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Willingness to Pay to Reduce Wild Fire Risk in Wild land-Urban Interface: A Comparative Analysis of Public Programs and Private Actions

By Laine Christman, Kimberly S. Rollins, Michael H. Taylor and Osasohan Agbonlahor

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A large number of private residences in the Western United States border public lands that are prone to wildfire. The public sector budget that covers fire suppression costs also covers pre-fire mitigation strategies and fuel reduction treatments that are designed to reduce the intensity, and therefore suppression costs, of wildland fires. Because wildfire suppression costs have been increasing faster than the overall budget for suppression and pre-fire mitigation strategies, public expenditures have become increasingly more weighted towards fire suppression and less toward pre-fire mitigation strategies[1]. This has resulted in a positive feedback – as less is invested in public lands pre-fire strategies, expenditures for suppression increase, further decreasing public investments in pre-fire mitigation. Escalating public expenditures for wildfire suppression have forced reallocations within fiscal years that have shifted funds away from pre-fire programs to reduce risk (fuel treatments near WUI communities and programs to assist private landowners to reduce risk on their lands). According to the United States Government Accountability Office (2007) suppression costs typically account for more than 60 percent of the annual federal costs of wildfire management activities and are rising.

Overall social costs of wildfire decline with private investments in mitigation efforts on private lands that border wildlands, as well as with public investments on public lands. Private investment can significantly reduce wildfire suppression costs. Properties that are well-protected (self-insured) allow limited wildfire suppression resources to be spread further to reduce costs to the public and to other private land-owners. Butry and Donovan (2008) point out that private investment reduces wildfire risk within a community and while leveraging public programs to reduce risk. They de-compose total damage averted from private mitigation efforts into two effects: direct damage averted and spill-over (indirect) damage averted, where direct damage averted is defined as the value of damage avoided accruing to the mitigating homeowner and spillover (indirect) damage averted is the benefit to the neighbors of the mitigating homeowner.

Private investment is generally in the form of the creation and maintenance of 'defensible space' in a zone that includes buildings and extends roughly 30 to 100 feet beyond. In addition to structural features of buildings, defensible space is clear of materials and landscape vegetation that are flammable, and includes landscaping specifically chosen to slow and/or stop the spread of fire. Once created, defensible space must be maintained: trees and other landscape vegetation must be pruned, dead woody material must be cleared, gutters and roofs must be cleared of dead leaves and pine-needs and other

activities as necessary to effectively reduce the likelihood that a wildfire that makes it to the property boundaries would ultimately cause damage to the built structures.

A question remains as to whether incentives for private effort are socially efficient. This paper identifies and quantifies incentives that influence private decisions to create and maintain defensible space on properties adjacent to public wildlands in the U.S. West. We conjecture that at least three phenomena are responsible for private underinvestment in defensible space: first, there may be spatial risk externalities among homeowners' investments in defensive space, in which a homeowner's incentives to invest are a function of what other homeowners do (Shafran 2008; Taylor et al. 2013); second, public land fuel treatments may be treated by private property owners as substitutes for private investment in defensible space, leading home-owners to invest less in areas where public mitigation efforts are implemented (Taylor et al. 2013); and third, private preferences may favor investments in defensible space actions on private lands that directly benefit the individual over those which benefit the community in general.

Our paper investigates the likelihood of owners of property that borders wildlands supporting private and public mitigation actions, to identify underlying motivations and disincentives. We conduct a contingent valuation study of homeowners in 35 Wildland Urban Interface (WUI) communities in Nevada. The 35 communities were chosen so that there is variation between and within communities in the level of objective wildfire threat faced by homeowners, where threat is defined in terms of defensible space and fuel accumulations and type on adjacent public lands. We analyze how variation in actual characteristics faced by homeowners as well as responses to survey questions influence Willingness to Pay (WTP) for private and public investments in mitigation.

Methods and Study Site

We used contingent valuation (CV) methods to measure individual household WTP for public and private wildfire risk reduction and to determine how WTP for each is affected by landscape type, level of risk, potential loss amount averted, and other factors that were considered to vary depending on whether the investment was on private or public land. Our data consist of responses from homeowners with homes in 35 wildland urban interface (WUI) communities that are adjacent to public wildlands throughout Nevada, and reflect four major landscape types that are characteristic of fire-prone landscapes in the arid U.S. West. These include sagebrush rangelands, grasslands, pinion pine and juniper woodlands, and dense higher elevation pine forests. Figure 1 is a map with the locations of these communities and Table 1 summarizes communities by the landscape type of the nearby public lands, home value and wildfire threat.

Table 1: Communities, Average Home Values, and Defensible Space by Vegetation Type

Figure 1: Map of Nevada with 35 Wildland-Urban Interface Communities

Every property in the sample was assessed for objective fire risk as a function of private defensible space and of the risk from public lands (Rollins, Christman and Lott 2013). During these assessments, GPS coordinates were recorded for each home. Residential addresses were obtained by overlaying GPS points from each home with tax assessor GIS files of property boundaries. A questionnaire was mailed out in September of 2012 to 2379 Nevada residents in the 35 communities, following Dillman (2000)[2]. A follow-up postcard sent out 2 months later. A second mailing was done in December with a second reminder postcard one month later. A total of 678 completed surveys were returned for a response rate of 28.5%.

After a series of questions about defensible space around their home, their knowledge of defensible space on private and public lands, their perception of wildfire threat from public lands and from their neighbors' investments in defensible space, respondents were asked two CV questions. The first provided them with a hypothetical probability that a wildfire would affect their home as well as a dollar amount of damage that they would sustain given the existing level of defensible space they maintained on their property and given the threat from nearby wildlands. They were then asked to consider whether they would invest in defensible space on their own property if it was certain to guarantee that the risk of loss would be reduced by a given probability decrease. In this case their loss would be zero. The 'bid' amounts were given as the amount that the investment would cost them. This was the "Private good". The second question referred to a situation in which they faced the same risk, and potential risk reduction – but this time through a program that would focus on the community as a whole and include the strategic use of defensible space and public lands fuel treatments. The change in risk was held to be the same as the private good – but the respondents were told that the fuels reduction and defensible space work would likely not be done exclusively on their own land, but it would give them the same level of protection as the private defensible space on their own land. In addition, the public program would benefit everyone else in the community by the same amount.

Eighteen versions of the questionnaire were randomly assigned and included 6 alternative risk reduction scenarios: two 4% reductions levels (10%-6%, and 6%-2%), two 2% reductions levels (8%-6% and 3%-1%), and two 1% reductions levels (10%-9% and 2%-1%). Dummy variables for each reduction level are included in the models (e.g., *p106, p62, p86, p31, p109,* and *p21*). In addition, the questionnaires were randomized so that the reductions in risk from the one-time investment would be effective (that is,

the vegetation treatments were maintained) for a total of either 5 or 10 years (*year5*). The private good question presented the respondent with one of three loss amounts. Should a wildfire occur, the respondent would incur either a $50,000 loss (*loss50k*), a $100,000 loss (*loss100k*), or a$200,000 loss.

The hypothetical public program to conduct mitigation measures on public lands surrounding the community consisted of 12 versions comprised of the same risk reduction level (i.e., *p106, p62, p86, p31, p109,* and *p21*) and reduction duration (*year5*) posed to the respondent in the private good question. A loss amount was not presented to the respondent in the public good question, since the risk of a fire occurring was at the community level, not the property level. The CV questions used in this analysis can be found in the appendix[3].

For the private property risk reduction question, respondents were provided six randomly assigned amounts for the bid set that ranged between $25 and $16,000[4]. Respondents were also asked if they would take action even if it cost them nothing. Similarly within the public risk reduction question, respondents were given a $0 bid amount and five more randomly assigned amounts for a bid set that ranged between $5 - $650[5]. A polychotomous, discrete choice format, i.e., 'definitely yes' (DY), 'probably yes' (PY), 'maybe' (M), 'probably no' (PN), 'definitely no' (DN), was used in each question allowing the respondent to provide their underlying level of intensity to support or reject the good at each bid amount.

Additional questions were asked to measure the respondent's attitudes toward wildfire risk, the attributes and efficacy of the mitigation actions, their experience with wildfire, and their level of trust in agencies. Questions were included to determine the respondent's attitudes about the risk of a wildfire occurring in or near their property, how much they worry about irreplaceable items that would not be covered by insurance (*notcovered*), and how much they worry about their house being damaged by a wildfire (*worfire*). To test for moral hazard, respondents were asked if they felt insurance would cover all losses that they cared about from a fire (*noloss*). To indicate risk adversity, respondents were asked how important it was to prevent losing their house (*prevent*) and how important gaining peace of mind (*mind*) was in their decision to invest in defensible space.[6]

Respondents were asked how they felt about indirect costs of defensible space to determine whether investment decisions are affected by externalities created by mitigation efforts. Respondents were asked to what extent the threat from their neighbors' properties contributed to the risk facing their house (*nghbr_risk*). As follow-ups to the valuation questions, we asked respondents if their responses to the public good were affected by reduced risk to the entire community (*altruism*). We included a variable for how likely it was that they would move in the near future, to control for this on their decision to invest (*move*). They were also asked if the risk and change in risk were too small to matter (*smallrisk*), and if the change was of no value to them (*novalue*). To gauge attitudes on the efficacy of the investments on risk reduction, they were also asked if they feel the work could not be done (*notpssbl*).[7]

We assessed attitudes regarding adverse effects of defensible space to control for these in WTP responses. The respondents were asked if they believed defensible space creates concerns for wildlife habitat (*wildlife*), reduces privacy (*privacy*), or makes their property unattractive (*ugly*). With regard to the public program, respondents were asked if they believed such a program was important to them (*imp*). We attempted to assess the substitutability of public and private risk mitigation measures on the likelihood of supporting the other program. After responding to the public CV questions, respondents were asked if they would rather invest the money on defensible space on their own property (*myprop*).[8]

Given that previous experience with wildfire has been shown to influence fire mitigation decision (Holmes et al 2013), we asked the respondents whether they had been evacuated from a house or had a house damaged by wildfire in the last five years (*exp5*). We also asked them how many fires they've experienced within one mile of their house since they've live in that residence (*fire_num*).[9] Finally we asked respondents whether if they 1) trusted agencies to manage vegetation on public lands (*manage*), 2) trusted agencies to mechanically thin successfully (*pub_thin*), and 3) trusted agencies to effectively prescribe burns on public lands (*pub_burn*) to measure the level of trust respondents have in agencies to conduct fuel treatments on public lands. [10]

Empirical Methods

In addition to estimating WTP, we estimated the predicted probabilities of each of the response categories (e.g., DN, N, M, PY, DY) using a multinomial logit (MNL), where prob (Response_{ijk}) denotes individual *i*, when presented with bid amount *j*, will chooses response *k*, where *k*= DN, N, M, PY, DY[11]. Within the MNL, there are four groups of explanatory variables. These categories include the bid amounts (b*j*); a vector of variables denoting the characteristics of the good, i.e., the levels of risk reduction, duration of time the levels are good for, and a loss amount (d*i*) [12]; a vector of demographic information (x*i*), i.e., whether the resident lives in a forested community (*tmbr*), the log of the household income (*lninc*), their highest level of education (*educ*), their gender (*male*), and their age (*age*), and a vector of attitudinal variables described in the previous section (z*i*). Table 2 lists the explanatory variables used in the final models. For a detailed discussion of the final explanatory variables used in the MNL, refer to the Results section. The final sample for the private good has 3,303 observations, and the final sample for the public good question contains 3,084 observations.

Table 2: Summary Statistics for Variables

Following others (Kobayashi et al 2010; Rollins et al 2008; Boxall et al 2003), a random effects logit (RFX) is used to estimate the probability of a DY to each good for calculating willingness to pay[13]. Prob (Yes*ij*) denotes individual *i*'s probability of responding with DY when presented with bid amount *j*. While the RFX model contains the same 4 groups used in the MNL model, the explanatory variables for the RFX model are different. Within the RFX models b*i*'s are the bid amounts corresponding to the good questions, and the x*i*'s includes the following variables: *tmbr, timespent, lninc, educ, male,* and *age*. Within the private good, z*i* includes the following shared variables: *mind, notcovered, altrusim , novalue, smallrisk,* as well as, *noloss*, which is unique to the private good question. Within the public good, zi contains *imp, manage*, and *myprop*. For a detailed discussion of the final explanatory variables used in the RFX model, refer to the Results section.

In the event a respondent left a question blank, if the respondent said M, PY, or DY to a larger bid, the missing observations for lower amounts were given the same response value. Similarly if the respondent answered PN or DN to a lower bid amount and left greater amounts blank, missing responses were given the same value as the previous answer. 102 observations were left blank and could not be recoded for the public good, and 202 observations for the private good.

In estimating the final WTP model, all variables that were not significant for at least one of the three models are omitted. Variables significant to some models but not others were retained in all for comparison analysis. All demographic information was used. Following Rollins et al (2009), respondents who responded that they would not accept the public good, even if it cost them nothing (DN or N to a zero bid amount) were considered to believe the public program would create disutility for them, or be "protestors" and therefore removed from the RFX model to estimate WTP. Similarly, within the private good, respondents that indicated that "I would not create defensible space on my property in this situation even if it cost me nothing" were removed from the analysis. Respondents that would not choose mitigation actions that cost them nothing may believe that they would suffer adverse effects from the actions. To measure the effect the level of certainty of being a non-protester has on to a WTP for the public program, the resulting subsample was split into two groups. One group of those who said *at least* "Maybe" to the zero bid, and a second smaller group of those who said "definitely yes" DY to the zero bid.

Results

The final subsample within the private risk reduction questions used in the MNL estimation includes 3494 observations from 584 individuals. The final subsample for the public good question includes 3343 observations from 541 individuals. Table 3 lists the bid amounts and variables for the

attributes of the two mitigation actions (i.e., level of risk reduction, duration of the reduction, and loss amount) and includes the marginal effects and associated standard errors. Additional covariates and their associated marginal effects and standard errors are listed in Table 4.

As expected, for both goods, as the bid amount increases, respondents have a higher probability of saying DN or PN, and a lower probability of saying PY or DY. Within both CV questions the magnitude increases moving from PY than DY and decreases moving from PN to DN. As well, the probability of a "Maybe" (M) response is positive in both cases but at a much lower magnitude than the other answers. These results indicate in both cases, respondents are more certain of rejecting a program that costs more.

For the private mitigation good, the risk reduction levels (*p106-p21*) are positive for DY with an increase in magnitude as the risk reduction levels increases incrementally from 1% to 4%. The risk reduction variables' coefficients for DN and PN are negative, though no trend in the magnitude is observed. This suggests people are sensitive to the amount of benefit gained by private defensible space, i.e., greater reduction in risk, and certainty of supporting a private initiative increases as the benefit increases. Conversely, in the public good context changes in the benefit of the program appears to have no effect of likelihood of support indicating respondents are reacting to additional, unobserved costs of a community-wide risk reduction program.

As expected, the likelihood of PY and DY to the $50,000 and $100,000 loss amounts decreases compared to a $200,000 loss. The magnitude of the decrease is approximate twice as much for the 50,000 loss than the 100,000 loss. This indicates, even within a hypothetical setting, respondents rationally consider the loss to them when making decision on the amount to defensible space investment.[14]

Respondents were more likely say DY to both programs if the effects lasted five years compared to the ten year programs, though the magnitude is quite small. For the private good, the results are unexpected but are possibly related to a large discount rate placed on the benefits over time (vegetation is likely to grow back completely after ten years). Conversely, we would expect these results for the public good since the payment is on an annual basis and respondents are likely reacting to a desire not to be locked into a payment for a decade.

Table 3: Multinomial Logit Marginal Effects for Effects of Bid Amount, Probabilities and Duration (year) on Response Categories

Prevent has a positive effect on the likelihood on PY for both goods, with the magnitude being approximately greater for the private good compared to the public. *Prevent* has a negative effect on PN for both programs but a negative effect on DN only within the private context. Similarly, *mind* has a

positive effect on DY for both programs with the magnitude of the effect being greater for the private good compared to the public. These results suggest while aversion to risk is an important incentive to both mitigation measures, respondents likely feel private actions reduce risk to their home more effectively than a community-wide program. Those who worry about irreplaceable items being damaged (*notcovered*) have an increased likelihood of saying DY and are less likely to say DN in the private context. This result is consistent with others who find moral hazard does not preclude wildfire mitigation practices (Talberth et al. 2006). Oddly, while we find *notcovered* is positive for DN for a public program, it has a negative effect on PY. These confounding results further strength the notion that respondent feel greater efficacy of risk reduction via private action.

As expected, *altruism* has a positive effect on DY for both programs with a greater magnitude within the public program. It also makes the respondent less likely to say DN within both programs, with the magnitude for the public program being approximately double that of the private. However, only within the public context is the effect negative on M and PN. As we'd expect, these findings suggest while both measures create spillover effects, respondents are more certain of these indirect effects within a community-wide program. If the respondent feels their neighbor's properties pose a risk to their home (*nghbr_risk*), it has a negative effect on DY and a positive effect on DN within the private setting, indicating residents' decisions are influenced by their neighbors' actions. Similar to previous findings that find spatial spillover effects in private defensible space (Shafran 2008; Taylor et al. 2013), this results suggest residents are less willing to do so if their neighbors don't have adequate defensible space, possibly due to a sense of hopelessness, i.e., the actions won't do any good if they are surrounded by high risk properties.

Those who would rather spend money on a private program than a public program (*myprop*) are less likely to PY or DY to the public good. As well respondents are more likely to say PN or DN and the absolute magnitude of the effect increases with certainty of response. This result suggests people view public and private wildfire risk reduction programs as substitutes with a high degree of certainty. This supports evidence by Taylor et al. (2013) who find the likelihood of investing in private defensible space decreases as the number of recent public fuel treatments in a community increase. This substitution effect is also detected in two of the demographic variables. *Age* has a positive effect on PY and negative effect on DN within the public program, but the oppose effect within the private program in which age reduced the likelihood of DY. Conversely, *timespent* has a positive effect on DY within the private program but not for the public program in which respondents are less likely to say PY and more likely to say DN. So while full time WUI residents have more time to devote to actions on their property thus increasing their likelihood for a private program, as residents grow older they are more willing to support public measures.

For the private program if respondents that feel the level of risk reduction is of no value to them (*novalue*), the reduction is too small to matter (*toosmall*), or feels the reduction in risk is not achievable (*notpssbl*), they are more likely to say DN or PN and less likely to say 'yes'.[15] These results supports the evidence of the risk reduction dummies (*p106-p21*) outlines previously as well as Winters and Fried (2001) which find WUI resident are sensitive to objective risk measure when deciding to support mitigation measures.

Residents who feel they trust agencies to successfully manage the vegetation in public lands are more likely to say DY and less likely to say DN. However, these effects are confounded by the positive effect on PN. So while trust is an important factor in supporting the public mitigation program, the results are nebulous suggesting uncertainty of response surrounds this variable.

Forested communities have the greatest chance of experiencing severe wildfire events.[16] Within our sample, as expected respondents of forested communities (*tmbr)* have a greater likelihood of saying DY for both programs indicating such residents are aware of the benefits gained from both public defensible space and public fuel treatments to reduce the chance of severe wildfires.

Table 4: Multinomial Logit Marginal Effects on Factors that Influence Response Categories

The random effect logit for the private program includes 3504 observation from 606 respondents. The random effects logit for the group that said at least M to the public program includes 3119 observations from 524 respondents and the final logit contains 1674 observations from 279 respondents. The WTP estimates for significant variables for the three regressions can be found on Table 5 following the approach outlined by Hanemann (1984).

Within the public program, respondents that said at least M to a no cost program have a modest annual WTP of $8 compared to $51 WTP by those who said DY. Both groups' had increasing WTP with increased reduction in risk gained from the program. Neither group's WTP seems to reflect differences on the initial level of risk. The M group had approximately a $6 per year WTP for a 1% reduction in risk compared to the DY group's $38 annual WTP. At 4%, the M group had a $9 per year WTP. For the M group we find a WTP of $42 for a 3%-1% reduction in risk but, due to the large coefficient on the risk reduction dummy, we find a $114 WTP for a 8%-6% reduction within the DY group. However, only the coefficients on the risk reduction indicators for the model of the M sample are significantly different from zero. These results suggest as certainty for supporting a no cost public program declines, people are more sensitive to the benefits gained from the program, and those who are definitely in support of a no cost program are more willing to support a paid program regardless of the amount of risk it reduces.

Respondents who support a no cost private program have a one-time average WTP of $308 and appear sensitive to the amount of risk reduction the program provides. On average, if the program yields a 1% reduction the WTP is between $127-$159 and increases to between $412-$476 for a 4% reduction. These results indicate two things. First, people have an overall higher WTP for a program that directly benefits them. Second, while WUI residents make rational decisions regarding risk mitigation, those who are more supportive of a no cost public program or a private program have a much higher WTP than those who are less sure. Respondent who received the *loss50k* and *loss100k* versions have an associated WTP of $152 and $287, respectively. If the respondent faces a $200,000 loss, the average WTP increases to $441. This increase in WTP as the "goods" increase not only demonstrates our design passes the scope test, but agrees with others who find WUI residents WTP is influenced by objective measures of risk and potential loss amounts (Holmes et al 2013).

Timber community respondents have a $91 higher WTP (at $369) for the private defensible space than non-timber respondents which have a $277 WTP. The DY group has a $61 higher WTP (at $74) than the M group for a public program within timber communities. Within both groups, timber respondents have approximately twice the WTP of those who live in rangeland communities. These results indicate people in timber communities, which are subject to extreme fire danger, seem to respond to the higher risk associated with forested WUI areas and those who are most supportive of a public program will pay a premium to mitigate this risk; however, *tmbr* was only found to be significant within the public program context.

Myprop has a negative effect on WTP within both subsample of the public program with a greater magnitude within the DY group. In both subsample, the desire to spend the money on one's own property lowerd WTP by half. Those who said yes to *myprop* within the M group have a $3 WTP compared to those would did not who have a $6 WTP. Those in the DY group who said yes to *myprop* have a $14 WTP compared to those would did not who have a WTP of $32. Conversely, altruism has the biggest effect on the M subsample, increasing WTP approximately ten times that of those who feel the program does not reduce risk to the others, who have virtually no WTP.

Table 5: Willingness to Pay Estimates

Discussion

When comparing two methods to reduce the risk of loss from wildfire where the risk reduction is the same, homeowners in WUI areas of Nevada indicate that they are willing to pay more for wildfire risk

mitigation measures that consist of defensible space on their own property than for a public program that would provide the same risk reduction to all of the members of their community, but might not be done on their own property. The average one-time WTP for a private program to reduce wildfire risk for 5 years is $308. The average annual WTP for a public program to reduce risk is $51 per year if the respondent indicated support of a no cost program, and $8 per year if the respondent is less certain about supporting a no cost program.

In general, we find WUI residents are sensitive to risk and loss from wildfire when making investment choices regarding public and private programs that mitigate risk. These results are consistent with previous work (Holmes et al. 2013). Unlike Winter and Fried (2001) who find initial risk levels impact WTP, we find no evidence of this in our study. As with previous work on spatial complementarities associated with wildfire mitigation (Shafran 2008; Taylor et al. 2013), we find evidence of positive spillover effects. Increased perceived risk of adjacent neighbors hinders investment while feelings of altruism provide incentives. Our results also indicate substitution effects between public and private programs, which support similar previous findings (Prante et al. 2011; Taylor et al. 2013). Respondents are less likely to support a public program if they feel the money is better spent on their properties. Similarly, the more time they spend in the community throughout the year, the more likely the respondent is to support a private risk mitigation and less likely to support a public program. Conversely the age of the respondent has the opposite effect.

Table 1: Communities, Average Home Values, and Defensible Space by Vegetation Type

Community	n	Population	Average Home Value	Defensible Space (%)
Sagebrush Communities				
Ely	247	4,255	$46,757	71%
Lund	121	282	$52,540	69%
Carvers	105	2,443	$56,772	67%
Cold Springs*	452	8,544	$139,303	60%
Virginia City*	290	855	$139,981	57%
Spanish Springs	645	15,064	$176,239	57%
Red Rock*	124	8,544	$184,511	48%
Spring Creek	786	12,361	$103,869	45%
Spring Valley*	48	157	$59,255	44%
Elko	111	18,297	$78,614	43%
Carlin	118	2,368	$47,026	41%
Topaz Lake*	123	157	$26,806	40%
Verdi	310	1,415	$218,208	39%
Sheridan Acres	44	11,312	$42,409	36%
Jarbidge	87	116	$28,048	31%
Mogul	186	1,290	$150,318	27%
Topaz Estates	717	1,501	$9,926	25%
Pinyon-Juniper Communities				
Eureka	87	610	$53,114	52%
Rancho Haven*	348	8,544	$125,560	49%
Austin	89	192	$33,664	47%
Manhattan	51	124	$25,814	39%
Kingston	119	113	$37,017	39%
Virginia Highlands*	500	855	$190,238	28%
Forested Communities				
Incline Village*	480	8,777	$319,224	32%
Galena Forest*	515	3,019	$396,711	30%
Saddlehorn Tumbleweed*	528	8,777	$329,505	21%
West Washoe Valley*	138	3,019	$419,794	19%
Tyrolian Village*	181	8,777	$143,884	18%
Champagne Burgundy*	86	8,777	$1,086,052	14%
Chimney Rock	211	2,152	$43,477	10%
Upper Tyner*	329	8,777	$310,435	9%
Allison Jennifer*	325	8,777	$232,168	5%
Crystal Bay	126	305	$360,667	1%
Grassland Communities				
Battle Mountain	145	3635	$49,118	45%
Lamoille	95	105	$152,866	32%

* The U.S. Census often aggregates small communities into larger districts, providing only a population estimate for the entire district. For those cases, the aggregated population measure is used, resulting in some communities having identical estimates.

Table 2: Summary Statistics for Variables

		PRIVATE				PUBLIC			
Variable	**Definition**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
lnamt	Log of dollar amount presented to respondent	6.91	1.51	3.22	9.68	3.42	2.06	0	6.48
p106	1= 10%-6% reduction in probability of fire; 0 otherwise	0.18	0.38	0	1	0.18	0.38	0	1
p62	1= 6%-2% reduction in probability of fire; 0 otherwise	0.17	0.37	0	1	0.16	0.37	0	1
p86	1= 8%-6% reduction in probability of fire; 0 otherwise	0.14	0.34	0	1	0.14	0.35	0	1
p31	1= 3%-1% reduction in probability of fire; 0 otherwise	0.17	0.37	0	1	0.17	0.37	0	1
p109	1= 10%-9% reduction in probability of fire; 0 otherwise	0.17	0.37	0	1	0.17	0.38	0	1
p21	1= 2%-1% reduction in probability of fire; 0 otherwise	0.18	0.39	0	1	0.18	0.39	0	1
year5	1= chance of fire occurring over 5 years; 0 otherwise	6.91	1.51	3.22	9.68	0.54	0.50	0	1
prevent	1= respondent feels they would prevent loss if possible; 0 otherwise	0.54	0.50	0	1	0.84	0.37	0	1
mind	1= respondent feels they gain peace of mind from the program; 0 otherwise	0.82	0.39	0	1	0.70	0.46	0	1
notcovered	1= respondent worries insurance wouldn't cover all loses; 0 otherwise	0.67	0.47	0	1	0.49	0.25	0	1
altruism	1= program reduces risk to entire community; 0 otherwise	0.48	0.25	0	1	0.69	0.46	0	1
nghbr_risk	1= respondent feels neigbors properties pose a risk to their property	0.53	0.50	0	1	0.33	0.47	0	1
novalue	1= respondent feels program is of no value; 0 otherwise	0.32	0.47	0	1	0.12	0.32	0	1
smallrisk	1= respondent feels the reduction in risk is too small; 0 otherwise	0.23	0.42	0	1	0.17	0.38	0	1
notpssbl	1= respondent feels program is not possible; 0 otherwise	0.16	0.36	0	1	0.23	0.42	0	1
tmbr	1= Timber community; 0 otherwise	0.23	0.42	0	1	0.25	0.44	0	1
timespent	Amount of time the respondent lived in house (0-100%)	0.25	0.43	0	1	85.22	30.84	0	100
lninc	Log of household annual income in $1000s	85.10	31.05	0	100	4.41	0.70	2.48	5.52
educ	Number of years of completed schooling	4.43	0.67	2.48	5.52	15.29	2.07	10	18
male	Respondent's gender; 1=male, 0 otherwise	15.28	2.06	10	18	0.61	0.49	0	1
age	Age of Respondent	0.61	0.47	0	1	62.13	11.01	20	91
loss50k	1= $50,000 loss from fire; 0 otherwise	0.31	0.46	0	1	-	-	-	-
loss100k	1= $100,000 loss from fire; 0 otherwise	0.37	0.48	0	1	-	-	-	-
noloss	1= respondent feels they can't afford to lose that much; 0 otherwise	0.44	0.49	0	1	-	-	-	-
imp	1= respondent feels risk reduction is important; 0 otherwise	-	-	-	-	0.59	0.49	0	1
manage	1= trust in government agencies that manage public lands; 0 otherwise	-	-	-	-	0.18	0.39	0	1
myprop	1= money is better spent on their property; 0 otherwise	-	-	-	-	0.43	0.49	0	1

Table 3: Multinomial Logit Marginal Effects for Effects of Bid Amount, Probabilities and Duration (year) on Response Categories

	PRIVATE PROGRAM					PUBLIC PROGRAM				
	No!!	**No**	**Maybe**	**Yes**	**Yes!!**	**No!!**	**No**	**Maybe**	**Yes**	**Yes!!**
Lnamt	0.061***	0.096***	0.021***	-0.062***	-0.117***	0.039***	0.064***	0.014***	-0.048***	-0.07***
	(0.006)	(0.006)	(0.005)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
P106	-0.344***	-0.396***	-0.082	0.118	0.704***	-0.044	-0.046	0.06	-0.046	0.076
	(0.085)	(0.102)	(0.097)	(0.09)	(0.095)	(0.07)	(0.082)	(0.079)	(0.09)	(0.087)
P62	-0.402***	-0.39***	0.018	0.093	0.68***	-0.076	-0.03	0.09	-0.037	0.053
	(0.085)	(0.102)	(0.097)	(0.09)	(0.095)	(0.071)	(0.082)	(0.08)	(0.092)	(0.088)
P86	-0.4***	-0.368***	0.015	0.09	0.663***	-0.115	-0.05	0.078	0.021	0.066
	(0.083)	(0.099)	(0.095)	(0.09)	(0.094)	(0.071)	(0.082)	(0.08)	(0.091)	(0.088)
P31	-0.334***	-0.399***	-0.018	0.066	0.685***	-0.004	-0.064	0.065	-0.053	0.056
	(0.083)	(0.1)	(0.096)	(0.091)	(0.096)	(0.071)	(0.083)	(0.081)	(0.093)	(0.089)
P109	-0.337***	-0.263***	-0.045	0.034	0.61***	-0.05	0.004	0.011	0.034	0.001
	(0.082)	(0.098)	(0.095)	(0.089)	(0.094)	(0.071)	(0.082)	(0.081)	(0.092)	(0.089)
P21	-0.352***	-0.314***	0.009	0.076	0.581***	-0.08	-0.004	0.068	0.018	-0.002
	(0.082)	(0.098)	(0.094)	(0.089)	(0.093)	(0.07)	(0.081)	(0.079)	(0.091)	(0.087)
Loss50k	0.032*	0.081***	0.05***	-0.059***	-0.105***	-	-	-	-	-
	(0.017)	(0.02)	(0.02)	(0.018)	(0.019)					
Loss100k	-0.019	0.052***	0.041**	-0.033**	-0.04***	-	-	-	-	-
	(0.014)	(0.017)	(0.017)	(0.016)	(0.017)					
Year5	-0.002	-0.006	-0.001	-0.017	0.025*	0.014	-0.014	-0.028**	-0.001	0.029**
	(0.011)	(0.013)	(0.013)	(0.013)	(0.014)	(0.011)	(0.013)	(0.012)	(0.014)	(0.014)
Log Likelihood	-4502.957					-4051.25				
Observations	3494					3343				

Notes: Standard errors in parentheses. Significance levels of 0.01, 0.05, and 0.10 denoted by three, two and one asterisks (***,**,*) respectively.

Table 4: Multinomial Logit Marginal Effects on Factors that Influence Response Categories

	PRIVATE PROGRAM					PUBLIC PROGRAM				
	No!!	**No**	**Maybe**	**Yes**	**Yes!!**	**No!!**	**No**	**Maybe**	**Yes**	**Yes!!**
Prevent	-0.049***	-0.03*	-0.023	0.101***	0.000	-0.012	-0.043**	-0.000	0.051*	0.004
	(0.013)	(0.018)	(0.019)	(0.022)	(0.022)	(0.015)	(0.019)	(0.021)	(0.027)	(0.028)
Mind	-0.059***	-0.05***	-0.011	0.01	0.11***	-0.081***	0.001	-0.006	0.009	0.077***
	(0.013)	(0.016)	(0.017)	(0.017)	(0.019)	(0.013)	(0.016)	(0.017)	(0.021)	(0.021)
Notcovered	-0.115***	0.047*	-0.01	-0.017	0.095***	-0.048**	0.031	0.011	-0.088***	0.095***
	(0.023)	(0.028)	(0.028)	(0.027)	(0.029)	(0.023)	(0.028)	(0.027)	(0.031)	(0.03)
Altruism	-0.049***	-0.007	-0.004	-0.017	0.077***	-0.082***	-0.042***	-0.048***	0.065***	0.106***
	(0.013)	(0.015)	(0.015)	(0.014)	(0.015)	(0.013)	(0.015)	(0.016)	(0.021)	(0.021)
Nghbr_risk	0.054***	-0.002	-0.005	-0.01	-0.037**	0.01	-0.005	0.016	-0.016	-0.005
	(0.011)	(0.014)	(0.014)	(0.014)	(0.014)	(0.012)	(0.014)	(0.013)	(0.015)	(0.014)
Novalue	0.027**	0.06***	-0.003	0.000	-0.084***	0.076***	0.001	-0.051**	0.007	-0.034
	(0.013)	(0.016)	(0.017)	(0.018)	(0.019)	(0.016)	(0.021)	(0.026)	(0.03)	(0.03)
Smallrisk	0.047***	0.141***	-0.06***	-0.094***	-0.034	0.014	0.095***	0.021	-0.087***	-0.042*
	(0.014)	(0.018)	(0.022)	(0.025)	(0.024)	(0.015)	(0.018)	(0.02)	(0.026)	(0.025)
Notpssbl	0.042***	0.045***	0.021	-0.059***	-0.049***	0.07***	0.009	-0.025	-0.054***	0.000
	(0.012)	(0.015)	(0.016)	(0.018)	(0.018)	(0.012)	(0.015)	(0.016)	(0.02)	(0.019)
Tmbr	-0.008	-0.028	-0.023	0.000	0.06***	-0.022	-0.022	0.006	-0.035**	0.073***
	(0.014)	(0.017)	(0.018)	(0.016)	(0.017)	(0.015)	(0.017)	(0.015)	(0.017)	(0.016)
Timespent	0.000	0.000	-0.001**	0.000	0.001***	0.001***	0.000	0.000**	-0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lninc	-0.031***	-0.027**	-0.011	0.062***	0.007	-0.01	-0.027***	-0.018*	0.057***	-0.001
	(0.009)	(0.011)	(0.011)	(0.011)	(0.012)	(0.009)	(0.01)	(0.01)	(0.012)	(0.011)
Educ	0.001	-0.008**	0.003	-0.001	0.004	-0.001	-0.002	0.002	-0.002	0.002
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Male	0.063***	-0.057***	-0.013	-0.046***	0.053***	0.006	0.021	0.008	0.013	-0.048***
	(0.012)	(0.014)	(0.014)	(0.013)	(0.014)	(0.011)	(0.013)	(0.013)	(0.015)	(0.014)
Age	0.001	-0.001	0.000	0.001**	-0.001**	-0.001***	0.000	0.001	0.001*	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Imp						0.023	-0.086***	-0.002	-0.017	0.082***
						(0.014)	(0.016)	(0.016)	(0.019)	(0.019)
Manage						-0.046***	0.029*	0.004	-0.016	0.029*
						(0.016)	(0.017)	(0.016)	(0.018)	(0.017)
Myprop						0.053***	0.049***	0.006	-0.036**	-0.072***
						(0.012)	(0.014)	(0.013)	(0.016)	(0.015)
Log Likelihood	-4502.957					-4051.25				
Observations	3494					3343				

Notes: Standard errors in parentheses. Significance levels of 0.01, 0.05, and 0.10 denoted by three, two and one asterisks (***,**,*) respectively.

Table 5: Willingness to Pay Estimates

	PUBLIC PROGRAM (annual)				PRIVATE PROGRAM (1-time)	
	Maybe to zero bid		DY to zero bid		Yes to zero bid	
Variable	**Mean**	**Std. Err.**	**Mean**	**Std. Err.**	**Mean**	**Std. Err.**
Average	7.89	0.18	50.92	1.34	308.02	6.03
10%-6% reduction	9.63	0.22	53.83	1.24	476.04	7.83
6%-2% reduction	8.81	0.20	44.47	1.02	412.28	6.78
8%-6% reduction	8.80	0.20	114.41	2.63	317.71	5.23
3%-1% reduction	9.18	0.21	42.16	0.97	369.35	6.08
10%-9% reduction	6.54	0.15	40.69	0.93	158.68	2.61
2%-1% reduction	5.01	0.11	36.38	0.84	126.73	2.08
$50k Loss	-	-	-	-	152.03	2.49
$100k Loss	-	-	-	-	286.84	4.70
$200k Loss	-	-	-	-	440.79	7.22
mind=1	8.18	0.18	53.59	1.32	357.22	6.03
mind=0	4.77	0.11	27.17	0.67	132.25	2.23
notcovered=1	12.47	0.27	48.00	1.26	399.93	7.50
notcovered=0	4.20	0.09	54.57	1.43	227.25	4.26
altruism=1	8.66	0.18	52.01	1.34	271.41	4.57
altruism=0	0.78	0.02	40.18	1.04	150.36	2.53
novalue=1	-	-	-	-	173.58	3.21
novalue=0	-	-	-	-	335.53	6.20
tmbr=1	12.35	0.26	74.32	1.63	369.21	6.81
tmbr=0	6.10	0.13	39.16	0.86	277.83	5.12
imp=1	8.82	0.19	57.44	1.38	-	-
imp=0	2.97	0.06	24.64	0.59	-	-
myprop=1	2.79	0.06	14.27	0.29	-	-
myprop=0	5.62	0.11	32.37	0.65	-	-
noloss=1	-	-	-	-	354.61	6.41
noloss=0	-	-	-	-	248.04	4.49
N	3119		1674		3504	

Figure 1: Map of Nevada with 35 Wildland-Urban Interface Communities

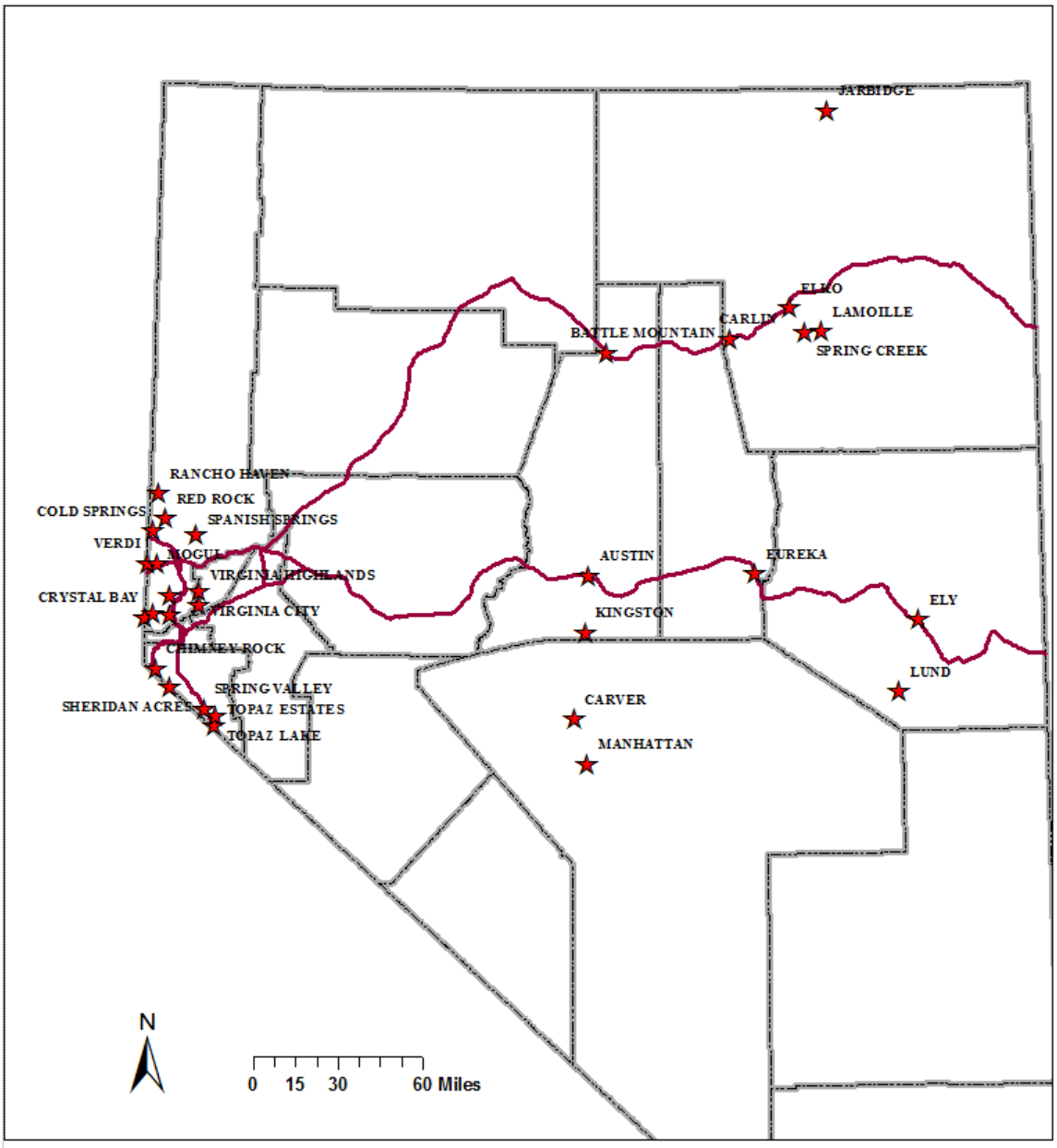
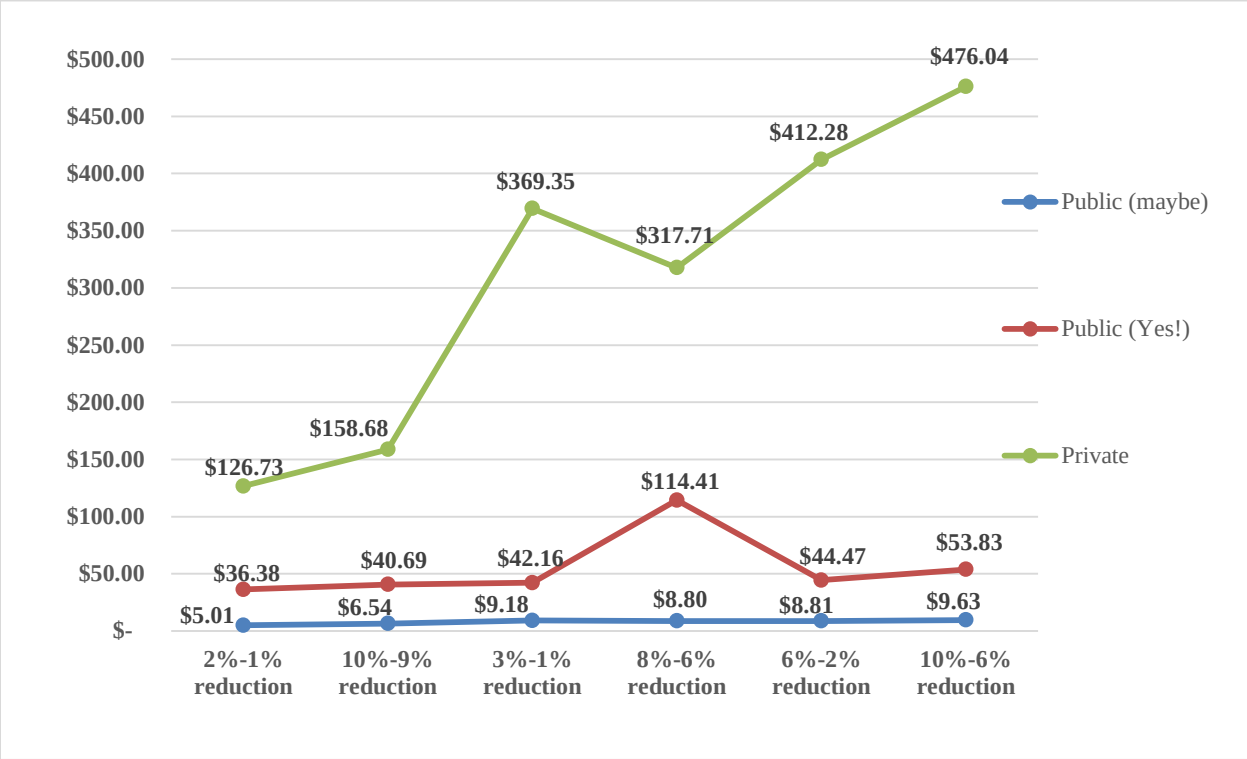


Figure 2: Willingness to Pay for Private and Public Investments in Wildfire Risk Reduction



Appendix: Random Effects Logit on Probability of Wildfire Risk Mitigation Measures

		Public Program		Private Program
		(≥ Maybe)	(= DY)	
Good Attributes	*Lnamt*	-2.551***	-4.309***	-4.224***
		(0.206)	(0.583)	(0.217)
	P106	-7.219*	2.612	14.403***
		(4.086)	(6.074)	(4.585)
	P62	-7.446*	1.788	13.796***
		(4.216)	(6.089)	(4.558)
	P86	-7.448*	5.861	12.695***
		(4.238)	(6.135)	(4.525)
	P31	-7.341*	1.558	13.331***
		(4.206)	(6.303)	(4.613)
	P109	-8.206*	1.406	9.763**
		(4.204)	(6.115)	(4.505)
	P21	-8.887**	0.924	8.813**
		(4.159)	(6.05)	(4.461)
	Loss_50k	-	-	-4.496***
		-	-	(0.938)
	Loss_100k	-	-	-1.815**
		-	-	(0.829)
	Year5	0.659	0.382	0.893
		(0.667)	(0.944)	(0.68)
Common Variables	*Mind*	1.374	2.926**	4.197***
		(0.961)	(1.455)	(1.178)
	Notcovered	2.777*	-0.553	2.387
		(1.448)	(2.047)	(1.491)
	Altruism	6.128***	1.113	2.495***
		(1.06)	(1.38)	(0.923)
	Novalue	-0.708	-3.422	-2.784**
		(1.272)	(1.733)	(1.098)
	Tmbr	1.798**	2.761**	0.016
		(0.794)	(1.221)	(0.012)
	Timespent	0.016	0.002	1.201
		(0.011)	(0.017)	(0.87)
	Lninc	0.352	1.768**	0.316
		(0.563)	(0.833)	(0.556)
	Educ	0.101	-0.058	0.299*
		(0.173)	(0.243)	(0.177)
	Male	-1.719**	-1.425	1.075
		(0.678)	(0.996)	(0.726)
	Age	-0.033	0.025	-0.04
		(0.033)	(0.044)	(0.033)
Private Good	*Noloss*	-	-	1.51**
		-	-	(0.754)
Public Good	*Imp*	2.777***	3.647***	-
		(0.977)	(1.363)	-
	Myprop	-1.785**	-3.529***	-
		(0.725)	(1.105)	-
	Observations	3119	1674	3504
	Log Likelihood	-904.08	-471.48	-960.11

Notes: Standard errors in parentheses. Significance levels of 0.01, 0.05 and 0.10 denoted by three, two and one asterisks (***,**,*) respectively. Willingness-to-pay in parentheses if covariate equals to 0, and without parentheses otherwise.

Private Risk Mitigation Question

Suppose there is a 6% chance that a wildfire will reach your house in any year for the **next 5 years**, and that if a fire should reach your house, **the loss to you would be $50,000.** Suppose you could **guarantee** to reduce the chance that fire will reach your home from 6% to 2% over the next 5 years, by creating and maintaining defensible space on your property and modifying your home.

To put this into perspective, this translates into reducing the probability that a wildfire will damage your property **sometime in the 5 year period from 27% to 10%.**

Would you spend…

Public Risk Mitigation Question

Your community faces a 6% probability of a wildfire each year. A **community program** would enlist fire experts to develop **a plan to create and maintain defensible space on lands in and surrounding your community.** The plan would be guaranteed to **reduce the annual probability** that wildfire would impact the community **from 6% to 2% for each year over the next 5 years**. To put this into perspective, this translates into changing the probability that a wildfire will impact your community **sometime in the 5 year period from 27% to 10%**.
The lower wildfire risk will benefit you and the entire community. While the plan may not change your particular property or structure at all, it would guarantee the fire risk reduction to your house.

This program would be carried out depending on the result of a **vote** of homeowners in your community.

If a majority votes "yes," then **every** resident would be assessed an annual fee to support the program. Your annual fee would be used exclusively to create and maintain defensible space that would reduce the risk of wildfire, and would not be used for any other purpose
If a majority votes "no" then no one would be assessed the fee and the program would not be launched and community-wide probability of a wildfire occurring would remain unchanged, at 6% per year.

How would you vote on a program that would **reduce** the annual probability of a wildfire impacting your community in the next 5 years **from 6% to 2%**?

Would you vote "YES" if …

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[1] Arno and Brown (1991), Snyder (1999), National Academy of Public Administration (2002) Calkin et.al. (2010) and others explain the rise in suppression expenditures as related to three main factors. The first and most important is the increased residential development in areas that border wildlands. The second is a century of fuel accumulation from over-suppression in fire-dependent ecosystems, and the last is warmer, drier weather conditions.

[2] The questionnaire can be found at http://www.unr.edu/business/research-and-outreach/core/esnr .

[3] A coded copy of the survey booklet can be found at http://www.unr.edu/business/research-and-outreach/core/esnr/projects.

[4] The private risk reduction bid set includes: $25, $50, $100, $200, $250, $400, $500, $750, $800, $1000, $1500, $1600, $2000, $3000, $4000 $6000, $8000, $12,000, and $16,000. Values for the bid design were determined through pretesting.

[5] The public risk reduction bid set includes: $5, $10, $20, $30, $50, $75, $90, $200, $500, and $650. Values for the bid design were determined through pretesting.

[6] *Worfire* is found not to be significant and is omitted from the final estimations. *Noloss* is not significant within the multinomial logit (MNL) regression and is omitted from the final MNL model but is retained in the WTP estimation model. Conversely, *prevent* is significant in the MNL but is omitted from the WTP estimation due to lack of significance is any specification between the two mitigation efforts.

[7] The variable *move* was not found significant in any model specification, and is not included in the final analysis. *Notpssbl* is included in the MNL analysis but not the final WTP estimations due to lack of significance.

[8] Wildlife, privacy, and ugly are found to have no impact on either mitigation question and are excluded from the final analysis.

[9] Contrary to previous results (Holmes et al 2013), neither measure of wildfire experience is found to be a significant incentive for investment and are subsequently removed from the final analysis.

[10] *Manage* was found to be the only significant predictor of likelihood to support public risk reduction efforts and is included in the final analysis.

[11] An ordered logit was not used as the ordinal restriction does not allow the coefficients to vary across outcomes. A multinomial logit model is appropriate so long as Independence of Irrelevant Alternatives (IIA) assumption holds. The IIA assumes categories cannot be substitutes for one another.

[12] The loss amounts only apply to the private good questions. Since the public good question was a reduction in the risk to the community, the loss amount was not applicable.

[13] Since a standard MNL cannot capture unobserved heterogeneity induced by a panel dataset, a random effects model should be specified to handle this variation (Holmes et al 2013).

[14] The loss amounts are only provided in the private program referendum.

[15] *Novalue* and *notpssbl* have a negative effect on DY with the magnitude being twice as much for *novalue* compared to *notpssbl*. *Smallrisk* and *notpssbl* have a negative on PY with a larger magnitude associated with *smallrisk*.

[16] The high density of fuel in forested areas creates a situation for severe fire behavior that is difficult to contain and a serious risk to WUI residences in forested communities. Communities located in rangeland lack this lateral fuel accumulation, making severe fire events less likely.