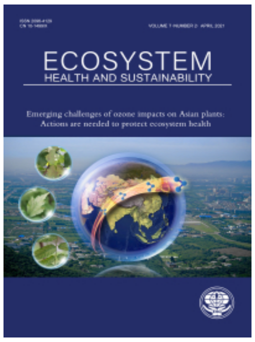

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Greenspace's value orientations of ecosystem service and socioeconomic service in China

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ABSTRACT

Background: Natural ecosystems provide necessary services for human beings, including ecosystem service values (ESVs) and socioeconomic service values (SSVs). The value orientations of ESVs and SSVs are mainly related to people's interaction with nature. This study reclassified greenspace from a perspective of exposed and non-exposed greenspace based on the level of interaction by people and greenspace. We applied an expert questionnaire to survey the SSVs value orientations of forestland, grassland, wetland, and water bodies, and quantitatively compared the value orientations between the ESVs and SSVs of greenspace in China. Result: (1) The values of exposed greenspace were relatively far higher than non-exposed greenspace, as it had both ESVs and SSVs. (2) The forestland and grassland had relatively high ESVs and SSVs, and are the priority for both the exposed and non-exposed greenspace. (3) Wetland had relatively high ESVs but low SSVs, which was unpopular for exposed greenspace. (4) The ESVs and SSVs of water body were relatively balanced. Conclusion: Greenspace had both ESVs and SSVs when they are exposed to human. Our study provided an innovative perspective to explore the value orientations of greenspace, which provides an actionable scientific basis for greenspace planning, design and construction in human habitat.

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Greenspace; exposure; ecosystem service values; socioeconomic service values; value orientations

Introduction

Greenspace was defined as "open, undeveloped land with natural vegetation," including parks, forests, playing fields, and river corridors (Mitchell and Popham 2008), and provided a variety of ecosystem services for human, such as erosion control and sediment retention services (Liu and Russo 2021), climate regulation services (Shi et al. 2020; Masoudi, Tan, and Fadaei 2021; Shah, Garg, and Mishra 2021), gas regulation services (Grote et al. 2017; Silva et al. 2019; Diener and Mudu 2021), as well as biodiversity conservation services (Gao et al. 2021). Value was the utility, benefit, or effect relationship between the attribute and function of the object and the needs of the subject (Kraft 1981). The services of ecological systems and the natural capital stocks contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet (Costanza 2012). Theoretically, ecologists usually emphasize greenspace's ecosystem service values (ESVs) as it provided a variety of ecosystem services for humans. In practice, greenspace designers always pay more attentions on the direct interaction between human and greenspace and the social services provided by greenspace, i.e., socioeconomic service values (SSVs). For instance, greenspace provided human beings with public open space for entertainment and social, and enhanced the price of real estate (Daams, Sijtsma, and Veneri 2019). In addition, emerging researches have indicated that greenspace can reduce anxiety (Bowler et al. 2010; Gascon et al. 2018) and stress (Coon et al. 2011; Mennis, Mason, and Ambrus 2018), and improve happiness (Capaldi, Dopko, and Zelenski 2014; Navarrete-Hernandez and Laffan 2019), which is important to people's health and well-being. Although the current ESV classification covers support service values, supply service values, regulation service values, and cultural service values, it is more suitable for the study of natural ecosystems rather than the ecosystems in man-made environment, such as urban green space. Especially for greenspace in urban environment, the ESVs evaluation limits on and simplifies the tourism values and esthetic values in cultural service values provided by landscape and the SSVs are largely

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underestimated, such as health service values, education service values, etc. In recent years, the role of greenspace in people's health and welfare has attracted more and more attention, and has become an important component of urban green infrastructure (Grabowski et al. 2022) and nature-based solutions (Wendling et al. 2021). The comparison between Greenspace's ESVs and SSVs will provide interdisciplinary scientific support for urban green space development and decision-making.

Value orientations were clusters of values concerning a specific domain (Inglehart and Baker 2000) and provided another way to measure broad value leanings (Taylor, Leckey, and Hochuli 2020). Moreover, value orientations influenced people's preferences or beliefs and guided people in various contexts (Say and Say 2010). So, the value orientations of nature were closely related to people's interaction. Extensive studies focused on people's value orientations of nature (Cramer et al. 1993; Bengston, Webb, and Fan 2004; Webb, Bengston, and Fan 2008), especially in forest value orientations. Lots of efforts (Bengston, Webb, and Fan 2004; Webb, Bengston, and Fan 2008; Li and Ernst 2015; Taylor, Leckey, and Hochuli 2020) have been made on traditional forest values as well as the objective ESVs of forests, for example, the values of carbon sequestration and wildlife habitat which were far from the ESVs actually obtained by human beings. Although the SSVs to human's physiology and psychology have been widely approved (Dobbs, Escobedo, and Zipperer 2010; Tyrväinen et al. 2014), few studies focused on the value orientations. As the value orientations have been explored in depth, the value orientations of different greenspace types were still not clear. Because the capacity of ESVs and SSVs is varied for different greenspace types, the value orientations of the actual ESVs and `SSVs that people obtain from different greenspace types remain to be explored.

In the 1990s, the United States Environmental Protection Agency put forward the concept of "exposure" in the "exposure assessment guidelines" (U.S.EPA 1992), which was defined as the intensity, time, speed, penetration, and absorption of some chemical, physical, or biological agents, and widely used in environmental risk assessment. More recently, researchers introduced the concept of "exposure" into greenspace-related studies and focused on the relationship between greenspace and human health and well-being on individual level (Song et al. 2018; Zhang et al. 2018; Zhang, Zhang, and Rhodes 2021a). Availability, visibility, and accessibility were widely used to measure greenspace exposure from different aspects (Labib, Lindley, and Huck 2020). The physical amount of greenspace was stressed on the availability of greenspace, and availability might be related to physical environmental processes (Bratman et al. 2019). Accessibility to greenspace referred to the spatial proximity of greenspace to locations of interest and may be linked to the range of human behavior (Ekkel and Sjerp 2017). The visibility of greenspace was defined as the amount of greenspace, which can be seen visually from a particular location of interest, and might be connected with restoration and attention-retention effect of nature (Labib, Lindley, and Huck 2020). Exposure provided a new perspective to study people's actual benefits from greenspace. Zhao et al. (2016) proposed Landsenses Ecology, which laid a theoretical foundation for the interaction between human and landscape. Landsenses Ecology, which referred to a scientific discipline studying land-use, construction, and management toward sustainable development, is based on ecological principles and an analysis framework composed of natural elements, physical senses, psychological perceptions, socioeconomic perspectives, process risk, and associated aspects, and summarized the human perception of landscape as hearing, smell, touch, vision, taste, wind sense, sense of direction, and psychological response (Zhao et al. 2016).

Considering the interaction between human and greenspace, in this paper, human perception and environmental exposure were introduced into greenspace to explore the value orientations of the ESVs and SSVs as well as to evaluate the actual ESVs and SSVs, which people obtained from four typical greenspaces (forestland, grassland, wetland (in a narrow sense) and water bodies) in China. Firstly, based on the perspective of exposure, the SSVs of greenspace were reclassified. Secondly, referring to the previous research (Xie et al. 2008), a similar methodology was carried out to survey the SSVs value orientations of greenspace. Finally, the value orientations including forestland, grassland, wetland, and water bodies were compared between the ESVs and the SSVs of greenspace. This paper provides an operational scientific basis for greenspace planning, design, and construction by introducing the perspective of exposure to focus on the value orientations in diffident greenspaces.

Methods

Reclassification of greenspace based on an exposure perspective

Based on Landsenses Ecology, people's hearing, taste, smell, touch, light sense, vision, and psychological feelings were considered as the pathways people exposed to greenspace. Therefore, greenspace was divided into two forms: greenspace that people directly interact with it by exposure pathways was defined as exposed greenspace, such as urban parks, road green belt, community greenspace, etc. Conversely, greenspace that people only indirectly or cannot interact with it was

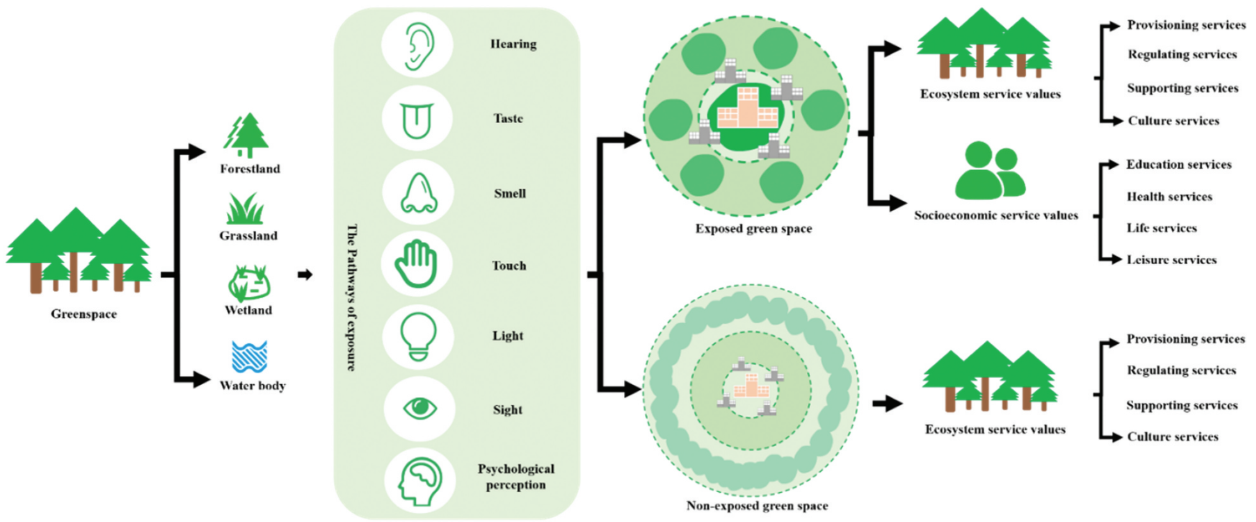

Figure 1. The classification and value system of greenspace based on exposure perspective.

defined as non-exposed greenspace, including cropland, nature reserves, water reservoirs, etc. (see Figure 1). Only when people exposed to greenspace, the socioeconomic benefits can be realized, such as alleviating anxiety, improving happiness, and raising real estate prices. Thus, only the exposed greenspace has substantial SSVs. However, both the exposed and non-exposed greenspace have ESVs, because whether or not people exposed to it, the ecosystem services of greenspace will still be delivered, such as supporting, provisioning, and regulating services.

The point of interest (POI) data in Gaode digital map (https://www.amap.com/) represented things in geospatial space (Lin et al. 2018; Huang et al. 2021) containing 44 layers (see Table 1). Therefore, POI was conducive to reflect the spatial distribution relationship between different places and greenspace (see appendix 1). Combined with the POI types related to greenspace (see Table 2) and its social services for humans, the classification system of SSVs was established to emphasize the socioeconomic benefits, including education, health, life, and leisure, and consisted of nine sub-categories (see Table 3). When POI was related to greenspace, people will prefer to choose the facility, because these facilities can provide social services for humans and generate additional values (Huang et al. 2021). For example, greenspace in schools can be regarded as educational resources, which can facilitate education activity and provide educational service values. Greenspace in hospitals can contribute to relieve stress and assist patients' recovery, so health service values can be realized. Meanwhile, greenspace in ecological restaurant enhance the people's dining experience, which produced life service values (see Table 2). What's more, the classification system and evaluation results of ESVs were referred to Xie et al. (2008), which included provisioning service values (food production and raw

Table 2. Classification of socioeconomic services based on POI types related to greenspace.

Socioeconomic services category	POI type
Education services	Universities and scientific research institute
	Science, education and cultural organization
Health services	General hospital
	Specialized hospital
	Medical treatment
Life services	Residential district
	Serviced apartment
	Business residence
	Restaurant
Leisure services	Sports activity
	Scenic spot
	Place of cultural interest
	Natural landscape
	Park and square

Table 1. POI layers.

ID	POI layers name	ID	POI layers name
1	Accommodation services	23	Insurance company
2	Administrative place names	24	Life service
3	Airports	25	Middle school
4	Animal medical places	26	Motorcycle Service
5	ATM	27	Natural place-name
6	Automobile sales	28	Office Building
7	Bank	29	Primary schools and kindergartens
8	Bank-related	30	Provincial Government
9	Bridge	31	Public security organs
10	Business residence	32	Regional and municipal governments
11	Car maintenance	33	Residential communities
12	Car service	34	Road ancillary facilities
13	Catering services	35	Scenic spots
14	Colleges and universities	36	Scientific and cultural services
15	Communal facilities	37	Securities company
16	Company enterprise	38	Shopping services
17	District and county governments	39	Specialized hospitals
18	Finance Company	40	Sports leisure services
19	Financial and insurance institutions	41	Traffic place-name
20	General hospitals	42	Train stations
21	Government agencies and social organizations	43	Transport facilities services
22	Health care services	44	Water system name

Table 3. Greenspace's ecosystem service values and socio-economic service value classification.

ESVs*		SSVs	
Category	Sub-category	Category	Sub-category
Provisioning services	Food production	Education services	Education
	Raw materials production	Health services	Medical treatment
Regulating services	Gas regulation	Life services	Restaurant
	Climate regulation		Housing
	Water conservation	Leisure services	Sports activity
	Waste treatment		Scenic spot
Supporting services	Soil formation and conservation		Place of cultural interest
	Biodiversity maintenance		Natural landscape
Culture services	Aesthetic landscape		Park and square

*Referring to (Xie et al. 2008).

material production), regulating service values (gas regulation, climate regulation, water conservation, and waste treatment), supporting service values (soil formation and conservation, biodiversity maintenance) and cultural service values (esthetic landscape).

Data sources

POI data originated from Gaode digital map (https://www.amap.com/). The ESVs of forestland, grassland, wetland, and water bodies came from Xie et al. (2008) (see appendix 2). The SSVs of forestland, grassland, wetland, and water bodies were from our survey results in China (see appendix 3). To explore the value orientations of ESVs and SSVs quantitatively, a 5-point scale ESVs was obtained by standardizing as described in sections below.

The spatial distribution of forestland, grassland, wetland, and water bodies in China was shown in Figure 2. Four typical greenspaces at a spatial resolution of 1 km × 1 km across the whole of China were extracted based on the 2015 LUCC data set at the Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (http://www.resdc.cn). Four typical greenspaces in mainland China covering 5,441,820 km^2 and accounted for 56.7% of

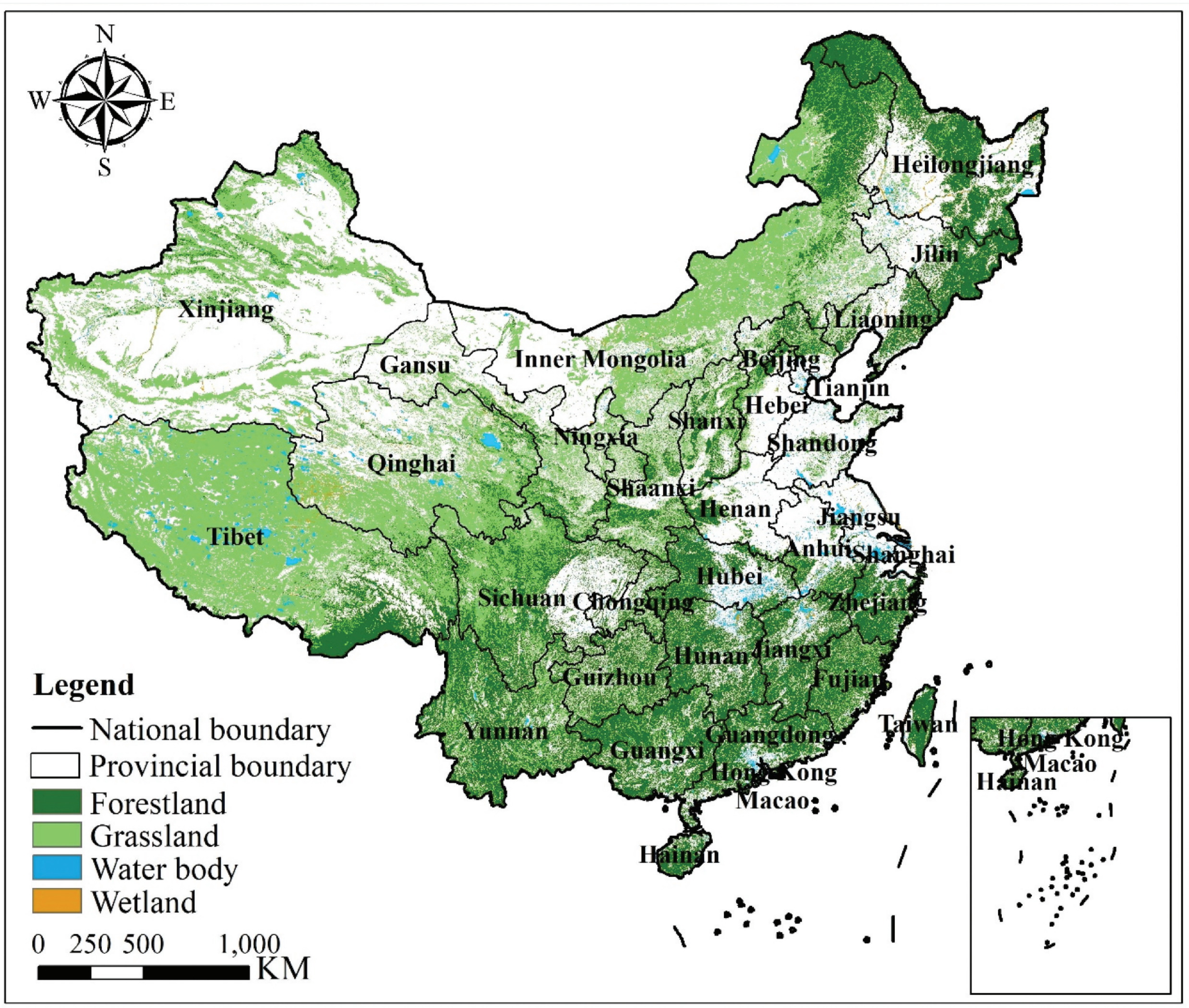

Figure 2. Spatial distribution of four typical greenspaces in China.

the total area. Among them, grassland had the largest area coverage with 2,990,576 km^2, the area of forestland, water bodies, and wetland were 2,990,576 km^2, 2,240,152 km^2, 155,149 km^2, and 55,943 km^2, respectively.

(This map was made based on GS (2019)1698 standard map downloaded from the standard map service website of the Ministry of Natural Resources, and the base map was not modified.)

Value orientations survey and evaluation of ESVs and SSVs of greenspace

2.3.1 The ESVs value orientations evaluation of greenspace

Xie et al. (2008) surveyed ecological experts by questionnaire to evaluate China's ecosystem service value equivalent per unit area for six ecosystems, including forestland, grassland, farmland, wetland, water body, and desert, and emphasized the values of ecosystem from ecosystem function. Xie et al. sent out 500 questionnaires and recovered 213, with a 42.6% effectiveness rate. They set the ecosystem service value equivalent of farmland production as 1 (Xie et al. 2003) and scaled the ESVs provided by other ecosystems relative to the annual benefits of farmland food production. To compare with the SSVs value orientations quantitatively, a 5-point scale ESVs was applied by standardizing based on the ESVs from Xie et al. (see section 2.5) and retained its relative scale.

The SSVs value orientations survey of greenspace

To ensure comparability with the value orientations of ESVs from Xie et al. (2008), a similar questionnaire method was applied to evaluate the socioeconomic benefits of greenspace. Through a WeChat online questionnaire (see appendix 3), the SSVs of four typical greenspaces were assessed by 130 Chinese experts with a professional background of ecology, and 124 valid questionnaires were returned. The survey contents included (1) the basic information of experts, including gender, age, education level, professional direction, school, etc. (2) The SSVs of four typical greenspaces, see appendix 3. The SSVs were divided into five grades with an equal of 1 (1.0 extremely low, 2.0 low, 3.0 medium, 4.0 high, 5.0 extremely high).

Quantitative comparison of value orientations of ESVs and SSVs of greenspace

The following seven steps were carried out to quantitatively compare and analyze the value orientations of ESVs and SSVs of greenspace in China. The summary results of the SSVs and standardized the ESVs were calculated. Further, the bias index (BI) was developed to compare the value orientations of SSVs and ESVs by a weighted average score.

(1) Calculating the SSV of greenspace by sub-category:

$$V_{sij} = \frac{1 \times n_{1ij} + 2 \times n_{2ij} + 3 \times n_{3ij} + 4 \times n_{4ij} + 5 \times n_{5ij}}{N} \quad (1)$$

where V_{sij} is the SSV of greenspace i in sub-category j. n_{1ij} is the number of people who deemed that the SSV of greenspace i in sub-category j is 1, n_{2ij} is the number of people who deemed that the SSV of greenspace i in sub-category j is 2,n_{3ij} is the number of people who deemed that the SSV of greenspace i in sub-category j is 3,n_{4ij} is the number of people who deemed that the SSV of greenspace i in sub-category j is 4,n_{5ij} is the number of people who deemed the SSV of greenspace i in sub-category j is 5. N is the number of people who deemed that greenspace i has the values. 1–5 is the score of the SSV.

(2) Calculating the ESV of greenspace by sub-category:

To compare with the SSVs conveniently, the ESVs form Xie et al. (2008) was standardized into a 5-point scale, i.e., corresponding the equivalent value of 0–0.1, 0.1–0.3, 0.3–0.6, 0.6–1 and 1–18.77 to 0–1, 1–2, 2–3, 3–4 and 4–5 scores, respectively.

$$V_{eij} = \begin{cases} 0 & (v_{ij} = 0) \\ 1 + \frac{v_{ij} - 0.1}{0.3 - 0.1} & (0.1 \le v_{ij} \le 0.3) \\ 2 + \frac{v_{ij} - 0.3}{0.6 - 0.3} & (0.3 \le v_{ij} \le 0.6) \\ 3 + \frac{v_{ij} - 0.6}{1 - 0.6} & (0.6 \le v_{ij} \le 1.0) \\ 4 + \frac{v_{ij} - 1.0}{18.77 - 1.0} & (1.0 \le v_{ij} \le 18.77) \end{cases} \quad (2)$$

where V_{eij} is the ESV of greenspace i in sub-category j. v_{ij} is the ESV equivalent factor of greenspace i in sub-category j.

(3) Calculating the SSVs of greenspace by category:

Considering the number of sub-category corresponding to each category was inconsistent, the mean value of sub-categories was used to represent its categorical values relatively.

$$V_{sim} = \frac{\sum_{g=1}^{n} V_{sij} n}{n} \quad (3)$$

where V_{sim} is the SSVs of greenspace i in category m. V_{sij} is the SSV of greenspace i in sub-category j. n is the number of sub-categories.

(4) Calculating the ESVs of greenspace by category:

$$V_{eim} = \frac{\sum_{g=1}^{n} V_{eij}}{n} \tag{4}$$

Where, V_{eim} is the ESVs of greenspace i in category m. V_{eij} is the ESV of greenspace i in sub-category j. n is the number of sub-categories.

(5) Calculating the SSVs of greenspace:

In order to measure the comprehensive values of greenspace, the mean value of four services was used to express its values relatively.

$$V_{si} = \frac{\sum_{l=1}^{n} V_{sim}}{n} \tag{5}$$

Where, V_{si} is the SSVs of greenspace i, V_{sim} is the SSVs of greenspace i in category m, and n is the number of categories.

(6) Calculating the ESVs of greenspace:

$$V_{ei} = \frac{\sum_{l=1}^{n} V_{eim}}{n} \tag{6}$$

where V_{ei} is the ESVs of greenspace i, V_{eij} is the ESVs of greenspace i in sub-category j. n is the number of categories.

(7) Comparing the SSVs and ESVs:

To reveal the value orientations between ESVs and SSVs, this paper constructed a bias index (BI) based on the relative ESVs and SSVs.

$$BI_i = \frac{V_{si}}{V_{ei}} \tag{7}$$

Where, BI_i is the bias index of greenspace i, V_{si} is the SSVs of greenspace i, V_{ei} is the ESVs of greenspace i.

Results

The value orientations of exposed and non-exposed greenspace in China

According to the standardized ESVs and SSVs (see Table 4), we drew Figure 3 showing the performance of each exposed greenspace and non-exposed greenspace. Combining the ESVs and SSVs, the total values of exposed greenspace were more than double of non-exposed greenspace, except wetland. The ESVs of forestland were 15.49, and the SSVs were 16.49. The ESVs and SSVs of grassland were slightly lower than forestland, which were 14.09 and 16.47, respectively. The ESVs and SSVs of water body were relatively similar, the values were 14.04 and 14.20. However, the ESVs and SSVs of wetlands were quite different, which were 14.82 and 10.26, respectively. Concretely, for exposed greenspace, forestland provided the greatest benefit to humans, achieving the highest values (31.98), followed by grassland, water body, and wetland. The highest values for forestland were mainly attributed to its values of health service (4.36), leisure service (4.35), supporting service (4.18), and regulating service (4.14). Grassland (30.56) had the second most values in the exposed greenspace and was more owing to the values of leisure service (4.28), health service (4.15), life service (4.06), and supporting service (4.06), compared to 2.32 for provisioning service values. Water body had the third most values with 28.24, within culture service and regulating services account for 4.19 and 4.13, respectively. The values of wetland were lowest (25.08) in four types of exposed greenspaces, because the values of education service, health service, life service, and leisure service were less than 3.00 and the provisioning service values were only 1.95. With respect to the values of four non-exposed greenspaces, forestland also had the highest values with 15.49, followed by wetland (14.82), grassland (14.09), and water bodies (14.04). The values of regulating services supporting services and culture service for forestland were generally more than 4.00, only provisioning service values were slightly lower than 4.00. Wetland was similar as forestland for the above-mentioned four category values. Only two categories' values of grassland and water bodies were relatively high including regulating service and supporting service of grassland and regulating service and cultural service of water bodies.

(EF: The exposed forestland, NEF: The non-exposed forestland, EG: The exposed grassland, NEG: The non-exposed grassland, EWB: The exposed water body, NEWB: The non-exposed water body, EW: The exposed wetland, NEW: The non-exposed wetland.)

i is the type of greenspace; m is the category of ecosystem service; j is the sub-category of ecosystem service.

The value orientations of ESVs and SSVs of greenspace in China

The value orientations of ESVs and SSVs in different categories were explored, including the values of provisioning service, regulating service, supporting service, cultural service, education service, health service, life service, and leisure service. The SSVs of forestland were higher than ESVs, because the provisioning service values were low, the values of health service and leisure service were high, and the values of education service and life service were medium (see Figure 4a). Although the values of regulating service and supporting service of grassland were high, the provisioning and cultural service values were low and medium, respectively, so the SSVs of grassland were

Table 4. Ecosystem service values and socioeconomic service values of greenspace.

Greenspace (type *i*)	*ESVs* (type *i*)	*SSVs* (type *i*)	Ecosystem services (category *m*)	*ESVs* (category *m*)	Ecosystem services (sub-category *j*)	*ESV* (sub-category *j*)	Socioeconomic services (category *m*)	*SSVs* (category *m*)	Socioeconomic services (sub-category *j*)	*SSV* (sub-category *j*)
Forestland	3.87	4.12	Provisioning services	3.11	Food production	2.10	Education Services	3.94	Education	3.94
					Raw materials production	4.11	Health services	4.36	Medical treatment	4.36
			Regulating services	4.14	Gas regulation	4.19	Life services	3.84	Restaurant	3.64
					Climate regulation	4.17			Housing	4.03
					Water conservation	4.17	Leisure services	4.35	Sports activity	4.09
					Waste treatment	4.04			Scenic spot	4.62
			Supporting services	4.18	Soil formation and conservation	4.17			Place of cultural interest	4.19
					Biodiversity maintenance	4.20			Natural landscape	4.51
			Culture services	4.06	Aesthetic landscape	4.06			Park and square	4.35
Grassland	3.52	4.12	Provisioning services	2.32	Food production	2.43	Education Services	3.98	Education	3.98
					Raw materials production	2.20	Health services	4.15	Medical treatment	4.15
			Regulating services	4.03	Gas regulation	4.03	Life services	4.06	Restaurant	4.00
					Climate regulation	4.03			Housing	4.11
					Water conservation	4.03	Leisure services	4.28	Sports activity	4.27
					Waste treatment	4.02			Scenic spot	4.30
			Supporting services	4.06	Soil formation and conservation	4.07			Place of cultural interest	4.00
					Biodiversity maintenance	4.05			Natural landscape	4.33
			Culture services	3.68	Aesthetic landscape	3.68			Park and square	4.50
Water bodies	3.51	3.55	Provisioning services	2.47	Food production	2.77	Education Services	3.35	Education	3.35
					Raw materials production	2.17	Health services	3.40	Medical treatment	3.40
			Regulating services	4.13	Gas regulation	2.70	Life services	3.67	Restaurant	3.72
					Climate regulation	4.06			Housing	3.61
					Water conservation	5.00	Leisure services	3.78	Sports activity	3.41
					Waste treatment	4.78			Scenic spot	3.97
			Supporting services	3.25	Soil formation and conservation	2.37			Place of cultural interest	3.65
					Biodiversity maintenance	4.14			Natural landscape	3.95
			Culture services	4.19	Aesthetic landscape	4.19			Park and square	3.92
Wetland	3.71	2.56	Provisioning services	1.95	Food production	2.20	Education Services	2.62	Education	2.62
					Raw materials production	1.70	Health services	2.26	Medical treatment	2.26
			Regulating services	4.56	Gas regulation	4.08	Life services	2.43	Restaurant	2.40
					Climate regulation	4.71			Housing	2.46
					Water conservation	4.70	Leisure services	2.95	Sports activity	2.36
					Waste treatment	4.75			Scenic spot	3.13
			Supporting services	4.10	Soil formation and conservation	4.06			Place of cultural interest	2.65
					Biodiversity maintenance	4.15			Natural landscape	3.59
			Culture services	4.21	Aesthetic landscape	4.21			Park and square	3.00

significantly higher than ESVs (see Figure 4b). For water bodies, the SSVs were close to the ESVs as the values in SSVs of education service, health service, life service, and leisure service were medium, and the values in ESVs of regulating service, supporting service and culture service were medium but the values of provisioning were low (see Figure 4c). In contrast, the ESVs of wetland were significantly higher than the SSVs, as the values of education service, health service, life service, and leisure service of wetland were all low (see Figure 4d).

(a: forestland, b: grassland, c: water bodies, d: wetland.)

Further, the value orientations of ESVs and SSVs of four typical greenspaces were compared quantitatively, including forestland, grassland, water bodies, and wetland. Although the SSVs of grassland were the same as forestland (see Figure 5), grassland's bias index (BI) was more obvious because of the lower ESVs of grassland ($BI_{Grassland} = 1.17$, $BI_{Forestland} = 1.07$). The BI of water bodies was close to 1.00 ($BI_{Water\ body} = 1.01$), the SSVs were slightly greater than the ESVs. Nevertheless, the wetland had distinct value orientations of ESVs ($BI_{Wetland} = 0.69$) because the ESVs were higher and the SSVs were significantly lower (see Figure 5).

Combining the characteristics of exposed greenspace and non-exposed greenspace and the evaluation of four greenspaces, forestland and grassland had the priority for both the exposed and non-exposed greenspace because they had high ESVs and SSVs. By contrast, wetland had high ESVs but low SSVs, so it was unsuitable for exposed greenspace. However, the SSVs of water bodies were close to its ESVs..

Discussion

The cause of differentiation in greenspaces' value orientations of ESVs and SSVs

The differences between ESVs of four greenspaces were related to their biological characteristics. For example, forestland had the highest ESVs because it provided multiple ecosystem services, such as the production of raw materials (Santos, Carvalho, and Barbosa-Póvoa 2021), dust and noise reduction (Xu et al. 2020), mitigation of urban heat island effect (Yao et al. 2020), soil formation and conservation (Borrelli et al. 2016), biodiversity maintenance (Salete Capellesso et al. 2021) and landscape esthetics (Hauru et al. 2014). Ecosystem services were positively related to biomass in general (Xie et al. 2008). For instance, grassland provided similar types of ecosystem services but its values of ecosystem services were lower than forestland, because the biomass of grassland was much less than forestland (Liu et al. 2011). Water body had strong services of water conservation, climate regulation, and waste treatment, but the services of raw material production, food production, and soil formation and conservation were relatively weak (see Table 4), so the values of regulating service and cultural service were higher, and the values of provisioning service and supporting service were lower (Zhang et al. 2011). Nevertheless, the differences in SSVs of the four greenspaces were related to people's exposure modes. According to Maslow's hierarchy of needs theory (Maslov 1987), safety demand was the basic need of human beings, so the safety of people's exposure behavior in greenspace directly affected the SSVs of greenspace. Water bodies and wetland contained significant risk factors for people's safety, such as slipping, drowning (Stephenson et al. 2020), and insect stings (Russell 1999). These hazard risks will naturally reduce people's exposure activities. Thus, the SSVs of water bodies and wetland tend to be low. By contrast, grassland and forestland were the main habitat for human beings for a long time. Especially, grassland greatly reduced the potential safety hazards for human by providing a wide field of vision and flat ground. Therefore, people prefer to carry out exposure activities in grassland and forestland, including outdoor education activities (Hall and Clover 1997; Otto and Pensini 2017), forest rehabilitation therapy (Sonntag-Öström et al. 2015), daily physical exercise, and social intercourse (Paul et al. 2020; Kajosaari and Pasanen 2021). Consequently, the SSVs including the values of educational service, health service, life service, and leisure service of forestland and grassland were relatively higher.

Enhance the values of exposed and non-exposed greenspace in China

Greenspace had ESVs but also had SSVs only when people exposed to it. However, the current urban green space planning had not pay attention to the importance of greenspace exposure and the SSVs of greenspace. To enhance the values of greenspace, it is important to enhance greenspace exposure from availability, accessibility, and visibility to increase the ESVs and SSVs of greenspace. Maintaining the health status of greenspace ecosystems is the basis of improving the ESVs, which is contributed to promote the availability and visibility of greenspace and provide various ecosystem services (Costanza 2012). The SSVs of greenspace can be improved through a variety of ways. In cities, forestland and grassland are popular because they had higher ESVs and SSVs. Although the SSVs of water body and wetland were relatively lower than that of forestland and grassland, planners and designers can integrate forestland and grassland into water body and wetland to increase the SSVs of greenspace as a whole. For example, a wetland park often includes some grassland and forestland to reduce the potential safety hazards for people exposed to wetlands. There are a lot of non-exposed greenspaces outside the city, transferring the non-exposed greenspace into exposed greenspace was recommended for improving its SSV by increasing their interaction with people,

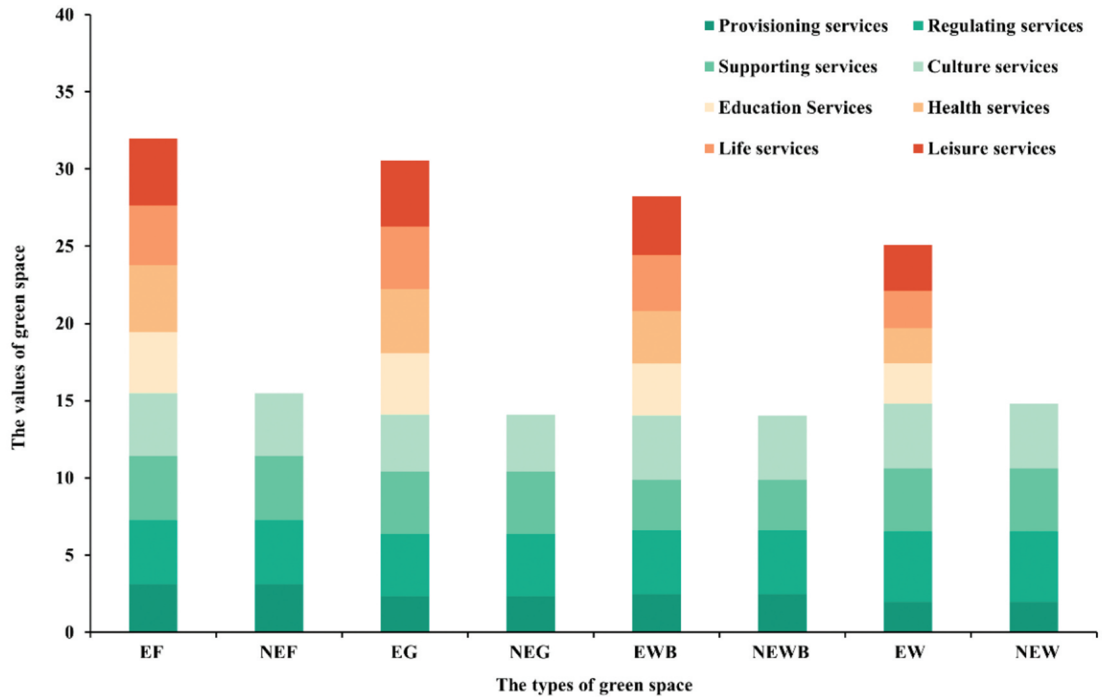

Figure 3. The value orientations of exposed and non-exposed greenspace.

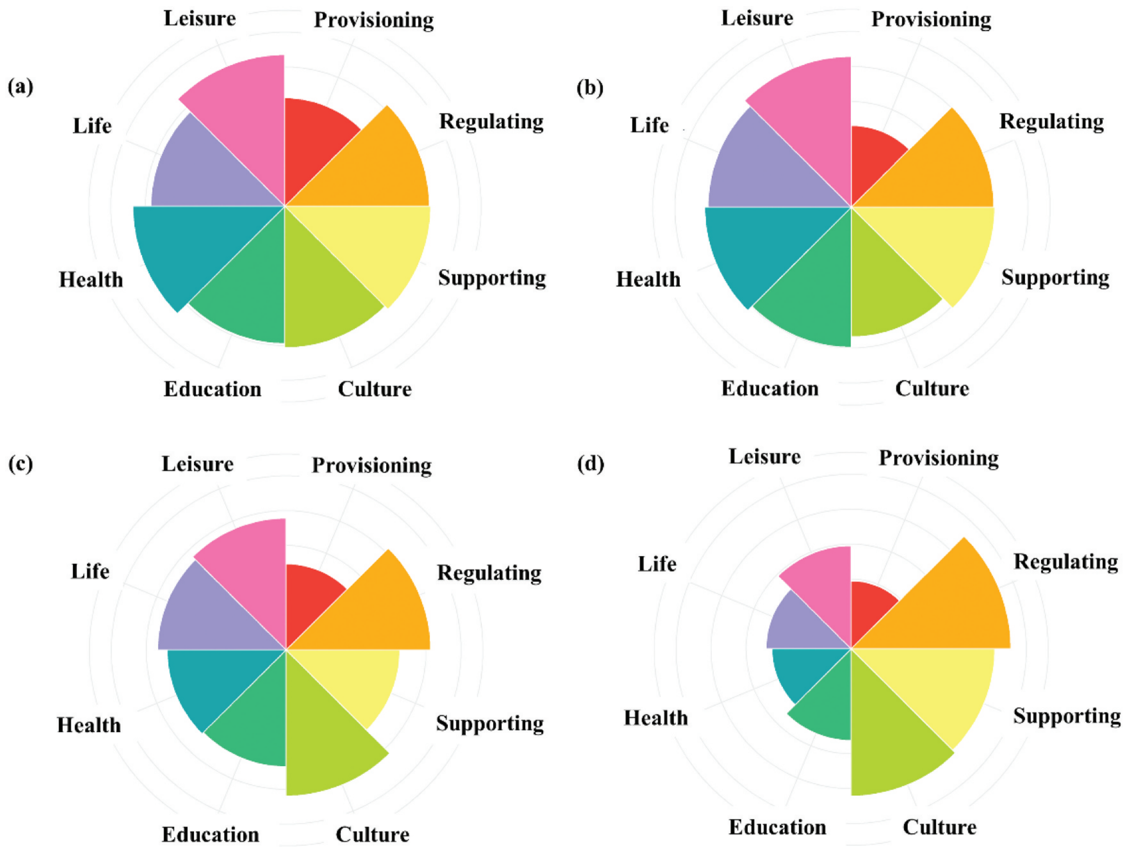

Figure 4. The value orientations of ESVs and SSVs in different categories in different greenspaces.

such as cropland and wildland around cities. Generally, improving accessibility (Wu et al. 2020) and attraction (Chen and Wu 2021) of greenspace were good solutions for increasing people exposed to greenspace. In terms of accessibility, the connection between greenspace and residential areas should be focused. The connection can be enhanced by perfecting walkways and traffic systems (Wan and Ma 2021) or introducing more natural ecosystems into cities (Chen and Chang 2015) to develop the positive interaction between human and greenspace.

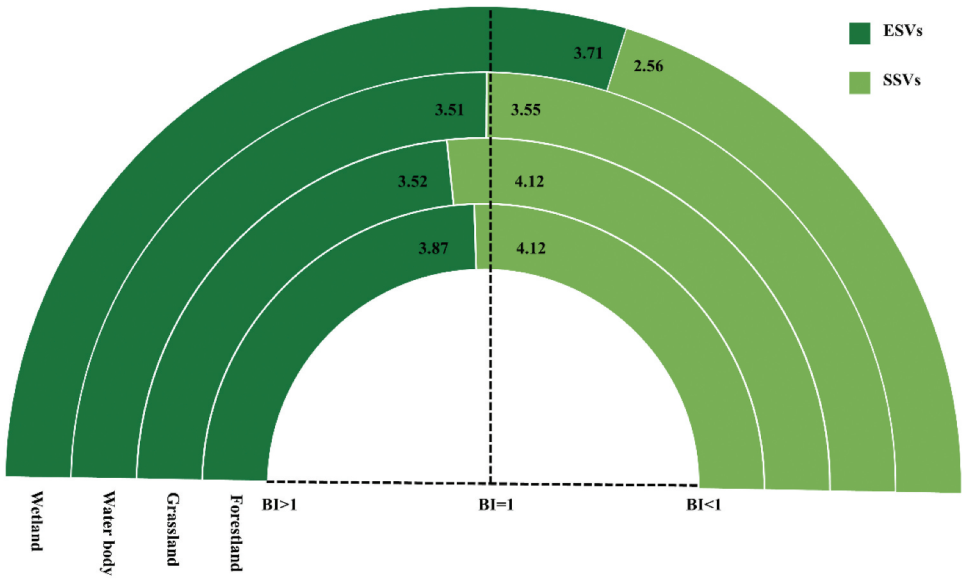

Figure 5. The value orientations of ecosystem service values and socioeconomic service values of greenspace.

Constructing ecological corridors (Zhao, Li, and Zhong 2019) can also increase the connectivity of greenspace (Koen, Ellington, and Bowman 2019) and enhance local ecological networks (Zhang et al. 2021b) to provide more exposure opportunities and enabling green justice (Kronenberg et al. 2020; Liotta et al. 2020). Meanwhile, the attraction of greenspace can be raised by improving the vegetation configuration and landscape design (Zhang and Piao 2012). On the other hand, the influence of the ESVs of non-exposed greenspace on the local socioeconomic development should not be overlooked. In addition, the benefits of ecosystem services of non-exposed greenspace obtained by people are highly affected by the distance between human and greenspace, such as climate regulation and pollution reduction, which are related to the temporal and spatial distribution pattern and size of greenspace (Bagstad et al. 2013; Wu 2013; Bagstad et al. 2014; Li et al. 2017; Hutchins et al. 2021). Considering the obvious localization characteristics of non-exposed greenspace's services, such as ecological risk prevention and climate regulation, the eco-environment benefits were often ignored by people. But once the extreme meteorological risks come like storm surge flooding events (Davlasheridze et al. 2019) and urban heat waves (Berardi, Jandaghian, and Graham 2020), the SSVs of the non-exposed greenspace become more apparent.

Limitations and future work

There were still some limitations in our research. Firstly, the concepts of exposed greenspace and non-exposed greenspace were initially put forward and the applications of four typical greenspaces, but the methodology to identify the exposed greenspace and non-exposed greenspace is not well developed. Therefore, identifying the spatial distribution of exposed greenspace and non-exposed greenspace around people will be an urgent work, especially in cities. Secondly, we only considered the value orientations of four typical greenspaces individually, including forestland, grassland, water body and wetland. The value orientations of combination of greenspace types should be explored to guide urban greenspace planning and design. Thirdly, we just compared the relative value orientations of different greenspaces, the quantitative valuation of the true or practical ESV and SSV of greenspace in unit area need further exploration based on the exposure characteristics of different greenspaces to different people as people's value orientations of greenspace may change with the time and place. Therefore, the availability, accessibility, and visibility should be integrated into the value orientations and evaluation study of greenspace exposure.

Conclusion

Greenspace supplied multiple ecosystem services and socioeconomic services to meet the diverse demands of humans. Therefore, greenspace had both ESVs and SSVs at the same time. Although the ecologist included the culture service value into the ESVs, the SSVs of greenspace are much underestimated, especially in population concentrated cities. Fewer researches on the value orientations of greenspace explored the value orientations of ESVs and SSVs in different greenspaces. In this study, a new perspective of human exposure was introduced into greenspace classification system, namely the exposed and non-exposed greenspace, and quantitatively evaluated the value orientations of the ESVs and SSVs of greenspace based on the values derived from an expert-based questionnaire survey. This study found that the values of exposed greenspace were far higher than non-exposed greenspace. For different greenspaces, forestland and grassland had high ESVs and SSVs (ESVs

$_{\text{Forestland}}$ = 3.87, ESVs $_{\text{Grassland}}$ = 3.52, SSVs $_{\text{Forestland}}$ = 4.12, SSVs $_{\text{Grassland}}$ = 4.12), wetland had high ESVs (3.71) but low SSVs (2.56), the ESVs (3.51) and SSVs (3.55) of water body was balanced. To maximize the values of greenspace, forestland and grassland should have the priority for both the exposed and non-exposed greenspace because they had high ESVs and SSVs (ESVs $_{\text{Forestland}}$ = 3.87, SSVs $_{\text{Forestland}}$ = 4.12, ESVs $_{\text{Grassland}}$ = 3.52, SSVs $_{\text{Grassland}}$ = 4.12). Wetland was less suitable for exposed greenspace, because it had high ESVs (3.71) but low SSVs (2.56). The SSVs (3.55) and ESVs (3.51) of water bodies were balanced. Further, the value orientations' differentiations of ESVs and SSVs among four greenspaces were discussed, which found that ESVs were positively related to the greenspace's biomass and SSVs were more related to the people's exposure modes. To improve the ESVs of greenspace, maintaining healthy greenspace ecosystems should be put first. Meanwhile, improving accessibility and attraction of greenspace can be good solutions to improve the SSVs of greenspace. In conclusion, this study provides an actionable scientific basis for greenspace's planning, design, and construction by introducing the perspective of exposure to comprehensively consider the value orientations of the ESVs and SSVs in different greenspaces.

Disclosure statement

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References

Bagstad, K. J., G. W. Johnson, B. Voigt, and F. Villa. 2013. "Spatial Dynamics of Ecosystem Service Flows: A Comprehensive Approach to Quantifying Actual Services." *Ecosystem Services* 4: 117–125. doi:10.1016/j.ecoser.2012.07.012.

Bagstad, K. J., F. Villa, D. Batker, J. Harrison-Cox, B. Voigt, and G. W. Johnson. 2014. "From Theoretical to Actual Ecosystem Services: Mapping Beneficiaries and Spatial Flows in Ecosystem Service Assessments." *Ecology and Society*. Society 19 2: 743–756. 10.5751/ES-06523-190264.

Bengston, D. N., T. J. Webb, and D. P. Fan. 2004. "Shifting Forest Value Orientations in the United States, 1980-2001: A Computer Content Analysis." *Environmental Values* 13 (3): 373–392. doi:10.3197/0963271041323312734.

Berardi, U., Z. Jandaghian, and J. Graham. 2020. "Effects of Greenery Enhancements for the Resilience to Heat Waves: A Comparison of Analysis Performed through Mesoscale (WRF) and Microscale (Envi-met) Modeling." *Science of the Total Environment* 747: 141300. doi:10.1016/j.scitotenv.2020.141300.

Borrelli, P., P. Panagos, J. Langhammer, B. Apostol, and B. Schütt. 2016. "Assessment of the Cover Changes and the Soil Loss Potential in European Forestland: First Approach to Derive Indicators to Capture the Ecological Impacts on soil-related Forest Ecosystems." *Ecological Indicators* 60: 1208–1220. doi:10.1016/j.ecolind.2015.08.053.

Bowler, D. E., L. M. Buyung-Ali, T. M. Knight, and A. S. Pullin. 2010. "A Systematic Review of Evidence for the Added Benefits to Health of Exposure to Natural Environments." *BMC Public Health* 10 (1): 1–10. doi:10.1186/1471-2458-10-456.

Bratman, G. N., C. B. Anderson, M. G. Berman, B. Cochran, S. D. Vries, J. Flanders, C. Folke, et al. 2019. "Nature and Mental Health: An Ecosystem Service Perspective." *Science Advances* 5 (7): eaax0903. doi:10.1126/sciadv.aax0903.

Capaldi, C. A., R. L. Dopko, and J. M. Zelenski. 2014. "The Relationship between Nature Connectedness and Happiness: A meta-analysis." *Frontiers in Psychology* 5: 976. doi:10.3389/fpsyg.2014.00976.

Chen, J., and Z. Chang. 2015. "Rethinking Urban Green Space Accessibility: Evaluating and Optimizing Public Transportation System through Social Network Analysis in Megacities." *Landscape and Urban Planning* 143: 150–159. doi:10.1016/j.landurbplan.2015.07.007.

Chen, Y.-S., and S.-T. Wu. 2021. "An Exploration of actor-network Theory and Social Affordance for the Development of A Tourist Attraction: A Case Study of A Jimmy-related Theme Park, Taiwan." *Tourism Management* 82: 104206. doi:10.1016/j.tourman.2020.104206.

Coon, J. T., K. Boddy, K. Stein, R. Whear, J. Barton, and M. Depledge. 2011. "Does Participating in Physical Activity in Outdoor Natural Environments Have A Greater Effect on Physical and Mental Wellbeing than Physical Activity Indoors? A Systematic Review." *Environmental Science & Technology* 45 (5): 1761. doi:10.1021/es102947t.

Costanza, R. 2012. "Ecosystem Health and Ecological Engineering." *Ecological Engineering* 45: 24–29. doi:10.1016/j.ecoleng.2012.03.023.

Cramer, L. A., J. J. Kennedy, R. S. Krannich, and T. M. Quigley. 1993. "Changing Forest Service Values and Their Implications for Land Management Decisions Affecting Resource-Dependent Communities." *Rural Sociology* 58 (3): 475–491. doi:10.1111/j.1549-0831.1993.tb00506.x.

Daams, M. N., F. J. Sijtsma, and P. Veneri. 2019. "Mixed Monetary and non-monetary Valuation of Attractive Urban Green Space: A Case Study Using Amsterdam House Prices." *Ecological Economics* 166: 106430. doi:10.1016/j.ecolecon.2019.106430.

Davlasheridze, M., K. O. Atoba, S. Brody, W. Highfield, W. Merrell, B. Ebersole, A. Purdue, and R. W. Gilmer. 2019. "Economic Impacts of Storm Surge and the cost-benefit Analysis of a Coastal Spine as the Surge Mitigation Strategy in Houston-Galveston Area in the USA." *Mitigation and Adaptation Strategies for Global Change* 3 (3): 329–354. doi:10.1007/s11027-018-9814-z.

Diener, A., and P. Mudu. 2021. "How Can Vegetation Protect Us from Air Pollution? A Critical Review on Green Spaces' Mitigation Abilities for air-borne Particles from A Public Health Perspective - with Implications for Urban Planning." *Science of the Total Environment* 796: 148605. doi:10.1016/j.scitotenv.2021.148605.

Dobbs, C., F. J. Escobedo, and W. C. Zipperer. 2010. "A Framework for Developing Urban Forest Ecosystem Services and Goods Indicators." *Landscape and Urban Planning* 99 (3–4): 196–206. doi:10.1016/j.landurbplan.2010.11.004.

Ekkel, E. D., and D. V. Sjerp. 2017. "Nearby Green Space and Human Health: Evaluating Accessibility Metrics." *Landscape and Urban Planning* 157: 214–220. doi:10.1016/j.landurbplan.2016.06.008.

Gao, Z., K. Song, Y. Pan, D. Malkinson, X. Zhang, B. Jia, T. Xia, et al. 2021. "Drivers of Spontaneous Plant Richness Patterns in Urban Green Space within a Biodiversity Hotspot." *Urban Forestry & Urban Greening* 61: 127098. doi:10.1016/j.ufug.2021.127098.

Gascon, M., G. Sánchez-Benavides, P. Dadvand, D. Martínez, N. Gramunt, X. Gotsens, M. Cirach, et al. 2018. "Long-term Exposure to Residential Green and Blue Spaces and Anxiety and Depression in Adults: A cross-sectional Study." *Environmental Research* 162: 231–239. doi:10.1016/j.envres.2018.01.012.

Grabowski, Z. J., T. Mcphearson, A. M. Matsler, P. Groffman, and S. T. Pickett. 2022. "What Is Green Infrastructure? A Study of Definitions in US City Planning." *Frontiers in Ecology the Environment* 20 (3): 152–160. doi:10.1002/fee.2445.

Grote, R., R. Samson, R. Alonso, J. H. Amorim, P. Cariñanos, G. Churkina, S. Fares, D. L. Thiec, Ü. Niinemets, and T. N. Mikkelsen. 2017. "Functional Traits of Urban Trees: Air Pollution Mitigation Potential." *Frontiers in Ecology and the Environment* 14 (10): 543–550. doi:10.1002/fee.1426.

Hall, B. L., and D. E. Clover. 1997. "The Future Begins Today: Nature as Teacher in Environmental Adult Popular Education." *Futures* 29 (8): 737–747. doi:10.1016/S0016-3287(97)00054-2.

Hauru, K., S. Koskinen, D. J. Kotze, and S. Lehvävirta. 2014. "The Effects of Decaying Logs on the Aesthetic Experience and Acceptability of Urban Forests – Implications for Forest Management." *Landscape and Urban Planning* 123: 114–123. doi:10.1016/j.landurbplan.2013.12.014.

Huang, Y., T. Lin, G. Zhang, Y. Zhu, Z. Zeng, and H. Ye. 2021. "Spatial Patterns of Urban Green Space and Its Actual Utilization Status in China Based on Big Data Analysis." *Big Earth Data* 5 (3): 391–409. doi:10.1080/20964471.2021.1939990.

Hutchins, M., D. Fletcher, A. Hagen-Zanker, H. Jia, L. Jones, H. Li, S. Loiselle, et al. 2021. "Why Scale Is Vital to Plan Optimal Nature-Based Solutions for Resilient Cities." *Environmental Research Letters* 16 (4): 044008. doi:10.1088/1748-9326/abd9f4.

Inglehart, R., and W. E. Baker. 2000. "Modernization, Cultural Change, and the Persistence of Traditional Values." *American Sociological Review* 65 (1): 19–51. doi:10.2307/2657288.

Kajosaari, A., and T. P. Pasanen. 2021. "Restorative Benefits of Everyday Green Exercise: A Spatial Approach." *Landscape and Urban Planning* 206: 103978. doi:10.1016/j.landurbplan.2020.103978.

Koen, E. L., E. H. Ellington, and J. Bowman. 2019. "Mapping Landscape Connectivity for Large Spatial Extents." *Landscape Ecology* 10 (10): 2421–2433. doi:10.1007/s10980-019-00897-6.

Kraft, V. 1981. *"The Science of Value."* Berlin: Springer Netherlands.

Kronenberg, J., A. Haase, E. Łaszkiewicz, A. Antal, A. Baravikova, M. Biernacka, D. Dushkova, et al. 2020. "Environmental Justice in the Context of Urban Green Space Availability, Accessibility, and Attractiveness in Postsocialist Cities." *Cities* 106: 102862. doi:10.1016/j.cities.2020.102862.

Labib, S. M., S. Lindley, and J. J. Huck. 2020. "Spatial Dimensions of the Influence of Urban green-blue Spaces on Human Health: A Systematic Review." *Environmental Research* 180: 108869. doi:10.1016/j.envres.2019.108869.

Li, J., and J. Ernst. 2015. "Exploring Value Orientations toward the human–nature Relationship: A Comparison of Urban Youth in Minnesota, USA and Guangdong, China." *Environmental Education Research* 21 (4): 556–585. doi:10.1080/13504622.2014.910499.

Li, D., S. Wu, L. Liu, Z. Liang, and S. Li. 2017. "Evaluating Regional Water Security through A Freshwater Ecosystem Service Flow Model: A Case Study in Beijing-Tianjian-Hebei Region, China." *Ecological Indicators* 81: 159–170. doi:10.1016/j.ecolind.2017.05.034.

Lin, T., X. Liu, J. Song, G. Zhang, Y. Jia, Z. Tu, Z. Zheng, and C. Liu. 2018. "Urban Waterlogging Risk Assessment Based on Internet Open Data: A Case Study in China." *Habitat International* 71: 88–96. doi:10.1016/j.habitatint.2017.11.013.

Liotta, C., Y. Kervinio, H. Levrel, and L. Tardieu. 2020. "Planning for Environmental Justice - Reducing well-being Inequalities through Urban Greening." *Environmental Science and Policy* 112: 47–60. doi:10.1016/j.envsci.2020.03.017.

Liu, Y., Y. Wang, P. Yu, W. Xiong, F. Mo, and Z. Wang. 2011. "Biomass and Its Allocation of the Main Vegetation Types in Liupan Mountains." *Forest Research* 24: 443–452.

Liu, O. Y., and A. Russo. 2021. "Assessing the Contribution of Urban Green Spaces in Green Infrastructure Strategy Planning for Urban Ecosystem Conditions and Services." *Sustainable Cities and Society* 68: 102772. doi:10.1016/j.scs.2021.102772.

Maslov, A. H. 1987. *"Motivation and Personality*. 3rd ed.)" ed. New York, NY: Harper and Row.

Masoudi, M., P. Y. Tan, and M. Fadaei. 2021. "The Effects of Land Use on Spatial Pattern of Urban Green Spaces and Their Cooling Ability." *Urban Climate* 35: 100743. doi:10.1016/j.uclim.2020.100743.

Mennis, J., M. Mason, and A. Ambrus. 2018. "Urban Greenspace Is Associated with Reduced Psychological Stress among Adolescents: A Geographic Ecological Momentary Assessment (GEMA) Analysis of Activity Space." *Landscape and Urban Planning* 174: 1–9. doi:10.1016/j.landurbplan.2018.02.008.

Mitchell, R., and F. Popham. 2008. "Effect of Exposure to Natural Environment on Health Inequalities: An Observational Population Study." *Lancet* 372 (9650): 1655–1660. doi:10.1016/S0140-6736(08)61689-X.

Navarrete-Hernandez, P., and K. Laffan. 2019. "A Greener Urban Environment: Designing Green Infrastructure Interventions to Promote Citizens' Subjective Wellbeing." *Landscape and Urban Planning* 191: 103618. doi:10.1016/j.landurbplan.2019.103618.

Otto, S., and P. Pensini. 2017. "Nature-based Environmental Education of Children: Environmental Knowledge and Connectedness to Nature, Together, are Related to Ecological Behaviour." *Global Environmental Change* 47: 88–94. doi:10.1016/j.gloenvcha.2017.09.009.

Paul, A., T. K. Nath, S. J. Noon, M. M. Islam, and A. M. Lechner. 2020. "Public Open Space, Green Exercise and well-being in Chittagong, Bangladesh." *Urban Forestry & Urban Greening* 55: 126825. doi:10.1016/j.ufug.2020.126825.

Russell, R. C. 1999. "Constructed Wetlands and Mosquitoes: Health Hazards and Management options—An Australian Perspective." *Ecological Engineering* 12 (1–2): 107–124. doi:10.1016/S0925-8574(98)00057-3.

Salete Capellesso, E., A. Cequinel, R. Marques, T. Luisa Sausen, C. Bayer, and M. C. M. Marques. 2021. "Co-benefits in Biodiversity Conservation and Carbon Stock during Forest Regeneration in a Preserved Tropical Landscape." *Forest Ecology and Management* 492: 119222. doi:10.1016/j.foreco.2021.119222.

Santos, A., A. Carvalho, and A. Barbosa-Póvoa. 2021. "An Economic and Environmental Comparison between Forest Wood Products – Uncoated Woodfree Paper, Natural Cork Stoppers and Particle Boards." *Journal of Cleaner Production* 296: 126469. doi:10.1016/j.jclepro.2021.126469.

SayA., and J. Say. 2010. "Conservation Psychology: Understanding and Promoting Human Care for Nature, Susan Clayton, Gene Myers. Wiley-Blackwell, Oxford (2009). 251 pp. Price 29.99, Paperback, ISBN: 978-1-4051-9409-9". *Biological Conservation*. Vol. 143(5) , 1305. doi:10.1016/j.biocon.2010.03.005.

Shah, A., A. Garg, and V. Mishra. 2021. "Quantifying the Local Cooling Effects of Urban Green Spaces: Evidence from Bengaluru, India." *Landscape and Urban Planning* 209: 104043. doi:10.1016/j.landurbplan.2021.104043.

Shi, D., J. Song, J. Huang, C. Zhuang, R. Guo, and Y. Gao. 2020. "Synergistic Cooling Effects (Sces) of Urban green-blue Spaces on Local Thermal Environment: A Case Study in Chongqing, China." *Sustainable Cities and Society* 55: 102065. doi:10.1016/j.scs.2020.102065.

Silva, L. T., F. Fonseca, M. Pires, and B. Mendes. 2019. "SAUS: A Tool for Preserving Urban Green Areas from Air Pollution." *Urban Forestry & Urban Greening* 46: 126440. doi:10.1016/j.ufug.2019.126440.

Song, Y., B. Huang, J. Ca, and B. Chen. 2018. "Dynamic Assessments of Population Exposure to Urban Greenspace Using multi-source Big Data." *Science of the Total Environment* 634: 1315. doi:10.1016/j.scitotenv.2018.04.061.

Sonntag-Öström, E., T. Stenlund, M. Nordin, Y. Lundell, C. Ahlgren, A. Fjellman-Wiklund, L. S. Järvholm, and A. Dolling. 2015. "Nature's Effect on My Mind" – Patients' Qualitative Experiences of a forest-based Rehabilitation Programme." *Urban Forestry & Urban Greening* 14 (3): 607–614. doi:10.1016/j.ufug.2015.06.002.

Stephenson, L., P. Stockham, C. van den Heuvel, and R. W. Byard. 2020. "Characteristics of Drowning Deaths in an Inner City River." *Legal Medicine* 47: 101783. doi:10.1016/j.legalmed.2020.101783.

Taylor, L., E. H. Leckey, and D. F. Hochuli. 2020. "Focus Groups Identify Optimum Urban Nature in Four Australian and New Zealand Cities." *Urban Ecosystems* 23 (1): 199–213. doi:10.1007/s11252-019-00910-5.

Tyrväinen, L., A. Ojala, K. Korpela, T. Lanki, Y. Tsunetsugu, and T. Kagawa. 2014. "The Influence of Urban Green Environments on Stress Relief Measures: A Field Experiment." *Journal of Environmental Psychology* 38: 1–9. doi:10.1016/j.jenvp.2013.12.005.

U.S.EPA. 1992. "Guidelines for Exposure Assessment".Federal Register 57:46304–46312

Wan, T., and Y. Ma. 2021. "Design of Slow Traffic System in New Urban Area Based on Accessibility." *Modern Electronics Technique*, 44(18): 53–57. doi:10.16652/j.issn.1004-373x.2021.18.011. (In Chinese).

Webb, T. J., D. N. Bengston, and D. P. Fan. 2008. "Forest Value Orientations in Australia: An Application of Computer Content Analysis." *Environmental Management* 41 (1): 52–63. doi:10.1007/s00267-007-9011-4

Wendling, L., J. Garcia, D. Descoteaux, B. Sowińska-Świerkosz, T. McPhearson, N. Frantzeskaki, D. L. Rosa, et al. 2021. "Editorial: Introduction to the Nature-Based Solutions Journal." *Nature-Based Solutions* 1: 100003. doi:10.1016/j.nbsj.2021.100003

Wu, J. 2013. "Landscape Sustainability Science: Ecosystem Services and Human well-being in Changing Landscapes." *Landscape Ecology* 28 (6): 999–1023. doi:10.1007/s10980-013-9894-9

Wu, J., H. Chen, H. Wang, Q. He, and K. Zhou. 2020. "Will the Opening Community Policy Improve the Equity of Green Accessibility and in What Ways? — Response Based on a 2-step Floating Catchment Area Method and Genetic Algorithm." *Journal of Cleaner Production* 263: 121454. doi:10.1016/j.jclepro.2020.121454.

Xie, G., C. Lu, Y. Leng, D. Zheng, and S. Li. 2003. "Ecological Assets Valuation of the Tibetan Plateau." *Journal of Natural Resources* 18 189–196. In Chinses

Xie, G., L. Zhen, C. Lu, Y. Xiao, and C. Chen. 2008. "Expert knowledge-based Valuation Method of Ecosystem Services in China." *Journal of Natural Resources* 23 911–919. In Chinses

Xu, C., L. Dong, C. Yu, Y. Zhang, and B. Cheng. 2020. "Can Forest City Construction Affect Urban Air Quality? The Evidence from the Beijing-Tianjin-Hebei Urban Agglomeration of China." *Journal of Cleaner Production* 264: 121607. doi:10.1016/j.jclepro.2020.121607

Yao, L., T. Li, M. Xu, and Y. Xu. 2020. "How the Landscape Features of Urban Green Space Impact Seasonal Land Surface Temperatures at a city-block-scale: An Urban Heat Island Study in Beijing, China." *Urban Forestry & Urban Greening* 52: 126704. doi:10.1016/j.ufug.2020.126704

Zhang, Z., J. Liu, B. Shen, P. Liu, W. Wei, P. Gao, and Y. Zhang. 2011. "Evaluation of Ecosystem Services of Yongding River in Beijing." *Acta Scientiae Circumstantiae* 31 1851–1857. In Chinese

Zhang, Y., and Y. Piao. 2012. "Study on Factors Influencing the Attraction of Green Space with Jinan and Tai'an in China as the Examples." *Chinese Landscape Architecture* 28 104–108. In Chinese

Zhang, L., S. Zhou, M. P. Kwan, F. Chen, and R. Lin. 2018. "Impacts of Individual Daily Greenspace Exposure on Health Based on Individual Activity Space and Structural Equation Modeling." *International Journal of Environmental Research and Public Health* 15 (10): 2323. doi:10.3390/ijerph15102323

Zhang, R., C. Zhang, and R. Rhodes. 2021a. "The Pathways Linking objectively-measured Greenspace Exposure and Mental Health: A Systematic Review of Observational Studies." *Environmental Research* 198: 111233. doi:10.1016/j.envres.2021.111233

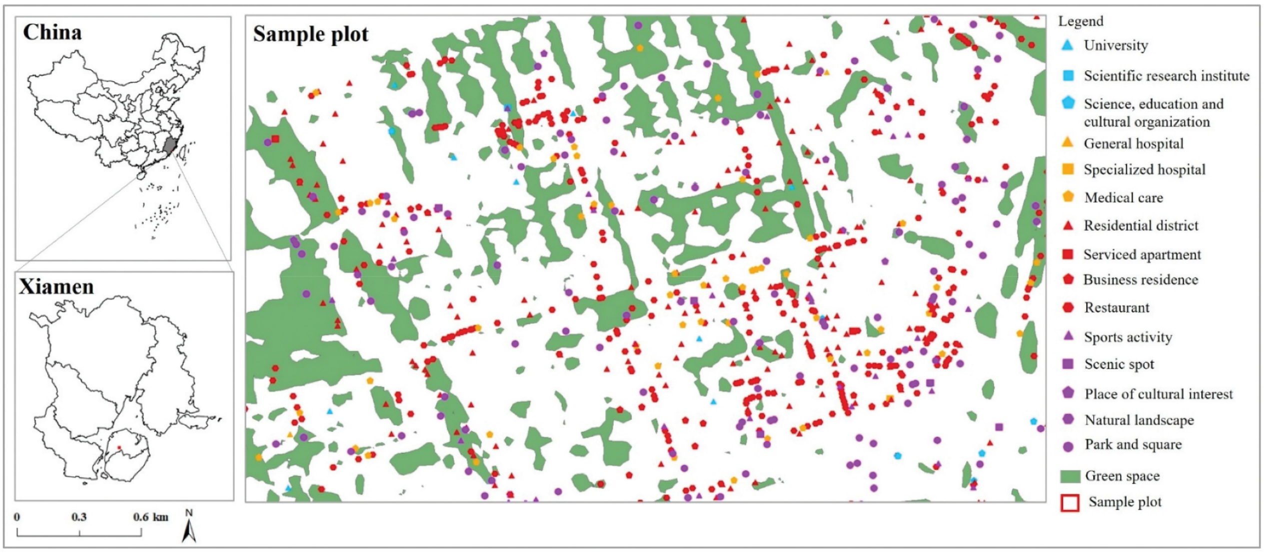
Zhang, R., L. Zhang, Q. Zhong, Q. Zhang, Y. Ji, P. Song, and Q. Wang. 2021b. "An Optimized Evaluation Method of an Urban Ecological Network: The Case of the Minhang District of Shanghai." *Urban Forestry & Urban Greening* 62: 127158. doi:10.1016/j.ufug.2021.127158

Zhao, J., X. Liu, R. Dong, and G. Shao. 2016. "Landsenses Ecology and Ecological Planning toward Sustainable Development." *International Journal of Sustainable Development & World Ecology* 23 (4): 293–297. doi:10.1080/13504509.2015.1119215

Zhao, C., W. Li, and Q. Zhong. 2019. "Study on Optimization of Xianlin Green Space Network in Nanjing Based on Ecological Corridor Constrution." *Modern Urban Research*, 42, (In Chinese): 28–35 doi:10.3969/j.issn.1009-6000.2019.10,004

Appendices

Appendix 1 The spatial distribution of greenspace and its relationship with various POI (an example in Xiamen City)



(This map was made based on GS (2019)1698 standard map downloaded from the standard map service website of the Ministry of Natural Resources, and the base map was not modified.)

Appendix 2

Table A1. Equivalent values per unit area of ecosystem services in China (Xie et al. 2008).

Items	Forestland	Grassland	Farmland	Wetland	Water body	Desert
Food production	0.33	0.43	1.00	0.36	0.53	0.02
Raw materials production	2.98	0.36	0.39	0.24	0.35	0.04
Gas regulation	4.32	1.50	0.72	2.41	0.51	0.06
Climate regulation	4.07	1.56	0.97	13.55	2.06	0.13
Water conservation	4.09	1.52	0.77	13.44	18.77	0.07
Waste treatment	1.72	1.32	1.39	14.40	14.85	0.26
Soil formation and conservation	4.02	2.24	1.47	1.99	0.41	0.17
Biodiversity maintenance	4.51	1.87	1.02	3.69	3.43	0.40
Aesthetic landscape	2.08	0.87	0.17	4.69	4.44	0.24

Appendix 3

1. What is your gender?						
☐ Male				☐ Female		Total number
79				45		124
2. What is your age?						
☐ 20-30	☐ 30-40		☐ 40-50	☐ 50-60	☐ >60	Total number
21	55		36	9	3	124
3. What is your education level?						
☐ Undergraduate		☐ Master		☐ Doctor		Total number
4		20		100		124
4. Where are you work?						
☐ School		☐ Research institute	☐ Enterprise		☐ Government	Total number
70		45	3		6	124
5. What is your professional title?						
☐ Junior title	☐ Intermediate title		☐ Associate senior professional title	☐ Senior professional title	☐ No title	Total number
11	18		38	45	12	124
6. Do you think green space is valuable for catering service?						
☐ Yes				☐ No		Total number
112				12		124
7. How much value do you think the four types of green space have for catering service?						
	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	5	12	31	34	30	112
Grassland	3	2	26	42	39	112
Water body	6	11	26	35	34	112
Wetland	31	30	30	17	4	112
8. Do you think green space is valuable for housing?						
☐ Yes				☐ No		Total number
120				4		124
9. How much value do you think the four types of green space have for housing?						
	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	4	7	20	39	50	120
Grassland	3	6	13	51	47	120
Water body	6	14	30	41	29	120
Wetland	35	30	25	25	5	120
10. Do you think green space is valuable for education?						
☐ Yes				☐ No		Total number
105				19		124
11. How much value do you think the four types of green space have for education?						
	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	3	8	20	35	39	105
Grassland	4	5	18	40	38	105
Water body	9	14	33	29	20	105
Wetland	25	27	24	21	8	105
12. Do you think green space is valuable for sports activity?						
☐ Yes				☐ No		Total number
118				6		124
13. How much value do you think the four types of green space have for sports activity?						
	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	4	10	15	31	58	118
Grassland	3	4	14	34	63	118
Water body	11	14	34	34	25	118
Wetland	39	23	36	14	6	118
14. Do you think green space is valuable for medical treatment?						
☐ Yes				☐ No		Total number
107				17		124

(*Continued*)

(Continued).

1. What is your gender?

15. How much value do you think the four types of green space have for medical treatment?

	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	3	2	17	16	69	107
Grassland	3	2	19	35	48	107
Water body	11	14	29	27	26	107
Wetland	38	23	31	10	5	107

16. Do you think green space is valuable for scenic spot?

☐ Yes	☐ No	Total number
118	6	124

17. How much value do you think the four types of green space have for scenic spot?

	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	2	1	7	20	88	118
Grassland	1	5	15	34	63	118
Water body	4	11	19	35	49	118
Wetland	21	18	29	25	25	118

18. Do you think green space is valuable for place of cultural interest?

☐ Yes	☐ No	Total number
115	9	124

19. How much value do you think the four types of green space have for place of cultural interest?

	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	2	4	19	35	55	115
Grassland	2	4	31	33	45	115
Water body	6	11	32	34	32	115
Wetland	24	32	29	20	10	115

20. Do you think green space is valuable for natural landscape?

☐ Yes	☐ No	Total number
114	10	124

21. How much value do you think the four types of green space have for natural landscape?

	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	2	3	8	23	78	114
Grassland	1	4	15	30	64	114
Water body	3	10	25	28	48	114
Wetland	6	20	26	25	37	114

22. Do you think green space is valuable for park and square?

☐ Yes	☐ No	Total number
120	4	124

23. How much value do you think the four types of green space have for park and square?

	☐ 1 (Extremely low)	☐ 2 (Low)	☐ 3 (Medium)	☐ 4 (High)	☐ 5 (Extremely high)	Total number
Forestland	2	3	14	33	68	120
Grassland	1	2	8	34	75	120
Water body	4	10	21	42	43	120
Wetland	20	27	25	29	19	120