

*A Historical View of Addressing the Connectivity of the Green Infrastructure by the Urban Plans*

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**Abstract**

Urban ecology sees today the city nature as a green infrastructure providing ecosystem services to the urban dwellers, contributing to their welfare and a sustainable urban development. However, the concepts included in this view are not as new as it seems. Ecosystem services are just a reiteration of the ecological economy view of nature as a natural capital providing goods and services to the human society. Similarly, although increasing attention has been paid lately to the green infrastructure and its role in addressing challenges faced by the modern society, including the mitigation of climate change effects, it is less known that the concept, that started being used relatively recently, in the '90s, has emerged at the end of the 21st century in the works of the prominent landscape architects and urban planners Frederick Law Olmsted and Ebenezer Howard. They argued in their projects, revolutionary for that time, for the need to combat urban sprawl through a strategic planning of vegetated systems and corridors, known today as “green infrastructure”. The designed components of the systems of urban parks and green spaces are similar to those of the “green infrastructure”, consisting of nodes (core areas/hubs) and connections. The relationship between nature and human well-being (known today as “ecosystem services”) and sustainability was also anticipated by their works. Most importantly, these early researches demonstrated that the green infrastructure is not optional, but must be strategically devised, holistically planned, and properly managed. This work aims to revisit the old works from a modern perspective.

Keywords: Ecological Infrastructure, Interconnection, Networks, Natural Systems, Landscapes, Strategic Planning, Urban Sprawl, Human Wellbeing

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## 1. Introduction

The name *green infrastructure* entered the usual vocabulary relatively recently, in the 1990s, but the idea of such an infrastructure was born in the 19th century, in the activities of urban planning and landscape architecture. The concept emerged to counteract the fragmentation of habitats and landscapes, because with the expansion of urban areas, green space had become increasingly fragmented, ignoring the benefits it offers, including that of maintaining the city's biodiversity (Zhang *et al.*, 2019).

The concept was also introduced in EU policies, and by 2010 it was already concluded that green infrastructure is important both theoretically and practically. In EU documents, the *green* infrastructure was assimilated as the *ecological* infrastructure, and the definition adopted by the European Commission (2013) was: “*a strategically planned network, made up of natural and semi-natural areas, as well as other environmental elements, which is designed and managed to provide a wide range of ecosystem services*”.

Today, the definitions of green infrastructure are numerous and diverse, depending on the authors who approach the concept (Mell, 2010) and the sector and context in which it is applied (Benedict and Mahon, 2002). On the whole, green infrastructure is seen as a specific landscape resource (e.g. a large park), as a component of a larger resource (e.g., a network of green spaces in a city), or as a concept that it incorporates a large number of green spaces and gives them a name (Kleiber *et al.*, 2002). However, the ecological aspect of the concept determined the name of *green infrastructure* (Walmsley, 2006).

Reviewing the definitions of green infrastructure in the last 30 years, both officially and in the specialized literature, it is observed that, broadly speaking, they have in common several key words: "network", "interconnection", "benefits", "planning", "management" and expressions such as "natural systems", "interconnected network" or "strategically planned network". The most often mentioned elements as being characteristic for the green infrastructure are: "access", "diversity of scales" to which it applies, "multi-functionality", "natural and human benefits", "biodiversity", "sustainability" and "**connectivity**".

The common idea remains that of **connectivity**, being observed that by creating a network of green infrastructures as wide as possible, more social, economic and environmental benefits can be obtained (Mell, 2010), offered to different social groups. Therefore, although the definitions are numerous, the consensus is that *green infrastructure is an opportunity for social, economic and environmental benefits* (Wright, 2011).

Studies and research have shown that green infrastructure is composed of different natural / reconstituted ecosystems as well as of landscape components. This system contains central areas/centers/*hubs* - which anchor green infrastructure systems, providing origins and destinations for wildlife and for ecological processes that take place here - and *links* - respectively the connections that allow the operation of the system and of the network of green infrastructure (Petrișor *et al.*, 2016). In order to work, these above-mentioned elements need to be protected, and this can be done through a **long-term planning** (Benedict and Mahon, 2002). By promoting integrated

land use management, the idea of *green infrastructure* it is closely linked to climate change mitigation, sustainable urban development and social equity, which in turn promote the principles of **sustainable development** (Mell, 2009).

The subject of green infrastructure is important from ecological, social and economic viewpoints and by involving planning activities at territorial level. This research is part of a larger study on the connectivity of green infrastructures and its relation with spatial planning.

## 2. Method

The article presents several results obtained in different studies, articles and books on the topic of green infrastructure, to identify the first uses of interconnected green infrastructure systems as a method of mitigating urban expansion. For this, the article proposes two case studies.

The first refers to the contribution of *Frederick Law Olmsted*, considered to be the "father of landscape architecture in America", who developed, together with the architect Calvert Vaux, the first *system of interconnected parks* to be implemented in its country. The urban parks that Olmsted designed in 1880 were connected by networks of green spaces that offered citizens opportunities to connect both socially and economically. At that time, it seemed that the focus was not on ecological issues, but rather on social and human ones.

This first case study will show that although terms such as *green infrastructure* or *ecosystem services* were not used in the 19th century, Olmsted's achievements demonstrate an early understanding of these notions, the components of these designed urban park systems being similar to those belonging to today's green infrastructure.

The second case study refers to another way of using green space to counteract the uncontrolled expansion of the city in nineteenth-century England, also contributing to the birth of current urban planning. Just as Olmsted is representative of America, so Ebenezer Howard is seen in Europe as a revolutionary of his time, proposing the design of polycentric networks of small urban towns connected by a **system of green infrastructure** in an effort to mitigate urban expansion - the "Garden City" theory.

In order to have a complete picture and to reach the more recent period, the article presents at the end the way in which the transition from *green ways* to *green infrastructure* was subsequently made.

## 3. Case Studies

### 3.1. *Frederick Law Olmsted's parks and alleys systems - the first example of urban planning*

In 1870 Frederik Law Olmsted started from the idea that no park, no matter how big or well designed, can offer people the same benefits as the nature, and if it were part of a park system, it would be more complete and even more useful than a single one (Benedict and Mahon, 2002).

Therefore, the urban parks designed by him together with the architect Calvert Vaux were connected by *parkways* that connected the elements of the system.

In the context of the industrialized cities that had begun to develop at that time, these first planned networks had many functions and were not mere refuges for the city's citizens. What is now known as the "Emerald Necklace" (a system of parks interconnected by alleys and waters) was one of the first planned networks having functions and capacities such as accessibility or the flood mitigation (Mell, 2010).

Theodore Eisenman describes the park system designed by Olmsted, citing Witold Rzbczynski (1999) as "a refined network of parks, alleys, boulevards, and public spaces that represented a degree of refinement in urban planning, previously unknown in the United States."

In Olmsted's view, the central component of the system was a large park, in order to counteract the daily stress of urban life, but there were also elements of secondary importance, such as picnic places or those intended for civic events, such as musical performances, activities for which was considered better to take place in planned places and not to interfere with the landscape.

The elements of this system were linked by alleys ("parkways"), represented by green strips about 200 m wide that connected the parks and playgrounds, creating neighborhood parks and through which it was possible to move from one park to another and through the city. The parkways were separated according to the type of transport, and the directions of travel were separated by rows of trees. The term and the concept of *parkway* have been preserved even today, and refer to a road with trees on the edges and through which commercial traffic is excluded (Beveridge and Rocheleau, 1995).

Olmsted designed the largest park system in the city of Buffalo (Figure 1), which today can be seen as a way to connect green infrastructure, in order to improve the quality of people's lives from a social, economic, mental and physical point of view. He provided compositions of **nuclei** and **connections**, similar to those of today's green infrastructure (Figure 2), in which the nuclei had different shapes and sizes and were represented by parks, reserves or arable land, and the connections were represented by vegetated corridors connecting the nuclei. These corridors could serve several purposes: they were biological conduits for wildlife, they could perform ecosystem processes such as flood management in riparian areas, or they could simply be opportunities for outdoor recreation.

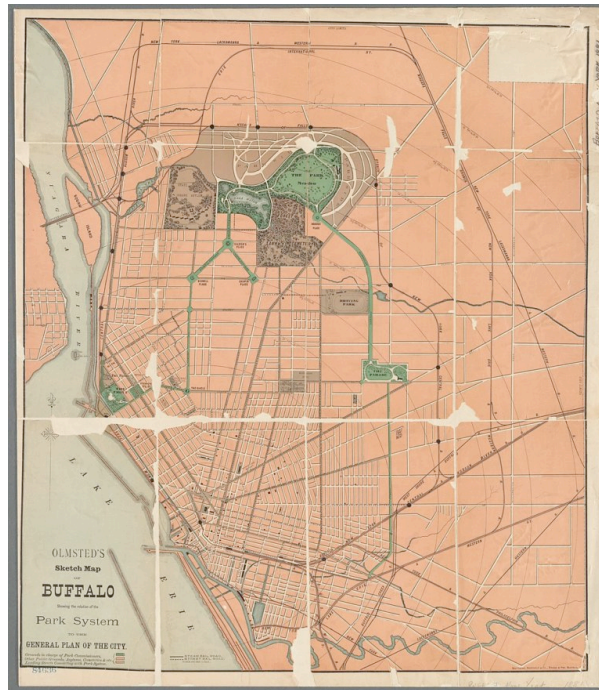


Figure 1: The Buffalo City Park System. Source: [https://commons.wikimedia.org/wiki/File:Olmsted\\_Buffalo\\_Map.jpg](https://commons.wikimedia.org/wiki/File:Olmsted_Buffalo_Map.jpg)

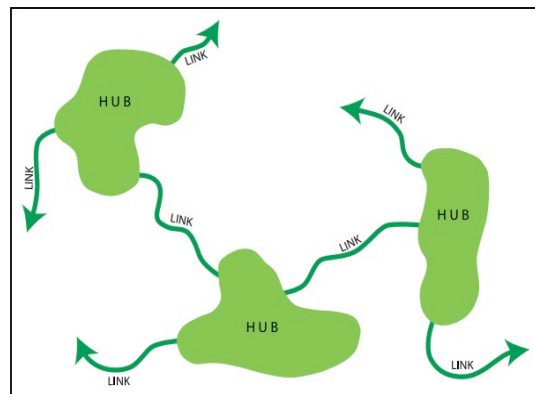
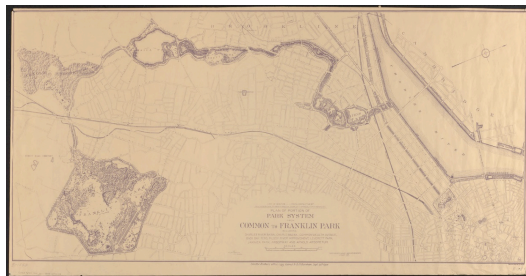


Figure 2: The plan of a park system in 1894 and the representation of the concept of green infrastructure today. Source: <https://www.digitalcommonwealth.org/search/commonwealth:ht2503205>

The park systems designed by Olmsted are still visited and cared for today. According to the Buffalo Olmsted Parks Conservancy, the Buffalo park system contained (Figure 3): 6 parks (of which the most important was Delaware Park), 7 promenade alleys (connecting individual parks with individual city streets) and 8 squares at the intersections of the alleys with the main crowded streets of the city, consisting of small spaces for flowers, sculptures, fountains or monuments (Figure 4), around which one could get either by walk or by bike or car, so that visitors could enjoy the natural beauties of the city (see also Frederick Law Olmsted – Designing America, <https://www.pbs.org/wned/frederick-law-olmsted/learn-more/olmsteds-buffalo-park-system-and-its-stewards/>).

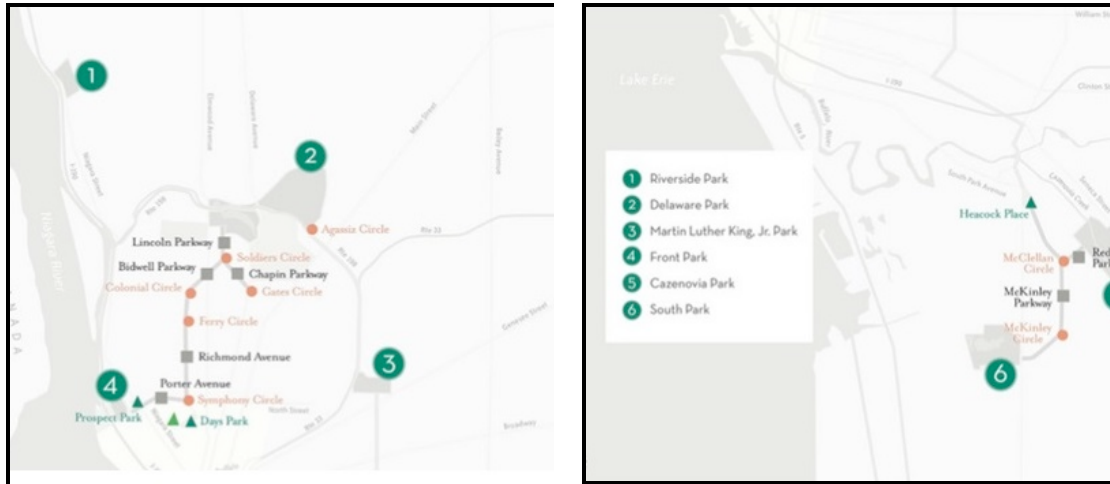


Figure 3: The system of parks and alleys designed by Olmsted in the city of Buffalo. Image source: <https://view.publitas.com/bopc/olmstedparkmap/page/4-5>



Figure 4: One of the squares designed by Olmsted (1911) to connect the park's alleys with the main roads of the city. Source: <https://kendev.com/history/history-buffalo-beautiful-olmsted-parks/>

Olmsted's stated goal was for the visitor to be able to walk from one park to another without leaving the green space and to feel "more in the park than in the city".

It was the largest park system, not only in Buffalo, but also in America, declared in 2015 by *The Guardian* as one of the best park systems in the world (for more details see <https://www.theguardian.com/culture/2015/aug/07/10-best-parks-urban-green-spaces-high-line-new-york-hampstead-london-park-guell-barcelona>). Olmsted declared in 1876 that the city of Buffalo was "the best planned city in the United States, if not in the world" (Kowsky and Olenick, 2013). Buffalo's park system has been designed to improve the quality of life in the city socially, economically, mentally and physically. Like other parks in the system, Delaware Park, the largest, has been developed and supplemented with other recreational land, and it was named

by the American Planning Association in 2014 "one of America's great places" and remains a popular destination among tourists and locals (Figure 5).



Figure 5: Delaware Park in 1898 and 2011 (Hoyt Lake). Image sources: [https://commons.wikimedia.org/wiki/File:Bridge\\_in\\_Delaware\\_Park,\\_Buffalo,\\_N.Y.\\_\(NYPL\\_b12647398-69605\).tiff](https://commons.wikimedia.org/wiki/File:Bridge_in_Delaware_Park,_Buffalo,_N.Y._(NYPL_b12647398-69605).tiff) and [https://commons.wikimedia.org/wiki/File:Delaware\\_Park\\_panorama.jpg](https://commons.wikimedia.org/wiki/File:Delaware_Park_panorama.jpg)

Benedict and Mahon point out that, if at that time the connection of parks was designed for the benefit of people - recreation, walking, cycling, public health, today it is considered that the idea evolved into modern concepts such as *greenways* and *green infrastructure*.

### 3.2. *The green infrastructure systems proposed by Ebenezer Howard as a measure to mitigate the uncontrolled expansion of the city.*

In England, Ebenezer Howard continued Olmsted's ideas in 1898. He was also considered radical for his time, proposing the design of polycentric networks of small urban areas, and by creating a system of **green infrastructure**, Howard hoped to mitigate or control urban expansion. His intentions were that each such a city to contain a sustainable transportation system, housing, green infrastructure, to provide affordable jobs and other services. Through this, he encouraged the daily use of green spaces in the immediate vicinity of homes.

Howard's theory at the time - *Garden City Theory* - consisted of planning an ideal concentric city of 2,400 ha and a population of 32,000 made of the urban and rural population that was integrated into the city (Howard, 1946). The city was circular, and in its center was a park (Figure 6). Through the 6 large boulevards 37 m wide that started from the center, the city was divided into 6 sectors.

The theory appeared in the context of the industrial revolution in the second half of the eighteenth century in European countries that led to the intensification of urbanization and generated social and environmental problems. The rapid growth of the urban population, the urban expansion, the growing demand for housing, the pollution of the air and water, the deterioration of the urban environment imposed **the need for an efficient urban planning**, adapted to the reality of that time.

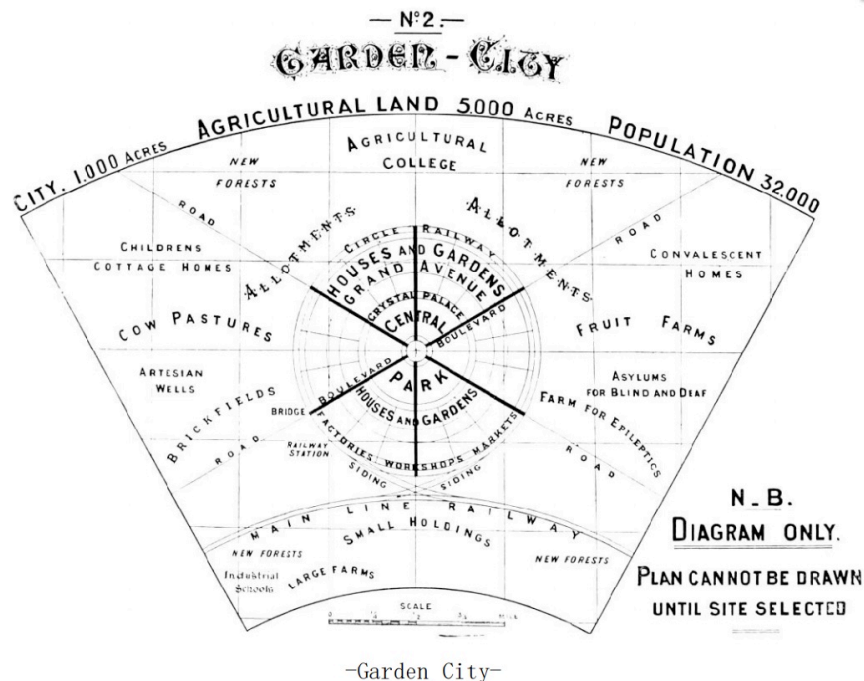


Figure 6: The Garden City Plan. Image source: <https://journals.openedition.org/cve/docannexe/image/3605/img-3.jpg>

It should be noted, however, that Howard's idea of a Garden City does not emphasize green space as having a recreational role (as in Olmsted's case), rather, it was conceived as a model in which industry and agriculture could be harmonized or, moreover, in which agriculture is considered a branch of industry.

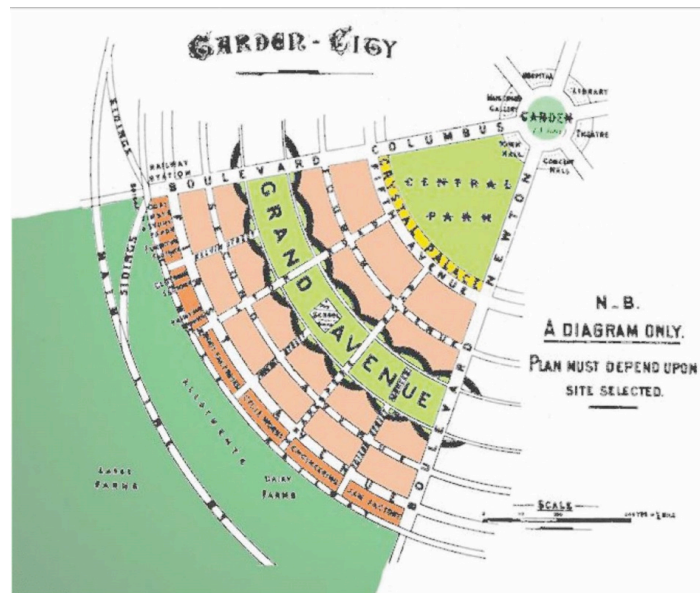
But how was this utopian city conceived?

From the center to the circumference, the city was crossed by 6 large boulevards that divided the city into 6 equal parts. In the center was a circular space - a **garden** (2.2 ha) surrounded by public buildings. According to this theory, the circular space was surrounded by a large **public park** (the Central Park - 58.7 ha) which contained large recreational spaces with easy access to all residents. Around this park is an archway that opens onto the park, where there is a building - "the Crystal Palace", where people could come especially on bad weather days to shop, and its circular shape being able to bring together the inhabitants of the city.

Passing from the Crystal Palace to the outside of the ring, there is a boulevard (Fifth Avenue) with trees. In front of it are houses - built in concentric rings, which lead to various boulevards or roads that converge to the city center. Here can live around 30,000 people from the city itself and another 2,000 from the surrounding agricultural area (with pink in the drawing), in about 5,500 housing units.

Towards the outside of the ring was Grand Avenue, 128 m wide, which forms a **green belt** about 5 km long (and which divided the outer part of the Central Park into 2 belts) (Figure 7). There was another **park** of 46 ha, and the boulevard was occupied by public schools and related play and sports areas, as well as churches.





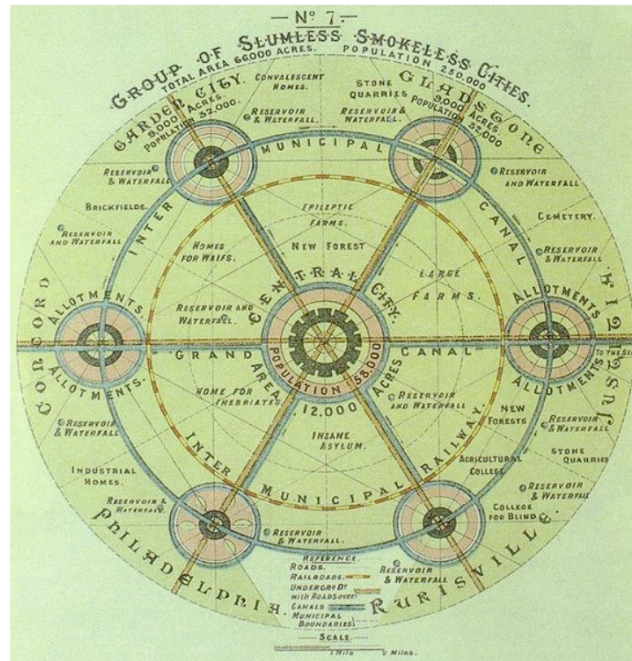
-Garden City- District and Centre-

Figure 7: The individual structures of the Garden City. Image source: <https://rethinkingfoodpioneervalley.files.wordpress.com/2014/12/ebenezer-howard-garden-city.gif>

Finally, on the outer ring of the city (represented in pink in Figure 7) were the factories, the markets, towards the railway that surrounded the entire city and which was connected by a railway that passed through the city. This allowed the loading of goods directly, reducing traffic on city roads, all machinery being powered by electricity.

Thus, this garden city would have been ideal for self-development and maintenance, and after reaching a population of 32,000 inhabitants, a similar second would develop in the vicinity, resulting in a cluster of garden cities, as satellites of a central city with 58,000 inhabitants. Cities isolated the green belt and were interconnected (Figure 8).

Of course, the Garden City theory is more a matter of social transformation than a matter of urban planning (Howard, 2013). However, the theory has been adopted by cities around the world and is of great importance for urban planning of green space. Emphasis was placed on the need for green spaces - such as the park and central boulevards - for services, but in particular, the use of green space was proposed to counteract the uncontrolled expansion of the city, which contributed to the birth of current urban planning.



-Social City-

Figure 8: The Social City - a central city surrounded by small satellite towns. Image source: <https://journals.openedition.org/cve/docannexe/image/3605/img-1.jpg>

#### 4. Discussions

Olmsted was not only one of the leading park designers of the 19th century, but he also predicted the connection between nature and human well-being, which underlies what we know today as *ecosystem services*. Contemporary studies of the **psychological benefits** of contact with nature in urban environments underpin Olmsted's intuition a century ago. Although terms such as "ecosystem services" and "green infrastructure" were not part of the 19th-century lexicon, his work attests to an early understanding of these concepts (Eisenman, 2013).

Subsequently, the Millennium Ecosystem Assessment (Reid *et al.*, 2005) identified 4 ecosystem services essential for human well-being: **support services** for soil formation, photosynthesis and the nutrient cycle; **supply services** with food, water, wood, fuel; **regulatory services** in relation to climate, floods, diseases and water quality; and **cultural services**, those that offer recreational, aesthetic and spiritual benefits.

From ecosystem services derive several components of well-being, including health, good social relations, security and freedom of choice and action (Figure 9). Some authors also demonstrate positive links between nature and social cohesion.

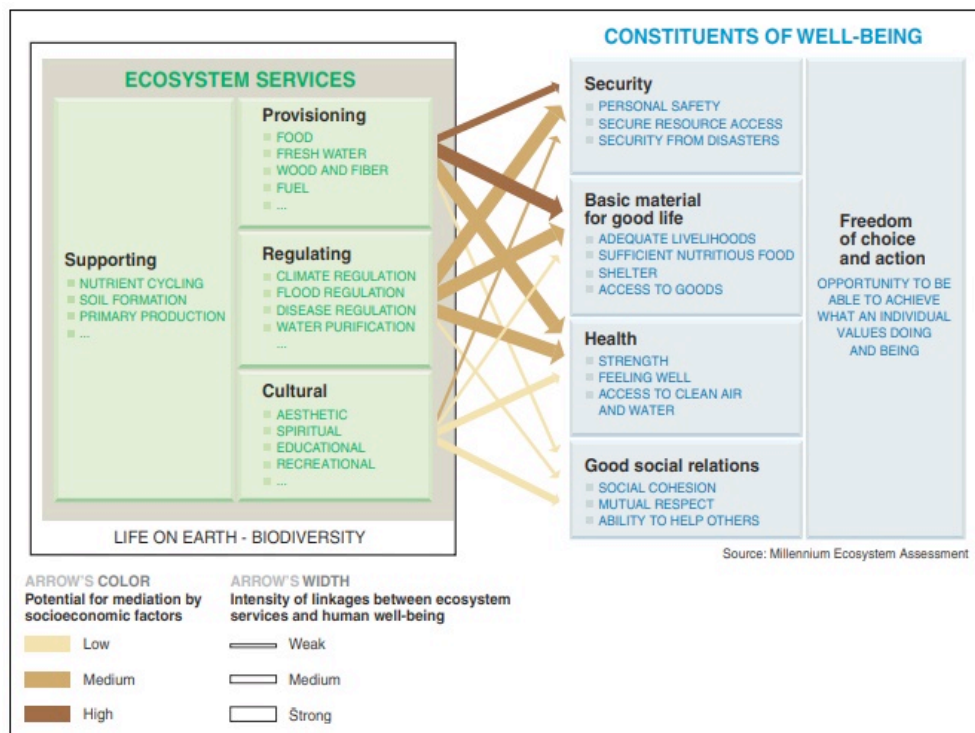


Figure 9: The links between ecosystem services and human well-being, according to The Millennium Ecosystem Assessment. Image source: <https://www.millenniumassessment.org/documents/document.429.aspx.pdf>

Olmsted intuited that in order to obtain as many benefits as possible on multiple levels, the connectivity of green infrastructures is a necessity. Another anticipatory thinking that Olmsted refers to is what is called **sustainable development** today.

He motivated the planning of his first system of parks and alleys by the need to meet the future urban development, and not just to look at the immediate satisfaction of the population. The idea is similar to today's definition of the concept of sustainable development, which states that it must meet the needs of the present without compromising the capacity of future generations to use their own needs in the future. He was a future-oriented spirit and had a systemic thinking about urban planning, believing in the development of cities.

He also stressed in his speeches that environmental protection should be a fundamental responsibility of democratic governance, which again reflects contemporary ideas on **social equity and sustainability**, both of which are particularly relevant today in the discourse of **urban ecology**.

And last but not least, what draws attention to the work of Olmsted, and later Howard, is the anticipatory thinking about the expansion of cities and the need for planning to counteract this growth in the future, in the idea that the city would be better served by an interconnected system of green spaces (parks) than by a single large park.

Following the achievements of Olmsted and his successors, including Howard, the "Greenways" were created after the 1950s, in order to conserve the ecological resources of landscapes. Although the emphasis was initially on the role of conserving riparian and ecological corridors, over time the emphasis has been on recreational and

leisure functions. **Greenways have influenced the planning and implementation of green infrastructure.**

Definitions of greenways have been proposed since 1987, seen as *networks of green and nature corridors* (Fabos, 1995). As greenways have evolved, the notion of *road* becomes *corridor*, which makes green networks seen as corridors of different widths that are connected together in a network similar to the road or rail network, the only difference being pre-existence of greenway corridors.

The greenway movement originated in the United States in the '50s, when the term *greenway* first appeared to describe recreational trails (for pedestrians and cyclists), designed to promote a healthy lifestyle and an environmentally friendly, non-motorized transportation, especially in urban areas.

In Western Europe, this concept became popular only in the '80s and '90s. Already in EU countries, greenways referred to **green corridors** dedicated to tourism, recreation and non-motorized transport. These routes have been designed along roads, railway corridors, natural corridors or unused roads, as being independent of motorized routes. Their motivation was "promoting an active and healthy lifestyle, conserving nature, reducing pollution from motorized transport and creating safe access to school or work" (Benedict and Mahon, 2002).

In 2005, Nicholls and Crompton (2005) stated that establishing greenways is essential in terms of land use planning. In Europe, some cities (Amsterdam, Helsinki, and Copenhagen) have been designed by creating urban fabric in conjunction with accessible and quality green spaces, with designers providing urban areas with large green spaces. Thus, each city used a network of **green infrastructure** to promote ideas that were previously found in the planning of greenways (such as social inclusion, recreation, economic regeneration).

Currently, the issue of greenways has started to be discussed with the development of green infrastructure, which was different in Europe from the US, evolving according to the existing planning problems in each part of the world. For example, in the US the creation of green infrastructure has been influenced by the creation of the Urban Green Agenda and the need to create a green space integrated into high-density landscapes and emphasizes the **ecological** benefits, not the social and economic ones. Americans Benedict and McMahon were the first to say that **green infrastructure restores the ecological role that greenways originally had.**

## 5. Conclusions

Looking at each part of a park as part of a corresponding urban plan, Olmsted demonstrated the need to combat modern urban sprawl through regional planning. By replicating the morphology, hydrology and plant composition of certain ecosystems, his work from the end of the nineteenth century laid the early foundations of what we understand today by **green infrastructure.**

Olmsted's greatest contributions were to predict the continuous expansion of cities, the need for strategic planning to deal with it, and the need for a physical system of

vegetated spaces and corridors - *green infrastructure* - essential in shaping urban expansion in time and space.

Howard also laid the foundations for revolutionary concepts of urban planning (decentralization, zoning), and in terms of green infrastructure, he laid the foundations for the concept of integrating nature into the urban fabric, including in the form of green belts.

Both Frederick Law Olmsted and Ebenezer Howard predicted that vegetated space and corridor systems could impede the continued expansion of cities. Their ideas contributed to the emergence of strategic planning, and their concepts served as antecedents in the birth of urban planning at the beginning of the 19th century.

As proof that the two had the right thinking, today it is considered that "green infrastructure is a simple but at the same time extremely complex approach to landscape planning" (Mell, 2016).

Green infrastructure is associated with ecological functions and the idea that its fundamental role is to connect people in green spaces has been preserved. We can conclude in this context that **green infrastructures must be designed as multi-functional spaces that can offer human and ecological benefits.**

## References

- Benedict M. A., McMahon E. T. (2002), *Green infrastructure: smart conservation for the 21st century*, Renewable Resources Journal 20(3): 12-17.
- Beveridge C. E., Rocheleau P. (1995), *Frederick Law Olmsted*, Rizzoli International Publications, New York, NY, USA.
- European Commission (2013), *Opinion of the European Economic and Social Committee on the 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Green Infrastructure (GI) — Enhancing Europe's Natural Capital' COM(2013) 249 final*, Official Journal of the European Union, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52013AE4135>
- Eisenman T. S. (2013), *Frederick Law Olmsted, green infrastructure, and the evolving city*, Journal of Planning History 12(4): 287-311.
- Fabos J. G. (1995), Introduction and overview: the greenway movement, uses and potentials of greenways, Landscape and Urban Planning 33(1-3): 1-13.
- Howard E. (1946), *Garden cities of tomorrow*, Faber, London, UK.
- Howard E. (2013), *Garden cities of to-morrow*, Routledge, London, UK.
- Kleiber D. A., Hutchinson S. L., Williams R. (2002), *Leisure as a resource in transcending negative life events: Self-protection, self-restoration, and personal transformation*, Leisure Sciences 24(2): 219-235.
- Kowsky F. R., Olenick A. (2013), *The best planned city in the world: Olmsted, Vaux, and the Buffalo Park system*, University of Massachusetts Press, Amherst, MA, USA.
- Mell I. C. (2009), *Can green infrastructure promote urban sustainability?*, Proceedings of the Institution of Civil Engineers-Engineering Sustainability 162(1): 23-34.
- Mell I. C. (2010), *Green infrastructure: concepts, perceptions and its use in spatial planning*, Doctoral Dissertation, Newcastle University, Newcastle, UK, <https://theses-test.ncl.ac.uk/jspui/bitstream/10443.1/914/1/Mell10.pdf>
- Mell I. (2016), *Global green infrastructure: lessons for successful policy-making, investment and management*, Routledge, London, UK.
- Nicholls S., Crompton J. L. (2005), *The impact of greenways on property values: Evidence from Austin, Texas*, Journal of Leisure Research 37(3): 321-341.
- Petrișor A.-I., Andronache I. C., Petrișor L. E., Ciobotaru A. M., Peptenatu D. (2016), *Assessing the fragmentation of the green infrastructure in Romanian cities using fractal models and numerical taxonomy*, Procedia Environmental Sciences 32: 110-123.

Reid W. V., Mooney H. A., Cropper A., Capistrano D., Carpenter S. R., Chopra K., Kasperson, R. (2005), *Ecosystems and human well-being-Synthesis: A report of the Millennium Ecosystem Assessment*, Island Press, Washington, DC, USA.

Rybczynski W. (1999), *A clearing in the distance: Frederick Law Olmsted and America in the 19th century*, Simon and Schuster, New York, NY, USA

Walmsley A. (2006), *Greenways: multiplying and diversifying in the 21st century*, *Landscape and Urban Planning* 76(1-4): 252-290

Wright H. (2011), *Understanding green infrastructure: the development of a contested concept in England*, *Local Environment* 16(10): 1003-1019.

Zhang Z., Meerow S., Newell J. P., Lindquist M. (2019), *Enhancing landscape connectivity through multifunctional green infrastructure corridor modeling and design*, *Urban Forestry & Urban Greening* 38: 305-317.

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