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Cultural Ecosystem Services Provided by Urban Green Change along an Urban-Periurban Gradient

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Abstract: Urbanization by densification is globally increasing and endangers maintenance of urban green and associated social-ecological systems. Cultural ecosystem services play a crucial role in human well-being, especially in urban areas. We analyzed perceived importance of cultural ecosystem services provided by green space in Berlin along an urban-periurban gradient. Based on extensive pretests, we designed a standardized questionnaire and conducted 558 face-to-face interviews. B using multiple regressions and principal component analysis, we show that perceived importance of cultural ecosystem services and patterns of urban green use are affected by an urbanization gradient and associated changes in population density. Important cultural ecosystem services decreases in urban core areas with higher population density, whereas people in periurban areas with more available green spaces exhibit a greater valuation of nature. In contrast, social relations and cultural diversity had the highest importance in the urban core, while cultural heritage, education, natural awareness, recreation, and aesthetical appreciation were higher valued in the less populated periurban areas, suggesting two bundles of cultural ecosystem services.

Keywords: bundles; ecosystem service; nature perceptions; urban green spaces; urban sustainability; spatial planning

1. Introduction

The world is undergoing the largest wave of urban growth in its history. Urbanization usually leads to densification of human populations, causing huge losses in urban green ecosystems. However, urban green ecosystems increase biodiversity, improve air quality, reduce noise levels, and contribute to public health [1–3]. Land-use planning for urban areas, hence needs a comprehensive socio-ecological understanding to balance the competing functions of land-use [4]. Urban green and water bodies can increase urban biodiversity and will, as cities grow in size and number, become increasingly important for nature conservation [5,6]. Cultural ecosystem services (*CES* in the following) can be used as an additional argument for urban nature conservation [7,8]. CES can be defined as "ecosystems' contributions to the non-material benefits (e.g., capabilities and experiences) that arise from human–ecosystem relationships" [8] (p.9) and range from aesthetical, educational, and religious human–ecosystem relationships [9,10]. They require that "a significant relationship between ecosystem structures and functions specified in the biophysical domain and the satisfaction of human needs and wants specified in the medical/psychological/social domain" exists [11] (p.8813). Urban landscapes

and green spaces had been neglected in CES research but gained more attention in the last years [12,13]. This is crucial, as the importance of CES especially in urban areas is expected to increase [13,14].

Urban green use and perception of CES provided by urban green spaces can be expected to be influenced by population density [5,15]. Urban green spaces provide opportunities to establish social relations and offers places to meet outdoors. In our study area, of Berlin city, the inner city parks and open spaces are used and designed as places to rest and to meet [10,16]. The perception of CES can be expected to be influenced by a multitude of variables such as age, education, or income [17]. Our results provide insights into the structure and socio-ecological interactions of green space use and CES perception that may help to inform urban densification approaches [18]. In contrast to several previous studies we included everyday recreation in nearby green spaces, which is often neglected in ecosystem service research [11].

CES are notoriously difficult to characterize and assess [11,19,20], and hence, the use of ecosystem bundles of related CES categories is suggested. Yet, creating such bundles is difficult if prior information and a deep understanding of the provision and characterization of CES is lacking. Hence, CES bundles are difficult to create and justify. In contrast, our study shows obvious bundles of CES along an urban-periurban gradient, which could be tested to uncover if this is a more generalizable trend.

As urbanization poses very different demands on ecosystem services [21], spatially explicit and conceptually comprehensive studies of social and environmental factors influencing CES are necessary. There are contrasting definitions for 'urban' depending on the size and structure of the urban area [15]. We base our urban-periurban typology on population density as an indicator. We present a way to comprehensively quantify CES in a non-monetary way and to form bundles of CES. The aim of our study was to assess the interlinkages of population densities on CES perception and green space use along an urban-periurban gradient. For this we: i) Assess the perception of ten different CES categories, ii) compare them across an urban-periurban gradient, and iii) show related green space use from which CES were provided.

Following a description of the study site of the city of Berlin, we describe our methods of data collection and analysis. We then present the perceived importance of CES, and uncover the influence of a population density gradient on this perception. Lastly, we explain the green space visiting behavior of the questioned inhabitants. Based on this, we illustrate two distinct bundles of CES that emphasize the heterogeneous character of the categories.

2. Methods

2.1. Study Site

The area of study is Berlin, the capital city of Germany and a federal state. The city area is 892 km^2, from which over 40% covers green or water bodies. With 3.5 million inhabitants in 2013, Berlin is the most populated city of Germany. Berlin has 12 boroughs with population densities ranging from 13.818 inhabitants/km^2 (Friedrichshain-Kreuzberg) to 1.466 inhabitants/km^2 (Treptow-Köpenick) in 2013. At the higher spatial resolution of city districts, population density differences are even higher [22–24]. As urban green is highly patchy and diverse, we include all aquatic and green terrestrial ecosystems regardless of their management: (1) Parks and open green spaces, including abandoned industrial sites, overgrown gardens, or other brownfield sites, (2) forests and other areas dominated by trees, (3) water bodies such as lakes, ponds and river sites, (4) the four designated recreational areas of Berlin (the areas around Müggelsee, Wannsee, Tegeler See and the Berliner Barnim, covering around 26.000 ha), and (5) the surrounding green spaces of Berlin belonging to the federal state of Brandenburg, such as, e.g., agricultural landscapes [1,18].

2.2. Research Design and Questionnaire Development

The preparatory work for this study included (1) extensive literature research and theoretical conceptualization of CES and (2) semi-structured interviews with Berlin inhabitants and experts

(n = 41). Further, two pretests consisting of (3) two focus groups with method experts and laypeople to improve the structure and wording of the questionnaire and (4) a pilot study (n = 65 interviews) were conducted.

The resulting questionnaire focused on three topics: (1) Actual green space use, visiting frequency, and time spend on the five above-stated green spaces. (2) Perceived CES importance, assessed using a 7 point scale (from clearly not important to very important) through 23 items (see Table S1). (3) Lastly, we asked for socio-demographic characteristics (age, income, education, and gender) and context information (perceived accessibility to public green spaces overall, access to balcony, home garden, etc.). Table 1 shows the scales and coding of the relevant questionnaire items (see also Table S1).

Ten CES categories were assessed in this quantitative research, based on our prior qualitative study [10], which resulted in an adjustment of the 10 CES categories of the Millennium Ecosystem Assessment [9] to specific understandings in Berlin and increased the cultural sensitivity of the analysis. Most prominently, the category of 'traditional knowledge systems' was substituted by the category of 'nature awareness'. Further, the category of cultural diversity was adjusted. The Millennium Ecosystem Assessment explanation for the CES of cultural diversity reads: "The diversity of ecosystems is one factor influencing the diversity of cultures" [9] (p.40). In our study, this means that culturally differing communities in large urban agglomerations have differing demands with respect to urban ecosystems. Specific social groups prefer places for barbecue, picnic, or other social functions, while others prefer shaded pathways, quiet resting places, or seek a feeling of solitude (for similar findings in Berlin, see Reference [16]; for a detailed description of the used CES please refer to Reference [10]).

Table 1. Scale and coding of the variables used in the analyses. *CES* = cultural ecosystem services.

Topic	Scale & Coding
Green space use	Aggregated from average visiting frequency (daily; 1-3 times per week; once per month; 1-6 times per year; never) on (1) parks and open green spaces, (2) forests, (3) water bodies, (4) recreational areas, (5) urban surrounding.
Average distance for traveling to urban green	1, 2, 4, 10km. Arithmetic means are given.
Importance of 23 different CES items	7 point rating scale (from 1 'clearly not important' to 7 'very important'). 23 items of CES importance was centered to eliminate individual overall importance, i.e., acquiescence. CES are: Social relation, recreation, education, cultural diversity, cultural heritage, natural awareness, aesthetic, sense of place, religious & spiritual, inspiration. Translated individual CES items are shown in Table S1.

Data were collected via a direct (face-to-face) survey in four districts of Berlin (Figure 1) using proportionate stratified random sampling of Berlin inhabitants >15 years of age. To select study sites according to their population density, we assigned each district of Berlin to four strata of decreasing population density. From each stratum, a district was randomly selected (Table 2). Since the population density is polycentric throughout Berlin, the selected urban–periurban gradient is not linear from core to periphery. The sampled districts show the structural composition of Berlin and reflect the lived experiences regarding population density of the participants. We adjusted the sample proportion of the three smaller districts in order to obtain sufficient sample sizes. As we were interested in systematic differences between districts, sampling weights were not used to adjust for the deviations from strictly proportional sampling (Table 2). Within the districts, streets, and households were chosen randomly. Data were collected on various days of the week between 09:00 and 21:00 o'clock to decrease selection bias. Selected household were contacted twice; after a second unsuccessful try, households were counted as dropouts. Since answers to questions related to natural environment may depend on the season [25] and were sampled in two rounds to decrease a bias depending on seasonal weather conditions. Data were collected in late autumn 2013 (November – December) and in late spring, early summer 2014 (April–June). An overall response rate of about 48% resulted in a sample size of n = 558

(round 1 n = 249, round 2 n = 309). Figures and tables indicate the respective sample size or range to account for an item non-response.

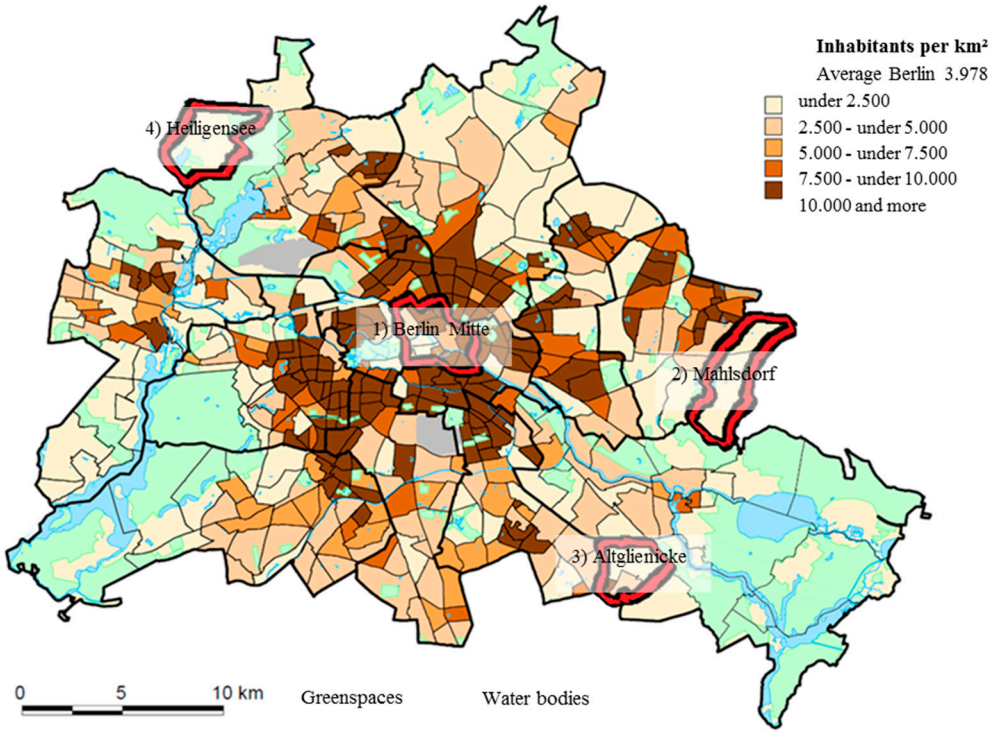

Figure 1. Inhabitants per km^2 in the federal state of Berlin. Map shows and names the sampled districts chosen through stratified random sampling based on population density. Source: Reference [23].

Table 2. Study sites description and sample size.

Study Sites		Sample Size
District: Berlin Mitte	Population density: 7.850 inhabitants per km^2; Characterized by blocks of flats. Borough: Berlin Mitte; located in former eastern Berlin	n = 219 (39.2%)
District: Altglienicke	Population density: 3.422 inhabitants per km^2; Blocks of flats and single houses; Borough: Treptow-Köpenick; located in former eastern Berlin	n = 128 (22.9%)
District: Mahlsdorf	Population density: 2.095 inhabitants per km^2; Blocks of flats and single houses; Borough: Marzahn-Hellersdorf; located in former eastern Berlin	n = 124 (22.2%)
District: Heiligensee	Population density: 1.665 inhabitants per km^2; Dominated by village structure and single or dispersed single houses; Borough: Reinickendorf; located in former western Berlin	n = 87 (15.6%)

2.3. Statistical Analysis

Data were analyzed using SPSS 21 (IBM Deutschland GmbH, Ehningen, Germany). As item non-response was low, missing data was excluded pairwise. Depending on the scale of measurement, correlations were computed by Pearson's chi-squared statistic (Cramer's V) for nominal variables, Spearman's rank correlation (Spearman's Rho) for ordinal and Pearson product-moment correlation (Pearson's r) for interval variables. CES importance was centered to eliminate individual overall importance, i.e., acquiescence. An inspection of correlations of population density showed negative relations with age and income (Age $r = -0.234$, Income $r = -0.197$, $p < 0.001$; age and income uncorrelated): The lower the population density, the older and the wealthier participants. Hence, while using a stepwise linear regression of the centered importance of each CES, we included the density

correlated variables age and income in a first step, and in a second step, the population density to control for interference.

Additionally, we conducted a principal component analysis (PCA) on the centered CES importance. This analysis reduced the 10 CES to two bipolar dimensions depicting individuals' differences. The vectors of the CES dimensions structured the perceptional space of the interviewees (Figure 2). The predictors (population density) and covariates (visiting frequencies, which also were centered) were projected in that space by correlational loadings. The closer the variables projection, the more similar they are. Variables lying opposite to each other can be interpreted as polar endpoints of an axis. This mapping shows how a CES is perceived in relation to other CES.

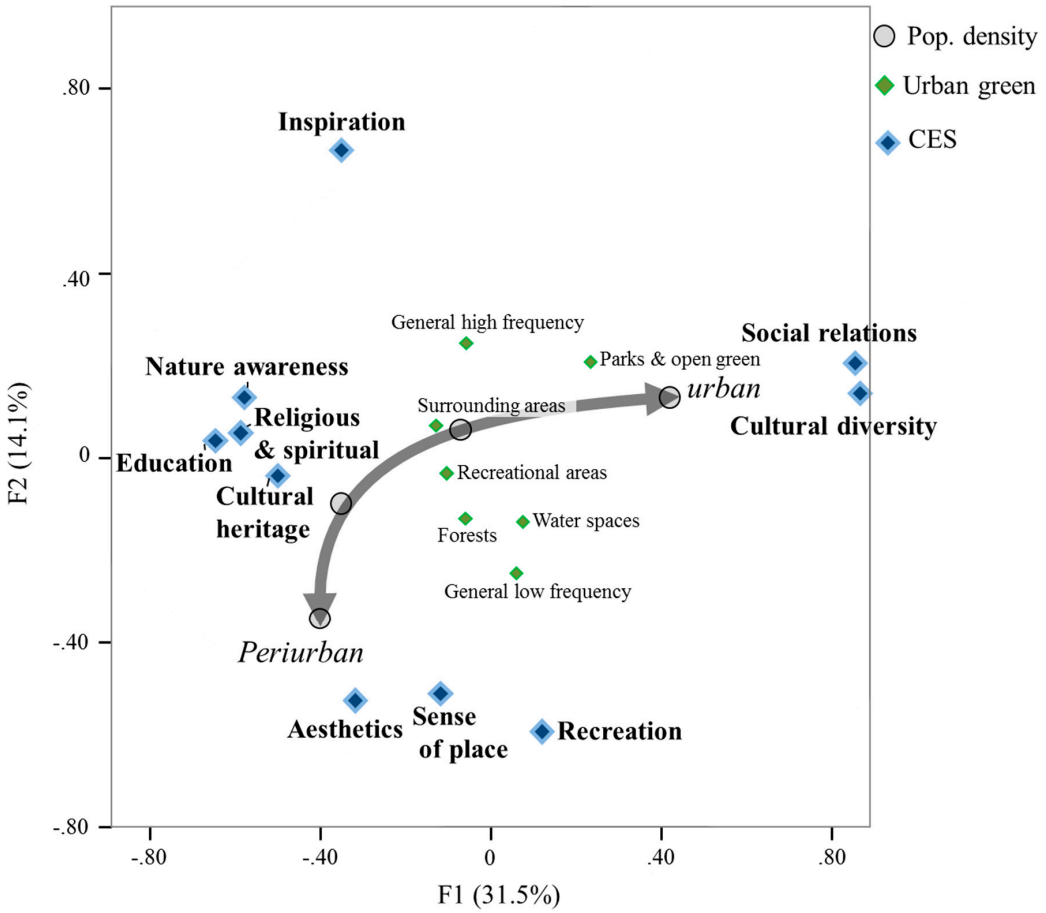

Figure 2. Factor loadings of cultural ecosystem services (CES) with means of four areas with differing population density (pop. density) and correlated visiting frequencies of five urban green spaces (urban green).

3. Results

Gender and age distribution of our sample are comparable to the distribution known for Berlin [22]. There is a slightly higher amount of individuals with higher education in the sample (compared to data from Reference [22]), possibly a result of a biased drop-out rate. For more details on socio-demographic information of the survey sample, see Figure S1.

The overall assessment of CES showed that aesthetics were perceived as the most important, with a mean rating of 5.8 on a seven–point scale. The second rank was reached by importance for nature awareness (5.3), followed by religious and spiritual values (4.7). The least importance received cultural diversity (4.0). Mean importance across the 10 CES was 4.6 (Table 3).

Table 3. The mean importance of cultural ecosystem service; Results of stepwise linear regression of cultural ecosystem service importance depending on population density with age and income as predictors in step 1 and population density added in step 2; regression coefficients from the step 2 model; $n = 513$.

Cultural Ecosystem Service	Overall Mean	Age	Income	Population Density	
		Beta	Beta	Beta	R^2 Change
Social relation	4.5	−0.324 ***		0.269 ***	0.065 ***
Recreation	4.0	−0.233 ***		−0.255 ***	0.058 ***
Education	4.0	0.163 ***		−0.243 ***	0.053 ***
Cultural diversity	4.0	−0.234 ***	−0.090 *	0.218 ***	0.042 ***
Cultural heritage	4.0	0.337 ***	−0.113 **	−0.126 **	0.014 **
Natural awareness	5.3	0.168 ***		−0.122 **	0.013 **
Aesthetic	5.8		0.115 *	−0.110 *	0.011 *
Sense of place	4.4	0.098 *	−0.242 ***		
Religious & spiritual v.	4.7	0.248 ***			
Inspiration	4.2	0.251 ***	0.116 **		

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

A stepwise linear regression of centered importance of CES on age and income in the first, and population density in the second step, confirmed the dependence of CES importance on the population density for seven out of 10 CES. Table 3 shows that inspiration, religious values/spirituality, and sense of place CES were of equal importance in all four sampled districts and not dependent on population density. Five of the ten CES decreased in importance with increasing population density: Cultural heritage, education, natural awareness, recreation, and aesthetical appreciation were higher in less densely populated areas. In contrast, the CES categories of social relations and cultural diversity increased with population density, being perceived as more important higher in the urban core. These results are confirmed by the PCA (Figure 2).

Figure 2 shows the results of the PCA, which group the 10 CES into four clusters that share similar perceptions. One cluster (1), which we named 'social aspects', consists of CES related to social relations and cultural diversity, indicating that these two CES are understood similarly. The second cluster (2) 'educational and spiritual aspects' consists of educational, religious and spiritual services, as well as natural awareness and cultural heritage. These services appeared to share a similar CES understanding. The third cluster (3), named 'aesthetics and recreation', is made up of aesthetical and recreational services and for sense of place. A fourth (4) cluster includes the single CES of inspiration. As Figure 2 shows, high population density is associated with a higher valuation of socially related CES services, as was found in the univariate analyses (Table 3). Visiting of parks and open green spaces are associated with importance of those 'social' CES and respondents from the urban core. At the opposite side of the graph, the educational and spiritual aspects are related with inhabitants of the periurban area. The second dimension contrasts the basic aesthetic and recreational services appealing to individual's seldom visiting urban green with inspiration especially important for individuals often stay in green spaces. Overall, the PCA confirms an urban-periurban gradient in which urban core and periurban areas are clearly influencing stated CES importance for urban green spaces.

Urban Green Space Use

37% of the inhabitants visit green spaces within a radius of one kilometer, 77% of the interviewees did not travel more than five kilometers. Traveled distance to green spaces was positively related to the population density (Rho 0.143, $p = 0.001$), showing that inhabitants of the urban-core traveled further to urban green than people inhabiting less densely populated areas. The mode of travel was also correlated with population density (Cramer's V 0.204, $p < 0.001$). While people in the urban core used public transport more frequently, individuals in the periurban areas more often went by foot or rode a bike when visiting green spaces. However, 70.5% of the respondents stated that accessibility to green spaces was good or very good, which was not correlated to population density. In total, parks

and open spaces have the highest visiting frequency (Figure 3). Population density was positively related to the visiting frequencies of parks and open green spaces (Rho 0.322, $p < 0.001$), i.e., inhabitants of the urban core visit these places more often.

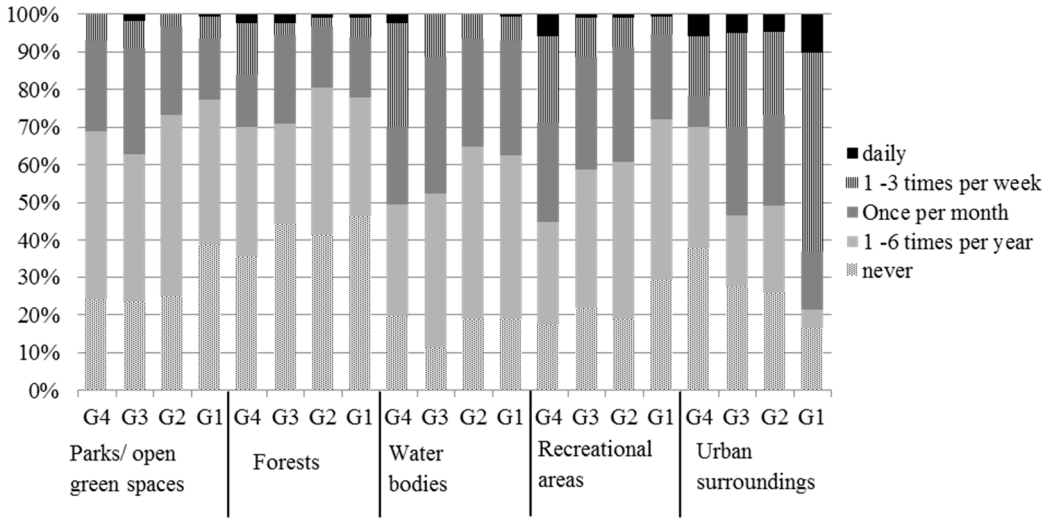

Figure 3. Use frequencies (%) of five urban green spaces in relation to population density. G1 = highest population density (urban core) to G4 = least densely populated area (periurban area), $n = 556 – 558$.

On average, parks and open green spaces are visited only for up to one hour. Population density is negatively correlated to time spent at water bodies (Rho 0.206, $p < 0.001$) and forests (Rho 0.171, $p < 0.001$). While respondents from the urban core visit lakes and forests less often than their periurban counterparts, they tend to stay significantly longer if they do. Inhabitants of the less densely populated areas visit the Berlin-Brandenburg surrounding longer, as the negative correlation with population density indicates (Rho −0.112, $p = 0.029$).

4. Discussion

Calvet-Mir et al. [26] showed that CES are perceived as the most important ecosystem services by home garden owners. Hence, CES, which are delivered more frequently by private green in periurban areas, should be provided by public urban green in areas where private green is scarce. This might explain the importance urban green spaces used for social relations under the conditions of cultural diversity in the urban core. Combined with the information that inhabitants of the urban core travel farther to reach green spaces, an increase of supply of urban green spaces in the city center should be considered. Yet, as the Berlin city administration focuses on urban densification, green spaces in the urban core will be subjected to increasing conversion pressure. Our results provide insights into the structure and socio-ecological interactions of green space use and appreciation that may help to better balance—environmentally as well as economically motivated—densification approaches [18].

Urban green provides opportunities for social relations, to leave the built environment, and have an outdoor place to meet family and friends. Berlin inner city parks and open spaces are, in fact, used intensively as a resting or meeting point, for festivities, as a living and dining space [10,16]. In 2012, about 54% of private households in Berlin were single households [27]. Thus, urban green spaces have a high value for social integration, to overcome the loneliness in a city and to strengthen personal social relations. CES associated with cultural diversity and social relations correlate with a visiting frequency of urban parks and open places, oftentimes the only green spaces easily accessible to the—younger and lower income—inhabitants from the urban core, especially for those who do not have home gardens or balconies [17]. The high demand of these green space qualities have to be incorporated into the urban planning process to guarantee an adequate supply in the face of high real estate values, in part reflecting the high population density.

While studies on CES were increasing [28], there are still several methodological and conceptual gaps. CES are described as difficult to value and assess [11,19]. While the valuation of non-material aspects of the human–environment interaction might be difficult; a relative negligence of socio-cultural aspects in ecosystem service research might unduly reduce the impact of CES demands on environmental policy and urban planning [5,8,29]. A possible way to tackle the problems of CES valuation could be the use of clusters or bundles of related CES. Yet, in an extensive review [28], it stated that only a small amount of studies focused on ecosystem bundles, especially in the realm of CES. In this study, we showed that CES are not only perceived in three related clusters [5,21,30]—we also show that the relative importance of the clusters changes systematically along a population density gradient from a city core to periurban districts. Specifically, we find that CES related to social relations and cultural diversity could be aggregated into a cluster of CES related social aspects. Educational, religious, spiritual, and cultural heritage values as well as values for nature awareness constitute a second cluster of educational and transcendental values of nature. Likewise, an aesthetics and recreation cluster can be formed. Meaningfully bundling CES could substantially decrease biases introduced by the selection of CES categories. Further social research into the empirical reality of deductively defined CES is likely to yield tools for quantifying CES without necessarily relying on often criticized monetary valuations [29]. Furthermore, it could simplify monetary as well as non-monetary assessment tasks in urban planning for which ten distinct CES yield an overly complex vector of indicators. Yet, our results also highlight the problematic decision of some CES research to not separate out different services but only measure the amenity value of all services bundled together. We further highlighted the heterogeneous character of CES [19] and want to stress the multiplicity of predictors of their valuation, such as age and income [17]. Since the study sample was collected in four districts varying in population density, other aspects, such as the distinction between East and West Berlin (here the majority of participants are from the Eastern part of Berlin), or more locally specific valuations could also be of interest regarding their influence on stated CES importance."

Our contribution to the better understanding on the locally specific perception and provision of CES along an urban–periurban gradient adds to the growing knowledge on enhancing and conserving ecosystem services. We understand CES as connecting particularly the social and ecological dimensions of urban sustainability, referring to the ability to maintain ecosystem services and biodiversity, the well-being of its inhabitants, and economic prosperity [31].

5. Conclusions

Results of our study showed that perceived importance of cultural ecosystem service (CES) decreases with population density and is higher in the urban core than in the periurban areas, where there are more green spaces available. In contrast, social relations and cultural diversity are perceived as more important in the urban core, suggesting two bundles of cultural ecosystem services in urban vs. periurban settings. We present ways to comprehensively quantify CES in a non-monetary way, and to form bundles or clusters of CES that contrast perceptions and related socio-ecological interactions in the urban core from periurban areas. There are many possible ways in which social variables such as age, education, or income might affect the valuation of CES. For simplicity, we have focused here on the population density, which is correlated with age and income and changes dramatically along the urban-periurban gradient. Policy and research related to CES should acknowledge such spatial differences in CES demand from urban green spaces. Especially urban parks and other green spaces in the urban core should create enough possibilities for a diverse use aimed at social relations. We need urbanization strategies that acknowledge spatial differences between urban and periurban sites, thereby acknowledging diversified demands. Our study gives one example on how to assess the importance of various CES in a more comprehensive way using qualitative and quantitative research methods.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/11/3/645/s1, Figure S1: Socio- demographic information of the survey sample, Table S1: Categories of cultural ecosystem services (CES) assessed by the corresponding questionnaire items.

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