

Literature Review

COPYRIGHT KELLY BRICKER



Human dimensions of winter use in Yellowstone National Park: A research gap analysis

By Elise T. J. Gatti, Kelly S. Bricker, and Matthew T. J. Brownlee

THE EARLIEST WRITTEN ACCOUNTS OF FORAYS INTO Yellowstone National Park during winter were made by hunters during the late 19th century. They probably entered what would become the nation's first national park on long wooden skis known as "Norwegian snowshoes" (NPS 2015c). Since then, much has changed in Yellowstone with regard to winter use. Today's winter visitors are still drawn to Yellowstone with the hope of viewing iconic wildlife, such as bison and wolves, as well as dramatic, snowy landscapes featuring contrasting, multicolored, and steaming geothermal features. However, the introduction of oversnow transportation technologies into the park, starting with snowplanes in 1949 and followed by snowcoaches and snowmobiles in the 1960s, has led to fundamental changes to park infrastructure, patterns of use, and conditions experienced by park visitors—as well as the social and economic fabric of surrounding communities (fig. 1) (Yochim 2006). As a result of real and perceived impacts of these technologies on

Abstract

This article summarizes findings from a literature review of scholarly publications and federal government documents related to winter use in Yellowstone National Park (Bricker et al. 2013). The researchers synthesized peer-reviewed periodicals and conference proceedings, government documents, and technical reports published between 1972 and 2013. We discerned and analyzed the following five research themes: (1) stakeholders and their experiences, (2) recreation impacts on park resources, (3) park management, (4) the Greater Yellowstone Area, and (5) methodology. We identified knowledge gaps that frame opportunities for further inquiry that can be useful to park managers and researchers interested in Yellowstone National Park and other protected areas with high winter use.

Key words

human dimensions, social science, winter, winter recreation, Yellowstone National Park

Figure 1 (opposite). While studies of motorized recreation and transportation have found some impacts on park wildlife and environmental quality, commercial guides were found to help mitigate impacts on wildlife while improved technologies have resulted in lowered emissions over time. Access to natural soundscapes was more important to visitors whose primary activity was human-powered transport.

park resources—in particular air quality, wildlife, and soundscape—there has been prolonged litigation and debate about what constitutes an appropriate balance among recreational access, technology, and resource protection in Yellowstone.

The conflict over winter use in the park has provided fertile ground for natural and social science researchers. Every year, the National Park Service fields requests from researchers regarding potential winter use investigations in Yellowstone. Nearly 25 years after the first winter use management plan was produced for the park, a team of researchers at the University of Utah generated a review of research regarding winter activity in Yellowstone. This review provides park managers and academic partners with a synthesis of what is known, what is not known, and opportunities for future inquiry (Bricker et al. 2013).

We started with the question, “What are the themes and gaps in the literature regarding the human dimensions of winter recreation in Yellowstone?” The term “human dimensions” in this study refers to the social attitudes, processes, and behaviors related to how Yellowstone is used by park stakeholders. The dimensions are considered at individual, institutional, community, and societal levels. Park stakeholders include (1) visitors, both domestic and foreign; (2) park staff, including park managers and frontline employees; (3) concessioner staff; and (4) constituents of the Greater Yellowstone Area.

Methods

We used a six-step, semi-inductive research synthesis method to identify themes and gaps in the literature (e.g., Cooper et al. 2009). We performed a literature search of peer-reviewed journal articles and conference proceedings, government documents, and technical reports. We delimited the study sample to materials published between 1972 and 2013, with 1972 marking the centennial of the establishment of Yellowstone National Park. This search involved several Internet databases, solicitations from Yellowstone staff to share key documents, and a reverse search through manuscript bibliographies. A detailed description of the databas-

es and Boolean search operators used is available in Bricker et al. (2013). The references were evaluated to try to focus on those sources that were subject to a high degree of review, including refereed manuscripts and vetted government planning documents as well as additional literature reviews that included Yellowstone National Park and the surrounding area. Books, non-refereed periodicals, dissertations, and theses were excluded from the analysis. Details and justifications on the criteria used to evaluate manuscripts are also available in Bricker et al. (2013).

In order to uncover thematic categories, we first prepared an annotated bibliography of each source. Multiple readers then independently identified key topics for each one. We met twice to review and synthesize the research. Ultimately, our synthesis provided us with agreed-upon groupings of topics into five themes: (1) stakeholders and their experiences, (2) recreation impacts on park resources, (3) park management, (4) the Greater Yellowstone Area, and (5) methodology. The research synthesis did not seek to support or refute any hypotheses, build theory, or evaluate the impacts of the evidence using meta-analytic techniques (i.e., effect size). Instead, we identified subthemes based on the constructs and issues identified in seminal works (e.g., Manning 2011) and by senior researchers. We characterized these based on how often the theme had been addressed in the literature (e.g., “themes studied in two or more works” or “themes studied in one work”). Research gaps included significant themes, connections, and opportunities that were identified by either previous authors or our research team but not otherwise scientifically explored in the literature we reviewed. The list of identified gaps is not intended to be exhaustive but rather reflects the authors’ review of previous literature, and seminal works of outdoor recreation authors (e.g., Manning 2011). This process provided the framework for prioritization. As such, the authors recognize and acknowledge the potential for subjective bias in developing research gaps.

Results and discussion

Citation characteristics

In total, the literature search and evaluation focused on 58 citations, including 23 peer-reviewed periodical articles, 28 government documents, five technical documents, and two conference proceedings. A full list of references is included in Bricker et al. (2013). Overall, the majority of the research-based manuscripts (i.e., not significantly related to official winter planning documents; $n = 30$) addressed the impacts of recreational use—especially by motorized vehicles—on natural resources, including wildlife, air quality, and the soundscape. The geographic focus of the articles ranged from specific areas within the park, to analyses of the broader context of the park in the surrounding area, and to



Figure 2. Regardless of their values, winter visitors to Yellowstone cited viewing natural scenery as the main reason for their visit. This finding was consistent for visitors on snowmobiles, who see snowmobiles as a means for viewing the park landscape, wildlife, and geothermal features rather than as a discrete recreational experience.

analyses of the park in the context of winter use at other national parks. Two of the manuscripts, namely Creel et al. (2002) and Cassirer et al. (1992), are “landmark” articles that have been cited more than 100 times according to Google Scholar.

While the date range of our search spanned 1972 to 2013, the earliest published document was the 1989 Department of the Interior background study used to inform Yellowstone’s first winter use plan environmental assessment. Only seven documents were published between 1989 and 1999, and most of these sources focused on the impacts of snowmobiles. Forty-six documents were published between 2000 and 2009, and only six between 2010 and 2013. There was no discernable pattern to the distribution of publications based on themes addressed or document types from the year 2000 onward.

Themes and gaps

Table 1 presents the themes and gaps based on how often they were addressed in the literature. The abbreviated discussions of research themes that follow highlight key points and references. Some of the 58 references were simultaneously included under multiple themes because of overlapping findings.



Figure 3. This gap analysis found many opportunities for research on stakeholders and their experiences. For example, much of the focus has been on park visitors, with only one study addressing concessioner staff and no studies examining the experiences and perceptions of gateway communities, park staff, or the nonvisiting public.

Research theme 1:

Stakeholders of the Yellowstone National Park experience

Seven manuscripts, all published between 2000 and 2013, explored the values, meanings, preferences, and motivations of park stakeholders (e.g., Borrie et al. 2002; Davenport and Borrie 2005; Davenport et al. 2000, 2002; Freimund et al. 2009; Mansfield et al. 2008; Tanner et al. 2008). Understanding visitor values can help park managers predict support for management decisions—values being more stable than attitudes and opinions (Yankelovich 1991). A major finding is that visitor-attributed values and motivations for visiting Yellowstone are not necessarily aligned with specific activities (e.g., snowmobiling; Borrie et al. 2002; Davenport et al. 2000). This may be because a majority of visitors to the park engage in a variety of activities during their winter visit (Davenport et al. 2000). Borrie et al. (2002), for example, found that visitors could be sorted into four clusters based on the values they attributed to Yellowstone: naturalists, human oriented, players, and park enthusiasts. Regardless of their values, winter visitors to Yellowstone cited viewing natural scenery (including wildlife and geothermal features) as the main reason for their visit (figs. 2 and 3) (Davenport et al. 2000; Tanner et al. 2008). This finding was consistent for visitors on snowmobiles, who see snowmobiles as a means for viewing the park landscape, wildlife, and geothermal features rather than as a discrete recreational experience (Davenport and Borrie 2005). This view was supported by the sole study that included concessioner staff (Freimund et al. 2009). In that study, concessioner staff perceived that visitors have

Table 1. Research themes and gaps

Categories	Themes Studied in Two or More Works	Themes Studied in One Work	Themes Not Studied (research gaps)
Stakeholders and their experiences	<ul style="list-style-type: none"> • Values and meanings attributed to Yellowstone by park visitors 	<ul style="list-style-type: none"> • Link between values and support for management action • Experiences of snowmobile users • Experiences of guides and concessioners 	<ul style="list-style-type: none"> • Comparison of different stakeholders' experiences and perceptions • Comparison of park visitors' experiences based on primary mode of transport • Place attachment in winter • Differences among seasonal experiences in Yellowstone • Values of nonvisitors • Displacement of visitors and businesses due to economic factors • Underrepresented populations and relevancy
Recreation impacts on park resources	<ul style="list-style-type: none"> • Air quality • Wildlife (bison and elk) 	<ul style="list-style-type: none"> • Soundscape • Water • Wildlife (excluding bison and elk) 	<ul style="list-style-type: none"> • Cultural resources • Night sky and light pollution • Vegetation
Park management	<ul style="list-style-type: none"> • Physical carrying capacity • Air quality at park entrances 	<ul style="list-style-type: none"> • Standards and indicators of environmental quality • Nonmotorized recreation 	<ul style="list-style-type: none"> • Social carrying capacity • User conflict between recreation types • Recreation diversity • Public consultation process evaluation • Demand/impact studies of park facilities and infrastructure
Greater Yellowstone Area	<ul style="list-style-type: none"> • Economic impacts of Yellowstone on Greater Yellowstone Area 	<ul style="list-style-type: none"> • Economic impacts of motorized recreation 	<ul style="list-style-type: none"> • Differences in snowmobiling experiences: Yellowstone vs. nearby national forest lands • Attitudes of area residents toward park management • Economic impacts of wildlife tourism • Economic value of ecosystem services • Dynamics of amenity migration (residents who move to a location because of proximity to recreational opportunities)
Methodology	<ul style="list-style-type: none"> • Quantitative research approaches 	<ul style="list-style-type: none"> • Qualitative research approaches 	<ul style="list-style-type: none"> • Qualitative approaches (e.g., ethnographies) • Social-spatial mapping • Long-term studies • Follow-up studies • Systematic reviews

changed from those using the park to experience snowmobiling to those who use snowmobiling to experience the park. The same research also found that concessioner staff believed that visitors appreciated the guided oversnow vehicle experience because of the transfer of knowledge that occurred through the interpretive services. These findings suggest the need to focus management planning and policies on the overall park experience rather than discrete activities.

This gap analysis found many opportunities for research on stakeholders and their experiences. For example, much of the focus has been on park visitors, with only one study addressing concessioner staff and no studies examining the experiences and perceptions of gateway communities, park staff, or the nonvisiting public. Research questions that target the values, experiences, and perspectives of these stakeholders, especially with respect to their influence on park management strategies, would help fill this gap. For example, what are the values attributed to the park by nonvisitor stakeholders? What is the extent of place attachment among winter guides or park staff? And how has use by local residents changed since the new commercial guide and best available technology (BAT) for snowmobiles requirements were introduced in 2004 and finalized in 2013? Additionally, a number of avenues remain to be investigated regarding park visitors. Comparative studies of the summer and winter seasonal experiences, of visitor experiences based on modes of transport, and of value orientations between visitors and nonvisitors (including park staff, concessioner staff, and citizens of the local community as well as the public at large who does not visit the park) could provide useful insights for park managers. Another possibility would be to explore the dynamics surrounding traditionally underrepresented groups in national parks, such as visible minorities (Taylor et al. 2011), as well as displaced concessioners during the winter season.

Research theme 2: Recreation impacts on park resources

Twenty-three manuscripts focused on the impacts of recreation and transportation, especially of motorized vehicles, on park wildlife and environmental quality (air quality, water quality, and soundscape). A complete list of those references is available in Bricker et al. (2013). As already reported, “wildlife is a major component of the Yellowstone experience” during winter (Caslick 1997, p. A-5). Visitors expect to see wildlife and value the park’s mandate to protect it (Tanner et al. 2008). The parks in the Greater Yellowstone Area (Yellowstone and Grand Teton National Parks and John D. Rockefeller, Jr., Memorial Parkway; also see theme 4) protect the largest and most diverse number of animal species in the contiguous 48 states, including a federally listed threatened, charismatic species—the Canada lynx (*Lynx canadensis*)—as well as the recently delisted grizzly bear (*Ursus arctos horribilis*), gray wolf (*Canis lupus*), and bald eagle (*Haliae-*

tus leucocephalus) (RTI International 2007). With the restoration of the gray wolf starting in 1995, the park is once again home to the same assemblage of large mammals present during precolonial times (NPCA 2006).

Winter visitors interact with wildlife while pursuing various outdoor activities, and the literature reports a variety of impacts on wildlife within the park. These include habituation of wildlife to humans, habitat disturbance, disrupted foraging behavior, interference with breeding behavior, and physiological stress responses during harsh winter conditions (Olliff et al. 1999). Wildlife responses depended on a number of factors, including (1) whether visitors stop, dismount, and approach the animal; (2) human interaction time; (3) number of vehicles; (4) proximity of animals to the road; and (5) size of animal group (Borkowski et al. 2006). Studies of wildlife (in particular elk, bison, and trumpeter swans) responses to oversnow vehicles (OSVs) found some impacts; however, 72% of the wildlife showed no visible response, with less than 1% fleeing from the area in response to vehicles (McClure 2009). Commercial guides were found to help mitigate impacts through a number of interventions (e.g., stopping at greater distances from wildlife, keeping people close to vehicles; McClure 2009). Regarding air quality, one of the main findings was that large reductions in emissions were achieved over time with changes to the models, engine sizes, engine cooling types, and technologies used in the park’s OSV fleets (Bishop et al. 2009). Regarding water quality, the levels of volatile organic compounds present in Yellowstone’s surface water runoff have been found to be within acceptable limits as established by the US Environmental Protection Agency (Arnold and Koel 2006). Regarding soundscapes, Freimund et al. (2009) found that visitors to the Old Faithful area expect to hear natural soundscapes, but those whose primary activity was human-powered transport (i.e., skiing or snowshoeing) thought that natural sounds were more important than the other groups.

The gap analysis found many opportunities for additional research on winter use impacts on park resources. Nonmotorized recreation has not been fully assessed. Concerning wildlife, little research has examined the impacts of winter use on grizzlies, wolves, bighorn sheep, mountain goats, and mid-sized carnivores such as bobcats, lynxes, martens, red foxes, fishers, and weasels that may be susceptible to behavioral and physical impacts. Studies of the impacts on vegetation, dark skies (light pollution), and cultural resources were also not found in our literature review, and more research is needed to measure noise impacts over long distances in remote environments (e.g., Menge et al. 2002). In terms of anticipating emerging technologies that may cause additional resource disruption, a 2014 NPS interim policy prohibits the use of recreational unmanned aircraft and drones in national

Understanding visitor values can help park managers predict support for management decisions—values being more stable than attitudes and opinions.

park units (NPS 2017). Arnold and Koel (2006) call for research on potential impacts from polycyclic aromatic hydrocarbons from engine emissions, which are known to be harmful to human and animal health and to be more persistent in the environment than previously studied volatile organic compounds. They also call for research on the impacts of vehicle fluids leaked on snow roads, noting that all of Yellowstone's waterways are classified as Class 1 Outstanding Natural Resource Waters, a designation that ensures a high level of protection and is enforceable under provisions of the Clean Water Act (Arnold and Koel 2006).

Research theme 3: Park management

Sixteen manuscripts focused specifically on issues related to park policy and planning documents. Since the publication of Yellowstone's first winter use plan in 1990, the National Park Service has completed a number of management plans that consider seasonal changes in resource access and management (e.g., Dustin and Schneider 2004; Yochim 2006; NPS 2015b). Many of these involved collection and synthesis of data related to various structured decision-making frameworks, including Limits of Acceptable Change models (NPS 2008, 2011; Sacklin et al. 2000) and Recreation Opportunity Spectrum tools (NPS 2007, 2008, 2011). Several studies on theme 2 were also specifically developed in the context of park policy decisions related to OSV carrying capacity, air quality, and the impacts of snow road grooming on wildlife.

Because the sources in this category were policy driven, there are a number of gaps and opportunities for additional related research. For example, while several studies referred to physical carrying capacity in the context of OSVs (e.g., Arnold and Koel 2006; Borkowski et al. 2006), there were no studies of social carrying capacity, or studies on conflicts between types of recreationists or on recreation diversity. The Recreation Opportunity Spectrum model has been used in winter planning (e.g., NPS 2008, 2011) but it has not been evaluated for its efficacy in this context. Public consultation has likewise been a planning component since the first park winter plan, but no evaluations of the efficacy of the National Environmental Policy Act methods and techniques in Yellowstone were located in this literature search.

Last, during the winter season an array of infrastructure, facilities, and services are maintained in Yellowstone, including privately run hotels, transportation, and guiding services in the park. With the exceptions of the impacts of groomed roads on wildlife (e.g. Bjornlie and Garrott 2001; Bruggeman et al. 2006) and impacts of idling OSVs on air quality (e.g., Bishop et al. 2009), park facilities and infrastructure received scant attention in the literature.

Research theme 4: Greater Yellowstone Area

Eight manuscripts focused on the relationship between Yellowstone National Park and its broader context—both in ecological and human terms (Jobes 1991; NPCA 2006; NPS 2004, 2007; Olliff et al. 1999; RTI International 2004, 2007; Yochim 2006). The Greater Yellowstone Area includes 20 counties in Idaho, Montana, and Wyoming that are part of the 34,375-square-mile (89,031 square km) Greater Yellowstone Ecosystem, one of the last remaining large, nearly intact temperate-zone ecosystems on Earth (NPS 2015a). The literature confirms that tourism comes with its own social and environmental challenges, among them the fragmentation of habitat in the Greater Yellowstone Ecosystem (NPCA 2006; Olliff et al. 1999). In human terms, the most prevalent research question addressed on this theme was the economic impact of Yellowstone National Park on surrounding communities (NPCA 2006; NPS 2004, 2007; RTI International 2004, 2007). One of the key findings is that Yellowstone National Park plays an important social and economic role both regionally and nationally (Jobes 1991; NPCA 2006). Another finding is that planning in Yellowstone is politically charged, with substantial investments made by national motorized recreation interests (Yochim 2006).

A number of gaps remain concerning the interactions between the park and its context. As noted under theme 1, research is needed regarding the values, perspectives, and experiences of surrounding residents, particularly in relation to park use, park management, and place attachment. The question of how park policies, including rules around concessioner permitting, influence the social and economic structures of gateway communities should also be explored. Similarly, the dynamics of amenity

Much of the focus [of past research] has been on park visitors, with only one study addressing concessioner staff and no studies examining the experiences and perceptions of gateway communities, park staff, or the nonvisiting public.

migration—when people move to an area for reasons other than economics, such as physical or cultural amenities and the impacts of seasonal tourism-related work—are also a topic yet to be examined. And finally, the economic impacts of wildlife tourism, the economic value of ecosystem services provided by Yellowstone, and differences in snowmobiling experiences inside and outside the park are also viable avenues for research.

Research theme 5: Methodology

The research synthesis found a lack of diversity in research approaches. Commonly used quantitative research approaches included (1) measurements of air quality, water quality, exhaust emissions, and sound levels of OSVs; (2) economic impact analyses of proposed management actions; (3) observer surveys recording human-wildlife interactions and wildlife responses to human stimuli; (4) OSV counts; and (5) visitor surveys of preferences, values, personal characteristics, and recreation activities (mail-in and on-site). Less commonly used approaches included radiotelemetry, benefit-cost analyses of Yellowstone-related tourism in the Greater Yellowstone Area, and measurements of stress hormone levels of wildlife in response to interactions with OSVs.

These results indicate several methodological gaps. When appropriate to the research question, future research might benefit from qualitative approaches, including case studies, interviews, focus groups, and ethnographies. Social-spatial mapping approaches could be used as well, including GPS visitor tracking (Beeco et al. 2014) and public participatory GIS, such as social-values mapping (Van Riper et al. 2012). The research synthesis did not uncover any evaluative, longitudinal, or follow-up studies; given the changing regulatory context, such studies would be useful in tracking trends and responses to new regulations. Future review-oriented research also could consider incorporating books and non-peer-reviewed material, such as dissertations and theses, into research syntheses.

Conclusions

This study provides a synthesis of the catalog of research on the human dimensions of winter use in Yellowstone National Park. Systematic reviews of research such as this allow park managers, researchers, and academics to assess the state of knowledge about their park on an ongoing basis. The gaps in knowledge and opportunities for further research can be useful to managers and researchers at Yellowstone and other parks with similar winter use profiles.

References

- Arnold, J. L., and T. M. Koel. 2006. Effects of snowmobile emissions on the chemistry of snowmelt runoff in Yellowstone National Park: Final report. YCR-2006-1. National Park Service, Yellowstone National Park Center for Resources, Fisheries and Aquatic Sciences Section, Yellowstone National Park, Wyoming, USA. Accessed 13 October 2013 at http://www.snowmobileinfo.org/snowmobile-access-docs/Effects-Snowmobile-Emissions-Chemistry-Snowmelt-Runoff_2006.pdf.
- Beeco, J. A., J. C. Hallo, and M. T. J. Brownlee. 2014. GPS visitor tracking and recreation suitability mapping: Tools for understanding and managing visitor use. *Landscape and Urban Planning* 127:136–145. <https://doi.org/10.1016/j.landurbplan.2014.04.002>.
- Bishop, G. A., R. Stadtmuller, D. H. Stedman, and J. D. Ray. 2009. Portable emission measurements of Yellowstone park snowcoaches and snowmobiles. *Journal of the Air and Waste Management Association* 59(8):936–942. doi:10.3155/1047-3289.59.8.936.
- Bjornlie, D. D., and R. A. Garrott. 2001. Effects of winter road grooming on bison in Yellowstone National Park. *Journal of Wildlife Management* 65(3):560–572. doi:10.2307/3803109.
- Borkowski, J. J., P. J. White, R. A. Garrott, D. Troy, A. R. Hardy, and D. J. Reinhart. 2006. Behavioral responses of bison and elk to snowmobiles and snow coaches. *Ecological Applications* 16(5):1911–1925. doi:10.1890/1051-0761(2006)016[1911:BROBAE]2.0.CO;2.
- Borrie, W. T., W. A. Freimund, and M. A. Davenport. 2002. Winter visitors to Yellowstone National Park: Their value orientations and support for management actions. *Human Ecology Review* 9(2):41–48. Accessed 30 October 2013 at <http://www.humanecologyreview.org/pastissues/her92/92borrieetal.pdf>.
- Bricker, K. S., M. T. J. Brownlee, and E. T. J. Gatti. 2013. Human dimensions of winter use in Yellowstone National Park: A research gap analysis (1972–2013). Department of Health, Kinesiology, and Recreation, University of Utah, Salt Lake City, Utah, USA.

- Bruggeman, J. E., R. A. Garrott, D. D. Bjornlie, P. J. White, G. R. Watson, and J. Borkowski. 2006. Temporal variability in winter travel patterns of Yellowstone bison: The effects of road grooming. *Ecological Applications* 16(4):1539–1554. doi:10.1890/1051-0761(2006)016[1539:TVIWTP]2.0.CO;2.
- Caslick, J. W. 1997. Impacts of winter recreation on wildlife in Yellowstone National Park: A literature review and recommendations. Unpublished Report. National Park Service, Yellowstone National Park, Wyoming, USA.
- Cassirer, F. E., D. J. Freddy, and E. D. Ables. 1992. Elk responses to disturbances by cross-country skiers in Yellowstone National Park. *Wildlife Society Bulletin* 20(4):375–381.
- Cooper, H., L. V. Hedges, and J. C. Valentine, editors. 2009. *The handbook of research synthesis and meta-analysis*. Russell Sage Foundation, New York, New York, USA.
- Creel, S., J. Fox, A. Hardy, J. C. Sands, B. Garrott, and R. Peterson. 2002. Snowmobile activity and glucocorticoid stress responses in wolves and elk. *Conservation Biology* 16(3):809–814. doi:10.1046/j.1523-1739.2002.00554.x.
- Davenport, M. A., and W. T. Borrie. 2005. The appropriateness of snowmobiling in national parks: An investigation of the meaning of snowmobiling experiences in Yellowstone National Park. *Environmental Management* 35(2):151–160. <https://doi.org/10.1007/s00267-003-0265-1>.
- Davenport, M. A., W. A. Freimund, W. T. Borrie, R. E. Manning, W. A. Valliere, and B. Wang. 2000. Examining winter visitor use in Yellowstone National Park. Pages 86–92 in D. N. Cole, S. F. McCool, W. T. Borrie, and J. O'Loughlin, compilers. *Wilderness Science in a Time of Change conference. Volume 4: Wilderness visitors, experiences, and visitor management*. Proceedings RMRS-P-15-VOL-4, 23–27 May 1999, Missoula, Montana. USDA, Forest Service, Rocky Mountain Research Station, Ogden, Utah, USA.
- Davenport, M. A., W. T. Borrie, W. A. Freimund, and R. E. Manning. 2002. Assessing the relationship between desired experiences and support for management actions at Yellowstone National Park using multiple methods. *Journal of Parks and Recreation Administration* 20(3):51–64.
- Dustin, D. L., and L. E. Schneider. 2004. The science of politics/The politics of science: Examining the snowmobile controversy in Yellowstone National Park. *Environmental Management* 34(6):761–767. <https://doi.org/10.1007/s00267-004-0082-1>.
- Freimund, W., M. Patterson, K. Bosak, and S. Walker. 2009. Winter experiences of Old Faithful visitors in Yellowstone National Park. Unpublished report. University of Montana Department of Society and Conservation, Missoula, Montana, USA.
- Jobes, P. C. 1991. The Greater Yellowstone social system. *Conservation Biology* 5(3):387–394. doi:10.1111/j.1523-1739.1991.tb00152.x.
- Manning, R. E. 2011. *Studies in outdoor recreation: Search and research for satisfaction*. Third edition. Oregon State University Press, Corvallis, Oregon, USA.
- Mansfield, C., D. J. Phaneuf, F. R. Johnson, J. C. Yang, and R. Beach. 2008. Preferences for public lands management under competing uses: The case of Yellowstone National Park. *Land Economics* 84(2):282–305. doi:10.3368/le.84.2.282.
- McClure, C. 2009. Wildlife responses to motorized winter recreation in Yellowstone: 2009 annual report. National Park Service, Yellowstone National Park Center for Resources, Yellowstone National Park, Wyoming, USA.
- Menge, C. W., J. C. Ross, and R. L. Ernenwein. 2002. Noise data from snowmobile pass-bys: The significance of frequency content. SAE Technical Paper Series 2002-01-2765. Society of Automotive Engineers, Warrendale, Pennsylvania, USA. <https://doi.org/10.4271/2002-01-2765>.
- NPCA (National Parks Conservation Association). 2006. Gateways to Yellowstone: Protecting the wild heart of our region's thriving economy. National Parks Conservation Association, Washington, DC, USA. Accessed 1 October 2013 at <http://www.npca.org/news/reports/Gateways-Yellowstone.html>.
- NPS (National Park Service). 2004. Economic impact analysis of the Temporary Winter Use Plan for Yellowstone and Grand Teton National Parks and John D. Rockefeller, Jr. Memorial Parkway. US Department of the Interior, Fort Collins, Colorado, and Washington, DC, USA. Accessed 1 October 2013 at <https://www.nps.gov/yell/learn/management/upload/economicimpact04.pdf>.
- . 2007. Winter use plans: Final environmental impact statement. US Department of the Interior, Washington, DC, USA. Accessed 1 October 2013 at https://www.nps.gov/yell/learn/management/upload/vol1_abstract_table_contents_summary.pdf.
- . 2008. 2008 Winter use plans environmental assessment: Yellowstone and Grand Teton National Parks and the John D. Rockefeller, Jr. Memorial Parkway. US Department of the Interior, Washington, DC, USA. Accessed 1 October 2013 at [https://www.nps.gov/yell/learn/management/upload/2008_winter_use_ea\(p1\).pdf](https://www.nps.gov/yell/learn/management/upload/2008_winter_use_ea(p1).pdf).
- . 2011. 2011 Yellowstone National Park: Draft winter use plan/environmental impact statement. National Park Service, Yellowstone National Park, Wyoming, USA. Accessed 3 October 2013 at http://www.nps.gov/yell/learn/management/upload/wu_deis_2011.pdf.
- . 2015a. Greater Yellowstone Ecosystem. Accessed 3 October 2013 at <https://www.nps.gov/yell/learn/nature/greater-yellowstone-ecosystem.htm>.
- . 2015b. Winter use: Management and planning archive. Accessed 3 October 2013 at <http://www.nps.gov/yell/learn/management/winterusetechicaldocuments.htm>.

- . 2015c. Yellowstone in winter: A history of winter use. Accessed 28 October 2015 at <http://www.nps.gov/yell/learn/management/timeline.htm>.
- . 2017. Unmanned aircraft systems. Accessed 31 October 2017 at <https://www.nps.gov/orgs/aviationprogram/unmanned-aircraft-systems.htm>.
- Olliff, T., K. Legg, and B. Kaeding. 1999. Effects of winter recreation on wildlife of the Greater Yellowstone Area: A literature review and assessment. National Park Service and USDA Forest Service Greater Yellowstone Winter Wildlife Working Group, Yellowstone National Park, Wyoming, USA.
- RTI International. 2004. Economic analysis of temporary regulations on snowmobile use in Greater Yellowstone Area. RTI International, Durham, North Carolina, USA. Accessed 3 October 2013 at <https://www.nps.gov/yell/learn/management/upload/enefitcostreportaug2004.pdf>.
- . 2007. Economic analysis of winter use regulations in Greater Yellowstone Area. RTI International, Durham, North Carolina, USA. Accessed 3 October 2013 at http://www.nps.gov/yell/learn/management/upload/final_economic_analysis.pdf.
- Sacklin, J. A., K. L. Legg, M. S. Creachbaum, C. L. Hawkes, and G. Helfrich. 2000. Winter visitor use planning in Yellowstone and Grand Teton National Parks. Pages 243–250 *in* D. N. Cole, S. F. McCool, W. T. Borrie, and J. O'Loughlin, compilers. *Wilderness Science in a Time of Change* conference. Volume 4: Wilderness visitors, experiences, and visitor management. Proceedings RMRS-P-15-VOL-4, 23–27 May 1999, Missoula, Montana. USDA, Forest Service, Rocky Mountain Research Station, Ogden, Utah, USA.
- Tanner, R. J., W. A. Freimund, W. T. Borrie, and R. N. Moisey. 2008. A meta-study of the values of visitors to four protected areas in the western United States. *Leisure Sciences* 30(5):377–390. <https://doi.org/10.1080/01490400802353026>.
- Taylor, P. A., B. D. Grandjean, and J. H. Gramann. 2011. National Park Service comprehensive survey of the American public 2008–2009: Racial and ethnic diversity of National Park System visitors and non-visitors. Natural Resource Report NPS/NRSS/SSD/NRR-2011/432. US Department of the Interior, National Park Service, Fort Collins, Colorado, USA. Accessed 24 December 2015 at https://www.nature.nps.gov/socialscience/docs/CompSurvey2008_2009RaceEthnicity.pdf.
- Van Riper, C. J., G. T. Kyle, S. G. Sutton, M. Barnes, and B. C. Sherrouse. 2012. Mapping outdoor recreationists' perceived social values for ecosystem services at Hinchinbrook Island National Park, Australia. *Applied Geography* 35(1):164–173. <https://doi.org/10.1016/j.apgeog.2012.06.008>.
- Yankelovich, D. 1991. *Coming to public judgment: Making democracy work in a complex world*. Syracuse University Press, Syracuse, New York, USA.
- Yochim, M. J. 2006. Victim or victors: Yellowstone and the snowmobile capital of the world. *Historical Geography* 34:159–184. Accessed 29 October 2013 at <https://ejournals.unm.edu/index.php/historicalgeography/article/viewFile/2922/2401>.

Acknowledgments

The authors would like to acknowledge the support of the Yellowstone administration of the National Park Service, in particular former management assistant Wade Vagias, currently superintendent of Craters of the Moon National Monument and Preserve. We also acknowledge the additional research contributions that were made by Katherine Araya Navarro, Siqi Gao, Ethan Leiter, Ryan Matz, Megan Moser, and Nikki Thompson, all University of Utah students in the graduate course “PRT 6960 Sustainable Tourism and Protected Area Planning and Management” (fall 2013).

About the authors

Elise T. J. Gatti (elise.gatti@utah.edu) is a doctoral candidate in the Department of Health, Kinesiology, and Recreation at the University of Utah, Salt Lake City, Utah. **Kelly S. Bricker** is a professor and chair of the University of Utah's Department of Parks, Recreation, and Tourism. **Matthew T. J. Brownlee** is an assistant professor in the Department of Parks, Recreation, and Tourism Management at Clemson University, Clemson, South Carolina.