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Elucidating social-ecological perceptions of a protected area system in Interior Alaska: a fuzzy cognitive mapping approach

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ABSTRACT. The Interior of Alaska is one of the few remaining places in the world with intact ecosystems. Protected areas in this region, particularly Denali National Park and Preserve and Denali State Park, are high-profile tourism destinations situated in a rural landscape that is inhabited by a diverse array of stakeholders. Public land management agencies are faced with the challenging task of engaging these rural residents in discussions about their relationships with a rapidly changing landscape to understand change and growth. This study evaluated residents' perceptions of social and ecological dynamics of protected areas in Interior Alaska using data from fuzzy cognitive mapping exercises that were part of focus groups and interviews across six local communities. Guided by an exploratory resilience framework, we established a baseline understanding of features that characterized social and ecological conditions at a regional scale. Results showed how residents valued a variety of socio-cultural, socioeconomic, and ecological features of the landscape. The region was predominantly characterized by tourism, sense of community, subsistence, and wilderness. Climate change and large-scale development were the primary drivers of change. Our findings also showed that although the characterization of the region was shared in many ways, there were nuanced differences articulated by residents in each community that warrant attention. These findings provide a structured platform for building resilience and interpreting variability in visions for the future.

Key Words: *community engagement; mental models; protected areas; resilience; social-ecological systems*

INTRODUCTION

Protected areas in the United States (US) are increasingly viewed as complex and interdependent social-ecological systems (SES) that require balancing the priorities of different stakeholder groups alongside ecologically focused management objectives (Folke et al. 2002, Wei et al. 2019, Berkes 2021). As a result, agencies have moved beyond a traditional paradigm of “nature for itself” toward one of “people and nature” founded on resilience, interdisciplinarity, and stakeholder engagement (Mace 2014). In parallel with these advancements, previous research and popular discourse have called for strategies that achieve more equitable and representative policy solutions (Agrawal 2001, Gray et al. 2015, Bennett et al. 2017) because enhanced effectiveness of stakeholder engagement leads to the development of trust (Ruiz-Mallén and Corbera 2013, Rist et al. 2016) and support for resiliency planning (Walker et al. 2002, del Mar Delgado-Serrano et al. 2015, 2018, Cumming and Allen 2017). Adaptive management that leverages collaboration can help in dealing with uncertainties from rapidly changing climates, particularly in subarctic regions of the world where impacts are magnified (Schultz et al. 2007, 2015). Because these environments are particularly vulnerable to climate change (Díaz et al. 2019), it is important to work with stakeholders attuned to local conditions to facilitate the identification, documentation, and transformation of systems into more sustainable futures (Xiang 2013, Knapp et al. 2014).

Guided by an exploratory resiliency framework (Cumming et al. 2005), we characterized residents' perceptions of the socio-cultural, socioeconomic, and ecological features of the Denali Region, particularly Denali National Park and Preserve and Denali State Park, in Alaska, US. Unlike previous studies that have analyzed mental models across stakeholder groups, we used a participatory method known as fuzzy cognitive mapping (Gray et al. 2015) to illustrate regional and community-level perspectives

of Interior Alaska as an SES. We also shifted focus to communities living adjacent to protected areas in the US, as opposed to previous research that has examined perceptions of park visitors (D'Antonio et al. 2013, van Riper et al. 2019) and protected area communities in non-US contexts (Palomo et al. 2014, Cebrián-Piqueras et al. 2020). Our approach recognizes that local communities are heterogeneous by unraveling the particularities of their relationship with the protected area. That is, we engaged local communities to support more inclusive conservation surrounding protected areas (Tallis and Lubchenco 2014), as well as to increase the likelihood that communities would be better positioned to make changes throughout and subsequent to our research endeavors (Stewart et al. 2004). We were guided by three objectives: (1) to characterize the socio-cultural, socioeconomic, and ecological features of a protected area landscape at a regional scale, (2) to compare how features are characterized at the community level, and (3) to understand how key drivers of change influence social-ecological conditions at a regional scale.

Community engagement in protected area research

Collaborative research with stakeholders in the context of protected areas has rapidly expanded over the past 40 years (Freeman 1984, Stringer et al. 2006, Manning 2011). This body of work has emphasized the importance of relying on long-term strategies for achieving conservation goals. Findings have also underscored the need to engage people early on in the decision-making process (Reed 2008, Plieninger et al. 2013, Raymond and Cleary 2013, de Vente et al. 2016) because local community members are more likely to support conservation policies that are co-created with decision makers (Agrawal 2001, Berkes 2004). This body of work has largely drawn from in-depth discussions about place-based challenges, recognizing that communities surrounding protected areas are complex and should not be managed using a “one-size-fits-all” approach (Hewlett and Edwards 2013, Sterling et al. 2017).

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For public land management agencies to better understand the priorities of residents, collecting and incorporating information about local knowledge is paramount (Ruiz-Mallen and Corbera 2013, Rist et al. 2016). Previous research has indicated that doing so can minimize social conflict (Mbaiwa and Stronza 2011), democratize science (Martin and Sherington 1997), and promote ecological and social well-being (Dougill et al. 2006). However, there may be a narrow understanding of that which constitutes knowledge beyond the scientific evidence that currently informs park priorities and decisions (Dowie 2009, Palomo et al. 2014). Identifying ways to represent resident understandings of the social and ecological dynamics that govern protected area systems is therefore crucial for developing meaningful dialogue between residents and public land management agencies.

Resilience and social-ecological system identity

Social-ecological resilience is generally regarded as a system's ability to withstand external pressures while maintaining its function and identity over time (Holling et al. 1973, Folke et al. 2002, Walker et al. 2002). Previous research has focused on understanding a system's structure and the role of dynamic relationships for determining resilience to external pressures, particularly those that can cause alternative regime shifts (Walker et al. 2004). Although resilience has been regarded as important for systems thinking to support management of SES, this phenomenon can be difficult to define and operationalize (Janssen et al. 2006, Quinlan et al. 2016). To further conceptualize social-ecological resilience, Cumming et al. (2005) developed a framework that defined resilience as the ability of a system to maintain "system identity." These authors argued that SES could be organized into components (or features) that represented the identity of a complex system. Although specific features and their relationships vary over spatial and temporal scales, the essential social and ecological attributes that define a system are preconditions for maintaining resilience. This framework has provided conceptual guidance for previous research, but empirical applications are less common, especially in the context of protected areas (Cumming and Allen 2017). Because the resilience concept is underpinned by normative assumptions about desired outcomes (e.g., resilience for whom?; Cote and Nightingale 2013), it is critical to understand how groups typically left out of protected area decision-making processes characterize the system's identity as a foundation for more inclusive resilience planning. Thus, our research aims to understand how communities, often directly affected by protected area decision outcomes, understand their home system.

Fuzzy cognitive mapping as a tool for resiliency planning

Fuzzy cognitive mapping is a methodology for measuring community perceptions of SES (Axelrod 1976, Kosko 1986, Kok 2009). This method has been used to understand the mental models of stakeholders and improve public involvement in environmental decision making about agricultural systems (Bahri et al. 2020), fisheries (Gray et al. 2012), lakes (Hobbs et al. 2002, Özemesi and Özemesi 2003), coastal zones (Kontogianni et al. 2012), and wildlife management areas (Gray et al. 2015). The fuzzy cognitive mapping approach has proven useful for modeling how people perceive the features and interactions of SES, particularly ones that are shrouded in complex dynamics and uncertainty (Gray et al. 2012). This approach is an active method

of elicitation that requires participants to initiate their own accounting of social-ecological dynamics to reveal local, place-based knowledge (Özemesi and Özemesi 2003, Satama and Iglesias 2020). Results of fuzzy cognitive mapping research have informed resource management decisions of how stakeholders understand the particularities of places (Vasslides and Jensen 2016). This line of research has also revealed potential points for policy discussion across stakeholders that subscribe to different beliefs systems (Christen et al. 2015). Further, this methodology can maintain sensitivity to diverse understandings of nature and competing interests of different stakeholders when managing places like protected areas (Peterson et al. 2006, Oldekop et al. 2016).

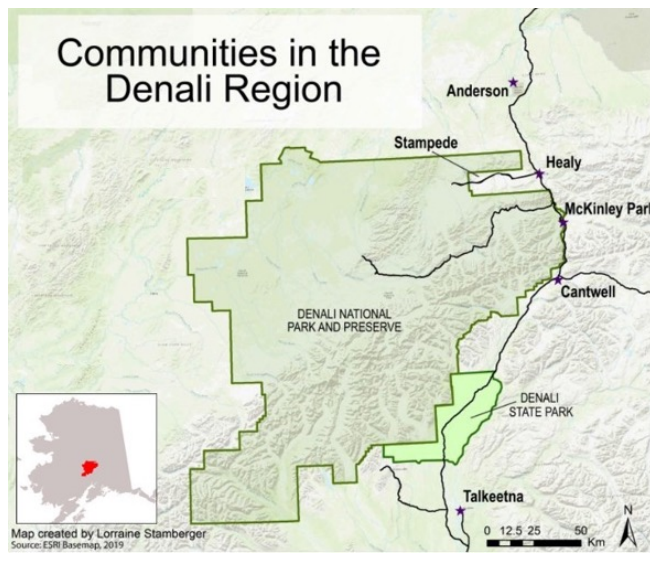
Data for fuzzy cognitive maps are generated through interviews or focus groups in which stakeholders identify and articulate the relationships among important features of an SES. The mapping exercise can be conducted on an individual basis (Kontogianni et al. 2012) or in groups whereby participants collectively converge on a shared representation of local places (Gray et al. 2015). Past research has also used fuzzy cognitive mapping to highlight the similarities and differences in belief systems across various stakeholder groups such as governmental agencies, local community members, and educational representatives (Gray et al. 2012, Vasslides and Jensen 2016, van Velden et al. 2020) by estimating the degrees of influence among key features within a complex system. Thus, results from this exercise are uniquely positioned to represent knowledge across individual and group scales in both qualitative and quantitative forms. The robust evidence generated using this technique can be brought to bear in discussions about policy outcomes that anticipate future states of an SES and strategies for engaging stakeholders in collaborative management of public resources.

METHODS

Study context

This research was conducted in the Denali Region of Interior Alaska, which we define as the six communities adjacent to Denali National Park and Preserve and Denali State Park (Fig. 1). Established in 1917, the national park includes 2,428,113 hectares located in Interior Alaska and home to the highest peak in North America, Mt. Denali (6190 m). Each year, Denali National Park attracts around 600,000 visitors (601,153 in 2019; National Park Service 2019). Denali State Park, established in 1970, is a tourist destination adjacent to the southeast corner of Denali National Park and Preserve and spans 131,620 hectares (ADNR 2020). During peak tourism season (June–August), the population of communities directly adjacent to Denali National Park and Preserve nearly doubles from the influx of seasonal employees working in the tourism industry. Tourism in Denali protected areas is fundamentally important for supporting the local economy, in part due to employment of over 100 residents year-round and many local businesses. Residents are directly affected by decisions being made about public lands, particularly through subsistence use, defined as the customary and traditional uses of wild resources for food, shelter, clothing, and other purposes that are permissible in the preserve areas of Denali established in 1980 as part of the Alaska National Interest Land Conservation Act (ANILCA). This piece of legislation tripled the park in size and created opportunity to hunt, fish, and gather within its boundaries (ADFG 2020).

Fig. 1. Study area



The six communities in our study area are situated along one of the only major highways that runs through Interior Alaska, the George Parks Highway. To the east of the national park is the Denali Borough that includes five of the communities included in the study. The borough spans 3,107,985 hectares and is home to about 1900 year-round residents. Although these communities are in close geographic proximity, each encompasses unique qualities that, in part, align with the three primary sectors of the regional economy, i.e., tourism, military, and energy extraction, and ways of life (e.g., subsistence use, recreation; Agnew::Beck 2018). Anderson is the furthest north of the borough communities, running perpendicular to CLEAR Air Force Station and is home to about 200 residents. South of Anderson is Healy, which is home to the Usibelli coal mine and Golden Valley Electric Association, major employers in the Denali Region. This community houses nearly half of the borough residents year-round and many seasonal park employees, doubling the borough's population in the peak tourism months. McKinley Village includes about 200 year-round residents and is home to many park employees. The Native Village of Cantwell spans the southern portion of the Denali Borough and was originally a settlement of Athabascan Natives and has since expanded to include non-native residents. Residents of Cantwell have special access to hunting in preserve areas of Denali National Park and Preserve that residents of other communities do not. The Stampede, although technically part of Healy, is characterized as a community situated along Stampede Road, which originates along the George Parks Highway on the northern side of the park and is comprised of recreationists, park employees, hunters, and dog mushers. Talkeetna is the sixth community that is part of our study. This community is located approximately 252 km south of Denali National Park and Preserve, though directly adjacent to Denali State Park, and is a driver of aviation tourism for both the national and state parks. Talkeetna is part of the Matanuska-Susitna Borough and is

located in close proximity to Denali State Park, which generates a significant amount of tourism. The local economy in Talkeetna relies on industrial tourism (i.e., the cruise ship industry), which generates an influx of visitors traveling to the state or national park, as well as hosting a National Park Service field station that serves as the launching point for most climbing expeditions on Mt. Denali. The collection of communities included in this study were selected in consultation with our partners at the National Park Service.

The National Park Service and Bureau of Land Management primarily govern Denali National Park and Preserve, whereas the State of Alaska's Department of Natural Resources is the primary managing body of Denali State Park. Although these entities operate under their own sets of goals, objectives, and management strategies, they often work in cooperation given the shared protected area border. Each of these entities recognizes that partnerships are critical for understanding climate-change impacts in Alaska, raising awareness of the effects of climate change, and evaluating the effectiveness and trade-offs of management strategies outside of protected area boundaries. Past studies have shown that residents of the Denali Region hold novel and insightful observations of landscape change useful for resilience planning, yet they feel that their observations are not represented in planning processes (Knapp et al. 2014). Given the complicated protected area governance landscape that traverses multiple federal, state, and local entities across formal and informal institutions governing resource management in Alaska (McNeeley 2012), protected area management entities are left with questions about how to best partner with residents in adjacent communities (Andrade et al. 2020).

Data collection

Data for this research were collected from 2019-2020 to understand perceptions of the current state of social-ecological conditions and vectors of change in the Denali Region. The design of our fuzzy cognitive mapping exercise was informed by qualitative interviews with experts in the Denali Region. That is, an initial typology of features was developed from a qualitative analysis of semi-structured and informal interviews conducted from 2018-2019 across key stakeholder groups ($n = 6$), which were audio recorded, transcribed verbatim, and thematically analyzed. These interview data were coded to align with modified social-ecological dimensions that were part of Cumming et al.'s (2005) resiliency framework. This process resulted in a list of 27 "features" that characterized the socioeconomic, socio-cultural, and ecological aspects of the Denali Region in both positive and negative ways (e.g., sense of community, seasonality, local business), and potential "drivers of change" (e.g., climate change, energy extraction). The purpose of developing this initial typology was to provide a launching point for brainstorming across a variety of participants who might have varying degrees of technical knowledge. Our aim was, in part, to provide examples of features that may characterize the region and determine how this expert-derived typology resonated with diverse residents in the Denali Region.

Building on past research that has used multiple methods to increase participation in the research process, we collected data through six focus groups (one focus group per study community;

Gray et al. 2015, Devisscher et al. 2016) and 14 interviews (Özesmi and Özesmi 2004, Gray et al. 2012) that included fuzzy cognitive mapping exercises. In particular, our design included both interviews and focus groups to maximize opportunities for residents to participate given constraints with recruitment resulting from a small population, remote location, and limited access to the study site. Our operative question was “how do local community members characterize Denali as a social-ecological system?” Building on an earlier phase of the study that involved semi-structured interviews for building trust and knowledge of key stakeholder groups (citation withheld for blind peer-review), we adopted a snowball sampling approach to identify new participants by asking for names of residents who would think differently about environmental management issues than the person being interviewed (Denzin and Lincoln 2005). The goal of using this technique was to obtain a sample of residents in the Denali Region that represented a variety of interests and perspectives. Focus group participants learned about our study through online advertisements that were shared by local leaders who indicated we were recruiting residents of the Denali Region with a preference for long-time residents because it is those residents who would likely have an established sense of how the region is characterized and has changed over time. That said, the composition of focus groups was mixed between long-time residents and newcomers to the region because we distributed an open invitation and recruited residents on a voluntary basis. Focus group participants also opted into the study and were vetted to ensure residency within the key communities. We adopted procedures outlined by Morgan and Krueger (1998) to initiate the flow of ideas through an appreciative dialogue about conditions in the Denali Region. This was followed by a discussion of social-ecological features of the landscape whereby participants were asked to reflect on the typology of 27 features that were listed in an activity sheet provided to each participant. We explained to participants how the typology was developed and then asked which features resonated the most, which should be removed from the list, and which were missing. This process lasted approximately 15 minutes and was aimed at reducing potential bias introduced by providing participants with a typology of features.

Participants were provided with step-by-step instructions for the fuzzy cognitive mapping exercise on page two of their activity sheet, as well as shown an example map. Participants worked independently and recorded significant features of the region on sticky notes that were placed on a blank 42.01 x 59.41 cm (A2) sheet of cardstock paper. All features on the sticky notes were structurally linked using directed arrows that indicated influence and either positive or negative relationships, noted by use of black or red pen, respectively. Finally, participants qualified the degree of influence among connections by thickening the arrows on the map, indicating a continuum in strengths of relationships from very weak to very strong. Selected individuals were asked to share their maps after the exercise was completed and a group reflection on Denali's social-ecological system ensued. The focus groups concluded with the research team asking whether anything was missing from the discussion. A team of at least two researchers was present during all focus groups. The discussions were tape

recorded and transcribed verbatim to generate qualitative data that complemented the information derived from the final fuzzy cognitive maps. The duration of each focus group ranged from 1-2 hours and interviews lasted from 45 minutes to 1.5 hours. All research procedures described here were approved by the University of Illinois' Institutional Review Board.

Data analysis

All participant maps were digitized using MentalModeler software developed for fuzzy cognitive mapping analysis (Gray et al. 2013). All maps were pooled into one regional sample regardless of the mode of data collection given the focus of this research on individuals' mental models and the identical methods employed across both interviews and focus groups. Data were converted into adjacency matrices in which the column and row labels represented the features, and the value within a given cell represented the weighted directed relationship between two concepts. A list of all features was compiled and redundant features (e.g., plural forms of a word, different names for the same concepts) were merged. Following past research (Kim and Lee 1998), when two features represented opposite directions of the same concept, the more prevalent feature was retained and the other was renamed, with the direction of influence reversed. The interaction strengths between features were then scored, with high interactions scored as (+/-) 0.75, medium as (+/-) 0.5, and low as (+/-) 0.25 (Harary et al. 1965). We also aggregated features based on their social meanings and frequencies of use (Özesmi and Özesmi 2004, Gray et al. 2012). For example, “subsistence,” “subsistence activities,” and “subsistence use” were all collapsed into the category “subsistence.”

An Excel-based program, FCMapper (Bachhofer and Wildenberg 2011), was used to calculate all map metrics. Based on similarity and clustering criteria (Harary et al. 1965, Kosko 1986), this software used mathematical pairwise comparisons that included categorical (i.e., low, medium, high) or continuous (i.e., -1-1) indicators of the strength of weighted edges. The strength of weighted edges revealed the relative significance of features and their relationships in the system (Kok 2009). Maps were aggregated into six community matrices and one regional matrix that included all participants and six community matrices that represented each of the six communities. Each feature was categorized as transmitter, receiver, or ordinary (Bougon et al. 1977, Eden et al. 1992). The categorization emerged based on the value of each feature's centrality, which determined the importance of each feature in a matrix. A value for each feature's outdegree centrality (i.e., its cumulative effects on other features) and indegree centrality (i.e., cumulative dependence from other features) was calculated. Drivers of change were features with the highest outdegree, relative to indegree centrality given the potential for these features to influence future sustainable states. Transmitter features (i.e., features with only outdegree centrality) influenced other features in the system, receiver features (i.e., features with only indegree centrality) were influenced by other features, and ordinary features included a combination of transmitter and receiver features. Density was determined by the ratio of receiver features to transmitter features and described the overall

connectedness of a map based on the absolute versus potential number of connections among features (Hage and Hararay 1983). Finally, qualitative quotes from the interviews and focus groups were analyzed and interpreted alongside the mapped data to deepen our understanding of structural patterns.

RESULTS

Fuzzy cognitive maps were collected from residents across six communities as part of focus groups ($n = 37$) and semi-structured interviews ($n = 14$). The average number of participants in each focus group was between 8 and 9 ($SD = 7.03$) and the average age across all participants was 52 years ($SD = 16.36$; Table 1). Maps that were incomplete or not compliant with instructions were removed, resulting in 38 maps that included 444 connections across 60 unique features. These features spanned 29 socio-cultural, 24 socioeconomic, and 7 ecological features in addition to 2 drivers of change (Fig. 2). All individual maps were combined into one map of the pooled sample that reflected the mental models of all participants. Six community maps were generated in addition to the pooled map to represent mental models of each of our six study communities.

Table 1. Number of participants by community in the Denali Region and graph indices.

Participants and graph indices	Total
Average age of participant, M (SD)	51.77 (16.36)
Anderson participants	2
Cantwell participants	6
Healy participants	5
McKinley Village participants	11
Stampede participants	7
Talkeetna participants	7
Number of features	61
Number of transmitters	7
Number of receivers	0
Number of ordinary variables	54
Number of connections	444
Density	0.07

The features with the highest centrality scores that were most important for characterizing the region were: tourism, wilderness, sense of community, and subsistence (Table 2). Tourism was the most central feature in the regional map and was considered an ordinary feature with equal indegree and outdegree centrality scores, indicating it could be interpreted as driving or receiving influence from other features in the system. According to most participants, climate change and large-scale development were designated drivers of change given their stronger outdegree rather than indegree influences. These drivers of change were perceived as having positive feedback loops in that increases in one driver resulted in increases of others. Sense of community, subsistence, and wilderness also emerged as highly central features that were affected by other features to a greater degree than they affected features of a system (Table 3). Although there were many shared perspectives across communities, unique patterns did occur (Table 4).

Table 2. The importance of each feature in the aggregated regional map indicated by indegree, outdegree, and overall centrality scores.

Features	Outdegree centrality	Indegree centrality	Overall centrality
Tourism	10.13	10.24	20.37
Sense of community	6.43	10.46	16.89
Subsistence	6.15	10.37	16.52
Wilderness	8.43	7.84	16.27
Recreation	5.69	10.29	15.97
Climate change	9.63	5.42	15.05
Wildlife	5.63	8.55	14.17
Healthy ecosystems	3.10	9.82	12.92
Local business	4.24	6.64	10.88
Rural lifestyle	4.08	6.28	10.36
Large-scale development	7.75	2.25	10.00

Socio-cultural features

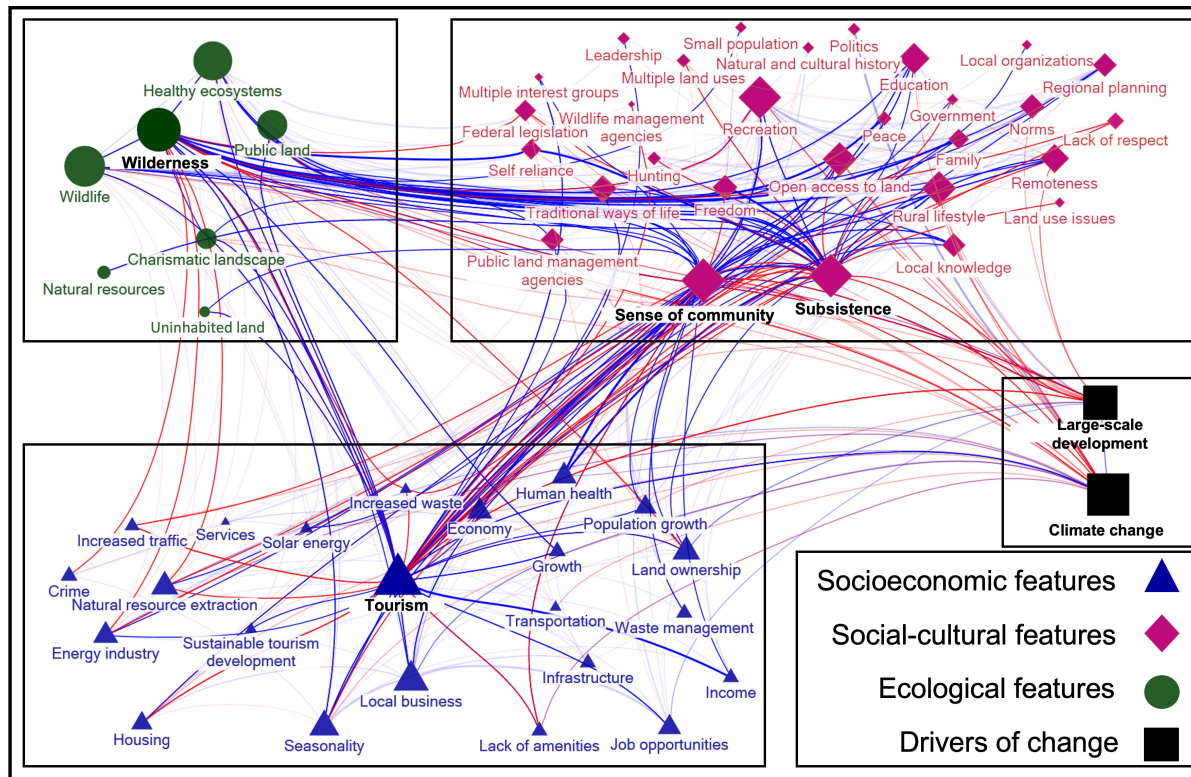
The Denali Region was predominantly characterized by socio-cultural features ($n = 29$). Sense of community and subsistence had the highest centrality scores, and thus, were considered most important. Sense of community included structural patterns of external pressures, many of which included positive connections. Results showed that although this feature may be vulnerable to change, many relationships within the system cultivated a stronger sense of community as evidenced by positive indegree connections. To illustrate the relevance of sense of community for the region's identity, one focus group participant explained:

There's an extremely diverse group of people in this room, we all sat down, had an amazing conversation. Nobody pounded fists, nobody freaked out. A lot of different opinions and views get put out at these meetings, and it is one thing that I truly, cherish about this [community], that we can come together and have these issues and, we got lots of them. As the more you guys sit down with us, you'll hear more and more things that come up in a small community. It's just part of being in a small community, but I love that we can come in, sit down, and work through some of these issues [Cantwell resident].

The experience of living within a given community, although less tangible, was integral to social-ecological resilience of the Denali Region and was acknowledged as an opportunity that could be leveraged for developing shared visions for the future.

Although sense of community was a feature identified by residents living in all six communities, it was most central for residents of Healy and McKinley Village, both of which have the large year-round populations, cohesive groups of residents with many shared interests, and are in close proximity to Denali National Park and Preserve. Both communities characterized sense of community in ways that reflected the pooled regional map, indicating that these residents perceived this feature as positively influenced by several external pressures that showed how the unique experiences and features of the Denali Region cultivated a strong sense of community. This feature was also important among Talkeetna

Fig. 2. Results from 38 aggregated fuzzy cognitive maps produced by residents from the Denali Region, Alaska. The mapped features span socioeconomic, socio-cultural, and ecological dimensions of resilience theory, as well as key drivers of change. The lines connecting all features show negative relationships in red and positive relationships in blue. The size of the nodes illustrate the relative importance of each feature in characterizing the region. The four features considered most central to the system (i.e., tourism, wilderness, subsistence, and sense of community) are in bold. The vertices connecting to central features or drivers of change are highlighted. All other connections are faded.



residents, but with fewer distinguishable patterns in relation to other features.

Subsistence was instrumental in how participants characterized places in the Denali region. Some residents believed that subsistence practices supported their system of community, self-reliance, and the rural lifestyles that drew many people to the area. However, our results showed that this feature was vulnerable to change because it was negatively influenced by 11 other features such as federal legislation, climate change, and tourism. We also observed that subsistence was instrumental in supporting recreation and socialization in rural Alaska. For example, one focus group participant indicated that subsistence was:

...about the food. It always has been, and it always will be. Same with the fishing. It's not about the group and grand, and the photos, and all that. To my family and to the vast majority of people in this borough, it's about the food [Cantwell resident].

Subsistence also carried deeper cultural meanings that were part of a traditional way of living, as articulated by a Native Alaskan participant who explained:

that's what I do to hunt because that is tied to my culture [Cantwell resident].

At the community level, although subsistence was particularly central across three communities (i.e., the Stampede, Talkeetna, and Anderson), this feature was not considered the most central in any one community. Interestingly, although subsistence was among the top four most central features across the three aforementioned communities, it was not particularly central among Cantwell residents' characterization of the Denali landscape. Given that the Stampede, Talkeetna, and Anderson are not primarily comprised of Native Alaskans, whereas the Native Village of Cantwell is, our results highlight the multiple meanings of subsistence across native and non-native residents and the complications around its role in characterizing the Denali Region.

Climate change and large-scale development emerged as drivers of change that could influence socio-cultural features of the Denali Region. More specifically, climate change directly and negatively influenced 6 of the 28 (21.42%) socio-cultural features. As climate change increases over time, residents indicated that local knowledge, open access to land, recreation, rural lifestyle, self-reliance, and sense of community decrease. These results indicate that climate change was primarily harmful to the essence of a rural lifestyle. Additionally, results showed that as the effects of climate change increase, residents' knowledge of local conditions may be rendered less useful. Similarly, large-scale

Table 3. Example quotations that illustrate the four most central features within the Denali region. Quotes were drawn from qualitative data that were generated during focus groups and used to deepen interpretation of individual mapping data.

Dimension and feature	Example quotation
Socio-cultural	
Sense of community	<i>That we can come together and have these issues and, we got lots of them...It's just part of being in a small community, but I love that we can come in, sit down, and work through some of these issues. [Cantwell resident]</i> <i>It's the people..that..drive me to areas you know not so much anymore but...you used to be able to drive around here and everybody you met would wave at ya you know? its still that way a lot but it it's just getting some many people that uh I don't know any more. [Healy resident]</i>
Subsistence	<i>...of course the subsistence is good for native Alaskans but tourism probably isn't as good for you know the subsistence. [Healy resident]</i> <i>I connected my subsistence with wildlife...cause like to subsistence live you got to have wildlife. [McKinley Village resident]</i>
Socioeconomic	
Tourism	<i>Tourism of course is this like ever present entity that's here. And I do think that largely it's positive, and a large positive impact on the community. [McKinley Village resident]</i> <i>One of the biggest challenges for protecting wilderness is the tourism and the impacts that it has on um the wilderness landscape. [Stampede resident]</i>
Ecological	
Wilderness	<i>Some would argue that [federal legislation] helps wilderness but I can also see a lot of negatives with that. [Cantwell resident]</i> <i>So it's kinda like the wilderness is pushing the tourism and the tourism is pushing back negatively on the um wilderness and the access one is an interesting issue. [Talkeetna resident]</i>

development negatively influenced socio-cultural features of the Denali Region. Specifically, large-scale development negatively influenced 8 of the 28 (28.57%) socio-cultural features including a rural lifestyle and subsistence or traditional ways of life.

Socioeconomic features

The socioeconomic features ($n = 24$) included in the regional map were primarily influenced by other socioeconomic features and, in turn, impacted other socioeconomic and socio-cultural features. The structural patterns of this dimension were unique in that these features were likely to exert the most influence over the other dimensions, as evidenced by more outdegree ($n = 156$) than indegree connections ($n = 116$). Of these, tourism was the most central feature in the regional map, including a total of 63 connections, 31 of which were outdegree and 32 indegree. Tourism was perceived to benefit local business and seasonality. One participant explained that they:

see tourism more and more as our income. And not only like directly income from the tax, but also as all the different businesses that have sprung up [the Stampede resident].

However, residents' ambivalence toward tourism also emerged given its negative influence on rural characteristics of the region, particularly sense of community and rural lifestyle. Further, tourism was positively influenced by wilderness and wildlife, whereas natural resource extraction was considered detrimental to tourism. Interestingly, one resident highlighted that:

wilderness is pushing the tourism and the tourism is pushing back negatively on the um wilderness [Talkeetna resident].

Tourism was the most similarly perceived feature across communities in terms of its importance and role in the system. It was the most central feature in four communities, and the second-most central feature in Talkeetna. In particular, similar structural patterns emerged at the regional scale and among residents of the

Stampede, Cantwell, and Talkeetna, indicating wide agreement of the role of tourism in characterizing the region. In contrast, Healy and McKinley Village residents perceived tourism as a central driver of change, including a relatively even mixture of positive and negative influences on the system. A McKinley Village resident explained the positive influence of tourism on sense of community. Healy residents perceived tourism as beneficial for the economy (e.g., job opportunities), but harmful for large-scale development, rural lifestyle, and natural resources. On the other hand, McKinley Village residents perceived tourism as positive for large-scale development, which differed from other communities.

Climate change and large-scale development had an impact on nearly 25% and 50% of socioeconomic features, respectively. Climate change was seen as a positive driver of features that related to growth (i.e., local business and tourism), but negatively influenced the local economies and the energy industry. Interestingly, climate change was positioned as positive for tourism for one major sector of the economy, but as negative for the energy industry, a second major sector of the economy. In total, there were three and five socioeconomic features that were positively and negatively influenced by climate change, respectively. Large-scale development was similarly viewed as beneficial for job opportunities and land ownership but did not impact other socioeconomic features like local business. Surprisingly, large-scale development was perceived as harmful for growth of the tourism industry, though this connection was weak.

Ecological features

Seven of the 60 features in the regional map were ecological (or physical). The ecological features were susceptible to influence, as evidenced by both indegree ($n = 82$) and outdegree ($n = 60$) connections. Wilderness was the most central ecological feature and the fourth most central feature in the regional map. All outdegree connections ($n = 21$) indicated that wilderness

Table 4. Centrality scores for most important features mapped by residents across six communities in the Denali Region. Centrality is the sum of the indegree and outdegree for each category and is an index of its connectedness to other variables within the map.

	Features	Anderson	Cantwell	Healy	McKinley Village	The Stampede	Talkeetna
Socio-cultural	Traditional ways of life	-	6.38	-	-	-	-
	Subsistence	3.00	-	-	-	6.13	6.25
	Open access to land	-	6.00	-	-	-	-
	Recreation	-	7.00	-	-	-	-
	Remoteness	5.63	-	-	-	-	-
	Rural lifestyle	-	-	5.38	-	-	-
Socioeconomic	Sense of community	-	-	5.13	13.25	-	6.00
	Tourism	-	7.21	5.88	14.88	7.08	6.14
	Education	2.00	-	-	-	-	-
Ecological	Healthy ecosystems	-	-	-	-	-	6.60
	Wilderness	-	-	4.75	8.46	6.75	-
	Wildlife	4.00	-	-	-	7.00	-

positively influenced tourism, subsistence, and sense of community. Features such as wildlife and public land management agencies ($n = 12$) positively influenced wilderness, while a similar number of features ($n = 11$) such as the energy industry and increased waste acted as negative influences. There was also ambivalence around how tourism impacted ecosystems in the Denali Region. One resident explained:

one of the biggest challenges for protecting wilderness is the tourism um and the impacts that it has on um the wilderness landscape so that is what I found challenging. [They went on to acknowledge that tourism could foster positive relationships between people and wilderness because it affords opportunities] to be passionate about protecting it so you could have a positive impact in that relationship [the Stampede resident].

Wilderness was in the top four most central features for Healy, McKinley Village, and the Stampede communities, which are in close proximity to Denali National Park and Preserve and include residents attuned to the technical language of resource management through employment or policy initiatives. Across these community, wilderness exhibited similar patterns to the regional map including positive impacts on socioeconomic and socio-cultural variables such as tourism and sense of community. Overall, these distinct communities indicated that wilderness was considered beneficial for features such as wildlife, healthy ecosystems, rural identity (e.g., self-reliance, freedom, and remoteness), and tourism. The Healy map included more positive than negative indegree connections, indicating that a small population, rural lifestyle, and wildlife benefited the wilderness feature. In contrast, the Stampede map included more negative than positive influences on wilderness, including large-scale development, natural resource extraction, and subsistence.

Ecological features were proportionally the most vulnerable to change due to climate change and large-scale development. That is, climate change and large-scale development were viewed as harmful for five (71.43%) and four (57.14%) ecological features, respectively. Both of these drivers negatively influenced healthy ecosystems, wilderness, wildlife, and the existence of charismatic landscapes. Drivers of change negatively influenced nearly all ecological features identified by residents, indicating that ecological features may be particularly vulnerable to change.

DISCUSSION

This study advanced knowledge of how residents in communities surrounding Denali National Park and Preserve and Denali State Park characterized the region as a dynamic and changing social-ecological system. This study drew from an exploratory resiliency framework (Cummings et al. 2005) to advance knowledge of how residents in communities surrounding Denali National Park and Preserve and Denali State Park characterized the region as a dynamic and changing social-ecological system. We responded to previous research that has called for stakeholder engagement that goes beyond traditional public comment periods (Agrawal 2001, NPS 2020) by facilitating in-depth discussions with residents over a five-year period about their knowledge and priorities for the future. We contend that effective community engagement requires representation of an array of perspectives at a regional scale, which can be better understood using participatory methods such as fuzzy cognitive mapping. We contend that effective community engagement requires representation of an array of perspectives at a regional scale, which can be better understood using participatory methods such as fuzzy cognitive mapping. Our findings indicated that, when taken in aggregate, residents in Interior Alaska had complex understandings of the interrelationships among features of resilience and characterized places mostly using socio-cultural and socioeconomic features, while fewer ecological conditions were discussed and considered vulnerable to change. We observed that tourism, sense of community, subsistence, and wilderness largely defined the region, whereas climate change and large-scale development were perceived as the primary drivers of change. Although our findings indicated several shared understandings of the Denali Region, unique differences did emerge in mental models across communities, highlighting the importance of documenting multiple perspectives for understanding change at the regional scale.

Perceptions of the Denali Region defined as a social-ecological system

The Denali Region was predominantly characterized by a collection of socio-cultural features that reflected residents' lived experiences in their communities and Alaskan culture (Tuan 1977), as well as concerns about landscape change that threaten their desired sense of place (Mathevet et al. 2016). Features such as sense of community, subsistence, rural lifestyle, self-reliance,

and remoteness were at the heart of how places were constructed and understood by residents. Sense of community was a particularly important feature of the Denali region that, in part, was expressed as important for creating space to discuss respective priorities in a safe space. This result extends previous research indicating sense of community dictates participation in adaptive co-management, which can increase resiliency and the sustainability of social-ecological systems (Plummer et al. 2012, del Mar Delgado-Serrano et al. 2018). Opportunities for empowering local communities to participate in protected area decision-making processes and policies will therefore be fundamentally important to direct change in ways that align with the views of local communities (Meek 2013, Bodin et al. 2014). Residents of Healy, Talkeetna, and McKinley Village, in particular, characterized sense of community as a central feature of the Denali Region. One reason for this could be a shared set of values and identities in each of these communities related to the national park in McKinley Village and Usibelli Coal Mine in Healy. That is, several residents of McKinley Village and Talkeetna are employed by the National Park Service (or related agencies) which has shaped community values, while Healy is home to the coal mine, a third-generation family-owned mine that sponsors many community events and activities throughout the year. These places are two of the three major drivers of the economy, demonstrating the interconnected dynamics of economic and social features that have shaped these respective communities over time.

Subsistence was a prominent feature of life in the Denali Region and complex in its definition given that it embodied multiple meanings according to different residents in the Denali Region. As a corollary, the unique dual management of Alaska's public lands, wildlife, and resources shared by federal and state agencies emphasizes different priorities and reflects the tensions among residents who feel disenfranchised (McNeeley 2012). Federal legislation was one of the key factors that negatively affected subsistence according to some participants. One reason for this could be the tension between Alaska Natives and the federal government regarding federal legislation, particularly ANILCA. Although ANILCA aimed to preserve subsistence rights for those who traditionally depended on this practice by prioritizing "rural" subsistence use, the federal government identified which communities were considered rural and granted special subsistence rights based on a suite of factors including population and economy. Historically, many Alaskan Natives have expressed preferences for subsistence rights being given to Natives over rural residents and disapproved of ANILCA (Anderson 2016, Starkey 2016). Preliminary research has indicated non-native residents are concerned about unilateral decisions being made about subsistence use across Native and non-native people and may see regulations on subsistence use as limiting recreation (Filyushkina and Verburg 2020). There is also a legacy of mistrust between Indigenous groups and management entities in Alaska (Blair and Kofinas 2020), indicating that Indigenous concepts about public land management priorities need to be understood for more inclusive conservation and social-ecological resilience (Kofinas et al. 2010, Knapp et al. 2014, Hill et al. 2020).

Socioeconomic features were highly influential in the reported state of conditions in Denali. Residents believed that the tourism feature maintained the structure of this social-ecological system

and provided support for the regional economy. In this sense, tourism was positioned as a tool for advancing conservation initiatives, while also increasing local livelihoods (Bushell and Bricker 2017). Protected area managers in the Denali Region have espoused similar values that recognize the importance of tourism, as reflected by Denali's General Management Plan (NPS 1986) that outlines steps for balancing the expansion of visitor opportunities with resource protection. However, in addition to the benefits, residents across the region also described the harmful impacts of tourism on socio-cultural, socioeconomic, and ecological features, indicating ambivalence toward its role in the system. This finding aligns with previous studies that have posited residents may not share an understanding with protected area managers about tourism's intended dynamic role for improving well-being at the local level (Joyner et al. 2019). This finding was true across communities in the Denali Region, demonstrating a shared understanding and ambivalence toward tourism's role in Denali. This may be the result of insufficient protected area management communication or lack of local representation in decision-making strategies, highlighting the need for agencies to better align the purported objectives for tourism activity with the needs of residents (Lovecraft et al. 2013). Navigating perceptions of the positive and negative impacts of tourism on a region is important because these perceptions likely influence residents' attitudes toward the future of tourism (Ko and Stewart 2002). Further, moving toward a more decentralized management approach that embraces value pluralism could demystify the discrepancies between residents and management agencies (van Riper et al. 2016).

Residents characterized the region using relatively few ecological features that were highly susceptible to socio-cultural and socioeconomic influences. Our findings suggest that socio-cultural, socioeconomic, and ecological processes are relevant to protected areas locally, but at broader geographic scales, socioeconomic and socio-cultural features have more bearing on social resiliency (Cumming et al. 2015). The reciprocal relationships that emerged among features such as tourism and wilderness showed how residents understood wilderness as a supporting feature for tourism, while tourism in turn was harmful for wilderness. Because wilderness emerged as a central feature characterizing the region, a better understanding of the ways that wilderness is positively and negatively impacted by multiple aspects of tourism in Denali is needed for future planning that accounts for multiple perspectives of landscape change. Residents within communities that had more technical knowledge of National Park Service management approaches characterized this feature as central. This could be, in part, a function of wilderness being a technical term defined by protected area agencies. Those less familiar with protected areas might define this feature differently. Further investigation of how wilderness is conceptualized will provide insight on potential transformations in the landscape that result from increasing levels of tourism (Xiang 2013).

The impact of key drivers of change on the current state of conditions

In addition to the features that characterized the Denali region, climate change and large-scale development were drivers of change that exerted substantive influence on the system. Because the causes and consequences of climate change are widespread

and more dramatic in subarctic regions, it could be that residents felt uncertain about the effectiveness of current strategies for adaptation. Ambiguity around how to address climate change and its impacts on the region may also have resulted in feelings of helplessness (Swim et al. 2012). Because climate change has vast and diversified impacts at a global scale that are beyond the control of an individual, broad institutional change that responds to the moral responsibility of government bodies is needed (Broome 2012). In a similar vein, climate change and large-scale development were viewed as having reciprocal positive relationships whereby the impacts of climate change created more opportunities for large-scale development, in turn, amplifying the effects of climate change. These patterns may also be explained by generally low levels of certainty and self-efficacy in decision-making processes (Bandura et al. 1999), corroborating past studies that have posited residents living in or near protected areas express feelings of disempowerment from management agencies (Reed 2008, Rist et al. 2016).

Although most results showed negative effects of climate change, participants reported this driver positively influenced tourism. Given that peak tourism seasons are highly weather dependent in the Denali Region (Smith 1993), it could be that residents understood warming temperatures to lead to extended tourism seasons throughout months that are historically too cold to attract visitors to Interior Alaska. Further, climate change negatively influenced natural resource extraction, another major sector of the regional economy. This could mean that residents believe future impacts will increase regional dependence on the tourism industry and decrease reliance on the energy industry.

The impacts of large-scale development, in contrast to those of climate change, were more centralized at localized scales. This feature negatively influenced the social-ecological fabric of Interior Alaska according to the study participants. Research in the context of rural communities has shown that changes from urbanization, such as development, at times contrast rural residents landscape perceptions (Foelske et al. 2019). In other words, residents who live in remote contexts may develop negative attitudes toward growth that can erode the rural character of a region. Proposals for energy development such as a natural gas pipeline (Hossain et al. 2016) and changes in the cruise-ship industry (Cervený 2004) indicate a trajectory for large-scale development in the Denali Region that could sway the current state of this system. Consequently, there is a strong need for more participatory planning that recognizes the distinct visions for the future among stakeholder interest groups.

Through interviews and focus groups, participants expressed the desire for management bodies to integrate their perspectives about landscape change into planning processes. One option for doing so is by legitimizing residents' perspectives as part of policy and park management. For instance, managers should encourage increased use of online community observation networks whereby residents can share observations through a website. This repository could serve as a valuable resource for protected area management and a multitude of interest groups to incorporate the role of residents' visions for the future into decision making. Additionally, findings from the community fuzzy cognitive maps provide important insights into how various residents understand

the social-ecological system of which they are a part. Protected area managers could use this information to develop participatory strategies that align for these shared and distinct perceptions of Denali as a social-ecological system.

LIMITATIONS AND FUTURE RESEARCH

Residents articulated an intricate understanding of the relationships among socio-cultural, socioeconomic, and ecological features that interacted within the Denali Region's social-ecological system. We showed that fuzzy cognitive mapping was a useful participatory tool for representing these complex ideas. However, there is an inherent risk of losing nuance through the mapping process due to the reduction of features and their connections. To mitigate this limitation, we generated qualitative data during focus groups and interviews to deepen our interpretations of how residents were interpreting landscape change. We recommend that future fuzzy cognitive mapping research builds qualitative questions into the research process to generate diverse forms of knowledge beyond the causal patterns among features. For example, interview questions related to the mapping exercise could elicit in-depth information that could explain particularities in the "sense of place" residents strive to preserve. This mixed-methods approach in environmental management contexts can further help to build trust and partnerships that increase the relevance and up-take of project findings (Creswell and Creswell 2017).

In this study, we opted to develop a typology of initial features of the region as a launching point for the fuzzy cognitive mapping exercises. Although asking participants to reflect on and modify this list was an initial step in our focus groups and interviews that generated useful discussion, doing so introduced potential bias in how residents articulated the features of the Denali Region. We recommend that future research carefully consider whether to provide an a priori list of study features. If so, the list of fuzzy cognitive mapping elements should be developed organically (e.g., from preliminary research) within the same study context.

The scales of representation in natural resource management research warrant further attention (van Riper et al. 2018, Kendal and Raymond 2019). Previous studies have facilitated fuzzy cognitive mapping exercises during focus groups (Gray et al. 2015) and interviews (Gray et al. 2012) to understand individual and group-level perspectives, respectively. Although maps collected during focus groups are typically co-created at the group level, we collected maps during both interviews and focus groups to aggregate individuals' mental models. At the group level, we faced difficulties with comprehension and accuracy of responses due to the inherent complexity of the exercise, especially during large focus groups in which the facilitators could not work with each individual participant. Consequently, approximately 25% of the maps collected were not included in the final analysis. In a similar vein, biases may have been introduced from the different data collection modes given that interview and focus group data were combined. On the one hand, power dynamics inherent to focus group discussions may have affected the responses of individuals toward leaders of the group. On the other hand, those participating in interviews were not exposed to the added benefits of deliberation on how the

community defined features of the region. We recommend that future research focused on individual mental models rely on interviews that allow researchers to better guide participants through the exercise. That is, one-on-one facilitation can minimize error and elicit in-depth models of important features and their connections.

This study laid the groundwork for future protected area's research to model future scenarios for resiliency planning. Specifically, our study revealed how residents characterized a protected area system at a regional scale to better understand the amount of pressure a system can withstand before shifting into alternate regimes, and thus, losing social resiliency (Walker et al. 2004, Cumming et al. 2005, del Mar Delgado-Serrano et al. 2015). It would be interesting and useful for enhancing protected area management and governance toward inclusive conservation that future studies compare local perceptions with the protected area managers to visualize and anticipate conflicting understandings of the social-ecological system, as well as explore implications for conservation and resilience. Specifically, the effects of external shocks on the input features and relationships of a system could be tested through evaluations of future hypothetical scenarios. This line of research carries the potential to generate explicit policy recommendations and inform resiliency planning based on modifications that emerge from different scenario outputs (Kontogianni et al. 2012, Gray et al. 2015).

CONCLUSION

This study aims to understand how communities surrounding Denali National Park and Preserve and Denali State Park characterize the region as a social-ecological system. Drawing on an exploratory resiliency framework, our results indicate that tourism, wilderness, sense of community, and subsistence are important socio-cultural, socioeconomic, and ecological features for maintaining the function and structure of system identity, while climate change and large-scale development are the predominant drivers of change. Additionally, although we saw many similarities across communities, differences in social-ecological perceptions arose from distinct communities, highlighting the nuanced perspectives across the region. Our study adds to a growing body of research related to community engagement in protected area decision-making processes, while, in practice, can support managers' efforts for inclusive conservation by guiding them in how to involve local communities in regional conservation planning. Consequently, we contend participatory research approaches that elucidate multiple perspectives at a regional scale are crucial for enhancing resource management decisions. These findings illustrate a plurality of visions for social-ecological change to build resilience at a regional scale.

Responses to this article can be read online at:
<https://www.ecologyandsociety.org/issues/responses.php/13424>

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Data Availability:

All relevant data and code underlying the findings described in the manuscript will be made fully available.

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APPENDIX 1. Transmitter variables (n = 33) identified by each community. These variables can be interpreted as drivers of change. Receiver variables (n = 16) identified by each community. These variables can be interpreted as most vulnerable to change.

Transmitter variables	Anderson	Cantwell	Healy	McKinley Village	The Stampede	Talkeetna
Industrial tourism*			X		X	
Lack of respect*		X	X			
Land management*					X	
Leadership*				X		
Politics*				X		
Solar energy*						X
Sustainable tourism development*						X
Industrial development*			X		X	
Land use issues*						X
Local organizations*		X				
Limited government oversight*					X	
Tourism growth*						X
Transportation*			X			
Transportation corridor*					X	
Wildlife management agencies*					X	
Traditional ways of life*						X
Norms						X
Open access to land						X
Land ownership						X
Federal legislation			X		X	
Natural resource extraction			X	X		
Public land management agencies				X		
Housing			X			
Education			X			
Climate change			X			
Population growth			X			
Local knowledge		X				

*Variables that emerged as transmitters in the regional map

APPENDIX 2. Receiver variables (n = 16) identified by each community. These variables can be interpreted as most vulnerable to change.

Receiver variables	Anderson	Cantwell	Healy	McKinley Village	The Stampede	Talkeetna
Peace						X
Economy					X	X
Government*						X
Natural resources				X		
Land ownership			X			
Large scale development			X			
Job opportunities			X			
Tax base*			X			
Regional planning			X			
Water table*			X			
Remoteness		X				
Public land	X					
Seasonality	X					
Local customs*	X					
Sense of community	X					
Local business	X					

*Variables that emerged as receivers in the regional map