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Assessing the Benefits of Reducing Fire Risk in the Wildland-Urban Interface: A Contingent Valuation Approach

Jeremy S. Fried
USDA Forest Service, Portland Forestry Sciences Laboratory
P.O. Box 3890, Portland, OR 97208
Phone: (503) 808-2058; Fax: (503) 808-2020; email: Jeremy_Fried@fs.fed.us

Greg J. Winter
Paul Schissler Associates
1101 Harris Avenue, Bellingham, WA 98225
Phone: (360) 676-4600; email: gregw@pacificrim.net

J. Keith Gilless
University of California Department of Environmental Science, Policy and Management
207 Giannini Hall, MC #3310, Berkeley, CA 94720
Phone: (510) 642-6388; Fax: (510) 643-5438; email: gilless@nature.berkeley.edu

Abstract

Wildland-urban interface (WUI) residents in Michigan were interviewed using a contingent valuation protocol to assess their willingness-to-pay (WTP) for incremental reductions in the risk of losing their homes to wildfire. WTP was elicited using a probability model which segments the risk of structure loss into "public" and "private" components.

Most respondents expressed positive WTP for publicly funded risk reduction activities. These respondents were characterized by tolerance for property taxes, perception of significant risk, high ranking of fire risk relative to other hazards, and high objective estimates of existing risk, and their WTP amounts were positively correlated with income and property value. Given that 97% of the respondents were insured against property loss, the large number of positive WTP responses suggests that substantial non-market and unreimbursed losses are experienced when structures are destroyed by wildfires.

Keywords:

CVM
non-market values
willingness-to-pay

Introduction

Residential development in areas with fire-adapted vegetation has created an extensive wildland-urban interface (WUI) in which the most important risks associated with fire are those to life and structures. As a result, wildland fire protection planning for these areas is moving away from a paradigm of suppressing vegetation fires to one of more comprehensive fire management. Considerable work has gone into the development of simulation models like the National Fire Management Analysis System (USDA Forest Service 1985) and the California Fire Economics Simulator (Fried and Gilless 1988), which were designed to assist fire agencies in evaluating the effectiveness with which they are meeting their mandates to minimize cost-plus-net-value-change or to provide equal protection for equivalent areas. Evaluations of effectiveness, however, have been limited by a lack of credible cost and value information. This problem has been especially acute in WUI areas, where the fire management problems are most complex, and the values at risk are greatest.

Prior research on the values at issue has taken a materials damage approach, ignoring risk and concentrating on ex post estimation of losses. This approach does not account for the implied utility effects of changing risk levels, and therefore underestimates the losses borne by risk-averse individuals (Adams and Crocker 1991). It also neglects the question of how to allocate responsibility for risk reduction between public agencies and property owners. Almost no work has been directed towards ex ante valuation of reducing the risk of losses from a property owner's perspective, even though such information is critical to justifying public or private investments to reduce fire risk.

Research on the value of reducing fire risk must address a host of special problems in addition to those normally associated with non-market valuation. For example, losses may be insured or uninsured. Insurance may be for replacement value or depreciated value, and coverage for out-of-pocket expenses such as temporary housing and meals varies. Homeowners often possess imperfect knowledge of their insurance status. Uncompensated losses associated with the destruction of family heirlooms or pets may be a significant component of total losses. Fire losses or near-losses may significantly affect perceptions of safety and emotional attachment to particular areas or structures.

The contingent valuation method (CVM) is well suited for ex ante valuation of reductions in fire risk (Adams and Crocker 1991). CVM measures the value of a non-market good by creating a hypothetical market in which maximum willingness to pay (WTP) for a good is assessed via mail surveys or personal interviews. Most CVM studies of risk reduction have dealt with threats to life or health, such as: hazardous waste risk reduction (Smith and Desvousges 1988); job-related risks and consumer product safety (Viscusi and Magat 1987); pesticide food safety (Eom 1994); and transportation safety (Schwab and Soguel 1995). The few studies that have looked at precautionary behavior by WUI residents have found willingness to take precautions to be related to proximity to recent fires, the time elapsed since recent fires, fire hazard awareness, hazard information, hazard experience, and risk perception (McKay 1985; Gardner and others 1987).

The primary objectives of this study were to determine the value of risk reduction to WUI homeowners, to identify factors which influence those values, and to explore linkages between risk reduction approach (public or individual) and perceived risk reduction value. This information can guide the formation and implementation of fire preparedness policies, particularly those involving education about individual risk reduction activities, fire protection user fees, and changes to the configuration of initial attack organizations.

The remainder of this paper reports the findings of a CVM survey of 285 households in Crawford County, Michigan, a WUI area which has experienced significant structure losses due to fire in recent years. WTP was elicited for: (1) a general program of risk reduction activities undertaken by the state (public RRAs); and (2) specific risk reduction actions that could be undertaken by a property owner (individual RRAs).

Risk Model

The probability of a structure being destroyed in a WUI fire (π) can be expressed as:

$$\pi = \mu\rho$$

where μ is the unconditional probability of a fire occurring in the neighborhood of the structure, and ρ is the conditional probability of the structure being destroyed should such a fire occur. This joint probability model is particularly well suited to a study of WTP for reductions in fire risk because it segments that risk into one component which is primarily addressed through the actions of public agencies (μ), and another component which is primarily addressed through the actions of property owners (ρ). This segmentation of risk is consistent with the notion of public agencies and property owners sharing responsibility for fire management in the WUI.

Public agencies can engage in a variety of RRAs through which they influence μ, including their expenditures on prevention and preparedness, the aggressiveness and effectiveness of their initial attack organizations, and their management of major fires. Property owners likewise influence ρ through RRAs such as maintaining a defensible space around their structures, providing for adequate fire service access, and incorporating fire-safe materials and design features into their structures (Cohen and Saveland 1997).

For this study, it was assumed that property owners would react equivalently to reductions in π resulting from a reduction in either μ or ρ, i.e., that they would treat contingent markets for public or individual RRAs as equally credible. Pretesting of the survey on 16 households[1] in the study area did not yield any indications that this assumption was implausible. Pretesting also revealed that: (1) property owners could readily grasp the relationship between public and individual RRAs and the joint probability risk model; (2) it was necessary to describe individual RRAs very explicitly in order to present a credible and understandable contingent market; (3) it is necessary to allow WTP estimates for individual RRAs to be expressed in terms of either money or time; and (4) respondents were uncomfortable estimating their WTP for public RRAs without knowledge of their current contribution to the funding of fire management agencies.

[1] Five names were provided by local fire managers as a starting point; these individuals were interviewed and asked for additional referrals to generate names of the other eleven individuals who ultimately participated in the pre-test. Pre-test participants were urged to "think aloud" during the interview and to ask questions about anything that was unclear to them. They were also asked follow-up questions at the end of the interview to assess the effectiveness of the communication.

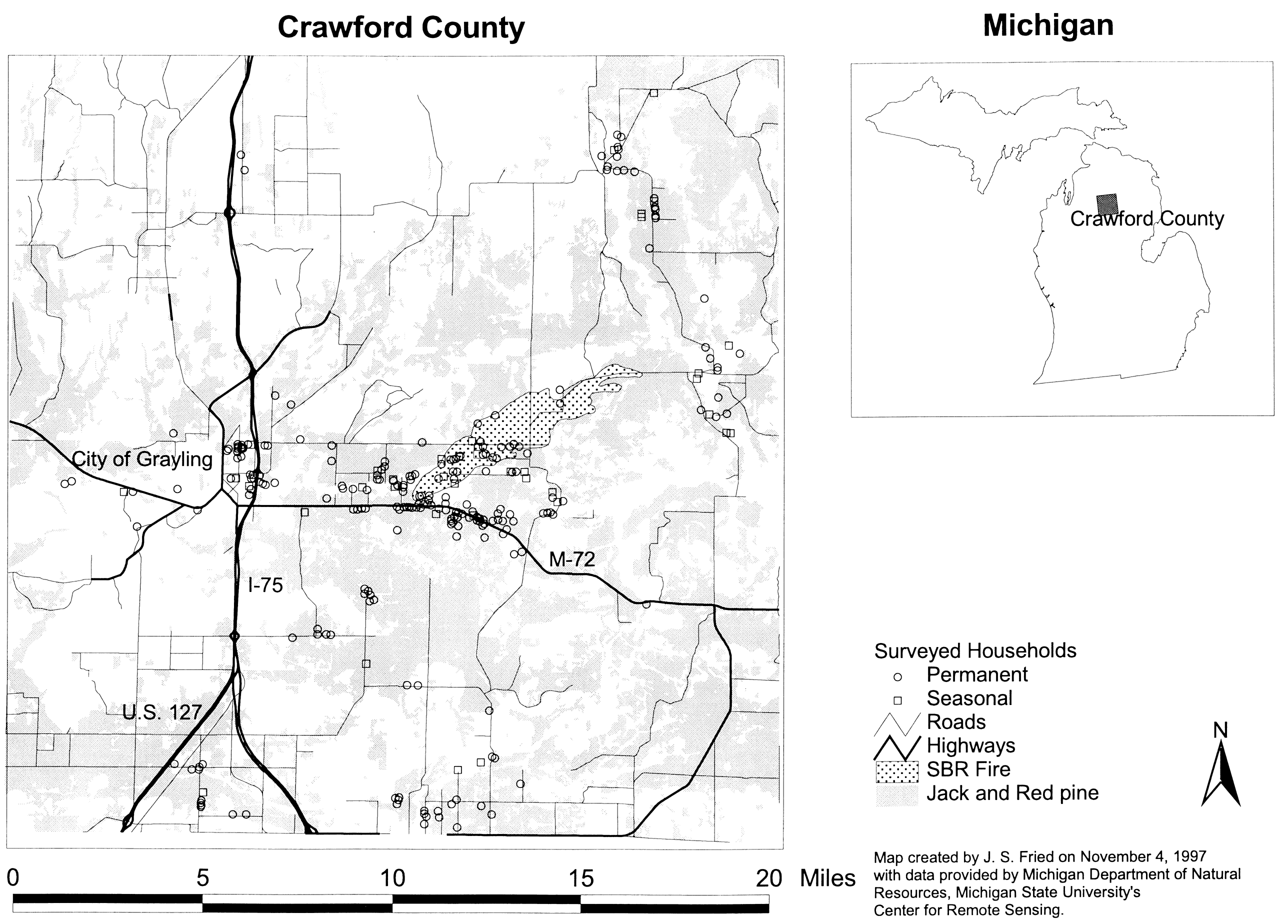

Figure 1. Map of Crawford County, Michigan, showing areas covered in jack and red pine, major roads, and perimeter of the 1990 Stephan Bridge Road Fire.

Survey Methods

Sampling households

The population sampled in this study consisted of households within a 100 square mile area of jack pine (*Pinus banksiana* Lamb.) forest in or adjacent to Grayling Township in Crawford County, Michigan. Public awareness of fire risk among residents is high due to the 1990 Stephan Bridge Road Fire (Figure 1), which burned 5916 acres, and damaged or destroyed more than 76 homes and 125 other structures (National Fire Protection Association, undated).

The first step in identifying these households was to obtain GIS coverages of roads, streams, and vegetation for the area from the 1980 Michigan Resource Information System (MIRIS). Unfortunately, the roads coverage contained only a fraction of the paved roads in the study area, and included no street names. Commercial maps of the study area were also woefully incomplete with respect to the road network. Further confusion with respect to the area's road network resulted from the ubiquitous local practice of using multiple names for the same road.

Telephone listings, tax records, and a "911" database summary were then consulted to identify as many of the households living in the study area as possible. A complete and correct list of names, addresses, and telephone numbers for all households living in the study area could not be developed due to deficiencies in these data sources. Telephone listings did not reflect unlisted numbers or households without telephones, making identification of seasonal residents particularly difficult. Commercial CD-ROM telephone listings included information on less than half of the households in the study area, so the more extensive listings in the 1993 Grayling telephone book had to be manually entered into a database, increasing the probability of data corruption. Addresses obtained from telephone listings were of limited utility for contacting households by mail, because the U.S. Postal Service recognizes only rural route and box numbers for a substantial number of the structures in the study area. An alternate address source, the Grayling Township property tax assessor's database, contained only legal property descriptions (i.e., referencing township, range and section rather than street address) and the mailing address to which property tax bills are sent. Over 40% of these tax bill addresses were outside the county, reflecting the study area's high proportion of seasonal residents. Even "local" tax addresses were not necessarily relevant, since many individuals held title to more than one property, and the records did not distinguish between properties with and without structures. Ultimately, address ranges along named roads had to be determined in the field utilizing maps and the telephone book database.

Starting from a list of households (with telephones) living on named roads in the study area, attempts to schedule interviews by telephone were problematic due to low at-home rates except in the evening hours, which were simultaneously the residents' preferred time to be interviewed. Interviewers therefore were directed to make door-to-door inquiries without prior telephone contact. Nevertheless, most households received a mailing informing them of study objectives and requesting their participation. Records were kept of all households who declined to participate regardless of contact method to allow calculation of an overall "decline-to-participate" rate, and to ensure against further contact. All interviews were conducted in-person, in or outside of respondents' homes.

Risk assessment

Two methods of assessing fire risk were employed in the survey. First, a standard forest fire hazard assessment form (Great Lakes Forest Fire Compact 1993) was used to score structural and site hazards for each structure at which an interview was conducted. Interviewers were trained in the use of this form via a one day training session conducted in the study area by a Michigan Department of Natural Resources Fire Prevention Specialist. Filling out this form with the respondent acted as an "ice-breaker" for the interview, and allowed the interviewer to classify the structure for purposes of the subsequent WTP questions. The form was given to the respondent at the conclusion of the interview as a tangible reward for participating in the study. Because this form was not designed to generate a quantitative assessment of fire risk, the information thus generated was not used in the course of the interview or in subsequent analysis.

Second, an estimate of π was made for each property using heuristic estimates of μ and ρ. The value of μ (and therefore π) for a single year is extremely small, so that the perceived value of risk reduction achievable for any given year might well fall below most households' threshold of concern. Estimates of μ (and by extension, π) were therefore defined for a 10-year period. An estimate of μ for the study area was derived from GIS coverages of vegetation and fire ignitions in the study area by calculating the sum of the area burned by fires igniting in jack pine during the past 12 years (the period for which fire ignition data was available), dividing this by the acres of jack pine in the study area, and multiplying this result by 10/12 to obtain a ten-year estimate. This procedure yielded an estimate of 0.15 for μ.

Table 1. Conditional (ρ) and joint (π) probabilities of fire loss by risk reduction action taken.

Action taken	Conditional probability (ρ)	Joint probability (π)[1]
None	0.93	0.14
Trees cleared	0.67	0.10
Grass mowed in fall	0.47	0.07
Debris free	0.27	0.04

[1]based on μ=0.15 for a ten-year period

A panel of local fire professionals was consulted for the purpose of estimating ρ. In their judgment, ρ was primarily determined by clearance of trees within 30 feet of a structure, fall mowing of grass to deprive spring fires of fuel, and maintenance of a debris-free zone about the home. Furthermore, they felt that the effect of these individual RRAs on ρ was hierarchical, with mowing and debris clearing providing no benefit without tree clearance, and debris clearance providing no benefit without both tree clearance and mowing. The panel's estimates of ρ for a 10-year period are shown in Table 1.

Household information

Survey interviews[2] started by asking respondents (one, self-selected member per household) about the duration and kind (seasonal or year-round) of their household's occupancy of a property, and if they anticipated moving out of the area within the next 10 years. Respondents were then asked about their awareness of fire risk when the property was acquired, their own estimates of μ and ρ, and their ranking of the risk of losing the structure on the property to a wildfire relative to being the victim of a burglary, tornado, or automobile accident. They were also asked to evaluate the current level of public expenditures on fire protection, to identify the entity they consider ultimately responsible for protecting structures from wildfires in Crawford County, and to relate their history of expenditures (of time and money) on annual or one-time individual RRAs over the past ten years.

[2] Interview protocols can be viewed on the web at: http://jeremy.msu.edu/pubs/ijwf1999/

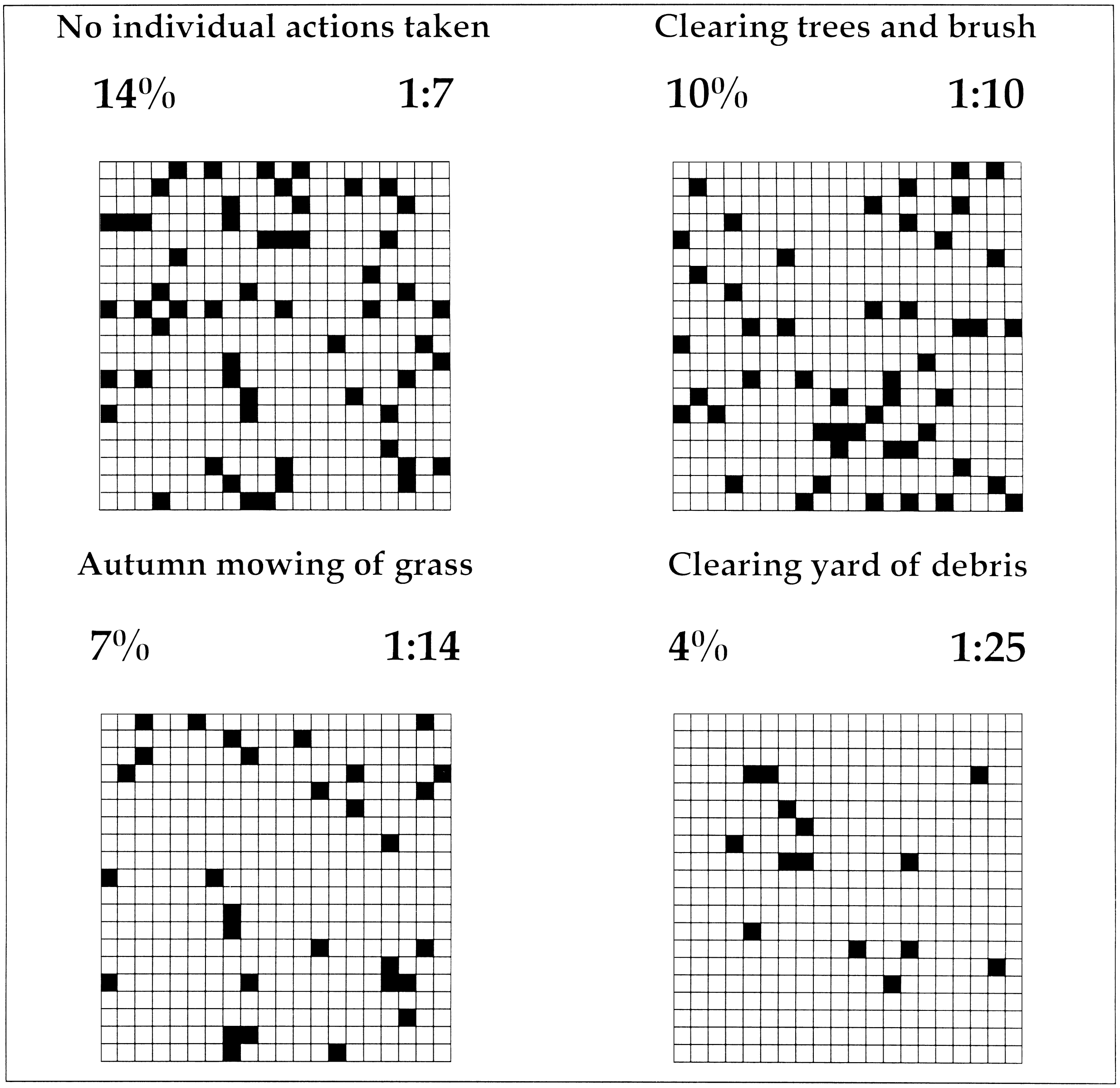

Figure 2. Risk card used to illustrate risk levels.

WTP for individual RRAs

To initiate the WTP questions, respondents were given the relevant estimate of π from Table 1 for the structure on their property (i.e., 0.14, 0.10, 0.07, or 0.04, depending on which of the 3 most important individual RRAs had already been taken). The RRA the respondent could take to incrementally reduce π was then identified for the respondent, along with the lower value of π that would result from taking that action. Given the hierarchical relationship of the three individual RRAs under consideration, the recommended action was always tree clearance if this had not already been done. If tree clearance already existed, the recommended action was mowing, if this was not already being done, and debris clearance otherwise. Respondents were also asked whether they would be more likely to invest time or money in undertaking the recommended action. Subsequent WTP questions were phrased in accordance with their answer to this question. Values of π, both current and projected, were communicated to respondents using risk cards showing percentages, odds, and appropriately shaded numbers of cells randomly distributed in a 20 by 20 grid (Figure 2). Presented with this information, respondents were asked:

> Keeping in mind that taking the action X will reduce the risk of your home being destroyed or damaged by forest fire over the next 10 years from the current risk of Y to Z, how much money (or time) would you be willing to spend to achieve this risk reduction?

For homes with the opportunity to undertake a second individual RRA, analogous information on the potential reduction in π was provided, and the question repeated. In an attempt to elicit respondents' true maximum WTP, all nonzero expressions of WTP were followed up by asking the respondent if they were not, in fact, willing to pay a series of incrementally higher values for the RRA. This procedure represents a combination of two approaches widely used in CVM studies: (1) open-ended questions and (2) interactive bidding games in which an initial value is explicitly specified (Mitchell and Carson 1989).

WTP for public RRAs

After obtaining WTP estimates for individual RRAs, respondents were provided with an estimate of their current contributions via property, sales, and income taxes towards fire protection costs, and asked to estimate their WTP for 2 levels of public risk reduction: (1) from their current level of π to the next lower level in Table 1; and then (2) for an additional reduction in π to the next lower level. Households already at the lowest level of risk ($\pi = 0.04$) were asked for their WTP for a reduction in π to one-half of that level ($\pi = 0.02$). Respondents were told that the risk reduction activities would only be undertaken if there was sufficient aggregate WTP among the affected public. The risk changes resulting from public RRAs were set equivalent to those from individual RRAs to minimize respondent fatigue and maximize the comparability of values for public and individual RRAs.

Risk cards were again used to illustrate risk levels. The specified payment mechanism was an increase in annual property taxes. Attitudes towards taxes were elicited in a series of follow-up questions.

Problems

Several problems were encountered in conducting the survey. "At-home" rates during periods of door-to-door canvassing were as low as 10%, and some residents were openly hostile in their refusals to be interviewed, or towards interviewers wearing Michigan Department of Natural Resources (MDNR) hats. Some respondents' antipathy towards the MDNR, which has primary fire protection responsibility in the study area, or towards public agencies in general, made it difficult to establish credible scenarios for WTP questions for public RRAs.

Of 344 households contacted, 285 (79%) agreed to be interviewed. It is difficult to assess the degree to which this sample is representative. The study area, having been defined by a particular type of forest cover, does not correspond closely to any political unit for which a demographic profile is available. Grayling Township tax records indicate that seasonal residents may be underrepresented in the study, which could have resulted in an underestimate of WTP given seasonal residents' generally higher household incomes.

Results

Summary statistics for the households interviewed are shown in Table 2. Median household income was in the range from $20,000 to $25,000, consistent with the median household income for Crawford County, Michigan, in 1990 of $21,497 (U.S. Department of Commerce Bureau of the Census 1992). The distribu-

Table 2. Household demographic and behavioral attributes.

Attribute	Value	Percent of sample
Income group	0-15K	21
N=267	15001-25K	29
	25001-44K	29
	44001+	21
Age group	18-25	2
N=281	26-35	8
	36-45	14
	46-55	17
	56-65	18
	66-75	25
	75+	16
Sex	Male	67
N=281	Female	33
Initial risk level (π)	4%	46
N=264	7%	19
	10%	12
	14%	24
Taken risk reduction action?	Yes	75
N=286	No	25
Plan to move within 10 years?	Yes	12
N=266	No	88
Insured against fire loss?	Yes	98
N=285	No	2
Seasonal resident?	Yes	17
N=284	No	83

Table 3. WTP, and payment vehicle preference for individual RRA.

Attribute	Value	Percent
Willing to take individual RRA N=127	Yes	72
	No	28
Preferred payment vehicle		
Time N=63	Non-zero, numeric	82
	"As much as it takes"	18
Money N=31	Non-zero, numeric	97
	"As much as it takes"	3

tion of respondents' property values was left skewed, with a range from $3,000 to $45,0000, a mean of $37,588, and a median of $30,000. Almost half of the households had undertaken all three of the individual RRAs upon which the conditional estimates of ρ were based, and 75% had already undertaken at least one RRA. Almost all indicated that they were insured against fire losses, and that their insurance covered both the structure and its contents. Only 12% of the homeowners planned to move out of the area within the next 10 years.

Of the 54% of the households who had not already undertaken all three of the individual RRAs upon which the conditional estimates of ρ were based, 72% were willing to invest time or pay a contractor to reduce their fire risk (Table 3). Two-thirds of these indicated a preference for doing the work themselves, choosing to express their WTP in time rather than dollars. Median WTP expressed in time increased from 20 hours for structures with an initial π estimate of 4% to 45 hours for structures with an initial π estimate of 14% (Table 4). Median WTP expressed in dollars, however, declined from $500 for structures with initial π estimates of 4, 7, or 10 percent, to $200 for structures with an initial π estimate of 14 percent. The proportion of households willing to invest time or money in RRAs

Table 4. Mean, median and standard deviation (SD) of WTP for (in hours and dollars) and percent of eligible population that are willing to invest in (via hours or dollars) 1 individual RRA, by initial risk level.

	WTP hours per year				WTP dollars per year				Willing to invest $ or hours	
π[a]	N[b]	Mean	Median	SD	N[b]	Mean	Median	SD	N[c]	%
.04	15	78	20	134	9	1390	500	2013	37	70
.07 & .10	23	78	32	621	9	2364	500	4793	55	65
.14	14	186	45	239	12	413	200	543	45	76
Total	52	163	31	435	30	1291	500	2871	137	70

[a] 7 and 10% risk levels were combined due to small sample size
[b] does not include zero or infinite bids
[c] includes zero and infinite bids

Table 5. Summary statistics for stated WTP for public RRA for each of 4 initial risk levels. In each group, the 1st row represents the 1st publicly funded risk reduction opportunity offered; the 2nd row represents the 2nd increment of risk reduction offered.

Initial risk	Offered risk	WTP dollars/yr Mean	WTP dollars/yr Median	Standard Deviation	N[a]	t-value[b]	Percent of bids >0 [c]
4%	2%	51	26	105	112	5.09*	62
2%	1%	11	0	25	87	3.99*	22
7%	4%	61	24	117	47	3.57*	55
4%	2%	9	0	31	32	1.61	16
10%	4%	109	40	223	29	2.63*	79
4%	2%	21	0	61	25	1.73	36
14%	7%	92	75	91	57	7.69*	86
7%	4%	16	0	28	45	3.87*	33

[a] smaller sample sizes for 2nd risk reduction valuation questions reflect a higher unit non-response than for 1st questions
[b] for the null hypothesis that the population mean is zero
[c] calculated as a percent of the total number of valid responses
[*] significant at the 0.05 level using a one-tail test

did not vary significantly as a function of the initial estimate of risk.

Median estimates of WTP for public RRAs were lower than for individual RRAs (for which WTP was expressed in dollars) resulting in a comparable reduction in risk (Tables 4 and 5). Median WTP expressed in dollars for individual RRAs was $200 to 500, compared to only $24 to 75 for public RRAs. Support for public RRAs, however, was widely expressed, with more than half of the respondents who were unwilling to pay for an individual RRA expressing a positive WTP for a public RRA (Table 6).

WTP for the 1st increment of public risk reduction was greater than WTP for the 2nd increment, regardless of the initial risk level (Table 5). This finding could be interpreted as evidence for a diminishing marginal utility for risk reduction via public programs. The proportion of non-zero WTP estimates for public RRAs to reduce risk by 1 level increased, though not monotonically, with initial risk level.

Fifty-three percent of respondents assigned equal responsibility to property owners and the government for protecting structures from wildfire, 26% assigned more responsibility to homeowners, and 21% assigned more responsibility to government (Table 7). Only 3% expressed the opinion that current government expenditures on fire protection are greater than "just right", while 38% thought they were less than "just right". Values for Somer's *d* statistic (a directional, ordinal measure of association) indicate that respondent propensity to express a zero WTP for public RRAs was not related to attitude regarding responsibility for fire protection. However, propensity to express a zero WTP for public RRAs was higher for respondents who viewed their current taxes as too high or thought that government spends more than it should on fire protection. This may indicate that some zero responses may in fact be protest bids, though no effort was made to remove such responses from the data or to determine how many were, in fact, protest responses.

Assuming that property owners' values and decisions could be described using an expected utility framework, it would be expected that willingness to pay for risk reductions should be positively related to income, the value of the property at risk, and risk level. Testing the data on WTP for public RRAs against these expectations was facilitated by viewing responses as a 2-stage process to account for the roughly bi-modal distribution of WTP estimates (Figure 3): (1) Respondents decide between making a zero or non-zero WTP estimate; (2) those willing to make a non-zero estimate decide what that estimate will be. Given this framework, the first decision was analyzed with a logit model, and the second with ordinary least squares (OLS) regression. For the logit model, explanatory variables tested included property value, income, initial risk level, respondent's estimate of the unconditional probability μ, property tax tolerance, and rank of wildfire risk relative to other hazards. Coefficients for all variables but income and property value were statisti-

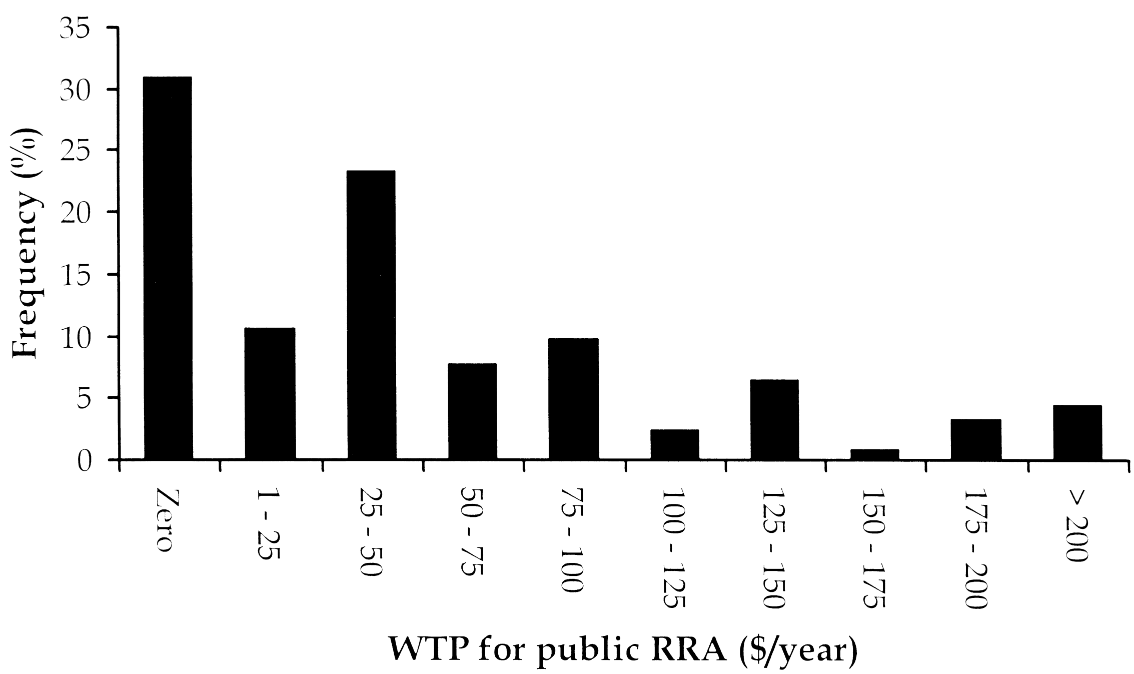

Figure 3. Distribution of bids for first increment of risk reduction via a public RRA.

Table 6. Percent[a] willing to pay non-zero amounts for public RRA by willingness to pay non-zero amounts for individual RRA.

	Non-zero WTP for public RRA	
Non-zero WTP for individual RRA	Yes	No
Yes	79	21
No	53	47

[a] of those eligible to be asked about their WTP for individual RRA

Table 7. Willingness to pay non-zero amounts for public RRAs, by attitudes towards wildfire protection spending and responsibility, and taxes.

	N	Percent	Percent of bids >0
Gov't spending on fire prevention/protection N=221			
Too much	3	1	0
Between	4	2	25
Just right	131	59	65
Between	46	21	74
Too little	37	17	86
Somers' *d*			0.185*
Entity(s) responsible for wildfire protection N=283			
Homeowners	25	9	59
Shared, more homeowners	49	17	67
Equally shared	151	53	74
Shared, more government	42	15	61
Government	16	6	62
Somers' *d*			0.000
Perception of property tax N=274			
Too much	63	23	43
Between	48	18	73
Just right	152	55	72
Between	7	3	100
Too little	4	1	100
Somers' *d*			0.202*

* significant at (p=.001)

Table 8. Logit model for the dichotomous decision to bid a non-zero amount for risk reduction achieved through public RRA and linear regression (OLS) model of ln(WTP) responses for respondents with non-zero WTP for public RRA.

Variable	Logit Model Coefficient	OLS Model Coefficient
Constant	-1.25*	3.353*
Risk level	0.38*	
Respondent estimate of μ	2.00*	
Property tax tolerance[a]	0.68*	
Wildfire risk rank[b]	0.34*	
Property value[c]		0.006*
Income[d]		0.133*
N	285	136
Model chi square	43.28	
Overall % predicted	74.31	
Adjusted R^2		0.217

* significant p<.05
[a] 1="too much" to 5="too little"
[b] 1="least serious" to 4="most serious"
[c] thousands of dollars
[d] on the scale bounded by 1: < $10K and 7: > $45K

cally significant (Table 8). The coefficients for each variable represent effects on the odds of making a non-zero WTP estimate. The odds of a non-zero bid increased with initial risk level, respondent estimate of μ, property tax tolerance, and ranking of wildfire risk relative to other hazards.

OLS regression of these same variables on non-zero WTP bids (log transformed) revealed that property value and income are the only significant predictors (Table 8). The significant, positive coefficients for property value and income group were consistent with expectations.

Discussion

This attempt to use the CVM to assess property owners' WTP for reductions in risk provided a number of insights into the WUI fire management problem, and revealed a number of problems that others should anticipate in the design of future CVM studies. Both are discussed in this section.

The frequency of zero WTP estimates for public RRAs results in a bi-modal distribution for WTP that can be viewed as the outcome of a 2-stage process in which respondents first decide whether or not to make a zero or non-zero response. The data collected in this study indicated that this decision is influenced by risk level and attitudes towards taxation and public fire pro-

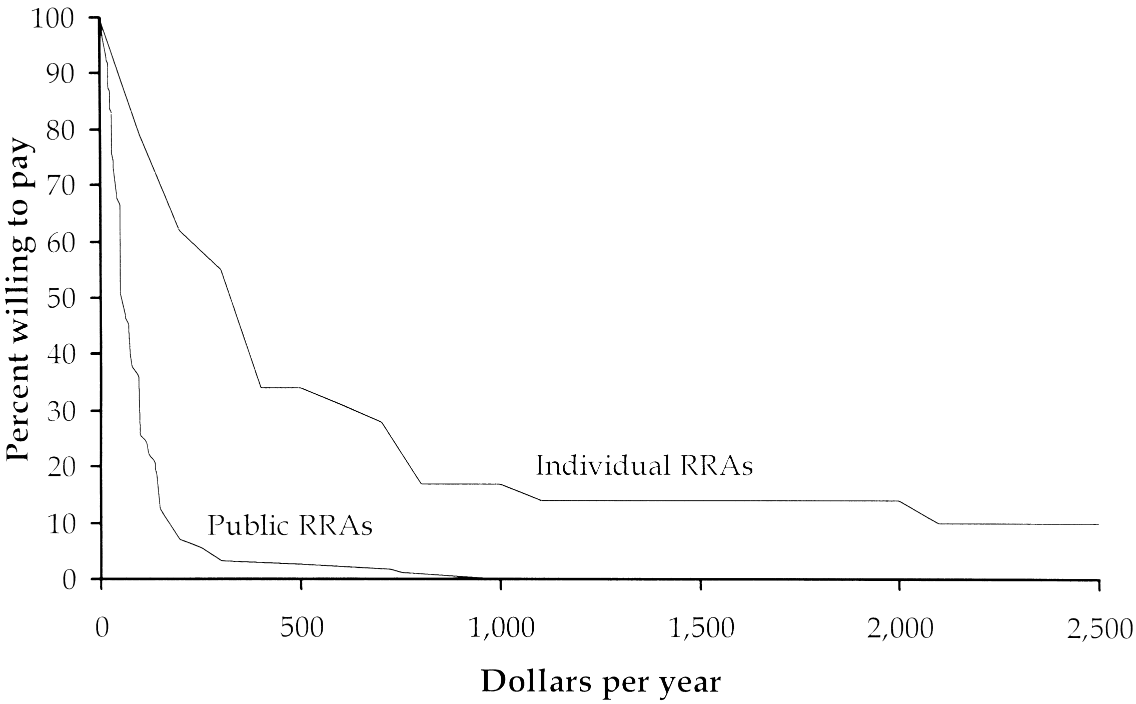

Figure 4. Percent of respondents who are willing to pay for public and individual RRAs, by amount.

tection agencies. The data also indicated that non-zero WTP estimates for public RRA are positively related to property values and income, but not necessarily to risk level. These results are generally consistent with a priori expectations postulated for this paper.

Estimates of WTP for both public and individual RRAs are highly skewed (Figure 4). This may reflect the distribution of attitudes towards risk across households, or it may be an artifact of the open-ended question format used to elicit the estimates. The frequency of very high WTP estimates for public RRAs was lower than for individual RRAs, perhaps due to the fact the respondents estimated WTP for public RRA following provision of information on their current tax contribution to fire management.

WTP estimates for individual RRAs were notably higher than for public RRAs of comparable effectiveness, yet many respondents who expressed zero WTP for individual RRAs had positive WTP for public RRAs. This inconsistency may reflect a starting point bias for public RRAs, a problem with the credibility of the public RRA scenarios, or a sampling problem with the households who had not already undertaken the three individual RRAs upon which conditional risk levels were based. It may also reflect either: (1) localized social constraints of a kind that have been largely overlooked in the WUI literature, e.g., restrictions on cutting vegetation near a popular trout fishing area on the Au Sable River; (2) more generalized constraints on the effectiveness of individual RRAs such as the difficulty of dealing with hazards on adjacent properties; or (3) a reluctance to alter their own property. Many respondents who were unwilling to engage in the most important individual RRA (tree clearance) indicated that they were quite willing to trade off higher risk of fire losses for the aesthetic and practical values provided by their trees. Several were quite emphatic with respect to the importance of tree cover to their continued residency. Others questioned the ethics of cutting a tree for any purpose.

CVM estimates of WTP for reductions in the private risk component for some respondents may be more a function of the cost of undertaking a RRA than a true valuation of the associated reduction in risk. In such cases, a nonzero WTP estimate may represent the minimum value of a RRA, and a zero WTP may represent an assessment that the cost of a RRA exceeds the value of the associated risk reduction. This was especially evident for respondents who mused aloud with respect to the cost of undertaking the action before providing an estimate of their WTP for it.

Many WUI residents are strongly predisposed to undertake individual RRAs themselves, and are only comfortable expressing their WTP for such RRAs in units of their own time. This data cannot be easily combined with WTP estimates expressed in dollars for those predisposed to work through contractors. A close parallel exists with reconciling travel time and expenditure data in the travel-cost method for valuing non-marketed recreational opportunities (Walsh 1986).

Conclusions

Economic analysis of programs to reduce fire losses in the wildland-urban interface would be improved by better information on how property owners value reductions in their risk of losses. From the results obtained in this study, the contingent valuation method would appear to be a promising approach for assessing property owners' willingness-to-pay for public risk reduction actions, willingness to pay for or personally undertake individual risk reduction actions, and for producing information that can be utilized in conjunction with stochastic simulation models of initial attack programs or probabilistic models of structure losses.

Institutional, economic, and cultural constraints on individual risk reduction activities point to an important role for public risk reduction activities. Most WUI residents appear ready to pay modestly higher property taxes to support public RRAs, although the level of antipathy towards the state agency charged with fire control in some areas may create some problems with the survey procedure outlined in this paper.

Many WUI residents appear ready to pay substantially more for individual RRAs than for public RRAs, but this finding needs to be confirmed by a larger sample of property owners who have opportunities to undertake individual RRAs.

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