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Understanding the role of local knowledge in the spatial dynamics of social values expressed by stakeholders

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A B S T R A C T

Understanding the myriad reasons why people value protected areas provides insight on how to align the decisions made by public land management agencies with diverse stakeholder interests. This study drew on survey data collected within the context of Denali National Park and Preserve to better understand the spatial dynamics of social values reported by frontcountry and backcountry recreationists that held differing degrees of local knowledge. Using a Public Participation in Geographic Information Systems (PPGIS) exercise and Social Values for Ecosystem Services (SolVES) mapping application, we observed differences in the point allocation and spatial distribution of social values associated with a protected area landscape. Wilderness, aesthetics and ecological integrity were the primary social values embodied by places within Denali. Backcountry recreationists engaged with a broader range of values and derived deeper benefits from recreation and therapeutic qualities of the landscape, whereas frontcountry recreationists expressed multiple, concentrated values for places in Denali that were accessible and symbolically important. We also observed that local knowledge provided a useful basis for better understanding social values, yet variation in knowledge was not spatially manifested. Our findings therefore advance the spatial prioritization of conservation initiatives that aim to represent and legitimize the voices of stakeholders in protected areas.

1. Introduction

How can the range of benefits provided to society by protected area landscapes be sustained for future generations? This question is a driving consideration for environmental planning and management agencies, which are increasingly faced with difficult decisions about how best to optimize public experiences in nature without sacrificing resource protection and economic growth in the face of change (Everhart, 2019; Manning et al., 2016; Winks, 1996). A rapidly growing body of research has examined the perceived benefits of nature using Public Participation in Geographic Information System (PPGIS) methods (Brown & Kyttä, 2014; Sieber, 2006) to legitimize, represent and incorporate public viewpoints into the decision-making process. This tool leverages spatial technology to integrate both social and ecological data while also recognizing the importance of engaging broad audiences to articulate the competing values of nature (Alessa et al., 2008; Bagstad et al., 2016; Sherrouse et al., 2011; van Riper et al., 2017). Given that public lands embody such a rich array of values and meanings (Brown & Weber, 2011; D'Antonio et al., 2013; McIntyre et al., 2008), participatory research that systematically documents the spatial qualities of places while representing the shared beliefs of stakeholders shows great potential for prioritizing decisions and ensuring that places such as America's "crown jewels" are managed in a way that aligns with stakeholder interests.

Previous research has investigated the spatial dynamics of "social values of ecosystem services," defined as qualities associated with landscape features or functions expressed by individuals and aggregated at the group level (Brown et al., 2020; Sherrouse et al., 2011). Building on both "instrumental" and "deliberative" paradigms that respectively involve objective identification of key attributes that characterize a system, and in-depth exchanges with stakeholders about the environment (Raymond et al., 2014), this line of work aims to represent the depth, range and complexities of how people perceive landscapes (Zube, 1982) in a way that fuzes knowledge of "sense of place" with

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generalizability (Gobster, Palmer, Crystal, & Ervin, 2003; Larson, De Freitas, & Hicks, 2013). To quantify and spatially examine the relative importance of social values across a landscape, value typologies originally conceptualized by Bengston and Zu (1995) and empirically tested by Brown and Reed (2000) have been used to represent why places are expressed to be important.

Participatory mapping elicits spatially anchored viewpoints in relation to ecosystem services as articulated by a range of policy frameworks (MEA, 2005; Díaz et al., 2015). Previous research guided by participatory mapping methods has employed spatial data created by respondents to better understand the relationship between places and human wellbeing, as well as and strengthen public involvement in policy and planning initiatives related to the environment (Brown & Fagerholm, 2015; Sieber, 2006). In particular, the cultural ecosystem services literature has involved mapping social values to draw out non-material goods and services that environments provide to human communities (Brown & Fagerholm, 2015; Chan et al., 2012; Kenter et al., 2019; Milcu et al., 2013; Plieninger et al., 2013; van Riper et al., 2012). In other words, participatory mapping exercises whereby people are asked to prioritize and spatially locate social values of ecosystem services provide an empirical pathway for operationalizing cultural ecosystem services.

The relationships between social and biophysical data indicate the affordances of landscapes by providing insight on how physical features are interpreted, the degree of place boundedness that people perceive (Beeco & Brown, 2013; Dorning et al., 2017; Malpas, 2012) and local knowledge of how people come to understand their environments (D'Antonio et al., 2013). Through participatory mapping, data can be generated to support the spatial prioritization of conservation initiatives (Chan et al., 2006; Knight et al., 2008; Whitehead et al., 2014) and identify tradeoffs based on the magnitude of difference among social values types (Martín-López et al., 2012; Palomo et al., 2014). For example, Johnson et al. (2019) illustrated non-linear relationships between social values and landscape metrics across the land and seascapes of two protected areas in the US and Australia. These authors directed managerial attention to high and low priority locations, and identified the most highly rated social values (i.e., recreation, aesthetics, and perceived biological diversity) that respondents would likely trade off against qualities that were deemed less important (i.e., cultural and spiritual values). This cross-national study extended a growing body of research that supports conservation planning for ecosystem services by adopting a meanings-based framework to guide natural resource management decisions (McIntyre et al., 2008).

Social and biophysical data mapped using participatory techniques merge cognitive and affective processes alongside indicators of the environments that people experience to show spatial compatibilities and tensions, while also leveraging stakeholder knowledge. Here, we define knowledge as the level of awareness gained from education and first-hand experience of places (Frick et al., 2004; Raymond et al., 2010). This conceptualization aligns with the idea of local knowledge that is often derived from interactions with a landscape (D'Antonio et al., 2012). This type of knowledge is distinguishable from Traditional Ecological Knowledge passed down from generation to generation among indigenous peoples (Berkes, 2004; Gadgil et al., 1993), expert or modern scientific knowledge (Freeman et al., 2014), and the process of knowledge exchange and integration (Díaz et al., 2015; Fazey et al., 2014; Tengö et al., 2017). Across multiple streams of literature, previous research has suggested knowledge of a study area influences the number and type of social values of ecosystem services that are mapped by survey respondents (Brown & Weber, 2011; Raymond et al., 2010).

Measurement of knowledge is challenging given its complexity, yet previous researchers have successfully observed different levels of understanding reported by stakeholders in a variety of contexts (Hakkarainen et al., 2020; Olli et al., 2001). D'Antonio et al. (2012) examined how knowledge of local conditions influenced visitor perceptions of natural resources in Rocky Mountain National Park, Colorado, U.S. These authors developed a multi-dimensional scale that spanned natural history topics and management issues, and observed both positive and significant effects of knowledge on perceived ecological impacts. Other studies have corroborated these findings and suggested that prior knowledge shapes the way people experience public land management contexts. For example, van Riper et al. (2017) investigated the relationship between perceived biodiversity and a suite of environmental indicators across subgroups defined by low and high self-reported knowledge of a protected area. The authors found that knowledge moderated the relationship between social and ecological data, in that respondents with low knowledge valued places that they visited in the protected area whereas those with high knowledge were more likely to ascribe meaning to a broader expanse of public lands that were not experienced first-hand. It could be that new experiences are framed by knowledge, and value assignments are a function of individual experiences that influence behavior (Arcury, 1990; Cebrián-Piqueras et al., 2017).

Two stakeholder groups that have been the focus of previous research and public land management policies are "frontcountry" and "backcountry" recreationists who hold distinguishable tastes and preferences for experiencing nature. Although these two groups have previously been dichotomized for ease of decision-making (e.g., Marks, 1988), these types of stakeholders and their use patterns can be situated along a spectrum. On one end of the spectrum, backcountry recreationists tend to prefer remote, wilderness-like conditions (Manning, 1985; Patterson & Hammitt, 1990; Taff et al., 2015), and are characterized by a desire for solitude and rugged places that require high skill levels to access. On the other end, frontcountry recreationists prefer spending time in developed settings that offer more amenities (Basman et al., 1996), and focus more attention on landscape aesthetics and ease of use (Lee et al., 2013). In this sense, the spectrum ranging from frontcountry to backcountry use represents a variety of motivations, expectations and specialization levels (Rice et al., 2020). Additionally, land itself has been designated as either backcountry or frontcountry to accommodate these different types of use and preserve a diversity of opportunities for nature-based recreation (Manning et al., 1996). Although this divide shows great potential for organizing research and prioritizing management decisions, the empirical basis for how frontcountry and backcountry recreationists value public land management contexts has yet to be established.

This study investigated how social values modeled in relation to landscape metrics were evaluated by frontcountry and backcountry survey respondents who reported different levels of local knowledge. Specifically, three objectives guided our research. We first examined the knowledge levels of respondents in the pooled sample and two subgroups defined by engagement in frontcountry and backcountry activities. Next, we determined the relative importance of social values. Finally, we quantified the spatial relationships of social and biophysical data for the three most intensely weighted social values using a Social Values for Ecosystem Services (SolVES) modeling tool (Sherrouse et al., 2011). This research engaged stakeholders in discussions through participatory mapping, and aimed to inform decisions being made about how to enhance the provision of diverse recreational opportunities while maintaining the ecological integrity of Denali National Park and Preserve.

2. Methods

2.1. Study context

This research was conducted in Denali National Park and Preserve (Denali) located in the Interior of Alaska (see Fig. 1). Spanning over six million acres, this protected area encompasses mountains and glaciers, alpine tundra and boreal forests, wetlands, and North America's tallest peak: Mt. Denali (20, 310′ above sea level). Numerous scenic and soundscape resources, intact ecosystems, high air quality, and over 300 documented cultural sites and paleontological resources are protected

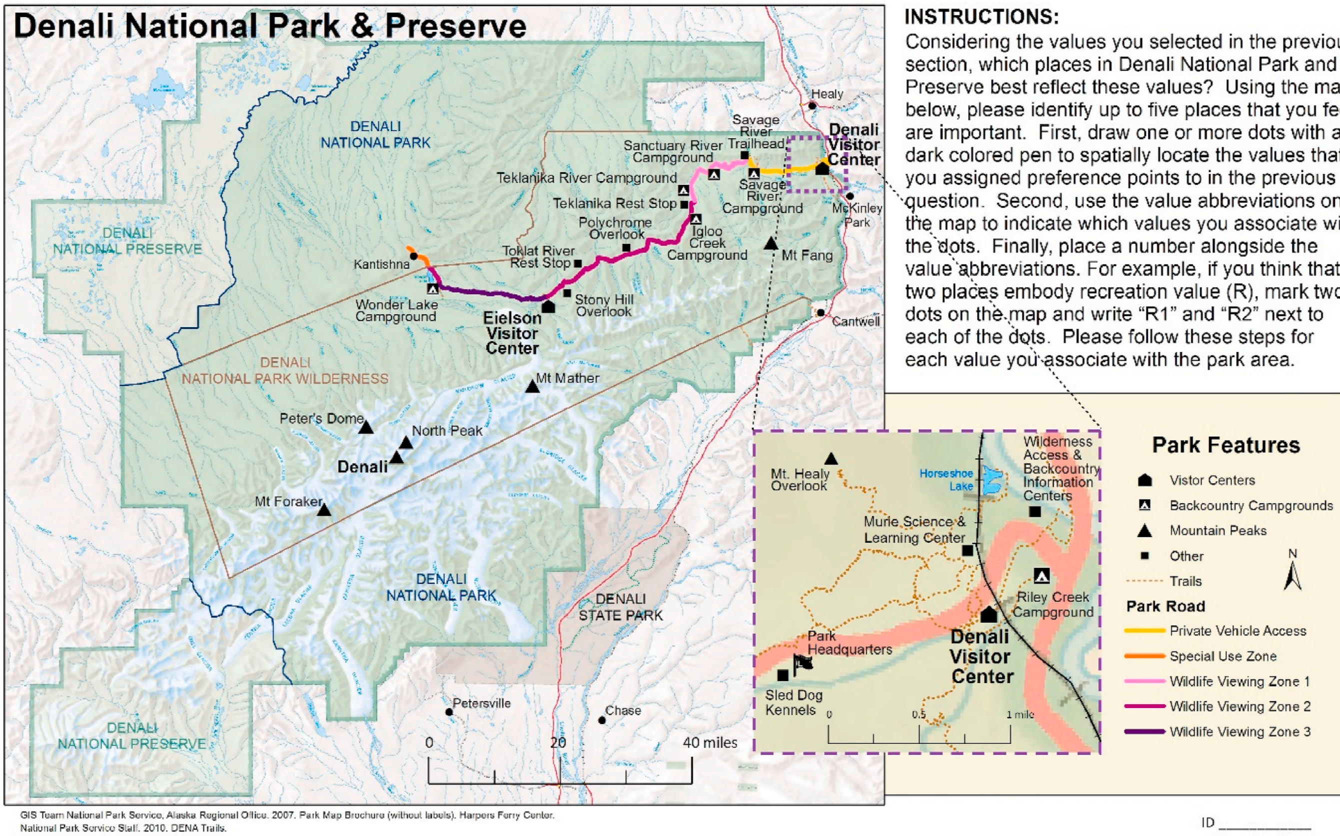

Fig. 1. Map used by respondents in the social value mapping exercise.

within the park. Denali was the first national park established in 1917 to protect wildlife and is home to a vast array of unique flora and fauna including charismatic species such as *Ovis dalli* (Dall sheep), *Alces alces* (moose), *Rangifer tarandus* (caribou), *Ursus arctos* (grizzly bear), and *Canis lupus* (Wolf) (Yost & Wright, 2001). The park's abundant wildlife attracts visitors from around the globe who come to observe these species in an ecologically intact environment (Miller et al., 2018).

Visitors to Denali participate in a wide range of activities. Wilderness recreation such as mountaineering and backpacking are of particular importance and are prioritized in park policies (Taff et al., 2015), alongside more common activities including hiking, camping and viewing wildlife. If people wish to travel into the heart of the park beyond mile 15 of a 92.5-mile road, a transit service, operated by the Park's concessionaire Joint Venture (Aramark & Doyon Inc.), is required. This bus system is a type of "value vector," given that it is the primary avenue for visitors to build appreciation and gain first-hand knowledge of the park's landscapes. There are 87 designated backcountry units in Denali, 41 of which have visitation quotas and group size limits (Stamberger et al., 2018). Overnight backcountry users are required to obtain a permit and are limited to seven consecutive nights in any single unit. In 2016, Denali attracted approximately 600,000 visitors to its frontcountry and backcountry areas[1] (NPS, 2019).

Several federal statutes provide guidance for decisions about resource management in Denali. The National Wilderness Preservation System, created in 1964 with the signing of the Wilderness Act (16 U.S. C. 1131–1136, 78 Stat. 890) Public Law 88–577, protects two million acres of congressionally designated Wilderness in Denali. With few exceptions, permanent roads, commercial services, motor vehicles, and permanent structures are prohibited in Wilderness areas. Additionally, the Alaska National Interest Lands Conservation Act (ANILCA; 16 USC 410hh-3233, 43 USC 1602–1784) Public Law 96–487 was passed by Congress in 1980 and established over 100 million acres of federal land in Alaska as conservation system units. This act tripled the size of Denali, designating the "old park" as Wilderness (i.e., the organic establishment of Denali National Park) and the north and south additions (i.e., the

Table 1
Definitions of 13 social values of ecosystem services assigned to places by survey respondents in Denali National Park and Preserve.

Social Value	Description
Aesthetic	I value Denali National Park for the attractive scenery, sights, sounds, or smells.
Ecological Integrity	I value Denali National Park for its intact ecosystem where predators (e.g., wolves) and prey (e.g., dall sheep) are in balance.
Cultural	I value Denali National Park because it preserves historic places and archeological sites that reflect human history of the island.
Economic	I value Denali National Park because it provides economic benefits from recreation and tourism opportunities.
Future	I value Denali National Park because it allows future generations to experience this place.
Intrinsic	I value Denali National Park in and of itself for its existence.
Learning	I value Denali National Park because I can learn about natural and cultural resources.
Wilderness	I value Denali National Park because it represents minimal human impact and/or intrusion into natural environment.
Spiritual	I value Denali National Park because it is spiritually significant to me.
Recreation	I value Denali National Park because it provides a place for my favorite outdoor recreation activities.
Therapeutic	I value Denali National Park because it makes me feel better, physically and/or mentally.
Scientific	I value Denali National Park because it provides an opportunity for scientific observation or experimentation.
Soundscape	I value Denali National Park because I can hear natural sounds

[1] The National Park Service counts total visits rather than visitors. Each entry into the park within 24 h is counted as one visit.

"new park") as the preserve. It also allowed the preserve to be managed for subsistence use and traditional livelihoods supported by motorized transportation for hunting, gathering and trapping routes, as well as limited guided activities in remote locations.

2.2. Survey administration and design

We distributed self-administered surveys to a representative sample of visitors during a time period that reflected the high use season (June–August 2016). Potential respondents over the age of 18 were approached by trained survey administrators and asked to participate in the study. For groups, the individual with the most recent birthday was asked to complete the survey to minimize potential group leader bias (Battaglia et al., 2008). The survey schedule was stratified by day of the week and time of day across four designated high-traffic areas in the park. Data were collected in the mornings and afternoons of 28 weekdays and 14 weekend days using survey tablets (Insignia MS-P10A6100) and Qualtrics software. Paper copies of the survey were also made available upon request. In response to previous research by Brown and Kyttä (2014), we sought to increase participation rates with on-site survey administration, and achieved a response rate of 90.6% (N = 667). Contact logs were used to monitor response rates and calculate potential non-response bias, none of which was detected on the basis of gender ($\chi^2 = 0.759$) and group size ($t = 1.967$, $df = 710$).

The on-site survey took approximately 20 min to complete and included a participatory value mapping exercise. This exercise involved two tasks designed to elicit preferences for the social values of ecosystem services. First, respondents allocated 100 hypothetical preference points across 13 categories of social values (see Table 1). Value categories were drawn from past research (Brown & Reed, 2000) and modified in response to discussions with Denali park managers and observations made during a scouting visit to the study site. Second, respondents situated these values on a paper map of the study context (see Fig. 2). A 34″ by 13" map of the park, created by the National Geographic Society, was displayed at the survey station for respondents to reference and discuss with the survey administrators. The map of Denali had an approximate scale of 1:225,000 and served as a visual basis for dialogue with survey respondents. Respondents then identified up to ten places in the park that they believed embodied the social values selected in the first step of the exercise.

2.3. Analysis and measurement

Analyses were performed in several phases that paralleled the three study objectives. We first defined respondents as frontcountry or backcountry using several criteria and in response to feedback from park managers. Specifically, backcountry respondents (n = 276) were selected if they received a backcountry use permit from the Backcountry Information Center or if they engaged in camping, hunting or mountaineering activities in response to the survey question "which of the following activities have you participated in during your visit?" Respondents surveyed in a campground were excluded due to the site's proximity to the park entrance and main park road. All other survey respondents who did not meet these criteria were categorized as frontcountry (n = 370). The next phase of analysis evaluated how local knowledge varied across these two survey subgroups and the pooled sample. To measure knowledge, 16 survey items were developed and adapted from past research (D'Antonio et al., 2012), tailored to the study context and presented using a 5-point Likert scale that ranged from "No knowledge" to "Proficient knowledge." These items reflected knowledge of physical resources, cultural resources and management practices within the protected area, and were shaped by an accumulation of experiences, first-hand observations and National Park Service interpretation that translated the meanings of places to visitors. The three dimensions of local knowledge were tested for reliability using Cronbach's alpha (α = 0.842 - 0.902). Independent-Samples t-tests were estimated to compare knowledge scores between frontcountry and backcountry respondents.

Given empirical differences between subgroups, the next phase of analysis evaluated the importance of 13 social values of ecosystem services for frontcountry and backgrountry respondents. Descriptive statistics were used to rank a pre-determined list of social values adapted from previous research (Brown & Reed, 2000; Sherrouse et al., 2011; van Riper et al., 2017) and determine their relative importance. Independent-Samples t-tests were estimated to compare the social value ratings between the two subgroups. To explore the spatial distribution of

Fig. 2. Boundary of Denali National Park and Preserve, Alaska.

Table 2
Spatial layers of on-ground environmental conditions for SolVES analyses.

Variable	Source	Description of Layer
Elevation	National Park Service DEM for Denali, 2004	Elevation raster (in meters) at a spatial resolution of 30 m.
Distance to Park Road	Raster created with Euclidean Distance tool	Straight-line distance between each raster cell and the Denali Park Road.
Slope	Raster derived from DEM layer	Slope raster (in degrees) calculated using the distance elevation model (DEM).
Landcover	National Land Cover Database (NLCD) 2011	Landcover type at a spatial resolution of 30 m. Land cover categories were collapsed to simplify using the 'Reclass' tool in ArcGIS.

social values assigned to Denali, all points that were spatially located by survey respondents were digitized using ArcGIS software (N = 3602) and analyzed using a kernel density estimation (Brown & Weber, 2011; van Riper et al., 2012).

For the final phase of analysis, the location of social value points, their assigned weights, and on-ground conditions were analyzed using the SolVES (Version 3.0) GIS mapping application developed by the U.S. Geological Survey (Sherrouse et al., 2011). The digitized value points were first examined using nearest neighbor statistics to describe the dispersion, clustering and randomness of points (Sherrouse et al., 2011, 2014). Each test returned a series of R-values (i.e., observed versus expected distance between points) and Z-scores (i.e., number of standard deviations from the mean). Next, SolVES employed Maximum Entropy (MaxEnt) modeling (Phillips & Dudík, 2008) to incorporate a series of landscape metrics into the analysis. These biophysical data layers were selected owing to their demonstrated potential to shape the perceived qualities of places (Clement & Cheng, 2011; Albritton & Stein, 2011; van Riper et al., 2017). The following landscape metrics were developed: 1) Elevation, 2) Distance to the Park Road, 3) Slope, and 4) Landcover (see Table 2). As an outcome from the analyses performed in SolVES and MaxEnt, spatial projections were created to explain why places were deemed important. Specifically, a logistic surface layer was built to predict which places were believed to embody social values according to the known relationships between social and biophysical data. The resultant raster map, comprised of grid cells with gradually changing data, displayed a standardized Value Index score on a 10-point scale (Sherrouse et al., 2014).

To evaluate goodness of fit and the predictive power of MaxEnt models for the frontcountry and backcountry survey subgroups, the digitized points were partitioned into "training" and "test" data (Phillips & Dudík, 2008). MaxEnt was set to reserve 25% of the digitized points to use as test data (Sherrouse & Semmens, 2014). Area under the curve (AUC) statistics were calculated to indicate the total area under the receiver-operating characteristic plot (ROC) for training and test data. Training AUC tested the goodness of fit of the MaxEnt models, while test AUC indicated the potential predictive power of the model. We followed Swets' (1988) classification that suggested AUC $\geq$ 0.90 = good, AUC $\geq$ 0.70 = useful and AUC $\leq$ 0.70 = poor model fit. Point data were digitized and stored using Arc GIS 10.4 software, and survey data were analyzed using IBM SPSS Statistics 24 software.

3. Results

3.1. Socio-demographics and trip characteristics

Results from an analysis of socio-demographic characteristics showed there was a nearly even distribution of male and female respondents (50.60% and 49.40%, respectively), and the average age was 44 years old (see Table 3). Sixty-eight percent reported an annual income between $50,000 and $199,999, and the majority (88.60%) identified as White. According to an analysis of zip codes, nearly three-

Table 3
Respondent socio-demographic profile including sample size, frequencies, mean value ($\bar{x}$), mode (Mo), and standard deviations (SD).

Socio-demographic variables	Mean (SD)	N (%)
Gender		
Male		330 (50.60)
Female		322 (49.40)
Age	$\bar{x}$ = 44.03 Mo = 28 (17.31)	
Household size	2.54 (2.49)	
Education		
Less than high school		2 (0.30)
High school graduate		88 (13.70)
Vocational/trade school certificate		24 (3.70)
Two-year college degree		44 (6.80)
Four-year college degree		222 (34.50)
Graduate degree		263 (40.90)
Income		
Less than $49,999		113 (19.30)
$50,000 to $99,999		197 (33.70)
$100,000 to $199,999		201 (34.40)
Greater than $200,000		74 (12.60)
Ethnicity		
Hispanic or Latino		28 (4.30)
Not Hispanic or Latino		622 (95.70)
Race[a]		
American Indian or Alaska Native		9 (1.40)
Asian		47 (6.30)
Black or African American		6 (0.90)
Native Hawaiian or other Pacific Islander		4 (0.60)
White		575 (88.60)

[a] Respondents could check all that applied so column totals may not equal 100%.

quarters (71.60%) were U.S. residents. The average group size was just above three people (*M* = 3.13, *SD* = 3.42), and the two largest group types identified by respondents were family (54.10%) and friends (26.50%), while 11.70% traveled alone and 7.60% identified their groups as a combination of family and friends. The average number of nights spent in the park or surrounding areas was 3.23. The average number of total previous visits reported was 5.14 (*SD* = 47.05), and nearly eight out of ten (79.90%) were visiting for the first time. The most common recreation activities were hiking (65.55%), taking bus trips (63.00%), photography (73.00%), and viewing wildlife (69.40%). Other common activities reported by visitors were staying in lodges (27.00%), camping (42.20%), and listening to natural sounds (43.00%).

3.2. Local knowledge and social values of frontcountry and backcountry recreationists

Respondents in the pooled sample did not consider themselves to have extensive knowledge of Denali's physical resources (*M* = 2.73, *SD* = 0.70), cultural resources (*M* = 2.17, *SD* = 0.83) and management practices (*M* = 2.62, *SD* = 0.83) (see Table 4). The one exception was the item that measured knowledge of Wildlife (*M* = 3.37, *SD* = 0.81). Local knowledge reported by frontcountry and backcountry respondents was then compared, and results from an Independent-Samples *t*-test indicated there were significant differences. Backcountry respondents reported higher knowledge of both physical resources ($t(630) = 2.58$, $p = 0.010$) and management practices in Denali ($t(638) = 3.07$, $p = 0.002$) than did frontcountry users. We found no significant differences in the

Table 4
Knowledge of the pooled sample and two subgroups of survey respondents defined by frontcountry and backcountry use, including mean values, standard deviations (SD), reliability estimates (α) and results from Independent-Sample t-tests.

Knowledge[a]	Pooled sample	Frontcountry subgroup	Backcountry subgroup	
	Mean (SD)	Mean (SD)	Mean (SD)	t-stat (df)
Physical resources (α = .842)	**2.73 (0.70)**	**2.67 (0.70)**	**2.82 (0.69)**	**2.58* (630)**
Wildlife[b]	3.37 (0.82)	3.32 (0.79)	3.44 (0.83)	1.94 (569)
Plant life	2.66 (0.90)	2.63 (0.88)	2.71 (0.93)	1.16 (652)
Insects	2.23 (0.92)	2.18 (0.92)	2.31 (0.92)	1.82* (651)
Water	2.96 (0.96)	2.81 (0.94)	3.18 (0.94)	4.86* (650)
Geology	2.70 (0.95)	2.68 (0.95)	2.73 (0.96)	0.72 (650)
Alpine ecology	2.47 (1.03)	2.41 (1.01)	2.57 (1.06)	2.03* (649)
Cultural resources (α = .902)	**2.17 (0.82)**	**2.21 (0.81)**	**2.12 (0.84)**	**−1.44 (637)**
Archeological resources[b]	1.90 (0.90)	1.90 (0.93)	1.90 (0.88)	−0.10 (598)
Cultural landscapes	2.24 (0.96)	2.27 (0.94)	2.20 (0.99)	−2.28* (650)
Historic and prehistoric structures	2.13 (0.96)	2.20 (0.94)	2.03 (0.99)	−2.28* (650)
Museum objects	2.16 (1.00)	2.24 (1.10)	2.04 (0.99)	−2.49* (650)
Human history and prehistory	2.46 (1.03)	2.47 (1.03)	2.44 (1.04)	−0.36 (652)
Management practices and issues (α = .896)	**2.62 (0.88)**	**2.53 (0.86)**	**2.75 (0.90)**	**3.07* (638)**
Wildlife management	2.91 (0.99)	2.85 (0.97)	3.00 (1.02)	1.97* (651)
Vegetation management	2.44 (1.06)	2.30 (1.01)	2.64 (1.10)	4.09* (653)
Fire management	2.56 (1.12)	2.46 (1.10)	2.70 (1.16)	2.64* (654)
Air quality	2.43 (1.12)	2.38 (1.10)	2.49 (1.15)	1.16 (652)
Water quality issues	2.61 (1.14)	2.51 (1.12)	2.75 (1.15)	2.67* (649)
Visitor experiences	2.78 (1.07)	2.27 (1.00)	2.85 (0.69)	1.51 (652)

*p < 0.05.
[a] Measured on Likert scale where 1 = "No knowledge" to 5 = "Proficient knowledge."
[b] Equal variances not assumed.

reported knowledge of cultural resources between the frontcountry and backcountry subgroups (t(637) = 1.44, p = 0.149).

3.3. Point allocation of social values of ecosystem services

Our pooled sample of survey respondents allocated the greatest number of points to *Wilderness* (M = 17.16, SD = 17.46), *Aesthetic* (M = 15.77, SD = 15.62), *Ecological Integrity* (M = 12.38, SD = 12.55), and *Future* (M = 10.28, SD = 10.86) social values. According to results from an Independent-Samples *t*-test, there were significant differences in the social value scores for the frontcountry and backcountry subgroups. Significant differences in value allocations existed for five of the 13 social values (see Table 5). On average, backcountry respondents allocated significantly more points to *Recreation* (t(641) = 4.24, p < 0.01) and *Therapeutic* (t(522) = 5.05, p < 0.01) social values, while frontcountry respondents allocated more points to *Aesthetic* (t(632) = −3.76, p ≤ 0.01), *Future* (t(643) = −2.05, p < 0.05) and *Learning* (t(632) = −3.15, p < 0.05) social values (see Table 6).

Table 5
Social values reported by the pooled sample and two subgroups of frontcountry and backcountry recreationists, including mean values, standard deviations (SD), and results from independent sample t-tests.

Social value type	Pooled sample	Frontcountry subgroup	Backcountry subgroup	
	Mean (SD)	Mean (SD)	Mean (SD)	t-value (df)
Wilderness	17.16 (17.46)	17.54 (18.80)	16.63 (15.38)	−0.68 (630)
Aesthetic	15.77 (15.62)	17.56 (17.96)	13.26 (11.09)	−3.76** (632)
Ecological Integrity	12.38 (12.55)	12.42 (13.75)	12.32 (10.65)	−0.10 (638)
Future	10.28 (10.86)	10.98 (12.21)	9.30 (8.55)	−2.05* (643)
Recreation	7.95 (9.70)	6.60 (8.55)	9.84 (10.85)	4.24** (641)
Intrinsic	6.23 (9.80)	5.59 (10.01)	7.12 (9.45)	1.95 (643)
Scientific	6.91 (8.27)	6.69 (8.41)	7.22 (8.07)	0.79 (643)
Therapeutic	5.02 (7.01)	3.84 (6.46)	6.68 (7.41)	5.05** (522)
Learning	5.42 (6.95)	6.10 (8.00)	4.48 (4.99)	−3.15* (632)
Cultural	4.33 (6.34)	4.53 (6.78)	4.05 (5.79)	−0.94 (621)
Spiritual	3.04 (6.46)	2.72 (6.51)	3.49 (6.39)	1.48 (638)
Soundscape	3.06 (6.11)	2.79 (7.02)	3.42 (4.56)	1.29 (638)
Economic	2.57 (5.12)	2.81 (5.18)	2.24 (5.03)	−1.38 (584)

*p < 0.05.
**p < 0.01.

3.4. Spatial analysis of relationships between social values and landscape metrics

Results from a kernel density analysis of all 13 social values for the pooled sample showed a general concentration of value points around the park road and major landmarks (see Fig. 3). Spatial clustering–indicated in Fig. 3 as the dark purple areas–occurred around landmarks such as Mt. Denali, Polychrome Overlook, Eielson Visitor Center, and Denali Visitor Center. The intensity of social value assignments and the regions perceived to be important were variable. That is, the darkly colored hotspots on the peak of Mt. Denali and the Denali Visitor Center indicated higher levels of value intensity than those at Polychrome Overlook and the Eielson Visitor Center. Generally, value assignments did not deviate far from major landmarks within the protected area.

The relationships between social and biophysical data examined using SolVES and MaxEnt (Sherrouse et al., 2011, 2014) were considered for the three most highly rated social values including *Aesthetics* (Value Index score = 9.7), *Wilderness* (Value Index score = 6.9), and *Ecological Integrity* (Value Index score = 5.0). Good fitting models, as indicated by training AUC, were found for the *Aesthetics* social value type mapped by frontcountry (AUC = 0.962) and backcountry (AUC = 0.971) respondents, *Ecological Integrity* social values preferred by frontcountry (AUC = 0.973) and backcountry (AUC = 0.947) respondents, and *Wilderness* social values among frontcountry (AUC = 0.944) and backcountry respondents (AUC = 0.940). Our models had good predictive capacity according to their corresponding test AUC values (0.961, 0.961, 0.966, 0.962, 0.933, and 0.949; Swets, 1988). Additionally, results from the nearest neighbor statistics (R-values and Z-scores) indicated significant spatial clustering for the point distribution patterns of *Aesthetics, Wilderness, Ecological Integrity* values.

Table 6
Average nearest neighbor statistics for select social values among frontcountry and backcountry visitors to Denali National Park and Preserve.

Value Type	Pooled Sample		Frontcountry Subgroup		Backcountry Subgroup	
	Mapped points	R-value (z-score)	Mapped points	R-value (z-score)	Mapped points	R-value (z-score)
Aesthetic	685	0.26 (−37.06)	418	0.28 (−28.44)	267	0.23 (−24.13)
Ecological Integrity	170	0.30 (−17.52)	95	0.20 (−14.87)	75	0.33 (−11.04)
Wilderness	567	0.36 (−11.49)	324	0.35 (−22.31)	243	0.38 (−18.46)

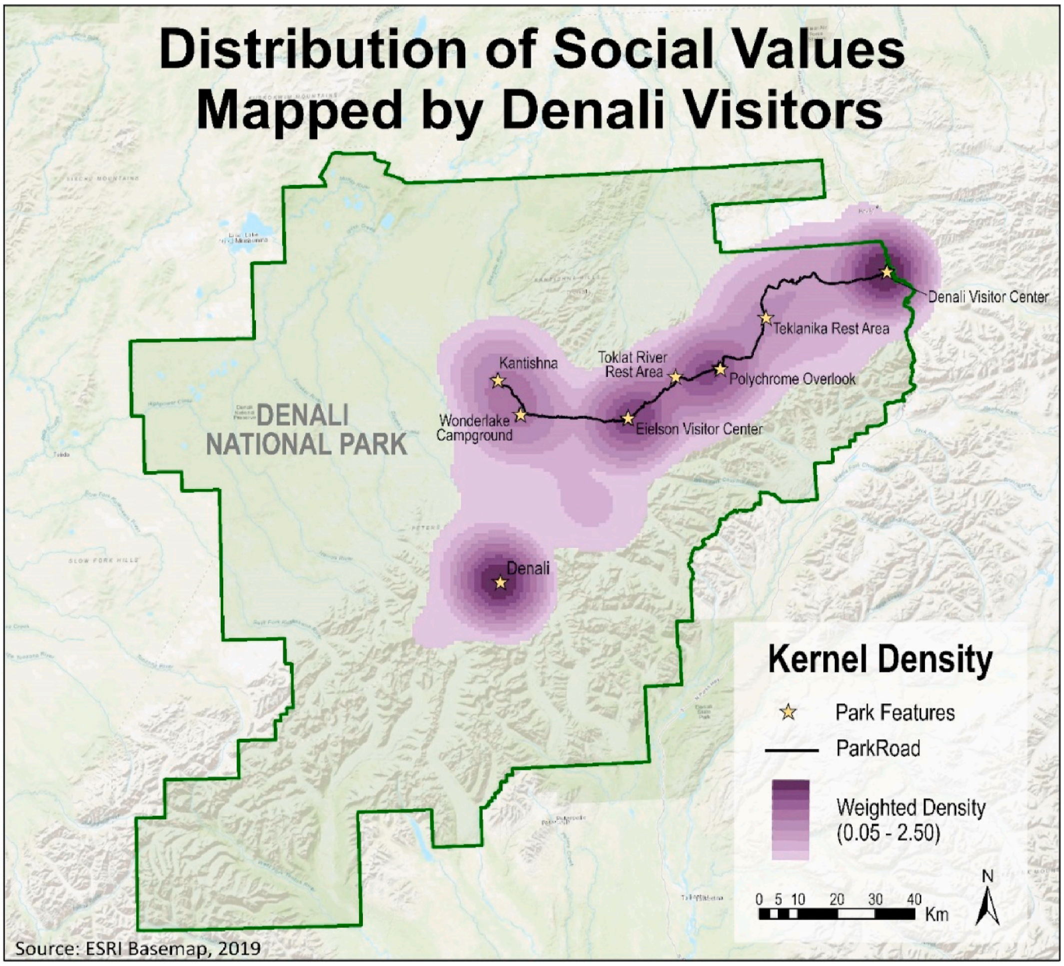

Fig. 3. Results from a kernel density analysis of all 13 social values.

The spatial patterns for all three social values modeled in relation to four landscape metrics varied both within and between subgroups. Results indicated that as distance to the road increased, the Values Index decreased (see Fig. 4). Positive correlations were found between the Value Index score and elevation, and this relationship was particularly pronounced for the *Aesthetics* social value type. The trends observed between the Value Index and slope were different between the two survey subgroups. As slope increased, the Value Index for frontcountry recreationists decreased across all three social values but increased for one of the social value types according to backcountry recreationists. In other words, landscapes with slopes that were not as steep were more likely to be valued for the purposes of *Ecological Integrity* according to backcountry but not frontcountry respondents. Results from our comparison between Value Index scores and landcover types showed consistency, in that dwarf shrubs with or without lichen (low or tall), White or Black Spruce with lichen, and bare ground from fire scares, ice, or snow were landcover types likely to be associated with all three social value categories. The one difference that emerged was that the dominant landcover of bare ground associated with *Wilderness* social values was greater for frontcountry than backcountry respondents.

4. Discussion

Parks and protected areas provide a diverse array of ecosystem services that are valued by the public and essential to human well-being. The value of these services can be quantified through mapping and aggregation at the group level to illustrate the perceived benefits of nature. Our results confirmed there were different subgroups that had a stake in management of Denali, including people who experienced frontcountry and backcountry environments (Basman et al., 1996; Manning et al., 1996). These individuals were distinguished by their reported levels of knowledge (D'Antonio et al., 2012) and expressed preferences for a range of social values that manifested in distinguishable use patterns (Brown et al., 2020; Brown & Kyttä, 2014). Our results extended previous research focused on the spatial dynamics of social-ecological conditions in protected areas (Engen et al., 2018; van Riper et al., 2017) and utility of participatory mapping as a process for informing management decisions in a spatially explicit manner (Alessa et al., 2008;

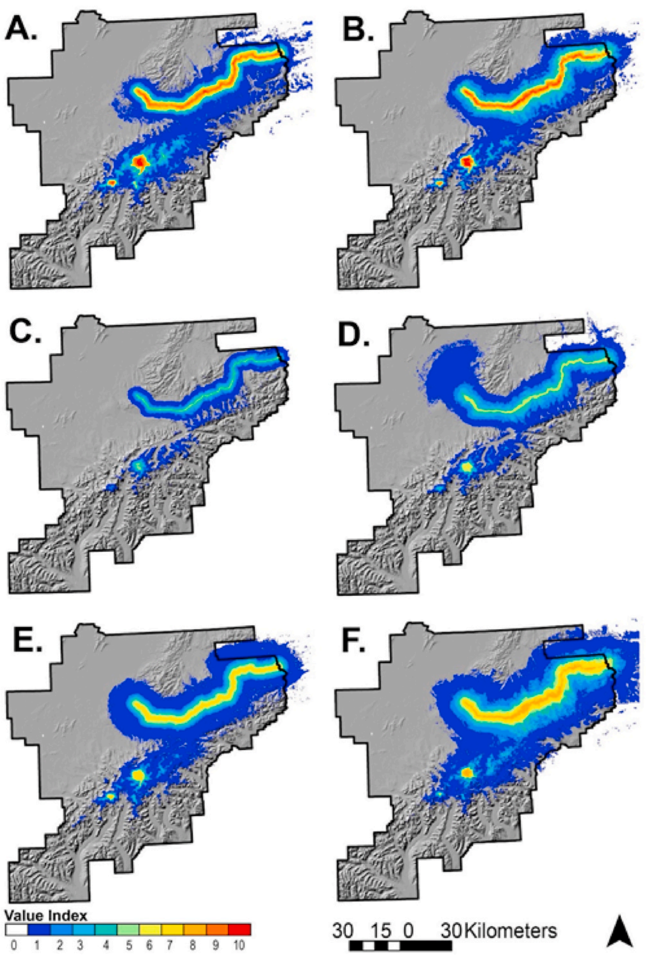

Fig. 4. Spatial distributions of *Aesthetics* assigned by frontcountry (A) and backcountry respondents (B), *Ecological Integrity* assigned by frontcountry (C) and backcountry respondents (D), and *Wilderness* values for frontcountry (E) and backcountry respondents (F).

Plieninger et al., 2013; Raymond et al., 2014; Sherrouse et al., 2011).

4.1. Knowledge of front and backcountry use

The multiple values of nature have been articulated by people with different levels and systems of knowledge. We adapted a multi-dimensional scale from D'Antonio et al. (2012) to examine the local knowledge of visitors to a protected area. Our results indicated that visitors to Denali who ventured into backcountry settings reported being more knowledgeable of physical resources and management practices than those classified as frontcountry recreationists. Given the diverse motivations and specialization of backcountry use (Bryan, 1977; Oh & Ditton, 2006; Rice et al., 2020; Virden, 1986), it could be that travel in these settings required greater skill and competencies in navigating the environment and protected area regulations. Knowledge of cultural resources was reported to be equal between the two subgroups, possibly owing to the accessibility of knowledge related to the recent history of all people, regardless of the expertise often associated with experiencing rugged landscapes.

Future research should consider the array of literatures that confront the topic of knowledge and work toward broad representation of different knowledge systems that can be taken into account during spatial planning and management (Fagerholm & Käyhkö, 2009; Hakkarainen et al., 2020). Our literature review unearthed distinguishable but interrelated streams of research focused on local knowledge derived from first-hand experience and observations (D'Antonio et al., 2012), Traditional Ecological Knowledge (Berkes, 2004), expert or scientific knowledge (Freeman et al., 2014), and the process of knowledge exchange (Díaz et al., 2015; Tengö et al., 2017). These bodies of work converged on the importance of bridging different knowledges that exist from local to global scales to advance sustainability initiatives (Reed et al., 2006). Therefore, we adapted an existing scale and evaluated its measurement properties using structural equation modeling techniques so that future research could be better positioned to empirically evaluate local knowledge of a protected area. Given the range of knowledge repertoires that exist, careful decisions need be made about how to conceptualize and measure knowledge in efforts to build on the extant literature.

4.2. Relative importance and spatial patterns of social values

This research identified the most important social values ascribed to the landscapes of Denali, while generating empirical insights on how ascribed values were spatially understood. The highest rated social values – *Wilderness, Aesthetics, Ecological Integrity,* and *Future* – were largely clustered along the road that provided access into and around key features of the protected area (i.e., stops along the park road bus tours), thereby reflecting the long-term influences of infrastructure and use patterns determined by management agencies (Fagerholm & Käyhkö, 2009). Given the existing impact of climate change on the park road infrastructure (e.g., permafrost thaw and landslides around the park road), the distribution of social values in Denali may change slowly over time (NPS, 2019). In line with previous research on high-risk recreation (Bowen et al., 2016), our results also indicated that backcountry respondents were likely to derive therapeutic benefits from their interactions with nature, as compared to frontcountry respondents who were more likely to benefit from scenery, opportunities for learning and protecting public lands for future generations.

4.3. Comparison of social and biophysical data in Denali National Park and Preserve

We generated spatial projections of areas within Denali that were likely to be valued by survey respondents according to relationships between social values and the underlying physical environment. We drew from kernel density estimations to identify places of value abundance (Alessa et al., 2008) and modeling results from SolVES (Sherrouse et al., 2011) to generate probabilistic spatial models that indicated which locations were associated with three social value types. These areas may signal points of social conflict given that many people see different types of values in the landscape or present opportunities for building stewardship in response to high levels of public concern (Brown & Raymond, 2014; Cebrián-Piqueras et al., 2017; van Riper et al., 2017). These findings can provide a basis for supporting better informed and more responsive resource management decisions.

Our results showed that frontcountry respondents had a strong affinity for being near the park road while backcountry respondents assigned social values to a broader expanse of space within the protected area. Because the only access to the center of Denali is the park road and visitors need special permits to venture into the backcountry, direct experience is instrumental in influencing where visitors ascribe social values (Johnson et al., 2019). In line with past research (Sherrouse et al., 2014), *Aesthetic* values were the most intensely assigned across both subgroups. These findings can be used by managers aiming to better represent and integrate public preferences in protected area management decisions. Adaptive management strategies focused on identifying and learning from the diversity of values people associate with nature-based destinations can also be informed by this research. Current approaches to management and policymaking for settings that garner public attention like the "crown jewel" protected areas in the US should carefully consider socio-cultural and economic data alongside information about the landscapes that people experience (Manning et al., 2016).

Our results showed a discernable relationship between the spatial distribution of social values and knowledge of survey respondents. Social values across both subgroups were intensely concentrated near key landscape features, particularly the park road and Mt. Denali. Because this protected area is known for having the highest peak in North America and this is a focus of interpretation by management agencies, it could be that Mt. Denali symbolized the perceived importance of the region regardless of whether this physical feature was experienced first-hand. Further, the Value Index scores (i.e., the spatially explicit non-monetary metric of value intensity) were higher in the backcountry subgroup across all three social values. Given that backcountry respondents had significantly more knowledge of physical resources and management practices, it follows that a physical landscape feature demarcated on a map would be most likely to embody social-ecological values. Our findings build on past research that has postulated a relationship between knowledge of a study area and the number and type of social values of ecosystem services mapped by respondents (Brown et al., 2020). This empirical evidence of the differences in how front-country and backcountry respondents value landscapes can be employed by public land managers who make decisions about different regulations that protect natural resources across spatial scales while maintaining the degree of value that different user groups associated with public lands (Marks, 1988).

The process of systematically engaging stakeholders in participatory exercises to learn about the multiple competing values of protected landscapes is more inclusive than traditional 'top-down' management strategies. Although expert derived knowledge is useful, it is important to marry these insights with those from lay audiences who are influenced by policy change, including local community members and people visiting protected areas. The PPGIS method employed in this research can generate spatially-explicit knowledge alongside in-depth observations about how best to govern public land management contexts. In this sense, social values of ecosystem services examined using participatory mapping techniques can build on both instrumental and deliberative paradigms (Raymond et al., 2014) in the quest to guide agency decisions. This research approach provides insight on visitor experiences in the outdoors as well as areas of management interest where there may be facility needs and geographic locations at risk of degradation (Brown & Weber, 2011; van Riper & Kyle, 2014).

4.4. Limitations and future research directions

There were multiple lessons learned from this study that can be used to guide future research focused on the perceived social values and existing biophysical conditions of protected areas. One important consideration is related to the process by which respondents were divided into subgroups to account for preference heterogeneity. Using survey site as an indicator of use is one approach that leverages existing information to classify respondents. In the context of this study, the place where visitors were surveyed was presumed to correspond to the environment experienced. In addition to considering the survey site, we also used data from a question about activity engagement. Our research approach was discussed with Denali park managers; however, it carried assumptions about what constituted particular experiences for visitors. It could be that respondents classified as frontcountry recreationists felt that their experience in Denali National Park was rugged enough to qualify as a backcountry experience. If there is space and capacity in a survey process, asking respondents to self-identify with a particular user group would have a greater likelihood of reflecting personal viewpoints. The tension between objective classifications and subjective assessments of park experiences should continue to be contemplated in the future.

In protected areas, there are often barriers to data collection from dispersed entry that require judgment and close communication with management agencies to capture representative samples of visitors (Monz et al., 2019). Frontcountry recreationists in Denali, for example, did not filter through one entrance station, and the availability of financial resources limited fieldwork to one season and data collection to one set of locations across a 6,000,000-acre protected area. Consequently, our dataset did not equally encompass all users, particularly people accessing remote locations via bush plane outside of the park, mountaineering expeditions that accessed the southern portion the park, visitation to remote wilderness lodges, and Alaska Natives (Taff et al., 2017). Along similar lines, cruise ship passengers were represented in our sample, though not specifically targeted. According to Fix, Ackerman, and Fay (2013), 51% of visitors to Denali reported sightseeing and wildlife viewing on a bus, and many of these individuals came to the park by way of a cruise, which did not align with the 11% of respondents in our sample who reported visiting as part of a cruise. Additionally, our sample did not include visitors during the off-use or shoulder seasons. Decision-makers in Denali and other protected areas that cater to a diversity of stakeholders would benefit from future research focused on engagement across broader spatial and temporal scales.

We observed that public participatory GIS was a useful tool for understanding how places within Denali were valued as well as democratizing the planning process. Our PPGIS process provided a platform for stakeholders to voice their opinions across a range of topics. Results generated using this technique can be incorporated into interpretive programs that facilitate discussions about the range of social values embodied by protected areas. Moreover, maps in PPGIS exercises function as boundary objects for both public (e.g., local municipalities) and private (e.g., concessionaire) entities to deliberate on where and how social values are accruing across landscapes as well as changing in distribution over space and time (Maczka, Chmielewski, Matczak, Jeran, & van Riper, 2019). This research approach can also enable protected area managers to track how values may differ in key locations for relevant and effective adaptive management. This could be especially relevant for managers of Alaskan protected areas who are responsible for more deeply understanding the values of Alaska Natives and other traditional users that engage in subsistence activities. Additionally, generating spatial data that link social and biophysical conditions bolsters important park interpretation programs in conservation, and in turn, facilitates co-production of knowledge practices in public lands outreach and planning.

5. Conclusions

Public land management agencies that oversee protected areas often work across spatial scales and require information from multiple stakeholder groups that hold diverse forms of knowledge and experiences with the environment. This study generates spatially explicit insights on the social and biophysical conditions valued by people who visit Denali National Park and Preserve and experience frontcountry and backcountry settings. We identify the primary reasons why a U.S. protected area is considered important and demonstrate that survey respondents defined by activity engagement express distinguishable social valuations. These subgroups differ in their local knowledge that spans the topics of physical resources and management practices but report similar understanding of cultural resources. Findings also indicate convergence on the landscape features deemed important and variation in the intensity and spatial extent of social values ascribed to landscape conditions. Our results provide guidance for agencies focused on sustaining nature-based settings and more effectively engaging diverse audiences in discussions about how to prioritize resource management strategies across spatial scales in ways that align with public interest.

CRediT authorship contribution statement

Carena J. van Riper: Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing, Funding acquisition. **Lorraine Foelske:** Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Saachi D. Kuwayama:**

Conceptualization, Formal analysis, Writing - original draft. **Rose Keller:** Writing - review & editing, Data curation. **Dana Johnson:** Writing - review & editing, Visualization.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.apgeog.2020.102279.

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