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How might we utilise the concept of botanic gardens' in urban contexts to challenge plant blindness?

Jasmine Daniel, Alessio Russo*, Bill Burford

School of Arts, University of Gloucestershire, Cheltenham, GL50 4AZ, United Kingdom

* Corresponding author: arusso@glos.ac.uk <https://orcid.org/0000-0002-0073-7243>

Abstract

Plant blindness remains an understudied Anthropocentric concept. There is a societal naivety to the importance of plants, and lack of awareness of the human impact of plant life, which renders many 'plant blind'. This research develops a Plant Blindness (PB) scale to address plant blindness within a botanic and urban space, pursuing an investigation into the motivations and beliefs of people in terms of plant awareness, plant fascination and conservationist efforts. Interviews with specialists within botany and horticulture suggest how we might better understand and utilise the function of botanic gardens' within an urban context, using botanic spaces to further amplify societal interest in plant life, thus challenging plant blindness. Botanic gardens' document collections of living plants, researching and setting exemplar sustainable and ethical standards for the conservation and cultivation of rare and threatened plants, educating and bringing global plant conservation to the forefront of our natural world. Botanic gardens research innovation, scientific knowledge, heritage and expertise in sustaining a globally diverse range of plant species could be advantageous in the future design of urban spaces. It is through establishing active engagement between botanic spaces and urban spaces that plant blindness can be challenged, establishing a future vision for botanic gardens and botanic spaces, exploring the role botany could adopt within society.

Keywords: urban space; plant awareness; urban space experience; biodiversity conservation; plant knowledge

Introduction

Plants are fundamental to the design of urban spaces as they provide several ecosystem services (MA, 2005; Quijas et al., 2010) however they receive little recognition for their role in our built environment. Furthermore, our inability to recognise plant diversity's significance is a societal concern. As humans, we have become 'plant blind' (Wandersee & Schussler, 1999). Wandersee and Schussler first discussed the concept of plant blindness in 1998, suggesting some individuals perceive animals as superior to plants. The original definition for plant blindness symptomised the 'condition' using four indicators, these were:

- (1) the inability to see or notice the plants in one's environment;
- (2) the inability to recognise the importance of plants in the biosphere and in human affairs;
- (3) the inability to appreciate the aesthetic and unique biological features of the life forms that belong to the Plant Kingdom;
- and (4) the misguided anthropocentric ranking of plants as inferior to animals and thus, as unworthy of consideration. (Wandersee & Schussler, 1999: 84)

This implied some humans fail to notice plants within their environment. The visibility bias constructed by humans of 'what you see is all there is' (WYSIATI) suggests when a flowering plant is not in flower, the brain witnesses the plant's visual homogeneity, struggling to see plant diversity (Kahneman, 2011). Less than 50 research papers have furthered Wandersee and Schussler's initial publication. However, plant blindness has major consequences within botany and horticulture, specifically on the longevity of botanic spaces and our planet's plant diversity. Generally, investigations into plant blindness have focused on deficient educative resources (Uno, 1994; Hershey, 1996), focusing on the American academic system. A failure to support botanic

education and inspire young people to adopt a lifelong interest in plants (Wandersee & Schussler, 2001) has encouraged study into the construct of botanical illiteracy (Uno, 2009). Wandersee & Clary (2006) suggested various principles to demonstrate a failure to cognitively focus our attention on plant life, providing an understanding of plant blindness and the social, physical and psychological factors that may contribute to its manifestation.

However, two decades on from the initial works of Wandersee & Schussler (1999), plant blindness is ever prevalent and advances in research are minimal (Kritzinger, 2018; Krishnan et al., 2019; Knapp, 2019; Thomas et al., 2021). Therefore, previous research on plant blindness mainly focused on the educational context (Amprazis & Papadopoulou, 2019). The absence of plant blindness within literature needs addressing as evidence suggests it remains instilled within society today. Botanic gardens' could 'cure' plant blindness through the conservationist and educative practice they promote (Wandersee and Schussler, 2001; Powledge, 2011), they are valued assets globally with qualities to create 'restorative environments' (Hartig, 2004). However, research argues they often fail to encourage the learning of plant collections within a twenty-first-century context (Darwin Edwards, 2000). This places the future of botanic gardens' under threat from a societal, political and economic perspective (Kramer et al., 2014). Addressing opportunities for botanic gardens to support urban spaces would establish a progressive relationship between plants and people. To this end, the aims of this study are (1) to unpack the ethnobotanical agenda of botanic gardens (2) to develop a Plant Blindness Scale to address the manifestation of plant blindness amongst users of a botanic and urban space in the UK (3) to pursue an investigation into the motivations and beliefs of the public in terms of their plant awareness, plant fascination and conservationist efforts.

Therefore, our study has addressed the following research questions:

1. Is the role of botanic gardens' changing?
2. What is the conservation practice taking place within botanic collections?
3. To what extent is the concept of plant blindness evident within botanic gardens' compared to the urban setting?
4. What is the future role of botanic gardens'?

Materials and methods

Mixed Methods Research

The research questions were addressed by concurrent mixed methods which combined quantitative and qualitative methods, capturing and generating a primary data set from various perspectives. We conducted interviews with Botanic gardens' in the UK, research specialists in the field of botany, as well as designing and conducting an online public survey.

Qualitative methods: Interviews with Botanic gardens'

Participants for this study were selected based on their expertise and experience in botanic gardens' and conservation. The selection process aimed to approach a diverse group of individuals from various locations, most of whom were in the UK. Contact was made with the participants via email or social media platforms such as LinkedIn. In total, 11 participants were included in this study. Data was collected through 11 in-depth, structured questionnaires from specialists working for botanic gardens and the Botanic Gardens Conservation International (BGCI)

The questionnaires were designed to gather information specific to each participant's perspective (see Appendix A). By interviewing a range of botanic garden specialists, we ensured a breadth of data was collected. Qualitative data analysis focused on description, classification, and connections. Data transcription centred on the interviewee's role and expertise before coding categorised any patterns in the data. The themes were condensed to unpack the overarching

arguments. Coding was maintained throughout, generating a multi-layered, rich dataset that answered the research questions and yielded rigorous conclusions (Creswell and Poth 2016). The interviews explored personal perspectives on plant blindness within the botanic space and visions for the development and outreach of botanic gardens

Online Public Survey

Hypothesis

When considering the botanic garden and urban space, it is possible that one could provide a greater appreciation of plant awareness, fascination and conservation. The experimental alternative hypotheses are:

H₁ 1. There will be a higher level of plant awareness in the botanical garden, relative to the urban space.

H₁ 2. There will be an increase in plant fascination in the botanical garden space, relative to the urban space.

H₁ 3. There will be a greater appreciation of conservationist efforts in the botanical garden space, relative to the urban space.

The PB scale focuses on each alternative hypothesis. Statements 1-5 refer to plant awareness (H₁ 1), statements 6-10 to plant fascination (H₁ 2) and statements 11-15 to conservationist efforts (H₁ 3).

Sample Size and Recruitment of Participants

For a two-independent sample t-test G*Power calculations a minimum sample size of 200 was suggested as suitable for medium effect ($d = 0.5$). The sample size was set at 200. Suitable given the assumption that botanic gardens' were considered to have a moderate to large effect on plant

blindness. Recruitment involved circulating an electronic advertisement throughout social media on community pages within England, which invited an opportunity to engage with people from different areas and backgrounds, and a breadth of ages. The research was carried out during a Covid-19 pandemic, therefore data collection within a physical urban or botanic space was not possible, meaning data was virtually collected to provide a videoed survey experience. Participants were able to complete the study in their own time (10 minutes was suggested). This limited the opportunity to attract an equal demographic range of participants for the public survey, however, future studies should acknowledge this.

Randomisation Procedure

The post was randomly allocated to social media forums with participants allocated a research condition; an equal number was selected for the botanic garden (n = 100) or urban space (n = 100). The randomisation process meant participants were in equal groupings and the allocated condition remained concealed from the participants and revealed in the latter stage of the experiment to reduce any bias.

Survey Design and Measures

The survey used JISC online survey software. The survey showed participants video footage from July 2020 of either a botanic garden (in South West England) or an urban space (a town in South West England). The composition captured a walking approach from a similar perspective using a Canon PowerShot SX610 HS to provide a realistic viewpoint experience. No soundtrack was used and background noise was removed to focus the research on visual environmental elements. Example video images are shown in Figure 1.



Figures 1. Examples of Botanic Space (A & B) and Urban Space (C & D) Video Footage.

Survey Procedure

Participants provided demographic details, and then watched a minute's footage of the botanic garden or urban space via a web-link; they were not told which video they would view prior to the experiment. The participants completed the virtual survey consisting of 15 PB scale statements that required a multiple-choice answer, for example, 'The plants in the video add value' using a five-point Likert scale ranged from 1 (strongly disagree) to 5 (strongly agree). The independent variable was the botanic and urban space. Potential covariates included participants' age and gender. The data was analysed using IBM SPSS Statistics (Version 25.0, IBM Corp, Armonk, NY: USA).

Plant Blindness (PB) Scale

The PB scale was designed for this research and is applicable to future studies. A mean score is calculated from the 15 statements (see Appendix B), with a lower score indicating greater plant

blindness and higher score indicating lesser plant blindness (see table 1). The PB scale considers measures adopted by the Eco-Centrism (EC) scale (Thompson and Barton, 1994); the New Ecological Paradigm (NEP) (Dunlap et al.,2000); the Nature Relatedness (NR) scale (Nisbet and Zelenski, 2013) and the Intentions to Act (ITA) scale (Bord et al., 2000). These measures are all tested methods of research that have proven advantageous in the collection of data surrounding people and nature. Research is yet to explore plant blindness within both urban and botanic spaces, therefore, the research cannot use a previously developed PB scale. The research assumes Wandersee & Schussler’s (1999) theory was comprehensive and the plant blindness indicators are sufficient.

Table 1. Plant Blindness (PB) Scale.

Degree of Plant Blindness	Score
Plant Blind	0 – 25
Significant signs of Plant Blindness	25 – 44
Some signs of Plant Blindness	45 – 64
No signs of Plant Blindness	65 - 75

Reliability

Cronbach’s alpha coefficient (Cronbach, 1951) was calculated to measure the PB scales reliability (see Table 2), demonstrating consistency. The scale represents the modelled cumulative estimation of each statement's score. The following equation (Equation (1)) was used.

$$\alpha = \frac{k \cdot \bar{r}}{1 + (k - 1) \cdot \bar{r}'} \quad (1)$$

Where k ($k = 15$) equals the number of variables (statements) over which α is calculated. The coefficient interprets the estimated correlation (relationship) between its value and the PB scale. The correlation is computed as a square root of alpha $\sqrt{\alpha}$. A score over 0.7 and below 0.95 indicates high internal consistency (Tavakol and Dennick, 2011); $\alpha = .863$ suggests the PB scale is reliable.

Table 2. Cronbach's Alpha.

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.863	.863	15

Most statements appeared worthy of retention, however, items 12 and 13 (see table 3) received a slightly lower correlation, with the alpha increasing to $\alpha = .877$ for item 12 should it be removed from the PB scale and $\alpha = .866$ when removing item 13. Future research should consider excluding these statements.

Table 3. Kruskal-Wallis H Test to Compare Botanic Garden and Urban Space Experience.

Significant p-values ≤ 0.05 are indicated in bold.

	Kruskal-Wallis H	Asymptotic Significance
Plant Awareness		
(1) The plants in the video add value.	.520	.471
(2) The plants in the video interest me.	2.891	.089
(3) I recognised a variety of plants in the video.	4.043	.044
(4) The plant life in the video engaged me.	.956	.328

(5) From the plant life in the video I recognise the season.	.977	.323
<hr/>		
Plant Fascination		
<hr/>		
(6) Seasonal changes in plants make me want to visit a place.	.000	.989
(7) A diversity of plant species makes me want to visit a place.	.000	.993
(8) Plants are fundamental to my enjoyment of a place.	9.645	.002
(9) Even in an urban environment, I notice plants around me.	4.081	.043
(10) I like to engage with plant life around me.	1.577	.209
<hr/>		
Conservationist Efforts		
<hr/>		
(11) I have an understanding of plant conservation and the future of plant diversity.	1.199	.274
(12) Conservation of plants is necessary because plants are not strong enough to recover from any human impact.	.848	.357
(13) Plants are not meant to die out or become extinct.	.003	.959
(14) I think we need to learn more about plants within society.	.095	.758
(15) My personal wellbeing is enhanced by plants.	.627	.428

The rating scale model (RSM) and a graded response model (GRM) from Rasch's Item Response Theory (Van der Linden, 2010) were applied which identified emergent patterns in the PB scale and attitudinal formation of the statements.

Missing Data

Of all survey results, 3/300 answers were missing; identified as random by Little's Missing Completely at Random (MCAR) Test, accepting the null hypothesis, and suggesting the data is missing randomly with $p = .117$.

Distribution and Baseline Checks

A Fischer's exact test assessed baseline differences in participants age and gender, indicating a statistically significant difference between gender and age engagement.

Ethics

Procedural and everyday ethical concerns were addressed prior to the research commencing. The research abided by the 'University of Gloucestershire's Research Code of Conduct and Data Protection Code of Practice.' Participants could withdraw from the research and anonymity was granted throughout both the data collection and analysis; supporting positive power relations between researcher and participants. The qualitative research remained overt to allow interviewees to intervene. Once informative details had been provided, consent was granted by all participants. The research appreciated possibility for bias in the respondent's answers, whilst ensuring integrity and credibility for all professional bodies and people considered within the research.

Results and Discussion

Demographic

The experiment was open to anyone aged 18+. Research has indicated gender and age to be correlating factors with environmental perception and behaviour (Williams et al., 2015), therefore participants' gender and age were collected, along with ethnicity (see Table 4).

Table 4. Demographic Information for Entire Sample and by Condition.

Characteristic	Individuals in Sample n = 200	Percentage of Sample	Individuals in Botanical Garden Condition n = 100	Individuals in Urban Space Condition n = 100
Gender				

Female	150	75	83	67
Male	44	22	13	31
Prefer not to say	6	3	4	2
Ethnicity				
White/ Caucasian	190	95	95	95
Hispanic/ Latino	1	0.5	0	1
Black/ African American	0	0	0	0
Asian	2	1	0	2
Prefer not to say	7	3.5	5	2
Age				
18-24	13	6.5	3	10
25-34	31	15.5	11	20
35-44	32	16	12	20
45-54	44	22	21	23
55-64	42	21	27	15
64+	34	17	25	9
Prefer not to say	4	2	1	3

Table 4 highlights more females participated in the botanic and urban space experiment. The urban space received greater attention from 25-54 year olds and botanic garden from those aged 54+, due to the randomised allocation procedure. The statistical significance means we reject the null hypotheses for H_0 .

Table 5. Significance Tests for Demographic Baseline Differences.

Measure	Fischer's Extract Test	p-Value
Gender	7.544	.017
Age	20.291	.002

Evolution of Ethnobotany's Agenda

The interviews identified that botanic gardens' should focus on society engagement through better plant conservation education. Botanic gardens have shifted towards becoming an 'educational landscape,' playing key roles in education as well as in biodiversity conservation and natural resources, recreation, and research (Chang, Bisgrove, & Liao, 2008; Lindemann-Matthies & Bose, 2007). However, as institutions, they have struggled to educate the breadth of society. Participant 7 suggests 'The science, horticulture and conservation expertise held within a botanic garden should radiate out, influencing surrounding districts and ultimately the wider city area.' Globally, Singapore sets a precedent example for the highest horticultural and ecological principles and standards in a city masterplan. Through integrating conservation, propagation and city planning they have introduced ex-situ conservation collections on street grid with rare species propagated throughout the city and clear 'roles' developed in individual spaces, focusing on 'learning, leisure, horticulture and conservation' (Participant 7). Participant 6 argued, botanic gardens should 'train, inform and empower individuals to be more impactful in their actions and advocacy'. Progressively, more individuals are moving towards ethnobotany as a 'conservation choice,' recognising plants as bettering our 'mental wellbeing' (Participant 1). Plant-based diets, eco-friendly products and general digital search and spending choices are more 'popular' commercially. Botanical gardens' have experienced a shift in their ethnobotanical agenda. Plant blindness is targeted through consumer attitudes and in doing so botanic gardens' have shifted their focus 'away from the historic aspects of the gardens' towards 'community/amenity-based agendas' (Participant 1).

Manifestation of Plant Blindness

The manifestation of plant blindness was a contested topic of conversation within the interviews with several participants suggesting that plant blindness is a societal issue opposed to a specific issue within the botanic gardens'. Participant 9 stated, 'botanic gardens are raising awareness of the importance of plants' and Participant 4 advocated that 'botanic gardens have a crucial role in combatting [plant blindness]'. Whilst Participant 1 responded that 'most visitors over the whole year have plant blindness to some degree' and Participant 11 suggested, 'although visitors to botanic gardens may appreciate the aesthetic botanic gardens', they may overlook the importance of plants.' The divided response was interesting, from the interviews, those working within the botanic gardens tended to perceive plant blindness as a separate issue to botany, whilst those engaged with research on botany noted the manifestation of plant blindness both within botanic gardens' and society more generally. This suggests plant blindness may sometimes be invisible to those working within botanic gardens and instead visible from a peripheral perspective. To address this further, the public survey was implemented to address the relationship between society and plant blindness. It specifically looked at the severity of plant blindness when exposed to two environments, either a botanic garden or an urban space. The alternative hypotheses suggested participants who watched the video of a botanic garden would report back a reduction in plant blindness and greater appreciation of plant awareness, fascination, and conservationist efforts than those viewing the urban space.

Quantitative Findings

The baseline check showed slight differences in group variables; however, no covariates were controlled as the variance in participant demographic remained similar for both botanic and urban space engagement. The statistical descriptive findings for individual PB scale components (table

6) highlights the statements mean and standard deviation, and correlation between statements and the scales total score.

Table 6. Descriptive Statistics for Individual Plant Blindness (PB) Scale Components.

Measure	Urban Space		Botanic Garden	
	M (95% CI)	SD	M (95% CI)	SD
Plant Awareness	19.120 (18.269, 19.924)	3.745	19.020 (18.132, 19.656)	3.739
Plant Fascination	20.650 (19.547, 21.466)	4.093	19.720 (18.621, 20.769)	4.472
Conservationist Efforts	15.490 (15.004, 16.129)	2.541	19.890 (19.364, 20.524)	2.799

Notes: 95% CI = bootstrapped 95% confidence interval M = mean SD = standard deviation.

Botanic Garden and Urban Space Comparison

Kruskal-Wallis H was carried out for each statement (see table 3). A p-value of ≤ 0.05 suggests a statistical significance within the data; strong evidence to reject the null hypothesis and retain the alternative hypothesis. The results indicate a statistically insignificant difference between plant blindness in the botanic garden and urban space, with only 3 statements showing a statistically significant difference (statements 3, 8 and 9). Statement 3 accepts the alternative hypothesis on ‘plant awareness’ and statements 8 and 9 on ‘plant fascination’. Concluding that levels of plant blindness do not change between the two spaces, showing similar levels of plant blindness.

Plant Awareness, Plant Fascination, Conservationist Efforts

Descriptive statistics (see figures 2, 3, 4) compare the results for the botanic garden and urban space, providing a visual understanding of mean score differences for plant awareness, plant fascination and conservationist efforts. There was no significant difference in the results; exposure

to the botanic garden and urban space had no influence on the participants plant blindness, therefore we reject the alternative hypothesis.

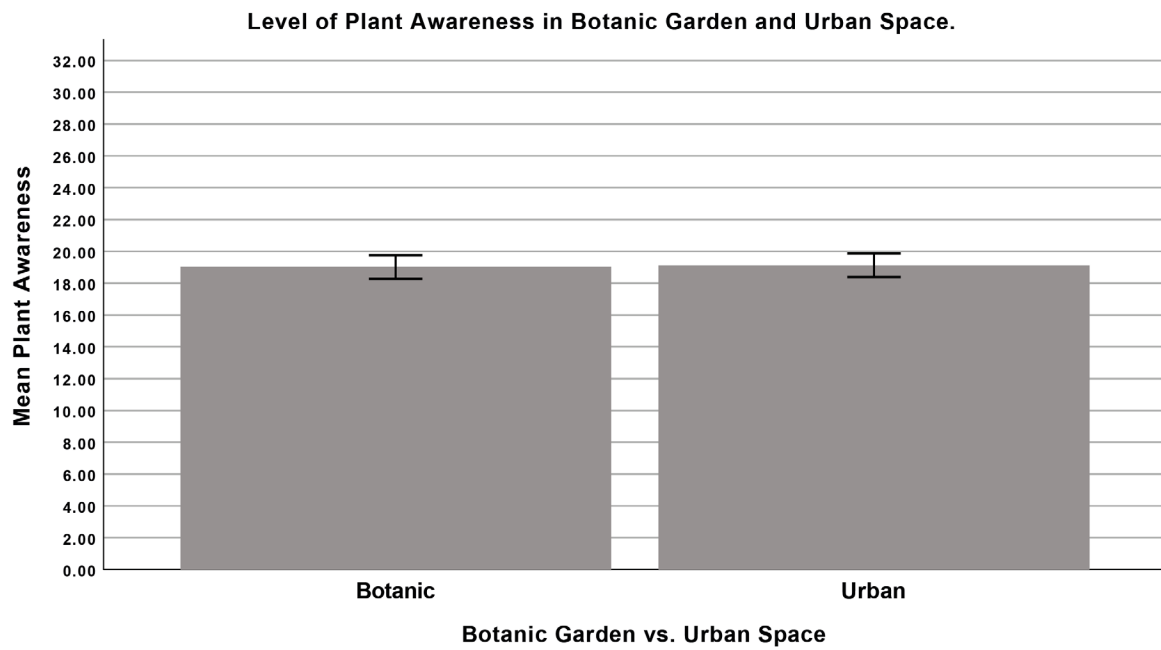


Figure 2. Plant awareness by Condition. Error bars representative of a 95% confidence interval.

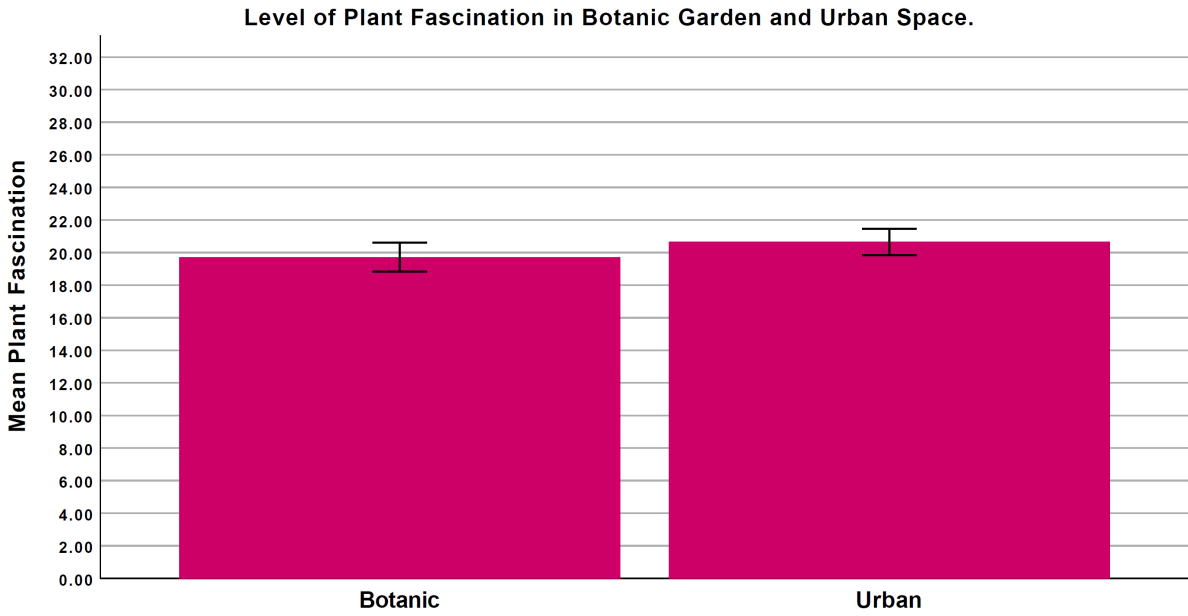


Figure 3. Plant Fascination by Condition. Error bars are representative of a 95% confidence interval.

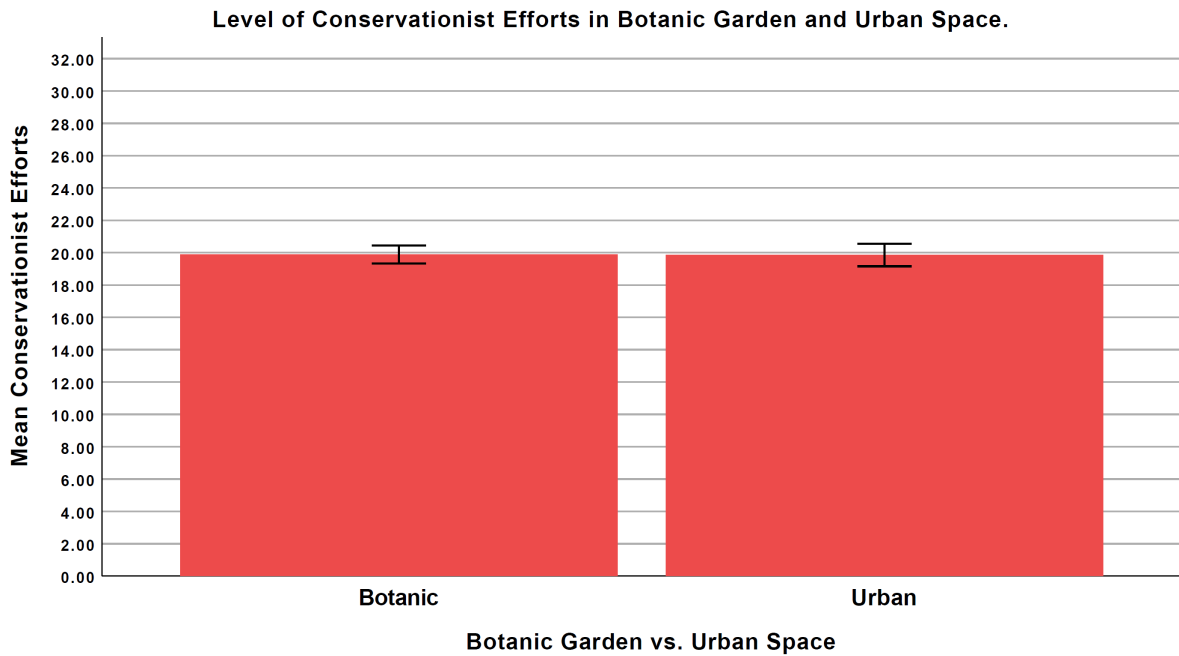


Figure 4. Conservationist Efforts by Condition. Error bars are representative of a 95% confidence interval.

Plant Blindness

Descriptive statistics compare mean plant blindness scores for the botanic garden and urban space (figure 5), showing an insignificant difference and similar mean score for each PB scale level.

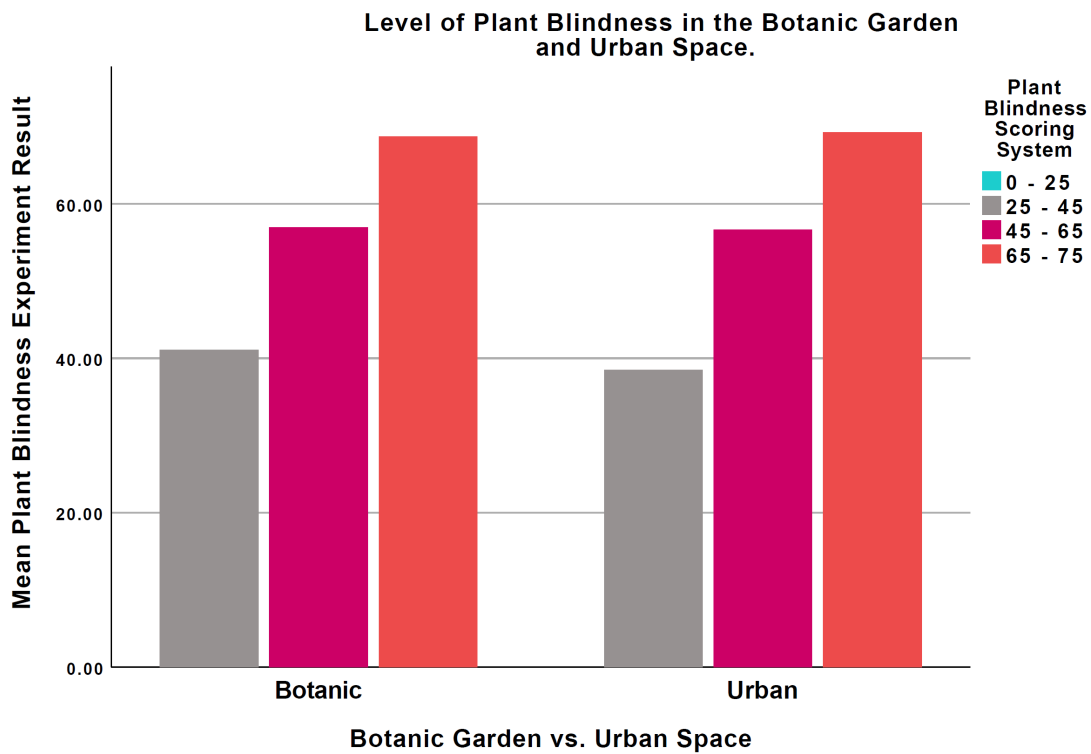


Figure 5. Overall Plant Blindness for the Botanic Garden and Urban Space.

Plant awareness, fascination and conservation efforts were not influenced by the participant's exposure to the botanic garden or urban space, rejecting all the alternative hypotheses. The outcome may be because the experience of the botanic garden and urban space was virtual as opposed to physical, although the comparable results suggest plant blindness is evident within society.

The insignificant relationship established between botanic gardens' and reduced plant blindness supports Wandersee & Schussler's (1999) publication on plant blindness, suggesting an inability to recognise plants within the immediate environment and the significance of plants in our biosphere, rendering them inferior. The relationship between plant blindness and the urban or botanic space is complex and stems beyond simply maintaining 'a love of nature, or enjoyment of only the superficially pleasing facets of nature' towards 'an awareness and understanding of all aspects of the natural world' (Nisbet & Zelenski, 2013: 2), including conservation and plant diversity's future.

Qualitative Findings

Research suggests botanists and the botanical societies often don't do enough work in promoting botany and botanical education (Hershey, 1989), with their incentive to change limited. Whilst the interviews recognised botanic gardens' as fundamental in raising awareness on issues of social and environmental integrity within their in-situ and ex-situ work; contributing to global action on moral concerns. Their social relevance and the economic pressures inflicted on the institutions have lessened their impact connecting people and plants, with audiences often unclear as to the role of the garden. Work should refocus botanic gardens and give precedence to the institution's social agenda. This requires a discussion between the whole sector of botanic institutions, developing a strategy to progress forward, focusing on communication under the umbrella of organisations such as the BGCI.

The BGCI is recognised as a driver of 'global understanding' to 'conserve those species that are threatened with extinction' (Participant 11). The BGCI could catalyse botanic gardens' to work together at a local, national, regional, and global level, helping them to establish a better understanding of plant blindness and promote the conservation of sustainable plant diversity. The

BGCI contributed to the development of the GSPC as a response to plant diversity loss, however, the GSPC only touches on plant blindness as an issue, rather than magnifying the problem. Participant 11 suggested plant blindness ‘may be worthwhile of consideration within the GSPC but may be difficult to measure explicitly’.

Participant 4 suggested, plant blindness ‘needs to be tackled more broadly – at a societal level’, with Participant 7 highlighting the ‘need to connect motivated individuals who care about global issues like climate change, deforestation and biodiversity loss to the potential knowledge, skills and empowerment botanic gardens' hold.’ Botanic gardens’ have a responsibility for delivering on the targets of the GSPC, particularly Target 14 on education and public awareness. This requires Botanic Gardens to engage further with the GSPC to enable greater outreach and funding to meet botanic gardens’ needs, supporting groups within society that are passionate about plant diversity and conservation. However, it is perceived that ‘not all gardens can focus on all elements of the GSPC’ (Participant 8), overwhelmed by the requirements the GSPC imposes on them. Reassessing the 16 targets and giving confidence to botanic institutions is necessary. The GSPC strategy ended in 2020 and no successor has yet been developed. Plant blindness should concentrate on all facets of society, requiring large scale efforts that utilise the full potential of the botanic gardens’ role. Botanic gardens must progress to provide both in-situ experiences to engage with the user, whilst also creating ex-situ action to survive a twenty-first century context. Many botanic gardens are detached from policy protocol nationally and internationally inhibiting the promotion of any social agendas. An absence of funding for botanic gardens further excludes public interest with the cost of entry suppressing the gardens accessibility for all. Studies suggested botanic gardens commonly present themselves as visitor attractions to provide the essential revenue (Martins-Loucao et al., 2014). Research implies that the cost of botanic gardens can be perceived as elitist and exclusive.

The demographic of botanic garden visitors is suggested as mostly white, older, educated, wealthy, middle-class audience (Vergou & Willison, 2016), confirmed within the demographic of participants within the UK choosing to participate in the public survey (see table 2), with not a singular Black/ African American person taking part. Participant 5 suggested, 'Where a pay barrier exists I fear many people are excluded' and Participant 3 noted that 'across my 20 year career in botanic gardens I have not noticed a significant change in demographics'. Young people were identified as the excluded demographic; '[we get] mainly young families and the older generation. I think many gardens struggle with the teens [in their] early 20s, until they have families' (Participant 8). Few botanic institutions actively target excluded audiences, often intensifying the divide between those with plant knowledge and those without a plant education. Participant 4 highlighted, 'we have target 'hard to reach' groups with whom we strive to engage more', whilst Participant 5 suggested the botanic garden 'operates more as a tourist attraction than what was once a much more accessible experience for the local population.' Many botanic gardens focus on sustaining their existing audiences or facilitating the 'tourist gaze' (Urry & Larsen, 2011), providing facilities and services that are financially attractive, opposed to funding the gardens aims and ethos. This conflict of interest emphasises the disparity amongst botanic gardens, confusing the ideals of gardens and how society should perceive them. Participant 11 suggested 'if you were to survey the general public to ask them what plants provide, I'd bet many people would say they look pretty, completely missing the fact that they are the basis of our ecosystems, the support system for our planet.' A failure to recognise the fundamental need of plants within our biosphere is a danger to the future conservation of plant diversity.

Seasonality was drawn upon within the interviews as key within the botanic gardens' annual calendar, facilitating enjoyment and interest for those working within horticulture and botany.

Several participants emphasised the pleasure and ambience of spring time in the botanic garden; 'it's bursting with promise and gorgeous new life' (Participant 2), 'the gardens are full of promise and lush new growth' (Participant 8), it 'brings hope and the opportunity to observe and record and monitor the emergence of plants as many of them awake from their winter dormancy' (Participant 11). The participants also recognised the importance of other seasons within the garden; summer is when more than 'ca. 5000 types of plant are in flower' (Participant 4), autumn is defined by 'transitioning colours' (Participant 2) and winter brings 'warmth and scent of a tropical glasshouse first thing in the morning' (Participant 5). Botanic gardens strive to define seasonal change by integrating planting into their landscape that enthuses visitors throughout the year, acknowledging that 'species bloom at different times, so acknowledging what species are going to provide most interest when is important' (Participant 8). Seasonality is however sensitive to climate change that shifts the timing of seasonal changes in temperature and weather. The temperature can impact many dimensions of plant life, including when a plant bears fruit, blooms, establishes foliage, or dies. A greater transparency between the botanic garden and general public would be beneficial, to construct an educated understanding on seasonality and plant life throughout society, to challenge plant blindness and ensure ethnobotany and horticulture are recognised as cogent professions in the twenty-first century.

Challenging Plant Blindness

Botanic gardens' are 'often the best managed, most biodiverse, and spatially complex green spaces in cities' (Participant 7), therefore we strive to find open green spaces in the urban realm, to connect with society on a new level. Through educative practice and capacity building that involves both the staff of botanic gardens and their public audience, the gardens will progress towards spaces of anthropocentric and visionary thinking. Active participation in local projects is

essential rather than being ‘aloof’ (Participant 5). Botanic gardens can influence community groups and infrastructure, providing long term social interaction and bringing together groups of like-minded individuals; providing physical activity, education, and plant engagement.

Participant 11 highlighted, ‘there have been a number of projects where botanic gardens' have worked with local communities to influence and shape the planting in urban spaces. An example at Cambridge University Botanic Garden would be community gardening projects supported by the garden.’ This demonstrates progressive active engagement, demonstrating an ability to adapt to societal wants and needs within a twenty-first century context and target plant blindness. Botanic gardens’ are not more intimately connected with biodiversity conservation, activism and movements such as RBG Kew Grow Wild Project; a large-scale outreach project designed to facilitate interaction between young people and native plants and fungi in their local spaces. Through taking an inclusive and educative approach to conservation work plant blindness is proactively addressed.

Botanic gardens' have the potential to facilitate a connection between the natural world and society, providing a connection with plant diversity through the implementation of physical action and education. Through a greater ‘education of visitors using interpretation boards that highlight the importance of plants [...] fun family trails to make plants interesting to a younger audience. As well as direct teaching of school groups, adult courses and FE and HE groups’ (Participant 11) botanic gardens’ become more integrated into society and reduce plant blindness. To remain grounded botanic gardens' should concentrate on their core values, acting as ‘ a refuge for those seeking a quiet, reflective oasis amongst the bustle of the city’ (Participant 5); ‘offering a space in which to get lost in a “sense of place” as much as to find a “sense of place”’ (Participant 10), whilst providing an understanding of botanic gardens’ that progresses beyond their ‘nature of being’

(Participant 2) and function as 'high quality green spaces' towards societal engagement, conservation, plant awareness and fascination. There is a desire to induce mindfulness in visitors (Moscardo, 1996) who have informed beliefs and perceptions on botanic gardens. Wandersee and Schussler (1999) advocated the idea of plant mentors to assist in the development of plant knowledge, suggesting mentors can help to nurture a primary interest between person and plant; targeting plant blindness. However, botanic gardens often lack the funding or educational capacity and support to motivate, engage and mentor individuals on a broad enough scale.

Whilst there is progressive work ongoing within some botanic gardens', focusing on connecting with society virtually, with Participant 1 highlighting that 'social media, [...] allows us to post plants that are currently flowering or other interest'. It was suggested that there is more that could be done, with Participant 5 stating that 'social media engagement is surprisingly inconsistent amongst botanic gardens and is a mechanism which should be deployed more readily, it's free and can aid integration.' Botanic gardens can have narrow and fixed notions of the 'narrative' they create, and this can result in them not targeting plant blindness on a broad enough scale. Representations of plants and nature through textual or cinematic expression can provide a visually transcendent experience that inspires and engages the user to want to learn or know more. Botanic gardens should take authority in encouraging virtual aids and documentaries that focus on virtually enthusing a wide demographic audience on plants underappreciated relevance. Botanic gardens are hugely important spaces culturally, economically, socially, and ecologically for raising public awareness on global plant diversity's future, therefore, gardens should progress beyond their physical narrative and connect with society virtually.

The Future of Botanic gardens'

Botanic gardens' have the opportunity to reinvent and reposition themselves at the forefront of plant conservation and climate change, as 'a voice of authority' (Dodd & Jones, 2010). Although the interviews showed signs of progressive behaviour within botanic gardens', drawing on the efforts of real plant conservation, the evidence suggests current strategic action is not effective or sufficient enough to prevent the decline of plant biodiversity and alleviate plant blindness. The research identified plant blindness as an issue both within botanic gardens and the urban botanic gardens'

Botanic gardens' should challenge plant blindness by utilising their expertise in plant knowledge and the valuable in-situ and ex-situ work they carry out. Botanic gardens' focus must be rooted in the collaborative actions of the staff and institutions, stimulating external connections with other botanic institutions, public bodies, organisations and the government. It is suggested that botanic gardens should collaborate within a network of botanic institutions to facilitate greater societal engagement. To challenge plant blindness within botanic gardens and the urban realm a network of action must be facilitated both in-situ and ex-situ to create a stronger movement towards an awareness of plants and protecting our planet.

By establishing a network of collaboration between botanic gardens', it is argued botanic gardens' can adopt a role of communicating plant collections 'outside the gates' (Participant 2); bringing the botanic garden into the urban environment. Participant 4 suggested, 'they play an important part in the urban environment – they are [an] 'oases in the city', with unparalleled levels of biodiversity'. Progressively more developers are turning to botanic gardens for advice on urban green spaces, providing the gardens with an opportunity to convey the multifaceted relationship between the natural world and humankind. Future development of the urban realm should 'include [not only] the value of individual green spaces but [also] the role of connectivity between green

spaces, with botanic gardens as high value ‘islands,’ connected to other parks and gardens through green corridors or nature ways’ (Participant 7). Urban green spaces are too often challenged by low plant diversity, compromising the future resilience of the urban environment. Botanic gardens' knowledge on plant diversity and horticulture should be utilised within the delivery of urban design, introducing plant species that are native to the developed area and intuitive ecologically driven designs, to ensure urban design becomes a sustainable practice supporting stable ecosystems.

‘The best botanic gardens' should be immersive, compelling and beautiful – we shouldn't rely on our audiences having an intellectual interest in the subject matter to become engaged’ (Participant 7). The research acknowledged that native flora must be showcased, enthusing the user with botanic interest, and engaging with society in an intuitive and meaningful way. Participant 7 stated, ‘Let's stop talking about ‘inspiring the next generation’ – what about the current one? [...] What value does a carefully planted taxonomic bed hold if it's devoid of colour, spatial complexity and incapable of supporting biodiversity? What value does an annual ‘wildflower’ sowing hold if it has no fidelity to wild plant community dynamics and a heavy environment footprint?’. As humans we too often lose our sense of direction towards conserving plant diversity. The relationship between humans and nature needs rebuilding (Leigh Hester, 2016) and botanic gardens' play a significant role in shaping this future. This requires ‘botanic gardens to have a clear ‘narrative hierarchy’ (Participant 7) within their research, to initiate greater change and policy action within the future design of urban spaces, drawing on co-curation opportunities and practices. Refocusing the role of botanic gardens maintains their function as a ‘source of learning and debate, as well as a celebration of plants around the world’ (Participant 2), whilst directing their work towards ‘raising awareness on the importance of plants to our planet's survival’ (Participant 9). Botanic

gardens must increase their validity and have confidence in their work, convincing those sceptical of plant diversity's uncertain future.

Conclusion

This paper addressed a future for botanic gardens' that challenges plant blindness, focusing on societal engagement that deepens our cultural understanding on conservation. The prevalence of plant blindness in society may be affected by the outreach work botanic gardens provide, and level of plant diversity that is cultivated by botanic gardens (Mounce et al. 2017) and their extensive plant collections provide opportunity for the delivery of urban spaces that challenge plant blindness, functioning as resilient ecosystems within a changing climate. While in-situ conservation remains the core of botanic gardens' work, ex-situ conservation accessible to the wider horticultural community is necessary to reduce plant blindness and catalyse a greater societal understanding of plant diversity conservation. Botanic gardens should establish a specialised role within society that intuitively networks with urban green space, including public planting, gardens, parks, nature reserves, and forests (as well as the communities which use them). This will enable urban spaces to deliver healthy environments that support a wealth of plant diversity, thereby reducing plant blindness.

Botanic gardens can drive research into plant diversity's future, creating compelling evidence for the benefit of green spaces and plants for users, funders and policy makers. However, they cannot facilitate this action alone, therefore, working and networking with key organisations will enable the gardens to collaboratively form new approaches and ideals.

Further research could address botanic gardens' future in the urban realm, how they could aid the development of green corridors, facilitate approaches to planting within an urban environment and look into the impact on plant blindness from a localised scale by mapping out the locations of the

botanic gardens' should continue to focus on botanic gardens in-situ and ex-situ practical work and education, and the preservation of plant diversity globally; to promote an intuitive and developed understanding of plant diversity and conservation within society. Although our research includes some international perspectives, the conclusions drawn from this study are mainly applicable to botanic gardens in the UK and other developed countries. As such, it is essential for future research to focus on botanical gardens in developing countries, particularly in the Global South. A range of ethnographic and cross-cultural studies have shown that plant blindness may not exist in certain cultures, particularly in non-Anglo/European societies like the indigenous communities of North America, Australia, and Asia (Margulies et al., 2019). Therefore, it is crucial to understand how plant blindness operates in these communities and how botanic gardens might contribute to combating it. By incorporating a wider range of cultural perspectives, future research can help to build a more comprehensive understanding of plant blindness and the role of botanic gardens in tackling this issue on a global scale.

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Author Contributions

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Supplementary material

Appendix A- Interview Questions

1. Introduce yourself and your work in 5 sentences (or less).
2. What influenced and inspired you to work in this field?
3. Please describe how botanic gardens contribute to your 'sense of place'.
4. What is your favourite time of year in botanic gardens and why?
5. How does the number and demographic of visitors to botanic gardens change through the seasons?
6. Have you noticed any change in the demographic visiting botanic gardens?
7. Have you noticed a change in the way visitors use botanic gardens to find their own 'sense of place'?
8. What should first time visitors to botanic gardens be sure to see?
9. What overlooked aspect regarding plants would you like to see as common knowledge?
10. What are the functional benefits of plants?
11. Do you see the concept of plant blindness an issue within botanic gardens? Please explain.
12. In what ways do botanic gardens challenge the concept of plant blindness?
13. Should plant blindness be considered within the next Global Strategy for Plant Conservation (GSPC) targets?

14. How is ethnobotany's agenda making progress in the twenty first century?
15. Who decides what is conserved within botanical collections and what is the reasoning behind this?
16. Who decides what plants are chosen for display in botanic gardens and the reasoning behind this choice?
17. Are we progressing away from the historic relevance and context associated with botanic gardens and their function? Please explain.
18. What do you see the future as for botanic gardens and do you see their role changing and evolving?
19. Do you think botanic gardens can become better integrated into our urban realm environment? Please explain.
20. How do you see botanic gardens shaping our future urban spaces? Do you have any examples of where this is already happening?

Appendix B: Plant Blindness (PB) Scale Survey

Degree of Plant Blindness	Score
Plant Blind	0 – 25
Significant signs of Plant Blindness	25 – 44
Some signs of Plant Blindness	45 – 64
No signs of Plant Blindness	65 - 75

Appendix C: Plant Blindness (PB) Scale Multiple-choice Interview Statements

Likert scale ranked from 1 (strongly disagree) to 5 (strongly agree).

1. The plants in the video add value.
2. The plants in the video interest me.
3. I recognised a variety of plants in the video.
4. The plant life in the video engaged me.
5. From the plant life in the video, I recognise the season.
6. Seasonal changes in plants makes me want to visit a place.

7. A diversity of plant species makes me want to visit a place.
8. Plants are fundamental to my enjoyment of a place.
9. Even in an urban environment, I notice plants around me.
10. I like to engage with plant life around me.
11. I have an understanding of plant conservation and the future of plant diversity.
12. Conservation of plants is necessary because plants are not strong enough to recover from all human impact.
13. No plant species are meant to die out or become extinct.
14. I think we need to learn more about plants within society.
15. My personal wellbeing is enhanced by plants.