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The Changing Human Dimensions of Alaska Parks





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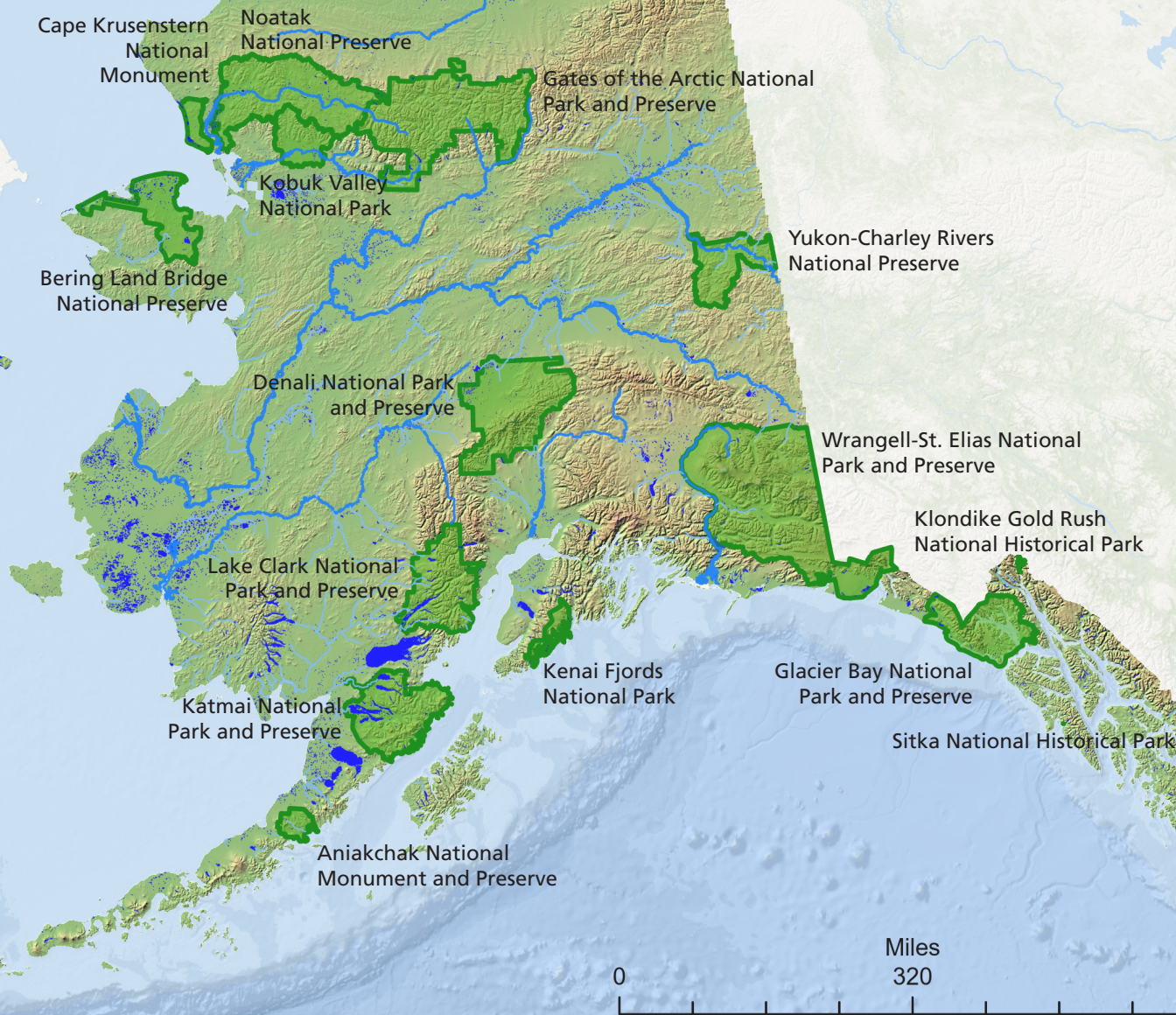


Table of Contents

The Changing Human Dimensions of Alaska Parks S. Gende	1	A Data-driven Approach to Transportation Planning in Denali W. Clark and D. Schirokauer	46
Managing Alaska's National Parklands as Resilient Social-Ecological Systems K. Jochum, S. Iverson, and C. Luby	2	The Ecology of Visitation: Investigating the Rise of Bear Viewing in Two Remote Alaska Parks E. Christian	52
Tribal-Federal Collaboration on Gull Egg Harvest in Glacier Bay T. Lewis, M. B. Moss, and D. See	14	Changing Visitation Patterns Present Challenges and Opportunities for Alaska National Parks H. S. Kim, S. Eagan, and D. Schirokauer	60
Centuries of Human-Caribou Relationship, Migration, and the Conflict Today's World Brings E. Creek and R. Fronstin	24	What to Do About Number Two? Insights from Decades of Human Waste Research and Management on Mount McKinley M. G. Loso and T. Chenoweth	70
Glacier Changes Drive New Challenges for Balancing Visitor Access and Natural Resource Protection S. Gende, J. Womble, and A. Bliss.....	36	Inclusive Conservation in the Denali Region of Alaska: Scenario Planning with Local Communities E. L. Salcido, C. J. van Riper, W. P. Stewart, D. N. Johnson, and R. Keller	80



The Changing Human Dimensions of Alaska Parks

Scott Gende, National Park Service

Alaskans interact with parks as both neighbors and visitors. People from around the world come to Alaska parks to enjoy the scenic wonder, learn about nature, view wildlife, hunt and fish, climb mountains, and more! Yet, the land- and seascapes of Alaska's parks are rapidly changing, which, in turn, influences the access, use, and enjoyment by people.

Parks are for people, and nowhere across the nation is this truism more apparent than in Alaska. Alaska Native peoples have used these lands, rivers, and oceans since time immemorial and access and use is codified for many parks as a result of the [Alaska National Interest Lands Conservation Act](#). Alaskans interact with parks and their resources as residents, neighbors, and visitors. People from around the world come to Alaska parks to enjoy the scenic wonder, learn about nature, view wildlife, hunt and fish, climb mountains, and more! Yet, the land- and seascapes of Alaska's parks are rapidly changing, which, in turn, influence the access, use, and enjoyment by people.

This issue highlighting *human dimensions* includes articles that explore the social, cultural, economic, and psychological aspects of how people interact with and experience Alaska's parklands. The articles describe dynamic challenges and emerging opportunities for management to ensure that the National Park Service mission is met and visitors have high-quality experiences.

A common theme for all contributed articles is that management decisions are often a result of finding compromises or the best possible outcome based on shared values and science. Because of that, some articles in this issue may be presented from a particular perspective or express opinions. Those opinions are the authors' own and do not necessarily reflect the views or opinions of the National Park Service.

Human dimensions are, and will continue to be, at the forefront of decision making in Alaska's national parks. Park managers continue to seek new tools and methods for meeting park purposes and building on some of the successes described in this issue. We hope you enjoy the diversity of articles and we send our sincere gratitude to the authors who shared some of their examples and perspectives.



Managing Alaska's National Parklands as Resilient Social-Ecological Systems

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National parklands in Alaska are different from parks in other states due, in large part, to the provisions of the Alaska National Interest Lands Conservation Act that ensure the continuation of subsistence use of resources. Here parklands function as social-ecological systems. As environmental conditions change, there are opportunities to think explicitly about management for their resilience.

Citation:

Jochum, K., S. Iverson, and C. Luby. 2025. Managing Alaska's national parklands as resilient social-ecological systems. *Alaska Park Science* 23 (1): 2-13.

The goal of this article is to lay out how the integration of the scientifically developed concept of social-ecological systems does apply to, and how it could further be developed, in land management agencies. To do so, we put the history and development of social-ecological systems (SES) and resilience theories into perspective within the National Park Service (NPS) parklands management in Alaska. Two co-authors are currently working on specifically funded projects to address the integration of social and ecological datasets to develop approaches that inform management decision making on the ground.

Many amazing projects are ongoing throughout the Alaska region in land management agencies working closely with local communities, such as oral history interviews of Elders to preserve their knowledge for future generations, documentation of traditional ecological knowledge and place names mapping, and in-season subsistence salmon teleconferences on the Copper River to increase awareness and collaboration, to name a few examples. Additionally, seven of the subsistence parks and monuments in Alaska have established Subsistence Resource Commissions made up of local residents that advise and inform the parks on resource management. This work is crucial for management success. However, in this article we specifically want to

highlight identified scientific theories and how the integration of those can lead to improved management decision making.

We pose that Alaska national parklands are examples of social-ecological systems. SES have been defined as: *complex, integrated systems in which humans are part of nature* (Berkes and Folke 1998: 414-436), and *system(s) with interacting and interdependent physical, biological, and social components, emphasizing the "humans in nature" perspective* (Chapin et al. 2009: 351). The SES concept is predated by earlier research on human ecosystems as an organizing concept, already identifying the future challenges we were to face if not considering humans in ecosystem management (Machlis et al. 1997).

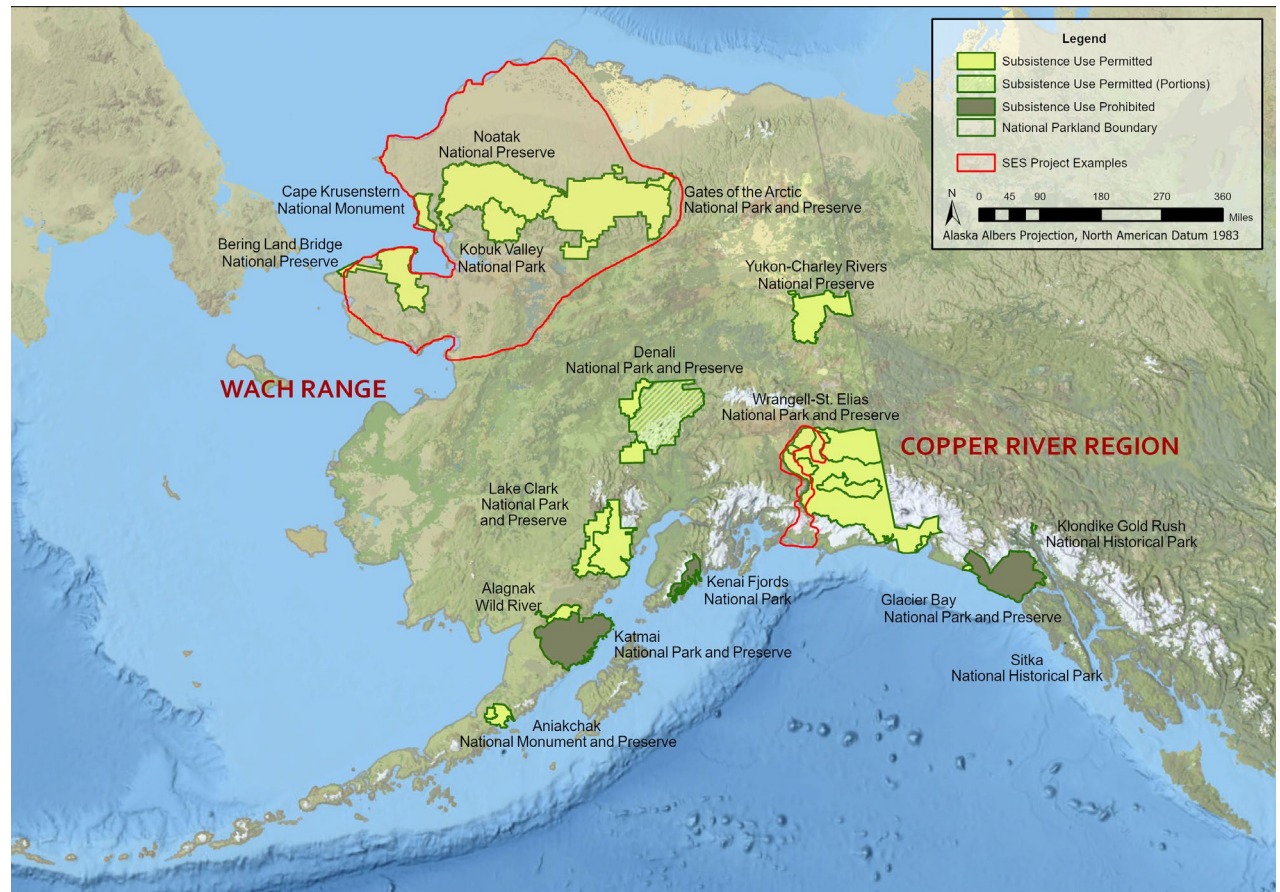
There are opportunities to rethink how we approach the management of Alaska national parklands. Specifically, it is crucial to manage NPS parklands for changes in resources, conditions, and human impacts and needs, compared to our current approach to managing resources while they are changing. These are different mindsets. The first approach is proactive and includes the idea of constant change in our planning documents and strategies. Although sometimes integrated on a local level, we lack the inclusion of interactions and feedback between the social and ecological

components of a system, its resilience, as well as the identification of barriers and, specifically, thresholds to system function in our current management approaches.

A broader argument has been made that all systems encompassing the use of natural resources by human societies, no matter their location or management objectives, should be managed as SES (Ostrom 2009). Here, we focus on Alaska's national parklands because of the extent to which Alaska is different from contemporary NPS management in most non-Alaska parklands and from federal land management objectives generally. A large difference in their management objective is that most Alaska's parklands are tasked to ensure the continuation of subsistence uses and allow for a rural preference under the [Alaska National Interest Lands Conservation Act \(ANILCA\)](#) for communities and individuals who have customarily and traditionally used these lands for subsistence purposes (Title 8 of ANILCA).

Several Alaska parks created under ANILCA have continuation of the subsistence way of life in their enabling legislation and each subsistence park and monument recognizes resident zone communities in regulation. The NPS Alaska regional office subsistence program and the Subsistence Advisory Council, made up of representatives from all subsistence parks, manage annual funding allocations for subsistence research and monitoring projects to be conducted on park lands in collaboration with subsistence communities. ANILCA (Title 8, §803) defines the term *subsistence uses* as:

the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family



consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade.

In Alaska, the NPS manages 15 park units (Figure 1), of which federal subsistence regulations apply in 12, including Aniakchak National Monument and Preserve, Bering Land Bridge National Preserve, Cape Krusenstern National Monument, Denali National Park

Figure 1. Overview of Alaska NPS parklands and where subsistence use is permitted or prohibited. Two examples will be highlighted in this article: (1) the Copper River salmon fishery including the Upper and Lower Copper River Management Districts; and (2) the Western Arctic Caribou Herd (WACH) that migrates through 5 parklands, including Noatak National Preserve, Kobuk Valley National Park, Cape Krusenstern National Monument, Bering Land Bridge National Preserve, and Gates of the Arctic National Park and Preserve.

(portions) and Preserve, Gates of the Arctic National Park and Preserve, Glacier Bay National Preserve, Katmai National Preserve, Kobuk Valley National Park, Lake Clark National Park and Preserve, Noatak National Preserve, Wrangell-St. Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve (Title 2 of ANILCA).

Local rural residents are legally allowed to harvest caribou, moose, salmon, muskox, Dall's sheep, brown and black bears, furbearers, berries, and other resources, for customary and traditional uses. Managers of Alaska's national parklands make decisions on federal public lands and waters related to setting in-season harvest regulations when delegated specific authority by the regulatory board. They might set seasons, bag limits, and other regulations for the harvest of subsistence resources. For example, the superintendent of Wrangell-St. Elias National Park and Preserve is the in-season manager for the fish population in the Copper River drainage and for the Chisana Caribou Herd, and Katmai National Preserve's superintendent for caribou within Game Management Unit 9C. In national preserves, harvest under state regulations is open to non-rural residents and to out-of-state hunters. Harvest regulations for preserves are determined based on state and federal regulations.

Managers of these subsistence parklands have multiple, and often competing, objectives including facilitating access, following legal guidelines, being responsive to stakeholders, and ensuring resources are conserved. To that end, and to inform NPS management of these activities, staff from individual parks, the NPS Alaska regional office, and national NPS programs expend significant financial resources

and time to research and monitor fish and wildlife population dynamics necessary to understand changes in distributions, predator-prey interactions, the impacts of novel environmental conditions, and other drivers that can influence the availability (adequate abundance, access, and seasonal distribution; Brinkman et al. 2016) of these subsistence resources for harvest. NPS staff also engage with, among others, the Federal Subsistence Board, Regional Subsistence Resource Advisory Councils, NPS Subsistence Resource Commissions, the Alaska Department of Fish and Game, the Alaska Boards of Fish and Game, and the public involved in reviewing, establishing, or revising regulations that govern activities involving harvest or access. In most Alaska national parklands, NPS is deeply engaged in efforts to understand the many complex interactions among cultural, ecological, social, economic, regulatory, and political aspects of ecosystems.

The scope and complexity of these subsistence-related interactions are specific to Alaska. National Park Service Management Policies (2006) recognizes parks as a remarkable collection of *places for recreation and learning by visitors* (NPS 2006: 1). While such framing certainly is correct, it also is incomplete. In Alaska, more than anywhere, national parklands are places where people and their activities have been integrated for thousands of years and remain inherent components of the ecosystems. (For a more in-depth consideration of the mandates, implications, and nuances of ANILCA, see the *Alaska Park Science* issue: [Commemorating ANILCA at 40.](#))

The concept of people as part of parkland ecosystems will be obvious to most *Alaska Park Science* readers because it is how we think about

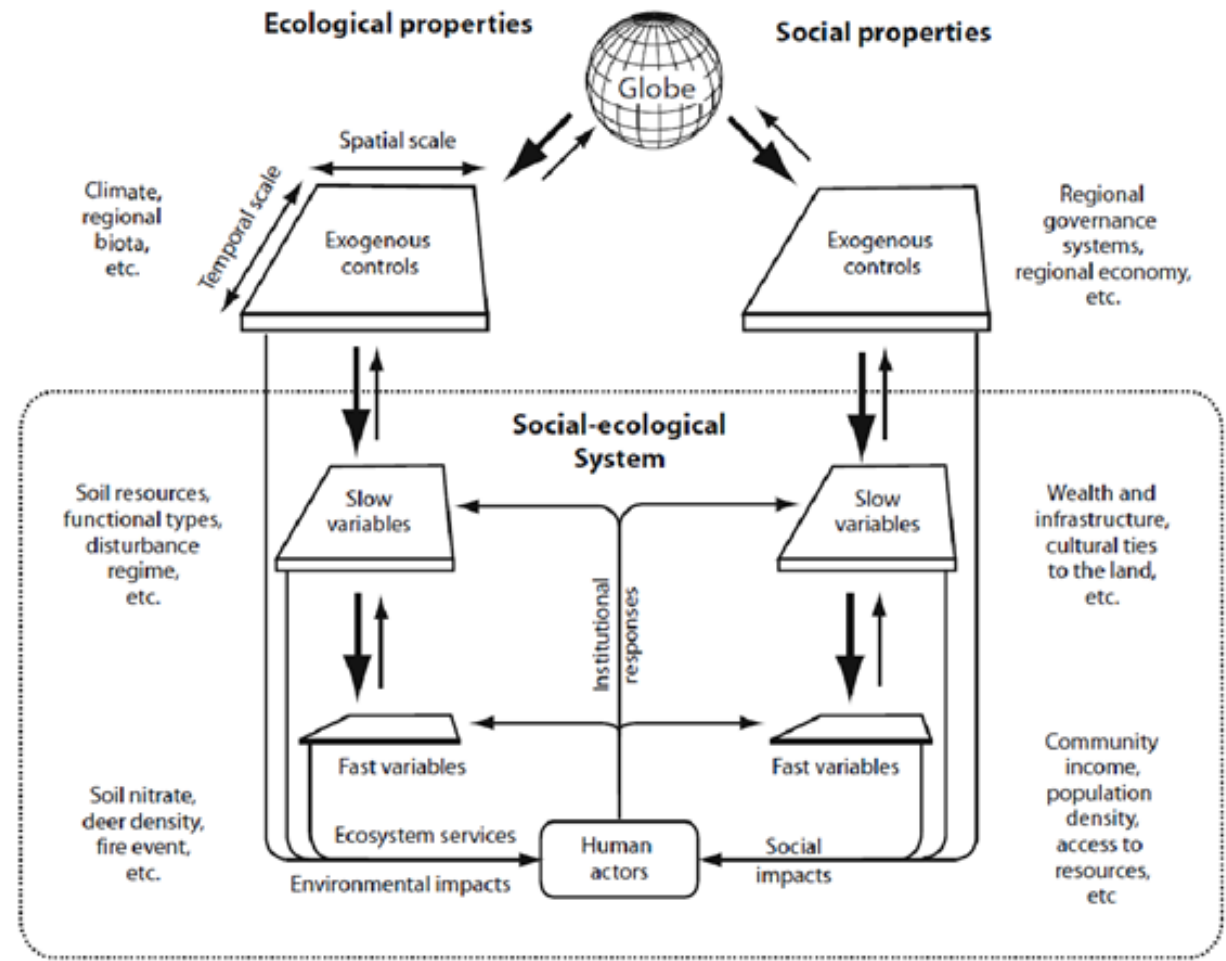
our work; how resource managers in Alaska organize, collaborate, and communicate among themselves and with others; and how they together strive to define and accomplish the NPS mission. Yet, it is insufficiently reflected in our institutional lexicon. Here, we review the origin and application of SES and suggest how it can be applied to manage NPS units holistically and for resilience to undesirable change. We begin by providing a brief overview of SES conceptual frameworks and explain their linkage to resilience theory, describe quantitative analytical SES frameworks, and discuss applications of two current Alaska examples. We conclude with recommendations for next steps toward the inclusion of a SES framework for Alaska national parkland management. The widespread implementation of SES framing for Alaska ecological research and management applications reflects and acknowledges reality and can facilitate the identification of important components and processes, as well as potential pathways and strategies, toward adaptation.

Social-Ecological System Frameworks

The first step for recognizing and using SES is adopting a framework. There are multiple frameworks within the overarching idea of SES, some of which are more “diagnostic” (Ostrom 2007, Chapin et al. 2009, Colding and Barthel 2019) while others describe advancements of specific modeling approaches (Fuller et al. 2017, Gagnon et al. 2023). Both types of frameworks highlight key properties and variables of a system that are important to be considered, as well as their interactions and feedback loops (Figure 2). Frameworks incorporating modeling approaches often draw upon diagnostic frameworks, develop these further, and apply a statistically rigorous approach to solve a

specific problem; for example, understanding perceptions of caribou availability to communities in relation to caribou movement under changing climatic conditions (Gagnon et al. 2023).

At a basic level, frameworks provide standardized nomenclature that has the potential to facilitate communication and common understanding among diverse stakeholders (McGinnis and Ostrom 2014). SES frameworks are often inherently complex, as many factors impact systems and their ability to function or adapt (Figure 2; Chapin et al. 2009). As any park manager in Alaska will attest, particularly when it comes to subsistence, decisions are complex and require superintendents to weigh social implications and biological impacts, both of which are highly uncertain (Machlis et al. 1997). Thus, the goal in applying SES to national parklands management in Alaska is not to prioritize one component over another or to attempt to simplify these inherently complex systems. Instead, by recognizing national parklands as SES, we can advance our ability to understand a system's complexity and identify components, their interactions, and their relative resilience, which possibly allows for broader acceptance and overall success in management approaches. For example, we could tackle a management problem in a way where we would (1) identify and physically draw an SES framework such as in Figure 2, identifying all properties, variables, and possible interaction between these components for the management area and problem we are focusing on, and following (2) bring together and collect baseline information on all system components before considering a management action.



Sometimes such approaches are already used intuitively to a certain degree, for example at the superintendent or program manager level, or when developing [Resource Stewardship Strategies](#) (RSS; a long-range planning document for a national park unit to achieve its desired natural and cultural resource conditions derived from relevant laws and NPS policies). The RSS is a strategic planning tool that considers a wide range of social and ecological resources such as communities' traditional use

Figure 2. An example of a social-ecological system framework that accounts for interactions and feedbacks among social and ecological components. (Chapin et al. 2009, Chapter 1: Framework)

of habitats, considering communities' food-security needs, but also understanding and predicting climatic changes into the future. It is a dynamic management tool, rather than a static planning document, provides a more balanced, integrated approach to natural and cultural resource management and the flexibility to meet the needs of a diversity of national parklands.

To expand on the integration of the RSS approach to become an SES approach would include identifying all social and ecological properties for each system we manage, focusing on interactions and feedback loops between these properties and between resource management priorities, considering the human actors and institutional responses to management approaches, identifying institutional barriers to management priority implementation, and integrating the concept of resilience of our systems in management (Figure 2).

SES are closely linked to the ecological concept of resilience and should be considered in unity. The concept of resilience was formed by "Buzz" Holling in the 1970s; he recognized that ecosystem function is far more complex than can be explained by mathematical and physical science models (Holling 1973, Folke 2006). He emphasized the importance of focusing on the *conditions for persistence* (the qualitative aspects of ecological systems to persist rather than stay the same over time) rather than *consistent non-variable* performance of a system (quantitative attributes). For example, the qualities that allow a forest to persist as a functioning forest rather than its ability to harbor particular species at fixed levels or to maintain an arbitrary level of primary production. Ecological resilience is measured by the magnitude of disturbance that can be absorbed before the system redefines

its structure by changing the variables and processes that control its behavior (regime shift; Gunderson 2000).

Holling (1973: 21) stated the need to apply the resilience paradigm to management of ecological systems so well:

A management approach based on resilience, would emphasize the need to keep options open, the need to view events in a regional rather than a local context, and the need to emphasize heterogeneity. Flowing from this would be not the presumption of sufficient knowledge, but the recognition of our ignorance; not the assumption that future events are expected, but that they will be unexpected. The resilience framework can accommodate this shift of perspective, for it does not require a precise capacity to predict the future, but only a qualitative capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take.

Holling's conceptual framework of resilience was expanded by many over the last decades (e.g., Walker et al. 2004, Folke and Gunderson 2010, Biggs et al. 2015). Specifically, Folke (2006) drew upon it as the emergence of a perspective for SES analysis, describing it as an integrated complex system. Overall, the resilience perspective shifts policies from those that aspire to control change in systems assumed to be stable to managing the capacity of SES to cope with, adapt to, and shape change (Folke 2006), and emphasizes the importance of acknowledging non-linear dynamics, thresholds, uncertainty, and surprise in a systems' persistence. In particular, it explains how periods of gradual change in a system interplay with periods of

rapid change (first gradual, then sudden) and how such dynamics interact across temporal and spatial scales.

Combining these two theoretical concepts, resilience and social-ecological systems, is key to developing lasting ecosystem-based management applications. In a resilient SES, disturbance has the potential to create opportunity for doing new things, for innovation and for development. In vulnerable systems, even small disturbances may have drastic social consequences (Adger 2006, Folke 2006). For example, impacts of natural hazards on communities are increasing worldwide and are projected to rise further due to urban expansion and climate change. A resilient coastal system could cope with natural hazards such as a flood, and could possibly trigger positive outcomes for the community, such as creating room for a more diverse and more productive ecosystem to establish. Whereas a vulnerable system might collapse after a flood and no longer be able to produce the same amount of ecosystem services or lose species richness due to losing ecosystem habitats.

In 2006, integrating resilience research toward understanding SES dynamics and its implications for sustainability was still in its infancy (Folke 2006). Today, the resilience perspective is increasingly used as an approach for understanding dynamics of SES. Since studies of interlinked human and natural systems have emerged as a field on its own, promoting interdisciplinary dialogue and collaboration is a widely used practice.

Modeling Approaches

SES is relevant as a conceptual framework, but advances in management and elevated

understanding occur through analytical application (Fuller et al. 2017, Gagnon et al. 2023). Despite it being statistically challenging to integrate differently collected data derived from various sources such as surveys and geographic information systems and to identify statistically appropriate ways to include continuous and categorical variables in one model, social and ecological data can be combined in modeling approaches when a spatial and temporal link exists.

For example, Gagnon and others (2023) bridged the incorporation of Indigenous and western scientific knowledge in a single model. The study demonstrates that environmental conditions such as large-scale temporal changes associated with caribou demography and cultural practices affect hunters' capacity to meet their needs in caribou. It further shows that hunters' perception of caribou availability is a better indicator for hunting success than the true availability of caribou on the landscape, as perceptions determine if hunters decide to spend resources and attempt the hunt in the first place. Using this complex approach bolsters our understanding of the intricate relationships between ecosystems and human welfare in environments exposed to rapid climate change and shows the benefits of long-term participatory research methods implemented by Indigenous and scientific partners. In this instance, the direct impact to management entities is that good communication with communities and understanding their attitudes and motivation (social factors) is of higher importance than putting extended effort toward tracking caribou movement (ecological factors); understanding both is important to see their interlinked nature. We can identify and evaluate

management decisions and allocation of often limited funds toward more effective and efficient management strategies when understanding the whole complex interdisciplinary system.

Similarly, a SES approach to fisheries management calls for understanding the many involved parties, such as rural communities, various management agencies, and advisory councils; the network of complex social and cultural interactions with the resource and among stakeholders; and the relative adaptive capacity and specific coping mechanisms of each stakeholder group. Fuller and others (2017), for example, constructed fisheries connectivity networks and, by doing so, were able to detect fishers' resilience and distinct functional units they operate within. Their network metrics directly informed policy makers of the social vulnerability of coastal fishing communities, especially their sensitivity and capacity to adapt to change.

Alaska Examples

In Alaska, the NPS is currently managing projects guided by the principles of SES whereby we are working closely with local communities and pursuing projects communities have identified to be of high importance. Two of these include (1) evaluating the availability of Copper River sockeye and chinook salmon to upper Copper River communities (human-salmon SES) and (2) evaluating the availability of caribou in the western Arctic (human-caribou SES).

The Human-Salmon SES

In the Upper Copper River, subsistence users face increasing food security challenges due to environmental and regulatory factors contributing to declining salmon availability

(DeSantis and Ward 2023). For these communities, salmon are central to cultural traditions, nutrition, social bonds, and economic stability (Naves et al. 2015). The practice of fishing for, harvesting, processing, sharing, and consuming salmon fosters mutual support and connection to place, but declining availability threatens these long-standing traditions and overall community wellbeing in Alaska.

In recent years, environmental shifts have placed increasing pressure on salmon populations, raising concerns about the long-term viability of subsistence harvests. The Gulf of Alaska, where the Copper River meets the ocean, has experienced unprecedented warming in the past decade (Walsh et al. 2018). Glacial melt is expected to increase river discharge and sedimentation, impacting fish health and habitat quality (Larsen et al. 2015). River erosion is changing channel locations and disrupting the quality of well-established and previously reliable fishing sites (USACE 2007). These shifts were underscored in 2018 and 2020, when record-low sockeye salmon returns prompted emergency government intervention, including a 41-day commercial fishery closure (Botz and Somerville 2021).

As environmental challenges intensify, competition among different user groups on the Copper River is also increasing (Figure 3). At the mouth of the river, commercial fishing occurs where chinook, sockeye, and coho salmon are caught primarily for commercial sale. Harvest levels at the mouth of the river have varied over the past 25 years with populations trending downward (Botz et al. 2024). There is also a personal-use fishery along the Copper River in the Chitina Subdistrict, where participation is limited to Alaska residents only that use dip

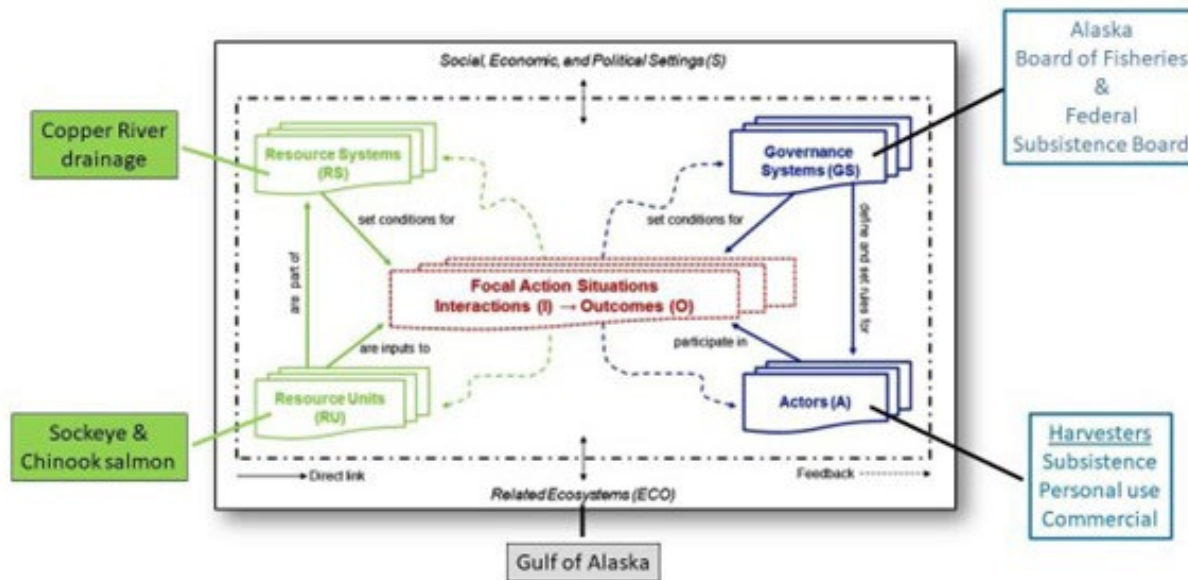


Figure 3. Initial SES framework for the Copper River salmon fishery social-ecological system (after McGinnis and Ostrom 2014), including “first-tier variables” represented by different colors. See McGinnis and Ostrom (2014) for associated second-tier variables, and Lamborn and others (2023) for other fisheries examples.

nets or fish wheels. In addition to personal use by all Alaska residents, subsistence fishing occurs at 4 locations along the river, intended for rural residents who depend on salmon for food security. Lastly, sport fishing (open to non-residents and fish are caught using a hook and line by hand) mainly targets chinook and sockeye salmon, with activity concentrated in the Gulkana, Klutina, and Tonsina Rivers, all tributaries to the Copper River.

Given these increasing pressures, understanding how these impacts are being

experienced by up-river communities is important. Our project build onto work conducted by Wrangell-St. Elias National Park and Preserve, documenting local and Indigenous Knowledge and incorporating biological data to inform management of subsistence fisheries in the federal waters of the Copper River by the superintendent based on his delegated authority. The park was successful in using this information to make changes to fisheries management in state waters through proposals to the State Board of Fisheries in 2024. This enacted regulatory change to the commercial fisheries at the mouth of the Copper River allowed an increased number of early run salmon to migrate to the headwaters, supporting subsistence communities.

The human-salmon SES project will analyze long-term quantitative subsistence, personal use, and commercial harvest data, and biological monitoring data (e.g., sonar and weir

counts) from the Copper River Basin. These data will be supplemented with qualitative data from community household surveys and from meeting minutes of federal subsistence advisory bodies, including Regional Advisory Councils and Subsistence Resource Commissions. These councils and commissions are comprised of groups of local rural residents that contribute to the management of subsistence resources.

By incorporating insights from community harvest surveys, federal subsistence meetings, and key monitoring sites along the river, this project aims to provide a broader context for how salmon availability is changing and how these changes are being experienced by up-river communities. The goal of this integrative approach is to contribute to a more holistic, informed, and responsive fisheries management strategy and a better understanding of food security within the region that adequately accounts for social and ecological components.

The Human-Caribou SES

In Northwest Alaska, the Western Arctic Caribou Herd (WACH) is a vital source of food and culture for local communities. The annual range of the WACH spans much of Northwest Alaska with the fall migration range overlapping 5 parklands. Since peaking at approximately 490,000 animals in 2003, the WACH has declined to an estimated 150,000 in 2023 (Joly and Cameron 2024). Alongside this population decline, both agency monitoring and local observations indicate a shift in the herd’s annual distribution and migration timing. Where caribou once crossed major rivers in August and September in the 2000s, they are now crossing as late as November (Joly and Cameron 2024). The decline in abundance and change in seasonal distribution has disrupted access to caribou,

leading to major concerns in overall availability of caribou to local communities. Exploring trends and patterns in availability are urgent research needs with important implications for caribou management and community well-being.

Many subsistence hunters rely on river corridors such as the Kobuk, Selawik, and Noatak to conduct fall hunts, harvesting caribou in or near the rivers prior to freeze-up. This hunting practice is efficient, accessible, and cost-effective, and yields high-quality meat while offering safe and culturally significant opportunities for younger generations to learn from Elders (Creek and Fronstin 2025). However, the rapidly changing migration (Gurarie et al. 2024) has prompted riskier and more expensive hunting efforts while river ice and snow conditions are unstable (WACH Working Group 2022). In some cases, this shift has disrupted long-standing practices of intergenerational knowledge transmission and community-based harvesting, illustrating the broader social-ecological consequences of herd instability. The loss of some river-based hunting opportunities represents not only an ecological change but also a cultural disruption, particularly for younger hunters who rely on these seasonal patterns to learn both practical and ethical aspects of subsistence hunting. For example, with caribou arriving later, local hunters are less able to harvest bull caribou because of the effect of the rut on the quality of the meat. They must then harvest some female caribou which can be problematic for herd growth and presents an ethical dilemma. This is one of many instances in Northwest Alaska of how the human-caribou SES is inextricably linked.

Caribou hunting involves inherent risks to life and livelihood; these risks are now compounded by shifting environmental and economic pressures. More variable river ice conditions during fall migration increase physical danger, while rising fuel and food costs intensify the economic burden of hunting (or not hunting). Uncertain migration timing complicates the decision to hunt, particularly for wage earners who must weigh time off work against the possibility of missing the herd. Understanding how these intertwined factors affect caribou availability—whether caribou are present in sufficient numbers (abundance), whether their migration routes bring them near communities (distribution), and whether subsistence users can reach and harvest them (access)—is crucial to understanding the SES.

This project will adopt a SES approach similar to the human-salmon SES by integrating both quantitative harvest and herd movement data and a qualitative analysis of public meeting transcripts from the mid-1990s to obtain a measure of if and how caribou availability to communities has changed over space and time. The first part of this project aims to document variation in trends and patterns of availability of caribou. The next step will be statistical modeling to estimate how different variables (ecological and social) influence changes in availability. The second part will investigate how changing caribou availability impacts broader food security measures for communities (e.g., sharing, commercial food purchasing). After identifying key variables associated with availability, the SES framework will guide an exploration of how shifts in caribou populations affect community food systems and well-being. This integrated analysis will identify

relationships between ecological change and food security outcomes.

By combining long-term quantitative data with a robust record of individual and community-level insights, this project will provide a comprehensive assessment of caribou availability over time by documenting long-term changes and modelling the evolving food systems in Northwest Alaska. Despite the herd's ecological and cultural importance, these dynamics have been underexamined but are critical to understanding and responding to the social-ecological consequences of caribou decline.

Benefits of Alaska SES Examples

These projects explore two different SES in Alaska but are guided by similar principles and offer beneficial outcomes for both subsistence users and resource managers, who can sometimes face challenges when trying to apply local knowledge in adaptive decision making. This research can serve as a resource for both communities and agencies to demonstrate mixed methods approaches (i.e., integration of quantitative and qualitative data) that can benefit the regulatory process and serve subsistence managers by defining multiyear patterns of the systems. It further can help inform resource managers about shifts in people's behaviors based on resource availability and identify resiliency of individuals and communities. Local collaborators are more likely to support an approach that accounts for their values and attitudes, and understand and accept the outcomes (e.g., management actions, policy decisions) that are informed by it.

Recommendations

We advocate for acknowledging that we are stewards of SES as an overarching, organizing principle for our institutional structure and function, and for our work together in Alaska. This has implications to how we organize ourselves, implement management strategies, and select the language we use in messaging. SES and subsistence should be framed in a holistic way to be managed successfully. As we embrace the SES approach, we will improve our management toolbox with complex, interdisciplinary, resilient frameworks and management approaches.

A few suggestions for how we can move toward creating such management opportunities:

- Develop conceptual SES frameworks for Alaska national parklands (parks, preserves, and monuments), and apply these in management decision making.
- Not just encourage but strongly support interdisciplinary and collaborative work when projects arise and require outside expertise from other disciplines. Prioritize collaborative development of competitive interdisciplinary project proposals.
- Engage with local communities, develop co-stewardship approaches and improve cross-cultural communication. Long-term consistent staffing for building understanding and trust is critical for park-community relationships. Supporting opportunities for ANILCA local hire and create conditions motivating federal employees to remain in long-term positions, especially at the local level.
- Collaborate with communities and Tribal organizations to identify strategies for co-production of knowledge that shapes research priorities and agendas. This includes the integration of local knowledge in each step of the management and research process from design to implementation, interpretation of results, and dissemination of findings.
- Identify NPS internal barriers (such as possibly limited financial resources, delays in hiring, high turnover in staffing) as well as opportunities (such as prioritize hiring interdisciplinary staff to fill previous disciplinary positions, hire a facilitator to help develop interdisciplinary training, and encourage integration and cross-training) to acquire missing expertise and make interdisciplinary teams effective.
- Build on the RSS approach. Consider investigating the concept of adaptive governance (an approach used for dealing with complex societal issues with many stakeholders and uncertainty about actions to be taken; Janssen and Van der Voort 2016) and how it could be integrated with our stewardship approaches.
- Additional possibilities could include: (1) increase the capacity for interdisciplinary positions and reconsider the balance between specialists and generalists, (2) add cross-training as developmental requirements, (3) identify pathways to educate people about other disciplines, and (4) identify the key role they can play when supporting other disciplines' work teams or interdisciplinary working groups.

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For centuries, hunters have relied on river corridors and the timing of the caribou migration for hunting. But recently, seasonal patterns of migration have changed, leading to decreased accessibility of this important food source.

NPS/KYLE JOLY





Tribal-Federal Collaboration on Gull Egg Harvest in Glacier Bay

Tania Lewis, Glacier Bay National Park and Preserve

Mary Beth Moss, Glacier Bay National Park and Preserve

Darlene See, Hoonah Indian Association

For the Ɓingít, egg harvest is not only a means of gathering food, but an opportunity for families to bond, for youth to actively and safely participate in community harvest, and for the intergenerational transmission of Indigenous Knowledge. After decades of restrictions on egg harvest, the park is using science to show how a renewed harvest practice can be sustainable.

Citation:

Lewis, T., M. B. Moss, and D. See. 2025. Tribal-federal collaboration on gull egg harvest in Glacier Bay. *Alaska Park Science* 23(1): 14-23.

Ɓingít Homeland

Since time immemorial, the lands and waters now encompassed by Glacier Bay National Park have been Homeland for the clans that comprise the Xunaa Ɓingít (Goldschmidt and Haas 1998). Oral histories describe a life of abundance in the glacially mediated landscape of *S'é Shuyee* (Area at the End of the Glacial Silt) before the little ice age drove clans to more protected areas (Dauenhauer and Dauenhauer 1987). Although the Xunaa clans eventually settled a large winter village in what is now Hoonah, Alaska, their hunters returned frequently to witness a glacial retreat that was almost as rapid as its advance. By the mid-1800s, salmon were recolonizing bedrock-stabilized streams in the newly revealed Glacier Bay landscape and diverse wildlife, including an abundance of bird life, had returned (Milner et al. 2011).

This new landscape, *Sít' Eeti Geiyí* (Bay in Place of the Glacier), was particularly suitable for colonial nesting seabirds that preferentially nest in rocky or early successional herbaceous habitats. In particular, glaucous-winged gull populations increased, colonizing the many islands of lower Glacier Bay. Their speckled eggs are treasured spring foods for the Ɓingít who relish this fresh and nutrient-rich food source after long months of subsisting on preserved fish and meats.

For the Ɓingít, egg harvest is not only a means of gathering food, but an opportunity for families to bond, for youth to actively and safely participate in community harvest, and for the intergenerational transmission of Indigenous Knowledge (Hunn et al. 2002). Glacier Bay was widely recognized as a premier egg harvest site and the Huna Ɓingít were proud to be the caretakers of this rich resource.

Although data are limited on the level of egg harvest occurring over time, oral histories, including those collected by Hunn and others (2002) suggest that egg harvest was a regular, annual practice for many Huna families well into the 1960s. Members of the 1899 Harriman expedition were treated to a meal of gulls eggs, boiled marmot and seal while in Dundas Bay (Goetzmann and Sloan 1982).

Park staff on summer patrols in the early years following the establishment of Glacier Bay National Monument described a Native culture involved in trapping, seal hunting, commercial fishing, prospecting, fishing, berry picking, and egg gathering (Traeger 1939, Been 1940). Throughout the 1940s, 1950s, and early 1960s, NPS policy toward this traditional use was “to permit the Indians to continue to take hair seals and to collect gull eggs and berries as they have done in the past until a definite wildlife policy can be determined...” (Cammerer 1939).



The traditional collection of gull eggs was permitted until policy changed around 1965 when the regulations to enforce the Migratory Bird Treaty Act of 1918 prohibited egg harvest.

NPS/MARY BETH MOSS

By 1965, however, the National Park Service (NPS) began enforcing the Migratory Bird Treaty Act of 1918 and related NPS regulations that prohibited egg harvest. It is likely that the Native community of Hoonah was still uncertain as to the exact NPS policy regarding egg collecting as the activity continued at some

level into the late 20th century. For example, Schroeder (1995) found that Huna Lingít gull egg harvest, although diminished in intensity, continued throughout all areas of the park well into the 1980s.

The eventual enforcement of these laws and regulations understandably strained relationships between the Huna Lingít and the NPS. The period of estrangement that followed is referred to as “the second little ice age,” by the Huna clans. For decades, Tribal members either gave up traditional activities now considered illegal or “were made criminals for our food” as a letter from the Huna Traditional Council of Elders described those that quietly continued to

harvest underground (*Juneau Empire*, October 22, 1992). Over time, tensions around the Lingít sense of estrangement grew, culminating in what became known as the Peaceful Demonstration—an event held in Bartlett Cove in 1992. During this event, hundreds of Tribal members traveled by seine boats to reassert their right to Homeland. While untrained NPS staff seem not to have fully understood the significance of this event to the Huna people, new cultural resource staff hired shortly thereafter began exploring options for repairing relationships with Tribal partners. In 1997, these individuals designed a workshop focused on collaborating with the Huna Lingít to collect traditional knowledge that might inform park management. During the workshop, Huna Elders described their longing for gull eggs, harbor seals, and mountain goats, noting that gull egg harvest was their primary focus.

In response, park staff initiated a two-pronged study to collect the information required for the thorough environmental analysis required to support egg harvest. First, an ethnography of bird egg harvest in Glacier Bay identified historic harvest locations and described traditional harvest practices (Hunn et al. 2002). One year later, U.S. Geological Survey (USGS) biologists used harvest strategies described in the ethnography to model the effects of harvest on a gull egg population at South Marble Island in Glacier Bay (Zador et al. 2006).

In the interim, the Hoonah Indian Association (HIA; the federally recognized Tribal Government) applied for and received a Special Purpose Permit from the U.S. Fish and Wildlife Service (USFWS) and Cultural Education Permits from the State of Alaska to collect gull eggs at Middle Pass Rock, a nesting

area outside park boundaries. To model good faith, the NPS provided logistical support to HIA harvesters in 2001, 2002, and 2003, providing vessel transportation to Middle Pass Rock and assisting with permit applications and reporting requirements. HIA Tribal members harvested eggs in each of these 3 years, although the island yielded fewer than 80 eggs on each trip (HIA files).

Regulations governing the subsistence harvest of migratory birds in Alaska are located in [Title 50 of the Code of Federal Regulations](#) (CFR) in part 92. In 1997, these regulations were amended to allow for spring/summer subsistence harvest of migratory birds by Indigenous inhabitants of specifically identified subsistence harvest areas in Alaska. In the early years following the amendment, harvests were authorized for numerous northern Alaskan communities. The ethnographic data collected by Hunn and others (2002) was also valuable in documenting that egg harvest was a traditional practice in Southeast Alaska. In 2004, the NPS assisted HIA in submitting data to that effect; based on that data, the annual regulations promulgated by the USFWS allowed for the harvest of glaucous-winged gull eggs by the permanent residents of Hoonah in Cross Sound and Icy Strait, but not within Glacier Bay National Park in subsequent years.

In following years, NPS prepared a Legislative Environmental Impact Statement (LEIS) that determined that egg harvest could occur within the park without impacting gull populations or other park resources. Based on these findings, Congress passed legislation in 2014 authorizing harvest of glaucous-winged gull eggs in Glacier Bay National Park (Lewis and Moss 2015).



Joining Forces: Traditional Knowledge and Science

Glaucous-winged gulls are long-lived birds with high site fidelity that nest on grass or rocks on islands or in cliffs with few land predators in Glacier Bay (Hunn et al. 2002, Lewis et al. 2017). These gulls generally lay 3 eggs/clutch with the ability to replace lost eggs and re-lay entire clutches if lost to tidal inundation, predation, or harvest. Gulls begin incubating after the 3rd egg is laid, at which point eggs begin to develop and hatch after 27 days. If eggs are lost or taken from 1- or 2-egg nests, gulls keep laying within a day or two until their clutch is complete. If eggs are lost or taken from a 3-egg nest it may take up to 2 weeks for the gulls to begin laying again (Zador et al. 2006).

Darlene See (HIA) and Tania Lewis (NPS) work together to document nest contents and egg size during an experimental gull egg harvest in 2015. The gull egg harvest plan will be an annual iterative process in partnership demonstrating systemic collaboration between tribe and park.
NPS/C. BEHNKE

Park biologists conducted glaucous-winged gull ground- and vessel-based surveys from 2012-2024 using methods described in Lewis and others (2017). They found 7 accessible colonies (Figure 1) with averages of 7-108 nests per colony and observed high variability in gull numbers and egg productivity between years (Lewis and Moss 2015, Lewis et al. 2017). Factors affecting gull nesting success in Glacier Bay include predation from bald eagles, tidal inundation, and habitat changes as herbaceous vegetation and shrubs fill in open grassy habitats. Forage fish are important to gulls during chick provisioning and low food availability has been linked to warmer sea surface temperatures. In Glacier Bay, overall gull productivity was lowest during the time of the Gulf of Alaska Marine Heatwave from 2016-2018 (Figure 2).

In 2015 the NPS partnered with HIA to begin experimental gull egg harvests. The initial objective was to return harvested gull eggs to the Huna Lingit community as many younger tribal members had never tasted them. An additional objective was to test for size differences between harvested eggs and replacement eggs about 3 weeks after harvest, because egg size has been found to be correlated to food availability and chick survival. There was no statistical difference in egg size between eggs collected during harvest and replacement eggs re-laid three weeks after harvest in 2015. From 2015 to 2024 researchers also compared the difference in number of eggs present during harvest vs. replacement eggs laid in harvested colonies (Figure 3). Harvesters took eggs from all nests from 2015-2020 but only harvested 1 and 2-eggs nests in 2023 and 2024. Replacement egg numbers were generally lower than numbers recorded during harvest from 2015-2020 (with the exception of Geikie in

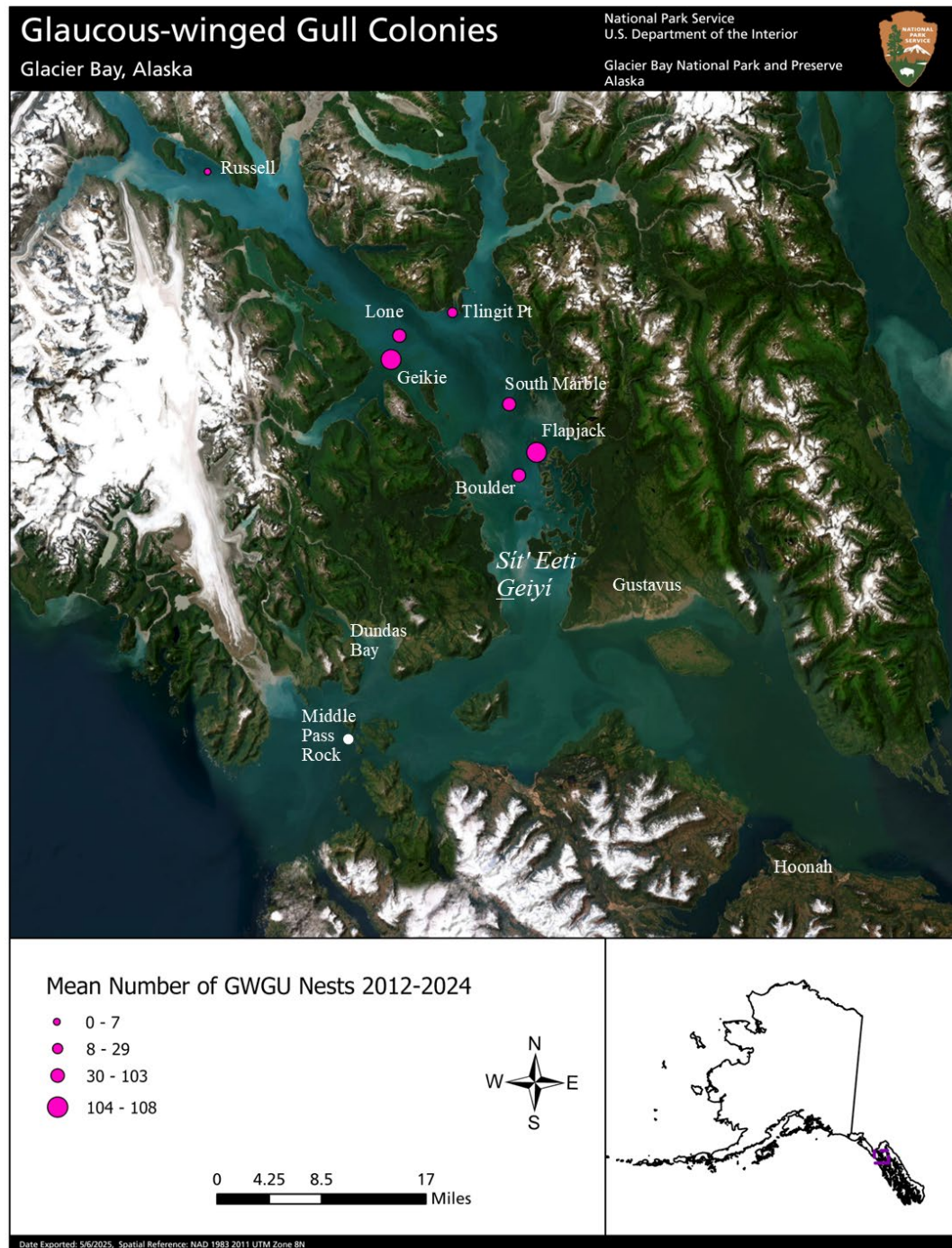


Figure 1.
Glaucous-winged
gull colonies
in Glacier Bay,
Alaska, 2012-
2024.

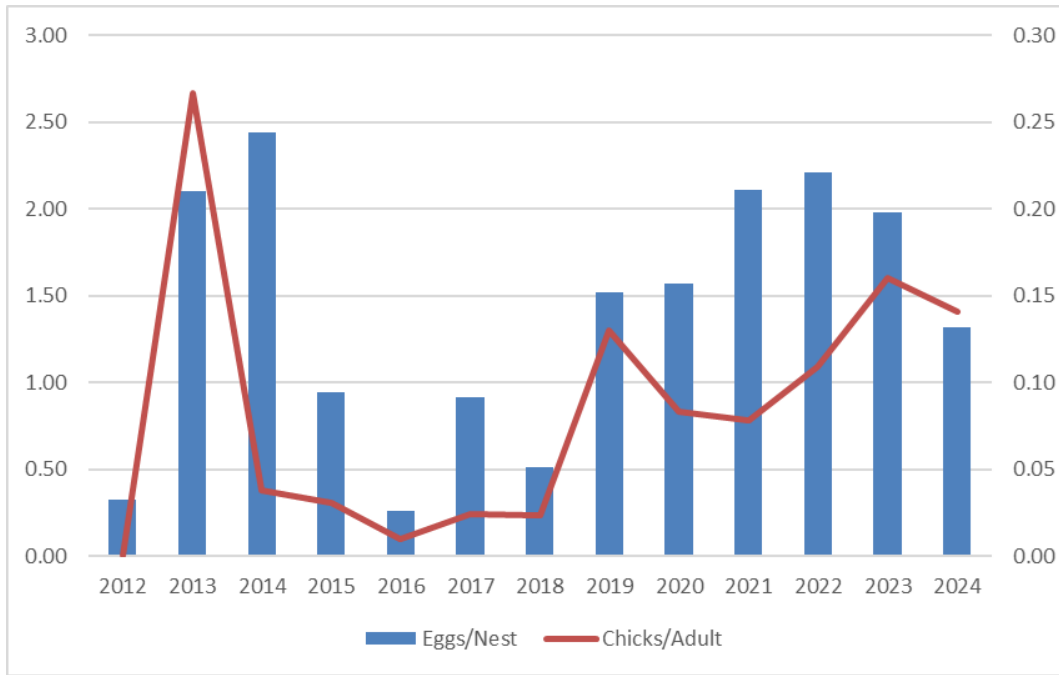


Figure 2. Yearly glaucous-winged gull productivity as measured in eggs per nest and chicks of the year per adult observed across all sites surveyed by year in Glacier Bay, Alaska, 2012-2024.

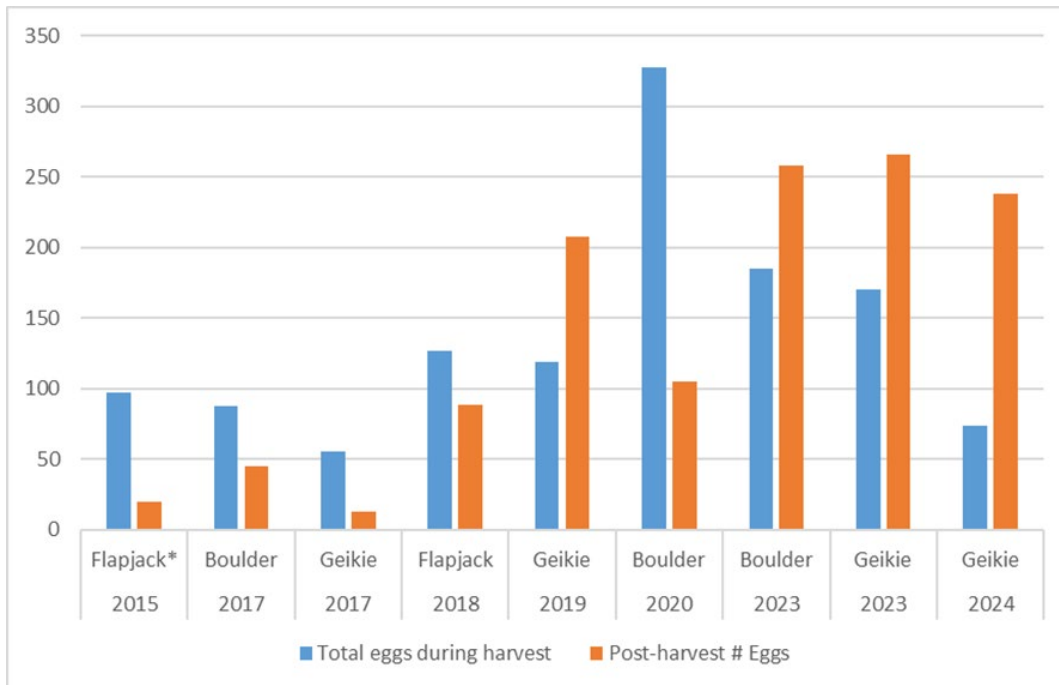


Figure 3: Number of eggs present during harvest vs. replacement eggs laid in harvested colonies from 2015 to 2024 in Glacier Bay, Alaska. Harvesters collected eggs from all nests from 2015-2020 but only harvested 1- and 2-egg nests in 2023 and 2024.

*Egg harvest occurred at only half of the colony at Flapjack in 2015.

Note that eggs were also harvested on Boulder in 2024, but replacement eggs were not counted so not included here.

2019, but higher in 2023 and 2024. This is likely due to an egg harvest strategy started in 2023 of only harvesting from 1-egg and 2-egg nests, which allowed gulls to continue laying without a delay. HIA and NPS collaborate annually on an egg harvest plan outlining the dates, locations, and harvest strategy of egg harvest.

What We Have Learned

Gull eggs are still treasured by Tribal members. Younger generations have not had access to them and may need more opportunity to acquire a taste. Egg harvest did not cause a decrease in egg size in 2015. There are fewer accessible gull colonies now than in the past, largely due to plant succession. Some colonies are increasing in size, some decreasing. Harvested eggs are sometimes developed, especially from 3-egg nests. Data on egg development of harvested eggs can be difficult to obtain as eggs are distributed to Elders throughout the community and taste for developed eggs varies. Harvesting eggs only from 1- and 2-egg nests allows for early and effective re-laying of eggs by gulls and for repeated harvest at the same location year after year with no apparent negative impacts to gulls. Glaucous-winged gull monitoring since 2012 has led to a large amount of data on yearly seabird nesting distribution, abundance, and productivity.

Challenges

One of the biggest challenges of the gull egg harvest and monitoring is limited access to study sites due to marine mammals and weather conditions. Steller's sea lions, including the threatened western distinct population segment, are increasing on at least one glaucous-winged gull colony and limit access to landing beaches. Harbor seals also regularly



Glaucous-winged gull adult and chicks at Geikie colony on August 3, 2023. Tribal members harvested 59 eggs on May 30 and by August the colony supported the highest number of gull chicks ($n=153$) observed since monitoring began in 2012. NPS/TANIA LEWIS



Since 2015, 982 eggs have been distributed to Tribal members and more than 20 harvesters have been able to practice this traditional harvest. NPS/MARY BETH MOSS



In some places, gull nesting sites are inaccessible because they are bordered by sea lion haul outs.
NPS/TANIA LEWIS

haul out near some colonies. The limited number of harvest locations is a challenge as is anticipating the timing of onset of laying from which to plan the egg harvest. Strong winds and high seas can prevent access to the colonies in May-June and cold rain can inhibit egg harvest and nest monitoring due to the potential for eggs to chill and die when incubating adults are disturbed from the nests. Another challenge in assessing gull productivity is that researchers can only conduct nest/egg counts until chicks are mobile, after which time chicks may flee into other gulls' territories and be killed. Lastly, the gull monitoring project has generated a large amount of data that has led to challenges in data management over the years.

Successes

Since 2015, 982 eggs have been distributed to Tribal members with a focus on Elders. Over 20 Native gull egg harvesters have had an opportunity to practice the traditional activity of harvesting eggs for their community as well as collect data during gull egg harvest. Eight students and entry-level biologists have gained experience in seabird monitoring to inform a traditional gull egg harvest. Tribal and NPS cooperation on gull egg harvests has become a model of Tribal-Federal co-management; this partnership is recognized by the Department of the Interior as one of four successful co-management programs in parks. Importantly, gull egg harvest and monitoring has generated a large amount of baseline data on seabird nesting that can be used to assess yearly breeding success, colony abundance and distribution, indices of marine ecosystem health, and to inform restrictions to recreation visitors protect nesting seabirds. Staff from the Tribe and the park continue to learn from each other in an iterative



Huna Indian Association members participate in all aspects of the program, including data collection.
NPS/C. BEHNKE

process that has led to increased awareness and respect, as well as harvest and monitoring strategies that maximize cultural benefits of egg harvest while minimizing negative impacts to gulls in Glacier Bay.

***Gunalchéesh* and Thank You!**

- Elders of Hoonah who maintained and fought for the right to continue this tradition
- Park leadership who supported this program
- Hoonah Indian Association harvesters
- National Park Service biological technicians, boat operators, and researchers: Lucas Beck, Christopher Behnke, Todd Bruno, Cheryl Cook, David Culp, Sofia Elizarraras, Julie Hower, Jim Lesh, Katja Mocnik, Justin Smith, Ashley Stanek, Elisa Weiss, Kiana Young, and Stephani Zador
- Gulls of Glacier Bay

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Centuries of Human-Caribou Relationship, Migration, and the Conflict Today's World Brings

Emily Creek and Raime Fronstin,
Western Arctic Parklands

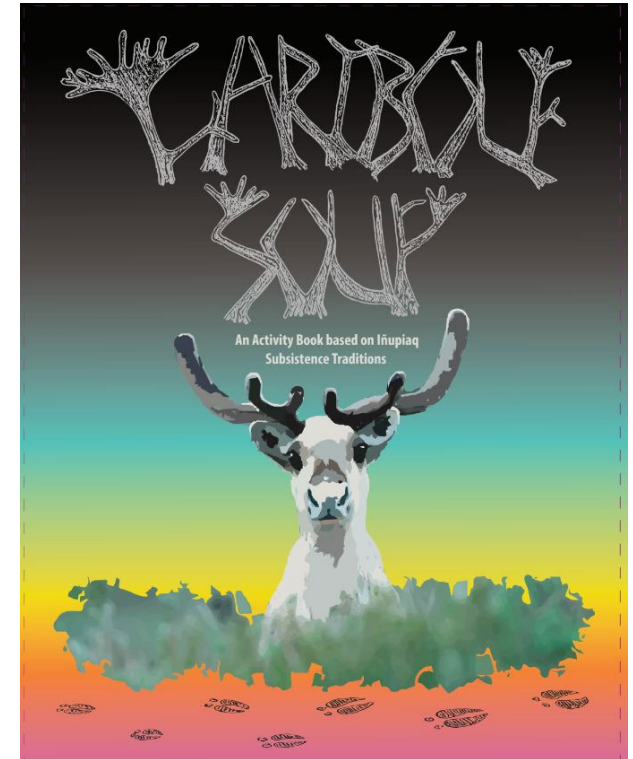
Noatak National Preserve allows for the continued use of resources for subsistence and non-resident hunting (sport hunting). But traditional Iñupiat world views and sport hunting practices can clash. This article highlights some of the reasons for this conflict, predominantly from the lesser-known Iñupiat perspective, challenges that the NPS face when trying to manage for both user groups, ways in which the National Park Service has documented the conflict over the years, and how we may continue to address the concerns of Noatak residents through management moving forward.

Citation:

Creek, E. and R. Fronstin. 2025. Centuries of human-caribou relationship, migration, and the conflict today's world brings. *Alaska Park Science* 23(1): 24-34.

Noatak National Preserve was established in 1980 under the [Alaska National Interest Lands Conservation Act \(ANILCA\)](#). As a preserve, it allows for the continued use of resources for subsistence and non-resident hunting (sport-hunting). Even prior to the establishment of the preserve through current times, local, primarily Iñupiat, world views and hunting practices clash with those of non-resident sport hunters who reside outside of Northwest Alaska and come to the region to hunt. This paper highlights some of the reasons for this conflict predominantly from the lesser known Iñupiat perspective, challenges that the National Park Service face when trying to manage for both user groups, ways in which the National Park Service has documented the conflict over the years and how we may continue to address the concerns of Noatak residents through management moving forward.

Noatak National Preserve sits in the middle of the 157,000 square mile migratory route of the Western Arctic Caribou Herd (WACH), adjacent to the herd's summer and wintering grounds. The preserve makes up a large portion of the Napaaqtugmiut and Nautaaqmiut Nations' traditional lands. These Nations traveled across what is now the preserve, following the migration of the caribou through the seasons. Today, descendants from these two Nations live in multiple villages surrounding



Iñupiaq subsistence traditions activity book published by NPS in 2023.

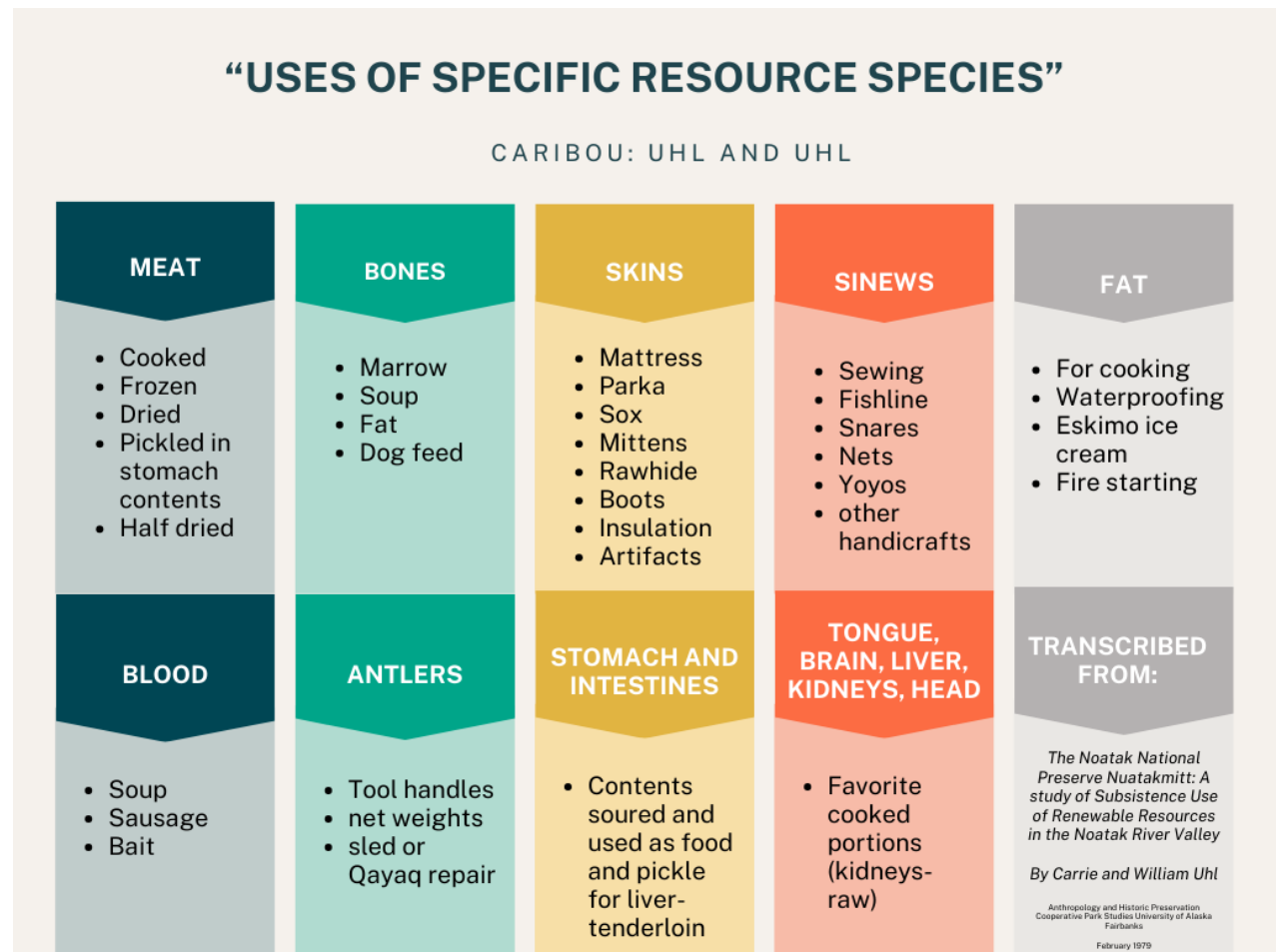
The Western Arctic Caribou Herd migrates through the Noatak National Preserve. Caribou are integrated in Iñupiat culture, which, at times, is at odds with the forces of outside culture. NPS

the preserve. In this paper, *Nuatakmiit* refers to the Iñupiat residents of Noatak Village (Uhl and Uhl 1979). Caribou, or *tuttu* in Iñupiaq, are one of the most important subsistence resources to Northwest Arctic communities. [Over 11,000 years of human use of this area](#) are evidenced in the archeological record. Faunal remains at house pits at known modern caribou crossing locations indicate heavy Iñupiat use of caribou dating to precontact times (1500 AD; Shirar 2009). Fragmented caribou remains found at these sites indicate marrow and grease extraction in addition to other uses of caribou meat, bone, hides, and organs. Stories, dances, and information are passed down in teachings of harvesting and processing practices. Countless placenames in the preserve are named specifically for caribou crossings such as *Kulavak*, which means female caribou (cow). Although tools, clothing, and modes of transport have changed, caribou have not lost their significance to the Iñupiat people.

The importance of caribou has been well documented in the region. Ernest Burch Jr. and Don Foote kept careful records of caribou use during their research years (Burch et al. 1999, Foote 1965). Caribou subsistence and its relevance to local users is more complex than simply the number of caribou harvested to sustain the nutrient and clothing needs of a community. For example, local knowledge includes specifics of what caribou to harvest, when to harvest, and for *which* items (Figure 1).

Pre-Park Research

In the first study done for the National Park Service (NPS), Bob and Carrie Uhl (1979), emphasized humans and their subsistence activities as part of the ecosystem when weighing



the potential new ANILCA legislation. They argued that because humans have been a part of the ecology for thousands of years, to not include their role in the ecosystem, “smacks of artificialization rather than preservation” (Uhl and Uhl 1979: 57). They highlighted the intricate knowledge of the land and rivers navigated for use as hunting grounds to provide *niqipaiq* (native food), such as caribou, moose, and fish.

In 1979, Jim Magdanz completed a fellowship in Northwest Alaska during the time when

Figure 1. The variety of ways caribou is used as a resource in Northwest Alaska. (Uhl and Uhl 1979)

ANILCA was being drafted. In his writings, Magdanz addresses the new obstacles brought about by state and federal land ownership and the conflicting concepts of wilderness among different user groups. Although the NPS and Alaska Department of Fish and Game (ADF&G) drafted regulations to recognize subsistence, residents were concerned that these wouldn't have the flexibility to keep up with fluctuating animal populations and changing needs of communities. Different user groups had distinct apprehensions.

Closing the parks and monuments to sport hunters forced them onto smaller swaths of land used for subsistence. Environmental groups were concerned that motorized forms of transportation would spoil the wilderness experience.

As new laws were written, the effort to ensure that humans would be acknowledged as part of the landscape was at the forefront. Thriving communities and continued cultural practices were well documented by pre-park research and illustrated the relationship of Iñupiat to the land. In addition, archeological evidence and hunting implements found in some of the most difficult-to-reach places on the landscape highlighted this depth of knowledge for new land managers. For example, *iñuksuk*, stone landmarks meant to resemble people used by Iñupiat for caribou herding, navigation, and landmarks are found throughout Noatak National Preserve.

Studying Conflicts in the Preserve

Three studies have examined the history of conflict between user groups in the preserve, 2 of the 3 interviewed different user groups about their use of caribou and perceptions of hunting. In 2015, Fix and Ackerman did a study on the

Conservation groups believe that harvesting animals, even for subsistence, is an ugly and obsolete part of our heritage. To which the NPS subsistence specialist at the time, Ray Bane, replied: 'Man can be a non-destructive part of the wilderness. He can be. There's a blanket of culture all over this area, an invisible blanket. When floaters float these rivers, they say, Look at this untouched land. It's not untouched. It's just been touched gently. Why not let it continue?'

—James Magdanz (Magdanz 1979, Eskimo Fish Camp)



Iñuksuk are used by Iñupiat to herd caribou, navigate, and mark key locations on the landscape.
NPS/ADAM FREEBURG

non-resident sport hunters who used Noatak National Preserve. In 2015, Gabriella Halas for her MA thesis, looked at the issue from the perspective of subsistence hunters. Finally in 2021, Deur, Hebert, and Atkinson published a review of the literature relating to traditional caribou hunting. These studies identified three major conflicts (1) aircraft use, (2) differences in hunting practices, and (3) spatial overlap of different hunter groups.

Aircraft Use

A long-standing and widespread conflict in Arctic Alaska involves the use of aircraft by non-resident sport hunters to access caribou and the resulting disturbances to local subsistence hunting. Communities across the region have consistently expressed concern that low-flying aircraft disturb caribou, interrupt migration, and divert animals away from traditional hunting areas, ultimately reducing harvest success for local hunters (Stinchcomb et al. 2019).

Traditional Knowledge (TK) provides strong support for these concerns. In a study conducted by Halas (2015), interviews with 113 active hunters and 20 knowledgeable Elders from Noatak revealed that most respondents perceived aircraft as having a negative effect on hunting success (Figure 2). Aircraft were reported to startle caribou, delay or divert migration away from the Noatak River, and disturb movement patterns—especially when landing sites and sport hunter camps were situated within migratory corridors. Similarly, Georgette and Loon (1988) found that hunting areas used by Noatak residents in 1987 remained consistent with those reported by Foote in 1965, indicating long-term reliance on specific river corridor locations now increasingly disrupted by aircraft.

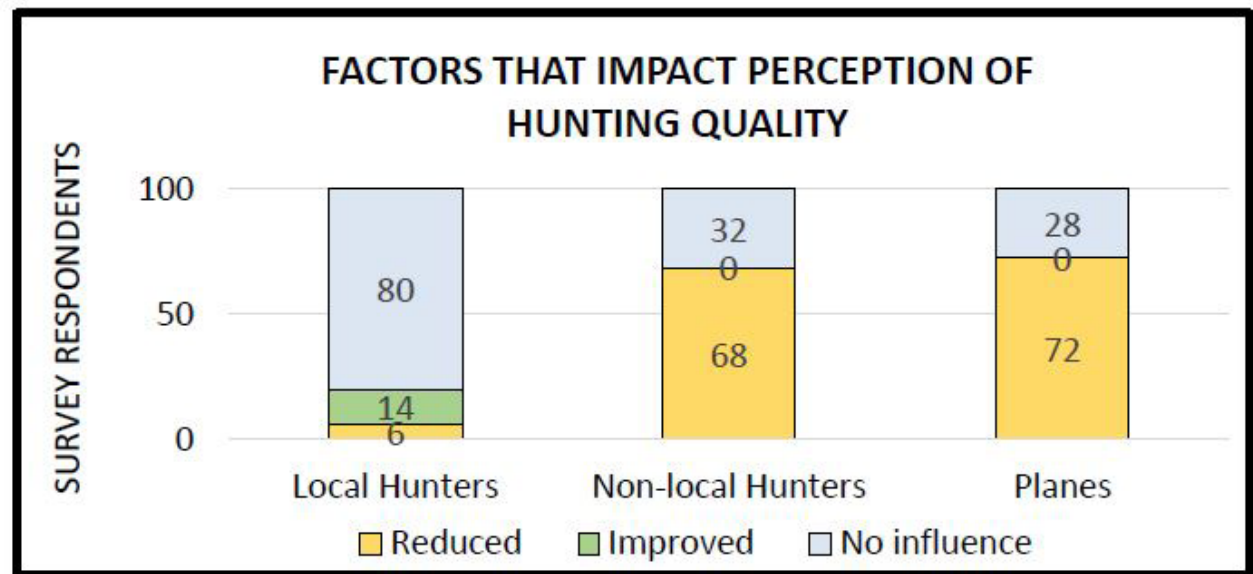


Figure 2. Interview respondents' rankings of impacts to hunt quality based on the frequency of encounters with other groups. (Halas 2015)

Scientific research further supports these observations, though with some limitations. A study by Fullman and others (2017), for example, found that known non-resident sport hunter camps and transporter aircraft landing sites did not affect large-scale migration. However, the study did not assess localized caribou movement or behavioral responses to low-level overflights—factors that may significantly influence harvest outcomes for subsistence users. Industrial development in Alaska during the 1970s spurred numerous studies on the effects of aircraft (small single engine and military jets) on caribou behavior. Here we'll only discuss caribou responses to the relevant small single-engine fixed-wing aircraft. Altitude emerged as the most influential factor: low-level flights were consistently shown to provoke strong panic responses (Calef et al. 1976, Fischer et al. 1977, Jakimchuk 1980, Maier

1996, McCourt and Horstman 1974, Surrendi and DeBock 1976). Maternal groups and calves were identified as the most sensitive cohorts (Calef et al. 1976, Fischer et al. 1977, Maier 1996, Valkenburg and Davis 1985), while reactivity increased during biologically vulnerable periods such as calving, rut, and insect harassment (Calef et al. 1976, Maier 1996, McCourt and Horstman 1974, Surrendi and DeBock 1976). Reactions were also influenced by current activity, with caribou being especially sensitive during feeding, bedding, and water crossings (Calef et al. 1976, McCourt and Horstman 1974).

Comparative studies have also shown that the Western Arctic Herd, which has had less exposure to aircraft, fled more frequently and for longer durations than the more habituated Delta Herd (Valkenburg and Davis 1985), though habituation is likely one of several

influencing factors. Regardless, repetitive aircraft disturbance on caribou has the potential for deleterious short and long-term effects. In addition to the risk of direct physical injury resulting from panic responses, it is well established that elevated stress can have lasting detrimental effects on animal health and reproduction. For example, in one study the variance in calf survival was explained by the exposure frequency of cows to low-level jet flights over certain biologically sensitive periods (Harrington and Veitch 1992). Disturbances during energetically demanding periods—such as insect harassment and late winter—could be particularly harmful, as increased activity may lead to the depletion of critical energy reserves. To mitigate these impacts, multiple studies recommend that flights remain above 1,000 feet AGL, with some responses during insect harassment, observed as high as 2,000 feet AGL (Calef et al. 1974, Jakimchuk 1980, McCourt et al. 1974a). Maier (1996) recommended prohibiting overflights altogether during sensitive biological periods. While these studies demonstrate that aircraft—especially low-flying planes—can affect caribou behavior and potentially long-term health and localized caribou movement, there remains a critical gap in linking these effects directly to quantitative impacts on subsistence harvest success.

To further understand the scope of aircraft presence in relevant areas, Stinchcomb and others (2020) conducted acoustic monitoring around a subsistence-based community in Arctic Alaska. They found that aircraft significantly altered the acoustic environment in traditional harvest areas, with noise levels highest near human development and decreasing with distance. Further, the area with the highest

harvest usage (within 30 km of villages in Stinchcomb's 2020 study) overlapped with the area of the highest aircraft activity. Thereby, leading subsistence users to travel further from their villages and traditional hunting grounds to escape disturbance.

Though causal links between aircraft disturbance and harvest outcomes are absent in peer-reviewed literature, the collective evidence—including TK, behavioral studies, and acoustic data—show that (1) subsistence users across the Arctic have consistently reported observing aircraft activity disturbing caribou and diverting local movement, (2) aircraft conclusively can affect caribou behaviour, and (3) there is a lot of aircraft activity around villages and traditional hunting grounds. Even in the absence of definitive causal links between aircraft disturbance and harvest, given the evidence that we have, precautionary measures are reasonable. Mitigating the potential impacts of aircraft on harvest can be achieved by implementing minimum recommended flight altitudes when flying over caribou habitat and establishing buffer zones that limit unnecessary aircraft activity within approximately 20 miles (30 km) of villages (or average area of customary use). However, because airspace regulation falls under the authority of the Federal Aviation Administration (FAA), success would depend on outreach, education, and the voluntary compliance of pilots.

Ultimately, this conflict centers on the availability of caribou to local subsistence users and concerns over disruptions to traditional harvest success. Under the rural priority established by (ANILCA), these concerns remain legitimate, urgent, and unresolved.

Difference in Hunting Practices

Another issue is in the perception of non-resident sport hunting vs. subsistence hunting. Subsistence users have depended on the WACH for millennia. Herd declines have major effects on the food security of local communities. The people who live in Northwest Alaska cannot go elsewhere to obtain their staple resources and grocery store products are disproportionately expensive or unavailable. When they hunt, they have to search for caribou and may travel many miles by boat, snowmachine, or all-terrain vehicle (ATV). Hunts can take days to weeks and are not always successful. Fuel in remote Alaska is several times the national average (up to \$15/gal at times). On the other hand, non-resident sport hunters have the means to pay to fly from around urban areas of Alaska and from around the world to come hunt the WACH. They are not reliant on the harvest as the main source of meat in their freezer. They have access to other hunts and grocery stores. When they arrive, they are dropped off by transporter service directly into an area that is known to have caribou, and each hunt is relatively quick and nearly always successful. ANILCA was written in part to address this issue:

Alaska is unique in that, in most cases, no practical alternative means are available to replace the food supplies and other items gathered from fish and wildlife which supply rural residents dependent on subsistence uses. (ANILCA Title 8, §801 (2))

This issue comes to a head in part due to the difference in hunting practices between user groups. Nuatakmiit hunters believe in a world of spirits where non-human animals must be shown respect, and proper behavior toward prey is rewarded by successful hunts, while disrespect

impedes success. Years of living as a part of the ecosystem has granted local subsistence users invaluable hunting knowledge that has been passed down through generations. Many Iñupiat and specifically Nuatakmiit continue to follow traditional rituals before, during, and after harvest. These practices are meant to aid in the success of individual hunters but also in the success of providing for others who depend upon the herd. In this light, non-resident sport hunters who don't practice these traditions can affect the success of all of the hunters after them (Deur et al. 2021).

One of the most important traditions in caribou hunting is letting the first caribou leader of the herd pass unharmed. Public meeting records from the most recent 2023 federal regulatory cycle document 12 references to these specific practices, with one being a summary of public hearing testimony held in Kotzebue (FSB 2023, NPS CAKR SRC 2023, NPS KOVA SRC 2023, NWARAC 2023). During the testimony, most comments referenced this issue (FSB 2023). To address this, the park has a video that non-resident sport hunters coming into Noatak National Preserve to hunt caribou are asked to watch ([Hunting - Noatak National Preserve \(U.S. National Park Service\) \(nps.gov\)](#)). The video emphasizes the importance of the area to Nuatakmiit subsistence hunters and asks visiting sport hunters to respect the tradition of allowing the first caribou to pass through a migration route unharmed. Lead caribou establish scent trails for the rest of the herd to follow; thus, if the first caribou is harvested, it prevents the migration route from being established. Unfortunately, this message does not reach all hunters who come into the area. It can also be hard for inexperienced

hunters to identify lead caribou. In a poll given to sport hunters who have used Noatak National Preserve, when asked about following local traditions, almost 20% of respondents shot at the first caribou (Fix and Ackerman 2015).

Another hunting tradition, often unknown to non-resident sport hunters, is that local subsistence hunters allow the caribou to cross the Noatak River before harvesting them. Similar to hunting the first caribou, shooting at caribou before they cross the river can prevent the others from crossing. Many non-resident sport hunters are unaware of these practices, and this causes conflict between user groups. Agencies provide online media and flyers to transporters to resolve this conflict. But community members in Noatak and Kotzebue say it is unresolved.

Finally, the hunter's selection of individual animals continues to be the center of the current conflict. Subsistence hunters seek the fall-time bull for its nutritious and tasty pre-rut meat and thick coat, while generally the goal of non-resident sport hunters is a bull's large antler rack. Wasted meat by non-resident sport hunters has been a long-standing concern and continues to be problematic. Residents report wasted meat found, "in dumpsters of local Kotzebue businesses, left to rot on wooden pallets on the airstrip tarmac, hung in shipping vans with no air circulation, or found hidden in the bushes outside of town" (Steinacher 2006; [A Crisis in the Making in Northwest Alaska, Alaska Department of Fish and Game](#)). Residents have also reported seeing hunters and transporters tossing unwanted meat into the ocean or nearby lagoons. The issue has been such a concern that local agencies collaborated to create and disseminate a flyer regarding

wasting meat. Despite requirements to salvage or donate meat, residents remain unconvinced that non-resident sport hunters are doing so properly.

Wasting meat offends everyone and it's against the law!



- Alaska Law requires that all moose and caribou meat must be salvaged for human consumption.
- In Unit 23 (prior to Oct 1) you are also required to leave the meat on the ribs, front quarters and hindquarters until it is brought out of the field. Meat may be de-boned once it has been transported to a state-maintained airport.
- Antlers may not be removed from the kill site until all the meat has been picked out.
- Meat must be transported out of the field in edible condition before or at the same time as the antlers.
- Failure to salvage meat carries a minimum fine of \$2,000 and seven days in jail.



Trophy antlers require trophy meat

Don't shoot it if you can't pack it all out.
Don't shoot early into a long hunt or float, or in warm weather.
Plan carefully with your guide or transporter...
A delayed pick-up is not an excuse for letting meat spoil.
Bad weather is not an excuse for bad meat—care for it properly.
Don't give questionable meat away—nobody wants it.
There are no freezers or meat storage facilities in Kotzebue.

Legal	Legal	Illegal
In and out of the field only. Properly salvaged.	Out of the field only. Properly de-boned.	In or out of the field. Inadequate salvage.

Your 'wilderness' is somebody else's backyard

Alaska Natives have been hunting, fishing and living here for thousands of years. Today federal and state managed lands provide opportunities for anyone to hunt, camp, fish and recreate—but you are still expected to do so legally and respectfully.

Leave a clean camp. Remove all garbage. Burn toilet paper.	Dismantle fire rings and all site modifications. Don't trespass on private lands or subsistence camps. Don't interfere with someone else's hunting.
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Respecting 10,000 years of knowledge

Alaska Native hunting traditions have evolved to allow for harvest of caribou without displacing their historic migration routes. Following these local practices is good for the caribou and good for hunter relations.

- Allow the first groups of caribou to pass undisturbed. There will be more following these leaders.
- If hunting along the Kobuk River, hunt only on the south side to allow the caribou to cross undisturbed.
- Do not place hunting camps so that they block the caribou trails or redirect the migration route.

This message supported by: Alaska Dept. of Fish & Game 907-463-1711 Sitka National Wildlife Refuge 907-463-3799 Northwest Arctic Borough Western Arctic National Parklands Bureau of Land Management

To report violations please call the Alaska State Troopers: Kotzebue 443-3922, Galena 656-1634 or toll free 1-800-478-3377

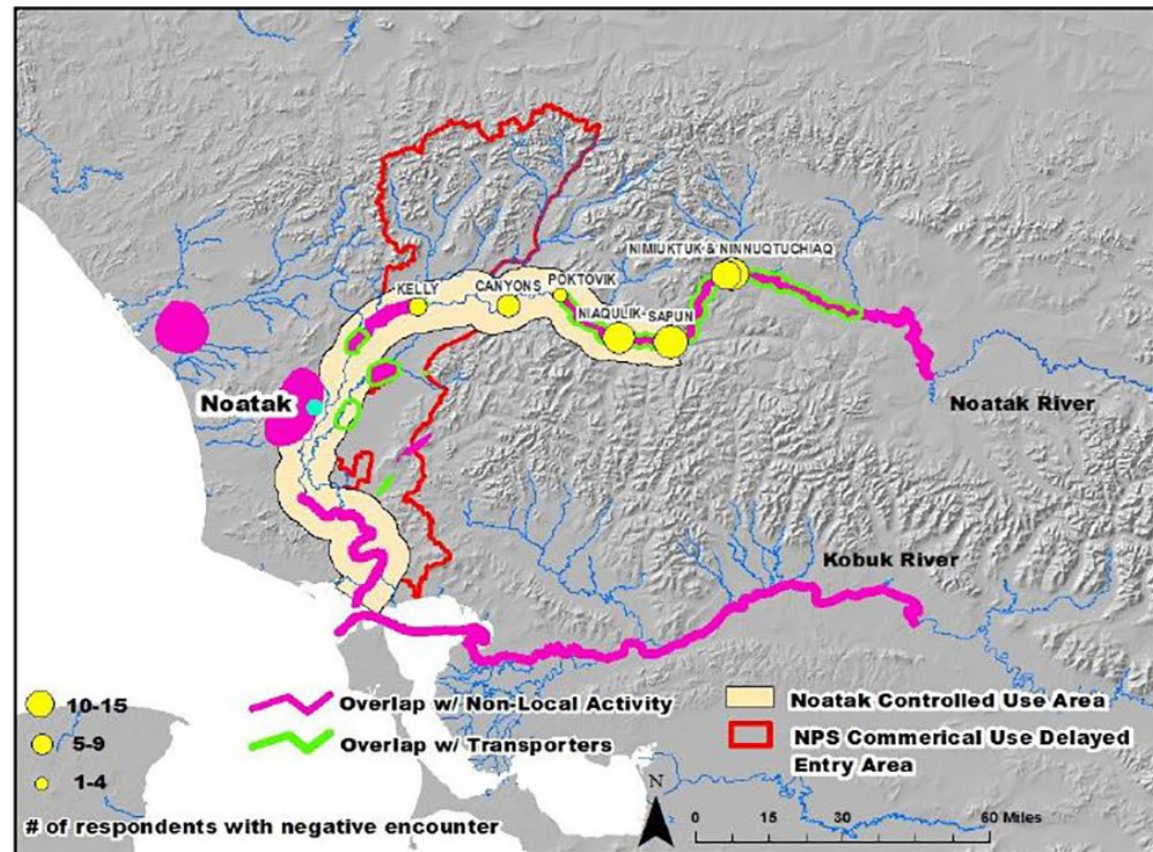
Multi-agency outreach on wasting meat and respecting traditional hunting practices.

Spatial Overlap of User Groups

Conflict over spatial overlap of subsistence and non-resident sport hunters has been a long-standing issue that continues to this day (Halas 2015, Magdanz 1979). The location where non-resident hunters are being dropped by transporters was another of the main concerns during the 2023 federal regulatory cycle. Halas (2015) looked at locations of overlap between user groups in Noatak National Preserve (Figure 3). She interviewed Nuatakmiit hunters about areas they'd used in the last 5 years as well as lifetime use areas and compared them to areas with non-resident sport hunting activity, including low-flying aircraft, hunting camps, and landings.

More than half of the hunters who responded to Fix and Ackerman's (2015) *Sport Hunter Survey*, said they did not receive information regarding subsistence areas to avoid or local hunting traditions to follow. When this information was received, the NPS was rarely the source (Fix and Ackerman 2015). Private allotments along the Noatak River, as well as favored and traditional camping spots are immensely important to local hunters for successful harvests.

In general, caribou hunting camps are positioned near well-established caribou river crossings, where riverine topography and conditions frequently funnel caribou into known fords. Camps are often situated at locations above the tree line with a clear view across the tundra, allowing hunters to watch for approaching caribou that begin to cross the river in mid-August—allowing hunters to assemble and prepare before the next pulse of migrating caribou meet the water (Deur et al. 2021: 46).



In 2022, the preserve was closed to non-resident sport hunters via a 2-year special action aimed at addressing user conflict. During the closure, non-resident hunters were transported to the open lands north of the closure, in the same Game Management Unit (GMU 23). In 2023 public meetings to discuss full closure of federal lands to non-resident sport hunting, there was growing concern from communities regarding this hunter displacement. During the fall caribou migration, caribou travel from north to south. This movement makes them accessible to local Nuatakmiit hunters. However, in the past 6 years, caribou have delayed or abbreviated their southward migration and stayed north

Figure 3. Areas of resident and non-local use and overlap. (Halas 2015)

longer or throughout the winter (Pers. comm. with caribou and local biologists Kyle Joly, Raime Fronstin, and Alex Hansen). This change has been detrimental to communities that rely on the herd for subsistence, and there have been several years in which villages have not had access to caribou. Subsistence users worry that the sport hunters positioned in the north may compound the effects that warmer weather is already having on the migration, inhibiting southward migration further (NPS CAKR SRC 2023, 2024; NPS KOVA SRC 2023).

Current Status

Wildlife management in Alaska is regulated by the [Federal Subsistence Board | U.S. Department of the Interior](#) (FSB) and the [Board of Game, Alaska Department of Fish and Game](#) (BOG). The FSB manages subsistence hunting and fishing on federal public lands in Alaska, prioritizing rural Alaskans' subsistence needs under ANILCA. The BOG oversees hunting regulations on state lands and waters, focusing on managing wildlife populations for both subsistence and recreational uses under state law. Both Boards have advisory councils that represent different regions in Alaska. These councils provide recommendations to the Boards, develop proposals to change regulations, review proposals submitted by the public, and provide an open forum for public concerns regarding wildlife and harvest matters.

Today the WACH is in a 20+ year decline, with a 2023 population estimate of 152,000 animals from its peak in 2003 at 490,000 animals (WACH Management Plan 2019: 2). Due to this decline, both the FSB and the BOG and approved (with modifications) caribou regulatory proposals submitted by concerned

local advisory committees to reduce subsistence bag limits from five caribou per day to fifteen caribou per year, per hunter, in which only one can be a cow (female caribou). The Federal Subsistence Board, using the [WACH Working Group Cooperative Management Plan](#) as a guide, approved the closing of all federal land in GMU 23, including Noatak National Preserve, to non-federally qualified subsistence users (non-resident sport hunters) until the herd reaches 200,000 animals ([Federal Subsistence Board Closes Federal Public Lands to Caribou Hunting by all Users in Units 11, 12 remainder, and 13 for 2024-2025 | U.S. Department of the Interior \(doi.gov\)](#)). The Board of Game, on the other hand, did not approve closure of state lands to non-residents, instead changing the hunt in GMU 23 from an unlimited registration hunt to a drawing hunt with up to 300 permits—which is more than the average annual number of hunters, effectively increasing the number of harvests. While local biologists agree that 300 caribou is not a biologically significant detriment to the herd, many locals argue that 300 caribou is enough to feed an entire village and is therefore significant to the people who depend upon them (NWARAC 2023, Kotzebue AC 2024). The average number of residents in a village in Northwest Alaska is 398. The significance of a harvested caribou has very different meanings to biologists, land managers, non-resident sport hunters, and local and Iñupiaq subsistence hunters.

There have been attempts to reconcile the different perspectives. In 2017, the Caribou Hunter Success Working Group was formed by Kotzebue state and federal agencies, NANA Regional Corporation, Maniilaq Association, and the Northwest Arctic Borough in response

to a motion by the Cape Krusenstern Subsistence Resource Commission to address a need for hunter education (Atkinson 2020). The Kiana Elders Council and Native Village of Kotzebue both worked with this group to create hunter ethics posters. Despite these efforts, concerns by subsistence users remain largely unchanged as of 2024. Continued requests for outreach have been called for (NWARAC 2023: 97):

[In reference to non-resident hunters]
Educate the outside users that there are villages out there, down there, and let them know that our cost of fuel is high and other people have no means to go out and hunt.

Conclusion

Preserving and protecting cultural and natural resources for the enjoyment of future generations is the mission of the NPS. “Hunter success,” “love for children,” and “respect for nature,” are 3 of the 18 values in the [Inupiat Ilitqusiut](#). These values are not so different from the NPS mission. This article attempts to illustrate the challenges that local Nautakmiit hunters face when outside hunters with different means of access and different hunting ethics come to their homeland. These are the challenges the NPS faces as well when attempting to manage resources for both hunting groups. The studies referenced in this article should continue to be referred to by management bodies as they make decisions for the protection of the caribou and the right to subsist. The complexity of these issues, diversity of people affected, and importance of food security warrant further investment. The NPS will continue to prioritize documenting these world views and seeking solutions to apply in management decisions.

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A bull caribou on the tundra in fall color, Noatak National Preserve.





Glacier Changes Drive New Challenges for Balancing Visitor Access and Natural Resource Protection in Glacier Bay National Park

Scott Gende, Alaska Region

Jamie Womble and Andy Bliss, Southeast Alaska Network

Park management decisions balance protection of resources and allowing access to them. Glacier Bay National Park and Preserve has long been able to do this by providing access to one tidewater glacier and protecting another for important seal habitat. But what happens when there is just one tidewater glacier? Can seals share their habitat with cruise ships?

Citation:

Gende, S., J. Womble, and A. Bliss. 2025. Glacier changes drive new challenges for balancing visitor access and natural resource protection in Glacier Bay National Park. *Alaska Park Science* 23 (1): 36-45.

The National Park Service (NPS) was founded on the mandate of preserving some of the nation's most cherished resources, and for the enjoyment and use by current and future generations. Recognizing the inevitable conflict produced by this dual mandate, [NPS Management Policies](#) (NPS 2006) acknowledge that virtually every type of use by park visitors impacts some resources in some way. What's more, the severity of resource impacts typically occurs across a continuum with no clearly defined, action-triggering threshold. Park managers are thus tasked with deciding which activities are appropriate, and then balancing the volume of visitors that should be allowed to partake in those activities relative to their expected impacts to the park's natural and cultural resources. An outcome of trying to resolve the conflict is that decisions on visitor access tend not to focus on preventing an impact from occurring but rather defining the degree to which the impact is deemed acceptable (Gende et al. 2019).

When faced with these decisions, a prudent starting point for park managers is to ask whether limiting access or managing natural resources in a certain manner runs counter to the park's founding purpose. Park purposes are derived from the act of Congress that set aside the unit for protection and provides the appropriate context for these decisions. For example,

the founding mandate of some historical parks is to preserve landscapes for "authentic interpretation" of significant historical events, such as an important battle. Doing so allows visitors to experience the area as it was at the time of the historical event, thereby helping the park to meet its fundamental purpose. However, this may result in active manipulation of the park's natural resources, such as maintaining a grassland that would normally be transforming into a forest due to successional dynamics (e.g., Young and Mahan 2023). In such a scenario, the impacts to the natural resources that result from intensive vegetation management is deemed acceptable in order to meet the site's founding mandate.

While the tension between visitor use/access and natural resource protection has long been at the forefront of park decision making, rapid, landscape-scale changes are now forcing many park managers to reconsider what were historically deemed acceptable tradeoffs. These decisions are becoming more pressing owing to altered trajectories of plant and animal populations and fundamental shifts in ecosystem processes.

Here we describe an emerging issue in Glacier Bay National Park and Preserve that exemplifies the inherent difficulty when balancing resource protection with visitor access. Initially

Cruise ship passengers get an up-close experience of a tidewater glacier.
NPS

protected, in part, to provide access to tidewater glaciers, Glacier Bay will soon only have one accessible tidewater glacier. This glacier provides habitat for a large aggregation of harbor seals and is protected by limiting access. Thus, some difficult questions arise: Can the park still meet its founding mandate if existing tidewater glacier access restrictions persist? If not, are there access alternatives that produce acceptable levels of disturbance risk to seals? Our goal is to contextualize these questions by summarizing (1) the park's founding purposes, (2) contemporary visitor access, (3) the dynamics of the tidewater glaciers and harbor seals in the park, and (4) the attributes of existing access regulations to help understand what's currently deemed acceptable.

Founding Mandates and Visitor Access at Glacier Bay

Glacier Bay was set aside for protection to achieve two fundamental purposes: to preserve an area that provides scientific opportunities to study landscape evolution in a dynamic glacial environment, and to protect an area where visitors can access and enjoy tidewater glaciers “of the first rank” by “ordinary travel.” In 1925, when Calvin Coolidge signed [Presidential Proclamation #1733](#) that first protected Glacier Bay as a national monument, “ordinary travel” was by large steamship. Steamships started making transits into Glacier Bay as early as the late 1880s with the specific purpose of providing passengers access to the tidewater glaciers. Over time, steamships gave way to ocean liners and ocean liners evolved into large cruise ships. Today's cruise ships, the largest of which (of those that currently visit Alaska) can carry nearly 5,000 passengers, bring more than 95% of the more than 700,000 visitors that annually visit



the park. In addition to bringing a large volume of visitors, cruise ships also provide access to the tidewater glaciers to a wide diversity of visitors spanning socioeconomic backgrounds and physical capabilities, thereby making the park more “...accessible to every segment of American society” (NPS 2006). Given that there are no roads and few trails in the backcountry of the park, and owing to their historical access and reference in the original proclamation, cruise ships represent an important means by which the park meets its founding mandate.

How does this access and enjoyment occur? When cruise ships visit Glacier Bay, they do not tie up to a dock or drop anchor to deploy

A cruise ship near the terminus of Margerie Glacier in Tarr Inlet.
NPS

tenders; all passengers remain onboard during the 8-12 hours the ship transits the fjord. Upon entry into the park, all cruise ships follow a similar course from the park's entrance in Icy Strait up the western arm of Glacier Bay's Y-shaped fjord and into Tarr Inlet to access and enjoy the Margerie Glacier. Depending on the density of icebergs calved from the glacier, the ships can often safely approach the glacier's terminus, providing an extraordinary experience for visitors. Ships typically spend one to several hours near the tidewater glacier, which also allows on-board interpretation to occur.

During most of the summer, however, cruise ships are prohibited (per CFR 36 13.1178, 2025) from a similar approach of the Johns Hopkins Glacier, located just around the corner in Johns Hopkins Inlet. This prohibition occurs despite the glacier being accessible, tidewater, and, by all accounts, of "first rank." The reason for this restriction, which spans from 1 May until 1 September, is based on resource protection: vessels can disturb seals and Johns Hopkins Inlet is the location of the largest seasonal aggregation of harbor seals in Glacier Bay, typically numbering over 2,000 individuals (Womble et al. 2020). Seals haul out on icebergs in the inlet for pupping, molting, and avoiding predators. Disturbance can send them back into the water thereby disrupting those vital activities. Observational studies conducted in Johns Hopkins and other glacial fjords demonstrate that the closer marine vessels approach seals, the greater chance the seal will abandon the ice and flush into the water (Jansen et al. 2010, Young et al. 2014). While the impacts of a disturbance event can vary in magnitude, seal pups are particularly vulnerable. If disturbed,



pups can become separated from their mothers, and statistical models have demonstrated that even small increases in time spent in the cold glacial waters can result in newborn pups entering negative energy balance with potential deleterious impacts on survival (Harding et al. 2005, Jansen et al. 2010).

The unrestricted access to Margerie Glacier, and the extraordinary experience it provides, helps the park meet the mandate for access and enjoyment of a tidewater glacier "of first rank." With this mandate met, the access restrictions for cruise ships to the Johns Hopkins Glacier are deemed acceptable, which allows the park to maximize protections from disturbance for the aggregation of seals in Johns Hopkins Inlet.

Icebergs are particularly important to seals when they are pupping or molting. If they are disturbed and flush into the water, it could interrupt their nursing and expose them to cold water and predators when they are most vulnerable.
NPS/JAMIE WOMBLE



Passengers view the Johns Hopkins Glacier from the deck of a cruise ship that is stopped at Jaw Point. The photo was taken in July 2023 and reflects the recent trend of ice density being increasingly sparse for much of the inlet and a clustering of harbor seals near the face of the glacier. The photo also demonstrates the difference in approach distances by cruise ships to the Johns Hopkins Glacier compared to a typical approach to Margerie Glacier. NPS

The Last Accessible Tidewater Glacier?

When Glacier Bay was first set aside for protection in 1925, a ship entering the fjord would be able to access a number of tidewater glaciers including but not limited to the Muir, Grand Pacific, Margerie, Lamplugh, McBride, and Johns Hopkins/Gilman (Figure 1; McNabb and Hock 2014). Today only Margerie and Johns Hopkins/Gilman glaciers are both tidewater and accessible, although their dynamics differ markedly.

Johns Hopkins Glacier is one of the few tidewater glaciers in Alaska that is advancing: its terminus advanced over 1 mile (1.6 km) since 1948 (McNabb and Hock 2014) and the lower reaches have thickened by over 328 feet (100 m; Larsen et al. 2007). Recent satellite-derived

velocity measurements and digital elevation models demonstrate that the terminus area of the glacier has slowed down and has continued to thicken and gradually advance in recent years (Kaluzienski et al. 2023). In sharp contrast, Margerie Glacier is both rapidly thinning and receding (Figure 2). While efforts are underway to better estimate the speed of recession, observations from NPS interpretative rangers traveling on cruise ships noted at least several years ago that the northern part of Margerie's terminus now ends on land (no longer reaches saltwater).

If the recent past is a gauge for the near future and projections of increasing temperatures continue, the grounding of Margerie Glacier, and its recession back into the valley, is

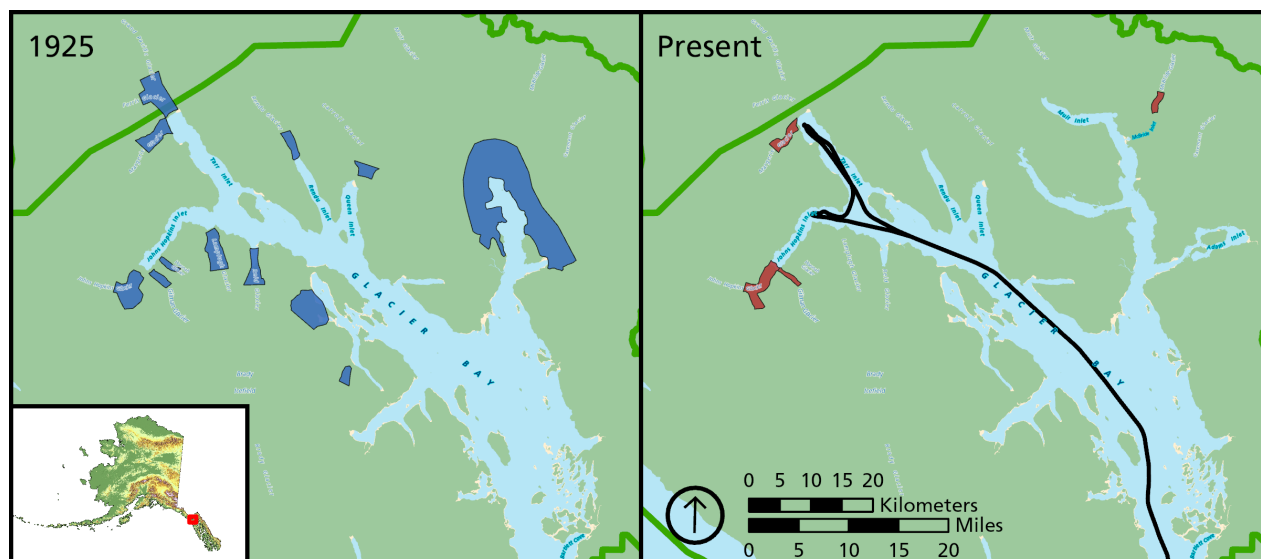


Figure 1. The distribution of tidewater glaciers in Glacier Bay in 1925 (left panel) compared to today (right panel). The colored polygons reflect only the lower reaches of the tidewater glaciers to highlight the contrast between the two time periods. The right panel also includes the route typically taken by cruise ships for most of the summer (until 1 September). Ships proceed up to the face of Margerie Glacier in Tarr Inlet but turn around at Jaw Point at the mouth of Johns Hopkins Inlet allowing passengers to view the glacier from 7 miles distant. Note that the only remaining tidewater glacier in the eastern arm of Glacier Bay (McBride) is inaccessible to ships and not safely accessible to smaller boats.

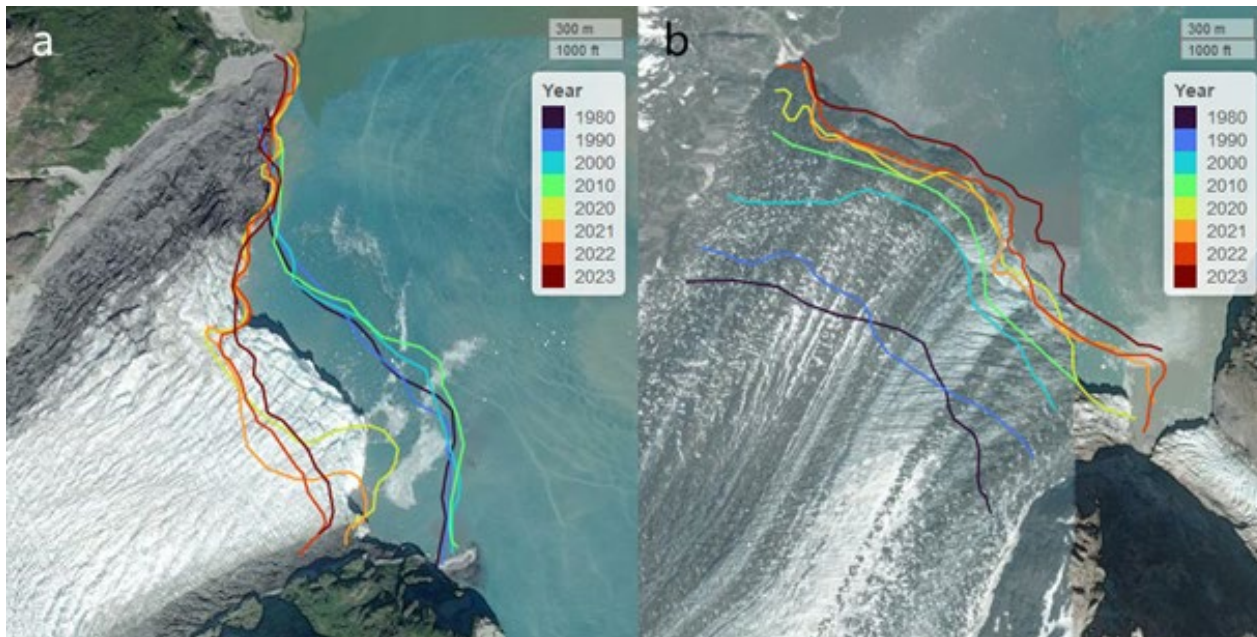


Figure 2. Margerie Glacier (a) in Tarr Inlet has started to retreat in recent years after decades of stability. Johns Hopkins Glacier in Johns Hopkins Inlet (b) has been advancing since the 1920s, making it unusual among glaciers in Alaska.

Outlines shown here were traced from Landsat and Sentinel satellite images (McNabb and Hock 2014, with updates by Bliss). Note: the color scale is decadal from 1980-2020, and then annual 2020-2023. Background images © ESRI.

imminent. Should this occur, the Johns Hopkins would become the last accessible tidewater glacier to cruise ships in the park.

Seasonal Dynamics of Seals and Ice

Managers at Glacier Bay National Park and Preserve have a long history of supporting research and monitoring efforts to help inform decisions when resources and values may be impacted by vessel operations and visitor activities (e.g., Gende et al. 2005, Piatt and Gende 2007). Given more than 30 years of managing visitor access in areas used by harbor seals, it's not surprising that the park has supported long-term monitoring of the harbor seal aggregations in Glacier Bay since the 1990s

(Mathews and Pendleton 2006, Womble et al. 2010, Womble et al. 2020). In sum, up to 4 replicate aerial photographic surveys are flown each year in mid-June, coinciding with the peak in pupping, and in mid-August to coincide with the peak in molting. In Johns Hopkins Inlet, the surveys follow a systematic route, whereas a more opportunistic route is flown to cover the myriad beaches, reefs, islands, and islets (collectively, "terrestrial sites") that are also used by seals throughout the summer. All photos are analyzed to estimate the total number of seals present. These data have generated important insights into the dynamics of seals and ice, with possible implications regarding access restrictions in Johns Hopkins Inlet.

Foremost, analysis of the data during the first several decades of monitoring revealed that, in June, icebergs and harbor seals were typically spread throughout the inlet including areas just up to, and at times beyond, Jaw Point. By August, the density and distribution of ice had diminished significantly (up to 7 times reduction) resulting in seals and ice becoming highly clustered near the terminus of the glacier (Figure 3; Womble et al. 2020, Womble et al. 2021). More recently, however, the phenomena of largely clustered ice and seals near the glacier's terminus has been documented during the June surveys as well (Figure 4), possibly due to the growth of the glacier's end moraine (Kaluzienski et al. 2023).

The second relevant finding is that ice density appears to influence seal reactions to an approaching vessel. In an observational study where seal flushing distances were quantified in response to private, tour, and charter vessels, in addition to cruise ships, Young and others (2014) found that seals tended to remain on the ice at closer approach distances during periods of low iceberg density compared to periods when icebergs are abundant. For that research, disturbance was defined as seals flushing from the ice into the water as a result of an approaching vessel, although it's worth noting that a seal can still be disturbed without flushing from the ice.

Together, the research and monitoring results demonstrate that the risk of seal disturbance, particularly near the mouth of Johns Hopkins Inlet, is comparatively much lower in recent years compared to several decades ago owing to larger expanses of open water free of both ice and seals. While these results are timely and scientifically derived, they do not resolve



The largest seasonal aggregation of harbor seals in Glacier Bay is associated with Johns Hopkins Glacier, typically including more than 2,000 seals.
UNESCO/MARK KELLY

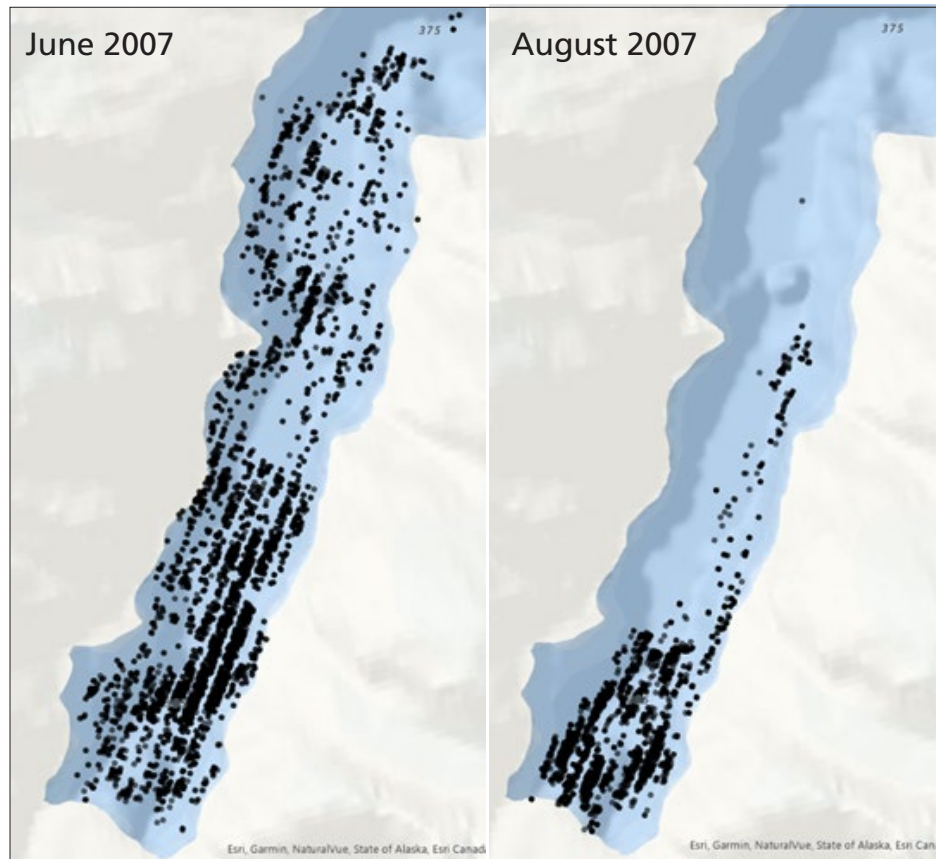


Figure 3. Harbor seal distribution in Johns Hopkins Inlet during June and August 2007 demonstrating the marked reduction in ice and seal distribution as the summer progresses.

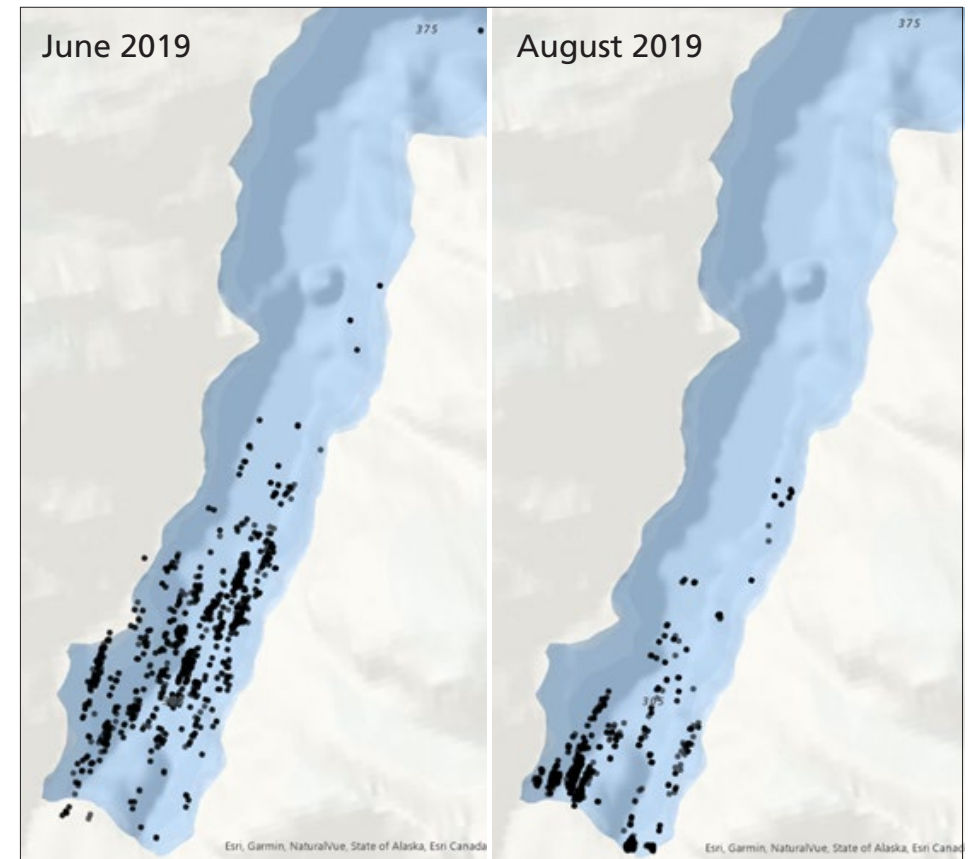


Figure 4. Harbor seal distribution in Johns Hopkins Inlet during June and August 2019 reflecting the trend in recent years of less ice and highly aggregated seals near the glacier throughout the summer.

whether the lower level of risk represents an *acceptable* level of risk. We thus review the attributes and implications of the existing access restrictions to help contextualize what's currently acceptable.

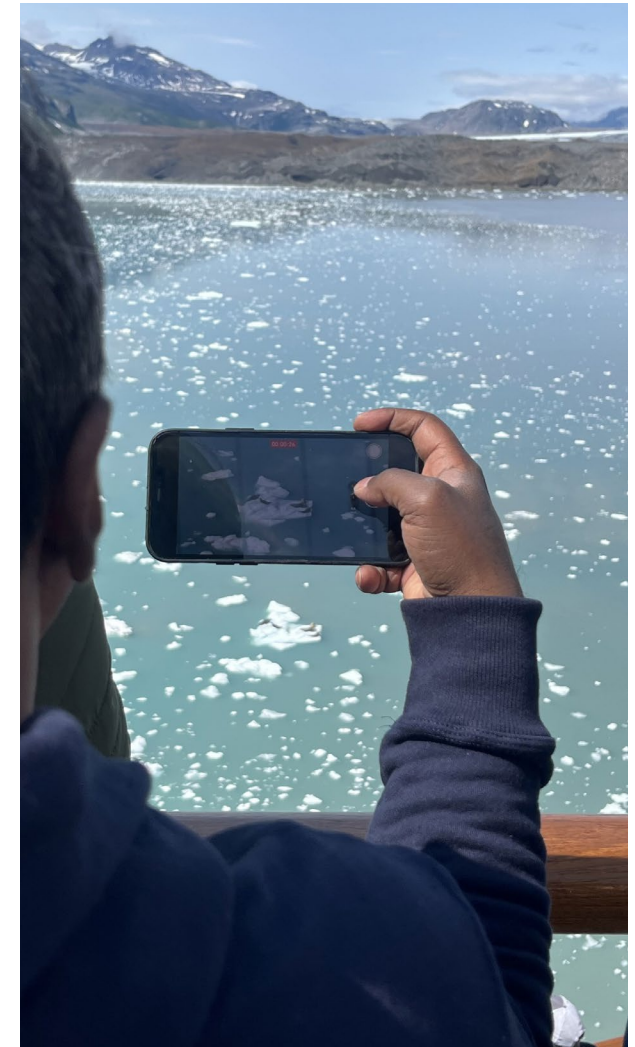
Acceptability in Disturbance Risk

Access restrictions to Johns Hopkins Inlet for cruise ships (and other vessels) have been in place since the 1990s by designating a line that demarcates when and where cruise ships can go. Prior to the tourism season, park staff communicate to the cruise ship companies the suite of restrictions and operating requirements for the upcoming summer, including a reminder of the "line" in place from 1 May through 31 August, that extends due west from Jaw Point separating the go/no-go area. This access regulation is easily understood, can be designated on an electronic chart, and is communicated in sufficient time prior to the season to allow ships to integrate into navigational planning. As a result, violations of the regulation are exceedingly rare.

However, the designation of a static line at Jaw Point, and the decision to allow access to Margerie Glacier throughout the summer, represents a management approach for reducing, rather than eliminating, the risk of disturbance to seals. For example, there are a number of days, particularly in the early part of the summer, when large volumes of icebergs and, at times, many hauled-out seals, have drifted past Jaw Point and into the area where cruise ships are allowed. While ships are expected to maneuver to avoid disturbing seals ("except when safe navigation requires"), icebergs drifting into the cruise ship route constitutes an infrequent yet unavoidable scenario throughout the summer. What's more,

private, tour, and charter vessels are afforded access to Johns Hopkins Inlet beginning 1 July (CFR 36 13.1178 2025) and these vessels have also been documented disturbing seals, albeit at lower rates than cruise ships (Young et al. 2014). Finally, monitoring data have demonstrated that a small number of harbor seals still use icebergs in Tarr Inlet during the summer, occasionally including mothers with newborn pups. Indeed, NPS interpretative rangers traveling on the ships regularly point out seals on ice to passengers as part of the outreach efforts when ships are near the Margerie Glacier.

Ship operators are expected to minimize risk of disturbance by making prudent navigational decisions based on ice distributions they encounter. Identifying a course that avoids aggregations of seals and minimizes a chance encounter is one of the primary goals for deck officers when they enter Tarr Inlet. In fact, it's not uncommon to see up to 4 deck officers, and the marine pilot, standing on the ship's bridge scanning the water ahead with binoculars to identify any seals hauled out on ice. Yet, as any vessel operator that has visited these areas can attest, the jagged nature of icebergs can often hide a resting seal until the vessel is too close to avoid it. What's more, the tide-driven currents and unpredictable winds can quickly close an open water lead creating the possibility that, even if a ship had no ice or seals around it during approach, ice and resting seals can quickly surround the ship upon exit. Not surprisingly, ship captains tend to be extraordinarily risk averse when it comes to proceeding into areas with even moderate iceberg density, in part to avoid the possibility of damaging the hull. This creates a somewhat self-regulating scenario: when icebergs (and seals) are likely to overlap



Passengers view harbor seals hauled out on an iceberg in Tarr Inlet, near the Margerie Glacier. The opportunity to see harbor seals contributes to the extraordinary experience of visitors to these inlets.

NPS

with the route the ships take, ship personnel are less likely to proceed. This is one of the reasons (in addition to time constraints) why, even after Johns Hopkins Inlet opens on 1 September to cruise ships, only a small number of them choose to travel all the way to the face of the glacier.

The current approach to managing acceptable levels of seal disturbance is based, in part, on static decisions: when and where vessels are allowed is designated independent of the actual conditions vessels would encounter in those areas during those periods. An alternative would be a more dynamic (adaptive) approach, although it is worth noting the hurdles that the park would face if it pivoted to a framework where access restrictions are based on ice and seal distributions encountered in real time. For example, recent studies have demonstrated that ice in the inlet can be highly variable depending on ice calving dynamics and local environmental variables including winds, currents, and tides (Kaluzienski et al. in press). Thus, it is unclear how long after a survey is conducted that the data would reflect the conditions in the inlet given that they can change daily or even hourly. Alternatively, the park could use satellite imagery to help inform the dynamic decision, although persistent cloud cover can preclude accurate information for weeks at a time. Finally, images from land-based cameras can be collected (and possibly transmitted) on an hourly basis (Keinholz et al. 2019, Kaluzienski et al. in press), but would need to be summarized and conveyed to ships in a useable format in near real-time—a labor-intensive and time-consuming process.

In 2023, a partnership was initiated between the NPS, the University of Texas, and Texas A&M University (with support from the National Science Foundation) with the goal of using existing data from research and long-term monitoring to better understand disturbance risk under possible alternatives to the existing access restrictions in Johns Hopkins Inlet. While the project will focus on developing state-of-the-art quantitative tools to explore different scenarios, ultimately it will be up to park managers to define acceptable risk levels relative to the benefits of enhanced visitor access. Through careful assessment of the science of seal behavior and a commitment to continued long-term monitoring of the seal population, the park is in excellent position to identify alternatives that fulfill the enabling legislation of the park and helping to resolve the inherent conflict of the dual mandate.

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A Data-driven Approach to Transportation Planning in Denali

William Clark and Dave Schirokauer, Denali National Park and Preserve

Wildlife viewing may be the core challenge of Denali's promise to its enabling legislation and the Organic Act and is the principal reason summer visitors come to Denali. Wildlife can be seen frequently from the bus, but buses can disturb or endanger wildlife. Data-driven vehicle management planning helped the park balance wildlife protection and wildlife enjoyment.

Citation:

Clark, W. and D. Schirokauer. 2025. A data-driven approach to transportation planning in Denali. *Alaska Park Science* 23 (1): 46-51.

In 1972, Denali National Park and Preserve (Denali) implemented the first (to the author's knowledge) regulated system for vehicle access into a national park. Since the Denali Park Road (park road) was completed in 1938, it has provided the only motorized vehicle access into the park (Figure 1). For much of the park road's 85-year history, there has been a direct relationship between the expansion of Alaska's transportation infrastructure and the increase in visitors—and traffic—at Denali. In the year following the completion of the Denali Highway (Alaska Route 8), which linked Denali to North America's expanding road network for the first time, Denali visitation doubled from 5,200 to 10,700. Visitation continued to increase every year through 1971 when there were 44,500 recorded visitors. In 1972, the year following the completion of the George Parks Highway (Alaska Route 3), which more directly linked Denali to Alaska's 2 largest cities and airport hubs, Denali visitation doubled again to 88,625. Today, Denali visitation is regularly around half a million visitors (500,000). As public lands face increased use, federal managers from the National Park Service (e.g., Acadia National Park, Rocky Mountain National Park), U.S. Fish and Wildlife Service (e.g., Kilauea Point National Wildlife Refuge), U.S. Forest Service (e.g., Angeles National Forest), and Bureau of Land Management (e.g., Red Rock Canyon National

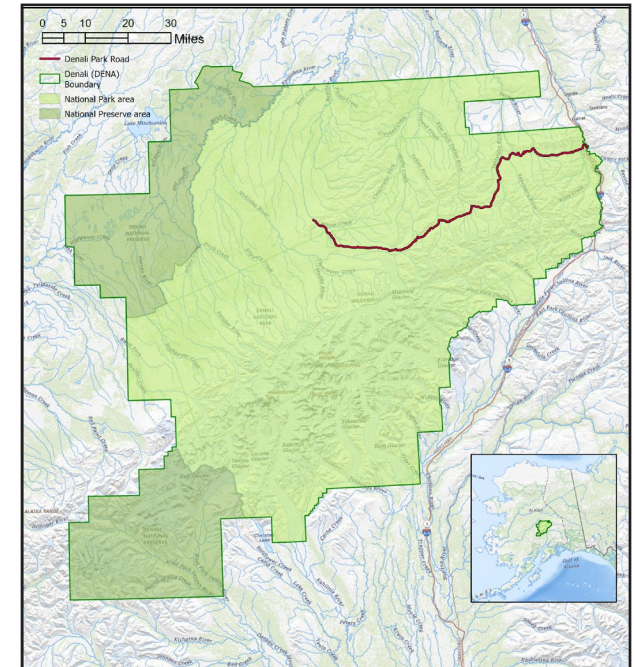


Figure 1. Denali National Park and Preserve is in interior Alaska. Access is provided by one main road (red) about 4.5 hours from Anchorage and 2 hours from Fairbanks.

Conservation Area) have begun to regulate the number or timing of vehicle entries for at least 13 public lands across America and dozens of other areas have some form of alternative transportation system (ATS) that served more than 26 million visitors in 2022 (NPS 2022).

While no major infrastructure improvements have been made in the more than 50 years since the Parks Highway was completed, Denali tourism demand has continued to increase in step with Alaska tourism broadly. In 2006, park managers initiated a comprehensive study to identify the quantity of traffic that could be accommodated on the park road while protecting park resources and maintaining high-quality visitor experiences—the Organic Act in action. The study has three focus areas: (1) factors important to visitor experience; (2) traffic effects on large mammal behavior; and (3) logistic constraints to park road traffic patterns. Collectively, these studies were synthesized into the [Denali Park Road Final Vehicle Management Plan and Environmental Impact Statement](#) (VMP; NPS 2012). The VMP was first implemented in 2013 and is intended to guide vehicle traffic management during the summer season in Denali for the next 20-30 years. It uses an adaptive management approach that includes annual monitoring of desired resource condition indicators. Since 2013, Denali has collected over 70,000 data points of 66 metrics related to 6 indicators of resource conditions, traffic conditions, and visitor experience.

Wildlife Viewing

Wildlife viewing may be the core challenge of Denali's promise to its enabling legislation and the Organic Act and is the principal reason summer visitors come to Denali (Fix et al.



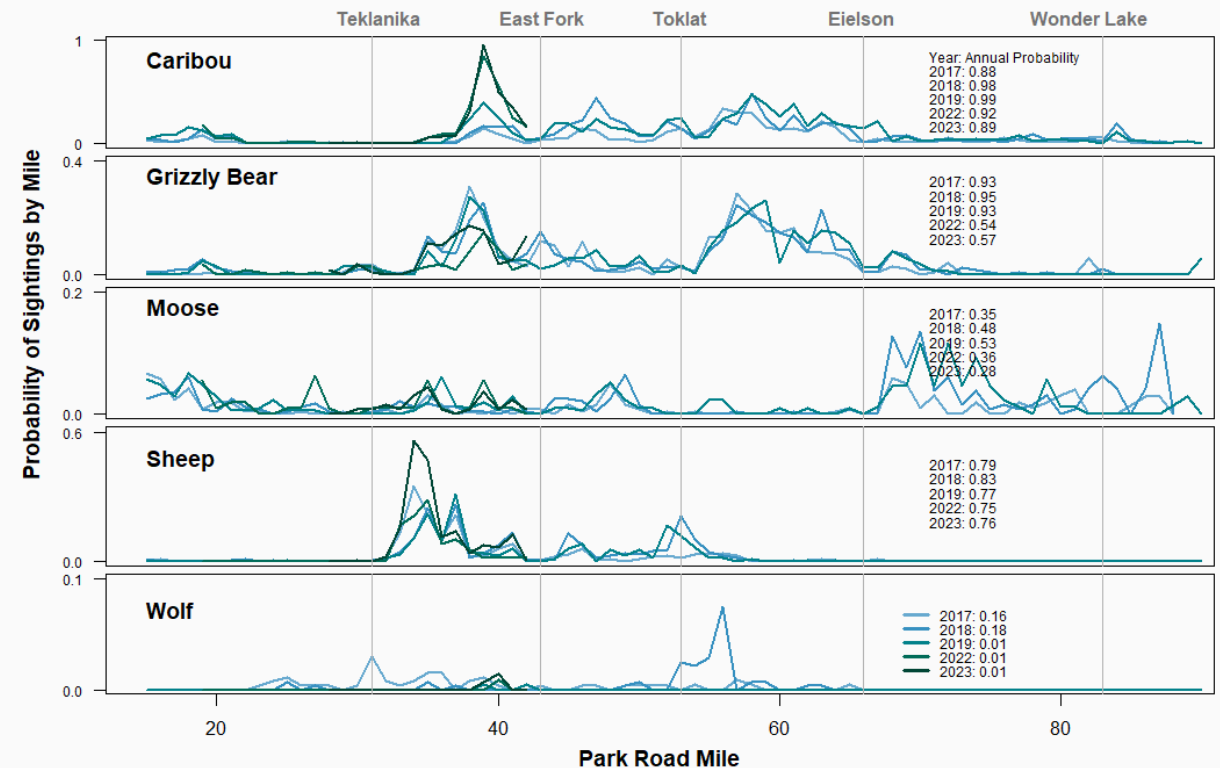
2013). Wildlife can be seen frequently from the bus, but buses can disturb or endanger wildlife. Maintaining the best-possible viewing conditions from both a visitor and wildlife perspective is critical. Under the best conditions, wildlife viewing events are enjoyed by just a few vehicles at a time: The bus slows to a stop and children are hushed as families are awestruck by a caribou's amber-flecked, brown eyes; the crenulations of a Dall sheep's thick, curling horns. With engines off, and listening closely, riders can often hear the soft pop of blueberries being pulled from their stems by a grizzly bear readying for an always-nearby winter. These are the indelible images fixed to the spirit of Denali visitors.

A close view of the crenulations of a Dall sheep's curling horn.
NPS/TIM RAINS

To protect opportunities for such encounters, the VMP established desired conditions for the number of vehicles present at wildlife viewing stops. We have collected over 24,000 observations at wildlife viewing events since 2013. Prior to the pandemic, the probability of seeing caribou, Dall sheep, grizzly bear, and moose was greater than their 10-year average (Figure 2, last 5 non-COVID years shown). In fact, caribou and moose were at recorded high probabilities and the probability for sighting grizzly bears tied for second highest on record. Wolves have been less frequently observed in the last 5 years.

It will be a few years until Denali is able to collect data again that are most directly comparable to 2013-2019. The COVID pandemic and a landslide have altered how the park road has been accessed since 2019—for safety reasons, staff could not observe bus trips in 2020 and 2021 and beginning in 2022, a landslide has blocked vehicle access beyond mile 43 of the park road. Thus, viewability data, historically calculated based on sampling to Eielson Visitor Center (mile 66), have been modified to samples to the East Fork River turnaround (mile 43). This change is not only a reduction of 23 road miles, but also missed opportunities through wildlife-rich habitats (Clark 2023).

The characteristics of viewing opportunities of grizzly bears are of particular interest to park managers because: (1) grizzly bears are generalists that often forage along the road corridor and may be vulnerable to traffic displacement effects, and (2) park visitors have indicated the high importance of grizzly bear sightings to their Denali experience (Keller 2019). Since 2013, the average viewing distance of grizzly bears has been 870 feet (265 m). When

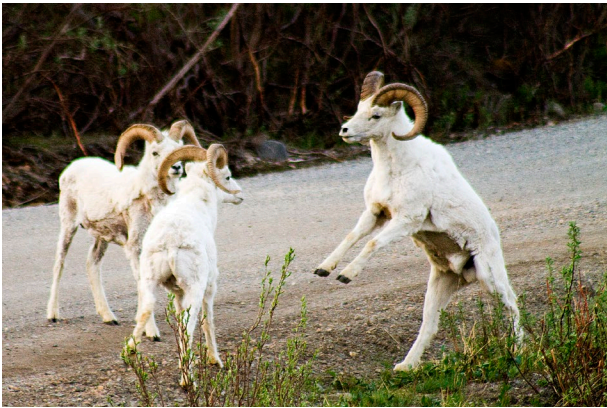


controlling for access differences, grizzly bears were observed significantly further from the road in 2022 and 2023 (1,200 feet and 1,082 feet [367 m and 330 m], respectively) than the 11-year average.

Interestingly, the percentage of time that bears were observed close to (less than 36 feet [11 m]) or on the eastern half of the park road has increased slightly since 2020. We will collect more years of data to investigate if the compressed road access could be a factor.

The landslide on the park road has presented an unprecedented opportunity to conduct a before-and-after study of traffic on a road in a world-renowned wildlife landscape. To further

Figure 2. The likelihood of seeing one of the big five mammals on the Denali Park Road (2017-2023; excluding the pandemic years, 2020 and 2021). For 2022 and 2023, public bus access has terminated at mile 43, the East Fork River Bridge, due to a landslide.



Grizzly bears often forage near the road corridor and are important to visitor experience (top).
NPS/MARY LEWANDOWSKI

Dall sheep frequently cross the park road and their behavior is negatively impacted by traffic volume (above).
NPS/NATHAN KOSTEGIAN

describe grizzly bear behavior in the presence and absence of park road traffic, Denali will examine the locations and activities of GPS-collared bears (about 12 individuals) on the nearly vehicle-absent (using vehicle-based observations) west side of the road compared to bears on the east side of the road exposed to more traffic. The study launched in 2022 and will continue for 2 years after the landslide-spanning bridge project is completed.

Vehicle Spacing

Beyond wildlife viewing, protecting the free movement of wildlife is also a management priority. Wildlife collar data from the 2006 study data suggested that vehicle spacing (gaps in traffic) is particularly important for Dall sheep. [Dall sheep frequently navigate from the Alaska Range south of the road to the mountains north of the road](#) (for reasons including seeking lambing grounds, browse, and protection from predation) and their movements became hurried and erratic in the presence of higher traffic volumes (Phillips et al. 2010). In fact, the movement speed of Dall sheep increased 5-fold when crossing the road compared to their other activities. Considering some sheep crossed the road over 50 times over the 4-month study, hurried movement to avoid road-based interactions has a real caloric cost that may reduce recruitment. To protect opportunities for wildlife to move freely from one side of the road to the other, Denali established a desired condition that every hour have a minimum of one 10-minute period when traffic does not pass, known as “sheep gaps.” This has been the most difficult VMP standard to meet. The VMP establishes a goal of meeting vehicle spacing standards 90% of the time (e.g., 90 of 100 days). Denali has met the standard 60% of the time.

When desired conditions are unmet, the VMP prioritizes adopting the least restrictive management tactic before escalating. Following several years of adapting vehicle schedules with mixed success, mandatory stopping at sheep gap sites was implemented in 2022. When a vehicle arrives at a critical wildlife zone identified in the VMP within the first 10 minutes of the hour, that vehicle is expected to stop until 10 minutes past the hour. The strategy appears to have been effective. Both sites (the only two currently open to vehicle traffic) met the VMP standard in both 2022 and 2023, marking only the first and second time that one of these sites met management goals since 2015. Moreover, the data show that 1 of the 2 sites would have failed to meet the desired condition had the mandatory stopping not been in place in 2022.

While the VMP may have been written to mean that traffic volumes should be at a level such that random 10-minute breaks in traffic occur every hour, that condition has been rare since 2013. Though not random, mandatory breaks in traffic are an effective and valuable management adaptation and emblematic of the creative solutions required from land managers as pressures on park facilities increase.

Closing Thoughts

At its core, the VMP is a monitoring program born of an opportunity to address carrying capacity. The concept is simple: *Within the park road corridor, at some level of traffic condition (e.g., quantity, frequency, or type), there will be measurable negative effects on natural and cultural resources and visitor experience.* Many of those negative effects can be curbed by requiring an ATS, such as a busing system.

ATSS are not a panacea because they can also have negative effects to the environmental, social, or economic qualities of a park (Spernbauer et al. 2022). Some of the environmental and social benefits are clear and calculable (e.g., carbon footprint), while others are harder to quantify. For example, ATSS are expensive to operate, rarely free, and not possible for all capabilities of visitor. It is important to ask, *who are we excluding from entry due to access or price barriers?*, which likely requires site-specific study. Denali is not immune to these challenges, and they should be considered.

Even so, Denali has observed successes. In 2019—the last year with access comparable to historic data—about 13,477 vehicles transited the park road, which is only 800 more vehicles than in 1984 (about 12,661 vehicles), and simultaneously increased park road access by 31% (about additional 68,000 visitors). Not many places in the world could claim that, let alone a high-profile North American national park. Many parks are challenged by capacity-related issues like crowds and traffic congestion, which threaten natural and cultural resources and the quality of visitor experiences. For managers looking to use data-driven means to maintain visitor experience and resource protection, the VMP may be a helpful model. Perhaps an ATS could benefit your favorite park.

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The Ecology of Visitation: Investigating the Rise of Bear Viewing in Two Remote Alaska Parks

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Alaska parks receive some of the lowest visitation numbers in the National Park System. Yet, as bear viewing interest becomes a dominant activity in southwest Alaska parks, visitor densities are increasing in areas with the highest densities of bears. To prevent overcrowding, reduce adverse bear-human interactions, and to mitigate environmental degradation to bear-viewing locations, parks incorporate visitor-use data into site-specific management decisions.

Citation:

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Bear viewing in Alaska has rapidly increased in recent years, concurrent with the state's tourism industry boom and the rise of social media as a preeminent cultural force (Brownlee et al. 2017-2020). Following the recovery from the COVID-19 pandemic, national parks in Alaska continue to see higher visitation rates in remote areas accessible primarily by boat or small aircraft, triggering renewed interest in reliable data on visitor use to ensure the well-being of wildlife and people alike. In low-access parks like Katmai and Lake Clark national parks and preserves, the question of gathering visitor-use data can present difficulties.

The remote nature of these parks, while appealing to some visitors, is challenging for researchers. People go to Alaska's wilderness expressly seeking solitude and frequently complete trips without interacting with any National Park Service (NPS) staff. Alaska parks receive some of the lowest visitation numbers in the National Park System. Yet, as bear viewing interest becomes a dominant activity in southwest Alaska parks, visitor densities are increasing in areas with the *highest* densities of bears. To prevent overcrowding, reduce adverse bear-human interactions, and to mitigate environmental degradation to bear-viewing locations, parks are charged with incorporating visitor-use data into a strategy for site-specific management action.

At Lake Clark and Katmai there are few reliable single-entry points and little-to-no front-country. Many visitors fly to their selected backcountry locations directly out of Anchorage or Homer. In these remote parks, places with the closest semblance to front-country (Port Alsworth in Lake Clark, Brooks Camp in Katmai), are already located deep within respective park boundaries, off highway systems, and without entrance kiosks and staff resources with consistent methods of counting incoming visitors. These locations are in themselves destinations, not entrances. In this context, baseline establishment of visitor norms, expectations, and experiences is more infrastructurally difficult.

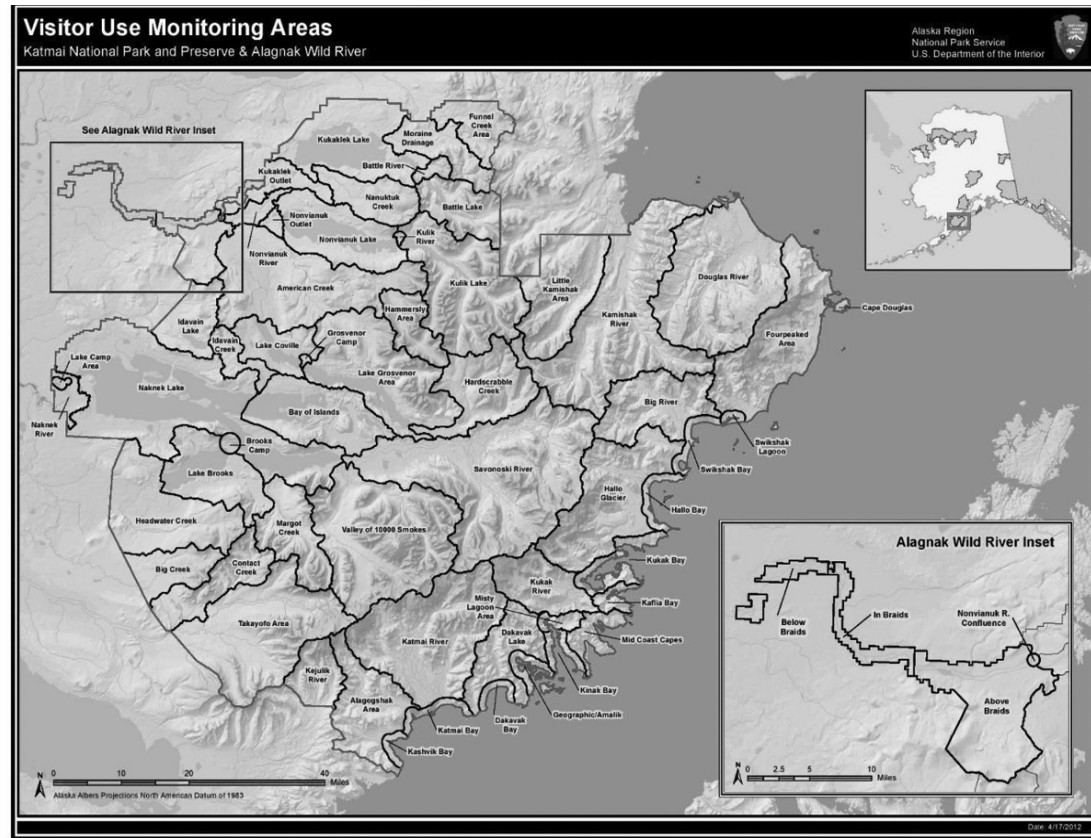
Monitoring visitor use in remote areas is expensive in terms of both access and staffing. The most obvious method for improving visitor-use knowledge—stationing staff at all high-use locations—is far costlier in large, remote parks compared to more accessible parks in other NPS regions. Estimating visitor-use numbers in Lake Clark and Katmai, for example, is primarily limited to the annual reports submitted by commercial use authorization (CUA) permit holders. CUA permit holders are businesses (air taxis, lodges, outfitters, and others) that operate within national parks and are required to submit reports to the NPS to track visitor use and ensure compliance with park regulations.

Their reports provide information on trip date, number of visitors transported or guided, areas accessed (Figure 1), and primary activity type. The reports are then aggregated by the parks for a quantitative understanding of visitor use.

Data on visitors is reported by CUAs as *visitor-use days*, counted for each day that any visitor engages in any activity within the park. The Southwest Alaska Inventory & Monitoring Network (SWAN) has analyzed visitor-use data for Lake Clark and Katmai since 2007. Trends are clear: bear viewing has rocketed upward since 2008 in Lake Clark, outpacing the second-highest reported activities, sport fishing and photography, by 42% in 2016. Between 2012 and 2019, bear-viewing visitor use days had tripled (Ehrenpreis and Kao 2021).

CUA reports provide vital information to parks, but the method is a simple index of visitor use that supplies the quantitative elements of park use, like amount and type. It does not provide substantive information about the quality of visitor experience. This information is vital to understanding to visitor experience in parks and how park resources should be managed as bear viewing activities increase. We do not have reliable and regular methods for identifying how close visitors are getting to bears, what level of risk they're taking or education they're receiving, how many groups are viewing bears at once, or other elements of their experience and the environmental conditions on site.

As visitor presence in these areas increases, so does the need to manage for visitor satisfaction, providing visitor safety education, and ensuring bear well-being. From 2017 to 2021, a series of visitor-use studies were conducted in Lake



Clark and Katmai by teams at the Clemson University Park Solutions Lab and the Kansas State University Applied Park Science Lab. Their research addressed visitor expectations amid increases in bear viewing and the development of methods for collecting better data on visitors in remote areas. Identifying how visitors perceive and evaluate environmental quality is critical to “[anticipating] public responses to the possibility of changing conditions” (Nettles et al. 2021: 18). The study sought to answer the following questions from a few different speculative approaches: How do we ensure that the bears are not detrimentally impacted by increased visitor attention? How do we ensure

Figure 1. A map showing the visitor use areas within Katmai National Park and Preserve.

that the visitors' experience is not lessened by overcrowding and degraded environmental conditions?

This research considers visitor use to be an intersection of social science and wildlife research, and advocates for further exploration of this approach. Questions of how visitors interact with wildlife and how wildlife respond to visitors reach into different fields of research, from human behavioral psychology to wildlife biology. The researchers' aim was to quantify relationships between visitor use and resource and social conditions at these parks and gather general baseline information about remote visitation (Nettles et al. 2021). The project had multiple components: (1) studies on visitor use satisfaction, the emotional effect of bear-viewing on humans, (2) the use of social media as a tool to understand visitation, and (3) the use of utilization distribution in visitor use research. The following summary refers to the results of the general visitor-use survey from Lake Clark (Figure 2 shows the visitor use monitoring areas for Lake Clark National Park and Preserve).

Visitor Use and Satisfaction at Lake Clark National Park and Preserve

Using visitor questionnaires, the first phase of the project identified a set of important indicators and associated thresholds when it came to visitor preferences for conditions during popular park activities—that is, a template for what visitors expect when they come to remote Alaska parks.

These indicators and thresholds provide a quantifiable means to analyze the subjective, preferential aspects of park use and visitor experience. Indicators and thresholds are terms foundational to normative theory, an approach

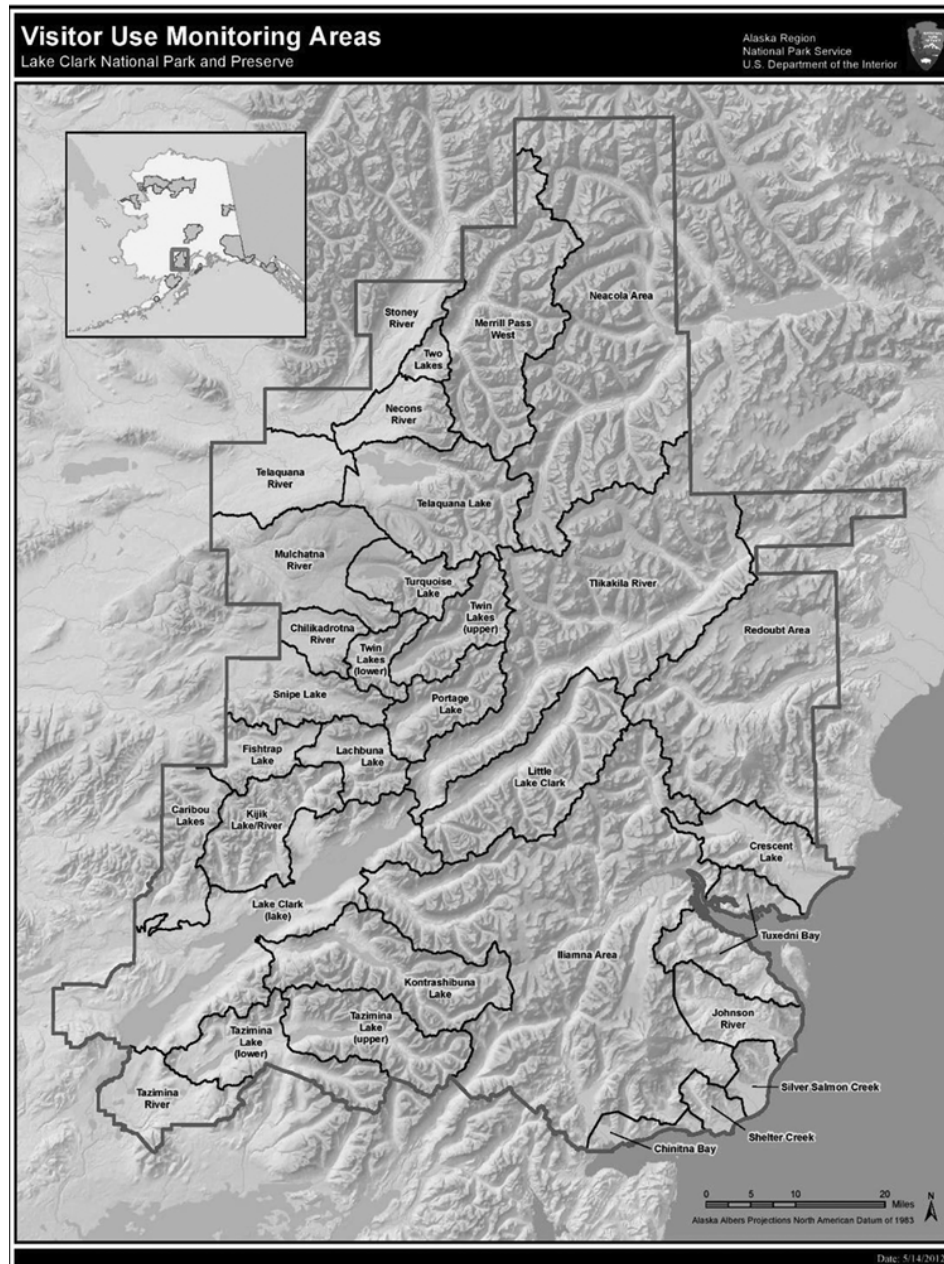


Figure 2. A map of the visitor use monitoring areas for Lake Clark National Park and Preserve.



In addition to bear viewers' experience, ongoing studies are looking at stress hormones in bears to understand their experience as visitation increases.
NPS/D. LILE

to social research postulating that visitors have shared beliefs about aspects important to their experience (Nettles et al. 2020). The indicators establish the variables of experience (as visitors perceive them) while the thresholds provide minimum acceptable conditions that determine a “negative” or “positive” experience. The indicator represents visitor expectation and the threshold represents a preference. The second phase of this project consisted of a second set of questionnaires assessing experienced conditions according to these norm-based thresholds:

1. **Indicator: Bear proximity.**
Threshold: The chance to view a bear at no closer than 9 yards and no farther than 220 yards.
2. **Indicator: Bears viewed.**
Threshold: The chance to view at least one (1) bear per hour and no greater than 17 bears per hour.
3. **Indicator: Minutes of human sound per hour.**
Threshold: No more than 23 minutes of anthropogenic sound heard per hour.
4. **Indicator: Vegetation degradation.**
Threshold: No more than 48% of the vegetation surrounding angling sites degraded.
5. **Indicator: Groups encountered.**
Threshold: No more than 6 other visitor groups encountered per day.
6. **Indicator: Groups within view.**
Threshold: No more than 6 other visitor groups within view at one time.

While CUA operators report that bear-viewing meadows are relatively unimpacted, bear viewing is likely to grow in popularity (Ehrenpreis and Kao 2021). To maintain these standards of visitor preference and prevent overcrowding and environmental degradation, parks may continue to monitor conditions and develop an evaluative standard for action when on-site conditions require it. At the time the study concluded, visitors reported in the second

questionnaire that they were satisfied overall with their experience, though this may change as bear-viewing popularity surges.

As use grows in intensity, specifically at bear-viewing sites, damage to environmental conditions and disturbance to wildlife affects the quality of experience bear-viewers are coming for, potentially disrupting quality of life for bears and visitor satisfaction thresholds. When conditions in an ecosystem change, cascading effects may occur that park managers must be prepared to address. Research on the bears' physiological state during times of high visitor density along the Cook Inlet coast is ongoing, as the Lake Clark natural resources team examines stress hormones in bear scat.

The Merging of Visitor Use and Wildlife Research

The Nettles-led research team also investigated the potential use of utilization distributions (UDs) as a means of better understanding commercial visitor use patterns. In wildlife research, utilization distribution is a common analysis technique used among biologists to track animals on both the individual and population level (Nettles et al. 2021). Rather than recording the total use of resources over an entire season and representing visitor use as a percentage, or a count, UD display the intensity of use across a particular place and time, represented as a 3D model that adjusts according to intensity over time. UD methods help establish where visitor densities are highest in the park and how those densities shift over a season (Nettles et al. 2021).

The researchers suggest that these spatiotemporal patterns of visitor use can help managers predict and anticipate crowding and

congestion in remote areas, reduce impact on sensitive ecological resources, and help identify staffing and resource allocation for specific places at specific times (Nettles et al. 2021). UD may be a helpful guide that could provide a more complete picture of visitor use that isn't captured by raw numbers. If applied to human visitation in parks, as Nettles and others suggest, the method carries an interesting implication about conducting visitor research in parks.

The study authors note that "this merging of both wildlife and social sciences is important, as temporal and spatial distributions of visitor use on public lands continue to be of high interest to both scientists and managers" (Nettles et al. 2021: 3) and "doing future research could not only increase understanding of visitor use but also develop the valuable connections between social and wildlife sciences needed for achieving positive human-wildlife coexistence" (Nettles et al. 2021: 15). While we cannot always have reliable data on where visitors are and what they're doing there, our understanding of where wildlife is at any given place and time is similar. Since the majority of park visitors, whose primary trip objective is to watch wildlife in its natural habitat, are following wildlife, utilization distribution in conjunction with ongoing methods of visitor data collection may be useful to determine where to focus staffing efforts.

This merging of social research with wildlife research in park science involves interpretation and education. It necessitates an informed public that respects and understands wildlife behavior and the impact human activity has on wildlife and protected areas. To mitigate impact, we have a responsibility to moderate behavior. The research suggests that the park's interpretive

efforts focus on promoting a culture of respect and self-awareness among visitors so that they conduct themselves as non-disruptively as any other wildlife population in the ecosystem. From a researcher's perspective, the study on utilization distribution suggests that gathering time- and location-specific visitor-use data and allocating park resources accordingly may help us to understand visitor activity in these high-use areas.

The recurring (and expanding) presence of visitors in specific wilderness locations is functionally introducing a higher quantum of human activity into an existing ecological landscape, even if an individual visitor is only a short-term or one-time observer. Research into visitor use and the ecology of visitation must reflect visitor presence as a semi-permanent environmental factor. Visitors are not incidental to these high-intensity sites; projections suggest that use will only continue to grow (Ehrenpreis and Kao 2021).

Emotions, Bears, and Broadening Dimensions of Park Use

Addressing how parks can ensure that visitors are interacting with wildlife in an educated and informed way, the researchers looked at the behavioral psychology of wildlife viewing. It examined the emotional responses, across a variety of simulated scenarios, that visitors experience in coastal brown bear interactions. Implementing video simulations and self-assessment questionnaires for a representative sample of the public, the study asked participants to rate the intensity of their emotional responses and then the likelihood of performing several actions on a scale of perceived appropriateness. CUA operators do

not have a standardized bear-viewing education program and visitors who come to parks for bear viewing come with diverse backgrounds and levels of preparedness. The study indicates that sometimes what visitors are supposed to do, and even directly instructed to do, conflicts with how they actually behave in reactions to encounters with “hostile” bears, when the visitor perceives hostility in the interaction (Nettles et al. 2020).

Respondents were generally aware of appropriate behavior, but the emotional impact of wildlife interactions heightened by fear had an adverse effect on the ability to make clear choices. This study highlights the gulf between cognition and emotion in bear-viewing visitors; extreme emotion may decrease the impact of safety education on human behavior. The scenario “subadult bear in a meadow” produced the highest degree of attentiveness and the scenario “sow and cubs in a meadow” produced the highest levels of hostility and fear—two negative emotional presets used by the study. While these are both appropriate responses to these scenarios, they also increase the potential for emotion to affect decision making.

The higher the perception of risk, the more likely an emotional response in the human viewer (Nettles et al. 2020). The authors suggest that “experiential training through photographs, videos, or virtual reality could help park visitors and area residents to imagine such scenarios and practice behaving appropriately” (Nettles et al. 2020: 18). Closing the gap between cognitive awareness and emotional response presents a goal to park interpretation and education programs when it comes to mitigating adverse bear-human interactions.



However, the concept of visitation itself begins to beg interpretive redefinition. There is already a distinction between park use and park visitation: traditional subsistence lifestyles or commercial enterprises like the CUAs are both forms of park use, where resources must be stewarded properly to ensure the longevity and the sustainability of these uses. But these practices are not visitation, an intrinsically short-term experience for the individual, but one that is collectively and continually expected to increase. An element of the visitation system

By improving our understanding of the intersection of social science, wildlife research, and educational outreach, we may continue to strive for positive human-wildlife coexistence in protected areas and ensure that our impact on the environment is sustainable for generations to come.
NPS/KARA LEWANDOWSKI

that has not yet been fully explored is the use of digital media to engage with national park experiences. While new virtual reality (VR) technology develops and the NPS gets increasingly savvy in the digital media world, employing social media as an experiential education tool for connecting audiences to bears arises as a broadening dimension of park use.

In the *International Journal of Wilderness*, researchers from the Nettles team examined whether social media, specifically geographical data from tagged posts, is a useful tool for gathering visitor-use data by activity type at Lake Clark and Katmai. Does the social media content containing national park geotags represent in-person visitors by location? The study concluded that services like Twitter (X) or Flickr provide limited usefulness in determining reliable data on in-person visitor activity, particularly in remote areas. Most social media users sharing park-related content were not park visitors to a ratio of about 20 to 1. Out of 3,784 users sharing park-related content, only 189 were confirmed to be in-person visitors (Dagan et al. 2020). Ninety-five percent of Twitter (X) posts about the parks were not visitors. Despite this, “high social media attention from non-visitors may be useful for the park in terms of extending the reach of their education or conservation messages” (Dagan et al. 2020: 24) and understanding public perceptions about remote parks, generally. The researchers intriguingly suggest that a new demographic begins to emerge, that of the “digital park visitor.”

While social media may not be effective for statistical analysis, these results support the idea that digital technology is a valuable tool

for educational outreach and accessible virtual experiences in parks (through video content, live webcams, and VR tech). In Katmai National Park and Preserve, for instance, bear-viewing livestreams reach more than 10 million viewers, potentially extending the range of low-access, remote parks to connect with people worldwide. Perhaps the virtual visitor becomes a kind of solution to the problem of increased visitation impacting bears by providing a platform for promoting general attitudes of respect around wildlife viewing among both digital and in-person visitors. This type of visitation has little impact on physical sites and bear-human well-being, accessible education and interpretive opportunities. Someone whose boots will never hit the ground in the remote Alaska wilderness is nonetheless given an opportunity to connect with park resources as digital media grows increasingly sophisticated. However, as general online awareness of the park increases, the visibility of park resources will also serve to drive increased visitation.

The increasing popularity of wildlife tourism in protected areas highlights the need to minimize impacts on wildlife and their habitat. With visitation climbing steadily in parks and protected areas in recent years, the complex nature of human-wildlife interactions suggests an interdisciplinary approach, proactively incorporating both social and wildlife sciences into an ecology of visitation. By improving our understanding of the intersection of social science, wildlife research, and educational outreach, the National Park Service may continue to strive for positive human-wildlife coexistence in protected areas and ensure that our impact on the environment is both minimal and sustainable for generations to come.

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Changing Visitation Patterns Present Challenges and Opportunities for Alaska National Parks

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Sean Eagan, Glacier Bay National Park and Preserve
Dave Schirokauer, Denali National Park and Preserve*

Environmental conditions and recent travel trends—including a longer cruise ship season—are changing how and when people visit parks. This presents some challenges as well as opportunities for park managers to adapt.

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Visitation to Alaska national parks has increased in the past decade (2014-2024), except for a short dip due to COVID between 2020 and 2022. Tourism to Alaska increased 63% from 1.66 million to 2.7 million people, with the growth largely driven by the cruise market which grew by 84% across the decade (McKinley Research Group 2025). Over the same time period, recreation visits to Alaska national parks increased 29% from 2.68 million to 3.47 million people (NPS 2025) with many parks, particularly those where cruise ships visit or passengers include park visits as part of tour packages, showing marked increases. In Glacier Bay, passengers on cruise ships of all sizes increased by nearly 50% since 2013. A combination of warming temperatures, increased number of cruise ship ports and port improvements, and a lengthening cruise ship season are expected to continue this trend of increased tourism and visitation to Alaska national parks (Figure 1). This article explores the implications for park management from these anticipated changes.

Shifting Visitor Seasons from Warmer Temperatures

High latitudes are warming more quickly than the global average; for example, the Arctic is warming nearly four times faster (Rantanen et al. 2022). Decreases in sea ice extent and

the warmest summer surface air temperatures on record have been documented recently (NOAA 2023). Related effects include earlier green-up dates (Fresco et al. 2021), and earlier snowmelt and later freeze-up determined from stream flow discharges (Blaskey et al. 2023). By extension the warming climate has become a key park management consideration because these changes impact visitation patterns and the length of the visitor season.

For example, in many parks in northern and Interior Alaska, the standard date for the start of public-related summer operations has been Memorial Day weekend, while the end of the season has been more variable, ranging from Labor Day through mid-September. A study looking at 3 parks across a latitudinal gradient (Gates of the Arctic, Denali, and Katmai national parks and preserves) determined that

Park visitation is a measure of how many visitors come to a park. The term *visitor* refers to a person recreating in a park as opposed to someone who comes to a park to harvest resources for traditional subsistence use based on generations of history.

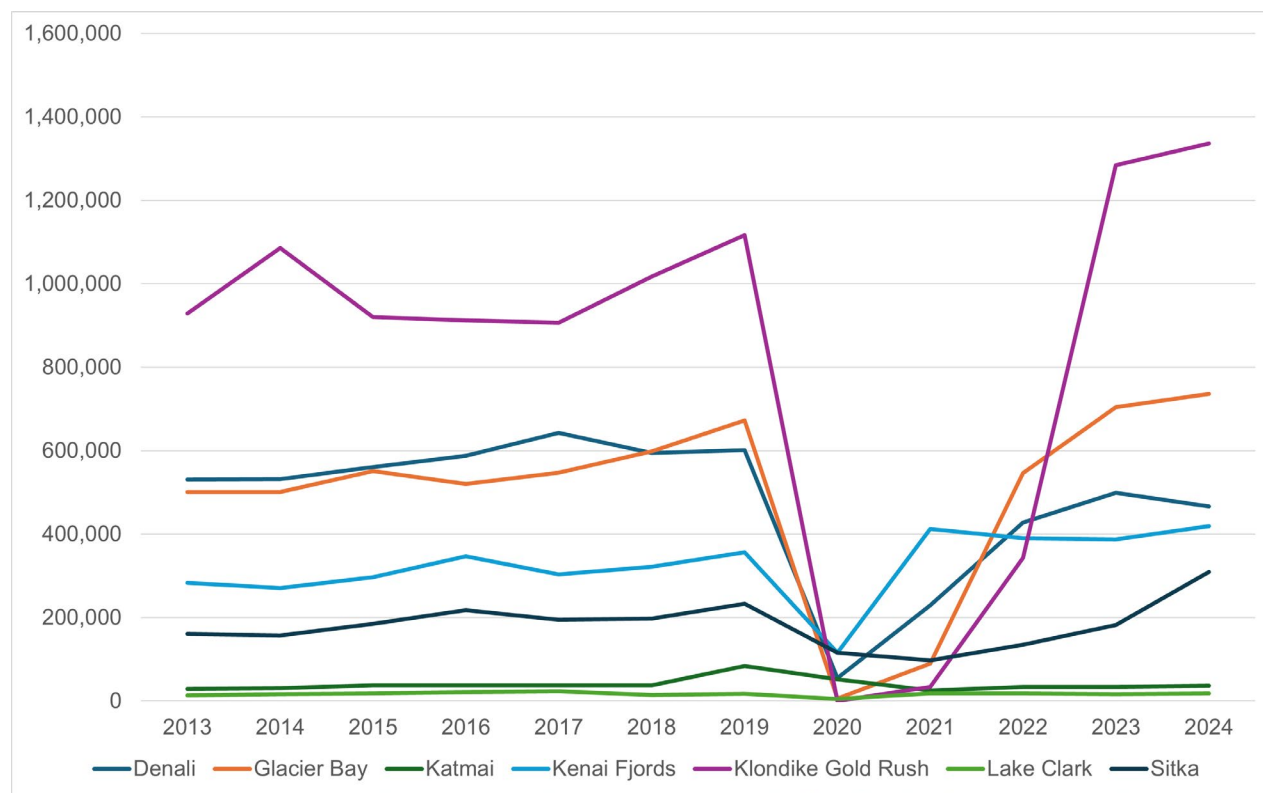


Figure 1. Visitation at parks with cruise ship ports or with cruise ship-associated packaged trips. The COVID-affected years from 2020-2021 explain the steep drop.

Data are from NPS STATS (2025). Glacier Bay, Katmai, Kenai Fjords, Klondike Gold Rush, Lake Clark, and Sitka parks have increased from 2013-2024, and Denali has decreased.

temperatures for the shoulder season months of May and September are becoming more similar to temperatures currently in June through August, likely leading to a longer peak visitor-use season (Albano et al. 2013). In Kenai Fjords National Park, access to Exit Glacier, a key visitor attraction, is limited by snow depth in the spring due to the inability to open the road. As the climate warms and winter rain replaces snow, conditions may allow for earlier road access (Walsh et al. 2023, Sousanes et al. 2023). When roads open earlier, park visitors often expect facilities such as visitor centers to also be open earlier. This happened in 2014-2016 when Seward experienced low-snow winters and the state-owned road to Kenai Fjords National Park was opened in mid-April, putting social

pressure on the park to open the park road and visitor facilities in late April instead of mid-May. While trails and restrooms were opened earlier in those years, the visitor center was not opened until Memorial Day weekend because it requires extensive staffing. (In contrast, in 2024, the road opened in mid-May, which shows that low-snowfall winters are not a certainty and prevents the park from counting on a consistent April opening for staffing decisions.)

With extended visitor seasons for parks, popular visitor activities such as wildlife viewing may also start earlier in the year and possibly continue later into fall. For example, bears, which are popular viewing experiences for visitors, are emerging from their dens earlier and hibernating later as temperatures warm (Johnson et al. 2018, Kurth et al. 2024). Their movements and distributions are also changing as the availability of fish, berries, and other food sources also shift (Taylor 2008, Pigeon et al. 2016, Deacy et al. 2017). These trends increase the opportunity for human-bear interactions, a recurring safety and management issue for many parks (Kurth et al. 2024).

Expansion of Cruise Ship Docks in Alaska

Another reason for changing visitation to Alaska's national parks is due to the expansion of the port infrastructure available for large cruise ships that bring a disproportionate number of tourists to Alaska. Favorable global economic trends, including a growing middle class with increased spending power (Brookings Institution 2021), also result in expanded cruise ship operations. In 2023, 1,650,000 cruise ship visitors were brought to Alaska compared to 951,000 visitors in 2006, an increase of over 70% (CLIA 2024). Southeast Alaska parks, such

as Glacier Bay National Park and Preserve, are currently seeing the visitor season extend from late April through mid-October, a marked change from 20 years ago when ships were rarely seen before 1 May and never after early September. To that point, in 2013, Glacier Bay had 575 cruise ship visitors in April; in 2023, there were 8,389 cruise ship passengers in April and 43,922 visitors in October (NPS 2025).

To accommodate the robust interest in Alaska cruises, the industry, some municipalities, and some private companies are modifying their existing infrastructure or investing in additional areas where cruise ships can dock. For example, in the past decade, Ketchikan, Juneau, Skagway, and Hoonah have expanded their ports to accommodate the largest ships that come to Alaska such as Royal Caribbean's Icon, which can carry up to 7,600 passengers. By spring 2026, the Alaska Railroad and other partners will be expanding the Seward cruise ship docking area to be able to accommodate larger cruise ship vessels holding more than 4,000 passengers in addition to expanding the cruise ship passenger terminal (ADN 2022, The Seward Company 2024). While Whittier, located relatively close to Anchorage, has had a long-term existing cruise ship dock, the city and its partners have recently constructed an additional "Head of the Bay" passenger terminal and cruise ship dock (City of Whittier 2024). This dock is expected to bring 100,000 more people through Whittier, which, like Seward, is part of the Alaska Railroad system. The first cruise ship arrived at this new Whittier dock in September 2024 (City of Whittier, pers. comm., September 11, 2024). Kenai Fjords National Park, located near the cruise ship port of Seward, and Denali National Park and Preserve, with an Alaska Railroad train



depot within park boundaries, can expect to see additional visitors as a result.

In Sitka, a private cruise ship docking terminal was constructed about 5 miles from downtown in 2011 and in 2022, this terminal was expanded to accommodate 2 cruise ships simultaneously, including a large ship capable of carrying 4,900 guests (KTOO 2021). In 2023, more than 500,000 cruise ship passengers visited Sitka compared to the previous record of 289,000 in 2008 (Wrangell Sentinel 2023). Sitka National Historical Park, located 1 mile east of the downtown area, is currently in the process of a visitor use management and transportation plan to address this increase in visitors.

The City of Nome is expected to have the very first U.S. deep-water port in the Arctic with expected completion by 2027 (USACE 2022). This is expected to increase cruise ship traffic to Nome including passenger excursions to the nearby Bering Land Bridge National Preserve.

Cruise ship passengers view Marjorie Glacier in Glacier Bay National Park and Preserve.

Even parks that do not have a gateway community near a port are being affected by the increase in cruise ship tourism. As of 2024, parks such as Lake Clark National Park and Preserve are seeing cruise ship visitors through packaged excursion trips (Lake Clark National Park staff, pers. comm., August 8, 2024). This has contributed to the increased number of visitors coming to coastal bear-viewing sites in mid-May, starting the visitor season around 2 weeks earlier and with larger groups.

Other Travel Trends

Another climate related social factor that may be influencing changes to park visitation in Alaska has been termed *coolcation*, defined as people seeking vacation destinations with cooler summer temperatures (Condé Nast Traveler 2023). The record summer heatwaves that have been affecting the lower-48 states and Europe



Exit Glacier in 1992, 2010, and 2024. The ability to see the glacier toe from the trail has changed significantly over time. Sightseeing to retreating glaciers is part of a trend referred to as *last chance tourism*.

NPS (1992), NPS/S. MCKNIGHT (2010), NPS/J. RODRIGUES (2024)

are expected to continue and possibly increase in frequency (Copernicus 2024, NASA 2024). 2024 has been identified as the warmest year on record with the hottest August documented in the 175-year record (NOAA 2025). The relatively cooler summer temperatures coupled with the long summer daylight make Alaska more attractive for a coolcation.

Another recent travel trend that is affecting Alaska is referred to as *last-chance tourism* (Lemelin and Whipp 2019) where people travel to destinations to see attractions that may soon vanish due to climate change or development (Forbes 2018). Alaska national parks support an extensive network of glaciers which are one of the primary destinations for those acting on, and engaging in, *last chance discourse* (commentary

about their experience; Abrahams et al. 2022). For example, the Exit Glacier at Kenai Fjords National Park has been retreating rapidly since 2004 (the glacier terminus has retreated over a half mile; NPS 2024).

Commercial airlines have shown a moderate increase in bringing visitors to Alaska, although patterns from cargo (rather than passenger) transport demonstrate the capacity for increase. Visitors coming by commercial airlines have increased over the decade from 578,400 in 2010 to 790,900 in 2019 with an average annual growth of 3.7% over the 10 years (McDowell Group 2020) for an increase of almost 40%. The busiest Alaskan airport, the Ted Stevens Anchorage International Airport, is located less than 10 [flight] hours from 90% of the industrialized world (McKinley Research Group 2023), and for cargo transportation in 2022, the Ted Stevens Airport was the 3rd busiest airport in the world (Airport Council International 2024). While cargo transportation is clearly different than passengers, the potential for parallel travel routes can be seen (Figure 2). For example, the proximity to the industrial world is reflected in the increase of winter

tourism for viewing northern lights (aurora borealis). Winter tourism in Denali National Park and Preserve has increased more than 15-fold from 981 visitors in 2000 to 20,966 visitors in 2024, straining the park's winter facilities. The air flight proximity to the industrialized world could also contribute to increased visitor numbers in spring and fall with an expanding summer shoulder season.

Management Challenges and Opportunities

While cruise ships and airlines are poised to accommodate more visitors in the shoulder seasons, the National Park Service is increasingly challenged to address the potential increase in overall visitor numbers and length of season. Managing visitor experiences is another challenge for park managers and includes addressing visitor expectations in a rapidly changing environment. Two frameworks may be particularly helpful when considering future management actions for parks: scenario planning and the Resist-Accept-Direct framework.

Scenario planning is a structured way of recognizing that the future is not always clear and provides a way to think through actions related



Figure 2: World map showing proximity of Anchorage represented by "AIAS" on the map to other major cities.

ALASKA INTERNATIONAL AIRLINES SYSTEMS 2024

to different possible futures (Schoemaker 1995). By exploring multiple possible futures instead of focusing on a single future, scenario planning can be particularly useful in conditions of high uncertainty (NPS 2013). This process is also a way to identify actions that can work across many of the various scenarios, leading to a more robust set of solutions. For example, the southwest Alaska parks used climate change scenarios to understand implications for riverine and coastal systems (Winfree et al. 2014). When considering park management actions related to visitors, it is important to consider how visitation may change in the future especially related to seasonality and overall number, as well as understanding how visitor experience may change.

In light of the uncertain rate of Exit Glacier retreat and future visitation numbers, Kenai Fjords National Park used scenario planning to identify robust management actions across various future scenarios (Kim et al. 2020). As mentioned earlier, visitor experience at Kenai Fjords National Park has greatly changed over the last 20 years for Exit Glacier, a key location in the park's frontcountry area accessible by road vehicle. Back in 2004, Kenai Fjords National Park released the *Exit Glacier Area Plan, An Environmental Assessment and General Management Plan Amendment* (NPS 2004), which focused on Exit Glacier as the primary park visitor attraction accessible by road. The purpose of the 2004 plan stated that "Exit Glacier provides visitors with a rare opportunity to easily approach a glacier on foot" and that visitors "can drive within one-half mile of the glacier terminus and walk a relatively easy path to its towering face of ice." In 2004, Exit Glacier was considered to be fairly stationary as the terminus (bottom edge) had receded only 184 feet (56 m) from 1974-2004 (Kurtz and Baker 2016). However, from 2003 to 2023, the terminus receded a half mile (2,640 feet [804 m]; NPS 2024) and the glacier is no longer accessible to most visitors. Today, some visitors still come to Kenai Fjords National Park expecting to stand next to a glacier, but the glacier has now retreated substantially up a steep slope and can no longer be accessed by the lower trails. Because of this major retreat of Exit Glacier, scenario planning was used to come up with robust solutions across different scenarios of the rate of Exit Glacier retreat and various visitation levels. These robust solutions were incorporated into the [2024 Kenai Fjords Frontcountry Management Plan Environmental Assessment](#) (NPS 2024), focusing more on the

frontcountry area as a whole with the intent to help shift visitor focus away from Exit Glacier. Park visitor programs have shifted beyond Exit Glacier to broaden people's understanding of glacial processes, the Harding Icefield, and the fjords with over 500 miles of coastline.

Another management tool for making decisions for park areas undergoing rapid change is the Resist-Accept-Direct (RAD) framework (Schuurman et al. 2020). This framework has been applied to ecosystems undergoing rapid, irreversible ecological change. While the NPS has often focused on restoring ecological systems within a historic range of variability, the RAD framework applies when this range shifts and the historic range of variability no longer applies. The RAD framework has park managers consider what makes the most sense: resist the change and try to restore back to the historic conditions, accept the change with little action to manipulate it into something different, or direct the change by actively managing it towards specific new desired conditions.

While the RAD framework focuses on ecological change, this framework can also apply to shifting park visitation. For example, when a new cruise ship dock near a railroad depot is built within Alaska, this may shift the visitation number in a railroad-accessed park much higher than in the past and across an expanded season. New visitor excursions can also cause an influx of visitors where they were not as prevalent before either in location, time period, or both. Depending on the visitor use management actions and related capacity of the park area, these greater numbers may be *resisted* (e.g., limit access due to resource damage and visitor capacities being exceeded); *accepted* (e.g., access can be allowed when capacities

are not reached and resource impacts are not occurring at unacceptable levels), or *directed* (e.g., management actions provide for a greater number of visitors in particular areas where resource damage can be minimized).

Overlaying visitor management on a shifting environment due to an extended visitor season and increasing visitation may be challenging, but combining scenario planning with the RAD framework may be particularly helpful for identifying a clearer set of robust options in an uncertain future. Several scenarios may warrant the same RAD framework strategy. Management actions that apply to more than one scenario are considered robust and management actions that cross over all of the scenarios are considered to be the most robust, as Kenai Fjords National Park found when they used the scenario planning as a starting point to determine management actions.

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What to Do About Number Two? Insights from Decades of Human Waste Research and Management on Mount McKinley

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For the National Park Service, top challenges in the management of visitor use often revolve around trash and human waste. The challenges of backcountry waste management extend, in unique ways, to glacial environments.

Citation:

Loso, M. G. and T. Chenoweth. 2025. What to do about number two? Insights from decades of human waste research and management on Denali. *Alaska Park Science* 23 (1): 70-79.

For the National Park Service (NPS), top challenges in the management of visitor use often revolve around trash and human waste. This is true in developed frontcountry environments along roads and developed areas, but in the backcountry and wilderness environments of parks with large natural areas the challenges are often greater. Traditional frontcountry tools like trash cans, dumpsters, outhouses, and restrooms are infeasible in many backcountry settings. What's more, the logistics of transporting waste out of the backcountry can be expensive and complicated. And yet the aesthetic and hygienic expectations of backcountry users are arguably even higher: wilderness visitors expect "pristine" environments and, at the same time, are more vulnerable than frontcountry users—due to limited washing facilities—to the risks posed by unmanaged waste.

The challenges of backcountry waste management extend, in unique ways, to glacial environments. Historically, most mountaineers climbing or trekking on glaciers simply tossed their trash and human waste into the snow or a nearby crevasse (a deep crack on the glacier surface). This practice was perhaps at the time consistent with the lower expectations historically prevalent in other backcountry environments, and it was perceived as having little practical consequence on remote glaciers visited rarely, if at all, by others. It also seemed

intuitive that crevassed waste just "goes away" because in the upper reaches of a glacier annual snowfall exceeds annual melt. This pattern assures that anything left in a crevasse—or even on the glacier surface—will in due time be buried by additional snowfall, encased in ice, and slowly carried away as the glacier flows interminably down valley. But the waste does not, of course, truly disappear. We now know that downstream—in the glacier's ablation zone where summer melt exceeds annual snowfall—buried and transported waste will someday emerge at the glacier surface.

The emergence of crevassed trash and human waste is perhaps like the unwelcome sight of dog poop melting out of the snowpack in our backyards each spring during breakup: a gentle reminder that things don't just go away. But what if instead of just the family dog, we're running a kennel back there?

On Mt. McKinley (Denali)—North America's highest peak—the most straightforward way up the mountain is via the West Buttress climbing route. Each year during peak climbing season, from early May to mid-June, over 1,000 aspiring mountaineers arrive via ski-equipped bush plane at a busy glacier landing strip and spend an average of 17 days each climbing the route on the upper Kahiltna Glacier. The crowded climbing route presents a stark contrast with the

The West Buttress climbing route on Mt. McKinley is, during the short climbing season, the most crowded backcountry location in Denali National Park and Preserve. Here, climbers dig into snow shelters at 14,200' before ascending the steeper upper mountain.

NPS/TUCKER CHENOWETH

rest of the backcountry in Denali National Park and Preserve, where visitor numbers (mostly backpackers) are strictly limited by quotas of 4-12 daily users per backcountry zone. Waste management is also easier in those zones, because (1) backpackers typically generate less trash to “pack out” because their trips are shorter, and (2) backpackers are generally able to shallowly bury their human waste in organic-rich soils where it will effectively biodegrade within a short time. In contrast, on the Kahiltna Glacier, for example, each climber starts with about 3 weeks of food and by trip’s end will have generated 17 days of trash and, more importantly, 17 days of solid human waste weighing (by a very conservative estimate—individual results will vary) about 4 1/2 pounds (2 kg). Since the early 1990s, when climber numbers first surpassed 1,000/year, that amounts to over two metric tons of human fecal waste per year. As of 2023, we estimate that at least 88 metric tons of human waste have been generated by mountaineers on the West Buttress since the route was first climbed by Bradford Washburn in 1951 (Figure 1). Here we describe the history and potential consequences of the National Park Service’s efforts to manage that waste and summarize existing research informing best contemporary practices.

Keeping the Mountain Clean

Trash and human waste management has evolved over the 70+ years of climbing on Kahiltna Glacier, which is now widely recognized as one of the cleanest high-use mountains (Mt. McKinley is one of the coveted “Seven Summits”) in the world. The dedicated mountaineering ranger staff, and especially now-retired ranger Roger Robinson, played a large role in this evolution, starting in the late 1970s

and early 1980s with efforts to clean up existing trash and discourage further littering through education and enforcement. Trash was managed quite simply: climbers were expected to carry all trash off the mountain and non-compliance was punished with a citation. Early efforts to manage human fecal waste were two-pronged: climbers were encouraged to dump their feces in deep crevasses, and, for areas without easy access to crevasses, latrines (over deep holes dug in the snow) were installed during the climbing season at high-use areas, especially high on the mountain. These efforts were mostly successful at keeping the glacier surface along the climbing route clean, but concerns grew about surface

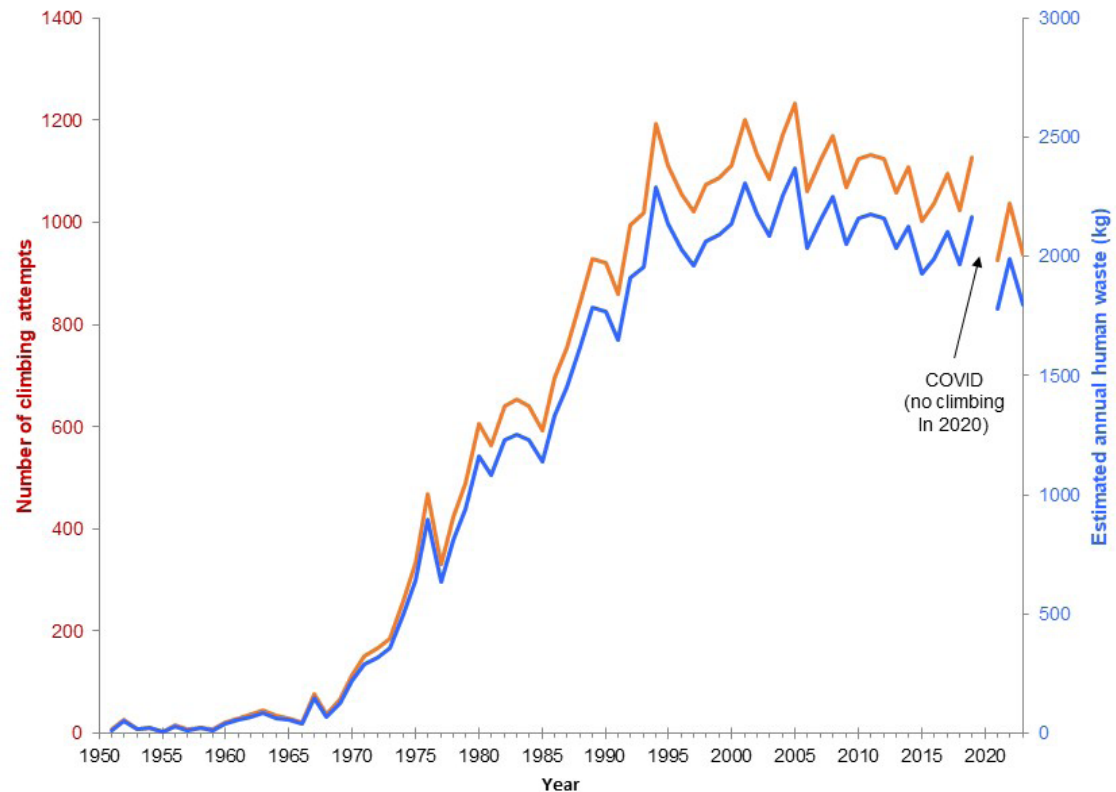


Figure 1. Numbers of climbers on Mt. McKinley’s West Buttress climbing route by year (red line) with an estimate of associated annual human waste generation (blue line). Note that climbing on the Kahiltna Glacier was prohibited during 2020 due to the COVID-19 pandemic.

Waste estimate assumes 17 days per climber with 113 g average stool weight per day. Based on the stool weight chosen, we calculate that in the last 73 years climbers have generated at least 88 metric tons of human waste on the Kahiltna Glacier.

contamination at the highest camps and about the increasing quantities of feces going straight into the glacier.

In the early 2000s, Denali ranger staff began the first experimental use of Clean Mountain Cans (CMCs; small-lidded plastic tubs specifically designed to receive and transport human feces and toilet paper during climbing expeditions) for temporary waste storage and removal. The rangers also solicited scientific help in understanding the trajectory and fate of crevassed human waste so, beginning in 2007, we teamed up with Alaska Pacific University graduate student Katie Goodwin and others to conduct a series of studies (Goodwin et al. 2012, Loso et al. 2013), the findings of which can be summarized as follows:

- Once buried in snow/ice, human waste remains intact and biologically active for a very long time (certainly decades and probably centuries),
- Crevassed waste will not be “ground up” in the glacier, but rather will emerge downstream on the glacier surface within roughly 50-200 years, depending on the specific location of burial, and
- No emergent waste has yet been found on the glacier surface, but low levels of *E. coli* are present in the Kahiltana River where it emerges from the glacier, suggesting that englacial waste may already be contaminating meltwater.

By the time those studies were completed, NPS had abandoned the use of pit latrines and required the use of CMCs by all West Buttress climbers. These changes helped to further clean up the glacier surface, especially at high

elevation and high use camps, but at that time it was still permissible to dump CMC contents (bagged feces and toilet paper—but not baby wipes or other trash) into large crevasses along the climbing route so that most waste still remained on the mountain.

Partly in response to the studies referenced above, the recent management trend has been to further restrict locations where CMC dumping is permitted. As of this writing, most climbers are allowed to crevasse waste in only one location at a large crevasse below the 14,200' Camp, and a substantial fraction of the feces they generate on the lower portion of the climbing route ends up being flown off the mountain. Additionally, several guiding companies volunteered in 2019 to begin “full packout” trips where they do no crevasse dumping and all solid waste is removed from the mountain. Because of these changes, a substantial fraction of the human waste now generated by climbers on Denali is ultimately carried on their backs or in their sleds back to the glacier airstrip and flown to Talkeetna at the end of their trip (Figure 2).

Downstream Consequences of Past and Ongoing Waste Burial

What will become of the large volume of human waste already deposited in the glacier? It is difficult to be certain until it finally emerges, but a recent anecdotal observation and a simple experiment provide some insight. In 2020, we used a helicopter to closely observe a very large ice cliff that drains glacial accumulation from Genet Basin, home of the 14,200' Camp. The cliff (Figure 3) is important because it sits about half a mile (1 km) downstream of the single large crevasse where human waste can still, as of 2023, be dumped by climbers. Our



Figure 2. Clean Mountain Cans (“CMCs”) that have been returned from Kahiltana Glacier to the ranger station in Talkeetna, where they are typically stored until picked up by a contractor to be emptied and cleaned at a municipal waste management facility.

These particular CMCs took a different path and were intercepted for return to the glacier as part of the experiment described in this article (Goodwin et al. 2012).

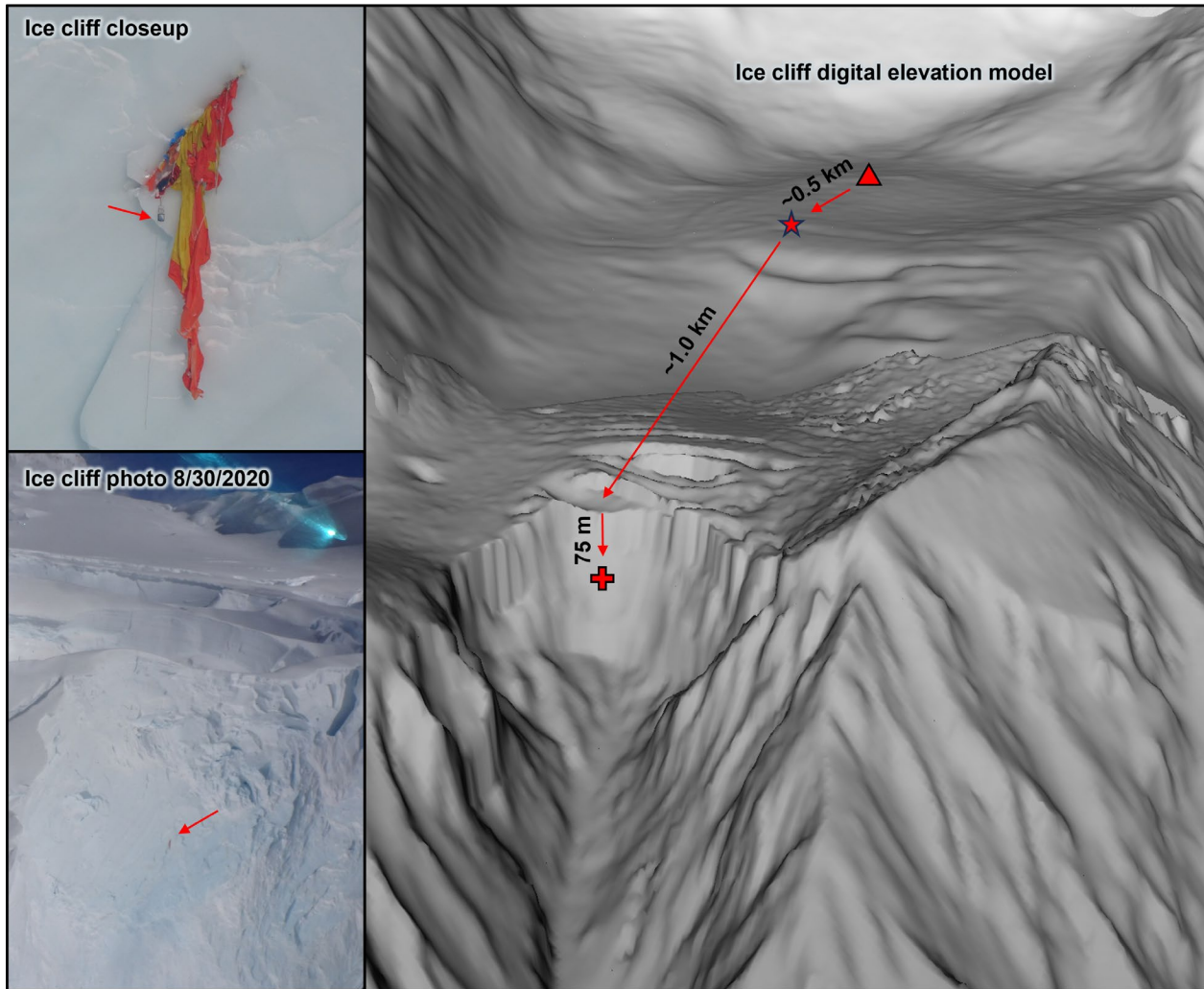


Figure 3. Photographs at left, taken from a helicopter on 8/30/2020, show an ice cliff just downstream from the 14,200' Camp in Genet Basin (red triangle in digital elevation model at right). Just visible in the ice cliff (red arrow in lower photo) is a yellow and orange nylon object (trashed tent).

Red cross in the digital elevation model shows the location of the ice cliff and compass, and their relationship to the crevassed glacier upstream. Red star shows the one crevasse designated by park management as suitable for disposal of human waste.

expectation that buried waste will emerge intact and predominantly undeformed by englacial transport was confirmed by a bright object we saw during that 2020 flight. Enlargement of photos taken that day show the object was yellow and orange nylon fabric (part of a tent?) and an apparently undamaged plastic compass. We don't know the story behind the burial of these items but infer from their location about 250 feet (75 m) below the glacier surface that a climber (illegally) dumped them in a crevasse some years or decades prior. In the dark, consistently cool englacial environment there is no reason to expect that a plastic bag of human feces would emerge any less intact and recognizable.

We know from our earlier research that large volumes of that intact, crevassed waste will start to melt out on the comparatively moderate terrain of the lower glacier in coming decades. What then? In what is likely a first (and last!) for the Denali climbing program, in 2016 we began a multi-year experiment in which we randomly selected several full CMCs from the Talkeetna ranger station and flew them to the lower Kahiltna Glacier, near the Pika Glacier tributary ("Little Switzerland") at about 3,600 feet (1,100 m) elevation. There, we dug a hole in the seasonal snow and deposited the CMC contents at the ice surface where crevassed waste would sit after melting out naturally. We then monitored the waste (Figure 4) and the local microclimate (Figure 5) for the following four summers.

What we found is that the volume of waste within the initially full biodegradable bags was notably diminished within two summers (Figure 4) and that what had initially smelled terrible was by that time almost completely

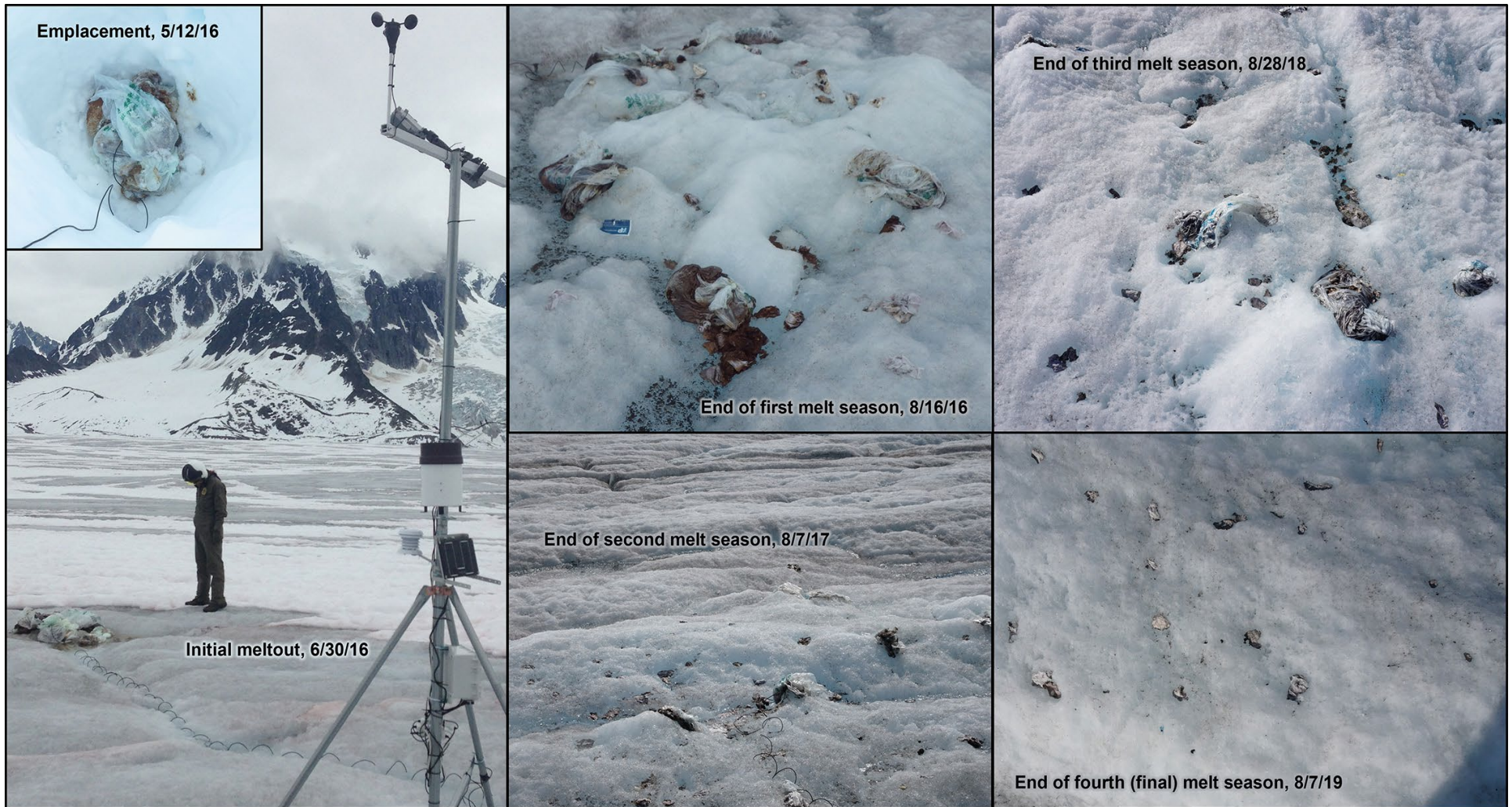


Figure 4. Natural degradation of experimentally deposited human waste on the surface of Kahiltna Glacier from 2016 to 2019. Waste was sourced from used CMCs and buried each winter by snowfall. Photographs depict the comparatively rapid degradation of the waste and biodegradable bags, and also the persistence of embedded trash, including baby wipes.

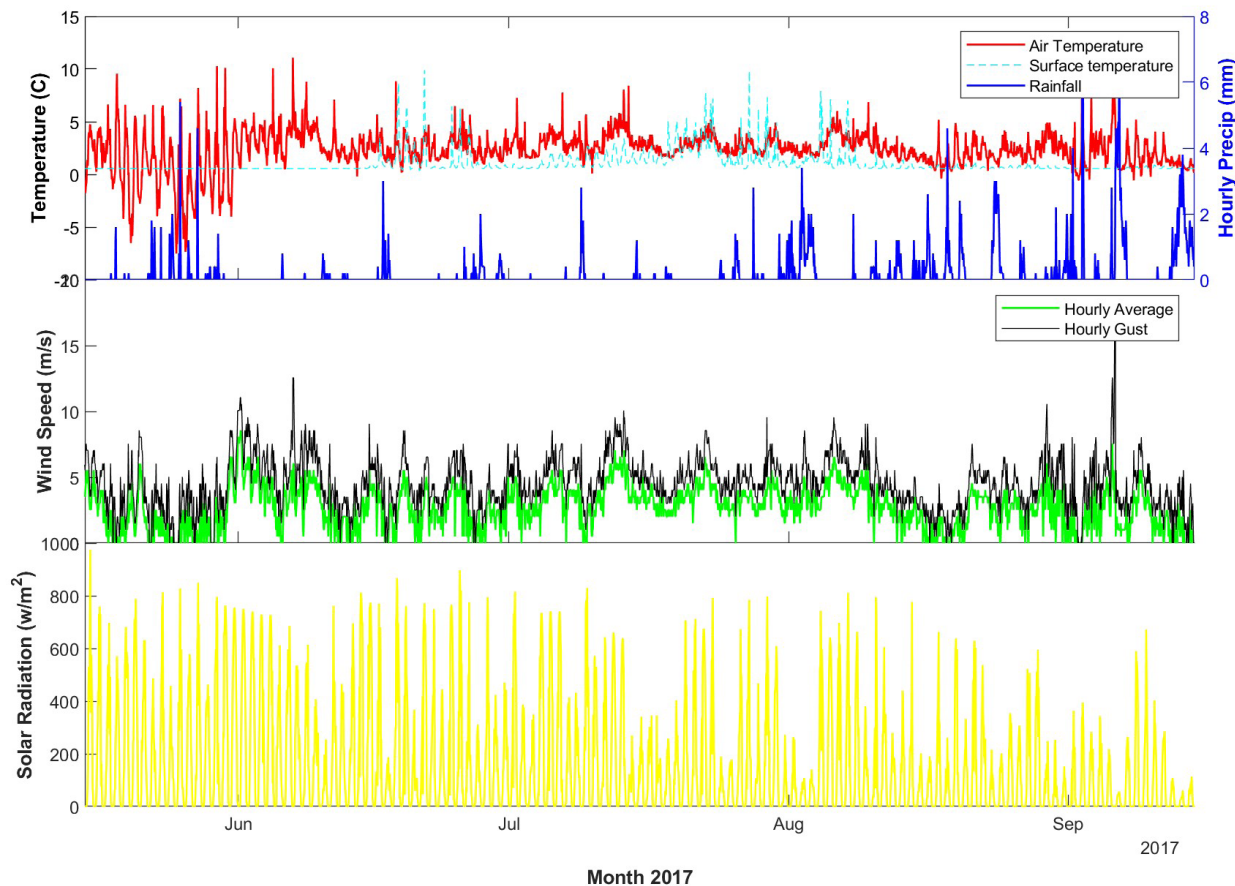


Figure 5. Typical climatic conditions during the 2017 melt season at the waste degradation experiment on Kahiltna Glacier (~1,100 m elevation). Upper panel shows air temperature, rainfall, and the ice surface temperature (which in early and late season is buried by seasonal snow).

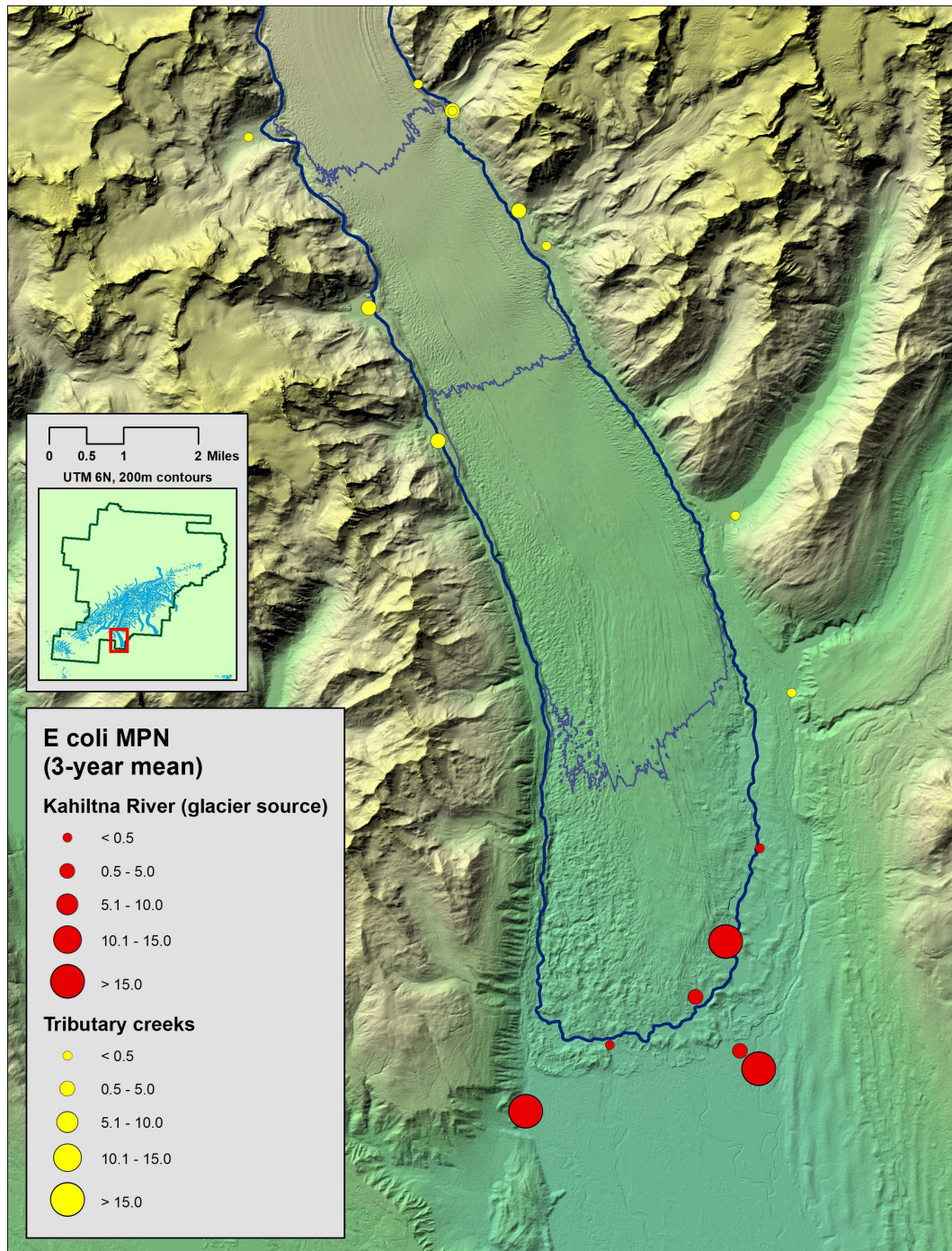
Middle panel shows hourly average and maximum windspeeds. Lower panel shows incident solar radiation.

Maximum seasonal snow depth at this site (not shown) was 1.17 m in winter 2016-17, and averaged 1.90 m over the four years of the experiment.

non-odorous. This is most obviously the result of the very different microclimate on the lower glacier surface. Compared with the dark, cool, steady environment within the glacier, recorded weather conditions at the glacier surface (when snow-free during the summer months, Figure 5) are mostly above freezing, windy, and exposed to substantial solar radiation and rainfall. By the end of the fourth (final) summer, almost all visual evidence of the bagged feces was gone. What remained at the end of this informative qualitative experiment was:

- Trash (not much, since it's against policy to place trash in the CMCs, but there were nonetheless some small items including a conspicuous Lufthansa boarding pass),
- Baby wipes (perhaps not technically trash, but definitely not biodegradable on the timeline of this experiment), and
- Detectable high levels of *E. coli* in small supraglacial meltwater streams immediately downstream of the experiment.

Consistent with previous research, new rounds of water quality testing in terminus area streams once again suggest that the Kahiltna River is already carrying measurable quantities of *E. coli* that are likely sourced from englacial human waste. Using techniques described more thoroughly in Loso and others (2013) and implemented with substantial effort by Denali Visitor Use Assistant Becca Stenerson, Figure 6 shows average concentrations of *E. coli* in Kahiltna River and tributaries during the summers of 2016, 2017, and 2018. Values shown are most probable number (MPN) for *E. coli* during an average of 4.4 measurements/site. Results confirm the previously documented pattern of higher concentrations of *E. coli* in the Kahiltna River than in small tributaries, which are the only plausible alternative source (besides englacial human waste) of such contaminants. As before, however, the absolute values of *E. coli* are very low: in all cases well below the EPA recreational waters threshold of 100 colony-forming units (cfu)/100 ml (Figure 6; those units are approximately equivalent to the MPN units used in our tests).



In summary, here's what we now know, with reasonable confidence, is happening with respect to human fecal waste on Mt. McKinley:

1. Crevassed waste (mostly feces and toilet paper, but including some trash) will emerge in coming years mostly unscathed by downstream glacial transport onto the less frequently visited lower Kahiltna Glacier.
2. While buried, human waste remains biologically active and is contaminating meltwater (albeit at levels well within EPA standards for recreational rivers) that ultimately discharges into the Kahiltna River.
3. Once emergent at the glacier surface, unsightly piles of human waste will efficiently biodegrade within 1-several years, leaving behind a longer (decade-plus?) residue of contaminated supraglacial streams and non-degraded trash, including baby wipes.

Owing to the decadal-scale timeline for transporting previously crevassed waste to the lower glacier through gradual flow, it is outside the scope of present managers to substantially alter these conditions in the next few decades. But over a longer timescale, conditions on the lower Kahiltna Glacier and in the downstream Kahiltna River will be determined by decisions

Figure 6. Most Probable Number (MPN) of *E. coli* (mammal/human-sourced fecal bacteria) measured in surface streams near Kahiltna Glacier between 2016 and 2018. Values shown are the average MPN from all samples (average $n=4.4$) collected during distinct visits to each site.

Red circles indicate streams that carry subglacial outflow from Kahiltna Glacier, while yellow circles indicate non-glacial tributary streams. Circle size indicates average MPN.

made now about the policies for trash and, especially, human waste disposal.

What's Next?

The existing waste management program on Mt. McKinley is by most measures a success. Human waste is rarely encountered on the glacier surface; an increasing amount is being carried out by the climbers, less human waste than ever is disposed of in crevasses; abandoned trash is uncommon; there are few outbreaks of communicable illness; and climbers (especially those accustomed to international climbs on popular mountains) commonly remark on the cleanliness of the mountain. None of this is an accident: it has taken years of concerted and coordinated efforts by climbing rangers, guiding services, independent climbers, scientists, and park management to get to this point. But this success is not without cost. Education and enforcement efforts by the Denali National Park and Preserve South District rangers are expensive. NPS pays for purchasing and cleaning CMCs. The life cycle of a CMC—which includes fabrication and shipping, getting repeatedly flown onto and off the mountain, and being trucked down to a waste disposal facility—has a carbon cost that contributes non-trivially to the already significant carbon footprint of a Mt. McKinley climb. And climbers on the mountain, especially including the guide services that have committed to a complete pack-out strategy, can attest that carrying CMCs up and down the mountain is, at best, difficult and unpleasant. Sometimes the added weight of a full CMC might arguably push exhausted climbers into dangerous travel conditions.

Meanwhile, the historic and diminished but ongoing practice of crevassing human waste

on Denali has real impacts. The very low levels of microbial contamination in Kahiltna River present a minor but measurable impact. The river is not regularly used as drinking water by any downstream communities, and even for occasional recreational use the contaminant levels are low enough to be considered safe. Nonetheless, the river is demonstrably carrying bacteria from crevassed waste and we cannot rule out the potential for negative impacts of that contamination on fish or other aquatic species. Emergent waste surfacing on portions of the lower glacier will someday soon present an unsightly aesthetic impact on wilderness character, and continued exposure of new piles will negate the otherwise good news that feces breaks down promptly on the glacier surface. To the rare backcountry traveler that encounters these piles many kilometers downstream from the standard climbing routes, the waste will give a very negative impression that undermines some of the wilderness character otherwise so exceptionally embodied in this designated wilderness on the remote south side of the Alaska Range. And to those same uncommon visitors, the locally high levels of contamination in nearby supraglacial streams will pose a potentially significant health hazard. Most persistently, trash and baby wipes inadvertently or illegally deposited with the crevassed waste may progressively accumulate on the lower glacier, resisting degradation and leaving a more distinct mark of human carelessness on the landscape.

NPS management will have to weigh the foregoing factors when considering any further changes in waste management practices on Mt. McKinley. Climbers no longer question the need to pack out all their trash, but the

requirement to pack out some or all human fecal waste remains a contentious issue on such a long expedition. Should all climbers be required to pack out an entire expedition worth of solid waste (both trash and feces)? Or conversely, would it be okay to backtrack a bit and allow for the crevassing of human waste in a few more locations so that climbers can travel a little more freely and, perhaps, safely? The new scientific results presented here, in combination with previous research and the hands-on experience of the ranger staff, provide some guidance.

If continued education and enforcement can further discourage the inclusion of trash and baby wipes in CMCs, it may be that a persistent zone of biodegrading human waste on lower Kahiltna Glacier is an acceptable consequence of well-managed human waste disposal on the West Buttress climbing route. In most parks, human waste management strategies generally involve the removal of waste (whether through plumbing, pumped vaults, or subsurface burial) to waste processing facilities where breakdown can proceed without compromising the health, safety, or enjoyment of park visitors. The argument could be made that Kahiltna Glacier does the same thing, albeit imperfectly, for crevassed human waste. Weighing opportunities for a safe mountaineering experience against the persistent impact of emergent waste on downstream wilderness character remains a challenge for management of high-use glacierized mountains worldwide, and Denali National Park and Preserve remains a leader in the field.

Acknowledgements

We thank the Denali South District mountaineering rangers whose efforts, over many years, have contributed to the maintenance of such a clean, safe, and rewarding climbing experience for visitors to one of the world's busiest and most sought-after mountaineering routes. In particular, thanks to ranger Roger Robinson, who worked tirelessly during his long career to highlight and address challenges in the human waste disposal process on Mt. McKinley and elsewhere. Thanks also go to researchers and field assistants who have contributed to this program over the years: especially Katie Goodwin who did the seminal work on this problem while pursuing an MS degree at Alaska Pacific University and Becca Stenerson, who did much of the field and lab work associated with the more recent round of water sampling. Thanks also to Guy Adema, Anthony Arendt, Rob Burrows, Adam Bucki, Matthias Braun, Dustin English, Scott Gende, Andy Hermansky, Chad Hults, Rich Johnson, Adrienne Lindholm, Joe Reichert, Dave Schirokauer, Haley Williams, and Joanna Young.

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Inclusive Conservation in the Denali Region of Alaska: Scenario Planning with Local Communities

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Public land management requires reflexive engagement, negotiation, and compromise among people who differ in how and why they value nature. A model for *inclusive conservation* involves engaging diverse audiences throughout the decision-making process—a shift that is needed to support the formation of more equitable policy solutions that remain in line with land management objectives.

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Public land management requires reflexive engagement, negotiation, and compromise among people who differ in how and why they value nature. The process of balancing visitor and resident interests while sustaining ecosystems is increasingly complicated by global environmental change and the range of relationships that people have with nature (Brownlee and Leong 2011, Mace 2014). A model for “inclusive conservation” involves engaging diverse audiences throughout the decision-making process (Goodson et al. 2024)—a shift that is needed to support the formation of more equitable policy solutions that remain in line with land management objectives (Raymond et al. 2022, Tallis and Lubchenco 2014). Inclusive conservation is especially relevant for protected areas in North America that are idealized by the public, owing to their layered historical meanings, exceptional ecological values, and roles as economic engines for local communities (Manning et al. 2016). In other words, the deep-seated appreciation that people have for protected areas can create tensions that need to be reframed, softened, and better understood through social science research. Moreover, given that resource management agencies have historically prioritized tourism in parks and protected areas (Runte 1997), there remains a disproportionate focus on enhancing visitor experiences rather than engaging gateway communities in dis-

cussions about the future (Johnson et al. 2022). Deep and meaningful partnerships with local residents around protected area management decisions are therefore needed to enhance connections between people and protected areas (Perry et al. 2018), as well as support adaptive planning in the face of change (Knapp et al. 2014).

Scenario Planning as a Tool for Protected Area Managers

Inclusive conservation requires not only fair representation and a broad base of respect among different interest groups, but also knowledge of the tradeoffs people make when considering alternative futures. Different visions for protected areas cannot be optimized simultaneously and the degree of uncertainty associated with preferred outcomes must be weighed in the process of making evidence-informed decisions (van Riper et al. 2011). Scenario planning is a promising pathway for evaluating tradeoffs, because it involves envisioning plausible future conditions, assessing their potential effects on key resources, and identifying how people will respond to change (Lo et al. 2022). Stated choice experiments can operationalize a scenario planning process by revealing respondents’ beliefs about what should happen in the future and elicit information about the tradeoffs people are willing to make to attain their preferred futures (Louviere et

Balancing visitor and resident interests while sustaining ecosystems is increasingly complicated. This article highlights a model for conservation that involves the public throughout the decision-making process.

NPS PHOTO

al. 2000). This technique asks respondents to choose between alternative sets of hypothetical future conditions and simultaneously offers insight on what people would be willing to pay for competing conditions (Loomis and Bilmes 2019). Stated choice experiments have generated useful results in the context of outdoor recreation research (Newton et al. 2020, Pröbstl-Haider et al. 2020), including assessments of resource (e.g., soil erosion, degradation), social (e.g., crowding, access), and managerial (e.g., educational signage, policy interventions) conditions in protected areas (Keller et al. 2025, Lawson and Manning 2002).

Empirical evidence that reveals why tradeoffs are being made is essential for achieving greater inclusivity. Although previous studies have predominantly relied on attitudinal explanations for guiding resource management decisions (Wallen and Landon 2020), the extant visitor use literature has explored a range of concepts such as indicators and standards of quality to monitor and evaluate crowding, soundscapes, and night skies (Manning et al. 2022), connections that form between people and places to enhance visitor experiences (Halpenny 2010), and human values (van Riper et al. 2019) to improve communication and provide foundational, long-term insights on how to change behavior (Andrade et al. 2023). Descriptive information such as socio-demographics, activity type, and previous experience has also proven useful to explain variation in how people think, feel, and act in relation to changing protected area landscapes (Brownlee and Leong 2011) and improve the outcomes that emerge from experiences in natural resource management contexts (Rice et al. 2020). Indeed, an understanding of the

diversity of preferences that people have for the future (what we term, *preference heterogeneity*) can provide useful decision support for managers and pathways for incorporating the perspectives of visitors and residents alike.

Research Purpose

We sought to establish a process for building inclusive conservation with the communities surrounding Denali National Park and Preserve and Denali State Park over a five-year period (see Figure 1). Multiple phases of research and mixed methods were employed to: (1) form partnerships, including a 10-person executive committee of local residents who represented different vested interests to guide the project; (2) characterize the current and future states of places through focus groups and interviews; (3) embark on a scenario planning process to understand residents' preferences for the future through a regional survey of residents in Interior Alaska; (4) evaluate how deliberation in an online discussion forum shifted the value positions of residents; and (5) support reflection throughout the research process and share findings with our project partners.

The first two qualitative phases of this project were supported by the National Park Service and involved building in-depth knowledge of community concerns. The third and fourth phases were supported by the National Science Foundation through a larger international research effort called [ENVISION](#) that culminated in reflections with decision makers (Raymond et al. 2022), as well as established a living online forum for discussion surrounding land management in the Denali region (Andrade et al. 2022).

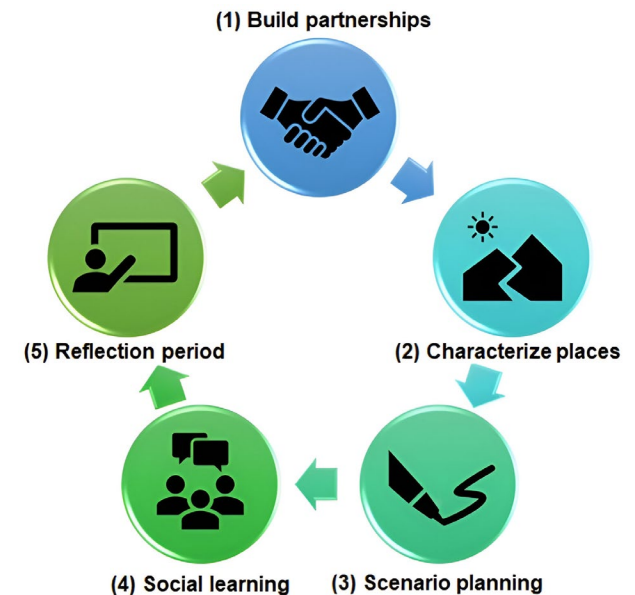


Figure 1. Five phases of our research to establish a process for inclusive conservation with communities in the Denali Region.

In the following sections of this article, we focus on the third phase of this project and share results from a stated choice experiment that was conducted to understand residents' preferences for the future. Specifically, we evaluated how tradeoffs were made among preferences for wildlife, fire management, tourism, and costs for achieving a desired future. We also showcase a decision support tool built from our stated choice results to guide resource management decision making in Alaska.

Data Collection

We administered a regional household survey to residents living in the Denali region across 10 communities from June to August 2020 during

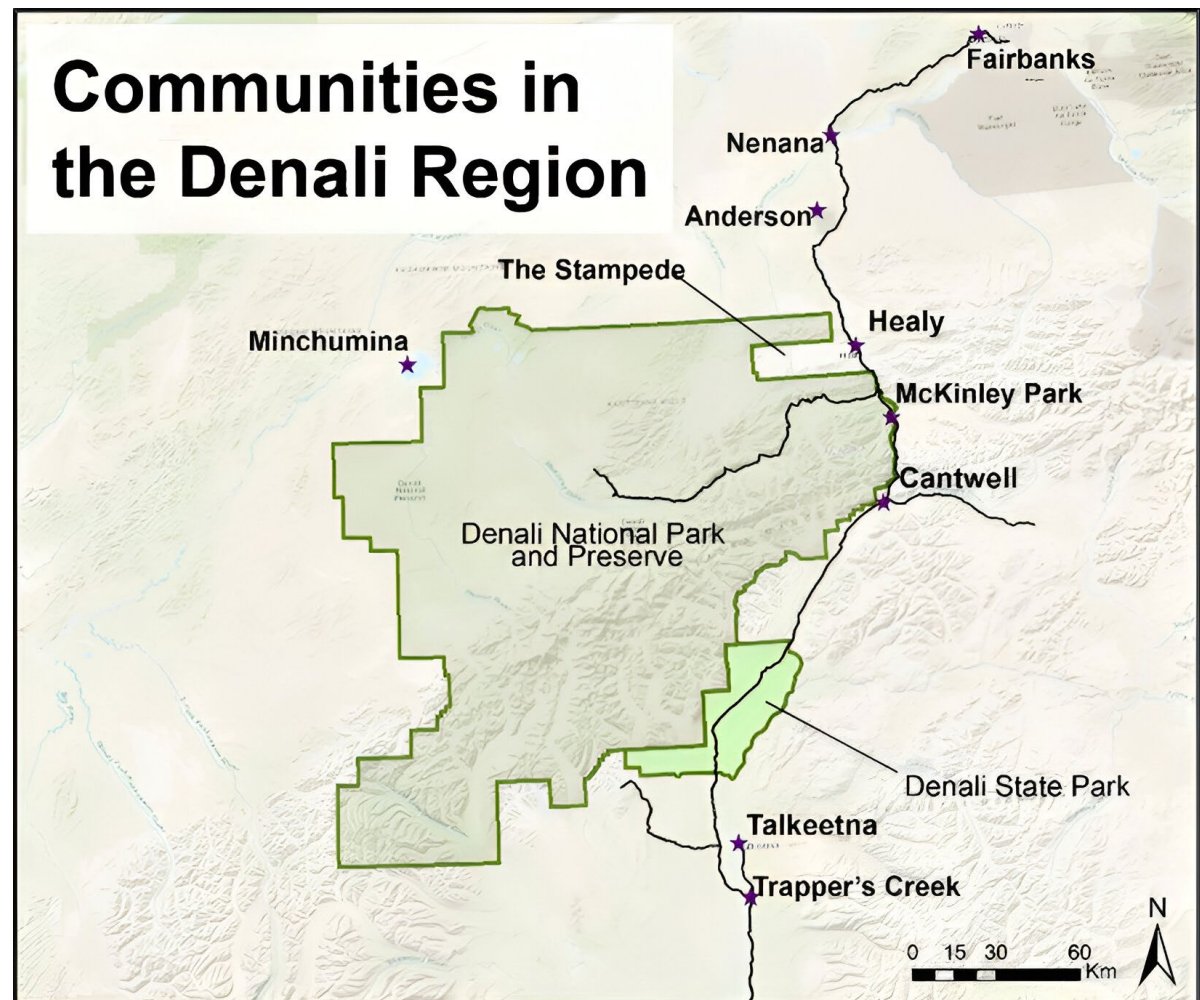
the third phase of our project (see Figure 2). A total of 3,000 households were contacted by mail on three different occasions and provided with tailored and personalized surveys. The opportunity to participate in the study was advertised widely through social media, on public venues, and word of mouth. Our survey was pilot tested and approved by the University of Illinois Institutional Review Board for ethical treatment of human subjects.

Scenario planning was implemented through a stated choice experiment. We measured respondents' preferences for hypothetical management scenarios that portrayed combinations of: (1) moose (*Alces alces*) population levels, (2) acres of Interior Alaska forest managed for fire, (3) off-season tourism in the Denali region, and (4) willingness-to-pay for desirable scenarios represented as a donation of personal dividends from the Alaska Permanent Fund. All attributes included either 3 or 5 levels reflecting a range of conditions that might be experienced over a 30-year period in response to climate change impacts. After viewing a 1-page instructional sheet, respondents were asked to evaluate 6 (out of 18) hypothetical planning scenarios. In each scenario, respondents chose between two hypothetical landscape management scenarios, or opted out by selecting a "no change" option (see Figure 3). The resulting choice data were analyzed with a random parameters logit (RPL) model using NLogit-6 statistical software.

Research Results

Socio-demographic Characteristics

A total of 303 residents participated in our study, yielding a 10% response rate. On average, respondents were middle-aged ($M=54.81$ years,



$SD=15.18$), had been living in Alaska for an average of 26.45 years ($SD=16.70$), and visited Denali National Park and Preserve and other public lands frequently. Respondents consisted of slightly more males (52.50%) than females; 73.50% held at least a bachelor's degree and 23.90% reported an annual household income of at least \$100,000. Racially, most respondents identified as White (80.20%), with 7.26% identifying as American Indian or Alaska

Figure 2. Map of the Denali Region and communities engaged during our research process.

Adapted with permission from Johnson et al. (2022).

Each scenario below is independent and includes three options. Please select the option that you would prefer for the area where you live.

Future Scenario 1

Suppose Option A and Option B were the *only* options available besides “No change” over **the next 30 years**. Which would you choose? *Please check the box that represents your choice.*

Attribute	Moose population 	Off-season Tourism 	Acres Managed for Fire 	Annual Cost 	I would choose 
Option A	15% Increase	25% Decrease in growth rate	15% Increase	\$0	☐ A
Option B	15% Increase	25% Increase in growth rate	15% Increase	\$75	☐ B
Option C	No change				☐ C

Figure 3. An example scenario from the stated choice experiment.

Native. Our sample demographics were broadly consistent with census-reported demographics of the Denali Borough, other than a slightly lower median annual household income (U.S. Census Bureau 2022).

Results from Stated Choice Experiment

Results showed that all 4 attributes explained the stated choices of Denali residents. Respondents preferred futures that included increases in moose populations ($\beta=0.02$) and acres of forest managed for fire ($\beta=0.02$). Conversely, respondents were less likely to choose hypothetical scenarios that conveyed increases in off-season tourism ($\beta=-0.01$). We calculated willingness-to-pay for these changes

by asking what respondents would be willing to donate from their Alaska Permanent Fund annual payments over the next 30 years. We found that they were willing to donate the most to increase the number of moose, at \$2.00 annually per 1% increase in population levels. Respondents would similarly be willing to donate \$1.81 annually per 1% increase in the amount of forest acres managed for fire, and \$0.89 annually per 1% decrease in the growth rate of off-season tourism. In other words, respondents would hypothetically be willing to donate \$30 for a 15% increase in moose populations, \$27.15 for a 15% increase in acres managed for fire, and \$22.35 for a 25% decrease in off-season tourism growth rates on an annual basis.

Preference Heterogeneity to Inform Scenario Planning

Public land managers require knowledge of the diversity of tastes and preferences that exist within a population (Pröbstl-Haider et al. 2020), particularly given increasing priorities for creating more inclusive protected area management decisions (Raymond et al. 2022). We therefore explored different options for identifying segments in our sample that would prove useful in the context of the Denali region. First, given the managerial utility of considering socio-demographic characteristics, we examined how age varied within our sample. We found that younger respondents prioritized acres managed for fire and annual cost, relative to older respondents. Second, as previous experience in a setting shows potential for informing more pointed management decisions (e.g., Guo et al. 2015), we considered how the number of years lived in Alaska varied within our sample. We found that more experienced



Focus groups were held in several communities (top: McKinley Village, above: Stampede).

residents more strongly prioritized increasing moose populations while de-prioritizing off-season tourism and fire management relative to comparative newcomers. Finally, we considered how attitudes (i.e., positive or negative evaluations of management interventions) provide a basis for preference heterogeneity given their stability over time (Heberlein 2012). We observed pronounced differences among subgroups defined by their attitudes and elaborate on these findings below.

Discussion of Findings

This research sought to establish a process for inclusive conservation in the region surrounding Denali National Park and Preserve and Denali State Park. We generated empirical findings to support Denali's Resource Stewardship Strategy, Strategy P (Monitor Trends in Adjacent Communities Population, Land Use and Economy) §86, specifically focused on "local community members' response to current and potential management strategies (including fire management)," (Denali National Park and Preserve 2009). We also used mixed methods through 5 phases of research to engage and partner with different segments in communities surrounding the region's protected areas. This process created a framework for incorporating diverse perspectives into decision making and turned the looking glass toward residents rather than visitors to advance an ongoing dialogue about how communities are visioning for a rapidly changing future in the Denali region. Here, we report on findings from a stated choice experiment focused on understanding the tradeoffs residents make among competing conditions.



Moose populations were most important to residents in their evaluation of the future. Forest fires and an uncertain future due to climate change were another driving consideration. Respondents had mixed feelings about off-season tourism—there were strong opinions for and against.

We made several key observations from our stated choice modeling results. First, moose populations were most important to residents in their evaluations of the future. It could be that respondents were considering the important role that moose play in ecosystem management, their utility for subsistence use, and charisma to draw tourists from outside the region (Salcido et al. 2023). Second, acres managed for forest fire were a driving consideration for respondents, which may be linked to concerns about climate change resulting in an increasingly uncertain future (Kasischke et al. 2010). Third, we observed that the pooled sample of survey respondents reported ambivalence toward off-season tourism; however, when segmenting our sample by attitudes toward management, strong preferences for and against off-season tourism emerged. Respondents with strong attitudes preferred a future with increasing levels off-season tourism, whereas those with weak attitudes preferred decreases in off-season tourism. Similar to other rural contexts, the Denali region is characterized by a low resident population, strong affinity for an independent lifestyle, and a strong sense of local community (Johnson et al. 2022, Cervený 2004). As such, this issue will require careful consideration and navigation by management agencies. Moreover, projections indicate that off-season tourism in the Denali region will increase in the future (Holsinger et al. 2019) so there is an urgent need to provide residents with opportunities to discuss how they would like to balance opportunities for economic gains in relation to preserving the qualities of places in a rural Alaska context that are experiencing developmental pressures.

Application of a Decision Support Tool

Empirical research on the tradeoffs people make to attain their preferred futures and the variation that exists within the population can be effectively communicated with protected area managers using decision support tools (Newman et al. 2005, Pröbstl-Haider et al. 2020). These tools allow managers to develop and then test different configurations of future scenarios, thus gauging how well their decisions to change different landscape conditions would be received by community members. For example, a manager might wish to understand the likelihood of support for efforts to redirect tourism in response to wildlife or environmental sustainability, as well as understand the economic benefits provided to gateway communities. These are complicated tradeoffs, but such insights may decrease the likelihood of conflict and enhance relationships that residents have with places and management agencies. We developed a decision support tool using our stated choice modeling results to evaluate three different management scenarios.

For illustration purposes, we used our Denali Decision Support Tool to show how subgroups defined by their attitudes toward management evaluated three scenarios: (1) *ecological optimization* that prioritizes ecological integrity by increasing acres managed for fire by 30%, maintaining current moose population levels, and decreasing off-season tourism by 25%, with \$100 in annual costs for residents; (2) *economic optimization* that prioritizes visitation to the Denali region by increasing off-season tourism by 25%, increasing acres managed for fire by 15%, increasing moose populations by 15%, and adding \$50 of annual costs to residents; and (3) *status quo management* whereby management

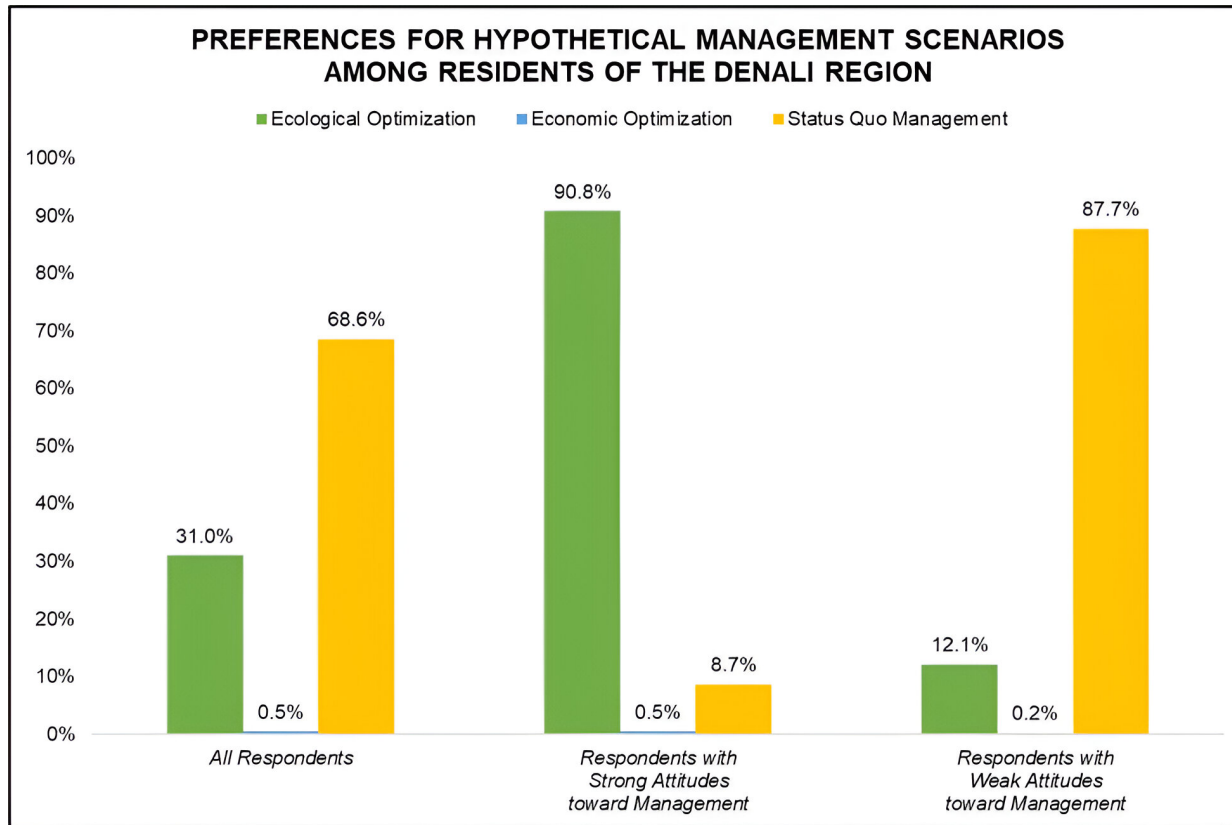


Figure 4. Output from a decision support tool that drew on attitudinal variables and results from a stated choice experiment. Findings show preferences for hypothetical management scenarios of ecological optimization, economic optimization, and status quo management among residents of Denali.

Percentages displayed above the bars indicate the likelihood that residents would prefer the associated scenario over either of the two alternative scenarios.

agencies would maintain current acres managed for fire, allow moose populations to follow their current trajectory with an increase of 30%, and maintain current off-season tourism trends, with no additional annual cost to residents over the next 30 years. We observed that all survey respondents preferred the *status quo* scenario. However, when accounting for preference heterogeneity, respondents with strong attitudes preferred the ecological optimization scenario, compared to respondents with weak attitudes that preferred the *status quo* (see Figure 4). Respondents were unlikely to support the economic optimization scenario regardless of their attitudes.

Concluding Thoughts

This project aims to help establish a process for inclusive conservation that works toward greater representation among people with different backgrounds living around protected areas in the Denali region of Alaska. Results from our stated choice experiment illustrate how tradeoffs are being made by residents when they envision the future, while our efforts to identify smaller and more homogenous subgroups reveal a diversity of residents' tastes and preferences for change that would be overlooked without insights from the environmental social sciences. These findings are presented to further facilitate dialogue among managers, researchers, and

residents about how best to respond to a rapidly changing environment in the Denali region of Alaska. We also showcase a decision support tool to advance the process of making evidence-based decisions through deliberation (Andrade et al. 2023) and capacity building with local communities (Perry et al. 2018).

Access the decision support tool here:
[Inclusive Conservation Around
Denali National Park and Preserve](#)

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