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Valuing hypothetical wildfire impacts with a Kuhn–Tucker model of recreation demand☆

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ABSTRACT

This study uses a nonmarket valuation method to investigate the recreation values of the San Jacinto Wilderness in southern California. The analysis utilizes survey data from a stated-choice experiment involving backcountry visitors who responded to questions about hypothetical wildfire burn scenarios. Benefits of landscape preservation are derived using a Kuhn–Tucker (KT) demand system. Model results suggest that recreationists are attracted to sites with recent wildfires that can be viewed up-close. For example, recreational welfare estimates increased for sites that were partially affected by different types of wildfires, with the greatest gains being observed for the most recent wildfires. Per person mean seasonal willingness-to-pay varied from a low of $10 to a high of $48, for total gains ranging from $62,223 to $635,286. However, wildfires that cause trail closures create welfare losses. Seasonal losses per person for complete closure of particular sites range from $3 to $221, for total losses ranging from $29,600 to $2.9 million.

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1. Introduction

Wildland fires affect millions of people worldwide. Globally it is estimated that 350 million ha of wildland burn annually (González-Cabán, 2008). In the United States, it has become a more serious problem in part due to increasingly dry conditions and forest management practices that have promoted ladder fuel accumulation. From 2000 to 2013, 37.3 million ha of wildlands burned while the USDA Forest Service (USDAFS) incurred suppression costs of $21.72 billion. This translates to an annual average of 2.66 million ha of wildlands burned at an annual average suppression cost of $1.34 billion (National Interagency Fire Center Wildland Fire Statistics, 2014). Considering that the figures reported in Table 1.1 only include the Forest Service, the values would be considerably larger when including other federal and state agencies with wildland fire protection responsibilities.

Fire suppression costs have increased dramatically in the past decade (80% more than the 1994–2003 decade) while congressional funding levels have remained flat (USDA, 2009). Land and forest managers need tools to understand which management strategies are more efficient. However, current tools used by USDAFS only consider cost of fire prevention or suppression, not the economic benefits a forest provides. Therefore, managers have limited information in their efforts to evaluate investments in and trade-offs associated with fire management strategies.

There are many types of natural and human-made disasters that damage or affect natural resources. Although fire is a natural part of many landscapes, catastrophic fires—often produced by a combination of both natural and human factors—are particularly damaging to forests. The impact of fire on natural resources and the associated economic consequences are difficult to estimate (González-Cabán et al., 2003). The difficulty arises because there is limited information about the effects of fire on nonmarket values provided by forests. Early studies (Flowers et al., 1985; Vaux et al., 1984) found that intense fires are likely to have negative impacts on recreation. Recent studies have explored these negative effects. Loomis et al. (2001) surveyed visitors of National Forests in Colorado to study the effects of fire on hiking and mountain biking visits and benefits. Using the travel cost method (TCM), the authors found that crown fires indirectly affected recreation benefits for mountain bikers, while having no significant effect on hiking trips. The present study follows a similar line of investigation but also utilizes stated preference methods to further investigate impacts on hiking.

Also using TCM, Hesseln et al. (2003) found that both hikers and mountain bikers in New Mexico reacted similarly to recovering prescribed fires and crown fires, with each group decreasing its visitation rate. Hesseln et al. (2004) also found similar results when surveying hikers and mountain bikers in four national forests in western Montana. Differences in results between Loomis et al. (2001) and Hesseln et al. (2003, 2004) suggest that geographic variations may help to determine how recreation users react to fire. Another possible explanation could be socio-economic differences between the two samples.

In studying two hiking trails in the Cascade Mountains affected by a large scale forest fire (40,000 acres), Hilger and Englin (2009) found that, in the short term, the forest ecosystem affected by fire had an increase in

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visitation, but trip values were largely unaffected. Englin et al. (2001) examined the long term dynamic path of recreation value following a forest fire in three different states: Colorado, Wyoming, and Idaho. Using the TCM the authors found that visitation increased immediately following a fire, then decreased for 17 years, and then rebounded for the remaining 8 years of their observation period. In a similar study by Boxall and Englin (2008) for canoeing in the Canadian Shield boreal forest, damages associated with a fire occurred immediately following a fire, but after 35 years of regrowth, the forest amenity values returned to pre-fire levels. The present study also considers how time since fire impacts visitation and values in a hiking context, while also controlling for other fire characteristics such as intensity and spatial characteristics of the burn.

This study uses the travel cost method to investigate relationships between wildfires and wilderness access value. The San Jacinto Wilderness serves as an excellent case study because it is a popular recreation area, accessible to millions of people throughout southern California, and at the time of the study it had not experienced a fire in several decades,[1] even though the area is considered to have a very high fire hazard severity rating (Cal Fire, 2015). The investigation utilizes a web-based survey to collect both revealed and stated choice data from backcountry visitors who responded to questions about past trip-taking behavior and hypothetical wildfire burn scenarios. Benefits/losses are derived from both the revealed and stated choice data using a Kuhn–Tucker (KT) demand system (Phaneuf et al., 2000; von Haefen et al., 2004). The results can help researchers to better understand the economic effects of wildfires, and fire managers to plan more efficient fire management strategies and reduce potential losses from wildfires.

2. Survey design

This study focuses on backcountry hikers who visit the San Jacinto Wilderness Area, San Bernardino National Forest in southern California (Fig. 2.1).[2] The wilderness covers 13,350 ha and is located within a 2.5 h drive from the highly urbanized Los Angeles, Orange, Riverside, San Bernardino, and San Diego counties. Elevations range from 1800 to 3300 m and flora varies from desert to alpine species. In 2011, 54,286 visitors obtained backcountry permits to enter the wilderness area (Andrew Smith and Bart Grant, personal communication, USDAFS and Mt. San Jacinto State Park Ranger, October 2013).

The wilderness area is regulated by both USDAFS and the California Department of Parks and Recreation. The most popular activity is day hiking. Recreationists enter the wilderness area via the tramway or by driving to the trailheads located in Long Valley and Idyllwild (Fig. 2.1). Recreationists entering the wilderness area must acquire a wilderness permit. The permits are free and are obtained at either the Idyllwild or Long Valley Ranger Station. According to Forest Service estimates, the compliance rate is approximately 75% (Andrew Smith, personal communication, USDAFS, October 2013). Thus barring any selection effects associated with those who submit permits versus who do not, we assume that sampling administered on recreationists who obtain a wilderness permit fairly represents the population of wilderness visitors.

An online survey was developed to collect information on past recreation visits to the wilderness as well as anticipated changes in recreation behavior in response to hypothetical fire conditions. An initial version of the survey was presented to three focus groups (October 2011 to March 2012) to evaluate the study design, clarity of wording, use of graphics, range of values used, and to consider if important issues were omitted or obscured. Revisions of the survey were pre-tested (May and June 2012) to evaluate whether or not respondents were answering questions in a sensible manner, verify that the web-based survey was working properly (i.e., survey link is active, questions are loading correctly), and verify the time required to complete the survey.

Recreationists were recruited into the survey while obtaining their wilderness permits at the USDAFS Ranger Station in Idyllwild and the Mt. San Jacinto State Park Ranger Station in Long Valley during the summer months of June 2012 to September 2012. To decrease self-selection bias and increase response rate, an undergraduate student was stationed at the Idyllwild Ranger Station on the weekends and once during the weekday during regular office hours (8 am to 4 pm).

The student approached recreationists on their way into the Idyllwild Ranger Station, and provided a brief description of, and incentives for participating in the study.[3] The student collected e-mail addresses of recreationists interested in participating and kept a count of those who declined to participate. E-mail addresses were used to send the survey link and two friendly reminders for those who had not completed the survey. A similar protocol was followed at the Long Valley Ranger Station, but a student was there only on the highest visitation days, Friday and Saturday. Across both ranger stations, active recruiting occurred on a total of 37 days during the sampling frame: 25 days at the Idyllwild Ranger Station and for 12 days at the Long Valley Ranger Station. Recruitment flyers also were made available by ranger station staff every day to recreationists at both sites.

Given the advantage of faster delivery, lower cost, and superior graphics (Berrens et al., 2003; Couper, 2000; Fricker and Schonlau, 2002), we elected to use a web-based survey. The survey was implemented using a modified Dillman (2007) approach: first an invitation e-mail, followed by the survey link, and then two friendly e-mail reminders to non-responders. The survey is divided into three sections.[4] The first section elicits the recreation trip behavior, preferred forest characteristics, and cost-related information for the past 12 months. The second section elicits trip taking behavior for hypothetical burn scenarios that contain five attributes of interest: percent of viewshed burned (25%, 50%, and 75%), intensity of fire (low, medium, and high), time since burn (recent: 0–5 years since fire, middle: 6–15 years since fire, and long: more than 15 years since fire), viewing distance (foreground, middle ground, and background), and trail affected by fire. In Idyllwild the four trails selected are: Deer Springs, Devil's Slide, Marion Mountain, and South Ridge; in Long Valley there is one trail: Long Valley. The five trails were selected because they have the highest visitation rates based on 2005 data.[5] The final section of the survey collects demographics and personal information, including gender, ethnicity, age, education level, employment status and income. The income information was used to derive the travel cost variable and test the income effect in the econometric model.

There are a total of 405 ($3^4 \times 5$) possible treatment combinations for the burn scenarios. A full factorial design was not implemented because higher order interactions are considered negligible and would require either a very large sample size or a large respondent burden to estimate. Instead, a fractional factorial design (Montgomery, 2005) was implemented. Using the SAS macro functions (Kuhfeld et al., 1994; Kuhfeld, 2010) a D-efficient design that is balance and orthogonal containing 45 treatment combinations was selected for the fractional factorial design.[6]

Survey participants were shown five different hypothetical burn scenarios (pictures), each containing the five attributes of interest. Each picture depicted a unique hypothetical scenario representing the landscape of the San Jacinto Wilderness if a fire were to occur. For example, one possible hypothetical burn scenario would be represented by a picture of a recent low-intensity burn in the foreground that burned 50% of the viewable area along the Deer Springs trail (Fig. 2.2).[7]

[1] A wildfire occurred recently (July 2013) affecting a part of the area, but not during the study period.

[2] Description is adapted from Baerenklau et al. (2010).

[3] Recruitment, e-mail and other scripts are available upon request.

[4] There are nine different survey versions. Surveys are available upon request.

[5] Out of a total of 34,218 permitted visitors to the San Jacinto Wilderness, 33,194 visited the 5 trails (Baerenklau et al., 2010). Similar results were found using 2011 wilderness permit data.

[6] No prior information on parameters was used to construct the D-efficient design. We considered a separate orthogonal design with 90 treatment combinations, but a design with 45 combinations was selected to achieve a lower respondent burden.

[7] Source of photos: S. Haase, USDA Forest Service, http://www.azfirescape.org/catalina/photo_point_full_index?page=10, http://www.natgeocreative.com/ngs/, https://www.flickr.com/, and http://www.google.com/imghp.