


Review

# Urban Ecosystem Services in South America: A Systematic Review

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**Abstract:** Nature within cities provides benefits for people known as urban ecosystem services. An assessment of urban ecosystem services is growing in South America, a biodiverse and highly urbanized region. To synthesize this growing body of knowledge in South America, we performed a systematic review identifying patterns in the literature and knowledge gaps. Our review shows that Brazil, Chile, and Colombia contribute the greatest number of studies. More than 80% of the studies were published in the last five years, revealing this as an emerging research topic in the region. More than half of the studies had an environmental perspective and focused on services provided by green spaces. Nearly all studies involved regulating services, followed by cultural services. We found clear knowledge gaps, including a paucity of assessments on supporting and provisioning services, as well as the lack of studies in several countries, evaluations concerning land cover other than parks, and large-scale assessments. Comparing ecosystem services in different planning scenarios is urgently needed to make informed decisions, aid nature conservation, and provide ecosystem services for all urban dwellers. This knowledge will contribute to achieving sustainable cities and equitable access to ecosystem services in South America.

**Keywords:** cultural services; environmental services; green space; Latin America; sustainable cities; urban ecosystem services



**Citation:** Muñoz-Pacheco, C.B.; Villaseñor, N.R. Urban Ecosystem Services in South America: A Systematic Review. *Sustainability* **2022**, *14*, 10751. <https://doi.org/10.3390/su141710751>

Academic Editors: Daniele La Rosa and Viviana Pappalardo

Received: 21 July 2022

Accepted: 22 August 2022

Published: 29 August 2022

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## 1. Introduction

Cities and towns are the home of more than half of the global human population. Currently, 55% of the world population lives in urban land, and it is projected that most (68%) humans will live in urban areas by 2050 [1]. As more people live in urban centers, they increase in size and number, challenging governments to ensure urban ecosystem functioning as well as the well-being of urban residents [2].

The ecological value of cities is commonly perceived as low due to the profound transformation of the natural environment [3]. Urban development causes strong impacts on the environment at local and global scales, changing land covers, biodiversity, water resources, biogeochemical cycles, and climate [4]. Despite the strong environmental impact of urban development, nature within urban landscapes can provide benefits for humans that are known as urban ecosystem services [5].

Ecosystem services are defined as “the benefits that people obtain from ecosystems” [6]. They are commonly classified into four types: (1) provisioning services, which comprise all the products obtained from ecosystems, such as genetic resources, food, fiber, medicines, biofuels, ornamentals plants, and freshwater; (2) regulating services, which are the benefits provided by ecosystem processes, such as the regulation of climate, water, and diseases, pollination, seed dispersal, flood prevention, and erosion control; (3) cultural services, which are the immaterial benefits people obtain from ecosystems, such as spiritual enrichment,

cognitive development, reflection, recreation and ecotourism, education, science, sense of place, the support of social relationships, and aesthetic values; and (4) supporting or habitat services, which are the ecosystem services that are necessary for the production of all other ecosystem services and includes habitat for species, primary productivity, and nutrient cycling [7].

Urban ecosystem services have received increasing attention [2,8,9]. They include a variety of benefits for urban residents and can improve climate resilience [10]. Despite the high level of global urbanization, with more people living in urban than in rural land, only 10% of the literature on ecosystem services has focused on urban landscapes [9]. If ecosystem services are the benefits that people receive from ecosystems, cities and towns are important places to understand and improve ecosystem service provision because more humans live there.

Urban ecosystem services have important effects on the human quality of life, and thus, they must be considered in developing strategies for sustainable development, urban suitability, and urban resilience [11]. However, about 60% of ecosystem services are degrading, or are used unsustainably, especially those associated with regulating and provisioning services such as water and air purification, natural hazard regulation, fuelwood, freshwater, and wild foods including wild fisheries [6]. The unsustainable use of most ecosystem services is diminishing the planet's capacity to provide those services [12]. This degradation of ecosystem services is also increasing inequities among people, leading to poverty and human conflict [6].

South America is characterized by high biological and cultural diversity and strong socioeconomic inequities [13]. It presents a high urbanization level, with 83% of people living in urban land, and it is estimated that more than 90% of people will live in urban land by 2050 [1,14]. Although studies on ecosystem services are growing fast [13], only a few studies in South America and Latin America have been included in international reviews on urban ecosystem services [2,8,9,15,16]. The few published systematic reviews on urban ecosystem services mainly summarize studies from North America, Europe, and Asia [2,8–10,15,17].

We present the first systematic review to synthesize the current knowledge on urban ecosystem services in South America. We performed a research synthesis by reviewing documents in Spanish and English language. We explored publication trends and geographical patterns, ecosystem service assessment, study analyses, and authors' recommendations (see Methods for details). Based on our research synthesis, we identified key knowledge gaps and research needs for achieving sustainable cities and towns.

## 2. Methods

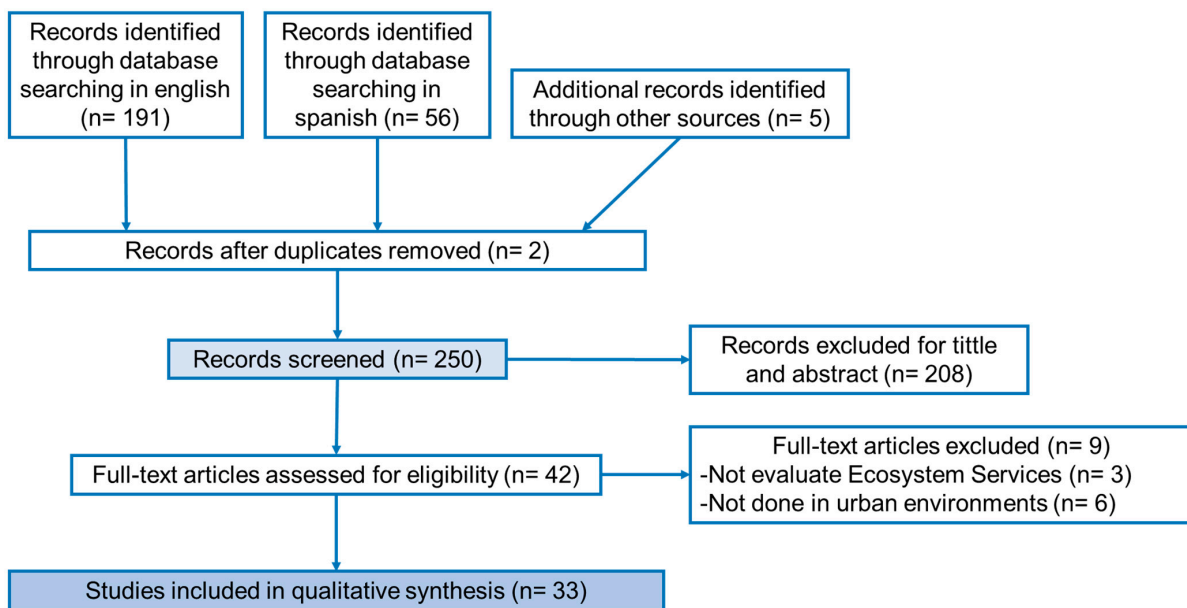
### 2.1. Literature Search

We used Google Scholar (<https://www.scholar.google.com>, accessed on 18 February 2021) to search documents, with help of Publish or Perish software [18]. Google Scholar was preferred over other search engines, such as Web of Science or Scopus, because it comprises documents from different languages and includes a large number of documents in the Spanish language [19]. In addition, it contains articles in indexed journals as well as the grey literature [20]. It is commonly encouraged to include the grey literature in systematic reviews because it represents an important part of knowledge production [21] and diminishes publication bias (because when study results are non-significant or contrary to common findings, they are less likely to be published [22]).

We conducted our search in February 2021. We searched for documents using the following combination of terms first in English and then in Spanish: "ecosystem services" AND (urban OR city OR town) AND (South America OR Argentina OR Bolivia OR Brazil OR Chile OR Colombia OR Ecuador OR Peru OR Paraguay OR Uruguay OR Venezuela). In both searches, "ecosystem services" was considered in the title. The titles and abstracts of all the identified documents were examined. Full texts were assessed when the studies fulfilled the following inclusion criteria: (1) they surveyed ecosystem services in urban environments, (2) they were located in South America, and (3) they were written in English

or Spanish. For all the papers that met the inclusion criteria, the list of references was read searching for new relevant documents (not found by the search engine).

We found 250 documents. From our searches on Google Scholar, we found 191 documents in English and 56 documents in Spanish, but 2 were duplicate records. Five additional documents were found from the list of references. After reading the title and abstract of the 250 records, 208 papers were excluded for not meeting the inclusion criteria described above, and 42 full texts were assessed. Of these, 33 (76%) studies met our inclusion criteria and comprised our qualitative synthesis, 24 of which were written in English, and 8 (24%) were written in Spanish (Figure 1). The nine documents that were excluded did not meet our inclusion criteria: three studies did not evaluate ecosystem services, and six were not conducted on urban environments.



**Figure 1.** Literature search flow diagram.

## 2.2. Data Extraction and Synthesis

Following the published global reviews on urban ecosystem services, we undertook a qualitative assessment and synthesis (e.g., [2,8–10,15,17]). For all the documents that met our criteria for inclusion, we extracted information to assess:

(1) Publication trends and geographical patterns—we extracted the year of publication, publication type (e.g., book chapter, journal article, thesis, or conference proceeding), city and country where the study was located, and the number of inhabitants in the study sites.

(2) Ecosystem service assessment—we extracted the type of ecosystem services assessed (provisioning services, regulating services, supporting services, and cultural services), the perspective (environmental: studies with an environmental science focus; social: studies that explore the social component, human perception, norms governing urban areas, or benefits for humans discussed under a sociological, health, anthropological or physiological perspective; and economic: economic assessment studies [8,23]); and the land cover types involved. For land cover types, we maintained the terms used in the studies. In addition, we further separated the land cover type “green space” (land covered by vegetation) into the following categories: large urban parks (>2 ha in size), small parks (<2 ha in size), green infrastructure (e.g., green walls or green pavements), urban vegetation (i.e., vegetation in the city located in different places including parks, streets, private gardens, etc.), urban forest (e.g., woody vegetation), and forest remnant. We also recorded the ecosystem services used (based on [2,6]), as well as the ecosystem services provided by fauna and disservices.

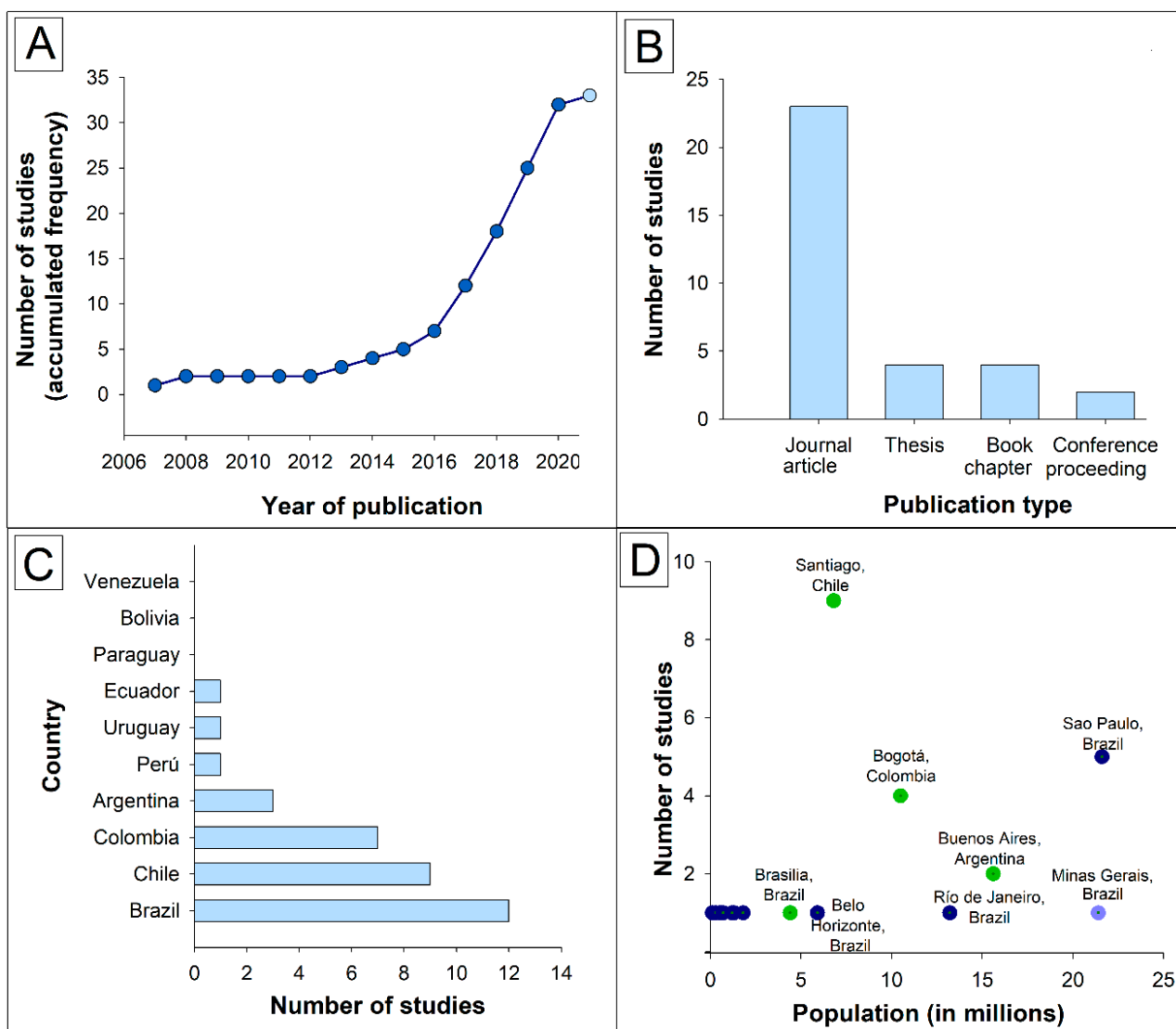
(3) Study analyses—we extracted the spatial scale (national and regional—studies with more than a single city or those at the watershed level; and local—in a single city), the type of analyses performed (conceptual, qualitative, and quantitative), and the type of data (empirical, database, satellite, bibliographic, expert opinion, and resident interview).

(4) Author recommendations—we extracted authors' recommendations for improving the current studies as well as recommendations for management and planning, among others.

### 3. Results

#### 3.1. Publication Trends and Geographical Patterns

The 33 studies included in our synthesis exhibited an increasing number of publications over time, especially since 2017. No studies were found before 2007. Seven (21%) studies were published from 2007 to 2016, whereas 26 (79%) studies were published from 2017 to 2021 (Figure 2A). These 33 studies comprised different publication types. Most studies (70%) were published in scientific journals, followed by book chapters (12%) and theses (12%, Figure 2B).



**Figure 2.** (A) Accumulated number of studies by year (note that studies in 2021 comprise only those in January and February); (B) number of studies by publication type; (C) number of studies by country; (D) relationship between population size and number of studies in study areas. Blue points correspond to cities. Green points show national capitals. We note that Minas Gerais is a State in Brazil (thus, it is depicted in a different color). To aid visualization, the last panel excludes a national assessment in Brazil.

We only found studies from seven of the ten targeted countries. The countries with a greater number of studies were Brazil with 12 studies (35% of the total), Chile with 9 (27%), and Colombia with 7 (21%). We did not find studies from Bolivia, Paraguay, and Venezuela (Figure 2C). Eighteen cities were evaluated (Figure 3). Among them, large cities received greater attention: Santiago de Chile exhibited the greatest number of studies (nine studies, 26%), followed by Sao Paulo, Brazil (five studies, 15%), and Bogotá, Colombia (four studies, 12%) (Figure 2D). All the studies involved a single city, except for two studies that used two different cities: one evaluated Bogotá, Colombia, and Santiago, Chile [24], while the other studied Santiago and Valparaíso, Chile [25].

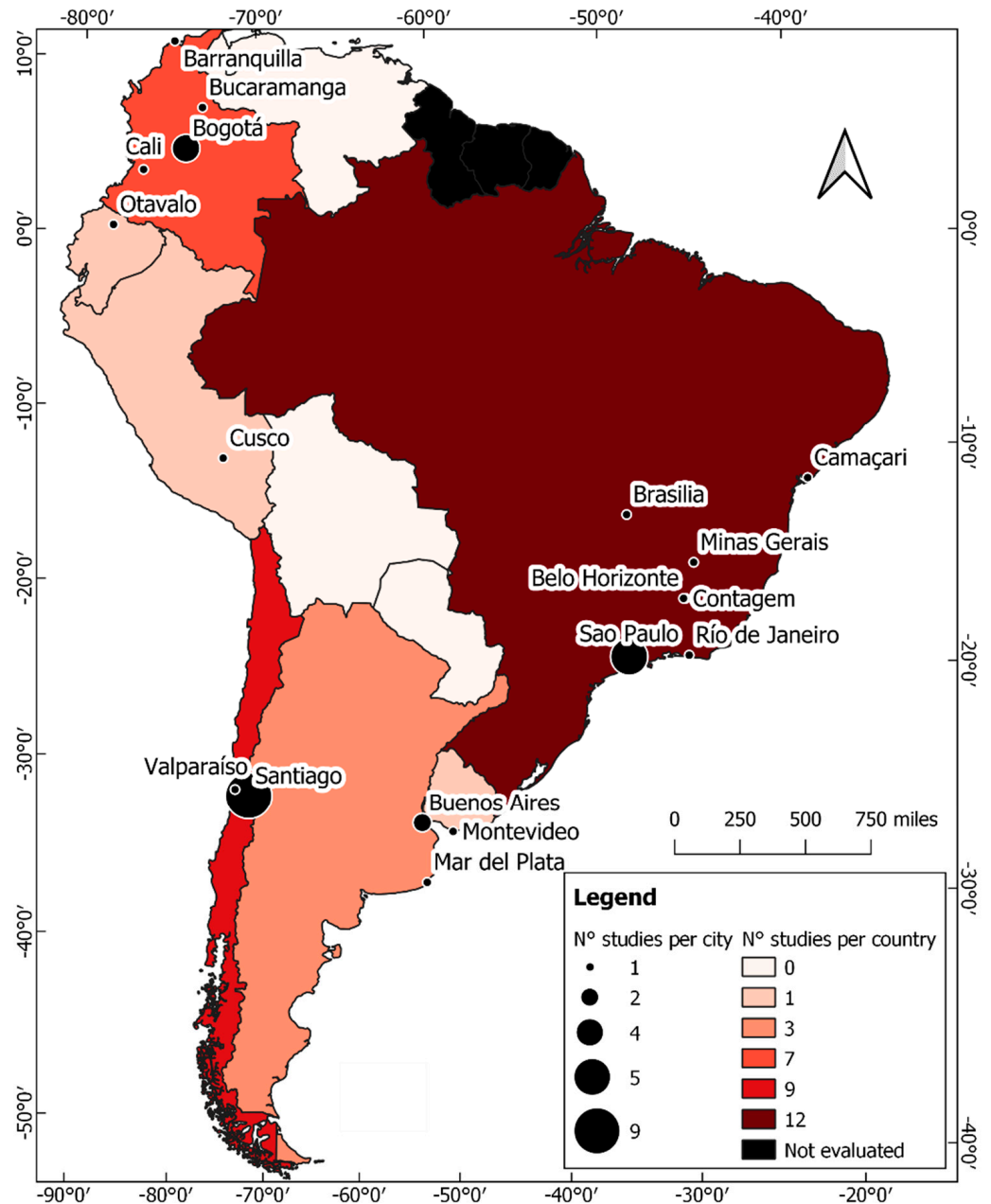
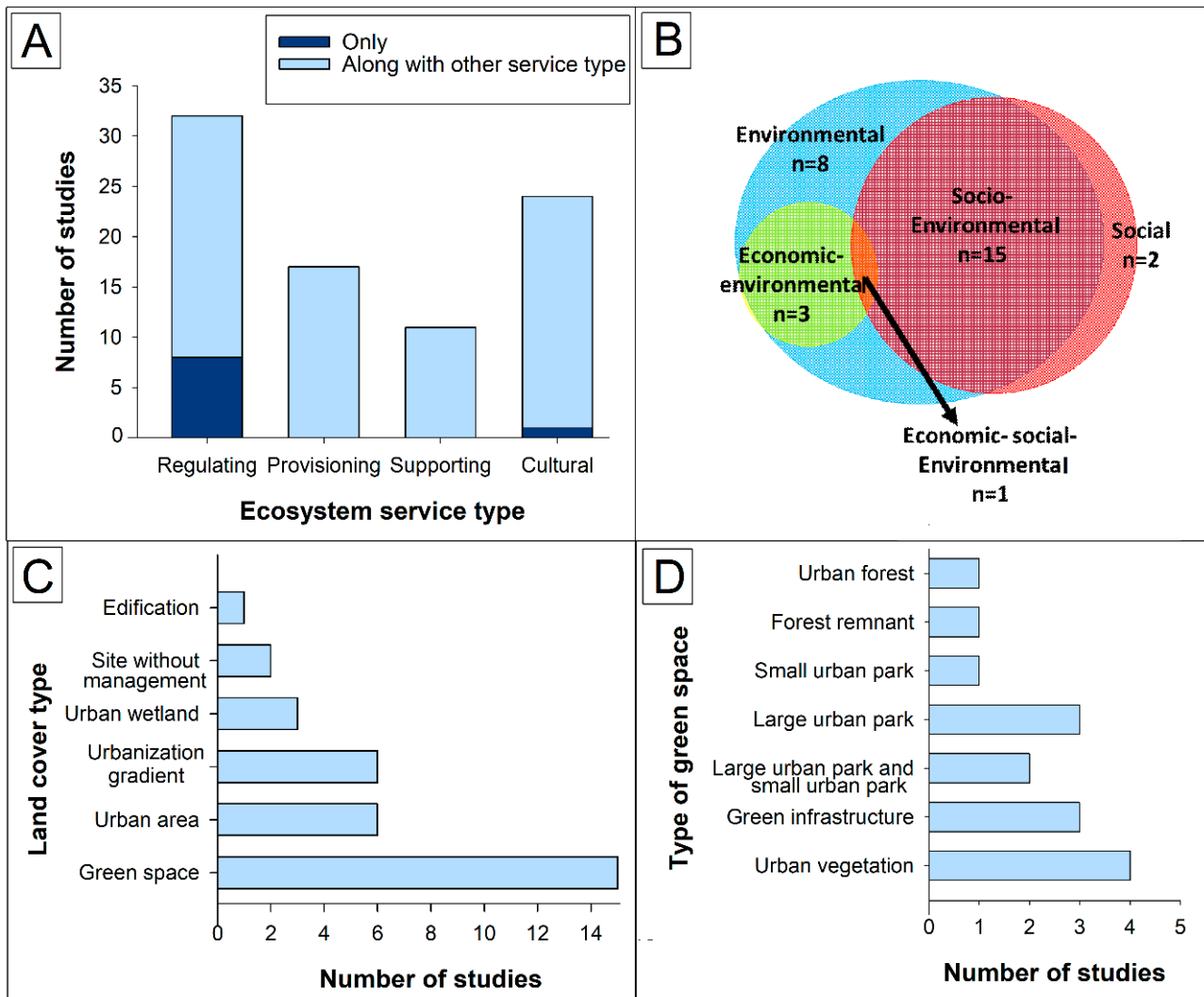


Figure 3. Geographical representation of the cities studied.

### 3.2. Ecosystem Service Assessment

Regarding the type of ecosystem service assessed, all the studies except one (32 studies, 97%) evaluated regulating services, followed by cultural services (24 studies, 73%), and supporting services (11 studies, 33%; Figure 4A). Provisioning and supporting services were only considered when the authors included several services (more than 20 services). Regarding their research perspective, 94% were focused on environmental aspects, 64% on social, and 18% on economic factors (Figure 4B). Only two (6%) studies explored environmental, social, and economic perspectives [26,27].

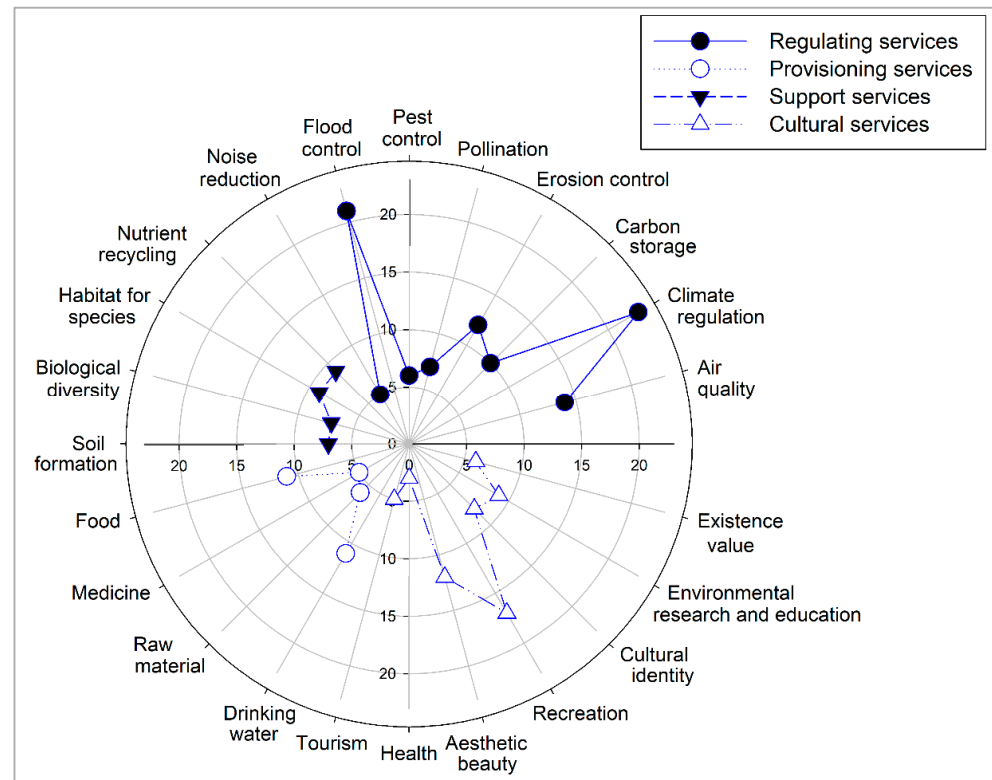


**Figure 4.** (A) Number of studies by ecosystem service type; (B) number of studies by perspective; (C) number of studies by land cover type; (D) number of studies by type of green space.

Regarding land use cover, nearly half of the studies (15 studies, 46%) focused on green spaces, followed by those focused on urban areas (6 studies, 18%, including built cover, favelas, and cities) and urbanization gradients (6 studies, 18%) (Figure 4C). Among the studies on green spaces, most studies focused on urban vegetation, followed by urban parks and green infrastructure (Figure 4D).

Among ecosystem services, climate regulations were the most frequent (23 studies), followed by mitigation of flooding (21 studies) and recreation (17 studies). The first two correspond to regulating services, whereas the third corresponds to a cultural service (Figure 5). Few studies considered mental and physical health (three studies), followed by tourism (five studies), which are both cultural services, medicine (five studies, provisioning

services), and noise reduction (five studies, regulating services). Almost half of the studies evaluated more than five ecosystem services (16 studies), whereas only 5 studies (15%) evaluated only one ecosystem service.



**Figure 5.** Number of studies according to the ecosystem services evaluated.

Among the most evaluated ecosystem services (climate regulation, mitigation of flooding, and recreation), we found that most studies highlighted the value of large green spaces dominated by pervious surfaces that provided a better quality of ecosystem services such as buffering extreme temperatures, flood control, and recreation. For instance, large parks with more than 25 ha significantly contribute to climate regulation [28]. In contrast, sites with lower nutrient retention present higher risks in the face of flooding [29].

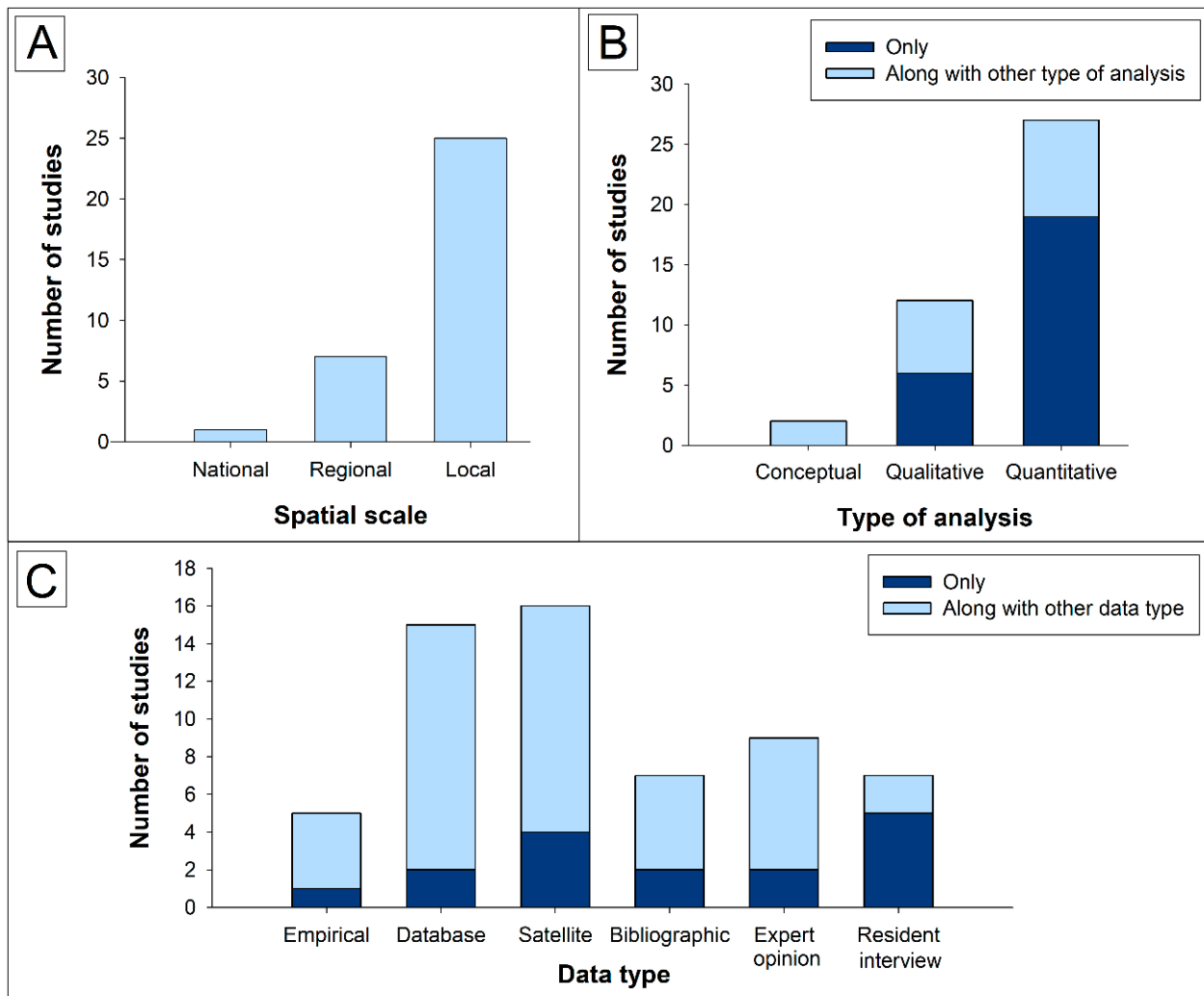
Only two studies included ecosystem services provided by fauna. They included birds (mainly hummingbirds) and pollinating arthropods (mainly butterflies). The ecosystem services that were evaluated were pollination, biological diversity, the provision of habitat for animals, cultural values, recreation, environmental education, and avitourism [30,31]. Only three studies assessed disservices, which included crops pest, pollen allergies, infrastructure damage, fear of dark areas, vector diseases, and garbage dumps [32–34].

### 3.3. Study Analyses

Regarding spatial scale, most studies (25 studies, 76%) involved local city-scale assessments, followed by regional (21%, which involved more than a single city, province, or watersheds); only one was on a national scale (Figure 6A).

Most studies (27 studies, 82%) included quantitative assessment. Of these, six studies also included qualitative assessments, and two studies involved qualitative and conceptual analyses. Qualitative assessments were the second most frequent analysis (12 studies, 36%), with only half of these studies focused only on qualitative assessment (Figure 6B). In total, 14 of the 27 quantitative studies involved maps. Of these, nine showed the provision of ecosystem services, and five involved geostatistics.

Regarding the type of data, nearly half the studies (49%) used satellite data, followed by the use of databases (46%); those mainly considered collections of climate data, land use, biodiversity, and socioeconomic data provided by municipalities or governments. Only five studies (15%) collected empirical data, which were mainly complemented with databases, satellite data, and bibliographic data (Figure 6C).



**Figure 6.** (A) Number of studies by spatial scale of analysis; (B) number of studies by type of analysis; (C) number of studies by data type.

### 3.4. Authors' Recommendations

Authors' recommendations in the revised documents involved urban planning and management. They involved landscape planning, nature conservation, improvement of green spaces, and the implementation of green infrastructure (Table 1). Four studies also recommended a better spatial resolution [24]; improvement in cartography showing the provision of ecosystem services to better inform urban planners [35]; a study of ecosystem services and disservices related to human health [32]; and a better study of the relationship between vegetation cover and the provision of cultural ecosystem services [36].



**Table 1.** Summary of the authors' main recommendations ([24–32,34–57]).

Recommendation	Authors
<b>Territorial and landscape planning</b>	
<ul style="list-style-type: none"> <li>Should consider ecosystem assessment, promoting equitable access and sustainable use of resources.</li> </ul>	Escobedo et al. 2015 [43], Iwan et al., 2017 [48], Reverte et al., 2020 [52]
<ul style="list-style-type: none"> <li>Should guarantee ecosystem services to achieve landscape sustainability.</li> </ul>	Montoya-Tangarife et al., 2017 [25]
<ul style="list-style-type: none"> <li>Should consider socioeconomic aspects and multiple scales to aim a harmonic territorial development.</li> </ul>	Ubilla and Villegas 2017 [55], Juanita et al., 2019 [32]
<ul style="list-style-type: none"> <li>Should consider topography because it can influence ecosystem services provision.</li> </ul>	Sanches et al., 2020 [53]
<ul style="list-style-type: none"> <li>Planned urban growth will increase urban density and green areas, favoring ecosystem services provision.</li> </ul>	de la Barrera et al., 2016 [41]
<b>Nature conservation</b>	
<ul style="list-style-type: none"> <li>Need to value geodiversity for long-term nature conservation and ecosystem services provided by abiotic factors.</li> </ul>	Motta 2019 [49]
<ul style="list-style-type: none"> <li>Need to consider different knowledge systems to guarantee the conservation of ecosystems and their services.</li> </ul>	Aguado et al., 2018 [27]
<ul style="list-style-type: none"> <li>Need to protect native species through habitat enhancement (e.g., reforestation) and improvement of ecosystem services provision.</li> </ul>	Collantes 2007 [30]
<ul style="list-style-type: none"> <li>Consider the economic value of ecosystem services and economic incentives to promote ecosystem conservation.</li> </ul>	Martínez 2008 [26]
<b>Improvement of green areas</b>	
<ul style="list-style-type: none"> <li>Improve distribution of green areas considering a network and sustainable maintenance and management of small and medium green spaces.</li> </ul>	Banzhaf et al., 2019 [39], Mujica and Karis 2021 [50]
<ul style="list-style-type: none"> <li>Provide parks in deprived urban areas to decrease the scarcity and inequity in access to ecosystem services.</li> </ul>	de la Barrera et al., 2019 [40]
<ul style="list-style-type: none"> <li>Consider vegetation type to provide ecosystem services that are needed.</li> </ul>	Fernandez 2019 [35], Banzhaf et al., 2019 [39]
<ul style="list-style-type: none"> <li>Park establishment and renewal should consider maintenance costs and the value of ecosystem services.</li> </ul>	Almeida et al. 2018a [28], Almeida et al., 2018b [38]
<b>Green infrastructure</b>	
<ul style="list-style-type: none"> <li>In highly built areas, green roofs and green permeable paving can mitigate ecological impacts.</li> </ul>	Ronchi and Arcidiacono 2019 [29]
<ul style="list-style-type: none"> <li>The green riparian corridor could improve ecosystem service provision and mitigate and adapt to climate change.</li> </ul>	Vásquez 2016 [57]

#### 4. Discussion

A growing body of knowledge on urban ecosystem services is emerging in South America, where more than 80% of the studies included in this systematic review were published in the last five years. Most research was performed in only three countries, involved local-scale assessments, focused on services provided by green spaces such as parks, and assessed regulating and cultural services. These common areas of research lead to clear knowledge gaps that we further discuss in this section. Researchers from South America highlight the need to improve landscape planning and green space management to ensure ecosystem service provision for all urban dwellers.

##### 4.1. Publication Trends and Geographical Patterns

Despite the limited number of publications included in our systematic review (33 documents), it was possible to describe clear trends and geographical patterns. For instance, our systematic review showed that ecosystem service assessment is a growing field of research in South America. Global reviews have reported a growing number of studies on urban ecosystem services since 2006 [2,8,9]. However, we found that the number of studies raised since 2017 in South America, revealing a 10-year time lag relative to global trends. The increase in the last few years has been mainly in Brazil, Chile, and Colombia, countries that will experience the highest population growth in the region by

2050 [1]. These three countries and México contribute to the greatest number of studies from Latin America [58]. However, in global reviews previously performed, Chile leads the publications from South America [2,8,15]. This difference could be due to an earlier development of this field in Chile that has been overpassed recently by Brazil—10 of the 12 studies found from Brazil have been published since 2018. Considering that Brazil's official language (Portuguese) was not included in this review, this country likely has a main role in knowledge production on ecosystem services in the region that might be overlooked in global reviews.

#### 4.2. Ecosystem Service Assessment

In South America, most publications evaluated regulating services, followed by cultural services. In the global and Latin American reviews previously published, regulating services contribute to the greatest number of studies, followed by supporting services [2,8,58]. Regulating and supporting services are likely studied more by different authors around the world due to their importance to guarantee the provision of the rest of the ecosystem services [10]. However, in South America, the supporting ecosystem services are poorly studied; such a poor understanding and lack of scientific interest might put all the ecosystem services that depend on biodiversity and ecosystem functioning at risk [59]. In contrast to the global and previous Latin American reviews where cultural services have been found to be the least common [2,8], several South American studies have assessed them possibly because they are easily recognized in cities (e.g., [24,50,60]), especially by local actors and residents (e.g., [26,27,57,61,62]). South America is characterized by its great cultural diversity and connection with nature [13]; therefore, cultural services such as spiritual and aesthetic values, social relationships, recreation, and a sense of belonging are of great importance. In addition, the first studies in Latin America on ecosystem services emerged under the frameworks of ethnoecology, cultural ecology, and political ecology [63], which might explain our results.

The most studied ecosystem services were climate regulation, flooding control, and recreation, consistent with global reviews [2,15]. We note that research has commonly focused on local climate regulation probably due to the increase in temperatures in urban land, or “heat islands”, which affect the health and well-being of city residents [64,65]. An important ecosystem component that regulates the local climate is vegetation [28,40]. However, not all residents have the same access to the services provided by vegetation because South American cities commonly exhibit strong segregation by socioeconomic groups, with the poor having less access to these services [43,66]. For example, it has been found that lower-income neighborhoods exhibit higher temperatures than higher-income neighborhoods probably due to their low vegetation cover and high impervious cover [40]. Under the current scenario of strong environmental segregation in South American cities, urban planning and vegetation management should aim to decrease the inequities in access to ecosystem services, ensuring a good quality of life for all urban residents.

In cities, recreation is an important service that is easily recognized and used by citizens [24,26,36,67]. The studies reviewed from South America commonly report a low provision of this service due to a low number of green spaces and difficult access [24,36]. In fact, the availability and access to urban green spaces in megacities are lower in South America than in other continents, such as Europe [68]. The low availability and access to green spaces might cause social and health impacts on city residents [69,70]. This low access to green spaces might be difficult to revert in developing countries because of poor urban and landscape planning, where the designation of lands as green areas is postponed, and therefore, land plots are commonly built [71].

In South America, flooding control is relevant particularly in tropical climates due to having larger precipitations than temperate zones (e.g., Europe and North America [72]). In addition, cities are vulnerable to flooding due to having large impervious surfaces, and thus, flooding will continue to be a problem as urbanization continues to expand [73].

Drainage systems such as green infrastructure, green permeable paving, green roofs, and rain barrels can contribute to the decrease in flooding [29,56].

Most studies assessed more than five ecosystem services, contrasting with the previous global reviews on the lack of multi-service assessment [2,74]. This might be due to the search strategy in studies in which the authors stated ecosystem services in the title of their work, which might lead to the inclusion of several ecosystem services. The use of multiple services is important for informing stakeholder decisions [75], as well as understanding interactions among services.

Both green and blue spaces provide ecosystem services that contribute to a healthy environment [76]. However, research on urban ecosystem services in South America has focused on green spaces—a finding that is common in global and regional reviews [2,8,17,58]. In cities, green areas are key providers of ecosystem services [77], benefiting the community through multiple services such as climate regulation, air quality, providing habitat for species, and recreation [11]. While in South America, urban vegetation and large parks receive more attention, in North America and Europe, research has focused on forest remnants and cultivated land [2,8]. Informal green spaces, such as vacant lands, have been poorly investigated, although recent scientific evidence emphasizes that they provide regulating and supporting services similar to urban parks [78]. Further investigation on ecosystem service assessments is needed in other lands, such as industrial lands and brown-fields (especially in stagnating and shrinking cities [2]), as well as community gardens that provide food for city residents [79].

Our review also revealed that the dominant perspective in South America is social-environmental. This result contrasts with the environmental or ecological perspective dominant in other regions [8]. Given that ecosystem services refer to the benefits that people obtain from nature, a social perspective is inherent [80]. In fact, most ecosystem services require the inclusion of production and their related social processes [81]. For instance, pollinating service by honeybees (a regulating service) requires the consideration of beehive management and silviculture; in livestock systems, water provision should consider grazing management and strategies to protect riparian areas (e.g., fences) [82]. Thus, future research needs to consider a more complete assessment of processes and interactions to comprehend and better manage the relationship between humans and the ecosystems they rely on. To ensure the sustainable use of ecosystem services, it is important to consider the environment as well as social and economic factors. Although economic factors are controversial, they contribute to making decisions on ecosystem management [83,84]. To further advance in this field, future research might focus on complex socioecological systems to enhance ecosystem services and human well-being.

#### 4.3. Study Analyses

Local (within a single city) studies comprised most of the assessments, in agreement with previous reviews [2,17,58]. There were seven studies at the watershed level and one at the national level (Brazil), but we did not find studies including more than one scale. It is important to perform multi-scale studies because ecosystem services are influenced by a variety of socioecological scales and can be provided and managed at different scales. For instance, food supply depends on pollination at a local scale, whereas water supply at a regional scale (watershed level) and market trends at a global scale [85]. Assessments on ecosystem services provision and fluxes at multiple scales will contribute to the development of conservation and land use plans to adequately protect and manage services [59].

Satellite data and databases dominated the literature. Changes in land use and cover are commonly evaluated in the literature, derived from maps, aerial photographs, and satellite data [2]. Satellite data are growing rapidly, as they allow the continuous and large-scale assessment and monitoring of ecosystem functioning and drivers of global change [86]. Although geospatial information is useful, the data and scales of analyses must be defined according to the research aim. Previous reports from Latin America and The Caribbean found that most studies involved field surveys, questionnaires, or interviews [58]. Questionnaires

or interviews are widely used to understand public perception of public and stakeholders, human impacts on flora and fauna, and interdisciplinary studies [87]. In interviews, the results can vary by the target group. For instance, in Ecuador, young educated Spanish speakers value more regulating services and those associated with science (e.g., pollination, scientific knowledge, environmental education, recreation), whereas old less formally educated people living in rural areas value more provisioning services (wood, wool, animal skins, medicinal plants) and agriculturally associated regulating services (pest control [27]).

#### 4.4. Authors' Recommendations

Researchers from South America underscore the need for better territorial planning, as it is the most relevant strategy affecting urban ecosystem services, regulating the capacity, demand, fluxes, and benefits of ecosystems [88]. Territorial planning influences ecosystem service provision by defining land use types, the spatial arrangement, distribution and density of housing and people, and the structure and function of urban systems [89]. Several authors call for ecosystem assessments, sustainable use of resources, and equitable access, but no studies have evaluated the effect of planning on ecosystem services provision. Few studies in the global literature have explored ecosystem services under different planning scenarios (e.g., [90–93]). Given that urbanization will continue to grow in South America [1], an evaluation of the effects of urban sprawl and densification under different planning scenarios is urgently needed to aid nature conservation and the services it provides (e.g., [94,95]).

Another common recommendation in the South American literature is the enhancement of green areas. Authors advise planners and policymakers to improve the distribution and connectivity of green areas within cities, to consider vegetation according to the ecosystem services that are needed by the community, as well as the maintenance costs and value of the ecosystem services provided. When designing green spaces, it is important to consider that not all plants provide the same ecosystem service [33]. We also found a paucity of studies estimating the environmental, social, and economic benefits of green space design and management in South America. For instance, in Rome, Italy, it was estimated that greater connectivity of green spaces will lead to 300,000 potential beneficiaries due to improved air quality and decreased costs by health illness from 40,700 to 130,200 EUR/year [96].

We note that our work does not attempt to be an exhaustive search of the literature but rather a sample of studies on urban ecosystem services in South America that we synthesized with a systematic review. In this way, a more exhaustive search could consider search words that comprise a variety of ecosystem services, nature services, or environmental services, including all the countries in the region (e.g., Surinam, Guyana, and Guayana Francesa), and additional languages (e.g., Portuguese, Dutch, and French).

Finally, we hope this systematic review helps guide future research to address key knowledge gaps and contributes to a growing body of knowledge to inform territorial planning, urban sustainability, and equitable access to ecosystem services in South America.

## 5. Conclusions

Our systematic review revealed that the topic of urban ecosystem services is an emerging field of research in South America. Only three countries accounted for 80% of the literature (Brazil, Colombia, and Chile), revealing a strong geographical bias. Most of the studies involved assessments at the local scale, focused on the services provided by green spaces (mainly parks), and assessed regulating and cultural services.

Among the different findings, it is important to highlight the fact that large green areas contribute to a large number of quantitative and qualitative features related to urban ecosystem services, such as temperature control, recreation, and flood control—the most evaluated services in South America. However, other less studied factors such as vacant lands can also provide many ecosystem services.

Several knowledge gaps remain to be addressed including research on provisioning and supporting services, evaluations of areas other than urban parks, studies at large spatial scales such as watersheds or regions, and comparisons of ecosystem services under

different scenarios of planning and management actions. A growing and varied body of knowledge on ecosystem services will allow research findings to better inform territorial planning, urban sustainability, and equitable access to ecosystem services in South America.

**Author Contributions:** Conceptualization, C.B.M.-P. and N.R.V.; methodology, C.B.M.-P. and N.R.V.; investigation and formal analysis, C.B.M.-P.; writing—original draft preparation, C.B.M.-P.; writing—review and editing, N.R.V.; visualization, C.B.M.-P.; supervision, N.R.V.; project administration and funding acquisition, N.R.V. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by ANID-FONDECYT 11201045 granted to N.R.V.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The authors will provide the data on request.

**Acknowledgments:** The authors acknowledge the funding received from ANID-FONDECYT 11201045 granted to N.R.V. and the Master's program in Wild Lands and Nature Conservation (Faculty of Forestry Sciences and Nature Conservation, Universidad de Chile) for providing support to C.B.M.-P.

**Conflicts of Interest:** The authors declare no conflict of interest.

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