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Understanding how urban communities make trade-offs between forest management and ecosystem service objectives

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ABSTRACT

Urban populations adjacent to forested areas value water-related ecosystem services and recreational opportunities. However, maintaining these benefits requires active forest management through thinning and prescribed burns, infrastructure development as well as issues of equity. These activities can also lead to public concerns over access fees, smoke emissions, and perceived negative impacts on forest health. This study aims to understand the tradeoffs between public preferences and forest management objectives in Wildland-Urban Interface montane forests. We employed an online survey using the Best-Worst Scaling (BWS) method to assess importance rankings and tradeoffs among forest management and ecosystem services attributes. The study focused on urban communities near the San Bernardino and Angeles National Forests in southern California, USA. Results reveal that residents' preferences between frequent visitors group and infrequent visitors group were inconsistent. Residents prioritized mechanical tree removal over prescribed fire as the most important forest management objective. Lakes emerged as the most valued ecosystem service attribute, surpassing rivers and waterfalls. Among recreational infrastructure, public restrooms ranked highest, followed by garbage bins and public grills. These findings provide insights for forest managers and policymakers by offering a framework that balances ecological needs with public preferences. The results are particularly relevant for implementing policies such as the Wildfire Crisis Strategy and forest management plans, by identifying potential conflicts and enhancing public support for forest management decisions.

1. Introduction

Peri-urban or Wildland-Urban Interface forests provide a range of essential ecosystem services including fresh water for human consumption, timber, climate regulation through carbon sequestration, recreational opportunities, and the conservation of biodiversity (Jenerette et al., 2022). However, these forests and nearby urban communities face growing threats from climate change and disturbances such as increased wildfire risk, urbanization, and insect outbreaks (Underwood et al., 2019). To address such challenges and sustainably supply ecosystem services, forest management interventions, such as prescribed fire and mechanical thinning, as well as recreation infrastructure like garbage bins and restrooms are necessary (Adams, 2013). Despite their benefits, these activities and infrastructure elements are often perceived by the public as ecosystem disservices (e.g., smoke emissions, unaesthetic landscapes), added financial burdens, or, conversely, essential for conserving biodiversity habitats (Liu et al., 2018). As such, managing forests for multiple objectives and diverse values requires careful consideration of these tradeoffs.

Among the various ecosystem services provided by these forests are water regulation (Jennerette et al., 2022) and recreation (Olschewski et al., 2012; Iranah et al., 2018), both of which are important to nearby communities and their residents. Water features such as streams, lakes, and waterfalls are particularly popular destinations for visitors (Tanner et al., 2022; Ureta et al., 2020). However, the increase in recreational activities can negatively affect forest ecosystems and their services they

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provide (Eagles and McCool, 2003), leading to issues such as soil compaction, pollution, trampling of vegetation (Amrein et al., 2005), degradation of water quality (Marion et al., 2016), and the accumulation of refuse and garbage (Atalay et al., 2023). To mitigate these impacts, increased infrastructure, including parking, trash bins, and restrooms, is necessary (Wang et al., 2021; Chen et al., 2017).

In the western United States, many forests are increasingly suffering from high tree densities and poor forest health, largely due to decades of fire suppression and exclusion (North et al., 2021; Nematian et al., 2021). These overgrown forests are more vulnerable to wildfires, which are likely to burn with higher severity, resulting in ecosystem degradation, ecosystem type conversion, flooding, and invasive species outbreaks (Westover, 2021). To address this growing issue, recent policies advocate for a substantial increase in both the scale and pace of fuel treatments, such as mechanical thinning and prescribed burning, to reduce wildfire risk and limit resulting damage to forests and nearby communities (North et al., 2021). In response, federal, state, and local governments are ramping up investments in fuel treatment programs (Martinez et al., 2023). One prominent initiative is the U.S. Department of Agriculture (USDA) Forest Service's "Wildfire Crisis Strategy" which aims to protect communities and enhance forest resilience (USDA Forest Service, 2022a, 2022b). However, the success of these efforts is often hindered by a lack of public support and the high financial costs associated with implementing both mechanical thinning and prescribed fire (Miller et al., 2020; Schultz and Moseley, 2019).

Forest managers are also grappling with the challenge of rising visitation (Monz et al., 2009). The Covid-19 pandemic led to a sharp surge in visitors to natural areas, exacerbating already high visitation levels (Ferguson et al., 2023). For example, visits to US national forests spiked in 2020 and have remained above pre-pandemic levels (USDA Forest Service, 2023). This influx of visitors often results in negative environmental effects and a diminished visitor experience. In California, the San Gabriel National Monument within the Angeles National Forest has been overwhelmed by litter, including "rotting food, barbecue grills, bottles, ice chests, soiled diapers and float toys" (Los Angeles Times, 2023). The situation became so severe that Fodor's Travel Guide placed the monument on its annual "Do Not Visit List" (Fodors, 2023).

Taken together, forest managers are faced with the difficult challenge of balancing increased visitation with the need to conserve ecological and cultural resources while enhancing visitor experiences (Ferguson et al., 2022). Compounding these challenges, longer and more intense wildfire seasons have had significant impacts on ecosystem services and costs. From 1995 to 2017, the fire suppression portion of the Forest Service's budget ballooned from 15 % to over 55 %, with 2015 marking the first year in which the majority of the budget was spent on fire suppression (USDA Forest Service, 2015; USDA Forest Service, 2017). Although fire suppression spending decreased to 40 % of the budget in 2022, it remains well above historical averages (Congressional Research Service, 2022). As a result, funds that would otherwise be allocated to critical forest management projects—such as trail maintenance, campgrounds, wildlife habitat conservation, or even fuel treatments—are frequently diverted to cover wildfire suppression costs (USDA Forest Service, 2015).

Given these realities, understanding the tradeoffs between ecosystem service supply and demand and forest management objectives is crucial, given limited resources and budgets (Bettinger et al., 2016). Stated preference methods, particularly Best-Worst Scaling (BWS), have emerged as valuable tools for estimating individuals' preferences for forest ecosystem services and management (Cheng et al., 2023b; Cheng et al., 2024). BWS is a relatively new method that requires survey respondents to select one 'best' and one 'worst' option in each task forcing tradeoffs between options (Finn and Louviere, 1992). While BWS has gained popularity across various fields since 2010, with 829 studies identified in a Scopus search, there remains a gap in the literature regarding tradeoffs in forest ecosystem services demand and associated management activities, especially in the context of the COVID-19 pandemic.

Therefore, the aim of this study was to determine the importance rankings and tradeoffs that diverse urban residents assign to different management objectives for nearby montane forests in southern California, using the BWS procedure. In doing so, we make the following modest contributions to existing literature on forest ecosystem services and the urban public's preferences for forest management. Our first objective is to apply the BWS method to a novel context to understand highly populated urban communities and their preferences for montane forest management and ecosystem service provision. By doing so, it extends the application of this rigorous preference elicitation technique to a critical area of environmental management that has received limited attention. This will also provide for a deeper understanding of how diverse urban populations value and prioritize different forest management strategies and ecosystem services, providing valuable insights for policymakers and fire managers in the Wildland-Urban Interface. The second objective of this study is to compare the preferences for forest management strategies and ecosystem services between urban residents who frequently visit nearby montane forests versus those that do not. This in turn will offer insights into identifying the differing awareness and priorities of frequent versus infrequent visitors related to montane forests; information that can be used to develop more participatory management strategies that address the needs of different user groups.

Additionally, this research examines forest ecosystem service and forest management preferences (e.g., recreation) in the aftermath of the COVID-19 pandemic (Grima et al., 2020; Derks et al., 2020). The global health crisis has significantly altered public perceptions and use patterns of natural spaces, particularly in urban-proximate areas (Ugolini et al., 2020). By capturing these potentially shifted preferences, our study offers a timely update to the literature on forest ecosystem services and forest management valuation. Moreover, it provides a methodological framework for assessing public preferences in times of rapid social change, demonstrating how stated preference techniques can be adapted to capture evolving societal values. These insights are crucial for informing adaptive management objectives that align with current public needs and expectations, especially in the context of the Wildland-Urban Interface areas facing multiple environmental and social pressures.

2. Data and methods

2.1. Study area

The study area was the northern and eastern Greater Los Angeles area comprised of the urbanized portions of Los Angeles, Riverside, and San Bernardino Counties in California, which form part of the second-largest metropolitan area in the U.S. With approximately 18 million residents located approximately 2–3 h from southern California's montane forests; ecosystems and watersheds serve as an important recreational destination (Clark, 2023). To define the survey population, we used population quotas and filtered respondents living in areas adjacent to the study area. Specifically, we targeted the socio-demographically diverse, U.S. Census-defined populations of the communities of San Bernardino, Fontana, and Highland, which are within a 1–2-h drive from the San Bernardino and Angeles National Forests (Fig. 1).

The high-elevation zones (above 1500 m) of the San Bernardino and Angeles National Forests are characterized by montane forests dominated by species *Pinus* spp., *Abies concolor.*, *Calocedrus decurrens.*, and *Quercus* spp., along with various shrubs, understory grasses, and forbs (Underwood et al., 2019; Keely and Syphard, 2018). These Wildland-Urban Interface forests offer extensive recreational opportunities, including hundreds of miles of hiking trails, campgrounds, designated wilderness areas, winter recreation resorts, wild and scenic rivers, multiple streams, and reservoirs. Additionally, they are home to the two

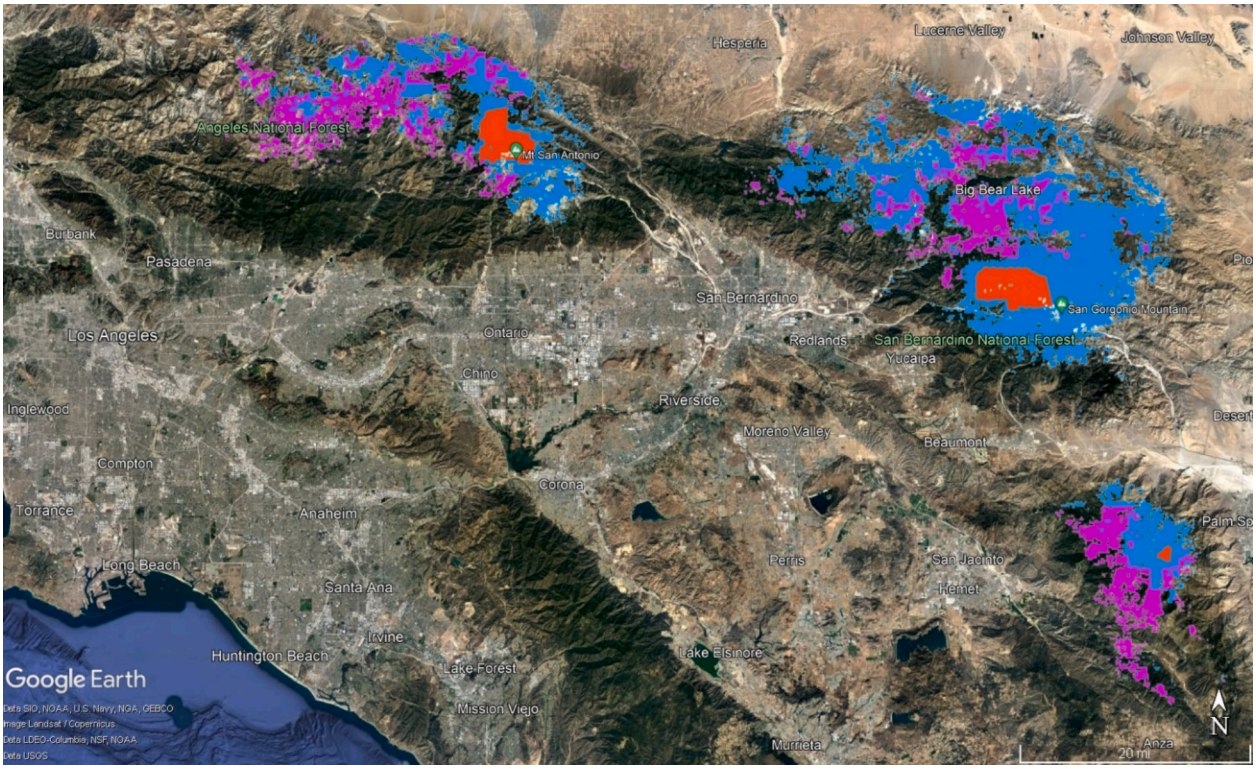

Fig. 1. The eastern portions of the greater Los Angeles US study area, the San Bernardino and Angeles National Forests, and location of upper elevation montane forests including Douglas-fir and Ponderosa pine (pink), lodgepole pine (red), and California mixed conifer (blue) forest types. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

highest mountains in Southern California (i.e., Mount San Gorgonio at 3500 m and Mount San Antonio at 3067 m) and are also a popular destination for off-highway vehicle use (e.g., Miller Canyon and Lytle Creek areas).

2.2. Survey design

We developed our survey instrument based on participatory information obtained from online meetings organized by the Southern California Montane Forest Project in January 2023. These meetings were attended by 66 participants, 95 % of whom were California residents, and over 80 % were either experts or active users of montane forests. Attendees provided valuable context-specific information that shaped the survey's design. The top five values identified by participants as critical for montane forest conservation were: biodiversity, watershed protection, community wildfire protection, recreation, and scenic values.

In February 2023, a focus group of 10 experts – including USDA Forest Service scientists, university researchers, and members of the Southern California Montane Forest Project – worked collaboratively to finalize the survey instrument. The group developed response items, identified ecosystem service and management structure-function attributes, and selected metrics. The goal was to ensure that the attributes were easily distinguishable and comprehensible to non-experts. The selection of forest-recreation infrastructure and management attributes was guided by Sklodowski et al.'s (2013) study, which provided foundation information for attribute levels. For water-related ecosystem services, the attribute levels were based on Hammitt et al. (1994), ensuring relevance to the study context. Additionally, recreation access and parking fee levels were based on current access and parking fees to the two national forests and Wang et al.'s (2017) findings that the mean willingness to pay (WTP) for forest recreation among visitors was approximately US$5, with a range between US$3 and US$9.

The draft survey instrument underwent a pilot test in March 2023, involving 20 participants, including experts, graduate students, and non-experts. The pilot testing helped refine the final version of the survey, which was launched online via Qualtrics in May 2023. The target population included individuals aged 18 and older residing in Los Angeles, Riverside, and San Bernardino Counties in California. To ensure representativeness, population quotas were randomly sampled by Qualtrics survey administrators, stratified according to U.S. Census data on age, gender, and income levels. The survey was approved by the University's Institutional Review Board, ensuring that ethical standards were met.

The survey instrument consisted of four sections: 1) introduction, consent, and participant screening, 2) awareness of, and visitation frequency to, montane forests, 3) choice experiments, and 4) socio-economic characteristics of respondents. The survey began with a consent question, followed by a filter question 'Do you live, or have you lived, in or near the cities of San Bernardino, Fontana, or Highland (San Bernardino County, California)?', to identify respondents who lived a 1–2-h drive and approximately 25 km from montane forests in the Angeles and San Bernardino National Forests.

A series of questions assessing respondents' familiarity with, and frequency of visits to, nearby montane forests was placed in the second block. A trap question was used to check if respondents paid attention when responding to survey items (Cheng et al., 2021; Cheng et al., 2024b). Instructions directed respondents to select 'none of the above' in response to a question unrelated to montane forests. As previously mentioned, residents "near the cities of San Bernardino, Fontana, or Highland" were defined as this study's sample population. Respondents' current zip codes were used to double check if they lived in the counties of Los Angeles, Riverside and San Bernardino, which comprise the Riverside-San Bernardino-Ontario Metropolitan Statistical Area (MSA) and the Los Angeles-Long Beach-Glendale Metropolitan Division (MD) as defined by the US 2020 Census. The initial completed sample was 868

responses. However, there were 43 respondents whose response time was below five minutes (Cheng et al., 2024a), 32 respondents whose zip code was outside our study area, and 27 respondents who failed to pass the trap question. Removing these respondents left a final sample of 766 responses.

2.3. Choice experiment

Respondents were provided with information that the current price to visit and park at a National Forest was $5. There are four context specific attributes as identified by focus group and a review of the relevant literature (Table 1): 1) forest thinning (two levels; prescribed fire and mechanical removal); 2) recreation infrastructure (three levels; public grills, garbage bins, and public restrooms); 3) water-related ecosystem services (three levels; rivers, waterfalls, and lakes); and 4) forest access via an additional parking fee (three levels; $1, $3, and $5). We note that "controlled fire" was used in the survey to facilitate comprehension by non-experts, but "prescribed fire" is used hereafter in the text. To minimize correlation between management alternatives, a fractional design was used to structure choice tasks (Lentner and Bishop, 1986). There were $2 \times 3 \times 3 \times 3$ possible combinations in the choice experiment's design space. A 99 % D-efficiency design resulting in nine BWS questions (Fig. 2) per respondent was determined by SAS macro % mktex (SAS, 9.4).

2.4. Econometric model

The paired method using dummy variable coding was employed to estimate the relative importance of attribute levels (Al-Janabi et al., 2010). This method assumes that individuals make their choices by evaluating all pairs and selecting the most significant option (Flynn et al., 2008). A multinomial logit (MNL) regression, a common approach for analyzing BWS data, was used to analyze the data from this paired method, as proposed by Lusk and Parker (2009). Following McFadden's (1973) random utility model (RUM), the indirect utility function for individual i, selecting alternative j on profile t can be expressed in Eq. 1:

$$v_{ijt} = \mathbf{x}_{ijt}\boldsymbol{\beta} + \epsilon_{ijt} \tag{1}$$

where v_{ijt} is the indirect utility individual i receives from selecting alternative j on profile t, $\mathbf{x}_{ijt}$ is a vector of attributes associated with alternative $j = 1, \ldots J$, $\boldsymbol{\beta}$ is a J by 1 vector of attribute coefficients, and ϵ_{ijt} is an unobserved random disturbance term from the extreme value distribution with an expected value of zero and variance σ_ϵ^2. The probability of selecting pair m takes the familiar MNL form in Eq. 2 as:

$$Pr[m \mid \mathbf{x}_{it}] = \prod_{t=1}\prod_{i=1}\prod_{k=1}^{J-1}\frac{exp(\mathbf{x}_{ijt}\boldsymbol{\beta})}{\sum_{k=1}^{J} exp(\mathbf{x}_{ijt}\boldsymbol{\beta})} \tag{2}$$

where $\mathbf{x}_{it}$ is the vector of attributes of all alternatives $j = 1, \ldots J$.

The MNL was estimated using Stata v15.1, (StataCorp LLC, College Station, TX, 2017). The routine uses maximum likelihood to estimate all model parameters (Cappellari and Jenkins, 2006).

Table 1
Forest management and ecosystem service attribute and levels used to develop choice experiment questions. Attributes were identified by focus groups and pilot study participants as indicators of forest management and ecosystem service provision.

Attribute (Source)	Definition	Levels
Fuels reduction (North et al., 2009)	Removing fallen branches, twigs, and dry shrubs with controlled fire or removing dead/unwanted trees by mechanical treatments to reduce the risk of fire and decrease forest density.	Controlled Fire* Mechanical Removal
Recreation infrastructure (Sklodowski et al., 2013)	Facilities and services provided by the US. Forest Service that allows for more access and comfort to visitors.	Public Grills Garbage Bins Public Restrooms
Water (Hammitt et al., 1994)	Providing access to water features (rivers, streams, lakes, etc.) within the national forest.	Rivers/ Streams Waterfalls Lakes
Parking fee (Wang et al., 2017; https://www.fs.usda.gov/main/sbnf/passes-permits/recreation;)	Paying an additional dollar amount to pay for parking to fund management activities.	$1 $3 $5

* The term "controlled fire" was used in the survey to better communicate the concept of prescribed fire to the general public. But the term "prescribed fire" is used in the text to better algin with the literature and expert audiences.

3. Results

The final sample size for the study was 766 respondents, corresponding to a margin of error of 3 % and a 90 % confidence interval. Table 2 shows that the demographic characteristics of the sample are generally consistent with those of the study area. However, respondents with annual household incomes below $100,000 were slightly overrepresented, while those with higher educational attainment, as well as Hispanics, Asian-Americans, and individuals with annual household incomes exceeding $100,000 are somewhat underrepresented relative to the greater Los Angeles area. Additionally, 46 % of respondents reported visiting a montane forest at least once per year, and 35 % were Hispanic.

3.1. Log-likelihood test

The log-likelihood of the unrestricted conditional logit model was −15,111. For those visiting a montane forest at least once per year, the group log-likelihood was −7349 while for those visiting a montane forest less than once per year the group log-likelihood was −7762. The log-likelihood of the restricted conditional logit model for pool data was −15,223. The likelihood ratio test compares the unrestricted and restricted models for the two subgroups and rejects the null hypothesis at the 5 % level of significance, indicating that frequency of visits had a significant effect on urban residents' preferences for forest management strategies and ecosystem services. Thus, we ran the regressions for the groups separately to present the BWS results.

3.2. BWS

Table 3 presents the maximum likelihood estimates from the BWS analysis for a group that visited a montane forest at least once per year and another group that visited a montane forest less than once per year. Following Al-Janabi et al. (2010), the attribute level *grills* was omitted and subsequently used as the base level for comparison. Our analysis revealed that all attribute levels were statistically significant at the 0.01 % level, indicating that respondents were able to clearly identify the differences between the attribute levels. A positive coefficient indicates that an attribute level was deemed more important than the base level, while a negative coefficient indicates that it was considered less important.

The results show that, except for *parking fees*, all attribute levels had positive coefficients suggesting that respondents valued these levels more than the base level. For frequent visitors, forest management generally was ranked as the most important attribute, specifically *mechanical removal* (0.7834) emerged as the most important level while *prescribed fire* (0.7076) was ranked as the second, followed by the ecosystem service attribute *lakes* (0.6394) which ranked third, *rivers* (0.6315) which ranked fourth, and finally *waterfalls* (0.5472) ranked fifth. Notably, while *lakes* and *rivers* ranked fourth, the estimated coefficients for these two attributes—0. 6394 and 0. 6315,

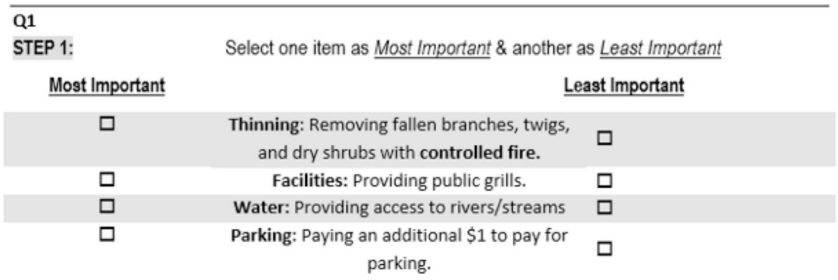

Fig. 2. Example of the Best Worst Scaling question.

Table 2
Socio-economic characteristics of respondents in urbanized portions of Los Angeles, Riverside, and San Bernardino Counties in California.[^, ^^]

Characteristic	Frequent Visitors (n = 352)	Infrequent Visitors (n = 414)	Sample total (n = 766)	Study area[^]
Age				[^^]
18 to 29	27.3 %	23.9 %	25.7 %	
30 to 44	37.1 %	23.4 %	29.7 %	28.9 %
45 to 64	30.6 %	34.5 %	32.6 %	32.7 %
65 and over	8.8 %	18.2%	13.8 %	19.6 %
Gender				
Female	39.9 %	57.8 %	49.5 %	49.8 %
Male	58.6 %	41.3 %	49.3 %	50.2%
Other	1.5 %	0.9 %	1.2%	N/A
Educational Attainment				
Bachelor's degree	33.2%	33.9 %	33.6 %	32.1 %
Ethnicity				
Hispanic/Latino (of any race)	35.6 %	32.3 %	34.0%	49.1 %
Race				
Asian (non-Hispanic)	5.4 %	12.2%	9.3 %	24.4 %
Black/African American (non-Hispanic)	17.3 %	10.6 %	13.4 %	14.5 %
White (non-Hispanic)	73.7 %	68.2%	70.5 %	52.7 %
Other (non-Hispanic)	3.6 %	9.0%	6.7 %	8.4 %
Annual Household Income				
< $35,000	14.4 %	32.6 %	24.3 %	21.7 %
$35,000 to $49,999	12.5 %	16.4 %	14.6 %	9.3 %
$50,000 to $74,999	21.8 %	21.1 %	21.4 %	14.9 %
$75,000 to and $99,000	21.6 %	13.5 %	17.2%	12.8 %
$100,000 or more	29.7 %	16.4 %	22.6 %	41.5 %
Political Ideology				
Conservative	30.3 %	25.6 %	27.8 %	N/A
Moderate	35.2%	45.9 %	40.9 %	N/A
Liberal	34.6 %	28.5 %	31.3 %	N/A

[^] The 2020 US Census Riverside-San Bernardino-Los Angeles County Statistical Area reports.

[^^] The US Census reports the metro area residents' age group from 20 to 29 years old category, which includes 14.4 % of the greater LA area.

respectively—were very similar. This indicates that respondents had similar important valuation for these two levels but still perceived a slight difference in their importance. On the other hand, paying an additional $5 *parking fee* (−0.2300) was ranked as the least important, placing 11th out of 11 options, indicating that respondents strongly preferred avoiding increased parking costs by an additional $5.

For infrequent visitors, among the attribute levels *public restroom* (1.2682) emerged as the most important, followed by *mechanical treatment* (1.1869) and *lakes* (1.1748). On the other hand, paying an additional $1 *parking fee* (−0.3681) was ranked as the least important, placing 11th out of 11 options, indicating that respondents strongly preferred avoiding increased parking costs by an additional $1. Interestingly, for both groups, *prescribed fire* – a key forest management practice, ranked lower than *mechanical removal*. This suggests that while respondents recognize its value, it is not regarded as critically important compared to other forest management and recreation options.

4. Discussion and conclusion

Our findings provide novel insights into public preferences for forest management strategies and recreational amenities, highlighting the importance of balancing ecosystem service provision with visitor experience. Indeed, sustainable forest management objectives, such as enhancing recreational infrastructure and managing wildfire risks, are essential tools to minimize the environmental impacts of increased visitor use and extreme events (Nematian et al., 2021; Bettinger et al., 2016; Wang et al., 2017; Chen et al., 2017). These approaches have become particularly relevant during the post COVID-19 pandemic era, as national forests have seen a surge in visitation. This increased use has put additional pressure on land managers to balance diverse forest visitor experiences with the protection of ecosystems from threats such as wildfire and overuse (Ferguson et al., 2022). By employing a relatively new stated preference approach, Best-Worst Scaling (BWS), we can better understand the importance and tradeoff decisions made by urban residents of the greater Los Angeles area, specifically concerning forest management activities, recreation infrastructure, and ecosystem services from nearby peri-urban or WUI montane forests.

Overall, our findings reveal several statistically significant differences in how frequent montane forest visitors (at least once per year) and infrequent visitors (fewer than once per year) groups value forest management and ecosystem service attribute levels related to forest management, recreation infrastructure, and ecosystem service objectives (Table 3). This finding is consistent with Cheng et al. (2024a) conclusion that the L.A. residents' preferences for ecosystem services between frequent forest visitors and infrequent visitors were inconsistent. In the frequent visitors group, the forest management attribute (e.g. "mechanical removal" and "prescribed fire") and the ecosystem services attribute (e.g. "rivers", "lakes", and "waterfalls") were ranked importantly, consistent with other studies.

For example, Santiago and Loomis (2008) found that people preferred forests with rivers and/or waterfalls, while Tanner et al. (2022) showed that visitors favored southern California national forest recreation sites with water bodies, often willing to travel longer distances to reach these sites. Interestingly, while Skłodowski et al. (2013) concluded that garbage bins were the most important infrastructure to improve visitation quality, respondents from both groups in our study did not prioritize garbage bins as highly (ranked 7th out of 11 attributes). However, within the infrastructure category, garbage bins were still considered more important than public grills for both groups. This is an encouraging finding for forest managers, given ongoing struggles to address litter issues and minimize negative environmental and social impacts (Fodors, 2023). Prior studies have shown that recreationists

Table 3
The MNL Best-Worst Choice scaling result of the frequent visitors group and the Infrequent visitors group.

	The Frequent Visitors Group				The Infrequent Visitors Group			
Attribute Level	Estimated Coefficient	Standard Error		Importance Ranking	Estimated Coefficient	Standard Error		Importance Ranking
controlled fire (prescribed fire)	0.7076	0.0536	***	2	1.0750	0.0541	***	5
mechanical removal	0.7834	0.0629	***	1	1.1869	0.0633	***	2
public grills	–	–	–	8	–	–	–	8
garbage bins	0.4677	0.0646	***	7	0.8577	0.0641	***	7
public restrooms	0.5253	0.0647	***	6	1.2682	0.0652	***	1
rivers	0.6315	0.0625	***	4	1.1602	0.0632	***	4
waterfalls	0.5472	0.0624	***	5	1.0494	0.0628	***	6
lakes	0.6394	0.0625	***	3	1.1748	0.0632	***	3
additional parking fee: $1	−0.2037	0.0622	***	9	−0.3681	0.0628	***	11
additional parking fee: $3	−0.2119	0.0622	***	10	−0.3349	0.0625	***	10
additional parking fee: $5	−0.2300	0.0623	***	11	−0.2317	0.0618	***	9
N	352				414			
Log Likelihood	−7349				−7762			

* Significant at 90 %; ** significant at 95 %; ***significant at 99 %.

often employ coping strategies when encountering undesirable levels of litter (Johnson and Dawson, 2004; Hall, 2007). More recently, Ferguson et al. (2023) also found that 30 % of respondents experienced litter/-trash, vegetation damage, and or/water pollution as a direct impact of the COVID-19 pandemic.

Our results are also consistent with Loomis et al. (2005), who concluded that California residents favored fuel reduction programs like prescribed burning and mechanical thinning. However, our approach offers the added advantage of identifying the specific trade-off respondents make between both these methods. Specifically, while "mechanical removal" was ranked highest (1st out of 11) in the frequent visitors group and second in the infrequent visitors group, "prescribed fire" was ranked second in the frequent visitors group and fifth in the infrequent visitors group. This suggests that while mechanical treatments are seen as more critical, residents still recognize the importance of prescribed burns in reducing wildfire hazards, relative to other recreation, forest management, and ecosystem service options for Southern California's montane forests.

The direct and indirect impacts of wildfire, such as loss of property and smoke emissions, are known ecosystem disservices for urban populations in the Greater Los Angeles area, thereby potentially influencing preferences (Cheng et al., 2024a). Therefore historical and recent fire events that occurred prior to and during 2020 - and subsequent smoke episodes that can last for days - likely shaped participants' choices in our study area and population. Perhaps this explains the preference for mechanical treatments, which do not emit smoke and are a more controlled process with immediate results, over prescribed fire (Table 3) which can be weather-dependent, occasionally difficult to control, and will result in some short-term smoke emissions. However, mechanical treatments are much more costly than prescribed fires to implement and as opposed to prescribed fire, mechanical treatment implementation is often limited by steep terrain and other accessibility issues (North et al., 2021). These nuanced insights provide valuable guidance for forest managers seeking to balance public preferences with sustainable yet cost-effective forest management practices (USDA Forest Service, 2022a, 2022b).

Despite the novel insights this study provides, we acknowledge some limitations. First, Asian-American and African American, and to a degree Hispanic, respondents were somewhat underrepresented in our sample, which is an issue given that the study area includes one of the largest Hispanic populations in any U.S. metropolitan area (Davis, 2024). We also note that respondents with annual household incomes below $100,000 were slightly overrepresented. This underrepresentation, as well as overrepresentation in some variables, might have implications for generalizing our findings, particularly in understanding the preferences and needs of urban communities with diverse demographics. Future studies should aim for more balanced sampling to capture a broader spectrum of perspectives, ensuring that the views of all community groups are adequately reflected.

Second, this study used zip code information to verify whether respondents were located within the defined study area and within a 1–2 h drive or ~ 25 km from the San Bernardino and Angeles National Forests. However, we did not account for variations in traffic conditions, particularly in the Greater Los Angeles area, which could affect the time it takes for participants to reach montane forests from their specific locations. Third, while the BWS method is effective in identifying trade-offs between forest management preferences, it does not directly estimate the willingness to pay (WTP) for specific ecosystem services or management actions. Indeed, WTP estimates could offer more precise guidance for forest managers by quantifying the monetary value that residents place on different forest attributes, which could, in turn, help allocate resources more effectively. Future research might consider complementing BWS with WTP estimation methods such as contingent valuation or conjoint analysis to provide a more comprehensive decision-making framework.

Fourth, only three models are suitable for analyzing the BWS data: paired-MNL (or paired-Conditional Logit; CL), marginal-MNL (marginal-CL), and ranked order logit; all of which hold the Independence of Irrelevant Alternatives (IIA) assumption (Aizaki and Fogarty, 2019; Cheng et al., 2023a). While other model structures (e.g. Mixed logit) do not require the IIA assumption, these are not feasible for implementing BWS due to specific data formatting requirements. Recently, Cheng et al. (2024b) proposed a Bayesian generalized ranked ordered logit model which releases this IIA assumption. Thus, future studies might consider estimating respondents' forest management-ecosystem service preferences by using the Bayesian generalized ranked ordered logit model.

Finally, we also note that our focus group and pilot study experts only identified developed recreation opportunities and infrastructure as attributes (Table 1). But it might also be important to consider "undeveloped" recreation uses (e.g., hiking trails, camping sites) or nearby wilderness areas, which may differ significantly from developed recreation sites (Thomas et al., 2022). These areas also often require specific improvements such as improved trails, signage, and more naturalistic facilities, to support sustainable recreational activities while preserving their environmental integrity. This distinction highlights an area for further study, as understanding the infrastructure requirements of wilderness areas close to cities is essential for effective land management and recreational planning.

Overall, our findings offer actionable guidance for shaping forest management policy, especially considering recent catastrophic fires in Los Angeles and policies such as the Wildfire Crisis Strategy. The finding that nearby urban residents in the greater Los Angeles area prioritize mechanical removal over prescribed fire as a preferred forest management technique is particularly relevant, as both approaches often face scrutiny from various interest groups and communities. Thus, understanding these preferences can help forest managers prioritize

interventions that align with public opinion while balancing ecological needs.

In conclusion, this study offers valuable insights into the preferences of urban communities regarding forest management and ecosystem service-related decisions. By aligning management objectives with these preferences, policymakers and forest managers can enhance visitor recreational experiences, protect vital ecosystems, and adopt a more inclusive approach to planning and implementation. These findings not only contribute to the ongoing discourse on sustainable forest management but also provide a roadmap for creating more sustainable and accessible forest environments for diverse groups of urban residents and visitors.

Credit authorship contribution statement

Haotian Cheng: Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Francisco J. Escobedo:** Writing – review & editing, Writing – original draft, Conceptualization. **Alyssa S. Thomas:** Writing – review & editing, Writing – original draft. **Jesus Felix De Los Reyes:** Data curation. **John N. Ng'ombe:** Writing – review & editing. **José R. Soto:** Supervision, Conceptualization.

Declaration of competing interest

None.

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Data availability

Data will be made available on request.

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