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ORIGINAL ARTICLE

# Social demand for multiple benefits provided by Aleppo pine forest management in Catalonia, Spain

**Elsa Varela[1,2] · Jette Bredahl Jacobsen[3] · Robert Mavsar[4]**

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**Abstract** This paper estimates the social demand for key benefits provided by Aleppo pine forests in Catalonia that can be enhanced by management. These so-called externalities are the side effects of forest management on citizens' welfare and can be either positive or negative. The externalities addressed are: biodiversity (measured as the number of tree species), accessibility for practicing recreational activities, $CO_2$ sequestration and annual burned area by wildfires. By the use of a choice experiment, an economic valuation method, we estimate in a joint manner people's preferences for these externalities and show that there is a social demand for their enhanced provision. Based on these estimates, we construct three hypothetical scenarios reflecting the range of likely outcomes of different management strategies and calculate the social demand for these scenarios. Results show that the highest gains in terms of social benefits are obtained under a scenario that minimizes the burned area (2044.23 €/ha year). Our estimates show that an increase in the investment in forest management is in line with the social demand for forest benefits and the social support that exists for a related cost increase for inhabitants.

**Keywords** Biodiversity · Carbon sequestration · Fire risk · Recreation · Economic valuation · Choice experiment

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✉ Elsa Varela
elsa.varela@upc.edu

1 Center for Agro-food Economy and Development (CREDA-UPC-IRTA), Edifici ESAB, C/Esteve Terrades, 8, 08860 Castelldefels, Barcelona, Spain

2 European Forest Institute, Mediterranean Regional Office (EFIMED), Sant Pau Historic Site, St. Antoni M. Claret 167, 08025 Barcelona, Spain

3 Department of Food and Resource Economics, Center for Macroecology, Evolution and Climate, University of Copenhagen, Rolighedsvej 23, Frederiksberg C, 1958 Copenhaguen, Denmark

4 European Forest Institute, Yliopistokatu 6, 80100 Joensuu, Finland

## Introduction

Since the late 1960s, agricultural land abandonment and decrease in traditional land use activities have led to an increased area and density of forest in the northern rim of the Mediterranean. Vegetation succession under land abandonment has turned mosaic-like landscapes into increasingly homogeneous patches highly vulnerable to forest fires where only few shade intolerant and pioneer species dominate, such as Aleppo pine (*Pinus halepensis*) (Lasanta-Martínez et al. 2005; Pausas et al. 2004b, Torras et al. 2009; Torras and Saura 2008). Coupled with this is the high risk of losing stocks of carbon due to forest fires (Nabuurs et al. 2008).

Evidence shows that moderately managed forest stands have a higher resilience towards forest fires and provide an enhanced flow of goods and services to the society when compared to unmanaged stands (Lasanta-Martínez et al. 2005; Torras and Saura 2008). Moderate-intensity silvicultural practices have shown to be positively related to species richness and diversity (Gil-Tena et al. 2007; Torras and Saura 2008) and in turn are expected to be better off in terms of resilience (Alloza et al. 2006; Bengtsson et al. 2000; Pausas et al. 2004a).

Forest management has a positive impact on the benefits society perceives from these forests. Surveys conducted in Spain indicate that recreationists in general prefer open forest landscapes (Bujosa Bestard and Riera Font 2010; Caparrós and Campos 2002; Sayadi et al. 2005). A feeling of accessibility and provision of a scenic view seem to be key aspects in people's preferences for forests (Edwards et al. 2012; Gómez-Limón and de Lucío Fernández 1999). Therefore, the highly dense and homogeneous Aleppo pine stands resulting from land abandonment and vegetation succession does not seem to match with people's preferences for recreational space.

There is evidence that the social demand for forest goods and services in the Mediterranean is steadily increasing (Croitoru 2007). However, social preferences are largely disregarded in forest management, partly due to the land being largely privately owned (CPFC 2008). Incorporating social demands would allow for more socially optimal decision-making and planning processes.

In this paper, we investigate public preferences and values for a number of benefits provided by Mediterranean forests that can be tagged as externalities from an economic point of view. Externalities in this context are the side effects of forest management on citizens' welfare. As such, these external effects of forest management can be either positive or negative. Externalities lack a market and hence a price, but do have a value for society, such as biodiversity conservation. Economic valuation methodologies allow estimation of these social values. The choice experiment (CE) method involves characterizing the object of study (here the status of Aleppo pine forests) in terms of its relevant features or attributes (for example, number of tree species or degree of accessibility for recreational activities) and the levels these take (for example, one or two tree species and high or low accessibility, respectively). Combining and varying attributes and levels systematically, different alternatives are created, and respondents are asked to choose between them. Hereby each attribute's relative importance to the others can be estimated (Hanley et al. 2001). Because one of the attributes included is a monetary one, citizens' choices will reflect their preferences with respect to trade-offs between a payment and changes in the level of these attributes, i.e. their willingness to pay (WTP) for these changes.

This study measures the demand of Catalan citizens for four key externalities that Aleppo pine forests provide and that are expected to be enhanced by management: biodiversity (measured as number of tree species); access for recreational purposes, considering physical access and to a lesser extent also visual openness; $CO_2$ sequestration; and burned area by wildfires. Aleppo pine forests are widespread along the Mediterranean and often constitute the only forest ecosystem that can thrive in the arid Mediterranean environments. This paper adds to the relatively limited empirical evidence on social preferences for forest management in the Mediterranean. The novelty of this study is that it addresses in a joint manner the social demand for key externalities that are provided by Mediterranean forests and whose provision depends on management. In particular, the trade-offs between fire resilience, biodiversity and carbon storage are important in this region. Furthermore, we develop a series of scenarios where we consider different levels of provision of these externalities and calculate the social benefits associated with such improvement (see Fig. 1). This allows us to illustrate the potential—and problems—of management with multiple objectives.

## Case area and focus of attributes and scenarios valued

### Case study area

Catalonia is the north-eastern region of the Iberian Peninsula. Within its 32,000 km$^2$ live 7.5 million inhabitants, 60 % of them within the Barcelona metropolitan area (GENCAT 2010). Forests and other wooded land cover almost 2 million hectares (GENCAT 2010) and more than 80 % of it is privately owned. Aleppo pine (*Pinus halepensis*) is the most widespread tree species in Catalonia. Pure Aleppo pine stands occupy almost 10 % of the forest area (Beltrán et al. 2011). The majority of these forests are privately owned, and slow growth and low timber yields that are characteristic for this region often result in poor or no forest management (Terradas et al. 2004). Public programmes have been launched to encourage and fund forest owners to create associations and adopt management plans for these stands. However, despite the described benefits that management would entail, it is not clear whether the Catalan population supports such measures and values the resulting benefits.

### Description of attributes

The key characteristics, or attributes, of the Aleppo pine forests that we would like to value are (see Table 1): biodiversity level (number of tree species), percentage of area of Aleppo pine forests suitable for recreation purposes, tons of carbon sequestered and expected burned area due to forest fires. These attributes and levels were selected after careful revision of the literature, consultation with forest managers and testing in two focus groups. The criteria for choosing attributes were (1) relevant for management and

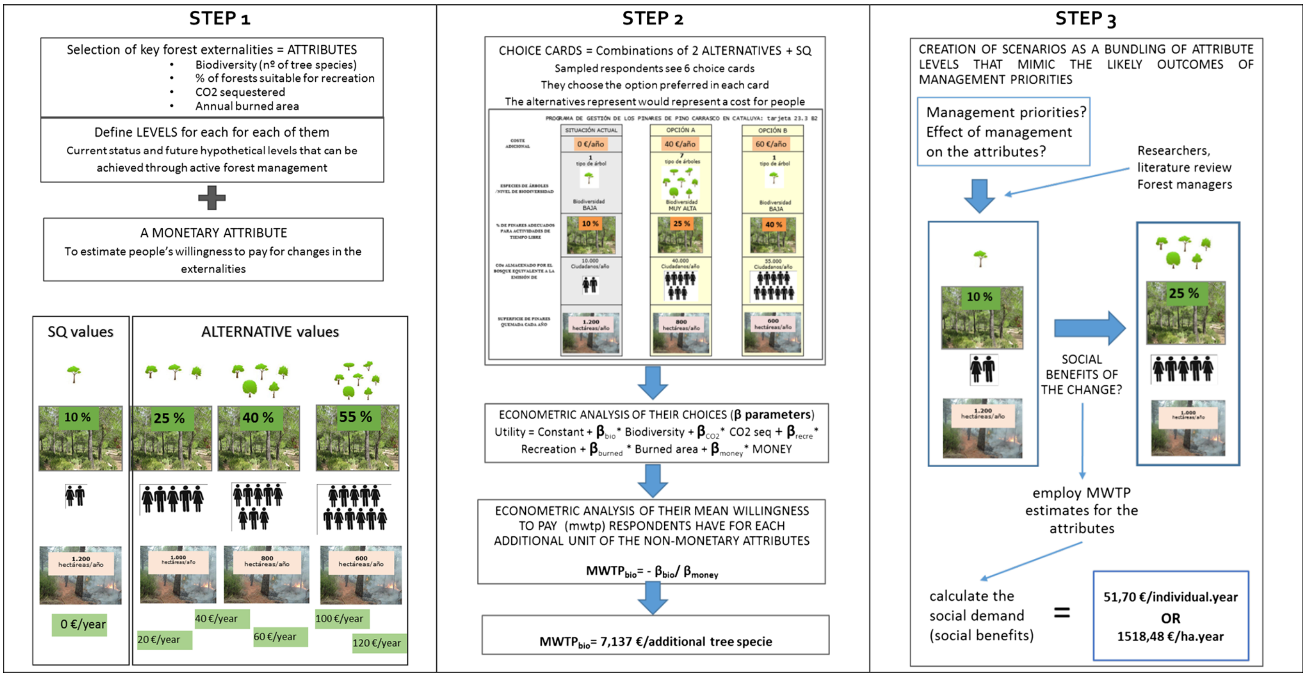


**Fig. 1** Schema of the steps followed in the development of this study

scientific correct and (2) assessed by people as being of value.

Tree species richness has been used as the biodiversity indicator for Catalan forests (Torras and Saura 2008). Biodiversity here can be considered as a structural attribute that can be modified directly through forest management, allowing to linking our estimates with forest management strategies. According to the data in the national forest inventory for the province of Barcelona (Ministerio de Medio Ambiente 1997–2007), estimates for plots where Aleppo pine is the main species show an average of seven tree species. The plots in Barcelona have a high site quality not common in the rest of Catalonia (Beltrán et al. 2011); after consultation with forest researchers and managers, we set this value as the maximum level for this attribute. Three more levels were set out with different amounts of tree species to assess the social preferences for increased biodiversity levels in Aleppo pine ecosystems. The attribute spelt out the number of tree species jointly with the expected biodiversity level. The base level was one tree species (*Pinus halepensis*) with a low biodiversity level, and it was augmented up to three, five and seven tree species (medium, high and very high biodiversity levels, respectively).

The recreation attribute was defined in terms of the percentage of Aleppo pine forests suitable for recreational activities. Aleppo pine stands very frequently show limited recreational possibilities due to their high tree density (up to 15,000 trees/ha), which makes it difficult to access and walk in the forest. Hence, the proposed alternatives showed an increase in accessibility as a result of the management activities undertaken; the images used to convey this attribute also considered the visual openness dimension of the forest structure. The base level for this attribute was set in 10 % of these forests suitable for recreation. The remaining three levels showed increased percentage areas of these forests suitable for recreation due to a higher accessibility to these forests: 25, 40 and 55 %.

Carbon sequestration is the third of the attributes that is likely to be improved through management. The levels for this attribute were defined based on the annual growth estimations for Aleppo pine plots in the National Forest Inventory for the province of Barcelona. Attribute levels were expressed in terms of $CO_2$ stored equivalent to the annual emissions of a number of Catalan citizens. The status quo level was set to the amount of $CO_2$ sequestered equal to the annual emissions of 10,000 Catalan citizens and the alternative levels were set out to: 25,000, 40,000 and 50,000 citizens' annual emissions, respectively.

A four-level attribute was set to directly estimate social preferences for the reduction in burned area in Aleppo pine forests. Forest fires burned 54,000 ha in Catalonia in the period 1996–2005, with 12,000 ha corresponding to Aleppo pine stands. The draft Catalan strategy for biodiversity set as a desirable objective reducing the burned area to 3000 ha/year, which represents a reduction of 55 % on the average annual burned area. Considering these estimates, the levels for this attribute were fixed with an upper bound corresponding to the current average annual burned area of Aleppo pine forests and the lower bound close to

**Table 1** Attributes and levels

| Attributes | Levels |
|---|---|
| Number of tree species (biodiversity) | 1 (low biodiversity)[a] |
| | 3 (medium biodiversity) |
| | 5 (high biodiversity) |
| | 7 (very high biodiversity) |
| % of Aleppo pine forests suitable for recreation (Area for recreation) | 10 %[a] |
| | 25 % |
| | 40 % |
| | 55 % |
| Carbon sequestered by the forests equivalent to the emissions of ($CO_2$ sequestered) | 10,000 citizens[a] |
| | 25,000 citizens |
| | 40,000 citizens |
| | 55,000 citizens |
| Annual burned area due to forest fires (decrease in annual burned area) | 1200 ha[a] |
| | 1000 ha |
| | 800 ha |
| | 600 ha |
| Annual payments (increase in regional taxes) | 0 €[a] |
| | 20 € |
| | 40 € |
| | 60 € |
| | 80 € |
| | 100 € |
| | 120 € |

This table presents the attributes used in the choice experiment set-up. On the left column, the four attributes conveying the main forest externalities plus the monetary attribute are listed. On the right column, the levels considered for each attribute are shown. Levels with an asterisk represent the current or status quo situation of no management for these forests. The rest of the levels represent improvements with respect to the status quo if management measures would be implemented. All the attributes and their levels present changes in the Aleppo pine forests assuming that the area covered by these forests is kept constant. The combination of attributes and their levels through experimental design produces alternative scenarios evaluated by respondents

[a] Status quo level

the objectives of the Catalan strategy. Hence, the levels of the burned area attribute were: 1200, 1000, 800 and 600 ha.

Finally, a monetary attribute was included to create the hypothetical market and to allow the estimation of social willingness to pay for changes in the provision of these forest externalities. The levels for this attribute were: 20, 40, 60, 80, 100 and 120 €. Notice that this does not reflect the cost of such management, as it is meant to determine the demand, and thus, appropriate levels are determined in focus groups and pre-testing.[1] The payment vehicle employed was a compulsory payment in the form of an annual increase in regional taxes which would be administered by a private foundation to improve the status of Catalan forests. This payment format and the levels were tested in the focus groups. The former has also been employed in previous studies conducted in Catalonia (Riera and Mogas 2004) and proved to work well.

## Description of scenarios analysed

To illustrate the implications of forest management, a set of scenarios was constructed combining the previous attributes and their levels, considering the most relevant management objectives according to the literature (Beltrán et al. 2011; Díaz-Delgado et al. 2002), i.e. fire prevention and biodiversity protection. While the scenarios are hypothetical and not geographically specific, they serve to show the range of possible consequences if one or another objective is pursued. We adopted a conservative approach, where we assumed beneficial (but not maximum) changes in the levels of the remaining attributes.

The first scenario shows the outcomes of forest management measures targeted at enhancing biodiversity, i.e. increasing tree species richness in these stands from one to five species. To achieve such a condition the stand would require silvicultural management measures such as thinning or tree pruning to reduce pine density, so that other species can gradually populate the stand. These measures are also expected to have an impact on the other attributes. Carbon sequestration is increased as the remaining trees are expected to grow at a higher rate once the excessive competence is reduced (Sabaté et al. 2002; Vayreda Durán 2012). The openness in the canopy would also produce an increase in the accessibility for recreation. Finally, the reduction in the vertical and horizontal continuity of biomass, together with the new tree species, would reduce the combustibility of the stand and decrease the burnt area.

The second management scenario shows the outcomes of forest management measures targeted at decreasing the annual burned area through improving the resilience of the stand towards forest fires. In this scenario, the number of tree species remains as in status quo (SQ) while improvements are achieved in the other attribute levels. Carbon sequestration is importantly improved compared to the SQ scenario as a result of the reduced competence among standing trees, avoided burned area and removed biomass employed in substituting oil energy sources. The reduction in the tree density and ladder fuels produces also an increase in the accessibility for recreation.

It is rather unrealistic to think that either biodiversity improvement or fire prevention will be developed in the whole area of Aleppo pine forests. Rather, different needs and priorities should be established at the landscape level. This is reflected in the third scenario where percentages of

[1] In 18 % of the cases where the highest bid was present, it was chosen, indicating reasonable closing of the demand.

45 and 55 % of the total Aleppo pine forest area are allocated to scenario 1 and 2, respectively.

## Methods

### Choice experiment

To estimate the compromises people are willing to make and to derive relative values of the attributes described above, a choice experiment (CE) was used.

CE is rooted on the Lancasterian theory of value (Lancaster 1966) and the random utility theory (McFadden 1974). Lancaster (1966) theory states that the utility that an individual derives from a good consists of the sum of the values of all the attributes or characteristics of that good or service, being a utility function a convenient (axiomatic) way to describe individual preferences over possible consumption bundles (Varian 1984).

In random utility models, individuals ($i = 1,\ldots,I$) are rational and maximize their utility when they choose from a set of alternatives ($j = 1,\ldots,J$). For each alternative $j$, the individual utility function ($U_{ij}$) is the sum of a systematic or deterministic element ($V_{ij}$) and a stochastic or random component ($\varepsilon_{ij}$):

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \sum \beta_{ik} x_{ijk} + \varepsilon_{ij} \quad (1)$$

where $x_{ijk}$ is a vector of $K$ explanatory variables observed by the analyst for alternative $j$ and respondent $i$ and $\beta_{ik}$ is vector of preference parameters that shows the preference of individuals for each of the variables and $\varepsilon_{ij}$ is a random error term affecting the choice but not observable to the researcher (Louviere et al. 2000).

If we represent the individual's choice in terms of probabilistic inference, we obtain the following expression for the choice probability that an individual $i$ will choose the alternative $k$ over the alternative $j$:

$$\begin{aligned} &\mathrm{P}(U_{ik} > U_{ij}) = P\left[(V_{ik} - V_{ij}) > (\varepsilon_{ij} - \varepsilon_{ik})\right] \\ &\quad k \neq j,\ k,j \in C \end{aligned} \quad (2)$$

The probabilistic model will depend on the assumption we make on the distribution of the difference between the random terms. Assuming that $\varepsilon_{ji}$ is identically and independently distributed, the probability of an individual $i$ choosing alternative $j$ over a set of alternatives $J$ is given by the conditional logit model:

$$\mathrm{Pr}_i(j) = \frac{\exp(\beta x_{ij})}{\sum_j^J \exp(\beta x_{ij})} \quad (3)$$

Compared to conditional logit model, random parameter logit (RPL) models are flexible estimation methods that are been increasingly employed to model people's preferences (Train 2003). In RPL models, the individual's $i$ deterministic part of the utility function is usually represented as a linear additive expression:

$$V_{ij} = \gamma_j + \beta_i x_{ij} = \gamma_j + \bar{\beta}_i x_{ij} + \theta_i x_{ij} \quad (4)$$

where $\gamma_j$ is an alternative specific constant (ASC) for each alternative $j$. It takes the value of 1 for the current alternative and the value of 0 for the rest of alternatives. It shows whether the individuals are willing to move from the current or status quo (SQ) alternative. $\beta_i$ is the vector of individual preference values, which now is allowed to incorporate heterogeneity as it deviates from the population mean $\bar{\beta}$ by the vector $\theta_i$, which provides an estimate of the standard deviation of the preference parameters across the sampled respondents. $x_{ij}$ is the associated attribute vector of attributes.

In this paper, we adopt an RPL model, where heterogeneity in the preferences is addressed for each attribute, allowing a normal distribution around the mean. The cost is kept fixed to ease calculation of marginal rate of substitution or willingness to pay (see below). However, we included a discrete grouping, for this parameter to allow for some heterogeneity. Thus, the probability for individual $i$ of choosing $j$ in a sequence of choices $t$, can be expressed as:

$$\Pr_i\left(j|p_i, x_{i,}\Omega\right) = \sum_{c=1}^{C} \pi_c \int \prod_{t=1}^{T} \frac{\exp\left(\gamma_j + \beta_i x_{ijt} - \alpha_{c_i} x_{ijt}\right)}{\sum_{j=1}^{J} \exp(\gamma_j + \beta_i x_{ijt} - \alpha_{c_i} x_{ijt})} f(\theta_{c_i}|\Omega_c) d(\theta_{c_i})$$

where $\alpha$ is the parameter for price of the $c'$ discrete class and $\pi_c$ the probability of belonging to this class. $f(\theta_{c_i}|\Omega_c)$ is the distribution, where $\theta_{c_i}$ are the random parameters and $\Omega_c$ their distribution. $\pi_c$ is estimated simultaneously, requiring its summation to 1.

Because one of the attributes considered is always a monetary one, the mean marginal willingness to pay (MWTP) measures (i.e. how much people would be willing to pay to get an additional unit of attribute $j$) can be calculated for each of the $j$ non-monetary attributes according to the formula: $\mathrm{MWTP}_j = -\beta_j/\beta_{\mathrm{cost}}$. In this study, the MWTP has been calculated considering the two attribute cost estimates averaged by their joint probabilities: $\frac{\beta_j}{\mathrm{CostA} \times \mathrm{probA} + \mathrm{CostB} \times \mathrm{probB}}$.

### Choice cards and sampling strategy

In CE valuation studies, respondents are asked to make trade-offs between different alternatives, generated by a combination of attributes and levels. One of the alternatives corresponds to the SQ and entails no extra costs for the respondents as it is the situation they experience nowadays; the non-SQ alternatives involve changes with respect to the SQ and their implementation would represent

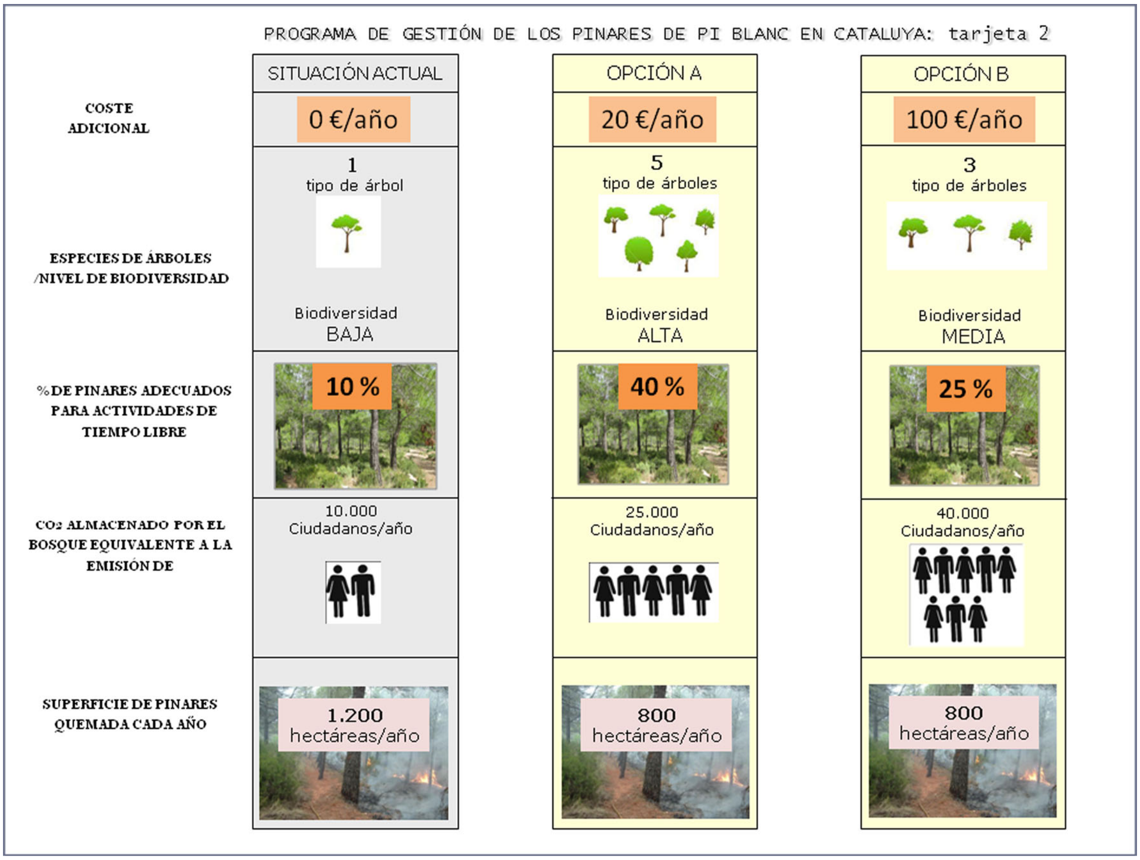


**Fig. 2** Example of a choice card

a cost for the respondents in the form of an increase in regional taxes. The groupings of SQ and non-SQ alternatives are known as choice sets or choice cards (Bennett and Adamowicz 2001) and most commonly involve the SQ scenario and two alternatives (see Fig. 2) from which respondents are asked to choose their preferred one. Information on how the choice cards are generated can be found in Appendix 4.

The valuation questionnaire[2] showed introductory information on the Aleppo pine forests and the attributes to inform the laypeople participating on the survey of the issue at stake. The choice exercise constitutes the core part of it, where each respondent had to see six choice cards and select in each of them their preferred alternative. The questionnaire finalized with a series of debriefing questions about the exercise and some socio-economic questions to shape respondents' profile.

A representative sample of 410 Catalan citizens was interviewed through face-to-face questionnaires during the months of August and September 2011 by a poll agency that administered the questionnaire to the sampled respondents. The sample of people was selected randomly in itineraries followed by the interviewers; the sample was weighted according to population size, age and gender. The sample was further stratified into three blocks belonging to urban, metropolitan and rural municipalities and considered the geographical distribution of the respondents along the subregions of Catalonia.

[2] The valuation questionnaire is attached as supplementary material.

## Compensating surplus scenarios

The MWTP estimates calculated for each attribute can be employed to calculate the social demand for a specific scenario generated by a bundle of attributes' levels. Social demand (or social preferences) for each of these scenarios is calculated through compensating surplus (CS) (see Eq. 8). CS estimates represent respondents' average willingness to pay to move from the SQ scenario to the different scenarios representing changes in the levels of forest attributes due to management measures.

The social welfare for compensating surplus (CS) scenarios is obtained using the formula described by Hanemann (1984):

$$\mathrm{CS} = -(V_1 - V_0)/\beta_{\mathrm{cost}} \tag{8}$$

where $V_0$ and $V_1$ represent the utility in scenario 0 and 1, each with a different combination of attribute levels. In this study, $V_0$ corresponds to the no management scenario and $V_1$ to management scenarios for Aleppo pine forests where the levels of the attributes are improved compared to the no management or status quo scenario.

## Results

### Sampled population and protest responses

The socio-demographics of the 410 respondents are summarized in Table 2. Overall, our sample is higher educated, shows a lower representation of elder people and includes less respondents in the higher income interval than the average Catalan population.

A total of 180 respondents always chose the SQ option, i.e. they did not want to pay to improve the status of Aleppo pine ecosystems. A protest answer in a valuation questionnaire corresponds to the respondents that may have a value for the good or service at stake but they refuse to participate in the hypothetical market. This refusal may be due to varied reasons, for example lack of trust in the institutional set-up or rejection to attach a monetary value to these goods or services. There is not a general consensus on how to treat these responses, although a common procedure is to remove them from the ulterior econometric analysis and keep only genuine zeros for the analysis (Soliño et al. 2010), thereby avoiding a bias caused by the format of the survey. To disentangle protest answers from genuine zeros, those respondents were asked for the reasons behind that decision in a close-ended question. Out of these, 113 were identified as protesters by having chosen the option "I pay enough taxes and I think that the state should pay for the environmental goods". These were removed from the sample leading to a final sample of 297 respondents for subsequent analysis; no clear socio-economic profile was found among the protesters.

### Preference parameters

Several models were tested, including conditional logit models, random parameter logit models and latent class models. Among these, a discrete mixture model (DM) was chosen. The four non-monetary attributes were modelled as random parameters with a normal distribution. The cost attribute was kept fixed in order to calculate WTP (Train

**Table 2** Sample and Catalonia population

| Variable | Sample | Catalonia population |
|---|---|---|
| Gender (%female) | 50.6 | 49.0 |
| Age (%) | | |
| 18–39 years old | 41.71 | 37.98 |
| 40–59 years old | 37.32 | 34.50 |
| 60–79 years old | 19.51 | 21.23 |
| >80 years old | 1.46 | 6.29 |
| Municipality size (%) | | |
| Metropolitan (>100,00 inhabitants) | 33.5 | 32.2 |
| Urban (20,000–100,000 inhabitants) | 37.3 | 36.8 |
| Rural (<20,000 inhabitants) | 29.2 | 31.0 |
| Education (%) | | |
| Unfinished primary school | 1.5 | 1.5 |
| Primary school finished | 7.6 | 7.3 |
| Secondary school finished | 13.7 | 49.9 |
| Professional qualification | 30.0 | 6.3 |
| University degree | 23.9 | 19.3 |
| Net annual income | | |
| 0–9000 € | 8.05 | 10.4 |
| 9001–14,000 € | 14.15 | 11.9 |
| 14,001–19,000 € | 13.41 | 15.3 |
| 19,001–25,000 € | 15.61 | 14.7 |
| 25,001–35,000 € | 24.15 | 18.6 |
| 35,000 € and more | 12.68 | 29.2 |

Population data for Catalonia and or our sample, according to the classes adopted for selecting the sample (gender, age classes, municipality size) and according to the questions included in the valuation questionnaire (education and net annual individual income)

**Table 3** Attribute estimates for DM model

| Variables | Level range for the attribute | $\beta$ Coefficients (SE) | SD of parameter distributions (SE) | Multiplying factor ($\beta \times$ factor) (the multiplying factor should be applied when calculating WTP estimates) |
|---|---|---|---|---|
| No of tree species/ biodiversity | 1–7 species | 0.936 (0.308)*** | 2.09 (0.379)*** | 1/10 |
| $CO_2$ sequestered | Corresponding to emission from 10 to 55 thousand citizens | 0.704 (0.349)** | 2.49 (0.428)*** | 1/100,000 |
| % of forests suitable for recreation | 10–55 % of the forest area | 0.469 (0.269) | 0.622 (1.02) | 1/100 |
| Annually burnt area | 600–1200 ha | −0.641 (0.261)*** | −1.92 (0.367)*** | 1/1000 |
| Cost A | € | −0.973 (0.128)*** | Fixed | 1/10 |
| Cost B | € | −23.9 (1.87)*** | Fixed | 1/10 |
| Probability A | – | 0.731 (0.0263)*** | – | |
| Probability B | – | 0.269 (0.0263)*** | – | |
| ASC | | −2.25 (0.205)*** | Fixed | |
| Log-likelihood | | −1357.339 | | |
| No of observations | | 1782 | | |
| No of individuals | | 297 | | |
| Pseudo-R-squared | | 0.300 | | |

This table shows the estimates for the preference parameters ($\beta$ coefficients) for each of the attributes. The non-monetary attributes were assumed as random and each of them distributing according to a normal distribution; this way we allow them to have some heterogeneity around the mean estimate, i.e. not everybody has the same preferences for a given attribute, but these have a normal distribution. The cost parameter is allowed to vary between two values, each with its probability, and it is assumed to be fixed (no standard deviation)

Significant at *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

2003), but to allow for heterogeneity, we introduced a discrete mixture approach in which the cost attribute was allowed to be distributed according to two different fixed distributions. This model was estimated using Biogeme software (Bierlaire 2003), with a panel structure and 500 Halton draws. The attribute levels were scaled when modelling for the sake of easiness in interpretation, so they should be rescaled for calculating WTP estimates. Table 3 shows the estimates corresponding to this model.

Our results showed that all attributes except the percentage of forests suitable for recreation are statistically significant and with the expected sign. These also present statistically significant standard deviation, indicating that heterogeneity in preferences exists for these attributes across the sample. The recreation attribute did not retrieve statistically significant results, indicating that it does not play a significant role in determining the preferences of our respondents. The negative value of the ASC indicates that our respondents *ceteris paribus* are willing to depart from the SQ situation. These results in attribute preferences reveal that people consider and compromise among the bundle of attributes when making their choices. Thus, they do not focus only on one of them such as burned area reduction, as it may be expected due to the prominence of this problem in the region. Instead they consider other attributes when making their choices. These other attributes are primarily biodiversity, i.e. to a large extent a passive use value, whereas a highly user-related attribute such as recreational accessibility does not significantly contribute to shape their choices.

The two different distributions considered for the cost attribute are reported together with their associated probability, where Cost B shows values more than 20 times higher than these achieved for the Cost A estimates. More than one quarter of the sample (26.9 %) can be allocated to Cost B estimates, being these respondents very sensitive to the cost attribute. Consequently the results show that even though average WTP is high, this is not evenly distributed in the population.

## WTP and CS estimations

Table 4 reports the marginal willingness to pay (MWTP) for each of the attributes and the standard errors and

**Table 4** Mean willingness to pay for the attributes

| Variables | MWTP estimate (SE) | 95 % confidence interval |
|---|---|---|
| No of tree species/biodiversity | 7.137 (2.169)*** | 2.887, 11.388 |
| $CO_2$ sequestered | 0.00054 (0.000)** | 0.00004, 0.00104 |
| % of forests suitable for recreation | 0.358 (0.203)* | −0.039, 0.755 |
| Annually burnt area | −0.049 (0.019)** | −0.087, −0.011 |

95 % confidence intervals are calculated by the K& R procedure

This table shows the estimates of mean willingness for each of the non-monetary attributes and expresses the amount of money people would pay to obtain an extra unit of each these attributes, i.e. €/extra unit, with each of them expressed on its respective units of measurement: number of tree species, tones of $CO_2$ equivalent to citizens emissions, % of forest area suitable for recreation and ha annually burnt, with respect to the status quo level

Significant at *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

confidence intervals estimated by the Krinsky and Robb (1986) procedure with 1000 replications. All MWTP estimates are statistically significant at the 10 % level and represent the social demand for an additional unit in each of the attributes.

Three scenarios have been generated by combining different bundles of attributes' levels. Results shown in Table 5 represent the social preferences for these CS scenarios in € per individual and also in € per hectare of Aleppo pine forest.

The compensating surplus results (i.e. the gains in social benefits produced by each of the scenarios with respect to the SQ scenario) are calculated using the MWTP for individual attributes and produced both in €/individual year and also in €/ha of Aleppo pine forest year. Comparing the values obtained by the three scenarios in terms of social benefits in € per hectare, the fire prevention scenario obtains the highest estimates, 2044.23 €/ha, followed by the area-wise combined scenario, 1807.64 €/ha, and the biodiversity protection scenario, 1518.40 €/ha.

## Discussion and conclusions

This study assesses from economic valuation perspective the social demand for four key externalities produced by Aleppo pine forests that are expected to be enhanced by forest management: biodiversity, $CO_2$ sequestration, access for recreational purposes and burned area by wildfires. By assessing them in a joint manner, we acknowledge the multifunctional character of these stands and analyse people's willingness to perform compromises between these attributes when making their choices.

We design three scenarios that mimic the effects on these externalities that management measures may have and for which we calculate the social benefits they would produce. The outcomes of fire prevention maximization throughout all the Aleppo pine area would produce the higher social benefits, despite being very unlikely to attain due to budgetary restrictions and biodiversity-related concerns.

### Valuation of attributes

Biodiversity is a highly significant attribute in shaping people's preferences among the four non-monetary attributes people had to trade-off in this survey. These results are in accordance with studies showing that people hold a higher preference for the environmental value of forest (e.g. biodiversity protection, carbon sink) as the most preferred benefit over, for example, recreational values (Kumar and Kant 2007). Studies assessing jointly recreational and biodiversity values point in the same direction (e.g. Horne et al. 2005; Jacobsen et al. 2012). Interestingly, this holds in a situation of economic crisis and in a Mediterranean context where forests appear in the media mainly referred to wildfire suppression. These results show that enhancement of forest biodiversity can no longer be seen as solely an objective for conservationists but rather for the population as a whole.

The attribute for recreation was formulated as a percentage of the forest suitable for recreation and was found insignificant. Conveying recreation to the respondents in terms of improved accessibility, but not as improved recreational facilities (signs, walking paths or picnic areas, for example), may have contributed to reduce the use value dimension of the attribute and hence its "attractiveness". Hence, improving recreational values may imply making investments in infrastructures and not only improving accessibility to the stand.

Social awareness regarding forest fires and burned area is very high among the population (IESA/CSIC 2007) and management measures in Aleppo pine forests are importantly aiming at increasing the resilience of these stands towards forest fires (Riera Mora 2014). However, our findings show that respondents also value other services provided by forests which is in accordance with previous studies where the population shows concerns on the way it

Table 5 Compensating surplus scenarios

| Management scenarios | Attribute levels | | | | Area covered (%) | Compensating surplus (estimates of social benefits) | |
|---|---|---|---|---|---|---|---|
| | Bio diversity | $CO_2$ | % suitable for recreation | Burned area | | € individual year$^{-1}$ | € ha$^{-1}$ of Aleppo pine forest year$^{-1}$ |
| *Increasing biodiversity in the whole Aleppo pine area* | | | | | | | |
| BIO | 1 → 5 | 10,000 → 25,000 | 10 → 25 | 1200 → 1000 | 100 | 51.79 | **1518.48** |
| *Increasing fire prevention in the whole Aleppo pine area* | | | | | | | |
| FIRE | 1 | 10,000 → 55,000 | 10 → 55 | 1200 → 600 | 100 | 69.72 | **2044.23** |
| *Area-wise scenarios maximizing fire prevention and biodiversity* | | | | | | | |
| BIO-wise | 1 → 5 | 10,000 → 25,000 | 10 → 25 | 1200 → 1,000 | 45 | 69.72 | 683.31 |
| FIRE-wise | 1 | 10,000 → 55,000 | 10 → 55 | 1200 → 600 | 55 | 51.79 | 1124.32 |
| Total | | | | | | | **1807.64** |

This table shows the management scenarios we have simulated by combining the attributes and their levels. These scenarios try to mimic what changes may occur in the attributes if some management measures would be undertaken to improve biodiversity and fire prevention, respectively. In each scenario the change with respect to the status quo for each attribute is indicated. Based on these, the calculation of the compensating surplus (i.e. the social gain or demand) for each scenario is calculated on an individual basis and also per hectare of Aleppo pine forest. The last scenario makes an area-wise estimation, considering that different percentages of the total Aleppo pine area are devoted to either fire prevention or biodiversity

Bold values indicate the final figures of the calculations of the three differnet scenarios

will be achieved and the likely impacts it may produce on the landscape (Varela et al. 2014). When nowadays resources allocated to forest management are mainly focused on forest fire suppression, our results show that other interests towards forests exists among the citizens and should be acknowledged in the allocation of available budget.

The results retrieved for the last environmental attribute, $CO_2$ sequestered, are also significant with WTP estimates in accordance with outcomes from previous studies (Brey et al. 2007), indicating awareness of the climate change problem and the value of potential contributions of forests in this regard.

Finally a comment is needed in relation to the two different cost estimates used. This was done to take into account the large heterogeneity in the population regarding cost sensitivity, resulting in different WTP. This can be due to large differences in income and hence in marginal utility of money. As more than a quarter of the sample have a very high sensitivity to the cost parameter, any policy based on setting up tax schemes to fund such management, may meet considerable resistance in the population—despite the average WTP being high. Consequently a fair burden share is of importance.

## Management scenarios and policy implications

Mediterranean forests are well known for their multifunctional character, able to provide a multiplicity of timber and non-timber forest goods and services (FAO 2013). Nevertheless, maximizing the provision of one of these services may cause the decline in other services (Bennett et al. 2009), due to trade-offs or even competing functions.

The respondents in our survey were faced with alternatives where they had to make compromises between the different attributes and their levels. Therefore, the estimates obtained enable assessing the social demand while acknowledging the trade-offs between these externalities from a social demand point of view. The scenarios estimated represent final outcomes that could be obtained if a series of management measures were implemented. Our results show that either fire prevention or biodiversity enhancement, or a combination of both produce significant and positive results in terms of social demand when compared to abandonment scenarios where ultimately fire suppression capacity will determine the configuration of the landscape (Regos et al. 2014). Therefore, fire risk should be considered as one of the criteria when deciding on management alternatives together with the compromises it may impose when promoting biodiversity, not only from an ecological but also from a social point of view.

Some of the future improvements of our approach include making tighter linkages with ecological models and incorporating to the area-wise allocation of management measures a series of criteria such as forest owners' demands, fire risk or biodiversity conservation requirements.

The CS estimates assess the social profitability of these scenarios. The forest owner (private) profitability and the opportunity costs that he would face when undertaking this type of management in these Aleppo pine stands may provide negative returns (Górriz-Mifsud et al. 2016). This mismatch of social and private profitability may justify the setting up of subsides or payments for environmental services schemes to make both ends meet.

In 1999, the provincial council of Barcelona, DIBA, launched a programme to restore and improve the resilience of the stands severely affected by wild fires during the 1980s and 1990s, most of them Aleppo pine stands (Riera Mora 2014). This programme has allocated 53 €/ha year, during 15 years to restore 25,000 ha of forests. At the provincial level, the bulk expenses allocated to fire prevention were around 20 €/ha for the period 2010–2012 for the whole province. These values are still relatively high when compared to estimates on investment in silvicultural management at the Catalan or Spanish level (10 €/ha and 36.71 €/ha, respectively) (ASEMFO 2012). Overall our results support the efforts currently undertaken by public administrations to encourage forest owners to manage their stands, showing that there is a social demand for the improved flow of benefits that would arise from this action. Still our estimates are distinctively higher than the investments allocated to manage these stands. This is in line with the recommendations made by forest-related institutions that signal the need of increasing investments on forest management to improve the resilience of our stands and to create rural employment (SECF 2011).

Finally, this study also shows that people value the outcomes derived from forest management, such as improved biodiversity, accessibility and carbon sequestration, or reduced burned area. This finding is important for the design of incentive mechanisms that do not only target forest management but rather assess current provision of services (Vedel et al. 2015) and secure certain levels of provision for targeted ecosystem services (Prokofieva and Gorriz 2013).

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