



Evaluation of a risk reduction in forest fires in a Mediterranean region

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Abstract

The risk of forest fires has been a subject of study from different disciplines, but its economic evaluation has received relatively little attention. This paper discusses the main issues involved from an economic perspective, and presents the results of a referendum application to evaluate a 50% reduction of the risk of forest fires in Catalonia, Spain. Results and specific risk valuation problems are discussed with some detail.

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1. Introduction

Forest fires are a usual element in the Mediterranean basin. There are many forest fires in Catalonia (Spain) each year. The amount of forests affected varies considerably from year to year. The last large fires in the region happened in 1986, 1994, and 1998. It constitutes one of the forest problems that has consistently attracted more attention from the media. Also, it has become an issue of political debate. Both manifestations—media and politics—reflect a social concern for forest fires.

The administration devotes a considerable volume of resources every year to try to diminish the number of hectares devastated by fire. It seems logical to ask the question of whether not enough resources are still devoted to this policy, or conversely whether too much money is invested already.

This paper tries to help to answer those questions for a given Mediterranean region, Catalonia, with an active forest policy. The discipline of economics has developed the instruments to assess the social economic value of risk reductions of forest fires. Instruments like the contingent valuation method (CVM), travel cost method, or hedonic price functions are the most well known (Mitchell and Carson, 1989).

The number of valuation studies of policies to reduce the risk of forest fire is very small, and—to

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our knowledge—no social valuation exercise has been undertaken on this matter in the Mediterranean region. The usual economic figures derived from forest fires reflect private costs (timber, cork...), which can be much lower than the actual social loss. Even if the whole loss is estimated, its translation to the evaluation of risk reduction policies is not straightforward. It would seem more reasonable to conduct an ad hoc study designed to evaluate such policies. This is the way taken in this paper, using a referendum valuation format.

The next section summarizes the studies that use CVM for measuring the economic value of reductions of forest fires. Section 3 presents some data on forests and risk of forest fires in Catalonia, as well as the main policy currently in place. The case study used is described in Section 4. It is followed by a section on the valuation exercise, where the main results are underlined. Finally, some conclusions and further research suggestions are given.

2. Selected literature review

One of the first studies on forest fire related values was the one of Vaux et al. (1984). It looked at the impact of fires on the economic value of forest recreation. Its primary objective was to demonstrate the viability of CVM for valuing such consequences. It involved 70 students rating photographs of burned and unburned forests and then expressing a willingness-to-pay (WTP) for the preferred scene.

Loomis et al. (1996) applied CVM to estimate the WTP for protecting the old-growth forest from catastrophic fires in Oregon. The simulated fire prevention and control program proposed to the respondents would reduce by half (3500 acres) the number of acres of old-growth forest that would burn in Oregon each year. They used a dichotomous choice format followed by an open-ended WTP question. The annual value per household in the sample was \$90. In terms of social value per acre of old-growth forest protected from fire, the WTP was \$28.

Following the previous exercise, Loomis and González-Cabán (1998) used CVM to estimate the economic value to California and New England residents

of implementing a fire management plan to reduce the number of acres of old-growth forests that burn in California and Oregon. The elicitation question took the format of a dichotomous choice. The estimation of the WTP was obtained through a random effects probit model to account for the panel data. The average WTP to reduce catastrophic fire in 2570 acres was of \$56 per household.

3. Fire risk

Forestry land (when including shrub land and others) accounts for more than half of the surface of Catalonia, while one third of the region is devoted to agricultural uses. Although the composition of the forest varies from the coastal areas to the Pyrenees and the inland plains, most of the masses are composed of Mediterranean species. The dominance corresponds to the pine, with 50% of the surface, followed by quercus, with some 40% (Ministerio de Medio Ambiente, 1996). Forest fires have become more frequent and more severe in the last years. They cause economical, social, and ecological losses. The burned timber has less value in the market for the forest owner; sometimes houses and other premises get damaged; many non-timber products are also affected, like mushroom production or medicinal herbs; recreationists experiment a loss in their welfare; the biodiversity of the area is diminished; carbon stored by trees is released to the atmosphere; the risk of erosion increases significantly in hilly areas; a number of accidents happen every year with fire fighters.

Forest fires in the Mediterranean basin have always been a natural factor shaping the characteristics of the ecosystem. This has led to the adaptation of some species to fire, like the serotin pines of Mediterranean pinewood (*P. halepensis*, *P. pinea*, and *P. pinaster*). Also, several species have a remarkable capacity to sprout after fire, like holm oak (*Q. ilex*) or kermes oak (*Q. coccifera*), or the resistance of bark of cork oak (*Q. suber*) to fire.

In this study, the policy to be evaluated was the reduction of fire risk due to a fire prevention and fighting program. To estimate the risk of fires in Catalonia, data on hectares burned per year from 1983 to 1998 were taken into account. Table 1 shows the basic data.

Table 1
Annual forest surface burned in Catalonia

Year	Hectares burned
1983	15 225
1984	3431
1985	7566
1986	43 290
1987	1215
1988	1002
1989	1298
1990	668
1991	3231
1992	757
1993	3328
1994	62 575
1995	2202
1996	531
1997	625
1998	14 130
Total	161 074
Annual mean (Ha)	10 068
% Over forest surface	0.75%

Source: Departament de Medi Ambient (2002).

A forest fire risk can be expressed in several ways. For the purpose of a referendum exercise, the most suitable way to express it was found to be the average percentage of forests burned per year, although a more elaborate risk index could be constructed. This was found in a series of focus groups sessions (for a description of this technique, see for instance Desvoves et al., 1984) and expert opinions, and confirmed in a pilot survey that preceded the final design of the questionnaire. This standard procedure in valuation studies is explained in many textbooks (see for instance Mitchell and Carson, 1989). The mean number of hectares affected each year in Catalonia is of some 10 000, or a 0.75% of the forestry area, although with a great deal of dispersion, with approximate 1 year per decade of relatively high devastation (Table 1).

4. Study design

4.1. Fire prevention program

The narrative of the proposed policy indicates that the fire prevention program would reduce by half the

current annual risk of forest fires in Catalonia and, therefore, the average annual number of hectares burned from 10 000 to 5000. The program has several distinctive features. It provides a scheme to remove brush and dead wood from given forest areas. It also incorporates a clear cutting program of forestry areas surrounding residences and along some roads. The number of permanent guards watching for fires is also proposed to increase, according to the program, in order to detect them in an earlier stage.

The official estimation is that the program would decrease the risk of forest fires in approximate 50%. This was the main reason to adopt this amount of reduction and not a more drastic or modest one in the valuation exercise. The reduction was found to be credible both in the focus group sessions and throughout the actual exercise. If instead of trying to value this specific reduction only, one would like to value reductions by other percentages (say 25 or 75%), a different design of the exercise would be required. For instance, several subsamples could be determined and apply a different reduction policy to each subsample. The same approach can be taken if instead of a referendum valuation, standard CVM was applied. Alternatively, one could apply other stated preference methods, like contingent ranking, contingent choice, and alike (Morrison et al., 1996), which allow for estimations of marginal reductions. To obtain the optimal reduction percentage, a social cost-benefit approach could be taken. All these possibilities were beyond the scope of the exercise, which concentrated on the evaluation of an already proposed policy.

The amount of money the administration devotes to forest prevention, including cleaning programs, was established in 3 Euros per person and year, in round numbers, which translates into approximate 9 Euros per hectare and year. The cost of the new program was estimated in 9 Euros per person and year, which is equivalent to 15 Euros per hectare and year². This reflects the cost of the new policy and therefore it does not include the cost of lost timber.

² Although Euros are used here, values in the survey were expressed in Spanish pesetas.

Both the current and new public policy dealing with forest fires are charged to all the citizens, and not only to forest owners. This current practice does not seem to have evolved into much protest from the general public, and it was adopted in the study. In the focus group sessions no concern was raised from the participants, and there were no reports of protest of this kind from the actual interviews either. This may be due to the strong component of Mediterranean forests as public or collective goods, in the economic sense of the concept. Forest functions like landscape, recreation³, mushroom picking, CO₂ sequestration, soil erosion prevention, among others, all affected by fires, benefit the society at large, and not only forest owners. The relative social importance of those forest attributes in Spain has been the object of other papers (Mogas et al., 2002).

Before asking respondents whether they would pay for a fire reduction program, they were asked about the relative importance of different forests functions, like recreational use, CO₂ sequestration, or erosion reduction. In this way, respondents had in mind some of the main consequences of forest fires for the general public.

4.2. Referendum question

The valuation question adopted a pure referendum format. In a referendum format, the surveyed people face a choice of voting yes or no to a predetermined policy package with a given cost. Unlike the CVM dichotomous choice format, where a yes or no answer to different bid amounts is required, the pure referendum format maintains the same bid throughout the sample.

All valuation methods have advantages and disadvantages. One of the main limitations of the pure referendum is that it only informs about the degree of approval of the provision of a public good, and whether the median maximum WTP is above, equal, or below a certain value, but in general it does not infer the actual mean or median maximum WTP for the good. The pure referendum approach would not be suitable if the researcher wants to find out the social

value of marginal changes in the risk of forest fires, for instance, but it seems the most appropriate if the researcher (or decision maker) wants to find out whether a given program will be accepted by a given percentage of tax payers. Referendum type questionnaires tend to be easier to answer than other more complex valuation formats. Referenda seem more suitable when dealing with the provision of public goods (Mitchell and Carson, 1989, p. 97), or when the good is not very familiar to the public (Mitchell and Carson, 1989, p. 296). Since the referendum approach involves the calculation of yes votes over the total number of votes, the format has the advantage of being much less demanding statistically than other formats where econometric models with stronger assumptions are required (McFadden, 1994). Also, it can be proved that referenda are a form of strategy-proof social choice functions, i.e. not vulnerable to manipulation (Arrow et al., 1993). A person cannot improve her welfare by saying yes to a program if her WTP for it is lower than the cost she would have to pay if implemented. This property does not hold, in general, for more sophisticated methods (Arrow et al., 1993). To our knowledge, however, a referendum approach has not been used so far to evaluate forest policies, which constitutes an additional contribution of this paper.

To know if the average Catalan person would be willing to pay the extra cost of 6 Euros per year (from 3 to 9 Euros) for the proposed program, respondents were asked the following question:

Due to forest fires, each year an average of approximate 10 000 ha of forest are burned in Catalonia, which is close to 1% of the whole forest area. Currently, the administration devotes some 3 Euros per person and year to preserve and clean the forests. The risk of fires could be reduced by half, and on average some 5000 ha of forest would burn per year. To implement this program some 9 Euros per person and year would be required.

Would you pay 6 Euros more per year in taxes in order to implement this program that reduces the risk of forest fires by 50%?

The last part of the questionnaire included some demographic and socioeconomic questions such as age, education, membership to an environmental

³ In Catalonia, 80% of the forest are privately owned, and the access to the forest is free and not restricted.

Table 2
Socio-demographics of the survey respondents

Variable	Sample	Catalonia average
Age (>18 years)	20%	20%
18–29	30%	31%
30–44	30%	27%
45–64	20%	22%
65 or over		
Gender (% male)	50%	49%
Income (net disposable income per month in Euros)	552	705
Environmental organization (% of respondents belonging to an environmental organization)	5%	Not available
Visitation (% of respondents that have gone to the forest in the last year)	61%	Not available
Municipality size (<10 000 inhabitants)	21%	20%

Source: Institut d'Estadística de Catalunya (2002) and Instituto Nacional de Estadística (2002).

organization, or income, which allows to check for the representativeness of the sample and to analyze the relationship between preferences for the program and the socioeconomic characteristics of the population.

4.3. Sample design

The sample size was of 479 people. This sample was chosen so as to be representative of the Catalan population in terms of location, age and gender. The socio-demographics of the respondents who completed the surveys with valid responses are summarized in Table 2. The proportions of age, gender, and the size of the municipality of residence of the sampled people are not statistically different from those of the Catalonian population over 18 years old (Table 2). However, on average, respondents reported a rather lower income than the average of the population for Catalonia⁴. This might be due to a perception of reporting income as being a sensitive question. The sample size was proportional to the population for the four Catalan provinces, and within each province the proportionality was kept between municipalities of different size brackets. Interviews were conducted face-to-face at the residence of the sampled persons. The typical length of the interview was approximately

10 min. The survey was administered during the second half of 1999.

5. Results

5.1. Statistical results

This section analyzes the responses of the individuals to the valuation question. Table 3 summarizes the basic statistics of the referendum results. At 95% confidence, the approval rate of the population would be between 58.7 and 67.4%. Therefore, the majority of the population would be willing to pay the extra 6 Euros for the proposed risk reduction.

5.2. Contingency analysis

To study the relationship between the socio-demographic variables and the preferences for the forest fire reduction program, two-way contingency tables are used (Tables 4–9). Each cell contains the frequency and the percentage of responses. A χ^2 -statistic is used to test for independence between the two variables. Associated to each χ^2 value, a probability of independence between the two variables is

Table 3
Referendum results

Answer	Frequency	%	Confidence interval (%)
Yes	302	63.05	(58.7, 67.4)
No	177	36.95	(32.6, 41.3)

⁴ χ^2 -tests of independence were performed to determine whether the sample had the same socio-demographics than the Catalonia population.

Table 4
Relation between acceptance of the program and the recreational use of forests

	Yes to payment	No to payment	Total
Visited a forest in the last 12 months	200 41.75%	92 19.21%	292 60.96%
Did not visit a forest in the last 12 months	102 21.30%	85 17.74%	187 39.04%
Total	302 63.05%	177 36.95%	479 100%

$\chi^2=9.51886$, prob.=0.00203.

Table 5
Relation between acceptance of the program and the membership to an environmental organization

	Yes to payment	No to payment	Total
Member of an environmental organization	12 2.50%	9 1.88%	274 4.38%
Not member of an environmental organization	290 60.55%	168 35.07%	205 95.62%
Total	302 63.05%	177 36.95%	479 100%

$\chi^2=0.32873$, prob.=0.56641.

Table 6
Relation between acceptance of the program and size of the municipality of residence of the respondent

	Yes to payment (%)	No to payment (%)	Total (%)
From a municipality of less than 10 000 inhabitants	79 16.49%	25 5.22%	104 21.71%
From a municipality between 10 000 and 100 000 inhabitants	81 16.91%	69 14.40%	150 31.31%
From a municipality of more than 100 000 inhabitants	142 29.65%	83 17.33%	225 46.98%
Total	302 63.05%	177 36.95%	479 100%

$\chi^2=12.71546$, prob.=0.00173.

reported. A probability of 1 indicates perfect independence, while a value of 0 means that the two variables are highly related.

The cross-relation between the acceptance of the program and the respondent having visited a forest during the last 12 months is significant (Table 4), indicating that people more likely to directly enjoy the forests are also more likely to agree to pay the 6 Euros for the risk reduction program.

The relationship between the willingness to accept the program and being a member of an environ-

mental organization is not significant, as reported in Table 5.

As reflected in Table 6, people living in larger urban areas (municipalities of >100 000 people) are almost twice as much likely to accept the program and payment than the people living in a more rural environment (municipalities of <10 000 people). The survey contained no debriefing question that could explain the reason for the significant difference in preferences, although it could be an interesting topic for future research.

Table 7
Relation between acceptance of the program and the age of the respondent

	Yes to payment	No to payment	Total
Between 18 and 29 years of age	78 16.30%	23 4.80%	101 21.10%
Between 30 and 44 years of age	85 17.74%	51 10.65%	136 28.39%
Between 45 and 64 years of age	85 17.74%	49 10.23%	134 27.97%
More than 65 years of age	54 11.27%	54 11.27%	108 22.54%
Total	302 63.05%	177 36.95%	479 100%

$\chi^2=16.63494$, prob.=0.00084.

Table 8
Relation between acceptance of the program and gender of the respondent

	Yes to payment	No to payment	Total
Male	159 33.20%	80 16.70%	239 49.90%
Female	143 29.85%	97 20.25%	240 50.10%
Total	302 63.05%	177 36.95%	479 100%

$\chi^2=2.47837$, prob.=0.11542.

The results presented in Table 7 suggest that older people are less likely to accept the program for reducing the risk of forest fires than young and middle-aged people.

The cross-relation between the acceptance of the program and the gender of the respondent is not significant (Table 8), whereas the results presented

in Table 9 suggest that having higher income increases the acceptance to pay for the risk reduction program.

6. Conclusions

Forest fires are one of the hazards Mediterranean forests have to face. Not much attention, so far, has been devoted to the economic valuation and evaluation of policies aimed at reducing the risk of forest fires, especially in Europe. This paper provides an application of the pure referendum method for evaluating from a social point of view a proposed policy that involves a 50% reduction of the risk of fires in the north east of Spain.

The main result is that 63% of the sampled population would be willing to pay the estimated extra-cost of 6 Euros per person and year of a program to reduce the risk of forest fire by half. At 95%

Table 9
Relation between acceptance of the program and the monthly income of the respondent

	Yes to payment	No to payment	Total
Less than 900 Euros per month	129 41.48%	94 30.22%	223 71.70%
Between 901 and 1500 Euros per month	48 15.43%	21 6.75%	69 22.18%
More than 1500 Euros per month	17 5.47%	2 0.65%	19 6.12%
Total	194 62.38%	117 37.62%	311 100%

$\chi^2=9.41332$, prob.=0.00903.

confidence, the result for the whole population is expected to be within a bracket between 58.7 and 67.4% of approval. This implies that the majority of the population would agree with the fire prevention program presented, at the given cost. However, if the legislator required a two-third majority approval, the program might or might not be desirable (with the results at 95% confidence).

From the contingency analysis of some demographic variables in relation to the acceptance of the program, it seems that people living in larger urban areas, having higher income, using forest for recreation activities, and middle-aged people are more likely to agree to pay the extra 6 Euros for the risk reduction program than the rest of the population. However, this paper has not tried to explore the reasons of these relationships, although it could constitute an interesting future research. In the same line, it would be interesting in the future to check for other social characteristics, in particular to split the sample between forest owners and the rest of the population.

Further research could compare the referendum results to those obtained from other methods, and to estimate the decay in the approval rate as more money is demanded or a lower risk reduction is offered. Also, a test to see whether values for risk reduction obtained in one Mediterranean region could be transferred to another one with some accuracy could be conducted. Further research could also test whether the results would hold over much different regions, once adjusted by differences in social and ecological variables.

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