Willingness to Pay for Fuels Treatments for Forest Fire Risk Reduction at Lake Tahoe

Kimberly Rollins, University of Connecticut, kimberlyrollins@uconn.edu
Muhammad Umer Zahid, University of Connecticut, umerzahid@uconn.edu
Michael H. Taylor, University of Nevada, Reno, taylor@unr.edu

Selected Paper prepared for presentation at the 2022 Agricultural & Applied Economics Association Annual Meeting, Anaheim, CA; July 31-August 2

1. Introduction

According to the National Interagency Fire Centre (NIFC), there were 58,985 wildfires in United Sates in the year 2021 that burnt almost 7.126 million acres of land. Out of these, 8,619 were in California, which burned approximately 2.6 million acres while damaging or destroying 3,629 structures[1].The Caldor Fire in Sierra Nevada south of Lake Tahoe, was one such example. The fire lasted for 67 days, burned roughly 221,835 acres (including 9,885 acres in Lake Tahoe Basin), destroyed 1,003 structures, and caused evacuation of more than 50,000 residents. The regional drought combined with hot weather and strong winds resulted in extremely active fire behavior, sparking new wildfires, referred to as spot-fires (USDA Forest Services, 2021). These spot fires, contributed to increasing the spread of fire and made containment efforts even more difficult for firefighters.

The impact of catastrophic wildfires, such as the Caldor Fire, is not limited to the loss of natural resources, infrastructure and the millions of dollars spent in containment. The loss of critical ecosystem services, destruction of natural beauty, secondary health impacts, business disruptions, and a sense of insecurity among the residents, are all associated intangible losses. According to a report published by the California Council on Science and Technology (2020), the reported outcomes of wildfires are often limited to those that are attributable to the physical fire itself - that is, the outcomes occurring during the fire or within or near the fire's parameter. The report suggested a framework to comprehensively capture all associated wildlife events in addition to the physical wildfire, including damage or destruction of physical assets, harm to health, changes in ecosystem processes and changes in economic activity. Such a framework would encapsulate the

[1] https://www.predictiveservices.nifc.gov/intelligence/2021_statssumm/intro_summary21.pdf

total social costs, including non-monetary negative externalities, and better highlight the urgent need for undertaking immediate steps to prevent, mitigate and prepare for wildfires.

Multiple studies have shown that forest wildfires in the western US are increasing in frequency, size and acreage burnt per annum (Miller et al, 2009). Due to the severity and intensity of wildfires in recent times, the application of fuel treatments has become an essential fire management tool (Loudermilk et al, 2014). Fuel treatment programs reduce combustible materials through mechanical thinning (removal of trees from overstocked forests) and prescribed burns (low-intensity, controlled burns to clear excess debris from forest floor) (USDA Forest Services, 2021). Several studies highlight the effectiveness of fuel treatment programs in managing wildfires. Loomis et al (2019) showed how mechanical thinning and prescribed burning resulted in reduced wildfire suppression costs and property damages. Petrakis et. al (2018) used multi-temporal remote sensing data and cloud computing in east-central Arizona to show how fuel treatments were effective in reducing burn severity and increasing post-fire recovery.

The cost of fuel treatment programs is enormous, given the scales necessary for effectiveness, and the vast areas of U.S. forested regions needing attention. The economic benefits of catastrophic fire risk reduction have been given as a key factor in decision-making to determine when and where to invest in fuel treatments. Several studies focus on expected future wildfire suppression costs averted to generate benefit-cost scenarios useful for forest and land management agency planning for where and when to apply fuels treatments (see for example, Taylor et al, 2015; Northern Arizona University 2013). In addition to avoided suppression costs, Thompson et. al (2017) also included avoided area burnt and avoided damages in a model that assesses the cost-effectiveness of fuel treatments at different scales of investment. However, accounting for agencies' costs averted does not fully account for the economic benefits of forest treatment programs, which improve overall forest health and limit effects of exposure to fire risk faced by residents, along with providing benefits to non-residents, including passive use values. In their study of several watersheds in the Denver area, Jones et al (2022) estimate that fuel treatment benefits would need to be triple what they estimated in their analysis of costs averted to return a positive net social economic benefit and concluded that a wide range of economic co-benefits that accrue to society should be included.

Several studies use non-market valuation methods to quantify benefits of wildfire risk reduction. Donovan et al., (2007), for example, use a hedonic property model to measure wildfire impacts on urban interface households, but failed to capture economic costs to visitors. Starbuck et.al (2006) estimate the value of recreation benefits, but do not consider non-use values. Forest health values include use and passive use values from realization that a healthy forested ecosystem is maintained for current and future generations (Loomis et al., 2005). A number of studies also gauge attitudes towards risk reduction. Wibbenmeyer et. al (2013) employed choice experiment questionnaires with U.S wildfire managers to measure their attitudes towards different wildlife risk components and gauged whether those attitudes were consistent with efficient allocation of wildfire suppression resources. Sanchez et. al (2022) estimated California's homeowner's willingness to pay to reduce the risk of wildfires in and around their residences by using a choice experiment to ascertain the importance of risk perceptions when adopting risk-mitigating behavior.

In order to reduce wildfire risk, the USDA Forest Services and State Forestry agencies have offered cost-sharing programs to residents to undertake wildlife risk reduction actions (Sanchez et. al, 2022). Such programs mostly target homeowners to inform and involve them in reducing wildfire risk at their private properties. For such cost-sharing arrangements to be effective, it is important to ascertain the dollar amount individuals are willing to pay for wildlife risk reduction. Our paper aims to estimate that WTP for fuel reduction programs in Lake Tahoe region, not only by private residents, but also by non-residents. The remaining structure of our paper is as follows: Section 2 describe s the study design. In Section 3, we provide our econometric model to estimate willingness to pay. In Section 4, we discuss results.

2. Study Design

This study uses the Contingent Valuation Method (CVM) to measure willingness to pay (WTP) for forest treatment programs in the Lake Tahoe Basin. The study was developed in collaboration with agencies engaged in science and management to target the problem of forest health in the Lake Tahoe Basin. A survey was designed, in accordance with the methods and recommendations of Dillman (2007), to collect data regarding residents' willingness to pay to reduce the impact of wildfires. Demographic data was collected in addition to WTP data in order to analyze differences in preferences among various social groups.

Surveys for the study were conducted between March - June 2015. Pre-testing was conducted between October 2014 – February 2015. Before pre-testing, focus groups were held in Reno, Nevada between June 11 - July 10, 2014. Address lists were purchased to include representative samples from four regions within 4 hours driving distance to the Tahoe Basin: Residents in the Lake Tahoe Basin (California and Nevada), urban areas in Nevada and rural areas in Nevada[2]. Tables 1 summarize response rates (of usable addresses) by version and sample region. A total of 372 surveys were returned out of 2000 for an overall response rate of 18.6%.

[2] The pilot included two additional regions: rural and urban areas outside of the Basin in California that are within 4-hours' drive. However, the response rates from these areas was below 5% - likely indicative of the large numbers of substitute recreational sites, relative to substitutes for Nevadans in the same categories - and these were dropped from the final sample.

Table 1: Proportion of Total Sample by Region

Region	**Proportion**
Lake Tahoe Basin - California	27.79 %
Lake Tahoe Basin - Nevada	26.92 %
Urban Nevada	23.16 %
Rural Nevada	22.14 %

The survey was based on a referendum format (Annex 1) that provided a hypothetical forest management program to a group of residents and visitors to the Lake Tahoe region. The respondents were informed that in order to reduce the risk of a highly-destructive, large wildfire breaking out, 10,000 acres of public forest were to be thinned every year for 10 years. As part of the hypothetical scenario, the respondents were first asked to vote in terms of yes or no, whether they would pay *x* amount of dollars to support such a program if it reduced the risk of wildfire from *a*% to *b*%. A majority "yes" vote would mean that all households would be committed to an annual increase in costs from a variety of fees that would equal a given dollar amount each year, for ten years. At the end of ten years, the program would be reconsidered.

The two main components of the referendum were: (a) the bid amount - $*x* that the respondents were asked to contribute, and (b) the risk reduction scenario (the decrease in percentage risk from *a% to b%*). The bid amount was generated during the pre-testing stage where two different pilots were conducted, in which multiple bid amounts were presented with a polychotomous response format that allowed individuals to indicate their levels of certainty. The final bid amounts were as follows: $5, $10, $ 15, $25, $40, $80, $200

The risk reduction scenarios were different wildlife risk-reduction ranges representing realistic scenarios for enhancing existing forest fuels treatment programs in the Basin. While various levels of increased annual fuels treatment could decrease the risks of fire, we used specific ranges to develop a total of five different risk reduction scenarios, which were randomly assigned to survey respondents. They were as follows:

- Risk reduction from 52% to 23%,
- Risk reduction from 76% to 23%,
- Risk reduction from 52% to 41%
- Risk reduction from 76% to 52%
- Risk reduction from 76% to 64%

The survey included two bid levels, and a dichotomous (yes/no) response, which was generated using the distribution of yes/no bids from the pilot. For example, an individual was asked if he/she would vote *yes* or *no* to a Fuel Treatment Program that reduced risk of destructive wildfire from 52% to 23%, if they were to $40 per annum for the next ten years. A second follow-up question was then asked with a different bid amount to ascertain the WTP range for the individual. The second bid amount was dependent on the initial response – that is, if the individual votes *yes* to the first question, a higher bid amount was then proposed. If they voted no, a lower bid was included in the second question. A follow-up question asking if the respondent would vote yes if the cost was zero to their household was asked to identify individuals who believed that they would be worse off with the proposed programs (which could impose inconveniences at specific times of the year when maintenance/fuels treatments were being done).

Materials describing the current threats and the proposed programs were refined through focus groups, meetings with local residents, members of management agencies who deal with the public, and responses to survey pretesting. An information sheet was designed to describe current threats and proposed programs to maintain forest health and reduce fire risk. The information sheet included: what would occur over the next several years if nothing is done to change the current rates of accumulation of fuels and how this would be likely to affect people who use the region, what controls are required to control the existing problem and to maintain control over a ten-year time frame.

The information sheet included forest health information and photos showing a "current" scenario, and two photos representative of what the same spot would look like after a fire "with treatment" and "without treatment." The sheet described "historical" information about how wildfire behavior in the region has changed by noting that prior to development, fire was a natural and frequent occurrence in the Tahoe Basin, with small frequent fires serving to control and maintain fuels so that the risk of catastrophic large fires was lower than it is today. The "before" scenario was then based on current levels and rates of fuels accumulations and risk for fire, while the "after-with treatment programs" and "without treatment" scenarios were described as reductions in the expected increases in risk (Annex 2). The survey also included questions regarding what information the participant was and was not already familiar with, and whether the information seemed accurate to the participant.

All respondents were mailed an invitation to take part in the internet-based survey (using Qualtrics) and provided with a URL, access code, and the information sheets that corresponded with their version of the survey. The web-based survey also included links to the information sheets corresponding to each respondent's survey. A second reminder postcard was followed with a packet containing a booklet form of the survey, information sheets and return mail envelopes, as well as a reminder of the URL and access code. After a second reminder postcard, a second, and final mailing was sent that contained a booklet, information sheets, return mailing materials, URL and access code.

3. Econometric Model

To estimate a choice an individual makes with regards to whether or not to pay for fuel treatment programs in order to reduce a wildfire risk at Lake Tahoe Region, a random utility model was used. We constructed a binary logistic regression model to quantity households' WTP for fuel treatment programs:

$$Logit\big(P(WTP_i = 1)\big) = X_i'\beta + \varepsilon_i \qquad \textbf{(1)}$$

Where $P(WTP_i = 1)$ is the probability that a respondent is willing to pay for fuel treatment program at an offered payment level and $P(WTP_i = 0)$ is the probability that a respondent is not willing to pay and β is the vector of coefficients associated with explanatory variables (X_i). $\varepsilon_i$includes unobservable.

Coefficients from the binary logistic regression informs direction of association of independent variables with willingness to pay. However, they cannot be directly interpreted to determine the probability that a household will pay to implement prescribed fuel treatment program. Therefore, these coefficients were expressed as marginal effects to facilitate interpretation. A marginal effect determines the change in probability of WTP for implementing prescribed treatment program when there is a unit change in the value of the independent variable:

$$\frac{d\hat{P}_i}{dX_i} = \frac{\exp\,(X_i'\beta)}{\left[1+\exp\left(X_i'\beta\right)\right]^2} \qquad \textbf{(2)}$$

To estimate household's WTP, we rely upon responses to two dichotomous choice questions. An individual was first asked if he/she would vote *yes* or *no* to a Fuel Treatment Program that reduced risk of destructive wildfire for a specific amount per year for the next ten years. If a response is positive, it indicates that the WTP is at least as great as the first specified amount and triggers a second question: are they willing to vote in favor of an even greater amount? However, a negative response to the first question suggests that the WTP is less than the first specified amount and triggers a second question: are they willing to vote in favor of paying an even lower amount?

Each respondent is classified into a payment interval: $[Y_{iL}, Y_{iU},]$ where the lower bound value (L) is either negative infinity for a respondent who says no both times or the lowest payment presented and accepted (if a respondent's first no response is followed by a yes response). The upper bounds are defined in a similar way (either the highest payment requested and accepted (if they first say yes, followed by a no) or plus infinity (if they said yes both times). This means that the true WTP for some respondents will fall within an interval of real values while this interval will be left-censored for the respondents who said no twice and right-censored for the respondents who said yes twice. After collecting the interval information for each respondent, the contribution of respondent i to the likelihood function's value is represented either by an interval or else is right or left censored

$$\Pr(Y_{iL} \leq WTP_i \leq Y_{iU}) \quad = \Pr(Y_{iL} \leq X_i'\beta + \varepsilon_i \leq Y_{iU}) \text{ for interval data}$$

or

$$= \Pr(X_i'\beta + \varepsilon_i \leq Y_{iU}) \text{ for left-censored data}$$

or

$$= \Pr(Y_{iL} \leq X_i'\beta + \varepsilon_i) \text{ for right-censored data}$$

The log-likelihood function to be maximized is given in equation (3) for the sample of N respondents, where the subset LC are located in the left-censored interval, the subset RC are located in the right-censored interval and the subset I are located in the (uncensored) interval. Φ(.) is the standard normal cumulative probability density function. Implicitly, –(1/σ) is the coefficient on the payment requested, so this represents the scale factor used in valuation. As Cameron and James (1987) show the estimated coefficients from (3) can be used with equation (1) to obtain estimates of mean WTP.

$$LLF = \sum_{i=LC} log\, \Phi\left(\frac{Y_{iL}-X\beta}{\sigma}\right) + \sum_{i=RC} log\left(1 - \Phi\left(\frac{Y_{iU}-X\beta}{\sigma}\right)\right) + \sum_{i=I} log\, (\Phi\left(\frac{Y_{iU}-X\beta}{\sigma}\right) - \Phi\left(\frac{Y_{iL}-X\beta}{\sigma}\right) \qquad \textbf{(3)}$$

The log-likelihood function to be maximized is given in equation (3) for the sample of N respondents, where the subset LC are located in the left-censored interval, the subset RC are located in the right-censored interval and the subset I are located in the (uncensored) interval. Φ(.) is the standard normal cumulative probability density function. Implicitly, –(1/σ) is the coefficient on the payment requested, so this represents the scale factor used in valuation. As Cameron and James (1987) show the estimated coefficients from (3) can be used with equation (1) to obtain estimates of mean WTP.

4. Results and Discussion:

The study used a variety of questions to inquire about the levels of awareness of fire risk and, importantly, the specifics of forest treatment programs using photos of before and after treatments and examples of how treated areas affect ecological health and habitat and respond to ignition. More than 85% of our respondents were aware of fire risk at Lake Tahoe region.

Table 2 summaries the demographic characteristics of our respondents, how they were affected by Fire and the distribution of our proposed Treatment. The average age of the respondents was 57 years, 34% of them were female, and on average the respondents had completed 15 years of education. Along with education levels, household income was another important variable of interest to determine WTP. 36% of the respondents had a household income greater than $100,000. To identify those respondents most affected by the Fire, (binary) information was collected on (a) change in travel plans due to forest fire, and (b) change in landscaping or structures at home to reduce wildfire threat. 34% of the respondents had to make changes in travel plans due to forest fire, while a large majority the respondents (72%) had to make some changes in their homes' landscape/structures to reduce the threat of wildfire. This is consistent with the awareness among respondents of wildfire risk, and also reflects their efforts in mitigating risk of wildfire at their private properties.

Table 2: Summary Statistics

Summary Statistics	
Demographics	
Age (Years)	57
Female (Binary)	0.34
Education (Years)	15
Household Income Greater than $100,000 (Binary)	0.36
Residents at Lake Tahoe Region (Binary)	0.64
Awareness (Binary)	
Affected By Fire	
Change in Travel Plans due to Forest Fire (Binary)	0.34
Change landscaping or structures at a home to reduce wildfire threat (Binary)	0.72
Treatment Propsed	
Wildfire Risk Reduction from 52% to 23% (Binary)	0.16
Wildfire Risk Reduction from 52% to 41%. (Binary)	0.15
Wildfire Risk Reduction from 76% to 23%. (Binary)	0.12
Wildfire Risk Reduction from 76% to 52%. (Binary)	0.19
Wildfire Risk Reduction from 76% to 64% (Binary)	0.38
N	372

As identified earlier, respondents were randomly presented with one of the five different risk reduction scenarios. Table 1 highlights that distribution, highlighting how the “Wildfire Risk Reduction from 76% to 64%” was the most commonly frequently presented treatment plan (to 38% of the respondents), while “Wildfire Risk Reduction from 76% to 23%” was the least proposed plan (to only 12% of the respondents). This distribution was associated with how realistic the scenarios were, and the aim was to highlight different ranges impact sensitivity to wildfire risk, and hence the WTP. A total of 372 individuals responded to our survey. However, in the final analysis only 321 responses were considered after accounting for missing and

Table 3 highlights the marginal effect of explanatory variables on WTP. The payment amount that the household has to pay annually for 10 years has a negative effect on the WTP and this result was highly significant at 1% significance level. Age and Gender does not have significant impact on WTP. On the other hand, more educated person is more likely to pay for fuel treatment program in order to reduce wild fire risk. Similarly, household with income greater than $100,000 are more willing to pay for fuel treatment programs; the result is highly significant too. Furthermore, we found that, in comparison to risk reduction from 52% to 41%, households are more willing to pay when wildfire risk is reduced from 52% to 23%, 76% to 64%, 76% to 52% and 76% to 23%. The results suggest that respondent WTP was sensitive to levels of fire risk reduction. Higher the risk starting level, higher the willingness to pay for fuel treatment programs. Also, the greater the difference between risk reduction in a scenario, the more people are willing to pay for the treatment programs

Table 3: Marginal Effects of Explanatory Variables on Willingness to Pay

	Marginal Effect
Payment Amount	-0.122***
	(0.009)
Age	0.001
	(0.001)
Female	0.019
	(0.029)
Years of Education	0.016**
	(0.007)
Household Income	0.084***
	(0.029)
Resident	0.050*
	(.028)
Change in Travel Plans due to Forest Fire	0.059**
	(0.028)
Change landscaping or structures at a home to reduce wildfire threat	0.068**
	(0.030)
Risk Reduction 52% to 23%	0.110**
	(0.045)
Risk Reduction 76% to 23%	0.171***
	(0.051)
Risk Reduction 76% to 52%	0.089**
	(0.045)
Risk Reduction 76% to 64%	0.051
	(0.038)
N	321

` Note: Risk Reduction 52% to 41% is a baseline category; Standard errors in parentheses; $p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$

In table 4, we have calculated annual per household WTP for fuel treatment programs that would reduce wildfire risk in Lake Tahoe region. We estimate an average WTP over all respondents to be $88 per year for ten years with a 95% confidence interval of between $79 and $97. The mean WTP for residents was much higher ($109) than non-residents ($70). It is likely the case that the residents also factored in personal losses when deciding whether to contribute to the forest management program. The mean WTP of respondents who underwent a Change in Home Structure was $106, which was $35 higher than those who did not report any change in Home Structure.

This also shows that the former group is more risk-averse and willing to spend extra for mitigating risk, whether that be to their private homes or to the society at large.

Table 4: Willingness to Pay Per Year For 10 Years For Fuel Treatment Programs

Willingness to Pay Per Year For 10 Years For Fuel Treatment Programs				
	WTP	**95th % Confidence Interval**		**Obs**
Whole Sample	88	78.8	97.3	321
Residents	109	96.7	121.3	213
Non - Residents	70	57.5	83.3	108
Change in Home Structure	106	93.9	117.3	234
No Change inn Home Structure	71	59.7	82.7	87
Risk Reduction 52% - 41%	44	40.5	747.9	47
Risk Reduction 52% - 23%	106	82.5	129.3	48
Risk Reduction 76% - 64%	68	59.1	77.7	125
Risk Reduction 76% - 52%	89	71.5	106.7	62
Risk Reduction 76% to 23%	178	131.6	225.9	39

Additionally, the risk reduction scenarios were reflective of the sensitivity towards undertaking a fuel treatment program. The Risk Reduction scenario that decreased risk by the most, from 76% to 23%, had the most significant impact on WTP. We observed that the mean WTP at the highest risk reduction range (76% to 23%) of $178 was approximately 4 times higher than the WTP of $44 at the smallest risk reduction range (52% to 41%). The mean WTP for reduction from the higher risk level of 76% (WTP between $68 and $178) was generally greater than reductions from the lower risk starting levels of 52% (WTP between $44 and $106).

References:

Cameron, T. A. and James, J. D. 1987. Efficient Estimation Methods for Closed- ended Contingent Valuation Surveys. *The Review of Economics and* Statistics. 69(2):269-276.

Donovan, Geoffrey H.; Champ, Patricia A.; Butry, David T. 2007. Wildfire risk and housing prices: a case study from Colorado springs. *Land Economics, Vol. 83(2): 217-233*

Dillman, D. A. 2007 Mail and internet surveys: The Tailored design method. *John Wiley & Sons*

Ellsworth, Todd.; Stamer, Marc. 2021. Caldor Fire – Assessment Report. *USDA Forest Service*

Ecological Restoration Institute, Northern Arizona University. 2013. The efficacy of hazardous fuel treatments: A rapid assessment of the economic and ecologic consequences of alternative hazardous fuel treatments

Feo, Teresa J; Mace, Amber J.; Brady, Sarah E.; Lindsey, Brie. 2020. The Costs of Wildfire in California. *California Council on Science and Technology*

Jones, Kelly W.; Gannon, Benjamin.; Timberlake, Thomas.; Chamberlain, James L.; Wolk, Bret. 2022. Societal benefits from wildfire mitigation activities through payments for watershed services: Insights from Colorado. *Forest Policy and Economics*

Loudermilk, Louise; Stanton, Alison; Scheller, Robert M.; Dilts, Thomas E.; Weisberg, Peter J.; Skinner, Carl; Yang, Jian. 2014. Effectiveness of fuel treatments for mitigating wildfire risk and sequestering forest carbon: a case study in the Lake Tahoe Basin*. Forest Ecology and Management 323: 114-125.*

Loomis, John. 2005. Updated outdoor recreation use values on national forests and other public lands. *U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station..*

Loomis, John; Sánchez, José J.; González-Cabán, Armando; Rideout, Douglas; Reich, Robin. 2019. Do fuel treatments reduce wildfire suppression costs and property damages? Analysis of suppression costs and property damages in U.S. National Forests. *U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 70-84.*

Miller, J.D., Safford, H.D., Crimmins, M.; Thode, A.E. 2009. Quantitative Evidence for Increasing Forest Fire Severity in the Sierra Nevada and Southern Cascade Mountains, California and Nevada, USA. 2009. *Ecosystems 12, 16–32*

Petrakis, E.R.; Villarreall, L.M.; Wu, Z., Hetzller,R.; Middleton, R.B.; Norman, L. 2018. Evaluating and monitoring forest fuel treatments using remote sensing applications in Arizona. *Forest Ecology and Management*

Sánchez, José J.; Holmes, Thomas P.; Loomis, John; González-Cabán, Armando. 2022. Homeowners willingness to pay to reduce wildfire risk in wildland urban interface areas: Implications for targeting financial incentives. *International Journal of Disaster Risk Reduction. 68(6)*

Starbuck, Meghan; Berrens, Robert; Mckee, Michael. 2006. Simulating changes in forest recreation demand and associated economic impacts due to fire and fuels management activities. *Forest Policy and Economics 8(1): 52-66*

Thompson, Matthew P.; Riley, Karin L.; Loeffler, Dan; Haas, Jessica R. 2017. Modeling fuel treatment leverage: Encounter rates, risk reduction, and suppression cost impacts. Forests. 8: 469.

Taylor, Michael.; Sánchez Meador. A; Kim; Yeon-Su; Rollins, Kimberly ;Will, Hank. 2015. The Economics of Ecological Restoration and Hazardous Fuel Reduction Treatments in the Ponderosa Pine Forest Ecosystem. *Forest Science. 2015-12-16, Vol.61 (6), p.988-1008.*

Wibbenmeyer, Matthew J.; Hand, Michael S.; Calkin, David E.; Venn, Tyron J.; Thompson, Matthew P. 2013. Risk preferences in strategic wildfire decision making: A choice experiment with U.S. wildfire managers. *Risk Analysis. 33(6): 1021-1037.*

Annex 1 (Referendum):

Reducing Wildfire Risk at Lake Tahoe: What is it Worth to You?

A recent study of forest conditions in the Lake Tahoe area concluded that:

- If a fire broke out near homes and recreation areas around Lake Tahoe, there would be a **risk%** chance that it would become a highly-destructive, large wildfire.
- This chance would be **reduced to risk%** if 10,000 acres of public forest were thinned every year for 10 years.
- Current funding **cannot** achieve the goal of 10,000 acres thinned each year for 10 years.

Suppose a **forest management program** is proposed to treat 10,000 acres per year for 10 years. Program costs would be covered by residents of California and Nevada and by visitors to the Lake Tahoe region through a variety of fees. Examples include: special sales taxes, property taxes, and user fees. **Funds would be dedicated to this program only. Forest thinning needs and funding levels will be reevaluated at the end of this 10 year period.**

The Referendum

Suppose you and all other residents of Nevada and California are asked to vote on this program.

- **If a majority votes NO:** The program will not be implemented. Even if you vote YES, the program will not go forward and funds will not be collected.
- **If a majority votes YES**: The program will be implemented. Even if you vote NO, the funds would still be collected from you to support the program.

How would you vote if the annual costs to your household were as shown below?

These costs may seem very high or low to you. Different versions of this questionnaire present different dollar amounts, so that we get a wide range of responses overall. For each dollar amount, please consider your household budget and needs, along with the value you place on Lake Tahoe rforests and reducing wildfire risk.

1. How would you vote if the cost to you was $ <A> per year for the next 10 years?

   ☐ YES ☐ NO

2. How would you vote if the cost to you was $ <B> per year for the next 10 years?

   ☐ YES ☐ NO

3. Would you support this program in principle, if it cost your household nothing?

   ☐ YES ☐ NO

Annex 2 (Forest health information sheet):

Wildfire: A Threat to Lake Tahoe Forests

The wildfire threat at Lake Tahoe was not always as high as it is today. Historically, frequent small fires maintained forest health by removing brush, small trees, and dead wood. These fires also created a **patchwork** of **lightly wooded** areas interspersed throughout more **heavily wooded** areas. This patchwork prevented fires that ignited from becoming large and destructive. Fire helped to create fire-resilient and drought-tolerant forests.

Nowadays forest fires at Lake Tahoe are extinguished as quickly as possible to protect human life and property. Over time, this has created vast unbroken expanses of heavily wooded areas that would fuel large, destructive fires. Recent studies have concluded that a forest fire ignition near any one of many populated areas around Lake Tahoe has a strong chance of becoming a large, destructive wildfire with devastating effects on the ecosystem, recreation, infrastructure, housing stock and local economy.

Wildfire and forest condition in the Lake Tahoe area

Heavily wooded and **lightly wooded** areas look different, and respond differently to fire, as described below.

Heavily Wooded Area Before Fire

Lightly Wooded Area Before Fire

1 Year after fire: heavily wooded area

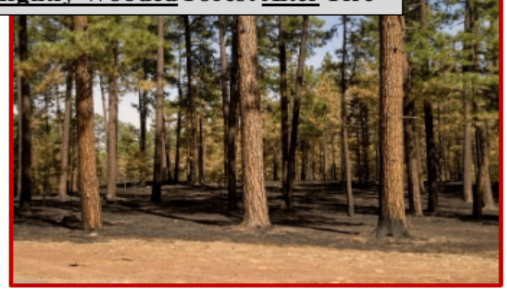
- Burned areas noticeable for *many years*
- *Most* vegetation and trees are killed
- Erosion is *more* likely
- Erosion reduces Lake water clarity
- Habitat for wildlife is lost

1 Year after fire: lightly wooded area

- Burned areas less noticeable after *a year*
- *Most* large trees survive
- Erosion is *less* likely
- Lake water clarity *not affected*
- Habitat for wildlife remains

Heavily Wooded Area After Fire

Lightly Wooded Forest After Fire



Steps to control fire risk in Lake Tahoe area forests

The Lake Tahoe area contains 191,000 acres of forest with **heavily wooded** areas and **lightly wooded** areas. **Currently, the proportion of heavily forested area is much too high**. Forest managers can perform forest treatments to create lightly wooded areas that will break up large, unbroken heavily wooded areas. This patchwork reduces the risk that ignitions will result in large and destructive fires.

At this time, there is insufficient funding to recreate and maintain lightly wooded forest.

- **Decisions must be made about wildfire forest treatments in Lake Tahoe area forests**
- **A decision to do nothing allows the risk of a large, destructive wildfire to continue to grow**