The Effects of Fire on Hiking Demand: A Travel Cost Study of Colorado and Montana

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Abstract—*Surveys were conducted on 33 sites within National Forests in Colorado and Montana to test how forest fires affected recreation demand in the two states. Data were collected on the actual number of visits and on the intended number of visits if the area had been subject to a recent high intensity crown fire, a recent prescribed fire, or an old crown fire (all depicted in photos). A travel cost model was estimated by pooling actual and intended visitation responses in both states. Results indicate that Montana hikers take slightly more trips but have lower net benefits or consumer surplus ($12 per trip) than do Colorado visitors ($55 per trip). Also, the demand functions do not react similarly to prescribed fires. Whereas annual values in Colorado increase over time, there were no significant changes in visitation or net benefits for Montana respondents. However, demand functions do react similarly in response to crown fires, resulting in a decrease in visitation and value over time. This latter result provides evidence in support of increased fuels management as outlined by the National Fire Plan.*

Introduction

Fire managers and recreation managers need cost-benefit information to determine the most effective and efficient fuels management techniques, such as mechanical treatments or prescribed burning. In addition to using accounting costs, a complete economic analysis should include social costs and benefits associated with fire. For example, it may appear that prescribed burning is more cost effective than mechanical treatments given the accounting costs per acre. If burning generates significant negative social impacts in the way of increased health costs from smoke and diminished aesthetics, the economic cost of burning may be higher than the cost of mechanical treatments. It is important to incorporate social values when determining fire management methods, particularly in high-use recreation areas. However, this is difficult given that there are little data available to estimate fire effects on nonmarket amenities.

While a few past research efforts have been conducted to assess the effects of fire on recreation (Englin et al. 1996), much of this work has been in Canadian boreal forests or does not include effects on popular activities including hiking and mountain biking. Furthermore, there is little quantitative information available for fire managers to evaluate the differential effects that wild and prescribed fire have on recreation visitation and values. Several studies have been done that indicate fire effects cause decreases in aesthetic value. Vaux et al. (1984) used the Contingent Valuation Method (CMV) to estimate the economic effects of burned areas on recreation. Results indicated that higher intensity fires negatively affected recreation values. Flowers et al. (1985) conducted similar research with respect to the northern Rocky Mountains

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and determined that there was no clear consensus regarding the treatment of fire duration. Englin et al. (1996) and Boxall et al. (1996) used the travel cost method to assess changes in value on canoeing in Manitoba, Canada. The travel cost method (TCM) was used by Loomis et al. (2001) to evaluate fire effects on hiking and biking in Colorado. They found that there were differential effects on hiking and biking visitation as a result of different fire ages and the presence of crown fires. Similarly, consumer surplus for bikers was indirectly affected by crown fire. Finally, Englin et al. 2001 provide a comparative analysis of fire effects over time in the Intermountain West.

The Colorado survey was replicated in Montana and comparisons were made between states to test whether results are generalizable between states. Therefore the same survey and survey methodology were used to test the differences in fire effects on recreation between Montana and Colorado. Because the survey was designed to estimate demand for recreation in National Forests based on actual trips taken and contingent behavior based on three fire scenarios, the Lolo, the Bitterroot, the Flathead, and the Helena National Forests in Montana were used. The survey instrument was identical except for years trips were taken. An overview is provided of the methodology used in both states, followed by a discussion of the model and hypotheses. Finally, results of the regression models and findings are presented.

Methodology

The travel cost method (TCM) was used to estimate the demand for recreation in Montana as based on the survey by Loomis et al. (2001) conducted in Colorado. Using the resulting demand curve, consumer surplus or net benefits per individual, per trip can be calculated by integrating the area under the demand curve. Actual and hypothetical trips were measured as a function of site characteristics including elevation and species, as well as fire characteristics including the presence of a crown fire, fire age, and percentage of burn observable from the trail, demographics, and travel cost information.

Travel cost data included the cost of gas, camping, and other travel related expenditures. The treatment of travel time is often problematic in the TCM. Omitting travel time can lead to specification errors and an underestimation of the true value of the recreation trip (Allen et al. 1981). A traditional solution to this problem has been to value travel time as a fraction of the wage rate and add it to the monetary cost of travel to create one composite variable. This approach is taken here. To minimize the multicolinearity of travel cost and travel time, travel time is multiplied by 40% of the respondent's wage rate. This approach is used by federal agencies in TCM (U.S. Water Resources Council 1983). Thus the travel cost variable and hence consumer surplus will not exhibit omitted variable bias, but it should not be strongly influenced by the particular value of travel time chosen.

A count data specification of the TCM demand model is employed since the number of trips taken (whether actual or intended) is a non-negative integer. Typical count data specifications include the Poisson and Negative Binomial (Creel and Loomis 1990). These count data models are equivalent to a semi-log of the dependent variable functional form.

Fire Effects TCM

To test differences between Colorado and Montana, a pooled interaction model is used with intercept shifters and slope interaction terms for Colorado observations. The model is specified by equation 1.

$$\text{TRIPS} = \beta_0 + \beta_1(\text{Respondent's age}) + \beta_2(\text{Burn observed}) + \beta_3(\text{Crown fire}) + \beta_4(\text{Time since prescribed fire}) + \beta_5(\text{Time since crown fire}) + \beta_6(\text{Elevation}) + \beta_7(\text{Travel cost}) + \beta_8(\text{Acres}) + \beta_9(\text{Actual vs. hypothetical trips}) + \beta_{10}(\text{Income}) + \beta_{11}(\text{Gender}) + \beta_{12}(\text{Lodgepole pine}) + \beta_{13}(\text{Group size}) + \beta_{14}(\text{Travel time available}) + \beta_{15}(\text{Value of aging prescribed fire}) + \beta_{16}(\text{Value of crown fire}) + \beta_{17}(\text{Colorado}) + \beta_{18}(\text{Travel cost for Coloradoan}) + \beta_{19}(\text{Crown fire in Colorado}) + \beta_{20}(\text{Time since prescribed fire in Colorado}) + \beta_{21}(\text{Time since crown fire in Colorado}) + \beta_{22}(\text{Value of recovering prescribed fire in Colorado}) + \beta_{23}(\text{Value of crown fire in Colorado}) + \beta_{24}(\text{Dirt road access}) + \beta_{25}(\text{Value of aging crown fire}) + \beta_{26}(\text{Value of aging crown fire in Colorado}) \quad [1]$$

Model variables and definitions are given in table 1.

Table 1—Model variables and descriptions.

Variable	Description
Trips taken	Trips planned and trips taken by the respondent.
Acres	Size of fire in acres.
Age	Respondent's age.
Burn observed	Percentage of fire observable on trail.
Crown fire	crown fire = 1, no crown fire = 0.
Time since prescribed fire	Number of years since low intensity fire.
Time since crown fire	Number of years since stand replacing wildfire.
Dirt road	Access was on dirt road = 1, otherwise no = 0.
Elevation	Trailhead elevation above sea level.
Travel cost	Individual share of travel costs plus value of travel time to site.
Actual vs. hypothetical	Actual trip taken = 0, intended trip = 1.
Income	Household income of survey respondent.
Gender	Male = 1, Female = 0.
Lodgepole pine	Lodgepole pine present = 1, other species = 0
Group size	Number of people in group.
Travel time available	Total time available for non-winter vacation (weekends plus paid vacation).
Value of aging prescribed fire	Interaction between travel cost and fire age to test whether individual net benefits per trip changes as prescribed fires recover.
Value of crown fire	Interaction variable between total cost and crown fires to test the effects of crown fires on individual net benefits.
Colorado	Colorado respondent = 1, Montana respondent = 0.
Travel cost for Coloradoan	Interaction between Colorado and travel cost to test differences in individual net benefits between Colorado and Montana respondents.
Crown fire in Colorado	Interaction between Colorado and Crown fire to test how crown fire influences trips taken in Colorado.
Time since prescribed fire in Colorado	Interaction between Colorado and time since prescribed fire to test how trips differ according to fire age.
Time since crown fire in Colorado	Interaction between Colorado residents and areas recovering from crown fires to test how the number of trips taken changes.
Value of crown fire in Colorado	Interaction variable between total cost, crown, and the dummy for Colorado to test the effects of crown fires on consumer surplus for Coloradoans.
Value of recovering prescribed fire in Colorado	Interaction between Colorado, total travel cost, and areas recovering from prescribed fire to test whether individual net benefits change.
Value of aging crown fire	Interaction between travel cost, presence of a crown fire, and fire age to test how value changes in response to recovering crown fires.
Value of aging crown fire in Colorado	Interaction between travel cost, presence of a crown fire, and fire age to test how value changes in Colorado in response to recovering crown fires.

The model is specified to calculate consumer surplus and to indicate whether fire effects have an influence on visitation and value of trips taken, and how this differs between Colorado and Montana. Consumer surplus is the area under the demand curve between current travel cost and the choke price that reduces trips to zero. Because a count data model is used which is equivalent to a semi-log demand function, consumer surplus is calculated as $1/\beta_{\text{Travel Cost}}$ (Loomis et al. 1999). To calculate the consumer surplus per trip for individual Colorado trips, the coefficient for the interaction term is included, which is specified by equation 2.

$$1/(\beta_7 + \beta_{18}) \quad [2]$$

To test the effects of fire age on consumer surplus we combined travel cost variables with time since prescribed fire for both Montana and Colorado. Specifically, if fire age has an effect on the price slope of the demand curve, the coefficient β_{15} will not be equal to zero. Equations for consumer surplus per trip for Montana and Colorado are given by equations 3 and 4.

$$1/(\beta_7 + \beta_4 * \textbf{Time Since Prescribed Fire}_t) \quad [3]$$

$$1/((\beta_7 + \beta_{18} + (\beta_4 * \textbf{Time Since Prescribed Fire}_t) + (\beta_{22} * \textbf{Value of Recovering Prescribed Fire in Colorado})) \quad [4]$$

T-tests are used to test whether there are significant positive or negative effects of the fire variables. Specifically, time since fire age, presence of a crown fire, and time since crown fire, crown fire in Colorado, time since prescribed fire in Colorado, and time since crown fire in Colorado are of interest. Finally, regression results are used to estimate the effects of fire on value per day and the number of trips taken over time. We note that our demand model does not explicitly include a variable for the price or travel cost to substitute sites. Therefore the absolute value of our estimates of visitor net benefits may be overstated.

Data Collection

Sample Design

Three National Forests in Colorado were selected that provided a sample of the possible combinations of fire age and acres burned and were logistically functional to sample. The Arapaho-Roosevelt, Gunnison-Uncompaghre and Pike-San Isabel National Forests were chosen. This provides two Front Range National Forests and one interior National Forest. Four National Forests in Montana were selected for this study based on fire history and recreation use. They include the Bitterroot National Forest, the Flathead National Forest, the Lolo National Forest, and the Helena National Forest. Each forest included areas that experienced fire in 2000 and areas without fire to be used as control sites. The mean fire size was 27,000 acres while the median fire size was 1,200 acres. With respect to fire age, the oldest actual fire was 24 years old and the newest, one year. Sites sampled that were not affected by fire were coded as –50 years.

Sampling occurred over 35 days during the main summer recreation season in Colorado in 1998. A total of 10 sites over the three National Forests were sampled. This schedule generally allowed one sampling rotation of two days (one weekday and one weekend day) at nearly all recreation sites during July and August. Twenty-two Montana sites were sampled for a total of 25 days in 2000. Because of fire activity in the Bitterroot Valley, and in Montana in

general, all recreation areas were closed for use. Prior to closure, sampling occurred over 11 days. After fire restrictions were relaxed, sampling continued an additional 14 days. The survey was concluded in 2001 after all surveys were distributed. Sampling occurred over 34 days between June and August inclusively and was conducted on both weekdays and weekends in both years.

Survey Protocol and Structure

The interviewer intercepted individuals at each trailhead as respondents were going to or coming from the trails. The interviewer introduced herself and gave her university affiliation and purpose. Respondents were told they could complete the survey on site, or take it home and mail it back in a postage paid return envelope included in the package. Surveys were disseminated to individuals 18 years or older.

Respondents were asked to provide their primary recreation activity and important attributes of the site. Next they were asked to provide travel time, travel distance, and travel cost to the site. Travel cost included gas cost only. Individuals were then asked to provide the number of trips taken to the site, as well as planned trips for the remainder of the year. Finally, respondents were asked how their visitation might change if the cost of their trip increased.

The following section of the survey presented three fire scenarios using color photographs of the following:

- High-intensity crown fire: blackened, standing trees with little greenery.
- Light prescribed burn: underbrush burned, trees burned on the lower portion of the trunk, reddish needles on lower branches, green needles on the majority of the trees.
- High-intensity 20-year-old burn: standing dead trees, white trunks, downed trees mixed with new greenery.

Contingent trip behavior analysis was based on photos that depicted trails in such conditions. Respondents were asked how their visitation to each site would change if half the trail resembled the photo. This enabled efficient conveyance of the effects that high-intensity crown fires, prescribed fires, and older burns have on recreation demand.

Contingent behavior was also assessed based on price using increased trip costs ($3, 7, 9, 12, 15, 19, 25, 30, 35, 40, and 70). Respondents were asked to record the number of trips they would take if travel costs were increased. This provided additional price variability to supplement the natural variability in travel costs due to different originations.

Site characteristics were included to control for variability among sites. Attributes were chosen based on those that were significant in past forest recreation studies (Englin et al. 1996). Site characteristics included elevation, elevation gained on trail, miles of dirt road with respect to access, and the number of recreation activities occurring on the site. Fire history information included fire age, size of burn, and intensity. Finally, vegetation type and the presence of water was recorded.

Results

In Colorado, there were 14 refusals out of 541 contacts made. A total of 527 surveys were handed out. Of these, 354 were returned after the reminder postcard and second mailing to non-respondents for an overall response rate

of 67%. The total number of contacts made in Montana was 1,074 of which there were 24 refusals. In total, 1,050 surveys were disseminated, and 559 were returned after first and second postcard reminders were mailed. The overall response rate was 53%.

Of the visitors in Colorado sampled at the trailheads, 59% were hiking and 30% were mountain biking. The remainder of visitors (11 percent) were horseback riding or on motorized vehicles. Of the visitors to the 22 sites in Montana, approximately 78% were hiking, camping, and sightseeing. The next largest categories were biking at 10%, fishing at 7%, and swimming and water related activities at 5%. Only hikers and mountain bikers from each state were included in the analysis for consistency.

In Colorado, visitors drove an average of 77 miles (one-way) and their share of the gasoline costs was $12. In Montana the average distance traveled was 98 miles (one-way) and the average individual cost of gasoline was $9.50.

The demographics of the Colorado sample indicated that 44% of respondents were female, and that the sampled population had an average age of 36.5 years and education level of 16.3 years. The typical household earned $67,232. Demographics for Montana indicated that 49% of respondents were female, the sampled population had an average age of 39 years and education level of 16.0 years. Average household earnings were $55,135. Averages for Colorado and Montana are summarized in table 2.

Table 2—Descriptive statistics of travel survey for Colorado and Montana.

Variable	Colorado	Montana
Trip characteristics		
Travel distance (one way)	77 miles	98.6 miles
Average gas cost per respondent	$12	$9.50
Hikers	59%	77%
Other	41%	23%
Demographics		
Percent females	44%	49%
Age	36.5 years	39 years
Education	16.3 years	16 years
Household income	**$67,232**	**$55,135**

Significant fire variables are displayed in table 3; the model is significant with a p-value of 0.000. The model has an adjusted R-squared value of 25%. There is a significant difference between trips taken in Montana (10 per individual per site) and trips taken in Colorado (7 per individual per site).

Travel cost including the value of travel time is also negative and significant for Montana at $p < 0.01$. Surprisingly, total time available for travel had a negative effect on the number of trips taken and was significant at $p < 0.01$. With respect to site characteristics, LP (lodgepole pine) had a significantly negative effect on the trips taken whereas site elevation was positive and was significant at $p < 0.01$. While aspen, Douglas-fir and ponderosa pine were also evaluated, they were highly correlated with lodgepole pine and therefore omitted from the model. As expected, the coefficient on dirt road access was negative indicating that people take fewer trips if access is not paved. The Actual-Hypothetical variable was positive and significant indicating that respondents overstated the number of trips they would take indicating hypothetical bias for contingent behavior estimates versus the number of actual trips taken.

Table 3—Significant Montana and Colorado fire variables. (Trips = dependent variable.)

	Coefficient	Significance (p)
Acres	-0.0000	< 0.00
Crown fire	0.2107	< 0.00
Time since prescribed fire	-0.0036	< 0.00
Time since crown fire	0.0106	< 0.00
Travel cost	-0.0866	< 0.00
Value of crown fire	0.0002	< 0.00
Value of recovering crown fire	0.0003	< 0.11
Coloradoan	-3.4067	< 0.00
Travel cost for Coloradoan	0.0683	< 0.00
Time since prescribed fire in CO	-0.0155	< 0.00
Crown fire in Colorado	-0.1176	< 0.16
Time since crown fire in CO	-0.0005	< 0.20
Value of recovering crown fire in Colorado	0.0005	< 0.08
Value of crown fire in Colorado	0.0113	< 0.03
Value of recovering prescribed fire in Colorado	-0.0002	< 0.00
R-squared		26%
Adjusted R-squared		24%

Significant demographic variables include income ($p < 0.01$) and gender ($p < 0.01$), which were negative, and group size ($p < 0.01$) and respondent's age ($p < 0.01$), which were positive. As income increases, the number of hiking trips taken tends to decrease. The negative coefficient on gender indicates that females take more trips. The positive coefficient on age indicates that older people take more trips. Surprisingly, group size was positive indicating that larger groups take more trips.

Consumer surplus

Using the coefficient for travel cost (TC), the consumer surplus per trip for Montanans is $11.54 with a 95% confidence interval of $10.89 to $12.28. Using the coefficients for travel cost and the interaction variable between Colorado and total cost to calculate the consumer surplus per trip, the average net benefit for Coloradoans was $54.59 per individual per trip with a 95% confidence interval of $33.79 to $141.94. These results are similar to other studies such as Walsh et al. (1992), who estimate the national average value of hiking to be $29, and Rosenberger and Loomis (2000), who updated the Walsh study arriving at a value of $37.

The effects of fire age on consumer surplus were tested using the value of recovering prescribed fire in Montana and Colorado. Change in consumer surplus was significant in Colorado. As prescribed fires recover, net benefits per individual in Colorado increase. For example, a 25-year-old fire would result in consumer surplus of $89, and for a 50-year old fire, consumer surplus increases to $242. While the value of a recovering prescribed fire was significant in Colorado ($p < 0.01$), the value of recovering prescribed fires in Montana was not significant indicating that consumer surplus in Montana is not affected by time. The increase in annual value for Colorado is 346% over 50 years, whereas over the same time frame, the increase in annual value in Montana is 1.7%. Changes in visitation and value are shown in table 4.

Alternately, the economic effects as a result of a crown fire were statistically significant for both Montana and Colorado, yet the difference in visitation between states was not significant. Given a crown fire, annual individual benefits decrease in Montana by 86.7% and 69.3% in Colorado. These results are statistically significant, and have implications from both policy and management perspectives.

Fire effects

The time since prescribed fire had a slightly positive effect on visitation in Montana and Colorado, and was significantly different between states ($p < 0.00$). However, absolute differences are small enough to have no policy implications when considered alone. For example, trips taken in Montana increases from 11.25 with no fire, to 11.34 with a 25-year-old fire. For a 50-year-old fire, the average number of trips increases to 11.45. Over the same period, trips taken in Colorado increases from 10.28 to 10.30 and 10.33. Thus, the outward shift of the demand curve over the fire recovery interval indicates a very small increase in visitation.

Table 4—Visitor use and benefits with fire age.

Prescribed fire	**0 years**	**25 years**	**50 years**	**% change**
Colorado				
Trips	10.28	10.30	10.33	
Value	$54.59	$89.10	$242.20	
Annual value	$561.18	$917.61	$2,501.92	+346 %
Montana				
Trips	11.28	11.30	11.45	
Value	$11.54	$11.54	$11.54	
Annual value	$130.17	$130.40	$132.13	+1.7%
Crown fire	**0 years**	**25 years**	**50 years**	
Colorado				
Trips	10.28	10.28	10.28	
Value	$54.59	$25.66	$16.77	
Annual value	$561.18	$263.78	$172.40	-69.3%
Montana				
Trips	10.25	9.98	9.71	
Value	$11.54	$2.83	$1.62	
Annual value	$118.28	$28.24	$15.73	-86.7%

The presence of a crown fire was positive and statistically significant ($p < 0.00$), yet there was no difference between states. Trips in Colorado increase from 10.28 to 11.38 given a crown fire, and from 10.25 to 11.48 in Montana. The effect on visitation of time since crown fire was negative and significant for both states ($p < 0.01$). The interaction term indicates that older crown fires receive fewer visits than newer crown fires. Trips to areas with crown fires that are 25 and 50 years old decrease slightly from 9.98 to 9.71 in Montana with no change in Colorado. This may be explained by the initial interest in seeing effects of severe fires.

Conclusion

The average number of individual trips taken per site in a no-fire situation in Colorado was 10.28 with individual net benefits per trip of $55. The number of individual trips taken per site in Montana was similar at 10.25 with individual net benefits of approximately $12.

With respect to fire effects, findings indicate that wild and prescribed fires have varying effects on recreation demand and value in each state. When visitation and value are considered in conjunction, however, prescribed fires result in increased annual values in Colorado (346%). While this is significant, the change in Montana is not (1.7%). Alternately, crown fires in both states result in decreased annual values of 69.3% in Colorado and 86.7% in Montana. While respondents in each state do not behave similarly with respect to prescribed burning, these results provide support for the National Fire Plan (USDI/USDA 2002). In Colorado, prescribed burning not only increases the annual value of recreation over time, but may mitigate increasing social costs resulting from crown fires. In Montana, whereas prescribed fire does not increase value over time, it may have value in terms of mitigating the negative effects on annual recreation values as a result of crown fires.

Because of the rapid pace of education in natural resources, particularly with media coverage of fire, it would be useful to conduct the same survey in the future to test differences over time. While results may be used to generate the social costs of prescribed fires, such costs may fall over time with education and increased knowledge, and may have a different pattern in other states.

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