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Beyond green: Broad support for biodiversity in multicultural European cities

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ABSTRACT

While urban growth contributes to the biodiversity crisis, biodiverse greenspaces within cities could support both human wellbeing and biodiversity conservation. Yet, urban greenspaces are under pressure due to the rapid densification of cities worldwide. Urban conservation policies thus need broad support, ideally from people with different sociocultural backgrounds. Whether urban residents prefer *biodiverse* over simply *green* spaces, however, largely remains an open question. We tested how diverse respondents ($N = 3716$) from five European cities valued three levels of biodiversity (plant species richness) in four ubiquitous greenspace types. Our field survey revealed that biodiversity matters: People largely prefer higher plant species richness in urban greenspaces (i.e., parks, wastelands, streetscapes) and agree that higher plant species richness allows for more liveable cities. Despite variation across European cities, positive valuations of high plant species richness prevailed among different sociocultural groups, including people of migrant background. The results of this study can thus support policies on a biodiversity-friendly development and management of urban greenspaces by highlighting social arguments for integrating biodiversity into urban development plans.

1. Introduction

Urban growth contributes to the biodiversity crisis (Güneralp and Seto, 2013), but cities may also be part of the solution as urban habitats can harbor surprisingly high biological richness (McKinney, 2002; Kowarik, 2011; Nielsen et al., 2014; Shwartz et al., 2014). Yet, urban greenspaces are under pressure due to the rapid densification of many cities around the globe (Lin and Fuller, 2013; Haaland and Konijnendijk van den Bosch, 2015). In parallel, urban areas of high human interest may coincide with places of high conservation value (Kasada et al., 2017). Given the competing interests in urban development, policies aimed at biodiversity conservation in cities thus need substantial support from urban societies. Important arguments are the benefits of urban greenspaces regarding improved human health and wellbeing (Shanahan et al., 2015; Hartig and Kahn, 2016), with people being happier when outdoors in green environments (MacKerron and Mourato, 2013). The vital question on the added value of biodiversity to human health and wellbeing still remains (Botzat et al., 2016; Soga and Gaston, 2016): Is *green* enough, or do residents especially value *biodiverse* greenspaces?

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There can be a significant gap between conservation objectives and perceived wellbeing (Clayton et al., 2017). Whether biodiversity really matters for urban residents remains unclear, since previous studies on the valuation of urban biodiversity are scarce, difficult to compare (Botzat et al., 2016) and yield ambiguous results (e.g., Fuller et al., 2007; Carrus et al., 2015 vs. Dallimer et al., 2012; Qiu et al., 2013). Botzat et al. (2016) report that only 51 out of 200 studies on urban biodiversity valuation and perception addressed the community, species or genes scale, although species level matters most for biodiversity conservation. Furthermore, the majority of studies focused on formal greenspace types (e.g., Johansson et al., 2014 for forests, Qiu et al., 2013 for parks, Lindemann-Matthies and Marty, 2013 for gardens), and only few studies exist on informal greenspace types, such as roadsides (Todorova et al., 2004; van Dillen et al., 2011; Weber et al., 2014) or wastelands (Brun et al., 2017; Mathey et al., 2017). For the most part, they do not consider that people of diverse backgrounds may have different views on urban biodiversity (Botzat et al., 2016).

In addition, some previous studies suggest that transnational surveys can provide further insights into how environmental or geographic settings may influence greenspace preferences while operating at different biodiversity scales (e.g., Lafortezza et al., 2009 for parks, Loder, 2014 for green roofs, Rupprecht et al., 2015 for informal greenspaces). At the same time, valuation studies on urban green that assess sociodemographic or cultural characteristics use such background variables largely in describing the sample and rarely include or even combine them in statistical modeling (however see, e.g., Shwartz et al., 2013; Lindemann-Matthies, 2017). The remaining knowledge gaps are critical, since identifying relationships with nature in times of a biodiversity crisis should also take into account the sociocultural context of individuals (Clayton et al., 2017; Dickinson and Hobbs, 2017; Fischer et al., 2018) and integrate social concepts into both urban ecology (Jorgensen and Gobster, 2010) and biodiversity conservation (Rissman and Gillon, 2017). In cities that act as human population hubs, in particular, greenspace management needs to account for the manifold needs and perceptions of the users (Vierikko et al., 2016; Aronson et al., 2017; Fischer et al., 2018).

Herein, we report results from a first international survey on urban biodiversity valuation at the species scale. Our field survey assessed how residents of five European cities, covering a range from northern to southern Europe, value biodiversity (plant species richness) in four ubiquitous greenspace types: parks, wastelands (a novel type of urban nature arising naturally on abandoned land; Kowarik, 2011), streetscapes with trees, and forests. To account for multicultural urban societies, our study includes people from different sociocultural backgrounds. Respondents were asked to rate photo collages showing scenes with different levels of plant species richness within each greenspace type—first, regarding their personal preferences and, second, the contribution of such scenes to creating liveable cities. We hypothesized that the valuation of greenspace settings (*i*) increases with higher biodiversity level (plant species richness) and is related to (*ii*) the geographic context and (*iii*) sociocultural background of the respondents.

2. Materials and methods

2.1. Study design

This field survey addresses cities as socio-ecological systems by coupling social and ecological variables (Pickett et al., 2011; Rissman and Gillon, 2017) to investigate how diverse human urban population groups value biodiversity. We assessed the respondents' valuation concerning four urban greenspace types (park, wasteland, streetscape, forest), and in five European cities: Bari (Italy), Berlin (Germany), Edinburgh (United Kingdom), Malmö (Sweden), Ljubljana (Slovenia); see Fischer et al. (2015) for details. As indicator for biodiversity, we chose plant species richness. The term biodiversity in this study, therefore, refers to the diversity between species, and details the existing knowledge on biodiversity valuation below the ecosystem or community level (Botzat et al., 2016; Pett et al., 2016). Species richness of one taxonomic group is frequently used as a biodiversity indicator (Heink and Kowarik, 2010); indeed, Pearman and Weber (2007) showed that richness in common plant species is positively correlated with species richness in other taxonomic groups (birds, butterflies). In our study, we operationalized this indicator by differentiating between three levels of plant species richness (i.e., low, medium, high), based on measured plant species richness.

To increase sample diversity, responses were collected using two survey media: a self-administered online questionnaire with embedded photographic stimuli and standardized face-to-face interviews that were combined with the same images, and during which the respondents answered the questions without interviewer assistance. Respondents were either randomly (online version) or rotationally (face-to-face interview version) presented with one of three survey combinations. Each combination showed photo collages of an urban park, the most important greenspace type, and either (a) an urban wasteland, (b) an urban streetscape, or (c) an urban forest.

The total sample size (N = 3716) included respondents from Bari (n_1 = 868), Berlin (n_2 = 1324), Edinburgh (n_3 = 460), Ljubljana (n_4 = 558), and Malmö (n_5 = 506). There were n_a = 1630 paper-and-pencil and n_b = 2086 online survey version respondents. Numerous cases (N = 1606) were excluded from the analyses due to incomplete or missing age data. The age of respondents ranged from 18 to 99 years (M = 38.85, SD = 16.11), and 58% were female. Fifteen percent of the survey sample had a personal migrant background (i.e., were born in a different country), and an additional 14% reported a migration history in their parents' or grandparents' generation. Fig. S1 shows the origins of these subsamples per European city.

2.2. Materials

The visual stimuli for the evaluations were three city-specific photographic images (compiled collages) of standard scenes in each of the four urban greenspace types. Their foreground showed (partly multiplied) sections of local greenery. For streetscapes, a fourth photograph was included that showed bare ground, that is, a no-vegetation condition because this setting prevails in many cities. Thus, we created 13 city-specific but comparable visual stimuli (Fig. 1) that represent scenes at human eye level and field of vision with similar light conditions (Latimer et al., 1981) and flat topographic structures (Hagerhall et al., 2004; Kaplan, 2007; Kaplan et al., 1989) without aspects that might bias vegetation evaluations such as humans, animals, litter, or open water (e.g., Dallimer et al., 2012; Gobster and Westphal, 2004; Han, 2007; Hull and Stewart, 1992; Kaplan, 2007; Patsfall et al., 1984; Ulrich, 1981, 1986; van der Jagt et al., 2014).

The raw photographic material and the corresponding vegetation surveys with measurements of plant species richness were collected in late spring/early summer, according to common detailed standard protocols and under continuous review to maximize comparability (Fischer et al., 2015). For example, general camera settings were defined in the protocols, including specific lens height and camera angle, as well as general environmental settings (i.e., weather and light conditions or even topographic structures). The aim of the standard settings was to provide the highest comparability between the series in each of the cities and between each of the biodiversity levels, already in the raw material. We selected the final raw photographic material by comparing the visual appearance of the photographic material (highest comparability within the city scenes and between the corresponding scenes of the other cities) and species richness according to the vegetation lists in the series in one greenspace type across the cities (Table S1). Differences in species numbers between the raw material allowed us to determine three disctinct levels of plant species richness, i.e. three biodiversity levels within each series of stimuli that displayed low, medium and high biodiversity. Although the different local vegetation and

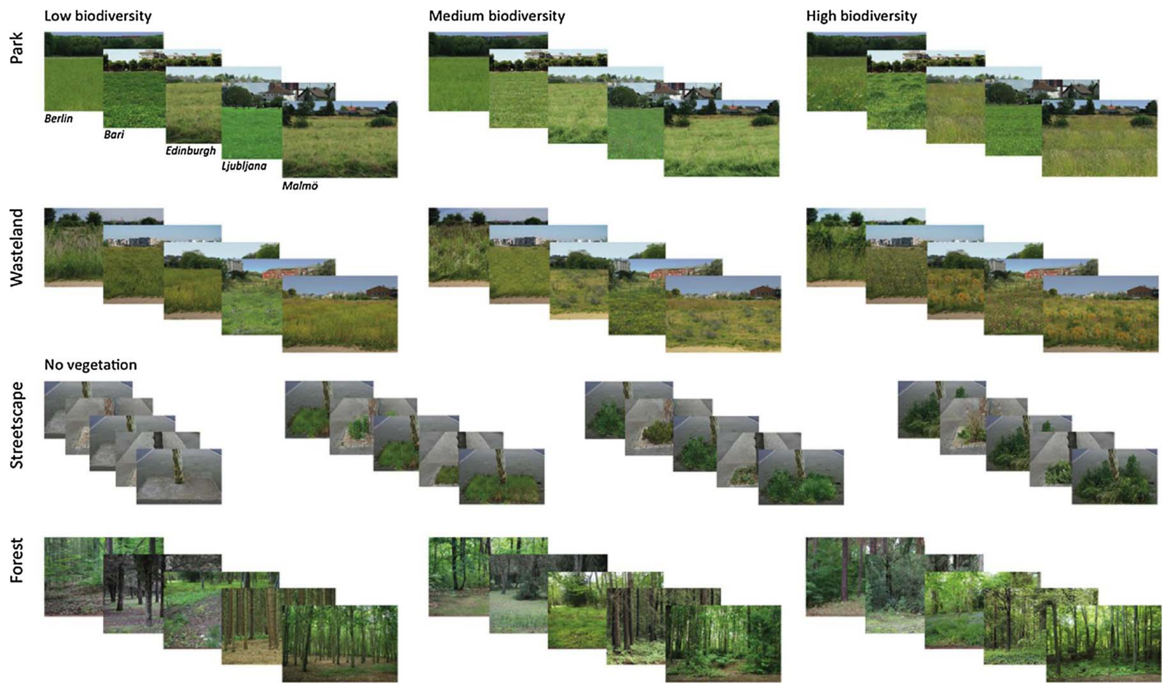

Fig. 1. Stimuli series for three biodiversity levels (plant species richness) in five European cities and four greenspace types, used in the field survey. The streetscape scenes included a fourth variant without ground vegetation (no vegetation). Pictures for the photo collages were generated using a standardized protocol.

structural elements may potentially bias the results, as they slightly diverge from each other, we preferred to use photo material that showed local urban green infrastructure. This ensured that respondents were equally familiar with the scenes within each of the five geographic regions, instantly recognized the greenspace type shown, and that valuations were not biased by unfamiliarity of plants or building structures. This is important as familiarity has been shown to highly influence the respondents' emotional reactions to the scenes displayed (e.g., Gustafson, 2001; Scannell and Gifford, 2010; van der Jagt et al., 2014). The stimuli were printed in high resolution for the interviews and displayed accordingly for the online survey.

The questionnaire consisted of a first section, which assessed respondents' valuation of plant species richness in the two greenspace types mentioned above (i.e., greenspace type park *plus* greenspace type wasteland, streetscape or forest), and a second section that assessed respondents' sociocultural backgrounds. In the first section, respondents were asked first to carry out a personal general valuation, which may be largely determined by aesthetic preferences and personal needs or memories regarding greenspaces, and second to consider the value of ecosystem services independently of their individual needs and preferences. The items evaluated respondents' preferences for each of the three alternative meadows in a park by asking "How do you like each of these three variations of a meadow in a park?" using a seven-point Likert scale (1, [like] *not at all* – 7, [like] *completely*) and whether the depicted green areas contributed to creating a liveable city by asking "Do such meadows contribute to better life conditions in a city?" using a five-point Likert scale (1, [contribute] *not* – 5, [contribute] *very*). The same items were used to evaluate respondents' preferences for each of the pictures of the second urban greenspace type in question. The Likert scales used were tested for equidistance in German and English (cf. Rohrmann, 2007) and, thus, were treated as interval-level data. In the second section, 20 variables were assessed to describe respondents' sociocultural background (cf. European Social Survey, 2012) and their relation to nature (for details, see Table S2).

The survey and concept of the photographic stimuli were developed with in-depth qualitative (N = 7) and quantitative (N = 979) pre-tests in German in the year preceding the study (Fischer et al., 2015). The English master version of the questionnaire was translated into 10 different languages that represented those spoken most often in the five European study cities. The translation was conducted by local translation teams (one scientist, two translators for each language) that secured linguistically equivalent and culturally tested language versions following guidelines of the International Test Commission (2005). For each language version a backward translation procedure, as described in Hambleton (2005), was used to compare the English master version of each European city with the back-translated version. Each translation team discussed the deviations and checked whether items were culturally appropriate and adequate for the target population within the local context of their city (cf. van de Vijver and Hambleton, 1996). This applied, for instance, to different ways of describing the different levels of the educational systems or simply to the number of digits in the postal code. Overall, we used 19 versions of the questionnaire with slight differences in wording or category descriptions, as listed in Table S2.

The recruitment of respondents followed standardized strategies: (a) People were approached randomly in public places such as parks, squares, shopping malls, administrative offices; (b) people were assessed at official cultural events such as summer celebrations and festivities; and (c) target groups were recruited with the help of unions, societies and social networks. With a constant update on the variation in the overall sociocultural backgrounds of respondents, we were able to target underrepresented groups as the study progressed. In sum, ca. 45% of the respondents were assessed using face-to-face interviews with a rejection rate of 36%. Fifty percent of the face-to-face interviews were conducted inside a building, 50% outside a building (43% of these in a greenspace, 57% outside but not in a green environment). As analyses of pretest data revealed only slight differences between the ways how respondents were accessed, we did not include a variable referring to this in the main analyses to keep to the main topics of this study. Data were collected from May to August 2015; the face-to-face interviews were conducted by trained staff of the European city teams according to a standard protocol (Fischer et al., 2015).

2.3. Statistical analyses

All analyses were conducted using the open statistical software R (R

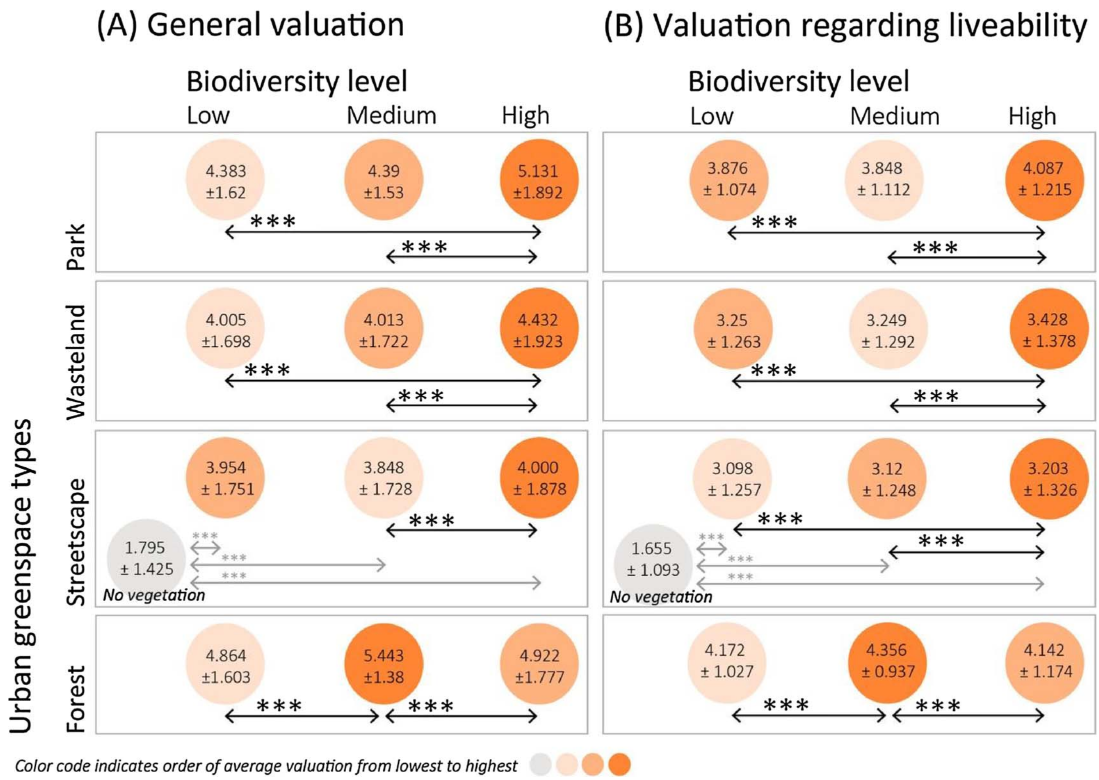

Fig. 2. Valuation of different biodiversity levels in the greenspaces of five European cities. Respondents rated standardized photo collages depicting three levels of plant species richness (i.e., low, medium, high biodiversity level) in four greenspace types; for the streetscape type, a collage without ground vegetation was also shown (Fig. 1). Valuations are based on a Likert scale for (A) general valuation (1, like *not at all* to 7, like *completely*) and (B) valuation regarding liveability (1, contribute *not* to 5, contribute *very*). Numbers represent mean ± SD of the valuation at each level of plant species richness; significant differences between levels (*t*-tests, Table S3): *** $p < 0.001$.

Core Team, 2016). We performed three different types of statistical analyses for (A) a general valuation and (B) a valuation regarding liveability to (1) test for differences in the valuation between the biodiversity levels within each of the greenspace types, (2) find out whether the geographic context (i.e., the city) matters for the valuation ratings within each of the greenspace types, and (3) identify those sociocultural background variables (i.e., covariates) that are related to the valuation ratings in the four greenspace types.

2.3.1. *Testing for differences*

Repeated measures analyses of variance (rmANOVAs) were used to test for mean differences between ratings of pictures with different levels of plant species richness, followed by paired sample *t*-tests to identify differences in mean valuation between individual pictures.

2.3.2. *Geographical context*

The relationship between ratings of the pictures and the respective European city was analyzed using logistic multinomial log-linear regression analyses from the "nnet" package (Ripley et al., 2016). For the probability plots that were calculated to display the results, probabilities per category (i.e., per city; variable *City*, see Table S2) were derived from the logistic multinomial log-linear regression analyses, using a logistic link function, and weighted by the number of respondents belonging to the respective city in order to account for differences in subsample size. The logistic models were used not only to model the effects of different cities as constant random factors but also to non-linearly predict differential effects of city residency over the entire spectrum of possible valuation responses.

2.3.3. *Identification of sociocultural background variables*

Using the "lme4" package (Bates et al., 2015), mixed linear multivariate regression models were applied to investigate the relationship between mean ratings on the different levels of plant species richness and the included sociocultural background variables while accounting for the nested sample structure. The nested structure was defined by the five cities (variable *City*, see Table S2), which were allowed to randomly differ regarding their regression intercepts. All sociocultural background variables entered in the regression equation for the mixed linear regression analyses are explained in detail in Table S2: *Frequency of use*, *Role of nature*, *Gender*, *Age*, *Personal migrant background*, *Migration history in family*, *Language*, *Education*, *Current work*, *Occupation*, *Expert*, *Marital status*, *Children*, *Gardening*, *Dog walking*, *Nature orientation*, *Health*, and *Chronic illness*. We used design plots to display how the categories' means of the sociocultural background variables vary from the overall mean of valuation ratings. Hereby, those categorical variables are displayed that were significantly related to the valuation ratings in the respective model.

Effect sizes were estimated in terms of (Cohen's) δ for paired mean comparisons, partial η^2 for multiple mean comparisons, conditional R^2 for mixed linear regression models, and McFadden's R^2 for multinomial regression models. Histograms of the error distributions for the linear models are depicted in Fig. S2. Aggregated bar charts depicting frequency distributions for the valuation ratings are displayed in Fig. S3. Despite the skewed distributions of some rating scales, parametric analyses were used for mean comparisons, as they have been found to show robustness against deviations from the normal distribution and higher statistical power than their non-parametric counterparts (e.g., Schmider et al., 2010). Statistical power was computed using G*Power 3 (Faul et al., 2007). All tests had a power of $1 - \beta > 0.95$ for the detection of small effects ($f < 0.1$). When required, significance levels were adjusted by applying the *Bonferroni* correction to a total α-level of 0.05. All tests were run two-tailed, except for the *t*-tests, which were run one-tailed to test for higher mean ratings in higher levels of plant species richness.

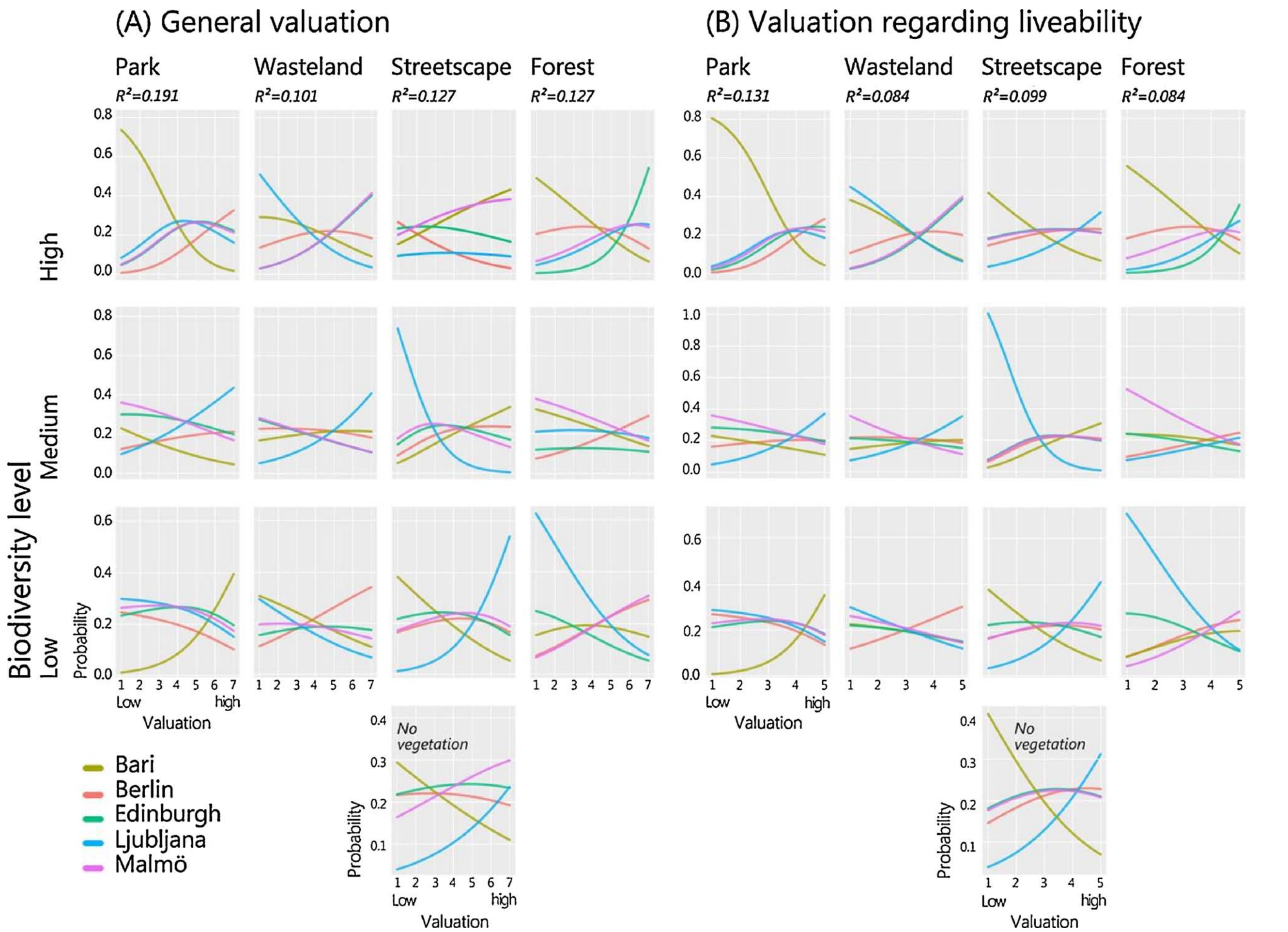

Fig. 3. Probability plots displaying how respondents from each of the five European cities value the three biodiversity levels (plant species richness), based on a Likert scale ranging from a low valuation (1, like *not at all*) to a high valuation (7, like *completely*) for the general valuation (A) and for the valuation regarding liveability (B) ranging from a low valuation (1, contribute *not*) to a high valuation (5, contribute *very*). The probabilities for the low, medium, and high biodiversity levels are depicted separately. For streetscapes, a fourth probability plot displays how respondents valued the no-vegetation scene. R^2 represents McFadden's R^2 of each model, which gives the proportion of variance in the response variable, explained by the background variables. See Table S4 for model fits of the underlying logistic multinomial log-linear regression analyses.

3. Results

First and foremost, our results show that urban residents valued most levels of plant species richness differently, and with positive relationships between plant species richness and valuation (Fig. 2; for details, see Table S3). Hereby, the respondents' preferences increased along with the three biodiversity levels in parks and wastelands, and the most diverse streetscape scene also received the highest mean rating (Fig. 2A). In the streetscape series, all scenes with wild vegetation growing in tree pits around street trees generally received more positive ratings than the scene showing no vegetation around the trees (Fig. 2A). Similar results for the question regarding liveability substantiate these findings (Fig. 2B). In contrast, the medium biodiversity level received the highest ratings in the forest scenes for both general valuation and valuation regarding liveability (Fig. 2).

Valuation ratings for the biodiversity levels differed across the study cities. This is illustrated by the probability plots that show whether the respondents from a city were likely to indicate a low or high valuation for a certain scene (Fig. 3; for details, see Table S4). Each of the figures displays the probability of how people in one of the five cities value each of the biodiversity levels of the respective greenspace type. The colored lines in each figure stand for one of the five cities. The higher these lines are set in a figure (y-axis, displaying probability), the more likely it is that the respondents of the respective city indicated the corresponding valuation rating on the x-axis (displaying low to high valuation). For example, residents of Bari/Italy specifically preferred park scenes with a low biodiversity level over those with a high biodiversity level in contrast to residents of the other four cities (Fig. 3). The olive-green line that represents Bari's respondents shows very low probability for low valuation ratings and high probability for high valuation ratings in the low biodiversity level, meaning that they assigned low biodiversity levels a high value compared to the other cities' residents, and vice versa; the line sharply increases, whereas the lines of the other cities gradually decrease. In contrast, the results for Bari show that for the high biodiversity level in parks the probability is rather high for people that indicated a low valuation, as the olive-green line starts with a probability of more than 0.7 on the y-axis. Within the wasteland series, respondents in Ljubljana/Slovenia disliked the high biodiversity level (blue line), whereas those from Edinburgh/UK and Malmö/Sweden specifically preferred the same biodiversity level (overlapping dark green and purple lines). Overall, Fig. 3 indicates that the valuation of respondents in the five European cities diverges strongly for several biodiversity levels and greenspace types, while it converges and overlaps in others.

The sociocultural background of respondents was related to the valuation ratings, although less than expected (Fig. 4; for details, see Table S5). Among many others, only two sociocultural background variables were consistently, and positively related to the ratings of biodiversity levels across all four greenspace types and both types of valuations: nature orientation (the extent to which respondents

Sociocultural background variables	(A) General valuation				(B) Valuation regarding liveability			
R^2	0.135	0.161	0.294	0.188	0.119	0.182	0.324	0.146
Gender	■	◇	○	▲	□	◆	○	△
Age	□	◇	○	▲	□	◆	○	▲
Marital status	□	◇	○	△	■	◇	○	▲
Children	□	◇	○	△	□	◇	○	▲
Dog walking	□	◆	●	△	■	◆	○	△
Gardening	■	◆	○	▲	□	◆	○	△
Nature orientation	■	◆	●	▲	■	◆	○	▲
Role of nature	■	◇	○	▲	■	◇	○	▲
Frequency of use	■	◆	●	▲	■	◆	●	▲
Expert	□	◇	○	△	■	◆	○	△
Education	■	◇	●	△	□	◇	●	▲
Occupation	□	◆	●	△	■	◆	●	△
Current work	□	◆	●	△	□	◆	●	△
Personal migrant background	□	◇	○	△	■	◆	●	▲
Migration history in family	□	◇	○	△	□	◇	○	△
Language	□	◇	○	△	□	◇	○	△
Health	■	◇	○	△	□	◇	○	△
Chronic illness	□	◇	○	△	□	◇	○	△

□■ Park ◇◆ Wasteland ○● Streetscape △▲ Forest
Black symbols indicate significant relationships

Fig. 4. Valuation of biodiversity levels (plant species richness) in urban greenspaces in relation to different sociocultural backgrounds. The figure summarizes the results of statistical models that related the sociocultural background variables of the respondents to their valuation ratings. Valuation was assessed by (A) the general valuation of a person and (B) the valuation regarding liveability, and in four different greenspace types. Symbols represent the greenspace types park, wasteland, streetscape, and forest. Black symbols indicate significant relationships between valuation and any background variable, as revealed by mixed linear multivariate regression models (Table S5). R^2 represents McFadden's R^2 of each model, which gives the proportion of variance in the response variable, explained by the sociocultural background variables. For details on the sociocultural background variables see Table S2. Details on how each significant categorical background variable and their categories, as revealed by the models, relates to the valuation ratings are provided in Figs. 5, S4 and S5, respectively.

incorporate nature into their daily lives) and frequency of greenspace visits. In addition, the role that nature plays when visiting a public greenspace was consitently (and, again, positively) related to the two greenspace types park and forest. Some background variables were significantly related to valuations of individual types of greenspaces, but without a clear pattern across the greenspace types or the two valuation scales: gender, age, walking a dog regularly, gardening activities, educational background and current occupation. Other background variables did not show any significant relationship with the ratings at all (e.g., variable *Chronic illness*) or did for one valuation question only (e.g., variable *Marital status*).

While Fig. 4 summarizes the findings of the multivariate analyses and gives an overview, which sociocultural background variables are related (or not) to the valuation of biodiversity across the greenspace types, the probability plots go into detail. Fig. 5 depicts those categorical sociocultural background variables that were significantly related to the respondents' valuations of the biodiversity levels in the greenspace type park, both for the general valuation and the valuation regarding liveability (see Figs. S4 and S5 for the other greenspace types). The horizontal lines display the average valuation of the three biodiversity levels by all respondents. The different symbols display the average valuation of different categories within a background variable, e.g., female vs. male within *Gender*, and for the three biodiversity levels (each in a different color). The position of the symbols in relation to the horizontal lines shows how the categories' means for a respective background variable vary from the average valuation by all respondents.

For example, the variable *Frequency of park use* is related to biodiversity valuation in parks, with respondents that often visit parks indicating a higher general valuation for the medium and high biodiversity levels (Fig. 5A). In parallel, these people rated all biodversity levels higher than did people that rarely visit parks when it comes to the valuation regarding liveability (Fig. 5B). Also for the other three greenspace types, frequent park users indicated a higher general valuation (Fig. S4) and a higher valuation regarding liveability (Fig. S5) for all three biodiversity levels. The variable *Gardening activities* related to the general valuation of park biodiversity also, with active gardeners rating the high biodiversity level higher than people that did not garden; vice versa, active gardeners valued the low and medium biodiversity level less than non-gardeners (Fig. 5A). In wastelands and forest, all biodiversity levels were rated higher by active gardeners than by those respondents that did not garden themselves (Fig. S4).

Referring to the world region where respondents were born, the personal migrant background mattered, but only for the valuation regarding liveability and with inconsistent results for greenspace types (variable *Personal migration background*). In other words, migrants from Asia considered a high biodiversity level in parks and forests to contribute less to liveability than average, while they maintained the opposite for streetscapes. Interestingly, the children and grandchildren of migrants valued the scenes similarly to respondents without a migrant history (variable *Migration history in family*).

Apart from the patterns that were revealed by the multivariate analyses, comparing the explained variance of *all* models—that is, those models that helped explain the role of the geographic context and those that incorporated the sociocultural background of the respondents—sheds light on patterns beyond each of the variables tested: The variance explained by the sociocultural background variables, i.e., the fixed covariates (and random effects) in the mixed linear regression

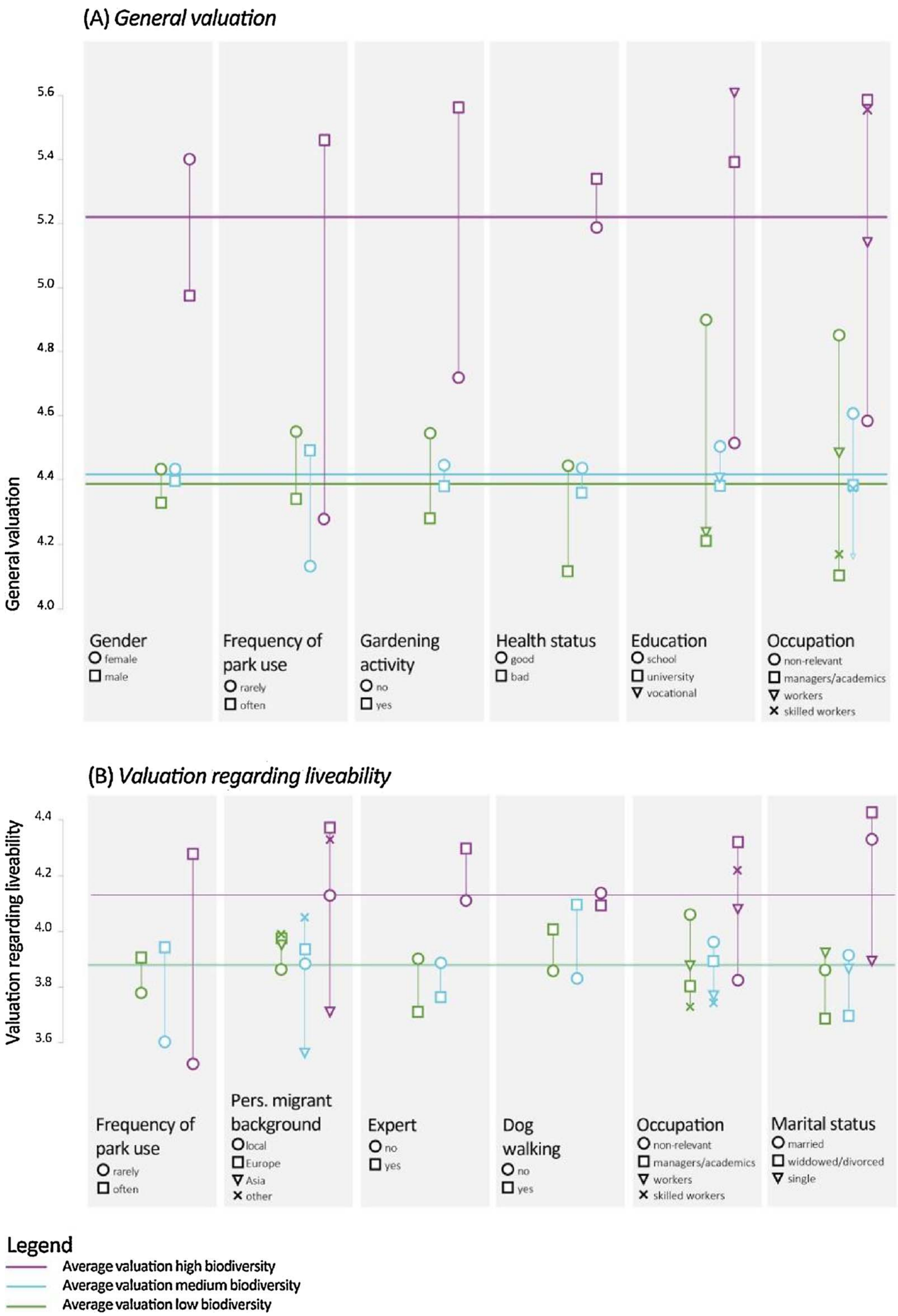

Fig. 5. Valuation of biodiversity levels (plant species richness) in urban parks across sociocultural groups. Design plots show how the categories' means vary from the average for (A) the general valuation and (B) the valuation regarding liveability in the greenspace type park. Different symbols display the average valuation of each category within a variable, e.g., female vs. male, and for the three biodiversity levels (each in a different color). The horizontal lines display the average valuation of the three biodiversity levels, respectively. In (B), the overall mean values for low and medium biodiversity overlap. Only the categorical background variables that were significantly related to the valuation in the multivariate analyses are shown (see Table S5 for model details and Figs. S4 and S5 for other greenspace types).

models was about the same for both general valuation and valuation regarding liveability (see Fig. 4 and Table S5 for values of $R^2_{conditional}$). In contrast, the relationship between a respondent's city and rating in the log-linear model was consistently higher for the general valuation compared to valuation regarding liveability (see Fig. 3 and Table S4 for values of $R^2_{McFadden}$). This indicates that the general valuation rating showed a more distinctive pattern depending on city residency compared to the valuation regarding liveability. The background variables in the mixed linear regression model, on the other hand, shared a comparable amount of variance with both types of ratings across the four greenspaces types. Interestingly, the model including the background variables explained (by far) the largest amount of variance in the ratings for the streetscape, whereas the largest variance shared with city residency was observed for the greenspace type park.

4. Discussion and conclusions

The main insight of this study is the broad support for urban biodiversity in multicultural cities across Europe, despite generally changing relationships with nature and anticipated differences among sociocultural groups (Clayton et al., 2017). Respondents' preferences increased with level of plant species richness in parks and wastelands, and the most diverse streetscape scenes also received the highest mean ratings (Fig. 2). Overall, our results clearly indicate that *biodiverse* greenspaces provide people in cities with an added value in relation to simply *green* spaces. This includes both the general (i.e., personal aesthetic or need-orientated) valuation of biodiversity as well as the valuation regarding the contribution of biodiversity for creating liveable cities. Despite the increasingly evidenced decline in direct human experiences with nature (Soga and Gaston, 2016) biological richness in plant species obviously still matters for urban residents—in a positive way.

The forest scenes differed from the general pattern, likely due to the effects of denser woody structures in the scenes with a high biodiversity level, which may make it difficult to visualize the entire setting (Edwards et al., 2012) and that may relate to feelings of unsafety (e.g., Kuo et al., 1998). Also in studies outside of the context of forests, people indicated to appreciate more those species-rich assemblages that were less complex (Lindemann-Matthies et al., 2010 for species evenness in grasslands, Hofmann et al., 2012 for vegetation structures in wastelands).

Generally positive valuation ratings for all biodiversity levels in the wasteland scenes (Fig. 2) contrast with studies that revealed negative or ambivalent associations with such spaces (e.g., Krekel et al., 2016; Brun et al., 2017). Given that past studies operated at larger spatial scales, signs of neglect such as abandoned built structures and litter may have masked positive biodiversity effects (Nassauer, 1995). By excluding such elements from the photo collages, our approach identified positive valuations for wasteland vegetation. In a similar vein, all scenes with wild vegetation in the streescapes were largely preferred over the unvegetated scene (Fig. 2). These results support policy integration of informal greenspaces (Rupprecht and Byrne, 2014) into urban green systems with benefits for biodiversity conservation, as such greenspaces may be biologically rich (Kowarik, 2011; Bonthoux et al., 2014).

Results of this pan-European field survey advance our understanding of the intersection between people and biodiversity in cities as previous studies conducted at the biodiversity level of species richness showed ambigious results, were generelly scarce, rarely included different greenspace types, and often only touched upon the sociocultural background of the people (Botzat et al., 2016). Differently, this transnational study used comparable biodiversity measures in four ubiquitous greenspace types and included people that are ususally understudied such as people with migration history.

4.1. Geography matters

Urban residents differed in how they valued specific scenes (Fig. 3), making it clear that the geographic and cultural contexts matter in biodiversity valuation. This finding provides new insight at the continental scale, since up to now cross-country studies on urban nature valuation have been very scarce (Botzat et al., 2016). Few studies refer to valuation at the level of different greenspace types (e.g., Rupprecht et al., 2015). Similarly, benefits to self-estimated wellbeing were traced back to different greenspace use and climatic conditions of the study regions (Lafortezza et al., 2009). On the contrary, in our cross-country field survey we set a focus on biodiversity at the species scale and used standardized material of the greenspace photo collages while still reflecting local conditions (Fig. 1). In this way, we were able to disclose possible differences in valuations among cities that were more independent from local settings. The revealed differences may thus indicate attitudes towards biodiversity (Ives and Kendal, 2014) that differ at an international scale.

Such variation may also be related to respondents' familiarity with the specific greenspace type that was shown in the photo collages, an important factor in environmental valuation (Gustafson, 2001). All greenspace types exist in each city, but certain types are more common in some cities than in others. For example, meadow-like grasslands are less common in parks in Bari than elsewhere—and Bari was the city where people were likely to prefer the scene with low plant species richness over the scene with high plant species richness (Fig. 3). This finding is in line with the results obtained in North America, where participants in one study city were more familiar with the local vegetation type than those of another city, where different vegetation types dominate the local landscapes (Loder, 2014). Moreover, attitudes to wilderness are inextricably linked to social values and beliefs that vary within and among societies (Kirchhoff and Vicenzotti, 2014), and may thus affect the valuation of wasteland vegetation in the study cities. Efforts towards a demand-oriented inclusion of urban wilderness in greenspace planning, e.g., by incorporating wastelands in the urban geen infrastrucutre, may thus help reconnect people with nature (Kowarik, 2017). By revealing varying patterns among cities, our study implies that planning approaches would benefit from a better understanding of urban wilderness as a socio-ecological system.

4.2. Culture matters

In general, our findings illustrate public support for biodiverse greenspaces, with some variation between greenspace types and certain sociocultural groups (Fig. 4). Our study demonstrates on a broad basis that urban dwellers value urban plant species richness more when they have stronger ties to nature, in keeping with some prior local studies (Lindemann-Matthies and Bose, 2007; Shwartz et al., 2013). Ties to nature can arise from experiences of wild nature during childhood (Wells and Lekies, 2006; Colléony et al., 2017), but it is mainly private gardens and yards where children experience nature today (Hand et al., 2017). A related notion is the important role that the “luxury effect,” might play; i.e., urban areas with higher family incomes have been shown to have higher levels of plant diversity (Hope et al., 2003). This implies that people may experience different levels of diversity depending on their economic status. In fact, people in wealthier countries were found to have higher environmental concern than people in poorer countries (Franzen and Vogl, 2013). In our study, however, proxies for living standard, such as occupation or education, were not related to the valuation of biodiversity levels in a consistent pattern, indicating a widespread and generally positive valuation of plant species richness in this sector (Table S5).

Besides public greenspaces, gardens are important places for connecting people with nature (Freeman et al., 2012). A person's appreciation of nature can intensify through active gardening which, vice versa, associates to ecological concern and considerations (Clayton, 2007). With our study on biodiversity valuation, we detail this attitude towards nature, as for the high biodiversity level, respondents that gardened value parks, wastelands and forests more than non-gardeners (Figs. 5, S4 and S5). Having intense contact with nature or engaging with “green”, that is, for example, with environmental or ecological topics can also arise from a person's professional background. Previous studies at the ecosystem scale showed that differences exist in how people–green experts vs. lay people–assess urban nature (Hofmann et al., 2012 for wastelands, Qiu et al., 2013 for parks, Todorova et al., 2004 for roadsides), and that landscape and environmental experts perceive lower restorative effects than non-professionals when exposed to nature (Hoyle et al., 2017). Our study determined positive relationships between a person's green expertise and valuation regarding the liveability of cities for parks and wastelands (Figs. 5 and S5). Green experts especially valued wasteland sites at all levels of plant species richness more positively than did non-experts. Based on these results, our study advances existing knowledge in the comparison between expert and non-expert valuation at the biodiversity level of plant species richness.

While most studies on the valuation of natural components in cities have considered sociodemographic background variables such as age and gender (Botzat et al., 2016), our multivariate analyses did not prove consistent patterns across the greenspace types for these basic demographic variables in combination with other sociocultural variables (Fig. 4). For example, we determined a higher valuation of all park scenes in female respondents than in male respondents (Fig. 5). This finding is in line with Hoyle et al. (2017), who found that female visitors benefitted more from walking through urban grasslands—the dominant natural feature in the park scenes of our field survey. Surprisingly, female respondents also valued the medium and high levels of plant species richness in forests higher than did male respondents (Fig. S4). This counters a previous study at the ecosystem scale, which determined that women indicated a lower safety and preference for woodlands and their edges than did men (Jorgensen et al., 2002). However, since Jorgensen et al. did not conduct a multilevel analysis (i.e., including a wealth of sociocultural variables per model, and analysing their interplay), the comparability between their study and ours remains limited. Gender with regard to perceived safety in forests often interconnects to additional factors, such as environmental settings (e.g., isolation of a place), and may relate to traditional role models (Jansson et al., 2013).

Our field survey also sheds light on dog walkers as a sociocultural group that may have different views on greenspaces, as dog walking was found to increase outdoor physical activity, the feeling of safety or social contacts (Dalton et al., 2016; Knight and Edwards, 2008). Dog walking related only to the valuation of biodiversity in wastelands, with generally lower preference for these sites than people who did not regularly walk a dog (Figs. S4 and S5). This is especially interesting as studies on wastelands found dog walking to be a prominent activity in these places (e.g., Rall and Haase, 2011). Yet, previous studies did rarely specify the vegetation context that starkly differs among wastelands (Bonthoux et al., 2014).

Given the expected changes in the character of future societies (UN, 2015), studies that help predict how increasingly multicultural societies may assess biodiversity within the urban green are necessary for successful future greenspace development. Some rare studies on urban biodiversty valuation at the ecosystem level introduce respondents' migration histories in the sample description (Botzat et al., 2016), without directly including them in statistical analyses. Above the species level, studies demonstrated differences in landscape preferences between people with migration background and native Dutch people (Buijs et al., 2009), and illustrated that personal life context and migration history relate to a person's forest perception (Jay and Schraml, 2009). A recent valuation study (Lindemann-Matthies, 2017) at the species level indicated that people from a wide range of nationalities differed in what plant combination they preferred in experimental grassland arrays, with a lower variation in responses among people with a migration background than those without a migration background. In this regard, our results show a distinct pattern: in all greenspace types, people with a personal migration background differed in their valuation regarding liveability from respondents without a migration background (Fig. 4). While our study design did not allow for causal inferences, our findings suggest that differences in how plant species richness is valued between people with and without a migrant background may gradually decrease with time. Valuation differs significantly for those who were migrants themselves (first-generation migrants), but not for the children and grandchildren of these groups (Table S5). At the same time, our results illustrate that it is especially people who migrated from countries outside Europe that differ in their valuation. Therefore, our investigation emphasizes that studies including migration-specific characteristics of respondents should consider various factors, such as the temporal and geographic aspects of a persons' migration history.

By linking the valuation of urban biodiversity to the geographic context *and* the sociocultural background of respondents, our results imply that a high proportion of variance in peoples' valuation can be explained by such characteristics; hence, both geography and culture matter (Figs. 3 and 4). In particular, the variation in the valuation of park scenes was explained by the geographic background of respondents (Fig. 3; 19% explained model variance). This finding indicates that within cities people prefer similar park settings, but between cities park valuation differs greatly. At the same time, the valuations of the streetscape scenes were highly correlated with the sociocultural background variables (Fig. 4; 32% explained model variance), indicating that preferences for streetscapes, in particular, depend on the sociocultural background and point to a similar pattern at the transnational scale.

4.3. *Towards biodiverse cities as shared environments*

Insights from this survey support urban conservation policies and encourage further steps towards developing future cities as shared environments for people with divergent roots and sociocultural backgrounds, as well as for other living organisms. Greenspace management may hereby act as a key component in fostering biodiversity (Aronson et al., 2017) and, with a diversification of the urban landscape may counteract the extinction of nature experiences in cities (Colléony et al., 2017). A first step is to enhance the incorporation of informal green elements in urban development plans. Wild vegetation in wastelands as well as biodiverse vegetation growing in tree pits around street trees generally received positive ratings. Given the omnipresence of tree pits in cities worldwide, the small added effects of these microsites would supplement the various functions of traditional green in streetscapes (Honold et al., 2016; Säumel et al., 2016). A second step forward is to plan for both human wellbeing and biodiversity conservation, usually separate objectives that can play in concert. Because differences in valuing specific types of urban greenspaces exist among cities, policies on biodiverse urban development need to account for geographic differences. Yet, the prevailing positive valuations of high plant species richness in this pan-European study indicate opportunities to increase urban plant species richness without compromising the aesthetic perceptions of different sociocultural groups while simultaneously improving human wellbeing. This is an important insight in times when urban societies are becoming increasingly multicultural. Arguing for biodiverse greenspaces and biodiversity-friendly management from a social perspective would thus help to counteract declines in human–nature interactions and support biodiversity conservation, both of which are vital challenges in a rapidly urbanizing world (Shwartz et al., 2014).

Conflicts of interest

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.gloenvcha.2018.02.001.

References

Aronson, M.F.J., Lepczyk, C.A., Evans, K.L., Goddard, M.A., Lerman, S.B., MacIvor, J.S., Nilon, C.H., Vargo, T., 2017. Biodiversity in the city: key challenges for urban green space management. Front. Ecol. Environ. 15, 189–196. http://dx.doi.org/10.1002/

fee.1480.
Bates, D., Mächler, M., Bolker, B., Walker, S., 2015. Fitting linear mixed-effects models using lme4. J. Stat. Softw. 67, 1–48. http://dx.doi.org/10.18637/jss.v067.i01.
Bonthoux, S., Brun, M., Di Pietro, F., Greulich, S., Bouché-Pillon, S., 2014. How can wastelands promote biodiversity in cities? A review. Landsc. Urban Plan. 132, 79–88. http://dx.doi.org/10.1016/j.landurbplan.2014.08.010.
Botzat, A., Fischer, L.K., Kowarik, I., 2016. Unexploited opportunities in understanding liveable and biodiverse cities. A review on urban biodiversity perception and valuation. Glob. Environ. Change 39, 220–233. http://dx.doi.org/10.1016/j.gloenvcha.2016.04.008.
Brun, M., Di Pietro, F., Bonthoux, S., 2017. Residents' perceptions and valuations of urban wastelands are influenced by vegetation structure. Urban For. Urban Green. http://dx.doi.org/10.1016/j.ufug.2017.01.005.
Buijs, A.E., Elands, B.H.M., Langers, F., 2009. No wilderness for immigrants: cultural differences in images of nature and landscape preferences. Landsc. Urban Plan. 91, 113–123. http://dx.doi.org/10.1016/j.landurbplan.2008.12.003.
Carrus, G., Scopelliti, M., Lafortezza, R., Colangelo, G., Ferrini, F., Salbitano, F., Agrimi, M., Portoghesi, L., Semenzato, P., Sanesi, G., 2015. Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. Landsc. Urban Plan. 134, 221–228. http://dx.doi.org/10.1016/j.landurbplan.2014.10.022.
Clayton, S., Colléony, A., Conversy, P., Maclouf, E., Martin, L., Torres, A.-C., Truong, M.-X., Prévot, A.-C., 2017. Transformation of experience: toward a new relationship with nature. Conserv. Lett. 10, 645–651. http://dx.doi.org/10.1111/conl.12337.
Clayton, S., 2007. Domesticated nature: motivations for gardening and perceptions of environmental impact. J. Environ. Psychol. 27, 215–224. http://dx.doi.org/10.1016/j.jenvp.2007.06.001.
Colléony, A., Prévot, A.-C., Saint Jalme, M., Clayton, S., 2017. What kind of landscape management can counteract the extinction of experience? Landsc. Urban Plan. 159, 23–31. http://dx.doi.org/10.1016/j.landurbplan.2016.11.010.
Dallimer, M., Irvine, K.N., Skinner, A.M.J., Davies, Z.G., Rouquette, J.R., Maltby, L.L., Warren, P.H., Armsworth, P.R., Gaston, K.J., 2012. Biodiversity and the feel-good factor: understanding associations between self-reported human well-being and species richness. Bioscience 62, 47–55. http://dx.doi.org/10.1525/bio.2012.62.1.9.
Dalton, A.M., Wareham, N., Griffin, S., Jones, A.P., 2016. Neighbourhood greenspace is associated with a slower decline in physical activity in older adults: a prospective cohort study. SSM Popul. Health 2, 683–691. http://dx.doi.org/10.1016/j.ssmph.2016.09.006.
Dickinson, D.C., Hobbs, R.J., 2017. Cultural ecosystem services: characteristics, challenges and lessons for urban green space research. Ecosyst. Serv. 25, 179–194. http://dx.doi.org/10.1016/j.ecoser.2017.04.014.
Edwards, D., Jay, M., Jensen, F.S., Lucas, B., Marzano, M., Montagné, C., Peace, A., Weiss, G., 2012. Public preferences for structural attributes of forests: towards a pan-European perspective. For. Policy Econ. 19, 12–19. http://dx.doi.org/10.1016/j.forpol.2011.07.006.
European Social Survey, 2012. Round 6. Available from http://www.europeansocialsurvey.org/. (Accessed 26 January 2017).
Faul, F., Erdfelder, E., Lang, A.G., Buchner, A., 2007. G* Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav. Res. Methods 39, 175–191. http://dx.doi.org/10.3758/BF03193146.
Fischer, L.K., Kowarik, I., Botzat, A., Honold, J., Haase, D., Kabisch, N., GREEN SURGE, 2015. Interaction of Biological and Cultural Diversity of Urban Green Spaces (Publication D2.2, EU). Available from http://greensurge.eu/working-packages/wp2/D2.2_20151226.pdf. (Accessed 26 January 2017).
Fischer, L.K., Honold, J., Botzat, A., Brinkmeyer, D., Cvejić, R., Delshammar, T., Elands, B., Haase, D., Kabisch, N., Karle, S.J., Lafortezza, R., Nastran, M., Nielsen, A.B., van der Jagt, A.P., Vierikko, K., Kowarik, I., 2018. Recreational ecosystem services in European cities: sociocultural and geographic context matters for park use. Ecosyst. Serv. http://dx.doi.org/10.1016/j.ecoser.2018.01.015. (accepted).
Franzen, A., Vogl, D., 2013. Two decades of measuring environmental attitudes: a comparative analysis of 33 countries. Glob. Environ. Change 23, 1001–1008. http://dx.doi.org/10.1016/j.gloenvcha.2013.03.009.
Freeman, C., Dickinson, K.J.M., Porter, S., van Heezik, Y., 2012. My garden is an expression of me: exploring householders' relationships with their gardens. J. Environ. Psychol. 32, 135–143. http://dx.doi.org/10.1016/j.jenvp.2012.01.005.
Fuller, R.A., Irvine, K.N., Devine-Wright, P., Warren, P.H., Gaston, K.J., 2007. Psychological benefits of greenspace increase with biodiversity. Biol. Lett. 3, 390–394. http://dx.doi.org/10.1098/rsbl.2007.0149.
Güneralp, B., Seto, K.C., 2013. Futures of global urban expansion: uncertainties and implications for biodiversity conservation. Environ. Res. Lett. 8, 014025. http://dx.doi.org/10.1088/1748-9326/8/1/014025.
Gobster, P.H., Westphal, L.M., 2004. The human dimensions of urban greenways: planning for recreation and related experiences. Landsc. Urban Plan. 68, 147–165. http://dx.doi.org/10.1016/S0169-2046(03)00162-2.
Gustafson, P., 2001. Meanings of place: everyday experience and theoretical conceptualizations. J. Environ. Psychol. 21, 5–16. http://dx.doi.org/10.1006/jevp.2000.0185.
Haaland, C., Konijnendijk van den Bosch, C., 2015. Challenges and strategies for urban green-space planning in cities undergoing densification: a review. Urban For. Urban Green. 14, 760–771. http://dx.doi.org/10.1016/j.ufug.2015.07.009.
Hagerhall, C.M., Purcell, T., Taylor, R., 2004. Fractal dimension of landscape silhouette outlines as a predictor of landscape preference. J. Environ. Psychol. 24, 247–255. http://dx.doi.org/10.1016/j.jenvp.2003.12.004.
Hambleton, R.K., 2005. Issues, designs, and technical guidelines for adapting tests into multiple languages and cultures. In: Hambleton, R.K., Merenda, P.F., Spielberger, C.D. (Eds.), Adapting Educational and Psychological Tests for Cross-Cultural Assessment. Lawrence Erlbaum, Mahwah, NJ, pp. 3–38.
Han, K.T., 2007. Responses to six major terrestrial biomes in terms of scenic beauty, preference, and restorativeness. Environ. Behav. 39, 529–556. http://dx.doi.org/10.1177/0013916506292016.
Hand, K.L., Freeman, C., Seddon, P.J., Recio, M.R., Stein, A., van Heezik, Y., 2017. The importance of urban gardens in supporting children's biophilia. Proc. Natl. Acad. Sci. U. S. A. 114, 274–279. http://dx.doi.org/10.1073/pnas.1609588114.
Hartig, T., Kahn, P.H., 2016. Living in cities, naturally. Science 352, 938–940. http://dx.doi.org/10.1126/science.aaf3759.
Heink, U., Kowarik, I., 2010. What criteria should be used to select biodiversity indicators? Biodivers. Conserv. 19, 3769–3797. http://dx.doi.org/10.1007/s10531-010-9926-6.
Hofmann, M., Westermann, J.R., Kowarik, I., van der Meer, E., 2012. Perceptions of parks and urban derelict land by landscape planners and residents. Urban For. Urban Green. 11, 303–312. http://dx.doi.org/10.1016/j.ufug.2012.04.001.
Honold, J., Lakes, T., Beyer, R., van der Meer, E., 2016. Restoration in urban spaces: nature views from home, greenways, and public parks. Environ. Behav. 48, 796–825. http://dx.doi.org/10.1177/0013916514568556.
Hope, D., Gries, C., Zhu, W., Fagan, W.F., Redman, C.L., Grimm, N.B., Nelson, A.L., Martin, C., Kinzig, A., 2003. Socioeconomics drive urban plant diversity. Proc. Natl. Acad. Sci. U. S. A. 100, 8788–8792. http://dx.doi.org/10.1073/pnas.1537557100.
Hoyle, H., Hitchmough, J., Jorgensen, A., 2017. All about the 'wow factor'? The relationships between aesthetics, restorative effect and perceived biodiversity in designed urban planting. Landsc. Urban Plan. 164, 109–123. http://dx.doi.org/10.1016/j.landurbplan.2017.03.011.
Hull, R.B., Stewart, W.P., 1992. Validity of photo-based scenic beauty judgements. J. Environ. Psychol. 12, 101–114. http://dx.doi.org/10.1016/S0272-4944(05)80063-5.
International Test Commission, ITC, 2005. ITC Guidelines for Translating and Adapting Tests. Available from https://www.intestcom.org/files/guideline_test_adaptation.pdf. (Accessed 26 January 2017).
Ives, C.D., Kendal, D., 2014. The role of social values in the management of ecological systems. J. Environ. Manag. 144, 67–72. http://dx.doi.org/10.1016/j.jenvman.2014.05.013.
Jansson, M., Fors, H., Lindgren, T., Wiström, B., 2013. Perceived personal safety in relation to urban woodland vegetation – a review. Urban For. Urban Green. 12, 127–133. http://dx.doi.org/10.1016/j.ufug.2013.01.005.
Jay, M., Schraml, U., 2009. Understanding the role of urban forests for migrants – uses, perception and integrative potential. Urban For. Urban Green. 8, 283–294. http://dx.doi.org/10.1016/j.ufug.2009.07.003.
Johansson, M., Gyllin, M., Witzell, J., Kuller, M., 2014. Does biological quality matter? Direct and reflected appraisal of biodiversity in temperate deciduous broad-leaf forest. Urban For. Urban Green. 13, 28–37. http://dx.doi.org/10.1016/j.ufug.2013.10.009.
Jorgensen, A., Gobster, P.H., 2010. Shades of green: measuring the ecology of urban green space in the context of human health and well-being. Nat. Cult. 5, 338–363. http://dx.doi.org/10.3167/nc.2010.050307.
Jorgensen, A., Hitchmough, J., Calvert, T., 2002. Woodland spaces and edges: their impact on perception of safety and preference. Landsc. Urban Plan. 60, 135–150. http://dx.doi.org/10.1016/S0169-2046(02)00052-X.
Kaplan, R., Kaplan, S., Brown, T., 1989. Environmental preference: a comparison of four domains of predictors. Environ. Behav. 21, 509–530. http://dx.doi.org/10.1177/0013916589215001.
Kaplan, R., 2007. Employees' reactions to nearby nature at their workplace: the wild and the tame. Landsc. Urban Plan. 82, 17–24. http://dx.doi.org/10.1016/j.landurbplan.2007.01.012.
Kasada, M., Matsuba, M., Miyashita, T., 2017. Human interest meets biodiversity hotspots: a new systematic approach for urban ecosystem conservation. PLoS One 12, e0172670. http://dx.doi.org/10.1371/journal.pone.0172670.
Kirchhoff, T., Vicenzotti, V., 2014. A historical and systematic survey of European perceptions of wilderness. Environ. Value 23, 443–464. http://dx.doi.org/10.3197/096327114X13947900181590.
Knight, S., Edwards, V., 2008. In the company of wolves: the physical, social, and psychological benefits of dog ownership. J. Aging Health 20, 437–455. http://dx.doi.org/10.1177/0898264308315875.
Kowarik, I., 2011. Novel urban ecosystems, biodiversity, and conservation. Environ. Pollut. 159, 1974–1983. http://dx.doi.org/10.1016/j.envpol.2011.02.022.
Kowarik, I., 2017. Urban wilderness: supply, demand, and access. Urban For. Urban Green. http://dx.doi.org/10.1016/j.ufug.2017.05.017.
Krekel, C., Kolbe, J., Wüstemann, H., 2016. The greener, the happier? The effect of urban land use on residential well-being. Ecol. Econ. 121, 117–127. http://dx.doi.org/10.1016/j.ecolecon.2015.11.005.
Kuo, F.E., Bacaicoa, M., Sullivan, W.C., 1998. Transforming inner-city landscapes: trees, sense of safety, and preference. Environ. Behav. 30, 28–59. http://dx.doi.org/10.1177/0013916598301002.
Lafortezza, R., Carrus, G., Sanesi, G., Davies, C., 2009. Benefits and well-being perceived by people visiting green spaces in periods of heat stress. Urban For. Urban Green. 8, 97–108. http://dx.doi.org/10.1016/j.ufug.2009.02.003.
Latimer, D.A., Henry Hogo, H., Daniel, T.C., 1981. The effects of atmospheric optical conditions on perceived scenic beauty. Atmos. Environ. 15, 1865–1874. http://dx.doi.org/10.1016/0004-6981(81)90222-5.
Lin, B.B., Fuller, R.A., 2013. Sharing or sparing? How should we grow the world's cities? J. Appl. Ecol. 50, 1161–1168. http://dx.doi.org/10.1111/1365-2664.12118.
Lindemann-Matthies, P., Bose, E., 2007. Species richness, structural diversity and species composition in meadows created by visitors of a botanical garden in Switzerland. Landsc. Urban Plan. 79, 298–307. http://dx.doi.org/10.1016/j.landurbplan.2006.03.007.

Lindemann-Matthies, P., Marty, T., 2013. Does ecological gardening increase species richness and aesthetic quality of a garden? Biol. Conserv. 159, 37–44. http://dx.doi.org/10.1016/j.biocon.2012.12.011.

Lindemann-Matthies, P., Junge, X., Matthies, D., 2010. The influence of plant diversity on people's perception and aesthetic appreciation of grassland vegetation. Biol. Conserv. 143, 195–202. http://dx.doi.org/10.1016/j.biocon.2009.10.003.

Lindemann-Matthies, P., 2017. Perception of plant species richness by people with different nationalities—an experimental study. Landsc. Res. 42, 482–497. http://dx.doi.org/10.1080/01426397.2017.1305343.

Loder, A., 2014. 'There's a meadow outside my workplace': a phenomenological exploration of aesthetics and green roofs in Chicago and Toronto. Landsc. Urban Plan. 126, 94–106. http://dx.doi.org/10.1016/j.landurbplan.2014.01.008.

MacKerron, G., Mourato, S., 2013. Happiness is greater in natural environments. Glob. Environ. Change 23, 992–1000. http://dx.doi.org/10.1016/j.gloenvcha.2013.03.010.

Mathey, J., Arndt, T., Banse, J., Rink, D., 2017. Public perception of spontaneous vegetation on brownfields in urban areas. Results from surveys in Dresden and Leipzig (Germany). Urban For. Urban Green. http://dx.doi.org/10.1016/j.ufug.2016.10.007.

McKinney, M.L., 2002. Urbanization, biodiversity, and conservation. Bioscience 52, 883–890. http://dx.doi.org/10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2.

Nassauer, J.I., 1995. Messy ecosystems, orderly frames. Landsc. J. 14, 161–170. http://dx.doi.org/10.3368/lj.14.2.161.

Nielsen, A.B., van den Bosch, M., Sreetheran, M., Konijnendijk van den Bosch, C., 2014. Species richness in urban parks and its drivers: a review of empirical evidence. Urban Ecosyst. 17, 305–327. http://dx.doi.org/10.1007/s11252-013-0316-1.

Patsfall, M.R., Feimer, N.R., Buhyoff, G.J., Wellman, J.D., 1984. The prediction of scenic beauty from landscape content and composition. J. Environ. Psychol. 4, 7–26. http://dx.doi.org/10.1016/S0272-4944(84)80016-X.

Pearman, P.B., Weber, D., 2007. Common species determine richness patterns in biodiversity indicator taxa. Biol. Conserv. 138, 109–119. http://dx.doi.org/10.1016/j.biocon.2007.04.005.

Pett, T.J., Shwartz, A., Irvine, K.N., Dallimer, M., Davies, Z.G., 2016. Unpacking the people-biodiversity paradox: a conceptual framework. Bioscience 66, 576–583. http://dx.doi.org/10.1093/biosci/biw036.

Pickett, S.T.A., Buckley, G.L., Kaushal, S.S., Williams, Y., 2011. Social-ecological science in the humane metropolis. Urban Ecosyst. 14, 319–339. http://dx.doi.org/10.1007/s11252-011-0166-7.

Qiu, L., Lindberg, S., Nielsen, A.B., 2013. Is biodiversity attractive?—On-site perception of recreational and biodiversity values in urban green space. Landsc. Urban Plan. 119, 136–146. http://dx.doi.org/10.1016/j.landurbplan.2013.07.007.

R Core Team, 2016. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.

Rall, E.L., Haase, D., 2011. Creative intervention in a dynamic city: a sustainability assessment of an interim use strategy for brownfields in Leipzig, Germany. Landsc. Urban Plan. 100, 189–201.

Ripley, B., Venables, W., Ripley, M.B., 2016. Package 'nnet' (R Package Version 7-3). Available from https://cran.r-project.org/web/packages/nnet/nnet.pdf. (Accessed 26 January 2017).

Rissman, A.R., Gillon, S., 2017. Where are ecology and biodiversity in social–ecological systems research? A review of research methods and applied recommendations. Conserv. Lett. 10, 86–93. http://dx.doi.org/10.1111/conl.12250.

Rohrmann, B., 2007. Verbal qualifiers for rating scales: sociolinguistic considerations and psychometric data. Project Report. University of Melbourne. Available from http://www.rohrmannresearch.net/pdfs/rohrmann-vqs-report.pdf. (Accessed 26 January 2017).

Rupprecht, C.D.D., Byrne, J.A., 2014. Informal urban greenspace: a typology and trilingual systematic review of its role for urban residents and trends in the literature. Urban For. Urban Green. 13, 597–611. http://dx.doi.org/10.1016/j.ufug.2014.09.002.

Rupprecht, C.D., Byrne, J.A., Ueda, H., Lo, A.Y., 2015. 'It's real, not fake like a park': residents' perception and use of informal urban green-space in Brisbane, Australia and Sapporo, Japan. Landsc. Urban Plan. 143, 205–218. http://dx.doi.org/10.1016/j.landurbplan.2015.07.003.

Säumel, I., Weber, F., Kowarik, I., 2016. Toward livable and healthy urban streets: roadside vegetation provides ecosystem services where people live and move. Environ. Sci. Policy 62, 24–33. http://dx.doi.org/10.1016/j.envsci.2015.11.012.

Scannell, L., Gifford, R., 2010. Defining place attachment: a tripartite organizing framework. J. Environ. Psychol. 30, 1–10. http://dx.doi.org/10.1016/j.jenvp.2009.09.006.

Schmider, E., Ziegler, M., Danay, E., Beyer, L., Bühner, M., 2010. Is it really robust? Methodology-Eur. 6, 147–151. http://dx.doi.org/10.1027/1614-2241/a000016.

Shanahan, D.F., Lin, B.B., Bush, R., Gaston, K.J., Dean, J.H., Barber, E., Fuller, R.A., 2015. Toward improved public health outcomes from urban nature. Am. J. Public Health 105, 470–477. http://dx.doi.org/10.2105/AJPH.2014.302324.

Shwartz, A., Cheval, H., Simon, L., Julliard, R., 2013. Virtual garden computer program for use in exploring the elements of biodiversity people want in cities. Conserv. Biol. 27, 876–886. http://dx.doi.org/10.1111/cobi.12057.

Shwartz, A., Turbé, A., Julliard, R., Simon, L., Prévot, A.-C., 2014. Outstanding challenges for urban conservation research and action. Glob. Environ. Change 28, 39–49. http://dx.doi.org/10.1016/j.gloenvcha.2014.06.002.

Soga, M., Gaston, K.J., 2016. Extinction of experience: the loss of human–nature interactions. Front. Ecol. Environ. 14, 94–101. http://dx.doi.org/10.1002/fee.1225.

Todorova, A., Asakawa, S., Aikoh, T., 2004. Preferences for and attitudes towards street flowers and trees in Sapporo, Japan. Landsc. Urban Plan. 69, 403–416. http://dx.doi.org/10.1016/j.landurbplan.2003.11.001.

United Nations, Department of Economic and Social Affairs, Population Division, UN, 2015. World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. (Publication ESA/P/WP.241). Available from https://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf. (Accessed 26 January 2017).

Ulrich, R.S., 1981. Natural versus urban scenes–some psychophysiological effects. Environ. Behav. 13, 523–556. http://dx.doi.org/10.1177/0013916581135001.

Ulrich, R.S., 1986. Human response to vegetation and landscapes. Landsc. Urban Plan. 13, 29–44. http://dx.doi.org/10.1016/0169-2046(86)90005-8.

van der Jagt, A.P.N., Craig, T., Anable, J., Brewer, M.J., Pearson, D.G., 2014. Unearthing the picturesque: the validity of the preference matrix as a measure of landscape aesthetics. Landsc. Urban Plan. 124, 1–13. http://dx.doi.org/10.1016/j.landurbplan.2013.12.006.

van de Vijver, F.J.R., Hambleton, R.K., 1996. Translating tests: some practical guidelines. Eur. Psychol. 1, 89–99. http://dx.doi.org/10.1027/1016-9040.1.2.89.

van Dillen, S.M., de Vries, S., Groenewegen, P., Spreeuwenberg, P., 2011. Greenspace in urban neighbourhoods and residents' health: adding quality to quantity. J. Epidemiol. Commun. Health 66, e8. http://dx.doi.org/10.1136/jech.2009.104695.

Vierikko, K., Elands, B., Niemelä, J., Andersson, E., Buijs, A., Fischer, L.K., Haase, D., Kabisch, N., Kowarik, I., Luz, A.C., Száraz, L., van der Jagt, A.P., Konijnendijk van den Bosch, C., 2016. Considering the ways biocultural diversity helps enforce the urban green infrastructure in times of urban transformation. Curr. Opin. Environ. Sustain. 22, 7–12. http://dx.doi.org/10.1016/j.cosust.2017.02.006.

Weber, F., Kowarik, I., Säumel, I., 2014. A walk on the wild side: perceptions of roadside vegetation beyond trees. Urban For. Urban Green. 13, 205–212. http://dx.doi.org/10.1016/j.ufug.2013.10.010.

Wells, N.M., Lekies, K.S., 2006. Nature and the life course: pathways from childhood nature experiences to adult environmentalism. Child. Youth Environ. 16, 1–24. http://dx.doi.org/10.7721/chilyoutenvi.16.1.0001.