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Assessing public perceptions of ecosystem services in peri-urban mediterranean wetlands: a case study for a restorative NBS in Catalonia, Spain

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Abstract

Recent research has assessed public perceptions of Mediterranean rivers, but there are limited investigations into the public perceptions of Mediterranean wetlands, especially in urbanized spaces like peri-urban parks. This study addresses this gap by assessing public perceptions across different sociodemographic groups for their level of awareness of different ecosystem services in a peri-urban park located in the Mediterranean region of Catalonia, Spain. Parc del Falgar is the site of a fluvial restoration project aimed at improving water quality by retaining and transforming nutrients through the park's nature-based solution. A two-part survey was organized using a 5-level Likert scale, and a multiple-choice sociodemographic questionnaire followed by semi-structured interviews with local actors. Regression models and Mann-Whitney U tests were used to analyze the gathered data and evaluate differences between groups, incorporating Bonferroni adjustments to account for multiple comparisons. The findings revealed that age significantly affects perceptions of the park's ecosystem services, resulting in a greater awareness of the park's biodiversity and wetland restoration. Visitors living closer to nature and those with higher incomes were more aware of the park's cultural ecosystem services including recreational and leisure activities. Through interviews with local actors, this study discusses the juxtaposition of traditional environmental learning with modern digital technology for ecosystem service awareness and highlights different learning preferences across social groups for the uptake of ecosystem service awareness. Management proposals from interviewees stress involving scientific and non-scientific experts to capture the full range of the park's ecosystem services.

Keywords Ecosystem services · Public perceptions · Sociodemographic groups · Wetland restoration · Peri-urban park

Introduction

According to the Living Planet Index, fluvial biodiversity has decreased by 83% between 1970 and 2014, making fluvial ecosystems one of the most deteriorated ecosystems globally and in the Mediterranean (Grooten et al. 2018). In Catalonia, Spain, the decline in fluvial biodiversity has reached 92% (Brotons et al. 2020). Initiatives such as the Catalan Wastewater Treatment Plan and the Water Framework Directive have aided in implementing more local adaptations for treating anthropogenic-charged wastewater. These include using nature-based solutions (NBS) aimed at sustainably managing natural or modified ecosystems that also address ecological and societal challenges to benefit both people and nature (IUCN 2020). Importantly, the urgency of restoring wetlands as an integral part of the Mediterranean's urban landscape cannot be overstated. Over the

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past five decades, Spanish wetlands have seen a distressing decline of over 60% in the ecosystem services (ES) that they provide due to changing land uses (Zorrilla-Miras et al. 2014). Drivers of change include increasing interactions between people and natural spaces, which have resulted in a greater demand for the ES that fluvial systems provide. The pressure on fluvial systems has been so strong that they are currently unable to provide many ES demanded mostly by urban people (Vidal-Abarca et al. 2014). In parallel with European initiatives like the Nature Restoration Law (*The EU #NatureRestoration Law*2023), aimed at addressing biodiversity loss and the effects of global change on aquatic and terrestrial ecosystems, there is a growing interest in assessing ES in fluvial landscapes and evaluating their perceived benefits to the public (Vidal Gimenez and Ruiz Mas 2020).

Public perceptions of mediterranean peri-urban wetlands

While recent research has assessed public perceptions of Mediterranean rivers, there are limited investigations into the public perceptions of Mediterranean wetlands, particularly in urbanized spaces like peri-urban parks. Assessing social perceptions of the ES provided by fluvial restoration helps identify and attribute value to the many ES in urban fluvial environments (Durán Vian et al. 2018). These services are abundant and range from provisional services such as water supply, regulatory services like water purification, cultural services such as aesthetic appreciation, and supportive services like nutrient retention (Keeler et al. 2012; Vidal-Abarca et al. 2014). Wetlands in urban environments increase awareness of the associated environmental impacts and risks for the growing demand for ES (Velasco et al. 2018), while awareness of wetlands' ecological attributions has translated into a willingness to pay a fee to ensure the conservation and sustainable use of the fluvial landscape (Pueyo-Ros et al. 2018). Additionally, compared to other land-cover types, wetlands are often perceived as enhancing aesthetic beauty and environmental quality (Pederson et al. 2019). However, potential ecosystem disservices can decrease wetlands' likeability in urban spaces. These include pests, poor accessibility, unattractiveness, and antisocial activities (Plieninger et al. 2022; Scholte et al. 2016). Nevertheless, peri-urban wetlands are socially desirable, and water landscapes are known to foster positive interactions between people and nature, increasing nature affinity and social conviction to protect natural aquatic spaces (Carrus et al. 2015; García-Llorente et al. 2020; Romagosa et al. 2020).

As defined by the Millennium Ecosystem Assessment (MEA), cultural ecosystem services (CES) encompass spiritual and religious aspects, recreation and ecotourism, aesthetic qualities, inspiration, education, sense of place, and cultural heritage (MEA 2005). The goods and services derived from CES are more difficult to evaluate due to their intangibility (Chan et al. 2012). Yet, their assessment is useful in urban planning as CES supports long-term sustainability for restoration projects in urban spaces (Riechers et al. 2016). Relational value for nature can arise when our perceptions of nature impact our identity, well-being, preferences, and beliefs, facilitating or, in some cases, excluding value for it (Chan et al. 2016). Relational values for ES extend beyond preference-based valuation to encompass the meanings ecosystems hold for people, emphasizing the need for qualitative approaches that capture contextual and place-based perceptions to understand how these relationships contribute to well-being (Stålhammar and Thorén 2019). In peri-urban environments, NBS plays a critical role in enhancing CES by creating opportunities for recreation, strengthening a sense of place, and promoting environmental learning (Flood et al. 2021; Hausmann et al. 2016). The uptake of such services occurs through cognitive, communicative, and regenerative mechanisms that shape human interactions with nature and ultimately contribute to well-being (Huynh et al. 2022). Encouragingly, CES research in Europe has been concentrated in Spain, yet water-related areas remain underexplored across the Global North (Madrigal-Martínez et al. 2025). Given that urban restoration projects aim to regain biodiversity and mitigate environmental disturbances caused by urban expansion, then integrating CES into NBS planning is essential for enhancing both ecological and social outcomes.

This study aims to address the gap in the literature for public perceptions of peri-urban Mediterranean restorative wetlands by investigating public perceptions of different landscape components at Parc del Falgar, a peri-urban fluvial park in Les Franqueses del Vallès, Catalonia (Spain), and comparing perceptions across different sociodemographic profiles to understand levels of awareness for the park's ES. Semi-structured interviews with local actors explore different management proposals for improving ES awareness. These included outdoor learning, citizen science, and interactive digital learning spaces.

Our study is guided by four research questions:

1. What are the public perceptions of Parc del Falgar and its surrounding wetland restoration?
2. What are the main differences in perceptions among different sociodemographic park visitors?
3. How do sociodemographic characteristics affect awareness of the park's ES?
4. Which management proposals can improve people's perceptions of Parc del Falgar?

Study area and methods

Study area

Parc del Falgar i la Verneda is a peri-urban park inside the municipality of Les Franqueses del Vallès in northeast Spain (Fig. 1). It was officially inaugurated in March 2019 and covers an expansive area of approximately 170,000m^2. It's located between the Congost River, belonging to the Congost River Basin, a significant sub-basin within the broader Besòs River Basin in Barcelona, Spain. The river's flow is maintained throughout the year and is sustained by water from nearby wastewater treatment plants (WWTP). At the south end of the park, there is a newly inaugurated educational facility. Several children's playscape zones and exercise equipment are in the recreational zone, and a circuit goes around the entire park that is used for walking and cycling. Before the opening of Parc del Falgar and Verneda Park, the space was occupied by different industrial groups, including a concrete plant, while the remaining landscape was barren agricultural land. The current terrain of Parc del Falgar is considered mostly dirt with grassy plains. Throughout this study, 'Parc del Falgar' refers to Parc del Falgar i la Verneda.

Inside Falgar is an artificial fluvial system consisting of several landscape elements. These include a stream, two wetlands, and a shallow lake that has a total surface of 21,430m^2. Starting at the north entrance, water flows into an artificial stream extending roughly 200 m which is considered the main bioremediation system. The water then moves through the first wetland, which consists of halophytes (cordgrass) that are salt tolerant and act as barriers and habitats for various aquatic and land animals. Water then reaches the second, larger wetland that is surrounded by *Phragmites australis* (reeds), a powerful plant that supports the removal of accumulated nutrients such as ammonium, heavy metals, and micropollutants (Milke 2020). Lastly, water enters a shallow lake with a high capacity for eliminating microbes such as E. coli. Acting as a flow-through chain of aquatic ecosystems, these systems are biogeochemically reactive and contribute to retaining and transforming nutrients through their self-purification capacity. The fluvial space

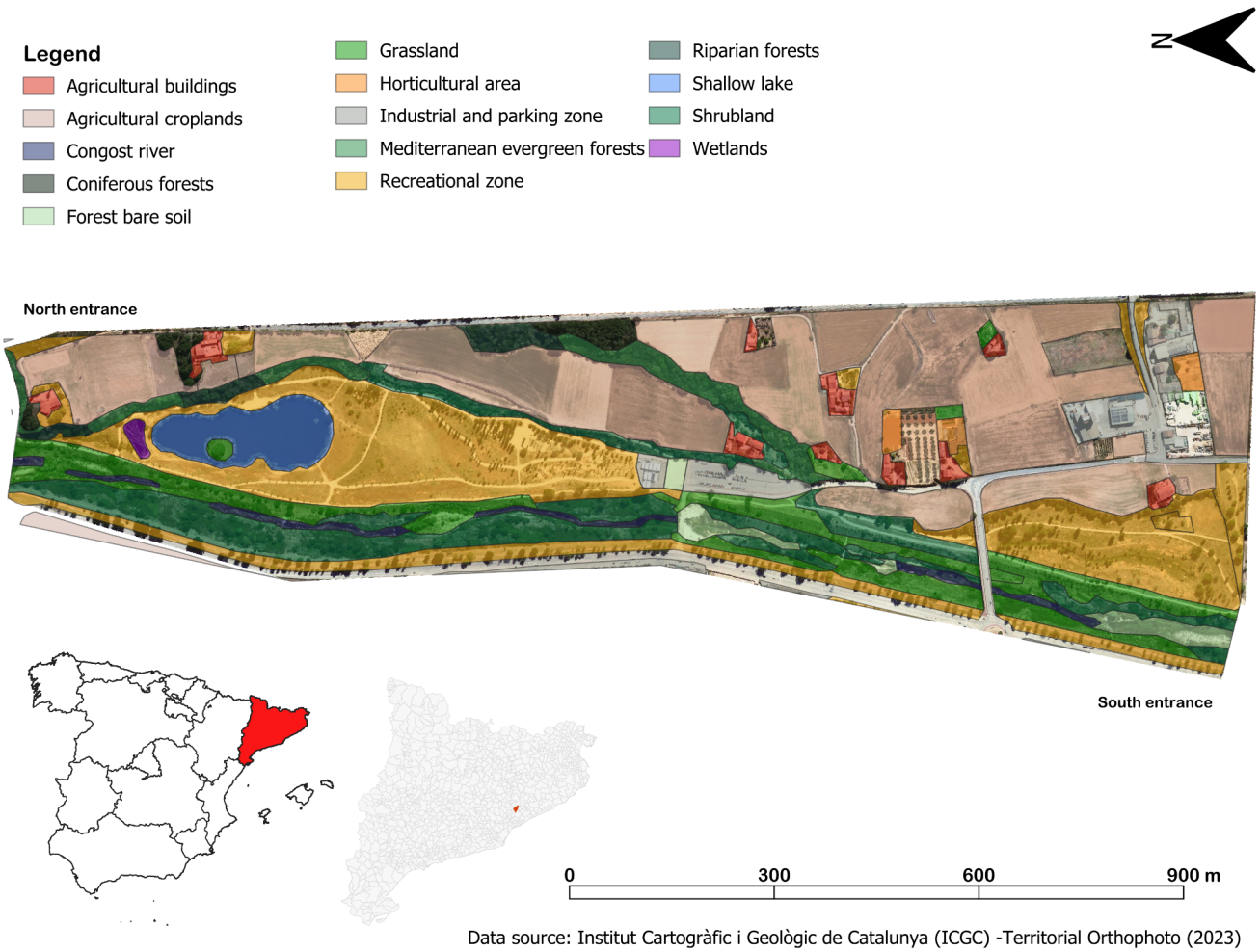

Fig. 1 Land use land cover map of Parc del Falgar. Les Franqueses del Vallès, Spain

is monitored for phosphorus (P), ammonium (NH_4^+), and E. coli nutrient levels that are collected monthly. Data for NH_4^+ was collected from January 2023 to July 2023 recording the intake and outtake levels for ammonium in the water as it enters the system compared to when it flows out of the system (Supplementary Material Fig. S5). Thick vegetation surrounds the parameters of the shallow lake and wetlands where habitats for native and migratory species are situated. Park benches and a walking trail circle the parameters of the entire fluvial space where a designated bird-watching area is located. The park is a part of the Natura 2000 Network, a coordinated EU initiative to protect vulnerable habitats and biodiversity.

Data collection methods

Survey questionnaire

This study carried out a two-part survey consisting of a 25-question participant questionnaire using a 5-level Likert scale and a multiple-choice sociodemographic questionnaire (See Fig. S1). Several investigations assessing the public perception of ES have used participatory approaches via questionnaires, focus groups, surveys, and interviews for their ability to capture information from the respondents (Dunford et al. 2018; Koschke et al. 2014; Croasmun & Ostrom 2011). Additionally, Likert scales have extensively been used in the socio-cultural valuation of ES (Maestre-Andrés et al. 2015). The use of a Likert scale asks respondents to answer within a range of agreeability while providing information that makes it possible to assess the main attitudes of the user population. Personal characteristics like age, income, and education are often studied when evaluating the public perception of ES, suggesting that the preferences of the user population should be accounted for (García-Llorente et al. 2020; Perni and Martínez-Paz 2017; Martín-López et al. 2012; Madrigal-Martínez et al. 2025). In our study, the level of agreement with the statements followed a scale from 1 to five, with one denoting "I strongly disagree" and five "I strongly agree".

A second part of the survey included the profiles of users at Falgar to evaluate the differences in social perceptions between socio-demographic groups. Social characteristics have been shown to affect the perceptions of users in fluvial spaces (Scholte et al. 2016). To that extent, eleven sociodemographic questions were developed and asked using a multi-choice scale. Questions included age, gender, level of education, employment status, personal income, frequency of visits to the park, mode of transportation, municipality of residence, percentage of residential natural surroundings, and interest in environmental volunteer work (See Fig. S2). Gender was evaluated following the SAGER guidelines, which define gender as the socially constructed roles, behaviors, and identities of women, men, and gender-diverse people that occur in a historical and cultural context and may vary across societies and over time. Table S1 depicts the summary of sociodemographic profiles ($n = 92$).

The survey statements are divided into three distinctive categories: general park statements (GPS), cultural ecosystem services (CES), and regulatory ecosystem services (RES), respectively (See Tables S2 and S3). The statements were individually ranked and quantified producing a value that was given to the different ES and general park information statements. The data was then compared to the sociodemographic profiles. A pilot questionnaire was carried out to define some of the final survey's parameters and improve respondents' comprehension. Questions that were given an "NA" or where respondents preferred not to answer were not included in the statistical analysis.

Data collection was random, at face-to-face intake, and took place on seven separate days spanning from the end of March to the beginning of May 2023. The time of data collection was divided into two sessions: morning collection from 10:00–14:00 and afternoon collection from 16:00–20:00. Both workdays and weekends were used to collect data. Researchers entered the south end of Parc del Falgar and walked northbound circulating through the various park spaces, i.e., the playground, exercise area, bike paths, and fluvial space. Park users were approached with a memorized script that included the researcher's name, a short introduction to the study, and a request to participate. Researchers spoke exclusively in Catalan and Spanish (See Fig S1 and S2). (See Table S5).

Semi-structured interviews

We conducted 5 interviews with local actors who at the time of the interview were involved with Parc del Falgar and the restoration system. They were selected based on reputation or recommendation and were distinguished into the following categories: municipal agency (one interviewee), higher education (one interviewee), and scientific institution (3 interviewees). The interview questions were formulated to enhance understanding of the main survey results by exploring potential management and communication proposals to improve some survey results regarding, *inter alia*, public knowledge on biodiversity, the park's recreational activities, and addressing the growing number of park visitors (See Table S4 and S5). The interviews lasted nearly 60 min and were recorded with the interviewee's consent. Interviews were transcribed and then translated from Spanish to English.

Data analysis methods

Qualitative data analysis of interviews

A Thematic Network as described by Attride (2001) was developed to organize and derive themes from the texts by extracting the themes prominent in the interviews at different levels and interpreting the qualitative data into a thematic analysis. Thematic networks are commonly employed in qualitative analysis because they utilize features shared among various qualitative approaches (Attride 2001). A coding framework was constructed based on the theoretical underpinnings guiding the research questions and the prominent themes that emerged during the interviews. Texts from the interviews were dissected into segments and coded by the distinct ES that was being addressed. Themes were identified through the interpretation of the collective texts and then further arranged into Basic Themes or simple characteristics of the data. The Basic Themes were then clustered together into similar issues identified as Organizing Themes that reflect the main assumptions stressed throughout the texts. Finally, Global Themes were deduced from the lower-order themes, representing what the interviews are about as a whole in the context of the analysis (See Table 1).

Statistical analysis

Our research was conducted using the R programming environment (version 4.0.2). To establish a foundational understanding of the data, we applied descriptive statistics to assess the central tendencies and dispersion of the variables. For example, we calculated the mean ratings for each statement from the collective responses of all participants. This approach provided a non-segmented overview of perception rankings across the dataset, enabling us to gauge the distribution of responses (Fig. 2).

We employed linear regression modeling to analyze quantitative and ordinal variables. Essential pre-modeling

Table 1 The framework for the thematic networks is divided into three columns: proposals expressed from the semi-structured interviews with local actors (Basic Themes) followed by the broader interpretation of the proposals (Organizational Themes), and the most abstract ideas expressed in interviews (Global Themes). Each Basic Theme has a correlating ES: Cultural Ecosystem Service (CES), Regulatory Ecosystem Service (RES), and General Park Statements (GPS)

	Basic Themes	Organizing Themes	Global Themes
CES	**1** Coordinating with schools is a tool for promoting student discovery, while educational activities facilitated through public and private partnerships can increase awareness of the park's ES		
CES	**2** Knowledge presented by distinct actors in the community will foster park ownership, appreciation, and a sense of well-being	Environmental stewardship through knowledge-sharing	
CES / RES	**3** Citizen science initiatives can encourage social participation and learning, while challenges to public monitoring should be addressed		Coordinated Stakeholder Engagement
CES / GPS	**4** The city council has a responsibility to the public and it should lead public outreach and collaborate with diverse actors to fund educational programs at Falgar	Shared governance	
CES / GPS	**5** The municipality's libraries are an important component for increasing the reach of resources and information for different ages		
CES / GPS	**6** Sponsorship with local companies and partnerships with local NGOs and naturalist organizations can do more than the City Council		
CES	**7** Talks and activities, including some playful and family activities for learning about more significant content	Park value is enhanced through adaptive learning spaces and inclusive communication	Equity and Inclusivity in Environmental Education
CES	**8** The nature classroom can serve as a meeting point for people who are active in botany and birdwatching		
CES	**9** Publish a series of articles in the park's Municipal Bulletin for communicating the space's value		
CES / GPS	**10** Charge a basic fee for the nature classroom so that income does not impact visitors' interests or accessibility	Addressing demographic differences through diverse educational approaches	
CES	**11** Organize painting contests for older visitors, drawing contests for children, and photography contests for youth		
CES	**12** All microbial processes at Parc del Falgar can be explained on screens in the nature classroom. This is informative and interactive and can be in the form of cartoons		

checks included confirming linearity, testing for independence, assessing homoscedasticity, and ensuring the normality of residuals.

To explore differences in perceptions among individuals categorized by various dichotomous and nominal sociodemographic variables, we employed the Kruskal-Wallis test. This choice was informed by the non-normal distributions of perception scores across the groups, as evidenced by the Shapiro-Wilk test results. The Kruskal-Wallis test is a robust non-parametric method and does not assume a normal distribution of the dependent variable. Additionally, research suggests that for data derived from five-point Likert scales, non-parametric methods like the Kruskal-Wallis test can perform comparably to their parametric counterparts, such as ANOVA, in terms of statistical power (de Winter and Dodou 2010).

Upon identifying significant differences through the Kruskal-Wallis test, we conducted further investigations using the Mann-Whitney U test for pairwise comparisons. This test is particularly beneficial for analyzing ordinal data or data lacking inherent measurement units, such as perceptions or attitudes (Conroy 2012). Our results are interpreted based on the Mann-Whitney U statistic, providing insights into the relative rankings between groups.

Similar to other research (Zaldo-Aubanell et al. 2024), we quantified the magnitude of observed differences using the "common language effect size" (CLES), derived by rescaling the Mann-Whitney U statistic relative to the maximum possible value (the product of sample sizes from the two compared groups) (Fritz et al. 2012; Kerby 2014; McGraw and Wong 1992). A CLES greater than 0.5 indicates a higher probability of an observation from Group 1

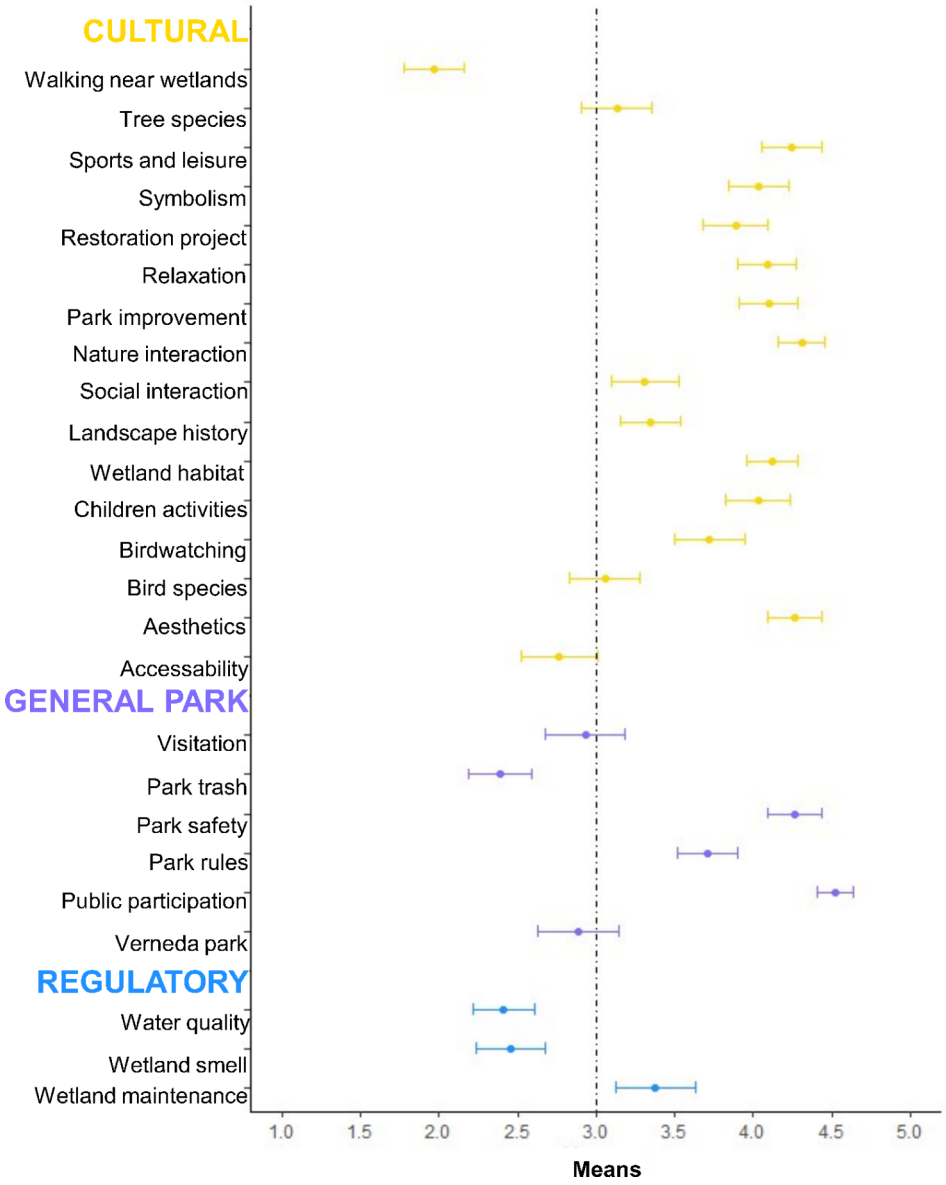

Fig. 2 Mean ratings and 95% confidence intervals obtained from all survey responses without the segmentation of sociodemographic profiles ($n=92$). Scale from 1 (strongly disagree) to 5 (strongly agree). Statements are categorized into 3 distinct groups: CES, RES, and General Park Statements

scoring above an observation from Group 2, providing a straightforward interpretation of effect size. Additionally, given the complexity introduced by multiple comparisons, we applied the Bonferroni correction to mitigate the risk of Type I errors (Rothman 1990). We also explored less conservative adjustments such as those proposed by Holm and Benjamini & Hochberg to strike a balance between avoiding Type I and Type II errors (Holm 1979; Benjamini and Hochberg 1995). Recognizing the limitations of overly conservative approaches (Gordon et al. 2007), we grouped tests by independent variables, considering each as separate families of comparisons, thus refining our analytical strategy.

Age, Income, and Visits were changed from nominal to numeric and ordinal variables to produce an adequate representation as well as further analysis of the data. The new quantitative variables are as follows, "Num_age", "Num_income", and "Num_visits" (see Table 3). Ordinal variables often represent ordered categories that reflect an underlying progression. In this case, ordinal variables are treated as numerical variables to estimate the relationship between the ordinal variable (sociodemographic) and the outcome variable (statements) while assuming a linear. This is illustrated in our data by presenting the coefficients obtained from linear regression models that demonstrated a statistically significant effect. Each regression coefficient specifies the anticipated change in the mean rating of a statement per one-unit increase in the respective sociodemographic variable. Employing linear regression analysis clarifies the direction and magnitude of these relationships and offers a straightforward and interpretable framework for understanding how these sociodemographic factors influence statement ratings. This method ensures a robust analysis, providing clear insights into the effects of sociodemographic variables on perceptions.

We present both unadjusted and Bonferroni-adjusted p-values, accommodating the varying rigor required by exploratory and confirmatory research contexts (Armstrong 2014). This dual-reporting approach enhances the transparency of our methodologies and contributes to ongoing debates about optimal statistical practices in complex research environments (Bender et al. 2001). All statistical tests were conducted with a significance threshold set at $p<.05$.

Results

Public perceptions of Parc del Falgar

Figure 2 depicts the mean ratings and 95% Confidence Intervals obtained from all survey responses.

CES statements show that visitors may not be as knowledgeable of the park's bird and tree species nor use the wetlands for birdwatching (M: 3.05, 95% CI: 2.83 to 3.27 and M: 3.72, 95%CI: 3.49 to 3.94). Additionally, for the statements "I interact with others at the park" (social interaction), (M: 3.31, 95%CI: 3.09 to 3.52) and "The park connects us to the history of the landscape" (Landscape history), (M: 3.34, 95%CI: 3.15 to 3.53), suggest visitors may be indifferent about social interactions and their connection to its historical context. Conversely, respondents strongly agree with the CES statement "I am relaxed by the wetlands" (Relaxation), (M: 4.08, 95%CI: 3.90 to 4.27), suggesting that the restoration project promotes tranquility.

The General Park statements revealed that visitors feel safe at the park (M: 4.26, 95%CI: 4.09 to 4.44) and agree that the park rules are being followed (M: 4.26, 95%CI: 4.09 to 4.44). Respondents strongly agree with the statement, "Public participation is important for improving the quality of the park" (Public participation), (M:4.52, 95%CI:4.40 to 4.63), suggesting recognition for the role that community has in improving the park landscape.

The RES statements show that on average, respondents disagreed with the statement "the water from the wetlands is bad quality" (Water quality), (M: 2.41, 95%CI: 2.21 to 2.60), suggesting that visitors have positive perceptions for the water quality. Respondents disagreed with the statement "The wetlands smell bad", (M: 2.45, 95%CI: 2.23 to 2.68), suggesting that visitors are not bothered by the natural odors of the wetlands, and reported indifference for the statement "The vegetation around the wetlands needs maintenance" (M: 3.37, 95%CI: 3.12 to 3.63), suggesting unfamiliarity about the wetland's upkeep.

Effects of visitor characteristics on public perceptions

Differences in public perceptions affected by categorical sociodemographic variables

Our results show that differences exist in the public perceptions regarding Parc del Falgar depending on the sociodemographic characteristics of visitors. Table 2 presents significant pairwise comparison. We observed that respondents who live with children under 18 years old tend to disagree more than respondents who do not live with children under 18 to the following CES statements: "The wetlands are a symbol of Falgar" (M. (IQR): 4 (1) −4 (1), CLES = 0.38, p-value = 0.046), "I'm relaxed by the wetlands" (M. (IQR): 4 (1) −4 (1), CLES = 0.36, p-value = 0.020), and "The park landscape has improved with the implementation of the wetlands" (M. (IQR): 4 (1) −4 (1), CLES = 0.38, p-value = 0.046). These results suggest that respondents

Table 2 Pairwise comparisons of nominal sociodemographic variable levels using the Mann-Whitney U test. Scale from 1 ("strongly disagree") to 5 ("strongly agree"). For each comparison, the structure is consistently presented as "group 1 - group 2". "group 1" serves as the reference point for the calculated common Language effect size (CLES) in every pair. Thus, results can be read as follows: median of group 1 (Interquartile range group 1)– median of group 2 (Interquartile range group 2), CLES value. the CLES values represent the probability that a randomly selected observation from "group 1" will rank higher than one from "group 2". Statistical significance is indicated by the letter followed by an specific number: the letter denotes the significance level with values; a = p-value < 0.05; b = p-value < 0.005; and c = p-value < 0.0005. the number differentiates between unadjusted (1) and Bonferroni-adjusted (2) p-values, which consider each independent variable as a separate family of comparison

	Statements										
Nominal Sociodemographic variable	"I'm aware the wetlands are part of a restoration project"	"I am aware of children's activities	"The wetlands provide habitat for aquatic and land animals"	"The wetlands smell bad"	"Walking around the wetlands is difficult"	"The wetlands are a symbol of Falgar"	"I enjoy the aesthetics of the wetlands"	"The park encourages sports activities and leisure"	"I interact with others at the park"	"I'm relaxed by the wetlands"	The park landscape has improved the implementation of the wetlands"
Children under 18											
Yes—No						4 (1) −4 (1), 0.38 $^{a}_{1}{}^{b}_{1}$			4 (0) −3 (2), 0.71 $^{a}_{2}{}^{b}_{2}$	4 (1) −4 (1), 0.36 $^{a}_{1}{}^{b}_{1}$	4 (1) −4 (1), 0.38 $^{a}_{1}{}^{b}_{1}$
Education											
University grad—Other				2 (0) −3 (1), 0.23 $^{a}_{2}{}^{b}_{1}$	2 (1) −2 (1), 0.25 $^{a}_{1}$		5 (1) −4 (1), 0.74 $^{a}_{1}$				
Highschool—Other					2 (1) −2 (1), 0.30 $^{a}_{1}$						
No formal education—Other					1 (0) −2 (1), 0 $^{a}_{1}$						
Residential surroundings											
Between 30-50% - <30%							5 (1) −4 (0.5), 0.67 $^{a}_{1}{}^{b}_{1}$	5 (1)– 4 (2),0.68 $^{a}_{1}{}^{b}_{1}$			
>50% - <30%								5 (1) −4 (2), 0.66 $^{a}_{1}$			
Employment status											
Retired—Student	4.5 (1) −4 (1), 0.72 ^{a2}	1 (0) −1 (1), 0.33 $^{a}_{1}$	4 (1) −3 (1), 0.81 $^{a}_{2}{}^{b}_{1}$								
Retired—Full-time		1 (0) −1 (1), 0.32 $^{a}_{2}{}^{b}_{1}$	4 (1) −4 (0), 0.62 $^{a}_{1}$								
Student—Full-time			3 (1) −4 (0), 0.25 $^{a}_{1}$								
Retired– Looking for empl.	4.5 (1) −2.5 (1), 0.94 $^{a}_{2}$										
Student–Looking for empl.	4 (1) −2.5 (1), 0.89 $^{a}_{1}$										
Not looking—Looking for empl.	4 (0) −2.5 (1), 0.95 $^{a}_{1}$										
Full-time—Looking for empl.	4 (0) −2.5 (1), 0.85 $^{a}_{1}$										
Looking for empl—part-time	2.5 (1) −4 (1), 0.05 $^{a}_{1}$										
Interest in volunteering											
No - Yes				2 (2) −2 (0), 0.63 $^{a}_{1}{}^{b}_{1}$							

who live with children under 18 prioritize different aspects of Falgar and are less perceptive of the wetlands ES. For instance, they agree more with the statement, "I interact with others at the park", than respondents who don't live with children under 18 years old (M. (IQR): 4 (0) −3 (2), CLES = 0.71 (p-value = 0.001).

For education levels, university graduates tend to disagree more with the RES statements "The wetlands smell bad" and "Walking around the wetlands is difficult" than visitors who listed "other" as their level of education: (M. (IQR): 2 (0) −3 (1), CLES = 0.23, p-value = 0.004) and (M. (IQR): 2 (1) −2 (1), CLES = 0.25, p-value = 0.012). Similarly, respondents with a highschool level education are more likely to disagree with the statement "Walking around the wetlands is difficult" than a respondent who listed "other"(M. (IQR): 2 (1) −2 (1), CLES = 0.30, p-value = 0.047), Moreover, the CES statement "I enjoy the aesthetics of the wetlands", (M. (IQR): 5 (1) −4 (1), CLES = 0.74, p-value = 0.016) indicates a university graduate would agree more in appreciating the natural aesthetic of the wetlands compared to a respondent who marked "other" for their level of education. We can infer that higher education levels can support improved levels of awareness for distinct ES around the wetlands. Nevertheless, when comparing the RES statement "Walking around the wetlands is difficult", visitors who marked "other" as their education level are more likely to agree with the statement than visitors with "no formal education" (M. (IQR): 1 (0) −2 (1), CLES = 0, p-value = 0.033), suggesting that perceptions of the wetlands' accessibility may be influenced by factors beyond formal education.

For "Residential surroundings" we sought to understand if the amount of natural landscape in visitor's residential areas influences their perceptions of the park's ES. A significant difference was found between residential surroundings with 30-50% and <30% of the natural landscape and the statement "I enjoy the aesthetics of the wetlands", (M. (IQR): 5 (1) −4 (0.5), CLES = 0.67, p-value = 0.015), suggesting that visitors who live in areas with the more natural landscape are more likely to perceive the wetland aesthetics positively. Additionally, visitors surrounded by 30-50% of a natural landscape agreed more with the statement "The park encourages sports activities and leisure" than respondents surrounded by less than 30% of a natural landscape (M. (IQR): 5 (1) −4 (2), CLES = 0.68, p-value = 0.011), while visitors surrounded by more than 50% of the natural landscape agreed more (M. (IQR): 5 (1) −4 (2), CLES = 0.66, p-value = 0.040) than visitors living in areas with less than 30% of natural landscape for the statement "The park encourages sports activities and leisure". These results suggest that greater accessibility to nature in residential surroundings may contribute to a stronger perception of nature's role in facilitating recreational activities.

For employment status, retirees were more likely to disagree with the statement "I'm aware of children's activities" compared to students and full-time employment respondents, (M. (IQR): 1 (0) − 1 (1), CLES = 0.33, p-value = 0.028) and (M. (IQR): 1 (0) − 1 (1), CLES = 0.32, p-value = 0.003). Additionally, retirees are more likely to agree with the statement "The wetlands provide habitat for aquatic and land animals" than students and full-time employment, (M. (IQR): 4 (1) − 3 (1), CLES = 0.81, p-value = 0.003) and(M. (IQR): 4 (1) − 4 (0), CLES = 0.62, p-value = 0.045). Interestingly, our results showed that students were more likely to disagree than full-time employment with the statement "The wetlands provide habitat for aquatic and land animals", (M. (IQR): 3 (1) − 4 (0), CLES = 0.25, p-value = 0.007). Examining the results from the CES statement, we can infer that retirees have a greater perception of the statement "I am aware that the wetlands are part of a restoration project" compared to students and respondents who are looking for employment, (M. (IQR):4.5 (1)– 4 (1), CLES = 0.72,p-value = 0.040) and (M. (IQR): 4.5 (1) − 2.5 (1), CLES = 0.94, p-value = 0.003). We found that students, full-time employment, and those not looking for employment have a greater awareness of the statement "The wetlands are part of a restoration project" compared to respondents looking for employment, (M. (IQR): 4 (1) − 2.5 (1), CLES = 0.89, p-value = 0.026), (M. (IQR): 4 (0) − 2.5 (1), CLES = 0.85, p-value = 0.016), and (M.(IQR): 4 (0) − 2.5 (1), CLES = 0.95, p-value = 0.026). Comparatively, respondents looking for employment were less likely to agree that the wetlands are a part of a restoration project compared to part-time employment, (M, (IQR): 2.5 (1) − 4 (1), CLES = 0.05, p-value = 0.032). Lastly, our results revealed that respondents with an interest in environmental volunteer work were more likely to disagree with the statement "The wetlands smell bad" compared to respondents who answered with having no interest (M. (IQR: 2 (2) − 2 (0), CLES = 0.63, p-value = 0.033).

Differences in public perceptions affected by quantitative sociodemographic variables

Table 3 represents the statistically significant effects of the quantitative sociodemographic variables on the mean ratings of statements.

Results indicate that the statement "Walking or cycling around the wetlands is difficult because of overgrown vegetation and bushes" was negatively associated with age, suggesting that as an individual ages, there's a greater likelihood that they will disagree with this statement compared to the youth visitors. (β = -0.151, p-value = 0.017). For the statements "I am aware that there are educational activities for children at the park", "I know the bird species at the park", "The wetlands provide habitats for aquatic and

Table 3 Statistically significant coefficients (βi) obtained from the regression models with significant effects on the statements. Statistical significance: [a] = p-value < 0.05; [b] = p-value < 0.005; [c] = p-value < 0.0005. The number indicates whether the p-values are unadjusted (1) or Bonferroni-adjusted (2), considering each independent variable as a separate family of comparisons

	Statements						
Quantitative sociodemographic variables	"Walking or cycling around the wetlands is difficult"	"There are educational activities for children at the park"	"I know the bird species at the park"	"The wetlands provide habitats for aquatic and land animals"	"I'm aware of the wetland restoration project"	"The park landscape has improved with the implementation of the wetlands"	"The park encourages sport and leisure"
Num_age	-0.151 [a]$_1$	0.150 [a]$_1$	0.162 [a]$_1$	0.170 [b]$_1$	0.211[b]$_1$	0.188 [b]$_1$	
Num_income							0.505 [a]$_1$
Num_visits						0.149 [a]$_1$	

land animals", "I'm aware that the wetlands are part of a restoration project", and "The park landscape has improved with the implementation of the wetlands", age was found to have a positive association, (β = 0.150, p-value = 0.0269, β = 0.0.162, p-value = 0.027, β = 0.170, p-value = 0.001, β = 0.211, p-value = 0.002, β = 0.188, p-value = 0.002), suggesting that older park users tend to have a greater awareness of the CES occurring at the park compared to youth visitors.

Regarding annual income, a positive trend suggests that park users with more income tend to agree more with the statement "The park encourages sports activity and leisure", (β = 0.298, p-value = 0.007). As for the number of visits, the results show a positive trend for the statement "The park landscape has improved with the implementation of the wetlands" where the more frequent visits to the park tend to reveal a greater perception of park improvement (β = 0.149, p-value = 0.009).

Interviewee proposals for improving public perceptions of ES awareness

Key insights derived from the interviews expressed that coordinated stakeholder engagement has the potential to shape public perceptions about Park del Falgar. Forms of stakeholder coordination are suggested to come from schools, public and private partnerships, the municipality of Franqueses, and non-governmental organizations. Assistance from these stakeholders can enhance environmental stewardship by providing the tools necessary for learning and creating a shared governance for promoting the park's ES awareness. For instance, coordinating with schools was proposed as an effective strategy to promote student discovery and transfer knowledge of ES between students and parents. Citizen science was also proposed to encourage community participation and learning across all age groups and with different experts. Likewise, interviewees expressed that the success of environmental stewardship, along with different educational and communication initiatives at Falgar, is a shared responsibility among local governance, the public, and private institutions. As one interviewee from the Consorci Besòs Tordera expressed, "It *does not necessarily have to be that everything comes from the administration. It can also be NGOs and naturalist organizations in the area. I believe that the initiative, private or certain groups, can do much more than the City Council".*

We found that interviewees like the idea of implementing citizen science at Falgar as it exposes opportunities for CES, such as shared learning and improved social participation. One interviewee from the Spanish National Research Council (CSIC) states, *"I think that the (fluvial) system could benefit from easy observations. For example, if there is an algae bloom, public observation from daily visitors can help report the changes…".* However, the interviews revealed distinct perspectives and considerations for citizen science initiatives. However, the director of the Consorci Besòs Tordera stated: "*I believe in popular science, but I don't know if society, Catalan, and Spanish societies, are prepared for this form of learning. I think the challenge to public monitoring is more than implementing it, it's that people must have a great level of understanding of science, and I have doubts about this".* This response was supported by a professor from the interviewee from the Universitat de Barcelona Department of Ecology at the University of Barcelona, (UB), who expressed "*If you do not know how to monitor, then you can't do much or any type of exercise. To be proactive in restoration, you must inform and give tools so that people are more interested in citizen science".* These ideas are visualized in Thematic Network 1 (Fig. S3).

Thematic Network 2 (Fig. S4) illustrates the key themes on which equity and inclusivity in environmental education were anchored: adaptive learning spaces, inclusive communication, and addressing socioeconomic disparities with dynamic learning approaches. According to the interviewees, the nature classroom should be a multifunctional learning space with the capability to connect with different park visitors. However, doubts about the nature classrooms' ability to provide added value to the park were revealed, and divided opinions between prioritizing immersive, hands-on experiences with nature and utilizing technology to enhance understanding of the park's wetland restoration arose. The director of the Consorci Besòs Tordera expressed, "*To communicate this information effectively, we would need*

screens for optimized visualization. This system needs to be visualized on a screen to derive interest in its microbial process. There is no other way because by just looking at the wetlands you cannot understand how the system is functioning at the microbial level". However, one interviewee from City Council expressed that: "*there was an idea very technological*, *such as putting up a lot of screens*, *but it was very expensive*, *and I have my doubts about investing so many resources in screens when what you want to explain is the nature that is outside of the classroom".* This statement was reinforced by a proposal for tangible nature activities from a professor at the Department of Ecology, (UB) suggesting, "*A contest related to photographing aspects of the park (and) events or activities in the area that have a connection to nature*, *like a treasure hunt".* Guided tours were also proposed by the interviewee at the Spanish National Research Council (CSIC) stating, "*Making tours of the park is not only informative*, *but it's a way to make the park more active in different faucets beyond student education".* This proposal is reinforced by an environmental technician at the Consorci Besòs Tordera who proposes tours done by retirees. The interviewee states, "*Older park visitors know that Falgar is part of a restoration project. They can explain this because they have a previous perspective of what Falgar was before the implementation of the fluvial restoration project. Their view of its evolution is quite interesting from a historical perspective".* Furthermore, interviewees evaluated the survey results for the levels of income's influence on ES awareness and expressed that while income may play a role in awareness, it is not the sole determinant of visitors' perceptions of ES. As the director at the Consorci Besòs Tordera argued: "*Normally*, *people's interests are fixed*, *whether they have an income or not".* This view is shared by the professor from the Department of Ecology, (UAB),who expressed that, "*Accessibility is one thing*, *and another thing is the cultural customs that influence you".*

Discussion

The implications of age on ES awareness

This study revealed age's significant impact on ES awareness. We found that older individuals can exhibit higher familiarity with the park's biodiversity than younger park users, suggesting awareness may be indicative of the accumulated knowledge and experience that comes with age (McGinlay et al. 2018). Similarly, RES and CES statements reveal that older age is associated with a greater perception of habitat and aesthetic qualities and a greater agreement with biodiversity-related statements. What's more, age can positively influence the perception of space, especially when perceptions are based on long-term experiences with the landscape (Zaldo-Aubanell et al. 2024). The accumulated knowledge and experience that comes with age was expressed as an advantageous tool for teaching ES awareness of the wetlands. Interviewees who proposed tours led by local retirees to pass down generational knowledge expressed this perspective. Guided tours of Parc del Falgar with older locals can foster learning opportunities about the park's history and connect the evolution of the restoration project to relevant ES (Mas-Ponce et al. 2023). These results demonstrate that environmental education may be shaped more by real-world and personal experiences with nature than by traditional educational settings. As such, learning led by the local community may integrate experiences, emotions, and memories with science that resonate with visitors' values, driving motivation to safeguard natural spaces in urban environments (Flood et al. 2021; Karimi et al. 2020).

Mixed management proposals for promoting ES awareness

Falgar's efforts to manage how ES are perceived were challenged in the interviews as tensions between valuing traditional forms of learning like signage, guided walks, and storytelling at the park and the use of citizen science were examined. For example, proposals from interviewees for improved uptake of ES awareness included organizing treasure hunts and photography contests. It has been observed that digital projects like photography can utilize both technology and tangible experiences in nature. In Fulvia et al. (2022), photography revealed insight into users' relational value for CES and perceptions of nature's benefits. In addition, place-based filmmaking is observed to increase environmental awareness, engagement, and science proficiency among younger participants (Littrell et al. 2020; Walsh and Cordero 2019). This type of learning, however, requires an investment in equipment, time, and physical activity, and not all park visitors may want to engage in ES in this way. Particularly, distinct socio-demographic characteristics can further stress these differences. For instance, (Langemeyer et al. 2018) found that older individuals involved in urban gardening often highlight physical activity as a key benefit, whereas younger participants, despite being equally active, may not consider it as significant. This indicates that engagement with ES may be influenced not just by the activity itself but also by the differing values and priorities across social groups.

Interviewees also proposed citizen science initiatives for monitoring the ES functions of the restorative wetlands. Citizen science can enrich CES and foster greater public support for restoration projects by helping to refine NBS design and management (Krasney et al. 2012). The interviewees

expressed that public reporting of observed changes in the wetlands and their surrounding biodiversity can lead to an accumulation of shared information, ranging from the wetland's odor to biodiversity knowledge. While diverse stakeholder engagement is crucial for enhancing ES awareness, and as expressed by interviewees, public administration can significantly contribute to this process by coordinating volunteer programs, providing resources for educational materials, and leveraging financial collaboration with distinct groups. Conversely, interviewees also indicated that actors beyond public administration are important in facilitating citizen science in public parks. These include universities, businesses, and NGOs that often possess resources that complement municipal efforts. Still, barriers to citizen science often involve a lack of resources and participant training, and in urban spaces, dissimilar priorities between institutional and community stakeholders can prevent effective citizen science initiatives (Scroggins et al. 2022). Instead, interviewees proposed interactive installations, which may provide improved communication with the park's ES.

Transforming the nature classroom into a digital learning space was a recurring proposal from the interviewees, as the use of screens, videos, and computerized activities would amplify the learning experience and improve landscape perception. As previously discussed for photography contests and citizen science, digital outdoor learning may be advantageous for the uptake of ES awareness. Younger visitors, who are already immersed in digital learning environments at school, may benefit the most from digital enhancements in public parks Walter (2013) points to adult learners between 18 and 35 years old engaging most effectively with visual, multimedia, and digitally enriched environments. However, implementing digital activities in public parks presents significant challenges for management, particularly regarding funding, maintenance, and user training. These concerns, raised by interviewees, are also well-documented in the literature (Ricoy and Sánchez-Martínez 2022; Xie et al. 2024). Again, learning preferences further complicate the feasibility of digital enhancements at Parc del Falgar. An unresolved question from the interviews is whether the interactive space can effectively accommodate diverse age groups and how age-related differences in learning will be addressed. As previously noted, older park visitors may develop a deeper understanding of Falgar's ES through direct, real-world experiences rather than through classroom-style learning. This preference may extend to digital learning, which could be less effective in enhancing their ES awareness and further complicate decision-making to fund interactive technology at the park. These concerns are echoed by a city council member, who expressed skepticism about allocating substantial resources to digital screens when the goal is to engage visitors with the natural environment itself. Additionally, one interviewee suggested introducing a fee for accessing the interactive space, which raises further questions about accessibility. Given these challenges, it is important to consider the strong evidence in the literature supporting tangible outdoor science and place-based learning as effective strategies for increasing engagement in environmental education across diverse sociodemographic groups (Damerell et al. 2013; Trott 2020; Walter 2013).

These contrasting management proposals for increased ES awareness highlight the need to distinguish between the various stakeholders at Parc del Falgar, as our results show that socio-demographic diversity makes it challenging to select a management approach that accommodates different learning preferences and ways of engaging with ES. This complexity arises from the fact that social groups perceive ES differently (Riechers et al. 2018). Nevertheless, subjective perception is relevant for the interpretation of the opportunities offered by nature-based infrastructure (Andersson et al. 2019). At Falgar, the purpose of the nature classroom should be to facilitate learning opportunities about the fluvial system and the park's surrounding habitats; it is a key component for nurturing varied accessibility and learning preferences and therefore aiding the interpretation of the park's ES. As such, some interviewees recommended a multi-functional approach to the nature classroom. In Durall et al. (2019), this involves co-designing and implementing technology-enhanced environmental learning. Similarly, interviewees propose that future management for the classroom should consider digital activities operating alongside in-person workshops, guided tours, storytelling, and signage while designating space for birders, botanists, as well as digital enthusiasts.

The influence of socioeconomic factors on CES awareness

Proximity to nature may enhance respondents' awareness of leisure and sports activities in Parc del Falgar and foster a greater appreciation for the wetland's aesthetics. Similarly, Pederson et al. (2019) found that local respondents perceived peri-urban wetlands as valuable for nature experiences and well-being, stressing that the location of wetlands in residential areas plays a crucial role in their contribution to human wellness, while Plieninger et al. (2022) emphasize that improved ES delivery by blue infrastructure can be delivered through the maintenance and restoration of existing water bodies. While contradictory perceptions of what is considered a "natural" or "healthy" ecosystem can vary among different socio-demographic groups (Cottet et al. 2013), on average respondents perceived the wetland's water quality in good condition and did not express annoyance by

the natural foliage around the restoration system. Appreciation for wilderness in urban areas drives biodiversity conservation and, in some cases, aesthetics is seen as the most preferred ES in natural settings (Carrus et al. 2015). While Falgar's wetlands were perceived on average as visually pleasant and without foul smell, recognizing ES, like water regulation for improved quality may not be as intuitive. As (Plieninger et al. 2022) suggest, ES that are not directly perceived require a critical reflection on the attributes of blue infrastructure and its effect on the ecosystem service supply. Such consideration may heighten understanding of the ecological functions of fluvial systems, leading to increased public support for the continued use and management of water-bodied urban landscapes. Interestingly, perceptions of water quality aligned with the physiochemical parameters monitoring the fluvial system documented from January 2023 to July 2023, which showed that ammonium outtake levels were meeting the national requirement for water quality (See Supplementary Material, Fig. S5).

Further evaluating accessibility to nature in residential surroundings may contribute to a stronger perception of nature's role in facilitating CES (Bonaiuto et al. 2003). CES such as recreation and leisure increase public motivation to maintain restorative environments because of their benefits on well-being (Berto 2005; Gidlöf-Gunnarsson and Öhrström 2007). At Falgar, these include walking, cycling, using the park's exercise equipment, birdwatching, and sitting on a park bench or under a tree. Accessibility also encompasses a psychological dimension. As defined by Andersson et al. (2019), accessibility is shaped by perceived social norms and the emotional responses of potential users. Our findings indicate that, overall, respondents feel safe, do not view litter as a significant issue, and trust that park rules are being upheld. This suggests that psychological barriers to engaging with the ES at Falgar—such as concerns related to well-being—are minimal and thus may aid in fostering a welcoming and accessible space for its visitors.

Interestingly, our results also suggest that greater income levels increase awareness of leisure and sports activities in Falgar. This finding indicates that it is also important to consider how socio-economic factors shape the type and quality of CES and its related benefits to well-being. For instance, Hoffimann et al. (2017) found that neighborhoods with lower socioeconomic deprivation had better access to green recreational spaces in the European City of Porto, while Scopelliti et al. (2016) similarly observed differences in indicators of well-being between income groups. Individuals in wealthier areas may have more opportunities to engage with CES, while those in lower-income neighborhoods might face barriers to accessing green spaces. While our study does not explicitly examine whether respondents with greater proximity to nature also tend to have higher incomes, it is important to acknowledge that income may influence the ability to access CES. Our results also show the effects of education on ES awareness. We demonstrated that higher levels of education increased awareness of the wetland habitat. However, the demographics of those marking "other" as their education level could provide valuable insights into the diverse educational backgrounds influencing these perceptions. Nevertheless, Petersen et al. (2021) found that respondents with higher education levels had increased participation in recreational activities and a greater likelihood of reporting better health and well-being (Petersen et al. 2021). It's worth noting that accessibility to the park's ES may be shaped beyond education, as we have previously demonstrated that informal learning experiences and personal interactions over time can also contribute to awareness of perceived ES. Additionally, an increased frequency of visits may lead to a greater appreciation of the wetland's aesthetic effect on the park's landscape, as our results suggest that repeated exposure improves perceptions of CES.

Future research

While our study provides valuable insights into visitor perceptions of peri-urban park ecosystem services, certain factors should be considered when interpreting broader generalizability. First, our shift to non-parametric methods - necessitated by non-normal data distribution and as confirmed by Shapiro-Wilk tests, means that our results primarily emphasize differences between visitor groups rather than precise population estimations. This limitation is likely influenced by the demographic composition of our sample, as nearly one-third of our respondents were older adults, which may not fully reflect the overall profile of park visitors. Additionally, while our findings align with broader research trends on urban park perceptions, reinforcing their external validity, future studies could further enhance generalizability by incorporating larger, more demographically balanced samples or comparing trends across multiple urban parks. Integrating visitor flow data and examining age-related differences in ES perceptions could also provide additional context to strengthen representativeness assessments. Lastly, applying multidimensional models that account for interactions between variables could deepen understanding of CES accessibility. Despite these limitations, our study successfully captures key perceptual trends, offering valuable insights into urban park management and informing future ecosystem service awareness proposals.

Conclusion

This study demonstrates how evaluating public perceptions of ES is necessary for thoughtfully approaching restoration management in peri-urban fluvial spaces. We explored levels of awareness for a peri-urban fluvial park's distinct ES by examining differences in socio-demographic characteristics and determined that age, income, and frequency of visitation are significant factors for awareness of ES. Older park users were more likely to notice changes in the park's landscape, biodiversity, and wetland restoration project. Visitors with higher income levels had a greater level of awareness for leisure and sports activities and more park visitation increased visitors' perceptions of the wetland's wild aesthetics and agreeability that the park landscape has improved with the implementation of the wetlands. We discussed that living closer to nature increases CES awareness for recreation and leisure and discussed potential challenges between the variables income and education and accessibility for the intangible and context-specific nature of CES. Expert interviews with local actors generated mixed proposals for managing the uptake of ES awareness at Parc del Falgar. These included technology-enhanced and community-centered approaches such as photography, filmmaking, citizen science and digitally interactive activities for engaging visitors and bridging gaps in ES accessibility. The interviews also stressed that the importance of traditional environmental learning like storytelling, signage, and guided walks for ES awareness shouldn't be overlooked. Our research concludes that dissimilar priorities between interviewees, limited funds for resources, and differing values and priorities across social groups must be addressed to improve ES awareness of the park's wetlands.

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Declarations

Competing interests The authors declare no competing interests.

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