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Comparing the economic effects of fire on hiking demand in Montana and Colorado

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Abstract

We conducted surveys on 33 trails within National Forests in Colorado and Montana to test whether forest fires affected recreation demand. Data were collected on actual and intended number of visits. A count data travel cost demand model was estimated by pooling actual and intended visitation responses in both states. Results indicate that Montana hikers take more trips yet have lower net benefits ($12/trip) than do Colorado visitors ($55/trip). The annual value of trips taken decreases in both states as areas recover from crown fires providing support for the National Fire Plan in terms of fire prevention and suppression.

JEL classification: Q 260

Keywords: Recreation demand; Travel cost method; Wildfire; Prescribed fire; National Fire Plan

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Introduction

Fire managers and recreation managers need cost and benefit information to determine the most effective and efficient fuels management techniques, whether they are mechanical treatments (e.g. thinning and pruning) or prescribed burning (e.g. broadcast burning or underburning). 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 costs in the way of increased health care costs from smoke and diminished esthetics, 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 non-market amenities.

Several studies have indicated that fire effects cause decreases in esthetic value. With respect to recreation, Vaux et al. (1984) used the Contingent Valuation Method (CVM) 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 and determined that there was no clear consensus regarding how to treat the duration of fire effects.

More recently, research efforts have been conducted to assess the economic effects of fire on the value and demand for recreation. Englin et al. (1996) and Boxall et al. (1996) use the travel cost method (TCM) to assess changes in value of canoeing in Manitoba, Canada. Loomis et al. (2001) look specifically at how fire affects values and visitation of hiking and mountain biking in the Intermountain west. Their findings indicate that fire does not affect recreation values or visitation equally across activities. Finally, Englin et al. (2001) compare fire effects on demand for recreation in Wyoming, Idaho and Colorado. Their results suggest that annual recreation values after a fire are highly non-linear.

The results of such studies give rise to questions regarding the National Fire Plan (USDI/USDA 2002). Whereas the policy is nationally focused, managers operate locally using site-specific information. Therefore, to what extent can the National Fire Plan (USDI/USDA 2002) be implemented successfully if populations in different regions react differently to prescribed and wildland fire? The objective of this research is to test how recreation users in different states are affected by crown fire and prescribed fire and whether there are differences in net benefits and visitation. Results will have implications for the implementation of a national fire policy, and the extent to which it should be applied uniformly.

We use the TCM as used by Loomis et al. (2001). We replicate the Colorado survey in Montana and make comparisons between states to test how respondents react between states and whether a national fire policy should be uniformly implemented. Specifically, we use the same survey as Loomis et al. (2001), and the econometric methodology developed by Englin and Cameron (1996) to test the fire effects on hiking in Montana and Colorado. The survey instrument was identical except for years trips were taken. We provide an overview of the methodology used in both states, followed by econometric methodology including a discussion of the model and our hypotheses. Finally, we present the results of the regression models and our findings.

Methodology

We use the TCM to estimate the demand for recreation in Montana and Colorado as based on the survey by Loomis et al. (2001), conducted in Colorado. (Colorado data were also used by Englin et al., 2001). Using the resulting demand curve, we are able to calculate individual net willingness to pay or consumer surplus per trip by integrating the area under the demand curve above price.

A count data specification of the TCM demand model is employed because the number of trips taken (whether actual or intended) is a non-negative integer. Also, because we are interested in both revealed and stated preference, we followed the methodology developed by Englin and Cameron (1996). Panel data were used by pooling revealed preference observations with stated preference observations to augment the overall database.

Actual and hypothetical trips were measured as a function of trail characteristics, fire effects, demographics and travel cost information. The general form of the Poisson model is given by

$$f(y_i|x_i,\beta) = \frac{e^{-m(x_i,\beta)}m(x_i,\beta)^{y_i}}{y_i!}, \tag{1}$$

where y_i is the number of trips taken, which is a non-negative integer valued random variable, m is the average value of y and β is a vector of parameters to be estimated. The maximum likelihood estimator (MLE) of the parameter β is obtained by maximizing the log likelihood function,

$$l(\beta) = \sum_{i=1}^{N} y_i \ \log \ m(x_i,\beta) - m(x_i,\beta) - \log(y_i!). \tag{2}$$

The Poisson estimator used here may also be interpreted as a quasi-maximum likelihood estimator (Creel and Loomis, 1990).

Travel cost data include the cost of gas and a fraction of the value of travel time. The treatment of travel time is often problematic in the TCM given that it is related to travel cost. Omitting travel time, however, 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. We take this approach here. We multiply travel time by 40% of the respondent's wage rate and add it to individual gas cost. This approach is conventionally used by federal agencies using the TCM (US Water Resources Council, 1983). Thus, the travel cost variable and hence consumer surplus will not exhibit omitted variable bias.

Finally, because we sampled onsite, there is the risk of endogenous stratification and truncation. To correct for oversampling avid recreation users, we used the method developed by Englin and Shonkwiler (1995) whereby we subtract one from the observed number of trips taken.

Fire effects TCM

To test differences of fire effects between Colorado and Montana recreation users, we used a pooled interaction model with intercept shifters and slope interaction terms for Colorado observations. The model is specified by

$$\begin{aligned} \text{TTRIPS} = {} & \beta_0 + \beta_1(\text{AGE}) + \beta_2(\text{ACRES}) + \beta_3(\text{BURNOBS}) \\ & + \beta_4(\text{CROWN}) + \beta_5(\text{FIREAGE}) + \beta_6(\text{CROWNFIREAGE}) \\ & + \beta_7(\text{ELEVATION}) + \beta_8(\text{DIRTROAD}) + \beta_9(\text{TCOST}) \\ & + \beta_{10}(\text{HYPAC}) + \beta_{11}(\text{INCOME}) + \beta_{12}(\text{GENDER}) \\ & + \beta_{13}(\text{LP}) + \beta_{14}(\text{GROUPSIZE}) + \beta_{15}(\text{TTBUD}) \\ & + \beta_{16}(\text{TCFIREAGE}) + \beta_{17}(\text{TCCROWN}) + \beta_{18}(\text{CO}) \\ & + \beta_{19}(\text{COTC}) + \beta_{20}(\text{COCROWN}) + \beta_{21}(\text{COFIREAGE}) \\ & + \beta_{22}(\text{COCROWNFIREAGE}) + \beta_{23}(\text{COTCFIREAGE}) \\ & + \beta_{24}(\text{COTCCROWN}) + \beta_{25}(\text{TCCROWNFIREAGE}) \\ & + \beta_{26}(\text{COTCCROWNFIREAGE}) \end{aligned} \tag{3}$$

Model variables and definitions are given in Table 1.

We are pooling data across sites within a state but we have distinguished sites from one another by using demand shift variables that define variations in each site. However, we assume the same response of hikers within a state to a given change in site characteristics such as elevation.

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 we used a count data model, which is equivalent to a semi-log demand function, consumer surplus per individual per trip for Montana (MT) is calculated as $1/\beta_{\text{TCost}}$, or in our model $1/\beta_9$, as shown in Eq. (4a) (Loomis et al., 1999). To calculate the consumer surplus for Colorado trips, we include the coefficient for the travel cost interaction term for Colorado (CO) in Eq. (4b):

$$\text{CS}_{\text{MT}} = -1/(\beta_9), \tag{4a}$$

$$\text{CS}_{\text{CO}} = -1/(\beta_9 + \beta_{19}). \tag{4b}$$

Table 1. Model variabl

Variable
TTRIPS
AGE
ACRES
DIRTROAD
% BURNOBS
CROWN
FIREAGE
CROWNFIREAGE
ELEVATION
TCOST
HYPAC
INCOME
GENDER
LP
GROUPSIZE
TTBUD
TCFIREAGE
TCCROWNFIREAGE
TCCROWN
CO
COTC
COCROWN
COFIREAGE
COCROWNFIREAGE
COTCCROWN
COTCFIREAGE
COTCCROWNFIREA

Table 1. Model variables and descriptions

Variable	Description
TTRIPS	Trips planned and trips taken by the respondent.
AGE	Respondent's age.
ACRES	Acres burned.
DIRTROAD	Dummy variable, 1 = dirt road access.
% BURNOBS	Percentage of fire observable on trail.
CROWN	Dummy variable, 1 = crown fire.
FIREAGE	Age of fire — negative values: −10 is ten years old, −20 is a 20-year-old fire.
CROWNFIREAGE	Interaction between crown fire and fire age.
ELEVATION	Trailhead elevation above sea level.
TCOST	Individual share of travel costs.
HYPAC	Dummy variable: 1 = hypothetical response to contingent scenario, 0 = actual trip taken.
INCOME	Household income of survey respondent.
GENDER	Dummy variable for gender, 1 = male, 0 = female.
LP	Dummy for presence of lodgepole pine.
GROUPSIZE	Number of people in group.
TTBUD	Total time budget available for non-winter vacation (weekends plus paid vacation).
TCFIREAGE	Interaction between travel cost and fire age to test whether value per trip changes with fire age.
TCCROWNFIREAGE	Interaction between travel cost, crown fire, and fire age to test the effect on value of aging crown fires.
TCCROWN	Interaction variable between travel cost and crown to test the effects of crown fires on consumer surplus.
CO	Dummy variable for Colorado: 1 = Colorado, 0 = Montana.
COTC	Interaction between Colorado and travel cost to test differences between Colorado and Montana.
COCROWN	Interaction between Colorado and crown fire to test how Crown fire influences trips in Colorado.
COFIREAGE	Interaction between Colorado and fire age to test how trips differ according to fire age.
COCROWNFIREAGE	Interaction between Colorado, crown fire, and fire age to test how trips differ according to crownfire and fire age.
COTCCROWN	Interaction variable between travel cost, crown and the dummy for Colorado to test the effects of crown fires on consumer surplus for Coloradoans.
COTCFIREAGE	Interaction between Colorado, travel cost and fire age to test whether trip value changes in Colorado with fire age.
COTCCROWNFIREAGE	Interaction between Colorado, travel cost, crown fire, and fire age to test the effect on value of aging Crown fires.

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. However, the effects of substitutes are implicitly included given the differences in fire age and the presence of crown fires which may result in visitors taking fewer trips to sites included in the model and more trips to other sites not included in our model.

To test the effects of fire age on consumer surplus we use TCFIREAGE and for Colorado, COTCFIREAGE. Specifically, if fire age has an effect on the price slope of the demand curve, the coefficient $\beta_{\text{TCFireage}}$ will not be equal to zero. Equations for consumer surplus as affected by fire age for Montana and Colorado are given by Eq. (5) and (6)

$$\text{CS}_{\text{MT}} = -1/(\beta_9 + \beta_{16} * \mathit{FIREAGE}_t), \quad (5)$$

$$\text{CS}_{\text{CO}} = -1/[((\beta_9 + \beta_{19} + (\beta_{16} * \mathit{FIREAGE}_t) + (\beta_{23} * \mathit{COTCFIREAGE}_t))]. \quad (6)$$

Our hypotheses tests are as follows:

$$\text{H}_0 = \beta_5(\text{FIREAGE}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_5(\text{FIREAGE}) \neq 0, \quad (7a)$$

$$\text{H}_0 = \beta_4(\text{CROWN}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_4(\text{CROWN}) \neq 0, \quad (7b)$$

$$\text{H}_0 = \beta_{21}(\text{COFIREAGE}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{21}(\text{COFIREAGE}) \neq 0, \quad (7c)$$

$$\text{H}_0 = \beta_{20}(\text{COCROWN}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{20}(\text{COCROWN}) \neq 0, \quad (7d)$$

$$\text{H}_0 = \beta_{24}(\text{COTCCROWN}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{24}(\text{COTCCROWN}) \neq 0, \quad (7e)$$

$$\text{H}_0 = \beta_{23}(\text{COTCFIREAGE}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{23}(\text{COTCFFIREAGE}) \neq 0, \quad (7f)$$

$$\text{H}_0 = \beta_{16}(\text{TCFIREAGE}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{16}(\text{TCFFIREAGE}) \neq 0, \quad (7g)$$

$$\text{H}_0 = \beta_{17}(\text{TCCROWN}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{17}(\text{TCCROWN}) \neq 0, \quad (7h)$$

$$\text{H}_0 = \beta_{25}(\text{TCCROWNFIREAGE}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{25}(\text{TCCROWNFIREAGE}) \neq 0, \quad (7i)$$

$$\text{H}_0 = \beta_6(\text{CROWNFIREAGE}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_6(\text{CROWNFIREAGE}) \neq 0, \quad (7j)$$

$$\text{H}_0 = \beta_{22}(\text{COCROWNFIREAGE}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{22}(\text{COCROWNFIREAGE}) \neq 0, \quad (7k)$$

$$\text{H}_0 = \beta_{26}(\text{COTCCROWNFIREAGE}) = 0, \text{ vs. } \text{H}_\text{a} = \beta_{26}(\text{COTCCROWNFIREAGE}) \neq 0. \quad (7l)$$

Using t-tests, we can determine whether there are significant positive or negative effects of the fire variables on visitation. Specifically, we are interested in FIREAGE, CROWN, CROWNFIREAGE, and for Colorado, COCROWN, COFIREAGE, and COCROWNFIREAGE. With respect to consumer surplus, we are interested in the effects of crown fire, COTCCROWN, TCCROWN, and fire age, COTCFIRE-AGE, TCFIREAGE, and aging crown fire, TCCROWNFIREAGE, COTC-CROWNFIREAGE. Finally, we will use regression results to estimate the effects of fire on value per trip, and the number of trips taken over time.

Data collection

Sample design

Three National Forests in Colorado that were logistically functional to sample were selected to provide a sample of the possible combinations of fire age and acres burned. 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, Flathead, Lolo, and Helena National Forests. Trails in Montana were chosen based on fire history including fires that burned in 2000.

Fire size ranged from 15 acres to a quarter million acres. In terms of fire class size, we sampled areas primarily in class D (100–299 acres), E (300–999 acres), F (1000–4999), and G (5000 + acres). The mean fire size was 27,000 acres while the median fire size was 1200 acres. For each trail selected that had a fire history, we recorded actual fire age and other fire-related characteristics. The oldest actual fire was 24 years old and the newest, 1 year. Trails sampled that were not affected by fire were coded as –50 years.

We sampled 35 days in Colorado during July and August of 1998. A total of 10 trails 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 trails during July and August. Montana trails 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 in July and part of August. Prior to closure we sampled 11 days. After fire restrictions were relaxed, we sampled an additional 14 days. We concluded the survey in Montana in 2001 after all surveys were disseminated. Sampling occurred over 34 days between June and August inclusively in 2001. Sampling was conducted on both weekdays and weekends in both years.

Survey protocol and structure

The interviewer intercepted individuals at each trailhead as respondents were returning from the trail. The interviewer introduced herself, and gave her university affiliation and purpose. Respondents were told that 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 only individuals 18 years or older.

Respondents were asked to provide their primary recreation activity (hiking, biking, swimming, etc.) and to rank important attributes of the trail (wildflowers, views, water, etc.). Next they were asked to provide travel time (h), travel distance (miles), and travel cost to the trailhead. Travel cost included gas cost, camping fees and other supplies, each listed separately. Individuals were then asked to provide the number of actual trips taken to the trail, as well as planned trips for the remainder of the year.

The next set of questions focused on contingent behavior given changes in trip cost and changes in trail attributes. Contingent behavior was based on increased trip costs which were randomly assigned to the respondent from the vector \$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 individual travel costs to the trail were increased. This provided additional price variability to supplement the natural variability in travel costs due to different visitor residential locations.

In the next section, contingent behavior based on fire effects was presented using three fire scenarios with color photographs of the following:

- High-intensity crown fire: a 2-year-old burn with blackened, standing trees with little greenery.
- Light prescribed burn: a 2-year-old prescribed fire in the underbrush, with 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 actual photos that depicted burned conditions. Respondents were asked how their visitation to each trail would change if 50% of the trail resembled the photo. (Due to budget limitations, we could not include the percentage of the trail burned as a variable.) This enabled us to efficiently convey the effects that high-intensity crown fires, prescribed fires, and older burns have on recreation demand.

Trail characteristics

We also included trail characteristics to control for variability among trails. Attributes were chosen based on those that were significant in past forest recreation studies (Englin et al., 1996). Trail characteristics included elevation, elevation gained on trail, dirt road access, and the number of recreation activities occurring at the trail. Fire characteristics in Colorado were collected from the USDA Forest Service Kansas City fire analysis statistics system (KFAS) and verified with the district offices. Fire characteristics for Montana were collected through contact with each of the Forest Service district offices on the four national forests. Data were verified onsite and with a GIS. Such characteristics include fire size, intensity (flame length), crown fire, percentage of fire observable from the trail, burn extent, and actual fire age. We also recorded vegetation type and the presence of water and views. Finally, because the three contingent behavior scenarios presented in the photographs were

pictures of actual fire
for each scenario for

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to fire characteristics
example, fire age for
was 2 years old, and
the percentage burn
sixth row included co
actual fire history an

Survey results

In Colorado, there
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and second mailing
total number of conta
In total, 1050 survey
postcard reminders w
Of the Colorado vi
mountain biking. Th
motorized vehicles. C
were hiking, campin
10%, fishing at 7%
from each state were
In Colorado visito
driven was 77 miles
Group size in Monta

pictures of actual fires, we coded fire characteristics using actual intensity and fire age for each scenario for the contingent behavior observations.

Econometric model construction

The database used for our analysis was constructed by stacking actual observations and contingent behavior observations for each person. A variable, HYPAC, was created to record whether data were revealed preference or stated preference. Actual trips taken for the previous year and the current year were recorded as HYPAC = 0. For the contingent behavior scenarios, this variable was coded as HYPAC = 1. Individual observations were stacked into six rows thereby giving us six observations for each respondent. The first and second rows represented actual trips taken in the previous year and the current year. Trail data and fire characteristics were recorded in these two stacks as actual observations and fire history. Rows three through five represented, for each individual, stated preference responses relating to the three scenarios—the high-intensity crown fire, the low-intensity prescribed burn, and the 20-year old high-intensity crown fire. Other trail characteristics remained the same, however, but we coded the fire history according to fire characteristics relating to each of the three scenarios shown in the photos. For example, fire age for the high-intensity crown fire was 2 years old, the prescribed fire was 2 years old, and the old crown fire was 20 years old. In each of these three cases, the percentage burn observable (BURNOBS) was recorded as 50%. Finally, the sixth row included contingent behavior based on increased travel costs. In this row, actual fire history and trail characteristics were used.

Survey 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 1074 of which there were 24 refusals. In total, 1050 surveys were given out and 559 were returned after first and second postcard reminders were mailed. The overall response rate was 53%.

Of the Colorado visitors sampled at the trailheads 59% were hiking and 30% were mountain biking. The remainder of visitors (11%) were horseback riding or on motorized vehicles. Of the visitors to the 22 trails 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 from each state were included in the analysis for consistency.

In Colorado visitors were on-site for an average of 5 h. The average distance driven was 77 miles one-way (123.2 km) with average individual gas costs of $12. Group size in Montana was approximately three individuals who stayed onsite an average of 11 h. Visitors spent an average of \$12 in gas costs, and traveled a distance of 98 miles one-way (156.8 km).

The demographics of the Colorado sample indicated that 44% of respondents were female, had an average age of 36.5 years and education level of 16.3 years. The average household size was 2.54 people. The typical household earned \$67,232. Demographics for Montana indicated that 49% of respondents were female, with an average age of 39 years and edcuation level of 16.0 years. Average houshold earnings were \$55,135.

Regression results using a Poisson count model for the pooled Colorado and Montana data are displayed in Table 2. Based on the likelihood ratio statistics, the model is significant at $p<0.01$. The model has a pseudo R-squared value of 0.37. The pseudo $-R^2$ is known as the McFadden R^2 and is calculated as, $1-[L_{\mathrm{m}}/L_0]$ where L_{m} is the maximum value of the log likelihood function and L_0 is the restricted log likelihood when all the coefficients are restricted to zero (This is an analog to the R^2 reported in linear regression models. It has the property that it always lies between zero and one.)

Although there is a statistically significant difference between the demand for hiking in Montana and Colorado as evidenced by the coefficient of CO, β_{18}, the number of trips taken in each state differs only slightly. The mean number of trips taken generated from the pooled interaction model in Montana is 2.9, whereas the mean number of trips taken in Colorado is 3.0.

Travel cost including the value of travel time (TCOST) is also negative and significant at $p<0.01$. Surprisingly, total time budget (TTBUD) had a negative effect on the number of trips taken and was significant at $p<0.01$ indicating that substitution may be taking place for people with more leisure time available. With respect to trail characteristics, LP (lodgepole pine) had a significantly negative effect on the trips taken whereas trail elevation was positive. Both were significant at $p<0.01$. While aspen, Douglas-fir and ponderosa pine were also evaluated, they were highly correlated with LP and therefore omitted from the model. The HYPAC variable was positive and significant at $p<0.01$ indicating that there was hypothetical bias for contingent behavior estimates; respondents overstated the number of trips they would have taken in a given scenario. To correct for this, we estimated trip demand and value by setting HYPAC to zero. As expected dirt road access was negative and significant at $p<0.01$.

Significant demographic variables include income ($p<0.01$), gender ($p<0.05$), group size ($p<0.01$) and age ($p<0.01$). As income increases, the number of hiking trips taken tends to decrease. The negative coefficient on gender indicates that females take more trips. The coefficient on group size was positive indicating that larger groups tend to take more trips. The coefficient on AGE was positive ($p<0.01$) indicating older people take more trips.

Fire effects

The time since prescribed fire had a slightly positive effect on visitation in Montana and Colorado, and was significantly different between states ($p<0.01$).

Table 2. Montana and

Variable
State demand and inter
Constant (C)
Colorado (CO)
Travel cost (TCOST)
Colorado travel cost (
Travel cost & fire or st
Travel cost × fire age
Travel cost × crown
Travel cost × crown
Travel cost × fire age
Travel cost × crown
Travel cost × crown
(COTCCROWNFIRE
Fire effects
Acres burned (ACRES
Crown fire (CROWN)
Fire age (FIREAGE)
Crown × fire age (CRO
Fire age × Colorado (
Crown fire × Colorado
Crown fire age × Colo
Demographic variables
Age (AGE)
Income (INCOME)
Gender (GENDER)
Group size (GROUPS
Total time budget (TT
Trail attributes
Elevation (ELEVATIO
Dirt road access (DIR
Lodgepole pine (LP)
HYPACT (HYPAC)
R-squared
Adjusted R-squared
Probability(LR STAT

*Significant at 10%,
**Significant at 5%,
***Significant at 1%.

However, absolute c
example, trips taken
year-old fire (Table

Table 2. Montana and Colorado pooled data for hikers

Variable	Coefficient (Std. Error)
State demand and intercept slopes	
Constant (C)	2.2137 (0.0831)***
Colorado (CO)	−3.4067 (0.0956)***
Travel cost (TCOST)	−8.66E-02 (2.66E-03)***
Colorado travel cost (COTC)	0.0683 (0.0030)**
Travel cost & fire or state interactions	
Travel cost × fire age (TCFIREAGE)	−1.97E-07 (9.38E-07)
Travel cost × crown fire (TCCROWN)	0.0002 (1.41E-05)***
Travel cost × crown fire x fire age (TCCROWNFIREAGE)	0.0003 (0.0001)
Travel cost × fire age x Colorado (COTCFIREAGE)	−0.0002 (6.13E-05)***
Travel cost × crown fire x Colorado (COTCCROWN)	0.0113 (0.0052)**
Travel cost × crown × fire age × Colorado (COTCCROWNFIREAGE)	0.0005 (0.0002)*
Fire effects	
Acres burned (ACRES)	−7.31E-05 (6.23E-06)***
Crown fire (CROWN)	0.2107 (0.0367)***
Fire age (FIREAGE)	−0.0036 (0.0010)***
Crown × fire age (CROWNFIREAGE)	0.0106 (0.0020)***
Fire age × Colorado (COFIREAGE)	−0.0155 (0.0018)***
Crown fire × Colorado (COCROWN)	−0.1176 (0.0852)
Crown fire age × Colorado (COCROWNFIREAGE)	−0.0087 (0.0066)
Demographic variables	
Age (AGE)	0.0304 (0.0009)***
Income (INCOME)	−2.90E-06 (3.23E-07)***
Gender (GENDER)	−0.2264 (0.0207)***
Group size (GROUPSIZE)	0.0242 (0.0066)***
Total time budget (TTBUD)	−0.0023 (0.0003)***
Trail attributes	
Elevation (ELEVATION)	0.0002 (1.79E-05)***
Dirt road access (DIRTROAD)	−0.2777 (0.0385)***
Lodgepole pine (LP)	−0.9168 (0.0339)***
HYPACT (HYPAC)	0.2003 (0.0244)***
R-squared	0.2638
Adjusted R-squared	0.2468
Probability(LR STAT)	0.000

*Significant at 10%,
**Significant at 5%,
***Significant at 1%.

However, absolute differences are small enough to have no policy implications. For example, trips taken in Montana increases from 1.71 with no fire, to 1.83 with a 20-year-old fire (Table 3). For a 40-year-old fire, the average number of trips increases

Table 3. Visitor use and benefits with fire age

Prescribed fire		0 years	20 years	40 years	% change
Colorado					
	Trips	0.73	1.21	2.01	
	Value	$ 54.59	$ 79.10	$ 143.54	163%
	Annual Value	$ 39.60	$ 95.54	$ 288.67	629%
Montana					
	Trips	1.71	1.83	1.96	
	Value	$ 11.54	$ 11.54	$ 11.54	0%
	Annual Value	$ 19.73	$ 21.14	$ 22.65	15%
Crown Fire					
Colorado		0	20	40	
	Trips	0.94	1.01	1.09	
	Value	$ 55.21	$ 28.87	$ 19.55	−65%
	Annual Value	$ 52.13	$ 29.28	$ 21.29	−59%
Montana					
	Trips	2.15	1.78	1.48	
	Value	$ 11.57	$ 10.80	$ 10.12	−13%
	Annual Value	$ 24.87	$ 19.26	$ 14.98	−40%

to 1.96. Over the same period, trips taken in Colorado increase from 0.73 to 1.21 and 2.01(Table 3). Thus, the outward shift of the demand curve over the fire recovery interval indicates a very small increase in visitation alone.

The presence of a crown fire was positive and statistically significant ($p<0.01$), yet there was no difference between states. Trips in Colorado increase from 0.73 to 0.94 given a crown fire and from 1.71 to 2.15 in Montana (Table 3). The effect on visitation of time since crown fire was negative and significant for Colorado and positive and significant for Montana ($p<0.01$). The interaction term indicates that Montana residents visit older crown fires less than newer crown fires. Trips to areas with crown fires that are 20 and 40 years old decrease slightly from 1.78 to 1.48 in Montana and increase over the same time frame in Colorado from 1.01 to 1.09 (Table 3).

Consumer surplus

Using the coefficient for travel cost (TCOST), the consumer surplus per trip is calculated as $1/(\beta_{\mathrm{TCost}})$ for Montana and $1/(\beta_{\mathrm{TCost}}+\beta_{\mathrm{COTC}})$ for Colorado. Consumer surplus in Montana is \$11.54 and consumer surplus per trip for Coloradoans is \$54.49. To calculate the confidence intervals around consumer surplus, we use the second-order Taylor series approximation provided by Englin and Shonkwiler (1995). The variance of the consumer surplus is calculated using

$$\mathrm{Var}\left(\frac{1}{\beta_{\mathrm{TCost}}}\right) = \frac{S^2}{\beta^4_{\mathrm{TCost}}} + 2\frac{S^4}{\beta^6_{\mathrm{TCost}}}, \tag{8}$$

where the first term is the first-order Taylor approximation and the second term is the correction necessary for the second-order Taylor approximation of the variance (S) of consumer surplus (Englin and Shonkwiler, 1995). The variance of the Colorado travel cost is calculated by adding the variance of the Montana travel cost, the variance of the Colorado travel cost and two times the covariance of the two travel cost parameters. The 90% Confidence interval for Montana is \$11.24—\$11.87, and for Colorado is \$49.92—\$60.21. We also tested the effects of fire age on consumer surplus for both prescribed and crown fires. Annual visitor use and change in net benefits per individual are displayed in Table 3.

The effects of prescribed fire on annual value for recreation users in Colorado over time increase dramatically given a significant increase in value per trip. Annual total value increases from \$40 in year zero, to \$289 forty years after a fire, an overall increase of 629% (Table 3). While annual values increase in Montana the effect is not significant resulting in only a 15% increase in value from \$20 to \$23 over the same time horizon.

Examining the effect of recovering crown fires over time, the opposite is true in both states. Although there is a slight decrease in trips over time in Colorado, the value per trip decreases significantly resulting in decreased annual values from \$52 in year zero to \$21 forty years later, a decrease of 59% (Table 3). Montanans also experience reduced visitation and value over time as areas recover from crown fires. Annual values fall from \$25 to \$15 forty years later, a decrease of 40% (Table 3).

Conclusion

Overall, Colorado and Montana respondents' recreation benefits reacted in a direction similar to crown fires (negatively) and to prescribed fires (positively). Annual values increased in both states as areas recovered from prescribed fire increasing 629% in Colorado but only 15% in Montana. While the increase in visitation was very small, net value per trip increased 163% in Colorado. Conversely, there was no discernable change in net benefits in Montana as a result of prescribed fire; the increased annualized value resulted solely from increased visitation. Finally, although both states experienced increases in annual value net benefits varied significantly between the two states, differing initially by \$20, and in year forty by \$266. Reasons for this may be twofold. First, mean incomes for survey respondents were approximately \$55,000 in Montana and \$67,000 in Colorado. This would suggest that the opportunity cost of hiking would be greater in Colorado. Second, different values may stem from the percentage of rural and urban populations in each state. In 1998 the urban population in Colorado was 85% as compared to 35% in Montana (Rural Health Research Center, 2002). Such differences, while not explicitly tested, might affect visitation and values due to different social and cultural beliefs pertaining to the environment.

Annual values in response to aging crown fires decreased over a 40-year time horizon in both states (down 59% in Colorado and 40% in Montana). Although respondents in each state reacted similarly, there were significant differences in the extent to which respondents reacted. While net benefits per day dropped, the change in visitation in Colorado was not significant. However, the change in both visitation and value were significant in Montana. These findings suggest that in Colorado increases in annual values over time from prescribed burning are small. Similarly, in Montana, while the increase in value over time resulting from prescribed fire is small, there is support for prescribed burning when we consider the alternative. The occurrence of crown fires and their long-term effects in both states have negative influences on recreation use and benefits. For areas surveyed in each state, fire behavior and fire effects would be similar for both crown and prescribed fires. Again, differences in values may stem from differences in income and demographics with respect to rural and urban components of the populations.

These results suggest that while absolute differences exist between values and trips taken between states, the direction of changes in annual recreation value in response to crown fire and prescribed fire are similar in the two states. The implications for fire managers are that crown fires reduce the value of recreation over time and therefore, that prescribed fires may mitigate negative social effects in Montana. Furthermore, because reactions in both states followed the same patterns, managers following the National Fire Plan (USDI/USDA, 2002) could implement projects and expect similar results in Montana and Colorado. However, it is clear that visitation and net values per individual per trip are significantly different suggesting care should be taken in employing national figures to project state costs and benefits resulting from fire management. These results are consistent with Englin et al. (2001), who find that recreation values differ across ecological communities.

With respect to the use of panel data and stated preference variables, we made no attempt to identify sequence effects and thereby assume that responses are independent. An important refinement to future studies would be to evaluate these effects. Finally, because of the rapid pace of education in natural resources, particularly with media coverage of fire, it would be useful to conduct this survey on the same Montana and Colorado trails in the future to test differences in attitudes and knowledge of visitors regarding fire and fuels management techniques over time. While our results may be used to generate the current costs of prescribed fires, such costs may change over time with education and increased knowledge, and may have a different pattern in other states. Similarly, although possible, we did not directly test for changes in visitation resulting from substitution to sites not included in the model, which may decrease our values. Future studies could incorporate these effects.

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