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ANALYSIS

A willingness-to-pay function for protecting acres of spotted owl habitat from fire

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Abstract

A contingent valuation survey was used to estimate the economic value to California and New England residents of implementing a fire management plan to reduce acres of old growth forests that burn in California and Oregon. Using a random effects probit model to account for the panel nature of the data, the average willingness to pay to reduce catastrophic fire on 2570 acres was $56 per household. Since acreage of habitat protected is a statistically significant variable in the willingness-to-pay function, this function can be used by managers to evaluate the incremental benefits of different fire management plans that reduce additional acres burned. These benefits can serve as justification for funding of prescribed fire and fuel reduction programs to protect critical habitat of the Northern and California Spotted Owl.

Keywords: Contingent valuation; Old growth forests; Fire; Spotted owls

1. Introduction

Present federal fire management policies primarily incorporate the economic values of traditional multiple uses in decisions regarding fire management efforts. There is growing recognition within the Federal agencies that protection of other environmental values beyond traditional multiple uses needs to be incorporated into fire decision making (González-Cabán and Chase, 1992; González-Cabán, 1993). These values often reflect public desire to know that rare and distinctive ecosystems exist (e.g. existence value, proposed by Krutilla, 1967) and will be protected for future generations (bequest value) as well as being

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available for visits at future times (option value). Along with recreation, these three values are sometimes referred to as Total Economic Value (Randall and Stoll, 1983).

These values may be particularly important for preservation of old growth forests for threatened species such as the Northern Spotted Owl. Approximately 7 million acres of old growth forests have been designated by the US Fish and Wildlife Service as Northern Spotted Owl Critical Habitat Units under the Endangered Species Act. This designation eliminates clear cutting and restricts the logging that can be done. However, due to past fire suppression increasing fuel loads, one significant threat to preservation of habitat stems from possible catastrophic fires.

The State and Federal agencies in California have adopted a pro-active approach to protect old growth forests before the California Spotted Owl populations decline to the point where they must be listed as a Threatened specie. The USDA Forest Service has made substantial modifications to its forest management practices in the Sierra Nevada to maintain a viable population of California Spotted Owls. However, due to past fire suppression, the risk of crown or stand replacing fire is considered by biologists to be the largest remaining threat to the survival of the old growth on which the California Spotted Owl depends (Verner et al., 1992). The Technical Assessment stated "Severe wildfires in Sierran mixed-conifer forests may represent the greatest threat to current owl habitat" (Verner et al., 1992, p. 258). Forests where owls are found are more susceptible to fires than other forest types (Verner et al., 1992, p. 248).

While fire risk and fire suppression costs are high, there has traditionally been little funding for non-commercial timber fuels reduction programs (USDA Forest Service, 1993, pp. IV-56). Funding is inadequate for the increased demands that the California Spotted Owl management program will require (USDA Forest Service, 1993, pp. IV-56). The joint Federal and State California Spotted Owl Policy Implementation team recognized the need to develop non-traditional budget justifications for funding the fire risk reduction efforts such as prescribed burning of ladder fuels (CASPO, 1992).

2. Study objectives

Our goal is to provide managers with a function relating willingness-to-pay (WTP) for acres of old growth forests in California and Oregon that are protected from stand replacing or catastrophic fire. These estimates may prove useful in justifying the added cost of prescribed fire and other fuels management prescriptions needed to protect critical habitats of the Northern and California Spotted Owl. Lastly, this analysis serves to demonstrate the practicality of developing willingness to pay functions for managers to estimate the benefits of other environmental values of forests, such as water quality or recreation protected by fire management.

3. Valuation methodology

Vaux et al. (1984) conducted the first study on the influence of fire on the economic value of forest recreation. The authors state, "Willingness-to-pay is an appropriate measure for valuing the effects of fire on forest recreation" (Vaux et al., 1984). This is consistent with Federal benefit-cost directives which require the use of WTP as a measure of benefits (US Water Resources Council, 1983).

Vaux et al. (1984), also concluded that the Contingent Valuation Method (CVM) would be appropriate for measuring such values. CVM uses a questionnaire or survey to create a hypothetical market or referendum, and then allows the respondent to use it to state or reveal his or her WTP for recreation, option, existence and bequest values (Mitchell and Carson, 1989). The first part of a CVM survey presents the current and proposed change in quantity or quality of the resource. Second, the respondent is told how they would pay for the proposed change. There are two types of provision rules, with the specific type depending on whether the good is a pure public good like air quality or an excludable public good like recreational use of particular area. In the case of provision of a pure public good, once it is provided, all individuals

consume the same quantity and it is not possible to exclude non-payers. In this case the ideal provision rule is a voter referendum of the form "if the majority votes to pay the cost, the public good is provided to all members of society." A less ideal provision rule is of the form "if enough people agree to pay the cost, all members of society will get the public good." In the case of recreation where exclusion is possible, the provision rule is more direct: "If you agree to pay the stated amount, you get the improved quality/quantity; if you do not agree to pay, you remain at the current level." The recommended WTP question format asks respondents to state whether they would pay a specific dollar amount that varies from respondent to respondent (Arrow et al., 1993).

Using responses from a survey to measure WTP is not without objection. The main concern is with the validity of responses, specifically would the respondent actually pay the dollar amounts they agree to pay in the survey? There have been dozens of studies testing the validity of stated WTP by comparison of values derived from other methods. A summary of these studies by Carson et al., 1996, determined that CVM derived estimates of WTP for recreation were slightly smaller than WTP from actual behavior based methods for valuing recreation. Nonetheless, concerns remain about the degree of accuracy of CVM estimates of WTP for existence and bequest values for natural resources the public is unfamiliar with (see Diamond and Hausman, 1994 for criticisms). However, the empirical test-retest studies have demonstrated CVM to be reliable at eliciting such values (Loomis, 1989, 1990; Reiling et al., 1990). CVM is a recommended method for use by Federal agencies for performing benefit-cost analysis (US Water Resources Council, 1983), for valuing natural resource damages (US Department of Interior, 1994), and was upheld by the Federal courts (US District Court of Appeals, 1989). A 'blue ribbon panel' co-chaired by two Nobel laureate economists stated that CVM can produce estimates reliable enough to be a starting point for administrative and judicial determinations (Arrow et al., 1993).

4. Study design

To statistically estimate willingness to pay as a function of acres protected, data was collected using a survey of California and New England households to determine their WTP to reduce fire intensity and acres burned of spotted owl habitat in old growth forests in California and Oregon.

4.1. Incorporating technical information on fire

To provide for realistic fire management scenarios, data on the frequency, extent and intensity levels of actual fires under current management efforts in old growth forests that are habitat of the California and Northern Spotted Owls was obtained from USDA Forest Service fire and wildlife specialists in Oregon and California. Discussions with fire management staff provided a list of additional fire management actions that could be undertaken by the Forest Service to reduce the intensity and extent of fire in California and Oregon old growth forests.

4.2. Survey design

A survey booklet was developed to provide the basic information to respondents prior to eliciting their WTP. For example, the California survey stated that "..an average of 462 forest fires occur per year. Each year, these fires burn about 14240 acres of old-growth forests in National Forests and Parks in California. The area is equal to 2436 city blocks or 23 square miles, equivalent to an area 4 miles wide and 5.75 miles long."

Then the elements of the Fire Prevention and Control Program that would reduce the acres burned was listed:

1. Fire hazard reduction: Reduce the number and area of high intensity fires through physical removal of brush and small kindling-like deadwood on the forest floor and through once-a-decade prescribed fires. This will reduce the risk of high intensity fires which burn all the way to the top of the large mature trees.
2. Earlier fire detection: This includes more fire lookouts and fire detection airplane flights to discover small, low intensity fires before they grow into large, high intensity fires.

3. Increased fire protection: This includes more fire patrols, maintenance of existing firebreaks surrounding these old growth forests, fire safety education and enforcement of fire regulations.
4. Quicker and larger fire control response: This requires having more fire fighters and equipment located closer to old growth forests in California (and Oregon).[2]

The narrative of the California Program indicated that the program reduces the acres of high intensity fires and total acres of old growth forests burned by all intensities of fire by 20% or 2850 acres each year in California. California residents were asked their WTP to reduce the amount of old growth forests in Northern Spotted Owl critical habitat units (CHUs) in Oregon that burn each year by 20% or 1400 acres. The third program was a combined California and Oregon program, reducing acres burned by 4250 acres.

5. WTP questions

Households were told that there was insufficient funds to pay for the improved fire prevention and control programs. Survey respondents were then asked the following, ''Thinking about Program B, which reduces the proportion of high intensity fires and also includes a 20% reduction in the acreage of old-growth forest that burns each year: If Program B were the only program available and your household was asked to pay $X each year to help pay for Program B would you pay this amount? Yes/No/(don't know).''

The same basic wording was also used to ask the WTP question for the Oregon fire control program and for a program that combined the California and Oregon programs. All respondents were asked the same three programs, in the same order regardless of their answer to any one program.

[2] Copies of the survey instrument are available from the authors.

The means by which all households would pay was a closed-ended or dichotomous choice question. The dichotomous choice format simply asks the person if they would pay a given dollar amount for the program each year. The respondent has only to decide if the value to him or her is worth at least this price or not.

To check the representativeness of the returned surveys against the population, simple demographic questions such as age, education, membership in environmental organizations and income were asked.

5.1. Attitudinal indicators of importance

Before asking respondents whether they would pay for a fire protection program for Spotted Owl critical habitat, respondents were provided an opportunity to reflect on why they may care about these forests. The first set of questions asked about the relative importance of old growth forests in California and Oregon for recreational use, providing timber, as habitat for plants and wildlife, providing jobs, and providing scenic beauty. A four-point Likert scale allowed individuals to rate the relative importance of these various reasons for valuing old growth forests in California and Oregon. This neutral response format (that precedes the dollar valuation questions) will also aid in explaining the WTP responses.

5.2. Pre-tests

A complete mail booklet and survey script was developed and then pre-tested on a small sample of California and New England residents. The procedure was identical to that of the actual survey: (a) an initial telephone contact (using random digit dialing) to solicit participation, obtain a mailing address to send the booklet to and arrange a time for the call-back interview; (b) mailing of the booklet; (c) completing the interview over the phone. The pretest was used to refine the range of bid amounts for the dichotomous choice question. Fifteen different bid amounts ranging from $4 to 250 were randomly assigned to survey respondents.

6. Estimation of WTP using the probit model

Since the printed dollar amount ($X) varies across the sample, the dichotomous choice format allows the analyst to statistically trace out a demand-like relationship between the probability of a 'yes' response and the dollar amount (Hanemann, 1984). Since each respondent answers three such dichotomous choice questions (one at each acreage level), these responses may be correlated. With a small sampling fraction of the entire population of households, a random effects probit model is a suitable statistical approach (Greene, 1990, pp. 486–495; Madalla, 1987, pp. 309). Further, Madalla, 1987, pp. 309–317) suggests that when we desire to estimate coefficients on the influence of an individual's demographics on responses, these cannot be identified with a fixed effect model, but it can with a random effects model. The random effect probit model is:

$$R_{it} = \boldsymbol{\beta} \boldsymbol{X}_{it} + u_i + \epsilon_{it} \quad (1)$$

where $\boldsymbol{\beta}$ and $\boldsymbol{X}$ are vectors of coefficients and explanatory variables, respectively; i, indexes individuals in the sample and t, indexes the number of responses per person; u_i is an unobservable characteristic specific to individual i. It is a random disturbance that is common to and constant over a given individual's responses and assumed to be uncorrelated with the other regressors (Greene, 1990, pp. 486-496; Madalla, 1987); ϵ_{it} is the transitory error due to random response shocks across individuals (Alberini et al., 1994); R is a binary variable, taking on a value = 1 for a Yes response (i.e. Yes would pay $X).From Eq. (1), Hanemann (1984) provides a formula to calculate the median WTP for the individual. The formula is:

$$\text{Median WTP} = B_0/(B_1) \quad (2)$$

where B_1 is the coefficient estimate on the bid amount and B_0 is either the estimated constant (if no other independent variables are included) or the grand constant calculated as the sum of the estimated constant plus the product of the other coefficients times the mean of the respective independent variables for each individual.

7. Sample design

Random digit dialing (RDD) was used to initially contact 737 households in California and 709 households in the New England states of Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island and Vermont. The initial contact phase involved briefly explaining the general topic of the survey, soliciting agreement to complete an in-depth telephone interview at a mutually agreed upon date/time and finally obtaining their mailing address to send the information booklet. A total of 499 California households and 449 New England households were scheduled for in-depth interviews, reflecting an initial participation rate of 68 and 63.3%, respectively. The 948 scheduled households were mailed the survey booklet that contained the background information on old growth forests, maps, and information about current and proposed fire management programs. A total of 358 interviews were completed out of 499 that were scheduled in California for a completion rate of 72%. In New England, 314 interviews were completed out of 449, yielding a 70% completion rate.

8. Response rate

Combining the two response stages the overall response rate for California was 49 and 44% for New England. The samples had a slightly larger proportion of males (52-53% male) as compared to the population proportion for California (50%) and New England (48.3%). There was less than a 10% difference between the household income of the sample and that of the respective populations.

9. Statistical results

To allow managers to calculate WTP for reductions in expected acres burned, the probit WTP function is estimated including a variable for acres. Since economic theory suggests diminishing marginal value to greater and greater reductions in acreage burned, the natural log of acres were estimated. Table 1 presents the results. Both the

Table 1
Probit equation for WTP to reduce fires in old growth forests

Variable	Coefficient	*T*-Statistic	Variable mean
Constant	−2.2254	−13.10	1
Lacres[a]	0.1746	9.04	7.85
Ogexist[b]	0.0857	7.02	3.47
Envqimp[c]	0.2354	12.13	3.74
Income[d]	0.000003	10.32	46388
Age[e]	−0.0052	−9.08	46.5
Donate[f]	0.1076	5.67	0.34
Bid[g]	−0.00462	−18.38	87.91

$N = 1875$; % Correct Predictions = 66.77; Pseudo $R^2 = 0.11$
[a] Lacres is the log of acres; [b] Ogexist is the importance of knowing old growth forests exist; [c] Envqimp is the importance of the quality of the environment; [d] Income is household income; [e] Age is person's age in years; [f] Donate is a dummy variable for whether they had contributed to an environmental organization in the past 12 months; [g] Bid is the dollar amount respondents were asked to pay.

bid amount and the natural log of acres are statistically significant at the 0.01 level. This suggests respondents carefully considered the details of the survey questions. In particular, the negative and statistically significant coefficient on bid suggests that the higher the dollar amount respondents were asked to pay, the less likely they would pay. This demonstrates they took the dollar amount they were asked to pay seriously. The fact that acres is significant implies that the amount of habitat protected influenced their probability of paying a given dollar amount. As might be expected the three responses were correlated ($P =$ 0.78 and is significant at the 0.01 level).

10. Benefit estimates

Using Eq. (2), probit coefficients are used to calculate median willingness to pay per household for reducing the acres burned by the sample average of 2570 acres. This estimate is $56 per year, with a 95% confidence interval of $52–60 (confidence interval calculated using an approach of Park et al., 1991). What is more useful for fire policy analysis is the incremental or marginal WTP as a function of acres of old growth forests that no longer burn. Table 2 provides estimated values per household for preventing fires on between 700 and 5000 acres of old growth in California and Oregon. These values per household are converted to values per acre per household.

Generalizing the sample to the population involves two issues. First is the extent of the affected population. Since distant New England residents had a positive WTP for the California and Oregon programs, and these are National Forests, we believe the appropriate affected population is nationwide. The second factor is the representativeness of the data.

Our overall survey response rate is slightly less than 50%. Thus, we provide two national benefits: (1) household values are expanded upward to values for the US as a whole applying our average WTP per household per acre to all US households; (2) the value per household per acre is applied to just the proportion of US households that would respond to the survey. Essentially, this assumes that non-respondents WTP is zero. Given our response rate this has the effect of cutting our aggregate benefit estimate in approximately half. This provides a conservative estimate of WTP since it is unlikely that all people who refused to participate in the survey have zero WTP.

The values per acre are quite substantial, especially for reducing the first 1000 acres that burn. If stand replacing or catastrophic fires in old growth forests are reduced from their current 21000 acres annually to 18000 acres, the marginal benefit is $632000—1.359 million per acre using the US sample expansion excluding and including non-respondents, respectively. Either estimate of incremental WTP for reducing fire can be com-

Table 2
Willingness to pay to reduce acres of old growth forests burned in Oregon and California

Acres protected	WTP per household	Marginal WTP per household per acre	US households	
			All households value per acre	Respondents only value per acre
700	$6.64	—	—	—
1000	$20.12	0.0449	$4 490 600	$2 088 130
2000	$46.30	0.0262	$2 618 000	$1 217 400
2569	$55.75	0.0166	$1 662 000	$772 800
3000	$61.61	0.0136	$1 359 200	$632 000
4000	$72.48	0.0108	$1 086 600	$505 250
5000	$80.91	0.0084	$842 800	$391 900

pared to the manager's estimate of the cost of reducing catastrophic fires in old growth forests through fuel load reduction via prescribed fire or mechanical means. For most fire management actions we have reviewed, the cost per acre is well below even the lowest benefit per acre figure (Table 2).

11. Conclusion

The case study in this paper demonstrates that the contingent valuation method is a promising approach to include a broad range of societal concerns about environmental values into public land management agency fire decisions. Our specific example provides a willingness to pay function for reducing acres of old growth forests that burn in Oregon and California.

Public land managers in California and Oregon now have a powerful tool for estimating the economic benefits of reducing acres burned of old growth forests that are habitat of the Northern and California Spotted Owl. Judicious use of this tool should aid managers in developing budget requests for fuels reduction and prescribed fire programs to protect endangered species habitat.

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