

UNIVERSITY OF WAIKATO

**Hamilton
New Zealand**

**Willingness-to-Pay for Prescribed Fire
in the Colorado (USA) Wildland Urban Interface**

Pamela Kaval
University of Waikato

John Loomis
Colorado State University

Andrew Seidl
Colorado State University

Department of Economics

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Corresponding Author

Pamela Kaval

Department of Economics
University of Waikato,
Private Bag 3105,
Hamilton, New Zealand

Fax: +64 (7) 838 4331
Phone : +64 (7) 838 4045
Email: pkaval@mngt.waikato.ac.nz

Abstract

During the summer of 2001, survey data were collected from Colorado residents living near public lands (i.e., the wildland urban interface). Data were collected by telephone after mailing respondents a survey. These data include detailed information of respondents' views towards wildfire management and willingness-to-pay (WTP) values for prescribed burning. Results indicate that Colorado residents living near public lands are aware that fire is a natural process in their area and are in favor of using prescribed burning for fire risk reduction. They also are willing-to-pay an annual tax for prescribed fire undertaken on the public lands near their homes. Respondents' support for adopting a fire risk mitigation policy based on prescribed fire depended on perceived fire frequency intervals. The substantial WTP values for prescribed burning indicate that the public living in the wildland urban interface could potentially pay an annual tax, so the burden of wildfire management need no longer predominantly lie in the hands of the general taxpayers.

Keywords

Prescribed burning
Controlled burning
Wildfire management
Contingent valuation
Public involvement

JEL Classification

Q23, Q27, Q34

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1. Introduction

The state of Colorado, located in the Rocky Mountain region of the United States, is composed of numerous vegetation zones; from dryland crops in the lower plateau, to Douglas Fir and Ponderosa Pine in the montane zone, to Subalpine Fir and Engelmann Spruce in the subalpine areas (Romme et al., 2001, Theobald et al., 2003; Klett et al., 2005). Prior to European settlement, the lower elevation forests of Colorado experienced frequent low intensity surface fires approximately every one to 30 years (Larimer County, 2005; Veblen et al., 2000). In the higher elevation forests, fires occurred at a lower frequency, only once every 50 to 500 years, but they were typically of a higher intensity than the fires at lower elevations and were commonly stand replacing (Erickson, 2002; Veblen et al., 2000; Larimer County, 2005).

European settlement in the 19th century changed the traditional fire patterns in Colorado. During this period, United States land use policy focused on fire suppression, a policy in which wildfires would be immediately extinguished after ignition. High rates of population growth throughout the 20th century brought a substantial number of rural residential properties into the wildland urban interface (WUI)¹ and at a nontrivial risk of catastrophic loss of property due to wildfire. The 20th Century policy of fire suppression has both reduced the number of Colorado wildfires and caused a large build-up of fuels in the forests. While fire suppression may lead to a smaller number of fires, the fuel build-up yields larger and more intense fires. It is hypothesized that a return of frequent small fires, in the form of prescribed burns, may decrease the amount of fuels in the Colorado forests and possibly reduce the chances of high intensity wildfires in the WUI. This burning may also restore ecosystem function to its pre-European inhabitation state. In addition, prescribed burning is believed to be beneficial to commercial timber stands by removing unwanted brush, small grasses and shrubs. With the small vegetation removed, trees are no longer competing for water and nutrients and more energy can be put into tree growth. Prescribed burning is also known to help eradicate diseases. In longleaf pine forests, for example, prescribed fire has been used effectively to control brownspot disease (SCFC, 2006).

Public support for selected fire policy alternatives such as prescribed burning has become part of the decision criteria for federal land management. In particular, the National Forest Management Act and the National Environmental Policy Act require active participation of the public in management decisions (USDA Forest Service, 2000; National Environmental

¹ The wildland urban interface is defined as those homes that are near undeveloped lands and bear a risk of landscape fires damaging their property. In our study, we defined the wildland urban interface as those properties located within 10 miles of an undeveloped land such as a National Forest or National Park.

Policy Act, 1969). A number of factors may contribute to public support for fire policy alternatives, particularly prescribed burns for wildlife risk mitigation. Public understanding (knowledge of the cause and effects of wildfire), awareness (realization that wildfire is part of the natural ecology) (e.g., Zwolinski et al., 1983; Cortner et al., 1990; Cortner et al., 1984; Loomis et al., 2001; Loomis et al., 2000), perceived and actual risk of wildfire, and personal experience with either wildfires or prescribed burns (e.g., Vogt, 2003) have been found to correlate with support for fire prevention policy including prescribed burning.

Many studies have been conducted to understand public awareness and support for prescribed fires (Table 1). Studies have been conducted in states that commonly experience wildfire: Arizona, California, Colorado, Florida, Montana, New Mexico, and Wyoming. All studies found a large percentage of the respondents surveyed to approve of using prescribed burning for fuel reduction. This approval rating ranged from a low of 55% in Montana and Wyoming to a high of 91.7% in Arizona (Zwolinski et al., 1983; Taylor and Daniel, 1984; Gardner et al., 1987; Manfredo et al., 1990; Bright et al., 1993; Loomis et al., 2001; Behavior Research Center, 2002; Vogt, 2003; Winter and Cvetkovich, 2003).

<<< Table 1 >>>

Support for the use of prescribed burning does not tell us whether people feel that their home might be in danger of wildfire (perceived risk) nor whether the historical record and current conditions create a potentially dangerous fire situation (actual risk). Nelson et al. (2003) found that 68% of Minnesota respondents believed their home was at risk from wildfire and Monroe and Nelson (2004) found that 84% of homeowners in Florida and Minnesota were aware of their risk to wildfire. Higgason discovered that 48-78% of Colorado respondents living in the WUI believed that a wildfire would threaten their neighborhood at their current location (Higgason, 2002). Of these respondents, less than 47% believe that their home was prepared to survive a wildfire. Primary concerns of wildfire were loss of property, loss of life, and loss of visual appeal (Higgason, 2002).

The Colorado State Forest Service did a survey in 1995 to find out the “actual” risk of homes in western Larimer County Colorado (where a significant portion of our study was conducted) and they found that actual loss potential due to wildfire was 57% (Larimer County, 2005). Based on the recent Colorado studies, we may be able to tentatively contend that perceived and actual fire risks are roughly in line with one another; on average people appear to be neither overly optimistic nor pessimistic about their individual risk of catastrophic loss from wildfire.

Public awareness of the wildfire ecosystem of their area, experience with viewing successfully controlled prescribed fires, and public support for prescribed fire as a fire risk mitigation alternative coupled with a perceived risk of residential damage due to wildfire should translate into a pledge of financial support for the policy. Loomis et al. (2002) conducted a contingent valuation study of Florida residents asking their willingness-to-pay (WTP) for prescribed burning in their area. A contingent valuation study uses the contingent valuation method, a stated preference method, to determine what people are willing-to-pay for a particular non-market good. The collected information can then be aggregated to estimate a demand function that represents public WTP. In this study, they found that Florida residents were willing-to-pay \$557 annually (90% confidence interval: \$387-\$1249) for prescribed burning.

In our study, we attempt to see if Colorado residents living near the Colorado wildland interface are knowledgeable about the natural fire regime in the area surrounding their home, if they are in favor of prescribed burning, and if this favorability transforms into a WTP for prescribed burning. To do this, Colorado residents living within the WUI were asked about their views towards wildfires, wildfire risk, and WTP for prescribed burning. Our hypothesis was that Colorado residents would be knowledgeable about wildfire and wildfire frequency in their areas and would have a WTP for prescribed burning on public lands near their homes. We also hypothesize that WTP will be higher if their perceived fire danger and perceived fire frequency are relatively high.

2. Methods

2.1. The Survey

To gather public wildfire opinion information, a survey booklet entitled ‘Managing Fires on Public Lands: What Do You Think?’ was created. The survey was initially developed and then modified in a series of focus groups in Colorado and California. Focus groups were helpful for question wording and for determination of the range of values to use for the WTP question. The modified survey was pretested and consideration of all pretesting comments resulted in the survey’s final version. The final version of the survey included eight pages of questions and two color pictures that were inserted into the survey for use with some of the questions (Figure 1). The first picture is a low intensity prescribed burn one year after fire in a Colorado ponderosa pine forest where most underbrush was killed, however, standing trees were not. This picture was to be used alongside low intensity prescribed burn questions. The second picture was of a high intensity burn one year after fire in a Colorado ponderosa pine forest where all underbrush and standing trees were killed. This picture was to be used with the high intensity wildfire questions. The forests in these two pictures were similar in stand

density (trees per hectare) and tree size (d.b.h. - diameter at breast height). We felt that these pictures were easier for respondents to conceptualize than to present data of actual stand density and tree sizes, because many people may not understand those numbers and because visual appeal has been shown to be among the most important factors people consider in weighing fire risk management alternatives.

<<< Figure 1 >>>

115 survey participants in twelve WUI communities located within ten miles of a forest (undeveloped wildland): Leadville, Twin Lakes, Nederland, Rollinsville, Estes Park, Masonville, Bellevue, rural Fort Collins, Red Feather Lakes, Dinosaur, Creede, and Pagosa Springs were contacted randomly by phone during the summer of 2001 and asked to participate in a survey. Of those who agreed to participate in the study, a follow-up phone interview was scheduled approximately seven days from the initial call and a survey was mailed to their homes. This was enough time for the participant to receive the mail survey and go through it at their leisure before the follow-up phone interview. During the follow-up phone interview, respondents were asked for their responses to the mail survey and once the interview was complete, they were then asked to place their survey in the self addressed stamped envelope to be mailed back to us. In this way, results could be logged in twice: once from the phone interview and again from the mail survey.

In all, 115 people were contacted with 103 who agreed to do the survey and 12 who did not. Of the 103 who agreed to complete the survey, 99 people followed through. Therefore, the response rate of those contacted was 86% and the response rate of those contacted that said they would complete the survey was 96%.

Demographic variable data was compared with information from the 2000 U.S. Census for respondents specific towns of residence (U.S. Census, 2000) to determine the representativeness of our sample. Variables analyzed included sex, household size, ethnicity, age, and income. Overall, our respondents were found to be 51% female with an average household size of 2.41 persons. Average ethnicity across our sample was 94% Caucasian, average age was 48, and the average household income was approximately \$68,000 annually. We found all five variables to fall within the 95% confidence interval (CI) for the respective variables in their respective towns (refer to Kaval, 2004 for more detail). Therefore, we believe that the random sample that we selected is an accurate representation of people living in the Colorado WUI even though our sample size is small.

2.2 Survey Questions

In order to test our hypothesis, we needed to determine perceived fire danger, perceived fire frequency, and WTP for prescribed burning. To determine perceived fire danger, we asked respondents a yes/no question as to whether they felt their home was at risk of burning down from a wildfire. The exact question wording is as follows:

Are you concerned that a fire on public lands may endanger your home?
(Circle One) Yes No

To determine perceived fire frequency, we asked respondents first to look at the photo of the forest one year after a high intensity burn (Figure 1b.). Then we asked:

Take a look at Photo #1 (Figure 1b.), this is a photo of a forest one year after a high intensity wildfire. In your opinion, how often does a wildfire such as shown in Photo #1, occur in the area where you live. For example, once every 5 years, once every 10 years, twice a year, etc. _____ Fire frequency

Next we wanted to determine the public value for prescribed burning. For the purposes of this survey we defined prescribed fire as “Prescribed fires or controlled burns are those fires that are set purposely in a designated area to accomplish one or more specific objectives such as removal of underbrush and dead wood to reduce available fire fuel, reduce the number of wildfires, and/ or reduce wildfire intensity.”

Following the economic valuation literature previously cited, we used the contingent valuation method (CVM) technique to derive the WTP information. The contingent valuation WTP question for this study focused on the decision to adopt a prescribed burning program for mitigating fire risk. Respondents were then to use their perceived fire frequency information to answer the following WTP question about the public lands in their area:

Using prescribed burning (Photo #1: Figure 1a.), public land management agencies could reduce the frequency of a wildfire (Photo #2: Figure 1b.) on the public lands surrounding your home such as National Forests and National Parks by half. Would you pay an increase of \$X a year more in taxes for a prescribed burning program such as this?

(Circle One) Yes No

The WTP question was asked as a dichotomous choice—would you pay \$X each year for a prescribed burn policy, yes or no, where \$X varied across the sample from \$5 through \$1500. These values were determined in the focus groups. The responses to the dichotomous choice WTP question would then be analyzed using a logistic regression model.

The logistic regression model is appropriate when the dependent variable represents a qualitative response such as yes or no. For our model, the dependent variable is y_t ; where $y_t=0$ if the respondent is not willing-to-pay for prescribed fire and $y_t =1$ if the respondent is willing-to-pay their bid amount.

3. Results and Discussion

Respondents were mailed an eight page survey to obtain their views towards wildfire management and WTP values for prescribed burning. Survey results provided a great deal of insight into the public's views of wildfire and wildfire management. The first set of survey questions yielded information about the respondents' basic wildfire knowledge, location of their homes to public lands, and whether they felt their home was in danger from wildfire (Table 2). This information showed that 100% of respondents had read or heard about wildfires and 98% had read or heard about prescribed fires on either National Forests, National Parks or other public lands. All respondents' homes were located in the WUI with 34% of properties bordering public lands.

<<< Table 2 >>>

61% of respondents were concerned that a fire on public lands may endanger their home. This is what we call the "perceived wildfire risk." We believe that the results from this question are logical because many of the respondents have proper defensible space surrounding their homes or live in a town center where they are in less danger of fire; even though they are in the WUI. Perceived wildfire risk estimates were comparable to actual wildfire risk. Actual wildfire risk to homes near forests in Larimer County, Colorado, an area that represents several of our study locations, estimated that 57% of homes in the WUI had high fire loss potential (Larimer County, 2005). We believe this indicates that respondents are knowledgeable of the wildfire ecosystem of their area. These results also concur with study that was published one year after our study in which Higgason (2002) showed that 48-78% of Colorado respondents believed a wildfire could threaten their neighborhood.

To determine perceived fire frequency, respondents were asked to state how often they believe fire to occur on the public lands closest to their home. Results show that 92% of respondents felt that wildfires occurred at least once every 30 years in their area. A small percentage (<5%) believed that fires occurred less than once every 50 years. These results follow actual fire frequency rates in their area. In the lower elevation ponderosa pine forests (that a majority of the respondents live in), fires do occur frequently (less than once every 30 years) and in the higher elevation lodgepole pine and spruce fir forests that a small

percentage of the respondents may live in, fires occur less than once every 50 years (Romme et al., 2001; Theobald et al., 2003; Larimer County, 2005; Veblen et al., 2000; Erickson, 2002) (Figure 2).

We then asked respondents to select which fire management technique they would prefer if they had to choose only one (Figure 3). Over 86% of the respondents believed that prescribed fires should be conducted, however, they varied as to which wildfire management policy should accompany the prescribed fire management technique (i.e., whether to also allow wildfires to burn but protect homes, allow wildfires to burn freely and do not protect homes, or to immediately extinguish wildfires). Only 10% of respondents were not in support of prescribed fires and 4% of respondents were not sure. This represents a high public acceptance of prescribed fires.

One year after our study, the USFS asked Colorado residents opinion on forest fire management. This study showed that 20.4% of respondents believed “all fires must be extinguished regardless of cost (Winter and Cvetkovich, 2003).” We believe this statement is similar to our statement in which “all wildfires should be extinguished and prescribed fires should not take place.” In our study, only 7% of respondents believed this. We believe this to be the case because our respondents lived in the WUI area while the USFS chose random Colorado homes. Four percent (4%) of respondents in the USFS study did not answer, which correlates with our 4%. Nine percent (9%) of the USFS respondents believed that “fires must be allowed to take their natural course when burning in wildland or wilderness areas, even if structures are involved.” And 66.4% of USFS respondents believe that “we probably have to let some fires burn, but must protect residences.” We can not exactly determine which of our questions these correspond with, but we do know that 50% of our respondents felt that homes should be protected while 4% of our respondents believed that fires should burn freely.

The fire frequency information, in conjunction with the background questions, makes it reasonable to infer that respondents are knowledgeable about wildfire, wildfire risks, and fire frequency in their area. This may make it easier for fire managers to introduce forest fuel reduction by prescribed fire into areas near the WUI of Colorado.

While there have been several studies of Colorado residents after our study took place, no Colorado study besides this one has asked Colorado residents for their WTP value for prescribed burning. In our study we find that, overall, 66% of the respondents were willing-to-pay for prescribed fires. At the low level of \$5 annually, all respondents were willing-to-pay for prescribed fire, while at the higher level of \$1500 annually, only 14% were.

A logit regression model was estimated on the WTP bid for prescribed fires, this is the “base model.” The results of the base model showed that the bid variable was significant at the 99% level. Logit results are as follows (with P-Values in parenthesis):

$$\text{WTP for Prescribed fire (yes, no)} = 1.208 - 0.0018\text{BidAmount}$$

$$(0.000) \quad (0.002)$$

The logit results enable us to calculate the median, mean and confidence intervals for WTP. To calculate the median value, we use the formula (Hanemann 1984):

$$\text{Median} = C / (-\text{Bid Coefficient}), \text{ where } C \text{ is the constant term.}$$

The formula for the mean value is (Hanemann 1989):

$$\text{Mean} = \ln(1 + e^C) / (-\text{Bid Coefficient})$$

Using the simulation approach of Park et al. (1991), we were able to calculate the confidence intervals. Mean, median, and confidence intervals (CI) calculated are presented in Table 3. These results show respondents have a high WTP for prescribed fire management. The mean value for prescribed fire was \$796 with a 90% confidence interval of \$545 and \$1583.

<<< Table 3 >>>

To test our hypothesis that WTP will be higher if perceived fire danger and perceived fire frequency are relatively high, danger and frequency variables were added to the base model. Results are as follows (with P-Values in parenthesis):

$$\text{Prescribed Fire} = 2.333 - 0.003 \text{ Bid} - 0.852 \text{ Danger} - 0.024 \text{ Freq}$$

$$(P\text{-Values}) \quad (0.000) \quad (0.001) \quad (0.174) \quad (0.033) \quad \text{McFadden } R^2 = 0.185$$

Where: Bid = The bid amount (Range \$5-\$1500)

Danger = Respondents’ perceived danger as to whether they felt their home was in danger of a wildfire burning it down (1=yes, 0=no)

Freq = Respondents’ perceived wildfire frequency on the public lands in their vicinity (once every five years = 5, once every 10 years = 10, etc.)

Because interpretation of the coefficient in a logit model is not direct or straightforward as it is in an ordinary least squares (OLS) regression, coefficients were converted into WTP values. To do this, all coefficient values except the bid amount were divided by the absolute value of the bid coefficient (Cameron 1988; Richardson 2002). Results show that if the

number of wildfires that is perceived to occur in the vicinity of the respondents increases (fire frequency), their WTP increased (\$8/year). In this same way, if the respondent felt that their home was in danger of burning in a wildfire (wildfire danger), their WTP increased by \$284. However, the wildfire danger variable was not significant.

One potential implication of these results relates to the public provision of services to protect private property. Most property owners own private insurance to mitigate the potential financial loss due to accidents including weather events such as flood and fire. People who live in areas prone to flood (within the 100 yr floodplain) are often required to carry flood insurance and in some particularly risky floodplains, insurance is impossible to obtain, discouraging development. No such fire loss insurance requirements exist for those who choose to live in the WUI of Colorado. Since the average annual WTP is about \$800 and the average home in the study region is about \$240,000 (average property value is \$300,000). Annualizing the price of the home at 5% would yield an annual value of \$12,000. Therefore, if we can assume a total loss of built property (the home) in the event of a fire, the implied individual perceived risk is about 1/15 annually (one fire in 15 yrs). This aligns with actual fire risk in the area, as the lower elevation forests of Colorado, where a majority of respondents live, experienced frequent low intensity wildfires approximately every one to 30 years prior to European settlement (Larimer County, 2005; Veblen et al., 2000). If we assume that people are rational, then we must conclude that the public is expected to subsidize the mitigation of the private fire risk voluntarily entered into by these people. Based on these calculations, their annual WTP of \$800 aligns actual risk with perceived risk of living on the WUI.

4. Conclusions

Wildfire suppression policies in the western United States have created a large build-up of wildfire fuels. This has resulted in wildfires of extremely high intensity, which is cause for concern because an increasing number of people are building homes in the wildland urban interface (WUI). One method that can be used to alter the risk profiles of wildfire damage is prescribed burning. In this study, we attempted to see if people living in the Colorado WUI were knowledgeable about wildfires and prescribed fires and see if they had a willingness-to-pay (WTP) to reduce the risk of their home burning in a wildfire.

Surveyed Colorado WUI homeowners were found to be knowledgeable about the natural occurrence of wildfire in their area. They were aware that their homes may be at risk from wildfire and were well-informed that prescribed burning could be used as a fuel reduction technique. Over 85% of respondents approved of public land managers using prescribed

burning to reduce wildland fuels and approximately 66% had a WTP for prescribed burning in their areas. Mean annual WTP for prescribed burning was nearly \$800, this value was dependent on respondents perceived fire frequency.

Many discussions with older respondents revealed that homeowners living in the WUI were not only aware of the danger to their homes, but in the past, readily did something about it. Prior to illegalization, many homeowners would backfire their properties to reduce the risk of a wildfire burning their homes. Backfiring is a process in which potential wildfire fuel loads in the vicinity of their homes was reduced by burning the land surrounding their home. Therefore, backfiring is a type of prescribed burning technique. However, the government eventually banned backfiring.

Currently, homeowners can still do something to reduce wildfire fuel loads around their homes, they can clear a 30 meter defensible space. In Colorado, it has been found that homes with the proper defensible space zones that were hit by the 2002 Colorado Missionary Ridge Fire were all saved (Binkley, 2003). Some homes with defensible space that were hit by the 2002 Hayman fire, the largest wildfire in the state's recorded history, were also saved (CUSP, 2003; Cohen and Stratton, 2003). While defensible space has been shown to save homes from wildfire, defensible space is not mandatory in most of Colorado and is not a common practice.

This study reveals that people living in the WUI are willing-to-pay for fuel load reduction on the public lands near their homes via prescribed burning. This implies that homeowners living in a wildfire area know about the wildfire risk to their homes and are willing to do something about it. In the past, homeowners could backfire their properties, but this is no longer allowed without a great deal of paperwork and supervision. As this study showed a high WTP for controlled burning, perhaps prescribed burning can be partially funded by an increased tax on those people living in the wildfire vicinity. Another option could comprise of a special wildfire insurance fee for all homes that are located near undeveloped lands at risk of wildfire. All of these at-risk homes could pay the extra fee in their insurance and be asked to create a defensible space zone around their home. For those that do not create the defensible space zone, a higher fee would be charged. This fee difference would provide incentives for homeowners to create a defensible space around their home.

As this study shows, perhaps it is time to adopt strategies to reduce risk in the WUI by making the public that voluntarily entered into a wildfire risk area subsidize its mitigation.

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Table 1: Public approval of prescribed burning in previous research

Study	Approximate Study Year	Location	Response
Winter and Cvetkovich (2003)**	2002	Colorado Arizona California New Mexico	6.25 (Colorado) 6.6 (Arizona) 6.25 (California) 6.1 (New Mexico) Scale of 1 to 8 where 1 is strongly disapprove and 8 is strongly approve
Vogt (2003)**	2003	Colorado and Florida	Moderate approval in Colorado and High approval in Florida
Behavior Research Center (2002)	2000	Arizona	87% Approval
Loomis et al. (2001)	1999	Florida	65% Approval
Bright et al. (1993)	1993	Yellowstone National Park visitors	86% Approval
Manfredo et al. (1990)	1989	Montana (MT) and Wyoming(WY)/ Other 48 States	MT & WY 55% Approval/ Other States 48% Approval
Gardner et al. (1987)	1987	San Bernadino County, Southern California	61.7% Approval
Taylor and Daniel (1984)	1984	Tucson, Arizona	91.7% Approval (after reading informational brochures)
Zwolinski et al. (1983)	1981	Tucson, Arizona	80% Approval

**Note that these studies were conducted after our survey was complete.

Table 2: Respondents answers to wildfire related questions

Read or heard about wildfires on public lands	100%
Read or heard about prescribed fires on public lands	98%
Lived near public lands (within 10 miles)	100%
Land bordered public lands	34%
Felt their home was in danger of wildfire	61%

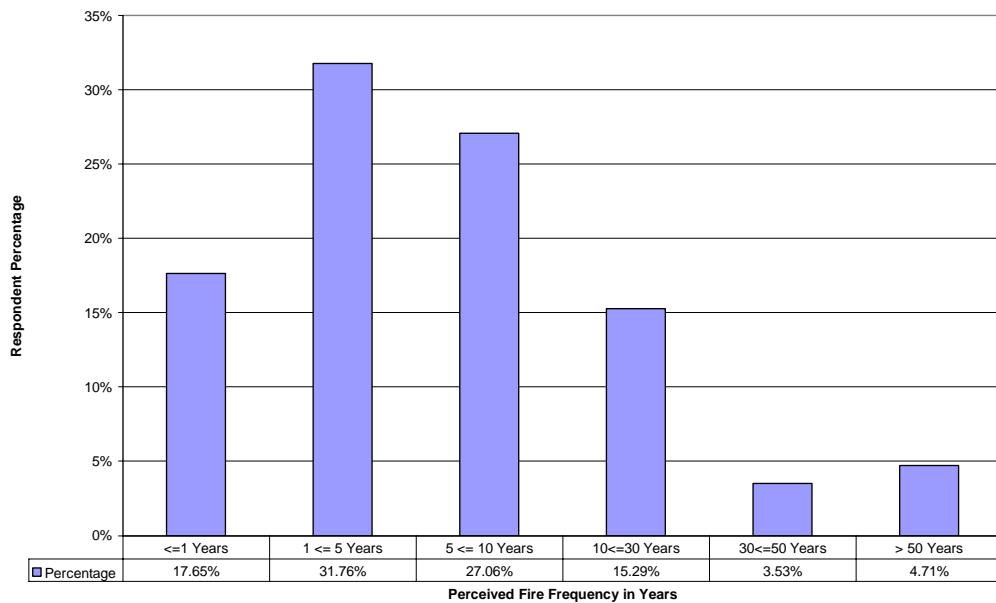
Table 3: Willingness-to-pay value for prescribed fire

90% Confidence Interval on Mean WTP			
Median WTP	Mean WTP	Lower Bound	Upper Bound
\$655	\$796	\$545	\$1,583

Figure 1: (1a.) One year following a prescribed fire low intensity burn (left) and (1b.) One year following a high intensity wildfire (right).



Figure 2: Respondent perceived fire frequency for their area



Note: In this figure, <=1 means respondents felt wildfires occurred at least once a year

Figure 3: Respondents fire management preferences

