Analysis and evaluation of the quality of open spaces and green zones in periurban landscapes, the greengates as strategic nodes of green infrastructures.

The case of the northern border area of the municipality of Fuenlabrada (Madrid, Spain) in its contact with the area called Bosque Sur and the case of the cities of the Dutch Randstad and their mediation or buffer zones.

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Abstract

The aim of this paper is, starting from the problem of peripheral landscapes produced by urban sprawl forms, to define a methodology for analysing the quality of peripheral public space in municipalities surrounded by natural spaces of environmental value, in order to evaluate their potential quality as environmental corridors, civic axes and natural gateways. To define the evaluation with proper indicators the investigation is based in the origin of the urban greenbelts and in the case study of the northern boundary of the municipality of Fuenlabrada (Madrid, Spain) with the Bosque Sur Periurban Forest Park and its comparison with Midden-Delfland, a buffer-zone belonging to the area known as Randstad Holland.

Keywords: greengates, periurban territories, green infrastructure

1. Introduction. Urban sprawl as a form of urban growth

Peri-urban territories have evolved since the mid-20th century towards a remarkable dispersion of their built space, with a large proliferation of industrial land infrastructures and operational landscapes (Brenner & Nikos, 2020) which have led to the fragmentation of originally natural areas.

The dynamics of urban growth resulting from the so-called Capitalocene (Moore, 2017) have caused a substantial reduction of the natural space which, originally, due to its size, was the container of the limited built space of the isolated municipalities and which has become a stressed "edge" space in which its natural and landscape qualities are strongly altered.

The European Union, through the European Environment Agency (Agency, 2016) has issued reports on the situation in such territories, warning about this complex problem and proposing measures to build detailed guidelines and support for national operational policies.

The report *Urban sprawl in Europe* highlights the environmental and socio-economic problems of these growth patterns. Even in areas where the expansion of built-up space has continued to take place despite a declining population (Haase, et al., 2014).

In addition to proposing parameters for measuring urban sprawl, the report proposes different methodologies for its analysis: those that insist on the need to work with as many variables as possible, others that propose integrating the different variables and the third, which opt for measures based on one or a few variables.

Spatial policy measures propose a review of spatial and urban planning, but also highlight the relevance of possible actions in favour of biodiversity recovery and enhancement and nature conservation.

Reflection on how to analyse and plan these complex territories, made up of overlapping layers like a palimpsest (Corboz, 1983). Built up over the years, it has developed in Europe from examples such as the Dutch Randstad, the Italian Veneto, the Flemish Diamond or the German Ruhrgebert.
The need for an integral conception of the territory from a strategic vision implies an architectural understanding of the territory, with a special sensitivity for the exploration of the structures and formal features of different natural and rural spaces and the effects of urban sprawl (Alonso Teixidor, 2024).

1.1 The empty territories of urban sprawl

In peri-urban landscapes shaped by the urban sprawl growth model it is essential to consider spaces not colonised by urbanisation, such as protected natural spaces, as vital nuclei of the territory, from which green infrastructures can cushion the effects of the urban continuum and provide natural continuity in already urbanised territories.
In addition to the areas protected for their natural and environmental value, it is necessary to point out the relevance of the areas bordering the municipalities, which are usually places with a higher level of biodiversity, as opposed to some large open spaces. The so-called *third landscape* (Clèment, 2020), the one that escapes from territorial exploitation practices, which does not belong to a protected natural environment and is not considered as a place to be designed, is an agglutinating space of great biodiversity with a great regenerative capacity in natural and environmental terms.
These hinge spaces, between the naturalised urban space, the third landscape, and the protected natural spaces, can be considered as greengates, gateways to nature from the city, and at the same time, as connecting focal points and carriers of biodiversity.
In this research we approach two areas: the model set by Midden-Delfland and the southern periphery of Madrid, with Bosque Sur, as a study of a complex peri-urban space. The work intends to emphasise the strategic spaces of connection between the urbanised space and the peri-urban green areas, based on a historical review of the origins of the recognition of the need for a link between city and nature, in order to promote a healthy habitat.

2. The origins of green belts. Boundary and landscape

The edges of growing cities are often areas of ambiguity, particularly unstable in their forms and uses. Many of the peripheries of post-industrial Europe's urban areas show considerable differences with those built along the growth of industrialisation: unstructured territories, made up of pieces of fragmented urbanisation in their forms and functions, physically connected -or segmented- by motorways, roads or railway lines. The underlying territorial processes have been overwhelmingly dominated by markets, often under conditions of high uncertainty, and with environmentally unsustainable outcomes (Teixidor, 2014).
The pressure exerted by residential and industrial growth and the growth of the operational landscapes serving the urban has led to the fragmentation and atomisation of undeveloped spaces, as well as to a formal lack of definition of the urban edges, which are configured as heterogeneous territories, not very permeable with their surroundings and disconnected from their territorial support.
However, they can be considered spaces of opportunity as growth buffer zones, as naturalisable territories, capable of hosting greater biodiversity and functioning as ecosystem services providing green and blue infrastructure to existing urbanised areas.

The integration of the city and nature was consolidated at the end of 19th century and beginning of the 20th century with Ebenezer Howard, intellectual father and promoter of the so-called English garden city, which can be seen -as Rasmussen (2010, p. 235) does in his work *Londres, ciudad única*- in continuity with the English tradition that proposes an alternative to the compact city that recovers an idealised vision of medieval England in which the city is situated in balanced harmony with the countryside and nature.

But the concept of preserving green zones as limits to growth in the city is also complementary to that of shaping and defining a peripheral landscape that is easily accessible to citizens. So green belts have a dual function: that of containing growth and that of providing healthy uses and natural landscapes.

One of the most important aspects of Howard's proposal is the awareness of the vertiginous increase in the size of a city like London and, therefore, his model of the city uses the idea of the limit as a fundamental instrument. A conception of the limit that is irremediably linked to the possibility of reaching it on foot, of being able to feel close and easily accessible the end of the urban environment and the beginning of another type of environment that is sometimes formalised as countryside and at other times as nature.

2.1 Ebenezer Howard and the notion of limit in the English Garden City

This idea of Howard (2018), which is an emancipating idea with respect to the confinement and overcrowding that the industrial city represented for most people, is linked to the image that English Romanticism had been creating since the 18th century, that of an inhabitant of the countryside -identified in Romantic imagery with a shepherd- who enjoys an ideal freedom that he uses to wander around the territory. This identification between walking and freedom is precisely what will make the proximity between the urban core and its surroundings so important in Howard's conception, introducing as a guarantee of this proximity the idea of a limit to urban growth as opposed to unlimited sprawl, an issue that in later developments of this same idea will also be taken up, both in Unwin's proposals and in the Green Belt of Abercrombie's Greater London Plan.

Howard's work abounds in references to walkable distances between its various parts (Howard, 2018) and it is a quality, its walkability, that determines so many of the characteristics of the proposed city: its dimensions, the proximity between its different elements and the construction of its clean and green atmosphere that makes walking a pleasant and liberating experience.

'(…) so that from any part of the city perfectly fresh air and grass and sight of far horizon might be reachable in a few minutes' walk. This the final aim' (Ruskin, 1865 in Howard, 2018, p. 53). This is part of the second of the three quotations with which Howard begins the first chapter of his work and with it he states that his urban proposal contains the idea of the proximity between the countryside and the city, that is, that the undeveloped outdoors should be within easy walking distance of the city (Fig. 1). It is not only that the city and the countryside merge -the city in the garden-, that the dwellings of its inhabitants are surrounded by trees or that these and the streets are part of the garden, but also that the countryside must always be close by. And close means on foot, i.e. walking a reasonable distance.

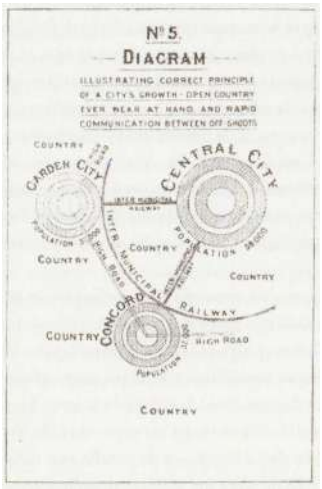

Figure 1. Diagram by Howard in which he tries to explain the relationship between the different garden cities. The commentary accompanying the diagram states 'open country ever near at hand'.
Source: Howard, 2018, p. 195

2.2 The proximity between the countryside and the city in Arturo Soria's Linear City

This idea, for example, was perfectly embraced by Arturo Soria. His linear city contains a city that can be infinite in one direction, along the line, but which always has the countryside nearby, at a walkable distance in the transversal direction (Fig. 2). Indeed, This is another urban model -contemporary to Howard's- which also raised this issue even in its formal conceptualisation. Here, its creator assumes the idea of proximity between the city and its surroundings and makes it more radical in formal terms: The linear city of Arturo Soria is urban –endlessly urban- in one direction -the longitudinal- but at the same time, if in Arturo Soria's time it had been crossed transversally, it would have been possible to be completely outside the urban environment in barely three minutes on foot. Its linear configuration imposes -from its very form- that proximity between the countryside and the city that is so important for the formalisation of the new urban model.
The city envisioned by Howard is not only a city in the garden but, above all, a city close to the garden, or rather, a city within walking distance of the garden. As the famous diagram of the magnets so aptly expresses it, Howard (2018, p. 47) does not despise the advantages of the city, but thinks it is possible to reconcile them (Howard, 2018, p. 50) with the benefits provided by the countryside. With those advantages that life in small communities had. Among others, with the advantage of proximity to the non-urban environment, i.e. the countryside and nature.

Figure 2. Oblique view of Arturo Soria's Linear City with the city in the foreground and the nearby rural landscape extending from its edges to the horizon.
Source: https://commons.wikimedia.org/wiki/File:Ciudad_Lineal-acuarela.jpg

2.3 Limits, nature and proximity in the Australian city of Adelaide

Howard (2018, p. 193) mentions in his work the case of the Australian city of Adelaide, designed by Colonel Light, which, according to Hall (1996, p. 99),, was instrumental in providing the idea that once a city had reached a set population limit, another settlement should be created, separated from the first by an undeveloped area. The proposal for Adelaide, a typical colonial grid, included a substantial land reserve surrounding both the original core and its subsequent growth to the north of it. Light's proposal included in this wide belt -originally nine hundred and thirty hectares- just a few amenities, but above all it was dominated by the course of the Torrens River -or Karrawirra Parri River, according to the aboriginal name- as the main natural element that articulated this space and the relationship between the two settlements. This prominent inclusion of the river -with its natural course highlighted- also brings Light's proposal (History Trust of South Australia , 2019) closer to the contemporary sensibility regarding the value of primal nature as opposed to that which has been modified by human intervention.
However, Light was at least sufficiently skilful and pioneering to formalise that reserve of land which guarantees immediate contact between either of these two Adelaide urban centres and a green belt dominated by the River Torrens (Fig. 3), while, for example, in Hampstead, the city built by Unwin and Parker following Howard's teachings, and in Arturo Soria's Linear City, where this immediacy with respect to the countryside was fundamental, the growth of their respective metropolises has ended up absorbing the garden city proposed in each case, completely erasing the countryside from its surroundings.

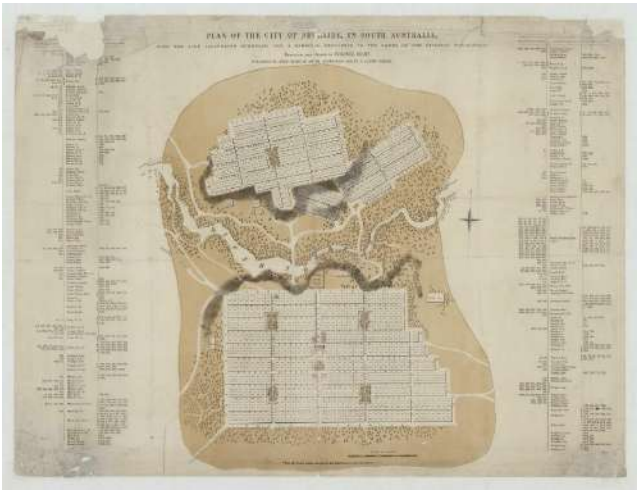

Figure 3. Plan of the proposal for Adelaide by Colonel William Light with the two cores and the space between them characterised by the presence of the river.
Source: https://adelaidia.history.sa.gov.au/panoramas/lights-plan-of-adelaide-1840

2.4 The challenge of the endless city

The city proposed by Howard was designed from the perspective of walking. It has behind it a tradition of rediscovering the landscape from the perspective of the walking human being as opposed to the acceleration proposed by the automobile. The image of medieval England as a country of villages that characterised the imagery of the Romantic period was also key to Howard's conceptualisation and is precisely illustrated in the idea of direct access to the environment. Even in medieval towns, their size was also adjusted to distances that allowed them to be easily traversed or exited in the direction of the surrounding countryside in a short time. In the collective memory of Ebeneezer Howard's contemporaries, the image of pre-industrial London portrayed, for example, by Daniel Defoe, is still vivid. Defoe's work (1986), *A Tour through the Whole Island of Great Britain,* is considered by scholars of British history as a fundamental text that allows to visualise -despite some inaccuracies and inventions- the image of Britain just before the emergence and consolidation of the Industrial Revolution (Rogers, 1986, pp. 10-11). In the case of London, especially, this transformation moves between the beginnings of suburban expansion -intensely speculative- after the Great Fire of 1666 and the definitive demographic explosion of industrialisation. And although Defoe himself is astonished at the size the city has recently acquired (Defoe, 1986, p. 286), in fact, it is still a contained and manageable city, especially from the perspective of the stroller, and he himself walks without difficulty from the centre of London to some of the first suburbs -Islington, Newington, Chelsea, London, Newington and Chelsea (Defoe, 1986, pp. 287-288) or Hackney, Newington, Tottenham, Edmonton (Defoe, 1986, p. 337)- which are now just parts of the immense city.
London at that time was of a contained size that allowed access on foot to its natural and rural perimeter. From what is probably the earliest description of London by Thomas Becket's twelfth century biographer -William Fitz-Stephen-, Ackroyd (2012, pp. 83-84) highlights the immediate countryside and nature surrounding the city: past the wall, to the west 'were gardens and vineyards among which were the mansions of the noble and powerful'; to the north, 'stretched meadows and pastures bordering on 'an immense forest', of which Hampstead and

Highgate are now its only remnants'; to the north-west 'there was a meadow now known as Smithfield, where every Friday horses were sold'; and in other meadows around 'pigs and oxen were slaughtered and sold'. Even in the 16th century, cities were still relatively small and, although part of the population might live outside the city walls in the emerging suburbs, these were far from being extensive. And so, what still distinguished medieval cities like Exeter, capital of a vast province, from the sprawling patches that would emerge after the Industrial Revolution, was that 'one could have walked around the entire circuit of the city walls in half an hour, or could have reached the open country form the centre of the city in any direction in fifteen minutes' or ' Even London, with its sixty or seventy thousand people, was soon left behind if one had in mind to see the green fields and natural heaths' (Hoskins, 1981, p. 147).

3. Urban Green Rings and Greenheart as contemporary territorial strategies

Indeed, several authors (Freestone, 2002) claim that the origin of the Green Rings lies in the proposals made by Ebenezer Howard at the end of the 19th century. The background described above pointed to a problem -that of the unrestricted growth of the metropolis and to the need for a new form of urban development-, but they also opened the way to address a response, indicating to planners the inescapable need to maintain or generate links between the intensely built space of the city and a contrasting rural or natural environment.
The consideration of this system of open spaces as a tool for urban planning has served, in the development of numerous European cities (London, Vienna, Frankfurt, etc.), not only to combat sprawl, but also to provide solutions of a social and environmental nature, promoting the protection of natural areas and the conservation of agricultural and livestock areas, providing leisure and recreational areas for citizens.
Green Rings are not instruments that have served to formalise similar peri-urban spaces, but they have become a tool to define new concepts such as urban green infrastructures, so recurrent in the design of new urban models aligned with the fight against climate change and environmental responsibility (Ahern, 2007).
The classic form of green belts is that of a ring of open spaces surrounding the city, although it can often take on irregular shapes depending on the geographical characteristics of the area. (Aguado, et al., 2017)

However, growth containment associated with green buffer spaces has historically been conceived primarily with three formal outcomes: Greenbelt, Greenheart and the Finger Plan (Vejre, et al., 2014). There are studies that assess the effectiveness of some versus others in terms of growth restriction (Kuhn, 2003). However, they all agree on the clear social benefit they provide as spaces for the use and enjoyment of citizens and for the definition of a habitable landscape connected to the urban environment.

4. Midden Delfland in Randstad Holland

With the double purpose of understanding Bosque Sur -the study area where the Green Arc of Madrid meets the northern edge of Fuenlabrada- and having a reference on this type of space, a comparison and contrast area has been chosen in the Netherlands: Midden-Delfland. This is a buffer zone between Rotterdam and The Hague, two of the largest cities in a country credited for its culture of spatial planning.

The meaning and role of Midden-Delfland, are better understood it in its context, within the Dutch multi-scale territorial system where landscape and planning intersect. A good approach to this system is provided by the short section on the Netherlands in Peter Hall's classic book

'Urban and Regional Planning' (Hall, 1992, pp. 197-202), which is complemented by the much more recent and extensive 'The Randstad: A Polycentric Metropolis', edited in 2021 by Vincent Nadin and Wil Zonneveld (Nadin & Zonneveld, 2021). The following text draws on both sources, as well as on unpublished academic work by Ignacio Bisbal, Marcos Delgado, Javier Malo de Molina and Emilio Ontiveros, which also drew on the sadly no longer available bulletins of the Netherlands Institute of Geography, IDG.

4.1 The Randstad, the denser urban structure of Western Europe

The west of the Netherlands lies at the centre of a metropolitan belt, with an axis between London and Milan, which concentrates a high proportion of Europe's economy and urban population. There, at the mouth of the Rhine, is one of the most important urban regions in Europe, with a population of around 7 million inhabitants. Almost 40% of the Dutch population is concentrated in just 5% of the country's surface area, reaching a higher degree of metropolitan concentration than in Great Britain or France.

4.1.1 A polynuclear model

Despite the high density, an observer's impression is not that of a large, saturated metropolis. What was once a medieval network of small towns, became an important enclave in the 19th century thanks to its industrial and commercial development. The transformation of the Rhine into a major artery in Western Europe made its mouth the prize for the Netherlands. Thus, as Germany became an industrial power, the Netherlands also developed as a trading power. In 1850, the cities in the west of the country were separate entities. By 1950, these cities had extended to almost touch each other, forming an urban perimeter. This territorial structure is called the Randstad (edge city or ring city), a term coined in 1938 by Albert Plesman, founder of the Dutch airline KLM, describing what the view from his aeroplane (Nadin & Zonneveld, 2021, p. 10)

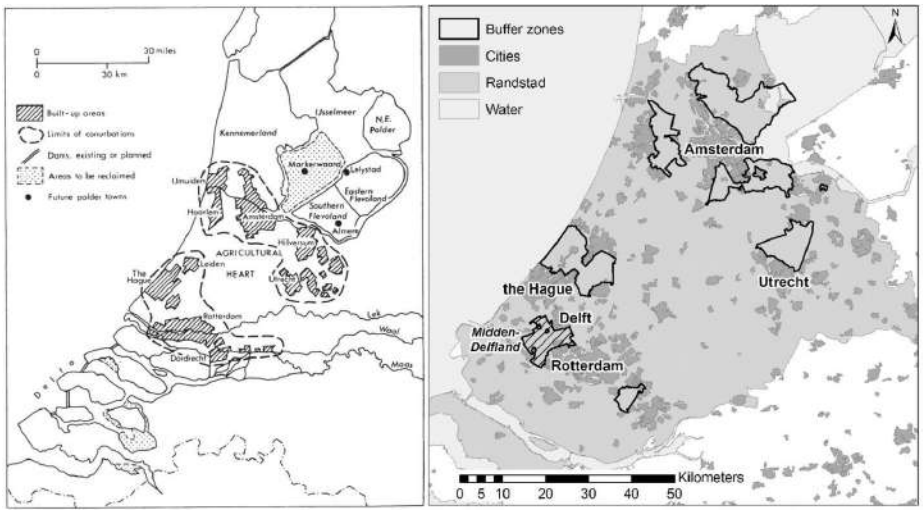

Figure 4. Left: Randstad Holland (Hall, 1992, p. 198)
Right: Midden-Delfland and other buffer zones in the Randstad (Koomen, 2008, p. 38)
Sources: Referred bibliography

4.1.2 Morphology and programme

The Randstad adopts the layout of a ring of cities physically separated along a 180 kilometre horseshoe-shaped line. The ensemble comprises the four most populous cities in the Netherlands: Amsterdam, Rotterdam, The Hague and Utrecht, as well as a number of intermediate cities such as Haarlem, Leiden, etc. Each city is separated from its neighbours by green zones and all of them overlook a large, less urbanised inner area, called Green Heart, which is protected by planning (Fig. 4). This polycentric territorial model is not limited to a physical aspect but is also operational. The larger cities in this structure adopt differentiated functions: the seat of government and international justice are in The Hague; the largest port and heavy industry in Rotterdam; the financial world, tourism and culture in Amsterdam; congresses and research and development venues take advantage of the railway node in Utrecht. This configuration avoids certain problems of large mono-nuclear cities, shortening commuting times and reducing traffic jams (Hall, 1992, p. 197).

4.2 The Randstad's metropolitan *Green Heart*

4.2.1 Evolution of the concept

Historically, the Green Hart had been a marshy area unsuitable for the development of cities, which sought dry and elevated sites. From the early Middle Ages onwards, thanks to windmills, this land was drained for agricultural use (Korthals Altes, 2018). The area remained as such until the development of settlements around its perimeter began to threaten it. In 1960, the 1st Dutch Spatial Planning Guideline highlights this area and decides to preserve it as an agricultural area free of urbanisation. The 2nd Guideline (1966) sought to control the growth of settlements within the Green Heart by designating a few suitable localities and thus maintaining the defensive sense of planning. It was not until the 3rd Guideline (1973) that other functions of the area, compatible with its agricultural status, were considered: recreational programmes and the development of ecosystems through planting. Until then, the Green Heart had an almost conceptual character, lacking clear boundaries. Although in theory residential growth and new roads were to be avoided within it, in practice its extension was reduced in areas close to large cities.

Figure 5. The Randstad's Green Heart. To the left, Midden-Delfland.
Source: Prepared by the authors of the paper

4.2.2 The role of the Green Heart in planning

In 1990, with the 4th Guideline, its boundaries were precisely delimited and in 1996 the Green Heart Administrative Platform was established. This platform, although it had no legislative powers, was the forum for discussion of Green Heart issues. This made it possible to gather precise statistical data on the Green Heart municipalities, their population, land use, etc. In terms of growth within the Green Heart, restrictions were set for businesses, offices and new communication infrastructures, and residential growth was limited to the six historic urban centres. Three landscape types associated with specific uses were delineated: a) the lake environment (for ecosystem conservation and recreational programmes); b) the marsh and grassland areas in the north and on both banks of the Lek River (subsistence agriculture and ecosystem conservation); c) grasslands in the west (agricultural farms, greenhouses, and forestry). In addition, it was decided to invest in creating new ecosystems, developing new networks of canals for recreational boats and cycle paths, and planning the transition areas between the large cities and the Green Heart.

4.2.3 Tensions over the Green Heart

A prevailing idea in successive planning guidelines in the Netherlands has been the fundamental need to keep the Green Heart of the Randstad undeveloped. However, demographic and economic pressures ignored this recommendation and resulted in the Green Heart being diminished: south of Amsterdam, at Schiphol airport, east of Utrecht, along the Rotterdam-Delft-The Hague-Leiden line, and on the periphery of inner towns.

4.3 ***Midden-Delfland: a buffer zone between Rotterdam and Delft***

4.3.1 Countering the Randstad' saturation

In a context of high population growth, buffer zones emerged as areas of containment of urbanisation in the 1st Guideline to preserve the historic cities of the urban ring as separate and distinct points. These zones were designated as spaces for parks, drainage areas and public bathing areas. The treatment of these areas has evolved in a similar way to that of the Green Heart, from an exclusively defensive origin to a key role in planning as agricultural and recreational areas. Although they were planned as open spaces between cities to promote the active perception of the territory, since their conception these territories have been associated with important infrastructures and, therefore, exposed to high noise and environmental pollution, as well as to continuous pressures to take away part of their surface. However, it was not until the 3rd Guideline that eight buffer zones were identified on the Randstad map and a specific plan was proposed for the one known as Midden-Delfland (Fig. 6). That buffer zone status saved the Midden-Delfland polder landscape from housing development and the expansion of glasshouse horticulture (Feddes/Olthof, 2017).

Figure 6. Midden Delfland. The buffer zone of southern Randstad.
Source: Prepared by the authors of the paper

4.3.2 Origin, evolution, extent and functional division since the Reconstruction Act

Midden-Delfland was an intermittently inhabited peatland landscape until the Middle Ages, when it was drained for exploitation, and sandy-bedded hillocks emerged as a unique landscape. After the Second World War, the growth of the surrounding towns gradually reduced its extent, leading to the passing of the Midden-Delfland Reconstruction Act in 1977, which remained in force until 2010. As a result, 'green belts' of recreational areas were placed between the peripheral towns and the agricultural core of Midden-Delfland. In 2004, Midden-Delfland became a municipality by merging the municipalities of Maasland and Schipluiden (Midden-Delfland, 2024) with Den Hoorn. The buffer zone maintains an area somewhat larger than that of the municipality itself, covering 6,700 hectares, of which 68% is used for agriculture, 28% for recreational purposes and the remaining 4% for natural areas. The area is divided into three main zones with 27 subdivisions to which one or two main functions are associated. Near the settlements, the recreational function is predominant (playgrounds and rest areas, facilities for windsurfing, sailing, rowing, sport fishing, campsites and leisure in forest areas). In the rest of

the areas the original agricultural function prevails, shared with recreational use (footpaths and cycle paths).

Figure 7. View of access from Delft to Midden-Delfland along Delftse Schie canal.
Source: Google Street View

4.3.3 The Midden-Delfland® Vision 2025

At the initiative of the municipality of Midden-Delfland, in 2005, the central government, the province, local municipalities and civil society organisations promote the Midden-Delfland® Vision 2025, which includes the report 'Midden-Delfland Gateways'. These gateways are conceived as strategic entry points connecting the city to the countryside, articulating various functions: enhancing the urban-rural relationship, making landscapes and their transitions accessible and legible, providing information and orientation, serving as parking, transfer and departure points for recreational, cultural and historical routes, etc (Fig. 7).

Understanding the sequence in which these gateways serve as a passageway to a buffer zone - Midden Delfland- which itself constitutes a major gateway to the Green Heart landscape, may help conceiving the possibility of a similar articulation in the relationship between Fuenlabrada and its surroundings.

5. Fuenlabrada, Madrid Sur and the Green Arc

5.1 Fuenlabrada and Madrid Sur

Fuenlabrada shares with the rest of the cities in the southern belt of the city of Madrid a similar origin and evolution: old rural settlements born next to crossroads in the territorial structure of the south of the region which, especially from the 1950s onwards, took in -precariously arranged as commuter towns- the population that emigrated from various rural areas of the country -mainly Andalusia and Extremadura- in search for employment in the capital, a movement that was accentuated in the 1970s (Cabrero Garrido, 2004, pp. 407-408) which promoted an indiscriminate and sprawling growth that will begin to be managed, by providing facilities and infrastructures, in the 1980s after the arrival of democracy in Spain and economically boosted by its entry into the European Community (now the European Union).
Fuenlabrada sits on a very flat territory on the border between the sub-basins of the Jarama and Guadarrama rivers. It is an area that has left behind the steep slopes of the north of Madrid and has entered the flat territory, with no significant elevations, of the area of the middle course of the Tagus River basin. However, it is also a scarcely consolidated space, with some valuable interventions that need to be reinforced, but which is exposed to the persistent pressure of urban

growth -from all the surrounding settlements- which, at the very least, compromises its identity and dilutes its potential and its value as a civically and ecologically valuable space, threatening its long-term survival. It is a territory that historically has been home to agricultural fields (Cabrero Garrido, 2004, p. 396) whose activity is still relevant and remains settled on an east-south-west arc around the city.

The northern fringe has long since abandoned its agricultural condition and, in fact, composes a metropolitan void that transcends the limits of the city itself and forms part of a wider structure that forms the backbone of a sort of incipient conurbation formed by the larger cities to the south of Madrid, known as Madrid Sur (Fig. 8). Fuenlabrada is thus, together with the cities of Móstoles, Alcorcón, Leganés and Getafe, part of a kind of archipelago of cities that make up the southern sector of the metropolitan ring of Madrid which together have a total population of 948,337 inhabitants (INE, 2023), a population that, if it were considered as a single municipality, would represent the third largest city in Spain, behind only Madrid and Barcelona, but ahead of Valencia.

Figure 8. Madrid Sur. The conurbation that forms the southern metropolitan fringe of Madrid and the open space between its five cities (Fuenlabrada, Móstoles, Alcorcón, Leganés and Getafe).
Source: Prepared by the authors of the paper

All these cities in the conurbation (Fuenlabrada, Móstoles, Alcorcón, Leganés and Getafe) are separated from each other by an open space that accommodates some recreational uses, but which, above all, serves as a base for the layout of major infrastructures such as the railway, an arc of the third major ring road around the municipality of Madrid (M-50) and some radial roads. It is a space with enormous potential as a buffer zone that can accommodate the large infrastructures mentioned above -especially the M-50-, act as a barrier to the sprawl that would eventually lead to the merging of all these cities into one urban continuum and provide citizens with an open space with facilities and leisure activities incorporated into an area that should take advantage of the natural and ecological conditions of the place, providing an habitat that is clearly differentiated from the urban environment. However, it is also a scarcely consolidated space, with some valuable interventions that need to be reinforced, but which is exposed to the persistent pressure of urban growth -from all the surrounding settlements- which, at the very least, compromises its identity and dilutes its potential and its value as a civically and ecologically valuable space, threatening its long-term survival.

5.2 Green Arc / Arco Verde

This space around which the cities of Fuenlabrada, Móstoles, Alcorcón, Leganés and Getafe orbit is also linked to a larger initiative, known as Green Arc (Arco Verde), that connects the three natural parks of the Madrid region (Cuenca Alta del Manzanares, Curso Medio del Río Guadarrama and Parque Regional del Sureste) and other natural areas of interest through the network of cattle trails and other paths and tracks, creating a great corridor of more than 200 kilometres that surrounds the city of Madrid and connects the municipalities of its metropolitan area (Fig. 9) (Comunidad de Madrid, 2024).

Figure 9. The Green Arc around Madrid.
Below left, the area of Madrid Sur where Fuenlabrada and Bosque Sur are located.
Source: Prepared by the authors of the paper

Therefore, the potentially valuable heart that articulates the southern conurbation of the metropolitan crown acquires a greater dimension by entering into synergy with the structure of the Green Arc, a ring that links the most valuable natural landscapes of the Madrid region. Thus, any resident of Fuenlabrada would have at his disposal -from the gateways that this research proposes (Fig. 10)- both the wide space that separates it from the bordering cities to be found in the south of the metropolitan crown, as well as access to a vast territory of enormous landscape and ecological value, a connection that allows a restoration of equilibrium between life in the intensely urban environment of the cities and the beneficial contrast offered by the contact with open spaces of diverse ecological value. Both projects -the heart of the southern conurbation and the Green Arc- represent an opportunity to reconsider and restore many ecosystems that have been degraded from their natural condition as a result of human activity. In the case of Fuenlabrada and the southern conurbation, the space that articulates it is a space historically linked to agricultural activity whose abandonment should be taken as the starting

point for a process of renaturalisation that counteracts the climatic urgency by investing in ecological improvement. Access to these territories must also contribute to their recognition by citizens. Recognition that should lead to their enhancement and, consequently, to the demand for their conservation, maintenance and protection. It is in this initiative that the present research is framed.

Figure 10. Map of Fuenlabrada (left) with red brackets as access points to Bosque Sur (right)
Source: Prepared by the authors of the paper

6. Evaluation of peri-urban greengates in quantitative and qualitative terms. Indicators and design criteria

Understanding the city as an ecosystem implies redefining our conception of the urban from a holistic approach to the dialogue between nature and the city. The return to nature, its recovery or reintroduction on the support of the consolidated city, situates our research in the contemporary framework of the renaturalisation of cities. Urban renaturalisation is a multiple challenge: economic, social and physical-spatial. Economic, because it involves reversing a development system linked to the urbanisation of grey infrastructure. Social, because of the need to transform the collective thinking that links progress with consumption and individual freedom towards a purpose of environmental commitment. And physical-spatial because all regeneration relies on existing support, image and formalisation of decision-making over decades that have not had the possibility to build with nature. The emergence of the concept of 'nature-based solutions' has meant the integration of multiple strategies with a multi-scalar multi-functional and place-specific approach. In addition, we can add the conditions of connectivity, strategy, inter- and transdisciplinarity, and social inclusiveness (Tzoulas, et al. 2021).

In order to implement measures aligned with nature-based solutions, it is necessary to define a systematic prior assessment of the areas where improvements are intended to be made in order to reveal shortcomings and assess possible opportunities.
To this end, a methodology is proposed based on the analysis through indicators that provide us with a prior diagnosis, with the aim of implementing appropriate measures that respond effectively through tools supported by nature-based solutions.
Focusing the problem on the case study of peripheral landscapes, we must define specific indicators that allow us to bring together the varied characteristics of these heterogeneous areas.

6.1 Indicators and reference methodology

Recent studies assessing both quantitative and qualitative indicators of green areas are referenced.
The so-called Grenn Area Indicator GEA is a basically quantitative indicator, that does a valoration of the area of biologically available surfaces (i.e., those covered by vegetation, open water, permeable paving and storm water infiltration, etc.) compared to total parcel area. Likewise, ecosystem approaches provide a conceptual framework to aid decision making in urban planning for green infrastructure (Stange, et al., 2022).
Despite their complex development, the GEA indicators, used as ordinances to guarantee a minimum of green areas in new developments, are exclusively quantitative in nature and are, therefore, incomplete for assessing edge areas, which are located on the boundary between urbanised and undeveloped territory.

Other indicators such as sustainability indicators related to green areas add aspects related to proximity to green spaces and urban green corridors, recommending maximum distances depending on the size of the green area under consideration (Barcelona, 2008).
With regard to the quality of green spaces, other authors add other aspects (de la Barrera, et al., 2016) associating size with greater diversity in the ecosystem services provided, also point to the greater capacity to host cultural offerings of those green areas that have the capacity to host a greater variety of people. (older people, young people or children) favouring greater social interaction. Greater vegetation cover is also considered to provide greater biodiversity and environmental comfort.
If we interpret green areas as part of other natural or naturalised superstructures, we can also add topological indicators, that can assess the potential of defining green infrastructures capable of connecting natural areas of regional character with other smaller areas of peri-urban and urban scale. The valuation of green areas, not only for their isolated status as environmental havens, but also because of its capacity to connect with others of greater or lesser size, it adds a more complex vision that makes it possible to contribute to territorial environmental improvement at different scales (Lafortezza, et al., 2013).

Another key aspect is related to the accessibility of green areas, which is particularly important given the particularities of the peri-urban landscape.
In terms of equity and inclusion, other authors propose indicators to measure the Quality and accessibility of green spaces: (Yao, et al., 2014)
‘(i) the Effective Green Equivalent (EGE) referring to the GS area that effectively has a benefit for each inhabitant; (ii) the Average Effective Green Equivalent (AEGE), which is the average of EGE for all inhabitants; and (iii) the Inequality Coefficient (IC) which is based on the Gini coefficient of income inequality, exchanging income with the EGE of residents’

As for the methodology of analysis, we propose as a methodological basis the one proposed by Fariña, Higueras, Román and Pozo in the Guide for Planning Healthy Cities (Fariña, et al., 2022) in its section on the Introduction of nature in the city, referring to peri-urban green areas in the vicinity of the city. The proposal consists of mapping existing public spaces and urban green areas, also representing the peripheral open areas and valuing the identified green areas as a whole from their potential to generate a green infrastructure. In this way, the value of the existing green is signalled and enhanced in order to connect it and shape a resilient continuous system.

7. Conclusion

7.1 Possible indicators for the evaluation of green areas in the peri-urban landscape

We found a series of indicators associated with green areas, which we could characterise and qualify for application in the analysis and diagnosis of peri-urban areas (Fig. 11)
We therefore define several groups of indicators:
- Intrinsic indicators: quantitative and qualitative indicators of the areas to be analysed such as size, heterogeneity, biodiversity, landscape quality, environmental comfort,
- Contextual indicators: proximity to protected natural areas, proximity to areas of agricultural or livestock use, proximity to residential areas, continuity with urban public spaces, pedestrian, cycling or public transport accessibility.
- Extrinsic indicators: fragmentation due to large infrastructures, edge uses with environmental impact: landfills, industries, logistics centres, power stations,
- Social indicators: daily use of the space, citizen involvement in the implementation, transformation and design of the green area, citizen involvement in the care and maintenance of the space, identification with the place, physical and mental health.

Figure 11: Proposal of indicators for green areas of the peri-urban space. Based on benchmark indicators in Point 6 (Indicators and reference methodology)
Source: Prepared by the authors of the paper

Social indicators are especially relevant, as they reflect the impact that a green area can have on the population that can enjoy it, providing health benefits, as long as the open space has quality, provides environmental comfort and is well connected and easily accessible to citizens of any age and condition.
Just as the search for a healthier city generated the first garden city and infinite city models, nature-based solutions are well suited to respond to basic social needs for health and well-being. The permeability of natural spaces to urban spaces on the periphery is a fundamental factor in ensuring a better quality of life. For this reason, it is necessary to emphasise the strategic character of greengates as places of connection of urban edges with quality and wide-ranging natural spaces.

7.2 Greengates as a strategic enclave for integration between nature and city. Identification and Project

With the use of the proposed indicators and being aware of the problem of peri-urban areas and the existing situations of disconnection between urban peripheries and nearby natural spaces, the analysis and design of greengates is key to their role as nodes of continuity of green infrastructures.
Taking as a model the design of the urban edge elements of the cities that make up the Midden-Delfland and assuming as a case study the northern periphery of the municipality of Fuenlabrada, we can propose a working methodology for the identification of those spaces that can be transformed into greengates favouring green and natural continuity.
With the aim of ensuring greater continuity between urban and peri-urban green spaces, it is proposed:

- Represent, characterise and quantify the system of urban green spaces, with their hierarchy, such as neighbourhood parks, urban parks, ornamental gardens, boulevards, street trees, etc. And also, if there are private landscaped areas of interest (because of their size or the size of the vegetation).

- Represent, characterise and quantify the peri-urban green system, with protected natural spaces on a territorial scale, blue infrastructure, reforested areas, wetlands, orchard areas, paths, etc., and all spaces with environmental or landscape potential in the surrounding area.

- To analyse, with the help of the proposed indicators, this structure from the point of view of quantity and quality of the green system, so that it can become a green infrastructure, capable of generating a healthy physical and mental environment for the entire population.

- Finally, in the potential green infrastructure revealed, key nodes or transition points between the peri-urban public space and the immediate natural space will be identified. These greengates will be defined in order to prioritise continuity from the built space and to encourage the shaping of the previously identified green infrastructure.

The project and design of connection nodes between the urban and its natural environment is relevant in peripheral areas. The complexity and growth of cities has created barriers and blurred spaces of natural value that are beginning to be recovered through the definition of green infrastructures. The proposal and development of the greengates could reduce uncertainty and respond with contemporary criteria to the necessary proximity between the urban environment and the natural environment, as already announced by the first visionaries and creators of the garden city.

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