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Research paper

Perception and knowledge of plant diversity among urban park users

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HIGHLIGHTS

- We compared plant species richness perceptions between park users and a botanist.
- Park users better recognized cultivated versus wild plants compared to the botanist.
- Plant species richness is mainly appreciated for the beauty and sense of well being it provides.
- Park users may accept a park more hospitable to wild plants but not less managed.
- We propose recommendations conciliating plant conservation and park users' needs.

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ABSTRACT

For several decades, ecological studies have suggested that urbanized environments can be viewed as biodiversity refuges, thus broadening conservation concerns from pristine to urban green areas. Despite the increasing motivation to conserve areas where humans live and work, the conservation of urban biodiversity rarely takes citizens' knowledge, perception, and needs into account. Interdisciplinary-based conservation is thus urgently needed in order to bridge this gap. We therefore studied a park located in Paris (France) where we combined ecological and human sciences to question a botanist and 100 park users about their knowledge and perceptions of plant richness. We then assessed the role of plant richness on people's perception of the services provided by the park. Our findings show that park users mainly recognized the cultivated plants promoted by gardeners, whereas the botanist more frequently observed spontaneous plants. Furthermore, the plant richness estimation by park users was much lower than the botanist's count. The users were attentive to the surrounding plant richness because of its beauty and its effect on their sense of well-being, whereas its role in biodiversity and ecological functions were less relevant. Finally, although the knowledge of plant richness among park users was poor and focused on ornamental plants, they preferred to consider wild plant management in terms of cohabitation rather than removal, which may indicate a desire for more naturalistic landscapes. We discuss these results and propose several recommendations for improving biodiversity conservation in green parks without undermining the park users' well-being.

1. Introduction

Over the past 30 years, biodiversity conservation has become an environmental and political issue in cities (Adams, 2005; Bennett, 1991; Clergeau & Désiré, 1999; Miller & Hobbs, 2002). Until recently, cities had relatively limited territories, and the biodiversity conservation within their boundaries was not a priority. However, urban development has become a central component in

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land transformation processes and is now one of the leading causes of species extinction worldwide (McKinney, 2006). Yet a growing number of studies have revealed that cities can harbor relatively high plant species richness (Angold et al., 2006; Dana, Vivas, & Mota, 2002; Godefroid, 2001; Kent, Stevens, & Zhang, 1999; Ricotta, Celesti Grapow, Avena, & Blasi, 2001; Zerbe, Maurer, Schmitz, & Sukopp, 2003), partly as a result of diverse human activities that generate heterogeneity in habitat conditions and may increase species establishment and richness in cities (Muratet et al., 2008). Both landscape planners and ecologists need to focus management efforts on urban biodiversity, which requires greater information about the factors affecting animals and plants in these human-dominated landscapes.

Preserving and restoring biodiversity is not the only issue of green area management in cities and, particularly, public green spaces where the interaction between humans and nature is essential. In green spaces, urban dwellers seek contact with nature (Yli-Pelkonen & Niemela, 2005), a healthy environment (Jim & Chen, 2006; Tzoulas et al., 2007), well-being (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007), and social interactions (Burgess, Harrison, & Limb, 1988; Sullivan, Kuo, & Depooter, 2004). Understanding public perception and the services provided by green spaces can thus improve the design, management, and attractiveness of existing green spaces. In return, an improvement of green spaces may increase the usage and enjoyment of such spaces as well as engage people to take part in conservation programs (Shwartz, Turbé, Simon, & Julliard, 2014). It is thus essential to understand the human component of the ecosystem and its interaction with the environment (Burgess et al., 1988; Grimm, Grove, Pockett, & Redman, 2000; Kinzig & Grove, 2001). In this respect, one of the main challenges at the interface between ecology and social sciences is to investigate how nature is perceived and appreciated by people in urban green spaces and how it may be linked to ecological issues such as the protection of species diversity and the provision of ecosystem services.

The interaction between humans and nature has long been studied through the prism of landscape perception and preference theories (Appleton, 1975). For instance, the aesthetics of landscape is a primary aspect in the attractiveness of nature (e.g., Kaplan & Kaplan, 1989). People also positively value landscape elements that they perceive to be natural, although with a certain level of order and care, while they negatively consider elements that are seen to be wild and messy, even though these can occur in true ecosystems (Nassauer, 2002). From these studies, the relationships linking perception, preferences, and ecosystems are uncertain since aesthetic and natural-looking landscapes do not always relate positively to biodiversity (Gobster et al., 2007). For instance, while lawns are one of the city dwellers' favorite types of urban green space, it has been shown that well-maintained lawns offer poor conditions for many species (Muratet et al., 2008; Shwartz, Shirley, & Kark, 2008).

This study investigates how plant species richness is perceived by people and its role in their well-being. Although relatively easy to measure, species diversity *per se* and its role in people's perception and preferences has rarely been studied to date (Fuller et al., 2007; Dallimer et al., 2012; Qiu, Lindberg, & Nielsen, 2013).

Despite the extensive use of biodiversity in policy-making and science, some studies have found that this concept is not widely recognized and known among people (Lindemann-Matthies & Bose, 2008). Although biodiversity is perceived as a source of pleasure and well-being, the experience and skills necessary for identifying plants and so appreciating biodiversity are often lacking, especially among urban populations (Clergeau, Mennechez, Sauvage, & Lemoine, 2001). Few studies have demonstrated an association between perceived and actual species richness in urban parks (Fuller et al., 2007; Qiu et al., 2013). Biodiversity (i.e., species richness) is most often underestimated (Dallimer et al., 2012; Shwartz et al., 2014), perhaps because people do not share the same knowledge as scientists about animal and plant species. Biodiversity recognition and acceptance among urban dwellers appear to predominantly focus on an aesthetic or symbolic perception (Smardon, 1988): managed flower beds, lawns, and ornamental trees are highly requested, whereas wildness is less appreciated (Lizet, Wolf, & Celecia, 1997). Whether citizens also value ecological function (e.g., air, water, and soil quality maintenance) and other nature-preserving roles of urban green spaces and biodiversity (e.g., species richness) is poorly known (Jim & Chen, 2006). A better understanding of people's perception of biodiversity is thus important in order to assess biodiversity-based ecosystem services and the importance of its preservation in urban parks.

In this paper, we present an interdisciplinary study conducted in a park located in Paris (France) that combines ecology and sociology to address the following questions. How do park users perceive plant species richness and what do they expect and need from it? What degree of plant species diversity is observed by a botanist, and how much does this diversity differ from or converge with what is perceived by park users? We further address questions concerning management, while considering Allendorf and Yang (2013) assertion that management can be improved by taking into account people's pre-existing perceptions. Which types of management might satisfy both park users and scientists like botanists? And what types of plantings are park users ready to accept so as to maintain or improve park plant species richness? Responses to such questions are essential in order to identify sustainable solutions that can benefit both people and biodiversity conservation in urban areas.

2. Methods

2.1. Study area

The survey was conducted in Paris (48°51′23.68″N, 2°21′6.58″E), a city that covers a total area of 105 km^2 and is the most densely populated city in France (20,775 inhabitants/km^2 vs. 113 inhabitants/km^2 on average in France, INSEE, 2006). We studied the emblematic urban "Parc des Buttes Chaumont" that covers 25 ha and attracts more than three million visitors annually, making it one of the most popular recreation areas in the city (Mairie de Paris, 2013). It is one of the oldest and largest parks in Paris and was envisioned as a garden showcase when established in 1867. Buttes Chaumont is a reconstructed space composed of lawns, shrubs, and woods, 7 km of paths, a grotto, and waterfalls. Many of the trees found in the park today were planted when the park was created. To be representative, our study covered the three most popular areas of the park (Fig. 1). Area (1) is located at the heart of the park around an artificial lake of 1.5 ha that surrounds a rocky and prominent island with steep cliffs (hereafter, "around the lake"). The central mountain is a vestige of the old quarry occupying part of the site, which was totally transformed to resemble a natural landscape (Fig. 1a). A suspension bridge links the mountain to the surrounding landscape. The lake is surrounded by a 600 m path that passes through lawns, shrubs, and small woods and ends at a grotto with an imposing waterfall. Owing to its numerous sceneries, the area around the lake is very attractive for park visitors. Area (2) extends over an area of 3 ha located at the southern end of the park. It is used as a "playground" by families with children and is situated close to the entrances. It is composed of small hills covered by lawns, small bushes, and scattered trees, and interconnected by many small paths (Fig. 1b). Area (3) is established around the "main walking path" between areas (1) and (2). The 300 m path is wider and more straightly aligned than the other paths in the park, which tend to be more narrow and winding. It is lined with trees, shrubs,

Fig. 1. Maps of the Parc des Buttes–Chaumont and the three studied areas within the park.

lawns, benches, and flower beds (Fig. 1c). Each area is composed of lawns, small patches of shrubs and herbaceous plants, and scattered mature trees, making the structure of each area relatively similar. Plant species richness and composition, however, differ between areas.

2.2. Plant data

In July 2009, the plant communities in each of the three park areas were sampled by a professional botanist employed by the National Museum of Natural History. In each area, lawns, shrub/herbaceous patches, and scattered trees were inventoried. All trees present in each study area were identified, shrubs and herbaceous plants were sampled in three patches, and herbaceous plants of three lawns were sampled in $10 \times 1\,m^2$ quadrats (Table 1). All vascular plant species were identified, including both cultivated and spontaneous species. The plants were classified as native versus exotic (for the definition, see Richardson et al., 2000) according to a list compiled by botanists at the National Botanical Conservatory of the Parisian region (CBNBP, 2011).

Table 1
The three park areas divided into three habitat types, together with the mean species richness and the number of inventories realized in each habitat (broadly proportional to the area occupied by each habitat in the park).

Park area	Habitat inventoried	Number of inventories	Mean species richness (standard deviation)
Area 1: around the lake	Planted trees	1	35
	thicket habitat	3	16 (14)
	lawn habitat	3	9 (7)
Area 2: playground	Planted trees	1	28
	thicket habitat	3	41 (15)
	lawn habitat	3	11 (8)
Area 3: main walking path	Planted trees	1	21
	thicket habitat	3	34 (9)
	lawn habitat	3	9 (3)

2.3. Social data

In July 2009, we also conducted face-to-face semi-structured interviews ($n = 100$) in the three park areas. As we wanted to interview regular park visitors, we first asked people if they visited the park more than once a week (90% of people encountered). We then interviewed an almost equal number of people at the playground ($n = 34$), around the lake ($n = 33$), and at the walking path area ($n = 33$). The interview lasted 20 min on average and followed a standardized questionnaire in French consisting of seven questions that addressed people's general attitudes, knowledge, and perceived benefits in terms of the park under investigation and its plant species richness (see Appendix A). Four closed-ended questions (yes/no, see 1, 2, 4, 5 CQ in Appendix A) broadly measured the emotional attachment to the green space area and assessed park users' impressions of plant species richness in the park area as a personal, ecological, or social need. Three open-ended questions (see 1, 3, 4 OQ in Appendix A) allowed respondents to express in their own words their knowledge and perceptions about the plants and park, which could be different from those anticipated in the closed-ended questions. The open-ended questions were placed before the closed-ended questions so as not to influence respondent's answers (see Appendix A). The respondents were then asked to name plants and estimate the number of different plants growing in the area where they were interviewed (6 and 7 OQ in Appendix A). The aim was to generate data relating to which type of plants the park users observe or/and know and to compare this with the plant inventory data. Where necessary, the interviewers provided some explanations regarding the questions.

The final part of the questionnaire gathered socio-demographic information about the respondents, including gender and age group. Such data was used as a control in order to understand whether the sample was representative of the general population. However, we did not aim to determine a specific association between socio-demographic status, perception of plant species richness, and knowledge of ecosystem services because our sample size was not large enough to compare results between groups of respondents.

2.4. Data analysis

We assessed the differences between the taxa named by the botanist and those named by park users. First, we transformed the park user estimation ($Rich_{est}$) to obtain a deviation (Dev_{ecol}) from the botanist's count (the number of species recorded by the botanist: $Rich_{bota}$) as follows:

$$Dev_{bota} = \frac{(Rich_{est} - Rich_{bota})}{(\sqrt{Rich_{bota}})}$$

For each park area, we calculated Dev_{bota} to allow a comparison of the park users' answers, regardless of the area studied.

Second, we assessed differences in the observations recorded by park users and the botanist through distance-based redundancy analysis, an ordination method that compares distances among groups (distance base redundancy analysis, dbRDA; Legendre & Anderson, 1999). Using the *vegan* library from R software (Oksanen et al., 2011), we calculated the floristic distances between the botanist and park users – measuring the dissimilarity in the taxa recorded or named – using semi-metric Bray-Curtis measurements based on mean abundance-based matrices. We then performed dbRDA to explore the relationship between observation dissimilarities among park users and the botanist.

Third, using the *hierpart* library from R software (Walsh & McNally, 2008), hierarchical partitioning and randomization (1000 times) were performed on squared correlation coefficient (r^2) values to identify any significant independent effect of the park users' attentiveness, i.e., their answers to question 3OQ (Appendix A) with regard to the estimated or named species richness. The statistics and graphic displays were computed using R software (R Development Core Team, 2013).

3. Results

Among the 100 respondents, men represented 45% of the population and women 55%. Regarding age, 10% of surveyed park users were aged between 15 and 24 years, 27% between 25 and 34 years, 23% between 35 and 44 years, 16% between 45 and 59 years, and 24% 60 years and older. Although the age and gender of respondents were relatively well distributed, we averaged responses over the entire sample as it was too small to test for subclass differences.

3.1. What does an urban park represent to park users?

To investigate park users' perceptions of the park, we first analyzed the answers to the closed-ended question "What does this park represent to you?" (1CQ, Appendix A). Most park users viewed the park as a refuge from urban activity, a place for reflection, and an area of relaxation (94%, 80%, and 92%, respectively). The respondents were less unanimous in viewing it as a place for social gatherings (64% in agreement).

The answers were expanded when park users were able to respond to the same question without restriction in an open-ended question (1OQ, Appendix A); we subsequently grouped answers into five categories (Appendix B). Well-being was by far the most frequent reason for coming to the park (61% of park users' answers); it also corresponds to the two most frequently stated close-ended responses (i.e., refuge from urban activity and place for relaxation). The four other reasons provided by park users were not proposed in the closed-ended question and included: finding a place of greenness and a beautiful place (17% of answers for each), leisure, and proximity.

3.2. Which species do users know compared to those recorded by the botanist?

The taxa were mostly cited by park users (6OQ, see Appendix A) at the genus level (43 vs. 3 and 13 at the family and species level, respectively). To facilitate the comparison with the botanist's observations, usually made at the species level, we analyzed all floristic data at the genus level, i.e., 52 different taxa cited by park users compared with 124 taxa observed by the botanist (see completed lists of taxa observed by the botanist and those named by users in Appendix C). Only five visitor citations did not correspond to taxon (floral bushes, lawn, herb, weed, and bush with yellow spots) and so were removed from the analyzed data set.

The taxa cited by park users were highly variable and differed significantly from those observed by the botanist (dbRDA result, $p = 0.001$). There was an overrepresentation of trees in the taxa mentioned by park users; nine out of ten taxa named by the park users were trees, which represented only one-fifth of plants observed by the botanist. Exotic taxa, particularly ornamental plants, were also overrepresented in the taxa mentioned by the park users. Seven out of the ten taxa named by the park users were exotic, while these represented only one-third of plants mentioned by the botanist.

The frequency of citations and observations regarding the 28 taxa reported by both the park users and botanist were significantly different (Chi-square test = 1463.57; $p < 2.2e-16$, Fig. 2). Native herbaceous taxa in the park user citations were underrepresented compared to the observation frequency of same taxa by the botanist (6% vs. 60% observed by the botanist). Conversely, exotic trees were over-cited by park users relative to the botanist's observations (60% vs. 12% observed by the botanist). The genus *Trifolium* (i.e., clover species) was by far the most frequently observed taxon in the park by the botanist (73 observations vs. 2 park user citations), whereas the genus *Aesculus* (i.e., chestnut tree species) was the most frequently cited taxon by park users (33 vs. 7 observations by the botanist).

3.3. What plant species richness do the users quantify compared to the botanist?

On average, the park users could identify only three taxa in a park area (versus 77 species observed by the botanist), but they were also asked to estimate the plant richness around them in each of the studied areas (7OQ, Appendix A). The deviation from the botanist's count (Dev_{ecol}) was very high for park users who could only name a small number of taxa, being less than 4 (absolute $Dev_{ecol} = 27$ on average), but it became more realistic for those who named between 4 and 10 taxa (absolute $Dev_{ecol} = 5$ on average). In both cases, the park user estimation was generally an underestimation (61% of negative Dev_{ecol}, see Fig. 3).

3.4. What do park users expect and need from this plant species richness?

Of the respondents, 90% claimed to be broadly attentive to the plant species richness (2CQ "Are you attentive to plant species richness?", Appendix A). The open-ended question (3OQ, Appendix A) allowed people to express why they were attentive to this diversity. We grouped answers into the sensations produced (32% of answers), aesthetic aspects (25%), biodiversity (e.g., the environment and landscape) (20%), knowledge (e.g. the opportunity to learn) (11%), and ecological functions (2%). Nevertheless, many

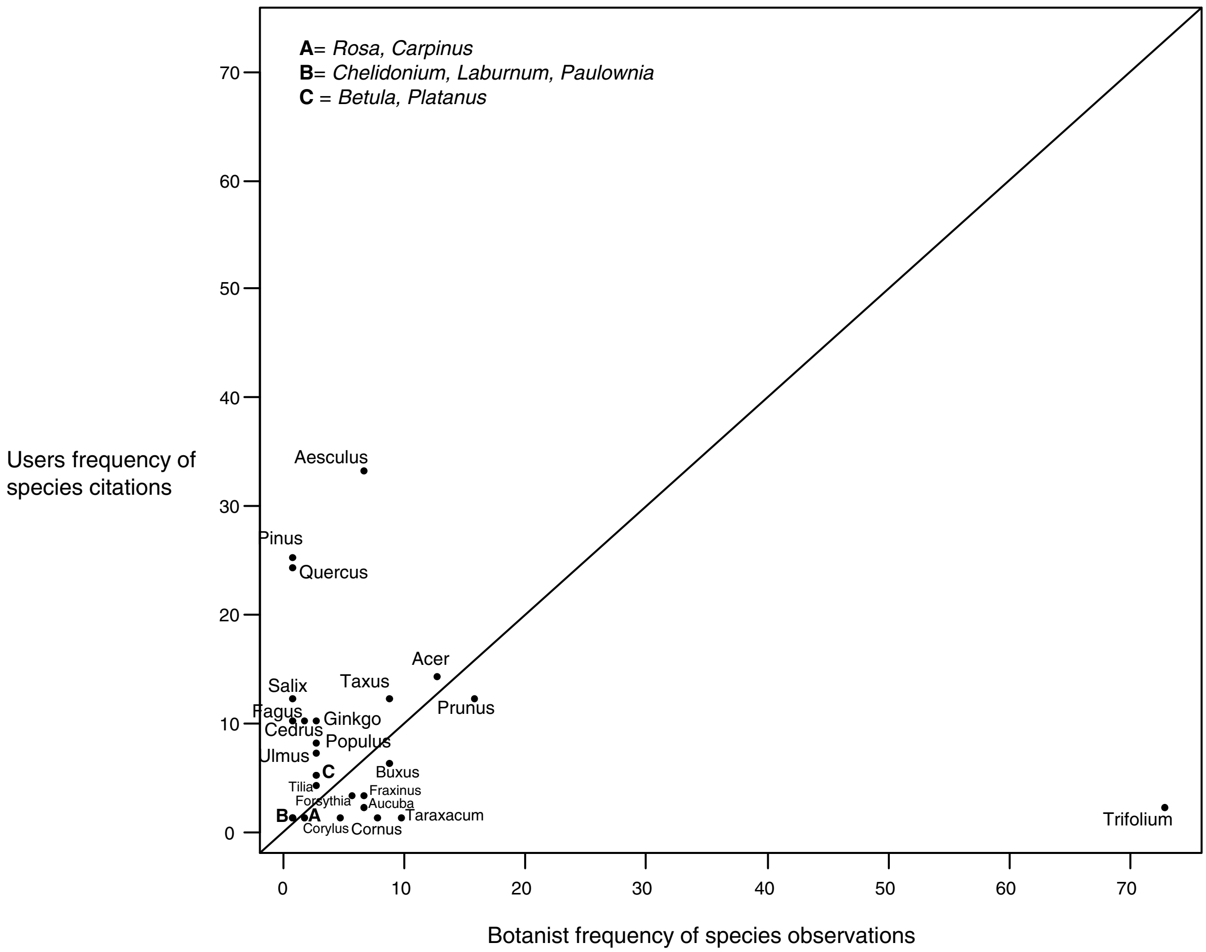

Fig. 2. Frequency of the botanist's observations for 102 park samples on the abscissa axis and frequency of citations among 100 park users for the 28 taxa cited by both park users and the botanist on the ordinate axis.

responses to this open-ended question were irrelevant (24% of park users' answers).

To further explore the park users' perception of the role of plant species richness in this park, we analyzed 4OQ "What is the role of plant species richness in this park?" (Appendix A). We classed responses into the five main categories used to define answers to 3OQ (Table 2).

Here, we observed an evolution in the responses: biodiversity appeared in 32% of answers to 4OQ versus 20% in 3OQ, while ecological functions appeared in 23% of answers to 4OQ versus 2% in 3OQ. Although most park users answered 4CQ (Appendix A), two reasons received a poor response: there was a relatively high number of non-responses ("I cannot say") to the role of plant species richness in "water quality protection" and "soil composition" (one-third responses). We therefore decided to remove these two poorly answered questions from the analysis.

The park users were quasi-unanimous in associating plant species richness with an aesthetic role, a health benefit, temperature regulation, air quality, and noise reduction (99%, 94%, 93%, 91%, and 91%, respectively) and broadly tended to associate plant

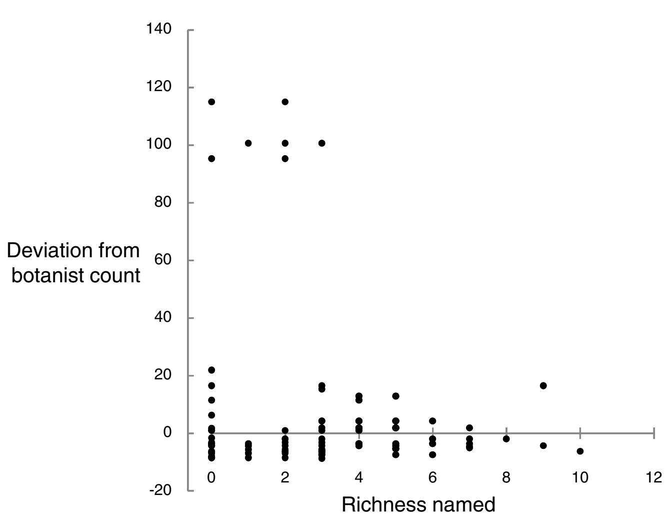

Fig. 3. Deviation of park users' estimation of richness from the botanist's count as a function of the number of species named.

Table 2
Number of items answered by 100 park users to open-ended questions 3OQ ("Why are you attentive to plant species richness?") and 4OQ ("What is the role of plant species richness in this park?").

Category of answers	Number of answers	
	3OQ	4OQ
Biodiversity	20	32
Knowledge	11	7
Aesthetic	25	21
Ecological function	2	23
Sensations	32	23
No answer	24	20

species richness with a change of scenery and the presence of other animals (87% and 81%, respectively). However, the park users were less unanimous in associating this diversity with a source of knowledge (75% in agreement) and, on average, they did not agree with viewing plant species richness as a subject of discussion (44% in agreement).

3.5. How does the interest of park users in plant species richness influence their knowledge?

The park users' plant knowledge was related to their interest in the vegetation present in the park (Fig. 4). For the open question "Why are you attentive to plant species richness?" (3OQ, Appendices A and B), respondents who were attentive to the diversity of landscape and species in the category "biodiversity" cited significantly (at the upper 95% confidence limit, Fig. 4) more taxa than other respondents (4.3 ± 3 vs. 2.6 ± 2).

3.6. How do park users perceive the management of the park?

The park users were queried about their weed species acceptance (versus species voluntarily cultivated by gardeners) (5CQ, Appendix A): 78% responded that they would like to see the species cohabitating, 18% would like to favor weed species, and 4% preferred only cultivated species.

4. Discussion

4.1. Park benefits

To date, few studies have investigated people's motivation to visit urban green spaces like parks or gardens (Chiesura, 2004; Connell, 2004; Fuller et al., 2007; Jim & Chen, 2006; Özgüner & Kendle, 2006). In our study, 61% of the people interviewed spontaneously indicated that they visited the park for their well-being; this included passive activities, such as resting, enjoying the tranquility, and meditating. Our study thus shows that the Parc des Buttes Chaumont is viewed as a refuge from the surrounding urban environment that enhances the well-being of the user. This is in accordance with the study of Chiesura (2004) conducted in an Amsterdam park in which three types of park user benefits are distinguished: relaxing for 73% of respondents, listening to and observing nature for 55%, and escaping from the city for 32%. Visiting a park also appears to be a relatively passive pursuit, as only small numbers of visitors engage in more active forms of leisure during their visits; in our study, only 14% of users reported visiting the park for leisure activities. Our results are similar to Connell's (2004) findings in a study conducted in gardens. She analyzed the characteristics, behavior, and motivation of visitors to 13 gardens in Great Britain, showing that the dominant pastime was sitting in the garden (74.7% of visitors).

We then delved deeper into the perception of park benefits by questioning respondents more specifically about their perceptions of plant species richness and the role played by this diversity. Our questioning was motivated by the increased public concern about environmental issues, its impact on biodiversity in France (CREDOC, 2013), and its role in terms of human's well-being, especially in urban parks (UNEP, 2008). In the Parc des Buttes Chaumont, the users were mainly attentive to their personal sensations and well-being (1OQ and 4OQ). Our findings are thus in accordance with studies conducted in Europe and North America, which reveal that well-being and aesthetic reasons are the main motivations for visiting parks (Chiesura, 2004; Connell, 2004; Fuller et al., 2007). However, our respondents did not cite the theoretical ecological functions behind plant species richness as one of the primary reasons for paying attention to biodiversity in the park (2% of answers to 3OQ). When these answers were proposed in closed-ended questions, respondents nevertheless agreed that plant species richness may hold an environmental ecosystem function, such as playing a role in temperature regulation and air quality (22% of answers to 4OQ). These results may indicate that people are unaware of some of the ecological concepts yielded by plants like regulating functions.

In China, however, a recent study suggested that people are aware of the potential environmental benefits, like air and water quality, provided by green parks in Chinese cities (Jim & Chen, 2006). In this study, oxygen release, aesthetic enhancement, noise abatement, CO_2 sequestration, and air pollutant absorption were stated to be the most important benefits generated by urban green spaces by the inhabitants of Guangzhou (Jim & Chen, 2006). Jim and Chen (2006) suggested that the motivation for Guangzhou's inhabitants to visit parks depended on the urban environment and main environmental issues that people would have experienced during their lifetime. In this region, people are more affected by environmental problems like pollution than the inhabitants of cities like Paris. A perception of the benefits provided by urban parks may thus strongly vary between studies conducted in different regions owing to the local environmental context. Alternatively, it can be interpreted as a lack of understanding of scientific questioning and words. The relatively high number of "I cannot say" responses with regard to "water quality protection" and "soil composition" benefits (4OQ) may support the idea that these questions belong to an academic milieu and are not shared by the general public of park users.

4.2. Plant species richness and characteristics

The inventories performed by a botanist in the Parc des Buttes Chaumont recorded 139 plant species, which is equivalent to the 134 species found in a park of relatively similar area (25 ha) in Flanders (Hermy & Cornelis, 2000). Cultivated exotic species contributed to around half of this number, as 52% of the species recorded were exotic species originating from other countries and continents. All of these exotic species were introduced into the region for ornamental reasons, and all are commonly cultivated by the park's gardeners except for one: *Conyza canadensis*, an exotic species involuntarily introduced. Although the number of exotic species was similar to the richness of native species, their frequencies were small and did not exceed 9% in the botanist's records. Conversely, among the native species recorded in the park, the majority were spontaneous species generally considered to be weeds, including *Trifolium repens, Hordeum murinum*, and *Veronica chamaedrys*, which were observed in 65%, 41%, and 30% of the botanist's records, respectively.

The repartition of species origins among strata was likewise unbalanced. We found that 66% of tree observations and 74% of shrub observations corresponded to exotic species versus 3% for herb species. The proportion of exotic species mirrors those found in other studies. Nagendra and Gopal (2011) studied the tree composition of urban parks in Bangalore (India) and found 77% of the trees observed to be exotic. In Guangzhou (China), Jim (2002) observed 56% trees to be exotic in 21 urban parks. The unbalanced distribution of species origins among strata may arise as a consequence of planting exotic trees and shrubs as opposed to exotic herb plants. Lawns were composed of spontaneous native plants only.

4.3. Divergences in the perception of plant species richness

Here, we present the results of the plant species richness in the Parc des Buttes Chaumont from a scientific perspective. The park users estimated and perceived plant species richness differently

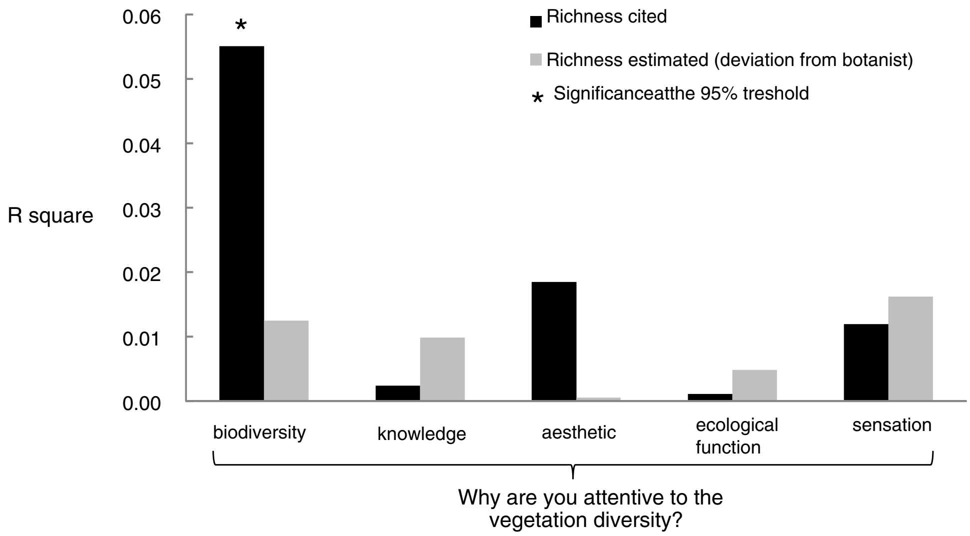

Fig. 4. Distribution of r^2 of the independent effects on richness both cited (in black) and estimated (in gray), as calculated from hierarchical partitioning (1000 randomizations). A significant contribution at the upper 95% confidence limit is illustrated with a star.

to the botanist: the latter reported the best representativeness of plant species richness in this area in a manner as unbiased and exhaustive as possible, whereas the park users came to the park to explore their emotions, and thus, they had a very different point of view from the botanist. Therefore, it is important to understand how park users may perceive the plant species richness of a park and how it influences their well-being.

We noted an important difference between the expert and park users' perceptions of diversity. Numerous taxa observed by the botanist were not identified by park users and vice versa. The park users' estimations of plant species richness also differed from the botanist's count, mostly underestimating diversity. The park users were more attentive to the diversity cultivated and promoted by the gardeners than to the richness of spontaneous plant species. This indicates that park users are partly disconnected from an experience of spontaneous biodiversity within urban green environments.

It appears that unlike botanists, park users are not aware of the geographical origin of plants, as previously shown by Chen, Adimo, and Bao (2009) in a study of Guanzhou's public garden (China). Thus, park users' knowledge and interest are not influenced by exoticism, as we could have supposed, but more by what garden managers let them observe, regardless of the origin of the cultivated species. Thus, gardeners and garden managers have an important role to play in terms of plant knowledge and perception among park users by staging flowerbeds and trees.

In our study, we showed that the numbers of citations by park users did not correlate with the effective species frequency in the park (defined as the number of botanist records). The park user citations were more frequent for well-known ornamental species, such as horse chestnut (*Aesculus hippocastanum*, 33 park user citations vs. 7 botanist records), or emblematic trees planted at the park's creation, such as gingkos (10 park user citations vs. 3 botanist records) and cedar (*Cedrus atlantica*, 10 park user citations vs. 2 botanist records). This focus on emblematic species was expected, as urban people have a strong general preference for types of plants that are always valued (Kendle & Forbes, 1997). The preference theory regarding coherence (sense of order and directing attention) and legibility (structuring space, differentiation, and readability) might also help to explain the popularity of such vegetation types (Kaplan & Kaplan, 1989).

Moreover, diversity was appreciated by respondents more through the different landscapes and the various colors of leaves and flowers than from a species point of view alone. This was also expected as aesthetics is one of the primary attractions of green parks (e.g., Kaplan & Kaplan, 1989). The diversity of landscape elements is likely viewed as a barrier against the homogeneity of the gray city, even though people are still aware of parks playing an ecological role as with air quality. This is consistent with the results of Leder, Belke, Oeberst, and Augustin (2004), who found high levels of visual landscape complexity to be frequently appreciated by people. We may therefore conclude that unlike the botanist, plant species richness was less observed by people from a cognitive viewpoint than an emotional one. We noted that people with a proclaimed interest in nature and ecology were able to mention more taxa. This shows that ecological knowledge could have a positive influence on preferences for species diversity.

4.4. Management perceptions

In the study of Fischer and Young (2007), many participants saw humans as harmful to biodiversity, while the majority of respondents in the study of Özgüner and Kendle (2006) preferred sites with a natural aspect (83%). Our study confirmed these two assertions, as the majority of park users preferred the cohabitation of spontaneous and cultivated plant communities as opposed to the removal of spontaneous species, i.e., weeds. Even if their knowledge about spontaneous diversity is rather poor, it appears that these respondents prefer conceiving plant management in terms of cohabitation rather than removal, which could reveal a desire for a change toward a more naturalistic landscape, but not necessarily a desire for less management. Özgüner and Kendle (2006, p. 154) observed that the notion of nature within an urban context did not mean "wilderness" in the sense of self-functioning space: "In a city-wide context, people see plants as representing nature, so a formal park of lawns and beds is observed as natural when it is contrasted with built-up environment". Similar findings were disclosed in our study: 39% of respondents visited the park to escape from the city, seeking nature, greenery, and the various landscapes offered by the park as well as its animals.

Moreover, through their diversity of plants and landscapes, urban green parks may have emotional and restorative benefits that can contribute strongly to human well-being. The evaluation of these benefits is therefore vital, and it should be integrated into the project assessment procedure and accounted for in policy decisions and urban planning strategies.

5. Conclusion

This study revealed that park users' knowledge of plant species is poor and depends on their interest about nature and ecology. Their biodiversity perception differs from the ecological concept, but it is also complementary based on the emotional perception of diversity.

While this study is a site-specific survey with limited participants, it is one of the few that has tried to show the intricate links among biodiversity, people's perception of biodiversity, and their capabilities to experience and benefit from this biodiversity in urban parks. Exploring these relationships is a prerequisite for assessing whether biodiversity conservation in urban green parks is valuable for human well-being.

The compromise between the maintenance of urban garden management and the evolution of gardens toward more natural environments is possible by taking spontaneous flora into account. This compromise could be based on collaborative work between gardeners and botanists. Park users are very attentive to the efforts of gardeners, and, as we showed, their basic knowledge about plants is mainly derived from gardeners. Park users are ready to accept gardens that are more hospitable to spontaneous plants provided that the resultant more natural aspect does not impact their contemplative passive pursuit, that is, their sense of well-being and need for beauty. Further studies should however investigate the exact role of gardener management practices on spontaneous plants in order to promote friendly practices toward spontaneous plants and a more natural aspect of parks. In addition, we need to understand how such management practices will be perceived by park users.

There is also a need for ecologists to popularize questions about the ecological functions of this spontaneous nature. Our study revealed that users could be oriented toward biodiversity and the ecological functions of plant species richness if they are confronted with them. Yet this can only be achieved if people become familiar with ecological concepts, which is unlikely in many cases. Understanding people's perception of biodiversity could serve to communicate with people better and educate them about ecological functions and services from an emotional perspective about biodiversity. Finally, although this study addressed important issues regarding users' urban park perception, it has an explanatory character such that no prediction or generality can be made. While a qualitative and quantitative analysis has been applied, we need to better understand how perceptions and knowledge of plant species richness vary among age and gender groups based on larger samples of respondents and park sites.

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Appendix A. Questionnaire submitted to 100 park users in the urban Parc des Buttes Chaumont. Open-ended questions are denoted by OQ and close-ended questions by CQ.

1OQ. What does this park represent to you?
1CQ. What does this park represent to you?

- a refuge from urban activity (y/n);
- a place for reflection (y/n);
- an area of relaxation (y/n);
- a convivial place (y/n).

2CQ. Are you attentive to plant species richness? (y/n)
3OQ. If yes, why are you attentive to plant species richness?
4OQ. What is the role of plant species richness in this park?
4CQ. What is the role of plant species richness in this park?

- a subject of discussion (y/n);
- a source of knowledge (y/n);
- a change of scenery (y/n);
- aesthetic, decorative (y/n);
- for noise reduction (y/n);
- to favor the presence of animals (y/n);
- for air quality (y/n);
- health benefits (y/n);
- for temperature regulation (y/n);
- for the soil composition (y/n);
- for water quality (y/n).

5CQ. What do you think about spontaneous species?

- We must let them cohabit with cultivated species (y/n);
- We must eliminate them to favor cultivated species (y/n);
- We must favor them, sometimes to the detriment of cultivated species (y/n).

6OQ. What species can you name in this park?
7OQ. How many species do you estimate to be present in this park?

Appendix B. Park users' answers to open-ended questions 1 ("What does this park represent to you?"), 3 ("Why are you attentive to plant species richness?"), and 4 ("What is the role of plant species richness in this park?") grouped according to main thematic categories and occurrence (multiple answers per user allowed).

Main categories	Occurrence in 1OQ (%)	Park users' answers
Well-being and sensations	61	Enjoyable–well-being–resting–calm–relaxing–peaceful–serenity–relaxation–reflection–fresh air–shaded–good for health–oxygen–taking a deep breath–taking some air–resourcing oneself–freedom–forgetting city life–going out of the city
Greenery	17	Greenness–evergreen–vegetation–practice of green–a piece of greenery–woody–resembling a forest–wilderness–grass vegetation–animals–plant species richness
Beauty	17	Beauty–nice park–lovely place–perspective–view–lovely view–landscape
Leisure	14	For the internet connexion–forming relationships–picnic–having fun–for leisure–jogging–enjoying oneself–for children–a new place to visit–taking photos
Proximity	9	Our garden–proximity–distance

Main categories	Occurrence in 3OQ (%)	Park users' answers	Occurrence in 4OQ (%)	Park users' answers
Biodiversity	20	Increasing park diversity–a lot of variety–presence of ginkgo–presence of rare species–a variety of plant species–many trees–shades of green–different colors–creating different landscapes–landscape feeling–season sensitive–birds–absence of animals	32	Bird protection–fauna improvement–hosting animals–it's ecological–spirit of nature–preserving nature–preserving our goods–richness–good for nature–role in species conservation–large range of species–wild parks–marked seasons–let the plants grow–season changes–vegetation renewal–diversity–plants must be adapted to the environment–preferable to uniformity
Knowledge	11	Out of curiosity–out of interest–for knowledge–species are labeled–species names are labeled–enjoy learning–to learn–lack of species information	7	Knowledge of nature–pedagogy–curiosity–interesting–discovery–knowing plants–good sampling of species
Aesthetic	25	It's aesthetic–beautifying the place–it's nice–flowerbeds are nice–it's beautiful and nice to see–for the visual aspect–high park maintenance–I love the work of gardeners	21	Aesthetic role, landscapes–visual enjoyment, I look at trees/birds–view–nice to see different plantings–landscape diversity–beautifying–nice to see flowers
Ecological function	2	Nature multiplies–we need trees to breathe	23	Balancing building areas–avoiding disease spread–for air quality–for ecosystem functioning–less warm–for breathing–more air–existence of an ecological system–balance of the planet–green lung–offset dense buildings
Sensations	32	Interest in contemplating–it's good for me–feeling better–feeling of fullness with nature–forgetting the city–getting out of town–relaxation–reflection–that's life–return to basics–pleasant–it pleases me–we imagine ourselves in the countryside–change of scene–break–we feel surrounded by nature	23	Charm–pleasure–for health–happiness–well-being–it's good for people passing alongside–meditation–breaking out of the city–harmony
Other	24	Closeness–novelty–popular object–going out of the city–desired space–tranquility–friendly–I like it–we see only that–important	20	Don't know (e.g., "it's good", "none")

Appendix C. List of taxa cited by park users and observed by the botanist

Stratum	Origin	Taxon cited at the genus level	Frequency of the botanist's observations for 102 park samples	Frequency of citations among 100 park users	Species observed by both botanist and park users
Herb	Exotic	*Begonia*	0	1	
		Choisya	5	0	
		Conyza	2	0	
		Coronilla	1	0	
		Cyclamen	0	1	
		Datura	0	1	
		Duchesnea	1	0	
		Hirschfeldia	1	0	
		Lepidium	1	0	
		Oxalis	2	0	
		Pelargonium	0	1	
		Pleioblastus	1	0	
		Rhododendron	0	2	
		Tropaeolum	0	1	
		Tulipa	0	2	
Herb	Native	*Achillea*	10	0	
		Agrostis	16	0	
		Alliaria	2	0	
		Anthriscus	4	0	
		Bellis	16	0	
		Calystegia	1	0	
		Capsella	7	0	
		Carex	1	0	
		Cerastium	1	0	
		Chelidonium	1	1	Yes
		Cirsium	1	0	
		Convolvulus	5	0	
		Dactylis	3	0	
		Dianthus	0	2	
		Digitalis	0	1	
		Elytrigia	7	0	
		Euphorbia	4	0	
		Festuca	6	0	
		Geranium	1	0	

Appendix C (*Continued*)

Stratum	Origin	Taxon cited at the genus level	Frequency of the botanist's observations for 102 park samples	Frequency of citations among 100 park users	Species observed by both botanist and park users
Geum	4	0			
		Glechoma	11	0	
		Hordeum	42	0	
		Hyacinthus	0	1	
		Lapsana	3	0	
		Lolium	91	0	
		Meconopsis	1	0	
		Narcissus	0	5	
		Papaver	0	2	
		Parietaria	5	0	
		Phragmites	0	1	
		Picris	1	0	
		Plantago	15	0	
		Poa	23	0	
		Polygonum	14	0	
		Potentilla	3	0	
		Ranunculus	9	0	
		Rumex	10	0	
		Senecio	1	0	
		Sonchus	3	0	
		Stellaria	1	0	
		Taraxacum	10	1	Yes
		Trifolium	73	2	Yes
		Urtica	2	0	
		Veronica	30	0	
Shrub	Exotic	*Aucuba*	7	2	Yes
		Berberis	6	0	
		Callicarpa	1	0	
		Cotinus	1	0	
		Cupressus	0	3	
		Elaeagnus	7	0	
		Evonymus	7	0	
		Forsythia	6	3	Yes
		Hibiscus	3	0	
		Kerria	3	0	
		Laurier	0	2	
		Lonicera	7	0	
		Mahonia	4	0	
		Osmanthus	1	0	
		Philadelphus	3	0	
		Phillyrea	3	0	
		Pyracantha	1	0	
		Sorbaria	1	0	
		Spiraea	7	0	
		Symphoricarpos	4	0	
		Syringa	4	0	
		Viburnum	4	0	
		Weigela	2	0	
Shrub	Native	*Colutea*	1	0	
		Cotoneaster	7	0	
		Frangula	2	0	
		Ilex	5	0	
		Rosa	2	1	Yes
		Sambucus	10	0	
Shrub	Native/exotic	*Cornus*	8	1	Yes
		Ribes	7	0	
		Rubus	2	0	
Tree	Exotic	*Abies*	0	8	
		Acacia	0	7	
		Aesculus	7	33	Yes
		Ailanthus	4	0	
		Albizia	1	0	
		Alnus	2	0	
		Broussonetia	2	0	
		Buddleja	5	0	
		Castanea	0	6	
		Catalpa	0	1	
		Cedrus	2	10	Yes
		Celtis	3	0	
		Cercis	3	0	
		Chamaerops	0	1	
		Cladrastis	1	0	
		Diospyros	3	0	

Appendix C (*Continued*)

Stratum	Origin	Taxon cited at the genus level	Frequency of the botanist's observations for 102 park samples	Frequency of citations among 100 park users	Species observed by both botanist and park users
Ginkgo	3	10	Yes		
		Gleditsia	3	0	
		Juglans	5	0	
		Lagerstroemia	1	0	
		Liriodendron	1	0	
		Maclura	1	0	
		Magnolia	1	0	
		Morus	1	0	
		Olea	0	1	
		Paletuvier	0	1	
		Parthenocissus	1	0	
		Paulownia	1	1	Yes
		Pinus	1	25	Yes
		Platanus	3	5	Yes
		Prunus	16	12	Yes
		Quercus	1	24	Yes
		Robinia	3	0	
		Sequoia	0	10	
		Sophora	5	0	
		Taxus	9	12	Yes
		Thuja	1	0	
		Toona	1	0	
		Zanthoxylum	1	0	
Tree	Native	*Buxus*	9	6	Yes
		Carpinus	2	1	Yes
		Corylus	5	1	Yes
		Crataegus	4	0	
		Fagus	1	10	Yes
		Ficus	0	1	
		Hedera	8	0	
		Laburnum	1	1	Yes
		Populus	3	8	Yes
		Salix	1	12	Yes
		Solanum	2	0	
		Sorbus	1	0	
		Ulmus	3	7	Yes
Tree	Native/exotic	*Acer*	13	14	Yes
		Betula	3	5	Yes
		Fraxinus	7	3	Yes
		Ligustrum	8	0	
		Tilia	3	4	Yes

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