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Do Looks Matter? A Case Study on Extensive Green Roofs Using Discrete Choice Experiments

Jan Vanstockem [1,*], Liesbet Vranken [2], Brent Bleys [3], Ben Somers [1] and Martin Hermy [1]

[1] Division of Forest, Nature and Landscape, Department of Earth and Environmental Sciences, KU Leuven—University of Leuven, BE-3001 Leuven, Belgium; ben.somers@kuleuven.be (B.S.); martin.hermy@kuleuven.be (M.H.)

[2] Division of Bioeconomics, Department of Earth and Environmental Sciences, KU Leuven—University of Leuven, BE-3001 Leuven, Belgium; liesbet.vranken@kuleuven.be

[3] Department of General Economics, Ghent University, BE-9000 Ghent, Belgium; brent.bleys@ugent.be

* Correspondence: jan.vanstockem@kuleuven.be; Tel.: +32-16-32-59-64

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Abstract: Extensive green roofs are a promising type of urban green that can play an important role in climate proofing and ultimately in the sustainability of our cities. Despite their increasingly widespread application and the growing scientific interest in extensive green roofs, their aesthetics have received limited scientific attention. Furthermore, several functional issues occur, as weedy species can colonize the roof, and extreme roof conditions can lead to gaps in the vegetation. Apart from altering the function of a green roof, we also expect these issues to influence the perception of extensive green roofs, possibly affecting their acceptance and application. We therefore assessed the preferences of a self-selected convenience sample of 155 Flemish respondents for visual aspects using a discrete choice experiment. This approach, combined with current knowledge on the psychological aspects of green roof visuals, allowed us to quantify extensive green roof preferences. Our results indicate that vegetation gaps and weedy species, together with a diverse vegetation have a considerable impact on green roof perception. Gaps were the single most important attribute, indicated by a relative importance of ca. 53%, with cost coming in at a close second at ca. 46%. Overall, this study explores the applicability of a stated preference technique to assess an often overlooked aspect of extensive green roofs. It thereby provides a foundation for further research aimed at generating practical recommendations for green roof construction and maintenance.

Keywords: discrete choice experiment; extensive green roof; aesthetic benefits; visual aspects; urban ecology

1. Introduction

Extensive green roofs are a promising type of urban green that can play a substantial role in the sustainability policy of cities [1]. They typically consist of multiple layers, are deliberately vegetated, usually do not interfere with other urban land uses, and are easy to construct on both existing and new buildings with roof inclinations ranging from 1 to ca. 40° [2,3]. While these green roofs, as typical examples of novel ecosystems (sensu Hobbs [4]), are regarded as a means of re-integrating vegetation and, more generally, nature into the urban environment [1,5], they also provide a wide range of ecosystem services [2]. Extensive green roofs can, for instance, play an important role in storm-water management [6], while noise pollution [7], the urban heat island effect [8,9], and the cooling needs of buildings [10,11] are reduced (see also [12]). Furthermore, these vegetated roofs increase roof membrane longevity [13] and urban biodiversity [14,15], while also improving roof effluent quality [16,17] and air quality [12,18]. Finally, extensive green roofs can make an urban environment more aesthetically pleasing [1], thereby providing psychological [19] and economic [20,21] benefits.

Despite increasingly widespread use and growing scientific interest, the aesthetic qualities of extensive green roofs are rarely studied in detail [22,23]. Recently, however, a number of studies assessed the preferences for different vegetation types [24–26] and plant traits, such as life form, flower presence, and plant height [27]. As the vegetation on extensive green roofs develops spontaneously after initial sowing or planting of specialized green roof species (e.g., *Sedum*, *Allium*) [28,29], attributes such as species mixture and flowering color will change as well. It is therefore hard to predict how the aesthetic qualities of the vegetation will evolve over time.

The visual aspects of extensive green roofs are also affected by a number of practical issues. First, previous research in Belgium revealed that up to 70% of plant species colonized the roof spontaneously, with most of the species generally being considered as weedy species (e.g., *Sonchus* spp., *Erigeron* spp.) [30]. Second, the extreme conditions (drought, shallow substrate, and extreme temperatures) to which extensive green roof habitats are exposed can lead to gaps in the vegetation [31,32].

The extent to which these aesthetic issues in turn affect the perception of green roofs has not been studied. In this study, we therefore investigate the importance of the visual aspects of extensive green roofs using discrete choice experiments (DCEs) [33,34] in an online survey to assess preferences for several extensive green roof characteristics, such as weed conspicuousness and gap percentage. In DCEs, a questionnaire is used to evoke a hypothetical market where a good or service can be traded. Choice data of respondents are subsequently recorded, are analyzed, and can be used to determine a willingness-to-pay (WTP) or willingness-to-accept (WTA) for the attributes of a good or service [35]. The advantages of this approach are that (1) it provides ex ante insights regarding the importance of visual aspects of green roofs at a low cost, (2) it allows for the separate investigation of specific visual aspects, and (3) its results are directly applicable to green roof practice. As green roof construction is sometimes subsidized by governments (e.g., Flanders (Belgium), New York (USA), Hamburg (Germany)), adapting green roof design, construction, and management based on respondent's preferences can improve the benefits resulting from these subsidies. With this study, we aim to gain insight on the impact of multiple visual aspects on respondents' preferences with respect to extensive green roofs. Furthermore, this study sheds light on the trade-offs between visual aspects and their relative importance in choice situations.

2. Discrete Choice Experiments: Background

While DCEs were initially developed in market and transportation research [36,37], the technique has since been used in multiple studies valuing the environment [35,38–40] (see [41] for a state of the art). In a DCE, hypothetical markets are set, considering both use and non-use values of goods and services. DCEs were founded in the microeconomic framework proposed by Lancaster [42], which states that consumer's utility for a good can be decomposed into utilities for the composing attributes of the good. Goods and services are therefore described by their different attributes and the levels that these take.

Respondents are confronted with a number of choice sets consisting of alternative goods or services, which systematically vary in at least one attribute. By instructing respondents to make a choice between these discrete alternatives, information on the preference parameters of an indirect utility function can be gathered [33]. As DCEs build upon the random utility maximization (RUM) framework [43], this function consists of deterministic (V_{ij}) and stochastic (ε_{ij}) components, which make up the utility (U_{ij}) for a respondent *j* for alternative *i*. This equation can be further adapted to DCEs if the deterministic utility component is specified as X_{ij}, a vector of attributes of the alternative *i* in the choice set, with *b* being the vector of parameter estimates corresponding to all *k* attributes and σ_j the vector of *k* standard deviation parameters [44]:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = bX_{ij} + \sigma_j X_{ij} + \varepsilon_{ij}. \quad (1)$$

In the RUM framework, it is assumed that an individual consistently selects the alternative that generates the highest utility level for him/her, which is determined by the attributes and their levels [44]. Parameter estimates for attributes can subsequently be inferred using the corresponding log-likelihood function [35,45]. After estimation, a mean marginal WTP (mWTP, also described as the implicit price) for any attribute (here *X1*) can be calculated:

$$mWTP_{X1} = IP_{X1} = \frac{-b_a}{b_y}. \quad (2)$$

In this equation, b_y is the parameter estimate of the cost attribute and represents the marginal utility of income, while b_a represents the parameter estimate corresponding to attribute.

3. Materials and Methods

The DCE is conducted by following the six steps described in [35].

3.1. Defining the Hypothetical Situation

In our survey, each respondent was asked to imagine a situation in which they were obliged to construct an extensive green roof on a hypothetical building that he/she owned and that was suitable for green roof construction. Alternatives described in the choice experiments pictured what the roof would look like after two years. Depicted prices would be fully paid by the owner and did not take possible subsidies into account. This situation can be considered increasingly realistic, as green roof construction has become obligatory in multiple cities such as Antwerp (Belgium) and Toronto (Canada). Nevertheless, respondents are asked to make a hypothetical choice. Therefore, a cheap talk script, which urged respondents to make realistic choices with regard to costs, was included to reduce hypothetical bias and improve estimate reliability.

3.2. Selecting Relevant Attributes and Levels

As the main goal of this study was to investigate the importance of visual aspects for extensive green roof perception, most attributes were directly linked to these characteristics. Attributes and their levels were gathered from expert knowledge, literature, commercially available green roof options, and observations during field sampling campaigns on extensive green roofs in Flanders (Belgium) in 2015 and 2016. A final selection of six attributes with three or four levels each was made (Table 1). For the construction method attribute, the three most commonly used roof construction techniques were included as levels (based on [46,47]). Three green roof vegetation types were selected based on the classifications made by [46,48]. These vegetation types are widely used across Europe [49]. Mosses (usually spontaneously colonizing) can have a significant visual impact on extensive green roofs. We therefore included increasing and realistic moss cover percentages. Because of possible subjective interpretations of what a weedy species on green roofs is and what they look like, we opted for a largely visual approach to present this attribute (see Figure 1 for an example). By considering both weed height (relative to the rest of the vegetation) and the roof surface area covered (from limited up to very high cover), three conspicuousness-related categories with clearly defined characteristics were created. A wide range of gap percentages was determined for the gap attribute, based on field observations. Again, a largely visual approach was taken to present this attribute and its levels. Finally, the cost was also included as an attribute, as this is necessary to allow for the calculation of the WTP (cf. [35]) and can have an important impact on respondent's preferences. The three cost levels span the average cost range of extensive green roofs, based on data collected from several green roof firms. Furthermore, a status quo alternative was included in all choice sets to make the DCE consistent with demand theory [35]. In this study, the status quo alternative was a representation of the current state of the average extensive green roof in Flanders that was based on field observations during the sampling campaigns (Table 1, underlined levels). Because all alternatives in the choice sets represent an extensive green roof, a forced choice format is followed.

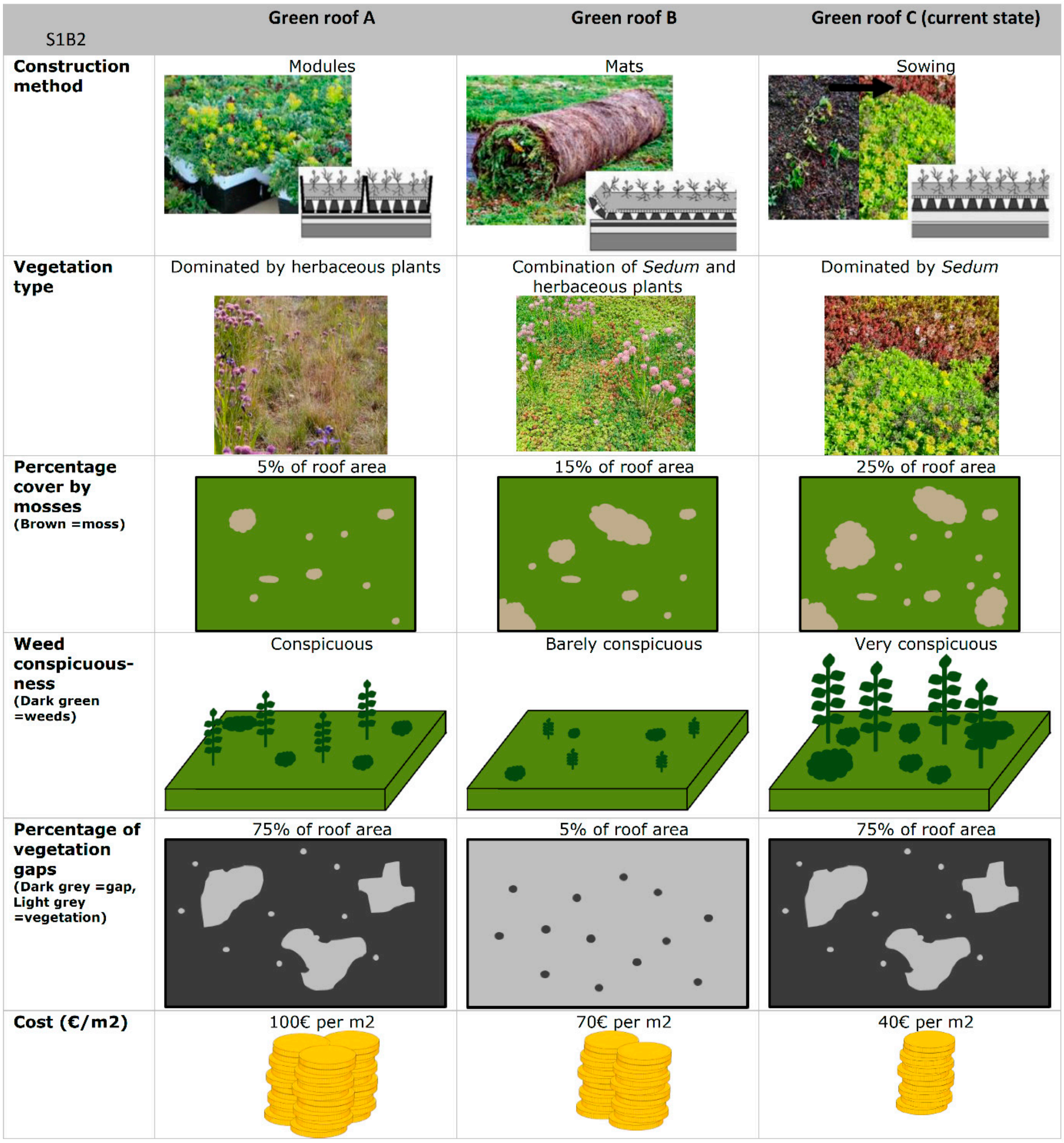

Figure 1. Example of a choice set consisting of two alternatives and a status quo indicating the current state of extensive green roofs in Flanders as observed during field sampling campaigns in 2015 and 2016.

Next, graphical representations of attributes and levels were created. Special attention was paid to the characteristics of the photographs and schematic representation, as these can influence respondent's preferences. Therefore, high-resolution photographs with identical lighting conditions and perspective and schematic representations with neutral colors (e.g., no red–green contrasts) were used. This process resulted in a set of clear and objective attribute and attribute level representations that were included in the choice sets presented to the respondents (see Figure 1 for an example). Selected attributes and levels, as well as their graphical representations, were tested in two focus group sessions to assess their understandability and representativeness, as well as discussed in an expert panel to guarantee the scientific validity of the used attributes and levels. To ensure well-informed choices by all respondents, unbiased definitions were created for all attributes and levels and were included in a background information sheet.

Table 1. Attributes and their corresponding levels. Status quo levels, which describe the current state of the average Flemish extensive green roof, are underlined.

Attribute	Levels	Description/Background
Construction method	Sowing	Applying seeds or cuttings to the substrate
	Mats	Applying mats with pre-grown vegetation to the roof
	Modules	Placing containers with pre-grown vegetation on the roof
Green roof vegetation type	Dominated by *Sedum* (succulents)	Ground-covering plants delivering year round cover
	Combination of *Sedum* and herbaceous plants	Mix of the above and larger plants which deliver color accents in summer
	Dominated by herbaceous plants	Domination by larger plants and grasses with flowering in summer
Percentage cover by mosses	5% of roof area	Lowest level of moss cover
	15% of roof area	Intermediate level of moss cover
	25% of roof area	Highest level of moss cover
Weed conspicuousness	Barely conspicuous	Limited coverage of unwanted species with height barely differing from rest of vegetation
	Conspicuous	Large coverage of unwanted species with height one to three times the height of the rest of the vegetation
	Very conspicuous	Very large coverage of unwanted species with height more than three times the height of the rest of the vegetation
Percentage of vegetation gaps	5% of roof area	Lowest percentage of coverage by gaps
	25% of roof area	Intermediate percentage of coverage by gaps
	50% of roof area	High percentage of coverage by gaps
	75% of roof area	Very high percentage of coverage by gaps
Cost: euro/m^2	40 euro/m^2	Lowest cost
	70 euro/m^2	Intermediate cost
	100 euro/m^2	Highest cost

3.3. Determining Optimal Experimental Design

In this step of the DCE process, all parameters and levels were subjected to statistical design to combine them into scenarios to be presented to the respondents. Using Ngene [50], a fractional factorial design was created, opting for a total of 24 choice sets divided over two blocks of 12 sets. This is generally considered the maximum number of sets presented to a respondent (e.g., [51]), as we can expect a trade-off between the block size (the amount of sets presented to a respondent and therefore the amount of information gathered from one respondent) and the possibility of respondents dropping out of the questionnaire due to its being too long or challenging [52]. The D-efficient design method was chosen as it gave the best results out of the multiple design methods that were tested and described in [53].

The final iteration of the D-efficient design was generated using multiple priors. These priors allow for the inclusion of prior knowledge gathered in earlier studies to deliver a better and more realistic design (containing less dominant alternatives or implausible combinations). In our case, however, no similar studies have been performed. Nevertheless, small priors were included to indicate if we expected a positive or negative effect for a parameter linked to a certain attribute, as advised by [54]. For construction method and vegetation type, small positive priors where added. Negative priors were included for moss cover, weed conspicuousness, gap percentage, and cost. Additionally, a small negative prior was added to the status-quo alternative, based on the expectation that most respondents would prefer to move away from the sub-optimal current roof situation.

Apart from the priors, several constraints were included to avoid the occurrence of dominant scenarios in the choice sets presented to the respondents. In particular, attention was given to the combinations of highest levels of attributes with negative priors as we expected that these would lead to unrealistic combinations (e.g., the sum of cover percentages exceeding 100%). Furthermore, the cost was also taken into account, making sure not to assign the highest price (100 euro/m^2) to a roof with the highest values for two attributes with negative priors. An overview of all constraints is presented in Table A1 (Appendix A).

3.4. Construction of Choice Sets and Questionnaire

Once the experimental design was completed, graphical representations for all 24 resulting choice sets were created, incorporating both the attribute levels of each choice in text and the corresponding graphical representations (see Figure 1 for an example). Subsequently, a questionnaire on respondent characteristics was created, including socio-economic questions regarding, e.g., education, income, and living environment.

3.5. Survey Execution: Preference Measurements

Qualtrics [55] was used to distribute the survey online. Its randomization algorithm was used to randomize which block of choice sets was presented to each respondent and the order in which choice sets within blocks were presented. The general structure of the questionnaire consisted of a short introduction (questionnaire procedure, attribute information sheet, and cheap talk script), followed by the actual choice experiment and the questionnaire of respondent characteristics. On 24 March 2016, after final testing, the survey was distributed using convenience sampling methodology: a link to the survey was published on social media and sent around to mailing lists and organizations in Flanders (Belgium). The survey was closed on 12 May 2016. Subsequently, incomplete responses were removed and the dataset was prepared for further analysis. A drop-out rate of ca. 50% was recorded with a total of 155 complete responses remaining, amounting to 5880 choice observations in total. Responses from students were excluded from the main analyses because they often do not have a real income and it is therefore unclear whether they can take budget constraints into account in a realistic manner. Results for the sample including students ($n = 242$; 8712 observations) are, however, included in Appendix B. To assess the representativeness of our results for the general population, we compared the characteristics of the respondents with the average characteristics of the population in Flanders [56].

3.6. Model Estimation: Econometric Analysis

The mixed logit (MXL) model was applied to estimate the indirect utility function (Equation (1)). As the model includes random components for model attributes, it allows for varying preferences across respondents [57]. By having respondent-specific variables (e.g., socio-economic characteristics) interact with the model attributes, the fit of the model was improved and observed heterogeneity between individual respondents was controlled for [58]. All categorical variables were dummy-coded: construction, vegetation, and weed conspicuousness. Coefficients were therefore estimated versus reference levels corresponding to the status quo alternative for these variables. Aside from green roof attributes, an alternative specific constant (*ASC*) was included to capture the variation in choices that are not explained by attributes in the model. In this study, the *ASC* expresses the change in utility that respondents perceive by leaving the status quo, which depicts the current state of extensive green roofs in Flanders. All model variables were considered random and assumed to have a normal distribution. For Gaps and *Cost,* however, a lognormal distribution was assumed, as the coefficient for these attributes was not expected to be evenly distributed around zero. The "mixlogit" command [59] in Stata was used to estimate the MXL coefficients, with 5000 Halton draws being made.

Conditions for a fully reliable mWTP estimation are consequentiality (choices resulting in real life consequences), coercive payment (respondents committing to paying a cost associated with their choices), and satisfying incentive compatibility conditions (where truthfully answering questions is the optimal strategy for a respondent) were not met in this study [60–62]. Therefore, attribute importance (see [63]) was considered next to WTP measures. Attribute importance was calculated in three steps: (1) utility ranges were calculated for all attributes; (2) all utility ranges are summed; (3) each attribute utility range is divided by the sum of all utility ranges, resulting in a percentage indicating the relative contribution of that attribute to the overall utility of a respondent. For the sake of completeness, conditional mWTP estimates were calculated using the delta estimation method for confidence intervals [64].

4. Results

4.1. Respondent Characteristics

The results of the general socio-economic questions (Table 2) indicate that the percentage of highly educated respondents in our sample (n = 139 or ca. 90%) is very high compared to the Flemish average of ca. 37% [65]. As for income, we see that 17% of all respondents did not want to share their monthly household income. Based on those that did indicate their income (n = 129), however, mean income is similar to the mean net monthly income per household in Flanders, i.e., 3291.44 euro, and percentages for each income range are comparable to the mean income quartiles of Flanders [66]. Our results suggest a bias for occupations that require a higher education (e.g., teachers) and are not manual labor-intensive (e.g., clerical professions). More than 80% of respondents indicated having at least a good familiarity with the concept of "green roofs", with only a small fraction of respondents having never heard about the topic.

Table 2. Summary of respondent characteristics for sample excluding students.

Variable	Value
Sample size, n	155
Gender (% of males)	55.48
Education (n (%))	
Secondary education	14 (9.03)
Higher education	139 (89.68)
Other	2 (1.29)
Income (n (%))	
Not answered	26 (16.77)
Of those who answered	101 (83.22)
Below 3001	54 (41.86)
3001–4000	35 (27.13)
Above 4000	40 (31.01)
Familiarity with green roofs (n (%))	
Extremely familiar	58 (37.42)
Very familiar	42 (27.10)
Moderately familiar/Heard of it	34 (21.94)
Slightly familiar	16 (10.32)
Not at all familiar/Never heard of it	5 (3.23)

4.2. Econometric Analysis

4.2.1. Mixed Logit Model

A mixed logit model for 155 respondents (5580 choice observations) was estimated in order to take preference heterogeneity into account (Table 3). Results indicate no preference of how the extensive green roof is constructed. Respondents do, however, have a significantly higher preference for a vegetation type consisting of a combination of *Sedum* and herbaceous species. Furthermore, lower and medium conspicuousness of weedy species is perceived as significantly positive and desirable, compared to a reference level of high conspicuousness. Respondents also distinguish between a medium or low level of weed conspicuousness, as the difference between both coefficients is significant (χ^2 = 34.87, p-value < 0.001). Further, an increasing cover of gaps and a higher price are both considered unwanted. Finally, the label "current state of extensive green roofs", indicated by the ASC (coded 0 for status quo, 1 if moving away from status quo) is not preferred, which indicates that respondents are inclined to move away from the current state of green roofs. The standard deviations calculated in the model indicate that there was significant variability in respondent preferences for all attributes except for moss percentage (Moss).

Table 3. Mixed logit model results indicate that cost, ASC, vegetation type, weed conspicuousness, and gap percentage significantly affect respondent preferences.

Variables	Coefficient (SE)	SD (SE)
Cost	−3.771 *** (−0.149)	1.023 *** (−0.15)
ASC	2.443 *** (−0.484)	3.537 *** (−0.462)
Construction (Mat)	−0.0679 (−0.121)	−0.513 * (−0.206)
Construction (Module)	−0.197 (−0.137)	0.84 *** (−0.188)
Vegetation (Combi)	0.657 *** (−0.145)	0.965 *** (−0.209)
Vegetation (Herbs)	0.273 (−0.167)	1.386 *** (−0.199)
Moss	0.000569 (−0.006)	−0.001 (−0.021)
Weeds (Low)	0.986 *** (−0.175)	−1.291 *** (−0.191)
Weeds (Mid)	0.536 *** (−0.13)	−0.042 (−0.596)
Gaps	−3.77 *** (−0.154)	0.971 *** (−0.164)
Log likelihood	−1247.950	
McFadden R^2	0.258	
Observations	5580	

Significance levels: *** $p < 0.001$; * $p < 0.05$; SE = Standard error, SD = Standard deviation.

Results for the MXL model including students (n = 242, 8712 choice observations) reveal similar preferences (Table A2 in Appendix B). While students' interpretation of budget constraints might be unrealistic, we argue that their preferences have meaning, as they may represent the preferences of future generations.

4.2.2. Attribute Importance and Conditional Marginal WTP Estimates

Results for relative attribute importance (Table 4) indicate that the gap percentage has the largest influence on respondent utility. While the cost attribute also has a large influence, all other attributes have a low importance (less than one percent).

Table 4. Relative attribute importance of all attributes.

Attribute	Relative Importance
Construction method	0.04%
Vegetation type	0.13%
Moss cover percentage	0%
Weed conspicuousness	0.2%
Vegetation gap percentage	53.37%
Cost	45.76%
ASC	0.49%

For the sake of completeness, the results for a conditional marginal WTP estimates are also presented (Table 5). However, not all conditions for reliable estimation were met in this study (see Section 3.6). Furthermore, all values are conditional on respondents having decided to construct a green roof. While respondents are willing to pay to move away from the current state of green roofs (the status quo) or have a roof with less weed conspicuousness, they will not pay as much for a roof which contains many gaps in the vegetation. They do however want to pay more for a roof with a mixed vegetation type.

Table 5. Conditional marginal WTP estimates (euro/m^2 × level) with 95% confidence intervals (delta method).

Attribute	Conditional mWTP (euro/m^2 × level)
ASC	0.65 (0.39; 0.9)
Construction (Mat)	−0.02 (−0.08; 0.04)
Construction (Module)	−0.05 (−0.12; 0.02)
Vegetation (Combi)	0.17 (0.1; 0.25)
Vegetation (Herbs)	0.07 (−0.01; 0.16)
Moss	0 (0; 0)
Weeds (Low)	0.26 (0.16; 0.36)
Weeds (Mid)	0.14 (0.07; 0.21)
Gaps	−1 (−1.1; −0.9)

5. Discussion

In this study, we investigated whether visual aspects have an impact on choice behavior in a context of extensive green roofs. It contributes to the current, limited literature about the importance of these aspects. By approaching this topic from a DCE perspective, we also succeeded in providing insights on the tradeoffs between different visual aspects of extensive green roofs.

In our results, we observed that several visual attributes of extensive green roofs have a significant effect on preferences. However, we have to be careful when interpreting the results. Although they are novel and indicative, the extent to which they can be generalized is limited by the relatively small sample size, the limited representativeness for the general Flemish population, and the self-selection bias towards participants interested in this environmental topic. When considering the MXL model, results show that a combination of vegetation, consisting of *Sedum* and herbaceous species, is significantly preferred over a standard *Sedum* dominated vegetation. This preference could be due to the increase in structural variation and larger diversity in species and flower colors, which is supported by earlier findings [27]. The herb dominated alternative, however, does not impact preferences significantly, despite earlier observations that meadow-like vegetation types were amongst the most preferred vegetation types for extensive green roofs [26,27]. Perceived messiness of roofs planted with grasses can, nonetheless, also have a negative impact on preferences [25]. This could explain why a combination of both vegetation types was preferred, as it provided a "best of both worlds" alternative in our study.

Additionally, we demonstrate that the visual impacts of gaps in the vegetation cover and the presence of conspicuous weedy species are significant and negative. The issue of gap formation significantly reduces preferences for green roofs. Although direct preference comparisons for (areas of) bare substrate and extensive green roofs have not been performed, we suggest that this comparison is similar to a comparison between gravel and extensive green roofs by which gravel roofs were found to be least preferred [26]. Reduction in weed conspicuousness from the reference level of high cover percentage and large weed height were found to significantly and positively impact preferences, although variation in the level of reduction (from high to medium or high to low conspicuousness) do not have a significantly differing effect. This suggests that, although a reduction of gaps, and therefore an increase in vegetation cover, significantly affects preferences, the specific species (planted or spontaneous) that provide this coverage also have a significant effect. As a largely visual approach is used for this attribute, respondents are expected to have applied their own definition of what a weedy species is in this study. The discussion on which species should be considered weeds (or not) does therefore not apply here. Despite mosses often being considered as negative on conventional roofs (see the many roof moss removal firms), no significant effect of their percentage coverage on choice behavior could be noted in this study.

Aside from actual green roof attributes, the label "current state", as represented by the ASC, is found to have a significant and large negative impact on respondent preferences. This result, because it is obtained for a dummy-coded approach, captures both the utility from moving away from the current state and the utility of the base level of the dummy-coded attributes. The ASC remained positive and significant when applying an effects coding approach.

The results for the relative importance of the different attributes indicate that variation in gap fraction had the highest impact on respondents' utility, shortly followed by the cost attribute. While these results somewhat confirm the observations made for the MXL model, they do indicate that there is a large difference in relative importance between these two attributes and all others. The "current state" label and weed conspicuousness influence respondents' choices to a much lesser extent, for instance. Overall, the relative importance indicates that extensive green roof price is a major factor in the decision-making process, but only after basic functioning and successful construction (e.g., a limited percentage of bare substrate) of the roof is guaranteed.

As the results for the full sample (including students) are similar, we see that the preferences of future generations are in line with those of the current generation, even though their interpretation of budget constraints could be considered unrealistic.

This study succeeds in revealing which visual characteristics of green roofs affect preferences. It therefore encourages further in-depth and large scale studies to link these insights to cost–benefit analyses (e.g., [67]) and other studies trying to value aesthetic benefits (e.g., [20]). A large-scale study, in which the self-selection bias towards participants interested in this environmental topic is taken into account, would allow for an in-depth analysis of preference heterogeneity and robust mWTP estimates when the necessary conditions (see Section 3.6) are met. Furthermore, by opting for a paid respondent panel or coordinated survey approach, respondent representativeness can be increased. In larger follow-up studies, alternative models such as latent class analysis [68] or hybrid choice models [69] could provide further insight into how respondent socio-economic characteristics control preferences.

Aside from the scientific implications, our results suggest that improvements to the current green roof practice are needed. If we consider the current state of extensive green roofs (e.g., presence of gaps, weedy species, and vegetation often dominated by *Sedum*), we observe that this state is often not the most preferred. Our model estimates indicate that improvements are needed, which is further supported by the significant negative preference of the label "current state". Several improvements can be attained by maintenance, e.g., (bi-)annual checks of roof functioning combined with removal of weeds, particularly during the first years after installing the extensive green roof or the use of slow-release fertilizers and periodic irrigation to reduce gap cover. An environmentally adapted design (e.g., use of suitable species to prevent weed colonization) and sound construction are also of importance. Estimates of relative importance partially support these results and indicate that, while price is a major factor, the basic functioning of the roof (e.g., limited percentage of gaps) has the highest impact on respondents' choices.

6. Conclusions

This study provides insights on the importance of the visual aspects of extensive green roofs by applying DCE to a context of urban ecology, i.e., urban green elements. Our results indicate that practical problems such as gaps and weedy species, together with diverse vegetation types, have a considerable impact on green roof preferences, with gaps having the highest relative importance of all characteristics. As we expect that urban green will become more important in addressing environmental challenges and that interactions between urban inhabitants and their green environment will become more intense, we believe that the relevance of studies like this one will continue to rise. Furthermore, by expanding the current knowledge of green roofs and the ecosystem services they provide, our results contribute to a better and more consumer-oriented practice for green roof firms.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Experimental Design

Table A1. Overview of constraints used in the experimental design process. Constraints were used to avoid unrealistic attribute level combinations.

Constraints
If moss cover is 25% and weed conspicuousness is high, then gap percentage should not be 75%.
If gap percentage is 75% and weed conspicuousness is high, then moss cover should not be 25%.
If gap percentage is 75% and moss cover is 25%, then weed conspicuousness should not be high.
If gap percentage is 75% and weed conspicuousness is high, then cost should not be 100 euro/m^2.
If gap percentage is 75% and moss cover is 25%, then cost should not be 100 euro/m^2.
If moss cover is 25% and weed conspicuousness is high, then cost should not be 100 euro/m^2.

Appendix B. Model Results Including Students

Table A2. Mixed logit model results (including students) indicate that cost, ASC, construction method, vegetation type, weed conspicuousness and gap percentage significantly affect respondent preferences.

Variables	Coefficient (SE)	SD (SE)
Cost	−3.669 *** (−0.114)	0.985 *** (−0.095)
ASC	1.905 *** (−0.317)	2.62 *** (−0.266)
Construction (Mat)	−0.0344 (−0.098)	0.589 *** (−0.149)
Construction (Module)	−0.243 * (−0.105)	−0.728 *** (−0.146)
Vegetation (Combi)	0.684 *** (−0.116)	0.966 *** (−0.157)
Vegetation (Herbs)	0.136 (−0.13)	1.394 *** (−0.162)
Moss	0.00483 (−0.005)	0.003 (−0.014)
Weeds (Low)	0.895 *** (−0.129)	1.033 *** (−0.148)
Weeds (Mid)	0.469 *** (−0.105)	−0.314 (−0.242)
Gaps	−3.735 *** (−0.115)	0.983 *** (−0.101)
Log likelihood	−2027.042	
McFadden R^2	0.218	
Observations	8712	

Significance levels: *** $p < 0.001$; * $p < 0.05$; SE = Standard error, SD = Standard deviation.

Table A3. Relative attribute importance for all attributes, based on MXL results including students.

Attribute	Relative Importance
Construction	0.05%
Vegetation	0.14%
Moss	0.02%
Weeds	0.18%
Gaps	53.86%
Cost	45.35%
ASC	0.39%

Table A4. Mean marginal WTP estimates (euro/m^2 × level) with 95% confidence intervals (delta method) for the mixed logit model, including students.

Attribute	Conditional mWTP (euro/m^2 × level)
ASC	0.52 (0.35; 0.69)
Construction (Mat)	−0.01 (−0.06; 0.04)
Construction (Module)	−0.07 (−0.12; −0.01)
Vegetation (Combi)	0.19 (0.12; 0.25)
Vegetation (Herbs)	0.04 (−0.03; 0.11)
Moss	0 (0; 0)
Weeds (Low)	0.24 (0.17; 0.32)
Weeds (Mid)	0.13 (0.07; 0.19)
Gaps	−1.02 (−1.09; −0.95)

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