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Mapping the social values for ecosystem services in urban green spaces: Integrating a visitor-employed photography method into SolVES

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ABSTRACT

Urban green spaces are among the relatively few places to connect with nature in cities and represent locations where city dwellers can experience a variety of critical ecosystem services. As urbanization increases, deepening our understanding of the connections between city dwellers and the natural environment has become critical. In this study, we investigated the social values for ecosystem services by demonstrating an approach that combines a visitor-employed photography (VEP) method with the Social Values for Ecosystem Services (SolVES) mapping tool and applying this method to an urban wetland park. As a result, a quantified value index (VI) informs managers of the type and extent of urban ecosystem services (UESs) acknowledged by the public. Social values for each UES and environmental variable are delineated in a quantitative and spatially explicit manner. These outcomes could help planners and managers target specific areas in need of construction or improvement. Notably, public perceptions in this study are derived from photographs taken by invited park visitors. Real-time and on-site visiting experiences tend to be more effective and robust than recalling points of interest after visiting and manually marking them on maps via questionnaires. All the data used in this study are likely available in other green spaces. This approach can be generally extended to UES assessments elsewhere.

1. Introduction

Currently, approximately 54% of the worldwide population lives in urban areas and this percentage is anticipated to rise in future decades (United Nations, 2011). In cities, the few places to experience nature are urban green spaces (Maller et al., 2002; Dallimer et al., 2014; Dickinson and Hobbs, 2017), which provide a variety of ecosystem services, such as provisioning, regulating, and cultural services (Green et al., 2016). These services are critical for supporting urban inhabitation sustainability and for enriching human life with meaning and emotion (Chiesura, 2004; Wolch et al., 2014; Gosal et al., 2018). In response, urban green spaces are expanding even faster than the population in recent decades (Fuller and Gaston, 2009; Seto et al., 2012; Chang et al., 2017). Because communities continue to invest efforts in delivering urban ecosystem services (UESs) to the city environment, assessing the social values of UES could potentially facilitate the success of future urban green space design, maintenance and enhancement as well as cities and human populations.

Human interactions with UESs can provide guidelines and practical advice on urban design and management actions (Ives et al., 2017), however, this knowledge remains poorly understood and implemented in practice (Graca et al., 2018). Although the use of urban green spaces is public dominated, their design is generally explicitly performed by experts (Plieninger et al., 2013; Kabisch et al., 2015), which may introduce a potential mismatch between designer's intention and user's perceptions (Plieninger et al., 2015; Larson et al., 2016; Daniels et al., 2018). Urban designers need to understand the extent to which the public associates UESs with different landscape characteristics as well as the factors underlying the association. However, the perceptions of UESs are site-specific and susceptible to change based on the combination and characteristics of landscape elements (Ives et al., 2017; Graca et al., 2018), such as landforms, land covers, designed attractions, and facilities. This subtle and fragile relationship increases the difficulty of assessing and quantifying the social values of UES. Moreover, the human perception of the environment is subjective and differs from person to person (Tyrväinen et al., 2007; Brown, 2008;

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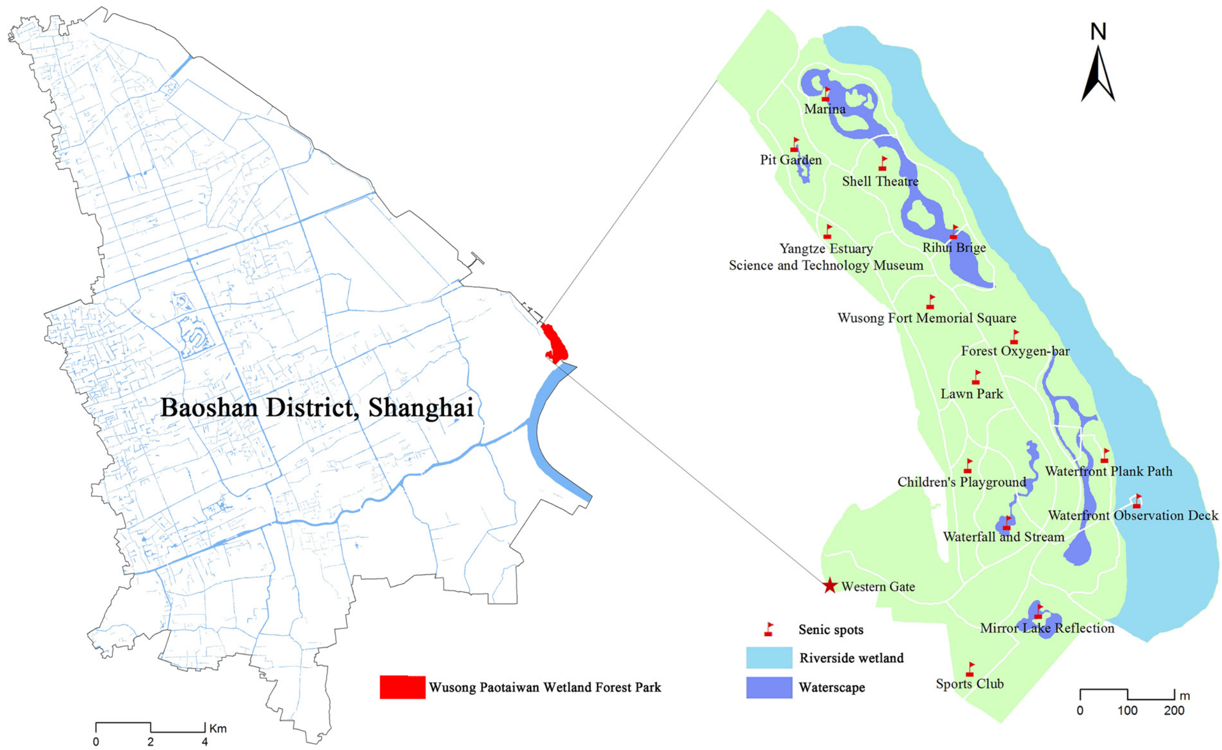


Fig. 1. Map showing the location and attractions of the study area.

Langemeyer et al., 2015), thus making the assessment even more challenging. Local green spaces, such as urban parks, operate as small-scale nodes in larger networks of urban green spaces and serve as hubs for environmental and civic engagement in cities (Langemeyer et al., 2018). However, large differences are observed among urban green spaces at the local scale, which requires an adaptive, flexible and innovative valuing process.

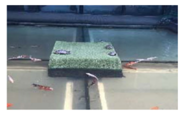
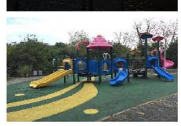
The methods of perceiving and valuing ecosystem functions are undergoing great change, mapping UESs is becoming a key tool for guiding decision-making (Martínez-Harms and Balvanera, 2012; Pietrzyk-Kaszynska et al., 2017; Graca et al., 2018). The mapped perceptions enable the localization of the most highly valued ecosystems in a landscape and allow for the identification of critical focal areas for UES management (Plieninger et al., 2013). In response to the need for incorporating quantified and spatially explicit measures of social values into ecosystem service assessment, Social Values for Ecosystem Services (SolVES, http://solves.cr.usgs.gov) was developed by the United States Geological Survey (USGS) in 2011 (Sherrouse et al., 2011). Since then, the SolVES model was successfully implemented to map social values for ecosystem services of national parks (van Riper et al., 2012, 2017), island (van Riper et al., 2012), national forests (Sherrouse et al., 2014; Bagstad et al., 2016, 2017, Sherrouse et al., 2017), and watersheds (Shoyama and Yamagata, 2016; Lin et al., 2017), etc.

Currently, most mapping data are collected by guiding people to locate values on paper maps (Tyrväinen et al., 2007; Plieninger et al., 2013; Ives et al., 2017) or digital maps (Pietrzyk-Kaszynska et al., 2017) through questionnaires. As to the SolVES model, mail survey represents the dominant use for landscape perception collection. Although questionnaire has broad coverage, concerns were raised about its intuitiveness and effectiveness in capturing visitors' experience given its off-site and/or non-real-time nature (Chenoweth, 1984; Sugimoto, 2013; Dickinson and Hobbs, 2017). Comparatively, there is an increasing awareness that the use of photographs could vividly portray the participants' opinions and perspectives on their experiences (Balomenou and Garrod, 2014). The visitor-employed photography method (VEP), which invites volunteers to photograph their liked and/or disliked scenes and then captures the visitors' landscape attitudes by deriving their intentions behind the photographs, was designed for capturing visitors' on-site and real-time perception while visiting. This method was developed by Cherem and Traweek in the 1970s (Cherem and Traweek, 1977) and has since been successfully used for urban parks (Taylor et al., 1995; Sugimoto, 2011, 2013), urban forest (Oku and Fukamachi, 2006; Heyman, 2012), landscape architecture (Chenoweth, 1984), water environments (Cherem and Traweek, 1977), etc.

The current main devices for VEP are digital cameras in conjunction with Global Positioning System (GPS) loggers (Sugimoto, 2011, 2013) or just digital cameras (Heyman, 2012; Balomenou and Garrod, 2014). The considerable impact that smartphones have had on the modern society, especially through the integration of camera, GPS navigation, in-app map and compass, making this device a promising tool for acquiring public perception on ecosystem services. Introducing smartphones as an alternative to the prevalent VEP devices has several advantages. First, smartphones connect with extended tools and platforms easier than digital cameras, the rapid development of the functions and apps could potentially bring innovation and creativity to research activities. Second, using smartphone is convenient, in this highly connected world, people already tend to carry smartphones around, moreover, the automated shooting mode requires far less technical skill than digital cameras. Third, the cost of carrying VEP investigations using smartphones tends to be lower than using digital cameras, with the "globalization" of the mobile phones, the vast majority of the world's population has access to a smartphone. The lower cost could potentially make the VEP method a much more accessible research tool than earlier efforts. The increasing acceptance of smartphones as the main photo-taking device of VEP method has been confirmed by researchers (e.g., Gye (2007), Prideaux and Coghlan (2010), and Lyu (2016)) and this trend is unlikely to change in the near future (Prideaux et al., 2018).

Considering the aforementioned knowledge gaps and advancements in research and technology, this study demonstrates an approach that combines a VEP method and SolVES mapping tool to investigate a wetland park in Shanghai, China. The objectives of this study are to (i)

Table 1
Ten predefined landscape types.

Landscape	Description	Example
Landform	Platforms, steps, lawns, squares, etc.	
Vegetation	Trees, flowers, shrubs, etc.	
Animal	Birds, fishes, butterflies, crabs, etc.	
Waterscape	Fountains, lakes, wetlands, etc.	
Structure	Pavilions, buildings, bridges, etc.	
Art installation	Sculptures, rockeries, etc.	
Service facility	Benches, lamps, garbage cans, etc.	
Pedestrian system	Footpaths, forest trails, wooden trestles, etc.	
Athletic facility	Basketball courts, tracks, etc.	
Recreational activity	Children facilities, picnics, dances, etc.	

assess, quantify and map the heterogeneous social values of UES by linking visitors' instant perception with landscape elements; and (ii) identify places that could be targeted through design, planning and management of urban green spaces to enhance UESs.

2. Methods

2.1. Study area

We conducted our study in the Wusong Paotaiwan Wetland (WPW) Park, Shanghai, China (Fig. 1), where the Yangtze and Huangpu rivers converge. The park covers a total area of about 106.6 ha, and 60% (approximately 63.6 ha) is pristine wetland. Wetlands benefit human beings in a variety of ways, including regulating services, biodiversity support, provisioning, and cultural services (Zedler and Kercher, 2005; Clarkson et al., 2013; Wang et al., 2014). The diverse benefits make wetlands suitable places for visitors to seek the social values of multiple UESs.

To improve the regional ecological environment and restore a harmonious relationship between human and nature, the Shanghai Government determined to reconstruct this area from a steel slag backfill and iron sandpit to a national wetland park. After six years of construction, this park opened to the public in October 2011 and has gained increasing popularity among tourists. Currently, the park is a place of natural charm and many artificial attractions, including the Yangtze River mudflats, manmade gardens, parkland and visitor attractions, the Shanghai Yangtze River Estuary Science and Technology Museum, children's amusement park, a commemorative square, a dock, and a gym. As a multifunctional park, this park serves as a combined location for recreation, sightseeing, amusement, and education.

2.2. Survey data

In this paper, we introduce the use of VEP as a method of acquiring data for mapping ecosystem services. To this end, we employed an Apple iPhone with the iSO application Map Plus. The Map Plus application is a powerful and versatile tool for viewing and editing maps, surveying, editing or managing geography or travel data. Its integration of camera, GPS navigation, in-app map, compass, note-taking and clock making it more powerful than the use of digital camera and GPS. The iPhone camera could guarantee qualified photos of the scenes; GPS could record the photo-taking locations and track the path; and the in-app map and compass can lead the participants with self-guided tours. Information and instructions on the Map Plus application can be found at http://duweis.com/en/mapplus.html. Currently, this application is freely available from the Apple App Store.

The experiment was conducted on November 7, November 22 and December 4, 2015. Thirty-two graduate students in their 20 s and early 30 s from the East China Normal University were recruited to conduct the experiment. Thirty-two is a reasonable sample size for implementing the VEP method given the area of our study site; similar sample sizes have been utilized in previous studies (Dorwart et al., 2007; Dandy and Van Der Wal, 2011; Sugimoto, 2011; Qiu et al., 2013; Sugimoto, 2013, 2017). Before the experiment, all participants received detailed instructions on using the Map Plus software and were reminded to fully charge their iPhones and leave enough storage space for new photographs. The participants then walked around the park taking pictures of "anything with a positive effect on their experience in the WPW Park". We did not limit the number of photographs because it is more natural for visitors to freely react to the stimulus (Sugimoto, 2013). After the experiment, all the valid photographs were collected from the participants. If multiple photographs targeted the same object, the participant was asked to include the one that had been taken first. Moreover, if a photograph was taken by mistake, the participant was asked to exclude it. In total, we collected 1212 photographs, and each participant took an average of 38 photographs (23–83 photographs per person). The procedures for data collection were adapted from previous studies that used digital cameras with GPS loggers (Sugimoto, 2011, 2013).

The next fundamental step is the photograph content analysis. Assessments of assigned landscape values are effective for sustainable landscape management (Kenter et al., 2015; Plieninger et al., 2015). A post-experience survey was administered after the visitation. For each photograph, the photographer was asked to (i) identify the main landscape among the predefined categories (Table 1), the largest area ratio was used when overlapping categories within a photograph caused confusion to subject elicitation, and (ii) allocate a hypothetical 100 score to seven social value types: aesthetic, educational, recreation, historic, biodiversity, life sustaining, and therapeutic values. The explanations for the seven social value types are listed in Table 2. These social values are among the most widely investigated by researchers (e.g., Clement and Cheng (2011), van Riper et al. (2012), Sherrouse et al. (2014), Bagstad et al. (2016), Lin et al. (2017) and van Riper et al. (2017)).

Table 2
Descriptions of the seven social value types employed in this study (adapted from Clement and Cheng (2011)).

Social value type	Description
Aesthetic	I value this scene because I enjoy the scenery, sight, sound, smell, etc.
Educational	I value this scene because I can learn about the environment through scientific observation or experimentation.
Recreation	I value this scene because it provides recreation activities.
Historic	I value this scene because it has natural and/or human history that matters to me, others or the nation.
Biodiversity	I value this scene because it provides plants and/or animals.
Life sustaining	I value this scene because it helps produce, preserve, clean, and renew air, soil, and water.
Therapeutic	I value this scene because it makes me feel better, physically and/or mentally.

2.3. Mapping tool

To calculate and map the social values of ecosystem services, the SolVES model was adopted. The main capabilities of the SolVES are its ability to: (i) generate spatially explicit maps with a 10-point VI (ranging from 1 to 10, indicating perceived social values of stakeholders); (ii) model the relationship between social values and landscape metrics (Sherrouse et al., 2011, 2014); and (iii) transfer value models from areas with primary survey data to areas lacking data (Sherrouse and Semmens 2014). The SolVES model requires various geospatial and tabular data to be imported into an ArcGIS geodatabase. In this study, the main data used to develop this model include a value allocation table, a survey point layer and three environmental metric layers. The value allocation table stores numeric values allocated to the seven social-value types of interest for each photograph. The survey point layer (n = 3098) stores the social value types that participants identified from each photograph, each point was spatially associated with the location where the photograph was taken and represents one social value type. The value allocation table and the survey point layer related to each other using a unique identifier for each individual photograph and social value type. The three landscape metrics representing the natural resource conditions were distance to roads (DTR, the horizontal distance to the nearest road), distance to water (DTW, the horizontal distance to the nearest lake, pond, spring or waterfall) and distance to the coastline (DTC, the horizontal distance to the coastline). The DTR and DTW measures are commonly adopted by researchers (e.g., van Riper et al., 2012; Bagstad et al., 2017; Sherrouse et al., 2017), while we specifically designed the DTC metric. The WPW Park is located at the convergence of the Yangtze River and Huangpu River and extends for 2250 m along the coastline. This area enjoys particularly favorable natural conditions that motivated the establishment and design of this park. Using the DTC metric, we intended to assess the effectiveness of the coastline design and how it affects the visitors' perceptions. These layers were estimated with the Euclidian Distance tool included in the ArcGIS Spatial Analyst Tools.

3. Results

3.1. Subjects, social values and locations of the photographs

Statistics of landscape subjects from the 1212 photographs are shown in Fig. 2. Waterscape and vegetation were the most frequently photographed landscapes, 283 (23.33%) and 249 (20.52%), respectively. Followed by the pedestrian system, structure, art installation, and landforms. While service facility, athletic facility, recreational activity, and animal were among the least photographed landscape types.

The allocated score of social values for each photograph are as shown in Table 3, the mean value along with the minimum, maximum and standard deviation is presented. Respondents unanimously assigned "0″ to the historic value of animal, athletic facility and recreational activity, the therapeutic value of animal, and the educational value of athletic facility. Nonetheless, varying scores, in some extreme cases range from "0″ to "100″ (e.g., aesthetic value of landform, pedestrian system, structure, vegetation and waterscape), were assigned to a same social value type and landscape category from different photographs.

Fig. 3 represents a density map showing the locations where participants took photographs. A grid with 10 × 10 m cells was adopted to delineate the density information. As shown, the maximum density is 21 photographs in one grid cell. The photographed hotspots were mainly taken along the road network and at attractions, such as the Pit Garden, Wusong Fort Memorial Square, Waterfront Bridge, Riverside Viewing Platform, Waterfall, and Stream.

3.2. Model validation

The goodness of fit of the SolVES model was calculated by the area under the curve (AUC) statistics (Table 4). AUC values above 0.70 are considered potentially useful models (Swets, 1988). Accordingly, all the UES types were suitable for our study area and qualified as potential models for further analysis.

To select meaningful UESs for mapping, the UES types with large value index maximum (M-VI), small R-ratio and large negative Z-score were kept. M-VI is the maximum index calculated for a specific UES type. A Higher M-VI indicates stronger preferences among the survey groups. R-ratio values less than 1 and large negative Z-scores identify statistically significant clustering point patterns (Brown et al., 2002). According to these three indicators together, the importance ranking of the seven UES types in descending order was aesthetic, recreation, biodiversity, life sustaining, historic, therapeutic and educational. Although all the UES models were statistically significant, we excluded the service types of historic, therapeutic and educational given their low ranking.

3.3. Quantification and mapping of UES

The VI map (Fig. 4) compares the magnitude of the values across the different UES types and exhibits the spatial distribution of social values for each UES. Different levels of perception could be clearly observed among the four investigated UES types. The M-VI was 10 for aesthetic value and 5 for the others. Additional warm colors (high-VI) are shown for aesthetic service compared with the remaining three types. These evidence indicated that aesthetic service was the most valued UES by the participants.

As to the spatial distribution of these UES types, high VI mainly appeared along the road network and surrounded some main attractions. A number of well-designed attractions, such as the Pit Garden, Lake Sightseeing Bridge, Waterfall and Stream, Riverside Viewing Platform and Lake, scored highly for the social values of aesthetic, recreation and biodiversity. While the life sustaining value mainly clustered in locations along the coastline and around some attractions, such as the Lake Sightseeing Bridge, Waterfront Bridge, and Riverside Viewing Platform.

The VI can also measure the responses of the UES to the associated environmental variables. Fig. 5 shows the relationship among the four interested UES types and the three selected environmental variables (i.e., DTR, DTW, and DTC). All the UES models exhibited a general decreasing trend as the DTR increased (Fig. 5a). Similarly, the VI

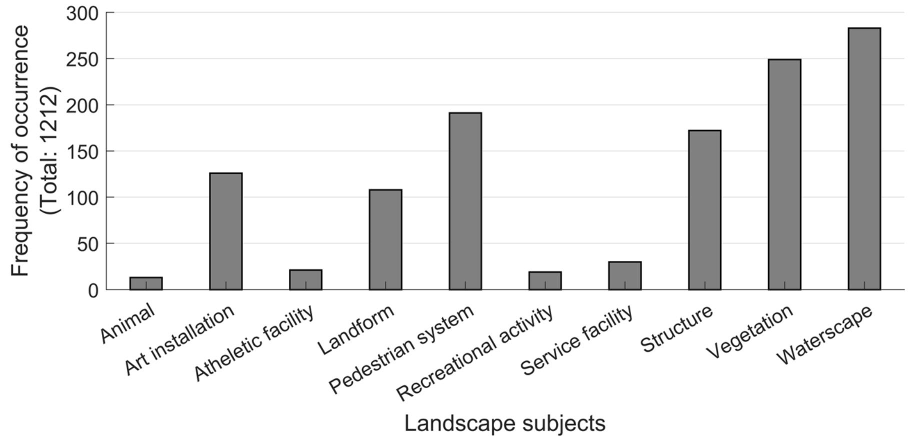


Fig. 2. Landscape subjects in the photographs.

decreased in general with the increase of DTW, albeit with fluctuations (Fig. 5b). However, the DTC showed a more complicated correspondence because its VI jumped between extremely high and low values when the distance went beyond 70 m (Fig. 5c).

4. Discussion

4.1. Reflections on urban park design

Several perspectives are derived from our approach to assessing the social values of UES. The photographed landscapes in the wetland park were assigned multiple UESs with varying scores, and this suggests that visitors respond to landscapes in complex ways and experience nature for different purposes. Similar findings have been found in other studies (e.g., Plieninger et al., 2013; Larson et al., 2016; Ives et al., 2017). The photo-taking process encompasses both cognitive and affective dimensions that weave together a variety of landscape attributes into an overall impression. Urban designers and planners are encouraged to associate heterogeneity with landscapes in urban green spaces and consider green spaces as a 'portfolio of places' (Swanwick, 2009). The mental construct of a landscape is composed of a compilation of impressions, beliefs and expectations, formed by information processed from a variety of sources over time and space (MacKay and Couldwell, 2004). Visitors' interpretations of landscape images can be used to integrate visitor-perceived social values with destination-promoted social values in a meaningful way.

The quantified VI shows the importance that visitors assigned to the investigated UES. The WPW Park is successful in aesthetic design, which strongly satisfies the park visitors. This finding is consistent with studies that indicate aesthetic value was the most obvious benefit served by urban green spaces (Chen et al., 2009; James et al., 2009; Pietrzyk-Kaszynska et al., 2017), and the most frequently assigned ecosystem service in green spaces (Tyrväinen et al., 2007). In addition,

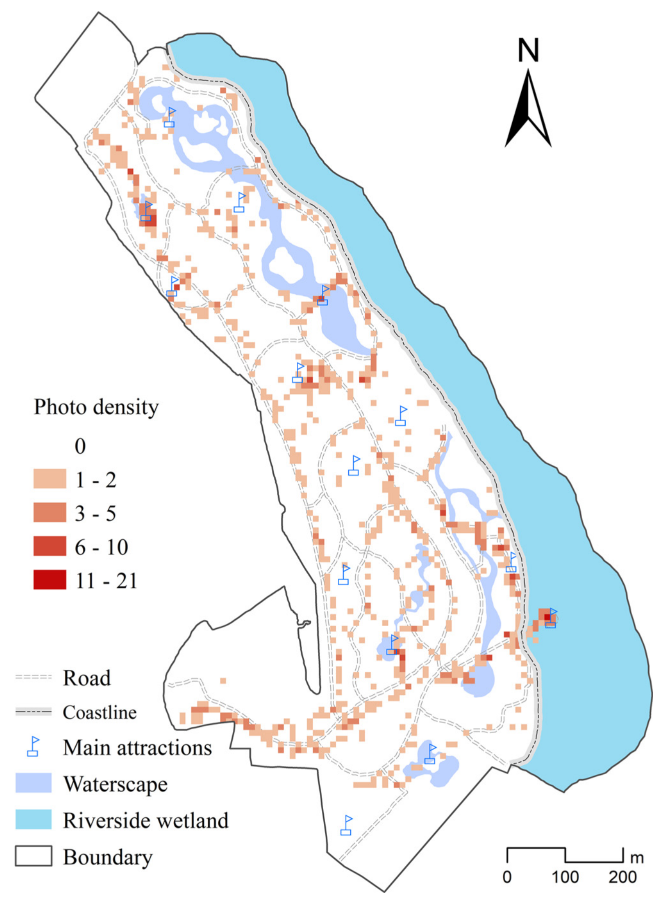


Fig. 3. Density map showing the visitors' photograph-taking locations.

Table 3
Allocated score to social values for landscapes, the statistics are mean (minimum, maximum, standard deviation).

	Aesthetic	Life sustaining	Historic	Biodiversity	Educational	Recreation	Therapeutic
Animal	37 (0, 90, 36)	32 (0, 60, 24)	0 (0, 0, 0)	18 (0, 50, 19)	3 (0, 40, 11)	10 (0, 30, 11)	0 (0, 0, 0)
Art installation	39 (0, 90, 26)	1 (0, 40, 6)	34 (0, 90, 32)	0 (0, 40, 4)	15 (0, 90, 22)	11 (0, 60, 16)	0 (0, 20, 3)
Athletic facility	11 (0, 50, 16)	8 (0, 40, 14)	0 (0, 0, 0)	1 (0, 20, 4)	0 (0, 0, 0)	23 (0, 70, 20)	57 (30, 100, 19)
Landform	36 (0, 100, 27)	5 (0, 60, 12)	11 (0, 80, 22)	8 (0, 70, 16)	4 (0, 100, 13)	20 (0, 80, 22)	15 (0, 80, 23)
Pedestrian system	28 (0, 100, 23)	6 (0, 60, 12)	1 (0, 50, 6)	12 (0, 70, 18)	1 (0, 80, 6)	12 (0, 80, 17)	40 (0, 100, 27)
Recreational activity	13 (0, 50, 17)	13 (0, 50, 18)	0 (0, 0, 0)	3 (0, 20, 7)	3 (0, 30, 9)	48 (0, 80, 24)	19 (0, 80, 24)
Service facility	22 (0, 70, 24)	4 (0, 30, 10)	3 (0, 80, 14)	6 (0, 50, 13)	30 (0, 100, 39)	18 (0, 80, 26)	16 (0, 60, 23)
Structure	42 (0, 100, 28)	5 (0, 70, 13)	9 (0, 80, 18)	3 (0, 50, 9)	14 (0, 100, 26)	16 (0, 80, 19)	12 (0, 90, 21)
Vegetation	39 (0, 100, 26)	20 (0, 100, 22)	1 (0, 50, 5)	24 (0, 100, 21)	2 (0, 60, 8)	9 (0, 80, 16)	5 (0, 60, 12)
Waterscape	39 (0, 100, 28)	24 (0, 80, 22)	2 (0, 50, 8)	19 (0, 80, 19)	1 (0, 50, 7)	12 (0, 100, 18)	2 (0, 70, 9)

Table 4
Performance of the established SolVES model for the seven UES types.

Social value type	Performance indicators				
	AUC	Sample size	R-ratio	Z-score	M-VI
Aesthetic	0.78	957	0.44	−32.94	10
Educational	0.8	150	0.44	−13.22	2
Recreation	0.78	521	0.48	−22.68	5
Historic	0.83	179	0.45	−14.19	4
Biodiversity	0.81	482	0.46	−22.75	5
Life sustaining	0.81	459	0.46	−22.14	5
Therapeutic	0.78	349	0.53	−16.94	3

the recreation, biodiversity, and life sustaining values were all perceived by the participants. In particular, people's attitudes towards biodiversity and life sustaining services are strongly related to vegetation cover (Dallimer et al., 2012). Vegetation cover influences the microclimate through evapotranspiration, shading, air purification, heat exchange, etc. and these benefits rely on the structure and composition of the vegetation arrangement (Graca et al., 2018). Thus, to enhance the delivery of biodiversity and life sustaining services, the vegetation structure and composition of urban green spaces must be acknowledged and improved.

However, the WPW Park also revealed an overall poor performance in delivering historic and educational values. These cultural services may be the most valuable contributions that urban green spaces have to offer (Chiesura, 2004; Gobster et al., 2007; Martín-López et al., 2012). Indeed, the WPW Park is enriched with history dating back to the Qing Dynasty, cultural reconstruction was an important highlight in the park's planning documents. Despite the construction of cultural spots, such as the Yangtze Estuary Science and Technology Museum and the Wusong Fort Memorial Square, additional efforts should be focused on manifesting these distinguished characteristics. Thus, the WPW Park represents a case in which the designers' intention failed the public's perception. Indeed, this mirrors a common failure of public space design in China. Oftentimes, visual appeal is stressed and uniform aesthetic rules are adopted in park construction throughout the country, making many parks look similar. We argue that parks should be not only visually appealing but also designed to enhance their multifunctionality.

Geographic factors influence the strength and diversity of social values (Ives et al., 2017). The mapped VIs were varied and responsive to the distance away from the selected environmental metrics (Fig. 5a–c). High recognition of social values surrounded the road and waterscapes, which magnified the importance of the road network and waterscape attractions. In China, most of the off-road areas in public green spaces are forbidden from entrance. The road network is the veins of the park, and a successful road network could maximize the activity area of visitors and enhance the visiting experience by mitigating overcrowding. The mapped values indicate that the road design in WPW Park is successful. Indeed, the roads in this park are well distributed, well connected and beautiful. In regards to the water, places closer to water bodies were more strongly preferred than places farther away, and this result is consistent with findings by Swanwick (2009) and Plieninger et al. (2013). People's affinity for water could be explained by an enhancement of the perceived orderliness and naturalness of the scene (Kaplan and Kaplan, 1989). Evidence also shows that the context influence people's perception for waterscapes (Herzog, 1985), and the varying extent of preference around the many waterscapes in this park provides evidence to this theory. The coastline was also found to function well in UES delivery, especially the life sustaining service, although its low altitude makes it susceptible to visual blocking.

4.2. Advantages and limitations of method

The importance of assessing and quantifying multiple UESs has been widely recognized, although this knowledge remains poorly implemented in urban design and management practices (Graca et al., 2018). This low implementation is partly the result of insufficient spatial detail at finer scales to provide practical guidance. This study presents a quantitative and spatially explicit approach that is useful for evaluating the social values of UES. In practice, mapped UES provisioning explicitly target areas for improvement.

To assess the accuracy and demonstrate the superiority of our new method of spatial data collection for the SolVES model, we discuss the similarities and differences between this study and Wang et al. (2016). Wang et al. (2016) was a previous effort of our team in adopting SolVES in the same WPW Park with similar research tasks, which involved 257 respondents in the questionnaire survey process. The majority of the findings are identical. Both studies identified high recognition of the social values were surrounded the road, waterscapes and some well-designed attractions, the perceived social values decreased with the increase in DTR and DTW. The similarities between these two studies confirm the validity of the method used in this study. Nonetheless, two major discrepancies should be noted. First, we find a significant difference in the perceived importance of different UES types compared with Wang et al. (2016). As previously stated, in urban green spaces, the public value the aesthetic service more than any other UESs (Tyrväinen et al., 2007; Chen et al., 2009; James et al., 2009; Pietrzyk-Kaszynska et al., 2017). This discrepancy arises from the spatial data collection process because visitors were asked to assign 1–4 social value points for each UES to cover all the UES types (Wang et al., 2016). This intervention could considerably impair the perceived importance

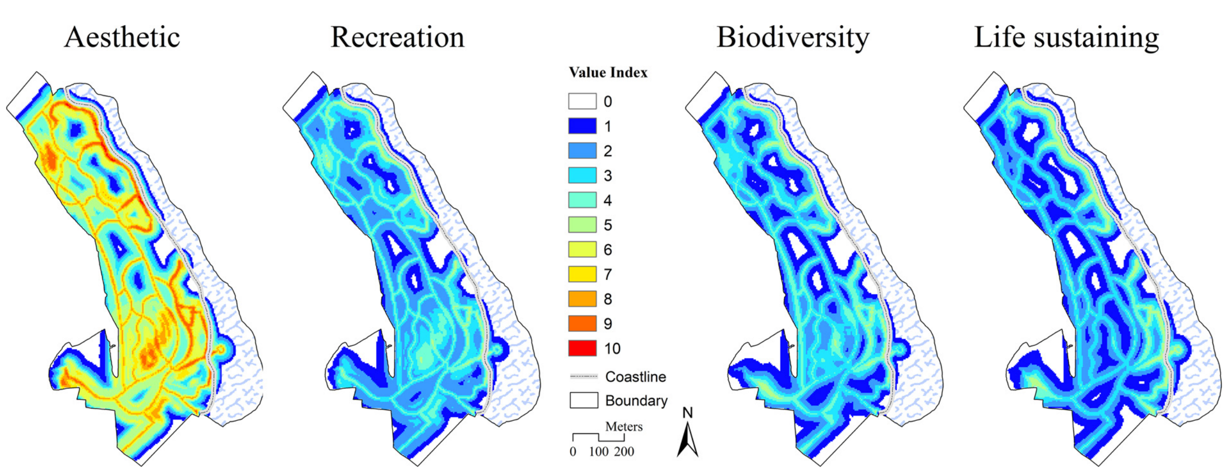


Fig. 4. Map showing the distribution of the social values: aesthetic, recreation, biodiversity, and life sustaining values.

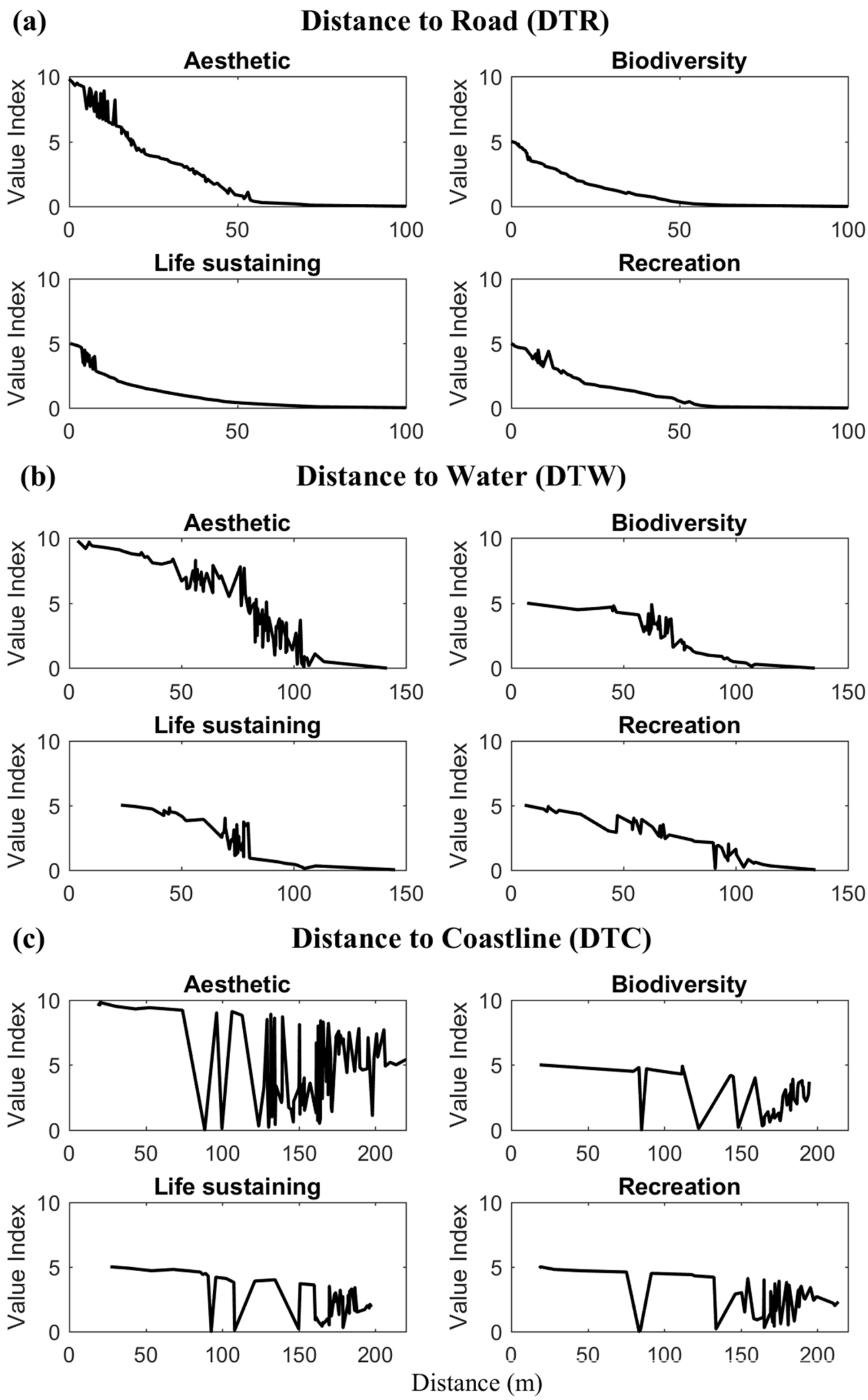


Fig. 5. Relationships among the landscape metrics (DTR, DTW, and DTC) and UES types (aesthetic, biodiversity, life sustaining, and recreation) characterized by the VI scores.

ranking of different UES types. The second discrepancy is that the mapped social perception in this study is more spatially continuous compared with that of Wang et al. (2016). The lack of spatial continuity is likely related to the method of data collection because the visitors' memories of the experience may be vague, and only the most impressed scenes tend to be preserved. In contrast, the VEP method captures the visitors' impressions and preserves their perceptions at a wider spatial range and longer time span. This study extends the data acquisition strategy for the SolVES model and thus could potentially increase the flexibility and versatility of this mapping tool. The same procedure can be applied to any other urban green spaces worldwide to aid in the improvement of the data collection process for SolVES model.

We argue that incorporating photographs in mapping public perception is more robust, reliable, instant and intuitive compared with traditional questionnaires. The use of photographs could more effectively document the participants' real-time opinions and impressions of their on-site experience than recalling points of interest after visiting and manually mark them on maps via questionnaires. In addition, individual survey respondents may interpret survey instructions differently, compromises may need to be made to account for different styles in the process of digitizing hand-mark points into a geographic data layer, which could potentially impair the accuracy of interpreted location. However, the readers should be well-informed that both data extraction and result interpretation for the SolVES model differ slightly between the use of questionnaires and photographs. On the one hand, in the process of data extraction, each photograph should be treated as one independent survey sample, and all the social value types with non-zero scores assigned for the photograph overlap each other in the photo-taking location. This result in a wider coverage of the destination by the increased number of social value points, and hence a more comprehensive spatial evaluation of the investigated destination. On the other hand, in the process of data interpretation, the photo-taking location is not where the ecosystem service actually generated but rather the Preferred Viewing Spot (PVS). The PVS is defined as a small area where visitors are inclined to stand, that provides a vantage point for sightseeing and photography (Sugimoto, 2017). This mismatch could potentially affect the mapped distribution of social values. However using smartphones as the photo-taking device tend to mitigate this impact, because smartphones do not have optics zoom lens. In this study, most of the photographs taken by the invited participants were near-sighted image (generally within 6 m), therefore it is suitable to use photo-taking locations for mapping social values.

Nevertheless, our investigation presented certain limitations that should be recognized. First, the VEP method is resource intensive, therefore, we include a relatively narrow age span and similar education level in the participant group. Studies show that individual factors, such as age, knowledge, and values, affect landscape perception (Gobster et al., 2007). For example, our participants did not include children and the elderly and their perspectives may differ from that of young adults. Children and the elderly are susceptible to environmental injustice (Shen et al., 2017), and with the increasing awareness of the environmental inequality of urban green spaces, including children and the elderly in the investigation has implications for educational opportunities and human wellbeing. Thus, including a larger age span and more diverse backgrounds is of considerable value. This shortage may be improved in a subsequent analysis. Second, in consideration of the functionality of this park, we only considered several UES types, mostly cultural services. Although these services are the most relevant in our case, including more comprehensive UES types is a potential area where improvements can be made in future studies.

5. Conclusions

This study assessed, quantified and mapped social values of the UES for the WPW Park, a national wetland park located in Shanghai, China. We captured visitors' instant perceptions of UESs via photographs with the help of the iSO application "Map Plus". We derived the quantified and spatial explicit social values using the SolVES tool. The integration of the VEP method extends the data acquisition approaches available for the SolVES model, which could potentially increase the flexibility and versatility of this tool. Overall, WPW Park is successful in building its aesthetic value and conveys evident biodiversity, life sustaining and recreation values. However, the rich history and educational merits of this park were largely overlooked by the visitors and need to be strengthened in future design to avoid a disconnect between the services defined by the planner and appreciated by the general public. Moreover, this study demonstrated that human perception plays an important role in UES utilization and evaluation. Social values of UES could serve as useful information for urban designers and landscape architects to enhance the performance of green spaces.

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References

Bagstad, K.J., Reed, J.M., Semmens, D.J., Sherrouse, B.C., Troy, A., 2016. Linking biophysical models and public preferences for ecosystem service assessments: a case study for the Southern Rocky Mountains. Reg. Environ. Change 16 (7), 2005–2018. https://doi.org/10.1007/s10113-015-0756-7.
Bagstad, K.J., Semmens, D.J., Ancona, Z.H., Sherrouse, B.C., 2017. Evaluating alternative methods for biophysical and cultural ecosystem services hotspot mapping in natural resource planning. Landsc. Ecol. 32 (1), 77–97. https://doi.org/10.1007/s10980-016-0430-6.
Balomenou, N., Garrod, B., 2014. Using volunteer-employed photography to inform tourism planning decisions: a study of St David's Peninsula, Wales. Tour. Manag. 44, 126–139. https://doi.org/10.1016/j.tourman.2014.02.015.
Brown, G., 2008. A theory of urban park geography. J. Leis. Res. 40 (4), 589–607. https://doi.org/10.1080/00222216.2008.11950154.
Brown, G., Reed, P., Harris, C., 2002. Testing a place-based theory for environmental evaluation: an Alaska case study. Appl. Geogr. 22 (1), 49–76. https://doi.org/10.1016/s0143-6228(01)00019-4.
Chang, J., et al., 2017. Assessing the ecosystem services provided by urban green spaces along urban center-edge gradients. Sci. Rep. 7 (1), 11226. https://doi.org/10.1038/s41598-017-11559-5.
Chen, B., Adimo, O.A., Bao, Z., 2009. Assessment of aesthetic quality and multiple functions of urban green space from the users' perspective: the case of Hangzhou Flower Garden, China. Landsc. Urban Plann. 93 (1), 76–82. https://doi.org/10.1016/j.landurbplan.2009.06.001.
Chenoweth, R., 1984. Visitor employed photography: a potential tool for landscape architecture. Landsc. J. 3 (2), 136–143. https://doi.org/10.3368/lj.3.2.136.
Cherem, G.J., Traweek, D.E., 1977. Visitor employed photography: a tool for interpretive planning on river environments. Proceedings River Recreation Management and Research Symposium, USDA Forest Service. General Technical Report 236–244. https://www.cabdirect.org/cabdirect/abstract/19781849866.
Chiesura, A., 2004. The role of urban parks for the sustainable city. Landsc. Urban Plan. 68 (1), 129–138. https://doi.org/10.1016/j.landurbplan.2003.08.003.
Clarkson, B.R., Ausseil, A.-G.E., Gerbeaux, P., 2013. Wetland Ecosystem Services. Ecosystem Services in New Zealand: Conditions and Trends. Manaaki Whenua Press, Lincoln, pp. 192–202. https://www.landcareresearch.co.nz/_data/assets/pdf_file/0020/77042/1_14_Clarkson.pdf.
Clement, J.M., Cheng, A.S., 2011. Using analyses of public value orientations, attitudes and preferences to inform national forest planning in Colorado and Wyoming. Appl. Geogr. 31 (2), 393–400. https://doi.org/10.1016/j.apgeog.2010.10.001.
Dallimer, M., et al., 2014. What personal and environmental factors determine frequency of urban greenspace use? Int. J. Environ. Res. Public Health 11 (8), 7977–7992. https://doi.org/10.3390/ijerph110807977.
Dallimer, M., et al., 2012. Biodiversity and the feel-good factor: understanding associations between self-reported human well-being and species richness. BioScience 62 (1), 47–55. https://doi.org/10.3410/f.13492968.793466289.
Dandy, N., Van Der Wal, R., 2011. Shared appreciation of woodland landscapes by land management professionals and lay people: an exploration through field-based interactive photo-elicitation. Landsc. Urban Plan. 102 (1), 43–53. https://doi.org/10.1016/j.landurbplan.2011.03.008.
Daniels, B., et al., 2018. Assessment of urban green space structures and their quality from a multidimensional perspective. Sci. Total Environ. 615, 1364–1378. https://doi.org/10.1016/j.scitotenv.2017.09.167.
Dickinson, D.C., Hobbs, R.J., 2017. Cultural ecosystem services: characteristics, challenges and lessons for urban green space research. Ecosyst. Serv. 25, 179–194. https://doi.org/10.1016/j.ecoser.2017.04.014.
Dorwart, C.E., Moore, R.L., Leung, Y.-F., 2007. Visitor employed photography: its potential and use in evaluating visitors' perceptions of resource impacts in trail and park settings, In: Burns, R.; Robinson, K., comps. Proceedings of the 2006 Northeastern Recreation Research Symposium; 2006 April 9-11; Bolton Landing, NY. Gen. Tech. Rep. NRS-P-14. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station: 307-315. https://www.fs.usda.gov/treesearch/pubs/12694.
Fuller, R.A., Gaston, K.J., 2009. The scaling of green space coverage in European cities. Biol. Lett. 5 (3), 352–355. https://doi.org/10.1098/rsbl.2009.0010.
Gobster, P.H., Nassauer, J.I., Daniel, T.C., Fry, G., 2007. The shared landscape: what does aesthetics have to do with ecology? Landsc. Ecol. 22 (7), 959–972.
Gosal, A.S., Newton, A.C., Gillingham, P.K., 2018. Comparison of methods for a landscape-scale assessment of the cultural ecosystem services associated with different habitats. Int. J. Biodivers. Sci., Ecosyst. Serv. Manag. 14 (1), 91–104. https://doi.org/10.1080/21513732.2018.1447016.
Graca, M., et al., 2018. Assessing how green space types affect ecosystem services delivery

in Porto, Portugal. Landsc. Urban Plann. 170, 195–208. https://doi.org/10.1016/j.landurbplan.2017.10.007.
Green, O.O., et al., 2016. Adaptive governance to promote ecosystem services in urban green spaces. Urban Ecosyst. 19 (1), 77–93. https://doi.org/10.1007/s11252-015-0476-2.
Gye, L., 2007. Picture this: the impact of mobile camera phones on personal photographic practices. Continuum 21 (2), 279–288. https://doi.org/10.1080/10304310701269107.
Herzog, T.R., 1985. A cognitive analysis of preference for waterscapes. J. Environ. Psychol. 5 (3), 225–241. https://doi.org/10.1016/S0272-4944(85)80024-4.
Heyman, E., 2012. Analysing recreational values and management effects in an urban forest with the visitor-employed photography method. Urban For. Urban Green. 11 (3), 267–277. https://doi.org/10.1016/j.ufug.2012.02.003.
Ives, C.D., et al., 2017. Capturing residents' values for urban green space: mapping, analysis and guidance for practice. Landsc. Urban Plan. 161, 32–43. https://doi.org/10.1016/j.landurbplan.2016.12.010.
James, P., et al., 2009. Towards an integrated understanding of green space in the European built environment. Urban For. Urban Green. 8 (2), 65–75. https://doi.org/10.1016/j.ufug.2009.02.001.
Kabisch, N., Qureshi, S., Haase, D., 2015. Human-environment interactions in urban green spaces - a systematic review of contemporary issues and prospects for future research. Environ. Impact Assess. Rev. 50, 25–34. https://doi.org/10.1016/j.eiar.2014.08.007.
Kaplan, R., Kaplan, S., 1989. The Experience of Nature: a Psychological Perspective. CUP Archive. http://willsull.net/resources/270-Readings/ExpNature1to5.pdf.
Kenter, J.O., et al., 2015. What are shared and social values of ecosystems? Ecol. Econ. 111, 86–99. https://doi.org/10.1016/j.ecolecon.2015.01.006.
Langemeyer, J., Baró, F., Roebeling, P., Gómez-Baggethun, E., 2015. Contrasting values of cultural ecosystem services in urban areas: the case of park Montjuïc in Barcelona. Ecosyst. Serv. 12, 178–186. https://doi.org/10.1016/j.ecoser.2014.11.016.
Langemeyer, J., Camps-Calvet, M., Calvet-Mir, L., Barthel, S., Gomez-Baggethun, E., 2018. Stewardship of urban ecosystem services: understanding the value(s) of urban gardens in Barcelona. Landsc. Urban Plan. 170, 79–89. https://doi.org/10.1016/j.landurbplan.2017.09.013.
Larson, L.R., et al., 2016. Ecosystem services and urban greenways: What's the public's perspective? Ecosyst. Serv. 22, 111–116. https://doi.org/10.1016/j.ecoser.2016.10.004.
Lin, Y.-P., et al., 2017. Integrating social values and ecosystem services in systematic conservation planning: a case study in Datuan watershed. Sustainability 9 (5), 718. https://doi.org/10.3390/su9050718.
Lyu, S.O., 2016. Travel selfies on social media as objectified self-presentation. Tour. Manag. 54, 185–195. https://doi.org/10.1016/j.tourman.2015.11.001.
MacKay, K.J., Couldwell, C.M., 2004. Using visitor-employed photography to investigate destination image. J. Travel. Res. 42 (4), 390–396. https://doi.org/10.1177/0047287504263035.
Maller, C., Townsend, M., Brown, P., St Leger, L., 2002. Healthy Parks, Healthy People: the Health Benefits of Contact With Nature in a Park Context: a Review of Current Literature. Deakin University Faculty of Health & Behavioural Sciences, Parks Victoria. http://www.georgewright.org/262maller.pdf.
Martín-López, B., et al., 2012. Uncovering ecosystem service bundles through social preferences. PLoS One 7 (6), e38970. https://doi.org/10.1371/journal.pone.0038970.
Martínez-Harms, M.J., Balvanera, P., 2012. Methods for mapping ecosystem service supply: a review. Int. J. Biodivers. Sci. Ecosyst. Serv. Manag. 8 (1-2), 17–25. https://doi.org/10.1080/21513732.2012.663792.
United Nations, 2011. Urban Population, Development and the Environment 2011. Department of Economic and Social Affairs, Population Division, New York, United Nations. http://www.un.org/en/development/desa/population/publications/urbanization/urbanPopDevEnv_2011.shtml.
Oku, H., Fukamachi, K., 2006. The differences in scenic perception of forest visitors through their attributes and recreational activity. Landsc. Urban Plan. 75 (1), 34–42. https://doi.org/10.1016/j.landurbplan.2004.10.008.
Pietrzyk-Kaszynska, A., Czepkiewicz, M., Kronenberg, J., 2017. Eliciting non-monetary values of formal and informal urban green spaces using public participation GIS. Landsc. Urban Plan. 160, 85–95. https://doi.org/10.1016/j.landurbplan.2016.12.012.
Plieninger, T., et al., 2015. The role of cultural ecosystem services in landscape management and planning. Curr. Opin. Environ. Sustain. 14, 28–33. https://doi.org/10.1016/j.cosust.2015.02.006.
Plieninger, T., Dijks, S., Oteros-Rozas, E., Bieling, C., 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. Land Use Policy 33, 118–129. https://doi.org/10.1016/j.landusepol.2012.12.013.
Prideaux, B., Coghlan, A., 2010. Digital cameras and photo taking behaviour on the Great Barrier Reef—marketing opportunities for Reef tour operators. J. Vacat. Mark. 16 (3), 171–183. https://doi.org/10.1177/1356766710372244.
Prideaux, B., Lee, L.Y.-S., Tsang, N., 2018. A comparison of photo-taking and online-sharing behaviors of mainland Chinese and Western theme park visitors based on generation membership. J. Vacat. Mark. 24 (1), 29–43. https://doi.org/10.1177/1356766716682554.
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. https://doi.org/10.1016/j.landurbplan.2013.07.007.
Seto, K.C., Guneralp, B., Hutyra, L.R., 2012. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proc. Natl. Acad. Sci. U. S. A. 109 (40), 16083–16088. https://doi.org/10.1073/pnas.1211658109.
Shen, Y., Sun, F., Che, Y., 2017. Public green spaces and human wellbeing: mapping the spatial inequity and mismatching status of public green space in the Central City of Shanghai. Urban For. Urban Green. 27, 59–68. https://doi.org/10.1016/j.ufug.2017.06.018.
Sherrouse, B.C., Clement, J.M., Semmens, D.J., 2011. A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. Appl. Geogr. 31 (2), 748–760. https://doi.org/10.1016/j.apgeog.2010.08.002.
Sherrouse, B.C., Semmens, D.J., Ancona, Z.H., Brunner, N.M., 2017. Analyzing land-use change scenarios for trade-offs among cultural ecosystem services in the Southern Rocky Mountains. Ecosyst. Serv. 26, 431–444. https://doi.org/10.1016/j.ecoser.2017.02.003.
Sherrouse, B.C., Semmens, D.J., Clement, J.M., 2014. An application of Social Values for Ecosystem Services (SolVES) to three national forests in Colorado and Wyoming. Ecol. Indic. 36, 68–79. https://doi.org/10.1016/j.ecolind.2013.07.008.
Shoyama, K., Yamagata, Y., 2016. Local perception of ecosystem service bundles in the Kushiro watershed, Northern Japan – application of a public participation GIS tool. Ecosyst. Serv. 22, 139–149. https://doi.org/10.1016/j.ecoser.2016.10.009.
Sugimoto, K., 2011. Analysis of scenic perception and its spatial tendency: using digital cameras, GPS loggers, and GIS. Proc.-Soc. Behav. Sci. 21, 43–52. https://doi.org/10.1016/j.sbspro.2011.07.010.
Sugimoto, K., 2013. Quantitative measurement of visitors' reactions to the settings in urban parks: spatial and temporal analysis of photographs. Landsc. Urban Plan. 110, 59–63. https://doi.org/10.1016/j.landurbplan.2012.10.004.
Sugimoto, K., 2017. Use of GIS-based analysis to explore the characteristics of preferred viewing spots indicated by the visual interest of visitors. Landsc. Res. 43 (3), 345–359. https://doi.org/10.1080/01426397.2017.1316835.
Swanwick, C., 2009. Society's attitudes to and preferences for land and landscape. Land Use Policy 26, S62–S75. https://doi.org/10.1016/j.landusepol.2009.08.025.
Swets, J.A., 1988. Measuring the accuracy of diagnostic systems. Science 240 (4857), 1285–1293. https://doi.org/10.1126/science.3287615.
Taylor, J.G., Czarnowski, K.J., Sexton, N.R., Flick, S., 1995. The importance of water to Rocky Mountain National Park visitors: an adaptation of visitor-employed photography to natural resources management. J. Appl. Recr. Res. 20 (1), 61–85. https://www.fort.usgs.gov/sites/default/files/products/publications/3608/3608.pdf.
Tyrväinen, L., Mäkinen, K., Schipperijn, J., 2007. Tools for mapping social values of urban woodlands and other green areas. Landsc. Urban Plan. 79 (1), 5–19. https://doi.org/10.1016/j.landurbplan.2006.03.003.
van Riper, C.J., Kyle, G.T., Sherrouse, B.C., Bagstad, K.J., Sutton, S.G., 2017. Toward an integrated understanding of perceived biodiversity values and environmental conditions in a national park. Ecol. Indic. 72 (Supplement C), 278–287. https://doi.org/10.1016/j.ecolind.2016.07.029.
van Riper, C.J., Kyle, G.T., Sutton, S.G., Barnes, M., Sherrouse, B.C., 2012. Mapping outdoor recreationists' perceived social values for ecosystem services at Hinchinbrook Island National Park, Australia. Appl. Geogr. 35 (1), 164–173. https://doi.org/10.1016/j.apgeog.2012.06.008.
Wang, H., Li, W., Kong, L., Zhang, Y., 2014. Ecoloical sensitivity evaluation of Wetland Park: a case of Yancheng Rare Birds Wetland Park. Chin. Landsc. Arch. 2014 (10), 112–115. http://www.cqvip.com/read/read.aspx?id=663606782.
Wang, Y., Fu, B., Lv, Y., Yang, K., Che, Y., 2016. Assessment of the social values of ecosystem services based on SolVES model: a case study of Wusong Paotaiwan Wetland Forest Park, Shanghai, China. Chin. J. Appl. Ecol. 27 (6), 1767–1774 (In Chinese).
Wolch, J.R., Byrne, J., Newell, J.P., 2014. Urban green space, public health, and environmental justice: the challenge of making cities' just green enough'. Landsc. Urban Plan. 125, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017.
Zedler, J.B., Kercher, S., 2005. Wetland resources: status, trends, ecosystem services, and restorability. Annu. Rev. Environ. Resour. 30, 39–74. https://doi.org/10.1146/annurev.energy.30.050504.144248.