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Social preferences for fuel break management programs in Spain: a choice modelling application to prevention of forest fires

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Abstract. This article reports on an economic valuation study of alternative fire prevention programs in the province of Málaga, southern Spain. The main aim of this study was to explore the social preferences for several forest fire prevention management issues. Fuel break programs were presented that differed in terms of cleaning technique (controlled grazing, prescribed burning and mechanical treatments), design (from traditional linear unshaded fire breaks to more landscape and environmentally friendly structures, such as shaded fuel breaks) and density (linked to annual burnt area). Results show that the population was clearly interested in the potential of the proposed programs to reduce fire. Lessons learnt from this study could be relevant for the development of fire prevention policies and specific prevention campaigns in Mediterranean forests.

Additional keywords: contingent ranking, random parameters, wildfires, willingness-to-pay.

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Introduction

Fuel breaks are commonly used in Spain to slow or stop the progress of bushfire or wildfire. When launching a fire prevention program, several decisions need to be made concerning these systems; namely the cleaning technique (e.g. brushcutting or prescribed burning), the design (shaded or unshaded) and the density of the grid.

This study was located in Andalusia, the southernmost region in Spain. Within the frame of the Andalusian Plan for Fire Prevention and Suppression (INFOCA), controlled grazing is being increasingly employed as a tool for fuel management. There is also a progressive substitution of traditional linear unshaded fuel breaks (where appropriate), to reduce costs and some of the potential negative effects of the use of heavy machinery and traditional fuel break designs on the landscape. However, no information is available on whether citizens care about these changes or regard them as having a positive influence on their welfare. The objective of this study was to assess the social preferences for several attributes related to fuel break management programs.

Environmental economic valuation can be used to incorporate social preferences to forest management. Among the different economic valuation methods, choice modelling (CM) involves a family of survey-based methods for modelling people's preferences for multiple goods and services (Hanley *et al.* 2001). CM involves the characterisation of the object of study, in our case fuel break management, through several attributes and the levels these take. These attributes are combined to create hypothetical scenarios or alternatives. Individuals make their choice based on these scenarios, and they implicitly make tradeoffs between the levels of the attributes of the different alternatives presented (including a monetary attribute allows estimation of the implicit price for each of the attributes).

Several economic valuation studies have tackled the issue of forest fires. Vaux *et al.* (1984) conducted the first study about the influence of fire on the economic value of forest recreation. Loomis and González-Cabán (1994, 1998) conducted contingent valuation (CV) studies across several states in the USA to estimate population willingness-to-pay (WTP) for protecting acres of spotted owl habitat in California against fire. Winter and Fried (2001) conducted a CV study to assess the value of collective fire protection at the wildland–urban interface, for residents of a Michigan jack pine (*Pinus banksiana* Lamb) forest. Their findings show that 75% of the 265 residents interviewed were willing to pay over $57 a year for a 50% reduction in fire risk. González-Cabán *et al.* (2007) applied the CV method to determine the level of support among Native American communities in Montana for two wildland mitigation strategies (prescribed burning and mechanical fuel reduction). Related to that study, a more complete overview is shown in Loomis and González-Cabán (2008). They conducted a CV study in three states to test residents' WTP for fuel reduction programs and found less support for mechanical fuel reduction than for prescribed burning. Kaval *et al.* (2007) applied CV to test WTP values of Colorado residents for prescribed burning. Perceived fire danger and fire frequency influenced respondents' WTP. Finally, Walker *et al.* (2007) conducted a CV study to compare WTP of urban and wildland–urban interface residents for forest fuel treatment programs.

In Spain, a limited number of studies have dealt with forest fire valuation. Riera and Mogas (2004) carried out a referendum application to evaluate a policy achieving a 50% reduction of the risk of forest fires as a result of a fire prevention and fire fighting program in Catalonia (Spain). They obtained an approval rate between 58.7 and 67.4%, meaning the majority of the population would be willing to pay the extra €6 for the proposed risk reduction. Riera *et al.* (2007) elicited the tradeoffs in perceived values for three climate-sensitive attributes of shrubland. Soil erosion was the attribute the population felt most concerned about, followed by fire risk and then plant cover. Soliño *et al.* (2010, 2012) and Soliño (2010) tested consumers' preferences using CV and CM for a policy replacing conventional electricity with electricity generated from forest biomass. Their results show that consumers have a preference for the secondary benefits related to the use of forest biomass, such as lower risk of forest fires. In contrast, Domínguez-Torreiro *et al.* (2013) found that risk of forest fire is not a significant attribute influencing social preferences for rural development programs in northern Spain.

This article reports on a study of people's preferences for alternative fuel breaks management options in Andalusia (southern Spain). The different alternatives were generated as combinations of cleaning technique, fuel break design and density of the grid. The approach chosen was contingent ranking (CR): respondents to the survey were asked to make a succession of choices from which the ranking of scenarios in each choice set could be inferred.

The preliminary focus groups showed that respondents identified preferences for risk reduction, therefore suggesting a related social value. This is a key finding, because respondents were clearly interested in the potential to reduce fire. Furthermore, the main results show that respondents are willing to pay almost €12 for a change in the fuel break cleaning practices towards either light machinery (backpack brushcutting) or controlled grazing. The attribute describing different options for the density of the fuel break coupled with a reduction in the burnt area shows the highest values of WTP, which range from €21.85 to €31.45.

The remainder of the paper is organised as follows: it begins with the description of the econometric model, the experimental design, the study area and the survey. Then, the models fitted with the results obtained from the CR survey are presented. The final section is devoted to discussion and conclusions.

Materials and methods

Contingent ranking

In the CR each respondent was presented with 16 choice cards, each one containing the 'status quo' alternative with no payment required, and three unlabelled fire prevention program alternatives. In each choice set, respondents were first asked to select the most preferred alternative, then 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 in each choice set.

The statistical analysis of responses is based on random utility theory. Individuals ($i = 1, \ldots, I$) are assumed to maximise their utility when they choose from a set of alternatives ($j = 1, \ldots, J$) from a choice set (C). For each alternative j of the choice set, the individual's 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.

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

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

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

Beggs *et al.* (1981) developed the econometric model to analyse 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:

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

Beggs *et al.* (1981) developed the econometric model to analyse 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:

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

where α_j is an alternative-specific constant (SQ) taking value 1 if the individual chooses 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 identically and independent distributed 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 makes the observed sequence of rankings $[y_1, y_2, \ldots, y_T]$ is calculated by solving Eqn 5 through simulation (Train 2003; Hensher *et al.* 2005):

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

Study area and experimental design

Málaga is a coastal province located in Andalusia, southern Spain (Fig. 1). Its 740 000-ha forest and other wooded land (FOWL), formed by Mediterranean species, account for almost half of its surface. Forest fires burnt an average of almost 1000 ha per year in Málaga from 1999 to 2008 (Ministerio de Medio Ambiente 2008). However, there is large variation between years, which is closely related to weather conditions, mainly the length of the dry summer season.

In Málaga, wildfire hazard reduction traditionally has been based on forest compartmentalisation by networks of unshaded linear fuel breaks. Scarification by angle dozer removing heavy ground fuels is widely employed for the maintenance of the fuel breaks. This is the most widespread situation in the province, although some changes have occurred in recent years: shaded irregular structures are becoming more abundant whereas controlled grazing activities are being developed within the regional network of grazed fuel breaks (Ruiz-Mirazo *et al.* 2011).

The CR attributes and levels were selected after consultation with forest fire prevention and suppression managers, as well as with several expert researchers[A]. In addition, three focus groups (FG) with potential respondents were conducted to secure good comprehension of the valuation questionnaire. The first FG tested whether the attributes and levels designed in collaboration with researchers were also relevant for laypeople. The main output from this session was that people linked the design of the fuel breaks with the amount of burnt area. The second FG was conducted in a mountainous rural area in Málaga, and tested general comprehension of the management attributes and appropriateness of the payment vehicle. People in rural areas held a deeper knowledge of fire dynamics but were also very critical of the forest fire agency. People in both FGs stated their preferences for the design attribute based on their perception of the risk of fire spread in each design. It led us to include a third attribute that clearly stated the expected burnt area regardless of the design of the fuel break network. The third FG tested the final version of the questionnaire. Finally, several pilot tests were conducted, each with 20 potential respondents, to test general performance of the questionnaire.

Three non-monetary attributes (Table 1), each with four levels, were employed to describe the alternative scenarios in fire prevention management in the province: fuel break cleaning tools, fuel break designs, and the density of fuel breaks and burnt area.

The levels chosen for the cleaning technique attribute were: scarification with an angle dozer (SWA), backpack brushcutting

Fig. 1. Study area.

Table 1. Attributes and levels

Attributes	Levels	Variable
Fuel break cleaning technique	Scarification with angle dozer[A]	SWA
	Backpack brushcutter	BB
	Controlled grazing	CG
	Prescribed burning	PB
Fuel break design	Linear unshaded[A]	LINU
	Linear shaded	LINS
	Irregular unshaded	IRRU
	Irregular shaded	IRRS
Density of fuel breaks (area burnt yearly)	Low (1000 ha burnt)[A]	LOW
	Medium (800 ha burnt)	MED
	High (600 ha burnt)	HIGH
	Very High (400 ha burnt)	VHIGH
Annual payment	€0[A]	COST
	€20	
	€60	
	€100	
	€140	

[A]Status quo level.

[A]Forest researchers from the Research Group of Mediterranean Pastures and Silvopastoral Systems from the National Research Council–CSIC from Granada (Andalusia) helped in setting the levels for the cleaning attribute plus the levels for the design attribute. Professor Rodriguez y Silva from the Fire Division of the Forest Engineering Department at the University of Cordoba helped us in setting the levels for the density of fuel breaks–burnt area attribute. The interaction with managers and researchers ultimately ensured that the outputs, in terms of social demand, were meaningful for research and management purposes.

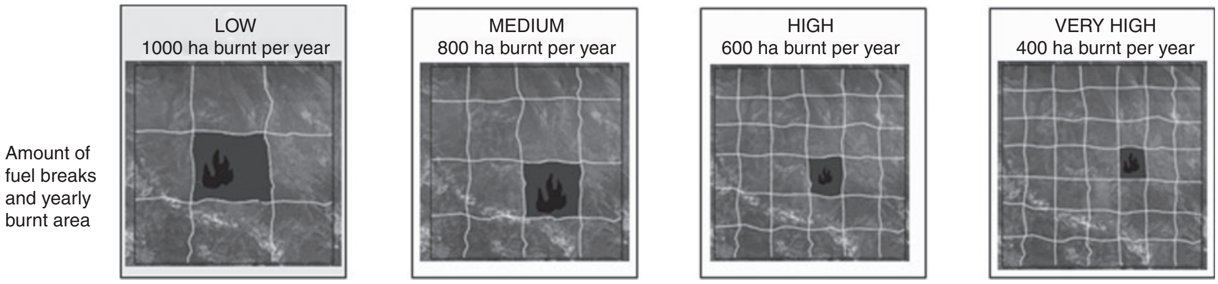

Fig. 2. Levels for the fuel break density and burnt area attribute.

(BB), controlled grazing (CG) and prescribed burning (PB). SWA is the most commonly used method in Málaga to clear up the fuel breaks, whereas BB, because of its higher cost, is restricted to very steep areas or landscape-sensitive (e.g. recreational) areas, where it may be difficult for angle dozers to access or the risk of soil erosion and soil losses would potentially be high, and where the effect of works by heavy machinery could reduce the attractiveness of these areas. Forestry agencies in Spain are introducing CG and PB to complement mechanical treatments, in order to reduce the costs of maintenance of fuel breaks and to improve fuel control beyond these areas (e.g. clearing practices in over-dense pine afforestation stands). The grazing of sheep and goats may be a suitable method for reducing landscape biomass to comply with fire prevention standards (Piñol *et al.* 2007; Robles Cruz *et al.* 2008; Ruiz-Mirazo *et al.* 2011). Regarding prescribed fire, its use as a management tool is still experimental in Andalusia, but it is showing promising results (Rodríguez y Silva 2004).

The 'design attribute' shows combinations of linear or irregular edges with the presence or absence of trees inside the structures, to create a four-level attribute for the design of fuel breaks: linear unshaded (LINU), irregular unshaded (IRRU), linear shaded (LINS) and irregular shaded (IRRS). In the light of improved knowledge of fire and fuel behaviour (Agee *et al.* 2000; Duguy *et al.* 2007; Schmidt *et al.* 2008; Oliveras *et al.* 2009), the design and spatial distribution of the traditional LINU structures is being reconsidered.

The third attribute – density of fuel breaks and burnt area – was included on the basis of the FG results. Most participants attached a higher risk of fire spread (and therefore a higher amount of burnt area) to shaded structures and they chose their preferred designs according to their perception of each structure's probability of stopping the fire. Individuals therefore would have been left to reach their own conclusions about the outcomes resulting from changes in the design of preventive structures (i.e. to what extent a certain fire break (FB) design results in more burnt area). This is highly undesirable when respondents have little familiarity with respect to the attribute in question and biased estimations result.

The previous findings, together with the potential relevance of the density of the network in a policy and management context, led us to include an attribute where explicit and plausible reductions in the annual burnt area were considered jointly with an increase in the network density. A denser network is expected to improve firefighter access, increasing the probability of success in the initial attack (Agee *et al.* 2000) and hence, reducing the annual burnt area (Husari *et al.* 2006). Although absolute standards for fuel break design and maintenance are difficult to define, Duguy *et al.* (2007) in their simulation show that FB networks result in a significant fire size reduction in relation to no FB.

The pictures shown to respondents (Fig. 2) consisted of an aerial view of a generic forest of 625 ha (2500 × 2500 m) where four different densities of FBs are represented. The first level of the attribute shows a density of FBs of 15 linear metres (lm) per hectare, corresponding approximately to the current situation in public forest lands in Málaga. The rest of the pictures show increasing densities of FBs: 25, 40 and 50 lm ha^{-1}. According to the researchers consulted, these ranges would allow for a reduction in the burnt area compared with the status quo situations of ~15, 35 and 45%.

The burnt square shown in each of the pictures was intended to illustrate to respondents the expected outcome of a denser network in which forest fires can be stopped more quickly compared with low density scenarios, resulting in a reduction of burnt hectares.

The fire researchers provided us with a set of ranges of plausible reduction levels in burnt area, depending on the density of preventive structures and on the vegetation structure. Within these ranges, the levels for this attribute had to be equally spaced in terms of burnt hectares, because of econometric requirements for subsequent estimations. The three given alternative levels to the status quo have reduced burnt areas with intervals of 200 ha, which represents a reduction in burnt area with respect to the SQ of 20, 40 and 60%. The aforementioned requirement means the figures and the images do not correspond exactly, but tests in FG showed respondents did not perceive this.

To summarise, the attribute levels were: (i) low density of FBs and 1000 ha burnt yearly (LOW) (ii) medium density of FBs and 800 ha burnt yearly (MED), (iii) high density of FBs and 600 ha burnt yearly (HIGH) and (iv) very high density of FBs and 400 ha burnt yearly (VHIGH).

Finally, a monetary attribute (increase in taxes) was included to calculate the value that respondents attach to a change in a particular attribute (implicit price) and relevant welfare change scenarios. The levels employed were €20, €60, €100 and €140 per year.

Fig. 3 shows an example from the 16 choice cards presented to each respondent. The choice sets utilised in our study were designed following an optimal-in-difference design as proposed by Street and Burgess (2007). The levels used to describe the status quo option reflect the currently most widespread management practice in Málaga.

The sample

A representative sample of 510 Málaga citizens was interviewed in December 2009. Interviews were conducted face-to-face

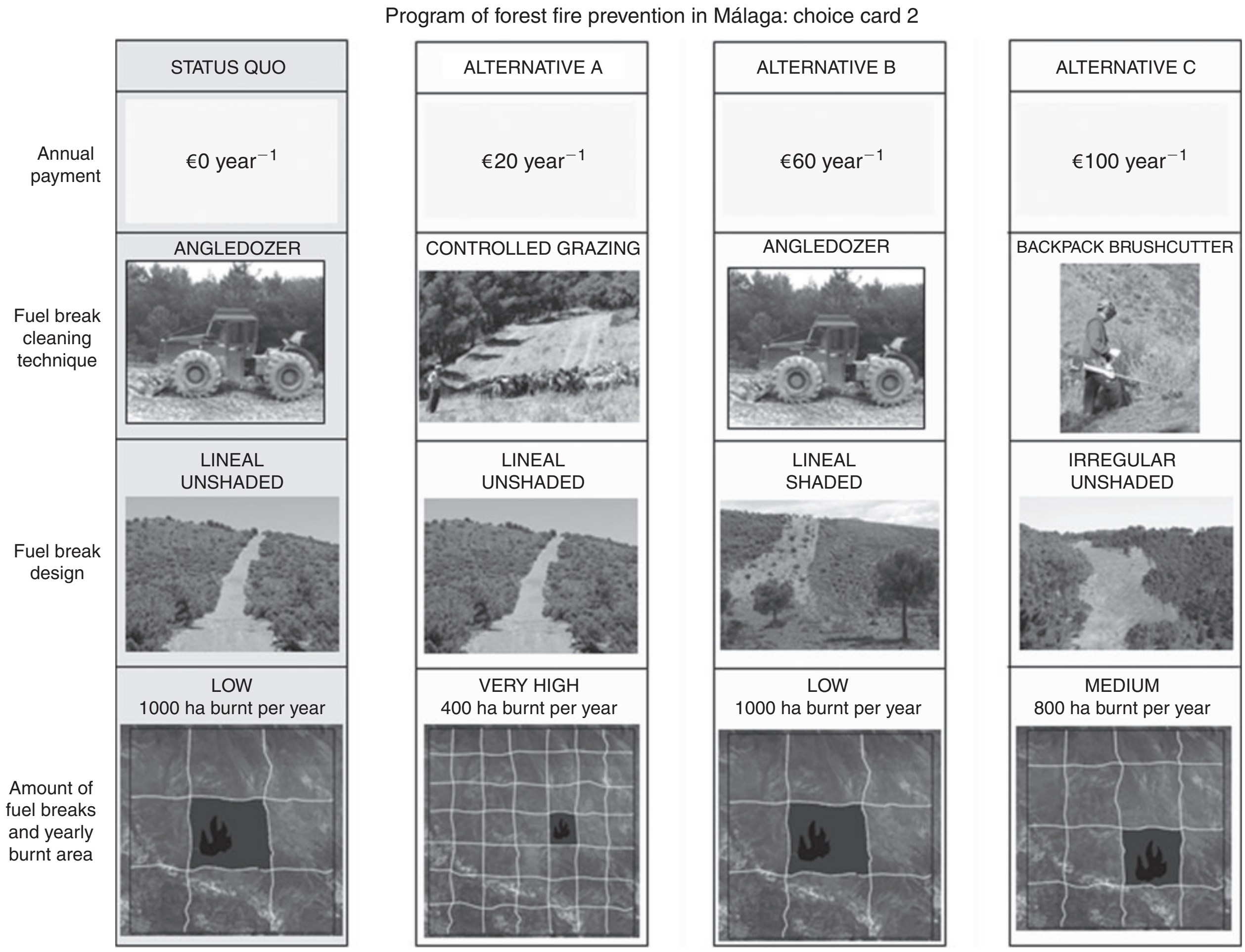

Fig. 3. Choice card example.

Table 2. Socioeconomics of the surveyed respondents

Variable	Sample	Málaga population
Sex (percentage 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 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	15.0%	12.1%
Primary school finished	26.2%	18.8%
Secondary school finished	35.8%	47.4%
Graduate	15.5%	18.3%

in respondents' houses. The sample included residents from 24 locations throughout the province and it was weighted according to their population size and stratified into three blocks belonging to urban, metropolitan and rural municipalities. The socio-demographic characteristics of the respondents are summarised in Table 2.

Follow-up questions were used to identify protest responses and inconsistent choices. They were removed from our sample, because they are assumed to give unreliable information about preferences, leading to a final sample of 397 individuals for the subsequent analysis.

Results

Within a Random Parameter Logit model specification, in our study all attributes apart from the cost were assumed to be normally distributed. The 'cost' attribute was 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 SQ were interacted with socio-demographic variables. After extensive testing, seven variables (Table 3) were included as interaction terms with the SQ in the final utility specification.

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). Results show that the expanded model (which includes socio-demographic interactions), gives a better fit than does 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. This is consistent with FGs where people regarded both techniques as valid options for reducing fuel loads in FBs. On the other hand, PB has a negative coefficient, indicating that its adoption reduces the wellbeing of respondents, i.e. their utility, in economic terms.

As for the FB design parameters, only IRRS is found to be statistically significant, suggesting that people's preferences are only influenced when a shift towards this design occurs. All the design parameters hold very low values, indicating a small contribution to respondents' wellbeing.

Concerning the parameters for the density of FBs, the HIGH and VHIGH parameters show that respondents experience a positive and higher utility when the density of FBs increases. These two parameters show the highest positive values, indicating that respondents hold a high value for the reduction of fire risk and burnt area. Specifically, this aspect seems to be the one they are most concerned about. This result is in accordance with the results from FGs where respondents clearly indicated an interest in the potential of these structures to reduce fire.

The positive SQ implies that people generally do not want a fire prevention program or that respondents perceive other negative effects. Nonetheless, the inclusion of socioeconomic interactions in the extended model captures the individual heterogeneity in attitudes towards these fire prevention programs. Urban dwellers have a higher probability of choosing an alternative to the current situation whereas rural inhabitants are more reluctant to pay for such changes. Recreationists have a higher probability of choosing an alternative program. These results are in accordance with studies where users typically tend to have higher valuations for landscape improvements (Hanley *et al.* 1998).

Budget constraints and household structure also influence respondents' choices. Results regarding income somehow counteract our expectations. However, the magnitude of the interaction term indicates that its contribution to the preference construction is very low. The probability of choosing the status quo scenario seems to be influenced by individual disposable income: the probability decreases with more (income-earning)

Table 3. Socio-demographic 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: > €1200; 0: €0–€1200)
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. RPL results

*, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$

	Attributes model		Expanded model	
	Mean coefficient of distribution (s.e.)	s.d. of parameter distributions (s.e.)	Mean coefficient of distribution (s.e.)	s.d. of parameter distributions (s.e.)
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			−0.604 (0.023)***	
VISIT			−1.241 (0.020)***	
WORK			0.950 (0.019)***	
INCOME			0.004 (0.000)***	
ADULTS			−0.169 (0.010)***	
CHILDREN			0.182 (0.011)***	
DIFFICULTY			0.511 (0.030)***	
Pseudo-R^2	0.1622		0.1770	
log-likelihood function	−16 566.59		−16 273.21	
Number of observations	6352		6352	

adults in the household and increases with the number of children at home. This suggests that respondents with children are mainly concerned with the budget constraint it would impose, and not so much with bequeathing an environment with less burnt hectares or with structures better integrated in the landscape, for example.

Encountering difficulties in answering the questionnaire increases the probability of choosing the current scenario. Our results support those of studies demonstrating that uncertainty leads to an increase in the probability of choosing the status quo alternative (Swait and Adamowicz 2001; Loomes *et al.* 2009; Balcombe and Fraser 2011;). However, it is worth mentioning that the respondents scoring the exercise as difficult or very difficult represent less than 11% of the final sample.

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

$$MWTP_k^j = -\frac{\beta_k^j - \beta_{base\,level}^j}{\beta_{\cos t}} \tag{6}$$

Table 5. Marginal willingness-to-pay (MWTP) results
*, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$

Attribute	Attributes model Mean MWTP (s.e.)	Expanded model Mean MWTP (s.e.)
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)***

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

Welfare changes can be obtained by using the compensating surplus (CS) formula described by Hanemann (1984)

$$CS = -(V_1 - V_0) \div \beta_{\cos t} \tag{7}$$

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 WTP to move from the status quo to the different fire prevention programs presented in Table 6. These programs are generated as combinations of the attribute's levels intending to mimic sound management scenarios. Low-density programs (LDP) represent a conservative scenario, where the network would remain the same as in the status quo situation. Medium-density (MDP) and landscape-friendly programs (LFP) include an eventual increase in the network density. The former are more similar to the current scenario, whereas the latter represents a shift towards more environmentally friendly scenarios by considering only irregular shaded designs for the prevention structures. In this case, SWA is discarded, because of its incompatibility with shaded structures.

Consumer surpluses calculated for the different management programs are provided in euros per individual per year, per hectare of FOWL and also per hectare of FB structures.

Changes in wellness are noteworthy when moving from LDP to MDP, surpassing €100 per individual and showing that an important social demand exists for a denser network and reduced burnt area. Despite LFP showing the highest surpluses among the three programs, the surplus gains when compared with equivalent MDP scenarios are moderate (below €15 per individual).

Comparison was established between LDP estimations and market rates published by TRAGSA (2011), a publicly owned company that executes nationwide nature protection works

Table 6. Fire prevention programs

Fire program	Fuel break attribute levels			Compensating surplus		
	Cleaning technique	Design	Density	(€ individual^{-1} year^{-1})	(€ ha^{-1} of FOWL year^{-1})	(€ ha^{-1} of fuel breaks year^{-1})
Low-density programs						
LDP1[A]	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

[A]Status quo scenario.

entrusted to different administrations. Comparison can only be established with the brushcutting technique, as controlled grazing and prescribed burning are far from commonly applied, and hence tariffs have not been developed for these tools to date. However, these tools are expected to represent reduced costs compared with light machinery (Rodríguez y Silva 2004; Varela *et al.* 2007). The cost of brushcutting activities ranges from €239 ha^{-1} to €3000 ha^{-1} according to shrub density and diameter, and land steepness. The value of €1283.91 ha^{-1} obtained in the CS scenarios would fall in the mid region of the cost ranges, showing that the values obtained (in terms of welfare gains) are within the range of market rates for biomass control activities.

LDP2 shows that the social demand for controlled grazing in the current scenario has a value of €1254.31 ha^{-1} of FB per year. The network of grazed FBs in Andalusia pays shepherds with a remuneration that ranges from €42 to €90 ha^{-1} per year, in proportion to the estimated grazing difficulty (Ruiz-Mirazo *et al.* 2011). Therefore, WTP results exceed the policy instrument actually being implemented for controlled grazing. However, these are still experimental programs, where the payments have not been established based on cost-efficient criteria.

Discussion

This study illustrates how the CR method can be employed to estimate WTP for different aspects of FB management and to establish social welfare derived from different management scenarios for these fire prevention structures. This study contributes to the limited literature on the estimation of economic values for forest fire prevention in a Mediterranean area where fires are one of the main threats to forest conservation.

Results show that the respondents, although being sensitive to other attributes, are most drawn to fire risk reduction through the increase in the density of F; this being the aspect they valued most. This is a relevant outcome that was also shown in the FGs conducted. The high density levels of prevention structures might not be feasible because of the high maintenance costs and ecological and visual effects these might entail. However, including them lets us capture the social demand for these levels and the value respondents hold for fire risk reduction.

Current payments to the shepherds, far from being overestimated, are significantly lower than the welfare gains that society makes from the implementation of the controlled grazing technique. The social values obtained for this technique exceed those of any policy instrument that would actually be implemented. However, they indicate that some room may exist, obviating budgetary restrictions, to allocate a higher budget to the enhancement of the grazed FB network in the region. Specific research on the costs and benefits for this technique would be the logical next step undertaken in the future for a thorough assessment of its suitability. In contrast, a negative mean WTP was found for prescribed burning, because this technique is largely unknown by respondents and familiarity with a given technique is a key variable for the social acceptability of fuels management treatments (McCaffrey *et al.* 2013).

The design of preventive structures contributes very little to respondents' wellbeing when compared with the other attributes. This result is in contrast with the technical or research debates where FBs design is a major issue (Agee *et al.* 2000; Husari *et al.* 2006; Duguy *et al.* 2007; Reinhardt *et al.* 2008; Schmidt *et al.* 2008) and leads us to consider that a relevant gap may exist between forest managers and society in terms of fire perception.

Conclusion

Results from this study could be useful for gaining an understanding of public preferences, and therefore tackling the challenge of incorporating fire hazard considerations with social demands for forests.

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