EVALUATION OF ECOSYSTEM SERVICES AND MANAGEMENT OF URBAN GREEN AREAS: PROMOTING HEALTHY AND SUSTAINABLE CITIES[1]

GUILHERME LEITE GAUDERETO[2]
AMARILIS LUCIA CASTELI FIGUEIREDO GALLARDO[3]
MAURÍCIO LAMANO FERREIRA[4]
ANA PAULA BRANCO DO NASCIMENTO[5]
WALDIR MANTOVANI[6]

1 Introduction

To promote healthy and sustainable cities, urban green space management must conciliate convergent challenges that derive from health, environment and development agendas (GALLO; SETTI, 2012). Urban green areas, such as urban parks (ARCE et al., 2014; CHIESURA, 2004; CONWAY; VANDER VECHT, 2015), squares, public gardens and road arborization (LOBODA; DE ANGELIS, 2005), are considered relevant in promoting sustainable development of a city and in offering ecosystem services that add well-being to human life. Furthermore the ecosystem services of urban green areas contribute to the mitigation of negative environmental externalities that result from urbanization (FERNANDES; BOTELHO, 2016; GÓMEZ-BAGGETHUN; BARTON, 2012).

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2. PhD student in Engineering from the Polytechnic School at the University of São Paulo (USP). Master's in Administration - Environmental Management and Sustainability at the University of Nove de Julho (Uninove) and bachelor's in environmental management at the University of São Paulo (USP). E-mail: guilherme.gaudereto@usp.br

3. Postdoc in Environmental Sciences at the School of Environmental Sciences at the University of East Anglia. Professor of the Postgraduate Program in Environmental Management and Sustainability at the University of Nove de Julho - UNINOVE. Professor at the Department of Hydraulic and Environmental Engineering of the Polytechnic School of the University of São Paulo (USP). E-mail: amarilislcfgallardo@gmail.com

4. PhD in Science from the University of São Paulo (CENA / USP), master's in Plant Biodiversity and Environment from the Institute of Botany (IBT / SP), Bachelor and Bachelor of Biological Sciences from Universidade Mackenzie. Researcher and professor of the Academic Master's Program in Intelligent and Sustainable Cities (PPG-CIS) of the University Nove de Julho. E-mail: mauecologia@yahoo.com.br

5. PhD in Applied Ecology from the University of São Paulo (ESALQ / USP). Master in Ecology of Agroecosystems by the University of São Paulo (ESALQ / USP). Graduation in Biological Sciences by the State University of Maringá (UEM). Professor of the Postgraduate Program in Environmental Management and Sustainability at the University of Nove de Julho - UNINOVE. E-mail: apbnasci@yahoo.com.br

6. Agronomist and Ph.D. in Ecology, Full Professor, University of São Paulo (USP). E-mail: wmantova@usp.br

Bolund and Hunhammar (1999) postulated that the proper treatment of urban ecosystems provides a range of ecosystem services, such as air filtering, noise reduction, flood control, waste treatment, and cultural values and recreation that exert a positive influence on the urban population's health and quality of life. Sandifer, Sutton-Grier and Ward (2015) highlight the evidences found in the literature on the compromise between biodiversity and ecosystem services and between exposure to nature and human health, as opposed to the little information available on the relationship between biodiversity and health.

According to Hildebrand, Graça and Hoeflich (2002), the environmental quality of the cities and the way it affects the population's health and quality of life are issues that compose the public administration agenda. The valorization of green areas has been discussed worldwide, both for the conservation of existing areas and the creation of new ones (CHEN; JIM, 2011), in order to attenuate environmental and health problems in a context of urban expansion and precariousness (CARBONE et al., 2015; HALE et al., 2011). Chen and Jim (2011) mention that urban managers must urgently assess the cost-effectiveness of conservation projects, in order to achieve health and sustainability goals.

In the last years, public policies have addressed the theme ecosystem services mainly with the objective of proposing instruments to reduce the loss rates of these services (GUEDES; SEEHUSEN, 2011). For example, the biodiversity strategy and action plans designed for local authorities focus on the problems of biodiversity and urban green areas (PRIP et al., 2010), being the reference adopted in many cities of the world, including São Paulo (CIDADE DE SÃO PAULO, 2011a, 2011b). When it comes to green space management, the Strategy Master Plan for São Paulo Municipality (Law 16050/2014) highlights the implementation of a municipal green space system and the preparation of municipal plans directly related to green areas, such as the Municipal Plan for Public Green Areas, the Municipal Plan for Conservation and Recovery of Areas Providing Environmental Services and the Municipal Plan for Urban Arborization, among others.

Despite some improvements implemented in the management of São Paulo city green areas (SEPE; PEREIRA, 2015), technical gaps still exist to be overcome. According to Carbone et al. (2015), the management of these areas must be improved not only when it comes to planning, but also to administrative and technical aspects.

In this context, the role played by ecosystem services in the environmental improvement in the cities has been highlighted in the literature (ELMQVIST et al., 2015; MCPHEARSON; KREMER; HAMSTEAD, 2013) as a tool for management and control of green areas in the urban network (GÓMEZ-BAGGETHUN; BARTON, 2012; MAO; HUANG; WU, 2015) and for the promotion of health and life expectancy (AGAY-SHAY et al., 2014; JONKER et al., 2014).

Having these assumptions in mind, this research was developed within the context of the offer of ecosystem services in urban green space planning and management as a mechanism of promoting healthy and sustainable cities. The objective of this study is to establish and test an index for the evaluation of ecosystem services in urban parks as a technical support to urban green space management. This methodological proposal seeks to facilitate the diagnosis of ecosystem services in urban green areas and its inclusion in public management of such important areas to the cities.

1.1 Functions and ecosystem services in urban green space management

Since the mid 1960's, a large number of studies have been identified that are directed to the evaluation of the functions and ecosystem services provided by nature with or without man's management (COSTANZA et al., 1997; DE GROOT, 1987; DE GROOT; WILSON; BOUMANS, 2002; FISHER; TURNER; MORLING, 2009).

The ecosystem function concept tries to translate the capacity of natural processes and components to provide goods and services (DE GROOT; WILSON; BOUMANS, 2002). Constanza et al. (1997) describe as ecosystem services those that result directly or indirectly from ecosystem functions and that satisfy human necessities. According to Costanza et al. (1997) and de Groot, Wilson and Boumans (2002), there are four categories of ecosystem functions:

- Regulation: able to regulate processes important to life support, by means of biogeochemical cycles and other biosphere processes. This primary function, besides the intrinsic relevance to the maintenance of ecosystems, offer a series of direct benefits to human health, such as clean air, water, soils and their properties, and biologic control services;
- Habitat or Support: contributes to the conservation of biological factors, genetic diversity and nature evolutionary processes;
- Production: refers to the biomass production, supplying food and raw materials for energy resources, phytopharmaceuticals and others;
- Information (cultural functions): of personal and collective enrichment, which generate opportunities for reflection, cognitive development and recreation, aesthetic and spiritual experience.

Some authors have made distinctions between approaches concerning ecosystem services and environmental services (SOUZA et al., 2016). Ecosystem services are seen with emphasis on the provision of natural functions to well-being, whereas environmental services are usually associated with those obtained with man's help for the increase of biodiversity in favor of human use (ELOY; COUDEL; TONI, 2013). Souza et al. (2016) employ environmental services to characterize the benefits to the quality of life guaranteed by management practices of natural resources. The latter approach is customarily used for the payment of environmental services, as in the case of Costa Rica, where there is a national fund to compensate positive externalities generated by private forests (CHOMITZ; BRENES; CONSTANTINO, 1999), or as discussed by Wunder (2015) regarding the Brazilian Amazonia. For Guedes and Seehusen (2011) the term environmental services entails a broad scope including, besides the ecosystem services themselves in their classical definition, the services made available by management actions. The approach related to ecosystem services is usually more associated with studies that analyze the quality and importance of certain regions (COSTANZA et al., 1997), as adopted by Worm et al. (2006) for the loss of biodiversity in ecosystem services provided by oceans, and by Naidoo et al. (2008) in the global mapping of ecosystem services aiming at the definition of conservation priorities.

A series of studies have been using the ecosystem services approach to the promotion of health in the cities (KENWARD et al., 2011; MATHEY et al., 2015). Jennings, Larson and Yun (2016) demonstrate the relationships between urban green areas, efficient ecosystem services providers, and the consequent benefits for physical, psychological and social health of the population.

Jackson et al. (2013), after carrying out a systematic analysis of previous studies, identified a positive relationship between ecosystem services and human health as the services of air filtering; water filtering; water regulation; cultural relations for the appropriation of nature. Sandifer, Sutton-Grier and Ward (2015) emphasize the relevance of the development of research concerning the human interaction with nature and the improvement of human health and resilience.

2 Method

This research of quantitative nature and exploratory objective proposes the development of an index – from combined indicators – for the evaluation of ecosystem services in urban green areas. The use of indexes as indicators is recognized by decision makers as an important environmental planning and management tool (ASLAKSEN et al., 2015; BÖHNKE-HENRICHS et al., 2013; DE GROOT et al., 2015; NAHUELHUAL et al., 2014). In spite of other indexes, such as that proposed by Larondelle and Haase (2013) to evaluate ecosystem services in the urban context, applied to different European cities, we chose to establish a specific index in consonance with the objective of this research.

From indicators compiled from the literature, the Index of Ecosystem Services for Green Areas (*Índice de Serviços Ecossistêmicos para Áreas Verdes* – ISEAV) is proposed, by which the ecosystem services provided by urban green areas are measured. In order to validate ISEAV its application from primary data and the analysis of secondary satellite image data was performed. The satellite images were obtained from Google Earth, and the calculations of the areas were performed using the ArcGIS software resource for polygon area calculations.

2.1 Index of Ecosystem Services for Green Areas (ISEAV)

To compose ISEAV the regulation, habitat and production ecosystem functions proposed by de Groot, Wilson and Boumans (2002) were initially considered. Despite of extreme importance in urban green space management (Jackson et al. 2013), the cultural functions were not included in the scope of the index proposition. Differently from the other ecosystem functions, the cultural functions lack quantitative indicators considered representative for the cultural services and widely tested in previous studies. It is understood that the inclusion of indicators devoid of such characteristics for the cultural function could compromise the goal and the expected results for the integrated index. Therefore, this is a limitation of the index here proposed.

After defining the ecosystem functions, the ecosystem services provided by vegetation fragments in urban green areas were selected. For the analysis of each ecosystem service that composes the index, measurable and representative indicators discussed in the literature (ALVAREZ, 2004; CHIESURA, 2004; DE GROOT et al., 2015; NIEMEIJER; DE GROOT, 2008), capable of reflecting the quality of the goods and services produced by the urban vegetation, were used. To reach this goal, the classification of ecosystem functions presented by de Groot, Wilson and Boumans (2002) was detailed in consonance with the biodiversity criteria recommended in Act 91 of the Secretariat for the Green and the Environment of the Municipality of São Paulo (CIDADE DE SÃO PAULO, 2011c).

The ecosystem functions, ecosystem services and respective indicators are presented in Chart 1.

Chart 1 – Selected environmental indicators

Ecosystem function	Ecosystem service	Indicators
Regulation Function	Regulation of atmospheric gases	Outside of the adopted scale
	Regulation of the climate	Green cover
	Regulation of extreme climatic events	Pervious area and Green cover
	Regulation of the water cycle	Pervious area
	Pollution filter and waste treatment	Canopy
	Water supply	Pervious area
	Soil retention	Green cover and burlap
	Creation of soil	Canopy and burlap
	Regulation of nutrients	Canopy and burlap
	Pollination	Richness of species
	Biological control	Richness of species

Ecosystem function	Ecosystem service	Indicators
Habitat Function:	Refuge function	Habit Native/exotic Richness of species
	Nursery function	Habit Native/exotic Richness of species
Production Function:	Feeding	Scale of use
	Raw material	Scale of use
	Genetic resources	Scale of use (outside of the scope of urban green areas)
	Medicinal resources	Scale of use
	Ornamental resources	Use grade with this goal

Source: Prepared by the authors

It can be seen in Chart 1 that there are indicators that represent more than one ecosystem service and that there is more than one indicator for the analysis of the same service. The former is justified by the fact that the same indicator can be important for more than one ecosystem function or ecosystem service. In the latter, the urban context has influence on the decision. For example, it should be expected for the regulation of nutrients that in areas covered with canopy nutrient cycling would take place via burlap; however, the removal of organic matter from the soil is common in some urban parks. Besides, some areas covered with canopy are impervious, mainly sidewalks and squares.

To analyze each group of ecosystem functions, indicators were attributed, with the exception of the ecosystem service named regulation of atmospheric gases (Chart 1). This service is related to large-scale climatic processes and considering the local and urban ambiance of this study, it is outside the adopted scale (DE GROOT; WILSON; BOUMANS, 2002).

To broaden the range of potential ecosystem services to be generated by green areas, we chose local aspects that gather the greatest number of services and that were easily measured. The aim was to measure the whole set of fuctions of the ecosystem services and not only the individual services. Thus, Chart 2 describes the selected indicators and presents the respective sources that justify their inclusion as ISEAV components.

Chart 2 – Characterization and application of the ISEAV indicators

Indicator	Theoretical grounds and criteria of use of the indicators
Green cover	Area totally covered by vegetation visible in satellite images, independent of the plant habit (ALVAREZ, 2004). It involves the climatic regulation services (evapotranspiration, pollution filter, climatic softening) (BROWN et al., 2015), and plays a fundamental role in soil conservation (NIEMEIJER; DE GROOT, 2008).
Pervious area	Regulation function of the water cycle and fundamental role in situations of climatic extremes in the cities (dry and rainy seasons) (DE GROOT et al., 2015). The pervious zones were checked in the field and calculated using satellite images available in Google Earth. Certain regions, such as exposed soil, were also included in this calculation.
Canopy	The analysis considered as area covered by canopy the one with shrubs and trees (LARONDELLE; HAASE, 2013). The area was defined using satellite images (available in Google Earth) and calculated using the ArcGIS software by means of polygon areas, besides checking in the field.
Burlap	The correct soil maintenance is the basis of three ecosystem services: regulation and retention of nutrients and soil formation. The burlap is one of the main routes to transfer matter and energy to terrestrial ecosystems (DE SOUSA-NETO et al., 2017). It is a physical barrier against leaching processes, wind action and it cushions the effects of falling water (LIU et al., 2017). The observation of the burlap was made in the field, once in urban areas the management of this edaphic compartment can take place (FERREIRA et al., 2018). The quality of the burlap was not considered in this study.
Diversity of species	The diversity of species in a vegetation fragment offers the complexity and the base structure for an ever-growing ecosystem development in tropical forests (RODRIGUES; BRANCALION; ISERNHAGEN, 2009). This complexity, when already consolidated, is translated into an increase in the vegetation resilience and stability. The stability, which is influenced by the number of constituting species, is reflected in the ecosystem services associated with the biological control. Likewise, the greater producers' wealth is usually associated with the greater wealth of the whole community. The identification of plant species was based on the APG II classification system, by means of field work using binoculars, specialized literature (LORENZI, 1998, 2002, 2009; LORENZI et al., 2003), and the assistance of professionals when necessary.
Habit	Following Ivanauskas, Monteiro and Rodrigues (2004), the classification: tree, shrub, palm tree, herb, liana, epiphyte, hemi-parasite and parasite was used for the analysis of the vegetation habit in the field. The different species and growing habits are important indicators for refuge and nursery services, by allowing different types of ecological niches, besides considering the important function in carbon stock (in the case of woody plants).
Native and exotic	Considering the principles of the action plan for biodiversity (CIDADE DE SÃO PAULO, 2011b), Act 91 of 2010 from the Secretariat for the Green and the Environment of the Municipality of São Paulo (CIDADE DE SÃO PAULO, 2010), besides Rodrigues et al. (2009) and Conway and Vander Vecht (2015), it is believed that it is important to maintain the native biodiversity even in the cities, in favor of the adaptation of local species to this environment and the increase of the resilience to the local biodiversity, even if exotic species can offer several services beneficial to the city. The definition of the origin of the species followed the guidelines of Act 60 from the Secretariat for the Green and the Environment of the Municipality of São Paulo (CIDADE DE SÃO PAULO, 2011d) and the list of Brazilian plant species (JARDIM BOTÂNICO DO RIO DE JANEIRO, 2015).

Indicator	Theoretical grounds and criteria of use of the indicators
Production function indicators	For the analysis of the production function, we chose to assess the degree of exploitation of the natural vegetation resources by the population regarding: nourishment, raw materials, medicinal resources and ornamental use at three levels. At the lower level, there is little or local exploitation of the resource; at the intermediate level, the resource already stands out, while at the higher level there is an economic exploitation of the resource. Considering that the data obtained for these aspects are classified at only three levels, observations were made to the park administration for this characterization. Only the genetic resources services were excluded from the analysis of the production functions, because the exploitation of such resource is limited in urban environments.

Source: Prepared by the authors.
Observation: the criterion number of species was developed for the Atlantic Forest biome, as São Paulo city and the parks in which the index was applied are in this domain; for further ISEAV applications to other biomes, adaptations should be made to calculate this variable.

ISEAV is a quantitative integrated index (on a 0 to 10 scale) that aims to indicate the capacity of an area with urban vegetation to provide the ecosystem services presented in Chart 1 by means of the measurement of the indicators described in Chart 2. ISEAV is the average of the three indexes that composes it, related to the regulation, habitat and production functions, also measured on a 0 to 10 scale.

To calculate the indexes of the ecosystem functions, in the case of the same indicator being considered for more than one function, the attribution of a weight to the indicator was made according to the number of associated services. For example, canopy is an indicator of three ecosystem services of the regulation function index, and therefore in the formula for this index a weight of 3 is attributed to it.

To attribute a score for each indicator, simple methodologies were developed based on the literature, able to generate a numerical result for its use in the formulas. The dividing numbers were used so that each function could present as result a value from 0 to 10. The double evaluation of an area in more than one aspect does not interfere in the calculation of the index; once the same region offers several ecosystem services simultaneously and the calculation of the index is based on the analysis of each service individually (by means of indicators).

The formula for the calculation of ISEAV is:

$$ISEAV = FR + FH + FP / 3$$

Where:

- ISEAV = Index of Ecosystem Services for Green Areas
- FR = Regulation Function Index
- FH = Habitat Function Index
- FP = Production Function Index

The Regulation Function Index (FR) is obtained by the formula:

$$FR = D\ (3) + CV\ (3) + AP\ (3) + SP\ (3) + NI\ (2) / 14^{*}$$

For the Habitat Function Index (FH) the equation is:

$$FH = H + NEX + NI / 2.7^{*}$$

The Production Function Index (FP) is obtained by the formula:

$$FP = AF + EA + AM + EO / 1.2^{*}$$

The numbers indicated with asterisks (*) are fixed dividers used in order to produce results between zero and ten for each formula.

For the composition of ISEAV, the following indicators were used:

- Canopy (D): From 0 to 10, it is the percentage of the total area covered with canopy of trees and shrubs, being the score equal to the result divided by 10 (for example, 75% of the cover with canopy represents a score of 7.5 in the indicator).
- Green Cover (CV): From 0 to 10, it is the percentage of the total area covered with grass, or trees and shrubs. The attribution of a score also results from the division by 10 (as for canopy).
- Pervious area (AP): From 0 to 10, it is the percentage of the total area that is pervious divided by 10.
- Burlap (SP): From 0 to 10, it is the percentage of the total area covered with burlap divided by 10.
- Number of Tree Individuals (NI): From 0 to 10, it is the sampling of the number of tree individuals per hectare and attribution from 0 to 10, the score being: "10" for a number of individuals greater than 79; "9" between 79 and 72; "8" between 71 and 64; "7" between 63 and 56; "6" between 55 and 48; "5" between 47 and 40; "4" between 39 and 32; "3" between 31 and 24; "2" between 23 and 16; and "1" between 15 and 1.
- Habits (H): From 0 to 7, it is the number of habits observed in the field (being seven the maximum score).
- Native/Exotic Proportion (NEX): From 0 to 10, it is the division of the number of native species by that of exotic ones, being the result the percentage of native divided by 10 (for example, 90% of the native species attributes a score 9 to NEX).
- Access and use of fruit plants (AF): From 0 to 3, it is calculated by a 3-point system, in which a score is attributed according to the scale of appropriation of the aspect.
- Commercial Exploitation of the area (EA): As indicator AF.
- Access and use of Medicinal Species (AM): As indicator AF.
- Ornamental Exploitation of the area (EO): As indicator AF.

2.2 Study Areas: The Application of ISEAV

To check the ISEAV applicability, two green areas of equivalent sizes were selected in São Paulo city: the Buenos Aires and the José Emérito Brás parks. The areas have distinct vegetation cover typologies and differences are recognized in the quantity of tree individuals and size of the vegetation.

The Buenos Aires Park was a square until 1987, when it became a municipal park. Located in the central region of Higienópolis, a wealthy neighborhood, it was founded in 1912, with the objective of maintaining the view of the Pacaembu valley. The project of the French architect Joseph-Antoine Bouvard mixed landscape architecture styles and native and exotic plant species (WHATELY et al., 2008). The present area of the park is approximately 20,200 m^2 and the vegetation cover includes various types of trees, shrubs and grass species, distributed in the park according to landscape-architectural concepts

The José Emérito Brás Park was created by the Municipal Law 14456/2007 and is located close to the Brás metro station, also in a central region of São Paulo, but in a lower income neighborhood. It originated from a population mobilization in order to re-valuate the region. The Vereador Nazir Miguel kindergarten and the João Mendonça Falcão municipal school for children education do not belong to the park, despite being encompassed by it (CIDADE DE SÃO PAULO, 2007). Its vegetation cover is mainly grass species and sparsely distributed short trees.

3 Results

Table 1 presents the data regarding the Buenos Aires and José Emérito Brás parks for the application of ISEAV.

Table 1 – Results in area for the Buenos Aires and José Emérito Brás parks.

	Buenos Aires Park	José Emérito Brás Park
Total area	20,220.45 m^2 (100%)	19,131.7 m^2 (100%)
Canopy	15,009.27 m^2 (74.2%)	2,361.1 m^2 (12.3%)
Impervious area	5,420.71 m^2 (26.8%)	6,054.8 m^2 (31.6%)
Pervious area	14,799.74 m^2 (73.2%)	13,076.9 m^2 (68.4%)
Green cover	16,378.56 m^2 (81.0%)	13,076.9 m^2 (68.4%)
Burlap	3,700.34 m^2 (18.3%)	803.53 m^2 (4.2%)
Total number of species	92	36
Native species	33	15
Exotic species	54	21
Habits	6	5
Use of fruit species	Low	Low
Use of medicinal species	None	Low
Ornamental use	Medium	Low

Source: Prepared by the authors.

The application of the integrated index ISEAV to both parks, from primary and secondary data presented in Table 1, is reported in Table 2.

Table 2 – ISEAV for the Buenos Aires and José Emérito Brás parks.

Parks	ISEAV	Regulation Function Index	Habitat Function Index	Production Function Index
Buenos Aires	**5.69**	6.7	7	3.3
José Emérito Brás	**3.99**	3.8	4.8	3.3

Source: Prepared by the authors.

ISEAV values for the Buenos Aires Park were higher than those for the José Emérito Brás Park, as well as for the ecosystem function indicators that compose this integrated index, excepting the production function, whose scores were the same for both parks, as shown in Table 2.

The results for the Regulation Function, Habitat Function and Production Function indexes for each park, as well as the indicators that compose these indexes are shown in Table 3.

Table 3 – ISEAV Indicators

Index	Indicators	Buenos Aires Park	José Emérito Brás Park
Index of the Regulation Function	Canopy	7.4	1.2
	Green cover	8.1	6.8
	Pervious area	7.3	6.8
	Burlap	1.8	0.4
	Number of species	10	4
	Indicator value for the Regulation Function	**6.7**	**3.8**
Index of the Habitat Function	Habits	6	5
	Native/exotic	3	4
	Number of species	10	4
	Indicator value for the Habitat Function	**7**	**4.8**
Index of the Production Function	Access to fruit trees	1	1
	Exploitation of the area	1	1
	Access to Medicinal species	0	1
	Ornamental exploitation	2	1
	Indicator value for the Production Function	**3.3**	**3.3**

Source: Prepared by the authors.

The comparison of the data obtained for the ecosystem services for each park presented in Tables 2 and 3 shows that the values for the Buenos Aires Park are higher for most of the indicators, excepting the Production Function index and some aspects of this function, besides the proportion native/exotic species in the Habitat Function. The results for the Production Function were similar for both parks, because none provide these ecosystem services.

According to the ISEAV results, the Habitat Function has the best performance for both parks, reaching 70% (Buenos Aires Park) and 48% (José Emérito Brás Park) of the possible score. The high percentage obtained for the Buenos Aires Park responds to the high quantity of the species.

4 Discussion

The application of ISEAV to two urban parks of São Paulo city showed that it represents a comprehensive and integrated approach to the evaluation of green areas in cities, because the index considers not only the importance of green areas according to their ecological functions, as the Alvarez index (2004), but also the environmental services regarding regulation and production functions, which is pointed out by Brown et al. (2015) as essential to measure sustainability conditions of a city.

ISEAV represents not only a global index for decision making for the valuation of ecosystem services in cities, but it also identifies the fragilities and potentialities expressed by the individual indicators, providing information to managers for specific actions in the management of urban parks. These ISEAV characteristics are adjusted to Mathey et al.'s (2015) ideas on valuation of the potentialities of different types of ecosystem services relevant to the urban environment and for the population's quality of life.

According to McPhearson, Kremer and Hamstead (2013), city administrators try to increase the performance and the quantity of green areas to attend to different objectives of the urban planning for equity, resilience and sustainability. Therefore, ISEAV is aligned to these authors' ideas, in which the ecosystem services approach provides a useful structure to assess the status quo of a green area, it allows the establishment of goals and prioritizes strategies to improve the ecological functioning of these areas and to promote sustainability and health in the urban environment.

The association between ecosystem services and benefits for human health, as discussed by Jackson et al. (2013), can be attested for the indicators used in ISEAV. However, the cultural relationships, also identified as important by Jackson et al. (2013), were not assessed in this study, because cultural services were not incorporated in the algorithm for the index analysis.

Regarding the offering of ecosystem services and the effects on health, as observed by Hale et al. (2011), the parks should invest in areas for vegetable or medicinal herb gardens, which was not observed in neither parks, but this could be measured by ISEAV.

Still in this context, according to Sandifer et al. (2015), some studies indicate that the exposure to microbial biodiversity can improve health, specifically in the mitigation of certain allergic and respiratory diseases. Therefore, the valuation of the habitat function and the regulation function for these urban green areas could have a positive impact on these health aspects.

Regarding urban green space management, for the valuation of ecosystem services provided by both parks, possible arrangements for the payment of ecosystem services, as discussed by Andrade and Fasiaben (2010) could be implemented. This is in line with the incentive highlighted by the Strategic Master Plan (*Plano Diretor Estratégico* – PDE) 2014 of São Paulo Municipality (SEPE; PEREIRA, 2015) and the strengthening of economic instruments aimed at the preservation of urban green areas (CARBONE et al., 2015). The scope of ISEAV as characterization of ecosystem services and indicators would be the technical ground for the proposition of these schemes.

The results of the application of ISEAV attest Kenward et al.'s (2011) propositions on the use of governance strategies that could effectively promote sustainability in cities from the increase in offerings of ecosystem services.

5 Final considerations

The present research shows the feasibility of the proposal of an integrated index to access ecosystem services in urban green areas from indicators selected from the literature and quantitative data, allowing its application by means of a mathematical algorithm. The index integrates a diversified range of ecosystem services and functions, the positive repercussions being associated with the population's health. The use of the proposed index proved feasible and tangible from tests carried out in two parks of São Paulo city – the Buenos Aires Park and the José Emérito Brás Park.

The application of ISEAV in both areas allowed to demonstrate that the global index, as well as the individual indicators, can guide the evaluation of a urban green area as a provider of ecosystem services and can support the diagnosis of the quality of the offered ecosystem services, respectively, aiming at its valuation and its contributions to sustainability and health. These results indicate that ISEAV can supply important information and aid management and decision making of urban green areas. We consider that ISEAV could be employed in the urban green space management.

The research showed that the indicators are easily obtained by means of secondary and primary data. The indicators allow the representation of the present situation and give support to continuous monitoring and evaluation of the study area, constituting a versatile tool for urban green space management.

The application of ISEAV to areas with distinct vegetation characteristics corroborates the premise raised in the research on the ability to measure the magnitude of the different ecosystem services provided in an urban green area.

The Buenos Aires Park offers a wider range of ecosystem services in comparison to the José Emérito Brás Park. It is one of the oldest parks in São Paulo city and exceeded the José Emérito Brás Park in the quantity of plant species and better performance regarding the habitat and regulation functions.

The production function in both parks could be increased by initiatives such as the creation of vegetable or medicinal herb gardens. Although not analyzed in this research, these actions could also enrich the cultural services in urban areas. Habitat services, best evaluated in both parks, could be considered in programs of payment for ecosystem services, in light of the National Policy of Payment for Environmental Services that is under discussion in Brazil and the recent regulatory framework for the promulgation of the São Paulo Strategic Master Plan, which establishes mechanisms for this purpose.

It is recommended that future studies extrapolate the limits of the index proposed here, considering also: the insertion of the environmental information and the cultural functions in an objective way for these green areas; and adaptation of the index to other biomes in other urban contexts. It is also recommended that ISEAV be tested in other urban parks of São Paulo city so as to corroborate to its characteristic as a tool for decision making in urban green space management. The systematic application of this index would contribute to the evaluation of ecosystem services provided by green areas in a context of promoting healthy and sustainable cities.

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EVALUATION OF ECOSYSTEM SERVICES AND MANAGEMENT OF URBAN GREEN AREAS: PROMOTING HEALTHY AND SUSTAINABLE CITIES

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Abstract: Green areas and ecosystem services are emerging issues in the management of public areas with a view to promoting healthy and sustainable cities. The aim of this study is to establish and test an Index of Ecosystem Services for Green Areas (*Índice de Serviços Ecossistêmicos para Áreas Verdes* – ISEAV) to evaluate ecosystem services in urban parks as a technical subsidy for the management of urban green areas. The composition of the Index was based on quantitative indicators selected from a bibliographic review. In order to demonstrate the applicability of the Index, two parks of São Paulo city were selected - Buenos Aires Park and José Emérito Brás Park - and also primary and secondary data were used. The results demonstrate the feasibility of the proposition and application of this Index in two parks of São Paulo, where it was possible to obtain a diversified range of ecosystem services considered relevant for the health of the population.

Keywords: Urban Green Areas, Environmental Indicators, Ecosystem Services, Environmental Services, Urban Parks.

Resumo: Áreas verdes e serviços ecossistêmicos são temas emergentes na gestão de áreas públicas com vistas à promoção de cidades saudáveis e sustentáveis. O objetivo deste artigo é estabelecer e testar um índice para avaliação de serviços ecossistêmicos em parques urbanos como subsídio técnico à gestão de áreas verdes urbanas. A composição do Índice de Serviços Ecossistêmicos para Áreas Verdes (ISEAV) pautou-se em indicadores quantitativos, selecionados a partir de revisão bibliográfica. Para demonstração da aplicabilidade do ISEAV, foram selecionados dois parques paulistanos – o Buenos Aires e o José Emérito Brás – e utilizados dados primários e secundários. Os resultados demonstram a viabilidade da proposição e da aplicação do ISEAV em parques paulistanos, em que foi possível auferir uma gama diversificada de serviços ecossistêmicos considerados relevantes para saúde da população.

Palavras-chave: Áreas Verdes Urbanas; Indicadores Ambientais; Serviços Ecossistêmicos; Serviços Ambientais; Parques Urbanos.

Resumen: Zonas verdes y servicios ecosistémicos son temas emergentes en la gestión de áreas públicas con miras a la promoción de ciudades sanas y sostenibles. El objetivo de este artículo se refiere a establecer y probar un índice para la evaluación de servicios ecosistémicos en parques urbanos como subsidio técnico a la gestión de áreas verdes urbanas. La composición del Índice de Servicios Ecosistémicos para Áreas Verdes (ISEAV) se basó en indicadores cuantitativos seleccionados a partir de revisión bibliográfica. Para la demostración de la aplicabilidad del ISEAV se seleccionaron dos parques paulistanos – el Buenos Aires y el José Emérito Brás – y se utilizaron datos primarios y secundarios. Los resultados demuestran la viabilidad de la proposición y de la aplicación del ISEAV en parques paulistanos, en los que fue posible obtener una gama diversificada de servicios ecosistémicos considerados relevantes para la salud de la población.

Palabras clave: Urban zonas verdes; Indicadores; Servicios del ecosistema; Parques urbanos.