Economic valuation of forest fire programs in Andalusia (Spain): Social preferences and willingness to pay

Elsa Varela[A,F], *Marek Giergiczny*[B], *Pere Riera*[C], *Pierre-Alexandre Mahieu*[D], *Mario Soliño*[E]

[A] European Forest Institute, Mediterranean Regional Office (EFIMED), Sant Pau Historic Site - Santa Victoria Pavilion, St. Antoni M. Claret 167, 08025 Barcelona, Spain.
[B] Department of Economic Sciences, University of Warsaw, 00241 Warsaw, Poland
[C] Autonomous University of Barcelona, Institut de Ciencia i Tecnologia Ambientals, 08193 Bellatera, Spain
[D] LEMNA, University of Nantes, 44 322 Nantes cedex, France
[E] National Institute for Agriculture and Food Research and Technology (INIA). Forest Research Centre (CIFOR). Ctra. de la Coruña, km. 7.5, 28040 Madrid, Spain.
[F] Corresponding author. Email: elsa.varela.r@gmail.com

Abstract. The risk of forest fires has been relatively insufficiently studied from an economic perspective while it has been largely addressed by different academic disciplines like biology, ecology or physics. This study reports on an economic valuation survey of alternative fire prevention programs in the province of Malaga, southern Spain. Its main objective was to elicit social preferences and willingness to pay for several aspects related with forest fire management, such as: (i) fuelbreak cleaning technique (controlled grazing, prescribed burning and mechanical treatments), (ii) fuelbreak design (from traditional lineal unshaded firebreaks to more landscape and environmentally friendly structures such as shaded fuelbreaks) and (iii) fuelbreak density (linked to annually burned area). Results show respondents' preferences are namely influenced by fuelbreak cleaning techniques and by the density of the fuelbreak network. Furthermore, estimations on the welfare change for the population were analyzed for several alternative fire prevention programs that could eventually be launched in the region. Lessons learned from this study could be relevant for the development of fire prevention policies and specific prevention campaigns in Mediterranean forests.

Additional keywords: compensating surplus scenarios, contingent ranking, random parameters models, wildfires

Introduction

When launching a fire prevention program, some decisions are to be made on cleaning technique for the fuelbreak (e.g. brush cutting or prescribed burning), the fuel break design (e.g. shaded or unshaded) and the density of the grid, which could influence the expected annually burned area. These programs are developed by public agencies and are mainly based on technical and budget criteria. Among the fire prevention tools for sustainable forest management, fuelbreaks are commonly used in Spain to slow or stop the progress of bushfire or wildfire. Fuel treatments in fire prevention structures, like all vegetation changes, have temporary effects and require repeated measures to maintain desired fuel structure. Mediterranean shrubs are vigorous resprouters that easily end up colonizing these areas in short time period. Hence, it requires these structures be periodically cleared (ideally, every 2 to 4 years) to maintain a low biomass content so as to fulfill their mission.

The risk of forest fires has been extensively studied from different disciplines, like biology, ecology or physics, while economics has paid relatively less attention to it (Alexandrian *et al.*, 2005). Wildfires affect many non-market goods and services that are very important from a social point of view (Venn and Calkin, 2011). This article reports on an economic valuation study of alternative fire prevention plans in the province of Malaga, Andalusia (Southern Spain), with different level combinations of cleaning technique, fuel break design and expected annually burned area.

Environmental valuation can contribute to incorporate these values in forest management. In this way, choice modelling seems to be an appropriate technique for valuing fire prevention management since it can provide resource managers and policy makers with valuable info about public preferences for many potential alternatives (Holmes and Boyle, 2004). It mimics management decisions in fire prevention for they are concerned with changing attribute levels rather than estimating the change in an environmental good or service as a whole (Hanley et al., 2001).

A number of studies focusing on economic valuation of wildfires can be found, especially in the area of non-market valuation, e.g. using the travel cost method (Hesseln et al., 2004, Starbuck et al., 2006), contingent valuation method (Loomis and González-Cabán, 1994, Loomis and González-Cabán, 1998, Fried et al., 1999, Winter and Fried, 2001, Riera and Mogas, 2004, González-Cabán et al., 2007, Kaval et al., 2007, Walker et al., 2007, Soliño et al., 2010) or discrete choice experiments (Bengochea et al., 2007, Brey et al., 2007, Riera et al., 2007, Borrego, 2010, Soliño, 2010, Soliño et al., 2012). This study contributes to the limited literature on estimation of economic values for forest fire prevention, being the only Contingent Ranking application that focuses on fuel break management. It is also one of the few studies undertaken in the Mediterranean area where forest fires are one of the main threats for forests' conservation.

The paper is organized as follows. In the Material and methods section, the econometric model is described, as well the experimental design, the study area and the survey. In the Results section, the models fitted with the results obtained from the contingent ranking survey are presented. The final section is devoted to discussion and conclusions.

Material and Methods

Contingent Ranking

In the Contingent Ranking experiment (CR) each respondent was faced with 16 choice cards, each one containing the status quo alternative with no payment required, and three fire prevention program alternatives. In each choice set, respondents were firstly asked to select the most preferred alternative, secondly the least preferred alternative, and then the most preferred alternative of the remaining two. This approach leads to a full ranking of the four alternatives (including a status quo option) in each choice set.

The statistical analysis of responses is based on the Random Utility Theory. Individuals ($i = 1, ..., I$) are assumed to maximise their utility when they choose from a set of alternatives ($j = 1, ..., J$) from a choice set (C). For each alternative j of the choice set, the individual indirect utility function (U_{ij}) depends on i) a deterministic element (V_{ij}) and ii) a stochastic or random component (ε_{ij}), which cannot be observed by the researcher.

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (1)$$

If we represent the individual's choice in terms of probabilistic inference, we obtain the following expression for the choice probability:

$$P(U_{ik} > U_{ij}) = P\left[(V_{ik} - V_{ij}) > (\varepsilon_{ij} - \varepsilon_{ik})\right] \qquad k \neq j\,,\ k, j \in C \qquad (2)$$

The probabilistic model will depend on the assumption we make on the distribution of the difference between the random terms. The most common assumption made on the error terms is to consider that they are identically and independently distributed (*iid*) and that they follow a Gumbel distribution. Beggs et al. (1981) developed the econometric model to analyze the information from a ranking survey. Their model specification is based on the repeated application of a conditional logit model (McFadden, 1974) until a full ranking of all the alternatives has been achieved. The probability of any ranking of alternatives being made by individual *i* can be expressed as:

$$P_i\left(U_{i1} > U_{i2} > \cdots > U_{iJ}\right) = \prod_{j=1}^{J-1} \frac{\exp\left(V_{ij}\right)}{\sum_{k=j}^{J} \exp\left(V_{ik}\right)} \qquad (3)$$

More flexible estimation methods, such as the Random Parameters Logit (RPL), are not subject to the undesirable *Independence of Irrelevant Alternatives* (IIA) assumption implicit in the traditional conditional logit model. Moreover, RPL models provide with a tractable form to deal with unobserved preference heterogeneity (Train, 2003). In RPL models, the individual's *i* indirect utility function is usually represented as a linear additive expression:

$$U_{ij} = \alpha_j + S_{ij}\beta_i + \varepsilon_{ij} = \alpha_j + S_{ij}\overline{\beta} + S_{ij}\theta_i + \varepsilon_{ij} \qquad (4)$$

where α_j is an alternative specific constant (SQ) taking value 1 if the individual choose the *status quo* option and 0 elsewhere, β_i is the vector of individual preference values, which deviates from the population mean $\overline{\beta}$ by the vector θ_i, S_{ij} is the associated attribute vector, and ε_{ij} is an *i.i.d.* type I extreme value random component of utility. The random parameter specification supposes that parameters β vary in the population with density $f(\beta|\Omega)$, with Ω denoting the parameters of density. Therefore, the probability of individual *i*'s observed sequence of rankings $[y_1, y_2,...,y_T]$ is calculated by solving equation 5 through simulation (Train, 2003; Hensher et al., 2005):

$$P_i[y_1, y_2, ..., y_T] = \int ... \int \prod_{t=1}^{T} \prod_{j=1}^{J-1} \frac{\exp(V_{ij})}{\sum_{k=j}^{J} \exp(V_{ik})} f(\beta|\Omega) d\beta \quad (5)$$

Study area and experimental design

Malaga is a coastal province located in Andalusia, Southern Spain (Figure 1). More than the 77% of its area belongs to mountainous landscapes with typical Mediterranean vegetation and a significant diversity of ecosystems. From its area of 740,000 ha, forest and other wooded land (FOWL) account for almost half of its surface. Pine forests cover almost 50,500 ha while Holm oak (*Quercus ilex*) and Cork oak (*Quercus suber*) account for 23,900 ha and 18,600 ha respectively (Consejería de Medio Ambiente, 2010). On average, forest fires burned almost 1000 ha per year in Malaga for the 1999-2008 period (Ministerio de Medio Ambiente, 2008). However, the yearly burned surface varies greatly depending on the occurrence of large fires. For example, 2008 could be considered as a “good” year as less than 250 ha burned, in contrast with 2004 when the fire affected more than 2,000 ha (Ministerio de Medio Ambiente, 2006).

Figure 1. Study area

The CR attributes and levels were selected after consultations with forest managers and forest fire researchers along with focus groups helped in choosing relevant fuelbreak management attributes. Our hypothesis was that people are sensitive to changes in fire prevention management. Three non-monetary attributes at four levels were employed to describe the alternative scenarios in fire prevention management in the province: fuelbreak design, fuelbreak cleaning tool and amount of fuelbreaks. A monetary attribute was also included in order to estimate welfare measures. In addition to program alternatives, a description of the current situation (status quo alternative) was included. The selected attributes and their levels are reported in Table 1.

The levels chosen for the cleaning technique attribute were: scrapping with angledozer, backpack brushcutting, controlled grazing and prescribed burning. Scraping by angle dozers is the most commonly used method in Malaga. Nowadays, forestry agencies are introducing alternative tools to complement mechanical treatments with a double fold objective i) to reduce the cost of fuel management practices in firebreaks and fuelbreaks, but also ii) to improve fuel control beyond these areas (e.g. clearing practices in overdense pine afforestation stands).

In this sense, grazing of sheep and goats is a traditional practice in the wildlands of Mediterranean countries (Papanastasis, 2009). When this practice is planned and controlled at appropriate levels, it may be a suitable method for reducing landscape biomass and comply with fire prevention standards (Robles Cruz et al., 2008, Piñol et al., 2007, Papanastasis, 2009, Ruiz-Mirazo et al., 2011). Furthermore, the experimental use of prescribed fire as a management tool in Andalusia is showing promising results (Rodríguez y Silva, 2004). Nevertheless, because wildfire is such a sensitive issue for the population, policy makers are reluctant to assume the risks associated with this practice.

The location and spatial distribution of fuelbreaks is being reconsidered in the light of landscape criteria and improved knowledge of fire and fuel behaviour (Duguy et al., 2007, Agee et al., 2000, Schmidt et al., 2008, Oliveras et al., 2009). Thus, although lineal unshaded firebreaks are typically used in Malaga, a shift is gradually taking place from traditional firebreaks to more environmental and landscape friendly structures such as shaded fuelbreaks. In addition, the shape of these structures in Andalusia is progressively evolving towards designs adapted to the topography of the area, taking advantage of open spaces and departing from linear forms with high visual impact. This way, the fuelbreak design attribute combined lineal/irregular edges of preventive structures with the presence/absence of trees inside them (shaded/unshaded structures) to create a four levels attribute: unshaded lineal structure, irregular unshaded structures, lineal shaded structures and irregular shaded structures.

The third attribute, amount of fuelbreaks and area burned, was included as a result of the focus groups conducted. Preferences in valuing the fuelbreak design attribute were built based on the consideration of the risk of fire spread rather than on the preferences related to the landscape. To overcome these misunderstandings, information showing different amounts of firebreaks and their joint expected burned area was included. The levels for this attribute were showed to people in a manipulated aerial photograph where the area of a hypothetical burned plot decreased when the density of the network increased. Finally four levels of densities of the fuelbreak network and reduced yearly burned area in Málaga were defined: (i) low amount of fuelbreaks and 1000 ha burned yearly ii) medium amount of fuelbreaks and 800 ha burned yearly, iii) high amount of fuelbreaks and 600 ha burned yearly and iv) very high amount of fuelbreaks and 400 ha burned yearly.

Finally, the payment attribute was designed following the results from two pilot surveys. The final levels were: 20, 60, 100 and 140 euros per year. The monetary attribute shows the hypothetical cost an alternative would have for individuals in case it would be developed. The payment vehicle was an increase in taxes.

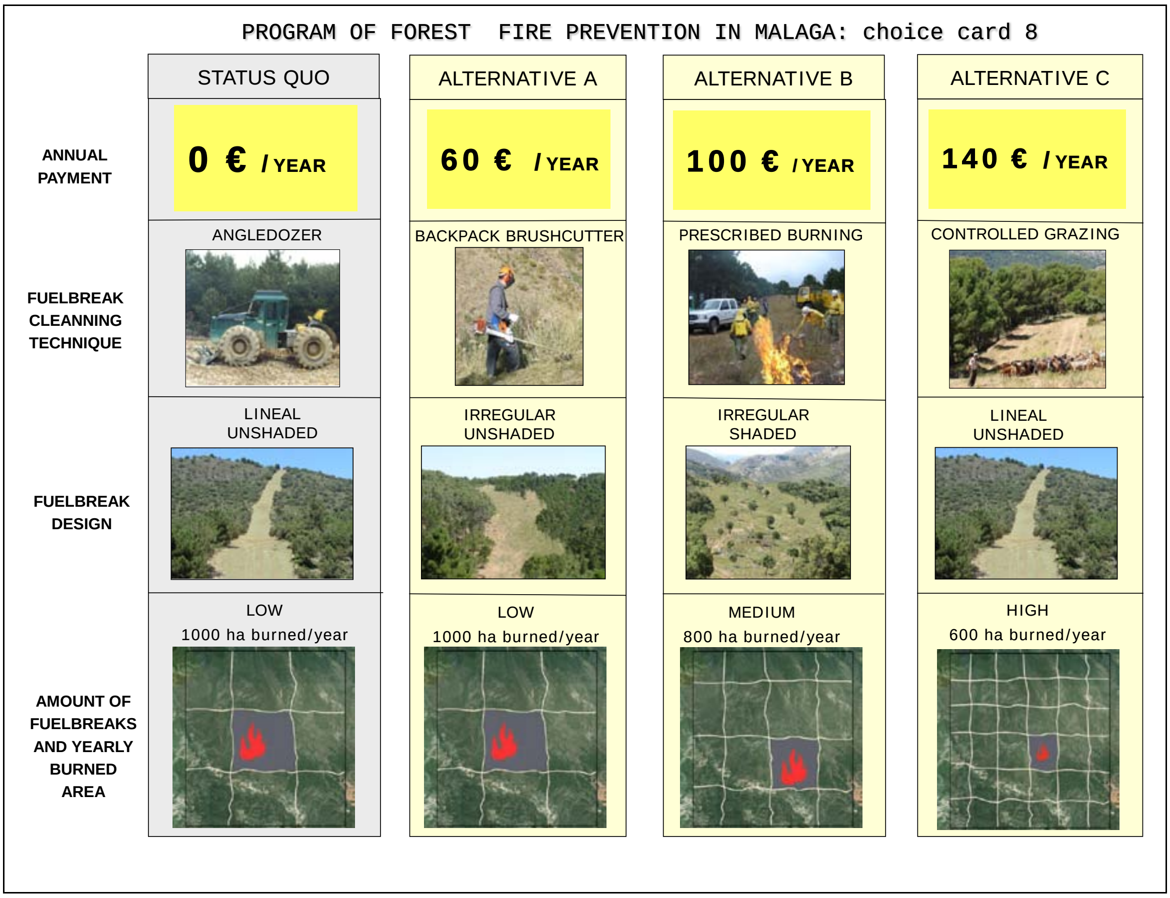
Table 1. Attributes and Levels

Attributes	Levels	Variable
Fuelbreak cleaning technique	Scrapping with angledozer*	SWA
	Backpack brushcutter	BB
	Controlled grazing	CG
	Prescribed burning	PB
Fuelbreak design	Lineal unshaded*	LINU
	Lineal shaded	LINS
	Irregular unshaded	IRRU
	Irregular shaded	IRRS
Amount of fuelbreaks (yearly burned area)	Low (1000 ha burned)*	LOW
	Medium (800 ha burned)	MED
	High (600 ha burned)	HIGH
	Very High (400 ha burned)	VHIGH
Annual payment	0 €*	COST
	20 €	
	60 €	
	100 €	
	140 €	

* Status quo level.

The choice sets utilized in our study were prepared following an optimal in -difference design as proposed by Street et al. (2005) and Street and Burgess (2007). Figure 2 shows an example from the sixteen choice cards presented to each respondent. The status quo option was identical for all respondents. The levels used to describe this alternative were: clearing technique based on scrapping with angledozer, lineal unshaded fuelbreak design, low amount of fuelbreaks (1,000 ha yearly burned area) and zero cost. These levels reflect the currently most widespread management practice in Málaga, Andalusia. These levels were also used in the design of the program alternatives.

Figure 2. Choice card example



The sample

A representative sample of 510 Malaga citizens was interviewed in December 2009. Interviews were conducted face-to-face in respondents' houses. The sample included residents from 24 locations along the province. The sample was weighted according to their population size and stratified into three blocks belonging to urban, metropolitan and rural municipalities. The questionnaire was administered to the population of 18 years old and older, proportionally to the population of each location.

The socio-demographic characteristics of the respondents who completed the surveys are summarized in Table 2. According to official statistics from IEA (2009), socio-demographic variables, such as gender or age, fit well to the Málaga population. Nevertheless, our sampled individuals were less well educated, with lower income and less metropolitan than the general population (Table 2). These results are common in stated preference studies (Domínguez-Torreiro and Soliño, 2011).

Table 2. Socioeconomics of the surveyed respondents

Variable	Sample	Málaga population
Gender (% female)	51.2	51.0
Income (net disposable income per month)	1021.4 €	1326.4 €
Age		
• 18 – 39 years old	40.2	40.8
• 40 – 65 years old	35.0	34.3
• 65 or over years old	24.8	24.9
Municipality size		
• Metropolitan (> 100,000 inhabitants)	40.9	44.7
• Urban (20,000 – 100,000 inhabitants)	40.4	34.7
• Rural (< 20,000 inhabitants)	18.7	20.6
Education		
• Primary school unfinished	15 %	12.1 %
• Primary school finished	26.2 %	18.8 %
• Secondary school finished	35.8 %	47.43 %
• Graduate	15.5 %	18.35 %

Likewise, follow-up questions to the ranking exercise are used to identify protest responses. A protest response is usually considered when respondents always (16 times) chose the status quo option as their preferred alternative. This type of choices may reflect a protest against some of the elements of the valuation scenario, a strategic behavior, or a genuine zero, i.e., the proposed fire prevention programs do not have any impact on individual’s preferences. There is no consensus on how to treat this kind of responses; (Jorgensen and Syme, 2000, Dziegielewska and Mendelsohn, 2007, Brouwer and Martín-Ortega, 2011) but the usual approach is only keeping the genuine zeros for analysis (Soliño et al., 2010). Taking into account several open-ended follow-up questions, 111 individuals were identified as protesters and a final sample of 397 individuals was considered for the subsequent analysis. Since we got 16 observations per respondent, the number of observations obtained is 6,352.

Results

Within a random parameters logit model specification some, or all, parameters are assumed to follow a specific distribution (normal, lognormal, triangular, among others). In our study all attributes apart from the cost were assumed to be normally distributed. A normal distribution was chosen as we expected respondents to have positive and negative preferences for the different attributes of fuel-break management. The cost attribute is assumed to be fixed as we wished to restrict it to be non-positive for all individuals (Train, 2003). Furthermore, this way the distribution of the marginal WTP for an attribute is then simply the distribution of that attribute’s coefficient.

To determine the possible sources of heterogeneity, the random parameters and the alternative specific constant (SQ) were interacted with socio-demographic variables. After extensive testing of the various interactions of the program attributes with the respondents' socio-economic characteristics, seven variables (Table 3) were included as interaction terms with SQ into the final utility specification.

Table 3. Socio-economic characteristics

Variable	Description
Town	Size of town of residence (1: urban and metropolitan area 0: rural area)
Visit	Visit the countryside for recreation in the last year (1: yes; 0: no)
Work	Working situation (1: unemployed; 0: other)
Income	Net monthly income (1: more than 1,200 €; 0: from 0 € to 1,200 €)
Adults	Number of adults in the household
Children	Number of children in the household
Difficulty	Difficulty in answering the questionnaire (1: difficult; 0: not difficult)

Table 4 presents the results of the attributes and expanded RPL models. The models were estimated with simulated maximum likelihood using 500 Halton draws (Train, 2003) and NLOGIT 4.0 software (Greene, 2007).

Most of the attribute parameters are significant and the sign and coefficients of the models responded to our expectations and to what was revealed in the previous focus groups. All the estimated standard deviations are significant, and the significance of the standard deviations and the existence of reverse preferences for most attributes indicate preference heterogeneity among the audience towards fire prevention issues. Furthermore, the relative magnitude of these standard deviations implies that the probability that people have reverse preferences is rather high for most attributes. Results show that the expanded model (which includes socioeconomic interactions), gives better fit than the attributes only model. Therefore, this model is the one used for further analysis.

Regarding the cleaning technique parameters, BB and CG show positive and close values, slightly higher for BB. This is consistent with focus groups results where people regarded both techniques as effective low impact management options On the other hand, PB holds a negative coefficient, indicating that the adoption of such management practice produces negative utility to respondents. This is an expected output since PB is largely unknown by laypeople. Hence, if it would be eventually incorporated as a management tool, targeted dissemination campaigns would be needed to increase social trust in agency (Absher et al., 2009) and approval of prescribed burning practices.

Regarding the fuelbreak design parameters, only IRRS is found to be statistically significant, suggesting that people’s preferences are only influenced when a shift towards this more landscape integrated design occurs. All the design parameters hold very low values compared to the other attributes, indicating their small contribution to respondents’ utility. Public perception on this issue clearly differs with that hold in technical and research arena where the design of fuelbreaks is a major topic. A higher public fire-related knowledge would surely help to bridge this gap, as a positive association between outreach activities and social acceptability has been found in fire prevention issues (Toman and Shindler, 2006).

Concerning the parameters for the amount of fuelbreaks, all the coefficients are significant and with the expected sign. The HIGH and VHIGH parameters show values that indicate their important contribution to utility construction, similar to that of the parameters associated with the cleaning tools. Respondents experience a positive and higher utility when the amount of fuelbreaks increases from the base level (and the respective burned area decreases). However, the utility increases at a decreasing rate, suggesting that a satiation point may exist. Thereby, individuals, when arrived to a certain density of fuelbreaks (and reduction of burned area) would be less willing to pay for further improvement.

The positive sign of SQ implies that people do not want (in general) a fire prevention program or that respondents perceive other negative effects. But the inclusion of socioeconomic interactions in the extended model let us to catch the (specific) individual heterogeneity towards these fire prevention programs. In this sense, the probability of choosing a program alternative increases significantly among respondents living in urban areas and visiting the countryside for recreation purposes.

Urban dwellers have a higher probability of choosing a program alternative while people living closer to the forests, rural inhabitants, are more reluctant to pay for changes in the management. Our hypothesis after conducting focus groups in rural areas is that it may be related with certain distrust in regional government, responsible for fire prevention management. Trust in agency has been suggested as a key psychological predictor of public acceptability of management actions (Absher et al., 2009), suggesting that trust-building and trust maintenance should be key goals of agency-citizen interactions (Winter et al., 2004). As Vélez Muñoz points out (Vélez Muñoz, 2009), fire prevention programs are mainly supported and demanded by urban citizens while rural inhabitants trend to have a critical view on agency programs, sometimes regarded as opposed to traditional practices. To overcome this situation, agency focus on local concerns in conjunction with citizen participation in the planning processes would contribute to build trust in agency personnel and decisions that is needed to foster public acceptance of these fuel treatment projects (Daniel et al., 2007).

People enjoying the forest for recreational purposes have a higher probability of choosing an alternative program. These results highlight the use component of the utility, and is in accordance with studies where users typically trend to have higher valuations for landscape improvements (Hanley et al., 1998). Evidence from the vast literature on recreational values pinpoints recreation benefits as a substantial part of total economic value of forests (Cubbage et al., 2007) and specifically in the northern Mediterranean, where these values are likely to grow (Croitoru, 2007).

Budget constraints and household structure also influenced respondents’ choices. Being unemployed raised the probabilities of choosing the status quo scenario and so did being more children in the household, while more adults at home would work the opposite. Individual disposable income is likely to rise with more (income earning) adults in the household and similarly, the individual budget would decrease with the number of children at home. This result shows that respondents having children are namely concern with the budget constraint it would impose, and not so much with bequeathing a better environment for future generations. Finally, encountering difficulties in answering the questionnaire and people having higher income augments the likelihood of choosing the current scenario as the most preferred.

Table 4. RPL results

	Attributes model		Expanded model	
	Mean coef. of distribution (Std. Err.)	**Std. Dev. of parameter distributions (Std. Err.)**	**Mean coef. of distribution (Std. Err.)**	**Std. Dev. of parameter distributions (Std. Err.)**
SQ	-0.394 (0.027)***	Fixed	1.136 (0.043)*	Fixed
BB	0.200 (0.012)*	0.365 (0.007)*	0.200 (0.012)*	0.366 (0.007)*
CG	0.184 (0.012)*	0.283 (0.007)*	0.183 (0.012)*	0.285 (0.007)*
PB	-0.274 (0.013)*	0.492 (0.008)*	-0.273 (0.013)*	0.485 (0.008)*
LINS	-0.005 (0.013)	0.124 (0.007)*	-0.003 (0.012)	0.108 (0.007)*
IRRU	0.005 (0.014)	0.575 (0.008)*	0.001 (0.014)	0.575 (0.008)*
IRRS	0.057 (0.013)*	0.211 (0.007)*	0.056 (0.013)*	0.167 (0.006)*
MED	0.028 (0.013)**	0.015 (0.007)**	0.028 (0.013)**	0.018 (0.007)*
HIGH	0.234 (0.013)*	0.642 (0.008)*	0.238 (0.013)*	0.589 (0.007)**
VHIGH	0.276 (0.013)*	0.770 (0.009)*	0.282 (0.013)*	0.740 (0.008)*
COST	-0.026 (0.000)*	Fixed	-0.026 (0.000)*	Fixed
TOWN x SQ			-0.604 (0.023)*	
VISIT x SQ			-1.241 (0.020)*	
WORK x SQ			0.950 (0.019)*	
INCOME x SQ			0.004 (0.000)*	
ADULTS x SQ			-0.169 (0.010)*	
CHILDREN x SQ			0.182 (0.011)*	
DIFFICULTY x SQ			0.511 (0.030)*	
Pseudo R-squared	0.1622		0.1770	
Log likelihood function	-16,566.59		-16,273.21	
No. observations	6,352		6,352	

*** p<0.01 ** p<0.05 * p<0.10

From the observed choices, individuals' preferences are transformed into implicit prices or marginal willingness to pay (MWTP) measures. For the effects-coded policy attributes, the MWTP for each level *k* of the attribute *j* is estimated using the formula (Lusk et al., 2003, Domínguez-Torreiro and Soliño, 2011):

$$MWTP_k^j = -\frac{\beta_k^j - \beta_{base\ level}^j}{\beta_{cost}} \quad (6)$$

where $\beta_{base\ level}^j = -\sum \beta_k^j$ and represents the estimated coefficient associated to the base level (or status quo) of the attribute *j*. Mean MWTP estimations are presented in Table 5.

Table 5. MWTP results

Attribute	Attributes model Mean MWTP (Std. Err.)	Expanded model Mean MWTP (Std. Err.)
BB	11.98 (0.753)***	12.00 (0.731)***
CG	11.33 (0.759)***	11.33 (0.735)***
PB	-6.37 (0.818)***	-6.27 (0.804)***
LINS	1.98 (0.760)***	1.96 (0.748)***
IRRU	2.41 (0.871)***	2.13 (0.860)**
IRRS	4.39 (0.804)***	4.25 (0.789)***
MED	21.85 (0.892)***	22.21 (0.886)***
HIGH	29.83 (0.878)***	30.35 (0.874)***
VHIGH	31.45 (0.872)***	32.04 (0.861)***

*** p<0.01 ** p<0.05 * p<0.10

This information could be of interest to policymakers when defining priorities for fire prevention programs. Nevertheless, the social welfare for future fire prevention scenarios is not summarized (Hanley et al., 2007). Welfare changes can be obtained by using the compensating surplus (CS) formula described by Hanemann (1984):

$$CS = -(V_1 - V_0) / \beta_{cost} \qquad (7)$$

where V_0 and V_1 represent the utility before (status quo scenario) and after the program under consideration. Therefore, CS estimates represent respondents' average willingness to pay to move from the status quo to the different fire prevention programs presented in the Table 6.

Table 6. Fire prevention programs

Fire program	Fuelbreak attribute levels			Compensating surplus		
	Cleaning technique	Design	Amount	€ per individual and year	€/ha of FOWL/year	€/ha of fuelbreaks/year**
Low density programs						
LDP1*	SWA	LINU	LOW	0	0	0
LDP2	BB	LINU	LOW	29.06	102.71	1283.91
LDP3	CG	LINU	LOW	28.39	100.34	1254.31
LDP4	PB	LINU	LOW	10.79	38.14	476.72
Medium density programs						
MDP1	SWA	LINU	MEDIUM	106.82	377.56	3020.46
MDP2	BB	LINU	MEDIUM	135.88	480.27	3842.16
MDP3	CG	LINU	MEDIUM	135.21	477.90	3823.22
MDP4	PB	LINU	MEDIUM	117.61	415.69	3325.56
Landscape friendly programs						
LFP2	BB	IRRS	MEDIUM	148.47	524.77	4198.16
LFP3	CG	IRRS	MEDIUM	147.80	522.40	4179.21
LFP4	PB	IRRS	MEDIUM	130.20	460.19	3681.55

* Status quo scenario. ** The estimated density of the fuelbreak network for the province of Malaga was 16 ml/ha and the average width considered for these structures was of 50 m. These figures were calculated based on orto-photos and GIS software.

These programs are generated as combinations of the attribute's levels intending to mimic sound management scenarios. From the basis of a given network density and design, the cleaning technique is varied creating different programs. Thereby Low Density Programs (LDP) show a conservative budget scenario, where the network would remain the same as in the status quo situation, i.e. low density of lineal unshaded fuelbreaks. Within these LDP, the cleaning tools are changed generating four different scenarios. In addition, two more groups of programs are assessed where an eventual increase in the network density is considered: Medium Density Programs (MDP) which hold a closer approach with the current scenario situation, with lineal unshaded structures and Landscape Friendly Programs (LFP) which represent a shift towards more environmentally friendly and more landscape integrated scenarios. In this case, scrapping with angledozer is not considered due to its incompatibility with shaded structures.

Consumer surpluses calculated for the different management programs are shown in € per individual and year. Estimates are provided also in € per ha of forest and other wooded land (FOWL) and also per hectare of fuelbreak structures along the province, allowing to establish comparison with estimates of cost and budget allocation on fire prevention and forest management.

Changes in wellness are noteworthy when moving from LDP to MDP, surpassing the 100 € per individual and showing that an important social demand exists for a denser network and reduced burned area. Despite LFP show the highest surpluses among the three programs, the surplus gain when compared with equivalent MDP scenarios are moderated, not surpassing the 15 € per individual.

The welfare estimates calculated for the area of fire prevention structures are substantially higher when compared to these calculated per hectare of FOWL. Because respondents were asked to value fire programs managing exclusively the area of fuelbreaks, it is conceptually more accurate to calculate welfare gains related to this area instead of for the FOWL area as a whole. However, it was decided to calculate both for demonstrative purposes. Finally, despite the high figures obtained from these calculations per hectare of fuelbreaks, it is noteworthy saying that the welfare increases obtained for LDP are within the range of market rates for mechanical biomass control activities.

LDP2 shows that the social demand for controlled grazing in the current scenario has a value of 100.34 € per hectare ha of FOWL per year and 1254.31 € per hectare of fuelbreak per year, respectively. The network of grazed fuelbreaks in Andalusia offers to the shepherds a remuneration that ranges from 42 to 90 € per hectare per year, in proportion to the estimated grazing difficulty (Ruiz-Mirazo et al., 2011). Our results show that administration payments for grazed fuelbreaks, even on their upper bound, would be lower than the social demand for this cleaning technique if it were calculated with respect to the provincial area of FOWL. These disparities among the currently paid amounts to the shepherds and our estimations become more extensive when this comparison is accurately established with respect to the estimations per hectare of fuelbreaks:42-90 €/ha vs. 1254.31 €/ha. These results show that these payments to the shepherds, far from being overestimated, are significantly lower that the welfare gains society obtained from them.

Discussion and conclusions

Lessons learned from this study could be relevant for the development of fire prevention policies and specific prevention campaigns. Results show that the attributes contributing to a greater extent to preferences construction are these related to the cleaning tools and network density (associated with a reduction in burned area). The results indicate that there are positive and significant economic benefits associated with controlled grazing that support its establishment as a common tool for biomass control. On the contrary, a negative mean WTP was found for prescribed burning. Even if this technique is recommended for its competitive financial costs, it seems that its application may decrease social welfare. Respondents seem to be most concerned about the amount of fuelbreaks as a way of diminishing the burned area. Nevertheless, they show a satiation point with respect to this attribute, what indicates they are concerned with the amount of fuelbreaks needed to reduce the burned area. On the contrary, the design of preventive structures doesn't seem to attract much attention among citizens. This result contrasts with technical debates where fuelbreaks design is a major issue and reinforces the idea that people fire related knowledge should be encouraged to bring closer society and technical concerns on fire prevention issues.

Comprehension on the aggregate economic value associated with a policy change requires understanding taste heterogeneity and thus who will be affected by these changes. Results show that the probability of choosing a program alternative increases significantly among respondents living in urban areas and visiting the countryside for recreation purposes. Trust in agency being higher among urban citizens and the high share of use component in shaping respondents utility respectively, could explain these outcomes. Budget constraints being either personal (unemployed) or familiar (household structure) and cognitive burden affected negatively to respondents' willingness to pay for an alternative program. These results seem to indicate that among these people having children, restrictions in disposable income played a bigger role in shaping their preferences than did their bequest value for forests. Finally, cognitive burden did also affect negatively to respondents' willingness to pay for an alternative program.

Lastly, three different groups of programs that mimic management scenarios were considered. The results show that a social demand exists for a denser fuelbreak network and reduced burned area, being the gains above 100 € per individual and year when compared to low density programs.

Welfare estimates for LDP scenarios for backpack brushcutting and controlled grazing are of 1,283 and 1,254 € per hectare respectively. These amounts lay within the range of market rates for mechanical biomass control activities and show that, people experience important gains in their welfare when these cleaning tools are promoted over the use of the angledozer as cleaning tool in the SQ scenario. Ultimately, when it comes to controlled grazing, estimates show that consumer surplus gains surpass by far the range of 42-90 € per hectare the shepherds receive when enrolling the network of grazed fuelbreaks of Andalusia. These results show that when social preferences are taken into account, payments to the shepherds are far from being overestimated. On the contrary, these results provide with additional support for the enhancement and promotion of such a program as a mean for controlling biomass and reducing prevention costs for forest agencies. Furthermore, beyond budgetary restrictions, social demand indicates that some room exists for an eventual increase in the amounts paid to the shepherds.

To sum up, the adoption of resource management programs should rely on their consistency with ecological processes. Accordingly, real fire prevention scenarios comprise a variety of network designs and cleaning tools that are combined depending on several criteria, such as topography, type of biomass or soil features. Subsequent consideration of social preferences could help to better shape fire prevention activities. Gaining understanding on the public preferences and underlying reasons that influence trust in agency would be desirable for the design of audience targeted campaigns on forest fire prevention as it may determine to a greater extent citizens' support to wildfire policies. Results from this study could be useful for this purpose.

Acknowledgements

Funding from Spanish National Research Council (CSIC) is acknowledged. This paper is part of the doctoral thesis of the first author. Authors are grateful to José Luis González-Rebollar, Francisco Rodríguez y Silva and José L. Oviedo for helpful comments. The ideas expressed in this piece of research do not necessarily reflect the views of the institutions they are affiliated with. All errors and omissions are the sole responsibility of the authors.

References

ABSHER, J. D., VASKE, J. J. & SHELBY, L. B. (2009) Residents' Responses to Wildland Fire Programs: A Review of Cognitive and Behavioral Studies. Albany, CA, Department of Agriculture, Forest Service, Pacific Southwest Research Station.

AGEE, J. K., BAHRO, B., FINNEY, M. A., OMI, P. N., SAPSIS, D. B., SKINNER, C. N., VAN WAGTENDONK, J. W. & PHILLIP WEATHERSPOON, C. (2000) The use of shaded fuelbreaks in landscape fire management. *Forest Ecology and Management,* 127**,** 55-66.

ALEXANDRIAN, D., LAMPIN, C., MAVSAR, R., MOGAS, J., RIERA, P. & TOLRON, J. (2005) Towards methods for studying the costs-to-benefits ratio of wildland fire prevention. EUFIRELAB: Euro-Mediterranean Wildland Fire Laboratory, a "wall-less" Laboratory for Wildland Fire Sciences and Technologies in the Euro-Mediterranean Region. **http://www.eufirelab.org**.

BENGOCHEA, A., FUERTES, A. M. & DEL SAZ, S. (2007) Análisis conjunto y espacios naturales: Una aplicación al Paraje Natural del Desert de les Palmes. *Investigación Agraria: Sistemas y Recursos Forestales,* 16**,** 158-168.

BORREGO, D. A. (2010) Value equivalency analysis: quantity compensation, distance decay and time treatment. . Barcelona, Autonomous University of Barcelona.

BREY, R., RIERA, P. & MOGAS, J. (2007) Estimation of forest values using choice modeling: An application to Spanish forests. *Ecological Economics,* 64**,** 305-312.

BROUWER, R. & MARTÍN-ORTEGA, J. (2011) Modeling self-censoring of polluter pays protest votes in stated preference research to support resource damage estimations in environmental liability. *Resource and Energy Economics,* 34**,** 151-166.

CONSEJERÍA DE MEDIO AMBIENTE (2010) Adecuación del Plan Forestal Andaluz. Horizonte 2015. Sevilla (Spain), Junta de Andalucía.

CROITORU, L. (2007) How much are Mediterranean forests worth? *Forest Policy and Economics,* 9**,** 536-545.

CUBBAGE, F., HAROU, P. & SILLS, E. (2007) Policy instruments to enhance multi-functional forest management. *Forest Policy and Economics,* 9**,** 833-851.

DANIEL, T. C., CARROLL, M. S. & MOSELEY, C. (2007) *People, fire and forests: a synthesis of wildfire social science*, Oregon State University Press.

DOMÍNGUEZ-TORREIRO, M. & SOLIÑO, M. (2011) Provided and perceived status quo in choice experiments: Implications for valuing the outputs of multifunctional rural areas. *Ecological Economics,* 70**,** 2523-2531.

DUGUY, B., ALLOZA, J. A., RÖDER, A., VALLEJO, R. & PASTOR, F. (2007) Modelling the effects of landscape fuel treatments on fire growth and behaviour in a Mediterranean landscape (eastern Spain). *International Journal of Wildland Fire,* 16**,** 619-632.

DZIEGIELEWSKA, D. & MENDELSOHN, R. (2007) Does “No” mean “No”? A protest methodology. *Environmental and Resource Economics,* 38**,** 71-87.

FRIED, J. S., WINTER, G. & GILLESS, J. K. (1999) Assessing the benefits of reducing fire risk in the wildland-urban interface: A contingent valuation approach. *International Journal of Wildland Fire,* 9**,** 9-20.

GONZÁLEZ-CABÁN, A., LOOMIS, J. B., RODRIGUEZ, A. & HESSELN, H. (2007) A comparison of CVM survey response rates, protests and willingness-to-pay of Native Americans and general population for fuels reduction policies. *Journal of Forest Economics,* 13**,** 49-71.

GREENE, W. H. (2007) NLogit Version 4.0, Econometric Software. New York and Sidney.

HANEMANN, M. W. (1984) Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses. *American Journal of Agricultural Economics,* 66**,** 332-341.

HANLEY, N., COLOMBO, S., MASON, P. & JOHNS, H. (2007) The Reform of Support Mechanisms for Upland Farming: Paying for Public Goods in the Severely Disadvantaged Areas of England. *Journal of Agricultural Economics,* 58**,** 433-453.

HANLEY, N., MOURATO, S. & WRIGHT, R. E. (2001) Choice modelling approaches: a superior alternative for environmental valuation? *Journal of Economic Surveys,* 15**,** 435- 462.

HANLEY, N., WRIGHT, R. E. & ADAMOWICZ, W. (1998) Using choice experients to value the environment. *Environmental and Resource Economics,* 11 (34)**,** 413-428.

HESSELN, H., LOOMIS, J. B. & GONZÁLEZ-CABÁN, A. (2004) Comparing the economic effects of fire on hiking demand in Montana and Colorado. *Journal of Forest Economics,* 10**,** 21-35.

HOLMES, T. P. & BOYLE, K. J. (2004) Stated preference methods for valuation of forest. IN SILLS, E. O. & LEE ABT, K. (Eds.) *Forests in a market economy.* Dordrecht (The Netherlands), Kluwer Academic Publishers.

IEA (INSTITUTO DE ESTADÍSTICA DE ANDALUCÍA) (2009) Estadística básica de Andalucía. Sevilla, Junta de Andalucía,.

JORGENSEN, B. S. & SYME, G. J. (2000) Protest responses and willingness to pay: attitude toward paying for stormwater pollution abatement. *Ecological Economics,* 33**,** 251-265.

KAVAL, P., LOOMIS, J. & SEIDL, A. (2007) Willingness-to-pay for prescribed fire in the Colorado (USA) wildland urban interface. *Forest Policy and Economics,* 9**,** 928-937.

LOOMIS, J. & GONZÁLEZ-CABÁN, A. (1994) Estimating the Value of Reducing Fire hazards to Old-Growth Forests in the Pacific-Northwest - a Contingent Valuation Approach. *International Journal of Wildland Fire,* 4**,** 209-216.

LOOMIS, J. B. & GONZÁLEZ-CABÁN, A. (1998) A willingness-to-pay function for protecting acres of spotted owl habitat from fire. *Ecological Economics,* 25**,** 315-322.

LUSK, J. L., ROOSEN, J. & FOX, J. A. (2003) Demand for beef from cattle administered growth hormones or fed genetically modified corn: a comparison of consumers in France, Germany, the United Kindom, and the United States. *American Journal of Agricultural Economics,* 85**,** 16-29.

MINISTERIO DE MEDIO AMBIENTE (2006) Los incendios forestales en España. Decenio 1996-2005. Madrid, Ministerio de Medio Ambiente.

Área de Defensa contra Incendios Forestales.

MINISTERIO DE MEDIO AMBIENTE (2008) Los incendios forestales en España durante el año 2008. IN CENTRO DE COORDINACIÓN DE LA INFORMACIÓN NACIONAL SOBRE INCENDIOS FORESTALES (Ed.). Ministerio de Medio Ambiente.

OLIVERAS, I., GRACIA, M., MORÉ, G. & RETANA, J. (2009) Factors influencing the pattern of fire severities in a large wildfire extreme meteorological conditions in the Mediterranean basin. *International Journal of Wildland Fire,* 18**,** 755-764.

PAPANASTASIS, V. P. (2009) Grazing Value of Mediterranean Forests. IN PALAHI, M., BIROT, Y., BRAVO, F. & GÓRRIZ, E. (Eds.) *Modelling, Valuing and managing mediterranean Forest Ecosystems for Non-Timber Goods and Services. .* Joensuu (Finland), European Forest Institute.

PIÑOL, J., CASTELLNOU, M. & BEVEN, K. J. (2007) Conditioning uncertainty in ecological models: Assessing the impact of fire management strategies. *Ecological Modelling,* 207**,** 34-44.

RIERA, P. & MOGAS, J. (2004) Evaluation of a risk reduction in forest fires in a Mediterranean region. *Forest Policy and Economics,* 6**,** 8.

RIERA, P., PEÑUELAS, J., FARRERAS, V. & ESTIARTE, M. (2007) Valuation of climate-change effects on Mediterranean shrublands. *Ecological Applications,* 17(1)**,** 91- 100.

ROBLES CRUZ, A. B., RUIZ MIRAZO, J., RAMOS FONT, M. E. & GONZÁLEZ REBOLLAR, J. L. (2008) Role of grazing livestock in sustainable use, fire prevention and naturalization of marginal ecosystems of southeastern Spain. IN RIGUEIRO RODRÍGUEZ, A., MC ADAM, J.

& MOSQUERA LOSADA, R. (Eds.) *Agroforestry in Europe. Current Status and Future Prospects.*, Springer.
RODRÍGUEZ Y SILVA, F. (2004) Análisis económico aplicado al control de la carga de combustibles en ecosistemas forestales mediterráneos. Quemas prescritas, una alternativa frente a los medios mecánicos. *II Simposio Internacional sobre Políticas, Planificación y Economía de los Programas de Protección Contra Incendios Forestales.* Córdoba (España).
RUIZ-MIRAZO, J., ROBLES, A. B. & GONZÁLEZ-REBOLLAR, J. L. (2011) Two-year evaluation of fuelbreaks grazed by livestock in the wildfire prevention program in Andalusia (Spain). *Agriculture, Ecosystems and Environment,* 141**,** 13-22.
SCHMIDT, D. A., TAYLOR, A. H. & SKINNER, C. N. (2008) The influence of fuels treatment and landscape arrangement on simulated fire behavior, Southern Cascade range, California. *Forest Ecology and Management,* 255**,** 3170-3184.
SOLIÑO, M. (2010) External benefits of biomass-e in Spain: An economic valuation. *Bioresource Technology,* 101**,** 1992-1997.
SOLIÑO, M., FARIZO, B. A., VÁZQUEZ, M. X. & PRADA, A. (2012) Generating electricity with forest biomass: Consistency and payment timeframe effects in choice experiments. *Energy Policy,* 41**,** 798-806.
SOLIÑO, M., PRADA, A. & VÁZQUEZ, M. X. (2010) Designing a forest-energy policy to reduce forest fires in Galicia (Spain): A contingent valuation application. *Journal of Forest Economics,* 16**,** 217-233.
STARBUCK, C. M., BERRENS, R. P. & MCKEE, M. (2006) Simulating changes in forest recreation demand and associated economic impacts due to fire and fuels management activities. *Forest Policy and Economics,* 8**,** 52-66.
TOMAN, E. & SHINDLER, B. (2006) Communicating the Wildland Fre Message: Influences on Knowledge and Attitude Change in Two Case Studies. IN ANDREWS, P. L. & BUTLER, B. W. (Eds.) *Fuels Management- How to Measure Sucess.* Portland, OR, Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
TRAIN, K. (2003) *Discrete Choice Methods With Simulation,* Cambridge, UK, Cambridge University Press.
VÉLEZ MUÑOZ, R. (2009) The Causing Factors: A Focus on Economic and Social Driving Forces. IN BIROT, Y. (Ed.) *Living with wildfires: what science can tell us. EFI Discussion Paper 15.* Joensuu (Finland), European Forest Institute.
VENN, T. & CALKIN, D. E. (2011) Accomodating non-market values in evaluation of wildfire management in the United States: challenges and opportunities. *International Journal of Wildland Fire,* 20**,** 327-339.
WALKER, S. H., RIDEOUT, D. B., LOOMIS, J. B. & REICH, R. (2007) Comparing the value of fuel treatment options in northern Colorado's urban and wildland-urban interface areas. *Forest Policy and Economics,* 9**,** 694-703.
WINTER, G., VOGT, C. A. & MCCAFFREY, S. (2004) Examining social trust in fuel management strategies. *Journal of Forestry***,** 8-15.
WINTER, G. J. & FRIED, J. S. (2001) Estimating Contingent Values for Protection from Wildland Fire Using a Two-Stage Decision Framework. *Forest Science,* 47**,** 349-360.