Alternative adaptation scenarios towards pesticide-free urban green spaces: Welfare implication for French citizens

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Abstract

Adaptation of urban green spaces (UGSs) to allow their maintenance without pesticides is likely to impact the value attached to these green infrastructures by urban citizens. To understand citizens' preferences for UGSs in this context, a Discrete Choice Experiment was administered in France in 2017, when a pesticide ban in all UGSs was implemented. It allows evaluating the impact on citizens' welfare of different UGSs management scenarios without pesticides. The scenario offering new recreational opportunities is by far the most valued by citizens. Only a minority is worse-off in the "laisser-faire" scenario, where the vegetation is much less controlled. Citizens suffer from welfare losses in the scenario "apparently as before" since it comes at the cost of deteriorated working conditions for maintenance teams. The policy recommendations drawn can contribute to greater social acceptance of the transition towards pesticide-free UGSs.

JEL classification : Q24, Q26, C25

Keywords : Choice experiment, France, Pesticides, Urban green spaces, Welfare measure

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Highlights :

- DCE allows to estimate the welfare impacts of different adaptation scenarios to the pesticide ban in French UGSs

- Citizens value most the scenario offering new recreational opportunities.

- Only a minority of citizens is worse-off in the “laisser-faire” scenario, where the vegetation is much less controlled.

- Citizens suffer from welfare losses in the scenario “apparently as before” since it comes at the cost of deteriorated working conditions for maintenance teams.

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1 Introduction

The European Commission announced two pesticide reduction targets as part to the Farm to Fork Strategy in May 2020. These are a 50% reduction in the use and risk of chemical pesticides and a 50% reduction in the use of more hazardous pesticides by 2030. This reduction concerns not only agricultural land, but also other types of land such as urban green spaces (UGSs). Pesticide use on amenity areas accounts for less than 3% of total pesticide use per year, but with strong environmental impacts, in particular on water contamination (Kristoffersen et al., 2008). Some European countries officially extended their pesticide reduction efforts to non-agricultural areas well before this EU legislation. In France for example, following a law voted in 2014, pesticides are banned in public gardens, parks and other green spaces since 2017. While some cities had started to reduce pesticide use well before the ban, the challenge for most municipalities is to adopt suitable technical solutions for pesticide-free management whose consequences on the UGSs will be accepted by the population. While the risk reduction associated to the consumption of food produced with less pesticides is now well acknowledged by citizens, the consequences of UGS management without pesticides are less tangibles for the users of the recreational services offered by UGSs.[4] Our research aims at understanding the conditions for social acceptance, necessary for a successful transition towards pesticide-free UGSs.

Discrete choice experiment (DCE) is now acknowledged as a relevant method to evaluate citizens' preferences for natural environment in cities, in particular to highlight their multiple dimensions and their non-use values. For instance, the method has been used to assess preferences for parks (Bullock, 2008; Tu et al., 2016; Campagnaro et al., 2020), tree lines (Giergiczny and Kronenberg, 2014), urban recreational trails (Arnberger and Eder, 2011) or for UGSs overall management plan in one city (Kim et al., 2020). This approach is especially valuable when preferences cannot be observed, since users rarely have in their everyday life the opportunity to choose among different UGCs (Liotta et al., 2020). The DCE method also allows estimating compensating surplus for shifts in UGSs management scenarios (McIntosh and Ryan, 2002). Knowing the distribution of the welfare impacts of a policy change allows making judgements concerning its social acceptability. This method has been used previously to measure the welfare impacts of alternative agricultural land and forest management scenarios. For example, Rodriguez-Entrena et al.(2012) have valued different soil management programs in order to value the carbon sink function of the Andalusian olive groves. Meyerhoff et al.(2009) have provided welfare measures for a more nature-oriented forest conversion program in Lower Saxony, Germany. We provide here a new case study for urban land management.

Building on the analysis of preferences for specific characteristics of UGSs managed without pesticides developed in Laille et al.(2020), we calculate the welfare impacts of three UGSs management scenarios without pesticides. They are compared to a benchmark hypothetical situation where all UGSs' attributes would be unchanged compared to

[4]Moreover, most of the literature focuses on willingness to pay for food products with less pesticides (Florax et al., 2005; Travisi and Nijkamp, 2008; Costa and Santos, 2016) and at the margin for other agricultural goods like flowers (Michaud et al., 2013). Preferences for pesticide reduction in non-agricultural goods and services, such as access to UGSs, have hardly been studied in the literature.

the situation before the pesticide ban. To do so, we rely on the estimates of a random parameter logit model applied to data collected with a DCE survey administered to a representative sample of the French metropolitan population. In this survey, each respondent was asked to choose between different hypothetical management schemes of the parks and gardens in his city (all without pesticides) defined by six characteristics likely to be impacted by the transition to pesticide-free management. The welfare measures obtained are useful to define the conditions for the transition to be accepted.

We find that the attribute most valued by citizens is the non-deterioration of recreational opportunities. Moreover, most citizens are willing to accept an increase in the budget allocated to UGSs for management scenarios favoring the presence of fauna and areas with a natural visual appearance. While it is less visible by citizens, the respondents do care about the working conditions of the UGS maintenance teams. As a result, most respondents suffer from a welfare loss in the scenario where vegetation is controlled at the cost of deteriorated working conditions. On the contrary, the scenario consisting in the improvement of recreational opportunities to compensate citizens for the changes in UGSs appearance is by far preferred by most of the respondents. We also highlight the heterogeneity in preferences, partly explained by gender, education, visit frequency to UGSs and general knowledge on the pesticide ban. The method can be replicated to estimate the welfare impact of other scenarios that would be envisaged by authorities in charge of the pesticide-free transition in other contexts.

The article is structured as follows. Section 2 presents the experimental design. The method for data analysis is exposed in section 3, and data in section 4. Section 5 discusses the results and policy implications. The last section concludes and highlights avenues for future research.

2 Experimental design

The survey consisted of several choice sets, each containing two mutually exclusive hypothetical options between which respondents were forced to choose their preferred one.[5] The options characterize an average UGSs in the city of the respondents and they are defined by a set of six attributes, each attribute taking one level.

2.1 Attributes and levels

The six attributes selected are the UGS characteristics of most interest for the users and most likely to be impacted by the transition to pesticide-free management. They are: recreational opportunities, visual appearance, fauna abundance, existence of information, working conditions for maintenance teams and the share of the city budget allocated to UGSs. The definition of attributes with their levels are presented in Table 1. They have been selected based on interviews with managers and local politicians in charge of UGSs, as well as technical references provided by the resource centre for UGSs management in France and the environmental economics and landscape management literature on preferences for UGSs. A pilot conducted with 75 citizens allowed testing their understanding of the attributes.

The originality of our approach is that the levels of the attributes have been defined to describe the evolution following the pesticide ban, therefore allowing the estimation of the welfare impacts according to the way the transition is managed. The reference level corresponds to an unchanged situation with respect to what could be obtained with chemical pesticides. The technical constraints have changed with the pesticide ban, but we assume that some of the UGS characteristics can be left unchanged. Recreational opportunities and working conditions are attributes which may be improved or deteriorated with the pesticide ban, leading to three levels: the second level corresponds to an improvement and the third level to a deterioration compared to the unchanged situation. Since it seems unrealistic to consider the case where the pesticide ban would generate a loss of wildlife and a reduction in the public budget allocated to UGSs[6], the second level for those attributes corresponds to a small increase and the third one to a major increase with respect to the "unchanged situation". The two remaining attributes have two levels. For the visual appearance, the reference level is "controlled" since it corresponds to the visual appearance obtained with pesticides, corresponding to the situation in most UGSs before the pesticide ban. The second level is a more "natural" appearance since UGS managers may decide to limit the control of the vegetation and accept more wildness. The information attribute takes the value "absent" (reference level) or "existing", if information campaigns directed towards citizens and maintenance teams are organized.

[5]There is no opt-out in our design since the transition to pesticide-free management is compulsory and the status-quo is not an available option. When opt-out is not allowed, respondents cannot sidestep the cognitive task of comparing alternatives (Dhar and Simonson, 2003; Dhar, 1997).

[6]Cheval et al. (2017) have found that the savings due to stopping the purchase of pesticides are largely lower than the increase in labor costs to manage UGSs without pesticides.

Table 1: Attributes

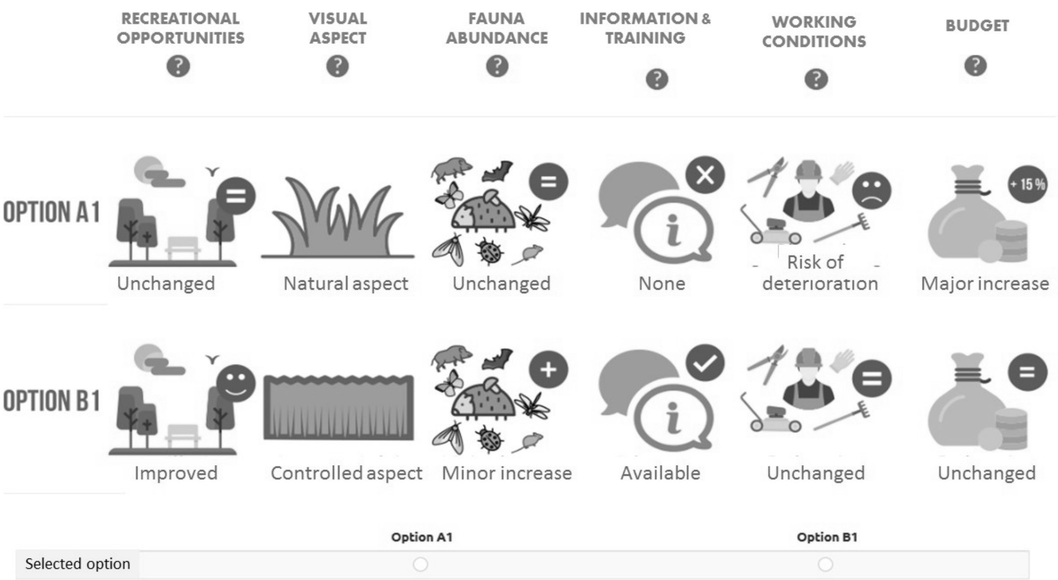
Attributes	Description	Level VARIABLE NAME
Recreational opportunities	They depend on the green area characteristics such as functionality, accessibility, security, and aesthetics. Pesticide-free management may require changes that could alter these characteristics for elements such as atmosphere, plantations, paths or furniture.	Improved USE(+) Unchanged* Reduced USE(-)
Visual appearance	The change to pesticide-free management implies the presence of more weeds in green areas such as urban parks, but also along footpaths, by 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* Natural NATU
Fauna abundance	Pesticide-free management may boost the populations of all types of local animal species (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 FAUNA(++) Minor increase FAUNA(+) Unchanged*
Information Training	Pesticide-free management creates many changes concerning the level of service of the green areas, the key skills required of workers, the organization of work, and the associated costs. To facilitate these changes, the local communities can decide to offer training and/or information for maintenance teams and residents.	Absent* Existing INFO
Working conditions	With 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 an increased risk of accidents or professional illnesses (e.g. due to noise, dust, exhaust gases, awkward positions). Being subjected 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 WORK(+) Unchanged* Risk of deterioration WORK(-)
Budget**	This concerns the local community budget allocated 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 reorganization of the space (e.g. new plants), sub-contracting, training workers, and informing the population.	0%,+5%,+15% BUDG

*: Reference level
** We have considered as inappropriate to have a monetary attribute presented as an increase in local taxes in euros per year given that the study encompasses all of the French metropolitan territory and the annual amounts of French local taxes are very different from one city to another

An efficient factorial design was applied in this study, using the Ngene software. We used the D-error criterion (0.079) to optimize the efficiency of the experimental design on the basis of prior results gleaned from the pilot survey. The 72 scenarios generated were then organized in 36 choice cards with two scenarios labelled "option A" and "option B" (Figure 1). These choice cards were splitted into 4 blocks of 9 choices. But in order to control for learning and lassitude, we created two versions of each block varying the order of the choice cards, for a total of 8 blocks. Lastly, to check for consistency, we duplicated one of the choice card.[7] To summarize, each respondent was randomly assigned to one

[7] The options proposed to each respondent were the same for the first and seventh choices, but the

Figure 1: Example of choice card



of the 8 blocks and did 10 choices (including one used only to check for consistency and therefore excluded from the estimations).

2.2 Scenarios

The DCE method allows providing estimates for the welfare impact of different transition scenarios, associated with multiple changes in attributes. We define an hypothetical benchmark scenario $S0$ and focus on three management scenarios Si defined by three different combinations of the six attributes described above, but the method can easily be used to assess the welfare impact of other scenarios. The correspondence between the three scenarios and the attributes is summarized in Table 2. While practitioners have developed typologies to differentiate UGSs according to the maintenance required -grass cutting, pruning, irrigating, weeding ...-(Allain, 1997), our scenarios are described by attributes of interest for the users and likely to be impacted by the pesticide ban.

The benchmark scenario ($S0$) corresponds to a situation where attributes are unchanged compared to the situation before the pesticide ban: recreational opportunities, fauna abundance and the working conditions are unchanged, the visual appearance is controlled (as commonly observed when chemical pesticides was available) and no information nor training for workers is available. It is hypothetical since it is impossible to maintain UGS characteristics identical without the help of chemical pesticides. Nevertheless, this benchmark is useful since citizens may be reluctant to changes in the visual appearance and services offered by UGSs and may expect such scenario to take place. During the interviews conducted before launching the survey, managers mentioned the importance of information to explain that this scenario is not applicable. As a result, we consider three alternative scenario judged as realistic by practitioners and evaluate welfare change with

names A and B were swapped.

$S0$ as a benchmark.

The *apparently as before* scenario ($S1$) consists in keeping as much as possible the attributes' levels similar to the situation before the pesticide (as in the benchmark situation $S0$). But without chemical pesticides, keeping the controlled visual appearance and allowing for the same recreational opportunities require extra work (for example for weeding) compared to the situation with access to pesticides. Agents' working conditions may be deteriorated. The change in the working conditions is thus the only difference between $S0$ and $S1$. This scenario is likely to be selected for the maintenance of iconic gardens such as those adjacent to the town halls.

The *laisser-faire* scenario ($S2$) consists in a drastic change in UGSs management in order to reduce the maintenance burden in the absence of the cheap and efficient solution to control vegetation (chemical pesticides). Weeds are more present, alternative landscaping management strategies are implemented, causing different textures and colors to appear (e.g. mulch). The visual appearance therefore evolves towards more "natural" or "wild", but can also be considered as "poorly maintained" by some. When the grass is cut less frequently, the recreational opportunities can be deteriorated. Users and workers are informed of the changes generated by the pesticide ban in order to understand why the laisser-faire is positive, in particular since it provides the opportunity for much more wildlife to develop in new habitats. With this reorganization, workers may appreciate an improvement of their working conditions.

In the *new opportunities* scenario ($S3$), the managers decide to reduce the maintenance burden by letting the vegetation evolving towards a more natural appearance. But contrarily to $S2$, investment in equipment are realized in order to improve the recreational opportunities and somehow compensate the change in the visual appearance. Fauna observation may also be a new opportunity offered to visitors. Workers may dedicate less effort to control the vegetation but will have to maintain these equipments. Their working conditions may therefore be neither improved nor deteriorated. While this reorganization is the consequence of the pesticide ban, the managers may decide not to communicate on the benefits of pesticide-free UGSs to the public and workers, but rather put the focus on the new recreational opportunities offered.

Table 2: Attribute levels associated with different scenarios

	S0 *Benchmark*	S1 *Apparently as before*	S2 *Laisser-faire*	S3 *New opportunities*
Recreational opportunities	Unchanged	Unchanged	Deteriorated	Improved
visual appearance	Controlled	Controlled	Natural	Natural
Fauna abundance	Unchanged	Unchanged	Major increase	Minor increase
Training & Information	Absent	Absent	Existing	Absent
Working conditions	Unchanged	Risk of deterioration	Improved	Unchanged

3 Method for data analysis

Discrete choice approach is based on Lancaster's demand theory (Lancaster, 1966) and the econometric modeling is based on the random utility theory (McFadden, 1974). Respondents are expected to select their preferred scenario from a set of hypothetical pesticide-free UGS management scenarios composed of six attributes (X).

The preferences of each individual $i = 1, ..., N$ for different options $j = 1, ..., J$ in choice set $t = 1, ..., T$ are defined as:

$$U_{ijt} = V_{ijt} + \epsilon_{ijt} = X'_{ijt}\beta_i + \epsilon_{ijt} \tag{1}$$

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

An individual i will choose an option k from J options, if $U_k > U_j \ \forall j \neq k$. The probability, p_{kit}, to 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:

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

In the Random Parameter Logit model (RPL), the parameters β_i (equation 1) are randomly distributed and vary over decision makers following a given distribution in order to represent the heterogeneity in respondents' tastes and cognitive abilities (Mariel and Meyerhoff, 2018). It can be decomposed into :

$$\beta_i = \beta + \Lambda z_i + \Gamma\nu_i \tag{4}$$

where β is a parameter vector representing the fixed means of the random parameter distribution, z_i is the vector of observed individual-specific characteristics that affect the mean of the random parameter distribution and Λ is the associated parameter matrix, allows us to take into consideration a possible interaction of individual characteristics and attributes. The random unobserved taste variation is represented by ν_i, a vector of uncorrelated random variables with mean zero and covariance matrix with known values on the diagonal, fixed by identification restrictions. Γ is a matrix defined a convariance structures among N random parameters. In the case of uncorrelated random parameters, Γ is a diagonal matrix, but individuals may have correlated preferences for different attributes (not only for different levels of the same attribute). In this case, Γ is a lower triangular matrix with non-zero off diagonal elements. Hess and Train (2017) demonstrate that the RPL model with full correlation among utility coefficients allow for all sources of correlation, including scale heterogeneity. As suggested by Mariel and Meyerhoff (2018), we compare the RPL model with full correlation among utility coefficients and the RPL with uncorrelated random parameters.

As commonly assumed in the literature (Hensher and Green, 2003), the coefficient associated with the cost attribute is considered to be constant, whereas the other RPL parameters are assumed to be normally distributed across population.[8] To account for non-linear relationships, all attributes were dummy-coded, except the budget attribute that was coded as continuous (+0%, +5% and +15%).

Comparing the impacts of different attributes: Marginal Rates of Substitution

We use Marginal Rate of Substitution (MRS) to interpret the relative impact of the attributes since they cannot be compared using attribute parameter size and significance. Indeed, the effect of an attribute can be due to a large weight relative to other attributes, but also to large differences in scale values associated with the levels, or some combination of both (Lancsar et al., 2007). In particular here, distances between the levels of different qualitative attributes don't have the same meaning. Investigating the relative importance people place on the various attributes requires a common scale, provided by the MRS tool.

Because of linear assumption about individual utility function and dummy-coded attributes, the MRS associated with attribute a at his level l is equal to the corresponding coefficients ratio:

$$MRS_{a,l} = \frac{\beta_{a,l}}{\beta_{BUDGET}} \tag{5}$$

where $\beta_{a,l}$ represents the coefficient of the corresponding non-monetary attribute, and β_{BUDGET} represents a proxy for the marginal utility of income.

The MRS can be viewed as the average weight in trade-off when moving from the reference level of attribute a to level l, expressed in percentage point increase in the city budget allocated to UGSs. Because of the common denominator, MRS allow comparing different attributes and show the characteristics to be prioritized in a context of limited financial resources. The median MRS provides useful information on the share of the population with positive (and negative) preferences towards an attribute's level.

Welfare measures

In order to assess the acceptability of alternative pesticide-free management scenarios, we measure the welfare impacts of the scenarios described in Table 2. We calculate the welfare impact as a compensating surplus (CS) (Espinosa-Goded and Ruto, 2010; Rodríguez-Entrena et al., 2012; Meyerhoff and Hartje, 2009). CS is the maximum amount of money a respondent would be willing to pay (or willing to accept) to have the same utility in the pesticide-free scenarios as in the hypothetical benchmark scenario. The welfare change is

[8] Even if assuming that there is no heterogeneity among the respondents in relation to budget is somewhat unrealistic, the budget parameter was specified as fixed in order to be able to compute the marginal rate of substitutions between the monetary attribute and the others.

thus expressed as :

$$CS_S = \frac{V_0 - V_S}{-\beta_{budget}} \tag{6}$$

where V_0 and V_S represent the conditional indirect utility associated respectively with the benchmark and the scenarios, and β_{budget} is the coefficient for the budget attribute.

A positive CS means that citizens are worse-off in the pesticide-free scenario compared to the benchmark: they request a compensation in the form of an increase in other municipal budget lines to accept the transition. A negative CS indicates that citizens are better-off with the transition: they are willing to accept an increase in the budget allocated to UGSs for this change.

4 Data

The sample is composed of 500 French citizens surveyed on line in fall 2017.[9] Thanks to stratified random sampling, the final sample of 500 citizens is similar to the French population in terms of region, gender, occupation category, and age (Table 3 (top)). More than 500 respondents were interviews but those who did not make the same choice for the two identical choice cards were qualified as "inconsistent" and removed from the sample. Survey length was on average 12 minutes (5% took more than 30 minutes and 5% less than 5 minutes). The Electronic Supplementary Material includes the full text of the survey.

Since previous research suggested that individual preferences for urban landscapes are shaped by socio-demographic variables (Giergiczny and Kronenberg, 2014; Tu et al., 2016; Chen et al., 2017), we also collected other information on respondents' characteristics, complementary to those used to build the representative sample (Table 3). 63% of the respondents have received higher education. More than half of the sample (55.2%) lives in large cities (more than 100000 inhabitants) and one third in small ones (less than 20000 inhabitants). City size may have an impact on preferences towards UGSs since small city inhabitants are more likely to have a private garden and the access to public parks and gardens is more limited in small cities. Those who have their own garden may also be more familiar with the efforts associated to controlling vegetation without pesticides. On the contrary, in large and medium size cities, there are more multiple dwellings, a minority of them with private parks.

Most of the respondents are frequent users of UGSs: only less than 10% have never visited UGSs in the last 12 months, 42.20% of them visited at least once a week UGSs in the last 12 months and 49.20% visited them less than once a week. Frequent visits to parks and gardens are not so surprising since most of the respondents live in big cities and they have interest in the survey topic if they decided to respond to the panel invitation. We also collected information about respondents' knowledge about the pesticide ban through three questions (bottom of Table 3). We then built a synthetic indicator of self-declared

[9] The respondents were selected from the *Opinionway* Internet panel composed of 100,000 persons. The panelists receive a financial compensation for participation to each survey. They are recruited through various channels to reduce sampling bias.

knowledge with vary from 0 (no prior knowledge) to 3 (complete knowledge). Despite the fact that the survey was conducted the same year than the implementation of the pesticide ban (2017), half of the respondents declared to have no prior knowledge and only 6.4% of sample believed they were perfectly informed (they can distinguish a pesticide-free managed green space, they declare to know since when the UGSs of their city are managed without pesticides, and they declare to be more informed than the general public on the topic of the survey). 42.8% of the respondents declared to have partial knowledge (they answered ”yes” to one or two of these questions).

The estimations presented in the next section account for potential interactions between the attributes and these socio-demographic and habits variables in order to measure to what extent they shape preferences' towards UGS characteristics.

Table 3: Definitions and descriptive statistics of socio-economic control variables

Variable	Description	% Sample	% French population
VARIABLES USED FOR STRATIFIED RANDOM SAMPLING			
Region	French geographical region where the respondent lives - 5 modalities:		
_IDF	Paris and Parisian region (*Ile-de-France*)	19	18
_NW	North West	23	23
_NE	North East	22	22
_SW	South West	11	11
_SE	South East	25	25
Age	Age category of respondent - 5 modalities:		
1	Between 18 and 24 years old	9.2	10
2	Between 25 and 34 years old	16.2	15
3	Between 35 and 49 years old	24.6	25
4	Between 50 and 64 years old	24.6	25
5	Above 65 years old	25.4	24
CSP	Occupational category - 4 modalities:		
_High	Higher socio-economic status	30.6	28
_Low	Lower socio-economic status	27.6	29
_Retired	Retired	27.8	26
_Unempl	Other Unemployed	14	17
Female			
1	if the respondent is a women	51	52
OTHER VARIABLES			
HigherEducation			
1	if the respondent has received higher education	63	63
Townsize	Size of the city where the respondents currently live:		
_small	Less than 20000 inhabitants	33.8	62
_medium	Between 20000 and 100000	11	23
_large	More than 100000	55.2	15
VisFreq	Answer to the questions "*In the last 12 months, how often have you visited UGSs on average?*"		
_0	I don't visit UGSs	8.6	
_1	Less than once a week	49.2	
_2	At least once a week	42.2	
KnowZP	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.		
3	If the respondents answered "yes" to the tree questions	6.4	
2	If the respondents answered "yes" to at least two of these questions	16.2	
1	If the respondents answered "yes" to at least one of these questions	26.6	
0	Otherwise	50.8	

Note: The top part presents variables used for quota sampling. The last column contains data for the French metropolitan population (Source: INSEE job survey 2012 and Recencement de la population 2017 and OECD(2019) for higher education). The bottom part describes control variables collected in the survey and used in the estimation.

5 Results of the discrete choice analysis

We discuss here the results of two versions of the RPL model with uncorrelated random parameters (Table 4).[10] The first model does not account for respondents' characteristics, while the second extends the model by interacting attributes with such variables. MRS estimates (Table 5) and welfare measures (Figure 2) for the three scenarios are based on estimations of the RPL model with interactions.[11]

5.1 Preferences for UGSs' attributes

In the left-hand size of Table 4, the estimated means of coefficients are all statistically significant (at the 1% significance level) and have the expected signs: respondents evaluate improvements in UGS characteristics positively but perceive a budget increase as negative. The standard deviations of all coefficients are significant and high, confirming that preferences are highly heterogeneous and the RPL model provides a significantly better representation of the choices than the conditional logit model does.

The attributes corresponding to a deterioration compared to the baseline situation (recreational opportunities and working conditions) have the highest numerical weight, albeit negative. On average, ceteris paribus, a deterioration in the working conditions generates a higher loss than the gain associated with improved conditions (-1.054 *vs* 0.337). The same effect is observed for the recreational opportunities (-1.272 for a deterioration *vs* 0.480 for an improvement). This is in agreement with prospect theory (Kahneman and Tversky, 1979). Furthermore, we provide a new input to the contrasted literature on citizens' preferences for wild-looking areas in cities (Sang et al., 2016; De Groot and van den Born, 2003; Harris et al., 2018; Arnberger and Eder, 2015; Tagliafierro et al., 2013; Bronnmann et al., 2020). According to our results, most respondents show strong preferences for a natural visual appearance as opposed to a more controlled appearance.

We rely on MRS (Table 5) to analyse the relative impact of the attributes to avoid scale issues. Since attributes are ranked according to the absolute values of the median MRS, attributes corresponding to a deterioration compared to the current situation are in the top of the ranking even if the MRS is negative. Improved recreational opportunities is the most preferred positive attribute (rank 3). While the attributes illustrating the concept of "nature in the city" are positively valued (rank 5 for the natural appearance and ranks 4 and 7 for the fauna abundance), respondents expect pesticide-free UGSs to offer at least the same level of recreational opportunities than before the pesticide ban. The respondents seem not to be bothered by animals since they prefer a major (rank 4) than a minor increase (rank 7) in fauna. The availability of information for citizens and workers and the improvement in working conditions are positively valued, but to a lesser degree

[10] Estimations of the RPL with correlated parameters, together with the correlation matrix are presented in the appendix (Tables A1 and A2). We find high correlations among some of the attributes but we cannot reject the null hypothesis that all out-of-diagonal elements of the correlation matrix of the random parameters are zero (see likelihood-ratio test below Table A1).

[11] Ranking of attributes are similar using the RPL with or without interactions, which shows that our estimates are robust.

(respectively rank 6 and 8). Still, it suggests that citizens are concern by the technical challenge of the transition to pesticide-free management and are able to empathize with maintenance teams.

Two characteristics are less consensual. While a majority of the citizens are in favor of a natural visual appearance or the improvement of working conditions, still 34% prefer a controlled visual appearance and 37% are not willing to accept an increase in budget for the improvement of the working conditions. The RPL model with interactions allows understanding what are the socio-demographic and attitudinal characteristics of those persons with differing preferences.

5.2 The influence of socio-demographic and attitudinal variables on preferences

In the extended model (right-hand side model in Table 4), we test the effect of the socio-economic and attitudinal variables described in Table 3 on the coefficients associated with each attribute. Only significant interactions are presented. Our results show the need to account for heterogeneity to provide relevant information on citizens' preferences. Gender, education, region, town size, knowledge on the pesticide ban and visit frequency seem to influence preferences, at least for some of the attributes. For example, respondents with higher self-reported knowledge on the pesticide ban give higher value to a natural visual appearance and a major increase in fauna abundance. This suggests information campaigns on the pesticide ban can increase the acceptability of the change in the visual appearance toward more natural. Those more informed are also less negatively impacted by the increase in budget. While the natural visual appearance is preferred on average, we observe heterogeneity with respect to town size: the preferences for the natural visual appearance is lower for citizens living in large cities compare to small cities and citizens living in medium size cities are on average more in favor of a controlled visual appearance. Surprisingly, the preferences towards information campaigns are not shaped by the self-declared knowledge of the topic, while we would have expected those who believe they are not well informed to value information. However, while males have no utility gains associated to information campaigns and training, females do. Visit frequency also shapes preferences: the utility gains associated with an improvement of the working conditions of the maintenance teams are largely reduced for those who visit UGSs at least once a week. During their frequent visits, they may have the opportunity to observe maintenance teams and they form their judgement that their working conditions are good enough based on these observations. Females are more in favor of an improvement in working conditions than males. Citizens who have received higher education are more impacted by a budget increase. This may be explained by the fact that they are more likely to anticipate that an increase in the budget allocated to UGSs will end up to an increase in their local taxes (in particular if they are also the wealthiest since local taxes in France are based on housing size and property ownership).

Table 4: RPL models with independant random parameters

	RPL uncorrelated		RPL uncorrelated with interactions	
VARIABLES	Mean	SD	Mean	SD
USE(-)	-1.304***	1.277***	-1.159***	1.305***
	(0.106)	(0.121)	(0.136)	(0.123)
USE(+)	0.550***	0.846***	0.575***	0.878***
	(0.0848)	(0.135)	(0.0875)	(0.136)
VISUAL(nat)	0.456***	1.128***	0.634***	1.116***
	(0.0737)	(0.0976)	(0.146)	(0.0998)
FAUNA(+)	0.288***	0.344*	0.303***	0.406**
	(0.0683)	(0.200)	(0.0706)	(0.180)
FAUNA(++)	0.460***	0.878***	0.254**	0.896***
	(0.0910)	(0.128)	(0.114)	(0.131)
INFO	0.305***	0.584***	0.101	0.570***
	(0.0624)	(0.105)	(0.0861)	(0.110)
WORK(-)	-1.087***	1.102***	-1.108***	1.130***
	(0.0960)	(0.118)	(0.0991)	(0.122)
WORK(+)	0.279***	-0.554***	0.307**	-0.567***
	(0.0813)	(0.158)	(0.130)	(0.157)
BUDG	-0.0921***		-0.0941***	
	(0.00614)		(0.00983)	
USE(-)xFemale			-0.366**	
			(0.176)	
VISUAL(nat)xKnowZP			0.171**	
			(0.0772)	
VISUAL(nat)xTownsize_medium			-0.685***	
			(0.247)	
VISUAL(nat)xTownsize_large			-0.414***	
			(0.158)	
FAUNA(++)xKnowZP			0.272***	
			(0.0911)	
INFOxFemale			0.430***	
			(0.123)	
WORK(+)xFemale			0.256*	
			(0.150)	
WORK(+)xVisFreq_2			-0.342**	
			(0.152)	
BUDGxRegion_NW			0.0235**	
			(0.0116)	
BUDGxHigherEducation			-0.0348***	
			(0.0105)	
BUDGxKnowZP			0.0194***	
			(0.00544)	
Nb of observations	4500		4500	
Nb of individuals	500		500	
Log likelihood	-2427.307		-2387.010	
Chi2	312.428		319.393	
AIC	4888.615		4830.020	
BIC	5009.400		5028.959	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Estimations obtained based on maximum likelihood simulations (1000 Halton draws)
Estimated with STATA14 “mixlogit” package

Table 5: Marginal rates of substitution: trade-off between increase in UGS budget and other UGS characteristics

Attribute	Median	95% CI		Rank	Frequency	
					Negative	Positive
USE(-)	-13,91	[-42,91;	14,23]	1	85%	15%
USE(+)	6,52	[-10,77;	24,42]	3	25%	76%
NATU	4,87	[-17,56;	27,14]	5	34%	66%
FAUNA(+)	3,17	[-5,16;	11,14]	7	21%	79%
FAUNA(++)	4,97	[-12,80;	23,07]	4	28%	72%
INFO	3,39	[-8,01;	14,91]	6	27%	73%
WORK(-)	-11,19	[-33,73;	10,43]	2	82%	18%
WORK(+)	1,90	[-9,87;	13,66]	8	37%	63%

Note: Attributes are ranked according to the absolute value of the median MRS. MRS estimated following the Krinsky and Robb (1986) procedure with 1000 draws. The lower and upper limits of a 95% confidence interval are given by the 26th and 975th sorted estimates of WTP, respectively (Hole, 2007).

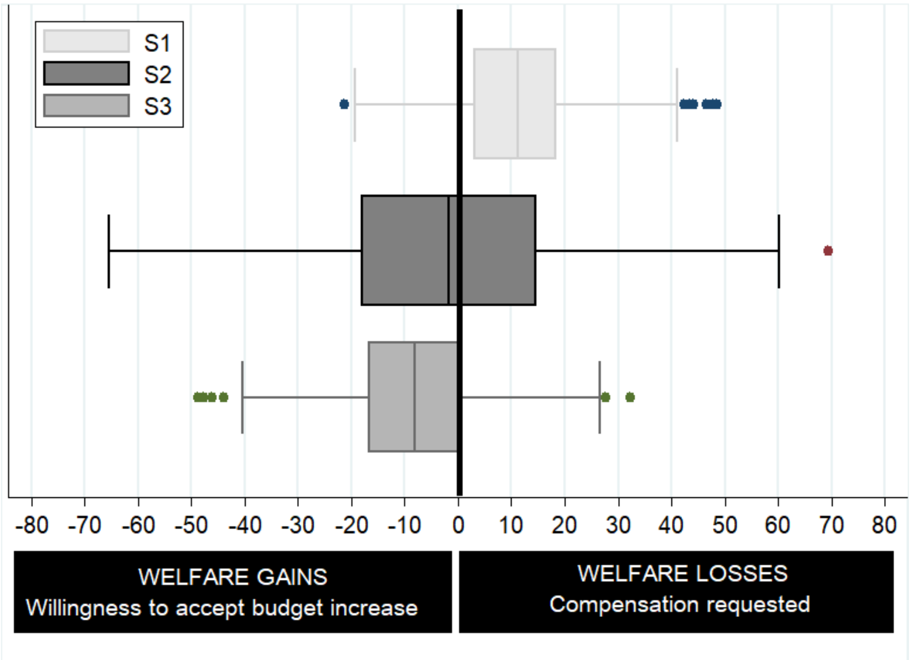
5.3 Welfare impact of different management scenarios

In order to measure the acceptability of alternative ways to realize the transition towards pesticide-free UGSs, we provide in Figure 2 estimates for the welfare impact of three pesticide-free management scenarios, compared to an hypothetical benchmark situation $S0$, where attributes are unchanged compared to the situation before the pesticide ban. Figure 2 presents the distribution of the compensation requested by citizens for each scenario, expressed in percentage points of budget allocated to UGSs. We focus the discussion on the median value since it's informing whether the majority of the population benefit from a positive welfare change, an indicator of social acceptance.

The median compensating surplus of the *apparently as before* scenario ($S1$) is positive (+11.20 percentage point of UGS budget), indicating that more than half of the respondents will suffer from a loss in utility if this scenario is chosen. Indeed, S1 consists in keeping unchanged the quality of use, visual appearance and fauna abundance (as before the pesticide ban), but it necessarily comes at the cost of deteriorated working conditions. To receive support from the majority of the respondents, the budget allocated to UGS in S1 should be reduced by 11 percentage points. But since workers need to use more time-consuming weeding techniques, this scenario is also likely to be the costlier. One could have think that the extra-efforts necessary to obtain a controlled visual appearance without pesticide would be valued by citizens but our results show the contrary since citizens empathize with workers. This scenario should therefore be avoided, at least not as a general rule for maintenance of all parks and gardens in a city. While the generalization of S1 is not desirable, it may be a relevant option in the case of an iconic garden surrounding a town-hall or major historical monument for example. In this case, if the extra-work is restricted to the maintenance of very specific areas and less labor-intensive scenarios are implemented in other types of UGSs, the deterioration of the working conditions and the associated welfare losses for citizens could be avoided.

The *laisser-faire* scenario ($S2$) was selected as a potential option to limit the maintenance burden in the absence of pesticides. The median compensating surplus for S2 is

Figure 2: Individual compensating surplus to accept the transition to pesticide-free scenarios



Note: CS>0 corresponds to a welfare loss compared to the the benchmark scenario and therefore requires a compensation in the form of a reduction of budget allocated to UGSs (allowing for an increase of funding for other local public services). CS<0 corresponds to a welfare gain: citizens are better-off with the transition and are therefore willing to accept an increase in share of the municipality budget allocated to UGSs.
The boxplot (constructed with the command graph hbox in Stata 14) depicts the CS data through their quartiles (the median in the center and the 25th and 75th percentile on the sides of the rectangle). The lines extending from the boxes (whiskers) indicates variability outside the upper and lower quartiles (the the most extreme values within 1.5x(upper quartile - lower quartile) of the nearer quartile are represented by the vertical lines). Outliers are plotted as individual points. CS estimated following the Krinsky and Robb procedure (1000 draws).

slightly negative (-1.75), suggesting that slightly more than half of the citizens are better-off if this scenario is chosen. This comes from the fact that citizens value the natural visual appearance and the abundance of fauna, while it was initially expected these attributes' levels could be associated with welfare losses. Moreover, citizens value positively the improved working conditions of the maintenance teams and the information campaigns, which further increase the welfare associated to $S2$. Still, the deterioration of recreational opportunities associated with this "*laisser-faire*" is strongly negatively valued by citizens and therefore limit the welfare gains in this scenario. Moreover, the confidence interval is very large, indicating that many users (47%) would require a compensation (in the form of an increase in other public services for example) to make up for those changes. This scenario is likely to be the cheapest to implement. It could therefore be implemented in areas where the public had anyway limited recreational opportunities before the pesticide ban or in peripheral parks where the experience of "nature-in-the-city" is particularly sought.

The *new opportunities* scenario ($S3$) is associated with the largest welfare improvement and is preferred by most of the respondents. According to our estimations, 50% of the respondents would be willing to bear an increase of more than 8.07 percentage point in UGS budget for this scenario to be implemented. This scenario offering new recreational opportunities was initially imagined as a compensation for the deteriorated visual appearance. But since citizens also positively value the natural visual appearance, the new opportunities available in $S3$ and not in $S2$ further improve welfare. This is true even if the need for the maintenance of new recreational equipment does not guarantee the improvement of the working conditions (contrarily to $S2$), and this scenario does not encompass information campaigns and training on pesticide-free management. $S3$ is also more consensual than $S2$ since the confidence interval is smaller. Still, a little more than a quarter of the population (26.2%) would suffer from a welfare loss. If the choice set would be restricted to the three scenarios analysed here, $S3$ should be favored, in particular if the improvement in recreational opportunities can be implemented at low cost. Previous available evidence already suggested that citizens highly value the presence of recreational facilities in UGSs (Arnberger and Eder, 2015; Campagnaro et al., 2020; Kim et al., 2020)

Our results show that there is no obvious scenario to be generalized since none are consensual. Indeed, in S2 and S3 some respondents are worse-off while the majority is better-off compare to the benchmark (and the opposite for S1). This suggests that one-size-fits-all approach is not only technically impossible but also socially undesirable, thus confirming the relevance of *differentiated management*, a common way of dealing with the pesticide ban when human and financial resources are constrained. It consists in applying to each public green area a specific treatment, with varying levels of performance depending on its category (park, garden or infrastructure), its cultural, social and biological function and its role in the city (Allain, 1997; Aggéri, 2010). Our approach can help to balance the costs of these different treatments with the value citizens place on each type of management scenario.

6 Conclusion

Discrete choice modelling has been applied to measure the welfare impacts of alternative transition scenarios towards pesticide-free UGSs. The question addressed in the article is not whether stopping pesticide use is beneficial for the population but how the transition to pesticide-free UGSs can be implemented so that it increases welfare for the majority of the population. We identified the UGS characteristics most preferred by the users and the trade-offs they are willing to make in a context of bounded budget. These estimations allow for the calculation of the compensating surplus requested by users to cover for welfare losses due to the change in UGS management to comply with the pesticide ban, according to three different scenarios. Thanks to stratified random sampling based on age, gender, occupation category and region, the study allows drawing conclusions taking as example the French population. The method used can also be extrapolated to other management scenarios.

Managers and local politicians have their own opinion on the acceptability by urban citizens of the changes resulting from the transition towards pesticide-free UGSs. During focus groups with UGS managers and local politicians, we heard the following: "citizens strongly dislike weeds and UGSs should not look like wild areas"; "less pesticides can benefit to fauna, but many urban citizens associate fauna with potential trouble making"; "dedicating a large share of the budget to communication with the general public is crucial". Our results challenge some of these opinions and allow providing evidence-based recommendations, that can help to remove barriers to a successful transition towards pesticide-free UGSs. In particular, we found that citizens have a strong preference for a natural visual appearance, which suggests that the costly control of the vegetation is not always desirable. We also observed that fauna abundance and the improvement in the recreational opportunities available in UGSs are valued by a large majority of respondents. On the contrary, information is only valued by females. With regard to attributes less visible by citizens, the respondents do care about the working conditions of the UGS maintenance teams: a majority prefer their working conditions are improved, and even more numerous are those who are strongly against their deterioration. We found evidence of loss aversion since citizens' utility is on average more impacted by the degradation of working condition or recreational opportunities than their upgrading. Overall, the transition is more likely to be accepted by making sure that recreational opportunities are not restricted and workers' conditions do not deteriorate.

The method used has some limitations. In particular, the results may be biased by framing effects, inherent to stated preferences surveys as responses are contingent on the ways in which information has been formulated and presented in the questionnaire. For example, one may question the implications of using a percentage to describe the change in the budget, instead of using real amounts (Kragt and Bennett (2012) found no impact of the wording of attribute levels as total versus proportional quantities). One may also question the relevance of having the same images with only an indication of the evolution trend (=, +, -). We are not aware of any reference in the literature assessing the difficulty for respondents to figure-out the differences across levels with such a presentation of the choice cards. Moreover, beyond these purely methodological aspects, the results do not provide information on preferences for UGSs diversity within one city (we only shed light on preferences for an average park or garden in the city of the respondents). This would be of particular interest for managers, since in the cities who have successfully managed the transition, *differentiated management* is implemented, relying on different management options according to the areas. Analyzing preferences for this diversity within a city would be an interesting addition to our research. Moreover, to be operational, the result indicating strong preferences for a natural visual appearance should be further investigated. Indeed, the exact meaning of a natural visual appearance is ambiguous when associated to areas such as urban green spaces where human interventions are necessaries (Allain, 1997). The definition of a natural visual appearance are likely to differ across individuals. Lastly, if data on the cost of the alternative management options would be available, complementary research could include weighing citizens' welfare measures against the costs of alternative pesticide-free management scenarios in order to carry out a comprehensive cost-benefit analysis.

In summary, this study demonstrates how stated preference methods (and DCE in particular) and the calculation of welfare measures can provide valuable and policy-relevant inputs that can support managers in the transition towards zero pesticide in UGS. These inputs include a deeper understanding of public preferences and their heterogeneity, but also quantitative welfare measures for the considered management scenarios.

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Table A1: RPL models with correlated random parameters

VARIABLES	RPL correlated Mean	RPL correlared with interactions Mean
USE(-)	-1.455***	-1.363***
	(0.120)	(0.155)
USE(+)	0.581***	0.609***
	(0.0951)	(0.0998)
VISUAL(nat)	0.456***	0.666***
	(0.0851)	(0.159)
FAUNA(+)	0.379***	0.389***
	(0.0873)	(0.0892)
FAUNA(++)	0.659***	0.489***
	(0.126)	(0.145)
INFO	0.331***	0.109
	(0.0720)	(0.0954)
WORK(-)	-1.226***	-1.248***
	(0.110)	(0.116)
WORK(+)	0.343***	0.343**
	(0.0981)	(0.149)
BUDG	-0.100***	-0.100***
	(0.00717)	(0.0109)
USE(-)xFemale		-0.262
		(0.182)
VISUAL(nat)xKnowZP		0.206**
		(0.0833)
VISUAL(nat)xTownsize_medium		-0.791***
		(0.269)
VISUAL(nat)xTownsize_large		-0.381**
		(0.177)
FAUNA(++)xKnowZP		0.284***
		(0.0971)
INFOxFemale		0.465***
		(0.131)
WORK(+)xFemale		0.249
		(0.168)
WORK(+)xVisFreq_2		-0.289*
		(0.170)
BUDGxRegion$_{NW}$		0.0234*
		(0.0124)
BUDGxHigherEducation		-0.0419***
		(0.0112)
BUDGxKnowZP		0.0216***
		(0.00581)
Nb of observations	4500	4500
Nb of individuals	500	500
Log likelihood	-2380.7648	-2384.489
Chi2	412.478	311.283
AIC	4851.530	4828.978
BIC	5171.254	5042.127

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimations obtained based on maximum likelihood simulations (1000 Halton draws)

Estimated with STATA14 “mixlogit” package

LR (model with interactions)$= -2 \times ((-2387.0099) - (-2384.489)) = 5.04 < 41,34 = \chi^2(28)0.05$

Table A2: Estimated correlation matrix of the random parameters (RPL correlated without interactions)

	USE(-)	USE(+)	VISUAL(nat)	FAUNA(+)	FAUNA(++)	INFO	WORK(-)	WORK(+)
USE(-)	1,691***							
USE(+)	-0,473***	0,684***						
VISUAL(nat)	-0,005	0,099	1,503***					
FAUNA(+)	-0,183	0,136	-0,058	0,731***				
FAUNA(++)	-0,557***	0,120	-0,074	1,218***	2,338***			
INFO	-0,147	-0,032	-0,039	-0,094	0,016	0,421***		
WORK(-)	0,750***	0,347***	0,061	-0,003	-0,384	-0,196	1,363***	
WORK(+)	-0,022	-0,061	-0,293*	0,186	0,309	-0,048	-0,379**	0,344**