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Assessing forest management strategies using a contingent valuation approach and advanced visualisation techniques: A Portuguese case study☆

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ABSTRACT

The assessment of alternative forest management strategies should account not only for the private benefits to forest landowners but also for the ecological, environmental and economic benefits valued by society. There are a number of empirical valuation methods that may contribute to that assessment. These methods involve several steps: data acquisition, model specification and estimation. In this paper, this approach is illustrated in the context of a survey regarding alternative management strategies for a forest area in Central Portugal by implementing a contingent valuation experiment where an advanced landscape visualisation technique is employed to generate the visual information conveyed in the valuation scenarios. Several econometric model specifications are considered as well as alternative approaches to handle zero willingness to pay values and protest responses. The results obtained suggest the potential of the proposed approach for an effective comparison of alternative forest management strategies.

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Introduction

Forest managers face a considerable challenge since in addition to providing a regular supply of market goods such as timber and cork, they are asked to sustain a healthy forest taking into account several ecosystem states and attributes that are not traded in the market. In fact, there is an increasing public awareness of the value of forests for wildlife and biodiversity protection, recreational uses and aesthetics. There are a number of empirical tools for estimating these non-market values that may help support forest ecosystem management planning. Davis et al. (2001) and van Kooten and Folmer (2004) provide a synopsis of such methods within the field of forest management and economics. Merlo and Croitoru (2005) further reviewed and applied these methods in the framework of Mediterranean forestry. Specific forest applications include, for example, the estimation of the value of reducing forest fire risk using the contingent valuation method (CVM) (e.g. Loomis and González-Cabán, 1997; Riera and Mogas, 2004). Holgén et al. (2000) also used the CVM to assess recreation values of landscapes designed by alternative management strategies.

Landscape-wide environmental and socio-economic management objectives constrain decisions at other spatial scales. In countries such as Portugal where private forests extend over 90% of the country's forest area, trade-off analysis between benefits and costs at both the holding and the landscape levels assumes even more importance. Since securing forest-wide social benefits usually requires additional costs for landowners, this trade-off information is key in effective forested landscape planning and policy-making. Stated preference methods (SPM) such as the CVM may help provide this information as they enable estimation of both use and non-use values. The application of SPM encompasses the construction of an hypothetical market for data acquisition, i.e. for eliciting values that individuals assign to unpriced goods and services. Assessing social and private benefits and costs of forest management strategies is also complicated by its temporal and spatial interactions at the landscape level of analysis. The design of valuation scenarios able to display perceptible forest changes at landscape-scale is a critical issue for SPM. Visual information is usually considered indispensable. Different ways of conveying visual information to obtain individuals and experts preferences for forest changes have been compared and tested in recent studies (Wilson and McGaughey, 2000; Karjalainen and Tyrväinen, 2002). Advanced visualisation techniques are being increasingly used to show forest changes at landscape-scale (Falcão et al., 2006). These allow the simulation of forest changes based upon actual inventory and geographical data. Therefore, these techniques are a promising tool to help in the design of valuation scenarios meant to convey realistic landscape-scale changes in environmental assets understandable by the general public.

A potential drawback of computer generated visualisations for SPM based surveys is that they often generate less impressive views in comparison with photographs. Yet, this can be a positive feature when valuation addresses total economic value because the aesthetic dimension is dimmed, what might induce individuals to better focus on the other attributes of the landscape. Thus, this type of visual information might be a better support to verbal information comparatively to photographs that highlight the aesthetic dimension of the asset to be valued. However, the potential effectiveness of this computer generated visualisations to support verbal information in the context of valuation needs to be tested.

This paper combines the use of the CVM with an advanced computer visualisation technique to address the complexity of the assessment process. The latter facilitates the presentation of visual impacts of alternative management strategies in a format that may be readily identified by forest managers and the public (e.g. Wilson and McGaughey, 2000; Luymes, 2001). The CVM was used to elicit total economic value (use and non-use values) of alternative forest management strategies for the Cantão das Hortas, a forest area in Central Portugal nearby the city of Coimbra. The valuation scenarios present the expected forest landscape changes resulting from alternative management strategies and resulting forest states in the following 30 years. The forest landscape changes were described verbally and depicted by the computer generated visualisations.

Empirical models are used to estimate the willingness to pay (WTP) of the general public for the implementation of alternative forest management strategies. Several econometric model specifications are considered, in particular, alternative approaches to handle zero values for the WTP and protest responses. These models are further used to assess the sensitivity of individuals' WTP

to socio-economic and survey specific factors, namely the impact of using the computer generated visualisations. The results obtained suggest the potential of the proposed approach for an effective comparison of forest management strategies.

The rest of the paper is organized as follows. "Problem and survey design" section describes the survey design and implementation, and the role of the landscape visualisation technique for data acquisition. In "Econometric models" section, alternative econometric model specifications used to estimate the total value of each management strategy are discussed. Estimation results are presented and discussed in "Results" section. Finally, "Conclusions" section presents some concluding remarks.

Problem and survey design

The forest management problem

The study area considered in this paper is Cantão das Hortas, a public forest area with about 400 ha located in Serra da Lousã in Central Portugal nearby the city of Coimbra. The area was afforested in the 1940s. Maritime Pine (*Pinus pinaster Ait.*) and Chestnut (*Castanea sativa Mill.*) cover types are dominant. These species may occur in pure or mixed composition, and in even or uneven-aged stands. Mixed stands occupy about 41.3% of the area while pure pine stands extend over 53 ha. The forest is diverse and other species are also present (e.g. *Quercus robur* L., *Cupressus* spp).

Three management strategies were considered for testing purposes. They extend over a 30 year period planning horizon. The first, strategy A, aims at maintaining the current landscape mosaic and the existing species diversity and stand density. The second, strategy B, encompasses even-aged management and it aims at maximizing net present value (NPV) subject to timber even-flow constraints so that approximately 7000 m^3 are removed every year. In the case of the third, strategy C, there are no constraints to NPV optimisation. This latter strategy disregards any concerns with ecological, economic or social sustainability.

A detailed characterization of each alternative management strategy in terms of outputs, costs and implications for the forest landscape was obtained through the use of the decision support system (DSS) described in Falcão and Borges (2005). As inputs, the DSS requires inventory and geographical data and used growth and yield. Through the use of silvicultural and management models, the outputs under each management strategy are then computed.

The DSS further includes an advanced tool for visualisation of the study area over the planning horizon in each management scenario (Falcão et al., 2006). This provides visual information in addition to the verbal descriptions delivered in the survey where respondents were asked to value the conservation strategies (A and B) as alternatives to a forest-mining strategy (C).

Survey design and implementation

The elicitation of individual's valuation of alternative management strategies through SPM requires the construction of a contingent market. This was done in three stages. Initially, management strategies were characterized so that the object to value was clearly defined. The DSS outputs for each strategy were summarized into five attributes: stand density, species and structural diversity, erosion risk, fire risk and financial opportunity cost.

Stand density is higher for strategy A and lower for alternative strategies, especially for Alternative C, due to the large clear-cuts in the first years of the horizon planning. Strategy B presents a higher species and structural diversity in comparison with strategy A. Strategy C corresponds to a rather poor scenario with respect to this attribute comparatively to the former alternatives. Soil erosion risk is low for strategy A, moderate for strategy B and high for strategy C. The forest fire risk is moderate for strategy B, higher for strategy A and changes over time in strategy C (being low when large clearcuts take place and high after 10–15 years when mature bushes have occupied the deforested areas). The financial opportunity costs of strategies A and B relative to strategy C amount to about 2784 and 741 thousand euros, respectively, as a consequence of lower timber sales (using a discount rate of 5% for a period of 30 years).

The valuation questions adopted a discrete choice referendum format (Mitchell and Carson, 1989). Individuals were asked about their willingness to pay a predetermined amount to support conservation strategies A and B. Thus, in the valuation scenarios, respondents had to choose between: (a) paying the amount requested to implement a conservation strategy (either A or B), or (b) not paying, knowing that this option would imply the implementation of the mining strategy C.

The prices assigned to secure the implementation of strategies A and B were randomly extracted from a set of six possible bid amounts. This set was based on the responses to an open format valuation question included in a pre-test survey involving 100 randomly selected individuals of the population surveyed. The bid amounts were chosen by selecting several values around the average of the WTP elicited by individuals in the pre-test survey and eliminating the tail values, following the usual rules of thumb for bid selection (Alberini, 1995; Kanninen, 1995).

The payment instrument was settled as an increase in the annual household income tax. Most respondents preferred this instrument to other approaches suggested in the pre-test survey such as an annual donation to a forest conservation fund or a municipal tax. Further, respondents protesting this instrument only rarely did accept other methods.

The second stage of the contingent market construction required the definition of the respondent population. Both the location and the size of the forest area being studied suggested the selection of 43,425 families resident in Coimbra as the public familiar to the area. The survey was thus administered to a random sample of Coimbra inhabitants, through personal interviews conducted by professional interviewers from a market research company (GBN-Gabinete de Campo de Estudos de Mercado, Lda). The total response rate was 80%. Interviews were conducted during the months of September, October and November of 2003. The final sample consisted of 900 successfully interviewed households. The average length of an interview was 28 min. Respondents were randomly selected among the individuals in charge of household payments.

Finally, the implementation of the contingent market encompassed the development of the CVM questionnaire. It provided the information needed to define and characterize the valuation scenarios just described. For that purpose, it included visual aids produced by the advanced visualisation technique. Computer generated images enabled individuals to assess visually the impact of each management strategy on the forested landscape. For example, respondents were able to check that strategy A would not lead to changes in the landscape over the planning horizon while strategy B would lead to clearcut openings (see Fig. 1). Respondents were also able to visualise the deforestation impact of strategy C. Besides the valuation questions, the questionnaire also elicited a wide variety of information that could help explain the variation in stated WTP values for the conservation strategies across respondents.

The questionnaire was structured into five parts. The first, elicited information about individuals' acquaintance with Cantão das Hortas and Serra da Lousã, and their perceptions and preferences regarding the landscape features. It further obtained information about substitute forest areas for recreation. The second part elicited information to assess individuals' understanding of attributes used to characterize each management strategy and their attitudes towards forest conservation. The third part consisted of a description of the valuation scenarios followed by the valuation questions. Detailed information on the characteristics of the forest (such as location, size, age and major tree species) was conveyed to the respondents. Each alternative management strategy was described underlining their impact on the following attributes: stand density, species and structural diversity, erosion risk, and fire risk. In the pilot survey, the valuation questions were implemented in a choice experiment format. However, respondents revealed an excessive cognitive burden when simultaneously presented with the three alternatives. Consequently, in the final survey, a CVM approach was adopted. Individuals had to make only pairwise comparisons considering strategy C as the baseline scenario: first Alternative A vs. Alternative C, and second Alternative B vs. strategy C. The questionnaire also included questions to determine why people decided to pay or not to pay for each strategy. This also provided information to identify protest responses. The fourth part elicited information concerning the individuals' social, economic and demographic characteristics. Finally, interviewers completed the fifth part with information about the interview characteristics as well as their evaluation of the plausibility of the valuation scenarios for the individuals.

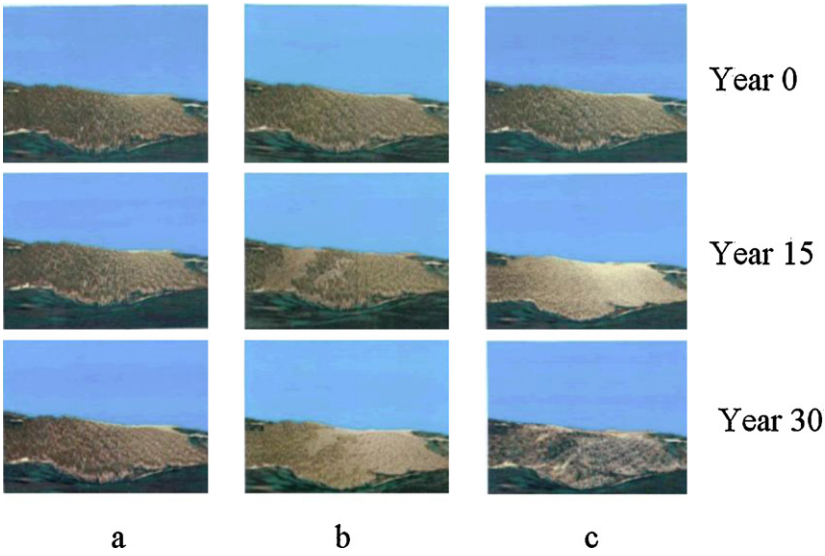

Fig. 1. Set of computer generated images used in the CVM valuation scenarios for the prospective landscape in Cantão das Hortas in the case of management strategies A (a), B (b) and C (c).

In order to further test the impact of the proposed visualisation technique, the questionnaire was conducted in two variants: one including both verbal and visual information to describe the alternative management strategies, and another delivering only the verbal information. The version including the computer generated images displaying the impacts of the alternative management strategies was assigned to 75% of the respondents. The other version was assigned to the remaining 25% of the respondents. The choice of which version to present to any given individual was random.

Econometric models

The econometric model used to estimate the values of the conservation strategies A and B vis-à-vis strategy C (the zero cost strategy in the CVM valuation questions) has to take into account the dichotomous choice format adopted in the questionnaire described in the previous section. If a respondent chooses strategy A (or strategy B) as opposed to strategy C then that individual's WTP to guarantee strategy A (or strategy B) is larger than the proposed bid. Assuming a parametric distribution function for WTP, denoted by $F(\cdot;\theta)$, where θ denotes a vector of parameters, the probability that a randomly selected individual is willing to pay the bid, denoted by *Bid*, is given by:

$$\text{Prob(Yes)} = \text{Prob(WTP} > \textit{Bid}) = 1 - F(\textit{Bid};\theta).$$

Given the sample of individuals and the corresponding Yes/No responses to the valuation questions, the vector of unknown parameters θ is estimated by maximum likelihood, from which mean and median WTP estimates can be obtained (e.g. Cameron, 1991; Hanemann and Kanninen, 1999).

The log-normal, log-logistic, or the Weibull are common choices for WTP distributions. These distributions imply that all individuals have positive WTP. However, if a non-negligible proportion of the individuals in the population is indifferent to a proposed alternative forest conservation strategy because it does affect their welfare, that is, they have a zero WTP, then another approach must be followed. One possibility is to use the spike model proposed by Kristöm (1997).[1] Based on the answers

[1] In our application we exclude the possibility of negative WTP given the nature of the problem. However, it is also possible to extend the analysis to such cases as in Kristöm (1997).

to the valuation question and to a preliminary question on whether the respondent would want to contribute at all to the proposed strategy, it is possible to construct an indicator S_i that tells if the individual is "in-the-market" ($S_i = 1$) or not ($S_i = 0$). In the particular application of this paper, $S_i = 1$ when: (i) the respondent answers positively to the preliminary question or (ii) when that answer is negative but, when asked to pay some positive amount, the respondent ends up accepting it; and $S_i = 0$ otherwise. Assuming a logistic distribution, the cumulative distribution function of WTP for the spike model is given by: $F(0; a,b) = 1/(1 + \exp(a))$ for zero WTP, and $F(A; a,b) = 1/(1 + \exp(a - bA))$ for positive WTP ($A > 0$). Mean WTP is given by $\ln(1 + \exp(a))/b$, and median WTP equals 0 if $1/(1 + \exp(a)) > 0.5$, and a/b otherwise. This model can be estimated by maximum likelihood as described in Kriström (1997). An alternative approach proposed by An and Ayala (1996) and Reiser and Shechter (1999) considers a mixture of two WTP distributions: a point mass at zero with probability p (an additional parameter to be estimated) capturing the proportion of individuals not "in-the-market", and the other a distribution with positive support for individuals "in-the-market". If a truncated logistic is used for the latter distribution, Kriström's spike model may be obtained as a particular case and can thus be statistically tested (see An and Ayala, 1996).

These models can also be extended to the case where the WTP distribution may depend on covariates (see McFadden, 1994; An and Ayala, 1996; Reiser and Shechter, 1999; Werner, 1999). For the spike model, the parameter a is replaced by $a + x'\beta$ where x denotes the vector of individual specific covariates and β is the corresponding vector of coefficients (for a recent application of this model see Yoo and Kwak, 2009). In this case, given the estimated model parameters, estimates of the conditional mean and median WTP, and of the probability of zero WTP, are in general calculated for an average individual, that is, using the mean values of the covariates over the sample.

There are also alternatives to the parametric estimation approach. In particular, Haab and McConnell (1997) recommend that, when the model does not include any covariates, to estimate the mean or median WTP one should follow a distribution-free non-parametric method. Given the proportion of negative answers to each specified bid, it is possible to obtain a monotonic non-parametric maximum likelihood estimator of the WTP distribution function. Such estimator is consistent (see Ayer et al., 1995) and can be computed using Turnbull's (1976) algorithm (see Haab and McConnell, 1997). A lower bound estimate for mean WTP can be obtained by using this estimated distribution function to compute the mean WTP in a way such that each offered bid is multiplied by the estimated probability that WTP falls between that bid and the next highest bid (see Haab and McConnell, 2002). Standard errors for this lower bound estimator can be obtained by the bootstrap method.[2] Median WTP is defined as the bid for which the WTP distribution function passes 0.5. Since the Turnbull estimator gives only point mass estimates at a discrete number of points, the estimated median is only identified within a range (see Haab and McConnell, 2002). As shown by Haab (1995), when the Turnbull estimator is implemented restricting WTP to be non-negative, it always yields non-negative estimates of WTP and is compatible with a spike at zero WTP. However, when it is necessary to consider the effects of covariates on WTP, parametric models are superior to distribution-free models (Haab and McConnell, 1997).

The above methods allow that a proportion of the individuals have a zero WTP. Such individuals are classified as being "not in-the-market" because they do not value the good and will always refuse to pay any positive amount for it. However, another reason why individuals may refuse to pay any positive amount to support a proposed strategy may be due to a protest objecting to particular features of the proposed valuation scenario (see Mitchell and Carson, 1989). For instance, individuals may have concerns about the fairness or efficiency of the proposed tax increase, or the inefficiency of the public administration in managing public funds. The identification of protests is typically based on the answers to specific follow-up questions included in the questionnaire about the motives for not paying. An individual is identified as having protest beliefs whenever the chosen motivations for not paying correspond to protest reasons.

In fact, many contingent valuation studies have reported high percentages of protest responses. Halstead et al. (1992) mention a number of studies where protest responses account for 50% or more of

[2] The bootstrap is implemented with 10,000 replications using a programme developed by Bergland (2001).

the sample. In this case, when using the previous approaches that do not distinguish between true zero WTP values and protest responses, individuals with a positive economic value for the proposed good that give a protest response end-up being considered as having a zero WTP, leading to underestimated WTP measures.

The usual approach followed in the literature to deal with protest responses is to remove them from the database used for estimation purposes. In this case, it is assumed that the true economic value of the good for protesters is not zero and equals mean WTP. Moreover, as shown in Calia and Strazzera (2001), only if, for an individual with specific socio-economic characteristics, the probability of obtaining a protest response is independent from that individual's WTP, is this approach a valid one. Otherwise, there will be a sample selection problem leading to estimation biases. As a solution, Strazzera et al. (2003) propose a simultaneous equations mixture model with sample selection that captures both zero WTP values and protest responses while properly accounting and correcting for the possible selectivity bias. Only if the correlation between the error terms in the selectivity equation and the WTP equation equals zero, is it valid to estimate WTP by excluding protest responses.

However, several authors argue that protest responses should not be excluded from the estimation sample, and consider them as expressions of true zeros in the sense that what is being valued is not only the good in itself, but also the proposed policy in terms of the method of payment and the means by which it will be provided (see the discussions in Halstead et al., 1992; Jorgensen et al., 1999; Jorgensen and Syme, 2000). Thus, when the objective of the CV study is to estimate the values of the alternative policy options, it may be valid to keep protest responses.

Halstead et al. (1992) recommend that, in general, a range of WTP estimates be presented, considering different treatments of protest responses. We follow the advice and consider the following approaches: (i) protest responses are considered as true zeros and included in the estimation sample, (ii) protesters are excluded from the estimation sample but WTP estimates are based on individual socio-economic characteristics for the whole sample, and (iii) a sample selection model is estimated. While approach (i) leads to underestimated WTP values if protest responses cannot be considered true zeros, (ii) leads to overestimated WTP values otherwise. Approach (iii) is used to check, and eventually correct, for selectivity bias when estimating WTP by approach (ii).

Results

The questionnaire design proved to be effective as the valuation scenarios were generally deemed plausible and relevant by the respondents. Almost all of the 900 respondents provided responses to the WTP questions: 873 regarding Alternative A and 875 regarding Alternative B. The use of the computer generated images did not have any significant impact in these response rates as the proportion of valid responses did not differ significantly in the two variants of the questionnaire (with and without using computer generated images).[3] Also, the cognitive effort that people had to put in the valuation task was evaluated as reasonable or good in 91% of the cases.[4] Furthermore, according to a Pearson chi-square test, there were no significant differences in these evaluations in the two variants of the questionnaire, suggesting that the use of the computer generated images had no impact on the respondent's cognitive effort.

The answers to the attitudinal questions, which were included to assess the individual's perceptions regarding the attributes of the alternative strategies for forest management, reveal that they perceived the broad interactions between forest and ecological aspects such as soil erosion, species and structural diversity, stand density and fire risk (see Fig. 2). Further, according to the collected information on the environmental value of the main species of the forest being valued, respondents classify these species has having high environmental value.

Respondents also felt that they were entitled to the provision of the forest as an environmental public good. For instance, 4 out of 5 respondents think that forest fuel management and cleaning

[3] The p-value of a statistical test of equal proportions of valid responses to the WTP questions in the two variants of the questionnaire was equal to 0.64 for strategy A, and 0.82 for strategy B.

[4] This information was provided by the interviewers at the end of each questionnaire and consisted of their evaluation of the time spent during the valuation questions in the scale: 1, Bad; 2, Reasonable; 3, Good.

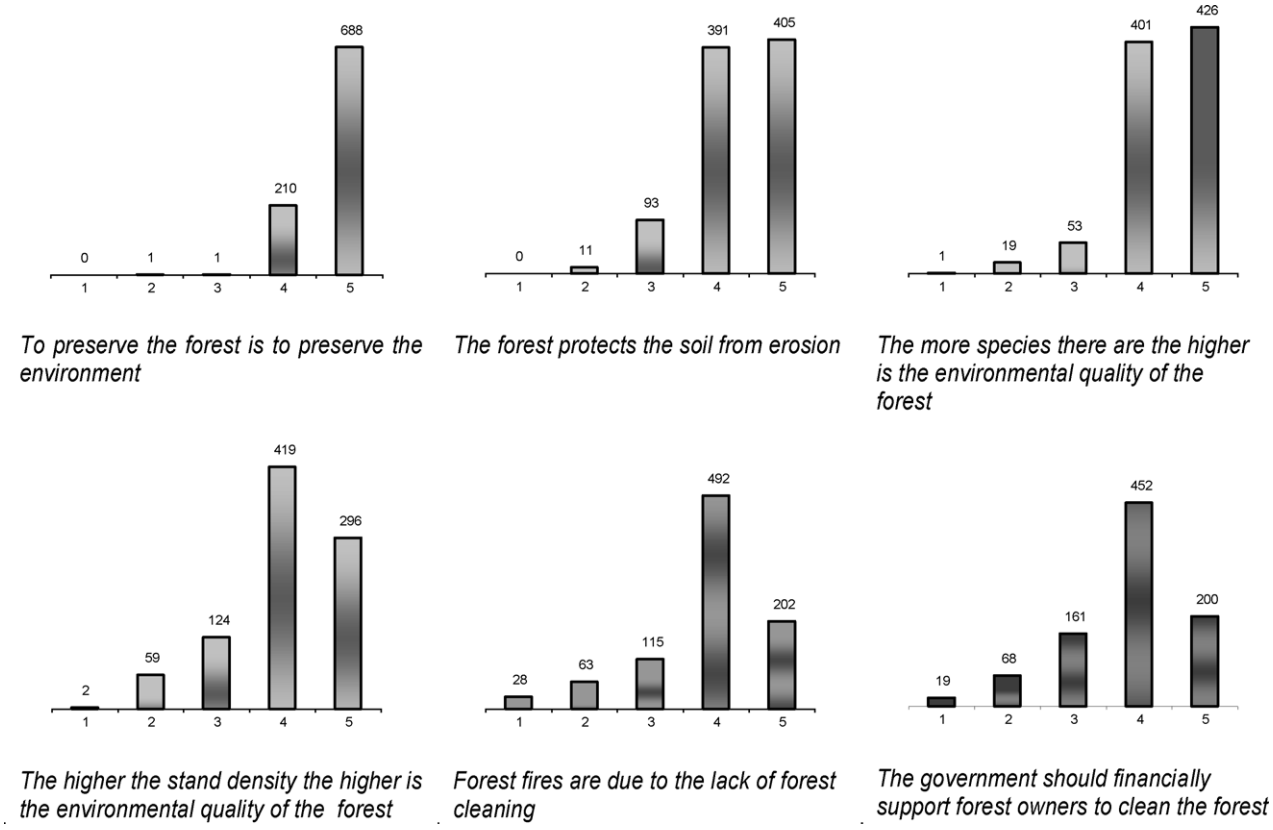

Fig. 2. Respondent's agreement with statements about forest, forest attributes and management (Likert scale: 1 = strongly disagree; 2 = disagree; 3 = neither agree or disagree; 4 = agree; 5 = strongly agree).

Table 1
WTP estimates for models without explanatory variables.

	Strategy A				Strategy B			
	Full sample		Excluding protests		Full sample		Excluding protests	
	Spike	Non-Par	Spike	Non-Par	Spike	Non-Par	Spike	Non-Par
Mean WTP	53.9 (6.8)	20.0 (1.0)	109.1 (18.1)	35.9 (1.2)	14.9 (1.1)	11.0 (0.8)	24.7 (1.7)	18.6 (1.3)
Median WTP	0	5–10	92.7 (15.4)	>50	0	0–5	17.2 (1.8)	15–20
Prob. WTP = 0	0.504 (0.017)		0.209 (0.018)		0.556 (0.017)		0.304 (0.020)	
Chow test	1.16	4.39	2.38	6.65	0.81	2.20	1.04	2.15
[*p*-value]	[0.56]	[0.62]	[0.30]	[0.35]	[0.67]	[0.90]	[0.59]	[0.91]
N.Obs.	873	873	513	513	875	875	515	515

Notes: WTP estimates are in euros. Standard errors appear in parentheses. The Chow test consists of a LR test of the null hypothesis of equal WTP distribution in two sub-samples: computer generated images used vs. not used.

should be compulsory. Absenteeism and the abandonment of forests by owners appear to be perceived as negative externalities. Yet, responses suggest that there is a willingness to pay landowners for the amenities their forests may provide. Around 75% of the respondents would support programs funding adequate forest management by landowners. Therefore, people are not expected to hold negative values regarding the two strategies A and B that were considered as alternatives to strategy C.

Models for the WTP were first estimated without including any explanatory variables. In Table 1 we present the results obtained using the spike model and the non-parametric approach for both strategies A and B. We also estimated mixture models, but the spike model always fitted the data significantly better so we do not present the corresponding results.[5] We first describe the results obtained using the full sample without treating protest responses. For the spike models, mean WTP estimates for strategy A and B are 54 and 15 euros, respectively. Median WTP estimates are zero in both cases as the estimated spike was larger than 50% for both strategies. In fact, the percentage of respondents that were not "in-the-market" ($S_i = 0$) was 50.3% (439 out of 873) for strategy A, and 55.2% (483 out of 875) for strategy B. The non-parametric approach was also used to obtain a lower bound estimate for the mean WTP. The results obtained were 20 and 11 euros for strategies A and B, respectively.

Next, we consider the treatment of protest responses. The identification of protests is based on the answers to specific follow-up questions included in the questionnaire about the motives for not paying for strategies A and B. An individual is identified as having protest beliefs whenever the chosen motivations for not paying, for both strategies A and B, correspond to protest reasons. Results are presented in Table 2. The most frequent protest motives are objections to pay more taxes, lack of trust in the government, and a belief that someone else should pay. These motives are among the most frequent protest behaviour motivations found in the literature (see Halstead et al., 1992; Lindsey, 1994; Jorgensen and Syme, 2000; Meyerhoff and Liebe, 2006), being responsible for the high protest responses rate observed in many cases for the valuation of different goods and/or valuation contexts (e.g. Lindsey, 1994; Dziegielewska and Mendelsohn, 2007; Jones et al., 2008; Cunha-e-Sá et al., 2010).

The spike models were re-estimated using the database excluding the protest responses. As can be seen in Table 1, the sample size is substantially reduced as protest responses accounted for around 40% of the sample.[6] We also compared the proportion of protest answers in the two variants of the questionnaire (computer generated images used vs. not used), but found no statistically significant differences.[7] Overall, the WTP estimates obtained are considerably higher than the corresponding

[5] To chose between these alternative models, we followed the approach proposed in An and Ayala (1996) and used the LR test to test for the null hypothesis of a logistic spike model against the alternative of a mixture model with a truncated logistic distribution.

[6] The total number of individuals identified as protesters is smaller than the totals appearing in Table 2 because it is required that protest responses are given for both strategies A and B.

[7] The *p*-value of a test of equal proportions of protest answers in the two sub-samples was equal to 0.77 for strategy A, and 0.98 for strategy B.

Table 2
Main reason not to be willing to pay for strategies A and B.

	Strategy A		Strategy B	
	Responses	%	Responses	%
Already pays enough taxes	294	60	314	49
Believe the payment would not be used for that purpose	33	7	43	7
Forest owners should pay	49	10	49	8
Believe that removed timber is enough to assure profitability	-	-	66	10
Municipalities should pay	3	1	2	0
Sub-total: protest reasons	379	78	474	74
Can't pay because of budget constraint	62	13	79	12
Would rather pay for more important things	10	2	13	2
Others	43	9	72	11
Sub-total: non-protest reasons	115	22	164	26
Total	494	100	638	100

estimates obtained with the full sample including protests. The resulting estimates for mean WTP are 109 and 25 euros for strategy A and B, respectively. The estimated spikes for strategies A and B are now much smaller and below 50% (21% and 30%, respectively). The percentage of respondents not "in-the-market" was 20.9% (107 out of 513) for strategy A, and 29.3% (151 out of 515) for strategy B. Consequently, in this case, median WTP is positive, with estimates of 93 and 17 euros. The non-parametric lower bound estimates of mean WTP are also higher giving 36 and 19 euros.

To check for any impact of the use of the computer generated images on the distribution of WTP, the parametric spike models and the non-parametric estimators were also computed separately for the sub-samples corresponding to the two variants of the questionnaire. We then used a Chow test by implementing a LR test that equals two times the difference between: (i) the sum of the log-likelihoods of the model estimated for the two sub-samples, and (ii) the log-likelihood of the model estimated for the full sample. Under the null hypothesis of no difference in the WTP distribution in the two variants of the questionnaire, the test follows a chi-square distribution with the degrees-of-freedom equal to 2 for the spike model (corresponding to the two parameters in this model), and 6 for the non-parametric estimator (corresponding to the six different bid values that were used). From the *p*-values of the Chow tests appearing in Table 1, we conclude that the estimated WTP distributions obtained from the two variants of the questionnaire are not statistically different for any of the cases considered. This result implies in particular that neither the mean nor the median WTP differ in the two variants of the questionnaire, meaning that the use of the visualisation techniques did not introduce a bias in the valuation exercise. It also follows that the standard deviation of the WTP distribution is not affected by the technique, so that, in this perspective, the use of the images did not make people feel more certain about their answer.

We also estimated spike models including a set of explanatory variables meant to address the impact on WTP of individuals' social, economic and demographic characteristics, their acquaintance with the forest, and specific survey design features such as the use of the computer generated images. A description of these variables appears in Table 3. A stepwise procedure for model estimation, which sequentially eliminates variables without significant explanatory power, was adopted.[8] Results for the final selected models for strategies A and B appear in Tables 4 and 5, respectively. As before, we consider estimation results for the full sample and for the sample excluding protest responses.

[8] When some of the variables are strongly correlated, both forward and backward sequential procedures should be used since in the presence of multicolinearity the forward selection method may be preferable as it starts with smaller models where the problem is not present. This problem could potentially arise for variables such as AGE/RETIRED and INCOME/EDUCATION/UNEMPLOYED. However, in the sample used in this paper, the correlation between these variables never exceeds 0.5. Moreover, both methods lead to the same final model.

Table 3
Set of explanatory variables.

Variable	Mean	S.D.	Min.	Max.	N.Obs	Description
FIG	0.78	0.42	0	1	900	=1 visual aids were showed to describe forest management strategies; =0 if not
AGE	44.4	12.1	18	67	900	individual's age
SEX	1.59	0.49	1	2	900	=1 for male; =0 if female
VISIT03	0.22	0.41	0	1	900	=1 if visited Serra da Lousã during 2003; =0 if not
COMPSL	0.27	0.45	0	1	900	=1 if classifies Serra da Lousã as the best; =0 if not
WKTRIP	0.73	0.45	0	1	900	=1 if goes on recreation trips at least once per month; =0 if not
SERVIS	0.34	0.47	0	1	900	=1 if the Serra da Lousã is the most visited; =0 if not
EDUCATION	0.46	0.50	0	1	900	=1 if individual has higher education; =0 if not
INFER16	0.29	0.46	0	1	900	=1 if household has individuals with less than 16 years old; =0 if not
RETIRED	0.11	0.31	0	1	900	=1 if individual is retired; =0 if not
OWWORK	0.11	0.31	0	1	900	=1 if individual is self-employed; =0 if not
UNEMPLOYED	0.06	0.23	0	1	900	=1 if unemployed; = 0 if not
INCOME	1413	950	350	5000	704	=Household average monthly income€
KNOWS	1.93	0.25	1	2	900	=1 if knows Cantão da Hortas; =0 if not
KNOWS_H	1.87	0.34	1	2	900	=1 if knows or heard about Cantão das Hortas; = 0 if not
Bid A	20.8	14.5	5	50	900	bid amount for strategy A
Bid B	21.2	14.8	5	50	900	bid amount for strategy B
BidB_gt_BidA	0.43	0.49	0	1	900	=1 if Bid B > Bid A; =0 if not

Table 4
Estimated spike models with covariates for strategy A.

	Full sample	Excluding protests
Constant	1.192*** (0.352)	2.178*** (0.554)
AGE	−0.033*** (0.006)	−0.038*** (0.009)
SERVIS	0.337** (0.143)	
WKTRIPS		0. 592*** (0.229)
EDUCATION	0.025 (0.295)	0. 556 (0.452)
FIG	−0.084 (0.225)	0.269 (0.311)
FIG * EDUCATION	0.564* (0.332)	−0.083 (0.508)
Bid A	−0.014*** (0.002)	−0 016*** (0.003)
Log Lik.	−740.09	−335.50
N.Obs.	873	513

	Covariate means evaluated	Covariate means evaluated:	
	At full sample	At full sample	Excluding protests
Mean WTP	49.3 (6.1)	97.7 (15.9)	101.2 (16.4)
Lower bound	37.3	66.6	69.1
Upper bound	61.4	128.8	133.2
Median WTP	0	88.6 (14.2)	88.3 (14.1)
Prob(WTP) = 0	0.503 (0.017)	0.201 (0.019)	0.190 (0.019)

Notes: Standard errors appear in parentheses. Lower and upper bounds for mean WTP correspond to 95% confidence intervals.
* Significance at 10%.
** Significance at 5%.
*** Significance at 1%.

Table 5
Estimated spike models with covariates for strategy B.

	Full sample	Excluding protests
Constant	0.751** (0.349)	1.250*** (0.481)
AGE	−0.025*** (0.006)	−0.019** (0.008)
SERVIS	0.280** (0. 142)	
WKTRIPS		0.369* (0.194)
EDUCATION	0.009 (0.293)	0.597 (0.372)
FIG	−0.243 (0.229)	−0.071 (0.289)
FIG * EDUCATION	0.751** (0.328)	0.172 (0.415)
BidB_gt_BidA	−0.102 (0.137)	−0.347** (0.175)
Bid B	−0.041*** (0.003)	−0.050*** (0.004)
Log Lik.	−833.44	−516.82
N.Obs.	875	515

	Covariate means evaluated	Covariate means evaluated	
	At full sample	At full sample	Excluding protests
Mean WTP	14.0 (1.08)	23.5 (1.66)	24.2 (1.68)
Lower bound	11.9	20.3	20.9
Upper bound	16.1	26.8	27.5
Median WTP	0	16.3 (1.74)	17.2 (1.74)
Prob(WTP) = 0	0.561 (0. 017)	0.305 (0.022)	0.295 (0.021)

Note: Standard errors appear in parentheses. Lower and upper bounds for mean WTP correspond to 95% confidence intervals.
* Significance at 10%.
** Significance at 5%.
*** Significance at 1%.

We first analyze the results obtained using the full sample. The variable AGE exhibits a negative impact on WTP for both strategies. It is consistent with the growing concern about nature conservation by younger generations. Another variable showing a significant impact on WTP for both strategies is SERVIS, which means that people that visit more often the Serra da Lousã value more forest conservation. The models also include the dummy variable EDUCATION, which equals one when an individual has higher education and zero otherwise, but it was not statistically significant. In order to capture an eventual impact on elicited WTP of using computer generated images, we included the dummy variable FIG, which equals one for individuals that were shown visual aids during the questionnaire and equals zero otherwise. However, this variable was never significant. Yet, the interaction variable FIG * EDUCATION was significant at 10% for strategy A and at 5% for strategy B, meaning that the use of computer generated visual aids to strengthen the valuation scenarios may have influenced positively WTP but only for those individuals with higher education. Apparently, the WTP of individuals with lower education was not impacted by further visual assessments of management strategies.

Because the elicitation of each individual's WTP for strategy B always comes after the WTP question for strategy A, it could be possible that the WTP answer for strategy B was biased and dependent on the bid amount suggested for strategy A. Therefore, for the case of strategy B, the model was estimated including a dummy variable intended to capture that potential sequential bias. The dummy variable, denoted as BidB_gt_BidA, is defined as taking the value of 1 when the bid amount offered for strategy B is higher than the one proposed for strategy A, and 0 otherwise. However, it was not found significant.

Mean WTP estimates are 49 and 14 euros for strategy A and B, respectively. In both cases, median WTP is zero because the estimated spikes exceed 0.5. We also note that these WTP estimates are quite close to the ones obtained previously for the spike models without covariates.

When the models were estimated with the protest responses excluded, the final set of significant explanatory variables changed slightly. The impact of the variable AGE was still significant and negative. The variable SERVIS was no longer significant but instead WKTRIPS became significant. In this case, individuals regularly going on leisure and recreation weekend trips value more forest conservation. In the case of strategy B, we also estimated the model including the dummy variable BidB_gt_BidA.

Table 6
Main reason to be willing to pay for strategies A and B.

Main reason to be willing to pay	Strategy A		Strategy B	
	Responses	%	Responses	%
To preserve forest for future generations	167	44	110	46
To preserve the environment and nature	128	34	74	31
To preserve a common good	78	21	50	21
To experiment recreational and aesthetical benefits from the forest	5	1	1	0
To help forest owners	1	0	2	1
Total	379	100	237	100

The significant negative impact on WTP that is now found suggests that people react negatively as they recognize that they are asked to pay more for a less amount of the good. The EDUCATION variable was not significant. Finally, we note that the dummy variable FIG capturing the use of computer generated visual aids used to complement the verbal descriptions, as well as the interaction variable FIG * EDUCATION, were never significant. We conclude that the use of the figures never influences elicited WTP in a significant manner when considering the sample without protests.

For the models estimated excluding protest responses, we computed WTP estimates in two different ways: with the covariates evaluated at the full sample means, and with the covariates evaluated at the means for the sample excluding protest responses. These are presented in Tables 4 and 5. However, for both strategies A and B, the difference between these two approaches is relatively small. This is a result of the fact that the sub-samples of protesters and non-protesters do not differ much in terms of the covariates that affect WTP. The WTP estimates are also close to the ones obtained with the models without covariates.

We also considered the sample selection model in Strazzera et al. (2003). The estimated correlation between the error terms in the WTP and the selectivity equations was not significant for both strategies A and B. Therefore, we conclude that provided protest responses are not considered as true zeros, the WTP estimates obtained by excluding the protest responses are valid in the sense that they are not affected by a sample selectivity bias.

The questionnaire also included other questions enabling the identification of the reasons why people were willing to pay for the conservation strategies. As can be seen from Table 6, respondents list the preservation of the forest for future generations and preservation of the environment and nature as the main reasons to pay for conservation strategies. Non-use values such as bequest and existence values thus emerge as prominent in WTP estimates. This is consistent with respondent's attitudes regarding forestry: "to preserve the forest means to preserve the environment" for 99.8% of the respondents. It is further consistent with the lack of use of Serra da Lousã, where Cantão das Hortas is located, for recreational purposes, which the survey shows to be extensible to other forest areas nearby the city of Coimbra. In fact, only 20% of the respondents had travelled to Serra da Lousã for leisure and recreation and only a few respondents mentioned use-values such as recreation as being important.[9] Individuals appear to emphasize forest aesthetic values associated with contemplative activities rather than active specialized recreational uses. Responses to the questionnaire showed that they are aware of forest environmental benefits and of the need for conservation policies consistent with the estimated positive WTP in order to avoid the forest mining strategy (strategy C).

To compute aggregate benefits, we use mean WTP estimates from the spike models with covariates. We first consider the results using the full sample estimates (first columns in Tables 4 and 5). Aggregate WTP present value for strategies A and B amounted to 32,937 and 9329 thousand euros, respectively. Using the lower bounds of the corresponding confidence intervals the values are 24,892 and 7922 thousand euros. If we further account for the effect on WTP of the use of the visual aids during the questionnaire, as captured by the variables FIG and FIG * EDUCATION, and follow a conservative approach by considering the case when no visual aids were shown, so that these variables

[9] The population prefers to enjoy recreational experiences by the seaside (e.g. beaches).

equal zero, we obtain 20,565 and 6652 thousand euros. The fact of including in our valuation study only the resident population in the main urban area of the region where the valued forest area is located (the city of Coimbra) also leads to a conservative estimate of the aggregate value since enlarging the scope of population might increase the total aggregate value of forest benefits. It follows that, even in the most conservative case, aggregate benefit values are always larger than the opportunity costs for both conservation strategies A and B comparatively to the mining alternative, strategy C. Strategy A presents the larger net benefits, whatever the case that is considered for the calculation of net benefits for strategy B. These conclusions still hold even if we use upper bound WTP estimates for strategy B. However, using a benefit–cost ratio criterion, strategies A and B are not statistically different as the corresponding confidence intervals overlap: benefit–cost ratios are equal to 11.8 and 12.6, with 95% confidence intervals given by (8.9, 14.7) and (10.7, 14.5), respectively.

Finally, we compute aggregate benefits based on the estimates obtained when excluding protest responses (last columns in Tables 4 and 5) with the covariates evaluated at the full sample means. Aggregate WTP values are 65,243 and 15,719 thousand euros for strategies A and B. Correcting for the sequential bias effect found in the case of the WTP elicitation for strategy B, by setting the variable bidB_gt_bidA equal to zero, the value is 17,094 thousand euros. As before, aggregate benefit values are larger than opportunity costs for both conservations strategies A and B comparatively to strategy C, strategy A gives significantly larger net benefits than strategy B, and the two strategies are not statistically different in terms of a benefit–cost ratio: 23.4 with confidence interval (16.0, 30.9) vs. 23.1 with confidence interval (19.3, 26.8), respectively.

Conclusions

The problem of assessing the impacts of alternative forest management and conservation strategies is usually complicated by the length of the temporal horizon and the geographical project scope. It is hard to anticipate and to describe them. Thus, the development of valuation scenarios to implement the CVM to elicit WTP for those strategies is a challenging issue. An innovative feature of the valuation study described in this paper is the combination of the CVM with an advanced computer visualisation technique to facilitate and strengthen the construction of the valuation scenarios and to better address the complexity of the assessment process. The latter facilitates the presentation of the visual impacts of management strategies and the combination of techniques might prove to be a fruitful and workable option. This is particularly relevant in situations as the one studied in this paper where a major reason for respondents' WTP for the conservation strategies is the provision of non-use benefits associated with the corresponding landscapes features.

One conclusion arising from the results of our study was that there was little impact of the visualisation techniques on the valuation tasks conducted in the questionnaire. We found no significant impact on the response rates, cognitive effort, protest responses, and WTP distributions. Only when the spike models with covariates were estimated for the full sample, did we find some significant effect but that was dependent on the level of education. Individuals with higher education incorporated the additional information conveyed by the landscape visualisation technique in their assessment such that their WTP for the conservation strategies increased. In the case of less educated individuals, the use of visual aids did not have a significant impact. However, when these models were re-estimated for the samples excluding protest responses, we found no significant impacts of the use of the visual aids. These results suggest that the use of the computer generated images was successful in the sense that no significant biases were introduced in the valuation exercise. However, the technique did not seem helpful in reducing the cognitive effort that people had to put in the valuation tasks, nor did it help people feel more certain about their answers. The image definition in-between photo-realism and schematic visualisation may have been insufficient to improve the understanding of the impacts of management strategies. Further research should focus on how to construct the visual aids in a way that can be understood by the target population and used to strengthen the CVM valuation scenarios.

Another contribution of the paper is to show that the treatment of zero WTP and protest responses influences significantly the estimation results, thus highlighting the importance of accounting for these issues in the design of the questionnaire used to implement the contingent market.

Finally, the benefits of forest conservation are sufficiently large to compensate the opportunity cost due to forgone timber sales. This is true even when considering confidence intervals that take into account the uncertainty in the WTP estimates. Nevertheless, the apparent quality of our estimates related to the adoption of good practice guidelines for survey design (according to major suggestions given for instance by Söderqvist and Soutukorva, 2009), does not preclude the presence of eventual hypothetical biases, namely, the "yea-saying" bias, commonly pointed to the discrete choice referendum format (Mitchell and Carson, 1989; Kanninen, 1995; Ready et al., 1996). This bias is often ascribed to preference uncertainty that may lead individuals to choose to pay the amount requested when they are not sure about that respect. Empirical evidence of this bias for public goods is provided in the meta-analysis conducted by Murphy et al. (2005).

Further, these benefits appear to be mainly due to non-use values, in spite of the results being obtained for a "resident population". These apparently surprising results might be explained by the urban characteristics of the city of Coimbra and the relatively low use of the forest area for leisure and recreation. Given the relative importance of non-use values, it might be expected that the aggregate WTP estimates could be even larger if the considered population was extended to a larger region. However, to confirm this conjecture would require collecting additional data.

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