Willingness-to-Pay Function for Two Fuel Treatments to Reduce Wildfire Acreage Burned: A Scope Test and Comparison of White and Hispanic Households[1]

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Abstract

We estimate a marginal benefit function for using prescribed burning and mechanical fuel reduction programs to reduce acres burned by wildfire in three states. Since each state had different acre reductions, a statistically significant coefficient on the reduction in acres burned is also a split sample scope test frequently used as an indicator of the internal validity of contingent valuation surveys. In this paper the dichotomous contingent valuation method is used to test for scope of the sensitivity of respondent's willingness to pay for prescribed burning and mechanical fire fuel treatment programs to the acreage reduction of wildfires. The logit models were estimated for white and Hispanic households in California, Florida and Montana. The results of logit regressions show that the acreage reduction variable is statistically significant at the 1% level among proposed programs and groups of people. The positive sign of this variable means that the more acreage reduction is proposed, the more likely people would like to pay for the fire fuel reduction programs. Because of the significance of acreage reduction variable in the willingness to pay function, this function can be used to evaluate the incremental benefits of different forest fire management plans that reduce additional acres burned. These benefits could be used as budget justification for prescribed burning and mechanical fire fuel reduction programs to protect forests from wildfires.

Keywords: California, cotingent valuation, Florida, mechanical fire fuel reduction, Montana, prescribed burning, scope test, willingness to pay.

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Introduction

On August 20, 2002 President George W, Bush approved the Healthy Forests Initiative to restore the health of forests and rangelands in the western United States, particularly on public lands and areas of the wild land urban interface. As part of this Initiative, natural resource agencies will increase the use of two fuel treatment methods: the prescribed burning and the mechanical fire fuels reduction. The prescribed burning method is defined as the controlled application of fire to existing naturally occurring fuels under specified environmental conditions following appropriate precautionary measure (Florida Division of Forestry, 2000). The mechanical fire fuel reduction method consists of mechanically removing smaller trees and vegetation. This mechanical fuel reduction method is especially effective at lowering the height of vegetation, which reduces the ability of fire to climb from the ground to the top or crown of the trees.

On public lands there are not market signals that reveal the demand or value for these fire fuel reduction programs. Providing this type of information would allow the program managers and policy makers to determine the efficient level of prescribed burning and mechanical fire fuel reduction programs (hereafter RX and Mech programs) in each state. To estimate this value, the contingent valuation method is often used and willingness to pay of the respondent to proposed programs is elicited.

Contingent valuation method is a direct survey method where any biases on the part of interviewers, the design and implementation of the survey or the respondent, can jeopardize the reliability and validity of the willingness to pay (WTP) estimates. One way the internal validity can be assessed is from the answer to a question: Does the willingness to pay vary with factors that would be expected to influence it under economic theory? (Arrow and others 1993). One of the logical checks is that the WTP should increase when more of the “good” is offered. This is usually termed a scope effect or scope sensitivity analysis. Scope sensitivity is considered a necessary condition for the validity of the WTP. Thus, the scope test, to measure the sensitivity of the WTP in accordance with the change in levels or extent of the public program, has attracted substantial research and it has been viewed as a critical test for a contingent valuation study. The scope test could be internal to the respondent or external to the sample. The internal scope test is used to test for differences in WTP for different levels of the good for the same respondent; the external test measures the change in WTP for separate respondents across the sample at different levels of the public good.

There have been scope tests conducted in CVM using in-person interviews (Carson, Wilks and Imber 1994), and a few mail surveys (Loomis and Ekstrand 1997). Carson (1997) indicates that while some CVM surveys do not pass a scope test that many do. Scope tests have been evaluated for environmental quality and visibility assessments (Smith and Osborne 1996) and in developing countries (Memon and Matsuoka 2002), but to our knowledge there have not been external scope tests for forest/forest fire management, nor for Spanish speaking respondents.

Study objectives

The purpose of this study is to conduct a scope test to determine whether the willingness to pay per household for prescribed burning and mechanical fire fuel reduction programs increases with the number of acres of forest protected among white and Hispanic households. To our knowledge this is one of the first scope tests of Hispanic respondents taking survey in Spanish. In addition, we provide WTP functions relating to WTP for acres of forests that are protected from wildfires that would be useful to managers and policy makers.

Regression equation and hypothesis of scope test

In our study of the fire fuels reduction programs, we carry out the scope test on the impact of a reduction in acreage of forest fires on willingness to pay. We expect that this acreage reduction variable should be significant and the sign of the coefficient is positive; specifically, the greater reduction in acreage of forest burned the more people would be willing to pay. We are able to conduct an external scope test because the amount of acreage reduction varies across the three states of California, Florida and Montana, and we control for differences in demographics and attitudes across states.

First we define the odds of voting for the prescribed burning program as: $A = P_i/(1-P_i)$ and then take the log for the logit model:

$$Ln(A) = \beta_0 + \beta_1 AcreReduction + \beta_2 RXBid + \beta_3 X_3 + \ldots\ldots + \beta_n X_n + u_i \quad (1)$$

Similarly for the mechanical fire fuel reduction program:

$$Ln(A) = \beta_0 + \beta_1 AcreReduction + \beta_2 MechBid + \beta_3 X_3 + \ldots\ldots + \beta_n X_n + u_i \quad (2)$$

To control for any differences across the states, we include respondent demographic and attitudes variables shown in table 1.

Table 1-- *variables in the logit willingness to pay model*

Variables	Variable explanation
VoteRXPr	Dependent variable: 1 if respondent votes for RX program, 0 otherwise
VoteMechPr	Dependent variable: 1 if respondent votes for Mech program, 0 otherwise
Acre Reduction	Acreage reduction in burned forest
Age	Age of the respondent
Educ	Education level of the respondent
Expsmoke	Dummy variable: 1 if the respondent experienced smoke from a wildfire or RX, 0 otherwise
Income	Household income of the respondent
Ownhome	Dummy variable: 1 if respondent owns a home, 0 if respondent rents
Respprob	Dummy variable: 1 if respondent suffers from respiratory or breathing problems, 0 otherwise
RXBid	Monetary amount respondent is asked to pay for RX program
MechBid	Monetary amount respondent is asked to pay for Mech program
Witnessfire	Dummy variable: 1 if respondent witnesses a wild fire, 0 otherwise

The scope test involves testing whether the sign of acreage reduction variable is positive or not. Therefore the null hypothesis is:

$H_{0:}$ $\beta_1 = 0$ and HA: $\beta_1 > 0$.

One tailed t- statistic test will be conducted.

Survey design

A survey booklet was developed to provide the respondent with the basic information of proposed programs prior to eliciting the WTP. The booklet began by discussing large wildfires in the three states in the previous year. It contained information and drawings contrasting wildfires and prescribed burning fire as part of the description of the public program. Then the wildfire acreage reduction and costs of prescribed burning program were described in more detail. After voting on the prescribed burning program, the mechanical fire fuel reduction was introduced as an alternative. The same elements like those in the RX program were described for this program; in particular the reduction in acreage burned by wildfires. The following WTP elicitation question was used for the prescribed burning program:

If the Expanded Prescribed Burning Program was undertaken in your county and state, it is expected to reduce the number of acres of wildfires from the current average of approximately A acres each year to about B acres for 25% reduction.

Your Chance to Vote: *Your share of the Expanded Prescribed Burning Program would cost your household $X……..a year. If the Expanded Prescribed Burning Program was on the next ballot would you vote: In favor ……. Against……*

The $X was replaced by the monetary bid amounts for prescribed burning, which were $10, $20, $30, $40, $60, $90, $120, $150, $250, and $350. The bid amounts of the mechanical fire fuel reduction are on average $10 higher that those of the prescribed burning program. The similar question also was used for the mechanical fire fuel reduction program. Table 2 shows the acreage reduction in each state.

Table 2-- *current acres burning and reduced acres burning by RX and Mech programs*

States	Current wildfire acres burned-A	Wildfire acres burned with program-B	Acreage Reduction	
			RX program	Mech program
California	362,000	272,500	89,500	89,500
Florida	200,000	150,000	50,000	50,000
Montana	140,000	105,000	35,000	35,000

Data collection and survey mode

To get a representative sample, random digit dialing of the population was used. The use of random dialing assures that nearly all households are eligible to be interviewed. The surveys were conducted using phone-mail-phone approach. The initial phone interview lasted about five minutes with questions focusing on the introduction of the survey purposes, and obtaining mailing addresses to send the in-depth survey booklet. The individuals were asked to read the booklet prior to the scheduled date of the phone WTP interview. The phone interviews were conducted in English with the white households and Spanish for Hispanic households in California (CA) and Florida (FL), and only in English in Montana (MT).

The survey response percentages in three states CA, FL and MT in the in-depth WTP interview are similar (72.8%, 72.2% and 72.9%, respectively). A chi-square test indicates they are not statistically different.

Statistical analysis of WTP responses

We pool data across three states to estimate the scope test model for RX and Mech programs controlling for any demographic or attitude differences among households of the three states. We test whether acreage reduction of

forests burned affects the probability of saying yes to the proposed bid amount.

Results for White Households

The initial regression is specified with demographic and attitude variables to control for any differences across states. The **Acre Reduction** variable is statistically significant at 0.01 and 0.1 level for both RX and Mech program respectively (table 3). The positive sign of this variable tells us that white households in these states would be willing to pay more for a larger reduction the number of acres of forests burned. The null hypothesis of no effect of acreage reduction is rejected and WTP is sensitive to reduction of burned forest acreage, i.e., sensitivity to scope is supported.

Table 3-- *logit regression results of scope test for white households*

Variables	RX program		Mech Program	
	Coefficient	t-statistic	Coefficient	t-statistic
Constant	1.4638	(1.84)	0.021	(0.03)
Acre Reduction	1.17E-05	**(2.4)*****	**6.37E-06**	**(1.65)***
RXBid	-0.00449	**(-6.36)*****		
MechBid			**-0.003**	**(-4.49)*****
Age	-0.00323	(-0.51)	0.0039	(0.73)
Educ	-0.0472	(-0.99)	-0.0117	(-0.29)
ExpSmoke	0.0247	(0.08)	-0.3698	(-1.45)
Income	2.81E-06	(0.91)	**5.40E-06**	**(2.13)*****
OwnHome	0.0228	(0.09)	-0.2139	(-0.96)
RerspProb	0.268	(1.14)	0.1095	(0.55)
WitnessFire	-0.07	(0.06)	-0.192	(-0.98)
McFadden R-squared	0.0735		0.0438	
Total observations	583		673	

* Significance at 10% ** significance at 5% *** significance at 1%

Results for Hispanic Households

For Hispanics, from the positive sign of the **Acre Reduction** variable and its significant t-statistic in table 4, we can see that the larger the acreage reduction of forest burned is proposed, the more likely the Hispanics say yes to the bid amounts. The **Acre Reduction** variable is statistically significant at 0.01 level; therefore we accept the alternative hypothesis with $\beta_1 > 0$ at this level. The scope or change in the amount of reduction in burned forest is statistically significant and therefore WTP is sensitive to amount of acreage reduction.

Table 4-- *logit regression results of scope test for Hispanic households*

Variables	RX program		Mech Program	
	Coefficient	t-statistic	Coefficient	t-statistic
Constant	1.493	(1.32)	1.7872	(1.83)
Acre Reduction	2.27e-05	**(3.4)*****	1.47E-05	**(2.63)*****
RXBid	-0.002716	**(-3.26)*****		
MechBid			-0.001152	**(-1.65)***
Age	-0.0069	(-0.89)	-0.000218	(-0.03)
Educ	-0.088	(-1.49)	**-0.1766**	**(-3.47)*****
ExpSmoke	0.2527	(0.96)	0.08188	(0.37)
Income	-4.28E-06	(-0.92)	1.11E-06	(0.28)
OwnHome	-0.2388	(-0.93)	-0.0989	(-0.46)
RerspProb	-0.095	(-0.33)	-0.2344	(-0.94)
WitnessFire	0.166	(0.61)	0.1355	(0.59)
McFadden R-squared	0.0779		0.06042	
Total observations	478		601	

Reduced form logit model

To estimate a more policy relevant WTP function for acreage reduction, we eliminated variables that were not consistently significant in order to focus the impact of significant variables on the probability of voting to pay the bid amounts. This model will exclude variables that are insignificant as inclusion of these will unnecessarily inflate the variance, reducing power of statistical tests to detect scope, and make the model more cumbersome for mangers to use.

Table 5 presents the reduced form logit models for white households. Scope is even more evident for the mechanical program as the statistical significance of the acreage reduction variable is now significant at the 1% level. These logit equations can be reparameterized into benefit or willingness to pay functions for reductions in acreage burned by following the procedure of Cameron (1988) to yield a

straightforward WTP function for reducing acres burned. By dividing the constant and acres by the absolute value of the bid coefficient we therefore obtain WTP per white household as a function of the reduction in acres burned from using the prescribed burning program:

WTP per household= $174.06+.002578 (Acre Reduction)

Table 6 presents the reduced form logit models for Hispanic households. Given the statistical significance of acres burned, scope continues to be evident for both the RX and Mechanical programs. For the mechanical program, although the bid amount is negative, it is not statistically significant.

Table 5-- *reduced logit regression results for white households*

Variables	RX program		Mech Program	
	Coefficient	t-statistic	Coefficient	t-statistic
Constant	0.7899	(3.04)***	-0.4819	(-2.16)**
Acre Reduction	1.17E-05	(2.7)***	1.05E-05	(2.9)***
RXBid	-0.004538	(-6.91)***		
MechBid			-0.00311	(-4.96)***

Table 6-- *reduced logit regression results for Hispanic households*

Variables	RX program		Mech Program	
	Coefficient	t-statistic	Coefficient	t-statistic
Constant	-0.2229	(-0.6249)	-0.9574	(-3.09)***
Acrereduction	2.50E-05	(4.69)***	2.03E-05	(4.69)***
RXBid	-0.00247	(-3.19)***		
MechBid			-0.000649	(-1.02)

Conclusion

The scope test conducted in this paper shows that willingness to pay for prescribed burning and mechanical fire fuel reduction programs among the whites and Hispanics is sensitive to the amount of reduction in acreage burned. The more acreage reduction proposed, the more people would likely pay. This finding is true for both white households taking the survey in English and Hispanics taking the survey in Spanish. The case study expands our stocks of knowledge regarding the scope test for evaluating the validity of the contingent valuation method. The resulting logit equations can be converted into benefit functions for each fuel treatment program for use by fire managers to evaluate the economic benefits of reducing forest fire acreages.

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