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Individual preferences regarding pesticide-free management of green-spaces: a discret choice experiment with French citizens.

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Abstract

To comply with the pesticide ban in effect in French urban green spaces (UGSs), managers have to modify their practices. Understanding citizens' preferences for UGSs whose characteristics are modified by the pesticide ban is a useful complement to technical research on alternatives to pesticides. We use a discrete choice experiment run online on a representative sample of the French population to analyze preferences towards characteristics of direct interest to the users (visual aspect, recreational opportunities, and information campaigns on pesticide-free UGSs) and less visible characteristics such as fauna abundance, working conditions, or the budget dedicated to the maintenance of such areas. We find that all chosen attributes have a significant impact on respondents' choice of UGS option. All citizens largely devalue options generating a major budget increase, but preferences towards other attributes are shaped by visit frequency to UGSs. Most users prefer a natural visual aspect to a controlled aspect, but this preference is even greater for frequent visitors. Visit frequency affects in particular preferences towards fauna abundance (valued only by those who frequently visit UGSs) and information campaigns (valued only by those who do not frequently visit UGSs).

JEL classification : Q24, Q26, C25

Keywords : Discrete choice experiment, Pesticides, Urban green spaces, Individual preferences, France

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1 Introduction

France decided to officially extend its efforts in pesticide use reduction to non-agricultural areas (i.e. gardens, parks, and infrastructures) in 2014, following other European Member States such as Germany, Denmark, the Netherlands, and Luxembourg. In force since January 1st, 2017, the Labbé law bans pesticide use in parks, on roads and walking paths, and in the forests accessible to the public.[1] To comply with the law, public managers of urban green spaces (UGSs) have to modify their practices, and major changes in UGS characteristics are likely to be observed. Green space planning is guided by standards and guidelines, but there is currently little understanding of the variety of values people assign to green spaces (Ives et al., 2017), and more specifically to pesticide-free UGSs. This paper aims at understanding inhabitants' preferences for UGSs whose characteristics are modified by the pesticide ban, using a Discrete Choice Experiment (DCE) run online on a representative sample of the French urban population.

In the economic literature, little or no attention is paid to preferences for pesticide reduction in non-agricultural goods and services, such as access to UGSs. The literature focuses mainly on the estimation of consumers' preferences for pesticide reduction in food products (Florax et al., 2005; Travisi and Nijkamp, 2008; Costa and Santos, 2016) and marginally on other agricultural goods such as flowers (Michaud et al., 2013).[2] This is surprising, given the increasing value associated with UGSs in urban environments. Many studies show that green spaces offer multiple benefits to human populations such as recreational or leisure opportunities, health benefits including stress release, and environmental benefits (Vandermeulen et al., 2011).

While access to UGSs is generally free, the environmental economics literature has developed methods to evaluate citizens' preferences and willingness to pay for access to such natural environments in cities. The literature includes hedonic studies showing that house prices rise with proximity to urban parks (Hoshino and Kuriyama, 2010; Poudyal et al., 2009) or stated preference studies estimating the willingness to pay for access to UGSs depending upon characteristics such as size, cleanliness, state and availability of facilities, or accessibility (Brander and Koetse, 2011; del Saz Salazar and García Menéndez, 2007; Latinopoulos et al., 2016). The discrete choice experiment (DCE) method has recently become popular because of the multiple dimensions of green spaces and the non-use values associated with their presence in cities. For instance, the method has been used to assess preferences for parks (Bullock, 2008; Tu et al., 2016), tree lines (Giergiczny and Kronenberg, 2014), and urban recreational trails (Arnberger and Eder, 2011). The DCE has been applied to elicit preferences for urban green infrastructure, but the attributes selected focus rarely on management options. To our best knowledge, only one study focuses on management options in urban land management and analyzes preferences for biological control

[1]The low n° 2014-110, called "loi Labbé", was adopted at the February 6th, 2014 (see *Journal officiel de la République Française* n°0033, February 8th, 2014, p.2313)

[2]Another strand of the literature examines farmers' willingness to reduce pesticide use and preferences for incentive contracts (Christensen et al., 2011; Jin et al., 2017; Kuhfuss et al., 2016).

in urban forests (Jetter and Paine, 2004). Using a residential questionnaire survey, Hirsch and Baxter (2009; 2011) have analyzed preferences for pesticide bylaws in Canada, and in particular how these preferences are shaped by the social context of pesticide use (e.g. yard aesthetics or neighborhood conflict avoidance) and sociodemographics (e.g. gender, income, city of residence) compared with variables of perceived health risk and pesticide use. However, the authors do not question preferences for management options without pesticides.

The management of UGSs without pesticides requires alternative strategies (e.g. manual, mechanical or thermic weeding) that bring potential negative impacts on working conditions and local public budgets but can also generate benefits due to more general changes: with no pesticide use, the visual aspect of green spaces is modified, and they offer different recreational opportunities, such as experiencing "nature in the city" and observing fauna. While technical references are available on alternatives to pesticides for green space management, this transition causes many challenges to local public authorities, who generally have limited information regarding citizens' preferences on which to build their decisions. Yet, local public administrations who voluntarily engaged in alternative management before the pesticide ban insist on the importance of public acceptance for a successful transition towards pesticide-free green space management. This is an additional argument motivating this paper.

The purpose of this study is to understand citizens' preferences for UGSs whose characteristics are modified by a pesticide ban.[3] To do so, we used a DCE run online on a representative sample of the French urban population. This method was used to examine individual preferences for alternative bundles of attributes characterizing the consequences of the shift to pesticide-free UGSs such as the consequences in terms of visual aspects, fauna abundance, recreational opportunities, communication to the population, training opportunities and working conditions for the workers, and the budget dedicated to the maintenance of such areas. Each respondent was asked to choose between a series of hypothetical green space management schemes (all without pesticides) defined by these characteristics.

We find that all chosen attributes have a significant impact on respondents' choice of UGS option. We find that the financial impacts are an important concern for citizens who largely devalue options with a major budget increase. As shown in various contexts by Kahneman and Tversky (1979), we also find that preferences are impacted more by a loss compared to the current situation (e.g. reduced recreational opportunities or risk of deterioration of working conditions) than by an improvement in these characteristics. Improving recreational opportunities and increasing fauna abundance are more important drivers of preferences than the existence of information campaigns, but only if these involve major changes. The results also show the importance of accounting for participants' heterogeneity. In particular, using a latent class model, we find that preferences are shaped

[3]The reader should be aware that this is a different exercise from the evaluation of citizens' willingness to pay for a pesticide ban in UGSs. In this exercise, we do not consider UGS management with pesticides as a status quo option.

by visit frequency to UGSs. Most users prefer a natural visual aspect to a controlled aspect, but this is even truer for frequent visitors. Visit frequency affects in particular preferences towards fauna abundance (only valued by those who frequently visit UGSs), information campaigns (only valued by those who do not frequently visit UGSs), and a budget dedicated to UGSs (accepted by frequent visitors, but only if it remains limited).

The remainder of this paper is organized as follows. The method is presented in section 2 and results in section 3. Section 4 concludes and gives indications for future research avenues.

2 Method

Discrete choice modelling is one of the main techniques used to estimate the non-market values of environmental services, including recreation (Louvière and Timmermans, 1990). Its formulation is based on Lancaster's demand theory (Lancaster, 1966) and McFadden's Random Utility Maximization framework (McFadden, 1974). Hypothetical pesticide-free UGS management scenarios composed of multiple attributes are presented to respondents. The latter are expected to select their preferred UGS management scenario from the set of proposed options based on their preferences for the attribute levels specific to each option and their individual socio-economic characteristics. The method relies on hypothetical choices, and it is particularly useful in a situation whereby citizens are not able to choose between different UGS management options in their city. Moreover, the DCE method enables analysts to estimate preferences for different attributes simultaneously, which is highly relevant in this instance, given the multiple dimensions impacted by the transition towards pesticide-free UGSs.

2.1 Discrete choice experiment design

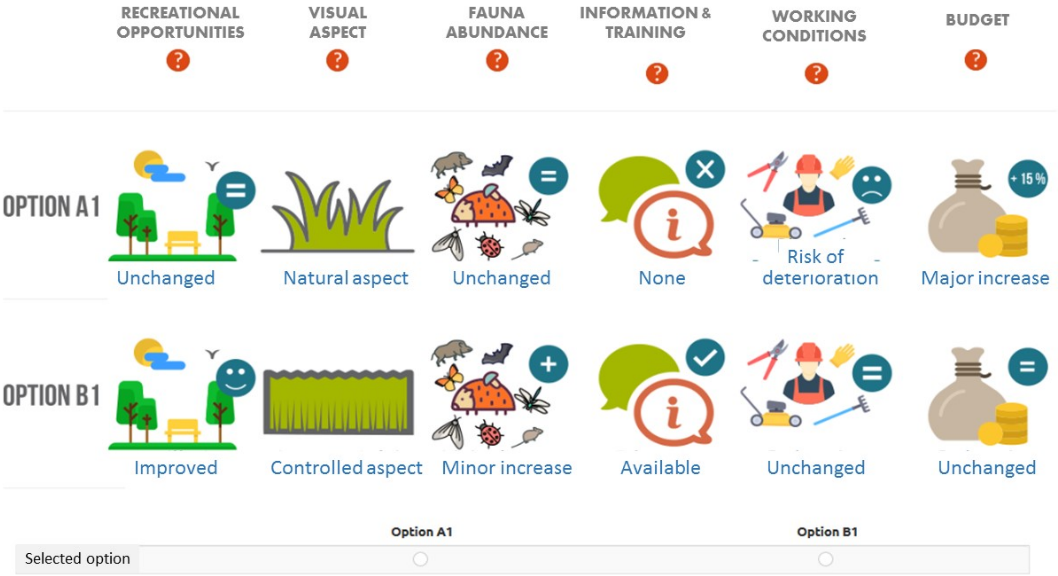
Many options are available to managers to organize the transition towards pesticide-free UGSs. To summarize the consequences of this transition, we selected six attributes to describe the hypothetical UGS management scenarios. Attributes and their corresponding levels were derived from the literature in landscape planning and environmental economics on preferences for UGSs, interviews with managers in charge of the transition towards pesticide-free UGSs, and a pretest study with 75 citizens. The main criteria for this selection were threefold: i) the desire to describe as precisely and realistically as possible the consequences of the transition towards pesticide-free UGSs, ii) the need to develop an operational experimental design whereby the independence between attributes is guaranteed, and iii) the concern to limit the cognitive burden for respondents by avoiding ambiguity and impossible combinations of attributes. The six attributes and their levels are presented in Table 1 and an example of choice card in Figure 1. The attribute descriptions are formulated in accordance with the language prevalent among the respondents in order to avoid misperceptions. Respondents were told to respond concerning the parks and gardens in their city.

Table 1: Attributes

Variable Name	Attributes	Description	Level
USE	Recreational opportunities	They depend of the green area characteristics such as: functionality, accessibility, security, and aesthetics. Pesticide-free management may require changes that may alter these characteristics for elements such as atmosphere, plantations, paths or furniture.	Improved Unchanged-*Ref* Reduced
VISUAL	Visual aspect	The change to pesticide-free management implies the presence of more weeds in green areas such as urban parks, but also along footpaths, walls or at the base of trees. Depending on what is desirable and the methods of management, this vegetation can have a natural or managed look.	Controlled-*Ref* Natural
FAUNA	Fauna abundance	Pesticide-free management may increase the development of local fauna of all types (e.g. birds, insects, small animals). Some of this fauna is useful for the maintenance of the green areas (e.g. controlling undesirable insects).	Major increase Minor increase Unchanged-*Ref*
INFO	Training and information	Training workers, information to inhabitants. Pesticide-free management creates many changes concerning the level of service of the green areas, the key skills required of workers, the work organisation, and the associated costs. In order to accompany these changes, the local communities can decide to put training in place and/or information for workers and inhabitants.	Existing Absent-*Ref*
WCOND	Working conditions	With the pesticide-free management, there is no longer any risk associated with manipulating pesticides but there are other factors that affect working conditions. They include physical working conditions and being exposed to risks that increase accidents or professional illnesses (e.g. noise, dust, exhaust gases, awkward positions). Being exposed to comments from members of the general public, who are sometimes aggressive, is also a psychological risk. With the change to pesticide-free management these risk factors evolve as the work changes, creating potentially better or worse working conditions.	Improved Unchanged-*Ref* Risk of deterioration
BUDG	Budget	This concerns the budget of the local community dedicated to green areas (maintenance and investment). Generally, 2 to 5% of the community's maintenance budget is dedicated to green areas. A change to pesticide-free management is expected to increase this budget for several reasons: the change in labour requirements, the purchasing of specific equipment, the reorganisation of the space (e.g. new plants), sub-contracting, training workers, and informing population.	Major increase Minor increase Unchanged-*Ref*

"*Ref*": Reference level

Figure 1: Exemple of choice card



The first attribute is the *recreational opportunities* (USE) offered by the green spaces. These depend on characteristics such as accessibility, functionality, security, or appearance. Available evidence suggests that citizens deplore the lack of recreational facilities (Arnberger and Eder, 2015). The managers interviewed confirmed that pesticide-free green spaces can offer different recreational opportunities, such as observing fauna or experiencing "nature in the city", but also drawbacks (e.g. if the lawn is too high). We selected three levels: unchanged, improved, and deteriorated recreational opportunities.

The second attribute identified is the *visual aspect* (VISUAL). The interviews revealed that the visual aspect is often impacted when pesticides are eliminated: weeds are more present, alternative landscaping management strategies are implemented, causing different textures and colors to appear (e.g. mulch, meadows, hedges, permeable paths). Available evidence suggests that urban dwellers enjoy the presence of open areas but dislike understory vegetation (Arnberger and Eder, 2015). Other studies, however, have shown that perceived greater naturalness generates higher aesthetic values and self-reported well-being (Ode Sang et al., 2016). Some visitors prefer dense vegetation and fallow-like settings (de Groot and van den Born, 2003; Harris et al., 2018). There was therefore no clear evidence on whether respondents would prefer a more natural or more controlled visual aspect. Hence, we proposed two levels of this attribute: controlled or natural aspect.

The third attribute is the *abundance of fauna* (FAUNA). The reduction of pesticides has been shown to favor the presence of insects and birds (INRA, 2005; Muratet and Fontaine, 2015). While part of this fauna is made of auxiliaries that can help to control pests, focus group interviews indicated that such fauna may not be desirable to all. Birds can be considered as a source of noise and dirt, and some people dislike insects and spiders.

The levels selected are unchanged fauna, minor increase, and major increase.

The fourth attribute is the existence or not of *information* to citizens to explain the change in practices towards pesticide-free management and its consequences, and to train managers, given that the latter have to learn new techniques (INFO). Cities that voluntarily engaged in alternative management before the Labbé law have invested largely in such information campaigns. Those cities that started their transition towards pesticide-free UGSs only when the move became mandatory may question the need for such costly measures. Therefore, we selected two levels: existence or absence of information.

The fifth attribute concerns the *working conditions* of the landscaping agents (WCOND). While health risks due to pesticide use have been eliminated with the ban[4], working conditions can nevertheless be impacted by pesticide-free management since workers have to spend more time on mechanical weeding or use potentially dangerous hot water or gas to eliminate weeds. Workers also often declare facing psychosocial risks due to frequent public exposure and the sometimes aggressive remarks addressed to them. We wished to test whether the citizens perceive the evolution of working conditions caused by the suppression of chemical weeding and whether they care about it. We selected three levels: unchanged, improved, and risk of deterioration of the working conditions.[5]

The sixth attribute is the *budget* dedicated to UGSs, covering servicing and investment costs. Increased workload for weeding and renovation of UGS, investment in new machineries or plantations, training and communication actions can increase the community budget dedicated to UGSs. An increase in the UGS budget line does not necessarily imply an increase in the total city budget if other budget lines are reduced. Moreover, given that the study encompasses all of the French metropolitan territory, selecting a level in euros per month or per year (as in Bertram et al. (2017) and Giergiczny and Kronenberg (2014)) that would be meaningful for every respondent was impossible.[6] For all these reasons, it was inappropriate to have a monetary attribute presented as an increase in local taxes. Instead, we used a qualitative monetary attribute: unchanged budget, an increase in the budget dedicated to the maintenance of UGSs of 5% (minor increase) or 15% (major increase), as in Bech (2003) and Bastian et al. (2017). This avoids the computation of willingness to pay but provides a means of examining the evaluation of the relative weights of the different attributes.

Two examples may be used to establish the relevance of these attributes. First, we may consider the example of an iconic garden surrounding a major historical monument.

[4]The interviews revealed that most users value the reduction in health risks due to pesticide-free management. Because this attribute would have had the same level for all pesticide-free management schemes, it was excluded.

[5]The loss level was labeled "risk of deterioration" to make this level more salient and acceptable (compared to "deteriorated"). Indeed, in the pre-test, several respondents declared that working conditions cannot be deteriorated with the change to pesticide-free management given that the health risk associated to pesticides is eliminated. As explained in the description of the attribute, other risk factors are important to take into account. The term "risk of deterioration" raises awareness on the fact that conditions can also be worsened compared to the management with pesticides. It does not aim at highlighting that losses are uncertain (vs sure gain).

[6]The annual amounts of French local taxes are very different from one city to another.

This garden is not open to the public, but it is visible by all visitors and passers-by. As a result, the manager decides to put extra effort into keeping the visual aspect similar to the situation before the pesticide ban. Such a visual result is possible only with extra work compared to the situation where pesticides were allowed. This decision may contribute to the deterioration of the agents' working conditions and increase the budget dedicated to the maintenance of this garden. The second example involves a UGS reorganized in order to reduce the maintenance burden in the absence of pesticides. The visual aspect has thus evolved towards more "natural", "wild", or "poorly maintained" depending upon people's opinions. The recreational opportunities are impacted since the grass is now cut twice a year only instead of frequent mowing in the past. Users and workers have been informed of the benefits associated with such changes. The public was also informed about the opportunity for more wildlife to develop in the new habitats created by the reorganization. These two examples illustrate differentiated management in the same city, as an option to deal with the cost increases brought by the pesticide ban in a restricted financial and human resources context. The attributes selected in the DCE describe the main trade-offs when organizing the transition towards pesticide-free UGSs.

The six attributes and their levels lead to 256 ($4^3 \times 2^2$) possible scenarios in a full factorial design. An efficient factorial design was applied in this study, using NGENE statistical software to generate the optimal set of scenarios taking orthogonality and level balance into account. We used the D-error criterion to optimize the efficiency of the experimental design on the basis of prior results gleaned from the pilot survey. We introduced two constraints to avoid unrealistic combinations of attributes.[7] To account for non-linear relationships, all factors were effect coded (Louviere et al., 2000). Consequently, for all factors, one level is defined as the reference category, and it is equal to the negative sum of the other level estimates. The number of scenarios generated was 72. The 72 scenarios were combined into four blocks of nine pairwise sets. The scenarios were given generic titles (option A and B) as unlabeled designs have been shown to increase respondents' attention to attributes and are therefore more suitable to investigate trade-offs between attributes (de Bekker-Grob et al., 2010; Hensher et al., 2015). We did not use an opt-out option since the pesticide ban applies to all French municipalities, and all UGSs are expected to change accordingly. An opt-out option would therefore be impossible. In addition, there were two versions of each block, in which the order of choices was varied in order to correct for the possible effects of learning or exhaustion. Moreover, we implemented a procedure to check for response consistency: in each block, the options proposed were the same for the first and seventh choices, but the names A and B were swapped. The respondents who chose option A in choice 1 but did not chose option B in choice 7 (and vice-versa) are qualified as "inconsistent". Overall, each respondent was randomly assigned to one of the

[7]On the basis of the interviews with UGS managers, we qualified as unrealistic first the scenario with a major increase in budget if simultaneously the recreational opportunities are reduced, the working conditions are deteriorated, and no information campaign is organized; second, the scenario with unchanged budget while working conditions and recreational opportunities are improved, and information is provided to the public.

eight blocks and was presented with 10 pairwise sets of scenarios.

2.2 Data and sampling

We surveyed online a representative sample of the French population in fall 2017.[8] The final sample of 500 respondents was selected by stratified random sampling based on parameters of age, gender, occupation category, town size, and region, and only include consistent respondents.

The survey was composed of five parts: first, the context of the survey was introduced by explaining the new law banning the use of pesticides in UGSs in France, the type of green space under study in the survey (i.e. parks and gardens), and an explanation of the choice task based on the example of the choice of vacations. The second part questioned respondents' habits related to their use of UGSs. The third part was the DCE itself: each respondent was presented with 10 discrete choices and asked to choose between a series of hypothetical green space management schemes without pesticides. The fourth part included questions on the heuristics used by respondents to choose between two options. The fifth and last part included questions on the socio-economic characteristics of the respondents. The full text of the survey is available in the supplementary material. Respondents took 12 minutes on average to complete the survey; 5% took less than 5 minutes, and 5% took more than 30 minutes.

2.3 Econometric estimation

Respondents are assumed to choose the preferred UGS management scenario between two proposed options based on their preferences for the attribute levels specific to each option.

We model the respondents' trade-off of the attributes following McFadden (1974) random utility approach. The random utility model can be applied to different configuration of discrete choice experiment including our framework: the choice over two options and a qualitative monetary attribute (Bech (2003); Baji et al. (2016); Van Puyvelde et al. (2016)).

It assume that each individual $i = 1, ..., N$ chooses between several options $j = 1, ..., J$ in choice set $t = 1, ..., T$ to maximize her utility, U_{ijt}, defined as:

$$U_{ijt} = V_{ijt} + \epsilon_{ijt} \tag{1}$$

with V_{ijt} is a function of observable attributes of the options and the respondents and ϵ_{ijt} an unobserved random component.

An individual will choose a modality k if $U_k > U_j \ \forall j \neq k$. The probability, p_{ki}, to

[8] The respondents were selected from an Internet panel of 100,000 respondents maintained by *Opinion-way*. In order to minimize the sampling bias, the panel is recruited through various channels. In order to ensure high participation rates, the panelists receive incentives for every survey they participate in.

observe the choice k of the individual i in choice set t is given by:

$$p_{ki} = Prob\left[\bigcap_{j\neq k}(U_{kit} > U_{jit})\right] = Prob\left[\bigcap_{j\neq k}(\epsilon_{jit} < V_{kit} - V_{jit} + \epsilon_{kit})\right] \tag{2}$$

In the baseline framework the random error terms is assumed to be *iid* following Gumbel distributions. The probability p_{ki} is thus given by:

$$p_{ki} = \frac{exp(V_{ikt})}{\sum_{j=1}^{J}(exp(V_{ijt}))} \tag{3}$$

The deterministic component of the utility is assumed to be a (linear) function of the attributes of the choices (X_{ijt}) as well as the individuals' characteristics (Z_{ijt}):

$$V_{ijt} = X'_{ijt}.\beta + Z'_{it}.\delta_j \tag{4}$$

The vector X_{ijt} in the equation (4) is the vector of attributes presented in section 2.1: USE; $VISUAL$; $FAUNA$; $INFO$; $WCOND$; $BUDG$.

As the budget attribute is qualitative, the estimation of willingness to pay for different levels of other attributes is not available. However, we estimate marginal rate of substitution between each attribute and one modality of the budget attribute. It allows us to compare individual valuation of different attribute between them.

To take into account the heterogeneity in respondents' tastes, as well as correlation in unobserved factors over repeated choices by each individual, and to relax the independence of irrelevant alternatives (IIA) property of basic model, we use mixed logit (ML) model and latent class (LC) model to estimate the parameters of interest.

Following Train (2009), in the ML model, the parameters β_i of the equation (4) are randomly distributed and vary over decision makers following a given distribution in order to represent that different people have different tastes, cognitive abilities, etc. We assumes that parameters are normally distributed: $\beta \sim \mathcal{N}(\mu, \sigma^2)$.

The probability, p_{ki}, to observe the choice k of the individual i in choice set t is given by:

$$p_{ik} = \int \frac{exp(X'_{ik}\beta)}{\sum_{j=1}^{J}(exp(X'_{ij})\beta))}\phi(\beta|\mu, W)d\beta \tag{5}$$

with $\phi(\beta|\mu, W)$ is the normal density with mean μ and covariance matrix W.

Accounting for the fact that the same respondent i faces several choice situations t, the probability of a particular sequence of choices made by respondent i is given by:

$$S_i = \int \prod_{t=1}^{T}\prod_{j=1}^{J}\left[\frac{exp(X'_{ikt}.\beta)}{\sum_{j=1}^{J}(exp(X'_{ijt}).\beta))}\right]^{y_{ijt}}\phi(\beta|\mu, W)d\beta \tag{6}$$

with $y_{ijt} = 1$ if the individual choose alternative j in choice situation t and 0 otherwise.

The choice probability does not depend on β parameters because integrated over β, but on their whole distribution. We thus estimate the mean and the standard deviation of distribution of each parameters. From these estimations and assuming normal distribution of parameters, we calculate for each attribute the percentage of respondents with a coefficient of opposed sign compared to the mean coefficient.

Another way to capture heterogeneity is the LC model. Unlike the ML model that captures heterogeneity at the individual level, the LC model accommodates preference heterogeneity at the class (or group) level. The rationale behind the LC model is based on the idea that the population can be sorted into a finite and identifiable number of groups of individuals (i.e., class). Within each class, individuals are relatively homogeneous with respect to their preferences. However, across classes, they have heterogeneous preferences. The LC model can be interpreted as a semi-parametric version of the ML model because the analyst does not need to make any distributional assumptions on the distributions of the random parameter (Greene and Hensher (2003)). In the LC model, each individual is assigned into a specific class that is probabilistically based on the individual's behaviours and latent perceptions but also depends on their socioeconomic characteristics (Boxall and Adamowicz (2002)).

The probability that the individual i belonging to class c chooses the option k rather than j in a given choice set is thus a joint probability of belonging to class c and choosing option k :

$$\begin{aligned} p_{ki} &= Prob\left[\bigcap_{j \neq k}(U_{ki} > U_{ji})\right] = \sum_{c=1}^{C} \frac{exp(X'_{it.k}\beta_c)}{\sum_{c=1}^{C}(X'_{it.k}\beta_c)} \\ &= Prob\left[\bigcap_{j \neq k} \epsilon_{ji} < V_k(X_{ki}) - V_j(X_{ji}) + \epsilon_{ki}\right] \end{aligned} \tag{7}$$

The choice probability that individual i in class c chooses option k in choice set t is expressed as:

$$p_{it}(k) = \frac{exp(X'_{it.k}\beta_c)}{\sum_{j=1}^{J}(X'_{it.k}\beta_c)}, c = 1, 2, ..., C \tag{8}$$

where β_c is a vector of segment-specifc utility parameters to be estimated.

The LC model admits as many values of β as the number of classes (one for each class). In our setting, two classes were considered based of Akaike Information Criteria (AIC) and Bayesian Information Criterion (BIC). Both the ML and LC models are estimated by the maximum simulated likelihood procedure.

3 Results

3.1 Sample characteristics and green space use

Beyond the socio-economic variables collected to select a sample representative of the French population (Table 2), we questioned respondents' habits related to their use of UGSs. Half of them can see a green space from their home or their workplace, but the frequency of visits to UGSs is highly heterogeneous. While only 8.6% never visit UGSs, 49.20% visit them less than once a week and 42.20% at least once a week. Despite the topicality of the issue since the pesticide ban was effective since January of the survey year (2017), not all respondents were well-informed about it: 24% of the respondents declare they are able to distinguish a green space managed with and without pesticides and 32% declare they know since when their city has banned pesticide use. Overall, 22% declare they are better informed than the general public on the survey topic, by virtue of their job, their studies, or those of another family member. In the estimations of preferences that follow, we verify whether respondents' visit frequency to UGSs and knowledge of the pesticide ban influence their preferences.

3.2 Results of the discrete choice analysis

The results from the ML model (Table 3) indicate that all attributes have a significant influence on the respondents' choice. The signs of estimated coefficients are all statistically significant (at the 1% significance level) and congruent with the theoretical predictions: respondents evaluate a budget increase negatively but evaluate improvements in UGS characteristics positively. The results of the ML model highlight the importance of accounting for heterogeneity, given the significance of the standard deviation coefficients. From the average and standard deviation coefficients, we can calculate the share of respondents with opposite preferences.

The budget attribute has the highest numerical weight (for the "major increase" level), albeit negative. The loss in utility associated with a major budget increase is higher than the utility loss for a minor budget increase, compared to an unchanged budget. The mean scores of the corresponding coefficient are -1.743 and -0.525. It is worth noting that some respondents prefer a major increase (11% of the respondents) or minor increase (17%) in budget to an unchanged budget. These results confirm the relevance of not constraining the model to produce only the expected sign coefficient (contrarily to common practice of adopting a lognormal distribution for the price coefficient (Hoyos, 2010)).

The second most important attribute is the quality of recreational opportunities. We find that on average, the loss of utility from a reduction in recreational opportunities is higher than the gain associated with improved opportunities (-1.544 *vs* 0.680). This is congruent with prospect theory (Kahneman and Tversky, 1979). The same effect is observed for the working conditions (-1.310 for a risk of deterioration of the working conditions *vs* 0.371 for improved conditions).

Two third of the respondents show strong preferences for a natural visual aspect as

Table 2: Definitions and descriptive statistics of socie-economic control variables

Variable		Description	Frequency (%)
		Quota variables for sample selection	
GENDER			
	1	if the respondent is a women	51
	0	if he is a man	49
AGE		Age category of respondent - 5 modalities:	
	1	Between 18 and 24 years old	9.2
	2	Between 25 and 34 years old	16.2
	3	Between 35 and 49 years old	24.6
	4	Between 50 and 64 years old	24.6
	5	Above 65 years old	25.4
CSP		Occupational category - 4 modalities:	
	High	Higher socio-economic status	30.6
	Low	Lower socio-economic status	27.6
	Retired	Retired	27.8
	Unempl	Other Unemployed	14
TOWNSIZE		Size of the respondent's town with respect to inhabitants number - 3 modalities:	
	Small	Less than 20 000 inhabitants	33.8
	Medium	Between 20 000 and 200 000 inhabitants	11
	Large	More than 200 000 inhabitants	55.2
REGION		French geographical region where the respondent lives - 5 modalities:	
	IDF	Paris and Parisian region (*Ile-de-France*)	19
	NW	North West	23
	NE	North East	22
	SW	South West	11
	SE	South East	25
FREQVISIT		Answer to the questions "*In the last 12 months, how often have you visited UGSs on average?*"	
	0	I don't visit UGSs - *Reference level*	8.6
	1	Less than once a week	49.2
	2	At least once a week	42.2
KNOWL		Answers to the questions "*Do you know since when the UGSs of your town are pesticide-free? Can you distinguish a green space managed with pesticides from one pesticide-free? Do you feel more informed than the general public on the topic of the survey (due to your job, studies or those of another household member)?*" These answers capture the respondent's knowledge of the survey topic.	
	1	If the respondents answered "yes" to at least one of these questions	49.2
	0	Otherwise	50.8

Table 3: Mixed logit estimation

Variables	Mixed logit	
	Mean	SD
USE_Improv	0.680*** (0.111)	1.090*** (0.166)
USE_Deter	-1.544*** (0.137)	1.491*** (0.160)
VISUAL_Natural	0.529*** (0.0895)	1.313*** (0.122)
FAUNA_MinIncr	0.310*** (0.0825)	0.515*** (0.196)
FAUNA_MajIncr	0.546*** (0.110)	1.138*** (0.168)
INFO	0.353*** (0.0752)	0.698 (0.150)
WCOND_Improv	0.371*** (0.0999)	0.727*** (0.176)
WCOND_Deter	-1.310*** (0.126)	1.316*** (0.149)
BUDG_MinIncr	-0.525*** (0.0881)	0.553*** (0.183)
BUDG_MajIncr	-1.743*** (0.151)	1.429*** (0.173)
Nb of observations	9,000	
LogLik	-2399.3565	
Chi2 (df)	375.25 (10) (P=0.0000)	

Standard errors reported in parentheses.
*Statistically significance codes: *** - at 0.1%, ** - at 1%, * - at 5%, . - at 10%.*
Estimated with STATA14 "mixlogit" package.

opposed to a more controlled aspect. Fauna abundance and the availability of information are positively valued by about 70% of the respondents, but to a lesser degree. Respondents seem not to be concerned by the potential damage caused by animals since they do not reject a major increase in fauna abundance. However, 32% prefer a stable fauna population to a major increase.

To what extent do these differences in coefficient estimates represent differences in estimated trade-offs? Table 4 shows the marginal rate of substitution between each attribute and a minor increase in budget, interpreted as an average weight in trade-offs.[9] In other words, it shows the characteristics to be given priority in a context of limited financial resources: improved recreational opportunities rank first, a major increase in fauna abundance ranks second, a more natural aspect ranks third, while improvement in working conditions and more information to citizens and workers are placed in fourth and fifth position.

We used a kernel density estimation of the individual parameters in the ML model, and the visual inspection suggests that there are at least two groups of preferences among respondents for three of the attributes (USE_Deter, WCOND_Deter, FAUNE_MajIncr), which argues for the use of a latent class model.[10] Table 5 presents the results of the latent class estimations with two latent classes and respondents' characteristics as determinants of class membership. Our sample can be divided into two main classes: class 1 comprises about 64% of the respondents, whereas class 2 comprises about 36% of them. Respondents

[9]We also calculated the marginal rate of substitution between each attribute and a major budget increase. Ranks are unchanged since it is only a matter of normalization.

[10]Those estimations are available on request.

Table 4: Marginal rate of substitution between each attribute and a minor increase in budget (derived from ML estimation)

	USE_Improv	USE_Deter	VISUAL_Natural	FAUNA_MinIncr	FAUNA_MajIncr	INFO	WCOND_Improv	WCOND_Deter
Mean	1.3443	-3.0884	1.0029	0.6129	1.0642	0.6722	0.7265	-2.5901
Lower bound	0.7082	-4.1766	0.5620	0.2599	0.5211	0.0.3018	0.3086	-3.5258
Upper bound	1.9803	-2.0003	1.4438	0.9659	1.6074	1.0426	1.1444	-1.6544
Rank	1	8	3	6	2	5	7	4

Confidence intervals (lower and upper bounds) are calculated using the delta method.

who frequent UGSs at least once a week are more likely to belong to class 2. No other socio-demographic variables explains class membership. Respondents with better knowledge of the pesticide ban have the same probability to belong to both classes.

Table 5: 2-class LC model

VARIABLES	Class 1	Class 2
USE_Improv	-0.036 (0.0773)	1.582*** (0.223)
USE_Deter	-0.494*** (0.0743)	-2.027*** (0.246)
VISUAL_Natural	0.166*** (0.050)	0.699*** (0.117)
FAUNA_MinIncr	0.092 (0.068)	0.598*** (0.135)
FAUNA_MajIncr	0.130* (0.074)	1.429*** (0.234)
INFO	0.299*** (0.050)	-0.195** (0.098)
WCOND_Improv	0.293*** (0.071)	-0.374** (0.161)
WCOND_Deter	-0.824*** (0.076)	-0.723*** (0.135)
BUDG_MinIncr	-0.376*** (0.066)	0.362** (0.167)
BUDG_MajIncr	-1.090***(0.081)	-0.908***(0.150)
VisFreq2	Ref	0.483** (0.224)
Constant	Ref	-0.759***(0.199)
Class share	64.4%	36.6%
LogLik		-2487
BIC		5174.55
LogLik		5018.25
LogLik		90.35%

Standard errors reported in parentheses.
*Statistically significance codes: *** - at 0.1%, ** - at 1%, * - at 5%, . - at 10%.*
Estimated with STATA14 ”lclogit” package (Pacifico and Yoo, 2012)

Looking at class 1 results reported in Table 5, the coefficient estimates are close to those estimated by the ML models in Table 3, except for the improvement in the recreational opportunities offered and a minor increase in fauna abundance, which are not statistically significant in the LC model class 1. On the contrary, the frequent users (respondents belonging to class 2) value more negatively the deterioration of the recreational opportunities and are more sensitive to an increase in fauna abundance (minor and major). The information coefficient is not significant for class 2, which stands out from the majority of the respondents in class 1 who express interest for information and training on the topic. This result may suggest that frequent users of UGSs are already well-informed due to the many signs already present in the cities at the time of the survey. Compared to class 1, class 2 is also characterized by the significance and negative sign of the improvement in the working conditions coefficient, suggesting that respondents believe that working conditions are already good enough. Nevertheless, class 2 respondents support an increase in the budget dedicated to UGSs if it remains limited. These frequent users of UGSs may be more aware of the extra costs of pesticide-free management and therefore accept such a budget increase in order to maintain the quality of use.

Our results show the need to assess the heterogeneity of the population preferences appropriately in order to provide relevant information to local policy makers and UGS managers. One important limitation of this survey is that it elicits the preferences for UGSs in the city of the respondents "in general" but does not indicate the preferences for the diversity of UGSs within one city. In fact, the notion of "differentiated management" signals that the transition to pesticide-free UGSs is generally organized differently in the different parks and gardens, allowing for different trade-offs between attributed according to the areas: the visual aspect may be more important in an iconic city center garden, while the recreational opportunities are more valued in a peripheral park. Further research could explore the characterization of preferences for this diversity within a city, as practiced by managers using differentiated management methods.

4 Conclusion

The study illustrates the application of discrete choice modelling to the choice of management options in the transition towards zero-pesticide UGSs. Such preferences cannot be observed in real life since users rarely have in their everyday life the opportunity to choose among different UGCs. The study identifies the users' preferred level of each UGS characteristic selected, namely recreational opportunities, visual aspect, communication with the population and UGS employees, working conditions for the workers, and the budget dedicated to the maintenance of UGSs; it also ranks the characteristics most valued by users.

We find that all chosen attributes have a significant impact on the respondents' choice of UGS option. We find that the financial impacts are an important concern for citizens who largely devalue options involving a major budget increase and that citizens give a higher negative value to losses in the recreational opportunities and working conditions than a positive value to gains. Our results show the need to assess the heterogeneity of the population preferences appropriately in order to provide relevant information to local policy makers and UGS managers. One characteristic of particular importance to understand users' preferences is the visit frequency to UGSs. This factor affects in particular preferences towards the visual aspect (the natural aspect if more valued by frequent users), fauna abundance (more valued by frequent visitors), and information campaigns (positively valued only by those who do not frequently visit UGSs).

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References

Amaya, A. (2003). 'None' matters. In *X Encuentro Economia Publica*, number Tenerife 5-8 Febrero, pages 1–24. Tenerife, S., ed.

Arnberger, A. and Eder, R. (2011). The influence of age on recreational trail preferences of urban green-space visitors: a discrete choice experiment with digitally calibrated images. *Journal of Environmental Planning and Management*, 54(7):891–908.

Arnberger, A. and Eder, R. (2015). Are urban visitors' general preferences for green-spaces similar to their preferences when seeking stress relief? *Urban Forestry & Urban Greening*, 14(4):872–882.

Bae, H. (2011). Urban stream restoration in Korea: Design considerations and residents' willingness to pay. *Urban Forestry & Urban Greening*, 10(2):119–126.

Baji, P., García-Goñi, M., Gulácsi, L., Mentzakis, E., and Paolucci, F. (2016). Comparative analysis of decision maker preferences for equity/efficiency attributes in reimbursement decisions in three European countries. *The European Journal of Health Economics*, 17(7):791–799.

Bastian, C. T., Keske, C. M. H., McLeod, D. M., and Hoag, D. L. (2017). Landowner and land trust agent preferences for conservation easements: Implications for sustainable land uses and landscapes. *Landscape and Urban Planning*, 157:1–13.

Bech, M. (2003). Politicians' and hospital managers' trade-offs in the choice of reimbursement scheme: A discrete choice experiment. *Health Policy*, 66(3):261–275.

Bertram, C., Meyerhoff, J., Rehdanz, K., and Wüstemann, H. (2017). Differences in the recreational value of urban parks between weekdays and weekends: A discrete choice analysis. *Landscape and Urban Planning*, 159:5–14.

Börger, T. (2016). Are Fast Responses More Random? Testing the Effect of Response Time on Scale in an Online Choice Experiment. *Environmental and Resource Economics*, 65(2):389–413.

Boxall, Peter C. and Adamowicz, Wiktor L. (2002). Understanding Heterogeneous Preferences in Random Utility Models: A Latent Class Approach. *Environmental and Resource Economics*, 23(4):421-446.

Brander, L. M. and Koetse, M. J. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management*, 92(10):2763–2773.

Bullock, C. H. (2008). Valuing Urban Green Space: Hypothetical Alternatives and the Status Quo. *Journal of Environmental Planning and Management*, 51(1):15–35.

Campbell, D., Mørkbak, M. R., and Olsen, S. B. (2017). Response time in online stated choice experiments: the non-triviality of identifying fast and slow respondents. *Journal of Environmental Economics and Policy*, 6(1):17–35.

Chalak, A., Balcombe, K., Bailey, A., and Fraser, I. (2008). Pesticides, preference heterogeneity and environmental taxes. *Journal of Agricultural Economics*, 59(3):537–554.

Christensen, T., Pedersen, A. B., Nielsen, H. O., Mørkbak, M. R., Hasler, B., and Denver, S. (2011). Determinants of farmers' willingness to participate in subsidy schemes for pesticide-free buffer zones—A choice experiment study. *Ecological Economics*, 70(8):1558–1564.

Commissariat général au Développement durable (2015). Les pesticides dans les cours d'eau français en 2013.

Costa, C. A. d. and Santos, J. L. (2016). Estimating the demand curve for sustainable use of pesticides from contingent-valuation data. *Ecological Economics*, 127:121–128.

de Bekker-Grob, E. W., Hol, L., Donkers, B., van Dam, L., Habbema, J. D. F., van Leerdam, M. E., Kuipers, E. J., Essink-Bot, M.-L., and Steyerberg, E. W. (2010). Labeled versus Unlabeled Discrete Choice Experiments in Health Economics: An Application to Colorectal Cancer Screening. *Value in Health*, 13(2):315–323.

de Groot, W. T. and van den Born, R. J. G. (2003). Visions of nature and landscape type preferences: an exploration in The Netherlands. *Landscape and Urban Planning*, 63(3):127–138.

del Saz Salazar, S. and García Menéndez, L. (2007). Estimating the non-market benefits of an urban park: Does proximity matter? *Land Use Policy*, 24(1):296–305.

Dhar, R. (1997). Consumer Preference for a No-Choice Option. *Journal of Consumer Research*, 24(2):215–231.

Dhar, R. and Simonson, I. (2003). The effect of forced choice on choice. *Journal of marketing research*, 40(2):146–160.

Filyushkina, A., Agimass, F., Lundhede, T., Strange, N., and Jacobsen, J. B. (2017). Preferences for variation in forest characteristics: Does diversity between stands matter? *Ecological Economics*, 140:22–29.

Florax, R. J. G. M., Travisi, C. M., and Nijkamp, P. (2005). A meta-analysis of the willingness to pay for reductions in pesticide risk exposure. *European Review of Agricultural Economics*, 32(4):441–467.

générale de l'alimentation du Ministère de l'Agriculture, D. (2016). Tendances du recours aux produits phytopharmaceutiques de 2009 à 2014 - Note de suivi 2015.

Giergiczny, M. and Kronenberg, J. (2014). From Valuation to Governance: Using Choice Experiment to Value Street Trees. *AMBIO*, 43(4):492–501.

Greene, William H. and Hensher, David A. (2003). A Latent Class Model for Discrete Choice Analysis: Contrasts with Mixed Logit. *Transportation Research Part B: Methodological*, 37(8):681-698.

Harris, V., D. Kendal, A.K. Hahs, and C.G. Threlfall. (2018). Green space context and vegetation complexity shape people's preferences for urban public parks and residential gardens. *Landscape Research*, 43(1):150–162.

Hensher, D. A., Rose, J. M., and Greene, W. H. (2015). *Applied Choice Analysis*. Cambridge University Press. Google-Books-ID: K0mqCQAAQBAJ.

Hirsch, R. and Hensher, J. (2009). The Look of the Lawn : Pesticide Policy Preference and Health-Risk Perception in Context. *Environment and Planning C: Government and Policy*, 27(3):468-490.

Hirsch, R. and Hensher, J. (2011). Context, Cultural Bias, and Health Risk Perception : The "Everyday" Nature of Pesticide Policy Preferences in London, Calgary, and Halifax. *Risk Analysis*, 31(5):847-865.

Hoshino, T. and Kuriyama, K. (2010). Measuring the Benefits of Neighbourhood Park Amenities: Application and Comparison of Spatial Hedonic Approaches. *Environmental and Resource Economics*, 45(3):429–444.

Hoyos, D. (2010) The state of the art of environmental valuation with discrete choice experiments. *Ecological Economics*, 69(8):1595–1603

INRA (2005). Pesticides, agriculture et environnement : Réduire l'utilisation des pesticides et en limiter les impacts environnementaux. Available at: http://institut.inra.fr/Missions/Eclairer-les-decisions/Expertises/Toutes-les-actualites/Pesticides-agriculture-et-environnement [Accessed January 28, 2019].

Ives, C.D., C. Oke, A. Hehir, A. Gordon, Y. Wang, and S.A. Bekessy. (2017). Capturing residents' values for urban green space: Mapping, analysis and guidance for practice. *Landscape and Urban Planning*, 161:32–43.

Jetter, K., and T.D. Paine. (2004). Consumer preferences and willingness to pay for biological control in the urban landscape.. *Biological Control*, 30(2):312–322.

Jin, J., Wang, W., He, R., and Gong, H. (2017). Valuing health risk in agriculture: a choice experiment approach to pesticide use in China. *Environmental Science and Pollution Research*, 24(21):17526–17533.

Kahneman, D. and Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, 47(2):263–291.

Kuhfuss, L., Préget, R., Thoyer, S., and Hanley, N. (2016). Nudging farmers to enrol land into agri-environmental schemes: the role of a collective bonus. *European Review of Agricultural Economics*, 43(4):609–636.

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, 74(2):132–157.

Latinopoulos, D., Mallios, Z., and Latinopoulos, P. (2016). Valuing the benefits of an urban park project: A contingent valuation study in Thessaloniki, Greece. *Land Use Policy*, 55:130–141.

Louviere, J. J., Hensher, D. A., and Swait, J. D. (2000). *Stated choice methods: Analysis and applications*. With a contribution by Wiktor Adamowicz.

Louvière, J., and H. Timmermans. (1990). Stated preference and choice models applied to recreation research: A review. *Leisure Sciences*, 12(1):9–32.

McFadden, D. (1974). Conditional logit analysis of quantitative choice behavior. In P. Zarembka, *In Frontiers in econometrics*, pp. 105–142.

Michaud, C., D. Llerena, and I. Joly. (2013). Willingness to pay for environmental attributes of non-food agricultural products: a real choice experiment. *European Review of Agricultural Economics*, 40(2):313–329.

Morris, J., Colombo, S., Angus, A., Stacey, K., Parsons, D., Brawn, M., and Hanley, N. (2009). The value of public rights of way: A choice experiment in Bedfordshire, England. *Landscape and Urban Planning*, 93(1):83–91.

Muratet, A., and B. Fontaine (2015). TContrasting impacts of pesticides on butterflies and bumblebees in private gardens in France. *Biological Conservation*, 182:148–154.

Ode Sang, Å., I. Knez, B. Gunnarsson, and M. Hedblom. (2016). The effects of naturalness, gender, and age on how urban green space is perceived and used. *Urban Forestry & Urban Greening*, 18:268–276.

Pacifico, , Daniele and Yoo, Hong Il. (2015). lclogit: A Stata Module for Estimating Latent Class Conditional Logit Models via the Expectation-Maximization Algorithm. *UNSW Australian School of Business Research*, Paper No. 2012 ECON 49. Available at SSRN: https://ssrn.com/abstract=2174146.

Poudyal, N. C., Hodges, D. G., and Merrett, C. D. (2009). A hedonic analysis of the demand for and benefits of urban recreation parks. *Land Use Policy*, 26(4):975–983.

Rose, J. M. and Bliemer, M. C. J. (2013). Sample size requirements for stated choice experiments. *Transportation*, 40(5):1021–1041.

Train, K. E. (2009). *Discrete Choice Methods with Simulation.* Cambridge University Press, Cambridge.

Travisi, C. M. and Nijkamp, P. (2008). Valuing environmental and health risk in agriculture: A choice experiment approach to pesticides in Italy. *Ecological Economics*, 67(4):598–607.

Tu, G., Abildtrup, J., and Garcia, S. (2016). Preferences for urban green spaces and peri-urban forests: An analysis of stated residential choices. *Landscape and Urban Planning*, 148:120–131.

Tversky, A. and Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, 5(4):297–323.

Tversky, A. and Shafir, E. (1992). Choice under conflict: The dynamics of deferred decision. *Psychological science*, 3(6):358–361.

Vandermeulen, V., Verspecht, A., Vermeire, B., Van Huylenbroeck, G., and Gellynck, X. (2011). The use of economic valuation to create public support for green infrastructure investments in urban areas. *Landscape and Urban Planning*, 103(2):198–206.

Van Puyvelde, S., Caers, R., Du Bois, C. and Jegers, M. (2016). Managerial Objectives and the Governance of Public and Non-Profit Organizations *Public Management Review*,18(2):221–237.