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DISSERTATION

PUBLIC VALUES FOR RESTORING NATURAL ECOSYSTEMS: INVESTIGATION INTO NON-MARKET VALUES OF ANADROMOUS FISH AND WILDFIRE MANAGEMENT

Submitted by

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY PAMELA KAVAL ENTITLED "PUBLIC VALUES FOR RESTORING NATURAL ECOSYSTEMS: INVESTIGATION INTO NON-MARKET VALUES OF ANADROMOUS FISH AND WILDFIRE MANAGEMENT" BE ACCEPTED AS FULLFILING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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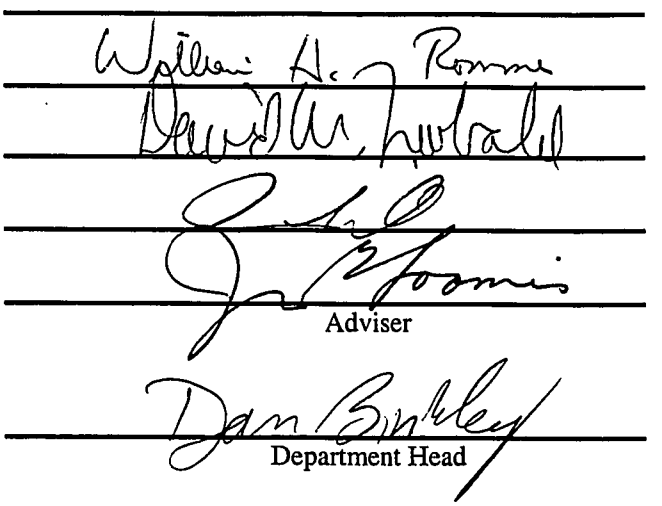

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ABSTRACT OF DISSERTATION

PUBLIC VALUES FOR RESTORING NATURAL ECOSYSTEMS:
INVESTIGATION INTO NON-MARKET VALUES OF ANADROMOUS FISH
AND WILDFIRE MANAGEMENT

This dissertation is composed of three papers, each using surveys as an aid to understanding public values. The public values on which I focus are related to restoring natural ecosystems. The first ecosystem is the Lower Snake River in Washington and the second is Colorado Forests.

The first paper, "Recreational Benefits of Removing the Lower Snake River Dams: A Test of Scope for Contingent Visitation Behavior," examines whether respondent recreation behavior would change if four dams were removed from the Lower Snake River. Removing the dams would restore the cold-water free flowing river ecosystem. This is a controversial topic of discussion. Dam supporters want the benefits of added electricity and the extended length of the inland shipping channel. Opposers feel the natural ecosystem may restore the nearly extinct native anadromous fish populations.

Snake River survey data allowed me to test two contingent visitation behaviors: whether to visit the Snake River if dams are removed and frequency of visitation for two groups of respondents; the general public and Snake River anglers. I found that if the dams were removed, 53.9% of the anglers that currently visit the Snake River would continue to visit. Of the general public subsample, 38.5% said they would definitely visit the river if the dams are removed; the remainder said they probably would. Scope tests were used to analyze general public and angler models. Results show the general public is not sensitive to fish catch rates. The anglers, however, are sensitive to salmon catch rates. From my results, it

seems that if the Lower Snake River is restored to its natural ecosystem, recreation in the area will continue to be important. Therefore, recreation benefits seem to be compatible with the ecology of returning the river to its natural state.

The second and third papers focus on Colorado forest ecosystems. Over the past century, wildfires have been suppressed in Colorado. Fire suppression has led to wildfire fuel buildup which in turn results in infrequent, but high intensity, wildfires. While high intensity wildfires can be part of a natural ecosystem regime, they also have the potential to burn homes that are located within the wildland urban interface, which is cause for concern. Colorado residents living within the wildland urban interface were surveyed to find out how they feel about various fire management prescriptions that may aid in restoring Colorado forest ecosystem health. The survey focused on two types of questions: contingent valuation willingness-to-pay questions and ladder of life well-being evaluation questions.

The first of the two fire papers is titled "Analysis of Public Perspectives of Wild and Prescribed Fires in Colorado." In this paper, I analyzed the survey information about three fire management techniques: prescribed fires, fire suppression, and fire prevention. Results show that people living near public lands in Colorado have high well-being values. They are aware that fire is a natural process and are willing-to-pay an annual tax increase between $507.00 and $654.90 for the fire management prescriptions. In total, over 66% of respondents were willing-to-pay for prescribed fires and fire suppression, while over 59% of respondents were willing-to-pay for fire prevention. It was also found that perceived fire danger and perceived fire frequency were influencing factors in how much a respondent was willing-to-pay for a particular fire management prescription.

The final paper in the dissertation is titled "Using GIS to Investigate the Relationship between Stakeholder Opinion about Wildfire and Landscape Context." This paper uses the information from the second paper and builds upon it by adding spatial modeling to the context. The spatial modeling was completed in ArcGIS and was used to calculate estimated actual fire danger of homes in Colorado.

GIS maps were used to create new fire danger variables, and included wildfire locations, slope, and vegetation. Additional variables created from these maps include wildfire distance from homes and vegetative fire danger of homes in their immediate vicinity (100 feet) and extended vicinity (one mile). It was discovered that willingness-to-pay values were, on average, positive. Willingness-to-pay values were found to vary among fire management techniques and fire danger variables. Overall, spatial modeling was found to be a helpful tool for this economic analysis.

These three papers showed that respondents are knowledgeable about their environments and are, in general, in support of restoring some natural ecosystems. They not only support these issues, but they are also willing-to-pay for them, thereby indirectly indicating importance of restoring natural ecosystems to the United States public.

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I have recently read through several dissertation and thesis acknowledgement sections trying to see how I should structure mine. In doing that, I came to the conclusion that since I am not the typical student, I should not write the typical acknowledgement; I should just write what I'm thinking and not worry about the proper structure. So here goes:

I am really excited to write these acknowledgements as it is "acknowledging" the fact that I just need to turn this in and I will be done. It's a great feeling. In a way, I feel like a movie star receiving an award and this is my acceptance speech, since I have so many people to thank and don't know where to start.

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In saying all this, I'd like to leave you with two of my favorite quotes:

"People are about as happy as they make up their minds to be." --- Abraham Lincoln

"Today is your day! Your mountain is waiting. So... get on your way." --- Dr. Seuss

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INTRODUCTION

Public values are one of the driving forces of public land policy today, especially since 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 Policy Act, 1969). These values influence and are influenced by the cultural, social, institutional, and economic framework within which an individual lives (Shultz and Zelezny, 1999). Three papers are presented in this dissertation to increase our understanding of public values towards ecosystem restoration.

Since my analysis focuses on public ecosystem restoration values, I will first explain ecosystems and restoration. Ecosystems are the dynamic interrelating complex of animal and plant communities. Within ecosystems, members typically benefit from each other in one way or another (Webnox, 2003; Learnthat, 2003). For instance, a field may grow grass that is eaten by a snowshoe hare; this hare is in turn eaten by a lynx. When the lynx dies, it decomposes, and as a result, "feeds" the grass.

The natural functions of ecosystems in the United States have undergone significant change in the past few hundred years from human disturbance. Some examples might include the creation of dams that have changed ecosystems from cold-water free-flowing rivers to warm-water lakes, the suppression of wildfires that has changed forests that once received frequent low intensity burns to forests that are not used to being burned, road and home development that has fragmented habitats and blocked wildlife migration corridors, and farmland creation that has reduced species diversity. As can be seen, there are many examples.

People are becoming aware of the changes we have made to our ecosystems and are realizing that the health of the ecosystems can be restored. It may not be necessary to return

conditions to presettlement forests, but it is important to try to help with ecosystem restoration efforts. Ecosystem restoration can increase biodiversity, enhance water retention capacity, and avoid extensive erosion possibilities (Arno, 1994; Anderson, 2003; Pfadenhauer, 2001; Turner et al., 1994).

The government is responding to ecosystem health concerns by creating and updating public land policies. Some examples include the Endangered Species Act and the U.S. Forest Service updated mission. One of the goals of the Endangered Species Act of 1973 is to aid in ecosystem conservation, which in turn helps with ecosystem restoration (Martin, 1995). The updated mission of the USDA Forest Service is to "sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations (USDA Forest Service, 2000 (2))." This policy also helps with ecosystem restoration.

The land on which ecosystems exist is typically managed by several agencies. For instance, the Mississippi River ecosystem travels through 10 of the 50 United States: Minnesota, Iowa, Wisconsin, Missouri, Louisiana, Illinois, Kentucky, Tennessee, Arkansas and Mississippi, and is effected by all the lands surrounding it. These lands are under various ownership such as the National Park System, National Forest System, U.S. Fish and Wildlife Service, Bureau of Land Management, State Parks, City Parks, and private land. Therefore, to manage an ecosystem requires collaboration among many agencies and individuals (Anderson, 2003; BLM, 1999).

Collaboration among agencies has been found to be a successful strategy in some endeavors. One example is the Bighorn Mountains located on over 5 million acres in Wyoming and Montana. They found that fire suppression had increased the number of trees per acre. The collaboration of land managers from the State of Wyoming, Bureau of Land Management, National Park Service, US Forest Service, and private landowners has resulted in returning the Bighorn Mountain forest communities to a more natural fire regime by practicing hazardous fuels reduction. They feel that this has made the area safer and the ecosystems healthier (Anderson, 2003).

In this dissertation, I focus on two ecosystem changes: removing dams on the Snake River in Washington to restore a free-flowing cold-water river system and changing fire management policies to try to restore a more natural ecosystem to the Colorado forests that once received frequent low intensity burns. Two of the ecosystem restoration methods considered for the Colorado wildfire fuel reduction program are the removal of underbrush and prescribed fires. Fire management techniques such as these can be used to reduce fuel buildup. Reducing fuel buildup can improve wildlife habitat, enhance aesthetic values, maintain endangered species, and create a diversity of plant communities (Turner, 1994; Arno, 1994).

In order to obtain public value data for this dissertation, surveys were used. The first paper makes use of the Snake River Recreation Survey, while the second and third are based on the Colorado Wildfire Survey: Managing Fires on Public Lands. Surveys are a powerful tool that can be used to provide public agencies with information about how the public wants public and private forest land to be managed.

In the fields of recreation and ecology, many times goods available are not sold in a market; examples might include biodiversity in Yellowstone National Park or hiking in Roosevelt National Forest. These goods aren't purchased in a market, but they do have value and many times these values are extremely high. For instance, the case of Mono Lake. Mono Lake is a water basin that provided water to the Los Angeles area since inception of a water aqueduct in 1941. The drop in water level has increased the salinity of the water, resulting in a decrease in the biological activity and size of the wetlands, as well as a decrease in bird and brine shrimp populations. An increase in the lake water levels could potentially restore some of the biological aspects of the area, however, it would result in less water from Mono Lake to the Los Angles area. It was originally perceived that reducing the amount of water available to Los Angeles would deprive the Los Angeles people of water benefits as they would need to obtain water from other more costly water supplies. However, a non-market valuation survey was conducted and found that people supported an increase in the water level of Mono Lake and were willing-to-pay higher rates for water to protect the Mono Lake ecosystem for birds,

fish, and recreation. Therefore, when considering the non-market values of the respondents, it was discovered that the benefits of improving the biological quality of Mono Lake far exceeded the costs of increased water rates (Jones and Stokes, 1993; Loomis, 1996; Loomis, 1987).

Non-market value information such as that from Mono Lake is typically collected through surveys. These surveys are distributed to individuals since individuals are believed to be the best judges of their own values (Hanemann, 1994).

In non-market surveys, the first goal is to create a hypothetical market. This hypothetical market serves as the context for the survey questions (Callen and Thomas, 1996; Loomis, 1996; Cameron and James, 1987). Once the hypothetical market is created, specific survey questions need to be created, such as paying for camping at a specific campground in Grand Teton National Park. General questions, such as paying for camping anywhere, are too vague and can not be valued properly as they are not creating the hypothetical market necessary (Hanemann, 1994).

According to Hackett (1998), there are 4 basic steps in creating a survey:

1. Focus on a particular environmental amenity that requires a public policy decision. In this case, we looked at salmon habitat restoration on the Snake River in Washington and fire management preferences for Colorado public lands.

2. Pretest the survey with small focus groups to determine understanding of the questions and when using a contingent valuation question, approximate estimates of what future respondents might be willing-to-pay

3. Use the information collected to create the surveys' final draft and distribute the survey.

4. Input and analyze the data (Hackett, 1998).

In this dissertation, I used two surveys: the Snake River Recreation Survey and the Colorado Wildfire Survey. The information from these two surveys enabled me to create three studies. In the first study, "Recreation benefits of removing the Lower Snake River

dams: a test of scope for contingent visitation behavior," I was able to utilize survey information to help understand whether people would continue to visit the Lower Snake River Recreation areas if four dams were removed and whether these visitation rates were sensitive to fishing quality. Two contingent visitation behaviors were analyzed, the decision of whether to visit the river and the frequency of river visitation. Scope tests would be used to analyze these statistics.

In the second study, "Analysis of Public Perspectives of wild and prescribed fires in Colorado," I was able to utilize survey information to understand how ladder-of-life and contingent valuation information influence public decisions and thoughts about various wildfire management techniques.

In the third study, "Using GIS to investigate the relationship between stakeholder opinion about wildfire and landscape context," I was able to combine the contingent valuation survey information with spatial models of fire danger to see which variables influenced the publics' decisions and thoughts about wildfire management techniques.

The contribution of this dissertation is to increase our understanding of public values toward management actions that attempt to restore natural ecosystems, whether through dam removal or prescribed fire.

CHAPTER 1

RECREATION BENEFITS OF REMOVING THE LOWER SNAKE RIVER DAMS: A TEST OF SCOPE FOR CONTINGENT VISITATION BEHAVIOR

ABSTRACT

The contingent visitation behavior method is used in a mail survey of the general public living in the Pacific Northwest and of Snake River visitors. The purpose of this study was to see whether people would continue to visit the Lower Snake River Recreation Areas if four dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) are removed and if visitation was sensitive to fishing quality. If dams are removed, current recreation opportunities such as warm water fishing, water skiing and motor boating will change. Dam removal will create a cold free flowing river with opportunities for cold water fishing, rafting, kayaking and canoeing.

In this report, I tested 2 contingent visitation behaviors: whether to visit the Snake River if dams are removed and frequency of visitation. Results show that if the dams are removed, approximately 12.7% of the general public will visit the river, while 53.9% of the anglers that currently visit the Snake River Recreation Areas will continue to visit. A probit model showed that the general public did not exhibit scope for the decision to visit or not. Specifically, the general public decision to visit is not dependent on fish catch rates. The general public did show scope in the count data model for number of trips to the river for steelhead trout catch rates. The probit model for anglers showed that anglers exhibited scope for salmon catch rates for the decision to visit, they did not exhibit scope for number of trips.

Keywords: scope test, Army Corps of Engineers, salmon, steelhead, contingent visitation behavior, Snake River, willingness-to-pay, WTP

INTRODUCTION

Between 1961 and 1975, the Army Corps of Engineers (ACE) constructed four dams on the Lower Snake River in Washington (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite). The dams were constructed for three main purposes: to produce electricity, to provide irrigation water, and to lengthen the inland shipping channel. The ACE was successful with their goals as the dams currently provide about five percent of the region's hydropower, provide farmers with irrigation water, and provide over 350 miles of an inland channel for ships to transport feed grain, forest products, automobiles, and container cargo (U.S. Army Corps of Engineers, 2002).

While electricity and barge transportation are benefits to the economy, declining stocks of salmon and steelhead are costs. Since dam construction, native populations of steelhead and salmon have become endangered and some populations have become extinct. It is believed that without breaching the dams, these declining populations of fish may become completely extinct by the year 2017 (Oosterhour and Mundy, 2001).

The dams have caused the fish populations to decrease as they expose fish to the danger of electrical turbines, increase water temperatures that are not conducive to salmon and steelhead, expose fish to more predators in holding areas near the dams, and disrupt fish migration. The government responded to dwindling fish populations by raising fish in hatcheries. The hatchery fish are transported by barge around the dams and released into the rivers. However, years of artificially raising and transporting fish have not increased the fish populations (Pernin et al., 2002).

On July 19, 2001, Representatives Jim McDermott and Thomas Petri introduced a bill to Congress entitled H.R. 2573, the Salmon Planning Act. This act acknowledges four important issues of the declining fish populations: 1. That some species of salmon and steelhead on the Snake and Columbia Rivers are on the brink of extinction, 2. That the treaty between the United States and the Native American Population guaranteeing Native American fishing rights on the Columbia River Basin is failing due to the small number of native fish populations, 3. That water near the dams is out of compliance with the Clean

Water Act because dissolved gas levels and temperatures are too high, and; 4. That the 1985 Pacific salmon Treaty signed with Canada is failing due to the minimal salmon runs (U.S. House of Representatives, 2001).

In response to concerns under the Endangered Species Act and the National Oceanic and Atmospheric Administration (NOAA) requiring analysis under the National Environmental Policy Act, the ACE pursued a study on their options. Four options were considered: 1. Maintaining the existing condition, 2. Breaching the dams, 3. Maximum transport of the juvenile salmon, and; 4. Major system improvements (also called adaptive migration). On February 20, 2002, the final ACE decision was to go forward with major system improvements. This option has been termed "the aggressive non-breach alternative" as hatcheries will be reformed and streams where salmon spawn will attempt to be restored. If specific goals are not met by 2003, 2005, and 2008, breaching will again be considered an option (U.S. Army Corps of Engineers, 2002).

In September 2002, RAND Science and Technology, a nonprofit institution that helps improve policy and decision-making through research and analysis, published a report entitled "Generating Electric Power in the Pacific Northwest." In this report they explore options available that would allow the four dams to be removed. They show that removing the dams will require the region to diversify its power supply and in doing so provide approximately 15,000 new jobs. For this reason, breaching the dams may not damage the state economically, and there is a 98% chance, if the dams are breached soon, that salmon and steelhead populations will recover (Pernin et al., 2002).

The removal of the four Lower Snake River dams is a very controversial issue. There has been a great deal of research completed showing how breaching the dams will affect the market economy and how it will affect the ecosystem. However, as part of any major action undertaken by the ACE, a benefit-cost analysis following the U.S. Water Resources Council Principles and Guidelines must be performed (U.S. Water Resources Council, 1983). In this paper, I focus on Snake River recreation visitor and general public responses to removing the dams as part of that benefit cost analysis.

CONTINGENT VISITATION BEHAVIOR

Various methods are available today to measure stakeholder preferences for non-market good valuation. Methods include travel cost, contingent valuation, and contingent behavior. The travel cost method (TCM) is a revealed preference method. The TCM asks a visitor the amount of money they actually spent on a trip (gas, food, lodging, entrance fees) and then uses this price to derive a demand curve from which willingness-to-pay is calculated. Contingent valuation measures stated preferences. Stated preference questions typically focus on willingness-to-pay (WTP), i.e., How much would you be willing-to-pay if a fee started to be charged at the campground you frequent? Contingent behavior, also a stated preference method, focuses on how a person's visitation behavior would change if something were modified. (Berrens et al., 1998; Bromley, 1995; Whitehead et al., 2000).

Contingent behavior is based on a hypothetical scenario. A sample scenario might be, "If they added a flush toilet to the campground you visit, would you go there more often, the same amount, or less often?" With this information and the original travel cost information, estimated use valuation can be calculated. For this reason, the contingent behavior method can be considered a modified or hybrid of TCM and stated preference. In this paper, I will be focusing on the contingent behavior model.

SCOPE TESTING

Contingent valuation and contingent behavior are non-market valuation techniques. As in all non-market valuation techniques, the question of validity is always considered. At the NOAA hearings in 1992, the reliability of contingent valuation was discussed. The NOAA report states that a scope test can be used to test the internal consistency (validity) of the contingent valuation design. If the scope test is passed, the study is more likely to be valid and vice versa (Arrow et al., 1993).

Scope tests analyze the responsiveness of survey answers showing that differences are economically intuitive. For example, if visitors were asked, "If the miles of trails reached

directly from the campground you frequent changed from the current 50 miles available to only 30 miles available, would you come here more often, less often, or the same amount? If your answer is more often or less often, how many times more or less?" Economic theory leads us to believe that with a smaller amount of trail availability, say 30 miles; less people will frequent the campground than when 50 miles of trails are available. If this result were statistically found to be true, then the scope test would be passed.

Typically, scope tests are used in conjunction with contingent valuation studies. In a 1997 study, Loomis and Ekstrand tested whether the public was willing-to-pay for protecting the Mexican spotted owl. Respondents were asked their WTP for a group of 62 threatened/ endangered species including the Mexican spotted owl as well as their WTP for protecting the owl alone. To pass the scope test, the WTP for the group of 62 species should be greater than the WTP for the protection of the Mexican Spotted Owl alone. It was discovered that the results between the two groupings were statistically different and that the WTP for the group of 62 were greater than the WTP for the owl alone, therefore, the scope test passed and the study was validated (Loomis and Ekstrand, 1997).

Not all contingent valuation studies pass the scope test. In a 1997 article on rural tourism development, Lindberg et al. attempted to measure tourism impacts in rural Oregon. In this study, respondents were asked for their WTP to reduce traffic congestion by 25% and 50%. It would be expected that the respondents would pay more to reduce the traffic by 50% than by 25%, but this was not found to be the case (Lindberg et al., 1997).

Although the scope test has been used to validate many contingent valuation studies (Kartman et al., 1997; Kartman et al., 1996; Lindberg et al., 1997; Smith and Osborne, 1996; Whitehead et al., 1998), as of this date, the scope test has not been used to test the validity of a contingent behavior model. One purpose in this paper is to test the scope of the Lower Snake River dam removal contingent behavior model.

OVERVIEW OF DATA SETS

The data for this dissertation was obtained from previously collected survey data. This survey instrument was created for the Army Corps of Engineers and entitled the Snake River Survey (University of Idaho, 1997). This survey was mailed out to two groups of respondents: anglers and the general public. The first groups of respondents, the anglers, were visitors to four Lower Snake River recreation access areas (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) approached on site by University of Idaho students during the period of May 1997 through October 1997. Upon agreeing to complete a mail survey, their name and mailing addresses were collected. Surveys and a two-dollar bill incentive were then mailed to the visitors. The Snake River Survey was sent to 910 anglers. This survey yielded 537 usable surveys for a response rate of 59%.

The second sample was mailed to the general public in Washington, Oregon, Idaho, Western Montana, California, and a group of the general public from the Lower Snake River Areas adjoining counties. The Snake River Survey was sent to approximately 8,800 potential general public respondents. This survey yielded 4,780 surveys for a response rate of 54%.

The Snake River survey provided a large amount of information. One of the questions asked respondents to state their travel expenses. This information was used to calculate Lower Snake River recreation area travel costs. The survey then described how natural and dammed river conditions differ, enabling respondents to answer the contingent behavior part of the survey. The contingent behavior questions asked whether they would visit the river if the dams were removed, and if so how often would they visit the river. The key scope variables are chinook salmon and steelhead fishing catch rates as well as salmon season length.

METHODS

There are two distinct contingent visitation behaviors that can be modeled: 1. The decision of whether to visit at all, and; 2. The frequency of visitation. I will be modeling both types of behavior and testing each for scope within this report.

The first model I will analyze is whether to visit at all. This is accomplished using a probit model analysis. The probit model is a cumulative normal distribution used to calculate the maximum likelihood estimates of the regression parameters. An ordinary least squares model is inappropriate to use since I am analyzing both qualitative (yes or no dichotomous choice variables) and other non-continuous variables. The probit model restricts predicted values of the dependent variable to being between zero and one. In our model, coding of the dependent variable was DY=1, PY+PN+DN=0.[1] For ease of understanding, variable names and definitions are presented in Table 1.

Variable	Definition
DY	Dummy variable in response to whether they would visit the Lower Snake River if the dams were removed where Definitely Yes (DY) = 1, or 0 if not
PY	Dummy variable in response to whether they would visit the Lower Snake River if the dams were removed where Probably Yes (PY) = 1, or 0 if not
PN	Dummy variable in response to whether they would visit the Lower Snake River if the dams were removed where Probably No (PN) = 1, or 0 if not
DN	Dummy variable in response to whether they would visit the Lower Snake River if the dams were removed where Definitely No (DN) = 1, or 0 if not
C	Constant Term
Salsea	Length of the Salmon Fishing Season in Days (Range: 20 to 75 days)
Salimp	Represents how important recreational salmon fishing in the river is to the respondent where 1 = Not Important, 2 = Slightly Important, 3 = Important, and 4 = Extremely Important
Gender	Dummy variable where 1 = male, 0 = female
Age	Respondents Age
Rivtrcost	Cost per trip of travel to Lower Snake River area of visitation
Hrstlhd	Hours it takes to catch a steelhead (Range: 4 to 23 hours)
Recdays	Number of days available for recreation
Rivtrtime	How long it takes the respondent to drive to the Lower Snake River recreation area in hours
Ownboat	Dummy variable where Ownboat=1 if the respondent owns a boat and 0 otherwise
Hrsal	Hours it takes to catch a salmon (Range: 0.1 to 75 hours)

Table 1: Variable Definitions

[1] DY= Definitely Yes, PY = Probably Yes, PN = Probably No, and DN = Definitely No

Equation (1):

$$DY = C + \beta_1 Ownboat + \beta_2 Salsea + \beta_3 Salimp + \beta_4 Gender + \beta_5 Age + \beta_6 Rivtrcost + \beta_7 Hrstlhd + \beta_8 Recdays + \beta_9 Rivtrtime + \beta_{10} Hrsal$$

Where:
DY = 1 if they would definitely visit the Lower Snake River if the dams were removed and 0 if they would not.
Ownboat = 1 if respondent owns a boat and 0 otherwise.
Salsea = Length of the salmon fishing season in days (Range: 20 to 75 days).
Salimp = How important recreational salmon fishing in the river is to the respondent where 1=Not Important, 2=Slightly Important, 3=Important, and 4=Extremely Important.
Gender = 1 if the respondent is male and 0 if the respondent is female.
Age = Respondents age.
Rivtrcost = Cost per trip of travel to Lower Snake River area of visitation.
Hrstlhd = Time it takes to catch a steelhead (Range: 4 to 23 hours)
Recdays = Numbers of days available for recreation.
Rivtrtime = Number of hours it takes respondent to drive to Lower Snake River Recreation Area.
Hrsal = Time it takes to catch a salmon (Range: 0.1 to 75 hours)

The second model representing frequency of visitation will be analyzed using a count data model, a particular specification of the contingent visitation behavior model. Since the number of trips is a non-negative integer, I needed to use a model, such as the count data model, that would accurately represent this type of data. Count data analysis is implemented with models such as a negative binomial or Poisson model. In this report, I will be using the negative binomial count data model since it is the natural generalization and is less restrictive than the Poisson model.

Equation (2):

$$Rivtrips = C + \beta_1 Ownboat + \beta_2 Salsea + \beta_3 Salimp + \beta_4 Gender + \beta_5 Age + \beta_6 Rivtrcost + \beta_7 Hrstlhd + \beta_8 Recdays + \beta_9 Rivtrtime + \beta_{10} Hrsal$$

Where:
Rivtrips = Expected number of trips per year if the dams were removed.
All other variables are as defined for Equations 1a. and 1b.

Prior to running the models, I first looked at the general characteristics of the data. After presenting the respondent with information on the salmon fishing season length, salmon catch rates, and steelhead catch rates, respondents were asked whether they would still visit the Snake River once the dams were removed. What I found was that 19.3% of the anglers said they would definitely still visit the river, while 53.9% of the anglers said they would

either probably or definitely visit the river. For the general public, the overall number of people that would either definitely or probably visit the river was 12.7%. However, for our study, I used a subsample of the general public respondents. The subsample I used included those people that said they would probably or definitely visit the river if the dams are removed. Of this subsample, I find that 38.5% said they would definitely visit.

SCOPE TEST HYPOTHESIS

My scope tests compare frequent users (the anglers) to the occasional user (the general public). While I expect frequent users to exhibit scope, I do not expect the occasional user to exhibit scope. In part, this is due to frequent users being more knowledgeable and experienced in making these decisions than infrequent users. I also feel this is due to the fact that changing the type of fish in a river will have a greater effect on anglers than the general public who may just be visiting the river for general recreation such as swimming or boating and not fishing.

The first scope hypothesis in this analysis involves testing whether angler contingent behavior for salmon season length, catching chinook salmon, and catching steelhead are different from zero. If these values are significant and the sign for the length of salmon season is positive, hours to catch a chinook salmon is negative, and/or hours to catch a steelhead salmon is negative, I believe that the anglers (frequent users) will exhibit scope. I use this test for both the probit models, Equation (1) and the count data model, Equation (2). The null hypothesis for the scope test is whether the coefficients on Salsea = 0, Hrsal = 0, and Hrstlhd=0:

$$H_o: \text{ß Angler}_{SALSEA} = 0,\ H_o: \text{ß Angler}_{HRSAL} = 0,\ H_o: \text{ß Angler}_{HRSTLHD} = 0$$

Theory suggests the alternative is:

$$H_o: \text{ß Angler}_{SALSEA} > 0,\ H_o: \text{ß Angler}_{HRSAL} < 0,\ H_o: \text{ß Angler}_{HRSTLHD} < 0$$

The second scope hypothesis used involves testing whether the general public contingent behavior for salmon season length, hours to catch a chinook salmon, and hours to

catch a steelhead salmon is different from zero. If these values are significant and are positive for salmon season, negative for catching chinook salmon, and/or negative for catching steelhead salmon, the general public exhibits scope. I believe that the general public (occasional users) will not exhibit scope. I use this test for both the probit model, Equation (1) and the count data model, Equation (2). For this test, the null hypothesis is:

$$H_o: \text{ß General Public}_{SALSEA} = 0,\ H_o: \text{ß General Public}_{HRSAL} = 0,$$
$$H_o: \text{ß General Public}_{HRSTLHD} = 0$$

Theory suggests the alternative is:

$$H_o: \text{ß General Public}_{SALSEA} > 0,\ H_o: \text{ß General Public}_{HRSAL} < 0,$$
$$H_o: \text{ß General Public}_{HRSTLHD} < 0$$

RESULTS

In the Snake River Survey, respondents reported their preferences for various types of recreation. These preferences aided in understanding the population being modeled.[2] The first four questions asked respondents to state their importance level of four Lower Snake River uses: reservoir boating recreation, reservoir fishing, recreational salmon fishing in the river and river boating recreation. Responses ranged from 1 through 4 where 1 represented not important and 4 represented extremely important. The anglers reported, on average, that they were more interested in river recreation (3.283) than reservoir recreation (1.967) (Table 2). Anglers also felt that reservoir fishing (2.952) was more important than recreational river salmon fishing (2.459), however this may be because salmon are currently endangered and not permitted to be harvested. This information shows that even though reservoir fishing is important, river recreation is more important.

For the general public, I find different results. The general public feels that reservoir recreation (2.316) is more important than river recreation (2.087). However, they feel that fishing for salmon in the river (3.203) is more important than fishing in the reservoir (2.407).

[2] In this paper I am only interested in the cold water river recreation information, warm water recreation activities were modeled in two previous papers by McKean (McKean, 1998; McKean, 1999).

Of the angler respondents, by the onsite sample design, I find that 100% of them had visited the Snake River in the year of 1998, while only 45.03% of the general public had visited the Snake River in 1998. Anglers made more trips to the Snake River in 1998 (12.867) as compared to the general public (7.879). Angler's trips (2.373) were approximately ½ day longer than general public trips (1.918). Anglers also spent more per trip ($140.77) than the general public ($126.36), but they brought more people with them on their trips. Therefore, angler cost/day/person was only $15.72 while for the general public it was $24.29. The combination of these questions tells the story that both anglers and the general public have a demand for river recreation and river fishing.

Variables	Value Description	Angler Response	General Public Response
Reservoir Recreation	Rank of 1 to 4 where 1 in Not Important and 4 is Extremely Important	1.967	2.316
Reservoir Fishing		2.952	2.407
Recreational Salmon Fishing		2.459	3.203
River Recreation		3.283	2.087
Visit Lower Snake River in Past Year	Yes = 1, No = 0	100.00%	45.03%
Fish for Resident Fish in 1998		73.89%	66.23%
Fish for Steelhead in 1998		37.86%	54.97%
How Many Trips in Past Year		12.867	7.879
Number of Days Per Trip		2.373	1.918
Cost of Trip		$140.77	$126.36
Number of People this Cost Paid for		3.773	2.712
Cost Per Person		37.31	46.59
Recreation Days		30.533	15.1119
Cost Per Day		$59.32	$65.88
Cost/Day/Person		$15.72	$24.29

Table 2: Recreation Variable Mean Responses

To interpret whether a variable exhibits scope, it must pass two tests. The first test is whether the p-value is significant (less than 0.100) and the second is for the variable coefficient to be of the expected sign. The expected sign would be positive for Salsea as it is expected that as the number of salmon season days increases, the respondent would be more likely to visit the river. The expected sign on Hrstlhd and Hrsal is expected to be negative as

the length of time it takes to catch a fish increases, the respondent is less likely to visit the river. Again, I feel that the anglers will exhibit scope and the general public will not.

A probit model was run to analyze the dependent variable DY (Table 3). The results of this model report that the general public does not exhibit scope. The p-values for Salsea, Hrstlhd, and Hrsal are not significant. Therefore, the general public is not sensitive to salmon season length and hours it takes to catch either a steelhead trout or chinook salmon. For the angler's probit test, I find Hrsal to exhibit scope. This means that as the hours it takes to catch a salmon increases, the angler is less likely to visit the river. I did not find Salsea or Hrstlhd to exhibit scope for anglers.

	Anglers		General Public	
	Coefficient	P-Value	Coefficient	P-Value
C	-0.019	0.986	-1.474	0.001
Ownboat	-0.028	0.923	0.307	0.021
Salsea	-0.017	0.133	0.002	0.581
Salimp	0.202	0.094	0.477	0.000
Gender	0.523	0.108	-0.160	0.432
Age	-0.007	0.550	-0.008	0.096
Rivtrcost	-0.000	0.762	-0.000	0.129
Hrstlhd	0.034	0.078	0.003	0.761
Recdays	-0.000	0.845	-0.000	0.659
Rivtrtime	-0.075	0.309	-0.023	0.338
Hrsal	-0.031	0.093	0.001	0.109
	McFadden $R^2 = 0.076$		McFadden $R^2 = 0.102$	

Table 3: Probit Model for DY

The next regression was the count data model for Rivtrips, where Rivtrips is the dependent variable representing the number of trips a respondent would take annually (Table 4). The count data model shows that the general public exhibits scope for Hrstlhd. Therefore, the general public is less likely to visit the Snake River recreation areas if the time it takes to catch a steelhead increases. Hrsal and Salsea do not exhibit scope for the general public. Also, Salsea, Hrstlhd, and Hrsal do not exhibit scope for the anglers. Therefore the number of trips taken is not dependent of salmon season or hours it takes to catch a steelhead or chinook salmon.

	Anglers Coefficient	P-Value	General Public Coefficient	P-Value
C	1.914	0.000	1.888	0.000
Ownboat	0.097	0.364	0.351	0.000
Salsea	-0.007	0.039	-0.001	0.522
Salimp	0.220	0.000	0.114	0.021
Gender	0.339	0.001	0.300	0.055
Age	-0.016	0.000	-0.015	0.000
Rivtrcost	-0.002	0.000	-0.001	0.000
Hrstlhd	-0.007	0.266	-0.016	0.025
Recdays	0.002	0.000	0.002	0.000
Rivtrtime	-0.080	0.000	-0.111	0.000
Hrsal	0.009	0.078	-0.000	0.653
	McFadden $R^2 = 0.255$		McFadden $R^2 = 0.061$	

Table 4: Count Data Model for Rivtrips

DISCUSSION

In this paper, I focus on recreation at the Snake River recreation areas if the four lower Snake River dams are removed. Therefore, I am focusing on cold free flowing water recreation. For Snake River recreation area warm water reservoir type recreation information, please refer to McKean 1998 and McKean 1999.

Results of the probit model show that households do not exhibit scope. This was the expected result. Households do not visit the river solely for fishing and therefore are not expected to be as concerned with catch rates and fishing season lengths. The anglers were found to exhibit scope for Hrsal. This is also an expected result. This shows that the anglers are sensitive to the number of hours it takes to catch salmon. However, Hrstlhd and Salsea were not found to exhibit scope for anglers. Therefore salmon season length and hours it takes to catch a steelhead do not significantly influence whether they visit the Snake River Recreation Areas.

Results from the count data model show that anglers do not exhibit scope for Salsea, Hrstlhd, or Hrsal. The general public does not exhibit scope for Salsea or Hrsal, but do exhibit scope for Hrstlhd. Therefore, the general public is sensitive to the number of hours it takes to catch a steelhead when considering number of trips. Of the general public

respondents that visited the Snake River in 1998, 55% had fished for steelhead while only 38% of the anglers had fished for steelhead.

While some of the information I expected did show up in the results, not all results turned out as expected. There are several reasons that I feel this may have happened. The first has to deal with catch limits. While this survey did not discuss catch limits (i.e., you may only be allowed to catch two fish per season), if respondents are used to having catch limits, this may have had an affect on their responses. If an angler may only catch two fish per season and they have caught their limit in the first day, they may not take any more fishing trips even though they would still be willing-to-pay for more fishing trips. However if they do not catch their limit, they may return to the river again and again until they have reached the number of trips they desire (Creel and Loomis, 1992).

Another possible reason could be related to survey question wording; perhaps the questions were not worded in the best way possible.

Since the scope results did not turn out exactly as expected, I do not feel that the scope results should be used in a policy recommendation. However, I did find a great deal of information from other questions that would be useful to policy makers. Both groups of respondents did find reservoir recreation and river recreation to be important. In addition, both groups of respondents reported that reservoir fishing and river fishing were important. In 1998, 100% of the angler respondents had visited the Snake River. When asked whether they would visit the Snake River if the dams were removed, 53.9% of the anglers said they would either definitely or probably still visit. These anglers also reported that 74% of them had fished for resident fish in 1998 and 38% of them had fished for steelhead.

In 1998, of the general public subsample, 45% had visited the Snake River recreation areas while 38.5% said they would definitely still visit the river if the dams were removed.

I also found that anglers currently go to the river for approximately 31 recreation days and spend approximately $15.72 per person per day. The general public visitors go to the river approximately 15 days per year and spend approximately $24.29 per person per day.

While I can not make a recommendation as to whether zero, one, two, three, or four dams be taken down, I have found that if the dams are taken down, both general public and anglers will still visit the Snake River Recreation Areas. It is also likely that other unsurveyed anglers will be interested in visiting the river if the dams are removed, in particular, river anglers that do not currently visit the area will be attracted to the free flowing river.

Since recreation is an important part of the Snake River recreation areas, I believe that these viewpoints of the general public and of anglers should be considered.

CONCLUSIONS

This paper analyzes how frequent users and occasional users of the Lower Snake River will react if the four Lower Snake River dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) were breached. This is an important consideration as breaching the dams will completely change habitat, fish species, and recreational opportunities. Currently, warm water reservoir fishing, water-skiing and motor boating are popular activities. However, if the dams are breached, river fishing, rafting, kayaking and canoeing will become more popular. This change may cause some people that currently enjoy the warm water recreation to find a substitute area to visit. However, it may attract new people that do not enjoy warm water recreation. I used a survey of current anglers and the general public to analyze visitation after dam removal.

In this paper, I focused on cold water river recreation. To test whether visitors will respond to differential anadromous fish catch rates, I performed scope tests comparing general public and angler responses with salmon season length, steelhead catch rates, and chinook salmon catch rates. When using the probit analysis technique, the general public did not exhibit scope for any of the three variables. This showed that the general public decision

to visit is not sensitive to salmon season length and catch rates for salmon and steelhead. Anglers are sensitive to the amount of time it takes to catch a salmon.

A second test using the count data technique had similar but different results. For the number of trips, anglers did not exhibit scope, while the general public exhibited scope for steelhead catch rates. Therefore the general public is sensitive to steelhead catch rates when considering number of trips while anglers are not.

Thus, I may regard the results of the contingent behavior survey with some skepticism. It may be that better communication of different catch rates using visual images or graphs might have resulted in the survey passing the scope test for more than just the anglers fishing for steelhead.

While I can not make a recommendation from these results as to whether the dams should be breached, results show that recreationists will continue to visit the Snake River Recreation Areas if dams are removed. Some anglers that currently visit for reservoir fishing may not return, but it is likely that river anglers that do not currently visit may start to visit the river.

CHAPTER 2

ANALYSIS OF PUBLIC PERSPECTIVES OF WILD AND PRESCRIBED FIRES IN COLORADO

ABSTRACT:

During the summer of 2001, survey data were collected from people living near public lands in Colorado (i.e. the wildland urban interface). These data include detailed information of respondent's views towards prescribed fire and wildfire management. These data also included demographic information, ladder-of-life information, as well as their willingness-to-pay values for fire prevention, fire suppression and prescribed burning. The ladder-of-life procedure is a well-being evaluation method, a type of stated preference, dealing with personal satisfaction. Contingent valuation is also a stated preference method. I analyzed how ladder-of-life and willingness-to-pay information influences decisions and thoughts of residents in fire danger areas. What I found was that people living near public lands in Colorado have high well being values. They are aware that fire is a natural process in their area and are willing-to-pay an annual tax increase of approximately $654.90 for prescribed fire, $507.00 for fire suppression, and $599.35 for fire prevention.

Key Words: Prescribed burning, controlled burning, ladder-of-life, wildfire, survey analysis, national forests, land management, public involvement, stakeholders.

INTRODUCTION

When a person goes to a national forest for a hike and there is not a fee, this does not mean there is not a value. Many environmental activities such as breathing fresh air, driving down a scenic byway and public protection of your home from a fire do not have direct costs to the users, but they do have value to them. Values such as these are considered non-market values. Currently there are several techniques available to analyze non-market values. These methods fall into one of two general categories: revealed and stated preference methods.

A revealed preference method is one that measures values revealed in the market. The typical method used to measure revealed preference is the travel cost method. The travel cost method asks a person to reveal their expenses for a trip and the number of trips taken. Expenses typically include fuel, campground fees and hotel costs. Expenses are then used to calculate cost per trip demand and from this net willingness-to-pay is calculated. A stated preference method represents what a person says they would do if they were presented with a situation. Two commonly used stated preference methods are the contingent valuation and the contingent behavior methods. Contingent valuation typically asks a person what they are willing-to-pay, while contingent behavior presents a person with a situation and asks what their behavior would be after the change. More recently, van Praag and Baarsma (2000) have introduced another method to estimate stated preference values. This method has been entitled the ladder-of-life or well being evaluation method. This method asks respondents how they feel about their lives. They then combine well being information with an income variable to calculate values.

In this paper, I will be looking at two stated preference methodologies: contingent valuation and well being evaluation. I hope to calculate values for both and then compare the two methods. Values I will be trying to estimate are for various fire management techniques that can be used to reduce the chance of a wildfire burning the interested party's home.

LITERATURE BACKGROUND

Many studies have been completed that analyze how survey respondents feel about fire. Recently, in 2002, Higgason studied survey responses of people living in the Wildland Urban Interface of Colorado. While they did not analyze monetary values, they did analyze preferences for fire management techniques focusing on the process communities use to adopt wildfire mitigation programs. Higgason discovered that 48%-78% of respondents believed that a wildfire would threaten their neighborhood at their current location. 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. A large number of the respondents acknowledged that their home may be affected by wildfire, but only 25-50% felt that prescribed fire should be used in their area. Approximately 78-99% of respondents felt that creating defensible space was a good thing (Higgason, 2002).

There was also a study done in 2002 in Arizona in the wake of the states largest fire, the Rodeo-Chedeski forest fire. In this study it was found that 60% of respondents felt that small trees and brush should be thinned around the forest communities, 87% of respondents support prescribed burn methods to help prevent wildfire by cleaning out underbrush and 76% of respondents believe old growth trees should be saved (Behavior Research Center, 2002).

LITERATURE BACKGROUND: CONTINGENT VALUATION

Part of the research conducted in this project used the contingent valuation method (CVM). Contingent valuation was first suggested in 1947 by Ciriacy-Wantrup (Ciriacy-Wantrup, 1947). This technique can be used to assess the value of non-market goods. It is a stated preference method and is traditionally conducted with surveys asking respondents "What is your maximum willingness-to-pay to have a particular program put into effect?" This information collected can then be aggregated to estimate a market demand schedule. Robert K. Davis (1963) was the first person to implement what is now known as contingent valuation.

In the early 1990's, a panel was put together to evaluate the validity of contingent valuation. This panel, the National Oceanic and Atmospheric Administration (NOAA) Panel on Contingent Valuation concluded that contingent valuation is a legitimate method to value non-market goods. They suggested the best method to gather contingent valuation information is with in-person interviews as these are the most reliable. If in-person interviews are not possible, phone interviews are recommended. Mail surveys are the next best option after phone interviews (Arrow et al., 1993; Hanemann, 1994; NOAA, 1993).

The NOAA panel also recommended closed ended or dichotomous choice questions such as "If it cost "X Dollars" for a prescribed burn, would you pay this amount?" While every individual may be asked the same question, different costs; $x_1 \ldots x_n$ may be distributed among the group. Individuals will then respond with an acceptance or rejection answer.

While there have been many contingent valuation studies completed, few have related contingent values with wildfire management. In 1995, Fried studied people living within a jack pine forested area. The jack pine forest experiences frequent occurrence of wildfire. In this study, Fried asked respondents if they would be willing-to-pay to reduce wildfire danger to their homes by creating a defensible space. Willingness-to-pay represented the cost of creating the defensible space (Fried et al., 1995). The reasons to ask these questions was that they felt most of the damages resulting from wildfire are non-market values that have not been previously accounted for. These non-market damages include loss of photographs, pets, and scenic views. Therefore, one of their goals was to account for these losses (Fried et al., 1995).

In Fried's study, surveyors went in groups of two knocking on doors of homes to find potential respondents. Respondent participation was less than 10% as data collectors found potential respondents to be hostile and violent. When tallying the results, what Fried discovered was that people in Crawford County Michigan preferred to create their own defensible space rather than pay taxes to reduce wildfire risk (Fried et al., 1995).

LITERATURE BACKGROUND: WELL-BEING EVALUATION METHOD

The second part of this research used the well being evaluation method. The well-being evaluation method is a way of evaluating people's satisfaction with life or happiness.[3] It is believed that the well-being evaluation method is a good complement to other contingent valuation methods as it can help to reduce strategic behavior.

While most contingent valuation methods available today directly evaluate monetary situations, the well-being method does not. It is a non-monetary way of evaluating an individual's utility. However, it can be combined with income information to obtain a monetary value (van Praag and Baarsma, 2000; Ng, 1997; Frey and Stutzer, 2002). This is what I will be attempting in this paper.

The well being evaluation method may be a good method to evaluate value as it is not asking a monetary question, since money is not always a good indicator of utility (Ng, 1997; Dixon, 1997). For instance, people of different income levels can have different satisfactions with life. A person making $20,000/ year but living in house next to a national park may value their life satisfaction really highly, whereas a person making $200,000/ year living in a big city that is under constant job pressures may not value their life satisfaction as highly. Another example was suggested by Karl Marx, he said that "a house may be large or small; as long as the surrounding houses are equally small it satisfies all social demand for a dwelling. But if a palace rises beside the little house, the little house shrinks into a hut (Lipset, 1960)."

As stated previously, in rating happiness, you are measuring an individual's utility. Utility is the amount of satisfaction one receives from a particular good or service. It is important for individuals to rate their own utility as it is believed that each individual is the best judge of their own thoughts or feelings (Morawetz et al., 1977; Frey and Stutzer, 2002; Easterlin, 1974; Dixon, 1997).

Psychologists have used happiness ratings as part of their research for many years, but economists have only introduced happiness ratings into their research in the 1960's. As

[3] Please note that from here on we will use the terms happiness, well-being, and ladder-of-life interchangeably.

of today, it is still not a commonly used economic technique. Easterlin wrote one of the first attempts that related happiness and economics in 1974. In this paper, he analyzed surveys from 19 countries between the years of 1946 and 1970. He used the survey data to see if happiness and status groups were related and found those in higher status groups to be happier than those in lower status groups (Easterlin, 1974).

In past studies of well-being evaluation, several observations have been made. One predominant observation was how happiness and income are related. In Easterlin's work (1974 and 1995), he found that within a country, at a given point in time, those with higher incomes are happier than those with lower incomes. Frey and Stutzer (2002) also state that in the United States, richer people are happier, on average, than poorer. However, in Leu et al.'s Switzerland study, when income was divided into 5 groupings[4] they found a slight increase between each higher income bracket, but the last bracket (Group 5) had a lower happiness level than Group 4. (Leu et al., 1997; Easterlin, 1974; Easterlin, 1995; Frey and Stutzer, 2002).

Early income happiness results intrigued Morawetz, who decided to analyze income and happiness in more detail. He studied happiness in two communities. Both communities were similar in age structure and religious belief system. The main difference between the two communities was their income distribution. One community had an unequal income distribution and the other community had an equal income distribution. What Morawetz discovered was that the more unequal the income distribution, the lower the individual happiness ratings (Morawetz et al., 1977).

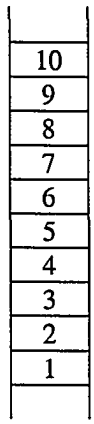
Well-being evaluation has been measured by asking respondents one of three typical question styles. The three styles of questions are the Gallup Poll, psychiatric measure of mental distress, and ladder-of-life. The first style of question is the Gallup Poll. Using a Gallup Poll style, the respondent is asked a question such as "how happy are you" and can

[4] Group 1 represented less than Sfr. 2,000, Group 2 was Sfr. 2,000-3,000, Group 3 was Sfr. 3,000-4,000, Group 4 was Sfr. 4,000-5,000 and Group 5 was Sfr. 5,000 and over)

select one of 3 or 4 multiple-choice responses. Typical responses include very happy, pretty happy, fairly happy, and not very happy (Easterlin, 1974).

The next style of question is the psychiatric measure of mental distress. This is a series of questions within a survey called a "general health questionnaire." The respondent is asked to answer approximately 20 questions related to their level of mental distress. Questions include "have you been unhappy and depressed" and "have you been thinking of yourself as worthless." The respondent rates each question on a scale of 1 to 4 where 1 represents disagree strongly and 4 represents agree strongly. The answers are totaled and a happiness ranking is calculated (Oswald, 1997).

The third format type is called the "ladder-of-life." This will be the way I evaluate well-being in this paper. The ladder-of-life was created in the 1960's by Cantril (Cantril, 1965). Cantril wanted a method of evaluating life in which the respondents could select their own satisfaction level. This was done with a question alongside a picture of a ladder. The ladder represented the best and worst possible life you could have, with the top of the ladder representing the best life (step 10) and the bottom representing the worst life (step 1) (Figure 1). The respondent could then circle the number on the ladder that they felt best represented their life.



This is the ladder-of-life. The top of the ladder (step 10) represents the best possible life and the bottom of the ladder (step 1) represents the worst possible life. Where on the ladder do you feel your life is at this point in time?

Figure 1: The Ladder-of-Life

The ladder-of-life method, also called the Cantril question, was then further developed into the well-being method by van Praag (van Praag, 1988; van Praag and

Baarsma, 2000). Van Praag and Baarsma did this by taking the Cantril Question one step further. They would first ask respondents where they felt they were on the ladder-of-life, and then they would present them with a situation and ask them if this situation actually presented itself, where then would they be on the ladder-of-life. This additional information gives researchers current and after change information.

One example of this type of modeling is represented in van Praag and Baarsma's airport study. First they asked residents living near an airport to rate their happiness levels. They then presented a situation explaining that if the airport expanded, so would airport noise. If the airport expanded, what would they rate their happiness level at? This example was called the Schiphol experiment as it was conducted for the Amsterdam Schiphol Airport (van Praag and Baarsma, 2000).

In the Schiphol study, van Praag and Baarsma took their data another additional step. By using respondent's happiness ratings for airport noise before and after the airport expanded and their values for income, they were able to run an ordered probit model and use it to determine the shadow price of airport noise. Airport noise shadow price was then used to calculate the compensation people in the Schiphol Airport area should receive if the airport were to expand (van Praag and Baarsma, 2000; Baarsma, 2000).

As the well-being evaluation seems to be a good complement to contingent valuation, I will be using this method here. One of my goals for this paper is to use ladder-of-life information collected in conjunction with income value to determine respondent's values for various fire management practices. I will then compare these results with the willingness-to-pay results.

SURVEY INFORMATION

The original version of the survey "Managing Fires on Public Lands: What Do You Think?" was created in the fall of 1999 by John Loomis and Pamela Kaval at the Resource Economics Department of Colorado State University, Fort Collins, Colorado (Loomis and Kaval, 1999). Prior to any survey being distributed to the general public, a survey must be pre-tested. We decided to pre-test the survey with people from various public land user

groups in order to include all aspects of land management that may not originally have been included.

Pre-testing was completed with in-person meetings called focus groups. Focus groups were used to collect survey data during the period of January through June of 2000. A total of seven focus groups were completed, representing a variety of interest groups. These interest groups consisted of:

Colorado Mountain Club – Fort Collins, Colorado (9 participants)
General Public Group – Denver, Colorado (11 participants)
Elk Hunters – Loveland, Colorado (11 participants)
Homeowners – Lake Tahoe, California (11 participants)
Timber Purchasers – Charleston, South Carolina (8 participants)
Cattleman Association – Grass Valley, California (7 participants)
Colorado Off Highway Vehicle Association – Longmont, Colorado (7 participants)

All focus group sessions occurred during a weeknight in a conference room near the participant's homes. Focus groups lasted approximately 2 to 3 hours. Participants were given $50 upon entering the conference room. The sessions were not video or audio taped, however, all information was hand recorded by both the participants on worksheets and the focus group leaders on flip charts.

Recruiting for the focus groups took on a varied approach. The homeowners in Lake Tahoe were contacted randomly through numbers in the phone book. Elk hunter's numbers were attained from Colorado Hunting and Fishing License information. The general public was contacted through a market research organization in Denver, Colorado. Numbers for all other groups were attained through their participating organizations.

Upon completion of focus group analysis, the survey was revised. This revised survey was tested with a few people in the Masonville, Colorado area. These participants were contacted by phone, mailed a survey, and then met with in-person. During the meetings, question wording was reviewed to discover any clarifications or changes that needed to be made. Once this process was completed, the survey was finalized.

The finalized survey encompassed eight pages of questions and two color pictures that were inserted into the survey for use with some of the questions. The first 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 simply entitled "Wildfire." The second picture was of a low intensity burn one year after fire in a Colorado Ponderosa Pine forest where most underbrush was killed, however, standing trees were not. This picture was entitled "Prescribed Fire." We chose these two pictures as we wanted to test people's views of the most dramatic wildfire affect. The forests in these two pictures were also similar in stand density (trees per hectare) and tree size (d.b.h. - diameter at breast height). Therefore we felt that these two pictures would represent what we wanted to test, even though they do emphasize some of the negative visual effects of fire and not the ecology of the area.

The survey's questions included demographics, willingness-to-pay for various fire prescriptions, as well as how different intensity fires would affect feelings towards different natural resources.

Survey participants were contacted randomly by phone during the summer of 2001. This process was detailed. First I selected several towns that border public lands. These towns included Buena Vista, Rangely, Red Cliff, Leadville, Twin Lakes, Nederland, Rollinsville, Estes Park, Masonville, Red Feather Lakes, Dinosaur, Creede and Pagosa Springs. I then used the www.uswestdex.com internet site provided by the U.S. West phone company to randomly select names.[5] I then typed in a random letter of the alphabet into the USWestdex for a town and printed out all available names in that category. I chose approximately five to ten alphabet letters for each town; five when there were several names and ten when there were only a few names for a letter. From this list, I selected which people to call. I selected to call only those people with full names listed (i.e., John Smith would be called, but J. Smith would not). I did this so when I made the phone contact I could ask for a specific person. After trying to call people on various days and various hours of the week, I found that the best response occurred Monday through Thursday between the hours of

[5] This company has recently changed hands. They are now called Q-West and the new internet site is: www.qwestdex.com.

6:30pm and 8:30pm. I found that during other times and days, people seemed more irritated and less responsive.

I did not have success with people in all of the towns I contacted. While most people that I talked to were somewhat receptive, people in towns such as Buena Vista, Rangely, and Red Cliff were unsuccessfully contacted. After all contacts were made, respondent information was collected from people in twelve Colorado towns: Leadville, Twin Lakes, Nederland, Rollinsville, Estes Park, the Masonville area (which includes Masonville, Bellevue, and rural Fort Collins), Red Feather Lakes, Dinosaur, Creede, and Pagosa Springs.

During the initial phone contacts, potential participants were asked if they would participate in a phone/mail/phone survey. Once a person agreed to participate, a follow up time approximately one week from original contact date was set up to go over the survey on the phone. Surveys and a $10 incentive were mailed to participants and participants were contacted for a second time by phone on the follow up day. During the second phone conversation, the interviewer reviewed the survey questions with the participant, filling out all responses in a blank survey. Upon completion, participants were then asked to return their copy of the survey in a postage paid envelope.

There was approximately $1000 available for surveys with a goal of obtaining 100 participants. After all was completed, 99 survey participants completed the survey. Three people contacted returned their $10 incentive. These three $10 incentives were then used to contact three more people. As can be seen in Table 5, 361 homes were called. Of the homes that were called, 246 homes had no response, either an answering machine picked up or no one picked up. In all, 115 people were contacted. Of the people contacted, 103 agreed to do the survey, while 12 did not. Of the 103 that 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%.

Survey Response Rate	
Number of Homes Called	361
People Contacted	115
Talked to and Said Yes	103
Talked to and Said No	12
Total that Completed the Survey	99
Response Rate of Those Contacted	86%
Response Rate of Those that Said Yes and Completed the Survey	96%

Table 5: Survey Response Rate

METHODS: CONTINGENT VALUATION MODEL

Since the completion of the NOAA panel's recommendations, CVM has been approved for use by federal agencies performing benefit-cost analysis. It has been found to be an extremely useful tool in evaluating environmental damage assessment such as the Exxon Valdez Oil spill. It has also been useful in valuation of endangered species, virgin forest preservation, as well as many other non-market good valuations. I feel that the usefulness of CVM has been demonstrated enough times that it is an appropriate technique for the project and will be the method I use (Arrow et al., 1993; Hanemann, 1994; NOAA, 1993).

The willingness-to-pay (WTP) questions for this study focused on 3 programs: fire suppression, fire prevention and prescribed burning. The responses to the dichotomous choice WTP question will be analyzed using a logistic model analysis. The logistic model can be used when the dependent variable represents a qualitative response such as choosing among a set of discrete alternatives. It can be used to explain a binary dependent variable (and hence can be called the binary logit model). This logistic model is similar to the normal distribution excepting in the tails, which have more weight in the logit model. The functional form of the logistic model is represented by the formula:

$$(1) \quad y_t = \frac{1}{1+e^{-(x_i'\beta+\delta+\varepsilon_t)}}$$

Where: y_t is the dependent variable. However, the equation is easier to work with if I linearize it. Linearizing the logistic equation results in the logit transformation, which is the log of the odds ratio.

$$(2) \quad \log it(y_t) = \ln\frac{y_t}{1-y_t} = x_t'\beta + \delta t + \varepsilon_t$$

In this case y_t is the WTP variable representing "0" if they are not willing-to-pay and "1" if they are (Greene, 2000; Gujarati, 1995).

Three willingness-to-pay questions were asked of the respondents. The initial question defined fire prevention as a process where the underbrush and some standing trees are removed to thin the forest to reduce the chances of a large fire. While I realized that there are other terms that can be used to define this process, this is the one that was used in the survey and therefore will be the way I define this term thought the rest of this paper. Once fire prevention was defined, respondents were asked:

> *If fire prevention would reduce the frequency of a wildfire (and they were referred to look at Photo #1) in the area where you live to half as often as it does now, would you pay an increase of (designated dollar amount) a year more in taxes for fire prevention each year? (Circle One) Yes No*
> *If no, please tell us why* _____

The second willingness-to-pay question followed the same format, except that it described fire suppression and then asked if the respondent was willing-to-pay for it. For this survey, fire suppression was defined as "having larger fire crews on standby and having more fire crews closer to fire prone areas of forests (Loomis and Kaval, 1999)."

The third question described prescribed fire and then asked the respondent if they were willing-to-pay for that particular fire management technique. Prescribed fires were defined as controlled burns in which fires 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 reduced wildfire intensity. There are rare instances where prescribed fires may get out of control, however most of the time there are no problems (Loomis and Kaval, 1999)."

Each survey had one designated dollar amount for all three questions. For example, if the designated dollar amount was $30 for fire prevention, it was also $30 for fire suppression and prescribed fire. Dollar amounts in the surveys ranged from $5 through $1500.

METHODS: WELL BEING MODEL

The ladder-of-life selection consisted of three questions. The first question asked the respondent how satisfied they currently are with their life:

There are many reasons people choose to live away from large cities. These may include enjoyment from living in the forests, proximity to recreation and wildlife, and better air quality. However, sometimes there are drawbacks such as driving distances to stores and risk of forest fires.

On a scale from zero to ten, where zero is very unhappy with your life and ten is the best possible life, how would you rate your satisfaction with your life?
Please circle the appropriate number.

0 1 2 3 4 5 6 7 8 9 10

←----------→

Lowest Life Satisfaction *Highest Life Satisfaction*

The first question was the lead in to the wildfire and prescribed fire questions. All of the follow-up ladder-of-life questions will be compared to this baseline.

The second ladder-of-life question rated wildfire. Respondents were first presented with a color picture of a high intensity wildfire in a Ponderosa Pine forest one year after the fire. The respondent was then asked the question, "Look at Wildfire Photo #1. If a wildfire like the one in Photo #1 occurred half as often in the area you live in, how would you rate

your life satisfaction with your life in this case? Please circle the appropriate number." Again, 'half as often' referred back to their response of estimated wildfire frequency.

The third and final ladder-of-life question was related to a low intensity prescribed fire. Respondents were presented with a color picture of a low intensity prescribed fire in a Ponderosa Pine forest one year after the fire. The respondent was then asked the question, "Look at Prescribed Fire Photo #2. If a prescribed fire like the one in the picture was carried out in the area you live in and reduced the frequency of a wildfire by half, how would you rate your satisfaction with life in this case. Please circle one number."

As suggested by van Praag and Baarsma 2000, well-being model valuation should be accomplished using an ordered probit model; therefore this is the procedure I will be using.

RESULTS

Demographic variable information was compared with information from the 2000 U.S. Census (U.S. Census, 2000). Variables analyzed included sex, household size, ethnicity, age, and income. Focus went to specific locations where there were more than five respondents; these include Masonville, Pagosa Springs, Estes Park, Nederland, and Red Feather Lakes.

Overall, our respondents were found to be 51% female, this corresponds directly with the Colorado average of 51%. Average household size was found to be 2.41 persons. Household size also directly corresponded with the 2.53 Colorado average. Average ethnicity across our sample was 94% Caucasian; this was significantly different from the Colorado average of 75%. Average age was 48, also different from the Colorado average age of 34. Household income average was approximately $68,000 annually; this matched the Colorado average only within the 99.99% confidence interval. While our respondents do not exactly match up with the Colorado 2000 Census average, this was not deemed to be a problem. Our survey targeted Colorado residents in the wildland urban interface, while the Colorado Census average was for the entire state. Therefore, we did not expect a perfect match (Table 6).

Colorado Total	2001 Survey Data Results	2000 Census Data	Nederland[1]	2001 Survey Data Results	2000 Census Data
Sex (% Female)*	50.51%	50.90%	Sex (% Female)*	29.41%	46.80%
Household Size*	2.41	2.53	Household Size*	2.29	2.30
Ethnicity/ (% Caucasian)	93.94%	75.00%	Ethnicity/ (% Caucasian)*	94.12%	97.10%
Age	47.70	34.30	Age***	48.71	32.80
Income***	$68,423.91	$47,203.00	Income**	$62,500.00	$50,588.00

Estes Park[1,2]	2001 Survey Data Results	2000 Census Data	Pagosa Springs[1]	2001 Survey Data Results	2000 Census Data
Sex (% Female)*	36.67%	52.00%	Sex (% Female)*	77.77%	50.90%
Household Size*	2.43	2.11	Household Size*	3.22	2.48
Ethnicity/ (% Caucasian)*	96.67%	95.10%	Ethnicity/ (% Caucasian)*	88.88%	74.60%
Age***	53.67	45.00	Age***	51.11	37.10
Income**	$82,037.04	$43,262.00	Income***	$77,777.78	$29,469.00

Masonville Area[1]	2001 Survey Data Results	2000 Census Data	Red Feather Lakes[1]	2001 Survey Data Results	2000 Census Data
Sex (% Female)*	43.48%	49.80%	Sex (% Female)**	81.82%	50.70%
Household Size*	2.35	2.45	Household Size*	2.18	2.00
Ethnicity/ (% Caucasian)*	86.96%	89.60%	Ethnicity/ (% Caucasian)*	100.00%	97.00%
Age*	31.04	28.20	Age*	61.82	54.40
Income*	$70,217.39	$44,459.00	Income*	$35,500.00	$33,527.00

*95% Confidence Interval

**99% Confidence Interval

***99.99% Confidence Interval

[1] Only those towns with more than 5 respondents were included

[2] Masonville was not considered a town by the census bureau. Therefore, we used Fort Collins to represent Masonville, as it was considered to be part of Fort Collins in the 2000 Census

Table 6: Respondent and Census Demographic Comparisons

We further subdivided our respondents by specific locations to get a more accurate comparison. There were five locations in which there were more than five respondents in an area. These areas include Estes Park, Masonville, Nederland, Pagosa Springs, and Red Feather Lakes.

In the Estes Park area, three of our variables: sex, household size, and ethnicity, fell within the 95% confidence interval (CI) with the Estes Park 2000 US Census data. In this area, 37% of our respondents were female, the average household size was 2.43 and 97% of respondents were Caucasian. Age and income corresponded with the 2000 Estes Park Census data within the 99.99% CI. Our average Estes Park respondent age was 54, while the census average was 45. Our average income for respondents was $82,000 annually, while the Estes Park census average was only $43,000 annually.

In the Masonville area, we find that all of our five variables corresponded within the 95% CI with the Masonville 2000 US Census data. We found that 44% of our Masonville respondents were women, compared to the 50% from the census. Our average household size was 2.35 while the Masonville census average was 2.45. Our Caucasian percentage was 87%, age was 31 and income was $70,000.

In Nederland, our numbers for sex, household size, and ethnicity all fell within the 95% CI with the Nederland census data. Our typical Nederland respondent was female 29% of the time, had a household composed of 2.29 people and was most likely (94% of the time) Caucasian. The mean age was 49 while the mean income was $62,500 annually.

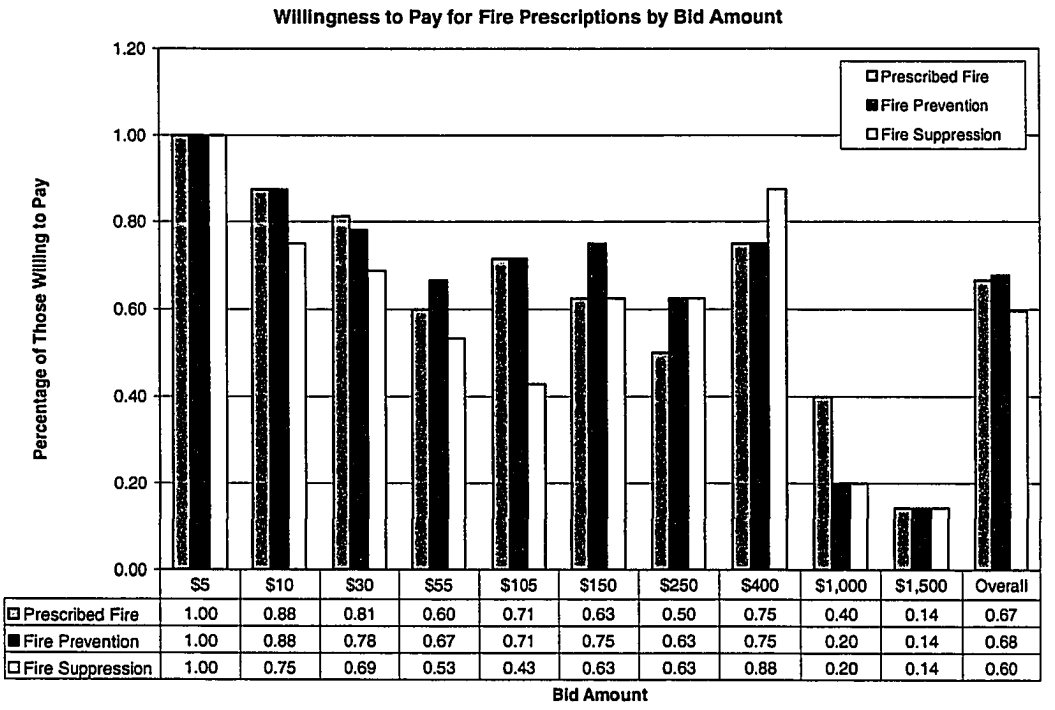
In Pagosa Springs, we again find our numbers for sex, household size, and ethnicity fell within the 95% CI with the Pagosa Springs census data. Almost 78% of our Pagosa Springs respondents were female. They had a household size of 3.22, average age of 51 and average income of $78,000 annually. Eighty-nine percent of the time they would be of Caucasian descent.

The Red Feather Lakes respondents matched up really well with the Red Feather Lakes 2000 Census Data. Household size, ethnicity, age, and income fell within the census data CI at the 95% level. Our respondents were female 82% of the time, they had a household size average of 2.18, they were always Caucasian, their average age was 62 and their average income was $35,500.

This information shows me that the random sample that we selected is an accurate representation of the Colorado wildland urban interface.

CONTINGENT VALUATION RESULTS

Overall, approximately 66% of the respondents were willing-to-pay for prescribed fires and fire suppression, while 59.6% of the respondents were willing-to-pay for fire prevention. What I typically expect to see with bid amounts is that at the lower bid amounts, a higher percentage, if not all, of the respondents will say yes. At the higher bid amounts I expect most if not all of the respondents to say no. This is the overall pattern of the bid amounts, but it is not monotonic (Figure 2). At the lower bid amount of $5, all respondents would pay, a 100% yes response. At the next bids of $10, $30, and $55 I see between 53% and 88% of the respondents saying they are willing-to-pay for prescribed fires. This makes sense, as the bid amounts get higher, the number of respondents willing-to-pay gets lower. But between the bid amounts of $105 and $250 I see a fluctuating pattern; at $105, 71% say yes for prescribed fires and fire prevention, then at a higher amount of $150, 75% say yes for fire prevention. The next bid amount is $250 and their yes responses are between 50% and 63%. But then surprisingly enough, at $400, between 75% and 88% of the respondents are willing-to-pay, this is almost as high of a yes percentage as the $10 and $30 bid amounts. Some of this fluctuation may be due to the small sample sizes at each bid amount, which yields a large variance on the percentages. After $400, I expected people not to pay anymore for fire management, but this was not the case. At $1000, 20% - 40% of the people were still willing-to-pay and at $1500, 14% were still willing-to-pay. What this tells me is that fire management is an important priority in some people's lives. People that live near forests are willing-to-pay for fire management. Their homes and property are very valuable to them and even at high annual tax rates of $1000 and $1500; some respondents are still willing-to-pay.

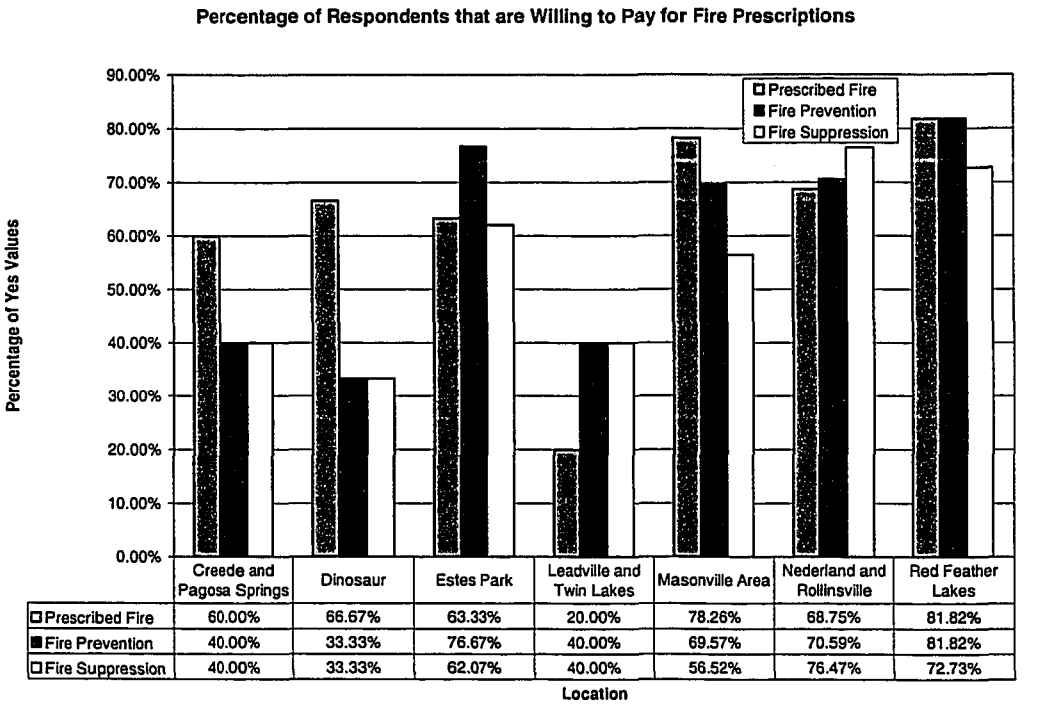


	$5	$10	$30	$55	$105	$150	$250	$400	$1,000	$1,500	Overall
Prescribed Fire	1.00	0.88	0.81	0.60	0.71	0.63	0.50	0.75	0.40	0.14	0.67
Fire Prevention	1.00	0.88	0.78	0.67	0.71	0.75	0.63	0.75	0.20	0.14	0.68
Fire Suppression	1.00	0.75	0.69	0.53	0.43	0.63	0.63	0.88	0.20	0.14	0.60

Figure 2: Willingness to Pay for Fire Prescriptions by Bid Amount

When analyzing the WTP questions by location, I also get interesting results, as can be seen in Figure 3. Here, I see that location has a significant impact on the percent willing-to-pay. Those respondents located in the Red Feather Lakes area, an area that has experienced several small wildfires in the recent past, had a high yes response of 72.73% - 81.82%. In the Masonville Area, an area that experienced a large wildfire the year previous to the study, also had yes responses of 56.52% - 78.26% with the highest responses for prescribed fires. This corresponds with the well-being results for the Masonville area. The lowest yes percentage was 20% for prescribed fires for the Leadville and Twin Lakes area. All other locations had yes responses for prescribed fires ranging from 60% through 68.75%. So I find that respondents living near public lands are, on average, in favor of paying for prescribed fires, while several residents of most areas are also willing-to-pay for fire prevention and fire

prescription.



	Creede and Pagosa Springs	Dinosaur	Estes Park	Leadville and Twin Lakes	Masonville Area	Nederland and Rollinsville	Red Feather Lakes
Prescribed Fire	60.00%	66.67%	63.33%	20.00%	78.26%	68.75%	81.82%
Fire Prevention	40.00%	33.33%	76.67%	40.00%	69.57%	70.59%	81.82%
Fire Suppression	40.00%	33.33%	62.07%	40.00%	56.52%	76.47%	72.73%

Figure 3: Percentage of Respondents that are Willing to Pay for Fire Prescriptions

In addition to the willingness-to-pay questions, respondents were asked to state which fire management technique they prefer if they had to choose only one. Figure 4 represents the information as to what the program respondents were in favor of. Surprisingly enough, only 7% of the respondents were against all prescribed fires and wildfires. This shows that respondents are knowledgeable about the areas in which they live and the importance of fires in the natural ecosystem. Over 85% of the respondents want to have prescribed fires, although they differ as to the particular prescribed fire management technique (i.e., whether to also have wildfires and protect homes, have wildfires and not protect homes, or not have wildfires).

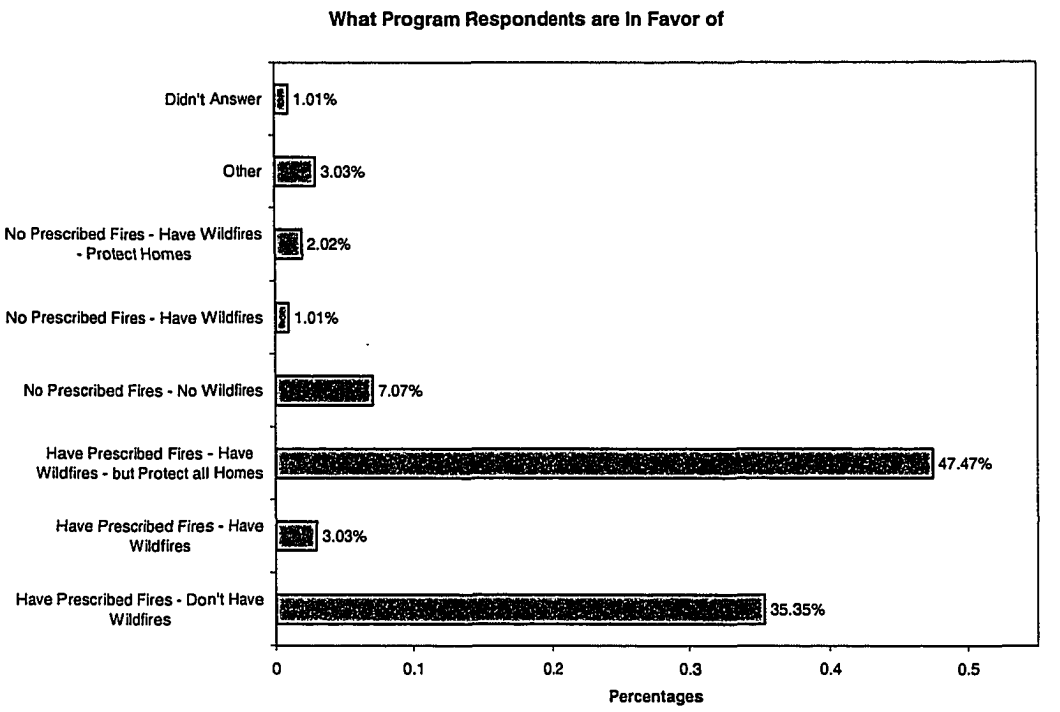


Figure 4: What Program Respondents Are In Favor Of

After tallying the general willingness-to-pay results, logit models were run separately on the willingness-to-pay bids for prescribed fires, fire suppression and fire prevention. All three results of the base model showed that the variables were significant at the 99% levels.

Logit results are as follows (with P-Values in parenthesis):

WTP for Prescribed fire = 1.208 - 0.0018BidAmount
(0.0) (0.002)

WTP for Fire Suppression = 0.806 - 0.0015BidAmount
(0.001) (0.007)

WTP for Fire Prevention = 1.301 - 0.0021BidAmount
(0.0) (0.001)

The logit results enable me to calculate the median, mean and confidence intervals for willingness-to-pay. To calculate the median value, I use the formula (Hanemann, 1984):

Median = C/(-Bid Coefficient)

The formula for the mean value is then calculated with the following formula (Hanemann, 1989):

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

Using a simulation approach of Park, et al. 1991, this enables me to calculate the confidence intervals.

Mean, median, and confidence intervals (CI) calculated are presented in Table 7. These results show respondents have high willingness-to-pay for fire management. They are willing-to-pay between $484 to $1737 annually for fire management in their area. They seem to prefer prescribed fires to the other fire management techniques although the overlapping CI's suggest there is likely no statistical significant difference in WTP. Since these values are high, this shows me that fire management is an important aspect to people that live near public lands when their homes and property are at risk to fire.

			90% Confidence Interval	
	Median	Mean	Lower Bound	Upper Bound
Prescribed Fire	$654.90	$796.41	$545	$1,583
Fire Suppression	$507.00	$739.70	$485	$1,737
Fire Prevention	$599.35	$710.47	$504	$1,303

Table 7: Logit Results for Willingness-to-Pay

Once the base model information was complete, I tested to see if any of the demographic information had an affect on the respondents. None of the demographic variables had an effect and therefore I will not present the insignificant models.

I then tested respondent's perception of wildfires and found significant results. The two questions that tested perceived wildfire danger include:

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

7. Take a look at the wildfire photo. In your opinion, how often does a wildfire such as shown in the Wildfire Photo occur in the area where you live. For example, once every 5 years, once every 10 years, twice a year, etc.
_____Fire Frequency

Results are as follows (Table 8):

Q11A - Fire Prevention		
	Coefficient	P-Value
C	1.072	0.029
Q11Bid	-0.003	0.003
Q3Danger	0.947	0.083
Q7Freq	-0.020	0.051
	McFadden R^2	0.221

Q11B - Fire Suppression		
	Coefficient	P-Value
C	0.663	0.153
Q11Bid	-0.002	0.009
Q3Danger	0.682	0.176
Q7Freq	-0.015	0.130
	McFadden R^2	0.129

Q13PF - Prescribed Fire		
	Coefficient	P-Value
C	2.333	0.000
Q11Bid	-0.003	0.001
Q3Danger	-0.852	0.174
Q7Freq	-0.024	0.033
	McFadden R^2	0.185

Table 8: Willingness-to-Pay Results when Perceived Fire Danger is Included

For the Fire Prevention question, I find that if the respondent feels their home is in danger of a wildfire, they are more willing-to-pay for fire prevention. I also found that as the infrequency of fire increased (data for frequency was coded 10 for once every 10 years, 100 for once every one hundred years, etc), the respondent would be less willing-to-pay for fire prevention.

For fire suppression, I find that danger and frequency did not have an effect on willingness-to-pay for fire suppression. For prescribed fire I find that respondents were less willing-to-pay for prescribed fire if the infrequency of fire increases.

As can be seen from Table 9, the willingness-to-pay value for fire prevention is influenced by fire danger ($315.67) and fire frequency (-$6.67). Fire suppression is not influenced by fire danger or fire frequency. Prescribed fire is influenced by fire frequency (-$8.00).

	Fire Prevention	Fire Suppression	Prescribed Fire
C	**$357.33**	$331.50	**$777.67**
Q3Danger	**$315.67**	$341.00	-$284.00
Q7Freq	**-$6.67**	-$7.50	**-$8.00**

*Note: Statistically significant values are bolded

Table 9: Willingness-to-Pay Amounts

WELL-BEING RESULTS

The first question "On a scale from zero to ten, where zero is very unhappy with your life and ten is the best possible life, how would you rate your satisfaction with your life?" (Loomis and Kaval, 1999), found that people living near public lands in Colorado had an average happiness rating of 8.404. This corresponds with Frey's report that people living in the United States have an average happiness ranking of 8.437[6] (Frey and Stutzer, 2002).

When ranking people's happiness by income, data results show differences and similarities to Easterlin, Frey and Morawetz (Figure 5). I found that the highest happiness rating occurred when people earned $40,000-$70,000 (8.905 on a 0 to 10 scale). This is higher than the 8.128 rating of people earning less than $40,000. So I see that up to the $70,000 range, people that earn more money are happier. But the lowest ratings occurred when people earned $70,000-$100,000 (7.889). This is similar to the results found in Switzerland (Leu et al., 1997) where people earning some of the highest income are less happy. However, on average, results did not show an increase in happiness with an increase in income.

[6] In Frey's report, rankings were based on a scale of 1 through 10. Frey's reported average happiness ranking was 7.67. By converting 7.67 to the scale of 0 through 10, we obtain a ranking of 7.67*1.1=8.437.

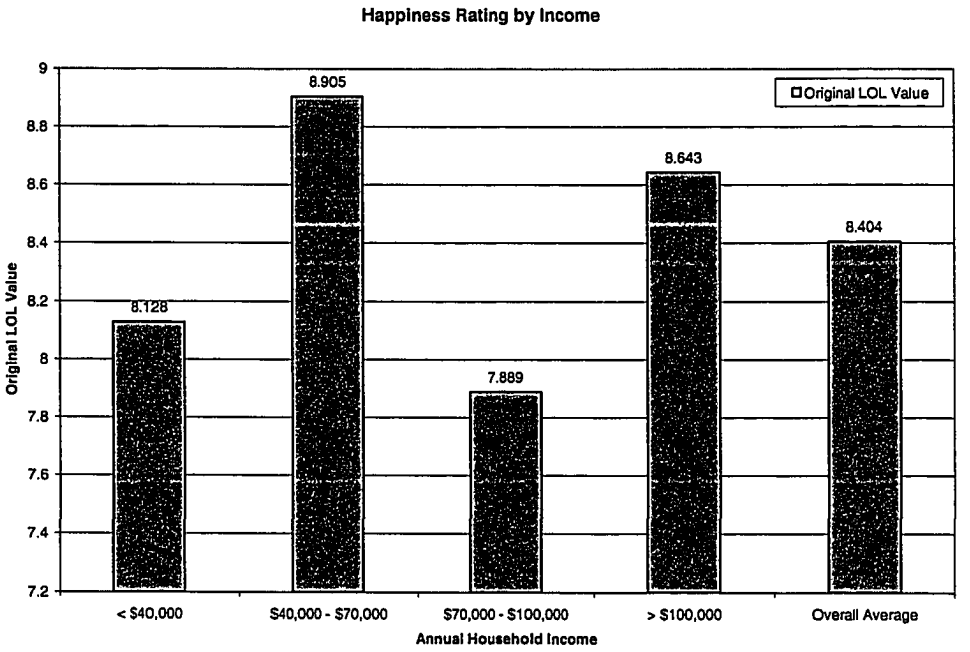


Figure 5: Happiness Rating by Income

If I were to categorize happiness ratings by per capita income (annual income/ family size), I also get similar results (Figure 6). I find that people living on an average annual income of <$15,000 are the least happy (7.864). Happiness increases to 8.455 for the $15,000-$30,000 range. It remains similar (8.409) in the $30,000-$45,000 range, increases to 9.33 in the $45,000-$60,000 range, and, as in the Switzerland study, decreases to 8.5 in the >$60,000 range.

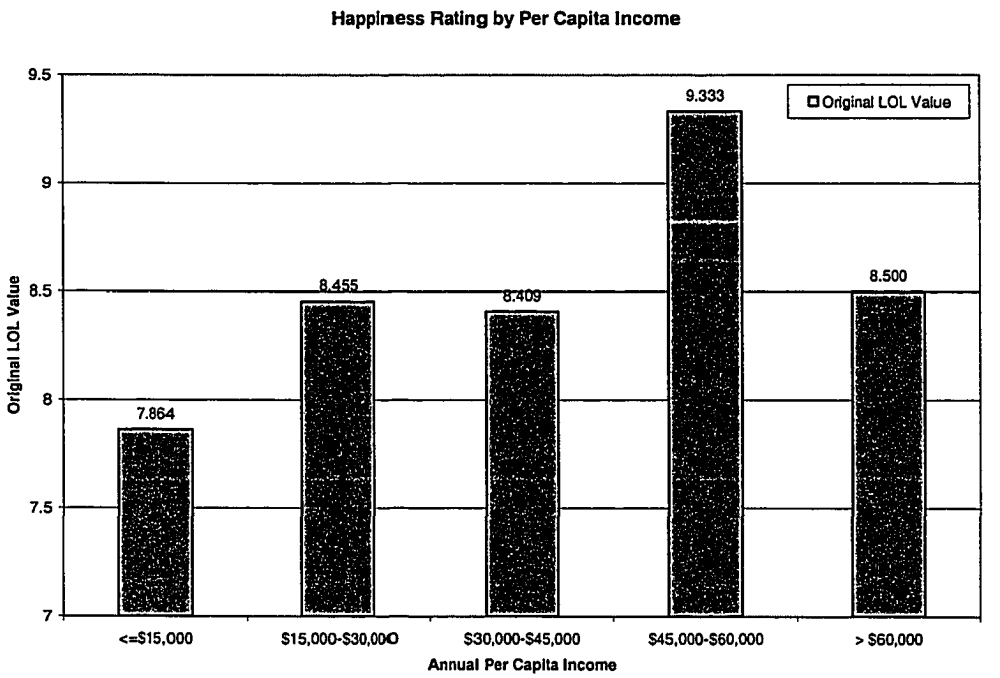


Figure 6: Happiness Rating by Per Capita Income

Another focus of previous happiness studies was happiness ratings by age. In these studies it has been found that when analyzing age and happiness, a U shaped graph is formed. The lowest point on the graph (base of the "U") represents people in the age bracket of 30 (Figure 7). People younger than 30 and older than 30 have higher happiness value rankings (Oswald, 1997; Dixon, 1997; Blanchflower and Oswald, 2000). In other studies, young people have been found to have a lower life satisfaction than older people (Frey and Stutzer, 2002).

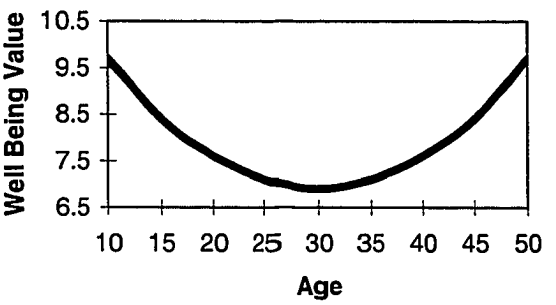


Figure 7: Example of U-Shaped Well Being Graph Where Age 30 is Lowest Point

In looking at happiness data by age I find some, but not all, of my results to correspond with the results from Oswald, Dixon, Blanchflower and Oswald, and Frey's research (Figure 8). I find that in the age bracket of 30, the second to lowest happiness values (8.042) exist. I also find that people in their 60's, 70's and 80's are happier than those in their 20's, 30's, 40's, and 50's. However, I find that happiness peaks in your 60's, but then decreases as you age. Happiness is ranked at 7.75 in your 20's, increases to 8.042 in your 30's, increases to 8.333 in your 40's but then decreases again to 8.056 in your 50's. I do not find a "U" shaped ranking in values.

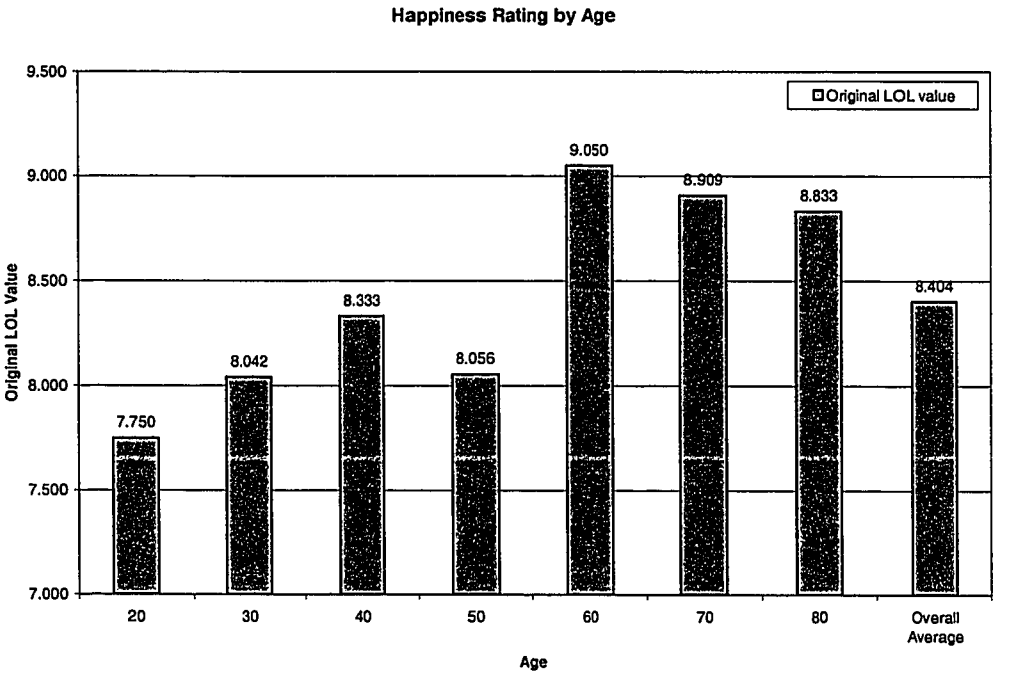


Figure 8: Happiness Rating by Age

The next two ladder-of life questions related to wildfires and prescribed fires. The questions asked how people would feel if these fires occurred half as often as they currently occur. While the authors felt that after the focus groups and pretests, these questions were understood as they intended, results indicate differently. The results seem to represent how a person would feel about their well-being after a wildfire occurred near their home and after a

prescribed fire occurred near their home. The following results will be presented as if this was how these questions were interpreted.

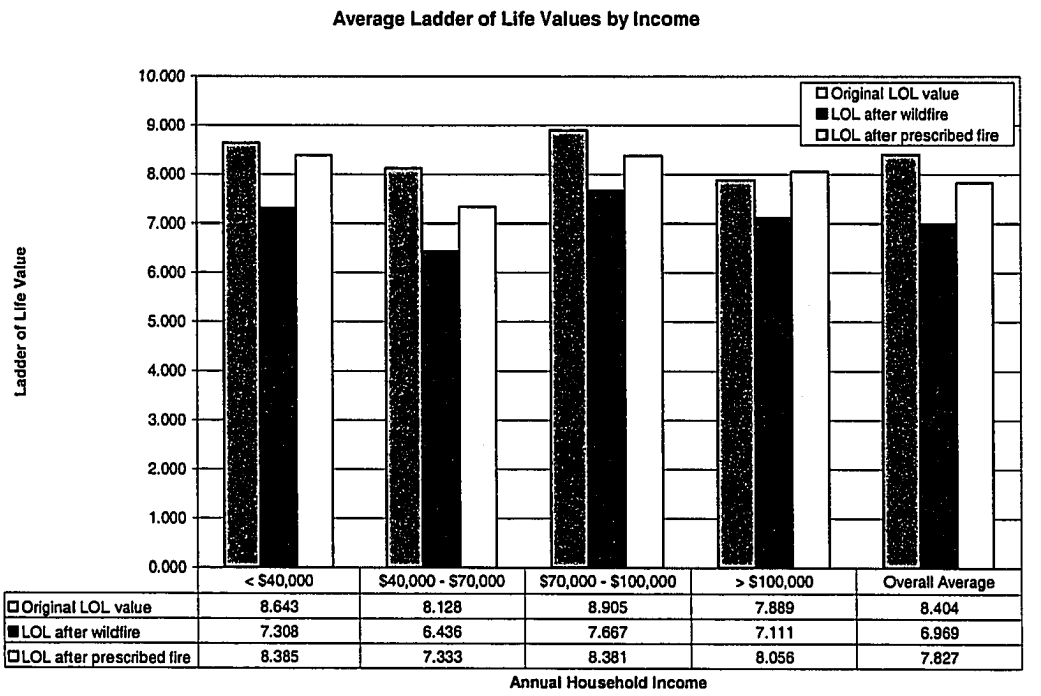
In general, I found that results varied across respondents (Table 10). As stated previously, the mean overall response to how people feel about their life currently on the 0 to 10 ladder-of-life scale was 8.404. If a wildfire was to occur, the mean response lowered to 6.969. However, if a prescribed fire were to occur, their life rating changed from 8.404 to 7.826. The results show that people living in homes near public lands in Colorado feel pretty good about their lives. If a wildfire were to occur, they would still feel good about their lives, but not as good as prior to the wildfire. The same situation results with prescribed fire. If a prescribed fire were to occur, they would still feel good about their lives, just not as good as prior to the prescribed fire. It also makes sense that the result after wildfire is lower than the result after prescribed fire since in this situation, I assume a majority of the canopy trees are still alive after a prescribed fire and the forest will recover faster.

Original LOL Value	8.404
LOL after Wildfire	6.969
LOL after Prescribed Fire	7.826

Table 10: Average Ladder-of-life Values

Results were found to be similar when analyzing ladder-of-life response averages by income (Figure 9). Here, respondents with incomes under $100,000, had initial LOL values ranging from 8.128 and 8.905 indicating that they are very satisfied with their lives right now. If a wildfire were to occur, LOL values decrease to 6.436 through 7.667. If a prescribed fire were to occur, LOL values would again be higher than the wildfire values, but lower than the original values. Prescribed fire LOL values range from 7.333 through 8.385. However, for respondents with an income above $100,000, I see something slightly different. Here, their current LOL value is 7.889. If a wildfire were to occur, this value would decrease to 7.111.

But, if a prescribed fire were to occur, the value would increase from the original LOL value of 7.889 to 8.056. Perhaps people in this income bracket feel that prescribed fires are very important in order to keep wildfires from coming through their landscape. Or it may also be that several of these respondents lived in the Masonville area where a large wildfire occurred the year previous to the study, the Bobcat Gulch fire. Therefore, since the wildfire did intensely burn the area for which they live, they wished prescribed fires occurred previously so the fire would not have been as intense.

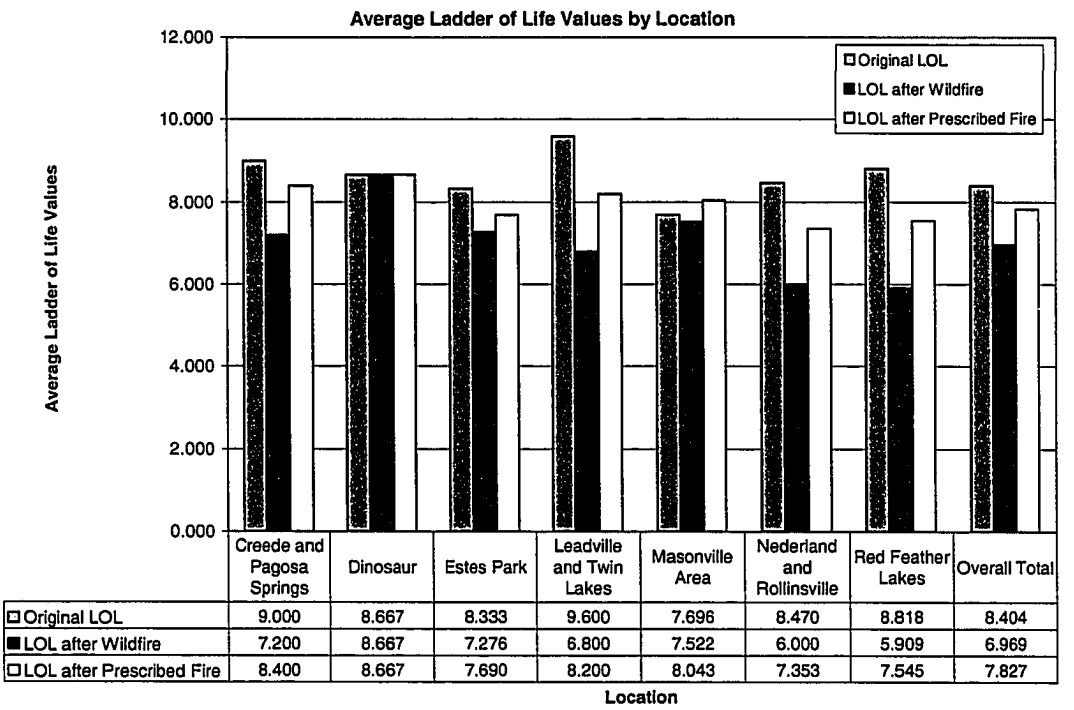


	< $40,000	$40,000 - $70,000	$70,000 - $100,000	> $100,000	Overall Average
Original LOL value	8.643	8.128	8.905	7.889	8.404
LOL after wildfire	7.308	6.436	7.667	7.111	6.969
LOL after prescribed fire	8.385	7.333	8.381	8.056	7.827

Figure 9: Average Ladder of Life Values by Income

I then analyzed the ladder-of-life questions according to the location of the respondent; these results are shown in Figure 10. In 5 of the 7 general locations I see that the original LOL values are high, LOL values after wildfire are lower, and LOL values after prescribed fire are between the wildfire and original values. This holds true for all locations except Dinosaur and the Masonville Area. In Dinosaur, I find that resident responses are invariant, their LOL values are the same for all well-being questions. The average value across all LOL questions for Dinosaur is 8.667. In the Masonville area, the value after

prescribed fire is higher than the original LOL value. I feel that the reasoning for this is that the Bobcat Gulch fire, a wildfire, ran through the Masonville Area in the year previous to the study (2000). The Bobcat Gulch fire was a high intensity wildfire that destroyed a great number of canopy trees in the area. It will take many years for the larger trees to come back to the area. I feel that area respondents learned from this fire, and now that the people in the Masonville Area have experienced high intensity wildfires, they now know first hand the benefits of prescribed burning.



	Creede and Pagosa Springs	Dinosaur	Estes Park	Leadville and Twin Lakes	Masonville Area	Nederland and Rollinsville	Red Feather Lakes	Overall Total
Original LOL	9.000	8.667	8.333	9.600	7.696	8.470	8.818	8.404
LOL after Wildfire	7.200	8.667	7.276	6.800	7.522	6.000	5.909	6.969
LOL after Prescribed Fire	8.400	8.667	7.690	8.200	8.043	7.353	7.545	7.827

Figure 10: Average Ladder of Life Values by Location

After reviewing well-being results, the next goal was to run an ordered probit regression focusing on the variables: original ladder-of-life, half of the frequency of wildfire occurrence, per capita income, family size, age, sex, ethnicity, and education.

I feel that two of these ordered probit regressions are important to present:

(3) Equation 3 (P-Values are in Parenthesis):

$$LOL = 3.22E\text{-}06\ House - 2.38E\text{-}12\ House^2 - 1.05\ Family + 0.114\ Family^2 + 0.016\ Age - 0.156\ Sex + 0.148\ Ethnicity - 0.016\ Education.$$

(0.078) (0.058) (0.001) (0.018) (0.037) (0.576) (0.344) (0.725)

(4) Equation 4 (P-Values are in parenthesis):

$$LOL = 1.90E\text{-}05\ PCInc - 1.29E\text{-}10\ PCInc2 - 1.398\ Family + 0.204\ Family^2 + 0.016\ Age + 0.000\ Sex - 0.394\ Ethnicity + 0.011\ Education$$

(0.134) (0.121) (0.013) (0.038) (0.034) (0.997) (0.005) (0.793)

Where:

LOL = Original Ladder-of-Life Value
House = Value of the Respondents Home
$House^2$ = $House^2$
Family = Number of individuals in the family that the reported income supports
$Family^2$ = $Family^2$
Age = Age of Respondent
Sex = Female (0) or Male (1)
Ethnicity = Race of Respondent (Where: 1=Native American, 2=Caucasian, 3=Black, 4=Hispanic, 5=Asian, 6=Multiple or Other)
Education = Highest year of schooling (Where 1= First year of elementary school through 21=Highest year of Graduate School)
PCInc = Per capita income which was calculated by Income/Family
$PCInc^2$ = $PCInc^2$

While not reported in these equations, income, which was expected to be an important variable, never was a significant variable. Therefore, I opted to try two different methods to include a monetary variable: value of the home and per capita income value (average annual income/ number of people using this income). In Equation 3, home value was included in the model. Here I find that the value of the respondent's home has a positive and significant impact on well-being. Age also has a positive and significant impact on well being.

In Equation 4, I used per capita income to replace value of the home. I did not find per capita income to be significant, although it does have a positive sign, saying that as income increases, well being increases. In this model, the size of the family has a significant impact on well-being. Age also has a positive and significant impact on well-being.

One of my goals in this paper was to use the ordered probit results to obtain a shadow price for ladder-of-life values, as van Praag and Baarsma did in their Schiphol experiment.

This would have resulted in values for reducing wildfire occurrence in half. However, since it seems that the follow-up ladder-of-life questions were misinterpreted, I could not conduct that part of the analysis. Since I could not estimate a significant income coefficient for the well being equations, I could not compare these values with CVM willingness-to-pay values as originally intended.

DISCUSSION AND CONCLUSIONS

In this paper I analyzed results from a 2001 survey entitled "Managing Fires on Public Lands: What Do You Think?" Two major types of questions were analyzed: willingness-to-pay and ladder-of-life. The idea was to show that value results from both types of questions have similar results.

Colorado residents living near fire danger areas are knowledgeable about fires. They seem to know that fires are an important part of the landscape. When asked to respond whether they would pay for prescribed fires, fire suppression or fire prevention, they seemed to have a positive attitude. Over 59% of respondents were willing-to-pay for fire prevention, while over 66% of the respondents were willing-to-pay for prescribed fires and fire suppression.

Responses to the willingness-to-pay CVM questions told two stories: the first was that respondents were willing-to-pay for fire prescription, fire suppression and prescribed fire. Willingness-to-pay values for the various fire prescription methods ranged from $507 to $655 annually.

The second story showed how perceived fire danger influenced willingness-to-pay. For fire prescription, willingness-to-pay was influenced by perceived fire danger and perceived fire frequency. Fire suppression willingness-to-pay was not influenced by fire danger or fire frequency. Prescribed fire willingness-to-pay was influenced by frequency but not by fire danger.

As the survey respondents were randomly selected people that live near public lands, I believe that the willingness-to-pay results can be extrapolated to the wildland urban

interface. After comparing my demographics to town demographics in which I surveyed more than 5 people in a town, I found that it matched closely for several of the towns. Therefore, I feel that I can extrapolate this information to Estes Park, Masonville, Nederland, and Pagosa Springs. This is an important finding, as annual willingness-to-pay values of $507 to $655 annually will not come close to paying for a wildfire management technique in an area. Since it seems that the towns are well represented, I feel that cost sharing in the towns would work.

The well-being questions showed me that Colorado residents living near public lands feel that their life is of a high quality. If a prescribed fire were to occur in the area in which they live, their quality of life would decrease slightly. If a wildfire were to occur in the area in which they live, their quality of life would decrease even more than in the prescribed fire instance. However, even though their quality of life slightly decreases after fire, it is still high.

Even though I did find these results, I do feel that some of the well being questions were not interpreted correctly. Therefore, I was not able to create value for these variables and therefore could not compare these values to the CVM values.

At the end of the survey, respondents were asked which fire management technique they would like to see used if they only have one choice, in this instance, over 85% of respondents stated that they would like to see prescribed fires occurring in the Colorado forests. Low intensity fires have been occurring on the landscape of Colorado through frequent intervals over the centuries, prescription fires might be an initial start in trying to return the natural fire regime of Colorado. It seems that since such a high percentage of the survey respondents agree with this matter of prescription fire, I feel that the residents know how important fire is to the natural landscape of Colorado.

While I believe the results of my well being questions did not turn out, I do believe that the well-being approach is a sensible way to evaluate respondent's utility and has valid potential in contingent valuation studies. However, questions must be worded in a way that the general public will interpret the questions in the same way the researcher has implied. To

do this for a survey such as this one, I would suggest adding two more well-being questions (to the original three). The first would be presented directly before the ladder-of-life question about wildfires. This question should ask, "if a wildfire like the one in the picture were to occur near your home, what would your well-being be." Then ask "if resource managers could reduce the chance of this fire from occurring by 50%, what would your well-being level be if they could reduce the chance of wildfire by 50%." Then create the two prescribed fire questions to follow the sentence wording of the two wildfire questions.

CHAPTER 3

USING GIS TO INVESTIGATE THE RELATIONSHIP BETWEEN STAKEHOLDER OPINION ABOUT WILDFIRE AND LANDSCAPE CONTEXT

ABSTRACT

Spatial modeling is an important tool that can be used in conjunction with economic analysis. In this study, I was able to use spatial modeling to help calculate estimated actual fire danger of homes in Colorado. Estimated actual fire danger values were then compared with survey responses such as perceived fire danger values and values for prescribed fire, fire prevention and fire suppression to determine variable relations.

It was discovered that respondent's values for willingness-to-pay vary among fire management techniques. All respondents were willing-to-pay an annual amount for all three techniques. However, different variables were found to influence how much they were willing-to-pay.

For the base model that only included perceived fire risk, I found that perceived fire danger to homes influenced willingness-to-pay for fire prescription and fire suppression, but not prescribed fire. However, frequency of wildfire did affect the willingness-to-pay for prescribed fire. When adding in the spatial data to the models, I found that whether the home has an approximately 9.144 meter (30 feet) defensible space zone around their home and whether the fire danger of the immediate 100 meter area surrounding their home had an influence on willingness-to-pay for fire prevention. For fire suppression, the spatial variable that had an influence on willingness-to-pay was the weighted average fire danger within one mile of their home. No spatial variables seemed to influence willingness-to-pay for prescribed fire.

Key Words: Prescribed burning, controlled burning, wildfire, geographic information systems, GIS, spatial modeling, defensible space, survey analysis, national forests, land management, public involvement, stakeholders.

INTRODUCTION

FIRE

Fire is an ever-present natural disturbance regime that has been occurring on the landscape prior to the existence of angiosperms during the Paleozoic Era (Agee, 1993). These landscape fires can be started in one of two basic ways: they can occur naturally or they can be human caused. Natural landscape fires typically start with a lightning strike, spontaneous combustion, or molten lava. Human caused landscape fires can be created purposely (i.e., a forest manager could prescribe a fire or an arsonist could start a fire), or accidentally, such as a campfire getting out of control or children playing carelessly with matches.

Colorado's landscape consists of a variety of vegetation classes and fire regimes. Colorado vegetation classes include Ponderosa Pine, Douglas Fir, Montane forests, aspen, and dryland crops, to name a few, each with their own fire regime (Romme et al., 2001; Theobald et al., 2003).

Several studies have been conducted in order to estimate frequency of wildfires. Brown et al., 1999, studied fire events in the Cheeseman Lake area of central Colorado. This study area encompassed a 4000 ha area of Montane Ponderosa Pine-Douglas Fir forest landscape. They recorded 77 fire years and 486 fire scars from 1197 through 1999, making the cutoff of 1197 since it was hard to find trees that dated back prior to that time. Fire intervals varied across the landscape between 1 and 29 years. When researching individual stands, it was found that there were short intervals of 1 to 10 years in length and very long fire intervals greater than 100 years, while other stands had intervals over 100 years.

Veblen et al., 2000, studied Ponderosa Pine forests at elevations of 1830 to 2800 meters in the northern Colorado Front Range. Their study area was bordered by Estes Park, Lyons, Eldorado Springs, and Nederland. They found that low elevation Ponderosa Pine forests on the northern Front Range experienced frequent surface fires. High elevation Ponderosa Pine – Douglas Fir – Lodgepole Pine had a lower fire frequency but had stand replacing fires. Fire exclusion in the western US during the majority of the 20th century

changed forest structure. Forests became more susceptible to pest and disease outbreaks as well as widespread crown fires.

In Ponderosa Pine forests, if surface fires are not present and frequent, stand densities increase, which leads to increased fuel levels (Cooper, 1960; Mutch et al., 1993; Covington and Moore, 1994; Arno et al, 1995; Fule et al., 1997). Veblen et al., 2000 also noted that fire suppression during 20th century has yielded a high fuel hazard that may lead to catastrophic fire in Ponderosa Pine forests.

The high elevation (2800 meters or 9000 feet to treelike) areas of Breckenridge are composed of mostly ancient and largely unclogged forests called the subalpine forests. These subalpine forests are typically composed of Engelmann spruce, alpine fir, and Lodgepole Pine (Erickson, 2002).

While most of the area surrounding Breckenridge is typically of low precipitation and humidity, the high elevation Ponderosa Pine and spruce fir forests are usually cooler and wetter. This moisture is due to snow packs that typically last into June. In July and August, these areas experience monsoon type rains. When the rainy season is over, it begins to snow again. Due to the wetness of these particular areas, fires are typically uncommon, except in extreme drought periods that occur on average of 100 to 500 years. The last recorded fire in the high alpine Breckenridge area was 1879 (Erickson, 2002).

Since fires are rare, the forests receive other types of disturbance such as blowdowns or insect infestations (i.e., Engelmann spruce bark beetle, Western Spruce budworm). However, when fires do occur, they are stand replacing and recovery from stand replacing fire can take centuries.

While Colorado studies in different areas and different vegetation types yield different fire information, there are a few general characterizations that can be made. Several of the Colorado forests types, such as Ponderosa Pine, have been extremely altered by Euro-American land uses such as livestock grazing, fire suppression, road construction, predator control, exotic species introductions and logging. This has resulted in a dense midstory of

mixed conifer trees. These dense midstories provide the ladder fuels for crown fires to establish (Allen et al., 2000; Covington and Moore, 1994; Swetnam, 1999).

Human wildland urban interface communities are vulnerable to these destructive crown fires and as the population of people in these areas increases, so does the risk to homes. However, what is done with these forests is a controversial topic, since the way people view fire is a topic that has been under constant flux. What people believed 50 years ago is different than what is believed today and what will be believed 50 years from now. These beliefs are typically ecologically based, but are also highly influenced by politics and the media, whose ideas may be totally irrespective of ecology. Some foresters believe that one of the largest influences in fire ecology was the movie Bambi and other media that has given the public the idea that fires are bad. This idea still prevails today (Lutts, 1992).

Resource managers that oversee an area rich in fire history would benefit from understanding the fire ecology of that particular area more completely. This information should be gathered for the specific area, as fire ecology in one area can not typically be extrapolated to other areas. Understanding fire ecology includes knowledge of past fire regimes, vegetation type, topography, and climate of the designated area as these variables all contribute to fire occurrence. Current common management techniques include prescribed fires, fire prevention, and fire suppression.

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. There are rare instances where prescribed fires may get out of control; however, most of the time there are no problems.

Fire prevention and fire suppression are two methods that can also be used to reduce the frequency of wildfires in an area. Fire prevention[7] includes removing underbrush and cutting down some standing trees to thin the forest and reduce the chances of a large fire. Fire

[7] As defined by our survey and therefore will be the definition we stay with throughout the paper to avoid confusion.

suppression[8] includes having larger fire crews on standby and having more fire crews closer to fire prone areas of forests. The purpose of fire suppression crews is to extinguish all fire starts immediately before fires are given the chance to spread.

Regardless of management objectives, wildfires will start. When a wildfire has started, there are several options available. The three options I presented in the survey include: to allow the wildfire to burn, allow the wildfire to burn in the forested area but make an effort to protect all houses and structures, or to extinguish the wildfire.

Extinguishing wildfires, suppressing fires, using fire prevention, and fire prescription are costly. Over the years, due to the increase in risks, the costs of fire management have increased significantly (Ingalsbee, 2003; EMS, 2001). The increase in costs include, but are not limited to, helicopters, fuel, and wages of firefighters for wildfires, and the ever-increasing costs of fire suppression, prevention, and prescription fires.

Most recently, public opinion has become a required part of the decision criteria for federal land management. Since public opinion of fire management is becoming very important, this paper will focus on how the public perceives that fires should be managed, more specifically, the public that lives within a few miles of public lands that bear the risk of landscape fires damaging their property. Therefore, I will present in the next section how to calculate fire danger.

WILDFIRE HOME DANGER AND PREVENTION

The population of the Wildland Urban Interface is growing. The increase in the number of homes increases the chance that a home will get caught in a wildfire and burn. Homes will not burn without the fuel requirements for ignition and heat requirements for continued combustion (Cohen, 2000). In the wildland-urban interface, a home will catch on fire typically in of two ways, ignition by wildfire flames and ignition by lofted burning embers, called firebrands (Cohen, 2001). To calculate the chance of a home burning, several

[8] As defined by our survey and therefore will be the definition we stay with throughout the paper to avoid confusion.

attributes must be considered. These attributes include defensible space (of the home characteristics and the home site), and surrounding area (area site) fire danger.

DEFENSIBLE SPACE

Defensible space is an area where "vegetation is modified to slow the rate and intensity of an advancing wildfire (Larimer County, 2003)." Typically, the term defensible space is used in conjunction with homes. As stated, having defensible space is not a 100% guarantee from property loss. However, defensible space is important to be done to reduce fire danger.

Defensible space is a "designated area around a home that is intentionally maintained so as to be free of any features that would tend to increase the risk of damage from wildfire (WHIMS, 2002; Larimer County, 2002)." There are three typical priority zones for defensible space. The first priority zone begins with the outside wall of a home and continues to approximately 9.144 meters (30 feet) surrounding the home, this zone includes both home attributes and regular maintenance attributes. The second priority zone consists of the land between 10 and 30 meters from the edge of the home (Vicars, 1999). The third priority zone is the area between 30 meters and 100 meters from the edge of the home (Figure 11).

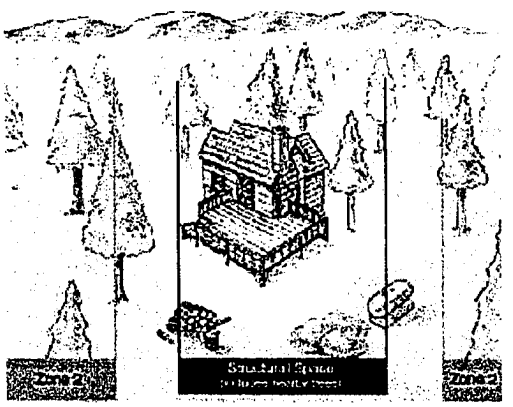


Figure 11. Defensible Space
From Colorado State Forest Service Defensible Space Firescaping (2003).

Defensible space begins with home attributes. Home attributes consist of structure design and maintenance. Design represents the way the structure is built and can affect flammability of a home. For instance, there can be wooden shingles on the roof which are flammable, or there can be non-flammable roofing materials such as metal shingles. Another design that can help reduce wildfire occurrence is siding; wooden or composition siding is more flammable than adobe. If the home has a chimney, the chimney can remain open possibly allowing wildfire embers to enter the home and start a fire or the chimney can be installed with a spark arrestor chimney cap. One more example is venting. If the vents are open, they can also allow wildfire embers to enter the home and possibly start a fire, whereas if the vents are screened, they might prevent the embers from entering the home (Vicars, 1999; WHIMS, 2002).

In addition to design attributes, regular maintenance attributes must also be considered. Regular maintenance includes removing leaves and needles from a home's roof, storing firewood at least 9.144 meters away from the home, and storing gas and propane at least 9.144 meters from the home (Vicars, 1999). All of these maintenance tasks reduce the chance of a wildfire burning the home.

To help reduce the chance of a structure catching on fire, all flammable material should be removed from Priority Zone 1. For extra protection, it is recommended that no vegetation besides grasses be planted within .9144 to 1.524 meters of the structure (Vicars, 1999).

In Priority Zone 2, there are also several recommendations that can be practiced to reduce chance of wildfire burning a structure. Trees can be thinned so tree crowns do not contact each other, dead limbs can be removed, lawns can be mowed so as to not let the vegetation grow above 3 inches, grass can be watered, and trees can be pruned so no branches are closer than 3.048 meters to the ground (Vicars, 1999; WHIMS, 2002; Larimer County, 2002).

A great deal of research has been completed that has tested the proper amount of defensible space for homes to survive a wildfire. The National Wildland/Urban Interface Fire

Protection Program was established in 1986 to promote wildland-urban interface research. This program is sponsored by four organizations: the National Fire Protection Association, the National Association of State Foresters, the Department of Interior land management agencies and the USDA Forest Service (Cohen, 2000).

One of the defensible space research projects was completed by Alexander et al.(1998). Alexander et al.'s field research was called the International Crown Fire Modeling Experiment. In this experiment, wooden walls were constructed to simulate walls of homes and were placed downwind from the edge of a forest fire.

Results from the Alexander et al. experiment show that the wall would ignite if it made contact with the flame. Wall ignition occurred where the wall was only 10 meters from the forest edge. Walls placed at the 20 and 30 meter distance experienced some fire scorch but did not ignite and since burning depends on ignition, it is believed that homes 20 to 30 meters from a forest edge (with no fuel in between) are safe from wildfire (Alexander et al., 1998).

The results from these studies assume one major characteristic: that the homes are built on a flat piece of land. If a home is built on a slope, the defensive space zone size must be modified. Building on a steep slope faces a higher fire hazard than one on a flat slope. To reduce the fire danger, a structure should be either located in a valley bottom or on top of a slope, as long as the distance between the top of the slope and the building is significant (Theobald et al., 2003; Ryan, 1976; CSFS, 2003).

However, homes are not always built in the safest areas. They may be built in a location that has a good view or a location that is near a lake. For this reason, Coulter (1980) has created a graph with defensive space distance recommendations for homes built on various slope grades (Figure 12). Here I can see that at a slope of zero, the recommended defensible space surrounding a home is a minimum of 9.144 meters. At a slope of 15, the uphill and side distance recommendations are approximately 11.5824 meters, while the downhill distance recommendations are 13.1064 meters. The graph peaks at a slope of 50, as people do not typically build homes on slope grades greater than 50 percent. At the slope of

50%, I find the uphill and side distance recommendation to be 18.288 meters and the downhill distance recommendation to be 30.48 meters.

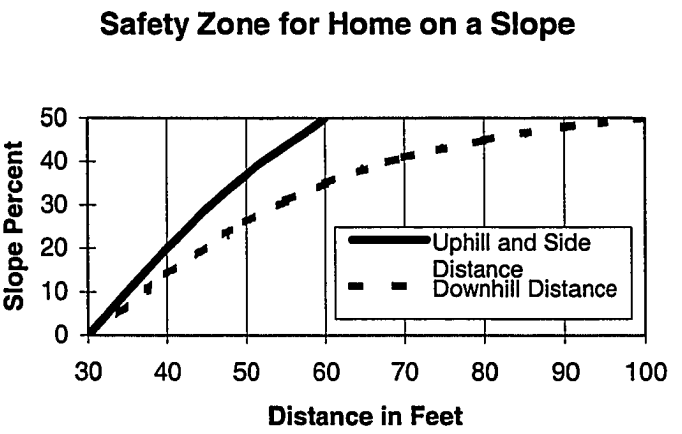


Figure 12: Recommended Defensible Space Zones for Homes on a Slope
(Reproduced from Coulter, 1980)

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[9] were also saved. While defensible space has been shown to save homes from wildfire, defensible space is not mandatory in most of Colorado. Of the four counties involved in the Hayman fire, Teller, Park, and Douglas do not have any defensible space regulations for wildland-urban fire risks. Jefferson County, on the other hand, does require defensible space but only on homes of sizes greater than 400 ft^2 that were built after 1996. While many of the homes did fit the size qualifications, they were built prior to 1996 and therefore few, if any, fell into this category (Cohen and Stratton, 2003).

[9] In 2002, Colorado experienced the largest wildfire in the states written history, the Hayman Fire. The Hayman fire encompassed 136,760 acres (CUSP, 2003) covering four Colorado counties. During its rage, it destroyed 132 homes out of a potential 794 (Cohen and Stratton, 2003).

FIRE HAZARD AREA

Defensible space recommendations typically advise managing 30 meters around the structure, however, this is not the only area of importance. Many studies also state that the full fire risk area of a structure is the zone from the house edge to 100 meters surrounding the structure (Vicars, 1999; VCFCA, 2000). There are several variables that need to be considered in this area surrounding the home.

In assessing various fire models, its seems that the most important fire danger variables are: dominant vegetation, slope, fuel loading, and fire ignition.

Dominant vegetation is one of the most important aspects in determining fire hazard. The type of vegetation significantly impacts whether a fire will be present and what type of fire and fire risk is possible. There can be no fire without fuel. However, fuel types vary significantly, and therefore some types of vegetation are more flammable than others. For instance, dense conifer forests are ideal conditions for crown fires. Deciduous forests, however, are unlikely to sustain crown fires.

Another variable of significant importance is slope. As stated previously, the steeper a slope, the faster the rate of fire spread. Therefore, a building on a steep slope faces a higher fire hazard than one on a flat slope. This does not mean that there are more fires on steep slopes than flat slopes; it just means that if a home is on a steep slope and a fire is coming towards the home, the chance that the fire will reach the home is significantly greater (Ryan, 1976).

Ryan (1976) studied statistics from Colorado fires (Table 11). This study encompassed 3,840 fires between the years of 1960 and 1973. These fires took place on 10 different national forests in Colorado: Arapaho, Grand Mesa, Gunnison, Pike, Rio Grande, Roosevelt, Routt, San Isabel, San Juan and White River National Forests. Results showed that 89.3% of fires occurred on slopes under a 50 percent grade. He also found that 8.7% of the fires occurred on slopes of 50 to 80 percent in grade and only 2% of the fires occurred on slopes over 80 percent in grade (Ryan, 1976). While these fires did occur prior to 1973, they are representative of Colorado and therefore we feel this information is valid.

Slope	Number of Fires	Percentage of Fires
< 50 percent	3429	89.30%
50 - 80 percent	334	8.70%
> 80 percent	77	2.00%
Total	3840	100.00%

Table 11: Colorado National Forest Fires between 1960 and 1973 by Slope

Another variable of significant importance is recent wildfire occurrence. If a wildfire went through an area in the past few years, wildfire hazard would be low due to lack of fuels. Therefore this will be one of the variables I will use in my model. Since the survey was completed in early 2001, I will focus on fires that occurred in the previous year, 2000. Another important variable is fire ignition. Fire ignition can be naturally caused by lightning, or man-caused, by an instance such as a campfire getting out of control. Ryan (1976) showed that cause of fires differs with elevation (Table 12). He found that in Colorado, between the years of 1960 and 1973, fires less than 1981.2 meters (6,500 feet) in elevation were caused more by man than by lightning (67% to 32%). At the elevations between 1981.2 and 2590.8 meters (6,501 and 8,500 feet), fires were caused more frequently by lightning (62% to 37%) and at elevations above 2590.8 meters (8,500 feet); fires again were caused more by man than by lightning (56% to 43%). From this information, what I see, on average, is that 52% of the time, fire is caused by lightning, while 47% of the time fire is caused by man. However, fires ignited by humans were typically larger than those ignited by lightning. While ignition is an important variable to consider, due to the nearly 50-50 ratio of lightning and man caused ignitions, I will not be using this variable.

	Elevation			
Cause	<1981 meters	1981 – 2590 meters	> 2590 meters	Overall Total
Lightning	32.61%	62.69%	43.82%	52.88%
Man	67.39%	37.31%	56.18%	47.12%

Table 12: Causes of Fire Ignition in CO at Various Elevations from 1960 through 1973

In this paper, I am combining information from three disciplines: fire ecology, resource economics, and spatial modeling. While there have been many studies completed in each of the individual disciplines and including two of the three disciplines, there have not been as many that have combined all three. I will try to mention the ones that I feel are most important to mention.

When combining wildfire issues, economics, and minimal GIS information, two people have completed extensive research in the area: Jeremy Fried[10] and Greg Winter.[11] Their research hypotheses were that people living in an area where wildfire is frequent would be willing-to-pay to reduce their risk of wildfire. Potential participants were located by using a GIS program to create a buffer of 100 square miles around the center of a jack pine forested area known for frequent wildfires. The potential participant homes were all located within this buffer (Fried et al., 1994; Winter and Fried, 1998; Fried et al., 1999; Winter and Fried, 2000).

It was believed that there were three ways that people living in the 100 mile buffer zone could reduce their risk of home burning: mowing the 30 foot defensible space zone around their homes regularly, removing all debris, such as brush piles, from the defensible space zone, and removing all jack pine trees that were adjacent to their homes. Respondents were educated in fire risk reduction to homes. Once education, they were then asked what they felt the probability of fire was in the vicinity and the probability of their home burning. Fried and Winter used these 2 probabilities to calculate fire risk. Respondents were then were asked if they would be willing-to-pay for one and/or two of the risk reductions (Fried et al., 1994; Winter and Fried, 1998; Fried et al., 1999; Winter and Fried, 2000).

Once all information was obtained, they used a logit model to aid in calculation of willingness-to-pay. Variables used included: initial risk level, perceived risk, and property

[10] Jeremy Fried works at the USDA Forest Service in Portland, Oregon.
[11] Greg Winter works at Paul Schissler Associates in Bellingham, Washington.

tax tolerance.[12] Results showed initial risk level, perceived risk and property tax tolerance to have a significant influence on respondent willingness-to-pay. Overall results showed that respondents preferred to reduce property risk themselves than to pay someone to do it in their annual taxes (Fried et al., 1994; Winter and Fried, 1998; Fried et al., 1999; Winter and Fried, 2000).

Higgason (2002) studied survey responses of people living in the Wildland Urban Interface of Colorado. She analyzed fire management preference techniques. Higgason discovered that over 50% of respondents believed that a wildfire would threaten their neighborhood. Of these respondents, less than 47% believed that their home was prepared to survive a wildfire. While a large number of the respondents acknowledged that their home may be affected by wildfire, only 25-50% felt that prescribed fire should be used in their area. Most of the respondents (78-99%) felt that creating defensible space is important (Higgason, 2002).

There was also a study done in 2002 in Arizona by the Behavior Research Center. In this study, 60% of respondents felt that fire prescription was important. Over 85% of respondents also support prescribed burning (Behavior Research Center, 2002).

Another important study was Griffin's (2000) evaluation of prescribed and wildfire burning on deer harvest. This study was conducted for the California Department of Fish and Game as they wanted to learn more information about how they would restore and improve deer habitat. To do this, Griffin overlaid wildfire and prescribed fire polygons as well as elevation, road, and trail information on a hunting zone map. The number of deer killed in each hunting zone helped to represent where deer were located in the area of the Southern California San Jacinto Mountains. Final results showed that prescribed burning has a positive effect on deer harvest, while wildfire did not (Griffin, 2000).

A large percentage of spatial studies of wildfires focus on wildfire patterns. They are typically trying to find a way to predict future wildfire locations by determining areas of high

[12] The question asked how they felt about property tax; was it too much, just right, too little, or somewhere in between?

fire danger. These studies are important for fire managers to not only determine areas of potential high fire danger, but to use this information to manage the areas and prevent possible home losses. According to Chuvieco and Salas, 1996, the critical variable to look at when studying fire systems is vegetation. They suggest vegetation can be determined by analyzing soil, meteorological data, and topography. In this study of fire risk in Spain, they used a 30 meter grid resolution to identify areas of low, moderate, high and extreme fire danger. Seven vegetation types were used to aid in determining fuel levels: litter, brush, dormant brush, brush beneath timber stands, tall shrubs, short grass, and a grass-litter understory. Ignition levels were also considered, as areas where there is more human activity such as roads and recreation areas have a much higher chance of ignition (by humans) (Chuvieco and Salas, 1996).

Vegetation seems to be an important part of fuel hazard calculation. In 2001, Romme et al. created a model to determine wildfire in La Plata County. Using vegetation classifications, they were able to determine three parameters that seem to be key in fire behavior: total potential heat release, rate of fire spread, and flame length. They used GIS along with the fire behavior model "Behave" to create their wildfire hazard assessment and map (Romme et al., 2001).

In 2003, Gentry also used GIS to create several models to estimate fire risk for the Clark County Idaho area. The models he created include: fuel load/vegetation moisture, fuel load/ rate of spread, fuel load/ intensity (heat release), slope/rate of spread, slope/suppression difficulty, aspect/sun position, and ignition source. They found that it was important to weight the structures at risk the most heavily (Gentry, 2003).

More recently, Space Imaging, a satellite imagery based company, received a contract on August 14, 2003 to support fire management planning and fire risk analysis for the Southern Group of State Foresters. This organization includes the U.S. Forest Service in Atlanta, as well as organizations in 13 states: South Carolina, Tennessee, Texas, Virginia, Alabama, Arkansas, Mississippi, Florida, Georgia, Oklahoma, North Carolina, Louisiana, and Kentucky. They will accomplish this task with their Wildland Fire Risk Assessment System

approach. One part of their approach consists of three variables: home roof type, proximity of fuels to roofs, and vegetation type. Roof type consists of composite, shake, and tile. Vegetation consists of six dominant classes: timber, brush, dormant brush and hardwood slash, short grass, closed timber, and chaparral. Once all data layers are entered into a GIS, three buffer zones are created at 27.432, 18.288, and 9.144 meters around the home. Risk is then determined by the fuel hazard of the vegetation and the type of roof. Highest risk would represent a home surrounded by highly flammable fuels that has a wooden shake roof and does not have an adequate (9.144 meters) defensible space (Hendrix and Cohen, 2001; Space Imaging, 2003).

While there have been dozens of other wildfire and GIS related studies completed, I feel that those presented here were most related to what I am accomplishing in this paper. While all the studies are different, there are several important variables that seem to stand out. The first is that vegetation is very important. Vegetation provides me with information on fire hazard as the fuel from each vegetation type has a different fire hazard level. It has also been seen that buffering around homes can help to determine the type of vegetation surrounding the home and its flammability. Defensible space should also be a Priority Zone to consider as it also aids in determining home fire risk in the wildland-urban interface.

METHODS

In this project, I tested the hypothesis that stakeholder opinion of fire is directly related to the fire danger of the area in which the stakeholders live:

$$Stakeholder\ values = f(area\ fire\ danger)$$

Where fire danger consists of both perceived and actual fire danger.

Hypothesis evaluation consisted of two major processes: contingent valuation to determine perceived fire danger and spatial modeling to determine actual fire danger.

CONTINGENT VALUATION

Contingent valuation is a method in which the value of non-market goods is assessed by measuring a person's willingness-to-pay (Ciriacy-Wantrup, 1947). Contingent valuation has been recommended by the National Oceanic and Atmospheric Administration (NOAA) Panel as a legitimate method for non-market good valuation. Information is typically gathered by in-person, phone, or mail surveys (Arrow et al., 1993; Hanemann, 1994; NOAA, 1993).

John Loomis and I created the mail survey entitled, "Managing Fires on Public Lands: What Do You Think?" in 1999. This survey was conducted in the summer of 2001 to obtain contingent valuation information (Loomis and Kaval, 1999). This survey encompassed eight pages of questions and two color pictures (Douglas Fir forest in Colorado one year after a prescribed burn and Douglas Fir forest in Colorado one year after a wildfire) that were inserted into the survey for use with some of the questions. The surveys questions included demographics, willingness-to-pay for various fire prescriptions, and various other questions referring to how people feel about wildfires, prescribed fires, and fire suppression (Refer to "Analysis of Public Perspectives of Wild and Prescribed Fires in Colorado" in this dissertation for more detail).

Survey participants were contacted randomly during the summer of 2001 through numbers in the phone book. Names were selected from various towns in Colorado that are on the border of public lands. The data from 73 respondents were used in this study. These respondents were from Leadville, Nederland, Rollinsville, Estes Park, Masonville, and Red Feather Lakes.

While many of the questions in the survey related to stakeholder opinion, the specific stakeholder questions I will be focusing my attention on include:

11a. If fire prevention would reduce the frequency of a wildfire in the area where you live to half as often as it does now, would you pay an increase of $___[13] a year more in taxes for fire prevention each year?

[13] These blank spaces ($___) on each survey were filled in with values ranging from $5 through $1500. While the dollar amount between participants was different, the values for 11a, 11b, and 13 in any one survey were the same.

11b. If fire suppression would reduce the frequency of a wildfire in the area where you live to half as often as it does now, would you pay an increase of $___ a year more in taxes for fire suppression each year?

13. Using prescribed burning, public land management agencies could reduce the frequency of a wildfire in National Forests and National Parks by half. Would you pay an increase of $___ a year more in taxes for a prescribed burning program such as this?

The yes/no answers to these willingness-to-pay questions are the dependent variables I will be using in the logistic regression models. The independent variables I will be using include perceived fire risk variables.

The two wildfire risk perception questions I will be using include:

3. Are you concerned that a fire on public lands may endanger your home? (Circle One) Yes No
7. Take a look at the wildfire photo. In your opinion, how often does a wildfire such as shown in the Wildfire Photo occur in the are where you live. For example, once every 5 years, once every 10 years, twice a year, etc.
_____Fire Frequency

SPATIAL MODELING

In this project, I used ArcMap, a GIS program, to conduct the spatial analysis of the data. This process consisted of 4 map layers: vegetation, home point locations, slope, and fire locations. The projection and datum for all data layers were unified to UTM Zone 13, NAD83.

The first dataset is the vegetation layer, a fine grained statewide landcover map of Colorado. The Colorado Vegetation Map (COVM) was created at Colorado State University by David Theobald, Nate Peterson and Bill Romme (Figure 13). Data are in raster format as a 30 meter ESRI GRID (Theobald et al., 2003).

I believe that the COVM is currently the best available statewide vegetation map for Colorado as it takes into account elevation, precipitation, slope, aspect, Bailey's ecoregions and soil. A map of a finer grain would be preferred to a 30 meter, however, these are typically only available for National Forests and since I am focusing on private homes, there

would not be enough information available for this project.

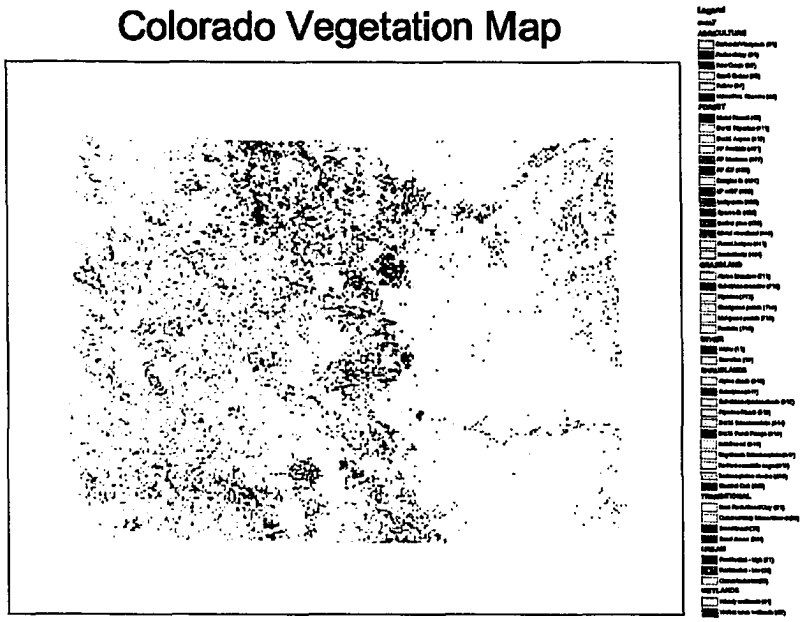


Figure 13: Colorado Vegetation Map

COVM vegetation types were cross referenced with Romme et al., 2001 La Plata County vegetation type to determine fire hazard. COVM vegetation types are presented in Table 13. Romme et al., 2001, vegetation types include urban, open water, tundra, dryland crops, irrigated crops, riparian vegetation, subalpine meadow, foothills/ mountain grassland, deciduous oak, big sagebrush, aspen, spruce fir, Douglas Fir, mixed conifer, juniper, pinyon juniper, and Ponderosa Pine. Use of GIS and Behave (a fire behavior model) aided Romme in calculation of heat release,[14] spread rate,[15] and flame length.[16] I used the average heat release, spread rate and flame length for each of the fuel categories (Table 14).

[14] "Heat release (btu/ft2), an indicator of the total potential damage from a fire, varies with fuel model type and fuel moisture, but is independent of slope and wind (Romme et al., 2001).
[15] "Rate of spread (chains/hour, a chain is 66 feet) is affected by fuel model, fuel moisture, slope and wind (Romme et al., 2001)"
[16] "Flame length (ft) is influenced by fuel model, fuel moisture, slope, and wind. Flame length is often used as a general descriptor of fire intensity and difficulty of suppression: a flame length of four feet is considered the upper limit for hand crews (Romme et al., 2001)."

	COVM Land Cover Types
11	Water
12	Snow/Ice
21	Residential (High density)
22	Residential (Low density)
23	Commercial/Ind./Trans
31	Bare Rock/Sand/Clay
32	Quarries/Mines
33	Transitional
43	Mixed forest
61	Orchard/ vineyards
81	Pasture/ hay
82	Row Crops
83	Small Grains
84	Fallow
85	Urban/Recreation Grasses
91	Woody wetlands
92	Herbaceous wetlands
300	Sand dunes
411	Deciduous Riparian
412	Deciduous Aspen
421	Ponderosa Pine Foothills
422	Ponderosa Pine Montane
423	Ponderosa Pine/Douglas Fir
424	Douglas Fir
428	Lodgepole Pine with Douglas Fir
429	Lodgepole Pine
432	Spruce Fir
435	Limber pine
440	Mixed Woodland
441	Pinyon/Juniper
450	Krummholtz
510	Alpine shrub
511	Subalpine Shrub
512	Subalpine Riparian Shrub
513	Riparian Shrub
514	Deciduous Intermountain
515	Deciduous Front Range
516	Salt desert shrub
517	Sagebrush intermountain
518	Eastern Sandhills sage
519	Eastern Plains Shrub
520	Gambel Oak
711	Alpine meadow
712	Subalpine meadow
713	Riparian Grassland
714	Shortgrass prairie
715	Mid-grass prairie, riparian grassland
716	Foothills grassland

Table 13: COVM Vegetation Types

Vegetation Type	Average Flame Length	Average Spread Rate	Average Heat Release
Urban, Open Water, Tundra	0.000	0.000	0.000
Dryland Crops, Irrigated Crops, Riparian Vegetation, Subalpine Meadow	2.567	23.000	116.000
Foothills/ Mountain Grassland	3.700	10.000	606.000
Deciduous Oak, Big Sagebrush	12.200	23.333	3420.000
Aspen	3.633	7.000	824.000
Spruce Fir, Douglas Fir, Mixed Conifer	3.233	7.667	601.000
Juniper	3.567	3.333	1622.000
Pinyon Juniper	3.633	7.000	734.000
Ponderosa Pine	12.200	17.333	2292.000
Overall Average	7.005	10.535	1289.366

Table 14: Fire Danger Statistics

The second layer in the spatial model consisted of home point locations. To obtain the best available information at respondent home locations, I visited each individual home and obtained the UTM coordinates of the homes with a Garmin Global Positioning System (GPS) unit.[17] In addition, I was able to obtain 9.144 meter (approximately 30 foot) defensible space and general vegetation information.

Defensible space for these purposes meant that either the home was located in a downtown area with no danger of wildfire affecting it or that within the 9.144 meter (approximately 30 feet) zone there were no observed debris on roofs and no woodpiles or other flammable vegetation nearby. Propane tanks were to be located 9.144 or more meters from the edge of the home. Basically, there was a 9.144 meter clearing around the perimeter of the home.

Out of the original 99 data observations collected, 73 were able to be digitized in ArcMap. 27 of the observations were not able to be mapped as post office boxes were the contact information given and therefore home locations were not available.

For part of the GPS locationing, cameras were available. Thirty-four home locations were captured on camera. A Canon Sureshot Waterproof Camera was used for the 4

[17] A special thank you to Derrick Kaval for letting me borrow this for so long.

Leadville homes and a Sony Digital Cybershot captured pictures for 16 Estes Park and 14 Nederland homes. In total, 58 pictures were taken of 34 homes (Figure 14). Also, for the Larimer County locations, I was able to obtain black and white and some color aerial photographs of the homes (Figure 15). This information was provided on CD's from the Larimer County GIS and Mapping Services Department (Larimer County GIS and MSD, 2000 and 2001).

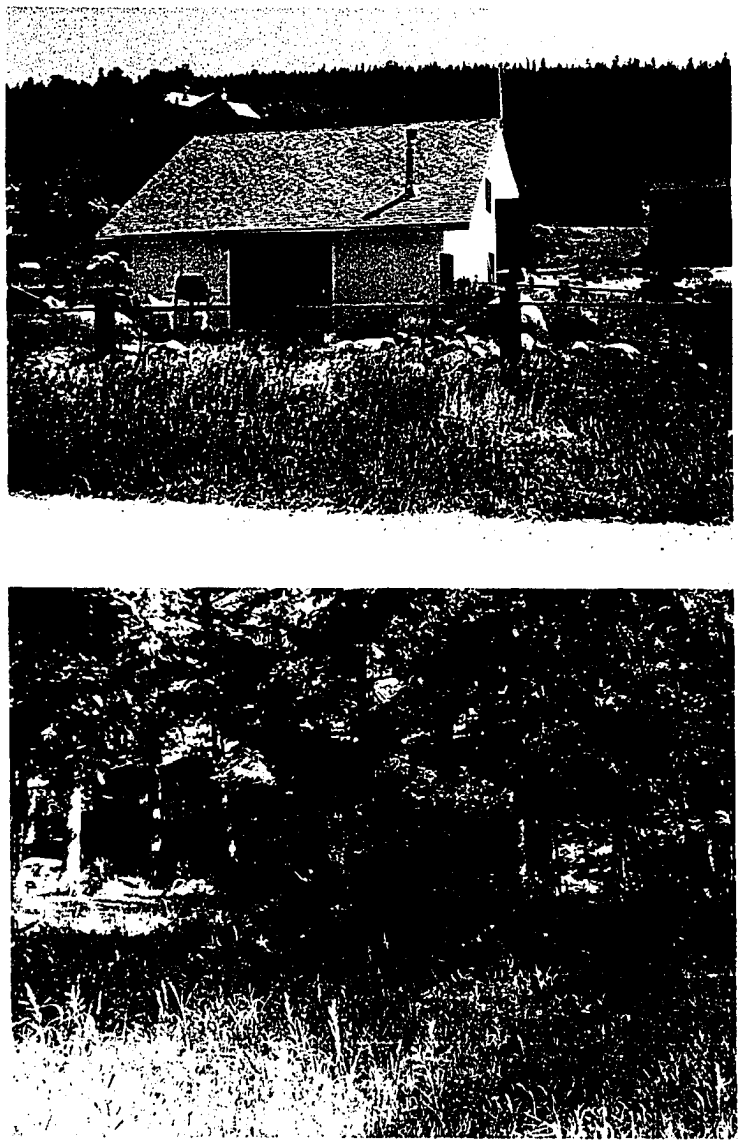


Figure 14: Top: Digital Picture - Home in Nederland, Colorado.
Bottom: Digital Picture – Home in Estes Park, Colorado (Kaval, 2003)

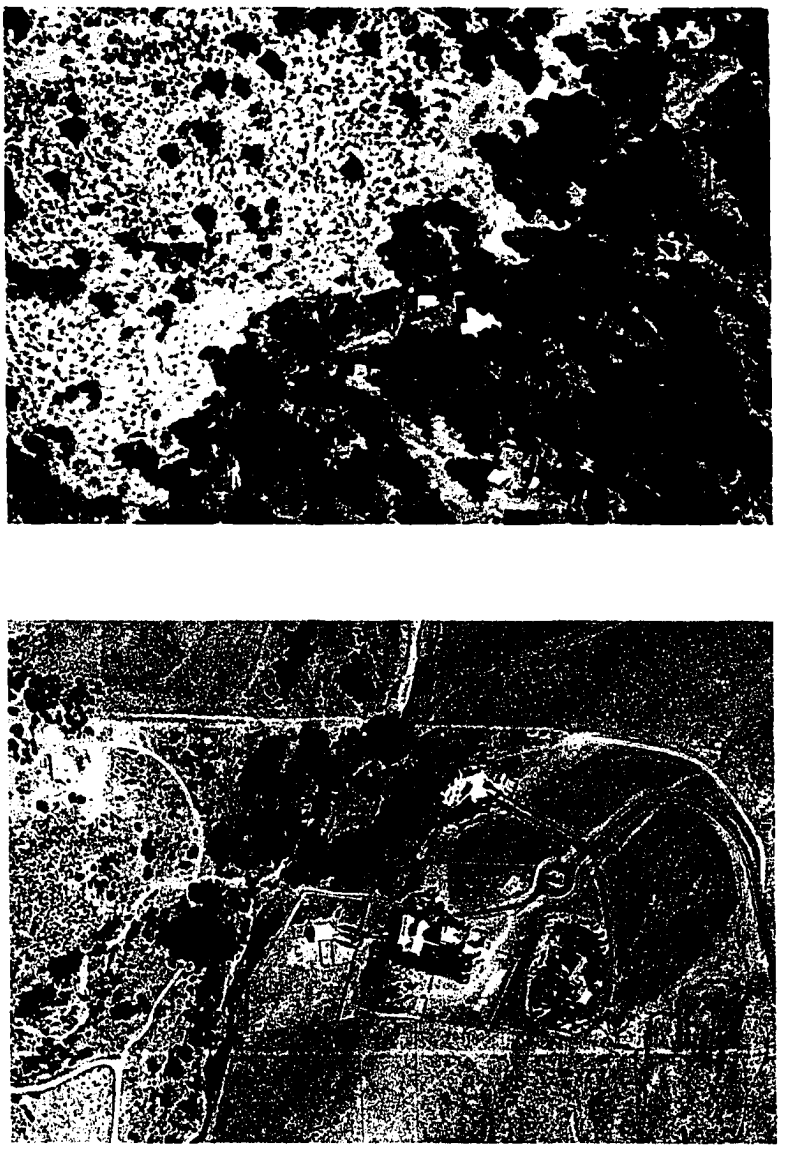


Figure 15: Two Aerial Photographs of Homes in Masonville, Colorado.
(Larimer County GIS, 2001)

With the information from the home visits, digital photographs, and aerial photographs, I was able to determine whether homes had an approximate defensible space of 9.144 meters surrounding the home. Out of the 73 homes, 23 had either the proper defensible space and/or were located in a downtown area where there was no fire danger. This information would be entered into the database where:

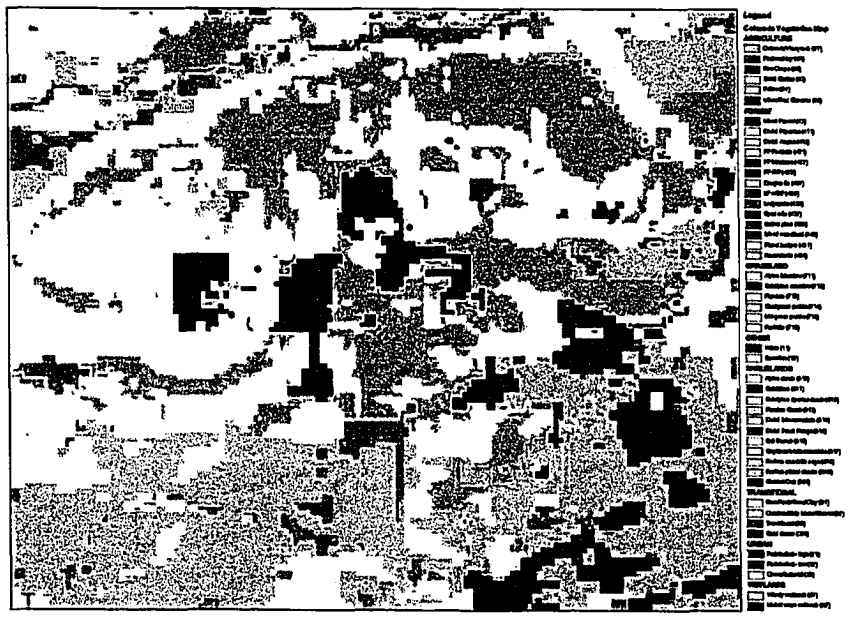
1 = minimum of 30 foot defensible space

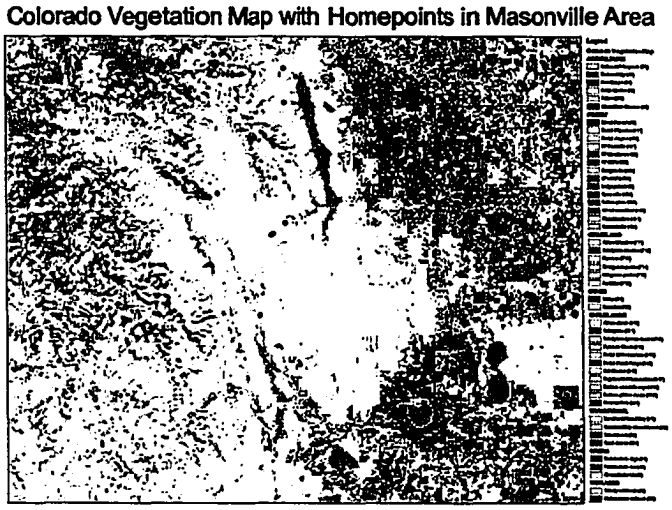
0 = defensible space zone is not adequate to protect home from wildfire.

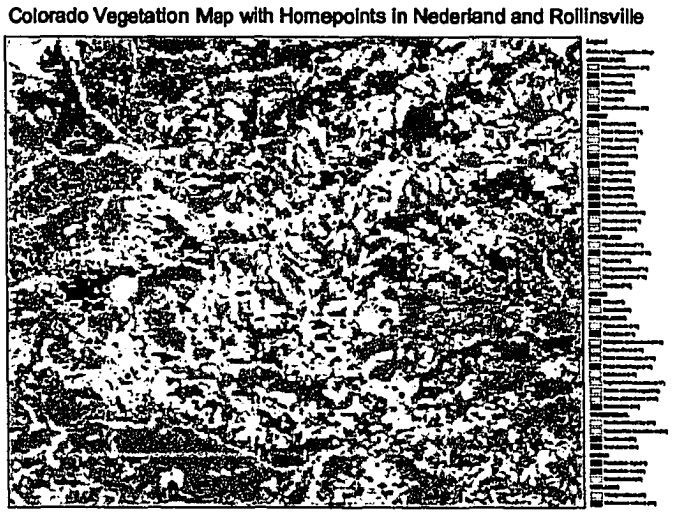
Once UTM information was obtained for the 73 homes, home point locations were entered into an Excel database. The database was then saved as a dBaseIV file and added to ArcMap. In order to plot the points, "display x,y data" was selected in the context menu (Figure 16).

Colorado Vegetation Map with Homepoints in Estes Park

Colorado Vegetation Map with Homepoints in Leadville







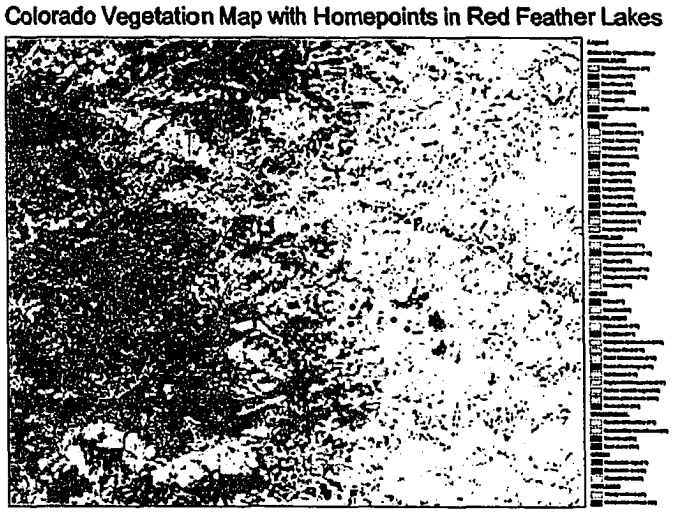


Figure 16: Home Locations Overlaid on Vegetation Map for Five Colorado Towns

The final layer of data was the 2000 Colorado Wildfires. Wildfires for the entire United States were obtained through the Colorado State Forest Service for the year 2000. The fires were polygon shapes in which each fire was saved as an individual shapefile. These shapefiles came to me in the Geographic Projection with units of Decimal Degrees in North American Datum (NAD) 27 before they were converted to UTM Zone 13, NAD83 (Figure 17).

In order to analyze which fires were closest to the homepoint locations, fires from the year 2000 were overlaid on a Colorado County Map provided by Colorado Department of Transportation. Homepoints were also placed on the county map. After evaluating all the fires in the United States, it was shown that the closest fires to all of the home locations were one of the four wildfires that occurred in Colorado and not wildfires in another state. The four Colorado wildfire shapefiles represented the Bobcat Gulch, High Meadow, Bircher, and Pony fires.

There were four major wildfires in Colorado in 2000 that burned over 49,000 acres. Two fires, the Bircher and Pony fires, were located in the Mesa Verde National Park vicinity. The Bircher fire burned approximately 10,600 acres, while the Pony fire burned approximately 5,283 acres. In the Denver vicinity was the High Meadow fire, which burned 10,500 acres and destroyed 51 homes. In the Fort Collins – Masonville area was the Bobcat Gulch fire that burned 10,600 acres and destroyed 22 homes.

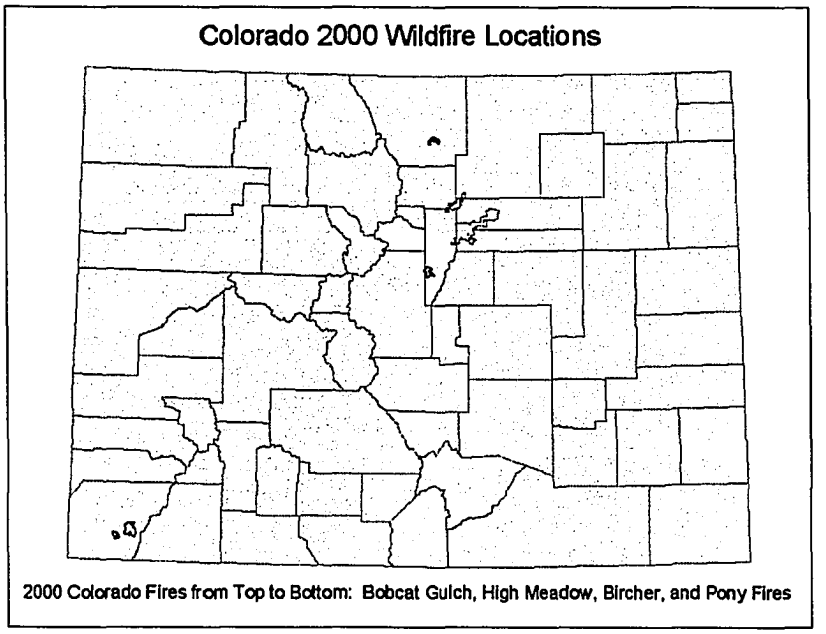


Figure 17: Colorado 2000 Wildfire Locations

THE MODEL

Once all layers were obtained, I was able to collect the spatial data needed for the analysis. The first task using the spatial data was to complete a proximity analysis by measuring the distance from the homepoint to the nearest edge of the nearest wildfire. Note that I did not find any of the respondent's homes to have been in a wildfire.

From the measurements, I determined that the closest home to a fire was in Masonville. This home was approximately 2,145 meters (approximately 1.33 miles) from the perimeter of the Bobcat Gulch Fire. The furthest home was approximately 83,200 meters from the perimeter of the closest fire.

Once measurements were completed, I set out to create buffers around the home datapoints. Originally, I thought that I would create 3 buffers: a 9.144 meter (30 foot) buffer to represent the immediate defensible space zone, 100 meters to represent the recommended defensible space area around a home, and 1609 meters (one mile) to represent actual fire risk. However, since the vegetation map is in 30 meter grids, the number of grid cells in the 30 meter buffer would be such a small number of grid cells, that I did not feel this was adding

enough information. I also felt that since I obtained adequate defensible space information from the on-site visit, I did not need to calculate the 30-foot buffers.

According to defensible space guidelines, the recommended buffer size for the complete home area is 100 meters (328 feet) surrounding the structure. Therefore, the first buffer zone was 100 meters (Vicars, 1999; VCFCA, 2000). It was the belief that people may not only consider the fire danger of the immediate area, but also of the surrounding area as wildfires can travel great distances from where they begin. In order to take into consideration the fire danger of the surrounding area, the second buffer zone was one mile in radius (Figure 18).

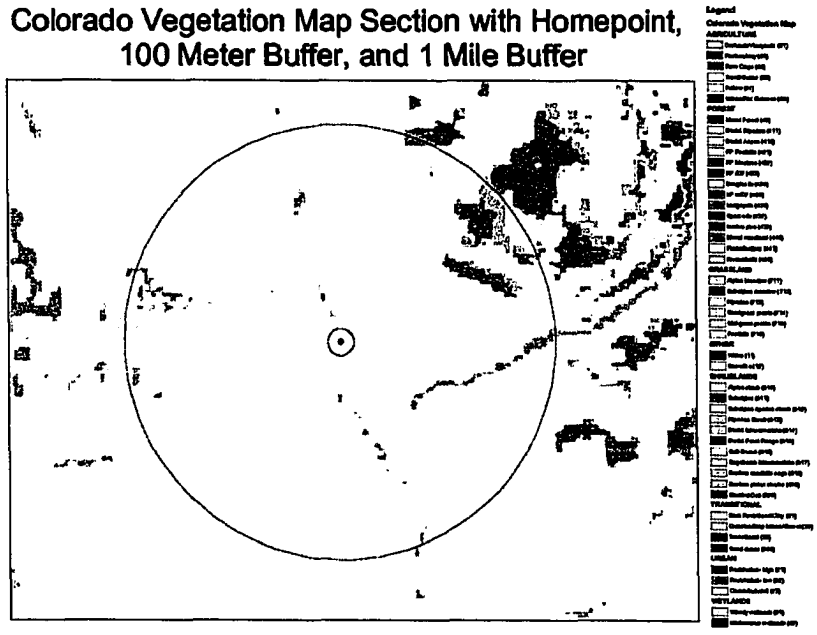


Figure 18: Colorado Vegetation Map Section with Homepoint, 100 Meter Buffer, and 1609 meters (one mile) Buffer

To compute fire hazard of the 100 meter vegetation area, I used the "combine" procedure in the raster calculator in ArcGIS. In order to do this, I first needed to convert the 100 meter buffered polygons to raster data.

Once the 100 meter polygons were converted to grid data, I was able to use the combine procedure. This information yielded both the type of vegetation and how much of the vegetation was located in each home area buffer (i.e., In the 100 meter buffer area for

home #2, 1.8 hectares consisted of Ponderosa Pine Montane, 0.27 hectares was Ponderosa Pine/ Douglas Fir, 0.63 hectares was Lodgepole Pine and 0.36 hectares was Short grass Prairie).

Once this information was obtained, I was able to combine it with Romme's heat release, flame length and fire spread to determine potential wildfire danger. I first did this for the fire danger of the immediate area (100 meter buffer). This yielded 3 variables:

Heat100 – average heat release in the 100 meter buffer

Spread100 – average spread potential in the 100 meter buffer

Flame100 – average flame length in the 100 meter buffer

Then came the more complicated task of determining the danger of the surrounding area. I was able to use the EucDistance information and vegetation information to create a weighted fire danger average. To do this, I weighted the area closest to the home more than the area furthest away from the home. As suggested by Theobald, 0 distance would be weighted as 1, 402 meters (¼ mile) as 0.75, 804 meters (½ mile) as .5, and 1609 meters (one mile) as .25 (Theobald, 2003). For this study, zero distance was the 100 meter buffer zone. This resulted in 3 weighted averages of wildfire danger over a one mile radius surrounding the homepoints:

Avgheat - weighted average of heat

Avgspread – weighted average of spread

Avgflame - weighted average of flame

The next data layer to consider was slope. I was able to obtain a DEM for the state of Colorado (USGS, 2001) (Figure 19). It was a 30 meter ESRI Grid, NAD 1983 UTM Zone 13N, GCS North American 1983. I was then able to calculate slope in percent from the DEM (Figure 20). After layering the homepoints on the slope map, I followed the same procedure as I did for the vegetation to come up with a weighted slope. First I computed the Euclidean distance, made the slope calculations, and then used the weighting procedure (100 meters = 1, 402 meters (¼ mile) = ¾, 804 meters (½ mile) = ½, 1609 meters (one mile) = ¼.)

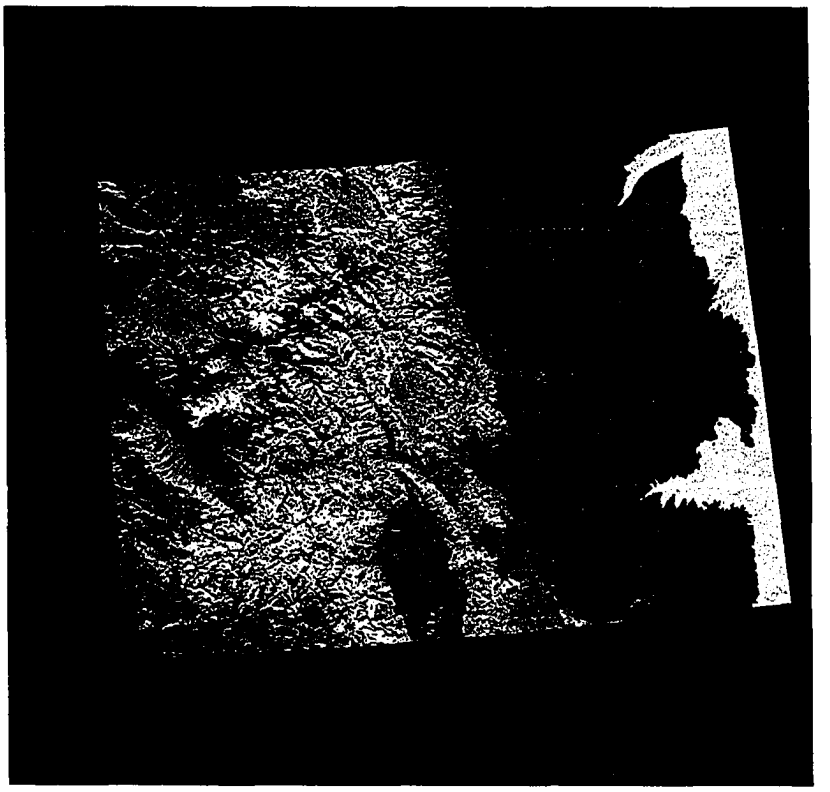


Figure 19: Colorado DEM (USGS, 2001) Note: This is not the picture of the DEM as it was projected or used. This is just one view of the Colorado DEM.

Once these variables were calculated (Table 15), I was then able to create the model. The hypothesis is that stakeholder opinion about wildfire is related to the perceived and actual fire danger of the area in which they live. The model consists of data obtained from the spatial analysis, data from the survey, and calculated variables. In order to test the hypothesis, I will be using a binary dependent logistic model. The logistic model is the most appropriate model to use since the dependent variable is binary where 1= "the respondent is willing-to-pay for the particular activity" and 0 = "the respondent is not willing-to-pay."

I ran 6 logistic regression models: the first three represented willingness-to-pay with perceived fire risk and the second three represented willingness-to-pay for perceived and actual fire risk. The three willingness-to-pay variables are: willingness-to-pay for fire suppression (WTPFS), willingness-to-pay for fire prevention (WTPFP), and willingness-to-pay for prescribed fire (WTPPF). These three variables were coded where 1= "yes, they are willing-to-pay," and 0= "no, they are not willing-to-pay." Again, even if they are not the

most appropriate terms, the definitions in the survey apply to these fire management terms. The independent variables will be: bid, danger, freq, firedist, defspace, heat100, spread100, flame100, avgheat, avgspread, avgflame, and slope.

Variable Name	Description	Expected Coefficient Sign
Bid	Bid Amount for WTP Questions: Varies between $5 and $1500	-
Danger	Whether the respondent feels there is a chance their home will catch on fire (1=yes, 0=no)	+
Freq	Frequency of wildfire reported by respondent. Once every 10 years=10, once every 100 years=100	-
FireDist	Estimated distance in meters from homepoint to edge of closest wildfire in 2000	-
DefSpace	If the home has a 9.144 meter (30 foot) defensible space (1=yes, 0=no)	No expectation
Heat100	Average heat coefficient in the 100 meter buffer area	+
Spread100	Average spread coefficient in the 100 meter buffer area	+
Flame100	Average flame coefficient in the 100 meter buffer area	+
Avgheat	Weighted average of the heat coefficient within a one mile radius around the homepoint	+
Avgspread	Weighted average of the spread coefficient within a one mile radius around the homepoint	+
Avgflame	Weighted average of the flame coefficient within a one mile radius around the homepoint	+
Slope	Weighted average of the slope coefficient within a one mile radius around the homepoint	+

Table 15: Variable Descriptions and Expected Coefficient Signs

I had expectations for the coefficient signs (Table 15). Bid represents the amount the respondent is asked whether they are willing-to-pay. I expect the bid coefficient to be negative because as the bid amount increases, the respondent would be less likely to pay. Distance represents the distance in meters of the homepoint to the closest edge of the closest fire. I expect that as the distance would increase, the respondent would be less willing-to-pay, therefore, I expect a negative coefficient. Frequency or fire interval is the reported frequency the respondent feels fires occur. For instance, if a fire occurs once a year, the frequency is one, whereas if the fire occurs once every 500 years, the frequency is 500. This coefficient is expected to be negative, as the occurrence of a fire takes longer, the respondent is expected to

be less willing-to-pay. Homedanger represents whether the respondent feels their home is in danger of wildfire. I expect this to be a positive coefficient as if there is danger, they would be more likely to pay. I expect the coefficients on spread100, heat100, flame100, avgspread, avgheat, and avgflame to all be positive, because as the fire danger in the immediate and more distant area increase, the respondent should be more likely to pay for a fire management prescription. I also expect the coefficient on slope to be positive because as the slope increases, the fire danger increases and therefore the respondent should be more likely to pay for a fire management prescription.

Prior to running the regressions, I checked the correlations of the variables. Many of them had a high correlation. Therefore, I would not be using all of them in the same model. The two most highly correlated variables were avgflame and avgheat (0.8799) and flame100 and heat100 (0.8738).

RESULTS

THE BASE MODELS

Three base models were run, one each for WTP for fire prevention, fire suppression, and prescribed fire (Equations 1, 2 and 3). Equation 1 represents fire prevention. In this model we see that willingness-to-pay is influenced by whether the respondent feels their home is in danger. If they feel their home is in danger, they are more willing-to-pay for fire prevention.

Dependent Variable: Q11A
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 09/27/03 Time: 16:14
Sample(adjusted): 1 73
Included observations: 62
Excluded observations: 11 after adjusting endpoints
Convergence achieved after 5 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.945305	0.631334	1.497313	0.1343
Q11BID	-0.003599	0.001783	-2.018720	0.0435
Q3DANGER	1.352920	0.670538	2.017662	0.0436
Q7FREQ	-0.017646	0.015025	-1.174391	0.2402

Mean dependent var	0.709677	S.D. dependent var	0.457617
S.E. of regression	0.397108	Akaike info criterion	1.064583
Sum squared resid	9.146291	Schwarz criterion	1.201817
Log likelihood	-29.00206	Hannan-Quinn criter.	1.118464
Restr. log likelihood	-37.35130	Avg. log likelihood	-0.467775
LR statistic (3 df)	16.69847	McFadden R-squared	0.223533
Probability(LR stat)	0.000815		
Obs with Dep=0	18	Total obs	62
Obs with Dep=1	44		

Equation 1: Base Model for Fire Prevention

Equation 2 represents fire suppression. In this model we see that willingness-to-pay is influenced by whether the respondent feels their home is in danger. If they feel their home is in danger, they are more willing-to-pay for fire suppression.

Dependent Variable: Q11B
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 09/27/03 Time: 16:15
Sample(adjusted): 1 73
Included observations: 61
Excluded observations: 12 after adjusting endpoints
Convergence achieved after 4 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.250844	0.580584	0.432055	0.6657
Q11BID	-0.001906	0.001154	-1.651684	0.0986
Q3DANGER	1.172675	0.610534	1.920736	0.0548
Q7FREQ	-0.006625	0.014401	-0.460012	0.6455

Mean dependent var	0.639344	S.D. dependent var	0.484176
S.E. of regression	0.457172	Akaike info criterion	1.284671
Sum squared resid	11.91334	Schwarz criterion	1.423089
Log likelihood	-35.18248	Hannan-Quinn criter.	1.338919
Restr. log likelihood	-39.88147	Avg. log likelihood	-0.576762
LR statistic (3 df)	9.397982	McFadden R-squared	0.117824
Probability(LR stat)	0.024442		
Obs with Dep=0	22	Total obs	61
Obs with Dep=1	39		

Equation 2: Base Model for Fire Suppression

Equation 3 represents prescribed fire. In this model we see that willingness-to-pay is influenced by whether the respondent feels that the frequency of fires near their home decreases or if the infrequency of fires increases, the respondent is less willing-to-pay. For instance, if the frequency is currently once every 5 years and changes to once every 20 years, the respondent will be less willing-to-pay for prescribed fire.

Dependent Variable: Q13PF
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 09/27/03 Time: 16:15
Sample(adjusted): 1 73
Included observations: 61
Excluded observations: 12 after adjusting endpoints
Convergence achieved after 4 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.706499	0.705334	2.419419	0.0155
Q11BID	-0.003093	0.001503	-2.058031	0.0396
Q3DANGER	-0.174931	0.684658	-0.255501	0.7983
Q7FREQ	-0.038058	0.020506	-1.855915	0.0635

Mean dependent var	0.639344	S.D. dependent var	0.484176
S.E. of regression	0.445701	Akaike info criterion	1.223545
Sum squared resid	11.32299	Schwarz criterion	1.361963
Log likelihood	-33.31811	Hannan-Quinn criter.	1.277792
Restr. log likelihood	-39.88147	Avg. log likelihood	-0.546199
LR statistic (3 df)	13.12671	McFadden R-squared	0.164572
Probability(LR stat)	0.004370		
Obs with Dep=0	22	Total obs	61
Obs with Dep=1	39		

Equation 3: Base Model for Prescribed Fire

BASE MODELS + SPATIAL MODELS

The next set of three logistic regressions represent not only the perceived fire danger reported by the respondents, but also the estimated actual fire danger represented by the spatial models. As different variables influenced the various fire management prescriptions, I will be presenting the best models from each of the management prescriptions.

The first model, Equation 4, represents fire prescription. In this model, I find that if the respondent has a defensive space surrounding their home, then they are more willing-to-pay for fire prevention. I also found that if the average heat within the 100 meter area

immediately surrounding the home increases, that the respondent will more likely be willing-to-pay for fire prevention.

Dependent Variable: Q11A
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 09/27/03 Time: 16:16
Sample(adjusted): 1 73
Included observations: 62
Excluded observations: 11 after adjusting endpoints
Convergence achieved after 5 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.685664	1.015069	-0.675485	0.4994
Q11BID	-0.004376	0.001934	-2.263290	0.0236
Q3DANGER	0.919315	0.775733	1.185093	0.2360
Q7FREQ	-0.026122	0.018880	-1.383585	0.1665
DEFSPACE	1.457635	0.875221	1.665448	0.0958
HEAT100	0.001954	0.001200	1.629005	0.1033

Mean dependent var	0.709677	S.D. dependent var	0.457617
S.E. of regression	0.394237	Akaike info criterion	1.054577
Sum squared resid	8.703661	Schwarz criterion	1.260429
Log likelihood	-26.69189	Hannan-Quinn criter.	1.135400
Restr. log likelihood	-37.35130	Avg. log likelihood	-0.430514
LR statistic (5 df)	21.31881	McFadden R-squared	0.285383
Probability(LR stat)	0.000705		

Obs with Dep=0	18	Total obs	62
Obs with Dep=1	44		

Equation 4: Logit Model for Fire Prevention

For the willingness-to-pay for fire suppression, Equation 5, I find a different result. Here the respondent is more willing-to-pay if the weighted average heat measure within one mile surrounding the home increases.

Dependent Variable: Q11B
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 09/27/03 Time: 16:16
Sample(adjusted): 1 73
Included observations: 61
Excluded observations: 12 after adjusting endpoints
Convergence achieved after 5 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-2.142335	1.246112	-1.719216	0.0856
Q11BID	-0.003068	0.001721	-1.782126	0.0747
Q3DANGER	0.479527	0.704729	0.680441	0.4962
Q7FREQ	-0.013070	0.018386	-0.710864	0.4772
DEFSPACE	0.227262	0.645689	0.351968	0.7249
AVGHEAT	0.008110	0.003660	2.215693	0.0267

Mean dependent var	0.639344	S.D. dependent var	0.484176
S.E. of regression	0.447585	Akaike info criterion	1.249938
Sum squared resid	11.01830	Schwarz criterion	1.457565
Log likelihood	-32.12312	Hannan-Quinn criter.	1.331309
Restr. log likelihood	-39.88147	Avg. log likelihood	-0.526609
LR statistic (5 df)	15.51670	McFadden R-squared	0.194535
Probability(LR stat)	0.008368		
Obs with Dep=0	22	Total obs	61
Obs with Dep=1	39		

Equation 5: Logit Model for Fire Suppression

Equation 6 represents the logit model for prescribed or controlled fire. In this model, none of the spatial variables have a significant impact on willingness-to-pay.

Dependent Variable: Q13PF
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 09/27/03 Time: 16:17
Sample(adjusted): 1 73
Included observations: 61
Excluded observations: 12 after adjusting endpoints
Convergence achieved after 5 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.828578	1.169408	0.708545	0.4786
Q11BID	-0.003477	0.001837	-1.892788	0.0584
Q3DANGER	-0.402101	0.763881	-0.526392	0.5986
Q7FREQ	-0.039706	0.021280	-1.865888	0.0621
DEFSPACE	0.364337	0.650482	0.560103	0.5754
AVGHEAT	0.002581	0.003317	0.778093	0.4365

Mean dependent var	0.639344	S.D. dependent var	0.484176
S.E. of regression	0.450664	Akaike info criterion	1.274126
Sum squared resid	11.17038	Schwarz criterion	1.481752
Log likelihood	-32.86083	Hannan-Quinn criter.	1.355496
Restr. log likelihood	-39.88147	Avg. log likelihood	-0.538702
LR statistic (5 df)	14.04128	McFadden R-squared	0.176038
Probability(LR stat)	0.015349		
Obs with Dep=0	22	Total obs	61
Obs with Dep=1	39		

Equation 6: Logit Model for Prescribed Fire

As interpretation of the coefficient in the logit models may be difficult, I converted the coefficients to willingness-to-pay values. To convert logit coefficients to willingness-to-pay values, I divide the coefficients for all values except the bid amount by the absolute value of the bid coefficient (Richardson, 2002). Results of all 6 equations are presented in Table 16.

In Table 16, I find that in the base model for fire prevention (Equation 1) the respondent will increase their willingness-to-pay for fire prevention by $375.92 annually if the respondent feels their home is in danger of wildfire. When the spatial variables are included (Equation 4) in fire prevention, I find that the respondent will increase their willingness-to-pay by $333.10 if their home has a defensible space. I also find that the respondent will increase their willingness-to-pay by $0.45 if the average heat value in the 100 meter area surrounding their home increases.

For the base model (Equation 2) for fire suppression I find that the respondent is willing-to-pay $615.25 more if they feel their home is in danger of wildfire. For Equation 5 that includes spatial variables, I find that the respondent will increase their willingness-to-pay by $2.64 if the weighted average fire danger in the one mile area surrounding their home increases.

For the base model (Equation 3) for prescribed fire I find that the respondents are willing-to-pay $12.30 more if their perceived value for frequency of fire increases. For the model including the spatial variable (Equation 6), I find that the respondent is willing-to-pay $11.42 more if the frequency of fire increases when the average heat and defensible space are also considered.

	Fire Prevention		Fire Suppression		Prescribed Fire	
	Base Model	Base + GIS	Base Model	Base + GIS	Base Model	Base + GIS
C	$262.66	$156.67	$131.61	$698.28	$551.73	$238.30
Q3Danger	**$375.92**	$210.08	**$615.25**	$156.30	$56.56	$115.65
Q7Freq	$4.90	$5.97	$3.48	$4.26	**$12.30**	**$11.42**
Defspace		**$333.10**		$74.07		$104.78
Heat100		**$0.45**				
AvgHeat				**$2.64**		$0.74

*Bold numbers indicate statistical significance

**All Bid Amounts were statistically significant

Table 16: Willingness-to-Pay Amounts

DISCUSSION AND CONCLUSIONS

In 2001, a survey was conducted to see if Colorado homeowners living within 10 miles of public lands were likely to pay for prescribed fires, fire prevention and fire suppression. It was discovered that the respondents were likely to pay for all three of these scenarios. I took this data one step further by adding spatial modeling layers. I layered fire vegetation, fire locations, and home site locations in order to determine fire hazard.

Fire hazard is a difficult variable to calculate as it is constantly fluctuating. It is dependent on vegetation, precipitation, elevation, slope, aspect, ignition sources, location of human residences, and time, to name a few. In order to take into account as many variables

as I could, I chose four layers for the spatial analysis. The four layers included a Colorado Vegetation Map, Colorado wildfire locations for the year 2000, slope calculated from a Colorado DEM (digital elevation model), and locations of the respondents' homes. From this I made several calculations. I measured the distance between fires and respondents homes. I analyzed the vegetation within the immediate area around the home, 100 meters, and the weighted average of fire danger within a 1609 meter (one mile) radius of the home. I also analyzed the weighted average slope within a 1609 meter (one mile) radius of the home. This information enabled me to make fire hazard calculations. Fire hazard calculation in conjunction with on-site calculations of defensible space and survey responses enabled me to come up with a model.

The model tested whether there is a relationship between stakeholder opinion about wildfire and landscape context. In all models (willingness-to-pay for fire suppression, fire prevention, and prescribed fires) I find that as the bid amount increases, the respondent is less likely to pay for the fire management prescription. However, this is where the similarities between all models stops. For the non-spatial model, I found that whether the respondent feels that their home is in danger affects willingness-to-pay for fire prevention and fire suppression. For the prescribed fire model, I find that wildfire frequency has an effect on willingness-to-pay.

For the full model including spatial variables I find that defensive space and the wildfire heat value both have an effect on fire prevention willingness-to-pay. For fire suppression, the average weighted heat value for the area has an affect on willingness-to-pay. For fire prevention, however, only frequency seems to have an effect on willingness-to-pay. This could be because fire prevention is man-caused and wildfire may not be man caused.

As the respondents were selected randomly, they represent people in the Wildland Urban Interface. In the second paper in this dissertation "Analysis of Public Perspectives of Wild and Prescribed Fires in Colorado," I compared whether the respondents were representative of some of the towns. I found that they were an accurate representation of Estes Park, Masonville, and Nederland. Therefore, I feel that this information can be

extrapolated to both the wildland urban interface of Colorado and the towns of Estes Park, Masonville, and Nederland.

In addition, I feel that spatial modeling is a good tool to use when analyzing economic data.

CONCLUSIONS

Three separate papers were created for this dissertation, all relying on survey analysis to investigate how the public values restoring natural ecosystems. In the first study, respondents were asked to state their willingness-to-visit a river after dams are removed. This action would result in a change from the current warm-water lake type ecosystem to a cold-water free flowing river ecosystem. In the past, scope tests were not typically used to evaluate contingent behavior models such as these, they were only used for contingent valuation models. Therefore, to investigate this previously unstudied issue, scope testing was used. In this study, it was found that anglers were more sensitive to recreation changes than the general public.

The second study evaluated public preferences for various fire management prescriptions through two types of questions: willing-to-pay and ladder-of-life. Willingness-to-pay questions are common in contingent valuation studies. However, ladder-of-life questions have only been used a few times in economic studies (Baarsma, 2000). The contingent valuation questions asked respondents whether they would be willing-to-pay for fire prescription, fire suppression, and prescribed fires. In this study it was found that people living near public lands have a high willingness-to-pay for prescribed fire, fire suppression and fire prevention. These values are significantly influenced by perceived fire danger. There were three ladder-of-life questions. The first ladder-of-life question asked respondents how they felt about their lives. The second and third questions asked respondents how their original responses would change if a wildfire (high intensity fire) or prescribed fire (low intensity fire) occurred the vicinity of their homes. The ladder-of-life questions showed that people living near public lands feel good about their lives. However, as the fire management questions may have not been phrased correctly, comparison of the ladder-of-life information and the contingent valuation method was not performed.

In the third study, I was able to combine fire ecology, spatial modeling and resource economics information. This was accomplished by comparing willingness-to-pay values from the Colorado Wildfire surveys with perceived and actual fire dangers collected from spatial modeling. It was discovered that the willingness-to-pay for Colorado residents living near forested areas varied with the type of management technique and the various variables of actual fire danger.

The three studies presented in this dissertation contribute to our understanding of public values toward management actions that attempt to restore natural ecosystems, whether through dam removal or prescribed fire.

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APPENDIX 1:

SNAKE RIVER SURVEY

Removing Dams from the Lower Snake River: What Do You Think?

WHY IS THE SNAKE RIVER IMPORTANT?

The Snake River is one of the largest rivers in the United States. The Snake River is also the largest tributary to the Columbia River.

Historically, these two rivers produced an abundance of salmon and steelhead. The fish were harvested commercially and recreationally. For many Native Americans living in this area, salmon are part of their traditional culture and a major source of food.

Today, dams on these rivers provide large amounts of electricity, barge transportation and reservoir recreation such as waterskiing and motorboating.

Due to many factors including the dams and destruction of habitat, Snake River chinook salmon, sockeye salmon and steelhead populations have fallen so drastically they are now listed under the Endangered Species Act.

As a possible method to aid recovery of these endangered salmon, removal of the four dams on the Lower Snake River has been proposed. We are currently in the process of studying the various effects that dam removal may have on people such as yourself.

This survey asks your opinion about the effects on recreation. Dam removal would replace many existing reservoir recreation activities such as waterskiing with new, river based recreation opportunities such as rafting. The type and quality of fishing would change as well.

WHAT ARE YOUR VIEWS ON MANAGING THE LOWER SNAKE RIVER?

The 140 miles of the Lower Snake River can be managed to provide alternative types of recreation activities. Please circle one number for each question to indicate the importance of these different uses to you.

USES OF THE LOWER SNAKE RIVER FOR	Not Important	Slightly Important	Important	Extremely Important
1. Reservoir recreation such as waterskiing & motorboating	1	2	3	4
2. Reservoir fishing for small mouth bass, catfish & bluegill	1	2	3	4
3. Recreational salmon fishing in the river	1	2	3	4
4. River recreation such as rafting, canoeing & kayaking	1	2	3	4

1. DID YOU VISIT THE LOWER SNAKE RIVER FOR RECREATION IN 1998?
(Circle One)
YES NO (skip two pages to "What are the Recreation Opportunities"---->)

1a. If YES in which of the following activities did you or your household participate?
(please check all that apply during the year)
___Fishing for resident fish ___Fishing for steelhead ___Hunting
___Motorized boating ___Jet skiing ___Waterskiing ___Sailing
___Camping ___Picnicking ___Swimming ___Sightseeing ___Cruise/tour boats

___Other please list_____

1b. Which dams/reservoirs did you or your household visit in 1998?
___ Ice Harbor/Lake Sacajawea ___Lower Monumental/Lake West
___ Little Goose/Lake Bryan ___Lower Granite/Lower Granite Lake

1c. Roughly how long does it take you to travel from your home, one-way to the Lower Snake River site you visit most frequently? _____ Hours

1d. How many recreation trips did you make to the Lower Snake River in 1998?
_____ # of Trips

1e. What was your typical or average cost for a trip to the Lower Snake River in 1998?
(Please include transportation, rental fees, boat gas, camping fees, lodging, food, bait, supplies)
Cost of a typical trip $_____ # of days per trip _____

1f. How many people were covered by these costs? # of people _____

1g. The price of gasoline, lodging and other trip costs often increase. If the cost of visiting the Lower Snake River site where you went most frequently in 1998 had been $_____ per trip higher, would you have still gone there?
(Circle one)
YES---> _____# of Trips at higher cost
NO

2. Did you participate in reservoir or lake recreation elsewhere in 1998?
(Circle one)
NO YES--> About what was the cost of a typical trip to those sites
$_____ (go to Q3).

3. If dam removal eliminated reservoir recreation along the Lower Snake River, would you or other members of your household visit other reservoirs or lakes in the region more often?
(Circle one)
3a. YES-->About how many more trips would you take each year to these other reservoirs or lakes?
_____ # Added Trips to Other Lakes

3b. NO -->In what other recreation activities would you engage in instead of reservoir recreation?
List Activities-->_____

WHAT ARE THE RECREATION OPPORTUNITIES OF NATURAL RIVER CONDITIONS?

Before we ask you whether you would visit the Lower Snake River if the dams were removed, we want to describe what the resulting free-flowing river would be like. Also see the map insert.

What Would the River Look Like?
Dam Sites: The earthen part of the four dams would be removed and the river would flow around the remaining concrete dam structure.
River Canyon: The 140 mile river canyon would be unchanged and is over 1,000 feet deep in places.
River Depths: Minimum river depths would be 4-6 feet during spring, summer and fall.
Islands: Prior to the dams, there were about 70 small islands. These islands will reappear with natural river levels. The islands would provide wildlife habitat as well as potential camping and lunch spots.
Vegetation: Would be re-established along the river and on re-emerging islands over a 5-10 year transition period.

What Would Recreation Access be Like?
Land Ownership: Federal, State and County ownership and management would continue. Generally there are no fees for most activities, except camping at developed campgrounds.

Roads to the river: 30 river segments would be accessible by car. There are several sections of paved road that parallel the river and provide access. (See map insert).
Several 10-20 mile segments of the river would remain unroaded and accessible only by boating or hiking.
Bridges across the river: Two existing paved roads across the middle of the river and existing road access at either end of the river would remain. (See map insert).

Trails: Old road beds and railroad beds in the canyon would re-emerge. Large portions of these would be suitable for hiking, mountain biking and horseback riding along the shoreline.

Boat ramps: 14 of the existing 27 boat ramps would be extended down to the river.

What Recreation Activities Would be Possible?
River Based:
River fishing, rafting, canoeing, kayaking, tubing, drift boats and jet boating would be possible.

Flows: During the high flow months of April to June, the entire 140 miles of river could be floated in boats such as rafts or canoes in about 7 days. During July and August, portions of the river could be floated on a typical weekend.

Rapids: Prior to the dams, the river had 63 named rapids. These were relatively small rapids.
Most of these rapids would return with dam removal.

Land Based:
Currently there are seven campgrounds, offering over 400 individual campsites located in the river canyon. The majority of these campgrounds have running water, flush toilets, tables, shade trees, and electrical hook-ups for RV's. These campgrounds and facilities would remain in place, however, they would be a few hundred feet further to the new river level.

There are also hotels and lodging available in nearby towns of Pasco and Lewiston (see map insert)

What Would the Fishing be Like After Dam Removal and River Restoration?

Resident Fish: Due to loss of reservoirs, catch rates for species such as smallmouth bass would be slightly lower than today, while fishing for species such as yellow perch, bullheads, catfish, and bluegill would be largely eliminated. Sturgeon fishing would improve with natural river conditions.

Steelhead Fishing:
It is expected that fishing for steelhead would improve from current catch rates averaging
1 steelhead for every 24 hours of fishing (3-4 angler days) to 1 steelhead per 14 hours of fishing.

Salmon Fishing:
It is expected that chinook salmon populations will increase to the point where they would no longer be endangered and fishing for chinook salmon in the Lower Snake River would occur each year.
Catch rates of 1 chinook salmon per 30 hours of fishing are expected over a short (20 day) season.

WOULD YOU VISIT THE FREE-FLOWING LOWER SNAKE RIVER?
Please take a moment to think about the material you have just read and look at the map insert of the river, boat ramps, campgrounds and distance to major cities.

1. Given where you live, about how long would it take you to drive to the Lower Snake River?
_____ hours.

2. About how far is that? (refer to map) _____ one-way miles.

3. Given the travel time, the description of the Lower Snake River, and the availability of other free-flowing rivers in the region, would you or other members of your household visit the Lower Snake River if the dams were removed, the river conditions were as described above and if fishing, your expected catch rates would be as listed above? (circle one)

a.Definitely YES b.Probably YES *c.Probably NO* *d.Definitely NO*
(If you circled c. or d. skip two pages to the top of "About You" page ------->)

4. Once the dams are removed and the free-flowing river restored, about how many recreation trips per year do you estimate you or other members of your household would make to the Lower Snake River each year?
_____ Expected # of Trips per year

5. What would be the main or primary activities you or other members of your household would participate in while visiting the free-flowing Lower Snake River.
(Please check all that apply)

___ Fishing for steelhead	___ Fishing for chinook salmon	___ Fishing for resident fish
___ Jet Boating	___ Jet skiing	___ Rafting/Kayaking/Canoeing
___ Sightseeing	___ Camping in Developed sites	___ Primitive camping
___ Picnicking	___ Swimming	___ Hunting
___ Hiking	___ Mountain Biking	

____ Other: _____

6. About how much would you anticipate it would cost you to travel to the place where you would most frequently visit on the Lower Snake River?
(Please include round trip transportation, any rental fees, boat gas, camping fees, lodging, food, bait, supplies).

$_____ per trip ----------> average # of days per trip _____

7. How many people would be covered by these costs?
average # of people _____

8. The price of gasoline, lodging and other trip costs often increase. If the cost of visiting the free-flowing Lower Snake River site where you would plan to go increased by $_____ per trip, would you still go there?

YES----> _____Expected # of Trips per year at the higher cost

NO

9. Do you currently visit other free-flowing rivers? YES NO (go to top of next page)

9a. If YES---> About what was the cost of
a typical trip to those rivers? $_____

9b. If the dams were removed on the Lower Snake River,
would you take fewer trips to these other rivers?

YES---> About how many fewer trips would you take each year to these other rivers?

_____ # of Fewer Trips to Other Rivers

NO

Section V About You

These last few questions will help us in determining how well the returned surveys reflect people living in the region. Your answers are strictly confidential and will only be used for the analysis of this study. You will not be identified in any way.

1. Are you ___ Male ___ Female

2. What is your age? ___ Years

3. Are you retired? (circle one) Yes No

4. What is your zip code?

5. Did you go fishing anywhere in the U.S. in 1998? (circle one) Yes No

6. Do you own a boat or other watercraft?
a. Yes--->Please circle: powerboat fishing boat cruiser jet-ski canoe kayak sailboat
houseboat drift boat jet-boat bass-boat raft float tube
b. No

7. Highest level of formal schooling? (circle one number)

1 2 3 4 5 6	7 8 9	10 11 12	13 14 15 16	17 18 19 20+
(Elementary)	(Jr.High)	(High School)	(College or Technical School)	(Graduate or Professional School)

8. Do you work outside the home? Yes No

9. When you participate in recreation, do you almost always go on weekends, holidays, vacations or other non-work days? (circle one) Yes No

10. How many days per year do you have available for outdoor recreation? _____ days per year

11. Including yourself, how many members are there in your household? #

12. How many contribute to paying the household expenses? #

13. Including these people, approximately what was your household income from all sources (before taxes) last year?

___ less than $10,000	___ $40,000 to $49,999	___ $80,000 to $89,999
___ $10,000 to $19,999	___ $50,000 to $59,999	___ $90,000 to $99,999
___ $20,000 to $29,999	___ $60,000 to $69,999	___ $100,000 to $149,999
___ $30,000 to $39,999	___ $70,000 to $79,999	___ over $150,000

Thank you for completing the survey!
If you have any additional thoughts on rivers, salmon or endangered species, please feel free to write them down on the back cover. When you are finished, please put the survey in our stamped return envelope and mail it back to us.

Thank You for Completing the Survey!

Please feel free to write down any additional comments on endangered species, recreation, reservoirs or river management on the Lower Snake River.

Snake River Survey Project
College of Forestry, Wildlife and Range Sciences
University of Idaho
Moscow, ID 83844-1136

Estimated time to complete this survey is 15 minutes. Send any comments regarding this estimate or any other aspect of this survey to the U.S. Army Corps of Engineers, Northwestern Division, Attn: CENPD-ET-PF, P.O. Box 2870, Portland, OR 97208-2870 or the Office of Management and Budget, Paperwork Reduction 1006-001, Washington DC 20503.

OMB 0710-0001, 9/98

APPENDIX 2:

FIRE SURVEY

Managing Fires on Public Lands:

What Do You Think?

Fire Policy on Public Lands:
We Need Your Input

The Forest Service and National Park Service are in the process of updating their fire management policy and would like your opinions. Your views on this topic are very important to federal agencies as they decide how to manage forests and wildlife in the future. Your answers to this survey will be used as input to federal agencies in the updates of their fire policies.

PLEASE READ AND FILL OUT THIS BOOKLET
PRIOR TO YOUR SCHEDULED PHONE INTERVIEW.

Background:

Fires are an ever-present and natural part of the landscape. In the forests, there are two basic fires that occur: wildfires and prescribed fires (prescribed fires are also called controlled burns).

Wildfires are caused by either natural means such as lighting, or by accidental means such as a cigarette or campfire. Wildfires can burn anywhere from less than an acre to thousands of acres.

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. There are rare instances where prescribed fires may get out of control, however 97% of the time there are no problems.

The Survey

There are no right or wrong answers to this survey. What we want to know is how YOU feel about fires. Feel free to write any additional comments directly on the survey or on an additional sheet of paper.

Please note: we realize most of your homes are near a national forest, park, or other public land. However, some of you may have more than one property you own, perhaps a piece of land you consider a cabin, getaway, or vacation home and one you consider home. If this is the case, please answer these questions according to the property closest to the public land.

1. Have you read or heard about wildfires on National Forests, National Parks or other public lands? (Circle One) Yes No

2. Have you read or heard about prescribed fires or controlled burns on National Forests, National Parks or other public lands?
(Circle One) Yes No

3. Are you concerned that a fire on public lands may endanger your home? (Remember, please refer to your property closest to public lands if you have two pieces of property. Please note that throughout this survey we will just use the term 'home' to represent this property)
(Circle One) Yes No

4a. Is your home located within ten miles of any public lands such as a National Forest, National Park, State Park or County Park?
(Circle One) Yes No

4b. If you answered Yes to 4a, Does your home border a public land?
(Circle One) Yes No

5a. Have you visited any forests in the past five years?
(Circle One) Yes No

5b. If you answered yes to 5a, Have you visited any forests in the past year?
(Circle One) Yes No

What Natural Resources are Important to You?

6a. Do you ever visit public lands? Yes _____ (If yes, go to question 6b and then 6c)
No _____ (If no, go to question 7)

6b. If you visit public lands, what activities do you participate in? Please check all that apply.
___ Hiking or Walking ___ Mountain Biking ___ Swimming ___Camping
___ Fishing ___ Hunting ___Rock Climbing ___ Cross Country Skiing
___ Target Shooting ___Downhill Skiing ___ Snowboarding
___ Motorized Boating ___Wildlife Viewing ___ Wildflower Viewing
___ Non-Motorized Boating___Picnicking ___ Gathering with friends
___ Birdwatching ___Scenic driving (on a paved road)
___ Gathering wood with a permit
___Off Highway Vehicle Driving (such as dirt bikes and ATV's)
___Four wheel driving (such as jeeps and trucks)
___Other (Please specify:_____)

6c. Think about the recreation activities you may have checked off in Question #6b. If there is a fire like the one shown in Wildfire Photo #1 in the area that you do your activity, will you still go there to participate in the activity?
Please check one.
____ Will still go there.
____ Will go there after the area recovers.
____ Will not go there anymore.
____ Will go there less often.
____ Will go there more often.

7. Take a look at photo #1. This is a photo of a 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.

8. There are many reasons people choose to live away from large cities. These may include enjoyment from living in the forests, proximity to recreation and wildlife, and better air quality. However, sometimes there are drawbacks such as driving distances to stores and risk of forest fires.

On a scale from zero to ten, where zero is very unhappy with your life and ten is the best possible life, how would you rate your satisfaction with your life?
Please circle the appropriate number.

0 1 2 3 4 5 6 7 8 9 10
Lowest Life Satisfaction ←----------→ Highest Life Satisfaction

What Natural Resources are Important to You?
Think about public lands you use and enjoy. Please rate the importance of these natural resources and public lands in terms of your use of National Forests, National Parks, State Parks, or County Parks.

Circle One number for each category

	Not Important	Somewhat Important	Very Important	Extremely Important
Vegetation such as Shrubs, Grasses, and Flowers	1	2	3	4
Recreational Use	1	2	3	4
Stream or Lake Water Quality	1	2	3	4
Wildlife Abundance and Diversity	1	2	3	4
Air Quality	1	2	3	4
Forests	1	2	3	4
Wilderness	1	2	3	4
Endangered Species	1	2	3	4
Cultural/ Historic Resources (such as Archaeological or Old Cabins)	1	2	3	4
Scenery	1	2	3	4
Protection of Soil	1	2	3	4
Livestock Grazing/ Rangeland	1	2	3	4

Effects of High Intensity Fire on Natural Resources You Use

Please look at the Wildfire Photo #1. This is a picture of a high intensity fire.
If a high intensity wildfire were to occur in the area by your home, would it have an effect on the natural resources you use? If it has an effect, would it be positive or negative?
Please circle the appropriate answer in the table below based on your experience and use of the forest.

	Beneficial	No Effect	Harmful	Not sure or don't know
Vegetation	1	2	3	4
Recreational Use	1	2	3	4
Stream or Lake Water Quality	1	2	3	4
Wildlife Abundance and Diversity	1	2	3	4
Air Quality	1	2	3	4
Forests	1	2	3	4
Wilderness	1	2	3	4
Endangered Species	1	2	3	4
Cultural/ Historic Resources	1	2	3	4
Scenery	1	2	3	4
Protection of Soil	1	2	3	4

Your Opinion on Wildfire Management

9. Look at Wildfire Photo #1. If a wildfire like the one in Photo #1 occurred half as often in the area you live in, how would you rate your satisfaction with your life in this case? Please circle the appropriate number.

0 1 2 3 4 5 6 7 8 9 10

Lowest Life Satisfaction ←----------→ Highest Life Satisfaction

10. How do you think wildfires like the one in Photo #1 should be handled? (Check One)
___ They should be allowed to burn
___ They should be allowed to burn, but houses and structures should be protected
___ They should be put out

Over the past few years the cost of fighting fires has been rising. Some of the increasing costs include helicopters, fuel, and wages of firefighters. We have also seen that more people are using National Parks and National Forests for recreation. Since the frequency of people using these areas is increasing, there is a greater chance of fire. Thus, the need to protect these public lands is increasing along with the cost to taxpayers such as yourself.

Fire prevention and fire suppression are two methods that can be used to reduce the frequency of wildfires in the area where you live.

11.a. Fire prevention includes removing underbrush and cutting down some standing trees to thin the forest to reduce the chances of a large fire.

If fire prevention would reduce the frequency of a wildfire (Photo #1) in the area where you live to half as often as it does now, would you pay an increase of $30 a year more in taxes for fire prevention each year?
(Circle One) Yes No If no, please tell us why

_____

11.b. Fire suppression includes having larger fire crews on standby and having more fire crews closer to fire prone areas of forests.

If fire suppression would reduce the frequency of a wildfire (Photo #1) in the area where you live to half as often as it does now, would you pay an increase of $30 a year more in taxes for fire suppression each year?
(Circle One) Yes No If no, please tell us why

_____

Effects of Low Intensity Fire on Natural Resources You Use

Please look at Prescribed Fire Photo #2. This is a picture of a low intensity fire.
If a low intensity prescribed fire were to occur in the area by your home, would it have an effect on the natural resources you use? If it has an effect, would it be positive or negative?
Please circle the appropriate answer in the table below.

	Beneficial	No Effect	Harmful	Not sure or don't know
Vegetation	1	2	3	4
Recreational Use	1	2	3	4
Stream or Lake Water Quality	1	2	3	4
Wildlife Abundance and Diversity	1	2	3	4
Air Quality	1	2	3	4
Forests	1	2	3	4
Wilderness	1	2	3	4
Endangered Species	1	2	3	4
Cultural/ Historic Resources	1	2	3	4
Scenery	1	2	3	4
Protection of Soil	1	2	3	4

Your Opinion about Managing Prescribed Fires

12. Look at Prescribed Fire Photo #2. If a prescribed fire like the one in the picture was carried out in the area you live in and reduced the frequency of a wildfire by half, how would you rate your satisfaction with life in this case.
Please circle one number.

	0	1	2	3	4	5	6	7	8	9	10	
Lowest Life Satisfaction	←											→ Highest Life Satisfaction

13. Using prescribed burning, public land management agencies could reduce the frequency of a wildfire (Photo #1) in National Forests and National Parks by half. Would you pay an increase of $30 a year more in taxes for a prescribed burning program such as this?

(Circle One) Yes No

If your answer is no, please tell us why?_____

14. No matter how much control there is, there will always be a small possibility of a wildfire occurring. Using your information on wildfires and prescribed fires, which would you prefer the public agencies to put into practice? (Check One)

___ Have prescribed burns and put wildfires out

___ Have prescribed burns and let wildfires burn

___ Have prescribed burns and let wildfires burn, but houses and structures should be protected

___ DO NOT have prescribed burns and put wildfires out

___ DO NOT have prescribed burns but still let wildfires burn

___ DO NOT have prescribed burns and let wildfires burn, but houses and structures should be protected

___ Other: Please specify: _____

_____

About You

These last few questions will help us in evaluating the representatives of our sample.
YOUR ANSWERS ARE STRICTLY CONFIDENTIAL AND WILL ONLY BE USED FOR THE ANALYSIS OF THIS STUDY. YOU WILL NOT BE IDENTIFIED IN ANY WAY!

1. Are you: ___ Male ___ Female

2. What is your age? ___ Under 18 ___ 18-25 ___ 26-35 ___ 36-45
___ 46-55 ___ 56-65 ___ 66-75 ___ 76 or over
3. Did you vote in the last election? (Circle One) Yes No
4. What is your zip code? _____
5. Are you currently a member of a conservation or environmental organization?
(Circle One) Yes No
6. Is your ethnic background (Circle as many as apply):
   a. Native American Indian b. White or Caucasian
   c. Black or African-American d. Hispanic or Latino
   e. Asian f. Other_____

7. What is the highest year of formal schooling you have completed? (Circle One)
<1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 >21
(Elementary) (Jr. high) (High school) (College or technical school) (Graduate or professional school)
8.a. How many people are there living in your residence? _____ (# People)
8.b. How many people are there in your family or household sharing the same budget?__
8.c. Of these people that share the same budget, how many earned money last year?___

9. Including these people on the same budget, approximately what was your household income before taxes last year? (check one)

___Less than $19,000	___$20,000-29,999	___$30,000-$39,999
___$40,000-$49,999	___$50,000-$59,999	___$60,000-$69,999
___$70,000-$79,999	___$80,000-$89,999	___$90,000-$99,999
___$100,000-$150,000	___$150,000-199,999	___over $200,000

Thank you for completing the survey! If you have any additional thoughts of questions on fire management or this survey, please feel free to write them down on the back cover and tell the interviewer when she calls.

APPENDIX 3:

WILDFIRE AND PRESCRIBED FIRE PICTURES

Wildfire Photo #1

Prescribed Fire Photo #2