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Green areas in an urban area and provision of ecosystem services: a bibliometric and integrative review

Áreas verdes no espaço urbano e a prestação de serviços ecossistêmicos: uma revisão bibliométrica e integrativa

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ABSTRACT: The process of urbanization is accomplished by changes in land use, that is, by the interaction between man and nature, so that there is a common loss of green areas in cities. However, the need and importance of green areas inside urban areas has been emphasized in order to provide quality to the provision of ecosystem services. Such services favor the quality of life and human well-being of people living in urban areas. Thus, nature-based solution practices have been encouraged as a form of innovation for urban planning and to overcome problems in cities. An integrative and bibliometric review on urban green areas and ecosystem service provision was proposed from 2009 to 2019. Among the results, there is a growing interest in the topic. There is recognition of the importance of green areas for population needs regarding human physical and mental health. In addition, the need for public actions in favor of urban planning involving the issue is recognized in order to provide equal access to existing areas and/or in areas that will be created.

Keywords: Land use. Vegetation. Urban planning. Urban well-being.

RESUMO: O processo de urbanização é realizado pela mudança no uso da terra, ou seja, pela interação do homem com a natureza, de forma que é comum que haja a perda do verde nas cidades. Contudo, tem-se percebido a necessidade e a importância do verde nas áreas urbanas para que se tenha qualidade na oferta de serviços ecossistêmicos. Estes serviços favorecem a qualidade de vida e o bem-estar humano das pessoas que residem no espaço urbano. De forma que estão sendo incentivadas as práticas de soluções baseadas na natureza, como forma de inovação para o planejamento urbano e para que os problemas nas cidades sejam superados. Foi proposto a realização de revisão integrativa e bibliométrica sobre as áreas verdes urbanas e a prestação de serviços ecossistêmicos, no período de 2009 a 2019. Dentre os resultados observa-se que há um crescente interesse pelo tema de pesquisa. Há reconhecimento da importância das áreas verdes para as necessidades populacionais, no que se remete à saúde humana física e mental E ainda, a necessidade de ações públicas em prol ao planejamento urbano envolvendo a questão, de forma a proporcionar acesso igualitário nas áreas existentes e ou naquelas que serão criadas.

Palavras-chave: Planejamento urbano. Vegetação. Bem-estar urbano. Uso da terra.

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INTRODUCTION

Changes in land use are one of the five major factors causing biodiversity loss (WRI, 2005). In this context, among the contributions to land use change is urban growth, which will accelerate in the coming decades, thus increasing this problem (SETO *et al.*, 2012; ELMQVIST, 2013). To expand the urban land use process, it is necessary to replace natural green areas for areas with anthropic use in most cases. The problem is aggravated when it happens in a disorderly way, mainly in developing countries (LIU *et al*., 2018).

As urban land uses are generally related to materials that have a high heat storage capacity (ALVES *et al*., 2019), such replacement results in changes in the local and regional microclimate, causing the so-called thermal discomfort to the population (LIU *et al*., 2018), among other issues. Thus, the urbanization process, considered a complex issue, implies a need to implement policies that help to identify and plan the proper use of land in order to reduce the threat that its expansion may pose to vegetation areas and, consequently, to local and regional biodiversity (HALLEUX *et al*., 2012).

The literature has recognized biodiversity as one of the main elements that help an ecosystem to provide its services (MACE *et al.*, 2012). The decrease in biodiversity has negatively influenced the provision not only of specific services but of its whole (CARDINALE *et al*., 2012; DUFFY *et al.*, 2017). Moreover, it should be noted that there is a dependence of human existence on the provision of these services (DAILY; DASGUPTA, 2001), bearing in mind that humanity depends on a healthy environment with natural resources available for use (COSTANZA; DALY, 1992). Thus, ecosystem services can be defined as the benefits that people derive from nature (MAE, 2005). On the other hand, individuals assist in the organization of structures that can expand or reduce the provision of these services (HAINES-YOUNG; POTSCHIN, 2010). Anthropogenic actions determine how changes in land use and conservation of green areas are defined (FEDELE *et al*., 2017). Thus, public actions permeate the context, as they may favor environmental protection through biodiversity conservation, which contributes to human well-being (MACE, 2014), creating a cycle between ecosystem conservation and human well-being (DÍAZ *et al.*, 2015).

Governmental public actions influence the flow of services offered by the environment to people (MACE, 2014). However, there is a need for advances in environmental public policies, so that public actions effectively contribute to this issue (COSTANZA *et al*., 2017). In this context, we propose to carry out a bibliometric and integrative review on urban green areas and the provision of ecosystem services.

2 METHOD

This review regarding studies of urban green areas follows the guidelines of Fink (2010) for conducting integrative reviews. The author proposed seven steps to conduct a review. The steps are 1) selection of a research theme, 2) selection of bibliographic databases, 3) choice of search terms, 4) screening based on practical criteria, 5) screening based on methodological criteria, 6) development of the review, and 7) synthesis of results.

After the first step, that is, the selection of the research theme, the databases were selected: Web of Science and Science Direct. For the search, therefore, descriptors were selected, as indicated in Table 1. They helped to identify scientific production related to the subject. Regarding practical criteria, we chose to screen articles written in English between 2009 and 2019. The methodological criteria used for screening were defined considering only peer-reviewed publications available in academic journals.

Table 1. Selection of files

Descriptors	Step 1	Step 2	Step 3	Step 4
"Green areas" and urban and "ecosystem services"	110	104	67	29

Step 1: search of articles in the databases;
Step 2: publishing within the pre-established period;
Step 3: selection of articles according to criteria: peer reviewed, published in academic journals, English language, exclusion of duplicates.
Step 4: exclusion of articles that do not address the theme.

Source: Research data (2020).

This selection allowed the analysis of 29 articles published within the period. They refer to urban green areas and ecosystem services produced in these areas. Elements of the bibliometric review were also used to identify the search results.

3 BIBLIOMETRIC ANALYSIS OF RESULTS

The number of articles analyzed refers to the temporal organization shown in Table 2. The results indicate that the production of knowledge related to the theme has expanded over the years considering the increase in percentage. This may be indicative of an increased interest of researchers in investigating the theme. The increased interest may be related to a need for a better understanding of the organization of urban space. 2018 stands out as the year with the highest number of publications.

Table 2. Temporal distribution of articles published in the period investigated

Publication year	Number of articles	Percentage (%)
2019	6	21
2018	12	42
2017	2	7
2016	3	11
2015	2	7
2014	1	3
2013	1	3
2010	1	3
2009	1	3

Source: Research data (2020).

Regarding the journals that published studies, 19 journals were identified. This number may indicate a diversity of journals interested in the subject. The highest number of publications was by *Urban Forestry & Urban Greening*. This journal published four articles during the review period. We also identified where such works were produced by identifying the country of the first author of each text. In general, most authors are in Europe: 90% of the production. The American and African continents are also part of the publishing context. Figure 1 shows the list of countries in which the authors of each published text are located, i.e., it shows the interaction between countries in scientific production. The first author's country is in blue, and the others in purple. Repeated relations were not considered for the elaboration of the Figure.

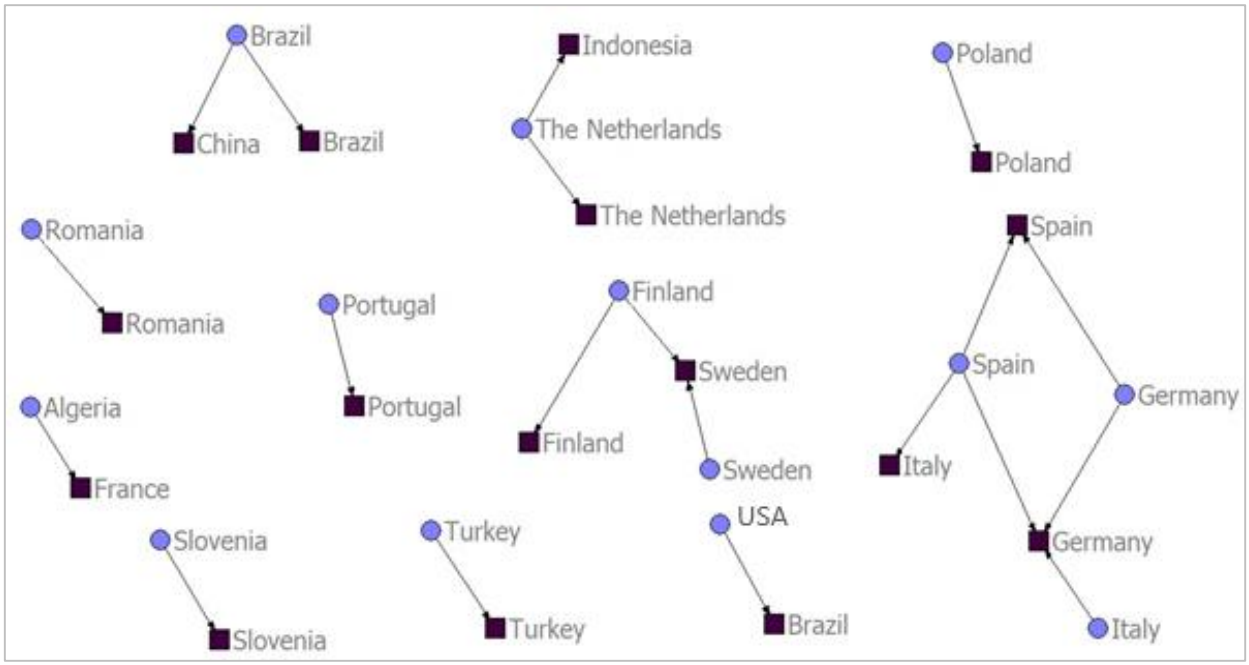

Figure 1: Relations between authors by country.
Source: Research data (2020).

Another perceived issue in reading the articles is that they use quantitative parameters in investigating the problem (83% of the production) because they tend to be an applied research using statistical tools and, in many cases, geotechnologies. Other productions refer to the mixed approach (14% of production), i.e., the use of quantitative and qualitative characteristics in a same research. And yet one of the productions used the qualitative as an approach to the problem. This reveals that currently research with qualitative and mixed approaches can be used more frequently in researches on the subject.

Figure 2 is a word cloud elaborated using the keywords of the analyzed publications. There are more prominent words because their use is more frequent in the selected articles, namely 1) *urban* 2) *services*, 3) *ecosystem*, and the words 4) *green* and 5) *environmental* follow those words. Most words were used in the search carried out in databases for the selection of articles related to green areas and ecosystem services.

Figure 2: Keyword Cloud
Source: research data (2020).

Regarding the composition of the authors per article, Table 2 shows its quantification. The highest percentages of publications are written by two, three and five authors (21% each), followed by four authors (17%). Thus, the production of knowledge regarding the subject is

performed collectively, that is, forming a collaborative network. This characteristic may be related to the interest of researchers on the subject and because these productions are related to complex problems that need an interdisciplinary approach for the development of the research.

Table 3. Authorship of articles

Authorship	Frequency	Percentage (%)
One author	1	3
Two authors	6	21
Three authors	6	21
Four authors	5	17
Five authors	6	21
Six authors	1	3
> six authors	4	14

Source: research data (2020).

4 EVIDENCE IDENTIFIED IN THE LITERATURE

When addressing green areas in urban spaces considering ecosystem services, consideration should be given to providing services that benefit human health and the well-being of the local population (PIRNAT, HLADNIK, 2019; SALATA *et al*., 2017; SZUMACHER; PABJANEK, 2017). For this, the organization of urban space must be strategic in order to generate accessibility of these areas to residents and visitors, reducing green inequalities (PIRNAT, HLADNIK, 2019; GRAÇA *et al*., 2018b). When planning cities, it should be considered that urban green areas need to be multifunctional given the different needs of the population (BATTISTI *et al*., 2019; BELMEZITI *et al*., 2018). The multifunctionality of green spaces becomes even more necessary when one considers that its creation can be a challenge (BELMEZITI *et al*., 2018), taking into account that in urban spaces, land is scarce and expensive, and green areas occupy large tracts of land (BELMEZITI *et al*., 2018). Therefore, there must be an assertive decision by planners regarding the creation of areas for the reduction of existing conflicts of interests in land use (BELMEZITI *et al*., 2018; ANDERSSON-SKÖLD *et al*., 2018; BORGSTRÖM, 2009). Thus, the diversity of ecosystem services that can be generated during the cycle of the vegetation can be included in urban planning, taking into account, however, the knowledge of its allergenic potential for the population (BATTISTI *et al*., 2019) and the safety of the area, especially for the elderly (GRAÇA *et al*., 2018a).

In order to be able to carry out local urban planning, some factors must be organized. If unplanned, they can hinder this process. The factors are 1) the existence of legal ownership of land, 2) the creation and enforcing of laws for urban management and or planning, 3) the

existence of resources for the maintenance and expansion of green areas, and 4) planning the expansion of the urban network as population increases, reducing the peripheral invasion areas that usually occur in vegetated areas (DE CARVALHO; SZLAFSZTEIN, 2019). It should be taken into account, in this context, that there are unoccupied areas in the current urban space that, when used, could contribute to urban sustainability, considering that they can avoid the process of expanding land use (GAVRILIDIS *et al*., 2019). In addition, identifying and sharing with the population the value of existing ecosystem services in vegetation areas can contribute to the conservation of areas (PEDERSEN *et al*., 2019).

Creating green spaces in cities cannot be done without defining a design for the area. It is possible to establish criteria to define which ecosystem services one wishes to offer and, furthermore, it is possible to improve these services depending on the vegetation and the management practiced (BELMEZITI *et al*., 2018; DEPIETRI *et al*., 2013). The identification of the vegetation best suited to the climate characteristics of the site is an important action for the maintenance of green areas (GRAÇA *et al*., 2018a; MOSER *et al*., 2015; LEHMANN *et al.*, 2014). Moreover, it should be emphasized that the action of the local population can hinder or boost the generation of ecosystem services. Therefore, it is necessary to raise awareness of the subject (GRAÇA *et al*., 2018b). The density of the vegetation and the density of the city around the green area can be determinant factors for the existing biodiversity (PINHO *et al*., 2016).

Consideration must also be given to the need for a balance between the supply or flow of ecosystem services and their demand. Public policies in favor of this issue may, through their actions, favor the existence of this balance. Different public actions may be performed in relation to the context (BARÓ *et al*., 2016). It is noted that urban green areas contribute to this balance in different ways. Some situations regarding their location in the urban area become more favorable compared to areas located in remote places (RIBEIRO; RIBEIRO *et al*., 2016). Urban green areas are part of the people's context and, therefore, the understanding and awareness of the importance of nature becomes easier through environmental education (RIBEIRO; RIBEIRO *et al.*, 2016). Moreover, the social or collective memory of local individuals, when transmitted to future generations, contributes to the maintenance of activities that help to produce ecosystem services that determine urban and peri-urban land use (KRZYZANIAK *et al*., 2018; BARTHEL *et al*., 2010). In this context, gardens favor the production of ecosystem services. They are considered resilience spaces of such production in urban areas through pollination, pest control, food production, among others (KRZYZANIAK *et al.*, 2018; BARTHEL *et al.*, 2010).

It should be remembered that small areas, such as private gardens and vegetable gardens, need to be valued as they tend to be forgotten by researchers. However, ecosystem services are also performed in these places and, together with other areas, comprise the production of these services in the cities (HEPCAN; HEPCAN, 2018). Local governments understanding this need

can encourage private landowners to create or maintain gardens in a qualitative and biodiverse manner, enabling different ecosystem services to be generated in small areas (HEPCAN; HEPCAN, 2018). In municipalities, the existing dichotomy between rural and urban needs to be overcome, especially when thinking about food production, whose demand is increasing due to the population increase in the world (GREN; ANDERSSON, 2018). This ecosystem service, traditionally performed in rural areas and mostly consumed in urban areas, can be favored by managers' decision-making regarding the location of urban green areas (GREN; ANDERSSON, 2018). The location of private vegetation areas in peri-urban regions should also be considered given that pollinating animals such as bees and birds could act as disseminators of missing plant species through unplanned urban expansion or monoculture production in rural areas (GREN; ANDERSSON, 2018).

Table 4 provides information regarding the objective and the main results identified in the analyzed publications. Studies point to 1) diagnostics in green areas regarding the best generation of ecosystem services, 2) a comparison of types of ecosystem services according to their importance in the opinion of local people, and 3) suggestion of the need to carry out urban planning including green areas and considering their importance.

Table 4. Summary of the publications analyzed

Author	Objective	Main Results
Pirnat and Hladnik (2019)	Examine how well the current distribution of green surfaces in both cities works in support of a sustainable urban development strategy.	Collaborative planning between the two cities would increase common benefits, including future economic, social influences and innovations.
Battisti *et al.* (2019)	Provide a description of the status quo of the residential green area.	Motivation for co-creation of paid and inclusive green spaces, and care by residents and real estate companies.
Maheng *et al.* (2019)	Investigate the existence of heat islands and the impacts of green areas to mitigate the impacts of heat islands.	Numerical simulations of urban climate using variations in size and distribution of green space show that the spatial and temporal distribution of urban temperature is sensitive to the size and distribution of green spaces.
De Carvalho and Szlafsztein (2019)	Identify the loss of urban vegetation and relate it to the provision of ecosystem services.	Given the fast loss of vegetation cover, with almost no recovering and monitoring of green areas, the supply of ecosystem services in Belém, Brazil, is declining, as is the quality of the urban environment.
Gavrilidis *et al.* (2019)	Determine the criteria necessary when planning new urban green spaces.	The proposed methodological framework provides a valuable approach to urban green space planning in the context of urban expansion in cities.
Pedersen *et al.* (2019)	Quantitatively establish the prevalence of cultural ecosystem services provided by urban and peri-urban wetlands.	Identifying and revealing values of cultural ecosystem services can increase the total value attributed to urban wetland areas and thus motivate the implementation of wetlands, despite competitive land use interests.

Belmeziti *et al*. (2018)	Describe the components of green space and relate them to possible urban services.	Suggestions in areas investigated on how to improve urban services without increasing green areas.
Almeida *et al*. (2018a)	Evaluate the costs and provisions of a subset of ecosystem support and regulation services in urban parks and examine the importance of these services from an environmental/economic perspective.	Green areas in urban parks provide valuable services to the municipality, and parks can be designed to meet the needs of surrounding areas.
Korpilo *et al*. (2018)	Investigate the suggestion that different types of data and their integration can provide sustainable spatial planning of multifunctional landscapes.	While preventing deterioration of areas with a high ecological and social quality is crucial; even lower quality areas should receive more attention in the literature and planning processes.
Hepcan and Hepcan (2018)	Calculate three regulatory ecosystem services: flow retention, storage and carbon sequestration.	A comprehensive approach is required by which all types of green areas are systematically planned and managed so that they can provide optimal services.
Gren and Anderson (2018)	Illustrate how the perspective of ecosystem services can influence the way we think and plan the urban-rural interface to support food production in the city surroundings better and meet the demands of urban expansion.	Plants intended for use on roofs are conditioned by weather conditions.
Azeñas *et al*. (2018)	Conduct a long-term experiment to evaluate five Mediterranean species for green roof implementation under Mediterranean climate conditions.	The studied species had a high aesthetic performance and water consumption throughout the rainy season, suggesting a potential role in the regulation of rainwater related to the reduction of runoff.
Almeida *et al.* (2018b)	Evaluate the costs and provision of a subset of support and regulation of ecosystem services in urban parks and discuss the role and value of these services from an environmental/economic point of view.	Green areas inside urban areas such as parks provide valuable services to the city community through processes of transformation of renewable natural inputs that would otherwise be wasted.
Graça *et al*. (2018a)	Investigate how the benefits (cultural, regulatory and economic) and losses/costs caused by street trees are perceived by citizens and influenced by a set of socioeconomic variables.	People in the city of Porto, Portugal, valued environmental benefits to a higher degree (particularly improved air quality) than cultural benefits.
Krzyzaniak *et al*. (2018)	Investigate changes in the public green space areas of Szczecin, Poznán and Wrocław in 1996-2013, and compare data on public vegetation with demographic data and changes in spatial development of these cities.	It is necessary to establish an appropriate proportion of public vegetation that must be inside the urbanized areas of cities. Otherwise, there would be a decrease in green areas in relation to residential areas.
Graça *et al.* (2018b)	Explore how different types of urban green spaces influence the delivery of ecosystem services in the city of Porto, Portugal, and how this variation is affected by a socioeconomic gradient.	Uneven distribution of green space types across all socioeconomic strata changes the delivery of ecosystem services throughout the city.
Zhou *et al*. (2018)	Investigate residents' preferences for cultural services along the urban gradient through map-based research around the Dutch city of Maastricht.	The results illustrate the heterogeneity of people's preferences for cultural services along the urban-urban gradient.

Andersson-Sköld *et al*. (2018)	Provide a method for measuring the contribution and assessment of multiple ecosystem services provided by urban vegetation that can be applied to routine planning processes.	Ecosystem services provided by urban green areas were characterized as highly important and compared to other important aspects in cities, such as improvements in public transport, housing, culture and entertainment; these services were rated as of equal importance.
Salata *et al.* (2017)	Connect existing field studies on land use-related matter particle distribution to define a preliminary methodological approach for mapping particulate matter concentrations.	Land use planning for sustainable air quality helps to predict health diseases.
Szumacher and Pabjanek (2017)	Analyze the selected land use types (forest, green urban area), land sealing, the selected ecosystem services (food supply, climate regulation, recreation) and biodiversity potential in 85 large cities (over 100,000 inhabitants) in the continental biogeographic region (Central and Eastern) in Europe.	They indicate the importance of monitoring changes in land use and ecosystem services for potential spatial planning interventions and regional policies.
Baró *et al*. (2016)	Promote an operational framework for assessing and mapping the capacity, flow and demand for ecosystem services to inform urban and landscape planning.	Mapping ecosystem service capacity, flow and demand can contribute to a successful integration of the ecosystem services approach into landscape and urban planning, as it provides a comprehensive view of the service delivery process considering both ecological and social factors.
Ribeiro and Ribeiro (2016)	Evaluate the immaterial benefits of Pedra Branca State Park, the largest urban park in Brazil, located in the city of Rio de Janeiro, the second most populous Brazilian city.	The park offers significant intangible benefits, according to respondents; aesthetic, recreation and ecotourism values are the most perceived.
Pinho *et al*. (2016)	Show that not all forested green areas are equal in importance regarding species, but that, based on a multi-rate approach and functional diversity, it is possible to assess green infrastructure in urban environments.	Vegetation density and, more importantly, the number of urban areas surrounding the forest (matrix) are more important for biodiversity than the number of forests alone.
Cord *et al*. (2015)	Investigating the city of Leipzig (Germany) using geocaching as a case-study to explore short-term recreation as a cultural ecosystem service.	Geocaching data provides interesting opportunities to explore spatial gradients, as well as recreation-related preferences and motivations.
Moser *et al.* (2015)	Characterize the dimensions of two urban tree species and predict future structural dimensions based on diameter at breast height and tree age.	Urban trees have considerably improved the climate in cities due to carbon storage, shading and cooling provided by individual trees, showing a direct relation with leaf area index and age. The tree growth pattern associations identified in this study can be used as guidelines for tree planting in cities and their ecosystem services; they can improve the management and planning of urban green areas.
Lehmann *et al.* (2014)	Develop a spatially compatible approach to geographic information systems (GIS).	Selected results from climate modeling are presented, confirming clear differences in the microclimatic effects of several vegetation structures at both city and urban district levels.
Depietri *et al.* (2013)	Assess the vulnerability of the urban population of Cologne to heat waves considering a number of social and ecological variables.	While vulnerability is greatest in central districts, attention needs to be paid to the periphery, where the most susceptible groups reside.

Barthel *et al.* (2010)	Explore social-ecological memory by analyzing how and where knowledge and practices related to the production of ecosystem services are retained socially and temporarily transmitted.	Managers of urban green areas and the social memory they carry can help counteract the decline of ecosystem services.
Borgstöm (2009)	Statistically assess current nature conservation in 209 municipalities in southern Sweden by analyzing the number, size, age and land cover patterns of nature reserves in relation to the degree of urbanization.	The most urgent challenge is to develop urban nature conservation strategies integrated into the urban context, including other green areas and built areas, the history of land use, and the requirements for local ecosystem services throughout the landscape.

Source: Research data (2020).

5 Final Considerations

There is interest by researchers on the production of knowledge related to the provision of ecosystem services in urban spaces. The volume of publications has generally increased in recent years. In this context, the existing consensus refers to the importance of the existence of green areas, as well as the provision of ecosystem services to people considering the diversity of benefits that these services promote to the population. There are recommendations regarding public actions to consider in urban planning, the need for the population to have equal access to green areas, and the benefits they promote to physical and mental human health.

Thus, the importance of a proper urban spatial organization is stressed. It needs planning and action by public agents for a greater effectiveness in the provision of ecosystem services. The population needs to have access to this issue in order to assist in the conservation and care of green areas, as well as to demand from public agents measures that guarantee access to the benefits generated by green areas in cities. Thus, such services need to benefit the entire population. For this, green areas must be organized in different areas of cities, interacting with the rural and peri-urban areas, including vegetation consistent with the local climate, so that there is quality and continuity of the benefits produced in these areas.

Analysis of the publications indicates that further research may proceed using qualitative or mixed methods. Since most current publications use quantitative methods, this can be considered a limitation.

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