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Preferences of Adults for Synanthropic Flora in the Sustainable Development of Polish Cities' Green Areas

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Abstract: Synanthropic flora (weeds, i.e., spontaneously developed plants) are plants that accompany humans, appearing as a result of anthropopressure as well as after its cessation. The potential of synanthropic flora in shaping green areas usually brings many measurable benefits that depend on land management in cities. This study aimed to determine the preferences and attitudes of adults towards synanthropic flora in settlement units. This article presents survey results from 447 city residents. The obtained results were statistically analyzed using the k-means clustering method to identify segments of respondents with similar attitudes and preferences toward synanthropic flora. Mann–Whitney U tests were employed to determine statistical differences in the demographic variables among the analyzed clusters of respondents. Additionally, multiple regression analysis was performed to identify the opinions and attitudes towards synanthropic flora that may influence their greater acceptance in the vicinity of residential areas. The results obtained in the multiple regression analysis indicate that the respondent's evaluation of the level of support for the introduction of more synanthropic vegetation into urban greenery (Yw) grows with the increase in the acceptance of synanthropic plants' occurrence in the surroundings. Residents' acceptance of synanthropic flora in green areas is at a relatively high level.

Keywords: synanthropic plant species; spontaneous vegetation; residents' opinions; green and sustainable design; settlement areas

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1. Introduction

One of the solutions to meet the environmental challenges that cities face nowadays is the enrichment of green infrastructure. There is a need to create more green spaces in both urbanized areas and those in the process of urbanization [1]. In urban areas, not only large areas covered with vegetation are important but also a network of small patches that allow vegetation to establish [2,3]. Critical to the effective functioning and success of a design is the proper selection of plant species. Not only are the characteristics of each species important in this but so is the diversity aspect [4]. Alternatively, it is possible to omit vegetation-destroying or maintenance practices. This allows for the expansion of spontaneous vegetation, although conscious choice and intentional introductions to increase diversity are useful in this way as well [3].

Among the spontaneous vegetation, there is a significant group of alien and invasive plant species that pose a threat to native vegetation [5–8]. Invasive alien plant species can cause biodiversity loss and thus alter ecosystem services [9]. By prudently introducing or

accepting the presence of spontaneous native flora by the people in charge, the resilience of plantings is increased [10,11] and so is the biodiversity [12,13]. This kind of vegetation reduces ecological and financial costs and increases the resilience of urban vegetation communities [14]. Accordingly, synanthropic species and spontaneous greenery, in general, can be beneficial in the design process of green infrastructure projects prepared on various scales. Spontaneous plant species are used in the design of larger-scale public green areas [15–18], but not exclusively. For example, smaller patches are provided by spontaneous greenery along roads, creating diverse landscapes [13], also colonizing trackways [19]. Synanthropic flora appears on green roofs as a result of cessation of maintenance, causing wilderness by default [12,20], or it is accepted during the maintenance process [10]. It could be also intentionally introduced [11,14]. Spontaneous plant species are also implemented in more sustainable farming systems [21] and even in show gardens [22,23]. They effectively colonize vertical elements as well, such as vegetation columns [24]. Synanthropic flora can also form the basis for more diverse novel urban meadows [25].

However, social acceptance of spontaneous vegetation and residents' preferences may be limiting factors for its use [26]. Preferences are influenced by plant trait effects, such as sustenance effects, ecosystem services [27] effects, and conservation effects [26], but most of all, they may be influenced by ornamental features. In the context of cultural considerations pointed out by Chang et al. [26], it may be questionable to take the results of residents' preference surveys conducted regionally and generalize them for the whole world. An example of significant differences, which may be due to cultural backgrounds, might be the preference of Berlin residents for wild grasslands [28] compared to Singapore residents' preference for lawns [29]. The presence of spontaneous plant species (and ruderal and wilder areas compared to standardly tended urban greenery) itself is often met with acceptance [28,30–32], sometimes under some conditions [29,33,34], or lack of acceptance prevailing, for example, in Latin American societies [34] or legacy cities [35].

In some studies, socioeconomic factors did not have a significant effect on the acceptance of synanthropic species [29]. However, the study by Li et al. [33] showed that people with higher education levels had a more positive attitude towards the occurrence of synanthropic species in urban spaces compared to those with lower education levels. The level of education may also influence the frequency of visits to sites, where synanthropic species occur [33]. It is still not fully clear how socioeconomic factors influence the acceptance of synanthropic flora.

This study aimed to recognize adults' preferences and attitudes towards synanthropic flora in settlement units.

The following scientific questions were formulated:

1. What aspects of the synanthropic plant species perception increase the overall residents' acceptance of these plants in urban spaces?
2. How do perceptions of synanthropic plants differ in terms of the demographic profile of respondents?

2. Materials and Methods

2.1. Study Design, Participants, and Questionnaire

This paper is grounded in the findings of a questionnaire research study conducted in 2023 using the CAWI method, facilitated by Google. The survey adhered to national and international regulations. Participants' personal information and data were anonymized, complying with the General Data Protection Regulation of the European Parliament (GDPR 679/2016). Ethical considerations throughout this study ensured the ongoing safety of participants and the integrity of the collected data.

Before commencing the questionnaire, participants were provided with a brief description of this study, its objectives, and a declaration of anonymity and confidentiality. To initiate participation in this study, respondents had to express voluntary consent, and they retained the option to terminate their involvement at any point.

Respondents refrained from disclosing their names and contact information, including IP addresses, and had the liberty to conclude the survey at any stage. Responses were recorded only upon participants clicking the "submit" button after completing the questionnaire.

The questionnaire comprised two sections. The first section focused on gathering socio-demographic data, encompassing characteristics such as gender, age, education, place of residence, and income. The second part of the questionnaire included inquiries related to synanthropic plants, incorporating questions about respondents' attitudes towards these plants on a 5-point Likert scale.

2.2. Statistical Analysis

To investigate a relationship between the level of acceptance of synanthropic vegetation in urban greenery (Yw) and opinions (attitudes) on the subject of synanthropic vegetation, a multiple regression model was applied. In the first step of the multiple regression model construction, it was necessary to perform descriptive statistics including correlation analysis for all potential independent variables, which, in the next steps allowed the development of the following multiple regression model. In the final model, 5 independent variables were used:

- X_1—The use of synanthropic vegetation found in turfgrasses has a positive impact on the visual attractiveness of a site.
- X_2—Synanthropic plant communities present themselves better than others.
- X_3—The presence of synanthropic vegetation in your estate improves the quality of life in that location.
- X_4—The introduction of synanthropic plants into estate arrangements is positive.
- X_5—I support the use of synanthropic plants for educational purposes—as elements of playgrounds or in the form of environmental workshops.

Both the dependent variable and independent variables were measured on a 5-point Likert scale. The R^2 value of the model was 0.656, which means that approximately 65.6% of the variability of the dependent variable Yw was explained by the independent variables included in the model. The value of the F statistic was 168.39, and the corresponding value of $p = 0.0000$, i.e., <0.05, which indicates that all independent variables significantly influenced the dependent variable Yw because p is smaller than the level of statistical significance assumed in this study, which is equal to 0.05.

The next step of the analysis was to develop descriptive statistics and perform difference tests for the dependent variable and independent variables. To determine whether demographic variables significantly differentiate the opinions expressed by the scales on which the studied variables were measured, additional analyses were performed in the form of the Mann–Whitney U test and the Kruskal–Wallis test.

2.3. Characteristics of Respondents

A total of 447 respondents participated in the survey, with over 70% being women. Regarding age distribution, the largest group consisted of respondents aged 18–25 (63.8%), followed by the second-largest group aged 36–55, accounting for nearly a quarter of the respondents (22.4%). Respondents aged 26–35 and over 55 were less represented, comprising 7.2% and 6.7%, respectively.

Education-wise, more than half of the surveyed population held secondary education qualifications (54.8%), while a third possessed tertiary education credentials (33.8%). The majority of respondents resided in cities with populations exceeding 500,000 inhabitants (45.9%). One-fifth of respondents lived in cities with up to 100,000 inhabitants (24.2%), and 20.1% resided in villages.

Income distribution demonstrated a relatively even division among respondents. The majority (38%) reported incomes ranging from EUR 576.16 to EUR 1037.06, while lower incomes were declared by 25% of respondents and higher incomes were reported by 27.5% (Table 1).

Table 1. Sample characteristics (n = 447, data in %).

Gender			
Female 71.36		Male 28.64	
Age			
18–25 63.76	26–35 7.16	36–55 22.37	Over 55 6.71
Education			
Primary 8.05	Vocational 3.36	Secondary 54.81	Higher 33.78
Place of residence			
Countryside 20.13	Towns up to 100 thous. Inhabitants 24.16	Towns between 100 and 500 thous. inhabitants 9.84	Towns over 500 thous. inhabitants 45.86
Per Capita Income PLN (EUR) [1]			
No answer	Under 2500 PLN (576.15 EUR)	2501–4500 PLN (576.16–1037.06 EUR)	Over 4500 PLN (1037.06 EUR)
9.40	25.06	38.03	27.52

[1] Exchange rate as of 5 February 2024.

3. Results

The analysis of the relationship between the level of residents' acceptance of synanthropic vegetation in urban greenery and opinions on synanthropic plants was conducted using the multiple regression method. The results indicate that the respondents' assessment of the level of acceptance of synanthropic vegetation in urban greenery (Yw) increases with an increase in acceptance of opinions on the subject: the use of synanthropic vegetation found in turfgrasses has a positive impact on the visual attractiveness of a site (X_1), synanthropic plant communities present themselves better than others (X_2), the presence of synanthropic vegetation in your estate improves the quality of life in that location (X_3), the introduction of synanthropic plants into estate arrangements is positive (X_4), and I support the use of synanthropic plants for educational purposes—as elements of playgrounds or in the form of environmental workshops (X_5) (Table 2).

Table 2. Parameter values of the multiple regression model.

Variables		**Assessment b**	***p*-Value**
The use of synanthropic vegetation found in turfgrasses has a positive impact on the visual attractiveness of a site	X_1	0.1604	0.0000
Synanthropic plant communities present themselves better than others	X_2	0.0771	0.0272
The presence of synanthropic vegetation in your estate improves the quality of life in that location	X_3	0.1403	0.0003
The introduction of synanthropic plants into estate arrangements is positive	X_4	0.3085	0.0000
I support the use of synanthropic plants for educational purposes—as elements of playgrounds or in the form of environmental workshops	X_5	0.2840	0.0000
Constant		0.3160	

The resulting model can be described by the following equation:

$$Yw = 0.3160 + 0.1604 \times X_1 - 0.0771 \times X_2 + 0.1403 \times X_3 - 0.3085 \times X_4 + 0.2840 \times X_5 + e \quad (1)$$

In the above model, all structural parameters standing by the explanatory variables Xi were statistically significant ($p < 0.05$).

The analysis of results highlights a remarkable 31% increase in the acceptance level of synanthropic plants in urban spaces as respondents increasingly support the introduction of these plants into estate arrangements (X_4). An intriguing 28% surge was observed in the acceptance of synanthropic plants, correlating with growing support for their use in educational contexts—both as elements of playgrounds and in environmental workshops (X_5). A dynamic increase of 16% in the acceptance level of synanthropic plants in urban spaces was noted when respondents expressed a higher opinion about the positive impact of using these plants in turfgrasses on the visual attractiveness of the area (X_1). Another noteworthy rise of 14% was observed when respondents positively assessed the influence of the presence of such vegetation on the quality of life in a given location (X_3). Additionally, a 7% increase was noted when there was a higher acceptance of the statement that synanthropic plant communities present themselves better than others (X_2). All these results indicate a clear trend of the increasing acceptance of synanthropic plants in urban environments, suggesting a growing understanding of their benefits and value for urban communities (Table 2).

Diversity in response levels for the component variables of the multiple regression model was examined, including all demographic variables. No statistically significant differences were observed in the majority of opinions regarding synanthropic plants based on their place of residence. Only for the variable "The use of synanthropic vegetation found in turfgrasses has a positive impact on the visual attractiveness of a site" (X_1), it was demonstrated that responses to this statement depend on the place of residence. There were also no statistically significant differences in responses from residents based on their incomes.

Respondents' answers to the analyzed statements varied statistically based on gender, age, and education, and these data have been presented in Tables 3 and 4 and Figures 1 and 2. For all statements, except for "Synanthropic plant communities present themselves better than others" (X_2), women evaluated the impact and presence of synanthropic plants more positively than men. Statistically significant differences were observed in opinions regarding the following statements: "The presence of synanthropic vegetation on your estate improves the quality of life in that location" (X_3), "The introduction of synanthropic plants into estate arrangements is positive" (X_4), and "I support the use of synanthropic plants for educational purposes—as elements of playgrounds or in the form of environmental workshops" (X_5) (Table 3).

Table 3. Opinions about synanthropic plants by gender (n = 447, means, Mann–Whitney test).

Variables	Men	Women	Z-Value U Mann–Whitney Test Men vs. Woman	*p*-Value
Level of acceptance of synanthropic vegetation in urban greenery (Yw)	3.98	4.19	−1.9	0.060
The use of synanthropic vegetation found in turfgrasses has a positive impact on the visual attractiveness of a site (X_1)	3.66	3.83	−1.27	0.203
Synanthropic plant communities present themselves better than others (X_2)	3.20	3.15	0.39	0.695
The presence of synanthropic vegetation in your estate improves the quality of life in that location (X_3)	3.53	3.85	−2.74	0.006
The introduction of synanthropic plants into estate arrangements is positive (X_4)	3.82	4.15	−3.16	0.002
I support the use of synanthropic plants for educational purposes—as elements of playgrounds or in the form of environmental workshops (X_5)	3.96	4.26	−2.64	0.008

Table 4. Opinions on synanthropic plants by respondents' age groups (n = 447, Kruskal–Wallis and Mann–Whitney test).

Statements	Age				
	Z-Value U Mann–Whitney Test for Pairs Age Groups				H-Value Kruskal–Wallis Test for Age
		26–35	36–55	Over 55	
Level of acceptance of synanthropic vegetation in urban greenery (Yw)	18–25 26–35 36–55	1.51	2.20 0.13	0.72 1.65 1.89	8.77 *
The use of synanthropic vegetation found in turfgrasses has a positive impact on the visual attractiveness of a site (X_1)	18–25 26–35 36–55	1.95 0.33	3.70 * 0.33	0.52 1.04 1.59	16.92 *
Synanthropic plant communities present themselves better than others (X_2)	18–25 26–35 36–55	0.37	3.24 * 1.51	0.39 0.57 2.17	12.50 *
The presence of synanthropic vegetation in your estate improves the quality of life in that location (X_3)	18–25 26–35 36–55	0.88	2.82 * 0.81	0.67 1.15 2.20	10.27 *
The introduction of synanthropic plants into estate arrangements is positive (X_4)	18–25 26–35 36–55	1.58	2.72 * 0.10	0.97 1.89 2.42	12.43 *
I support the use of synanthropic plants for educational purposes—as elements of playgrounds or in the form of environmental workshops (X_5)	18–25 26–35 36–55	1.26	3.21 * 0.68	0.23 1.10 2.01	13.70 *

* means that the p-value < 0.05.

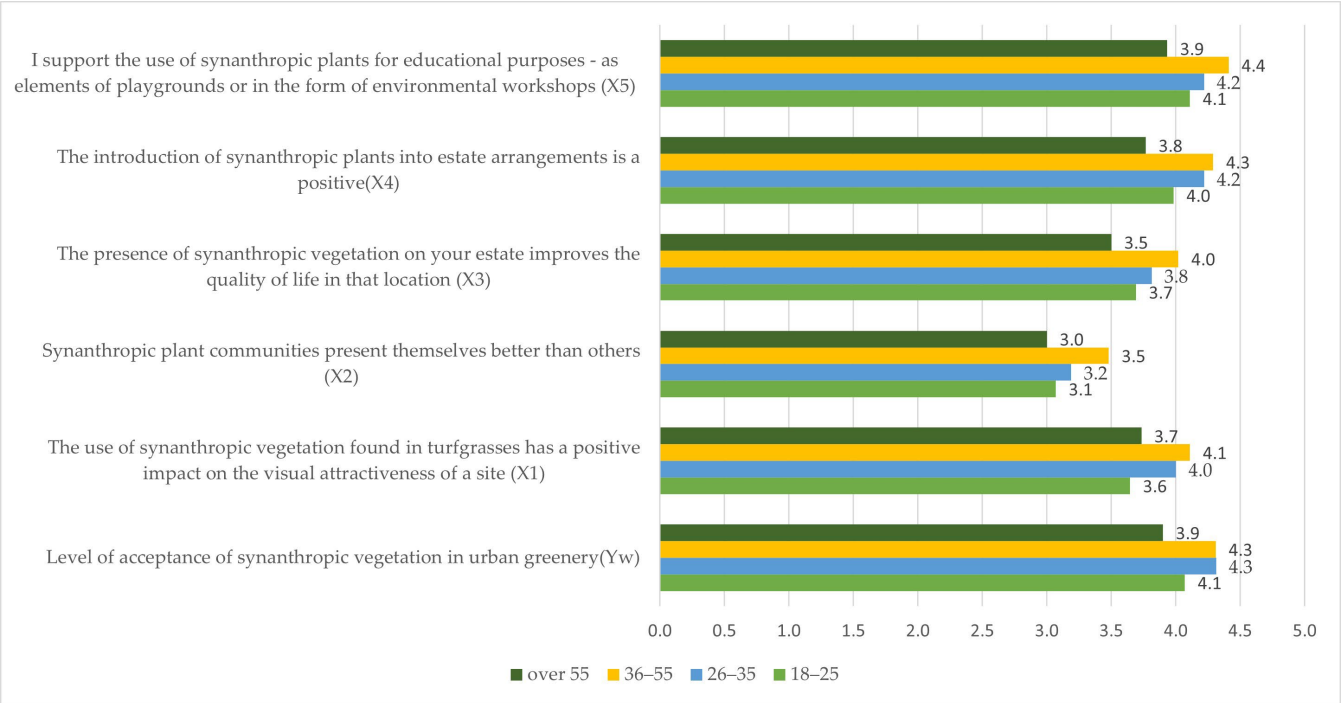

Figure 1. Opinions on synanthropic plants by the respondents' age (n = 447, data as means of answers).

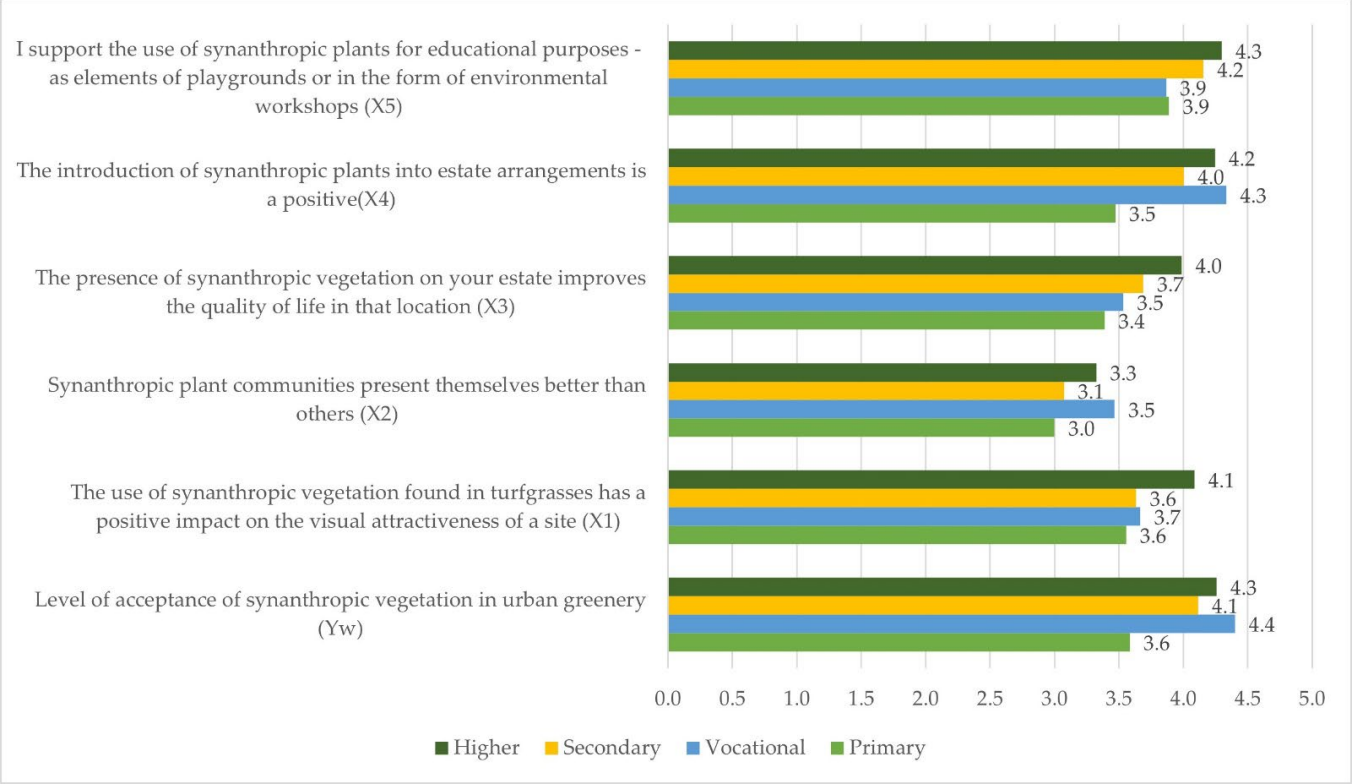

Figure 2. Opinions on synanthropic plants by respondents' education level (n = 447, data as means of answers).

Individuals in the 36–55 age group agreed most strongly with all statements regarding synanthropic plants, while the highest scores were observed among individuals in the 18–25 age group. Responses to all analyzed statements were dependent on the age of the respondents, and these dependencies were statistically significant in the Kruskal–Wallis test, with a p-value < 0.05, indicating statistically significant differences based on age.

Pairwise comparisons using the Mann–Whitney test revealed statistically significant differences between the youngest respondents and those aged 36–55. These differences encompassed all statements, except for "Level of acceptance of synanthropic vegetation in urban greenery (Yw)" (Figure 1 and Table 4).

Individuals with higher education were most in agreement with opinions regarding synanthropic plants for four out of six statements. For the remaining two statements concerning "Level of acceptance of synanthropic vegetation in urban greenery" (Yw) and "The introduction of synanthropic plants into estate arrangements is positive" (X_4), individuals with vocational education obtained the highest average responses. The Kruskal–Wallis test indicated that education significantly differentiated responses to all analyzed statements, except "Synanthropic plant communities present themselves better than others" (X_2). In the Mann–Whitney test, it was shown that for statements related to "The presence of synanthropic vegetation in your estate improves the quality of life in that location" (X_3) and "The introduction of synanthropic plants into estate arrangements is positive" (X_4), individuals with higher education more strongly agreed with these issues compared to those with basic education (Figure 2 and Table 5).

Table 5. Opinions on synanthropic plants by respondents' education groups (n = 447, Kruskal–Wallis and Mann–Whitney test).

Statements	Education				
	U Mann–Whitney Test for Pairs Education Groups				Kruskal–Wallis Test for Education
		Vocational	Secondary	Higher	
Level of acceptance of synanthropic vegetation in urban greenery (Yw)	Primary	1.51	2.20	0.72	8.77 *
	Vocational		0.13	1.65	
	Secondary			1.89	
The use of synanthropic vegetation found in turfgrasses has a positive impact on the visual attractiveness of a site (X_1)	Primary	2.29	2.12	2.99	12.40 *
	Vocational		1.23	0.56	
	Secondary			1.70	
Synanthropic plant communities present themselves better than others (X_2)	Primary	1.46	0.46	1.54	6.65
	Vocational		1.37	0.60	
	Secondary			1.96	
The presence of synanthropic vegetation in your estate improves the quality of life in that location (X_3)	Primary	0.49	1.32	2.81 *	12.84 *
	Vocational		0.32	1.36	
	Secondary			2.75 *	
The introduction of synanthropic plants into estate arrangements is positive (X_4)	Primary	2.68 *	2.55	3.84 *	19.95 *
	Vocational		1.38	0.41	
	Secondary			2.48	
I support the use of synanthropic plants for educational purposes—as elements of playgrounds or in the form of environmental workshops (X_5)	Primary	0.25	1.11	2.32	9.77 *
	Vocational		0.45	1.30	
	Secondary			2.24	

* means that the p-value < 0.05.

4. Discussion

Synanthropic species are sometimes noticed in surveys that do not focus on spontaneous greenery, where respondents refer negatively to their presence [36]. In general, cultivated species are valued higher than spontaneous species [30,32], even if they are native [32]. They are more often planted and tolerated in home gardens [37]. Some design interventions (adding ornamental plants or recreational elements, clearly demarcating composition elements) seem to have a positive effect on residents' perception of them [29,30,34,38].

According to our study, the more the respondents consider synanthropic plants as visually attractive, the more they accept them in urban spaces. Also, the more they appreciate the presence of synanthropic plants (in the context of life quality and education, i.e., the second group of factors), the more they accept that type of vegetation in the city. It is also worth noting that the acceptance of these plants in urban spaces increases if the respondents' opinions (about the beneficial impact of synanthropic plants on the visual attractiveness of the place) increase by one unit.

Meanwhile, negative residents' reactions could be evoked by unintentional vegetation overgrowth of infrastructural elements [35], although sometimes, the reactions are more positive [38]. In contrast, positive reactions could be evoked by the intentional introduction of synanthropic plants into areas strongly dominated by infrastructure, such as the creation of floral strips along roads [39]. Waterfronts, forests, and road edges are most often indicated as habitats where spontaneous plants should be preserved, according to residents [34]. Our study shows that people look favorably at synanthropic plants that are also used for educational purposes rather than only for their aesthetic characteristics.

The perception of spontaneous vegetation may be influenced by people's aversion to obstructed views (where vegetation is an obstacle). Better rated among spontaneous vegetation are those of intermediate stages of succession, resembling low grasslands [29,33,34,40], which may be precisely due to the obscuring effect. In our study, synanthropic species associated with turfgrasses met a fairly high level of acceptance too. Lower ratings for denser

and higher vegetation are motivated by the negative impact on the sense of security, despite the simultaneous positive impact on privacy [41,42]. What is especially important here is the legibility of the composition so that even spaces perceived as wild can be accepted [43]. However, even that effect is sometimes desirable, for example in the fort landscape, adding an aura of mystery [44].

The perception of synanthropic vegetation may also depend on both professional knowledge and personal experience. Spontaneous vegetation and its habitats are perceived as natural [31,33,34,40,45], wild [40,45], nostalgic [31], interesting [40], and complex [35], but also repulsive, abandoned [40], unkempt [34], and rubbish-strewn [33]. In counterpoint is cultivated vegetation, which evokes mostly positive associations as being better maintained, tidier [34,45], natural, and safe [34]. According to our study, people who think that synanthropic vegetation has an impact on their well-being are more likely to accept this type of flora in green areas. In our study, we compared the responses of the respondents who live in urban areas and countryside in Poland. Their preferences for spontaneous vegetation were the same, surprisingly. People from the countryside perceive spontaneous vegetation differently but simply as unnecessary plants. This probably results from their agricultural work—the perception of these plants as negatively affecting the crop quality. On the other hand, urban residents do not have good knowledge of spontaneous plants [46]. This may also be due to equating the presence of synanthropic species with site neglect. Such a perception by the Polish society was mentioned by Trzaskowska [47].

In our study, those with a higher or vocational education showed the highest acceptance of synanthropic plants. This result is similar to the one obtained in the study conducted by Li et al. [33], where higher acceptance was shown by respondents with a higher education level and professionals. However, according to a survey carried out in Leipzig, areas occupied by synanthropic communities are mainly used by less educated residents with lower income levels [33].

Educational attempts [34,48–51] and age may influence changes in the perception of synanthropic species. Our survey shows that these species are more likely to be accepted if they are to be used for such purposes (e.g., in the educational process). In our opinion, in the educational process, the necessity for synanthropic vegetation presence in green areas should be integrated with the need for adaptation to climate change. This study shows that both research and educational activities should be conducted in various countries as the years go by.

5. Conclusions

Synanthropic flora is generally accepted in green areas in Poland by people aged 36–55, but the level of acceptance is still not satisfying. The level of acceptance is also correlated with educational stage and knowledge about vegetation, as in studies conducted in the other mentioned countries (e.g., China and Singapore). Relations between the perception of synanthropic species and their function (for example, the role of synanthropic plants in education) have been observed in this study. Further attempts at education all over the world are required, which could be very helpful for people from all age groups to understand the benefits of native synanthropic flora in green spaces. The results indicate that environmental education concerning the value of spontaneous vegetation should appear at early levels of education. It would make that knowledge more accessible and could improve acceptance among groups other than those with a higher education level. The social acceptance of spontaneous vegetation and preferences are similar despite the place where people live (city or countryside), but the reasons for that effect could be different. This is particularly important in an era of continuing global urbanization. Environmental education should also focus on changing the image of synanthropic species, perceived as a sign of neglect. This may not be possible without intentionally ensuring the visibility of synanthropic species in non-neglected spaces; therefore, it is recommended to use those species in the design process. The results could be useful for landscape architects,

ecologists, and public authorities to formulate directions for shaping green areas and maintaining them, including sustainable development rules in cities.

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