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RESEARCH ARTICLE

Where wilderness is found: Evidence from 70,000 trip reports

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Abstract

1. Outdoor recreation is an essential way many people engage with nature. The provision of public spaces for recreation intersects with conservation practices motivated by intertwined social and ecological values, such as strict practices associated with the concept of 'wilderness'. Debates persist about how such concepts and management practices influence people's recreation experiences.
2. Many US public land management agencies facilitate opportunities for outdoor recreation, relying on management frameworks and tools intended to foster specific experiential qualities. But these frameworks and tools assume simplistic relationships between settings and people's experiences, and managers rarely assess these relationships.
3. This study uses a data set of nearly 70,000 crowdsourced trip reports from a hiking website to understand the qualities of visitors' experiences on trails. We study the geographic distribution of experiential qualities commonly associated with US wilderness areas: aesthetics, awe, challenge, pristineness, quietness, solitude and timelessness. Using analytical methods that rely on machine learning and natural language processing, we identify these experiential qualities in trip reports from hundreds of routes, and use generalized linear models to analyse relationships between the frequency of each experiential quality and the route's administrative, built, biophysical, geographic and social settings.
4. We find that four of the seven experiential qualities (aesthetics, awe, challenge and solitude) are commonly described in trip reports, each appearing in 15%–55% of manually coded reports. The extent to which setting characteristics explained variability in experiences differed, ranging from 34% of the variability in the proportion of trip reports describing aesthetics to 55% for awe. The setting characteristics associated with each experiential quality also differed, with characteristics such as trail mileage and summit destinations having stronger influences on experiential qualities than characteristics such as wilderness designation.

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5. *Synthesis and applications*. Our findings suggest the need to consider more diverse variables in experience–setting relationships, develop more robust models to characterize those relationships and create new data sources to represent understudied variables. These advances would help empirically inform and improve frameworks and tools used for recreation and wilderness planning and monitoring, and potentially promote more responsive management to evolving social–ecological values.

KEYWORDS

awe, crowdsourced data, experience, machine learning, natural language processing, outdoor recreation, solitude, wilderness

1 | INTRODUCTION

Outdoor recreation experiences yield diverse social and health benefits to people and are an essential way many people engage with nature worldwide (Lackey et al., 2021; Thomsen et al., 2018; White et al., 2021; Wolf et al., 2020). To provide opportunities for those experiences, public land managers commonly rely on frameworks and tools for recreation and wilderness management that define the types of settings where activities should be allowed and offer guidance on where to provide supporting services, facilities and maintenance (Casson et al., 2016; Cole & Williams, 2012; Landres et al., 2015; Manning, 2012). Management frameworks and tools are intended to facilitate certain qualities of experiences for people. For example, strict protection practices that are associated with the concept of 'wilderness' promote specific landscape values and influence people's uses of such areas (Casson et al., 2016; Engebretson & Hall, 2019; Saarinen, 2016). In the United States, 'wilderness character' is promoted in federally designated wilderness areas, to provide visitors with opportunities to experience challenge, self-reliance and self-discovery (Landres et al., 2015). But simplistic assumptions underpin the relationships between settings and the qualities of visitors' experiences, with frameworks and tools often functioning on relatively coarse scales and without mechanisms to evaluate if intended outcomes have been achieved (Blahna et al., 2020). Consequently, managers often only have anecdotal or coarse insights to help them understand visitors' experiences (Pietilä, 2017; Williams, 2007).

People's outdoor recreation experiences depend on a wide range of natural environments and are supported by various types and amounts of infrastructure development. Recreation settings are managed for both visitor use and ecological condition and can be characterized by their administrative, built, biophysical, geographic and social environments (Driver et al., 1987; McCool, 2006; Pietilä & Kangas, 2015). For pragmatic reasons, recreation research tends to characterize settings in parks and other protected areas based on a narrow and interchangeable subset of biophysical and built attributes (e.g. assessments of scenery or trail conditions), with only minor considerations of social attributes (e.g. assessments of the amount of human use or common categories of activities) (Blahna et al., 2020; Williams, 2007). Studies of how settings influence visitors' experiences have focused on a limited number of setting characteristics, using stated and revealed metrics such as satisfaction levels, perceptions of crowding, place attachment and changes in behaviours, use patterns or attitudes (e.g. Fix et al., 2013; Kil et al., 2014; Manning & Valliere, 2001; Wynveen et al., 2020). The connection between recreation settings and experiences is particularly relevant in the context of wilderness settings, where visitors might have specific expectations about types (or lack) of development, the presence of other visitors, noise levels and other factors.

Traditionally, outdoor recreation scholars and managers have assessed visitor experiences through singular measures such as 'satisfaction', disregarding the multiple, interconnected qualities of experiences that are meaningful in people's lives (Blahna et al., 2020). The reduction of complex and multifaceted outdoor experiences to simple evaluations limits appreciation for the diversity of benefits people experience. For example, visitors might revel in the awe of observing wildlife, find inspiration in returning to a special place year after year or bond with their companions over a shared struggle in difficult conditions. Ratings of satisfaction and similar measures do not capture these intertwined sociocultural and psychological dimensions of recreation experiences and the non-fungible meanings that settings hold for people (Cole & Williams, 2012; Williams, 2007). Traditional recreation research approaches also tend to view recreation settings in spatial isolation, disconnected from other sites in terms of use patterns or place meanings and counter to a mounting call to manage recreation as part of a social–ecological system (Hermes et al., 2018; McCool, 2022; Miller et al., 2022; Morse, 2020).

Scholars have identified the need for both a more complex conception of how settings and experiences are related, and more sophisticated tools for recreation managers to understand and evaluate connections between settings and their effects on the qualities of visitors' experiences (Blahna et al., 2020; Pietilä & Kangas, 2015; Williams, 2007). As Williams (2007, p. 31) describes, 'The significance of specific places, which people come to know through experience, is not easily captured in resource and social assessments [...] that focus on their general attributes (e.g., remoteness, scenic beauty).

Rather for people who know and use an area, its significance is more likely captured in narrative form (histories) as meanings, practices, and rituals'.

Questions about how people construct senses of place through recreation and leisure experiences emphasize the need for narrative data to understand relational processes (Derrien & Stokowski, 2014). But rich, narrative information about outdoor experiences across large areas and on fine spatial scales is often prohibitively time- and resource-intensive to acquire via primary data collection tools such as interviews, surveys, focus groups and participatory mapping (Hermes et al., 2018; Paracchini et al., 2014). To address this issue, studies have evaluated whether social media and other volunteered geographic information are a reliable source of geolocated information about outdoor recreation (Ghermandi et al., 2023; Wilkins et al., 2020). Data are available globally from platforms serving general audiences (e.g. the general public on Twitter) and specialized audiences (e.g. birders on eBird), and include practical, scientific, emotional and affective descriptions of people who are recreating, as well as the places and conditions where activities occur (Havinga et al., 2021; Toivonen et al., 2019). Social media images and short-form texts (e.g. image captions and tweets) have been analysed quantitatively to understand many aspects of outdoor experiences, including landscape values, subjective well-being, activity participation and experiences of tranquillity and aesthetic appreciation (Calcagni et al., 2019; Egarter Vigl et al., 2021; Lin et al., 2022; Oteros-Rozas et al., 2018; Schirpke et al., 2018; Song et al., 2020; Wartmann et al., 2021; Winder et al., 2022). Longer form texts such as blog posts and trip reports provide information about the qualities of people's experiences in more developed, narrative formats and have been analysed qualitatively to understand visitors' recreation experiences (Armstrong et al., 2021; Champ et al., 2013; Williams & Champ, 2015).

Large data sets, such as those generated by social media users, often require automated methods such as machine learning to analyse content that cannot be reviewed and coded using typical methods (Egarter Vigl et al., 2021; Lee et al., 2019; Winder et al., 2022). Studies using natural language processing (NLP) and natural language understanding have examined the spatial variation in the content of real-time, geolocated images and short-form texts such as tweets. Lin et al. (2022), for example, employ NLP to estimate the valence of sentiment in posts from within city parks (see also Plunz et al., 2019). Other studies similarly characterize experiences of silence and tranquillity across a landscape (Chesnokova et al., 2019; Wartmann et al., 2021). Yet to our knowledge, no studies have used these methods to classify long-form social media texts to understand more complex experiences and meanings in recreation settings. This presents a potentially valuable approach for understanding multiple qualities of recreation experiences, and where they occur.

In this study, we develop and test an approach for identifying the qualities of outdoor recreation experiences narratively described in long-form social media texts ('trip reports'), and then analyse the relationships between the experiential qualities identified and setting characteristics. Through an analysis of 1603 routes within a national forest in Washington (USA), our research questions examine seven experiential qualities commonly associated with federally designated wilderness areas: aesthetics, awe, challenge, pristineness, quietness, solitude and timelessness. We ask: (1) Do trail users write about these wilderness-associated experiential qualities in trip reports? (2) Can we use NLP and machine learning to develop automated processes to reliably identify text that describes these wilderness-associated experiential qualities? (3) Are trail users' descriptions of wilderness-associated experiential qualities more common for trips in settings that have specific administrative, built, biophysical, geographic and social characteristics? By answering these questions, our goals are to gain a deeper understanding of relationships between recreation experiences and settings, and to develop methods that can be adapted to answer context-specific questions. Ultimately, we hope this will help improve the frameworks and tools used to manage public lands recreation and wilderness, promoting more responsive and inclusive management approaches.

2 | BACKGROUND

Federal wilderness designations[1] and Recreation Opportunity Spectrum zoning offer examples of two influential management paradigms for public lands in the United States, both built on the explicit premise that managers can manipulate (or abstain from manipulating) setting characteristics to influence the qualities of visitors' experiences. Recreation is a main human use of wilderness areas and is managed to limit types and amounts of activities and impacts (Casson et al., 2016; Manning, 2012). The Wilderness Act (1964) outlines a specific type of recreation experience to be allowed in federally designated wilderness, which led to subsequent agency directives and guidance prescribing allowances for only human-powered, non-extractive activities that (in theory) facilitate specific experiential qualities for visitors (Landres et al., 2015; Manning, 2012). The act gave Congress the authority to designate wilderness in areas having 'outstanding opportunities for solitude or a primitive and unconfined type of recreation' (Wilderness Act, 1964, p. 891). Interagency strategies have since outlined how to promote values of self-reliance, physical and mental challenge, inspiration, solitude, timelessness and scenic appreciation (among others) in areas that are undeveloped (Engebretson & Hall, 2019; Landres et al., 2015).[2] Following a similar ethos, the Recreation Opportunity Spectrum, a planning tool developed in the 1970s and

[1]Federally designated wilderness in the United States aligns generally with the International Union for Conservation of Nature category 1b (wilderness) (Casson et al., 2016).

[2]We recognize that much of the early and contemporary thinking of what wilderness 'should be' in the United States and elsewhere reflects elitist and exclusive values, but we do not engage with these topics here.

used in US national forests and protected areas worldwide, delineates a system of zoning to inform recreation development, with a unidimensional spectrum ranging from 'primitive' recreation settings (similar to federally designated wilderness) to 'urban' recreation settings characterized by highly developed facilities and a high human density of use (Blahna et al., 2020; Driver et al., 1987). The Recreation Opportunity Spectrum dictates the type of infrastructure investments, levels of maintenance and social environments that are appropriate for each zone (Driver et al., 1987).

Wilderness and the Recreation Opportunity Spectrum are manifestations of theories that posit that managers can influence visitors' experiences through their manipulation (or lack thereof) of setting characteristics. Studies that examine them often conceive of visitors as rational consumers who shop for interchangeable sites for their recreation activities (Cole & Williams, 2012), focusing on the managerial and social conditions that lead people to report that they are satisfied with a recreation experience, that it has fulfilled their expectations or goals or that it has yielded desired (instrumental) outcomes or benefits (Manning, 2022). This 'motivation-based' recreation research tradition includes many studies (especially in wilderness settings) focusing on how evidence of other human use—such as encounters with other visitors and campsite impacts—affect visitors' experiences (Blahna et al., 2020; Borrie & Roggenbuck, 2001; Cole & Williams, 2012; Manning, 2012; Thomsen et al., 2023).

In contrast, 'experience-based' and 'relationship-based' recreation research traditions seek to refine conceptions of recreation experiences, adding a focus on the processes through which places and activities become meaningful over time (Brooks et al., 2006; Cole & Williams, 2012; Patterson et al., 1998; Williams et al., 1992). The theoretical development of the social construction of place in outdoor recreation and leisure research emphasizes that meanings or memories—relational by nature—may be an experience's most valuable outcome (Brandenburg & Carroll, 1995; Stokowski, 2002). This contrasts with the more instrumental, motivation-based perspective. Studies have used qualitative approaches to understand the relational development of senses of place in the context of outdoor recreation activities and public lands—with relatively small sample sizes and limited geographic scope (e.g. one campground, river or wilderness area) because of the time intensiveness of qualitative methods (Brooks et al., 2006; Patterson et al., 1998; Pietilä & Kangas, 2015). Quantitative approaches have also been used to develop and test constructs of place attachment, place dependence and place identity to measure the strength of place relationships (Beery & Jönsson, 2017; Budruk & Wilhelm Stanis, 2013; Jorgensen & Stedman, 2006; Wynveen et al., 2020). Some insights from this body of research have been integrated into place-based planning tools (see Farnum & Kruger, 2008), but they have rarely been incorporated into dominant management frameworks or tools (Cerveny et al., 2011).

Beyond research on outdoor recreation, studies of relationships between outdoor experiences and nature-based settings have included scholarship emphasizing relational values between people and nature, such as nature's contributions to social cohesion and spirituality (Chan et al., 2016; Jennings & Bamkole, 2019; Johnson et al., 2019; Pascual et al., 2017). But instrumental values of nature's benefits through recreation are still more common in ecosystem service assessments (though see Calcagni et al., 2019), as well as in traditional econometric approaches to valuing recreation. Economic values of recreation are often estimated based on the trade-off of travel costs incurred to visit a recreation site, assuming a person's choice represents the greatest net benefit (Kolstoe & Cameron, 2017; Lupi et al., 2020). Studies have often been geared towards conservation questions, but findings have rarely been used to directly inform recreation management frameworks and tools such as the Recreation Opportunity Spectrum, creating another gap in application (Morse et al., 2022; Stålhammar & Pedersen, 2017).

3 | METHODS

3.1 | Study area

This study focuses on recreation in the Mt. Baker-Snoqualmie National Forest, a 1.72-million-acre national forest in Washington, United States, that spans the western side of the Cascade Range from the Canadian border to Mount Rainier National Park (USDA Forest Service, n.d.-a). The national forest is composed of temperate coniferous forests and includes many alpine meadows, lakes, rivers and peaks. Many parts of the national forest are relatively accessible by car from the Seattle–Tacoma–Bellevue Metropolitan Statistical Area, and day trips constitute the majority of about 2 million annual visits (MBS, 2015, 2020). The national forest is managed by the US Department of Agriculture (USDA) Forest Service, in accordance with the agency's multiple-use mission, which includes managing for timber, recreation and other uses. Administratively, the national forest is comprised of four ranger districts and almost half of it is federally designated wilderness (including nine wilderness areas) (USDA Forest Service, n.d.-b). About 40% of the national forest's 1506 miles of official trails are in federally designated wilderness areas (USDA Forest Service, n.d.-b). The Mt. Baker-Snoqualmie National Forest is similar to other US national forests in terms of its management for multiple uses and its mix of wilderness and non-wilderness areas, and it exhibits recreational use patterns similar to other heavily visited national forests near major metropolitan areas.

The USDA Forest Service maintains a partnership with Washington Trails Association, a nonprofit organization in Washington that conducts trail maintenance and hiker advocacy and hosts an online hiking guide. This free hiking guide provides information about more than 4000 hikes statewide (WTA, 2023a). Each hiking guide entry includes a narrative description of the hike, the length and elevation of the trail, whether the hike provides access to a suite of predefined opportunities and biophysical characteristics (such as waterfalls), driving directions and the latitude and longitude of the trailhead. Washington Trails Association also hosts a crowdsourced 'trip report' platform, linked to the

hiking guide, where people are invited to post personal accounts of trips after visiting a trail. Trip reports range from lengthy narratives to more abbreviated reports (for instance, just describing road or snow conditions). More than 225,000 trip reports have been shared statewide since the website was launched in 1997 (WTA, 2023b). Nearly 30% of these trip reports are about trips in the Mt. Baker-Snoqualmie National Forest, reflecting the high amount of visitation and urban proximity of this national forest. Trip reports must be assigned to at least one of the hikes that are described in the hiking guide, but visitors can choose to assign their trip report to multiple hikes (e.g. if they link together multiple trails during a single trip). For the purposes of our study, we define 'hike' as a hiking opportunity that has its own page on the online platform, and 'route' as any single hike or combination of hikes that are linked together in a visitor's trip report. The outdoor recreation settings we consider in this article are routes in the Mt. Baker-Snoqualmie National Forest described on Washington Trails Association's online platform—meaning we consider the setting to encompass all the areas through which a route passes.

3.2 | Data

Washington Trails Association provided a publicly accessible web address for every trip report in their database. Using this locator, we downloaded the text from all trip reports that described visitors' trips in the Mt. Baker-Snoqualmie National Forest between 30 July 1997 and 2 December 2021 using a custom script written in Python 3 (Van Rossum & Drake, 2009). Data were anonymized before analyses by removing any information about the user who shared the trip report. We assumed that trip reports were about trips that occurred in the national forest if the trailhead was within its boundaries (determined using a spatial join). Our final sample included 470 hikes, which we believe represents all hikes within the national forest described on the platform as of December 2021. We downloaded 69,936 trip reports that visitors shared to 1603 routes, each of which included at least one of these hikes. The trip report corpus is comprised of 13,415,880 words, with an average of 192 words per trip report. Figure 1 shows the study area with points for the trailheads for the hikes included in the sample. The University

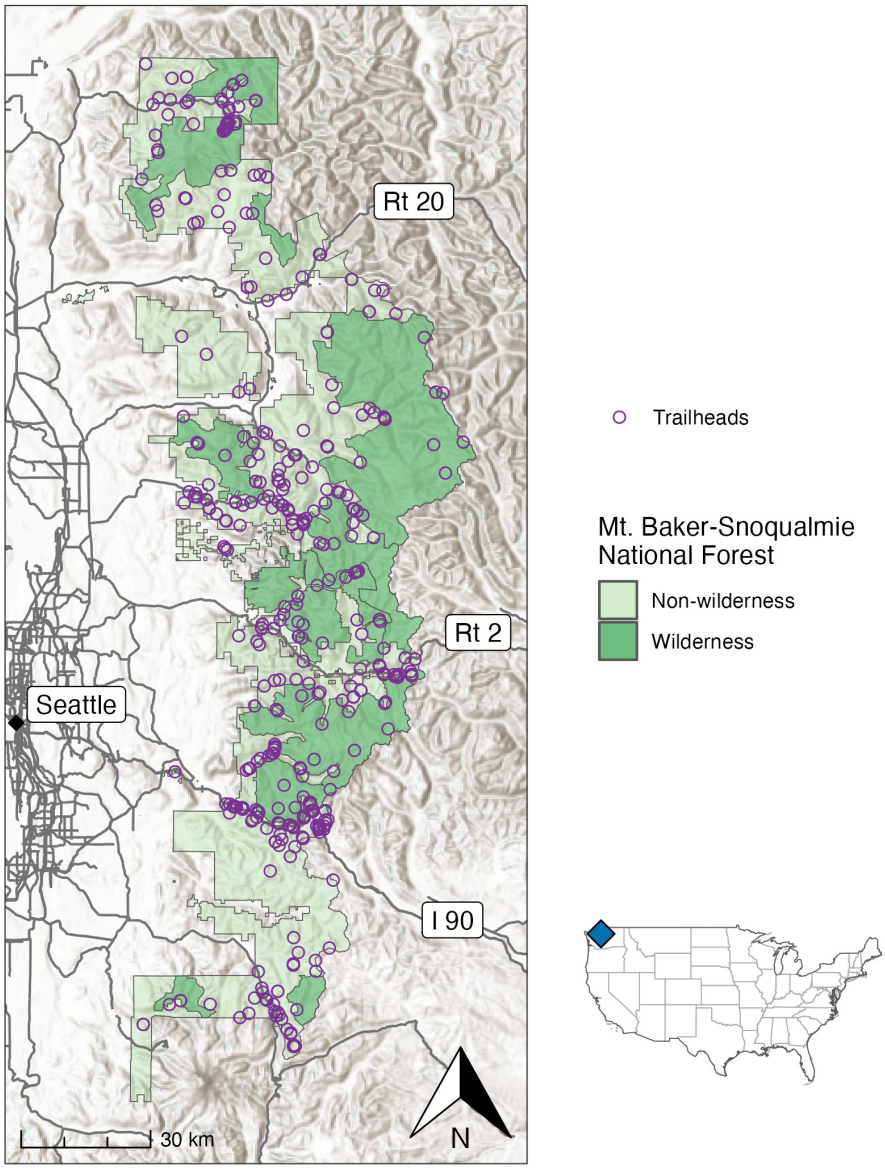

FIGURE 1 The study area, showing the boundaries of the Mt. Baker-Snoqualmie National Forest, wilderness areas within it and the trailheads for the 470 hikes in the Washington Trails Association hiking guide that we included in the sample. Map created with the R programming language using the sf, ggspatial and cowplot packages (Dunnington, 2022; Pebesma & Bivand, 2023; R Core Team, 2022; Wilke, 2019). Data from USDA Forest Service, Washington Trails Association, Washington Department of Transportation, Environmental Systems Research Institute map service and Natural Earth, facilitated by the basemaps and rnaturalearth packages for R (ESRI, 2009; Massicotte & South, 2023; Schwalb-Willmann, 2022; USDA Forest Service, 2019; WSDOT, 2023; WTA, 2023c).

TABLE 1 Characteristics for each route's recreation setting.

Characteristic	Description	Data source
Distance to city	Driving distance to the nearest city >50,000 people	Washington Trails Association trailhead locations + routing software
Road paved	Whether the trailhead is within 500 m of a paved road	USDA Forest Service roads shapefile and satellite imagery
Wilderness	Whether a trail enters federally designated wilderness	Manual classification based on Washington Trails Association trailhead location and USDA Forest Service and Washington State Recreation and Conservation Office trail shapefiles
Ranger district	The administrative unit (district) within which the trailhead is located	USDA Forest Service boundaries
Waterfalls	Whether a waterfall can be seen from the trail	Washington Trails Association hiking guide
Lakes	Whether the trail provides access to a lake	Washington Trails Association hiking guide
Rivers	Whether the trail provides access to a river	Washington Trails Association hiking guide
Summits	Whether the trail provides access to a mountain peak	Washington Trails Association hiking guide
Ridges/ Mountain passes	Whether the trail provides access to a ridge or mountain pass	Washington Trails Association hiking guide
Old growth	Whether the trail provides access to areas with large old trees	Washington Trails Association hiking guide
Trail mileage	The number of miles covered by the trail (generally roundtrip)	Washington Trails Association hiking guide
Trail steepness	Elevation gain/mile	Calculated from data in the Washington Trails Association hiking guide
Amount of visitation	Total number of trip reports to Washington Trails Association platform (1997–2021)	Washington Trails Association website

of Washington Institutional Review Board reviewed our study and determined that the research met regulations for the protection of human subjects and the study carried no greater than minimal risk to those subjects. Accordingly, they granted the study exempt status (IRB ID: STUDY00011103).

We used information from the Washington Trails Association hiking guide and other sources to compile data on 13 characteristics of each route's recreation setting that we hypothesized could influence recreation experiences (Table 1), including information about ease of accessing the recreation site, federal wilderness designation, biophysical characteristics, trail characteristics and visitation. We characterized trailhead accessibility by calculating the driving distance between the trailhead and the centre of the nearest city with more than 50,000 residents (from the 2010 Census) using the route-finding software GraphHopper (version 4.0, GraphHopper, n.d.) and OpenStreetMap (OpenStreetMap, n.d.). This provided a measure of accessibility from the population corridor that runs north–south along Puget Sound to the west of the national forest. Additionally, we manually determined whether the access road was paved using USDA Forest Service roads data (USDA Forest Service, 2019) and satellite imagery. For routes with more than one trailhead, we assigned the shortest driving distance and classified the access as paved if any of the component hikes had paved access. We also determined whether the route entered a federally designated wilderness area[3] (classified manually in QGIS by looking at the trailhead, the Washington Trails Association hike description and USDA Forest Service and Washington State Recreation and Conservation Office trail shapefiles) (USDA Forest Service, 2019; WA RCO, 2017). We included the ranger district in which each trailhead was located; if routes with more than one hike included trails in multiple ranger districts, we assigned the ranger district that the majority of component hikes began in, or, in the case of an even split, we randomly selected one of the ranger districts.

We considered several biophysical characteristics of the routes' settings, using 'trail features' described in the Washington Trails Association hiking guide. The hiking guide includes 12 trail features that a hike may include, which are assigned by staff and volunteers as they write or maintain the narrative hike description. We used a subset of these trail features, including waterfalls, lakes, rivers, summits, ridges/mountain passes and old growth (which is assigned for any hike that accesses areas with large old trees). We also included two characteristics that describe the trails themselves: trail mileage and trail steepness (the total elevation gain/total mileage). For routes that included more than one hike, we summed the total trail mileage and calculated trail steepness by dividing total gain by total mileage. Finally, to represent a social aspect of the recreation setting, we approximated the amount of visitation to each route by summing the total number of trip reports that had been posted to that route on Washington Trails Association's platform between 1997 and 2021. Previous work has shown that the number of trip reports is strongly correlated with the overall amount of visitation to trails ($r = 0.91$, Fisher

[3]Most wilderness areas were designated prior to the beginning of our study period, except for one that was designated in 2008, and one that was expanded in 2014.

TABLE 2 Wilderness-associated experiential qualities studied in Washington Trails Association trip reports.

Experiential quality (short code)	Text in legislation or agency guidance motivating inclusion in study	Definition operationalized for manual coding	Example excerpt from coded training data
Aesthetics	'…contain[s] […] features of scientific, educational, scenic, or historical value' (Wilderness Act, 1964, p. 891)	Remarks about an appreciation for or interest in the beauty of the natural landscape, views or scenery	'Enjoy your lunch at this beautiful lake between the mountains'
Awe	'…may include the immensity of an area and the connection people may feel to nature […and] inspirational and psychological benefits that individuals experience' (Landres et al., 2015, p. 13)	Expressions of emotion related to amazement, surprise, wonder, inspiration, sublimity or fear, including positive and/or negative dimensions	'With the spring melt also comes wild flowers!! Oh man were they everywhere. The whole hill side was covered. The mix of mountain views and wildflowers almost makes you forget that you are climbing a steep and exposed trail'
Challenge	'…include[s] the benefits and inspiration derived from physical and mental challenge' (Landres et al., 2015, p. 51)	Comments about the difficulty or toughness of an experience, including mental and/or physical challenges	'The coolness of the forest is left behind to well-maintained switchbacks that consistently gain altitude and test the hiker's cardiovascular fitness. It did to mine. I barely passed'
Pristineness	'…affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable' (Wilderness Act, 1964, p. 891)	Observations about an area being untouched by humans (visitors or managers) or showing no/few signs of their activities or impacts, including improvements, litter or campsites	'After you leave the forest behind, […] you can earn your happy walk through the beautiful, pristine alpine landscape and the fun rock scramble to the summit'
Quietness	'…without […] the sights and sounds of modern human occupation' (Landres et al., 2015, p. 11)	Descriptions of silence, the absence of loud noises and/or the presence of natural soundscapes including running water or birdsong	'At the Bathtub I ate a bit, and took in the lovely, ghostly silence of it all before heading down an alternate route'
Solitude	'…has outstanding opportunities for solitude or a primitive and unconfined type of recreation' (Wilderness Act, 1964, p. 891)	Comments about a physical separation from other people, including observing no/few people, having a trail or an area to themselves or being alone. Also includes a feeling of seclusion or psychological separation from other people	'We were the only ones at the trailhead and didn't see anyone else all day. It seems like a good place to go for solitude. There are about 7 parking spots at the trailhead'
Timelessness	'…encompassing attributes such as […] a sense of timelessness (allowing one to let go of day-to-day obligations, go at one's own pace, and spend time reflecting)' (Landres et al., 2015, p. 51)	Observations about an area or route not changing over time or being or appearing the same/similar as prior visits	'It got down below freezing & snowed a little overnight. But the springs make it all worth it! Such an amazing experience every time. It's one of those magical places'

et al., 2018). We estimated the visitation of routes comprised of multiple hikes as the total number of trip reports that had been posted for that particular multi-hike route, as well as the number of trip reports to individual component hikes, assuming that visitors on the multi-hike routes would have encountered visitors on the component hikes as well.

3.3 | Definitions of experiential qualities

We reviewed legislation and agency guidance documents to identify experiential qualities for which federally designated wilderness areas are managed in the United States (Landres et al., 2015; Wilderness Act, 1964). Based on this review, we decided to focus on seven wilderness-associated experiential qualities—some explicitly and others implicitly named—that we thought might be discernable within the trip report data set: aesthetics, awe, challenge, pristineness, quietness, solitude and timelessness (Table 2). For example, we chose to study 'solitude' because the Wilderness Act (1964, p. 891) explicitly describes managing for 'opportunities for solitude'. We chose to study 'quietness' even though it was not explicitly named, since Landres et al. (2015, p. 11) describe areas without the 'sounds of modern human occupation'. Table 2 includes our rationale for choosing each experiential quality. More than one experiential quality could be (and often was) described in a trip report.

3.4 | Analysis

3.4.1 | Coding experiential qualities in reports

We read a random sample of trip reports to address our first research question: Whether visitors write about experiential qualities that are associated with wilderness in trip reports. To ensure our definitions for each experiential quality were sufficiently clear for independent coders to consistently classify trip reports, we began by randomly selecting 40 trip reports to be coded separately by three individuals. Trip reports were read by each individual and coded for all seven experiential qualities based on an earlier draft of the definitions in Table 2. We compared the codes by calculating Krippendorff's Alpha to measure the inter-coder reliability for each experiential quality (Krippendorff, 2011), discussed coding disagreements and then modified the definitions for clarity. Our three coders had almost perfect agreement (sensu Landis & Koch, 1977) when coding for aesthetics and solitude (Krippendorff's Alpha = 0.86 and 0.84, respectively), and moderate agreement when coding for awe and challenge (Krippendorff's Alpha = 0.46 and 0.50, respectively). The other three experiential qualities were rare and agreement between the coders was low,[4] so rather than calculating Krippendorff's Alpha, we discussed the specific coded reports and adjusted the definitions accordingly.

Once our definitions were clear and operationalized, we randomly sampled additional trip reports to code. Beyond addressing our first research question, the coded trip reports also served as data for training and testing classification models to recognize each experiential quality (Section 3.4.2). These trip reports were read by one of two individuals and manually coded for the experiential qualities. To improve the efficiency of coding these long-form texts, we developed a custom software tool that presented coders with a single trip report at a time and provided a simple interface for marking whether or not the trip report described each experiential quality. We found that the cognitive load of reading for all seven experiential qualities at once was high, so the coder chose up to three experiential qualities to code per trip report for the duration of each session. We evaluated the frequency of each experiential quality in the coded data periodically and stopped coding for a particular experiential quality when we determined that either (1) we had a sufficient number of coded trip reports (about 150 trip reports describing a particular experiential quality) to train a classification model to recognize that experiential quality, or (2) relevant text occurred too infrequently to practically code enough trip reports for training. In total, the coders read 806 reports to code for aesthetics, 762 for awe, 1090 for challenge, 258 for pristineness, 266 for quietness, 1091 for solitude and 262 for timelessness (Figure 2). We determined that pristineness, quietness and timelessness appeared too infrequently in the sample to be practical or sufficient to train a classification model, and we excluded them from further analyses.

[4]Two coders did not classify any trip reports as describing pristineness, while the other coder classified four trip reports with this code. Timelessness was assigned to one trip report (by one of the three coders), while quietness was assigned to one trip report (by two of the three coders).

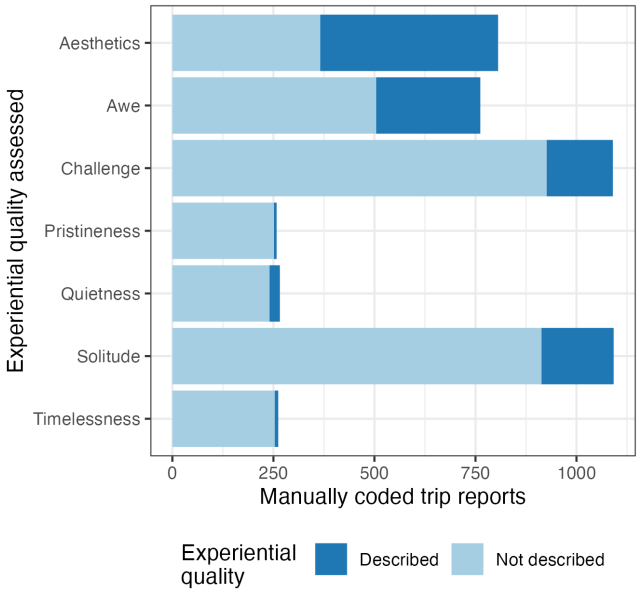

FIGURE 2 The total number of trip reports manually coded for each experiential quality, distinguishing between those that described the experiential quality (dark blue), and those that did not describe the experiential quality (light blue).

3.4.2 | Classifying reports by experiential qualities

To address our second research question, we evaluated the potential for NLP and machine learning to reliably automate the process of identifying text that describes wilderness-associated experiential qualities for the four qualities with greater than 10% frequency in the coded data set.[5] NLP is any form of computer manipulation and processing of human language (Bird et al., 2009). Our process included three steps: (1) processing the coded trip reports to create a clean and standardized corpus that is easier for a computer to interpret, (2) using this clean data set to train four models (one for each experiential quality) to recognize whether or not each trip report described the experiential quality and evaluate the performance of these classifiers, (3) applying the classifiers to every trip report in our study region ($n = 69{,}936$) to determine whether certain experiential qualities were more frequent on some routes than others. Each step is described in more detail below.

To prepare the data set, we removed stop words (insignificant but frequent words, such as *a*, *and*, *is*, *of*), punctuation and whitespace. The remaining words, referred to as 'tokens', were lemmatized[6] and converted to lowercase using spaCy version 2.3.4 (Honnibal et al., 2020). We described the text features in our corpus using the term frequency-inverse document frequency (TF-IDF) statistic, which is a measure of how often the term occurs in a trip report, offset by how often that term occurs across all trip reports. The strength of this method is that

[5]In computer science, the term 'label' is commonly used, while in the social sciences, 'code' is more common to describe the processes of assigning tags or categories to text with a particular type of content or style. For clarity and consistency in our interdisciplinary work, we have used 'code' throughout.

[6]By 'lemmatized', we mean mapped to the canonical form of the word (e.g. *appears* and *appeared* would both be changed to *appear*) (Bird et al., 2009).

the text features in the model are interpretable and we can determine which tokens are the most important for accurate prediction. The TF-IDF features were modelled using a random forest algorithm using the scikit-learn package in Python (Pedregosa et al., 2011).

Following data preparation, we trained and tested four classifiers. We first divided the coded trip reports for each experiential quality into two sets. Eighty per cent of the data for each class were used to train the classifiers (the training set). The remaining 20% of the coded data for each class were withheld to test the performance of the classifiers (the test set). Early model testing revealed that the classifiers performed better when we created a balanced training data set, so we randomly dropped a portion of the trip reports that did not include the experiential quality from the training set (downsampling) until we had an equal number of reports including the presence and absence of the awe, challenge and solitude classes. The test sets retained the same imbalanced distributions as the original population of trip reports. Table S1 shows the training and test set sizes for each experience class along with the number of reports containing the experience in each of the training and test sets.

We tuned both the feature extraction method and the classification algorithm to find the optimal hyperparameters based on the best F_1 score. For TF-IDF, we searched for the best ngram-range and the optimal number of features to include. For the random forest algorithm, we tested the following hyperparameter values: number of trees, the maximum depth of each tree, the maximum number of features to use to determine the best split for a node and the minimum number of samples needed to have in a leaf node. Following classifier tuning, we performed feature selection to filter out uninformative or detrimental features (words or pairs of words) from the feature set (the collection of tokens created during the cleaning process). We scored each feature using permutation feature importance to determine which words were the most important to improving classifier performance, and retained features in the feature set only if they had a permutation feature importance score greater than zero. The classifier was tuned again using only the most important words to find the best hyperparameters. Once the classifier was retrained, it was applied to all trip reports that were collected across the entire national forest to predict whether each trip report included discussion of the experiential quality.

3.4.3 | Relating experiential qualities to the recreation setting

To address our third research question, we explored whether variability in where visitors wrote about each experiential quality could be explained by administrative, built, biophysical, geographic and social characteristics of the setting. For this research question, we treated each Washington Trails Association route as our unit of analysis. For each route, we calculated the proportion of all trip reports tagged to this route between 1997 and 2021 that our classifier had identified as showing evidence of each experiential quality.

As in training our classifiers, we focused on trails in the Mt. Baker-Snoqualmie National Forest. However, we limited our data set to include only hikes with comprehensive descriptions in Washington Trails Association's hiking guide. We defined this to include hikes where the hiking guide included (1) a narrative description of the hike; (2) trail mileage, elevation gain and high point; (3) at least one of Washington Trails Association's trail features noted; and (4) a geolocated trailhead on the road system. Routes that included more than one hike were included if all the individual component hikes met the criteria above. Limiting the data set in this way ensured that we had complete setting characteristics (as defined in Table 1) for each route, and that the trails we included were official, system trails recognized by the USDA Forest Service. Applying these criteria left us with 261 hikes and 785 routes with 54,989 trip reports (average 70 trip reports per route).

We created four distinct generalized linear models to evaluate whether the qualities of experiences described in the trip reports could be explained by the characteristics of the recreation setting. This method builds on revealed preference theory, which assumes that patterns of visitation reveal preferences of users for various characteristics of the landscape (e.g. Donahue et al., 2018; Fisher et al., 2019; Hausmann et al., 2018; Samuelson, 1948). Here, we assume that if characteristics of the setting are fostering an experiential quality, that experiential quality will be described more often in trip reports from routes with that setting. In each case, our response was the proportion of all trip reports posted to a route that included evidence of a particular experiential quality (e.g. awe), as estimated by the NLP model, and the predictors were the setting characteristics described in Section 3.2. Most of the setting characteristics (road paved, wilderness, waterfalls, lakes, rivers, summits, ridges/mountain passes and old growth) were modelled as binary variables, indicating that that characteristic was either present or absent on the route. The amount of visitation variable was log transformed, and then all continuous variables were rescaled by subtracting the mean and dividing by two standard deviations so that our coefficients would be comparable to one another (Gelman & Hill, 2006). We checked for multicollinearity and found that all pairwise correlations between the setting characteristics were below |0.5| and all variance inflation factors were below 1.5. While we expected that some of the setting characteristics would be highly correlated with wilderness designation (e.g. more old growth on trails that enter wilderness), we did not find this to be the case. Instead, wilderness designation was weakly correlated with ridges/mountain passes ($r = 0.38$) and trail mileage ($r = 0.34$), but essentially uncorrelated with the other setting characteristics (all $r < 0.2$).

Because the total number of trip reports for a given route varied widely (ranging from 1 to 2192), we chose a random subset of 250 trip reports to calculate the proportion of reports that included an experience from all routes with more than 250 total trip reports. Without this step, our models effectively gave more weight to the characteristics of the most visited sites. We used the 'glm' function in 'R' version 3.6.3 (R Core Team, 2022), and chose to use the quasibinomial family rather than the binomial family to account for overdispersion in our response variable.

4 | RESULTS

4.1 | Experiential qualities in trip reports

We found that trail users write about experiencing aesthetics, awe, challenge and solitude in the trip reports that they submit to the Washington Trails Association platform, in ways that were identifiable through manual coding. Some experiential qualities were discussed more often than others, with 55% of coded trip reports describing aesthetics, 34% describing awe, 15% describing challenge and 16% describing solitude (Figure 2). A lower proportion of reports included descriptions of experiencing pristineness (3%), quietness (10%) or timelessness (3%).

TABLE 3 Test precision, recall and F_1 scores for each binary classifier.

	Precision	Recall	F_1
Aesthetics	0.82	0.85	0.83
Awe	0.71	0.69	0.69
Challenge	0.77	0.50	0.60
Solitude	0.69	0.33	0.42

4.2 | Classifier performance

Our classifiers were moderately successful at identifying text that described each of the four wilderness-associated experiential qualities (Table 3). The aesthetics classifier performed the best ($F_1 = 0.83$, where F_1 is the harmonic mean of precision and recall), with both high precision (82% of posts that were identified as including aesthetics by the classifier actually did include aesthetics according to the manual coding) and high recall (85% of all trip reports that included aesthetics according to the manual coding were correctly identified by the classifier). The solitude classifier was the least successful ($F_1 = 0.42$), but was still relatively precise (69% of reports identified as including solitude by the classifier included a description of solitude according to manual coding).

4.3 | The influence of setting characteristics on trail experiences

We found that certain experiential qualities were more commonly reported in particular settings (Figure 3). Positive relationships between the proportion of trip reports which included an experiential quality

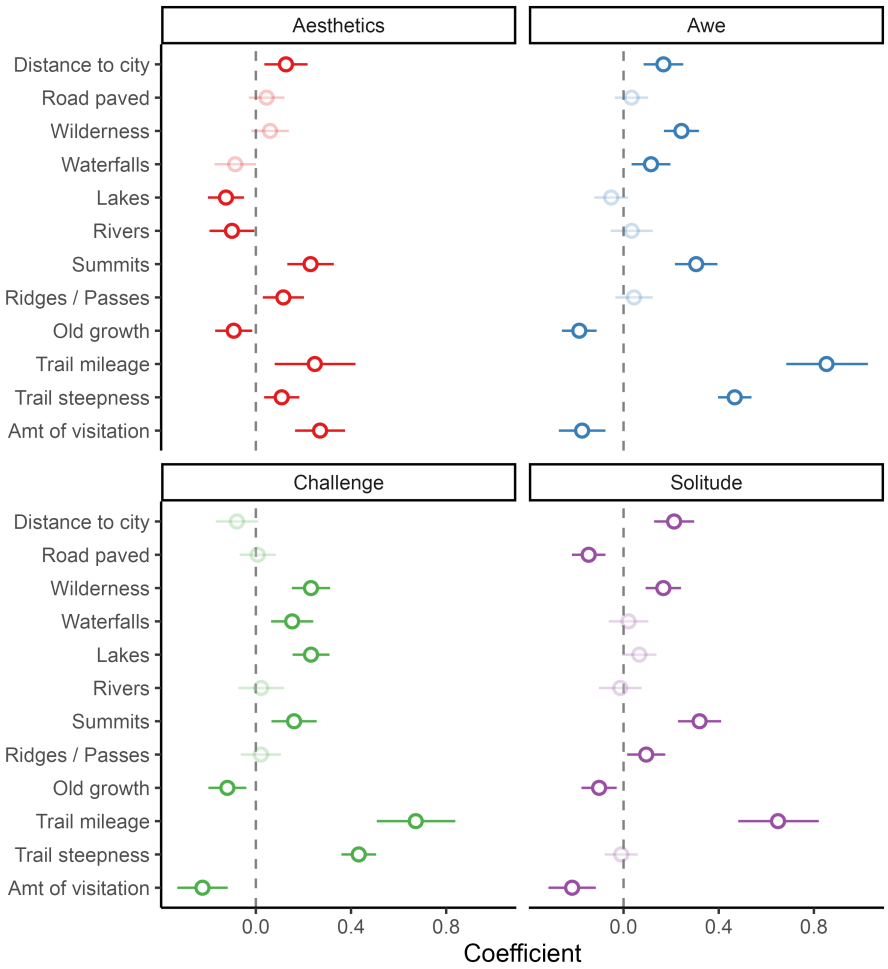

FIGURE 3 The relationships between setting characteristics and the frequency with which visitors wrote about each experiential quality. Circles show the coefficient estimate for each variable and lines indicate the 95% confidence interval. Points to the right of the dashed lines indicate a positive relationship between the variable and the experience, while points to the left of the dashed line indicate a negative relationship. Insignificant variables are partially transparent. The intercept and ranger district coefficients are not included in this figure.

and a particular setting characteristic are indicated by positive coefficients, with larger values indicating a stronger effect. The degree to which the settings explained variability in experiences differed. The setting explained 34% of the variability in the proportion of trip reports that included discussion of aesthetics (pseudo R^2=0.34, sensu Zuur et al., 2009); 35% and 38% of the variability for solitude and challenge, respectively; and 55% of the variability for awe.

A greater proportion of trip reports discussed aesthetics on routes that included longer, steeper trails and that accessed summits or ridges/mountain passes. We also found a significant positive relationship between reported aesthetic experiences and the amount of visitation a route received. Conversely, there were fewer reported aesthetic experiences on routes that included rivers, lakes or old growth.

Trip reports included discussion of awe-inspiring experiences more often on routes that included longer, steeper trails, or that accessed waterfalls or summits. Routes that accessed federally designated wilderness and were farther from population centres had a greater proportion of trip reports that included awe, while there was a negative relationship between the number of reports of awe and the amount of visitation on the route, or the presence of old growth.

Experiences of challenge were also reported more often on routes that included longer, steeper trails. This experience was more common on routes that included access to waterfalls, lakes or summits. There were significantly more reports of challenge on routes that entered federally designated wilderness, but fewer reports on routes that included old growth. Likewise, there were a smaller proportion of posts that included a description of challenge on routes that received more visitation.

Solitude experiences were reported more often on routes that included long trails, but there was no significant relationship between trail steepness and solitude. However, we did find that a greater proportion of trip reports described experiences of solitude on routes that included summits or ridges/mountain passes. Routes that were farther from population centres and not accessible from paved roads had a greater proportion of trip reports that reported solitude. This experiential quality was also more commonly reported on routes that entered federally designated wilderness. There was a negative relationship between the proportion of trip reports that reported solitude and old growth, as well as of the amount of visitation the route received.

Some setting characteristics had consistent relationships across the experiential qualities. We found that all four experiential qualities were more likely on routes that included longer trails, with the strongest relationships between trail mileage and awe or challenge (Figure 4). Wilderness designation was positively associated with all four experiential qualities, but only significant for awe, challenge and solitude (Figure 4). Summit access had a significant positive association with all four experiential qualities, while access to old growth had a significant negative association with all four experiential qualities.

5 | DISCUSSION

Our application of NLP and machine learning for classifying geolocated long-form texts gave us the ability to learn about multiple qualities of trail users' experiences over hundreds of routes, and across millions of acres of a national forest. Our intention was to expand singular measures of experience (such as scales of satisfaction or quality), using a secondary data source to better understand multiple qualities of recreation experiences, and where they happen. We found that overall—of the four experiential qualities that we were able to study using these methods—aesthetics was most common, followed by awe and solitude. Challenge was less common.

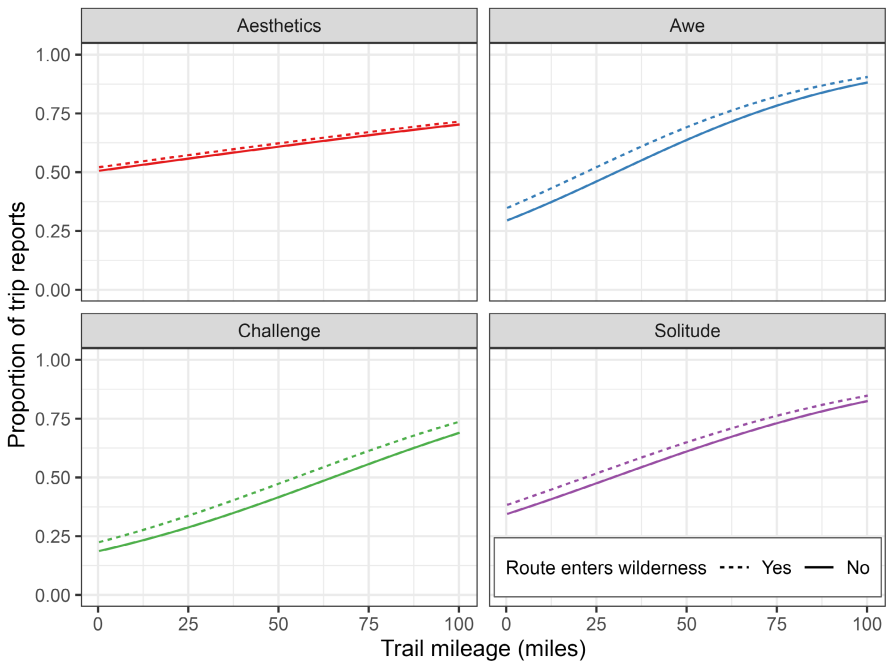

FIGURE 4 Predicted proportion of trip reports that include each experiential quality on routes with varying trail mileage and wilderness designation. Graphs assume mean amount of visitation, trail steepness and distance to city, that the trailhead is in Snoqualmie Ranger District, that the access road is not paved and that the route does not access rivers, lakes, waterfalls, summits, ridges/mountain passes or old growth.

Like other studies, our findings demonstrate the variability of experiences across different settings (Fix et al., 2013; Pietilä & Kangas, 2015). The four experiential qualities we modelled were influenced by many of the setting characteristics we included in our analysis, especially trail mileage and destinations such as summits. Unsurprisingly, the combination of setting characteristics associated with each experiential quality varied. For example, steeper trails on a route significantly and substantially increased the likelihood that a visitor reported a feeling of awe or challenge, while this setting characteristic had a more moderate positive effect on reports of aesthetics, and no significant effect on whether a visitor reported solitude.

5.1 | The influence of wilderness designations

One of our study objectives was to examine differences in recreation experiences in wilderness and non-wilderness areas. The question of what wilderness 'should be' in the United States—as a cultural construct and in its physical manifestation—has been debated by lawmakers, policymakers, agency officials, scholars and advocates over decades (Borrie & Roggenbuck, 1996; Engebretson & Hall, 2019; Fletcher et al., 2021; Nash, 2014). The debate between preservation and use has analogues worldwide, especially related to tourism promotion, demands for livelihoods and raw materials and ecological protection; these tensions persist even in areas where wilderness is not a formally delineated area (or concept) (Saarinen, 2016). Despite ambiguities and a lack of consensus, agencies in the United States have created standards for characterizing wilderness and developed monitoring systems to assess whether wilderness character has been preserved (Landres et al., 2015). We found that federal wilderness designation was positively associated with three of the four experiential qualities modelled (awe, challenge, solitude), even after controlling for all other setting characteristics we considered. But other characteristics in our model had a stronger influence on these wilderness-associated qualities than formal designation as wilderness. The opportunity to get farther away from the trailhead seemed especially helpful for enabling wilderness-associated experiences, and had a greater impact than wilderness designation on all four wilderness-associated experiential qualities (Figures 3 and 4). The weak correlation between trail mileage and wilderness designation in our study bolsters this finding—trail mileage is not simply a proxy for entering wilderness in this region. However, the longest routes in our study (>40 miles round trip; 6% of all routes) did all enter designated wilderness. Thus, our finding is most applicable to routes which are less than 40 miles long.

There are several potential reasons why longer trails are most strongly associated with all four experiences. First, it could be that walks on longer trails require more time spent outdoors, leading visitors to encounter a greater diversity of microsettings and creating more opportunities for wilderness-associated experiences. Or, a longer route could result in the mental or physical rewards of accomplishing a more challenging hike. Perhaps concurrent users are distributed over a greater distance, creating more opportunities to be alone. The feeling of 'being away' this may foster is an important concept in environmental psychology (Kaplan, 1995) and could also be theorized to facilitate wilderness-associated experiences. Psychological methods used to study emotional responses to stimuli (such as awe) could be useful for future research about the relationship between settings and wilderness-associated experiential qualities (Cochrane, 2012; Coghlan et al., 2012; Keltner & Haidt, 2003; Yaden et al., 2019).

Beyond trail length, we found higher incidences of visitors writing about each of the four wilderness-associated experiential qualities on routes that accessed summits. This finding is consistent with our expectations for aesthetics (expansive scenic views are common from mountaintops), awe (mountains are often associated with the sublime) and challenge (reaching the summit of a mountain is physically strenuous and generally seen as an achievement) (Cochrane, 2012). Reasons for the higher incidence of writing about solitude is less obvious; perhaps summits are conducive to solitude because they promote a feeling of visual expansiveness and remoteness, beyond the physical space of the summit itself. This could prompt introspection. We also know that what is described as solitude is often a more complex experience than simply being alone (Borrie & Roggenbuck, 1996; Engebretson & Hall, 2019; Hammitt & Madden, 1989), and has been conceived as a multidimensional construct itself, with important psychological dimensions such as the contemporary effects of as 'de-tethering' from digital connectivity (Lang & Borrie, 2021). Additional research is needed to further define, categorize and operationalize solitude and other wilderness-associated experiences, to quantify their prevalence and distribution in a way that informs land managers' planning and decision-making.

We found that routes which accessed old growth were associated with lower frequencies of writing about each of the experiential qualities, counter to our intuitions and previous research (Piff et al., 2015; Williams & Harvey, 2001), perhaps with the exception of challenge. Further research is needed to understand why this was the case; it is possible that other characteristics associated with old growth, but not included in our model, influenced these experiential qualities in our study area. Or, this could be related to the pattern of experiential qualities we observed for routes with summits (where visitors express experiencing aesthetic appreciation and awe much more frequently); such high points and long sightlines are not generally available in old growth forests. Much of the Mt. Baker-Snoqualmie National Forest is mature second-growth forest that may already appear large to the average visitor, despite being relatively young forest, so a lack of visual differentiation or awareness in areas with old growth trees could make it less impressive or noteworthy. A lack of clear or consistent definitions of old growth—a common phenomenon in old growth discourse (Pesklevits et al., 2011)—could also influence our underlying setting characteristics data. Many contributors help identify old growth as a feature for Washington Trails Association's hiking guide, which is more subjective than identifying other features such as summits or waterfalls. This could lead to an inconsistent inclusion of this feature, with potential for over-reporting.

In considering future research, it is important to note that federally designated wilderness areas in the United States are not necessarily managed very differently than adjacent lands. In some national forests, a wilderness designation provides a stark contrast to adjacent, non-designated lands where motorized recreation or logging might occur. Managers implement permit systems to cap day or overnight use through quotas in some wilderness areas. In the Mt. Baker-Snoqualmie National Forest, however, very few trails outside of federally designated wilderness allow for the motorized or mechanized activities that are prohibited in wilderness. The national forest does not have any areas under a permit system, so visitation is only limited by indirect factors, such as parking capacities at trailheads (USDA Forest Service, n.d.-a). These different contexts across wilderness areas in the United States and other countries would make for interesting comparisons in future research. We caution, however, that robust 'trip report' data sets likely do not exist in all potential study areas, and the richness of the secondary data used in the current study likely reflects distinct regional and national cultures and discourses around outdoor recreation, wilderness and nature (see e.g. Nash, 2014).

5.2 | Do settings explain experiential quality?

While the setting characteristics that we evaluated do have some explanatory power, our findings show that factors that were unaccounted for in our model also have important influences on trail users' experiences in our study area. The administrative, built, biophysical, geographic and social setting characteristics that we included do not fully explain the variability in where visitors reported each experiential quality; they only explain roughly a third of the variability in aesthetics, challenge and solitude, and just over half of the variability in awe. Taken together, this suggests that the types of setting characteristics we included—typical to recreation studies—are insufficient, likely because recreation experiences are multidimensional and variable, and based not just on immediate settings (Blahna et al., 2020). Thus, our findings suggest that the current focus on these setting characteristics in management frameworks is likely also insufficient for guiding actions that are intended to foster these types of experiences.

We suspect that other factors—beyond immediate settings—have strong influences on trail users' experiences, including personal and sociocultural factors. These often go unaccounted for in motivation-based research focused on visitor satisfaction and the management frameworks and tools they inform. As Williams (2007, p. 38) cautions, 'we fall prey to the consumer metaphor, which suggests that the quality of experience is almost entirely a function of the extent to which the performance of the resource exceeds visitor expectations. Instead, it is important to remind ourselves that people make their own experiences, they shape and adapt the situation, and they employ skills and knowledge to create their own satisfaction'. In other words, outdoor recreation experiences lead to outcomes and benefits that are not just 'received' from the setting—these are co-produced, sometimes the result of months, years or a lifetime of interaction (Brandenburg & Carroll, 1995; Stokowski, 2002; Williams, 2007).

5.3 | Management implications

Our research demonstrates the need for recreation and wilderness management frameworks and tools to be informed by setting characteristics beyond immediate, physical characteristics, so that they incorporate additional relevant social and psychological factors. For example, if a management goal is to provide opportunities for visitors to experience awe, then understanding the variation in when, where and how awe is experienced, and its relation to other factors—such as cataclysmic events and beauty, and the emotional introspection they induce—is critical for informing effective management (Keltner & Haidt, 2003; Piff et al., 2015). While these are more complex considerations for prescribing management directions than choices about the design of restroom or parking facilities, they are arguably more influential for people's meaningful outdoor experiences (ibid).

Setting characteristics do influence experiences to some extent, though, and the ones we included vary in their alterability by management interventions. While some of our study's setting characteristics can be manipulated (such as whether access roads are paved, how long trails are and how much visitation is received), many other setting characteristics are not ones over which managers have direct or meaningful influence, such as topographical and biophysical features. But managers do make decisions that influence how those features are accessed, and how many people can access them. For example, managers make decisions about constructing, maintaining and decommissioning trails, roads and other infrastructure. They also influence opportunities for trail users to experience aesthetic appreciation, awe, pristineness and timelessness through decisions about where to site conflicting uses (e.g. cell towers or oil and gas development) and how to route trails to avoid observing these activities. If managers are seeking to alter physical settings to create additional opportunities for visitors to experience awe, for example, our analysis suggests that one way to do is to create opportunities to access summits on long, steep trails. Generally, though, the range of decisions and actions that managers might consider are not well represented in the study characteristics we included because of data availability issues (see Section 5.4), so further research is needed to understand potential outcomes.

5.4 | Limitations and other future research

Our findings should be considered with several caveats. First, we have little information about the population writing Washington Trails Association trip reports about trails in the Mt. Baker-Snoqualmie National Forest, so we cannot describe whom our findings represent. We do know that visitors to the national forest tend to be richer, more predominantly white and have a larger proportion

of male visitors than the population of the Seattle metropolitan area (MBS, 2020). We might guess the trip reporter population for the national forest is similarly skewed, but we cannot evaluate this.

Second, it is important to recognize that just because something was not written about in a trip report, it does not mean it did not occur. Our classifiers worked better for some of the experiential qualities than for others, leading us to examine the prevalence and distribution of just four of the original seven across the entire trip report data set (Table 1). The other three experiential qualities we attempted to study (pristineness, quietness and timelessness) did not appear frequently enough in the data set to include in our subsequent analyses. The exclusion of the remaining three experiential qualities does not imply they do not exist in the trip reports nor that they could not be studied using other methods. Future research is needed to discern whether these experiential qualities are truly infrequent, or whether they are experienced by trip reporters, but infrequently written about. Alternatively, the language that visitors used to describe these experiences might differ from what we coded for in the training set. Underdeveloped definitions of these nuanced experiential qualities could have resulted in the difficulty we had in consistently coding for them. The difficulties we encountered are not insurmountable, however; other scholarship examining quiet and tranquillity, for example, has been able to identify expressions of those qualities, and the more nuanced and multidimensional definitions used in that work should inform how they are operationalized in future research that builds on our automated methods (Chesnokova et al., 2019; Wartmann et al., 2021). For our purposes, this might involve breaking complex experiential qualities into subcomponents (such as Lang and Borrie (2021)'s four dimensions of solitude), and greater investments in creating training sets for less frequently described experiences. Future research could also explore the potential to account for imperfect detection of the experiential qualities in the trip reports, perhaps by conducting a parallel survey that asked visitors directly to define elements of their experiences. The ability to quantify the proportion of experiential qualities that were written about (and detected) in trip reports could allow future research to include a quantitative measure of the 'detection probability', akin to imperfect detection methods used in species distribution modelling (Kellner & Swihart, 2014).

Third, we suspect our methods and findings are biased towards visual experiences. A future study could refine our analytic methods to determine the prevalence of writing about each of the senses within the data set, focusing on what trip reporters write about *how* they engage each of their senses on the trail (e.g. descriptions of what they hear, smell or touch). These sensory engagements were central to what early wilderness advocates imagined for wilderness in the United States (Engebretson & Hall, 2019), and can be understood as contributors to the senses of place that people develop (Raymond et al., 2017). Differences across countries and cultures in what people write about could be hypothesized to reflect different social constructs of wilderness or nature more broadly—and as a result, what warrants mention when writing about experiences.

Fourth, the data sources we used to characterize each route's recreation setting were (by necessity) based on limited and imperfect data about the landscape and types of settings that people experience from each trail. We used a relatively simple measure of wilderness for this study, focusing on whether a trail entered federally designated wilderness. This reflected our study interest in management frameworks, but future work with broader interests could use more nuanced measures of wilderness character beyond administrative boundaries. In addition, in areas where spatial data on Recreation Opportunity Spectrum zoning is actively updated and used, this could be a variable of interest (this was not the case in the Mt. Baker-Snoqualmie National Forest, so we did not include it in this study).

Finally, future research that adds a temporal dimension to analyses would be valuable, providing insights on seasonal and longitudinal shifts. Our setting characteristic representing the amount of visitation on a route was based on aggregated trip reports written over a 20-year span, and we know trail usage has increased with population growth in this time (Outdoor Foundation, 2020). Similar to Chesnokova et al.'s (2019) assessment of changing regional soundscapes, future research could use trip reports to help discern how changing trail usage, wilderness designations and other conditions affect experiential qualities and the development of senses of place. Studies could focus on areas where wildfires have recently burned, glaciers are receding or infrastructure investments have been made.

6 | CONCLUSION

We examined assumptions about outdoor recreation setting–experience relationships by analysing a data set of geolocated long-form texts from a trip-reporting platform. Our approaches using NLP and machine learning allowed us to analyse tens of thousands of crowdsourced texts to understand where and how often wilderness-associated experiential qualities occurred across a 1.72-million-acre national forest, and allowed us to understand them in relation to the administrative, built, biophysical, geographic and social settings where they took place. We found that wilderness designation was positively associated with three of the four experiential qualities modelled (awe, challenge, solitude), though other characteristics had a stronger influence, such as trail mileage and summits. Importantly, however, the setting characteristics we included only explained about a third of the variability in experiential qualities, meaning that other unaccounted-for characteristics of people and places are needed to understand that variation. This suggests the need to reimagine experience–setting relationships to include a greater diversity of factors, such as visitors' information sharing activities, on-site social interactions, senses of place and personal histories. This more complex conceptualization could inform the creation of new data sources to represent understudied variables, and the development of more robust models to understand how those relationships function. Such theoretical development would help integrate insights

from motivational, experiential and relational recreation research traditions, and refine the applied frameworks that are used to manage outdoor recreation. This, in turn, could help managers understand the effects of management actions (or inactions), and equip them to be more aware and supportive of people's diverse experiences across outdoor settings.

AUTHOR CONTRIBUTIONS

Monika M. Derrien, Samantha G. Winder, Spencer A. Wood, Lesley Miller, Emmi H. Lia, Lee K. Cerveny and Sonja Kolstoe conceived the ideas and designed methodology; Sarah Lange and Anna Roth helped develop the management framing and implications; Lesley Miller, Anna Roth, Spencer A. Wood and Samantha G. Winder collected the trip report and site characteristics data; Lesley Miller and Spencer A. Wood developed and tested the NLP methods and classifier model; Samantha G. Winder, Lesley Miller, Emmi H. Lia and Grace McGrady analysed the data; Monika M. Derrien, Samantha G. Winder and Spencer A. Wood led the writing of the manuscript; all authors provided critical feedback on the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data, scripts and trained classifier models are available on OSF at https://doi.org/10.17605/OSF.IO/BCXA2 (Winder et al., 2023).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Table S1: Size of training and test data sets used for each classifier, along with the number of trip reports in each set that included the experience.

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