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A Methodological Approach to the Spatial Aggregation of Values

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Abstract

A Choice Modelling (CM) experiment is developed with the purpose of gaining some insight on how to identify the relevant population for the valuation of an environmental asset. The experiment is based on a survey of Perth residents over the values they attach to Kings Park, the largest urban park in Western Australia, 4/5 of which is native bushland. We design the experiment in order to isolate NUVs form UVs so that trade-offs between attributes of the asset imply trade-offs between Use Values, Non-Use Values and money. One can then estimate the coefficients for each attribute and analyse the effect of distance on patterns of use. Preliminary results are obtained using data from a pre-survey trial of the questionnaire.

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Introduction.

In the context of Benefit-Cost Analysis and damage compensation, the issue of horizontal and vertical benefit aggregations is of primary concern. Horizontal aggregation is the aggregation of all elements of cost and benefits. Vertical aggregation refers to the vertical sum of individuals' marginal (net) benefit schedules. Valuing the benefits of a natural ecosystem, for instance, it is necessary to sum up the direct benefits such as the value of its products (wood, fishes, etc), and the indirect benefits such as the effects on agricultural ecosystems and aggregate them over all beneficiaries..

Since Krutilla (1967), it is understood that the social benefits of natural resources are not captured by market values (prices, fees). Society holds values that are not always related to use or consumption. Indeed, people may be motivated to pay also because they want to preserve the option to use the resource in the future (option value), or want their descendants to enjoy the resource (bequest values) or for the sake of nature (existence value). Option, bequest and existence values are usually referred as Non-Use Values (NUVs). Hence, aggregating Use Values (UVs) and NUVs makes up the true social value or the Total Economics Value of an environmental asset (Pearce and Turner, 1989).

Environmental economics has developed several tools to perform non-market evaluation to obtain estimates of benefits from non-market goods. Among these tools, the Stated Preference (SP) techniques are regarded as the only technique able to provide estimates of UV and NUV. SP techniques provide the necessary information for horizontal aggregation. Actually, notwithstanding several controversial issues, the Contingent Valuation method (CVM) and the Choice Modelling (CM) technique are widely employed in BCA and assessment of natural resource damage.

Largely neglected is the issue of vertical aggregation. How should we identify the population benefiting from the resource? How large is the extent of the market for natural goods? As pointed out by Smith (1993), progress in this direction is required because the issue is potentially more important than any refinement of per-unit estimates. As shown, among others, by Pate and Loomis (1997) benefits estimation is strongly influenced by assumptions as the relevant region. Aggregating over a small population may leave out some individuals with positive values. Similarly, values may be overstated if the sample estimate is extrapolated over too large a population.

For private commodities, aggregation requires to identify the spatial boundaries of the market. In the marketing science, it is common to use geographic information to describes the region of influence, or the region over which suppliers have a dominant market share. At the boundary of two market areas for the same private commodity, prices plus transportation costs must be equal (Beckmann, 1999). Given that transportation costs depends on distance and other spatial characteristics, the use of geographic information to trace the boundaries of market is clear-cut.

One can apply the concept of market areas to environmental assets as well, because the SP techniques create hypothetical markets for environmental assets. And, as in the marketing literature, one may use spatial or geographical information to track the scope of the market. Stretching the concept of market areas to environmental assets, however, is not straightforward.

Once it is recognized that NUVs are relevant elements in the TEV, some complexities arise.

Public goods have no market prices, and usually transportation costs are the only monetary expenses required in order to use an environmental resource. Hence distance and other spatial features determine the cost of getting to the environmental asset. That is, the net benefits from use (the UVs) are expected to be a decreasing function of distance. Some member of the public, though, benefits form the resource without incurring in any transportation costs. NUVs do not require use of the asset by definition, that is they are are not dependent on monetary or time expenditure, and hence are distance-independent.

Therefore, one would expect the (TEV) of a natural resource (use values plus non-use values) for a given consumer to decay as her distance from the asset increases, until TEV reaches a positive limit. Willingness to Pay (WTP) functions are then assumed to be distance-dependent up to a limit given by the non-use value of the natural resources. The market for an environmental good may have not spatial limits.

It may be argued that non-use values are related to the availability of information, and that information is, to a certain degree, distance-dependent (Sutherland and Walsh, 1985). This means that the TEV would approach a zero limit at a certain distance that identifies the limits of the market.

Several SP studies, mostly based on the Contingent Valuation (CV) technique, have adopted a 'spatial' perspective when aggregating values (see Sutherland and Wash, 1985, Loomis, 1996, Pate and Loomis, 1997, Bateman and Langford, 1997, Breffle *et al.* 1998, Bateman *et al.*, 2000).

This literature, however, has not yet produced conclusive results regarding the spatial boundaries of environmental markets. TEV is found to decrease as distance increases for some goods. For other assets, however, distance seems to have no effect on people's WTP (Pate and Loomis, 1997. In some cases, the "distance decay" effect, that is, the rate of WTP decrease over distance, is very low and WTP goes to zero well beyond the boundaries of a continent (see Loomis, 1995). Further, given the characteristics of the SP method, surveys tend to be biased towards users. That is, those more inclined to take part in the survey are more likely to be users of the asset under valuation (Bateman and Langford, 1997). Experience with the resource is assumed to induce higher NUVs, so a user-biased survey would over-estimate benefits when aggregated over the population of users and non-users. And even when differentiating between users and non-users in the context of a survey, aggregation needs the distribution of users and non-users in the population to be known.

It seems that spatial aggregation needs more empirical foundations. More evidence is needed on the spatial behaviour of UVs and NUVs, which in turn requires better methods to disentangle the two.

This paper is concerned with the development of a methodology to obtain estimates of NUVs and UVs exploiting some of the properties of the Choice Modelling (CM) technique. The survey concerns the largest urban park in Western Australia: Kings Park. It is approximately 320 hectares of bushland and 80 hectares of playgrounds and facilities and is located a few kilometres away from the Perth business district. By careful design of the bushland attributes, the CM survey tries to force respondents to make trade-offs between UVs, NUVs and money. These trade-offs provide a clue of the relative importance respondents assign to the UV and NUV elements held by each single attribute. The trade-offs and the weights assigned by respondents when they choose the preferred alternative, allow us to compute the relative importance of UVs and NUVs, to distinguish between them, and analyse the effects of distance and patterns of uses.

The paper uses preliminary data obtained while testing the questionnaire formats on few focus groups. Using a conditional logit model on this data set, we gain some insights on the relation between UV, NUVs, distance and use patterns.

After briefly revising the CM approach and comparing it with the CV method (section 1), the paper illustrates our methodological concepts and hypothesis in section 2. It follows with a description of the data and a preliminary data-analysis (section 3). Section 4 shows some results and section 5 concludes.

1. The Choice Modelling Techniques. Theoretical Foundations.

Increasingly popular among environmental economists, the Choice Modelling (CM) technique has its origin in market research and information theory (McFadden, 1986). Along with the discrete choice Contingent Valuation Method (CVM), it falls under the category of the Stated Preferences techniques. SP methods involve the elicitation of responses to predefined alternatives in the form of rating, ranking or choice. While discrete choice CVM applications require respondents to choose between a base option (usually the 'status quo') and a single alternative, the CM approach involves a more experimental and involved analysis of choice behaviour. Respondents are repeatedly asked to choose the preferred alternative in different choice sets, each containing a base option and two or three alternative. This array of choice sets and alternatives represents a choice situation via an accurate and complete description of the attributes and levels of each alternative. Respondents' choices reflect the trade-offs each individual makes between the attributes, permitting estimates of their relative importance.

CM has some advantages over CVM. It can split up the overall benefit estimation into estimation of the value of each attribute. It can easily accommodate substitution opportunities within the choice sets. It can provide benefit estimation for different and exclusive policy option within one survey (Blamey *et al.*, 1998).

CM is attractive in environmental valuation also because it involves a model structure that is used in the discrete choice CVM and discrete choice Travel Cost method. This model structure is based on Random Utility Theory (RUT). In the RUT, the overall utility U_{in} that can be obtained by individual n from alternative i is expressed as the sum of a systematic component V_{in} - which is assumed to be a function of the attributes X_i presented and the characteristics of the individual S_n – and a random component e_{in}. While V_{in} represents the observable or measurable component of utility, e_{in} captures the effect of omitted unobservable variables. More formally:

$$U_{in}=V_{in}(X_{in},S_n)+e_{in} \quad (1)$$

Alternative i is chosen over alternative j if $U_{in}>U_{jn}$. The probability of individual n choosing alternative *i* is:

$$Pr_{in} = Prob(U_{in} > U_{jn}) \text{ for all } j \in C_n$$
$$= Prob(V_{in} + e_{in} > V_{jn} + e_{jn}) \text{ for all } j \in C_n \quad (2)$$

where C_n is the choice set for individual *n*. V_{in} is a conditional indirect utility function and it is assumed to have a linear-in-parameter form:

$$V_{in} = \beta_1 + \beta_2 x_{in2} + \ldots + \beta_k x_{ink} + \alpha n(ASC_i * S_n) \quad (3)$$

where x_{ink} is the *k* attribute of alternative *i*, S_{nm} is the *m* characteristic of individual *n* and ASC_j is an alternative-specific constant. The e_{in} for all *j* in c_n are typically assumed to be independent and identically distributed (IID) and are Gumbell distributed. The probability of choosing alternative *i* is

$$Pr_{in} = \frac{\exp[\mu V_{in}]}{\sum_{j \in C_n} \exp[\mu V_{jn}]} \quad (4)$$

This formulation can be estimated using the multinomial logit model. The scalar factor μ is commonly normalised to one for any data set (Green, 2000).

In the search for alternative methods to estimate UV and NUV, the structure of the CM experiment has an appealing feature. We try to exploit the experimental design of attributes of alternative to force respondents to trade-offs UVs and NUVs, in order to obtain monetary measure of the relative importance of each class of value. The next section describes the asset under valuation, and its representation as presented to respondents.

2. Concepts, Attributes and Hypothesis of the Choice Modelling experiment.

The CM experiment describes three different management strategies for the urban bushland in Kings Park, Perth. Kings Park is a composite park, containing for 4/5 bushland and 1/5 facilities and playgrounds. Several surveys conducted by the Park Authority have shown the strong cultural and historical attachment of the people to the park. It is also the largest urban bushland in Western Australia, containing examples of native flora and fauna.

Attributes are presented as “management programs” that describe the *quality* and *quantity* changes (levels) of the available bushland deemed necessary to restore it or avoid further deterioration. By combining different levels of each management strategy, respondent are confronted with sets of choice alternatives. Table 1 illustrates these programs and table 2 gives an example of the choice sets presented to respondents.

The Weed Control Program (WCP) would *improve the quality* of the bushland by funding a weed eradication program. Weeds are non-native species that out-compete native flora and fauna, changing the quality of the bushland. The WCP would provide a healthier, weed-free bushland. If people attach NUVs to the native species in Kings Park (for cultural, bequests, option or existence reasons), the WCP would increase the NUVs of the park. In the questionnaire, the program is described in terms of changes in the percentage of bushland freed from weed (restored bushland). The idea that the survey tries to point out to the respondents is that the WCP would not change the use of the park, that is, would not change its UV. We think, indeed, that the UV of a native flower does not differ from the UV of a non-native one (and further, for common people it is often impossible to distinguish the two). In summary, the WCP asks respondents to trade-off money for NUV. We can write then:

$$\Delta NUV_b^{WCP} = X_{WCP} \qquad (5)$$

where ΔNUV_b is the change in NUV of the bushland and X_{WCP} gives the minimum amount of money that leaves the respondent indifferent between the WCP and the status quo. If NUVs are spatially-independent, we expect that the coefficient of the WCP program is not affected by distance. And if the pattern of use affects the magnitude of NUVs, such that users have higher NUVs than non-uses, the coefficient of the WCP program will vary according to the class of users.

The second program is called Nature Reserve Program (NRP). It aims to restrict people's access to the bushland, in order *to improve its quality*. It targets primarily degradation caused by human treading that damages native flora and increases weed encroachment, but requires that the bushland under the program be closed to the public. This would change the NUV and UV of the bushland. People would gain some NUV from an improvement of the quality of the bushland, but would lose some UV given that part of the bush is no longer accessible. The program is basically asking respondents if they are willing to accept a reduction of UV and money in order to get more NUV:

$$\Delta NUV_b^{NRP} = \Delta UV_b^{NRP} + X_{NRP} \qquad (6)$$

X_{NR} is the minimum amount of money for the NRP that would leave respondents as well off as in the Status Quo (no change in NUV and UV). The reason for introducing this program is that we want respondents to contrast it with the WCP and have a clear understanding of the trade-off involved by each program. By comparing the two programs, we hope respondents get the picture! In the questionnaire the NRP is described by the percentage change in the bushland that it is accessible to the public. Because the current level of this program is 100% (the whole bushland area is accessible), the changes in levels for this attributes are measured as reduction of accessible bushland. A non negative coefficient for this attribute means that people value positively the closure of the bush in order to improve its quality. In the case of distance independent NUVs, and distance-dependent UVs, we expect that the coefficient for the NRP to be positively affected by distance. Or, in other words, distant respondents and non-users would be willing to pay more for this program because they hev less UV to lose.

We also proposed a third program for the prevention of fires in Kings Park's bushland. We know that on average every year around 6 ha of Kings Park's bushland is destroyed by fire to such an extent that it is not usable for recreation for years. The Fire Control Program (FCP) would decrease this average. That is, it will *increase the quantity* of bushland that, on average, is available every year to the public. There will be more bushland to enjoy, making some people gain some NUVs and UVs for the bushland in exchange for the quantity of money X_{FC}:

$$\Delta NUV_b^{FCP} + \Delta UV_b^{FCP} = X_{FCP} \tag{7}$$

we describe the FCP in the questionnaire as the percentage of bushland annually destroyed by fire. An increase of bushland destroyed by fire would produce a loss given by:

$$-\Delta NUV_b^{FCP} - \Delta UV_b^{FCP} = -X_{FCP} \tag{8}$$

For this program, then, we expect a negative sign. Higher level of these attributes means that the program is not working or is not implemented. Respondents living close to the park and users are expected to value this program higher than non-user and distant respondents. Those last, indeed, would loose just NUVs if the program is not implemented.

The fourth attribute is the cost of each alternative. Respondents are asked to support the choice alternatives by paying via a tax increase. This payment vehicle is likely to create some protest, but it appears the most plausible given that Kings Park is actually funded with taxpayers' money.

An example of the choice alternative presented to respondents is given in table 2.

From the estimation of the probabilistic model we get the "*implicit price*" (*part worth*) of each program, that is, the marginal value of a unitary change in the quality or quantity of the bushland brought about by a given program. Implicit prices obtained by dividing the estimated coefficient of

Table 1. List of Attributes and their Characteristcs

Name of the program	*Objectives/ Major Target*	*Changes to the bushland*	*Costs*	*Expected gain and loss in values*
Weed Control Program (WCP)	Quality Improvement by Weeds eradication	- quality change - no quantity change	Money	▪ $+\Delta NUV_b^{WCP}$
Nature Reserve Program (NRP)	Quality Improvement by reducing human encroachment	- quality change - quantity change of accessible bushland	Money + quantity of accessible bushland	▪ $+\Delta NUV_b^{NRP}$ ▪ $-\Delta UV_b^{NRP}$
Fire Control Program (FCP)	Quantity Improvement by reducing average # of ha annually destroyed by fires	- no quality change - quantity change of usable bushland	Money	▪ $+\Delta NUV_b^{FCP}$ ▪ $+\Delta UV_b^{FCP}$

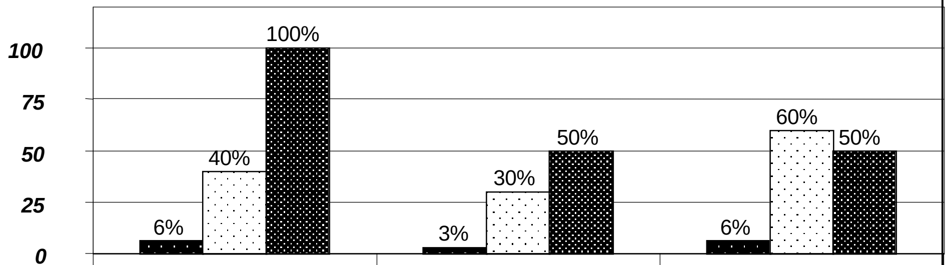
a given program to the estimated coefficient of the cost attribute times –1 (Bennett, 1999):

$$\text{Part worth} = -\left(\beta_{wcp}/\beta_{cost}\right) \tag{9}$$

We can interpret those implicit prices as the minimum amount of money that respondents are willingness to pay to get the quality/quantity change. The implicit price of the Nature Reserve program is then the X_{NR} in equation (5); the implicit price of the Weed Control program is X_{WC}, and so on. Once the coefficients of the probabilistic model are estimated (the βs), any changes they endure due to distance or use pattern will be reflected in the implicit prices.

Table 2. Example of the Choice Alternative presented to Respondents.

9) Suppose for now that these programs are the ONLY options to choose from. Please TICK below your preferred one.



	Current Management	Program 1	Program 2
% of Bushland annually destroyed by fire (FCP)	6%	3%	6%
% of restored Bushland (WCP)	40%	30%	60%
%of Bushland accessible to the Public (NRP)	100%	50%	50%
Levy on income tax = Cost to you ($)	$6*	$18	$18
Please tick your preferred option.	☐	☐	☐

* Recall that WA taxpayers are currently paying $6 a year for Kings Park's management.

How do these coefficients – and hence the implicit prices – change according to distance and use pattern?

After analysing the data and estimating the model, we will perform this exercise trying to answer this question.

3. Data Analysis and Model Estimations.

Our data comes from the pilot sessions we conducted to test the questionnaires. We have 37 good questionnaires in which respondents choose the preferred alternative over 8 choice sets, made up by three alternative each. We have then more than 800 choices that can be used to estimated the probabilistic model. Any result is to be considered prelimanary. Indeed, the sample is biased in several directions. There is an over-representation of female and university-educated respondents. Income distribution among the sample does not mimic the income distribution of the Perth population, but it over-represents both high and low income classes. We cannot say that it is biased in one single direction. However, these biases do not represent a major problem at this stage of the survey. Indeed, our focus is not the estimation of the effects of socio-economic characteristics on the WTP or on the implicit prices. We are concerned by the estimation of the coefficients of the attributes (the 'management programs") and their interactions with distance and patterns of use of the park. Information on distance is obtained by the questionnaire, in which respondents are asked to provide and estimate the time required to travel to the park, with indication of the mode of transport. It is not the geographic distance but, again, given the preliminary nature of this study, we hope that the estimated time distance would provide interesting insights for the following analysis.

The questionnaire also contains a set of questions regarding the respondents' use of the park. We recover the pattern of use from them, and distinguish between non-users, frequent, average and occasional users (table 3). Non users, by definition, hold just NUVs. It is logical to think that

Table 3.

SUB-SAMPLES	***Frequency of Visits***
Frequent User	≥ once per fortnight
Average User	≥ once every 3 months
Occasional User	≤ once a year
Non-User	never visits

frequent users have larger UVs than occasional users. Benefits from use are indeed related to the total number of time that individuals use the environmental resources. It is not the same, though, for NUVs. Unless we are able to establish empirically the relationship between the magnitude of NUVs and frequency of use, we cannot claim that NUVs for users are larger than NUVs for non-users.

Results

We use a conditional logit model to estimate the effect of each attribute, its interaction with distance and pattern of use on the probabilities of choices. The conditional logit model is similar to the multinomial model in every respect, except that the data consists of choice specific attributes instead of individual-specific characteristics. That is, the conditional logit model explains choice as a function of the characteristics of the choice alternatives (Green, 2000). In our exercise, the conditional choice model would provide coefficient estimates for each management program. We allow individual-specific effects in the model by introducing interaction terms that multiply an individual characteristic, such as distance, with the attributes. The individual characteristic is now changing across choices. The interaction effects measure the impact of individual characteristics on the coefficient of the attributes (Green, 2000). Results are summarised in table 4.

The pattern of use of the park is introduced in the model by distinguishing respondents according to their frequency of use and multiplying these categorical variables by the attribute levels. In the model, the base-line or ‘representative” respondent belongs to the “average user’ class.

For the average user, the WCP, the FCP and the cost attribute have all the expected signs. The WCP has a positive sign indicating that NUVs for the bushland in Kings Park are positive. FCP and the cost attribute have negative signs, as predicted. The sign of the FCP attribute requires some explanation. The program aims to *reduce* the fire damages and hence an increase in the value of the attribute means that the program is not working or it is not implemented. As such, an increase in the value of this attribute is valued negatively.

The fact that the NRP program has a not-significant coefficient (a recurrent result in several models we estimated) may be an indication that respondents either do not believe in this scenario or are not seriously concerned by the possibility of the park bushland being closed to the public. Indeed, Kings Park is mostly visited for its facilities and playgrounds. While respondents are willing to pay a positive price for NUVs, they are indifferent with respect to UVs of the bush. This is not necessarily in contradiction with the significant coefficient of the FCP. Fire has a strong impact on people’s imagination and this may explain the fact that the program is regarded as useful

Surprisingly, distance does not appear to affect the coefficients of the programs. Distance-interaction coefficients are not significant. One may be tempted to say that in the case of the WCP, this result is plausible because NUVs are not affected by distance. In other words, this result seems to confirm that NUVs are distance-independent. One may also claim that the relevance in people’s mind of fire control programs is such that they value positively any measure to contain fire damages. This would explain the absence of any distance effect on the FCP. Even the coefficient of the cost attribute is not affected by distance. No matter how far they live from the park, respondents reacted in the same (negative) way to the change in the monetary expenditure. It is possible that there is insufficient variability in the distance for it to affect the results. But it is important to note that the reaction to the cost attribute may be induced by the payment vehicle. The survey has indeed shown that the tax increase we propose is controversial. People felt like they are already paying too much tax, and tend to protest (even if only few express this view with a zero willingness to contribute to the programs). It is possible that this general discomfort with the payment vehicle overwhelms any other concern regarding paying for a distant park. In short, implicit prices do not change over distance..

table. 4. Estimation results

	coef	*z*	*p*
wcp	8.89E-02	3.1601**	0.0016
fcp	-1.56E-01	-1.8705**	0.061
nrp	2.91E-03	0.3766	0.71
cost	-4.60E-02	-3.5337**	0.00041
wcp : dist	7.14E-05	0.3449	0.73
fcp: dist	-6.90E-05	-0.1031	0.92
nrp: dist	-3.17E-05	-0.5145	0.61
cost: dist	-8.45E-05	-0.6969	0.49
wcp: useocc	-7.16E-02	-2.268**	0.023
fcp: useocc	7.44E-02	0.769	0.44
nrp: useocc	1.10E-03	0.1227	0.9
cost: useocc	1.10E-02	0.7375	0.46
wcp: usefreq	-5.72E-02	-1.3967*	0.16
fcp: usefreq	2.12E-01	1.5782*	0.11
nrp : usefreq	1.93E-02	1.5688*	0.12
cost: usefreq	2.52E-02	1.3963*	0.16
wcp: useNo	-8.42E-02	-1.6485**	0.099
fcp: useNo	-1.42E-02	-0.0674	0.95
nrp: useNo	-3.26E-02	-1.6372*	0.1
cost: useNo	-9.40E-02	-1.6698**	0.095
n=720			
Rsquare	0.142		
Likelihood Ratio Test	110		
Wald test	62.9	d.f. =20	
Score Test	83.8		
***significant at 5%* **significant at 10%*			

Compared to the average user, Frequent users appear to be less concerned by the cost, WCP and FCPs, while attaching greater importance to the NRP. They would pay more to avoid the bush being closed. This is, indeed, the program with a major impact on UVs. At the same time, they value less the FCP.

The model tells us the occasional user does not value the attributes very differently. The interaction of the attributes with this class of users is significant only for the WCP.

Non-users are more sensitive than the average users to the cost attribute, value less the WCP with respect to the average users, and also value positively the NRP program. This is not unexpected for the cost attribute in the light of the “user-pay principle”. It was well expressed by some respondents and confirmed by the fact that the frequent users are less concerned by the cost of the programs. Further, non users value the NRP program positively. This sounds contraddictory: why are non-users willingness to pay for using the resources? A possible explanation is that they are paying to preserve the option to visit the bushland in the future. Also they value less the WCP, suggesting that NUVs for non users are smaller than NUVs for all the other classes of users.

The interaction terms of the WCP and the pattern of uses deserve further comment. If the NUVs that are behind the WCP do not depend on use or previous experience of the park, one would find that those interaction terms are not significantly different from zero. Or that, while significant, they do not show a systematic pattern of variation between the classes of users. This is indeed what the estimation shows. Occasional users and non users value the WCP less than average users. This seems to suggest a relation between NUVs and use of the resource. In other word, less use means less NUVs. But this hypothesis is offset by the fact that even frequent users value the WCP less than the average users. There is no clear relationship between use of the park and NUVs.

4. Conclusion.

It is too early to draw any definite conclusion from this work in progress. What this exercise shows, is that;

- NUVs are distance independent;
- There is not a clear relationship between NUVs and patterns of use.

however,

In general this exercise with preliminary data seems to suggest the need to conduct careful sampling to fully capture the potential explanatory power of geographic distance. Further, the questionnaire itself needs to be sharper, to be more convincing in relation to the trade-offs between UVs and NUVs. In particular, the NRP and the FCP need to be presented in more credible ways. Further research is strongly needed to refine the CM technique and the experimental design we have sketched in this paper.

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