

Estimating visitor preferences for recreation sites in wildfire prone areas

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Received: 2 October 2021

Accepted: 20 July 2022

Published: 30 August 2022

Cite this:

Tanner S *et al.* (2022)
International Journal of Wildland Fire
31(9), 871–885. doi:[10.1071/WF21133](https://doi.org/10.1071/WF21133)

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ABSTRACT

Development into the wildland–urban interface, combined with heat and drought, contribute to increasing wildfires in the U.S. West and a range of damages including recreation site closures and longer-term effects on recreation areas. A choice experiment survey is used to estimate visitor preferences for vegetation and the effects of past fire at recreation sites. Intercept interviews are used to randomly select visitors at national forest sites near Los Angeles. The choice model results reveal that recreation sites with waterbodies and sites with tree cover, instead of shrubs or barren areas, are highly desirable, while evidence of past fires decreases the value of a site. We find the effects of past fire depend on vegetation type, fire intensity and time since the fire ended. Older forest fires and shrub fires are undesirable, but forest fires that reach the crowns of trees are least desirable. The findings add to evidence that fire damage to recreation areas extends beyond closures and depends on vegetation, which can inform the allocation of firefighting and prevention resources.

Keywords: choice experiment, random parameter logit model, stated preference, survey.

Introduction

Mediterranean-type climate regions play a significant role in the provision of ecosystem services (Underwood *et al.* 2018). These regions are characterised by chaparral communities, which are generally dominated by woody shrubland intermixed with an herbaceous understorey and have a natural fire return interval of 30 years or more (Van de Water and Safford 2011). They also have high levels of biodiversity (Cowling *et al.* 1996) and play an important role in reducing erosion, water provisioning services and carbon sequestration (Rundel 2018). People living in Mediterranean climate regions also benefit from outdoor recreation in chaparral ecosystems (Underwood *et al.* 2018), even though few studies have examined recreation in chaparral (Garnache *et al.* 2018) and, with the exception of Schmitz *et al.* (2007), even fewer address visitor preferences within chaparral. In our study area of Southern California, the combined impacts of drought, climate change and high levels of urbanisation have altered the natural fire regime to make chaparral communities less resilient, while the threat of large wildfires has increased (Underwood *et al.* 2009; Buechi *et al.* 2021). Frequent fires in populous areas such as Southern California pose a significant management challenge, as agencies must decide how to direct resources into wildland fire containment, closures and repair of damaged recreation sites.

This paper explores how the visible effects of past wildfires as well as other site attributes might affect recreation decisions by visitors to national forests. Visitor preferences for the environmental attributes of national forest sites in both chaparral- and woodland-dominated areas are estimated using choice experiment data from visitors to the Angeles National Forest in Los Angeles County, California. In light of the challenges faced by chaparral ecosystems, and Southern California in particular, we focus on preferences for three types of site attributes that are most salient for visitors to recreation areas in chaparral, specifically vegetation type, access to water and evidence of past fires.

This study contributes to a growing literature investigating the immediate and lasting impacts of wildfire on recreation patterns and preferences. Net economic losses due to wildfire damage can be quite large, especially in high-value recreation areas with large numbers of visitors, with a study of Yellowstone National Park estimating a net benefit loss of \$206 million¹ due to fires in or near the park, with additional decreases in spending of \$159 million in the region over the 15-year study period (Duffield *et al.* 2013). Where fires restrict access to recreation sites, economic benefit losses may exceed costs to repair and re-open sites (Lorber *et al.* 2021). Although visitation to areas generally decreases after a fire (Englin *et al.* 1996; Rausch *et al.* 2010), studies in general show large heterogeneity in the impacts depending on location, fire intensity, time since the fire and the activities of forest users. In some instances, there is evidence of temporal heterogeneity in effects. In several studies of recreation impacts of wildfire, recent fires display a non-linear recovery pattern, as initial trips increase, followed by longer-term declines and then a return to pre-fire visitation levels (Englin *et al.* 2001, 2008; Hilger and Englin 2009).

Differences within and across user groups create another potential source of heterogeneity in fire impacts. In visitor surveys conducted after hikes, Weill *et al.* (2020) find that hikers have heterogeneous perceptions of fire with many hikers having positive views. Interviews with visitors to the Boundary Waters Canoe Area Wilderness reveal that many visitors considered burned landscapes to be interesting and did not change their route choices based on past fires. However, the same visitors altered camping behaviours in burned landscapes (Schroeder and Schneider 2010). Other qualitative studies find changes to visitor attitudes towards fire management as well as changes to activities after a fire (Borrie *et al.* 2006). In the economics literature, several studies use trip data to estimate how economic benefits change from wildfire for people with different activity types. Specifically, there is evidence that mountain bikers may be more adversely affected by wildfires than hikers. Loomis *et al.* (2001), using a count-data travel cost model, find that trips by mountain bikers after a crown fire decrease both in quantity of trips and the value of each trip, while for hikers the number of trips remains steady and per-trip benefit increases. Similarly, Hesselein *et al.* (2003) use a Poisson count model and combined RP-SP data and find that demand by mountain bikers is nearly nonexistent after a wildfire. They also find that fire is associated with a decrease in the number of hiking trips, but an increase in per trip net benefits.

Comparing recreational groups is informative when visitors participate in distinct activities, but such comparisons ignore other potential sources of heterogeneity and may not be ideal in a setting where people participate in many activities on a single trip. At day-use sites in our study area, a large portion of visitors participate in multiple activities such as hiking,

relaxing, picnicking and swimming. This variation within and across activities and user types suggests the need to model heterogeneity without relying on potentially endogenous activity choices. To do so, we examine trade-offs between site attributes within a choice experiment framework for estimating recreation preferences (Boxall *et al.* 1996; Peng and Oleson 2017). This approach has also been used to examine heterogeneous preferences over site attributes in the recreation literature (Scarpa and Thiene 2005; Beharry-Borg and Scarpa 2010; Kosenius 2010; Zhang and Sohngen 2018) and in forest management (Christie *et al.* 2007; Calkin *et al.* 2012; Holmes *et al.* 2012; Varela *et al.* 2013; Japelj *et al.* 2016; Nordén *et al.* 2017) but has not been applied to chaparral ecosystems or wildfire-burned areas in forest sites.

Increasing equity in outdoor recreation has long been a management goal for the Forest Service and other agencies, yet inequity is still high, especially among Hispanic communities (Flores *et al.* 2018). Given that the Angeles National Forest is one of the most important areas for recreation in Los Angeles County, which is 48% Hispanic (U.S. Census Bureau 2021), we also test for differences in preferences for recreation sites in wildfire prone areas using both interactions in a conditional logit and a random parameters logit model.

Although the conditional logit model reveals some evidence that Hispanic visitors have different preferences for fire and vegetation, the random parameters logit results provide evidence of preference heterogeneity throughout the whole population for these attributes. We find very strong preferences for water and not much heterogeneity in this, suggesting all user groups will continue to put pressure on those resources, which might be exacerbated with population growth, drought and climate change. Consistent with the literature, we also find some heterogeneity in fire preferences, implying that for some visitors, visible effects of fire have a significant negative impact, while for others, the effects of fire are unnoticed or even positive for those who are interested in vegetation recovery patterns. However, there is less heterogeneity in the effects of severe fires, with crown fires in forested areas causing a significant negative impact for most people.

This paper offers three main contributions. First, while efforts to assess the effects of wildfire on recreation have concentrated on forest areas, chaparral has a significantly different wildfire regime and recovery pattern than conifer or hardwood forests, distinguished by intense crown fires which burn aboveground vegetation, followed by regeneration in the years afterwards, with many species reaching maturity in 3–5 years (Barro and Conard 1991). Hence, a fire's impacts on recreation in a chaparral-dominated area could look significantly different than in a woodland area. Because the Angeles National Forest spans both areas dominated by chaparral with few trees at lower elevations, as well as areas dominated by

¹The values used throughout the paper are in USD.

trees at higher elevations, it provides a unique opportunity to understand trade-offs between vegetation types in recreation decisions. Although there is some work on the value of Mediterranean forests (Merlo and Croitoru 2005; Croitoru 2007; Palahi *et al.* 2008), few studies focus specifically on chaparral. Second, the majority of wildfire studies occur in sparsely populated areas. In contrast, our data come from recreation sites near one of the largest metropolitan areas in the world. Third, there is mixed evidence regarding heterogeneity within visitors' preferences regarding sites showing effects from past wildfires.

Methods

Stated preference approaches, such as choice experiments, are frequently used to value changes in environmental services when direct observation is not available, such as when valuing hypothetical future changes or when the full range of changes in environmental services are not directly observed within a study population. This paper uses a choice experiment to examine national forest visitors' responses to various fire histories at recreation sites. A short intercept survey of visitors to a California national forest was followed by a longer online survey containing the choice experiment. Visitor choices across sites with different environmental attributes and fire histories were analysed using logit models.

Study area and onsite sampling

This study focuses on recreation in the Angeles National Forest, which spans roughly 2833 km² in the San Gabriel and Sierra Pelona Mountains outside of Los Angeles and receives more than 3 million visits per year (USDA Forest Service 2015). Much of the Angeles National Forest is covered by chaparral shrubland intermixed with oak and pine woodlands, while at higher elevations, the landscape is characterised by mixed conifer forests. The Angeles National Forest is roughly 30% forestland by area and contains roughly 117 km² of old growth forest (Warbington and Beardsley 2002).

Chaparral in Southern California is adapted to intermediate fire-return intervals, and high-intensity stand-replacing fires play an important part in regeneration (Moritz *et al.* 2014; Rundel 2018); however, ongoing changes to the natural fire regime are affecting recreation in the area. Large fires impact recreation through road and site closures as well as changes to vegetation and views which may affect recreation patterns for years. For example, the 2009 Station Fire burned for over a month, preventing access to multiple sites in the Angeles National Forest while the fire was active, and for years afterwards for damaged sites. In addition, the effects of past large wildfires were visible years later in many campgrounds, trails and picnic areas along the highway. An additional stressor on the recreation ecosystem services provided by chaparral ecosystems in Southern

California is ecological disturbance from overuse by visitors. Visitors are often drawn to sites with access to rivers and streams; however, the heavy use as well as certain recreation activities such as dam building leads to pollution and damage to fish habitat (Fig. A1). Hence, we also identify visitor preferences for access to water.

Data for this study come from an onsite intercept survey conducted in the Angeles National Forest during June–August 2016 with a follow-up survey conducted during November 2016 to February 2017. The survey research was reviewed and approved by the University's Institutional Review Board for Human Subjects Research. For the intercept survey we used a random sampling plan to draw interview sites (Fig. 1), days and times following the design and approach the Forest Service uses for its National Visitor Use Monitoring surveys (Zarnoch *et al.* 2011). At each site, national forest visitors were intercepted as they exited the recreation site. To ensure a random selection of people, for each vehicle or group of visitors the person with the most recent birthday was interviewed. Onsite survey respondents were asked to provide an email or mailing address for a detailed online follow-up survey.

Follow-up survey and choice experiment design

As recommended by Johnston *et al.* (2017) for stated preference research such as our choice experiment, the development of the survey utilised extensive qualitative research and testing. First, 49 in-person semi-structured interviews were conducted at recreation sites in July 2015, some of which tested our intercept instrument and some of which probed people on their recreation habits and how their recreation might change if a fire occurred nearby. Choice experiment questions were further tested in-person using paper survey instruments followed by cognitive interviews with 15 people at several sites in the Angeles National Forest in May 2016. Finally, in October and November 2016, the instrument was tested online in a webinar setting in a series of four individual cognitive interviews with people who had previously been intercepted in the forest and provided an email address.

Prior to any choice questions, the survey used text, images and interactive questions to inform respondents about the attributes they would face in the choice experiment, including vegetation, water and fire. They were shown an image of a typical chaparral landscape that would be found at recreation sites in the Angeles National Forest and asked about familiarity with recreation sites that had shrubs or trees. Fires were described as either 'forest fires' which could burn 'some plants' or 'all plants', or 'shrub fires' which only burned 'all plants'. Respondents were shown representative images of the impact of forest fires and shrub fires at different stages of recovery (Figs 2, 3). Respondents were also asked to think about attributes located 'nearby' and 'farther away' from the parking area, where nearby was illustrated in a figure and defined as the area within

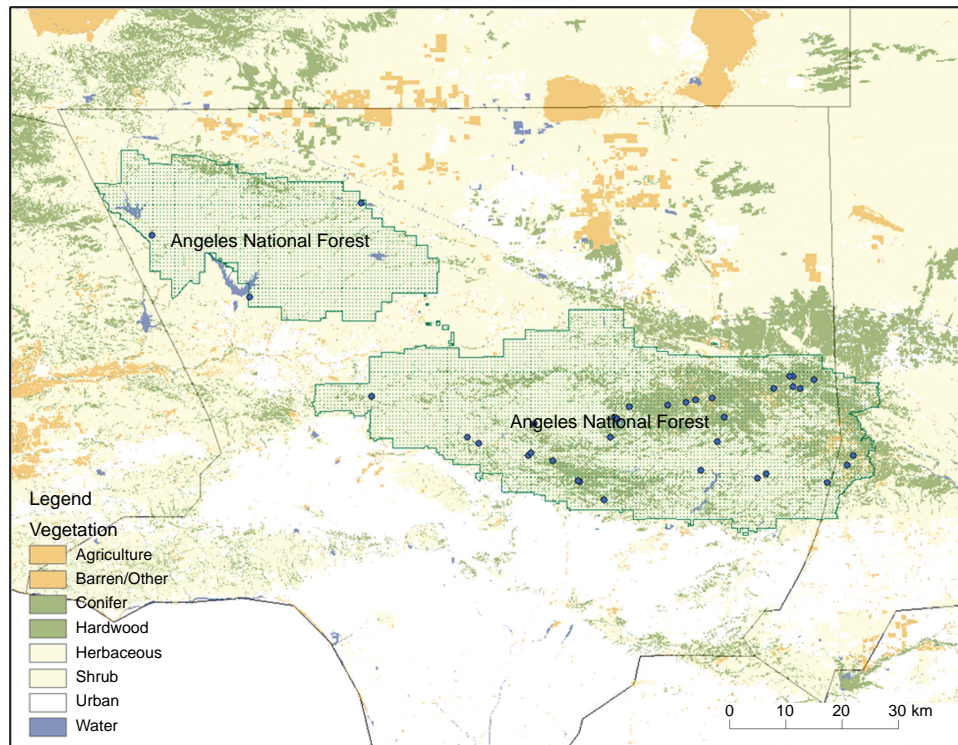


Fig. 1. Map of recreation survey sites.

Example of past fires where **all plants and trees burned**; after some years plants grow back. **Left:** Recent fire (less than 5 years old); **Right:** Old fire (older than 5 years).



Example of past fires where **some plants burned** but the tops of trees did not burn; after some years grass and shrubs grow back and the fire is less visible.



Fig. 2. Images of past fires in trees.

Example of **new** shrub fires (less than 1 year old)Example of **recent** shrub fires (1–4 years old) with new grass and plants**Fig. 3.** Images of past fires in shrubs.

a 5-min walk from the parking area, and farther away was defined as anything beyond a 5-min walk (Fig. A2). These definitions allow us to capture differences in preferences for attributes by distance because people may engage in different activities, e.g. picnicking or relaxing by the river within a short walk of the parking lot vs engaging in a hike or walk farther away from the parking lot. Of our choice experiment respondents, 73% considered hiking their main activity, while the next largest main activity category, consisting of people picnicking or relaxing included 8% of respondents. Although many people engaged in more than one activity, we observed while pre-testing a difference between those in the latter group, who frequently pitched tents and canopies, and stayed in the same general area for several hours or more, as opposed to hikers for whom the main activity was a longer hike.

Next, respondents answered three choice questions in which they indicated their preference over two forest recreation sites with varying plants, water and fire history (evidence of past fire). Respondents to the onsite survey ranged from people living in nearby communities to international visitors. To ensure that they saw realistic site choices in the follow-up survey, the choice experiment section was tailored to respondents according to the distance between their home ZIP code and a mid-point in the Angeles National Forest. Respondents were categorised into four origin distance zones: (1) less than

60 miles (97 km) one-way, (2) 60–150 miles (97–241 km), (3) 150–300 miles (241–483 km) and (4) over 300 miles (483 km). Respondents in zones 1, 2 and 3 saw different distances from home in their options, tailored to their distance from the Angeles National Forest. Those in zone 4, living more than 300 miles (483 km) away, received a version of the survey without choice experiment questions. People living more than 300 miles (483 km) away from the Angeles National Forest were excluded from the choice experiment analysis, as they did not live close enough for choices between sites to be a common decision (55 online respondents were in zone 4). A small number were international travellers, and others were from Northern California or otherwise more than a day's drive from the Angeles National Forest.

Three choice sets were shown to each respondent, and the overall design was grouped into 12 blocks of three questions each. An example of a choice experiment question given to respondents is shown in Fig. 4. In each of three scenarios they faced, respondents were asked to choose between two unlabelled sites to visit. These sites varied according to (a) vegetation nearby and farther away from the parking area, (b) presence of lakes or streams nearby and farther away from the parking area, (c) fire history farther away² and (d) driving distance from home. Choice experiment attributes and levels are given in Table 1. Driving distance from home is equal to baseline distance (ranging from 0 to 60 miles, or 0 to

²The survey stated that the sites we were asking about 'are safe' and 'have no history of fire near the parking area.' This was done to alleviate safety concerns that arose during pre-testing.

What the site is like:	Site A	Site B
Plants	Trees nearby Trees farther away	Shrubs nearby Trees farther away
Lakes or streams	None nearby None farther away	Some nearby Some farther away
Fire history farther away (over a 5-min walk)	Recent forest fire that burned some plants	Old forest fire that burned all plants (some new grass and plants)
One-way driving distance from home (miles)	20	30

9. Which of these National Forest sites would you prefer to visit?

	Site A	Site B
I prefer:	<input type="radio"/>	<input type="radio"/>

Fig. 4. Choice experiment question format.

Table 1. Choice experiment attributes and their levels.

Attributes ^A	Levels
Plants	Trees nearby, trees farther away Trees nearby, shrubs farther away Shrubs nearby, trees farther away Shrubs nearby, shrubs farther away
Lakes or streams	Some nearby, some farther away Some nearby, none farther away None nearby, some farther away None nearby, none farther away
Fire history farther away (over a 5-min walk)	Old forest fire that burned all plants (some new grass and plants) Recent forest fire that burned some plants Recent forest fire that burned all plants Recent shrub fire (some new grass and plants) None visible
One-way driving distance from home (miles)	Zone 1: 20, 30, 40, 60, 80 Zone 2: 60, 70, 80, 100, 120 Zone 3: 120, 130, 140, 160, 180

^AIn the econometric model and results we refer to plants as vegetation and lakes and streams as water.

97 km) plus 20 miles (32 km) if the respondent was in **zone 1**, plus 60 miles (97 km) if in **zone 2** and plus 120 miles (193 km) if in **zone 3**. The relevant choice experiment elements that vary by survey version are choice set, block and distance

bin. There are 36 combinations of block and bin, and each survey version was also available in Spanish.

NGene software (ChoiceMetrics 2014) was used to develop the attribute combinations using a design to minimise D-error subject to constraints on the feasible combinations of attributes. The feasibility constraints ensured the types of fire were consistent with the types of vegetation at sites between which respondents were choosing. For example, since effects of a shrub fire would be hard to see after a few years, we ruled out an 'old' fire at sites with mostly shrubs; we only included in the design a 'recent' shrub fire that was partially recovered, having some new grass and plants growing back. This is typical of the type of recovery visitors would observe at a recently opened site affected by a shrub fire in the last 1–3 years. Likewise, at sites where the vegetation was trees, the fire type could not be a shrub fire. If the vegetation was mostly trees, possible fire types were a recent fire that burned some plants, a recent fire that burned all plants, both of which would be visible, or an old fire that burned all plants. An old fire that only burned some plants would likely not be noticeable to a casual observer and was excluded from the design. Our choice experiment only examines fire farther away from the site since during pre-testing a 'nearby' fire caused safety concerns among respondents even when told the site had been safely reopened.

Econometric model

The standard econometric framework for analysing choice experiment data is based on random utility theory (McFadden 1973). The utility for an individual facing a choice consists of

a deterministic component and a random component. The utility function for individual i with option j is:

$$U_{ij} = \beta X_{ij} + \varepsilon_{ij} \quad (1)$$

where the observable component βX_{ij} depends on preference parameter β and a vector of attributes X_{ij} , and ε_{ij} is the random or unobservable component. Therefore, the probability that we observe individual i select site j is the probability that the utility from site j is the greatest in the available choice set C :

$$P(j) = P(\beta X_{ij} + \varepsilon_{ij} > \beta X_{ik} + \varepsilon_{ik}) \quad \forall k \in C \quad (2)$$

When the random error follows a type I extreme value distribution, the probability of observing choice j is:

$$P(j) = \frac{\exp(\beta X_j)}{\sum_k \exp(\beta X_k)} \quad (3)$$

Estimating this model with a common parameter vector β for the population leads to the conditional logit model. However, given results from prior studies showing that groups of visitors have differing responses to fire damage, we expect to find evidence of preference heterogeneity, and turn to more flexible specifications. We model preference heterogeneity in two ways: introducing demographic interaction terms with the preference parameters within conditional logit, and random parameters logit models, which assume a continuous distribution of preference parameters β_i throughout the population.

The probability of observing choice j in a random parameters set-up is:

$$P(j) = \frac{\exp(\beta_i X_j)}{\sum_k \exp(\beta_i X_k)} \quad (4)$$

Here, β_i is distributed across the population. The difference in estimation between the random parameters logit and conditional logit is that the conditional logit model only estimates a population average $\hat{\beta}$ while random parameters logit estimates a mean and standard deviation for $\hat{\beta}_i$ where $i = 1, \dots, I$. Since the choice experiment asked respondents to make tradeoffs between site attributes and distance, marginal rates of substitution estimates are presented as willingness to drive (WTD) and estimated as the negative of the ratio between the driving distance parameter, β_{id} , and the site attribute parameter, β_{ik} . For the conditional logit without interactions, the WTD for attribute k estimate is:

$$\text{WTD} = -\frac{\beta_k}{\beta_d} \quad (5)$$

and for the random parameters logit the above formula is evaluated at the mean attribute preference estimates.

Results

In total, 3651 people were approached for interviews during the intercept survey in the Angeles National Forest. The response rate was high, with 66% of intercepts agreeing to participate. Of 2260 completed intercept surveys, 1755 (77.7%) provided contact information, including 1685 email addresses and 70 mailing addresses. These 1755 people were contacted for the follow-up survey by email or mail between November 2016 and January 2017. In total 662 (38%) responded to the survey, and 546 responded to the choice experiment.

Summary statistics for choice experiment respondents are given in Table 2. Respondents were around 40 years old on average. One-third of respondents were female, and two-thirds male. They tended to be well off, with more than half of respondents having annual household incomes of \$75 000 or more. The largest minority group to respond were Hispanics or Latinos (22%) followed by Asians (16%). Most respondents cited their main activity as hiking or walking – roughly 75% – while another 8% were picnicking or relaxing. Many of them were regular national forest visitors with 33% having visited more than 25 times in the past 2 years.

The respondents were asked to rate how important certain site attributes are to their site choice prior to completing the choice experiment. Results from these attitudinal questions show that most people agreed that the presence of water and plant type at recreation sites affects their decision to visit. However, they were split on whether the presence of burned vegetation affects their decision; 32% strongly or somewhat disagreed, 34% were neutral and 33% somewhat or strongly agreed, showing evidence of substantial heterogeneity. A majority were neutral or not concerned about safety or air quality at sites with visible fire damage. Some had experience with wildfires affecting their planned forest visits; 42% had decided not to visit a national forest site because of concerns that there might be fire-related closures at least once in the past 2 years, while 32% had decided not to visit a site due to wildfire-related air quality concerns.

Conditional logit models

Table 3 shows the results of conditional logit models without (Model 1) and with interactions (Model 2). The conditional logit model correctly predicts the preferred alternative about 65% of the time using the option with the largest probability as the prediction criteria. Coefficients for all the site attributes have the expected signs based on the attitudinal questions and the cognitive interviews during the survey development and pretesting: trees are preferred vegetation over shrubs, water is a positive attribute and fire damage is a negative attribute in general. The omitted vegetation attribute level is 'shrubs nearby and shrubs farther away'.

Table 2. Summary statistics for choice experiment respondents.

	Variable	Mean	Min	Max	N
Demographics	Age	42	18	84	546
	Has children	0.31	0	1	495
	College degree	0.67	0	1	499
	Employed full time	0.64	0	1	496
	Gender	0.67	0	1	545
	Hispanic	0.22	0	1	541
	Asian	0.16	0	1	546
	White	0.60	0	1	546
	Income (\$1000s)	103	12.5	250	464
Experience	Have cancelled a trip because of concern about fire-related site closure	0.42	0	1	505
	Have cancelled a trip because of concern about air quality	0.32	0	1	506
Likert (1/5)	Wildfires are a natural part of national forests	4.3	1	5	506
	The presence of lakes and streams nearby affects my decision to visit a site	3.6	1	5	508
	The types of plants affect my decision to visit a site	3.2	1	5	508
	The presence of burned plants affects my decision to visit a site	2.9	1	5	505
	I am concerned that air quality may be poor at sites where past fires are visible	2.7	1	5	506
	I am concerned about safety when visiting a site where past fires are visible	2.4	1	5	507
Main activity	Hiking	0.73	0	1	546
	Relaxing/Picnicking	0.08	0	1	546

Note: Annual household income is converted to a continuous measure using midpoints of the following categories: less than \$25 000; \$25 000–49 999; \$50 000–74 999; \$75 000–99 999; \$100 000–149 999; \$150 000–199 999; and over \$200 000 (coded as \$250 000).

The results clearly show a strong preference for tree cover, especially locations with trees both nearby and farther away. Similarly, compared to sites with no water nearby, sites with lakes or streams are preferred, with the largest coefficient on the attribute for water both nearby and farther away. Estimates for the fire history attribute reveal a more nuanced picture. Though the coefficients for recent fires are negative and significant at the 1% level, there is weaker evidence for the parameters on types of fires where some vegetation may be recovering (old forest fires). There is much stronger evidence that recent forest fires are undesirable.

We introduce heterogeneity in Model 2 by interacting site attributes with a dummy variable for Hispanic.³ We explored different preferences for Hispanics because Forest Service managers in Southern California are interested in expanding outdoor access to underserved minority populations (Roberts *et al.* 2009; Flores *et al.* 2018). There is evidence that on average recent shrub fires at recreation sites do not matter as much to Hispanic respondents; a linear test of the hypothesis that the sum of the coefficients on recent shrub fire and the interaction are equal to zero is

non-significant, suggesting that Hispanic respondents were not responsive to recent shrub fires, while others were.

Random parameters logit model

The random parameters logit model allows for preference heterogeneity by assuming a continuous distribution of parameters across the population. In the specification used, vegetation, water and fire attributes are assumed to have a normal distribution. Use of a normal distribution allows for the fact that any attribute could be positive or negative to different people. We expect that for the vegetation and water attributes, there may be some people who care more strongly about tree cover or bodies of water nearby and others who care more strongly about having those attributes farther away. In addition, in pre-testing, some respondents indicated an interest in recreation sites with visible fire effects, suggesting there could be heterogeneity in preferences for sites with evidence of past fires.

Model 3 assumes that all site attributes (vegetation, water and fire history) are randomly distributed in the population

³Additional models that interacted income with distance and interacted respondents' experience with fire impacts or site closures did not result in any significant interaction effects.

Table 3. Conditional logit model with and without interactions.

Attribute	Level	Model 1	Model 2
Vegetation	Shrubs near, trees far	0.443** (0.041)	0.466* (0.043)
	Trees near, shrubs far	0.625*** (0.001)	0.522*** (0.010)
	Trees near, trees far	0.953*** (0.001)	0.918*** (0.002)
Water	None near, some far	1.048*** (<0.001)	1.082*** (<0.001)
	Some near, none far	1.077*** (<0.001)	1.064*** (<0.001)
	Some near, some far	1.509*** (<0.001)	1.488*** (<0.001)
Fire history (farther away)	Old forest fire that burned all plants	-0.118 (0.488)	-0.037 (0.839)
	Recent forest fire that burned all plants	-1.105*** (<0.001)	-1.1076*** (<0.001)
	Recent forest fire that burned some plants	-0.429*** (0.002)	-0.424*** (0.004)
	Recent shrub fire	-0.333*** (0.004)	-0.459*** (<0.001)
Hispanic × Veg	Shrubs near, trees far		-0.089 (0.795)
	Trees near, shrubs far		0.502* (0.070)
	Trees near, trees far		0.141 (0.696)
Hispanic × Water	None near, some far		-0.125 (0.619)
	Some near, none far		0.265 (0.332)
	Some near, some far		0.302 (0.287)
Hispanic × Fire	Old forest fire that burned all plants		-0.375 (0.200)
	Recent forest fire that burned all plants		-0.198 (0.522)
	Recent forest fire that burned some plants		0.045 (0.886)
	Recent shrub fire		0.542** (0.040)
Driving distance (round trip)	Distance	-0.011*** (0.007)	-0.011*** (0.006)
Sample size		546	541
Choice sets		1589	1574
AIC		2015.51	1990.76
BIC		2074.58	2103.34
Log likelihood		-996.75	-974.38

Note: P-values in parentheses: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

and independent from each other, while preferences for driving distance are fixed. Because we observe repeated choices by individuals, the model is estimated as a panel.⁴ Table 4 reports coefficients and standard deviations for Model 3. The basic results are similar to those shown in the conditional logit models. The estimates suggest that national forest visitors place a positive value on having some trees at recreation sites compared to sites with shrubs both nearby and farther away, and that they receive the most value from sites that have trees both nearby and farther away. However, there is evidence of significant

heterogeneity in vegetation preferences, as the standard deviation estimates for trees nearby and shrubs farther away as well as trees nearby and farther away are significant. Preferences for sites with visible effects of fires are negative, but we also find significant heterogeneity in preferences for fire types. Preferences for sites with a water feature farther away only are uniformly positive but there is significant evidence of heterogeneity in the preferences for sites with water nearby.

While the conditional logit models provide evidence that preferences for Hispanic visitors are different from other

⁴A model that also allowed all the preference distributions to be correlated did not converge, likely due to the very insignificant distributions around the preferences for the water attributes. Indeed, if water preferences are not given distributions, then a model with correlation in the remaining preference distributions does converge; it shows qualitatively similar results and little evidence of correlated preference distributions since only two pairs of attributes have significant covariance between their preference distributions at the 10% level and none are significant at the 5% level.

Table 4. Random parameters logit model and percent with a positive attribute preference.

Attribute	Model 3		Percent with positive coeff.
	Coeff.	Std. dev.	
Vegetation			
Shrubs near, trees far	0.599* (0.076)	0.474 (0.259)	100
Trees near, shrubs far	0.947*** (0.003)	1.134*** (0.003)	80
Trees near, trees far	1.354*** (0.004)	0.793** (0.014)	96
Water			
None near, some far	1.558*** (<0.001)	0.459 (0.274)	100
Some near, none far	1.575*** (<0.001)	0.665* (0.054)	99
Some near, some far	2.222*** (<0.001)	0.948** (0.014)	99
Fire history (farther away)			
Old forest fire that burned all plants	−0.126 (0.628)	0.772* (0.054)	44
Recent forest fire that burned all plants	−1.679*** (<0.001)	1.399*** (0.003)	12
Recent forest fire that burned some plants	−0.601*** (0.005)	0.830* (0.081)	23
Recent shrub fire	−0.526*** (0.006)	0.899** (0.039)	28
Driving distance (round trip)	−0.016*** (0.010)		
Sample size	546		
Choice sets	1589		
AIC	2016.86		
BIC	2144.21		
Log likelihood	−987.43		

Note: *P*-values in parentheses; ****P* < 0.01, ***P* < 0.05, **P* < 0.1. When the standard deviation parameter is not significant at 0.1 or less, the results suggest a lack of heterogeneity so the percent with positive absolute coefficient is set to 100 for positive and 0 for negative attributes.

people recreating in the Angeles National Forest, the effects are limited to certain fire attributes. Hispanic respondents prefer sites with trees nearby and shrubs farther away compared to sites with shrubs both nearby and farther away and slightly prefer sites with recent shrub fires over those with no evidence of past fires. However, results using the random parameters logit suggest that in the whole population, there is significant heterogeneity in preferences for all sites with trees nearby in addition to all fire types.

To further explore the role of heterogeneity in site preferences we compute the percentage of respondents whose estimated preference parameter is positive in the random parameters logit model. We find that essentially no respondents prefer sites without water to sites with some water either nearby or farther away. There is significant heterogeneity in preferences for vegetation, but the majority of respondents still prefer sites with trees to those with mostly shrubs nearby and farther away, and over 95% prefer trees far away to mostly all shrubs. We find the most evidence for preference heterogeneity in the effects of fires.

Roughly one-quarter of respondents have preferences implying they might prefer sites with visible recent fire effects except in the case of recent forest fires that burned all plants and 44% who might prefer sites with visible effects of an old fire that burned all plants.

Willingness to drive for attributes

In choice experiments, a common way to compare the strength of preferences across models is to express them in terms of people's willingness to trade off one attribute to obtain another. In this section, the estimated preference parameters are used to compute the additional distance an individual would drive round trip for a change in a site attribute, the WTD⁵. For the conditional logit and random parameters models we compute average WTD for a change in attributes using the full sample. Model 1 is conditional logit with no interactions, Model 2 is conditional logit with Hispanic interacted with all attributes and Model 3 is a random parameters logit model.

⁵Results are presented in terms of distance to reflect the choices made by respondents in the survey. Results in terms of willingness to pay (WTP) show very similar patterns and are available upon request.

Table 5. Willingness to drive (additional miles round trip for a change in a site attribute).

Model	Conditional logit			Random parameters logit	
	(1)	(2)	(3) Mean	25th Percentile	75th Percentile
Vegetation					
Shrubs near, trees far	41***	42**	38***	18	58
Trees near, shrubs far	58***	59***	59***	11	107
Trees near, trees far	89***	88***	85***	51	119
Water					
None near, some far	98***	98***	98***	78	117
Some near, none far	101***	105***	99***	71	127
Some near, some far	141***	145***	139***	99	180
Fire history (farther away)					
Old fire that burned all plants	-11	-11	-8	-41	25
Recent fire that burned all plants	-103***	-104***	-105***	-165	-46
Recent fire that burned some plants	-40***	-39***	-38***	-73	-3
Recent shrub fire	-31**	-32**	-33***	-71	5

Note: All values rounded to the nearest mile. Krinsky and Robb (1986) confidence intervals were computed for Model 2 using the mean of the demographic variable. Confidence intervals for Models 1 and 3 were computed using the delta method. For Model 3, the 25th and 75th percentiles of WTD were computed by using the normal distribution of the preference parameters.

*** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

In all the models presented, WTD for vegetation and water attributes is positive, while WTD for fire attributes is negative. The results in Table 5 show the average WTD for attributes estimated by each of the three models. Across the three models, respondents' WTD to visit a site with trees farther away compared to sites with shrubs nearby and shrubs farther away averages about a 40-mile (64 km) round trip (which translates to a maximum WTP around \$24⁶). Sites with tree cover nearby the parking lot are valued even more, with average WTD being on average about a 60-mile (97 km) round trip (equivalent to about \$36) if the site has trees nearby and shrubs farther away, and 90 miles (145 km) (\$54) for a site with trees both nearby and farther away. Sites with a water feature – in the Angeles National Forest these tend to be sites with rivers or streams, but sometimes lakes – are highly valued, with average WTD ranging between 100-mile (161 km) round trip (\$60) for sites with water at a distance from the parking area, to 145 miles (72 km) (\$87) for sites with water nearby and farther away. These results are consistent with observed recreation patterns, as those sites with streams and large shaded picnic areas were among the most heavily visited in our sample. The estimates represent WTD. However, in an area with many possible recreation sites, a visitor would generally not need to

drive as much as they are willing to reach a substitute site. The difference between the amount they need to drive for an attribute and what they would be willing to drive reflects the benefit of having the attribute available, which is analogous to why a consumer receives a net benefit when the price they pay for a good is less than the amount they are willing to pay.

As expected, sites with evidence of past fires are less desirable than those with no visible effects of past fires, but there is a wide variation in WTD estimates between the four categories of fire. If a site has been affected by an older forest fire that is in recovery on average across the models, respondents would drive about 10 more miles (16 km) in a round trip to avoid that site. Using the same assumptions to convert to WTP, they would require \$6 to visit that site as opposed to one without a past fire. However, if a site was affected by a recent forest fire that burned all vegetation, they would drive on average across the models about 104 more miles (167 km) in a round trip (\$62) to avoid that site. Recent forest fires that only affected some plants (like shallow ground fires as opposed to crown fires) and older shrub fires that are in recovery lie in between those two extremes.

Estimates of WTD for attributes across the specifications of the conditional logit and random parameters logit models are very similar. A Vuong's test for non-nested models

⁶To estimate WTP, we use \$0.2268 per mile driving cost calculated using driving costs estimated by AAA. To the per-mile driving cost, we add a time cost for recreation travel equal to one-third the annual income, computed assuming a high income of \$100 000 and an average driving speed of 45 mph.

showed that we are unable to reject the null hypothesis that the log likelihoods are the same across the conditional logit and random parameters logit models. The WTD to sites with mixed tree and shrub vegetation is a 41 mile (66 km) round trip in Model 1, which estimated average preferences in the population. The random parameters logit model also shows that on average visitors would be willing to drive 38 more miles (61 km) to those sites compared to sites with only shrubs. Similarly, WTD for trees nearby and farther away, water attributes and fire history attributes are nearly the same for the conditional logit model specifications and the random parameters logit model. To illustrate the implications of the heterogeneity, we use the distributional information to compute WTD at the 25th and 75th percentiles in estimated preference parameters in the sample (Table 5; columns 4 and 5). The 25th and 75th percentiles share the same sign as the means for eight of the 10 preferences, which reflects the patterns from the estimated heterogeneity reported in Table 4. These results also show that although there is significant heterogeneity in preferences, the average preference estimates are not biased when that heterogeneity is ignored.

Discussion and conclusions

This study uses results from a choice experiment survey to model national forest visitors' preferences for environmental attributes of national forest recreation sites and estimate WTD for sites with different vegetation, water and fire histories. The fire attributes span tree and shrub vegetation types, include different burn intensities and capture temporal effects of fire via old versus recent fires. We introduce and test for evidence of preference heterogeneity by employing conditional logit models with interactions and random parameters logit models and results are consistent across the classes of models used. Information about the different wildfire impacts across visitor groups and across vegetation types could improve the distribution of scarce resources for fuel treatment practices used for preventing and mitigating wildfires as well as post-fire restoration activities (Stockmann *et al.* 2010).

Results show evidence of some heterogeneity in preferences for vegetation at recreation sites; however, on average sites with trees are favoured by visitors, with sites with trees both near the parking lot as well as farther away being the most preferred. This indicates a preference for sites with long, shaded hiking trails as opposed to those that are more exposed. Although chaparral landscapes are unique and the subject of few recreation studies, our findings indicating that sites that are all or partially forested are preferred to sites dominated by chaparral are consistent with the limited literature that elicits visitors' preferences for landscapes with both chaparral and wooded vegetation types (Schmitz *et al.* 2007; Garnache *et al.* 2018).

In the Angeles National Forest, many sites along a stream are popular picnic sites in addition to having hiking trails, as opposed to other sites without water near the parking lot, which may have long hiking trails, but are not picnic sites. We find that recreation sites with a stream, river or lake nearby, farther away or both, are highly preferred to sites that have no water within hiking distance, and we find no evidence of heterogeneity in this. Our results imply that to benefit most recreationists, and potentially more for populations that are historically underrepresented in the use of national parks and forests, adding more sites along streams to disperse heavy use may be beneficial.

The study area is frequently affected by severe wildfires that sometimes close recreation sites and when sites re-open they can be left with visible burn scars that vary depending on the vegetation type and fire severity. We find evidence, as expected, that sites with visible effects from wildfires are less desirable than those with no visible effects of wildfires but that, as time passes and recovery improves, the effect is mitigated. Some previous recreation literature has found differences in perceptions after a fire (Borrie *et al.* 2006) and that some types of recreation trips may increase after a recent wildfire for a short time (Englin *et al.* 2001, 2008; Hilger and Englin 2009). However, we find that in the case of severe wildfires in Southern California that burn all the vegetation, recent wildfires generate larger dis-amenities than older forest fires or shrub fires. Recent forest fires that burned some plants, recent shrub fires and old forest fires that are still visible also cause net economic losses, but less so than severe, recent forest fires. In addition to short-term closure impacts, our results suggest the importance of accounting for persistent effects of some types of fire damage at high value recreation sites.

In our a priori exploration of preference heterogeneity, we find that the conditional logit interactions suggest that different groups of people may have heterogeneous preferences across site attributes, and in particular that Hispanic national forest visitors are less sensitive to sites with a recent shrub fire. This is consistent with previous literature that shows that minority groups use public lands differently than other groups (Chavez *et al.* 2008). In our random parameters model estimation, we find significant standard deviations for the vegetation, water and fire history attributes, suggesting that there is considerable heterogeneity in preferences for these characteristics.

The results identify two sources of heterogeneity in preferences for the vegetation, water and fire history attributes of recreation sites that may be of interest to forest managers. The construction of the attribute levels allows us to draw some conclusions about how any changes in economic benefits from forest fires change over time. We find significant evidence for differences in effects of fire over time. Sites that have been affected by wildfires are less preferred to sites with no visible effects of fire, but unlike some previous recreation literature, we find that recent wildfires cause greater net

economic loss than older forest fires and that visible damage can have a significant effect on site choices. Second, we identify heterogeneity across groups of people. The urban national forests in our study area are an important recreational opportunity for the diverse residents of Los Angeles and Southern California. One of the most important demographic trends in this area is a large and growing Hispanic population, who, compared to other demographic groups, are under-represented among national forest visitors⁷. Managers have an interest in understanding how recreation preferences differ across user groups. Past literature has looked at preferences for levels of development and amenities and diversity in the types of activities that visitors engage in (Chavez *et al.* 2008). We find that there are also significant differences in preferences over environmental attributes of recreation sites that could provide insight into how management activities can differentially affect people. Improvements in protection of site quality nearby parking or picnic areas appear more beneficial to some visitors such as those who are Hispanic, while trail maintenance and fire recovery in forested areas appear more valuable to other visitors. Finally, results suggest that, beyond their immediate effects, some types of wildfires in high-value areas with tree cover can have long-lasting effects on recreation which may impact efficient distribution of resources both for fuel treatment practices as well as restoration activities.

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⁷Hispanic visitors make up 8.3% of national forest visits in the Pacific Southwest Region (USDA Forest Service 2020). The Census Bureau estimates that 40% of the population in California is Hispanic or Latino, and 50% of the population in Los Angeles County is Hispanic or Latino (U.S. Census Bureau 2021).

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Data availability. The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclaimer. This research was supported in part by the U.S. Department of Agriculture, Economic Research Service. The findings and conclusions in this publication are those of the authors and should not be construed to represent any official U.S. Department of Agriculture or U.S. Government determination or policy.

Conflicts of interest. The authors declare no conflicts of interest.

Declaration of funding. This work was supported by the U.S. Forest Service, Grant 14-CS-11052007-030, and MSU AgBioResearch.

Acknowledgements. We are especially grateful to Joshua Knoll for his help collecting the data, and we thank Lori Srivastava, Jose Sanchez, Hugh Safford and the many USFS personnel that offered feedback at various stages of the work.

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Appendix



Fig. A1. East Fork of the San Gabriel River in the Angeles National Forest showing user-made dams and heavy recreational use. Photo by Charles White.

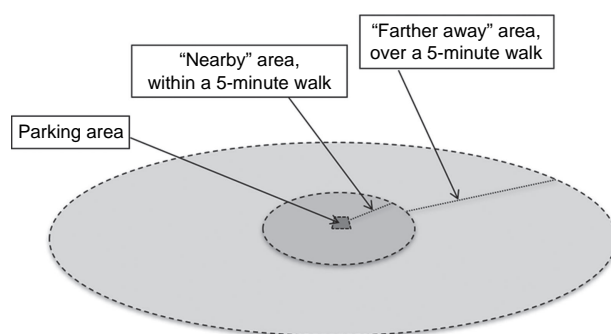


Fig. A2. Illustration depicting 'nearby' and 'farther away' from parking area.