Park located at the southern boundary of the Salamanca district plays an important role in UGS supply. Besides, many housing areas lack the presence of gardens or patios. There are 5870 patios, which represent 8% of the study area (Fig. 5). Moreover, the average area of these spaces is forty square meters, in some cases there are houses that only have access to one square meter of free space. The reason is that intense construction invaded these free spaces.

3.1.4.3. Quality. The 22% of the total UGS area is located in the patios of buildings and access to the rest of the green spaces is limited because those green spaces are components of the road network. The 50% of the built-up area is located at a distance lower than 500 m from a public green space, with an area higher than 0.5 ha. This is according to the recommendation of the European Commission about residential proximity to green spaces (Tarzia, 2003). However, there are many urban barriers, such as roads, that limit the access to such parks. The inhabitants (especially children and the elderly) are completely dependent on the Retiro Park but they encounter significant difficulties when trying to access the park. The maintenance of UGS is appropriate even though some problems arise on occasion. Nevertheless, the functionality of UGS is inadequate, since their size and siting do not allow the establishment of an adequate service.
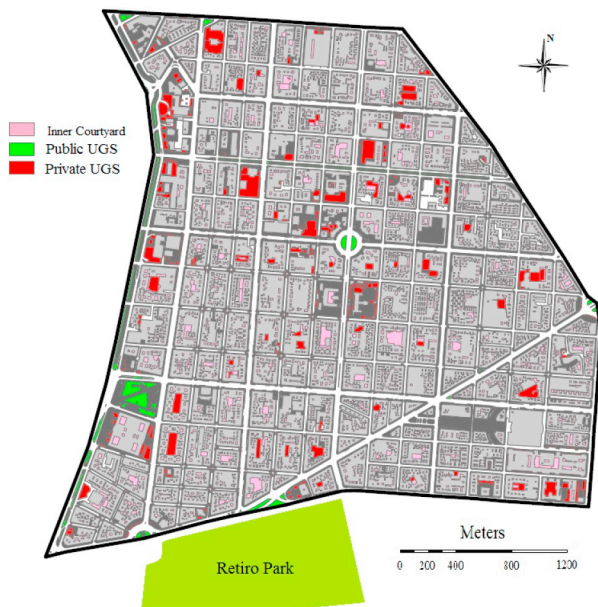
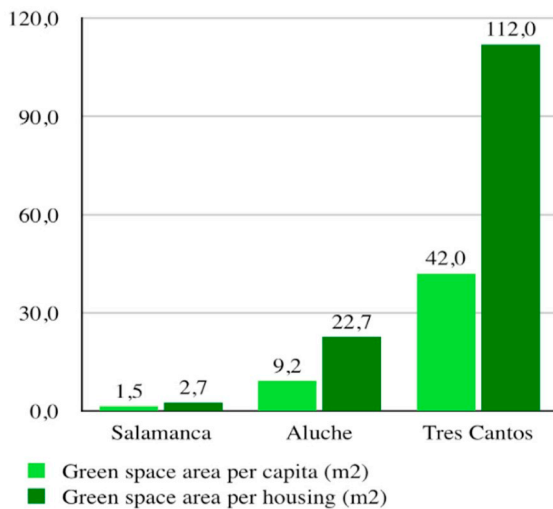**Fig. 5.** Salamanca. Courtyard, public and private UGS.

Fig. 6. Urban green spaces indicators. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3.2. Aluche

3.2.1. Urban project proposed

Aluche is located in the south-west part of Madrid, between the highway connecting the city to Portugal and Carabanchel village. The master plan of 1946 ("Plan general de 1946") and the city regulation of 1950 ("Ordenanzas Municipales de 1950") envisaged Aluche as a green area with restricted construction. The new master plan of 1963 (Plan General de Ordenación del Area Metropolitana de Madrid, 1963) created several districts around the core of Madrid, such as the La Latina District (which contains the Aluche neighborhood). This was because Madrid was facing a demographic pressure, and allowed for the construction of houses in areas destined for green spaces. These districts were designed as an auto-sufficient nucleus separated by green wedges. For this development, a new instrument was used: the Partial Urban Planning Plan. The construction of Aluche began with the "*Plan Parcial de la Ciudad Parque Aluche*" in the 1960s. In this plan, Aluche was composed of residential open blocks. The 63.25% of the total urban area was dedicated to plots, considered as a green matrix on which the

houses would be built. The idea of the plan was to create cores of housing and facilities and thus, the inhabitants could have access to shopping centers, sports halls, schools, and churches (Vilagrasa, 1997). Aluche was supposed to host 19,724 housing units. However, the partial plan fixed a density of 101.4 housing facilities per ha and a building volume of 2.4 m^3/m^2. The surface dedicated to ways was 15.74% of the total urban area, while the total public's UGS area fixed in the plan was 294,065.94 m^2. In other words, 15.06% of the total urban area (COPLACO, PAI Carabanchel Latina, 1963).

3.2.2. Planning evolution

After the Spanish civil war, master plans were articulated in partial plans, with the goal specifying the stipulations defined in those.

Therefore, the partial plan approved in 1963 transgressed the standards of the master plan of 1941 (COPLACO, 1982) and the city regulation of 1950 (Ordenanzas Municipales, 1951), in which the zone was described as a green space and a limited construction zone, respectively.

In 1963, a new master plan was approved that included zoning the area planned in the partial plan of the Aluche neighborhood and described it as a zone of housing with open blocks. Legalizing this way, the situation totally modifies the initial idea of the master plan of 1941 (COPLACO, 1982). The definitive approval of the partial plan of the Aluche neighborhood (COPLACO, 1964 ARCM. Sig.531720/1) (Fig. 7) was a plan lacking a real purpose of facilities and green spaces. Such spaces were poorly defined (COPLACO, 1982). Even so, the partial plan was slightly modified and the result was the increase of construction (around 25%) and the conversion of many green spaces into buildable lots (COPLACO, 1982). Those decisions created an unstructured neighborhood that is characterized by a plethora of urban promotions that lack public facilities and green spaces, as well as presenting various urban forms (Fig. 8).

This development has resulted in the fact that almost half of the space between open blocks (except traffic routes) is privately owned. The vast majority of this space belongs to the neighbor's community (Figs. 9, 10). The real estate pressure was not interested in the trough of the Luche stream and therefore, these lands were dedicated to the "Parque Aluche", green infrastructure that articulates the neighborhood (Figs. 7, 10).

3.2.3. Characteristics of the current situation

3.2.3.1. Population.
Nowadays, Aluche is a neighborhood composed of middle or lower middle class people. The district hosts 50,142
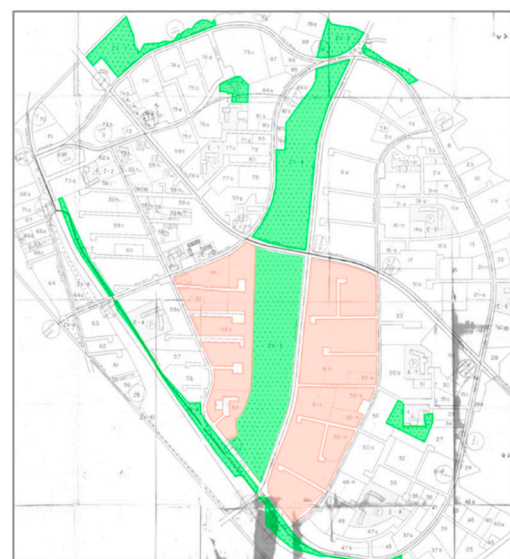

Fig. 7. Proposed partial plan "Ciudad Parque Aluche". UGS and two parcels. Source: Prepared by the authors from COPLACO, 1964 – ARCM. Sig.531720/1.

Fig. 8. Aluche. Two parcels evolution. Proposed partial plan vs. nowadays. Source: Prepared by the authors from COPLACO, 1964 – ARCM. Sig.531720/1).

inhabitants, 20,316 houses and a built-up area of 35.51 m². The average occupation is 2.45 inhabitants per housing (Anuario estadístico, 2008b). The district is affected by population aging and economic development indicators that are not so good. However, health indicators, such as life expectancy (Latina's district average 83.50; max. 84.05 belongs to Aluche neighborhood) is similar to the Salamanca district (mean 84.3) (Source: Madrid Salud, n.d.. Esperanza de Vida por Barrios en la ciudad de Madrid. 2009–2012. Tabla para el total de la población), which is acceptable.

3.2.3.2. Urban morphology. Aluche is the prototype of the 1960s dormitory town, where promotions of 100 or 250 houses are clustered. They are of variable quality and separated by roads. The vast majority of the buildings are collective open blocks (from 4 to 12 floors). The main problem is the incongruent spaces between blocks, as its size is not adequate and there is no relationship between them. For example, some gardens located between blocks are poorly maintained and used as a dump. Aluche created small areas for entertaining and relaxing but the maintenance cost is very high. There are business premises located on the ground floor of some buildings and this has affected the management of the free spaces between blocks. In subdivisions hosting business premises, communities could not use a fence, whereas subdivisions where such premises do not exist installed a fence and created parking spaces for inhabitants. Thus, many promotions were fenced and in turn, pedestrians have serious difficulties moving about the district. All this is a consequence of the lack of design of the free space so that it has coherence and provides urban functionality. The built-up area planned is almost sold out and Aluche is one of the densest urban areas of Madrid. As such, there is a lack of public facilities and green space due to intensive construction. This district reaches 148 housing units per ha (Table 1), but this figure
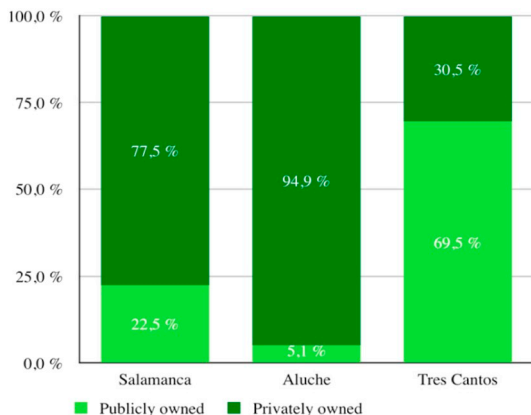

Fig. 9. Percentage of general spaces without large parks.

Fig. 10. Aluche. Courtyard, public and private UGS.

drops to 133 housing units per ha if we take into account the Aluche Park. The road network occupies almost half of the entire surface (Fig. 4) and it is the prevailing element of free space. The lane width is insufficient, as 90% of the buildings located in the study area do not have underground parking. Thus, the district has serious parking problems. Further, parking management is completely disorganized, the roads are invaded and some green spaces have been removed to create parking space. The road design is also not functional to ensure a secure pedestrian path. Only 23.3% of the total urban area is built (Fig. 4), so the free space is very important (74.1%). However, traffic lanes and vehicles invade the neighborhood.

3.2.4. Characteristics of UGS

3.2.4.1. Property regime. Except for the large parks, the majority of the UGS of the district (94.9%) are privately owned (Fig. 9), so the district lacks public UGS and neighbors look after the UGS. Some communities have no access to UGS and depend on public UGS; that is to say, the Aluche Park (Fig. 10).

3.2.4.2. Quantity. In the Aluche neighborhood, the proportion of UGS representing 9.18 m² per person and 22.66 m² per house in Fig. 6. However, without the large parks, the UGS area decreases to 6.15 m² per capita, and 15.17 m² per housing units. UGS represent 30.2% of the total urban area, and are just over a third of the free space, which is predominant in this neighborhood (76.7%) (Fig. 4). Further, the Aluche Park plays an important role in the UGS supply. Without this park, the UGS only represent one-fifth of the study area.

By studying the UGS quantity in respect to their size, it appears that 94% of the UGS has an area of < 500 m² (Fig. 11). This represents 57% of the general green space area and one-third of the total area of the UGS. Thus, only eight UGS have an area between 0.25 and 0.5 ha and only four of them are public lands. Moreover, no UGS has an area of between 0.5 and 5 ha (Fig. 10). The Aluche Park is the only large UGS in the study area and although its central position benefits the entire neighborhood, the lack of medium-sized spaces causes a functional deficit.

3.2.4.3. Quality. If we except the large parks, the percentage of the UGS is low (20,2% of the total urban area) and 9% of it corresponds gardens into components of the road network, so their access is limited or impossible. Besides, 95% of the UGS are privately owned, so some
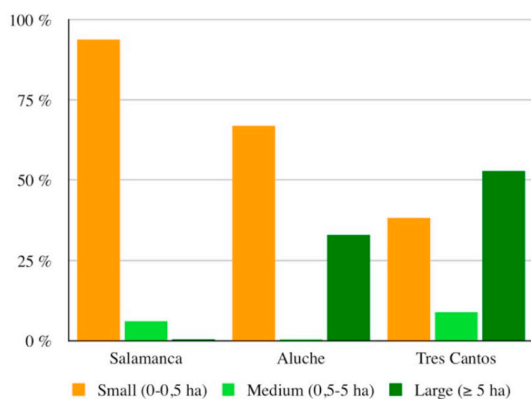
Fig. 11. Classification of UGS according to their size.

are located in fenced households. Access to those UGS is limited or prohibited, while some UGS are not visible from the road (Fig. 16). This is why UGS defer from their management and there are as many UGS with a high level of maintenance as some that are abandoned or poorly maintained. The main issue of the district is the fragmentation and the spread of vacant land due to undefined spaces between blocks. This affects the UGS' size and, therefore, their functionality and creates physical urban barriers, which limit the access to the UGS. Aluche Park's accessibility is adequate from the western border of the park and 91% of the built-up area has direct coverage. That is to say, 91% of the built-up area is located within a 500 m radius of Aluche Park. Thus, public area accessibility is correct, so the maintenance, conservation and functionality of Aluche Park has a decisive influence on the UGS' quality of the district (Table 4). However, this park alleviates the problems described earlier.

3.3. Tres Cantos

3.3.1. Urban project proposed

Tres Cantos is a town in Spain, located in the north-west of Madrid. Tres Cantos is the name of an urban project that was created in 1971. The project consisted of creating a new town with 36,000 housing projects, industries and facilities, a town where people could work, live in harmony with nature and enjoy a higher quality of life than in other towns. Ultimately, it would be a self-sufficient and balanced town. The idea of the plan was to create a city in the shape of a three-branched star. Two branches went to the highway in the east. The urban core was at the centre of the star, while there were sub-centres at the end of the branches and large spaces around them, such as public parks or dispersed residential areas. The urban core was supposed to house many urban promotions, while the two eastern branches constituted an arc hosting the industrial zone. The residential zones were composed of open blocks and each residential zone was supposed to have a number of housing projects between 500 and 800. In the residential zones, pedestrian ways were preferred to roads. The city was divided into sectors (residential, industrial) and also envisaged as a nucleus separated by roads. Public facilities were designed in each sector. The Proyecto de Planeamiento en grado de Avance del Plan Parcial de la Actuación de Tres Cantos, en Colmenar Viejo (COPLACO, 1971), the first master plan of Tres Cantos, was aiming for 36,000 housing units and an available volume of 24,122,116 m³. In this plan, the density restrictions were about 145 housing units per ha for residential compact zones, 33 housing units per ha for residential dispersal zones and 25 housing units per ha for commercial zones. In the plan, UGS were a priority. Between the eastern branches and the arc, the central park was designed around the three branches of the star, and there was a predominance of nature over construction. Large forestry zones were planned at the ends of the town.

3.3.2. Planning evolution

The green space standards fixed in 1971 suffered from modifications due to the creation of new planification documents; however, unlike Salamanca and Aluche, those modifications caused a proportional increase of green space quantity. Thus, the non-accomplishment of the plan has improved the situation of Tres Cantos. In the 1980s, the revision of the master plan, the *Plan General de Ordenación Urbana del municipio,* indicated several deficiencies into the document, including some aspects of the environment and the possible ecological impacts caused by too many roads and facilities, which were ignored (Menéndez de Luarca, 1986, p. 10). In 1984, the special planning *Avance del Plan Especial de Reforma Interior de Tres Cantos (PERI)* for the city reform was approved and thus, the housing number was reduced to 10,000 (almost a quarter of those initially planned) (Fig. 12). Further, the urban core was also reduced and could contain single-family homes. In 1986, the partial plan, *Plan parcial de Tres Cantos,* was created. It decreased the density to 0,75 m³/m² in the non-completed zones. Thus, family housing units were privileged in order to maximize the use of space and privatisation.

Public spaces were redesigned and encouraged private UGS to the detriment of large public UGS because there was an excessive offer of free space. In spite of a drastic building reduction, the UGS were somewhat reduced, even expanded (Fig. 13). The Central Park was redesigned with a slightly smaller area but at the same time, some plots initially dedicated to construction were incorporated into the UGS system (Menéndez de Luarca, 1986 p.72). Tres Cantos initially had urban parks but also, large green zones considered as protection areas, such as the Viñuelas forest and the transition areas of the Pardo Forest (large and valuable natural areas that represent a part of Madrid's natural heritage). These spaces were qualified for "forestry free spaces" and have remained strong over the years. Moreover, two categories of spaces were created: "forest areas of specially protection" and "generic forest areas". In the first category, a strict conservation of the natural values of the space was required, while in the second, greater tolerance was expected for leisure uses and other activities. In addition, the plan established two other categories: " open green spaces for public use" and publicly owned green spaces whose use, open to the public or not, remains undefined (Menéndez de Luarca, 1986, p. 71–73). That is to say, the modification of the planning sought to facilitate the management of the UGS system, but the area dedicated to this use was conserved and even larger.
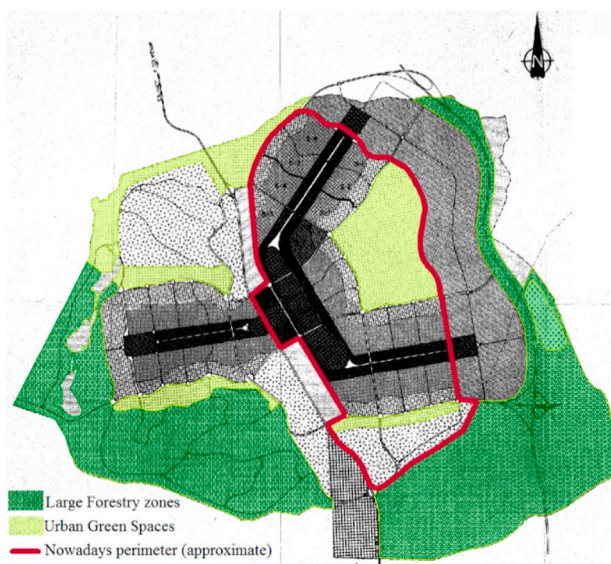

Fig. 12. Tres Cantos Master Plan and current perimeter (approximate).
Source: Prepared by the authors from COPLACO, 1979a – ARCM- Sig. 532,548/ 1.
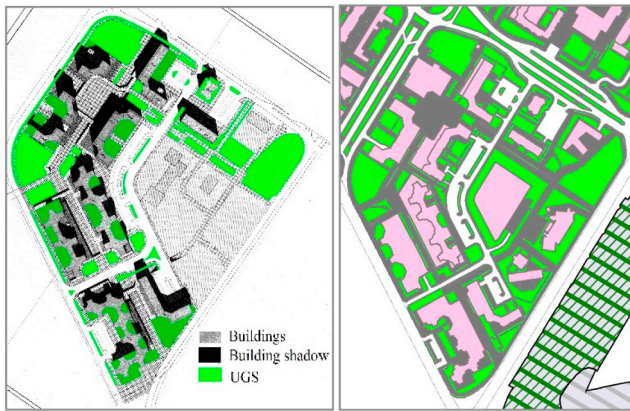
Fig. 13. Tres Cantos. Urban planning proposed vs. nowadays.
Source: Prepared by the authors from COPLACO, 1979b – ARCM- Sig. 532,548/1.

3.3.3. Characteristics of the current situation

3.3.3.1. Population. Tres Cantos is a city of new creation (1971) that nowadays is composed of 27,125 inhabitants and 10,481 housing units in 40.13 ha of built-up area, which represents a density of 158.64 inhabitant per hectare. The average occupation is 2.59 inhabitants per housing unit (Table 1). The population of Tres Cantos is young and almost half of the inhabitants (40.9%) are under the age of 30 years (Table 2).

3.3.3.2. Urban form. Residential collective and single-family constructions are the most representative of Tres Cantos, even though there are other construction types. The residential collective constructions have a typology of open-blocks, as well as closed or semi-closed blocks. Further, the area is composed of collective blocks that accommodate several functions, such as residential, commercial, sporting, and cultural. On the whole, the study area presents an average density of 61.3 housing/ha units (Table 1). As well, 23.5% of the total urban area is made of roads, and 20% is composed of pedestrian ways (Fig. 4). Thus, pedestrian circulation is suitable. Nevertheless, some private buildings are fenced and as such, pedestrians cannot cross anymore. Parking space and lane width are comfortable. In fact, the vast majority of the buildings have underground car parking so parking space in the street is not essential.

3.3.4. Characteristics of UGS

3.3.4.1. Property regime. The percentage of public UGS is very high compared with private UGS (Table 3). More than half of the area of UGS belongs to large parks in the Tres Cantos neighborhood (Fig. 11), and all of them are public property. But, considering only the general UGS, without the large parks included, the percentage of UGS area belonging to private owners is in the minority (30.7%) (Fig. 9).

In addition, private UGS are not evenly distributed, as they accumulate north of the neighborhood, in the first developed areas (Fig. 14).

3.3.4.2. Quantity. At present, the UGS' standard is well above the minimum levels required by the WHO (2012), being that the UGS area per capita is 42 m^2 and 112 m^2 per housing block (Fig. 6). Even without the large parks, which account for about half of the provision, the levels are adequate, being 20.43 m^2 UGS area per capita, and 52.87 m^2 per housing unit.

With the large parks, the UGS represent 50.4% of the total urban area, 60.8% of the free space and the free space area represents 82.8% of the total urban area. The UGS represent half of the total urban area, while the green space area is well balanced between the large parks and other green spaces (Fig. 4). In this case, the UGS are the main component of urban free space.

Table 3
UGS property regime. Percentage of total spaces.
Source: Prepared by the authors on the basis Madrid and Tres Cantos council databases, on January, 12 2010, and GIS measurements.

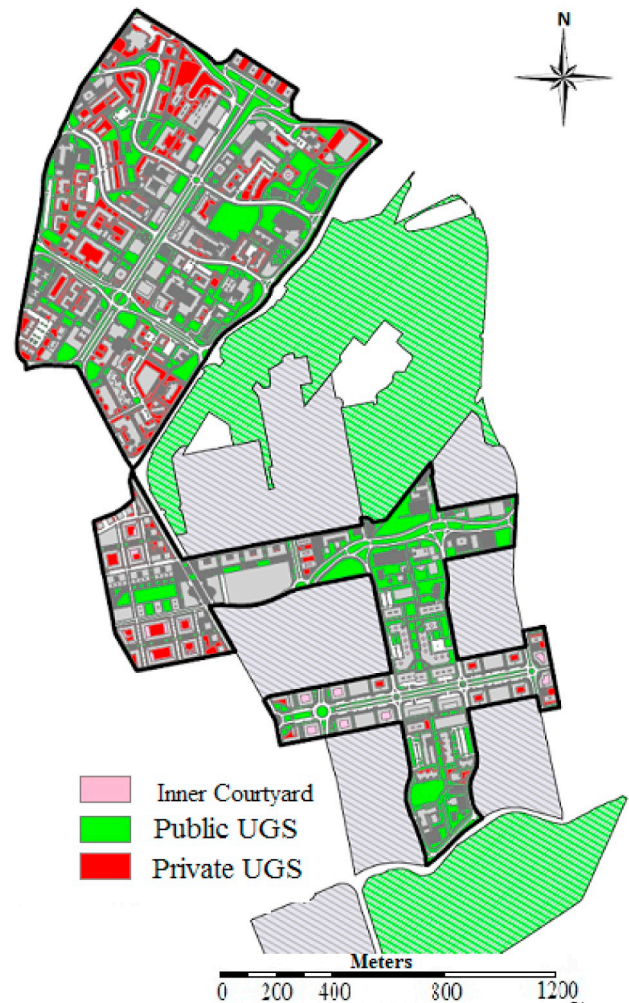|	Salamanca	Aluche	Tres Cantos
Public	22.5%	36.5%	86.5%
Privately	77.5%	63.5%	14.5%

Fig. 14. Tres Cantos. Courtyard, public and private UGS.

The majority of the UGS (80%) is under 500 m^2, but this only represents 30% of the total green space area (Fig. 11). Further, only 15 UGS have an area between 0,5 and 5 ha. Nevertheless, its distribution is uniform in the study area. In addition, the location of the large central park and the existence of the south large park, generate a good distribution of the UGS by size.

3.3.4.3. Quality. This neighborhood has the highest quality levels of the three cases studied, in the three aspects considered. On the other hand, globally, it reaches 75% (11.19/15) of the maximum established amount (Table 4).

Accessibility to the UGS of this district is very good due to its quantity, variety and distribution, while accessibility to the large parks is variable due to the spatial arrangement and geometry of the district (but still acceptable). The accessibility to the UGS is very good, since 98.6% of the built surface of the district is located < 500 m to a medium UGS or large park. There is a wide and comfortable network of pedestrian paths that connect them. Further, the number and

Table 4
Public UGS Quality per neighborhood.

	Salamanca	Aluche	Tres Cantos
Accessibility	1	2.71	3.28
Maintenance	0.9	2.73	4.1
Functionality	1	3.38	3.81
Global quality	**2.9**	**8.82**	**11.19**

arrangement of small UGS (private or public) guarantees even easier access to the population, including children or the elderly. The maintenance of the public UGS and many private UGS is adequate, especially as play areas for children. Thus, UGS are useful and have a diverse and well defined functionality.

4. Analysis and discussion

4.1. Serious breaches of the proposed planning

The three urban planning dispositions were not adjusted to the economic and political situation of the time. They were amended or the stipulations written in them were ignored since their approval. In the cases of Salamanca and Aluche, the conditions of the plans were transgressed due to the tremendous population pressure put on Madrid City. In either case, the building volume and the housing density were increased, removing UGS that were initially planned. The successive transgressions of the plans of Salamanca and Aluche have created dense urban areas lacking facilities. In this respect, the UGS system is one of the most affected entities, as shown by the several cases of these cities. For example, the poor quantity and quality of UGS in Porto was the result of the successive transgressions of the plans and the long period between the elaboration and the approval of them (Madureira et al., 2011). The absence of planning or long-term strategies has caused disastrous results relating to UGS(Rudd et al., 2018). This effect is taking place on the city, district, village and neighborhood scale. However, it also has pernicious effects on UGS even at a very low level of detail, such as in shopping centres (Senanayake et al., 2013). On the other hand, the plan of Tres Cantos contained oversized zones so the city has larger free spaces, which were fixed in the plan. In this case, plans were amended in an opposing direction due to the great economic crisis; thus, urban pressure was weaker than what was fixed in the plan. Yet, a great part of the UGS stipulations of the original plan were implemented, as some of the large UGS of Tres Cantos were already existing and were conserved (specifically the Viñuelas forest and the transition areas of the Pardo Forest) (Menéndez de Luarca, 1986, p.1–10). Therefore, when planning the UGS, considering existing natural spaces or high biodiversity value territories provides great benefits for the existence of the UGS system and its sustainability. This is a conclusion of Byomkesh, Nakagoshi, and Dewan (2012). As well, Rockwood (1995) concluded that urban plans and strategies have to include biodiversity conservation to create "ecologically sustainable urban landscapes". Yang, Huang, Zhang, and Wang (2014) showed that authorities should preserve original vegetation rather than create new green space. Hence, planners also need to create strategies before the creation of UGS systems or in the very early design of them for existing UGS preservation to integrate them in the UGS system, such as in Tres Cantos' case.

4.2. UGS quantity

The urban form design and housing density affect the system of UGS. However, there are other factors that significantly influence the final amount of UGS available. In this way, Salamanca and Tres Cantos have practically the same housing number per built-up area, but the housing number per ha in Salamanca is more than twice the number of

Tres Cantos (Fig. 3). In fact, both Salamanca and Tres Cantos have areas with similar urban forms, such as closed blocks with an inner patio. However, the index of the UGS area per capita is 28 times less, and the index of the UGS area per housing is 42 times less in Salamanca than in Tres Cantos (Fig. 6). The free space of Salamanca is lower but it appears that this zone and Tres Cantos have the same proportion of roads and pedestrian ways (Fig. 4). Salamanca has almost half of the free space of Tres Cantos and Aluche and its free space is unbalanced and dominated by roads. The built-up area is twice as large as the other study cases (56.2% of the total area; Fig. 4). Nonetheless, the main difference between the three cases is the proportion of the total area dedicated to UGS. The proportion of the total UGS area is very poor in Salamanca (4.3%, Fig. 4). Moreover, there are not many cities with a similar situation; for example, several administrative divisions of Colombo (Sri Lanka) contain an UGS area representing 10% of the total urban area (Senanayake et al., 2013). The UGS quantity is somewhat small in Aluche but the situation is not as bad. A similar quantity is present in several types of cities, such as Singapore, with 27.5% of the total urban area (Tan et al., 2013), in Metro Manila (Philippines), with 31% (Nor, Corstanje, Harris, & Brewer, 2017) and in Porto (Madureira et al., 2011). However, in Tres Cantos, the UGS quantity is well above of the other two cases (50.4%, Fig. 4). Anyway, this percentage is lower than expected of the average of European cities. According to the share of Green Urban Areas indicator of the European Union (European Commission and European Green Capital, n.d.) a medium value is from 50% to 60%. This is the Madrid city case. A low value is < 35% as is the case of Barcelona (Spain) or Porto (Portugal) and a great value is > 75% as is the case of Oviedo (Spain) or Perugia (Italy). So, only Tres Cantos are a medium position, Aluche and Salamanca neighborhoods are lowest of the ranking. This indicator is calculated at the city level, so it is possible that it does not adequately describe the urban reality of a neighborhood. Then, we consider World Health Organization (WHO) that recommended the availability of a minimum of 9 m^2 (recommended 10 to 15 m^2) of green space per individual, with an ideal UGS value of 50 m^2 per capita (Russo & Cirella, 2018; World Health Organization, 2012). It is fair to say that Aluche reaches the standard (9.5 m^2/capita) recommended by the WHO (Fig. 6), but Salamanca (1.5 m^2/capita) is at levels similar to those of overcrowded Asian cities, such as Colombo (Senanayake et al., 2013) or Mumbai (Kuchelmeister, 1998). These case studies illustrate that the UGS quantity compared to other uses of urban soil are critical factors of the successful planning and management of UGS (Baycan-Levent & Nijkamp, 2009) and should be taken into account at first. This is because even with urban renewal, areas with a history of low vegetation cover have limited opportunities for future increases of UGS (Tan et al., 2013).

4.3. UGS quality

Several problems arising from the evolution of urban planning have compromised the quality of UGS in addition to its quantity. The neighborhood with the highest overall quality is Tres Cantos, well above the other two cases (Table 4). Nevertheless, Aluche has a comparable figure for the functionality aspect, but this data is misleading, since the table is calculated for public UGS and the data is weighted according to the surface. Thus, in this neighborhood, the Aluche Park has a decisive influence in that value. That is, the functionality of the general UGS of the Aluche neighborhood is not good, only the functionality of Aluche Park is comparable.

At the city and district levels (municipalities), the accessibility of UGS is commonly reduced to the measurement of green surface per capita (Stähle, 2010). This measure may not reflect the importance of type, size, and function of UGS in terms of its true accessibility. So, it is recommended to reconsider the conceptual framework behind the measurement of accessibility to UGS at both levels (Ngom, Gosselin, Blais, & Rochette, 2016). In this work, accessibility has been considered in this sense, therefore, aspects, such as traffic, fences, building shadow,

or the fragmentation of a space for any reason, are discussed in relation to said accessibility.

4.3.1. UGS quality. Accessibility, traffics barriers and fenced

The lane width of Salamanca and Aluche decreased to match the new building volume fixed in the plans. Later, in Salamanca, vehicle traffic was boosted and space was provided for traffic and roads, but to the detriment of UGS and pedestrian ways. Thus, part of the UGS located in boulevards and squares were stuck in the components of the road network (Fig. 15). As such, the pedestrians cannot access those gardens, which are useless.

The importance of accessibility to UGS was studied by various authors (Huang, Huang, Wang, & Zhou, 2018; Khalil, 2014; Li et al., 2005; Morar, Radoslav, & Păcurar, 2014).

Another aspect related to urban traffic that directly accounts for the drop in UGS is the increase in parking needs, which was not foreseen in urban plans.

As a result, in Aluche, the inhabitants were facing a lack of parking spaces, so part of the UGS was used to create secure and fenced parking spaces (Fig. 16). This had an influence on the use and management of the UGS. Further, access to the UGS located in households is restricted or prohibited and some UGS are not visible from the streets due to fences. Those residual spaces are useless but their maintenance is very expensive. Moreover, pedestrians cannot cross households anymore, so the access to the UGS is difficult. This finding is consistent with Pauleit, Ennos, and Golding (2005), who observed this trend in the city of Merseyside in the UK. The authors found that rich areas lost more UGS because front gardens were converted into parking plots. In the case of Aluche, the loss of UGS resulted from a lack of planning.

4.3.2. UGS quality. Maintenance and functionality relation with size and propriety

A smart distribution of UGS is required to create a high quality UGS system (Tan et al., 2013). In the three case studies, only Tres Cantos has a proportional distribution of UGS with a wide range of sizes (Fig. 11) and an adequate distribution. This facilitates accessibility and the functional diversity of such a system.

In Salamanca, almost the entire UGS area is made of spaces with < 0.5 ha and in Aluche, there is no medium-sized UGS (between 0.5 ha and 5 ha) (Fig. 11).

One of the reasons for the poor quality of UGS in Aluche was the planning of the neighborhood in partial plans. The green spaces were proposed as an undefined base on which to situate the buildings. The ownership of these UGS happened to be of the community of proprietors of the houses. As such, this created isolated spaces with undetermined green areas, where open blocks were then built. Those urban forms and the lack of adequate designing of the UGS system in the partial planning created private spaces between blocks. Thus, UGS

Fig. 16. UGS hosting car parks.

designed in those spaces nowadays are abandoned or used as a dustbin because their access and maintenance is difficult by their shape and their size. Some UGS are very small and cannot be used as places for recreation and relaxation and their maintenance is expensive (Fig. 15). Presently, the city council has resigned to create UGS in some spaces and has left them vacant (Fig. 16). Some neighborhood house buildings of 4 to 12 floors that generate a shadow over the UGS (Fig. 16) hinder an adequate growth of the plants and reduce their attractiveness for the population. Free space is fragmented and dispersed, since most of the land dedicated to UGS is privately owned (Fig. 9). When the legislation is insufficient to guarantee access and provision to UGS in the city, the authorities should encourage the owners to create usable green spaces around the buildings (Morar et al., 2014). This concern is manifested at a European level and at other scales, and has formulated a strategy on green infrastructure, emphasizing a more ecological territorial planning and urbanism (Calaza, 2016).

On the other hand, the neighborhood has a poor urban structure due to the lack of connection and coherence between some housing developments and others. That results in poor accessibility to the green spaces and in turn, the pedestrians have difficulties walking through the neighborhood. Nor et al., (2017) found that uncoordinated urban plans threaten UGS systems, as they do not take into account "past, present and future changes to the urban and green space structure".

Consequently, the UGS of Aluche have a number of internal weaknesses, but the UGS functionality is acceptable due the large and public Park "Parque de Aluche" (Table 4). According to Baycan-Levent and Nijkamp (2009), planning and management authorities need to take into account local conditions and local needs. In this case, unlike the Salamanca neighborhood, there is scope for improvement that authorities should consider. In the case of Tres Cantos, there are also some housing developments in the form of open blocks over private parcels, but there are many more public UGS than in Aluche. Besides, the planning modification was made with coordinated partial plans. So, designing a system of public green spaces gives a structure to the urban fabric and provides access to the free spaces. The diversity of UGS sizes, their distribution and their relation to other free spaces (Fig. 17) provides a functional system that meets the needs of the inhabitants of this neighborhood. Both the private and public UGS fulfill their function
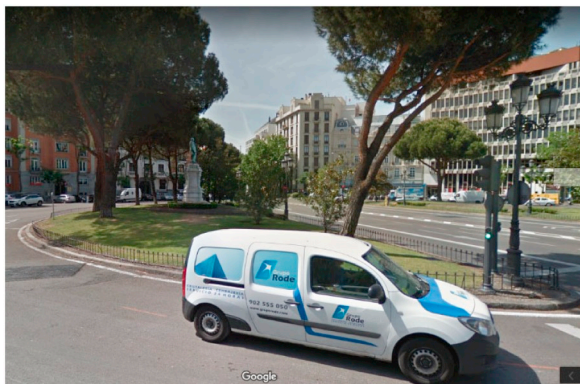

Fig. 15. Marqués de Salamanca Square. Example of small UGS isolated by the road network.
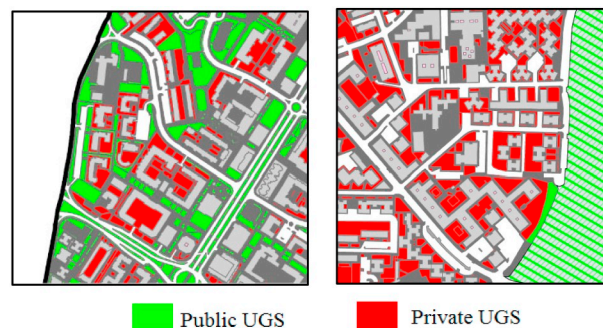

Public UGS   Private UGS

Fig. 17. Tres Cantos vs Aluche. Relation UGS system with private and publics spaces.

Table 5
Features comparative study cases.

POPULATION (Table I)	Salamanca	Aluche	Tres Cantos
Density (inhab/ha)	285.27	365.3	158.64
Housing density	163.74	148.01	61.3
URBAN MORPHOLOGY (fig. 4)	**Salamanca**	**Aluche**	**Tres Cantos**
Open block building vs. Closed manzana	closed	open	both
Built-up area	56%	23.3%	17.2%
Road area	24%	24.4%	17.3%
Pedestrian area	15.5%	22.1%	15.1%
General UGS % area	4.3%	20.2%	23.8%
Large park % area	0%	10%	26.6%
UGS Characteristics	**Salamanca**	**Aluche**	**Tres Cantos**
Property regime - % area private UGS (Table III)	77.5%	63.5%	14.5%
UGS area per capita (fig.6)	1.5	9.2	42.0
UGS area per housing (fig.6)	2.7	22.7	112.0
UGS system balanced by size (fig.11)	no	no	yes
Accessibility (Table IV)	1	2.71	3.28
Maintenance (Table IV)	0.9	2.73	4.1
Functionality (Table IV)	1	3.38	3.81

and are valued for it; therefore, the level of maintenance is high or very high in this case.

In summary, the three cases in the study present common features regarding urban planning, and their transgressions allow similarities to be established in the observed consequences over UGS (Tables 5 and 6). From this, conclusions are drawn about the aspects of planning, with more influence on the UGS' evolution.

5. Conclusions

Planning was not respected in any of the three cases studied. The problems occurring sometimes derived from the planning itself and others, from its lack of application. The UGS of Salamanca are fully non-functional, as the UGS situation in this district is extremely poor in terms of both quantity and quality. Both the general green spaces and the large parks lack a minimum provision. The few existing public UGS

Table 6
Planning characteristics vs. features current UGS. relationship.

	Salamanca	Aluche	Tres Cantos
Design and Planning Proposed and Evolution			
Initial master and partial plan are preserved	No	No	No
Building volume is maintained or decreased	No	No	Yes
Other free space component provision (sidewalks, lane width) is adequate	No	No	Yes
Master plan– partial plan– building are coordinated	No	No	Yes
Most UGS generals are public	No	No	Yes
Large parks initially proposed are maintained	No	Yes	Yes
Planning considers natural spaces already existing (forest, streams, agricultural land)	No	Yes	Yes
Summary features current UGS			
Quantity: General UGS is adequate	No	No	Yes
Quantity: Large park is adequate	No	Yes	Yes
Quality: General UGS is adequate	No	No	Yes
Quality: Large park UGS is adequate	No	Yes	Yes
There is a complete and functional UGS system	No	No	Yes

are stuck in the road network, which is why they are hardly functional. The reduction of the space was dedicated to roads in the plans, which led to the reduction or elimination of sidewalks and boulevards. Thus, the loss of UGS initially foreseen is a crucial problem.

Quantity indicators are slightly better in the case of Aluche. However, there is a severe problem of accessibility and fragmentation due to the lack of foresight in the plans in terms of parking space and the private property of the majority of UGS. Thus, the Aluche Park, which is the only large public space, is a structured part of the neighborhood and ensures an accessibility to the UGS. Further, it partially reduces the deficiencies in the UGS quantity and gives value to the system of the UGS. In the case of Tres Cantos, in-habitants enjoy a good dotation, as the UGS quantity is higher than the standards.

Those transgressions of the planning show that the most important factor affecting UGS systems is the building pressure on the territory planned. Independent of the type of plan and other urban considerations, the lack of planning about other typically urban uses (road network, parking space, etc.) constitutes an additional risk for the UGS system. This system is also very vulnerable to uncoordinated actions, such as partial plans developed in isolation without overall planning (case of Aluche). As such, guaranteeing access and public use of these spaces is a very effective planning measure. Besides, taking into account existing peripheral natural areas, such as forest areas, rivers or agricultural areas under the concept of green urban infrastructure planning, has proven to be very effective.

CRediT authorship contribution statement

Maria Jesus Garcia-Garcia: Conceptualization, Methodology, Investigation, Writing - review & editing, Supervision.**Lucille Christien:**Formal analysis, Writing - original draft.**Enrique García Escalona:**Methodology, Validation, Investigation.**Concepción González-García:**Formal analysis, Writing - original draft, Visualization.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cities.2020.102655.

References

Anuario estadístico 2008a. Información de los distritos. 04. Salamanca. Características generales. Information date: 25th October 2018: https://www.madrid.es/portales/munimadrid/es/Inicio/El-Ayuntamiento/Estadistica/Distritos-en-cifras/Distritos-en-cifras-Informacion-de-Barrios-/?vgnextfmt=detNavegacion&vgnextoid=0e9bcc2419cdd410VgnVCM2000000c205a0aRCRD&vgnextchannel=27002d05cb71b310VgnVCM1000000b205a0aRCRD (accessed 6th March 2019).
Anuario estadístico 2008b. Información de los distritos. 10. Latina. Aluche. Características generales. Information date: 25th October 2018: https://www.madrid.es/portales/munimadrid/es/Inicio/El-Ayuntamiento/Estadistica/Distritos-en-cifras/Distritos-en-cifras-Informacion-de-Barrios-/?vgnextfmt=detNavegacion&vgnextoid=0e9bcc2419cdd410VgnVCM2000000c205a0aRCRD&vgnextchannel=27002d05cb71b310VgnVCM1000000b205a0aRCRD (accessed 6th March 2019).
Barbati, A., Corona, P., Salvati, L., & Gasparella, L. (2013). Natural Forest expansion into suburban countryside: Gained ground for a green infrastructure? *Urban Forestry & Urban Greening, 12*(1), 36–43. https://doi.org/10.1016/j.ufug.2012.11.002.
Baycan-Levent, T., & Nijkamp, P. (2009). Planning and Management of Urban Green Spaces in Europe: Comparative analysis. *Journal of Urban Planning and Development, 135*(1), 1–12.
Bentsen, P., Lindholst, A. C., & Konijnendijk, C. C. (2010). Reviewing eight years of urban forestry & urban greening: taking stock, looking ahead. *Urban Forestry & Urban Greening, 9*(4), 273–280. https://doi.org/10.1016/j.ufug.2010.06.003.
Byomkesh, T., Nakagoshi, N., & Dewan, A. M. (2012). Urbanization and green space dynamics in greater Dhaka, Bangladesh. *Landscape and Ecological Engineering, 8*(1), 45–58. https://doi.org/10.1007/s11355-010-0147-7.
Calaza, P. (2016) Infraestructura verde. Sistema natural de salud pública. Mundi-Prensa Eds. Madrid. ISBN: 978-84-8476-713-8.
CCM (2001). Ayuntamiento de Madrid. *Censo de población y viviendas 2001*. Ciudad de Madrid. Población por tipo de vivienda y Distrito y barrio de residencia. https://www.madrid.es/portales/munimadrid/es/Inicio/El-Ayuntamiento/Estadistica/Areas-de-informacion-estadistica/Demografia-y-poblacion/Censos-de-Poblacion/Censo-de-poblacion-2001/?vgnextfmt=default&vgnextoid=

1136013c7bf39210VgnVCM1000000b205a0aRCRD&vgnextchannel=583011fc98916410VgnVCM2000000c205a0aRCRD.
CCM (2008a). Ayuntamiento de Madrid. Anuario Estadístico 2008. Información de los Distritos. Latina. Características Generales. Table D10T0108. http://www-2.munimadrid.es/CSE6/nas/Distrito10-2008.pdf (last accessed 13th October 2018).
CCM (2008b). Ayuntamiento de Madrid. Anuario Estadístico 2008. *Información de los Distritos. Latina. Población de derecho por grupos de edad y sexo a 1 de enero de 2008*. Table D10T0308 http://www-2.munimadrid.es/CSE6/nas/Distrito10-2008.pdf (last accessed 13th October 2018) .
CCM (2008c). Ayuntamiento de Madrid. Anuario Estadístico 2008. *Información de los Distritos. Salamanca. Características Generales*. Table D04T0108. http://www-2.munimadrid.es/CSE6/nas/Distrito4-2008.pdf madrid/es. (last accessed 13th October 2018).
CCM (2008d). Ayuntamiento de Madrid. Anuario Estadístico 2008. Información de los Distritos. Salamanca. Población de derecho por grupos de edad y sexo a 1 de enero de 2008. Table D04T0308. http://www-2.munimadrid.es/CSE6/nas/Distrito4-2008.pdf madrid/es. (last accessed 13th October 2018).
COPLACO (Comisión de Planeamiento y Coordinación del Area Metropolitana de Madrid) (1964). *Archivo regional Comunidad de Madrid (ARCM) signature. 531720/1 Acuerdo 36/1964. Aprobar definitivamente el plan Parcial de Ordenación de la ciudad Parque Aluche*.
COPLACO (Comisión de Planeamiento y Coordinación del Area Metropolitana de Madrid) (1979a). *Archivo regional Comunidad de Madrid (ARCM) signature. 532548/1 Proyecto de Planeamiento de Ordenación territorial y Urbano. 1979–1980. Urbanización del sector 2 del plan Parcial B, 1ª Fase de la Actuación Urbanísitica Urgente de Tres Cantos (Madrid) y Colmenar Viejo. Plano de Relación y emplazamiento*.
COPLACO (Comisión de Planeamiento y Coordinación del Area Metropolitana de Madrid) (1979b). Archivo regional Comunidad de Madrid (ARCM) signature. 532548/1 Proyecto de Planeamiento de Ordenación territorial y Urbano. 1979-1980. *Urbanización del sector 2 del plan Parcial B, 1ª Fase de la Actuación Urbanísitica Urgente de Tres Cantos (Madrid) y Colmenar Viejo. Plano de ordenación*.
COPLACO (Comisión de Planeamiento y Coordinación del Area Metropolitana de Madrid) (1982). *Latina (Colección Documentos Para Difusión y debate)*. Madrid: Ministerio de Obras Públicas y Urbanismo, Comisión de Planeamiento y Coordinación del Area Metropolitana de Madrid. Centro de Información y Documentación.
COPLACO (Comisión de Planeamiento y Coordinación del Area Metropolitana) (1971) Proyecto de Planeamiento en grado de Avance del Plan Parcial de Actuación de Tres Cantos, approved by the Commission, COPLACO, on December 22, 1971. In section 6 of document: http://www.madrid.org/contratos-publicos/1354363534369/1109266180653/1354363760654.pdf (accessed 2th/oct/2018).
COPLACO (Comisión de Planeamiento y Coordinación del Area Metropolitana) y PAI Carabanchel Latina (1963). *Estudio Urbanístico de Los Barrios* 101,102,103,104-105,106, 107-111, 112, 113-114, 115, 116, 117, Documento Anexo 3.1 Análisis Urbanístico. *Bis. Planeamiento. Plan Parcial de Ordenación no 104. Vol. Volumen 9*Madrid: Ministerio de Obras Públicas y Urbanismo, Comisión de Planeamiento y Coordinación del Area Metropolitana de Madrid Centro de Información y Documentación (1979, 1963).
Dadvand, P.; Tischer, C.; Estarlich, M.; Llop, S.; Dalmau-Bueno, A., López-Vicente, M., Valentín, A., Carmen de Keijzer, C.de, Fernández-Somoano, A., Lertxundi, N., Rodriguez-Dehli, C., Gascon, M., Guxens, M., Zugna, D., Basagaña, X., Nieuwenhuijsen, M.J., Ibarluzea, J., Ballester, F., Sunyer, J. (2017) Lifelong residential exposure to green space and attention: A population-based prospective study. Environmental Health Perspectives 125, no. 9: 097016. doi:https://doi.org/10.1289/EHP694.
Davies, C., & Lafortezza, R. (2017). Urban green infrastructu;in Europe: Is greenspace planning and policy compliant? *Land Use Policy, 69*, 93–101. https://doi.org/10.1016/j.landusepol.2017.08.018.
De Castro, C. M., & Plan Castro (1860). *Edición Facsímil de 1978*. Madrid. España: Colegio Oficial de Arquitectos de Madrid.
Decreto-Ley 7/1970, de 27 de junio, sobre actuaciones urbanísticas urgentes (B.O.E. 30-Abril-1970).
Erickson, L. (2004). The relationship of historic city form and contemporary greenway implementation: A comparison of Milwaukee, Wisconsin (USA) and Ottawa, Ontario (Canada). *Landscape and Urban Planning, 68*(2–3), 199–221. https://doi.org/10.1016/S0169-2046(03)00160-9.
European Commission, & European Green Capital. online 2019 http://ec.europa.eu/environment/europeangreencapital/in/events/feed/ (last accessed 8th. April 2019).
Fuller, R. A., & Gaston, K. J. (2009). The scaling of green space coverage in European cities. *Biology Letters, 5*, 352–355. https://doi.org/10.1098/rsbl.2009.0010.
Garcia Escalona, E. (2010). *El diseño de zonas verdes urbanas en distintos desarrollos de Madrid. Análisis de Salamanca, Aluche y Tres Cantos.* Final Degree projectE.T.S.I. Montes, Universidad Politécnica de Madrid.
García, M. J. (2006). In Universidad Politécnica de Madrid. E.T.S.I. Agrónomos (Ed.). *Evolución de la Planificación y el Diseño de Espacios Verdes en el Madrid Metropolitano durante el siglo XX* PhD. Thesis.
Garcia, M. J., Garcia, A. I., & Atkinson, A. D. J. (2008). Greenspaces planning evolution in Madrid in the 20th century, 100:193. *WIT transactions on the built environment.* New Forest, England: Geo-Environment and Landscape Evolution III.
Haaland, C., & Van den Bosch, C. K. (2015). Challenges and strategies for urban greenspace planning in cities undergoing densification: A review. *Urban Forestry & Urban Greening, 14*(4), 760–771. https://doi.org/10.1016/j.ufug.2015.07.009.
Hilal, M., Joly, D., Roy, D., & Vuidel, G. (2018). Visual structure of landscapes seen from built environment. *Urban Forestry & Urban Greening, 32*, 71–80. https://doi.org/10.1016/j.ufug.2018.03.020.
Huang, C., Huang, P., Wang, X., & Zhou, Z. (2018). Assessment and optimization of green space for urban transformation in resources-based city – A case study of

Lengshuijiang city, China. *Urban Forestry & Urban Greening, 30*, 295–306. https://doi.org/10.1016/j.ufug.2017.12.016.

INE (Instituto Nacional de Estadística) 2019. Variaciones intercensales. Alteraciones de los municipios en los censos de población desde 1842. http://www.ine.es/intercensal/ (last accessed 3th March 2019).

Jim, C. Y. (2004). Green-space preservation and allocation for sustainable greening of compact cities. *Cities, 21*(4), 311–320. https://doi.org/10.1016/j.cities.2004.04.004.

Jim, C. Y., & Chan, M. W. H. (2016). Urban greenspace delivery in Hong Kong: Spatial-institutional limitations and solutions. *Urban Forestry & Urban Greening, 18*, 65–85. https://doi.org/10.1016/j.ufug.2016.03.015.

Khalil, R. (2014). Quantitative evaluation of distribution and accessibility of urban green spaces (case study: City of Jeddah). *International Journal of Geomatics and Geosciences, 4*(3), 526–535.

Kondo, M. C., Fluehr, J. M., McKeon, T., & Branas, C. C. (2018). Urban green space and its impact on human health. *International Journal of Environmental Research and Public Health, 15*(3), 445. https://doi.org/10.3390/ijerph15030445.

Kuchelmeister, G. (1998). Urban forestry in the Asia-Pacific region – Status and prospects. Asia-Pacific forestry sector outlook study. *Working paper no.: APF- SOS/WP/44.* Bangkok: Forestry Policy and Planning Division, Rome & Regional Office for Asia and the Pacific.

Kühn, M. (2003). Greenbelt and green heart: Separating and integrating landscapes in European city regions. *Landscape and Urban Planning, 64*, 19–27. https://doi.org/10.1016/S0169-2046(02)00198-6.

Landry, S., & Pu, R. (2010). The impact of land development regulation on residential tree cover: An empirical evaluation using high-resolution IKONOS imagery. *Landscape and Urban Planning, 94*(2), 94–104. https://doi.org/10.1016/j.landurbplan.2009.08.003.

Lee, G., & Hong, I. (2013). Measuring spatial accessibility in the context of spatial disparity between demand and supply of urban park service. *Landscape and Urban Planning, 119*, 85–90. https://doi.org/10.1016/j.landurbplan.2013.07.001.

Li, F., Wang, R., Paulussen, J., & Liu, X. (2005). Comprehensive concept planning of urban greening based on ecological principles: A case study in Beijing, China. *Landscape and Urban Planning, 72*(4), 325–336. https://doi.org/10.1016/j.landurbplan.2004.04.002.

Lin, B., Meyers, J., & Barnett, G. (2015). Understanding the potential loss and inequities of green space distribution with urban densification. *Urban Forest & Urban Greening, 14*(4), 952–958. https://doi.org/10.1016/j.ufug.2015.09.003.

Madrid Salud. Indicadores de Salud. (http://madridsalud.es/indicadores-de-salud/), http://www.madridsalud.es/pdf/visram/indicadores%20salud/barrios/EV_BARRIOS.pdf (accessed 6th March 2019).

Madureira, H., & Andresen, T. (2014). Planning for multifunctional urban green infrastructures: Promises and challenges. *Urban Design International, 19*(1), 38–49. https://doi.org/10.1057/udi.2013.11.

Madureira, H., Andresen, T., & Monteiro, A. (2011). Green structure and planning evolution in Porto. *Urban Forestry & Urban Greening, 10*(2), 141–149. https://doi.org/10.1016/j.ufug.2010.12.004.

Menéndez de Luarca, J. R. (1986). Tres Cantos: En Busca de La Trama Perdida. *Consejería de Ordenación del Territorio, Medio Ambiente y Vivienda. Centro de Documentación.* Madrid: Comunidad de Madrid.

Morar, T., Radoslav, R., Spiridon, L.C., Păcurar, L. (2014) Assessing pedestrian accessibility to green space using GIS. *Transylvanian Review of Administrative Sciences*, no. 42 E/2014, pp. 116–139. http://rtsa.ro/tras/index.php/tras/article/view/94/90 (accessed on 18th October 2018).

Ngom, R., Gosselin, P., Blais, C., & Rochette, L. (2016). Type and proximity of green spaces are important for preventing cardiovascular morbidity and diabetes–A cross-sectional study for Quebec, Canada. *International Journal of Environmental Research and Public Health, 13*(4), 423. https://doi.org/10.3390/ijerph13040423.

Niță, M.-R., Anghel, A.-M., Bănescu, C., Munteanu, A.-M., Pesamosca, S.-S., Zeţu, M., & Popa, A. M. (2018). Are Romanian urban strategies planning for green? *European Planning Studies, 26*(1), 158–173. https://doi.org/10.1080/09654313.2017.1382446.

Nor, A. N. M., Corstanje, R., Harris, J. A., & Brewer, T. (2017). Impact of rapid urban expansion on green space structure. *Ecological Indicators, 81*, 274–284. https://doi.org/10.1016/j.ecolind.2017.05.031.

Núñez Granés, P. (1910) *Proyecto para la Urbanización del Extrarradio de la Villa de Madrid.* Ayuntamiento de Madrid. https://www.coam.org/media/Default%20Files/fundacion/biblioteca/muestras-fondos/docs/muestra-pedro-nunez-granes.pdf (last accessed 13th October 2018).

Ordenanzas Municipales de la Edificación en Madrid (1951). Ed. Sección de Cultura e Información. *Artes Gráficas Municipales.*

Pauleit, S., Ennos, R., & Golding, Y. (2005). Modeling the environmental impacts of urban land use and land cover change—A study in Merseyside, UK. *Landscape and Urban Planning, 71*, 295–310. https://doi.org/10.1016/j.landurbplan.2004.03.009.

Plan Castro (2018) *El Ensanche de Madrid.* Blog. Madrid: Edificios, lugares e historias sobre la ciudad (blog), 25 April 2018. https://edificiosmadridblog.wordpress.com/2018/04/25/plan-castro-el-ensanche-de-madrid/. (last accessed 13th October 2018).

Plan Castro, 150 años (2010). Ayuntamiento de Madrid. Área de Gobierno, Urbanismo y Vivienda https://www.madrid.es/UnidadWeb/Contenidos/Publicaciones/TemaUrbanismo/PlanCastro/plancastrocorr.pdf. (last accessed 13th October 2018).

Plan General de Ordenación del Area Metropolitana de Madrid. Ley 121/1963 de 2 de Dic. sobre el Area Metropolitana de Madrid. Boletín Oficial de la Provincia de Madrid. 1963/Dec/17. http://www.bibliotecavirtualmadrid.org/bvmadrid_publicacion/i18n/catalogo_imagenes/grupo.cmd?path=1119543 (last accessed 13th October 2018).

Rockwood, P. (1995). Landscape planning for biodiversity. *Landscape and Urban Planning, 31*, 379–385.

Rudd, A., Simon, D., Cardama, M., Birch, E., & Revi, A. (2018). The United Nations, the urban sustainable development goal, and the new urban agenda. In T. Elmqvist, X., et al. (Eds.), Urban planet: Knowledge towards sustainable cities (pp. 180–196).: Cambridge University Press. doi:https://doi.org/10.1017/9781316647554.011.

Russo, A., & Cirella, G. T. (2018). Modern compact cities: How much greenery do we need? *International Journal of Environmental Research and Public Health, 15*, 2180. https://doi.org/10.3390/ijerph15102180.

Schilling, J., & Logan, J. (2008). Greening the Rust Belt: A green infrastructure model for right sizing America's shrinking cities. *Journal of the American Planning Association, 74*(4 (21 October 2008)), 451–466. https://doi.org/10.1080/01944360802354956.

Senanayake, I. P., Welivitiya, W. D. D. P., & Nadeeka, P. M. (2013). Urban green spaces analysis for development planning in Colombo, Sri Lanka, utilizing THEOS satellite imagery – A remote sensing and GIS approach. *Urban Forestry & Urban Greening, 12*(3), 307–314. https://doi.org/10.1016/j.ufug.2013.03.011.

Sperandelli, D. I., Dupas, F. A., & Dias Pons, N. A. (2013). Dynamics of urban sprawl, vacant land, and green spaces on the metropolitan fringe of São Paulo, Brazil. *Journal of Urban Planning and Development, 139*(4), 274–279. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000154.

Stähle, A. (2010). More green space in a denser city: Critical relations between user experience and urban form. *Urban Design International, 15*, 47–67.

Tan, P. Y., Wang, J., & Sia, A. (2013). Perspectives on five decades of the urban greening of Singapore. *Cities, 32*, 24–32. https://doi.org/10.1016/j.cities.2013.02.001.

European common indicators: Towards a local sustainability profile. In V. Tarzia (Ed.). *Technical report.* Milano, Italy: Ambiente Italia Research Institute.

Taylor, J., Paine, C., & FitzGibbon, J. (1995). From greenbelt to greenways: Four Canadian case studies. *Landscape and Urban Planning, 33*(1–3), 47–64. https://doi.org/10.1016/0169-2046(94)02013-6.

Tilley, S., Neale, C., Patuano, A., & Cinderby, S. (2017). Older People's experiences of mobility and mood in an urban environment: A mixed methods approach using electroencephalography (EEG) and interviews. *International Journal of Environmental Research and Public Health, 14*(2), 151. https://doi.org/10.3390/ijerph14020151.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. *Landscape and Urban Planning, 81*(3), 167–178. https://doi.org/10.1016/j.landurbplan.2007.02.001.

United Nations (2014). *World urbanization prospects: The 2014 Revision.* Department of Economic and Social Affairs, and Population Division.

United Nations -Habitat (2013). *Streets as public spaces and drivers of urban prosperity.* Nairobi: UN-Habitat.

United Nations-Habitat (2016). *Global state of National Urban Policies Report.* Nairobi: UN-Habitat.

Van Herzele, A., & Wiedemann, T. (2003). A monitoring tool for the provision of accessible and attractive urban green spaces. *Landscape and Urban Planning, 63*(2), 109–126. https://doi.org/10.1016/S0169-2046(02)00192-5.

Vilagrasa, J. (1997). *Vivienda y promoción inmobiliaria en España.* Ed. Universidad de Lleida (978-84-8409-702-0).

World Health Organization (2012). *Health indicators of sustainable cities in the context of the Rio+20 UN Conference on Sustainable Development.* Geneva, Switzerland: WHO2012.

Xing, L., Yanfang, L., Liu, X., Wei, X., & Mao, Y. (2018). Spatio-temporal disparity between demand and supply of park green space Service in Urban Area of Wuhan from 2000 to 2014. *Habitat International, 71*, 49–59. https://doi.org/10.1016/j.habitatint.2017.11.002.

Yang, J., Huang, C., Zhang, Z., & Wang, L. (2014). The temporal trend of urban green coverage in major Chinese cities between 1990 and 2010. *Urban Forestry & Urban Greening, 13*(1), 19–27. https://doi.org/10.1016/j.ufug.2013.10.002.

Yokohari, M., Takeuchi, K., Watanabe, T., & Yokota, S. (2000). Beyond greenbelts and zoning: A new planning concept for the environment of Asian mega-cities. *Landscape and Urban Planning, 47*, 159–171 (ISSN: 0169-2046).

Zapatero Santos, M. A. (2017). La Densidad Urbana: Concepto y Metodología. Análisis Comparativo de los Tejidos de Madrid. *Final degree project*ETS Arquitectura, Universidad Politécnica de Madridhttp://oa.upm.es/45491/1/TFG_Maria_Antonia_Zapatero_Santos.pdf.