Individual and collective tradeoffs and importance for ecosystem services from montane forests

Highlights

- Ecosystem service values account for individual, rarely a collective perspective
- Importance of benefits to urban, Hispanic, infrequent visitors often excluded
- We identified significant tradeoffs between individual and collective importance
- All groups valued water-based benefits, non-Hispanics valued high forest densities
- Approach can inclusively account for tradeoffs diverse, urban communities make

Abstract

Accounting for the tradeoffs and importance urban, disadvantaged communities place on ecosystem services has implications for management of nearby forests. Although stated preference valuation approaches are used, they are based on an individual's perspective and rarely account for collective or societal values. Thus, alternative methods are needed to capture this dichotomy from urban communities who may not even be aware of these benefits to themselves or society at-large. We explored individual and collective importance and tradeoffs for ecosystem services/disservices by urban residents living near montane forests in greater Los Angeles California (USA). Using an online panel survey, individual (*I*-rationality) versus collective (*We*-rationality) scenarios, best-worst scaling (BWS) choice experiments, and latent class analyses, we ranked the importance and tradeoffs among ecosystem service (ES)-disservice (ED) attributes to residents based on frequency of visits to montane forest as well as Hispanic and non-Hispanic residents living nearby. Results show statistically significant tradeoffs and differences in importance rankings between individual versus collective valuation scenarios. Under the individual valuation scenario, non-Hispanics highly ranked the high forest density indicator, which has implications for wildfire EDs to montane forests and communities. Gender and income were more influential sociodemographic factors affecting importance for water and recreation-related ES than was education. Our BWS and econometric methods, attributes, and importance rankings can facilitate participatory process with diverse urban communities and designing more effective policies and management guidelines. This approach can also inclusively and equitably account for the tradeoffs and value that nearby urban communities place on ES/ED from Wildland-Urban Interface forests.

Keywords: Hispanics, Cultural Ecosystem Services, Regulating ecosystem services, Tradeoffs, Wildland-Urban Interface

1. Introduction

Forests near cities provide a suite of key ecosystem services and other market and non-market amenities (Friggens et al., 2014; Sloggy et al., 2022). However, their management and conservation are affected by changes such as: growing populations, wildfire, climate change, invasive species, and other socio-political factors (Jenerette et al., 2022). More specifically, these drivers can also affect the ecosystem structure, function, and subsequent provision of ecosystem services (Aznar-Sanchez et al., 2018); particularly in peri-urban or Wildland-Urban Interface (WUI) forests located near highly populated and diverse communities (Sloggy et al., 2022; Yadav et al., 2023). Although such forest ecosystem service valuation issues have been documented, less is known about how different urban community and socio-demographic groups living near these forests (e.g., disadvantaged communities, minority groups, low-income households, infrequent users) place importance on such ecosystem services either individually or collectively (Vatn, 2009).

Forests and other ecosystems in Mediterranean climates located near major population centers such as those of southern California in the United States (US) are important as they provide water supply and climate regulation (Plieninger et al., 2012; Underwood et al., 2019) but also cultural ecosystem services including recreation (Tanner et al., 2022). For example, recreation on US national forests in 2016 alone provided approximately $49 billion in benefits and 826,000 jobs (Cline and Crowley, 2018). Other recreation-related ecosystem services include hiking, picnicking, viewing scenery, and visiting heritage sites (Plieninger et al., 2012). Forests in Southern California have some of the highest numbers of recreation visits in the US and are frequently affected by frequent and severe wildfires, urbanization, and other extreme climatic events (Underwood et al., 2019; Yadav et al., 2023). Demand-based valuation studies in these forests are typically based on secondary data or elicited values where specific user groups such as highly educated, well informed, and frequent users predominate (Plieninger et al., 2012; Tanner et al., 2022). But to our knowledge, urban residents, Hispanics, or infrequent visitors are often not a focus of such studies.

Several studies from southern California, USA have assessed the use and perception of these WUI forests from different socio-demographic groups, particularly regarding recreation (Flores and Sanchez, 2020; Thomas et al., 2022) and water-related ecosystem services (Tanner et al., 2022). However, such studies often assess these values from individuals, not collectively, nor do these studies account for the tradeoffs that different sociodemographic communities make when valuing different ecosystem services. Indeed, the importance of different ecosystem services can change according to individual versus societal values as well as spatially and temporally (Darvill and Lindo 2016; Soto et al., 2018). Thus, information on the diverse values and tradeoffs that individuals and urban communities living in and near forests make regarding their ecosystem services is necessary in addressing issues of environmental justice and equitable governance (Yadav et al., 2023).

Ecosystem service valuation methods can better inform such forest management, planning, and conservation decisions (Sanchez et al., 2021). Stated preference valuation is one such method that estimates the value and potential demand for ecosystem services (Lienhoop et al, 2018; Cheng et al., 2023) and consists of asking respondents to base responses on their individual needs, rather than those of society (Lienhoop et al., 2015). However, ecosystem services affect not only individuals, but also society at large and future generations (Wilson and Howarth, 2002). Thus, considering only individual needs when making ecosystem services-related management and policy decisions is insufficient for understanding society’s needs (Dietz et al., 2005). As such, there is often a mismatch between personal preference and long-term societal values (Niemeyer and Spash, 2001; Groot and Steg, 2008; Vatn, 2009).

This dichotomy in individual versus collective valuation is particularly important given the ecological and socioeconomic complexity of US national forests located near cities. Accordingly, there is growing interest in social preferences and values, as well as in eliciting people's interest in collective or broad distributional considerations by asking individuals to consider their own opinions or preferences, in addition to others, for ecosystem services (Dolan et al., 2003). Vatn (2009) proposed the 'I-rationality' and 'We-rationality' scenarios to describe this mismatch between personal and societal needs, each respectively signaling which logic pertains to specific scenarios. In the 'I-rationality' scenario, an individual only counts self-interest, and costs and benefits. In the 'We-rationality' scenario, individuals are supposed to develop sound arguments and solutions concerning how best to comply with the common interest of society (Rommetvedt, 2005).

The role of environmental governance and individual versus collective rationalism has been addressed by Soma et al. (2016) and Horodecka and Vozna (2021), respectively. Alvarez-Farizo et al. (2007), for example, used choice experiments to understand individual versus collective interest in environmental valuation, while Lienhoop et al. (2015) discussed the role of institutions and deliberative valuation of biodiversity policies. Dolan et al. (2003) documented the importance of considering a range of perspectives because a person's preferences may depend on the perspective that the person is asked to adopt. Additionally, Soto et al. (2018) used a choice experiment method called Best-Worst Choice (BWC) to estimate homeowners' preferences for urban forest ecosystem services from their properties versus their surrounding neighborhood.

Although effective forest management and governance requires input from a diversity of people, Reed et al. (2018) notes there are few incentives for the public to participate in planning processes often due to time constraints, perception their input will not be considered by decision makers, and other factors. Conversely, the public that does participate is often over-represented by older, higher income, highly educated, white males (Davis et al., 2017). As such, the values of participants in planning processes do not always correspond to those held by nearby "minority" populations (Rasch, 2019) or consider the adaptive social capacity of adjacent communities (Sanchez et al., 2021). Thus, more collective, and inclusive ecosystem service valuation approaches are needed to account for diverse urban communities living near forests.

Therefore, the aim of this study was to better understand the importance and tradeoffs in how – individually and collectively – urban communities living near montane forests value cultural and regulating ecosystem services. The specific objectives were to 1) assess how nearby residents' frequent and infrequent visitation to montane forests influences individual and collective importance and tradeoffs for different ecosystem service attributes, 2) identify the differences between individual and collective valuation of montane forests among Hispanic and non-Hispanic residents, and 3) better understand how the socio-economic characteristics of respondents influence Objectives 1 and 2.

2. 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 (Appendix A). The study area is approximately 12,561 km^2 and has a population of approximately 18.5 million. As of 2020, the Greater Los Angeles area's population was 49.1% Hispanic, making it the largest majority-Hispanic metropolitan area nationally (U.S. Census Bureau, 2020). To address our objectives, we focused on the sociodemographic characteristics of urban communities located near montane forests (i.e., less than approximately 25 kilometers or a 1.5-hour drive in distance). We used the US Census defined populations of San Bernardino-Fontana-Highlands; communities that are within 1 hour drive from the montane forests of the San Bernardino National Forest - to define survey population quotas and filter out respondents living in distant areas. See Survey Instrument Section (2.4) for specific details and methods.

The study area has a Mediterranean-type climate and is part of the South Coast bioregion that encompasses urban, grassland, shrubland, woodland, and forest ecosystems that range from sea level to over 3000 meters in elevation (Keeley and Syphard, 2018). Located within the study area at elevations greater than approximately 1500 meters are high elevation montane forests. Montane forests are dominated by various *Pinus spp*., *Abies concolor*, and *Calocedrus decurrens* trees as well as other *Quercus spp* trees, shrubs and other understory grasses and forbs (Keeley and Syphard, 2018). These montane forests are key components in southern California's water supply and provide various recreation opportunities but are highly disturbed due to highly populated nearby communities, high recreational use, invasive species, and frequent and severe wildfires (Jenerette et al., 2022). These various disturbances within the montane forests have resulted in different forest structural and compositional attributes that subsequently affect ecosystem service supply (Underwood et al., 2019).

2.2 Best Worst Scaling

The Best-Worst Scaling (BWS) is a probabilistic data collection method for eliciting stated preference (Finn and Louviere, 1992). In BWS, rather than exclusively selecting the 'best' option, respondent are asked to select both the ‘best’ and the ‘worst’ options among the alternatives, forcing them to make tradeoffs (Bruzzese et al., 2022). For example, Tyner and Boyer (2020) used BWS to estimate the preferred reason for restoration and conservation and found that human health and protection of native species were the most preferred reasons. Soto et al. (2018) estimated homeowner’s consumer demand for key urban forest ecosystem service and disservice attributes and found that property value and tree condition were the most important attributes for Florida residents.

2.3 Survey Design

The survey instrument was developed based on an online workshop in January 2023. During these meetings, 66 participants were asked to rank the importance of different values and management activities related to the conservation of montane forests. The top five values selected were: biodiversity, watershed, community protection, recreation, and scenic values. Afterwards in February 2023, a focus group consisting of 10 experts developed a series of ecosystem structure-function-service indicators and attributes for montane forests. Three montane forest attributes were then used as attributes of forest-based ecosystem service provision and levels and that could be distinguished and perceived by non-experts. Given the importance of waterbodies to regulating and cultural ecosystem services in the study area (Tanner et al., 2022; Underwood 2019), we also included one water-based ecosystem service choice and types/levels (Table 1).

<<Table 1>>

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-demographics. The second block contained a series of questions that assessed respondents' familiarity with (i.e., Do you agree or disagree with the statement 'I do not know very much about montane forest') and frequency of visits to (i.e., how many times a year do you visit any montane forest in southern California) nearby montane forests. A check question was included to detect whether respondents paid attention when responding to survey items (Cheng et al., 2021; Cheng et al., 2024). Instructions directed respondents to select 'none of the above' in response to a question unrelated to montane forests.

In the third portion of the survey, split design approach was used to randomly assigned respondents to one of two versions of the choice experiments. The first version ('Individual') asked respondents to select the most and least important attribute levels to *them* (i.e. the most important to you) for each policy scenario. Respondents to the second version ('Collective') were asked to select the most and least important attribute levels to *their community* for each policy scenario. Respondents were presented with eight hypothetical ecosystem structure-service states with different attribute levels (Table 1). Four attributes and respective levels were tested: 1) forest density (low or high); 2) forest understory (bare or covered); 3) water (no water, streams, waterfalls, and lakes); and 4) forest diversity (low or high). The four-ecosystem structure-function states and attributes are regularly used indicators for subsequent regulating and cultural ecosystem services (Underwood et al., 2019).

A fractional, orthogonal main effect design was used to minimize correlation between policy scenarios and to structure the choice tasks (Lentner and Bishop, 1986). Specifically, there were $4 \times 2^3 = 32$ possible combinations in the choice experiment's design space. A 100 percent D-efficiency balanced design resulted in 8 BWS questions per respondent (Appendix C). In these respondents were instructed to select the most and least important levels, thereby making tradeoffs between the four attributes and their respective levels.

2.4 Survey Implementation

The survey was pilot tested with 20 experts and graduate students in March 2023 for cultural and technical relevance. The data were collected from an online Qualtrics survey launched in May 2023 for respondents 18 years or older via e-mails using a computer, cellphone, or tablet. Qualtrics panel population quotas were based on the US Census demographic characteristics for the cities of San Bernardino, Highlands, and Fontana, California as explained in the study area section (Appendix A). Therefore, after consenting to participate in the survey, respondents answered a screening question: "Do you live, or have you lived, in or near the cities of San Bernardino, Fontana, or Highland (San Bernardino County, California)?" To proceed with the survey, the respondent needed to respond 'yes' to this question. The sample frame was then stratified by US Census income level, gender, and age. In our respondent sample characteristics section below, we define how we selected those who "live of have lived" in the study area.

2.5 Econometric analysis

For research objectives 1 and 2, we used a paired method which considers each best-worst pair to derive choice frequencies, which is then used to estimate the importance of attribute/indicator levels (Flynn et al., 2008)). This method assumes that individuals can evaluate all pairs and levels before selecting the most important choice as a tradeoff among all pairs (Flynn et al., 2008). If one profile contains J levels, then the number of possible best and worst pair levels for the profile is $J \times (J-1)$. Following Al-Janabi et al. (2011) we extended the paired model method by including dummy variable to code our attribute levels. When an attribute was selected as the most important it was coded as one, otherwise as negative one (Al-Janabi et al., 2011). Following Soto et al. (2018), the paired method results were analyzed using multinomial logit regression (MNL).

Additionally, based on McFadden (1973)'s random utility model, the indirect utility was assumed linear in arguments with systematic and random components:

$$v_{ijt} = \mathbf{x}_{ijt}\boldsymbol{\beta} + \epsilon_{ijt} \quad (1)$$

where v_{ijt} is the indirect utility individual i receives from selecting alternative j on profile t, $\mathbf{x}_{ijt}$ and which is a vector of attributes for 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}. Appendix B provides a description of how choice probability can be generated from these data using a typical MNL model. For our third objective, we used a latent class logistic (LCL) regression to model the number of available latent classes for the respondents in the 'individual' scenario and estimate preference parameters for each latent class. Appendix C provides a description of how choice probability can be generated from these data using a typical LCL model. Both the MNL and the LCL models were estimated with Stata 15 using the Gauss – Hermite quadrature routine and simulated maximum likelihood.

3. Results

3.1 Objective 1

Initial sample population was 869 but 102 were filtered leaving *n*=767 respondents with socio-demographics were generally consistent with the study area (Table 2; Appendix D). Around 35% of respondents were Hispanic and 46% had visited a montane forest at least once per year. All indicator levels in each group and scenario were statistically significant at the 10% level (Table 3). The indicator level *low diversity* was omitted as the base. Additionally, estimated coefficients signs for the indicator levels in each group and scenario were positive, suggesting that the base level, *low forest diversity*, was the least important level (rank 10). Thus, the *low diversity* level was omitted as the base and was accordingly the least important level for each group and scenario.

<<Table 2>>

<<Table 3>>

For frequent visitors, the importance rankings between the two scenarios were generally consistent in that they highly valued water over forest-related attributes, but the importance rankings for lakes and waterfall were different (Table 3). In the 'individual' scenario, *streams* was ranked as the most important level, followed by *waterfalls* and then *lakes*. In the 'collective' scenario, *streams* was again ranked as the most important level, followed by *lakes* and *waterfalls*. For the infrequent visitors, the top three most important levels in order were *streams*, *lakes*, and *waterfall*. In general, both frequent and infrequent visitors under both scenarios (i.e., 'individual' and 'collective') most valued water over forest-related attributes (Table 3).

3.2 Objective 2

To avoid a "dummy variable trap", *low diversity* was omitted as the base as previously stated. All indicator levels in each group and scenario were statistically significant at the 10% level, except *low density* and *bare* for Hispanic in the 'individual' scenario and *bare* for non-Hispanic in the 'collective' scenario (Table 4). The insignificant indicator levels suggest that these levels were not significantly different to the base level, *low diversity*. All estimated coefficient signs of attribute levels in each group and scenario were positive, suggesting that the base level, *low diversity*, was the least important level across all four groups as was the *bare* attribute.

For Hispanic respondents, in the ‘individual’ scenario, *waterfalls* was ranked as the most important level, followed by *lakes* and *streams*. In the ‘collective’ scenario, *streams* was ranked as the most important level, followed by *lakes* and *waterfalls*. Overall, Hispanics most valued water over forest-related ecosystem service attribute (Table 4). In contrast, in the non-Hispanic, ‘individual’ scenario, the three most important levels were *streams*, *lakes*, and a forest-based ecosystem service attribute and level *high forest density*. In the ‘collective’ scenario, *streams* was ranked as the most important level, followed by *lakes* and then *waterfalls* (Table 4).

<<Table 4>>

3.3 Objective 3

Table 5 presents the maximum likelihood estimates results for the best fitting LCL model describing all Hispanic and non-Hispanic respondents in the ‘individual’ scenario. The indicator level *low diversity* was omitted and used as the base. Respondents had a 28% mean probability of belonging to Class I. Female respondents, respondents who indicated their political ideology as moderate and liberal, and who visited montane forest at least once per year were more likely to belong Class I (Table 5). In general, Class I respondents ranked water-based attribute levels as the most important, followed by forest understory, while tree density and forest diversity were ranked as least important.

<<Table 5>>

The mean probability of belonging to Class II was 20.2%. Respondents whose political ideology was moderate and liberal as well as females were more likely to belong to this class, however respondents from 45 years to 64 years old with annual household income from $50k to $74.999k category were less likely to belong to this class (Table 5). Respondents in Class II ranked the high forest density as the most important attribute followed by high forest diversity.

Water-based attributes were ranked as the third most important while forest understory indicators were regarded as least important.

Class III had a mean probability of membership of 26.9%. Female respondents were more likely in this class. However, respondents 18 to 64 years old and those with annual household incomes from $50k to $74.999k were less likely to be in Class III (Table 5). Among the four classes, this was the only class where all attribute levels were statistically significant at the 10% level, suggesting that respondents in this class could evaluate and distinguish each ecosystem level clearly. The water-based ecosystem service attribute was ranked as the most important by Class III respondents.

The mean probability of belonging to Class IV was 24.9%. Respondents with annual household incomes from $50k to $74.99k and respondents from 45 years to 64 years old were more likely in Class IV while female respondents were less likely to be in Class IV, relative to the other 3 classes (Table 5). However, residents who indicated their political ideology as moderate and liberal were less likely to belong Class IV, relative to Classes I and II. Also, Hispanics were less likely to belong to Class IV, relative to Class I. The respondents in Class IV ranked *forest density* as the most important ecosystem service, followed by *forest understory* while the water-based ecosystem service attribute levels were ranked as least important.

4. Discussion

This study used a choice experiment and BWS approach to better understand the importance and tradeoffs that urban residents of the greater Los Angeles USA make – individually and collectively – from ecosystem service attributes from nearby montane forests. Findings show some statistically significant tradeoffs in the importance rankings of ecosystem service indicator levels when comparing the individual and collective scenarios (Tables 3 and 4).

In the individual scenario, frequent visitors assigned a higher level of importance to waterfalls as compared to lakes, but this was reversed in the collective scenario (Table 3). Tanner et al. (2021) also found that sites with waterbodies and tree cover were highly desirable for visitors to National Forests in the Los Angeles area. In terms of individual versus collective valuation of environmental amenities, there is often a mismatch between personal preferences and long-term societal values (Niemeyer and Spash, 2001; Vatn, 2009). However, our results provide limited evidence for Vatn (2009)'s conclusion that individual preferences are contradictory to environmental resource and ecosystem service demand (Lienhoop et al., 2015).

Similarly, for Hispanic and non-Hispanic respondents in both the individual and collective scenarios, most of the significant differences and mismatches were between the water-related ecosystem services and the three levels that were all ranked as highly important (Table 4). Therefore, although there were statistically significant mismatches between frequent and infrequent visitors as well as Hispanic and Non-Hispanic respondents in both scenarios, results indicate that most respondent groups- except for Nono-Hispanics and high forest density which will be discussed later – generally prefer water-related regulating and cultural ecosystem services.

Our findings are similar to Tanner et al. (2022) who found that visitors preferred southern California national forest recreation sites with waterbodies and tree cover, and were willing to drive longer distances to the sites with water. Similarly, Hammitt et al. (1994) showed that forests with streams, rivers, and lakes were most preferred by respondents. Water was also one of the top three landscape features desired by respondents in the Netherlands (Van Berkel and Verburg, 2014). Although these studies took place in an agricultural rather than forest landscape, it suggests the strong importance attached to water may be independent of ecosystem type.

Schmidt et al. (2019) also found that cultural ecosystem services including experiencing, using, or learning about nature were most often located near water bodies.

Overall, when respondents had to assess the tradeoffs among the ecosystem services in Table (1), they generally valued water over forest-based ecosystem services. However, people's demand for water-related cultural ecosystem services can motivate them to engage with forest ecosystems directly and indirectly (Plieninger et al., 2015). Therefore, although residents may be initially drawn to waterbodies, the hydrological cycle is largely regulated by montane forests (Plieninger et al., 2012; Underwood et al., 2019). As such, the preference for water can not only be used to communicate the importance of montane forests in providing and regulating water supply (Underwood et al., 2019), but also to communicate the importance of other ecosystem services and their susceptibility to extreme climate change characterize southern California (e.g., drought, wildfires, floods; Manley and Egoh, 2022; Sanchez et al., 2021).

We found education levels were not a significant influence, but gender and income were, in regard to the importance of ecosystem services from montane forests (Tables 5). Generally, female respondents ranked *streams* and *lakes* as important while, males, those with the annual household income from $50k to $74.999k, and 45 years to 64 years olds ranked *density* and *understory* as most important (Table 5). These results provide further evidence of the heterogeneity of values for ecosystem services as observed by Álvarez et al. (2021) and that sociodemographics can significantly affect the importance rankings of ecosystem services (Table 5; Faehnle et al., 2014; Friggens et al., 2014). Martín-López et al. (2012) also found that people ascribed differing levels of importance to ecosystem services depending on gender, age, and urban or rural residency.

The importance of the high forest density indicator for non-Hispanic respondents has important implications for forest health, as well as wildfire-related ecosystem disservices to montane forests and communities in the WUI (Sanchez et al., 2021; Jenerette et al., 2022). Stephens et al. (2022) found that increased dead biomass and live tree densities were the two most influential factors in predicting fire severity and subsequent effects on forest structure and subsequent function and services as well as ecosystem disservices to nearby WUI and urban communities (Plieninger et al., 2012). Similarly, we found that two out of the four classes (i.e., Class II and IV) highly ranked high-density forests relative to the other attributes levels (Table 5). Respondents aged 18-29 were more likely to belong to these two classes. Plieninger et al. (2012) found that private landowners of "working" forests and rangelands (i.e., engaged in commercial livestock or timber activities) in California highly ranked the importance of fire prevention as well as wildlife habitat and recreation related ecosystem services. Sanchez et al. (2021) using visitor surveys and benefit transfers estimates in three California's Sierra Nevada National Forests did however identify that reduced forest densities were effective in improving their resilience to changes.

Our results found that Hispanics differentiate between their individual and collective valuation of ecosystem service and that they highly ranked water-based regulating and cultural ecosystem services as important (Table 4). Flores and Sanchez (2020) and Thomas et al. (2022) indicate that Hispanics overwhelming support protecting public lands, but also found that discrimination was a significant barrier to their use of public lands. Similarly, Yadav et al. (2023), found that urban communities as well as Hispanics and Asian-Americans were statistically and increasingly affected by wildfires during 2016-2020. Therefore, newer more inclusive and collective approaches are needed to account for urban, often overlooked, communities and how, why, and how much they value forest ecosystem services. Similarly, results indicate the need to educate non-Hispanic groups of the increased risk of wildfire disservices associated with this attribute.

Conclusion

Tradeoffs occur when people place an importance on a suite of different place-based ecosystem services as well as disservices. This study attempted to explore how urban residents living near montane forests make these tradeoffs, both individually and collectively, based on their frequency of visits, if they are Hispanic or not, and other socio-demographic characteristics. Tradeoffs are regularly “win-lose” interactions when multiple stakeholder groups value different ecosystem attributes differently in complex socio-ecological systems. Thus, our findings could be used to better inform different publics about the importance of conserving and managing montane forests for their water regulating ecosystem function, as well as their high fire severity risk potential.

Like previous studies on southern California’s forests and shrubland ecosystems, and as previously stated, we identified the importance of ecosystem service from water-related features across all groups. However, the importance of water-related and forest density attributes, on an individual and community level, has strong implications for the sustainable supply of ecosystem services from montane forests. Specifically, their proximity to high population centers, unchecked recreation, and in particular severe wildfires, increases their vulnerably to type conversion to shrublands or other invasives. Additionally, climate change can also decrease streamflow and baseflow threaten the provision of not just recreation ecosystems services but drinking water to nearby large metropolitan areas.

At the time of writing, recent policies such as the 2021 Bipartisan Infrastructure Law and the Wildfire Crisis Strategy, designated southern California montane forests as part of the "firesheds" that will receive substantial funding for wildfire mitigation practices and management to conserve them. Thus, our attributes and importance rankings can be used to establish restoration guidelines and decision-making priorities. Communities living near montane forest value them, despite infrequently visiting them; therefore, informing the public about their critical role in water supply, air quality via wildfire smoke, and respite from increased urban heating can be used to promote their conservation and proper management. We hope that the findings as well as methods from this study contribute to this discourse and can be used to communicate the importance of forest ecosystem services and disservices to underrepresented urban communities. Such science-based evidence provided by this study can hopefully lead to more equitable and inclusive participatory processes related to the management and conservation of peri-urban montane forests.

Competing interests: none.

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Table 1. Ecosystem Service (ES)/Disservice (DS) Attributes and Levels Used to Create Choice Experiments

Attribute	Definition	Levels (Sources, references)
Forest density (Minnich et al., 1995)	The number of tree stems per unit area (fire risk/ED)	Low (less than 200 stems/hectare) High (more than 200 stems/hectare)
Forest understory (Minnich, 2007)	Understory plant cover consisting of small shrubs, forbs, and grasses under 1 meter tall. A *covered* understory has visible plant understory. A *bare* understory is mostly bare soil or litter with little to no plant cover. (Cultural ES)	Bare (~ less than 25% plant cover) Covered (~ greater than 25% plant cover)
Water (Hammitt et al., 1994; Tanner et al., 2022)	Presence of water feature (s) within the national forest. (Regulating ES)	No water Streams Waterfalls Lakes
Forest diversity (Minnich, 2007; Soliño et al., 2018)	The number of visible trees, tall shrubs, and understory plant types. (Cultural ES)	Low (less than 5 plant types) High (more than 5 plant types)

Table 2. Respondent socio-demographic characteristics for the survey and the study area (Los Angeles, Riverside, and San Bernardino counties).

Characteristic	Individual (n = 377)	Collective (n = 390)	Survey Total (n = 767)	Study area ^
Age				
18 to 29	26.3%	25.5%	23.7%	^^
30 to 44	28.2%	31.5%	29.7%	28.9%
45 to 64	34.1%	27.6%	32.6%	32.7%
65 and over	11.2%	14.3%	13.8%	19.6%
Gender				
Female	49.2%	49.3%	49.5%	49.8%
Male	48.7%	49.1%	49.3%	50.2%
Other	1.9%	0.7%	1.2%	N/A
Educational Attainment				
Some High School	3.1%	2.8%	3.0%	18.8%
High School	29.6%	29.4%	33.6%	22.6%
Some College	34.4%	33.4%	34.0%	26.5%
Bachelor's degree	22.0%	18.5%	19.6%	20.4%
Graduate Degree	10.7%	15.0%	13.1%	11.7%
Ethnicity				
Hispanic/Latino (of any race)	34.6%	34.6%	34.6%	49.1%
Race				
Asian (non-Hispanic)	9.4%	9.9%	9.7%	24.4%
Black/African American (non-Hispanic)	13.9%	12.4%	24.3%	14.5%
White (non-Hispanic)	72.5%	74.4%	73.7%	52.7%
Other(non-Hispanic)	4.2%	3.3%	3.7%	8.4%
Annual Household Income				
< $35,000	23.2%	24.3%	23.8%	21.7%
$35,000 to $49,999	16.2%	14.0%	15.3%	9.3%
$50,000 to $74,999	21.2%	22.0%	21.7%	14.9%
$75,000 to and $99,000	18.4%	16.4%	17.2%	12.8%
$100,000 or more	20.8%	22.4%	21.3%	41.5%
Political Ideology				
Conservative	26.5%	31.1%	29.1%	N/A
Moderate	40.8%	41.1%	40.0%	N/A
Liberal	32.5%	26.9%	28.2%	N/A
Frequecy of Visiting the Montane Forest				

At least once per year	45.0%	47.1%	46.0%	N/A

^ The 2020 U.S. Census Riverside-San Bernardino-Los Angeles County Statistical Area reports
^^ The U.S. Census reports the metro area residents' age group from 20 to 29 years old category, which includes 14.4 % of the greater LA area

Table 3. The Best-Worst Scaling of Residents' for the 'Individual' And The 'Collective' Scenarios for Visiting the Montane Forest At Least Once A Year And Visiting the Montane Forest Less Than Once A Year Groups

	Visiting the Montane Forest At Least Once A Year								Visiting the Montane Forest Less Than Once A Year							
	Individual				Collective				Individual				Collective			
Attribute	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking
Low density	0.3547	0.0735	***	7	0.3793	0.0707	***	7	0.3744	0.0675	***	7	0.3221	0.0691	***	7
High density	0.5952	0.0742	***	4	0.5336	0.0713	***	4	0.6091	0.0682	***	4	0.5646	0.0700	***	4
Bare	0.2955	0.0734	***	9	0.1663	0.0706	**	9	0.1653	0.0672	**	9	0.1364	0.0688	*	9
Covered	0.4053	0.0736	***	6	0.3867	0.0707	***	6	0.3295	0.0673	***	8	0.2817	0.0690	***	8
No water	0.3518	0.0914	***	8	0.2282	0.0876	**	8	0.5418	0.0835	***	5	0.3989	0.0839	***	6
Streams	0.8219	0.0939	***	1	0.8986	0.0910	***	1	1.1505	0.0888	***	1	1.4803	0.0952	***	1
Waterfalls	0.6663	0.0928	***	2	0.6834	0.0892	***	3	0.8257	0.0854	***	3	1.2111	0.0909	***	3
Lakes	0.6425	0.0927	***	3	0.8228	0.0903	***	2	1.0514	0.0877	***	2	1.2714	0.0918	***	2
High diversity	0.4219	0.0785	***	5	0.4272	0.0756	***	5	0.4483	0.0721	***	6	0.5272	0.0740	***	5
Low diversity			***	10			***	10			***	10			***	10
N	169				184				208				206			
Log Likelihood	-3,290				-3,557				-3,941				-3,772			

* Significant At 90%; ** significant at 95%; ***significant at 99% levels of statistical significance

Table 4. The BWS Residents' Results for the 'Individual' And The 'Collective' Scenarios for Hispanic And Non-Hispanic Groups

	Hispanic								Non-Hispanic							
	Individual				Collective				Individual				Collective			
Attribute	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking
Low density	0.1216	0.0867		8	0.3625	0.0827	***	6	0.4824	0.0607	***	6	0.3403	0.0614	***	7
High density	0.3152	0.0870	***	6	0.5642	0.0835	***	4	0.7415	0.0616	***	3	0.5357	0.0620	***	5
Bare	0.1174	0.0866		8	0.2621	0.0825	***	9	0.2764	0.0605	***	9	0.0872	0.0613		9
Covered	0.1655	0.0867	*	7	0.2832	0.0825	***	8	0.4596	0.0607	***	8	0.3569	0.0614	***	6
No water	0.4003	0.1078	***	4	0.3638	0.1014	***	5	0.4838	0.0752	***	5	0.2903	0.0754	***	8
Streams	0.7704	0.1110	***	3	1.1447	0.1087	***	1	1.1109	0.0791	***	1	1.2113	0.0818	***	1
Waterfalls	0.7986	0.1115	***	1	0.9869	0.1065	***	3	0.7347	0.0762	***	4	0.9297	0.0788	***	3
Lakes	0.7895	0.1114	***	2	1.1289	0.1086	***	2	0.8997	0.0774	***	2	1.0060	0.0794	***	2
High diversity	0.3430	0.0927	***	5	0.3168	0.0886	***	7	0.4818	0.0648	***	7	0.5634	0.0658	***	4
Low diversity				8				10				10				9
N		122				139				255				251		
Log Likelihood		-2,348				-2,619				-4,885				-4,737		

* Significant At 90%; ** significant at 95%; ***significant at 99% levels of statistical significance

Table 5. The Latent Class Bets-Worst Scaling Results for the ‘Individual’ Scenario

	Class I				Class II				Class III				Class IV			
Attribute	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking	Estimate	Standard Error		Ranking
Low density	0.0070	0.1087		7	0.1270	0.1339		6	0.4079	0.1289	***	8	1.1777	0.1478	***	2
High density	-0.3988	0.1337	***	8	1.5714	0.1925	***	1	0.5533	0.1351	***	7	1.6271	0.1704	***	1
Bare	0.2437	0.1172	**	5	-0.5820	0.1554	***	7	0.3702	0.1278	***	9	0.8740	0.1493	***	4
covered	0.1845	0.1060	*	6	0.0418	0.1335		6	0.6457	0.1268	***	6	0.9073	0.1346	***	3
No water	0.4907	0.1443	***	2	0.0515	0.1713		6	1.0670	0.1440	***	4	0.2864	0.1440	**	5
Streams	0.5562	0.1584	***	1	1.1249	0.2127	***	3	4.0911	0.3824	***	2	0.1044	0.1559		7
Waterfalls	0.3548	0.1529	**	4	0.9567	0.2065	**	4	2.6801	0.2291	***	3	-0.1322	0.1544		7
Lakes	0.3840	0.1523	***	3	0.7884	0.2154	***	5	4.6261	0.6939	***	1	0.0177	0.1582		7
High diversity	0.1553	0.1091		7	1.2236	0.1727	***	2	0.7243	0.1307	***	5	0.2607	0.1241	**	6
Low diversity				7				6				10				7
Class Share	28.0%				20.2%				26.9%				24.9%			
Log Likelihood	-6,624															
AIC	13,423															
BIC	13,764															

Table 5. The Latent Class Best-Worst Scaling Results for the 'Individual' Scenario (Continued)

	Class I			Class II			Class III			Class IV	
Individual Characteristics	Estimate	Standard Error		Estimate	Standard Error		Estimate	Standard Error		Estimate	Standard Error
Age group 18 to 29	-1.5142	0.8612	*	-1.3330	0.8461		-2.5178	0.7417	***	-	-
Age group 30 to 44	-1.1483	0.8169		-0.8494	0.7698		-1.4844	0.6552	**	-	-
Age group 45 to 64	-1.7663	0.7824	**	-1.3807	0.7407	*	-1.4736	0.6237	**	-	-
Female	1.5898	0.4307	***	1.2825	0.4287	***	1.0391	0.3734	***	-	-
Hispanic	1.0913	0.4655	**	0.0758	0.5200		0.3744	0.4299		-	-
High school	0.0926	1.6906		-0.0721	2.0536		-0.6775	1.5735		-	-
Some college	-1.6332	1.6705		-0.2528	2.0229		-1.2244	1.5643		-	-
College	-1.1758	1.7606		0.9813	2.0883		-0.8128	1.6131		-	-
Graduate school	0.2536	1.8234		0.8242	2.1698		-1.0530	1.7199		-	-
$35,000 to $49,999	0.7893	0.7239		0.8323	0.7563		0.3054	0.6898		-	-
$50,000 to $74,999	-1.6819	0.6284	***	-1.6619	0.6613	**	-0.9629	0.4879	**	-	-
$75,000 to $99,000	-0.1399	0.6324		-0.1502	0.6465		-0.6124	0.5888		-	-

$100,000 or more	-0.1290	0.6697		-0.1176	0.6943		-0.0847	0.5723		-	-
Moderate	1.1005	0.5237	**	1.7496	0.5857	***	0.5791	0.4489		-	-
Liberal	1.1347	0.5163	**	1.0066	0.5559	***	-0.0381	0.4466		-	-
At least once per year	0.8983	0.4203	**	0.0509	0.4159		-0.5978	0.3817		-	-
Constant	0.0677	1.9016		-0.7418	2.2084		2.3384	1.6772		-	-
Class Share		28.0%			20.2%			26.9%			24.9%
Log Likelihood		-6,624									
AIC		13,423									
BIC		13,764									

* Significant At 90%; ** significant at 95%; ***significant at 99% levels of statistical significance