Burned forest area or dead trees? A discrete choice experiment for Catalan citizens

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ABSTRACT: This paper estimates the social-welfare change due to the application of additional fire prevention measures on Mediterranean forests. The discrete choice experiment is applied to elicit the social preferences regarding fire prevention measures in terms of their impact on fire behaviour –fire propagation and intensity- and to estimate the value of these measures for the society. The results of the study show that additional fire prevention measures increase the welfare of the Catalan population and that fire propagation is the descriptor of fire behaviour that most concerns the population. This information may be used by policy makers and environmental managers to design their programmes and activities.

¿Superficie forestal quemada o árboles muertos? Un experimento de elección discreta aplicado a la población catalana

RESUMEN: Este trabajo estima el cambio en el bienestar social por la aplicación de medidas adicionales de prevención de incendios forestales en los bosques mediterráneos. El análisis empírico se realiza a partir de una aplicación de los experimentos de elección discreta. Los resultados muestran que medidas adicionales de prevención aumentan el bienestar de la población catalana y que la propagación del fuego es la característica del comportamiento del fuego que más preocupa a la sociedad. Esta información puede ser de particular interés para los responsables políticos y gestores ambientales en el diseño de sus programas y actividades.

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1. Introduction

Mediterranean forests have significant functions as ecosystems and provide several provisioning, supporting, regulating and cultural services (Millennium Ecosystem Assessment, 2005). However, Mediterranean forests are one of the most vulnerable forest ecosystems in the world (Palahí *et al.*, 2008). For instance, in recent times the fire recurrence has increased notably as a result of climate change and changes in human socioeconomic activities and land use (Piñol *et al.*, 1998). Fire in the Mediterranean region has always been considered an ecological and evolutionary factor; however, the increasing occurrence of large and intense wildfires in non-fire-prone Mediterranean areas (Terradas, 1996) may compromise the future of species lacking efficient post fire regeneration mechanism (Piussi, 1992; Riera and Castell, 1997). Consequently, extensive regeneration capacity failure after large wildfire events is becoming one of the major factors threatening the conservation of many forests ecosystems in the Mediterranean region (Moreno *et al.*, 1998).

Nowadays, reducing the threat of forest fires through fire prevention measures is a strategy present in every wildfire management programme (i.e., Xanthopoulos *et al.* (2006) give a detailed description of the most widely used fire prevention measures in Mediterranean countries). In this paper we consider fire prevention as measures applied to mitigate wildfire risk by physically reducing the amount of available flammable vegetation within the forest, influencing the probability of fire ignition and potential fire behaviour. Wildfire propagation and intensity are the two primary descriptors of fire behaviour (Martins, 2001), and the effectiveness at limiting these depends on the type of prevention measures used (Butry, 2009). For instance, wildfire propagation is mainly limited with firebreaks and fuelbreaks (Xanthopoulos *et al.*, 2006) while prescribed fire limits both wildfire propagation and intensity (Butry, 2009).

However, the social preferences about fire prevention measures in terms of their impact on fire behaviour are unknown. Information about these social preferences could be useful in many ways. For instance, it may serve as a support tool in the design of policies and/or specific fire management programmes; or, if faced with a fixed budget to be devoted to wildfire mitigation, land managers may want to design fire prevention measures in which their impact on fire behaviour mirror the preferences of society. Thus, social preferences may allow policy makers to better identify priority-attention areas in wildfire management. To the best of our knowledge, only few studies deal with social preferences on fire prevention measures in the Mediterranean region. Riera and Mogas (2004) apply a two-alternative (referendum) contingent valuation method to estimate a social-welfare change due to the reduction of the forest fires risk in Catalonia (NE Spain); however, the influence of different fire prevention measures on the welfare of the Catalan population were not explored.

The purpose of this study is to elicit the social preferences regarding fire prevention measures in terms of their impact on fire behaviour –fire propagation and intensity– and to estimate the value of these measures for the society. This information may be used by policy makers and environmental managers to design their

programmes and plan their activities. The success of a particular programme strongly depends on its social acceptability. Thus, considering the public preferences for this programme is crucial for the programme's development and setting up and, therefore, for protecting and preserving the resources managed by it. We use the discrete choice experiment as a valuation methodology consistent with welfare economic theory (Unsworth and Bishop, 1994; Jones and Pease, 1997; Louviere *et al.*, 2000; Bennett and Blamey, 2001). With this method, social preferences for changes in wildfire propagation and intensity can be expressed in monetary units or in the units of another descriptor of fire behaviour.

The rest of the paper is organised as follows. Section 2 describes the methodology followed in this study. Section 3 deals with the survey application, questionnaire, and interviews. Section 4 gives the main results of the study. Finally, Section 5 discuses the findings and draws the main conclusions.

2. Methodology

2.1. Discrete choice experiment

The label "discrete choice experiment" refers to a survey-based valuation method that simulates the actual market behaviour (Hanemann and Kanninen, 2001; Bennett and Blamey, 2001; Carson and Louviere, 2011). This method, which belongs to the family of stated preference methods, is based on the idea that any alternative, or good, can be described in terms of its attributes, or characteristics, and the levels these can take. In a discrete choice experiment, respondents are presented with a series of choice sets comprising at least two alternatives and are asked to choose which alternative they prefer (Hanley *et al.*, 2001; Bateman *et al.*, 2002). An alternative is a combination of several attributes, where each attribute is assigned a value usually called level. These alternatives are described in a questionnaire format that details the attributes to be considered, the changes in quantity or quality levels that may occur, alongside with the payment the respondents' would incur as a result of the choice.

The discrete choice experiment is based on random utility maximisation (RUM) models (McFadden, 1973), in which the utility function for each respondent has the form:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad [1]$$

where U_{ij} is individual *i*'s utility from choosing alternative *j*, V_{ij} is the deterministic component of utility, and ε_{ij} is a stochastic element that represents unobservable influences on individual choice.

Usually, ε is assumed to be independent and identically distributed (iid) Gumbel.[1] However, unobserved information relevant to making a choice may induce correlation across the alternatives in each choice set and indeed across choice sets. This being the case, the stochastic element is partitioned into two additive parts. One part correlated across alternatives and heteroscedastic, and the other part is iid across alternatives and individuals, as shown in equation [2]:

$$U_{ij} = V_{ij} + \eta_{ij} + \varepsilon_{ij} \qquad [2]$$

where η_{ij} is a stochastic element with zero mean, whose distribution across individuals and alternatives depends, in general, on underlying parameters and observed data relating to alternative j and individual i; and ε_{ij} is a stochastic element with zero mean that is iid across alternatives and individuals, and does not depend on underlying parameters or data. For any specific modelling context, the variance of ε_{ij} may not be identified separately from V_{ij}, so it is normalised to set the scale of utility (Hensher, 2001).

The mixed logit model (Train, 1998) assumes a general distribution for η and an iid Gumbel distribution for ε. The basic distributions for η can be normal, lognormal, uniform and triangular. Denote the density of η by $f(\eta|\Omega)$ where Ω are the fixed parameters of the distribution (mean and variance).[2] Given that ε is assumed to follow an *iid Gumbel*, then the conditional probability in η of individual i choosing alternative j corresponds exactly to the Multinomial Logit model:

$$P_i(j/\eta)L_{ij}(\eta) = \frac{e^{V_{ij} + \sigma\eta_{ij}}}{\sum\limits_{k} e^{V_{ik} + \eta_{ik}}} \qquad [3]$$

where σ is the scaling parameter for random coefficients.

So, the probability of choosing the alternative corresponds to the integral of the conditional probability over all the possible values of η, which depends on the parameters characterising the distribution, this is (Munizaga and Álvarez-Daziano, 2001):

$$P_{ij} = \int L_{ij}(\eta)f(\eta|\Omega)\,d\eta \qquad [4]$$

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[1]   Gumbel distribution implies that the alternatives chosen from the choice sets must comply with the property of the independence of irrelevant alternatives (IIA). This property means that for each individual, the ratio of the choice probabilities of any two alternatives does not depend on the inclusion or omission of other alternatives in the choice set. The IIA assumption is normally tested using the Hausman and McFadden (1984) test.

[2]   Normal $\beta_i = \beta + \sigma\eta_{ij}, \eta_{ij} \approx N[0,1]$,
      Lognormal $\beta_i = \exp(\beta + \sigma\eta_{ij}), \eta_{ij} \approx N[0,1]$,
      Uniform $\beta_i = \beta + \sigma\eta_{ij}, \eta_{ij} \approx U[-1,1]$,
      Triangular $\beta_i = \beta + \sigma\eta_{ij}, \eta_{ij} \approx Triangle[-1,1]$
where β and σ are the fixed mean and the scale parameter, respectively, for the random coefficient β_i.

Models of this form are called mixed logit (ML) because the choice probability is a mixture of logits with *f* as the mixing distribution. The probabilities do not exhibit IIA, and different substitution patterns are obtained by appropriate specification of *f*.

The choice probability cannot be calculated exactly because the integral does not have a closed form in general. The integral is approximated through simulation. For a given value of the parameters, a value of η is drawn from its distribution. Using this draw, the logit formula $L_{ij}(\eta)$ is calculated. This process is repeated for many draws, and the mean of the resulting $L_{ij}(\eta)$ is taken as the approximate choice probability giving equation [5] (Hensher, 2001):

$$SP_i = SP(U_i > U_k) = \left(\frac{1}{R}\right)\sum_{r=1}^{R} L_{ij}(\eta^r)$$ [5]

where R is the number of replications (i.e., draws of η), η^r is the rth draw, and SP_i is the simulated probability that any particular individual prefers the alternative *j* in the choice set to any alternative *k*.

2.2. Survey scenario

Based on the results obtained in two of the above cited studies –Terradas (1996) and Piñol *et al.* (1998)– we hypothesised that if the current fire prevention programme continues unchanged a possible increase in the propagation and intensity of forest fires will occur in 10 years. This situation was considered as the "do nothing" or "businessas-usual" (BAU) scenario. Furthermore, for the alternative scenarios to the BAU scenario, it was assumed that applying additional prevention measures the propagation and intensity of forests fires could be reduced.

We used two physical attributes –wildfire propagation and intensity– to describe the future forest fire situations. The use of such scientific terms would have resulted in complex attributes that might not be fully comprehensible for all participants. Therefore, a suitable "translation" of the scientific description into widely spoken terminology needed to ensure that the general public would get a better understanding of what was being asked.

To express the fire intensity descriptor we used the percentage of dead trees in forest fires as a proxy. González *et al.* (2007) estimated that the average level of tree mortality in past forest fires in Catalonia was around 45%, or 45 dead trees out of 100. Given the absence of reliable predictions about average levels of this attribute in 10 years time, and to avoid an overestimation of the future situation, we assumed this 45% to be the average level of tree mortality in the BAU scenario. Therefore, average levels below 45% corresponded to situations in which additional fire prevention measures were undertaken (Table 1). When targeting focus groups, we found that tree mortality was a clear and well-understood concept, and the attribute levels were considered reasonable and credible.

The fire propagation descriptor was proxied by the average annual forest area affected by fires in Catalonia. This proxy was already used by Riera and Mogas (2004). In the period 1968-2006, around 10 Catalan forest hectares out of 1,000 were burned on average per year (GENCAT, 2007). We assumed this 10 ‰ to be the level of burned forest area in the BAU scenario. Thus, levels below 10 ‰ corresponded to situations in which additional fire prevention measures were undertaken (Table 1). Similarly to the case of fire intensity, the attribute levels posed no problems for participants.

In addition to the two physical attributes, we included a monetary attribute. We explained to respondents that reductions in tree mortality and burned forest area would have to be financed by them through an annual and indefinite payment. Payment levels were determined from personal interviews and focus groups, in which respondents stated their maximum amount they will be to pay for different scenarios; the extra cost for the BAU scenario was set to zero.

TABLE 1

Attributes and levels of the discrete choice experiment

Attribute	Description	Level
Burned forest area	Average burned forest area per year in 10 years time will be	10 burned hectares out of 1,000 (BAU situation) 7 burned hectares out of 1,000 6 burned hectares out of 1,000 5 burned hectares out of 1,000
Tree mortality	Average percentage of dead trees in forests affected by fires in 10 years time will be	45 dead trees out of 100 (BAU situation) 30 dead trees out of 100 25 dead trees out of 100 20 dead trees out of 100
Annual payment	Individual's annual payment from an additional fire prevention programme	0 Euros (BAU situation) 15 Euros 30 Euros 50 Euros

Source: Own elaboration.

We used an experimental design to structure the choice sets. There were 27 (i.e., 3^3) possible combinations or alternatives, excluding the *status quo* levels. The final experimental design consisted of 24 alternative prevention measures chosen following an orthogonal fractional factorial design (Louviere, 1988).[3] These were randomly grouped into blocks of 2+1 (BAU scenario). Three different choice sets were presented to each respondent. In each choice set, respondents were asked to choose their most preferred alternative out of the BAU and two alternative scenarios. Thus, the elicitation technique within the discrete choice experiments was the multinomial choice-sequence. Graph 1 reproduces a typical choice set, with the two physical attributes and the monetary attribute.

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[3]   The efficiency of the final experimental design was 85.03% (efficiency compared with optimal design for choice set size m=2, according to Burgess, 2007).
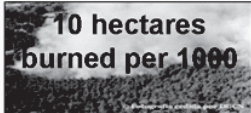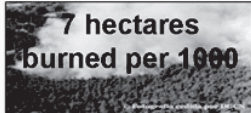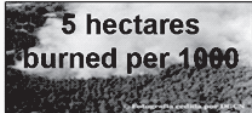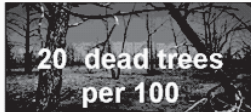
3.   Application, questionnaire, and interviews

We interviewed a representative sample of 207 Catalan citizens in June 2007. We conducted face-to-face interviews in the respondents' homes. The sample included residents in towns of over 30,000 people drawn randomly in three Catalan provinces –Barcelona, Gerona and Lérida. The selection of the respondents followed a random–route procedure to select a household, and then age and gender quotas to select the particular individual in the household. About 85% of the approached individuals agreed to be interviewed. The first part of the questionnaire presented the attributes to be valued, as well as the payment mechanism and its consequences. The central part of the questionnaire contained the choice exercise and a number of debriefing questions. The final part of the questionnaire was designed to collect some socio-economic data about the respondents.

GRAPH 1

Example of a choice set presented to respondents in the valuation survey

Source: Own elaboration.

The questionnaire included information about the current estimated average levels of burned forest area and tree mortality, and their expected average levels in 10 years time (the BAU situation). The predicted BAU scenario hypothesised the following value changes: the average annual burned forest area would increase from 7 to 10 hectares out of 1,000 hectares of forest; and average tree mortality due to forest fires from 30 to 45 dead trees out of 100 trees. Next, the questionnaire explained the possibility of modifying the future fire propagation and intensity levels by implementing additional fire prevention measures. Three alternative levels, apart from the BAU option levels, were offered for each physical attribute (Table 1). To further familiarise individuals with possible levels of change, participants were asked to pick for each attribute which out of the four levels they preferred, regardless of the cost to achieve it. If individuals picked the lowest attribute level, this could be indicating that lower attribute levels increase their welfare and, therefore, the attribute was considered to have a negative value. Thus, we could expect that alternatives with lower attribute levels have a higher probability of being selected. In this way, we could detect if the choices made in the valuation section were in fact consistent.

After the presentation of the physical attributes, we introduced the monetary attribute (Table 1). It was stated that the Catalan government was considering the implementation of an additional forest fire prevention programme and that this programme would be accomplished depending on the amount of money devoted to it. Participants were also told that the amount of money devoted to the programme would depend on their answers to this questionnaire. If on average, people would be willing to contribute certain amount of money to support the programme, then payments would be collected annually and indefinitely from all Catalan citizens. The money would be collected and administrated by an institution created specifically for this purpose. This payment mechanism was already used in Riera *et al.* (2007), where it was found that a compulsory contribution to an institution had no credibility problems. Respondents were then presented the choice sets with the BAU situation and the two alternatives, and were asked to pick their most preferred one.

The questionnaire was administrated on paper and read out by the interviewer. To better explain and present some of the topics, pictures and graphics were shown on separate cards. The average time of the interviews was approximately 15 minutes.

4. Results

A conditional logit model was initially used to detect the relationships between the levels of the attributes and the probability of respondents choosing particular alternatives. However, the Hausman and McFadden test rejected the IIA assumption at the 1% significance level. The rejection of the assumption implies that the ratio of choice probabilities of any two alternatives depends on the inclusion or omission of other alternatives in the choice set. Therefore, the random parameter or ML model was selected, which is less restricted and is not conditioned by the IIA.

The application of the ML model requires certain assumptions about the distribution of preferences. Initially, we assumed that preferences relating to the two physical attributes –burned area and tree mortality– were heterogeneous and followed a triangular distribution,[4] while preferences for the monetary attribute were assumed to be homogeneous (Table 2: Model 1). As shown in Table 2 (column 1), the signs of the coefficients of the random and non-random parameters are consistent with a priori expectations, and all variables are statistically significant at the 99% confidence level. The negative coefficient of tree mortality, burned area, and payment attributes suggests that, on average, for a Catalan citizen higher values of these attributes decrease her welfare. Therefore, alternatives with higher tree mortality, more burned area, and higher annual payments are less likely to be selected.

Table 2 (column 1) also shows the standard deviations for the random parameters. The standard deviation for burned forest area is statically significant at the 99% confidence level, which seems to reflect a heterogeneous preference composition of the surveyed population for this attribute. On the contrary, the standard deviation for the tree mortality attribute is not statically significant, which seems to indicate that preferences for this attribute are more homogeneous amongst respondents.

To further examine the source of the preference heterogeneity of the burned forest area attribute, we interacted the random parameter with the socio-economic variables in the utility function. Only the place of residence was found to be statistically significant at the 95% confidence level (Table 2: Model 2). This result suggests that differences in the marginal utilities held for the burned forest area may be, partly, explained by the different perception of respondents living in different provinces. More specifically, the negative coefficients of Barcelona and Lérida suggest that, on average, people living in these two provinces are more likely to select alternatives with less burned area than those living in Gerona.

Note that Model 2's coefficients are all significant at the 95% confidence level and display the correct sign, and that the tree mortality attribute is now incorporated as a non-random parameter. The goodness of fit of the two models is based on the McFadden's pseudo-R[2] (McFadden, 1973). The explanatory power of the models is adequate according to the conditional standards (Hensher and Johnson, 1981). The model fit comparison between Model 1 and Model 2 is based on the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC).[5] As shown in Table 2, Model 2 shows a slightly superior fit compared to Model 1, given that Model 2 reports lower values for both criteria.

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[4]   Given that lower levels of physical attributes were the most picked (i.e., higher probability of occurrence) within the levels considered we assumed a triangular distribution for both attributes.

[5]   The AIC criterion is defined as $AIC = -2 \ln L + 2n$, where n is the total number of estimated parameters in the model and the BIC criterion is defined as $BIC = -2 \ln L + n \ln(O)$, where 0 is the number of independent observations in the discrete choice experiment. A model with a lower BIC or AIC value is preferred to one with a higher value.

TABLE 2

Results of the ML regression analysis

Variable	Model 1 Coefficients (Standard Error)		Model 2 Coefficients (Standard Error)	
Random parameters in utility functions				
Tree mortality	-0.144**	(0.037)		
Burned forest area‡	-0.723**	(0.173)	-0.799**	(0.163)
Non-random parameters in utility functions				
Tree mortality			-0.137**	(0.032)
Annual payment	-0.053**	(0.011)	-0.051**	(0.009)
Standard deviations of parameter distributions				
Tree mortality	0.065	(0.187)		
Burned forest area†	1.280**	(0.464)	1.114*	(0.488)
Heterogeneity in mean				
Lérida			-0.233*	(0.113)
Barcelona			-0.155*	(0.067)
Log likelihood function	*-379.562*		*-374.833*	
AIC	1.633		1.617	
BIC	1.677		1.670	
Pseudo-R^2	0.262		0.276	
Observations	*1 413*		*1 413*	

**Significant at 1% level and *significant at 5% level. Estimates were obtained using 1,000 random draws to simulate the sample likelihood.

‡ This coefficient corresponds to the mean for the random coefficient of burned area.

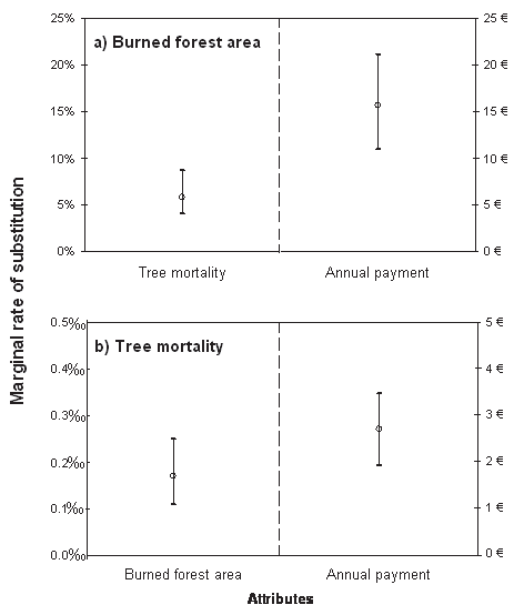† This coefficient corresponds to the scale parameter for the random coefficient of burned area.

Variable definitions: Burned forest area = average area of burned forest per year; Tree mortality = average percentage of dead trees in forests affected by fires per year; Annual payment = required payment per person per year for prevention programmes in Euros; Lérida = takes value 1 if the respondent resides in the province of Lérida and -1 otherwise; Barcelona = takes value 1 if the respondent resides in the province of Barcelona and -1 otherwise.

Note: 20% of respondents chose the status quo option (Annual payment = 0 Euros) quoting reasons other than lack of value for the programmes. These protest zeros were omitted from the analysis because these respondents probably have a positive WTP and by counting them as zero we would be underestimating the real WTP. Thus, the quantitative analysis was performed on a subset of 166 respondents.

Source: Own elaboration.

The estimated values for a marginal change in each attribute are inferred from Model 2 and represented in Graph 2. All values reflect the mean of the population with a 95% confidence interval, expressed in the units of the respective variable as they entered the regression. The marginal values for each attribute can be inferred by calculating the ratio $-\beta_i/\beta_j$, where β_i is the regression coefficient of the attribute to be valued and β_j represents the coefficient of the attribute in the units in which the value will be expressed. To get an additional percentage point decrease in the level of tree mortality, a citizen would, on average, be willing to consent (at most) to a 0.17 ‰ increase in burned forest area, and to pay (at most) 2.68 euros annually and indefinitely. The confidence intervals for the marginal value of each attribute were calculated using the Krinsky and Robb (1986) procedure with 2,000 repetitions.

GRAPH 2

Marginal rate of substitution

Values in relative units of attributes, with 95% CI for (a) a decrease in burned forest area in one hectare out of 1,000, and (b) a decrease of 1% in tree mortality. Physical attributes are expressed as a fraction of 100 (a) or 1,000 (b) on the left-hand vertical axis, while the monetary attribute is expressed in euros (2007 value) on the right-hand vertical axis. (a) A decrease in burned forest area in one additional hectare out of 1,000 (e.g., from 6 ‰ to 5 ‰) offsets (1) an increase in tree mortality of an additional 5.85 (4.08, 8.7) percentage points, the figures in parentheses denoting the limits of the 95% CI; and (2) the individual welfare equivalent of yearly expenditure of 15.69 (10.93, 21.05) euros. (b) A decrease in tree mortality of one additional absolute percentage point (e.g., from 20% to 21%) offsets (1) an increase in burned forest area of an additional 0.17 (0.011, 0.025) hectares out of 1,000, and (2) the individual welfare equivalent of a yearly expenditure of 2.68 (1.91, 3.46) euros.

Source: Own elaboration.

These estimations may also refer to the social value of the expected changes if different fire prevention measures were undertaken to diminish wildfire propagation and intensity in Mediterranean forests. Assuming a unitary price elasticity of demand, the amount of change in each attribute expressed in percentage points could be multiplied by its unitary value. For instance, according to respondents' perception, the increased welfare they would experience on average as a result of a reduction in tree mortality from 30% to 20% is equivalent to the welfare drop they would experience after a rise from 5 ‰ to 6.7 ‰ in burned forest area per year.

Likewise, different working scenarios for plausible fire prevention measures may be considered, and the social-welfare changes due to the application of each particular measure can be represented as the difference between the maximum expected utility of a fire prevention programme, with and without the change, divided by the estimated coefficient of the payment variable. Assuming a unitary price elasticity of demand, the closed-form expression for compensating surplus (CS) associated with a change in the quality of one alternative takes the form

$$CS = -\left(EU^1 - EU^0\right)/\beta_q \qquad [5]$$

where β_q is the estimated coefficient of the payment variable. EU^0 and EU^1 represent the maximum expected utility of the BAU scenario and the alternative scenario, respectively (Hanemann, 1984). From Model 2, several possible working scenarios were constructed by introducing different combinations of attribute levels indicating the possible outcomes of different fire prevention programmes (Table 3).

TABLE 3

Mean annual compensating surplus

	Policy A	Policy B	Policy C
Tree mortality (% of dead trees)	21	20	20
Burned forest area (‰ of burned area)	5	5	6
Social-welfare change (euros of 2007)	142.89 (109.37, 180.88)	145.57 (111.42, 183.61)	129.88 (99.41, 163.26)

Note: The confidence intervals for the compensating surplus were calculated using the Krinsky and Robb (1986) procedure with 2,000 repetitions.

Source: Own elaboration.

The results imply that respondents, on average, not only experience greater welfare with reductions in the propagation and intensity of forest fires, but also are willing to support a higher yearly expenditure for higher reductions. For instance, a change from the BAU or "do nothing" situation to an improved one as in Policy A implies that, on average, a citizen would be willing to pay 142.89 euros annually

and indefinitely. A higher reduction, as assumed by Policy B, increases the WTP to 145.57 euros. Again, the results mirror the trade-off between the propagation and the intensity of forest fires as perceived by citizens when they make choices. For instance, from Policy B to Policy C tree mortality remains unchanged, burned forest area increases in one additional hectare out of 1,000, and the individual's WTP reduces in 15.69 euros annually and indefinitely. This means that one additional hectare of burned area reduces the WTP by 10.78%. Likewise, in the change from Policy B to Policy A the burned forest area remains unchanged, while tree mortality increases in one additional percentage point. However, the individual's annual WTP reduces only by 2.68 euros. Thus, an increase in tree mortality by one additional percentage point reduces the WTP by 1.84%. The results suggest that, on average, one additional hectare (out of 1,000) of burned forest area concerns more Catalan population than one additional percentage point of dead trees.

5. Discussion

In contrast to the existing literature about forest fires in the Mediterranean region, our study not only provides the social value of fire prevention measures, but also suggests which of their impacts on fire behaviour are of highest concern to the Catalan population. This information may be used by policy makers and environmental managers to design their programmes and plan their activities. For example, if environmental managers in a particular region have a fixed amount of money to be devoted to the mitigation of forest fires, they may want to design a policy that considers both technical criteria and social preferences. Our results suggest that, on average, one additional hectare (out of 1,000) of burned forest area concerns more Catalan population than one additional percentage point of dead trees. In the survey there was no explicit question about the reasons for this preference. Nevertheless, this may be related to the fact that information on the quantity of burned hectares is often used by the media in Spain to quantify the consequences and the severity of a forest fire. Our results imply that policies more focused on the mitigation of forest fire propagation are those that increase the welfare of citizens further and are favoured by the Catalan population. However, the analysis has also some limitations. Our results are associated with the attribute levels given in Table 1. Thus, no conclusions can be given whether similar results would be obtained with different attribute values, since respondent's perception may vary significantly.

Independently of the attribute on which the prevention measures focus on, our study shows that the welfare of Catalan citizens is expected to rise with the implementation of any additional fire prevention measure. Similar results are found in the study of Riera and Mogas (2004), according to which two thirds of the Catalan population would be better-off with the implementation of a programme devoted to reduce the risk of forest fires in Catalonia. In addition, our results of the valuation section (sign and statistical significance of coefficients shown in Table 2) are consistent with the answers presented to familiarise respondents with the possible levels of change. Only in few cases, burned area and tree mortality have a positive value within the levels considered.

For the burned area attribute, there are some differences in the perceptions between respondents living in different Catalan provinces (similar results are also reported in Mogas *et al.*, 2006 and Hanley *et al.*, 2006). Although none of our questions explicitly set out to find the reason for these differences, we attribute them to the different proportion of forest area across the sampled provinces. In particular, Gerona is the province with the highest proportion of forest area, followed by Barcelona and then Lérida. Thus, we assume that people living in provinces with lower proportion of forests are more concerned about the size of burned areas, than people living in provinces with higher proportion of forest area.

In our application we followed current choice experiment practice (see, for example, Carson, 2000 and Hensher *et al.*, 2005, among others). In particular, we used focus groups in the questionnaire design process, and tested whether respondents overestimated the effects of such measures in which case, it could lead to misleading results. In this way, we asked respondents about their opinion on the occurrence possibility of a forest fire after the application of prevention measures. Only 4% of the respondents overestimated the effects of the measures by considering that it was not possible at all.

In summary, this study shows that additional fire prevention measures increase the welfare of the Catalan population. The attribute of highest concern to the population is fire propagation. This implies that, from a social viewpoint, reducing the burned forest area is the issue that should receive the highest priority when designing fire prevention programmes. However, the design of fire prevention programmes also depends on other factors such as vegetation type and characteristics, seriousness of the fire problem, available funds, available experience and expertise, etc. Thus, the public preferences should be considered in the decision making process, but are not the only factor influencing the design of fire management programmes.

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