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Why Do They Do That? Understanding Factors Influencing Visitor Spatial Behavior in Parks and Protected Areas

Abigail M. Sisneros-Kidd
Utah State University

WHY DO THEY DO THAT? UNDERSTANDING FACTORS INFLUENCING

VISITOR SPATIAL BEHAVIOR IN PARKS AND PROTECTED AREAS

by

Abigail M. Sisneros-Kidd

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Approved:

_____	_____
Christopher A. Monz, Ph.D.	Mark Brunson, Ph.D.
Major Professor	Committee Member
_____	_____
E. Helen Berry, Ph.D.	Jennifer Peeples, Ph.D.
Committee Member	Committee Member
_____	_____
Edwin Stafford, Ph.D.	Mark R. McLellan, Ph.D.
Committee Member	Vice President for Research and
	Dean of the School of Graduate Studies

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ABSTRACT

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Visitor Spatial Behavior in Parks and Protected Areas

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Abigail Sisneros-Kidd, Doctor of Philosophy

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Major Professor: Dr. Christopher A. Monz
Department: Environment & Society

Understanding patterns of visitor spatial behaviors in parks and protected areas allows managers to manage for existing use and associated impacts to resources in these areas, and potentially predict areas of future impact. While existing theory explains visitor behavior patterns and impacts along "nodes" (visitor destination areas) and "linkages" (pathways to destinations, including trails and roadways), very little research has investigated factors that may be influencing visitor behavior outside of these nodes and linkages. This dissertation examines several factors influencing visitor spatial behavior outside of the node-and-linkage framework and proposes a conceptual model that more completely describes factors influencing visitor spatial behavior patterns in parks and protected areas, expanding on the behavioral influence framework provided by the Theory of Planned Behavior.

GPS-based tracking and visitor survey data from three research projects conducted in two national parks were used to examine the influence of resource-related factors, minimum-impact education, and visitor characteristics on visitor spatial behavior

patterns. Results indicate that resource-related factors including terrain, resource condition (e.g., muddy trails or downed trees), presence of wildlife, edible berries, blooming wildflowers, etc., may influence visitor spatial behavior more than visitor characteristics, such as education level, activity expertise, or familiarity with minimum-impact recreation practices. Further, results show that minimum-impact education has the ability to influence visitor spatial behavior patterns, particularly visitor travel away from designated trails, when these messages are delivered in-person (by a uniformed volunteer), during the recreation experience.

The conceptual model developed from these results illustrates how resource-related, social (including crowding and descriptive norms), personal (including visitor basic needs), and managerial factors (actions managers take to influence visitor behavior, such as minimum-impact educational efforts) may result in visitor spatial behaviors that deviate from the node-and-linkage framework. Specific, measurable variables within these factors are identified that will enable future examination of *which* factors are influencing visitor spatial behavior in parks and protected areas, and to what degree. Understanding when and where specific behaviors may occur in any given park or protected area allows managers to develop management plans that effectively prevent negative impacts to park resources, and the visitor experience, that result from these behaviors.

(229 pages)

PUBLIC ABSTRACT

Why Do They Do That? Understanding Factors Influencing

Visitor Spatial Behavior in Parks and Protected Areas

Abigail M. Sisneros-Kidd

Visitors to parks and protected areas within the United States and worldwide often visit these areas with a particular destination in mind, such as seeing Old Faithful erupt in Yellowstone National Park or standing on the rim of the Grand Canyon in Grand Canyon National Park. These visitor use destinations, and the pathways leading to them, such as trails and roadways, see high levels of use, and as a result, impacts to soil, vegetation, air, water, soundscapes, and night skies that result from this use. The field of recreation ecology studies these impacts to park and protected area resources resulting from recreation use. Research conducted by recreation ecologists helps park and protected area managers prevent and minimize these impacts and preserve park resources for future generations.

However, not all recreation use and impacts occur along designated pathways and at visitor destinations. The impacts that result outside of these designated areas often cause more damage to park resources such as vegetation and soil. The studies presented in this dissertation examine what factors are influencing visitor behavior outside of these destinations and pathways, such as when visitors travel off of designated trails. The results provide managers with a set of factors that may influence visitor behavior outside of visitors' intended destinations. These factors will enable managers to better understand existing visitor spatial behavior patterns and associated resource impacts, and also predict

where resource impacts may be likely to occur due to visitor recreation use, enabling

prevention of future impacts from occurring.

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CHAPTER 1

INTRODUCTION

In the fields of recreation ecology and recreation resource management, management practices have been implemented under the assumption that visitors behave in spatially predictable ways. Spatially speaking, the primary assumption is that recreation, and its associated impacts, are confined (concentrated) to relatively small areas within a landscape (Gutzwiller, D'Antonio, & Monz, 2017; Hammitt, Cole, & Monz, 2015). The predominant conceptual framework used to describe these patterns of concentrated visitor use and impacts identifies "nodes" and "linkages" of recreation use and impact across landscapes, with nodes representing visitor destination sites and linkages representing the trails or other pathways connecting nodes (Manning, 1979). However, research conducted in two different parks and under several spatially distinct situations (on trails, on park roadways, and at "wildlife jam" events—traffic jams caused by wildlife) suggests that while the traditional "node and linkage" framework does describe a large portion of visitor spatial behavior, it does not account for all visitor spatial behavior, particularly that of visitors who deviate from the "node and linkage" pattern (such as travelling off-trail). Visitors departing from these concentrated areas of use are of concern, as their impact on surrounding natural resources, particularly soil and vegetation, may be disproportionately higher than in areas already experiencing high levels of use (Hammitt et al., 2015). Moreover, this framework assumes that visitor spatial behavior is influenced by visitor desire to reach an intended destination.

Emerging research on visitor spatial behavior suggests that spatial patterns and behaviors may not be as predictable as once thought. Other factors that may be

influencing visitor spatial behavior include resource-related and situational factors, social factors, personal factors, and managerial factors. Resource and situational factors may include physical terrain, vegetation, and wildlife in an area. Social factors include perceived crowding and descriptive norms (norms that describe what people *actually* do in a given situation, as opposed to injunctive norms that prescribe how people *should* behave). Personal factors account for visitor basic needs (food, shelter, safety, etc.) that influence visitor behaviors. Managerial factors may include minimum-impact education efforts, trail or area closures, or visitor use limits. This dissertation, presented in multiple-paper format, examines visitor spatial behavior in the context of three separate research projects conducted in Acadia National Park (ACAD) and Grand Teton National Park (GRTE). Field and analysis methods are presented that may help explain patterns in the unpredictability observed in visitor spatial behavior, and a conceptual model is presented that identifies several broad categories of factors influencing spatial behavior examined within the context of the Theory of Planned Behavior.

1. Understanding Visitor Spatial Behaviors—Off-Trail Use and Human-Wildlife Interactions

Spatial behaviors of visitors in parks and protected areas result in impacts to nearly all aspects of an ecosystem, from erosion and trampling on river banks when water-based recreationists attempt to access a stream to decreases in listening area within a soundscape that result from excess anthropogenic noise in a grove of redwood trees (Hammitt et al., 2015; Manning, Newman, Fristrup, Stack, & Pilcher, 2010). Research

within this dissertation will focus on the potential impacts of visitor spatial behaviors

related to off-trail hiking and human-wildlife interactions.

Recently, GPS-based tracking of visitors has become a popular technique for

understanding visitor spatial behavior patterns, as well as potential resource impacts that

may occur as a result of visitor behaviors (D'Antonio et al., 2010; Hallo, Manning,

Valliere, & Budruk, 2005; Hallo et al., 2012). Research conducted to date using GPS-

based tracking techniques has examined the spatial extent of visitor use within trail

systems (Beeco & Hallo, 2014; D'Antonio et al., 2010), off-trail networks of use around

popular visitor destinations (D'Antonio et al., 2010; Monz, D'Antonio, & Newburger,

2012; D'Antonio et al., 2013), and visitor perceptions of resource impacts resulting from

off-trail use (D'Antonio, Monz, Newman, Lawson, & Taff, 2013). Results from

D'Antonio and colleagues 2013 examination of visitor perceptions of resource impacts

from off-trail use are particularly relevant, as they suggest not only that visitors can

recognize landscapes altered by human impact, but also that impacts to soil and

vegetation are prevalent throughout the trails and visitor sites within the Bear Lake

Corridor of Rocky Mountain National Park, but tend to be spatially concentrated to

popular visitor attractions and sites, such as lakeshores and especially scenic viewpoints

(D'Antonio et al., 2013).

GPS-based tracking methods have also been used to examine actual visitor use

patterns compared to visitor-stated areas of preferred use (Beeco, Hallo, & Brownlee,

2014), visitor use patterns relative to density of visitor use (i.e., visitor use levels;

D'Antonio & Monz, 2016), as well as the condition (i.e., level of impact, as measured by

combined metrics of percent vegetation cover loss as well as soil erosion—see Marion,

1995) of areas experiencing off-trail visitor use (D'Antonio et al., 2013). Research

conducted by D'Antonio & Monz (2016) in a variety of popular visitor recreation

destinations, including meadows with scenic views, a waterfall, lakeshores, and mountain

summits in four different parks and protected areas suggests that visitor spatial behavior

may be a more important factor in driving ecological impact to an area than visitor use

levels. Further, results revealed that greater levels of visitor dispersion in an area can

occur at periods of lower visitor use than periods of higher visitor use, where a

concentration of visitor use patterns tends to occur. However, management practices have

typically been informed by the assumption that more visitor dispersion occurs during

periods of high visitor use, suggesting that existing management practices may be based

on an inaccurate assumption (D'Antonio & Monz, 2016). While GPS-based tracking

methods have been instrumental in documenting visitor spatial behavior patterns and

visitor perceptions of resource impacts, very little research (with the exception of Beeco

& Hallo, 2014, noted below) has been conducted utilizing GPS-based tracking that also

examines factors that may be influencing these observed visitor spatial behaviors.

Human-wildlife interactions, particularly the effects of recreation on wildlife, are

one of the most difficult aspects of recreation ecology to understand (Gutzwiller et al.,

2017). Most research on the impacts of recreation on wildlife have examined impacts at a

very small spatial scale, and thus have not resulted in the ability to generalize results to

the scale of a park or protected area, let alone an ecosystem. The lack of management-

unit, or landscape-level generalizations has impeded the ability of park and protected area

managers to develop management solutions to adequately protect and conserve wildlife

(Gutzwiller et al., 2017; Hammitt et al., 2015; Monz, Cole, Leung, & Marion, 2010). In

addition to understanding recreation impacts to wildlife at larger spatial scales,

understanding the factors influencing visitor spatial behavior is key to the successful

management of impacts to wildlife due to recreation. Understanding these factors

becomes particularly important for managers to minimize impacts to wildlife during

visitor-wildlife interactions when visitors are attempting to view and photograph wildlife

in their natural habitat. Equally important, understanding visitor spatial behavior will aid

in the ability of managers to develop management strategies that both protect wildlife,

and enable visitors to safely interact with wildlife in parks and protected areas.

**2. Factors Influencing Visitor Spatial
Behavior in Parks and Protected Areas**

A growing body of literature exists that examines the patterns of spatial behavior

of visitors in parks and protected areas, either through the use of direct observation (e.g.,

Park, Manning, Marion, Lawson, & Jacobi, 2008), visitor-drawn maps or trip diaries

(e.g., Hallo et al., 2005), or more recently, GPS-based tracking methods (e.g., Beeco &

Hallo, 2014; D'Antonio et al., 2010; D'Antonio & Monz, 2016; Hallo et al., 2012;

Newton, Newman, Taff, D'Antonio, & Monz, 2017). However, very little research has

examined the potential factors that may be influencing this spatial behavior. As

previously mentioned, recent research suggests that a more thorough understanding of

factors influencing visitor spatial behavior is warranted, as understanding these factors

may enable development of predictive models of visitor spatial behavior in addition to

providing a better understanding of the impacts of visitor spatial behavior on larger

scales, such as that of an entire park or protected area or an ecosystem (Gutzwiller et al.,

2017). Examining recreation behavior at a larger scale is important because visitor

spatial behavior (travel), throughout an ecosystem, results in impacts to park and protected area resources, including wildlife, vegetation, soil, water, air, and soundscapes. Existing research that does probe these influential factors suggests that factors influencing visitor spatial behavior fall into two categories: visitor destinations and visitor personal or visitor use characteristics.

2.1 Nodes and linkages—visitor destinations,
spatial behavior, and impact patterns

Perhaps the most widely used recreation management framework to describe patterns and factors influencing visitor spatial behavior is the "node and linkage" framework described by Manning in 1979 in his examination of impacts of recreation on soils and vegetation. Manning's node and linkage framework suggests that visitor use and subsequent impacts are concentrated along travel routes (linkages) and at visitor destinations (nodes). Along these nodes and linkages, concentrated visitor use results in direct impacts to the natural resource base, particularly soil and vegetation. However, these concentrated areas represent a very small percentage of the recreation area as a whole. The node and linkage framework suggests that visitor destinations such as scenic overlooks, campsites (and even features within campsites, such as picnic tables and fire rings), waterfalls, lakes, river edges, and mountain summits regularly attract visitors (Hammitt et al., 2015). Simply put, desirable destinations influence visitor behavior.

More recently, Wimpey and Marion, in their exploration of the spatial characteristics of an informal trail network in Great Falls Park, VA, examined the densities of visitor-created (informal) trails that formed within the study area (2011). Results indicate high densities of trails in proximity to cliff tops as well as the banks of

the Potomac River. Researchers Wimpey and Marion attribute these trails to the "goal directed behavior" of visitors wishing to access these sites, for which no "linkage" currently exists (2011). While the researchers in this study did not assess visitor motivations for off-trail travel, they speculated that in addition to access to desired destinations (attractions), other factors motivating off-trail travel may include: avoidance of an undesirable resource (e.g., muddy trail) or social (e.g., crowded trail) condition, exploration, accidentally deviating from the designated trail, shortcuts, or activities such as orienteering, nature study (e.g., birding, looking for rare plant species, exploring rock formations), or geocaching which may require participants to deviate from the designated trail (Wimpey & Marion, 2011).

2.2 Visitor personal and use characteristics
and spatial behavior

While past research has speculated that factors beyond desirable destinations may be influencing visitor spatial behavior, very little research to date has examined this concept spatially within a park or protected area. One notable exception is research conducted by Beeco and Hallo (2014), who used paired GPS tracking of visitors and a survey instrument to examine the influence of visitor personal characteristics, user group type, and knowledge of the destination on the spatial distribution and patterns of visitors to a complex trail system in Clemson, South Carolina. Beeco and Hallo's results suggest that of the variables studied, user group (activity) type was the most influential on visitor spatial behavior patterns. However, results also indicate that knowledge of one's destination (a reflection of a visitor's experience use history or familiarity with a place measured by frequency of visits), personal characteristics (including gender and self-

reported skill level), and motivations (skill development and physical fitness), all influenced visitor spatial travel patterns within the park (Beeco & Hallo, 2014). Additionally, research conducted by Newton (2016) in Grand Teton National Park has investigated visitor motivations in relation to their spatial behavior (collected via GPS tracking) on trails within the Moose-Wilson corridor. Newton's results suggest that hikers exhibit a variety of motivations for recreating, and hikers with different motivations travelled to different locations within the corridor. An improved understanding of factors influencing visitor spatial travel patterns can help parks and protected area managers better understand to what extent characteristics of the landscape and the visitor may be influencing resource conditions as well as the visitor experience within areas they manage.

3. Theory of Planned Behavior

While the conceptual model of nodes and linkages is the basis for understanding visitor spatial behavior and subsequent impact patterns in parks and protected areas, the predominant theories behind psycho-social factors influencing visitor behavior are the Theory of Planned Behavior (TPB) (Ajzen, 1991), and its predecessor, the Theory of Reasoned Action (TRA) (Fishbein, 1980). Both TPB and TRA suggest that visitor behavior is governed by intentions to behave in a certain way. Intentions are determined by beliefs and attitudes held by the visitor, as well as societal, and individually held norms, personal values, and emotions (Fishbein & Manfredo, 1992). TPB builds upon TRA by suggesting that an additional factor, perceived behavioral control (the perceived ability of someone to actually engage in a certain behavior, such as recycling) also

influences a person's behavioral intentions (Ajzen, 1991). Thus, according to these theories, in order to change visitor behavior (specifically to get visitors to adopt more environmentally friendly behaviors), the beliefs, and particularly, the attitudes of the visitor must first change. The mechanisms behind changes in beliefs and attitudes are influence and persuasion, discussed in the following section.

TPB is the most widely applied attitude theory in the human dimensions field (Manfredo, 2008; Miller, 2017;). Principles of TPB have been applied to visitor education and information campaigns in parks and protected areas following the logic that if education and information can modify visitor attitudes, or influence normative behavior of visitors, then these campaigns may successfully modify visitor behavior over the long-term to minimize impacts to park and protected area resources as a result of recreation (Vagias, 2009). However, very little research has been conducted to date examining the connection of visitor behavioral intentions to observed behaviors (Miller, 2017). A meta-analysis of research conducted through the 1990s suggests that TPB explains between 40-50% of behavioral intentions of people, on average, and explains only 19-38% of the variance in actual behaviors (Miller, 2017; Sutton, 1998). This begs the question; what factors may be influencing behavior after visitors set their behavioral intentions (e.g., "I am going to stay on trail while hiking today to help protect park resources") but before visitors engage in actual behaviors?

**4. The Influence of Influence: Persuasive
Communication Theory to Minimize
Undesirable Visitor Behaviors**

A wide body of literature exists regarding how to influence human behavior,

much of which has been applied to the fields of marketing and advertising (see, for

example, Cialdini, Reno, & Kallgren, 2007). However, this literature narrows when

applied to recreation and natural resource management settings (see Cialdini, 1990 and

the literature compiled in Manfredo, 1992). Much of the work examining behavioral

influence in recreation/natural resource management settings applies theories of social

psychology, including persuasive communication theory (Ajzen, 1992), the Elaboration

Likelihood Model of persuasion (Petty, McMichael, & Brannon, 1992) and the Theory of

Planned Behavior (Ajzen, 1991) to persuading (or attempting to persuade) visitors to

parks and protected areas not to engage in depreciative recreation-related behaviors.

Depreciative behaviors include theft, vandalism (e.g., carving one's initials in a tree

trunk) and uninformed or unskilled behaviors (such as camping closer than 200' from a

water source in the wilderness).

Persuasive communication techniques have also been used as part of interpretive,

education, or visitor communication strategies to influence visitor perceptions of

crowding and resource impacts by preparing visitors for the conditions that they are

likely to encounter on their visit (Roggenbuck, 1992). Education and interpretation

efforts can take the form of persuasive or informational signage (e.g., Widner &

Roggenbuck, 2000) as well as direct personal contact between interpretive rangers, other

staff, or uniformed volunteers and visitors. An example of a widely-recognized

persuasive campaign is the USDA Forest Service's Smokey Bear, who reminds visitors

that, "…only YOU can prevent forest fires!" Recently, as visitor use in parks and protected areas has increased dramatically (21% in Grand Teton National Park and 36% in Acadia National Park in the past five years; National Park Service (NPS), 2017a; NPS, 2017b) efforts to convince visitors to adopt minimum impact practices have gained traction as an effective way to influence visitor behavior while minimizing the burden on both management resources and the visitor's perception of being heavily managed.

However, the success of persuasive communication efforts is influenced by the content of the message itself, the timing of the delivery, characteristics of the visitors being influenced, and the "source" of the message, as well as the mode of message delivery (i.e., sign vs. pamphlet vs. personal contact with park staff or a volunteer (Roggenbuck, 1992). In his book, *Influence: The Psychology of Persuasion*, Robert Cialdini identifies six principles of social influence that can be used to direct human behavior: commitment and consistency, reciprocation, social proof, authority, liking and scarcity (2007). While not all of these principles are applicable to changing depreciative behaviors of visitors to parks and protected areas, several of these tactics have been used in park settings. Research has examined the ability of social proof—descriptive (what people actually do in a given setting) and injunctive (what society says that people should do in a given setting) norms to influence visitor behavior (Cialdini, 2003; Widner & Roggenbuck, 2000; Winter, Cialdini, Bator, Rhoads, & Sagarin, 1998). The principle of commitment has also been examined in the context of evaluating the effectiveness of a signed pledge (visitors sign a pledge not to engage in a certain behavior, such as theft of petrified wood) on decreasing depreciative behaviors of visitors (Widner & Roggenbuck, 2000). The use of authority (rangers in uniform, as well as official park or protected area

insignia on signs and information) is standard practice in parks and protected areas

(Winter et al., 1998). Finally, the principle of liking may help to explain visitor

compliance with requests by friendly volunteers to minimize depreciative behaviors.

While principles of social influence can be effectively used to minimize

depreciative or undesirable visitor behaviors in parks and protected areas, some of these

same principles may be influencing depreciative or undesirable visitor behaviors. For

example, activation of descriptive or provincial norms (norms determined by the local

setting or circumstance, such as a social trail created by visitors to circumnavigate a

downed tree blocking the designated trail) may result in undesirable, depreciative

behaviors if these norms are not aligned with injunctive norms (e.g., norms that suggest

acceptable visitor behaviors, such as staying on trail and not approaching wildlife)

(Goldstein, Cialdini, & Griskevicious, 2008). Further, the principle of scarcity may

explain visitor depreciative behavior that occurs during events such as "wildlife jams"—

traffic jams caused by wildlife, which are common in parks where charismatic megafauna

(bison, elk, wolf, moose) reside. During these instances, otherwise rule-abiding visitors

clamor for the opportunity to view or photograph wildlife in their natural habitat, and

people behave illogically, as their excitement to experience this once-in-a-lifetime

opportunity overrides all reason.

5. Leave No Trace and Minimum-Impact Education

Minimum-impact education campaigns, such as Leave No Trace (LNT), have

become popular programs for influencing visitor behavior in parks and protected areas.

Based on the success of USDA Forest Service Woodsy Owl and Smokey Bear

campaigns, the LNT program developed out of a need for visitor education about how to minimize visitor impacts to natural resources caused by backcountry recreation (Marion & Reid, 2001; Schwartz, 2017). In the late 1980s and early 1990s, a collaborative effort between the Forest Service, National Park Service, and Bureau of Land Management, with help from the National Outdoor Leadership School (NOLS), yielded a science-based, hands-on education program for teaching minimum-impact ethics (Schwartz, 2017; Marion, 2014). Today, LNT is the most widely-used minimum-impact education program across parks and protected areas in the United States (Lawhon, Newman, Taff, & Vaske, 2013; Vagias & Powell, 2010). Minimum-impact education campaigns, including LNT, are built upon principles of persuasive communication theory, which have informed the design and delivery of minimum-impact messaging (Schwartz, 2017).

A body of recent research has examined various aspects of LNT, including factors influencing the behavioral intentions of visitors to engage in LNT behaviors on overnight visits (Lawhon, Taff, Newman, Vagias, & Newton, 2017; Lawhon et al., 2013; Vagias, Powell, Moore, & Wright, 2014). Influential (or potentially influential) factors include variables such as self-reported LNT knowledge and perceived effectiveness of LNT (Lawhon et al., 2013), as well as (following the TPB) visitor attitudes, subjective norms, perceived behavioral control, and perceived knowledge of LNT practices (Lawhon et al., 2017; Vagias et al., 2014). While this research suggests that visitor attitudes toward LNT (Lawhon et al., 2017), perceived effectiveness of LNT (Lawhon et al., 2013), and perceived behavioral control of engaging in LNT behaviors as well as subjective norms all influence visitors' intentions to comply with LNT behaviors, these factors account for no more than 44% of variance in visitor behavior, leaving over half the variance in

behavior yet unaccounted for (Vagias et al., 2014). Visitor behavioral intentions are not the only (and are probably not the most influential) factor influencing actual visitor behaviors. Research has also compared day users and overnight users' attitudes and perceptions of LNT (Taff, Newman, Vagias, & Lawhon, 2014).

While a fair amount of research has examined the effectiveness of LNT/minimum impact education programs, in terms of improved LNT knowledge and observed and reported visitor LNT behaviors or behavioral intentions (see Marion & Reid, 2007, for a full review), little work to date has actually examined the effectiveness of LNT/minimum impact education on minimizing resource damage in parks and protected areas. Marion and Reid (2007) documented two instances of such research: a study examining the effectiveness of three different educational methods for reducing damage to trees and littering at campsites (Oliver, Roggenbuck, & Watson, 1985) and a study examining the effectiveness of signage at preventing visitors from tampering with rock cairns placed by park staff to mark the trails to mountain summits (Jacobi, 2003). No research could be found that examined the effectiveness of LNT/minimum impact education at altering visitor spatial behavior (such as off-trail travel) so as to minimize resource impacts.

6. Dissertation Outline

Despite existing theories and frameworks regarding visitor spatial behavior, the factors influencing visitor spatial behavior are poorly understood. Currently, the most widely-used theory to understand visitor spatial behavior, the Theory of Planned Behavior, only explains 38% of the variance in actual visitor behaviors at best (Miller, 2017; Sutton, 1998). However, visitor spatial behaviors, particularly undesirable

behaviors such as off-trail travel and unsafe interactions with wildlife, may account for significant impacts to park and protected area resources. Impacts include damage to natural resources including vegetation and soils, as well as the visitor experience. As such, additional research examining what factors beyond behavioral intentions may be influencing visitor spatial behavior in parks and protected areas is necessary. A deeper understanding of the factors influencing visitor spatial behavior will not only enable managers to better accommodate visitors, it will enable them to better manage and protect park and protected area resources that often are a critical component of the visitor experience.

This dissertation contains four chapters prepared for publication that contribute to the collective understanding of the factors influencing visitor spatial behavior. Various aspects of visitor spatial behavior are examined across three different research projects conducted in Acadia National Park (ACAD) and Grand Teton National Park (GRTE) between 2013 and 2016. In Chapter 2 I examine the factors influencing spatial behavior of visitors travelling in vehicles in the Moose-Wilson Corridor of GRTE using a statistical classification of behaviors observed using GPS-based tracking techniques. The results of this procedure are compared with survey data to identify patterns in visitor behavior (visitor types) based on spatial data collected from the GPS tracks.

In Chapter 3 I utilize data from a quasi-experimental study to examine how different messaging and modes of message delivery influence an undesirable visitor spatial behavior (off-trail travel) on trails leading to the summit of Sargent Mountain in ACAD. Chapter 4 also uses data from ACAD to investigate the role that visitor characteristics (including level of education, activity expertise, and knowledge of

minimum-impact hiking practices) have on visitor spatial behavior patterns, particularly off-trail travel, on trails to the summit of Sargent Mountain. Survey data collected in conjunction with GPS tracks of visitor behavior is analyzed across several messaging treatments to determine whether differences in visitor characteristics exist between visitors that stay on the designated trail and visitors that travel off of the designated trail.

Finally, in Chapter 5 I examine how specific park resources such as plants, wildlife, terrain features, etc. may be influencing spatial behavior by examining visitor behaviors during "wildlife jam" events (traffic jams caused by wildlife) occurring along the Moose-Wilson Corridor within GRTE. All of this data is then used to inform the development of a conceptual model that identifies several broad categories of factors influencing visitor spatial behavior. These factors are presented in the context of the Theory of Planned Behavior to better explain observed visitor spatial behaviors (and variance in these behaviors) in parks and protected areas. Management implications of this model are discussed.

A conceptual framework (Figure 1.1) illustrates the various components of the overall dissertation research and the relationship between individual objectives for the dissertation chapters, outlined below.

Chapter 2 Objective: Examine GPS-based tracking data of visitors in vehicles to better understand patterns in visitor spatial behavior.

> *Research Question 1*: How do park and protected area resources influence visitor spatial behavior?

Chapter 3 Objective: Explore the influence of minimum-impact education messaging on visitor spatial behavior in off-trail areas.

Research Question 2: How do management practices influence visitor spatial behavior?

Chapter 4 Objective: Investigate the role that visitor characteristics have on visitor spatial behavior.

Research Question 3: How do visitor characteristics influence visitor spatial behavior?

Chapter 5 Objective: Characterize the nature of visitor spatial behaviors during "wildlife jam" events, including potential resource factors influencing visitor behavior.

Research Question 4: How do other visitors influence visitor spatial behavior?

Chapter 6 (Conclusion) Objective: Develop a conceptual model of the drivers of visitor spatial behavior to better explain and inform management of visitor spatial behavior in parks and protected areas.

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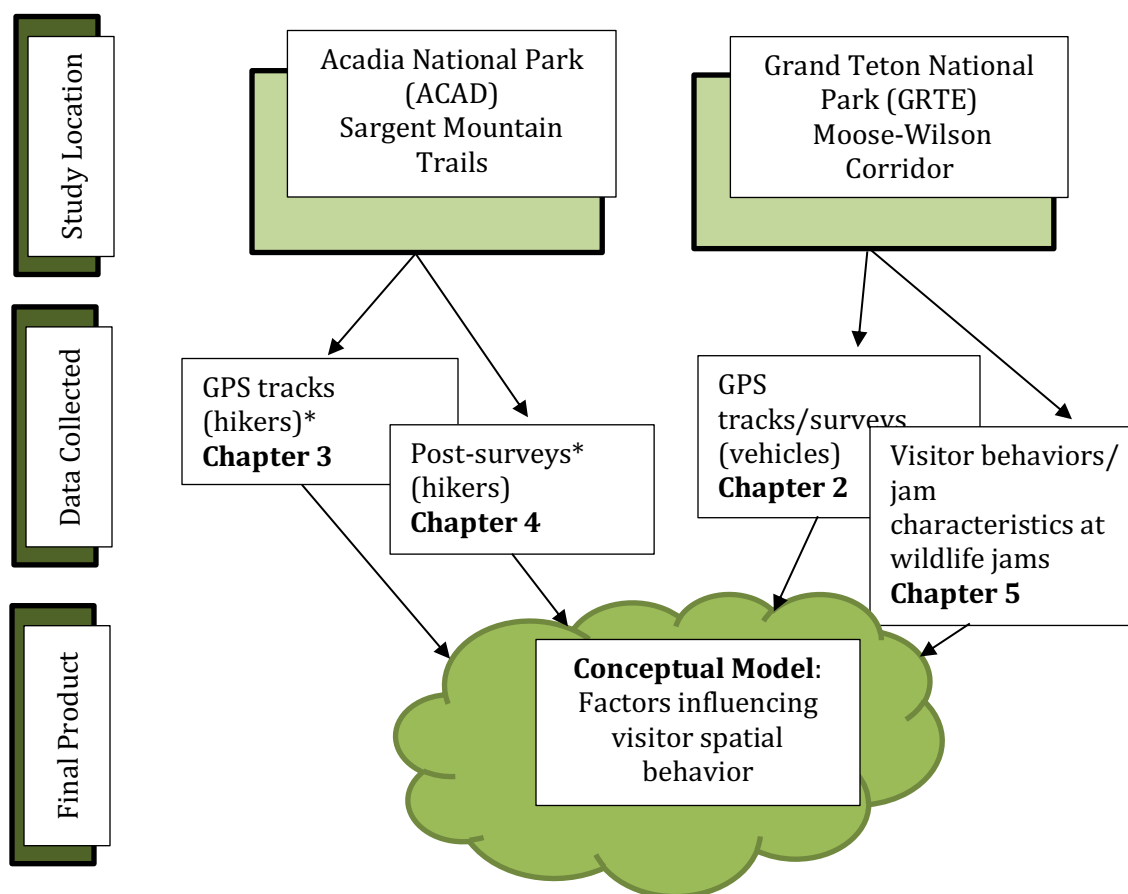
Figure 1.1. Conceptual framework of dissertation research components and objectives. Data collected from the two study locations are broken down by their use as inputs for dissertation Chapters 2–5. * Indicates that GPS track data from ACAD are also used as a component in Chapter 4 analysis.

CHAPTER 2

A GPS-BASED CLASSIFICATION OF VISITORS' VEHICULAR

BEHAVIOR IN A PROTECTED AREA SETTING[1]

Executive Summary

As tourism and visitation increases to parks and protected areas worldwide, concerns regarding degradation of natural resources and visitor experiences also increase. As such, understanding visitor use patterns and spatial characteristics is important for better management of social and ecological resources. In many parks and protected areas, transportation systems (including park roads, parking lots, personal vehicles, public transit services, bicycle and/or pedestrian paths, and Intelligent Transportation Systems (ITS) that help deliver visitors to their destinations within parks) are a primary way for tourists and visitors to interact with and experience natural environments. Transportation systems designed with visitor use patterns in mind can both provide a positive experience for tourists as well as minimize impacts to natural resources within parks and protected areas. Our research used Global Positioning System (GPS)-based technology and a statistical classification procedure to examine spatial and temporal patterns of vehicular visitation in the Moose-Wilson corridor of Grand Teton National Park. While GPS-based technology has been used in parks and protected areas to study the spatial behavior of hikers and bikers, it has not been widely utilized to study the spatial behavior patterns of

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visitors travelling in vehicles to park destinations. Similarly, statistical classifications have been used to understand visitor behavior patterns in parks and protected areas but are rarely applied to spatial data such as GPS tracks of visitor spatial movements. This classification based on spatial behavior resulted in the categorization of visitors into three types: Opportunistic Commuters, Wildlife/Scenery Viewers, and Hikers. These results expand existing literature suggesting that interpretable patterns of visitor spatial movements can result from classification studies using GPS-based collection of visitor behavior data. Understanding these patterns of visitor behavior is important for the management of social and natural resource conditions at park destinations as well as visitor experiences within the transportation corridor, as different types of visitors often exhibit different spatial behavior patterns. The classification and associated patterns of visitor behavior have important implications for managers of parks and protected area as different types of visitors may require different transportation and information needs in order to achieve their desired experience and minimize ecological impacts.

Key Words: GPS tracking; visitor behavior; vehicle movement; travel patterns; spatial classification

1. Introduction

Visitation to parks, wilderness, and protected areas worldwide continues to increase, largely due to a continued popularity of nature-based recreation and tourism (Balmford et al., 2009; Cordell, 2012). National parks in particular are increasingly popular tourist destinations (Newman, Taff, Newton, & Abbott, 2015). Popular national parks in the western United States such as Yellowstone and Grand Teton National Parks

have consistently reached or exceeded record levels of annual visitation in recent years, with annual visits to Yellowstone approaching 4.3 million (National Park Service, 2017). Recreation and tourism in parks and protected areas is a primary means for an increasingly urban populace to experience nature and is widely accepted as an important public good supported by government agencies and local communities (D'Antonio, Monz, Larson, & Rohman, 2016; Wolch, Byrne, & Newell, 2014). However, frequently associated with increases in visitation are concerns regarding both declining quality of experiences and degradation of natural area resources (Hammitt, Cole, & Monz, 2015). Thus, it is vital to manage visitor use and associated services in an adaptive manner, informed by the best available science (Manning, 2007).

Understanding human behavior in natural area settings is a longstanding theme of recreation and tourism research (Hammitt et al., 2015; Manning, 2011). Recent studies have utilized technological advances, like GPS-based tracking techniques, to understand the behavior of visitors while participating in recreational activities such as hiking and biking (Kidd et al., 2015; Monz, D'Antonio, & Heaslip, 2014). However, these recreational activities, which occur outside of a personal vehicle, are only one component of a recreation experience. Travel to and from recreation destinations as well as "driving for pleasure" are important, and understudied, aspects of recreation use in a park or protected area. To better understand the social (visitor experience) and ecological (impacts to natural resources) consequences of this human behavior, an emerging line of research is examining how transportation systems and people interact in parks (Monz, D'Antonio, Lawson, Barber, & Newman, 2016; Pettebone et al., 2011; Taff et al., 2013).

Transportation systems, defined broadly by Monz et al., "include all aspects of park design and services that function to deliver visitors to destinations within a park" (2016, p. 28). These systems include such components as park roads, parking lots, public transit (usually bus) services, bicycle and/or pedestrian paths, and Intelligent Transportation Systems (ITS) (Monz et al., 2016). In many parks and protected areas, transportation systems function as a way to manage visitor flow while also providing a way for visitors to interact with and experience natural environments (Manning, Lawson, Newman, Halo, & Monz, 2014; Orsi, 2015). Manning et al. (2014) suggest that road networks in many parks have traditionally been provided as a means of experiencing these landscapes via private vehicles. Indeed, domestic tourism to parks and protected areas in the US and many European countries is heavily reliant on personal vehicles as a mode of transport to and within the destination (Connell & Page, 2008). These observations support the assertion that a longstanding connection between transportation (particularly via personal vehicles) in parks and protected areas and outdoor recreation exists. Moreover, in some countries, particularly in Europe and North America, "driving for pleasure" has historically been one of the most popular activities and many national parks have been designed accordingly (Louter, 2009; Manning, 2011; Shaffer, 2013). Although transportation networks in parks define where visitors travel, recent literature suggests that understanding more about the characteristics and implications of park transportation systems is of growing importance (Manning et al., 2014)

A primary mechanism by which park transportation systems affect resource and experience quality is by influencing the spatial and temporal distribution of visitors, with resultant effects on ecosystem properties and experience attributes (e.g., crowding)

(Lawson, Newman, & Monz, 2017; Monz et al., 2016). In this paper, we seek to

understand the spatial and temporal patterns of vehicular visitation in parks and protected

areas by measuring movement patterns with global-positioning system (GPS)-based

technology. Most GPS-based analysis of recreation behavior focuses on spatial patterns

that occur at the spatial scale of a recreation site or recreation corridor (Beeco, Hallo,

English, & Giumetti, 2013). While these approaches are useful in understanding visitor

behavior on trails, the spatial patterns of vehicles are largely driven by the location of

roadways and parking lots. Therefore, vehicular visitation may be better understood via

the examination of individual-level behaviors (collected as individual GPS tracks) as

compared to examining the overall patterns of vehicle movement for an entire

transportation system or recreation destination. In this paper we provide an exploratory

examination of the GPS data via a statistical classification procedure to illustrate the

nature of human experiences in a specific natural area setting—a 7.7 mile recreation

corridor in the southern edge of Grand Teton National Park accessed via the Moose-

Wilson Road. This classification has potentially important management implications

regarding how to more sustainably accommodate and plan for various human uses within

a protected area.

1.1 Conceptual basis

Three emerging lines of research regarding the interaction between visitor

behavior and transportation systems in parks and protected areas informed this work.

First, several recent investigations have applied transportation simulation modeling

approaches in order to better understand and optimize visitor flow and deliveries to key

destinations within a protected area (Lawson, Newman, Choi, Pettebone, & Meldrum, 2009; Lawson et al., 2011; Lawson et al., 2017). Findings from these approaches and associated research suggest that park visitors have use characteristics and preferences that can be accommodated via refinements in transportation systems (e.g., Pettebone et al., 2011; Taff et al., 2013). Consequently, understanding visitor use patterns and spatial characteristics is an important basis for better transportation system design, management, and simulation model development.

A second research line has applied global positioning system (GPS) technology to better understand the spatial behavior of visitors in parks. Recently, GPS-based tracking techniques have proven to be a powerful alternative to descriptive measurement techniques traditionally used to understand visitor spatial behavior such as visitor use of paper diaries to self-report their movements (Beeco & Brown, 2013; D'Antonio et al., 2010; Hallo et al., 2012). GPS approaches have been used in several parks and protected areas to examine both social and ecological issues related to human spatial movement (D'Antonio et al., 2010; D'Antonio, Monz, Newman, Lawson, & Taff, 2013; Hallo, Manning, Valliere, & Budruk, 2005; Hallo et al., 2012; Kidd et al., 2015; Newman, Monz, Leung, & Theobald, 2006) and have proven to yield a wealth of data on many aspects of visitor movement including: destination locations, total duration, speed, and directionality. The use of GPS-based technology can be limited by the high initial costs of purchasing GPS units, the difficulty of retrieving the units in an open trail or road system, and by signal loss in areas of dense vegetation, canyon walls, or satellite location (Hallo et al., 2005, 2012). However, these limitations are overshadowed by the increased detail and accuracy of the data that can be collected about visitor spatial behavior

patterns, including the ability to capture off-trail and dispersed use patterns that may not follow existing or designated trails or pathways (D'Antonio & Monz, 2016: D'Antonio et al., 2010; Hallo et al., 2005). In addition, because burden to the visitor is minimal, the overwhelming majority of visitors are willing to carry GPS units in their vehicle or on their person. This willingness is evidenced by participation rates of up to 95% in some cases (Hallo et al., 2005, 2012; Kidd et al., 2015). These data and approaches lend themselves well to various spatial analysis techniques and integrate well with other protected area data sources that are spatially important.

Last, several recent studies have employed various classification procedures in order to investigate whether interpretable patterns exist in the spatial behavior of visitors in park and tourism settings. For example, daily tourism movement patterns derived from interviews and trip diaries were analyzed in a tourism destination in Hong Kong (McKercher & Lau, 2008). This work identified several factors that characterized spatial behavior including territoriality, number of stops per journey and patterns of multi-stop journeys, and ultimately identified eleven overall distinct movement patterns. Classification studies have also employed GPS-based data collection strategies for hikers and pedestrians and analyzed these data with various statistical and spatial analysis techniques (Beeco et al., 2013b; Grinberger, Shoval, & McKercher, 2014; Lightenberg, van Marwijk, Moelans, & Kuijpers, 2008; Meijles, de Bakker, Groote, & Barske, 2014). Although these approaches differ somewhat in terms of the type of settings investigated and the analysis approaches, overall findings from this work suggest that: (1) interpretable patterns exist in visitor spatial movements; (2) a range of both psychological and environmental influential factors exist; and (3) understanding these patterns can be

helpful to management and planning by providing information about visitors including where and how visitors spend their time. Perhaps most relevant, Beeco et al., (2013b) found that a four-category "wanderers-planners" typology exists in regard to self-reported activity styles of visitors to parks and protected areas. Built from the "tourist typology" literature, the work of Beeco et al. aimed to group visitors who may vary in their motivations and behaviors in order to better understand and predict behavior patterns (Beeco et al., 2013b; McKercher, Wong, & Lau, 2006). Groups were derived from visitor responses to a four-category "Wanderers-Planners" typology scale administered via questionnaire. These self-reported groups were then compared to actual visitor travel patterns observed from GPS-tracking of visitor spatial movements (time spent on primary and secondary roads and stopping locations). Results indicated that visitor spatial patterns did not differ between the different activity styles. These findings suggest that while visitor behavior in parks and protected areas may be a challenge to categorize, when patterns exist there are important implications for planning to accommodate visitors in protected areas and surrounding communities, ranging from the type and availability of information to the design of facilities.

The above three lines of research converge in this examination to determine whether human behavior in a park transportation context could be better understood via the development of a typology of actual, measured behavioral patterns. We seek to understand these spatial and temporal behavior patterns of vehicular visitation in parks and protected areas by measuring the movement patterns with GPS-based technology and providing an exploratory examination of the GPS data using a statistical classification procedure. If such an interpretable classification could be developed, it would provide

insight as to the nature of human experiences in natural area settings. This classification

would also have protected area management implications regarding how to more

sustainably accommodate and plan for various human uses. This is particularly important

as parks and protected areas transition from private auto-based access to more

sustainable, public transit systems. Transportation systems and recreation via personal

vehicle are a key—and sometimes overlooked—component of recreation management

(Manning et al., 2014).

2. Materials and Methods

2.1 Study area

The Moose-Wilson corridor (Figure 2.1) encompasses nearly 42 square kilometers

(16.2 square miles) in the southwest corner of Grand Teton National Park (GRTE),

Wyoming, USA. The park is located just north of the town of Jackson in northwestern

Wyoming, and south of Yellowstone National Park. The corridor is bounded by the Teton

mountain range to the west and the Snake River to the east and includes the Moose-

Wilson Road. The Moose-Wilson Road extends 12.4 km (7.7 miles) north from GRTE's

Granite Canyon Entrance, at the terminus of Wyoming 390, to the town of Moose, where

it intersects with Teton Park Road (Figure 2.1). The road is narrow, winding, and

contains an unpaved section just over 1.5 km (1 mile) long located roughly 1.5 km (1

mile) from the southern (Granite Canyon) entrance. Moose-Wilson Road provides access

to several park destinations including the Laurance S. Rockefeller (LSR) Preserve, home

to the LSR Preserve Center. From the LSR Preserve Center, visitors have access to

several trails leading to Phelps Lake, a popular day-use destination. The road also

accesses Granite Canyon and Death Canyon trailheads, popular for day use and which provide backcountry access for multi-day trips.

The historic Murie and White Grass ranches are also located within the corridor, and Sawmill Ponds overlook is frequently visited by those hoping to see wildlife (Brinkly & Allred, 2014; National Park Service, 2016). The road passes through a variety of ecosystem types, which provide habitat for numerous wildlife species; making it both an exemplary representation of the diversity of natural communities within GRTE, and also a prime wildlife viewing area within the park. Tourists often travels specifically to the corridor from around the globe hoping to catch a glimpse of elk, moose, or black bear (Monz et al., 2014; National Park Service, 2016).

The popularity of the trailheads in the corridor combined with increased use levels in recent years have resulted in levels of visitor use beyond what these trailheads and the road itself can accommodate. At the LSR Preserve, parking attendants queue cars in a waiting area when all available parking spots are full, and visitors can choose to wait for a spot, or to leave the parking lot and go elsewhere. Visitors to the Granite Canyon and Death Canyon trailheads, which are not staffed by parking attendants, often park in undesignated parking spots along the Moose-Wilson Road or Death Canyon Road, respectively (Monz et al., 2014). Heavy vehicle traffic in conjunction with visitors parking in undesignated parking areas encroaching on the roadway have resulted in safety concerns, and in part spurred the development of a Comprehensive Management Plan for the corridor (National Park Service, 2016). Throughout this paper, we will refer to designated parking areas as "attended" parking, whereas undesignated parking areas will be referred to as "unattended" parking. This distinction is important when considering the

potential ecological impacts of visitor behavior, as visitors parking in "unattended"

parking areas may cause damage to resources, particularly vegetation.

2.2 Study methods

      2.2.1 GPS-based data collection. Vehicle use/behavior data was collected using

GPS-based methodologies (D'Antonio et al., 2010; Hallo et al., 2012). Visitors were

randomly sampled as they entered the Moose-Wilson Road from Teton Park Road on the

north end and at the Granite Canyon entrance fee station on the south end of the road.

Sampling was stratified into six-hour sampling days (8am-2pm and 12pm-6pm) to ensure

representative samples of visitors travelling on weekends, weekdays, and during different

times of day. Sampling occurred for 77 days during periods of peak season use in the

summer (June 1-August 15) and fall (September 6-15; October 4-12) of 2014 and

resulted in 854 useable tracks (an average of 11.1 tracks collected each day) (Monz et al.,

2014). During sampling periods, a predetermined number of GPS units (typically four)

were handed out each hour to maintain an even distribution of GPS units across the day.

A random number table was used to determine the four "sampling times" each hour. At

the predetermined times, visitors to the corridor were asked to place a Garmin eTrex 10

GPS (Garmin International, Olathe, KS, USA) unit in their car for the duration of their

trip through the corridor. These visitors were instructed to keep the GPS unit somewhere

where the unit would continue to receive sufficient satellite signal for the duration of their

visit (e.g., hang on the rearview mirror, leave on dashboard, etc.). Visitors were also told

to leave the GPS units in their vehicle while recreating in the Moose-Wilson corridor

(hiking, wildlife viewing, etc.) so only vehicle movements and stopping behaviors were

recorded. Visitors were asked to return GPS units to research technicians or to drop boxes located at both ends of the road as they exited (Monz et al., 2014). The GPS units recorded the location of the vehicle in the Moose-Wilson corridor every 5 seconds. This interval was chosen to enable accurate depiction of visitor movement and stoppage patterns, while also minimizing the collection of excess data points to keep the overall dataset of reasonable size (which aids in cleaning and analysis of GPS data).

2.2.2 Data processing and analysis. All data were summarized and analyzed utilizing Microsoft Excel (Microsoft Corporation, Bellevue, WA, USA), ArcGIS (v.10.3, Environmental Systems Research Institute, Redlands, CA, USA), and SPSS statistical software (v.22, SPSS, Inc., Chicago, IL, USA). GPS tracks were exported as point features, individual visitor tracks were visually examined in geographic information system software (ArcGIS), and erroneous GPS data points (e.g., points that accumulated when visitors returned GPS units to drop boxes) were eliminated from visitor tracks before analysis (Monz et al., 2014). A number of variables were derived by visually examining each GPS track and determining whether visitors engaged in certain behaviors (e.g., stopping at various locations or entering or exiting the corridor before noon) or not during their visit (Table 2.1). Other variables are readily available from the information automatically collected by the GPS unit. Total time spent in the corridor was calculated from the entrance and exit times and the location and duration of vehicle stops in the corridor were also recorded. A "stop" was defined as any time a vehicle remained within a designated parking area in the Moose-Wilson corridor for 10 seconds (the time it took to record two positional locations) or longer. This relatively small stopping time was

chosen as a result of observed stopping behaviors at several locations where visitors often

pulled into the parking area, paused momentarily (perhaps scanning for wildlife), and left

almost immediately. For this analysis, undesignated parking locations (e.g., parking along

the road momentarily) were not examined.

A multivariate statistical approach was used to analyze these data. A standard

exploratory factor analysis (using principal component extraction) with a Varimax

rotation was employed as a data reduction technique to reduce the 21 observed variables

into a more interpretable set of factors illustrating patterns of visitor behavior. This

analysis followed recommendations by Jolliffe (2002) and Tabachnick and Fidell (2001)

in terms of appropriateness of using the principle component extraction given the level of

measurement of the data, factor loadings, and solutions. All factor loadings of less than

0.4 were suppressed to increase interpretability of results. Factor scores for the principle

components were saved and used as the inputs for a K-means cluster analysis in order to

classify visitors according to patterns of use as derived from observed behaviors obtained

from GPS tracks. This approach is common in survey scale reduction and classification

(Jolliffe, 2002) and has also been used to classify patterns of visitor use impacts (Monz &

Twardock, 2010). Statistical analysis closely follows that used by Leung and Marion

(1999) and Monz and Twardock (2010) to characterize backcountry campsites.

Finally, a spatial analysis of visitor use patterns derived from the cluster analysis

was conducted using ArcGIS software. Extracted cluster scores were joined to the

attribute table of the shapefile containing all visitor points using a common field. Then,

the 'Select by Attribute' feature was used to select out visitor tracking points based on

their associated cluster score. New shapefiles were created for points associated with

each cluster. The Kernel Density tool was then used to calculate and visually represent the density of point features around output raster cells. A Kernel density analysis was chosen instead of a simple point density to help compensate for differences in N between the clusters. In a Kernel density analysis, output rasters are calculated by adding values of all kernel surfaces at the point where they overlap the center of the raster cell, resulting in a smooth, curved surface applied to each point. This surface represents the density of points within a defined "neighborhood" surrounding those points (Environmental Systems Research Institute, Inc., 2016).

3. Results

Similar numbers of tracks were collected at the north and south ends of the Moose-Wilson Road, resulting in a total of 854 useable tracks and an acceptance rate of 73%. The vast majority of visitors who declined to carry a GPS unit cited time constraints related to taking the companion survey as their reason for not participating (GPS units were only handed out to individuals who also agreed to participate in the survey). Principal component analysis of the 21 measured vehicle behavior variables resulted in an interpretable, five-factor solution accounting for 65.0% of the variance within the data (Table 2.2).

The factor loadings of each variable were used to interpret each of the five factors. As a result of high factor loadings for "Total Time (Minutes) Spent in Corridor" and "Stopped at LSR," Factor 1 was interpreted as LSR Use. Factor 2 was interpreted as Afternoon Use due to highly negative loadings on the variables "Did Vehicle Enter Before Noon?" and "Did Vehicle Exit Before Noon?" Loadings of the variables "Total

Number of Stops in the Corridor," "Stopped at LSR," "Stopped at Granite Canyon," and

"Stopped at Multiple Locations" resulted in interpretation of Factor 3 as Multiple Stops.

Factor 4 loaded on the variables "Stopped at Sawmill Ponds" and "Time Stopped at

Sawmill Ponds" and was interpreted as Sawmill Use. Finally, loadings of variables

"Stopped at Death Canyon (Attended)" and "Stopped at Death Canyon (Unattended)"

were interpreted as Death Canyon Use.

The factor scores for each of these five factors were saved for each case (each

visitor) in the analysis, and a K-means cluster analysis procedure was performed using

these scores. Several iterations of the K-means procedure resulted in an interpretable

three-cluster solution (Table 2.3). For this analysis, larger, more positive cluster center

(mean factor) scores for a particular factor suggest that the factor is an important

component of that cluster (visitor type). Interpretation of the mean factor scores of the

final clusters suggest three clusters, or types of visitors based on spatial and temporal

behavior patterns.

While a complete analysis of the companion survey data that accompanied the

GPS tracks collected for this study is beyond the scope of this paper, some survey data

were analyzed in order to understand stated visitor motivations for travelling to the

Moose-Wilson Corridor. A more complete analysis of the paired survey and GPS data is

forthcoming (from Newton, 2016). For the purposes of this study, visitors' stated reasons

for travelling to the Moose-Wilson corridor ("What is the most important reason for your

visit to the Moose-Wilson corridor of Grand Teton National Park?") were analyzed for

each of the three cluster types (all survey questions can be accessed in Newman et al.,

2015). Analysis revealed that for Cluster 1, 30% (228) of visitors reported visiting the

corridor for commuting (using the corridor as a means to get to an intended destination somewhere outside of the corridor). An additional 20% (151) reported visiting the corridor in the hopes of seeing wildlife, while 11% (83) visited the corridor because of the scenic nature of the drive. For Cluster 2, 49% of visitors (29) reported travelling to the corridor in the hopes of viewing wildlife, while 19% (11) visited because of the scenic nature of the drive. Of the visitors who fell into Cluster 3, the majority—53% (16)—visited the corridor specifically to hike or access trails, particularly in Death Canyon (10%).

Based on the survey results, as well as the cluster means, three descriptive names were assigned to the clusters: (1) Opportunistic Commuters; (2) Wildlife/Scenery Viewers; and (3) Hikers. The Opportunistic Commuters were widely distributed across a range of destinations in the corridor and did not load highly on any single factor. Wildlife/Scenery Viewers scored highest on Sawmill Ponds use, an area known for wildlife viewing opportunities. Finally, Hikers scored highest on LSR and Death Canyon use, two primary locations for access to hiking trail networks. Descriptive information about the original variables used to classify the visitor types also helps to illustrate that the classification was successful (Table 2.4). This data suggests that Opportunistic Commuters tend to use the corridor in the afternoon, stop at the LSR, and make stops at multiple locations, while Wildlife/Scenery Viewers, on average, spend the longest time at Sawmill Ponds. Kernel density maps of visitor tracks grouped by resulting clusters reveal these same patterns (Figure 2.2).

4. Discussion

Increases in visitation to parks and protected areas have heightened the concern of managers regarding the potential for declining quality of experiences and degradation of natural area resources associated with accommodating more visitors (Hammitt et al., 2015). Understanding visitor behavior is imperative to developing effective strategies to manage visitors to minimize impact to resources while also maintaining the quality of the visitor experience (Hammitt et al., 2015; Manning, 2011). Visitor spatial behavior, both within and apart from transportation systems, can also affect the quality of natural resources and visitor experiences within parks and protected areas. Recent research suggests that how people use transportation systems in parks can affect both resource and experience quality via how they distribute visitors spatially and temporally. (Lawson et al., 2017; Monz et al., 2016). Transportation systems also serve as a tool that managers can use to address increased visitation in parks and protected areas (Manning, 2011; Monz et al., 2016; Pettebone et al., 2011; Taff et al., 2013). However, in order to properly utilize transportation systems as a tool, managers must understand the spatial components of transportation in parks and protected areas. This research applied classification techniques, rarely utilized on spatial data, to generate three, meaningful visitor types. These types were based on visitor behavior observed while visitors were using the Moose-Wilson Corridor in their personal vehicles. Understanding these visitor types can help inform management decisions related to protecting resources and providing quality visitor experiences. For example, a corridor where the vast majority of visitors fall into the "Opportunistic Commuter" visitor type may indicate that visitors are primarily tourists who value the ability and freedom to make spontaneous stops within the area, and

as such, may not be inclined to utilize mass transit systems intended to shuttle visitors to specific destinations, such as trailheads. Additionally, "Wildlife/Scenery Viewers" may value the opportunity to utilize interpretation-based wildlife or scenic tours in the corridor.

4.1 Classification of observed behaviors:
Expanding the literature

Existing literature suggests that classification studies using GPS-based collection of visitor behavior data result in interpretable patterns of visitor spatial movements (Beeco et al., 2013a; Lightenberg et al., 2008; Meijles et al., 2014). Our approach provides an empirical basis for some recent research related to the classification of visitors based on behaviors, particularly the work of Beeco et al. (2013a). Building on the work of Beeco et al. (2013a), our research used principle component extraction (Exploratory Factor Analysis) of observed visitor behaviors obtained from visitor GPS tracks to classify visitors into groups based on observed vehicular spatial behaviors instead of grouping visitors based on self-reported activity styles. Visitor vehicular behaviors (spatial movements) observed with GPS-based data collection methods were statistically classified into three distinct types of visitor behavior patterns; Opportunistic Commuter, Wildlife/Scenery Viewer, and Hiker. Visitor types derived from visitor behavior data obtained from GPS tracks paired with survey data of visitor reported reasons for visiting the corridor suggest that there are groups of visitors who are behaving in similar ways regarding how they access and use the corridor in their vehicles.

Our study highlights the utility of statistical classification procedures to identify patterns of visitor behavior derived from GPS-based observations. The classification of

visitor types in this way may indicate the needs of visitors. The vast majority of vehicular visitors (89.5%) were classified as Opportunistic Commuters; that is their spatial behavior was manifest in multiple stops within the corridor, including the LSR, and places other than Sawmill Ponds. These visitors behave as tourists to the park, and as such, may have different transportation and information needs than other types of visitors, such as hikers and backpackers. Further, their behavior may result in different types and intensities of impacts than visitors who tend to stop in only one location.

Heretofore, existing literature on statistical behavior classification based on GPS-tracking of visitors has focused almost exclusively on patterns of spatial behavior of pedestrians and hikers (Beeco & Hallo, 2014; Lightenberg et al., 2008; Meijles et al., 2014). The behavior of hikers and pedestrians is of concern to park managers because changes in visitor use patterns, particularly increases in dispersed use (use not confined to designated trails, viewpoints, campgrounds, etc.) can result in unacceptable natural resource and social conditions (Hammitt et al., 2015; Manning, 2011). While studying the movement and spatial behavior of pedestrians in parks and protected areas is necessary, only examining the behavior patterns of this user group gives an incomplete picture of visitor behavior patterns in parks and protected areas. Our data suggest that the majority of visitors to parks and protected areas behave as tourists, interested in seeing the highlights of the area, rather than as recreationists seeking a specific, activity-based experience. However, understanding vehicular behavior patterns is also important as vehicles and transportation systems support access to the pedestrian recreation system (hiking trails and dispersed use).

*4.2 Implications for personal vehicle
management and transportation planning
in parks and protected areas*

The vast majority of visitors to parks and protected areas in the USA arrive in personal vehicles. Many of these visitors engage in "driving for pleasure" and consider this activity to be a fundamental part of their experience in parks and protected areas (Manning et al., 2014). Vehicular use is also directly responsible for broad and local scale environmental impacts. Transportation studies can observe and describe many aspects of the transportation system including level of noise and potential impacts from pollution (Hammitt et al., 2015; Monz et al., 2016). However, describing or simulating the transportation system of a park or protected area does not elucidate patterns of behaviors at the individual level (Lawson et al., 2011; Lawson et al., 2017). Taking observed patterns of vehicle use and classifying these spatial patterns into distinct and meaningful types of vehicle behavior is an improvement on traditional studies of transportation systems.

Personal vehicle use has important "upstream" implications for pedestrian use patterns and related management in parks and protected areas, as these visitors depart their vehicles and experience the park by other means. For example, spatial analysis (Figure 2.2) and comparison of visitor behaviors based on cluster type (Table 2.4) suggest that Opportunistic Commuters tend to drive straight through the corridor, stopping at multiple places for short periods of time. It is possible that Opportunistic Commuters are disproportionately contributing to park impacts related to noise and emissions by idling more than other visitors. By understanding the characteristics of the Opportunistic Commuter, managers can focus their efforts on developing management

scenarios that can minimize impacts of driving (such as utilizing mass transit) yet also allow for a park experience where visitors feel free to explore. Similarly, understanding the characteristics of Hikers, who tend to visit and spend long periods of time at hiking destinations within the corridor (particularly Death Canyon) will be critical for the development of potential mass transit destinations and timetables to meet the needs of these visitors.

Findings also suggest implications for transportation planning in parks and protected areas. Different types of visitors likely have different transportation needs. Traditional transportation modeling efforts would be unable to distinguish the needs of different types of visitors. The classification procedures used, combined with spatial analysis and survey data, can allow us to predict potential visitor needs based on their observed behavior. For example, Opportunistic Commuters may not be interested in information intensive management strategies such as Intelligent Transportation Systems (ITS), as they may have final destinations outside of the park or protected area, or value the ability to visit an area in a more unconfined manner on their own timeline.

Alternatively, it is possible that Opportunistic Commuters may exhibit the behavior they do as a result of lack of information and may benefit from ITS and increased information about an area. In either case, this visitor group would likely benefit from areas to view wildlife and scenery from the road (pull-outs, or designated "wildlife viewing lanes").

Survey results collected in conjunction with GPS tracks suggest that wildlife viewing is one of the most important reasons why visitors travelling in vehicles use the Moose-Wilson Corridor (Newman et al., 2015; Newton, 2016). Wildlife/Scenery Viewers

are motivated to see wildlife but are more willing than the Opportunistic Commuters to stop and wait for a period of time at a location (like Sawmill Ponds) to see what appears. Though they may exhibit similar motivations to some members of the Opportunistic Commuter group (desire to see wildlife/scenery), their behavior differs. This highlights an important point—individuals with similar motives may exhibit differences in spatial behavior that are important managerially.

Unlike the Opportunistic Commuters, who would likely value the ability to view wildlife and scenery from the road, the Wildlife/Scenery Viewers would likely value numerous pull-outs and easy access to parking lots to view wildlife and landscape features for extended periods of time. In either case, with the addition of traffic lanes, pull-outs or parking lots, managers will need to take care to place these features far enough away from locations such as breeding grounds, nesting sites, or foraging areas to reduce potential impacts to wildlife and potential human-wildlife conflict. Finally, Hikers may value more information about hiking trails, bear safety, and other important information, such as parking lot regulations and permitting processes for overnight hiking in the backcountry. They may also value increased parking lot capacity at popular trailheads, such as Death Canyon, which often exhibit an overflow of visitors into "unattended" (undesignated) parking spots along Death Canyon road up to a mile away from the designated parking lot (Monz et al., 2014).

Though this research provides evidence of visitor behavior patterns related to vehicular travel, it is likely that there are other types of visitors that we are not observing that may be important to managers. It also raises the question as to whether transportation planning and other management actions could be used to influence behaviors and the

management implications therein. For example, there were relatively few Hiker visitor types in our sample (n = 30). This is likely due to the relatively small number of hiking trailheads in the corridor (there are three) and the difficulty of accessing these trailheads (two require travel on rough section of gravel road). The experiences that visitors are seeking may be a result of the nature or character of the transportation corridor itself and how the corridor is promoted by the park. Currently, the LSR Preserve is promoted as a destination within the Moose-Wilson corridor, and the road itself is promoted as a tourist destination that will provide visitors with a rustic, scenic experience, with opportunities to view wildlife (National Park Service, n.d.). Access to hiking trails is not highlighted (hence the low number of Hiker types), however, the abundance of wildlife in the area is, and thus opportunities to view wildlife, either as a Wildlife/Scenery Viewer or an Opportunistic Commuter is an important part of the corridor experience.

It is important to note that the differences in visitor spatial behavior patterns we observed are relatively subtle. Though visitors' stated motivations for travelling to the corridor may differ (e.g., viewing wildlife, commuting, viewing scenery) observed behaviors of these visitors may appear very similar. For example, some Wildlife/Scenery Viewers enter the corridor looking for wildlife. However, they may drive through the corridor and not see anything from their vehicle. Although they are motivated to see wildlife, they do not see any signs of wildlife, so they either do not stop or stop on a very limited basis. Though their motivations differ from the Opportunistic Commuters, there is no observable difference in their behavior when signs of wildlife are absent. This explains why there is some overlap in observed behavior between the different visitor types (clusters). While visitor motivations can shed light on visitor spatial patterns, other

factors (such as presences of wildlife or environmental conditions) also influence visitor behavior. Analyzing observational data of visitor behavior, such as GPS tracks, can help provide a more complete understanding of visitor behavior patterns.

The nature of the Moose-Wilson Corridor is such that visitor use patterns are limited regarding the places that people can go. As such, a statistical approach is critical to understanding the significance of these subtle spatial differences in visitor use, and the implications therein for transportation planning and management of both visitor experience and resource conditions within the corridor. Spatial analysis, such as kernel density maps, can depict coarse patterns in visitor behavior. However, these maps cannot tell us what these patterns mean. A statistical analysis, such as the EFA and cluster analysis used in this research, is necessary to provide insight regarding how these patterns are occurring, as well as a means of understanding and communicating these patterns that is both robust and interpretable for managers. When combined with survey data, we can also begin to understand why these patterns may be occurring.

5. Conclusions

Little research has examined spatial patterns of vehicular visitation to parks and protected areas despite vehicular visitation and tourism being an important historical and contemporary visitor experience, particularly in Europe and North America (Connell & Page, 2008; Louter, 2009; Manning, 2011; Shaffer, 2013). Our results suggest that the use of GPS-based observations of visitor behavior paired with statistical classification procedures can help illustrate meaningful patterns of visitor behavior in parks and protected areas. Past research has illustrated that various psychological and

environmental factors influence visitor spatial movements, and these patterns provide information about where and how visitors spend their time in parks and protected areas (Beeco et al., 2013a; Grinberger et al., 2014; Lightenberg et al., 2008; Meijles et al., 2014). GPS-based observation and statistical analysis of visitor behaviors can be used to elucidate patterns relative to the experiences sought by visitors that are specific to the experiences available at any given park or protected area. This data, especially when collected regularly, can provide parks and protected areas with information necessary for successful adaptive management of both park resources and the visitor experience.

GPS-based observations of vehicular spatial behavior, statistically classified and paired with survey data regarding the reason visitors travelled the Moose-Wilson Corridor of Grand Teton National Park in their personal vehicles, revealed three types of visitors: Opportunistic Commuters, Wildlife/Scenery Viewers, and Hikers. Understanding the resulting types of visitor vehicular behaviors is important for the management of social and natural resource conditions at park destination and for management of the visitor experience within a transportation corridor. Different types of visitors are searching for varied experiences, as is evidenced by differences in observed behaviors. Examining these behaviors for patterns allows managers to better understand the experiences that visitors are actively seeking, and better manage for these experiences sustainably in the present and future.

Our research is limited in that it did not investigate whether any similarities between motivations or activity styles exist within observed behavioral types of Opportunistic Commuter, Wildlife/Scenery Viewer, and Hiker. Future work that examines the existence of these similarities based on observed behaviors is warranted.

Such research would not only provide managers information about the spatial behavior patterns of visitors in parks and protected areas but would aid in the planning process relative to type and availability of information provided for different types of visitors and the design of facilities to meet the potential range of visitor needs in different locations within protected areas. Results from this type of study could highlight any similarities or differences between visitors' and tourists' perceptions of themselves or recreation opportunities and experiences in a given area and thus inform management of recreation, tourism, and transportation experiences, including transportation as both a tourism and recreation experience.

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Table 2.1

Vehicle Behavior Variables Extracted from GPS Tracks

Continuous Variables	Binary Variables[1]
GPS track start time	Did vehicle enter the corridor before noon?
GPS track end time	Did vehicle exit the corridor before noon?
Total time (minutes) spent in corridor	Did vehicle stop at Sawmill Ponds?
Time stopped at Sawmill Ponds	Did vehicle stop at Death Canyon (attended parking)?
Time stopped NOT at Sawmill Ponds	Did vehicle stop at Death Canyon (unattended parking)?
Total time stopped	Did vehicle stop at LSR*?
Total stops in the corridor	Did vehicle stop at Granite Canyon?
Total time spent driving in the corridor	Did vehicle stop at Poker Flats?
Size of group	Did vehicle drive through the corridor without stopping?
	Did vehicle stop at multiple locations?
	Entry/exit point match
	North or South entry point of vehicle

[1]For binary variables, No=1, Yes=2. *LSR is the Laurance S. Rockefeller Preserve.

Table 2.2

Results of Factor Analysis on 21 Vehicle Travel Behaviors in the Moose-Wilson Corridor

Factor Loadings[1]					
Vehicle Behaviors	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
Start Time		.935			
End Time		.898			
Total Time (Minutes) Spent in Corridor	.920				
Time Stopped at Sawmill				.653	
Time Stopped NOT at Sawmill	.930				
Total Time Stopped	.931				
Total Number of Stops in the Corridor			.881		
Total Time Spent Driving					
Size of Group					
Did Vehicle Enter Before Noon?		-.920			
Did Vehicle Exit Before Noon?		-.885			
Stopped at Sawmill Ponds				.723	
Stopped at Death Canyon (Attended)					.816
Stopped at Death Canyon (Unattended)					.784
Stopped at LSR	.535		.503		
Stopped at Granite Canyon			.585		
Stopped at Poker Flats					
Drove Through without Stopping			-.619		
Stopped at Multiple Locations			.815		
Entry/Exit Match	-.603				
North or South Entry				-.649	
Eigenvalue	5.086	3.380	2.503	1.420	1.269
% of variation explained (cumulative)	22.2	40.3	52.2	59.0	65.0

[1] Factor analysis with Varimax rotation. Loadings less than .4 were eliminated for ease of interpretation. (N = 849). Factors are interpreted as 1= LSR Use; 2= Afternoon Use; 3= Multiple Stops; 4= Sawmill Use; 5= Death Canyon Use.

Table 2.3

Final Cluster Center[a] from Analysis of Factor Scores of Vehicle Behavior

Factor name	Cluster (Visitor Type)[b]		
	1	**2**	**3**
N	760	59	30
LSR Use	-.072	-.047	1.91
Afternoon Use	-.032	.468	-.118
Multiple Stops	-.041	-.430	-.199
Sawmill Use	-.158	2.03	.014
Death Canyon Use	-.140	-.083	3.70

[a] Mean factor scores

[b] Cluster Names: 1= Opportunistic Commuters; 2= Wildlife/Scenery Viewers;
3= Hikers. (N = 849)

Table 2.4

A Comparison of Selected Vehicle Behaviors among Three Visitor Types in the Moose-Wilson Corridor

Vehicle Behavior	Visitor Type[1]		
	Opportunistic Commuter	**Wildlife/Scenery Viewer**	**Hiker**
N	760	59	30
Total Time (Minutes Spent in Corridor)	53.7	60.0	233.0
Time Stopped at Sawmill (Minutes)	1.73	23.51	.50
Time Stopped NOT at Sawmill (Minutes)	22.99	14.15	119.5
Total Time Stopped (Minutes)	24.71	37.66	200.0
Total Number of Stops in Corridor	.85	1.12	1.47
Did Vehicle Enter Before Noon?[2]	1.49	1.27	1.73
Did Vehicle Exit Before Noon?[2]	1.36	1.22	1.13
Stopped at Sawmill Ponds[2]	1.38	2.00	1.30
Stopped at Death Canyon (Attended)[2]	1.01	1.00	1.70
Stopped at Death Canyon (Unattended)[2]	1.07	1.05	1.93
Stopped at LSR[2]	1.27	1.03	1.13
Stopped at Multiple Locations[2]	1.23	1.11	1.43

[1] Values are means. [2] For binary variables, No=1, Yes=2.
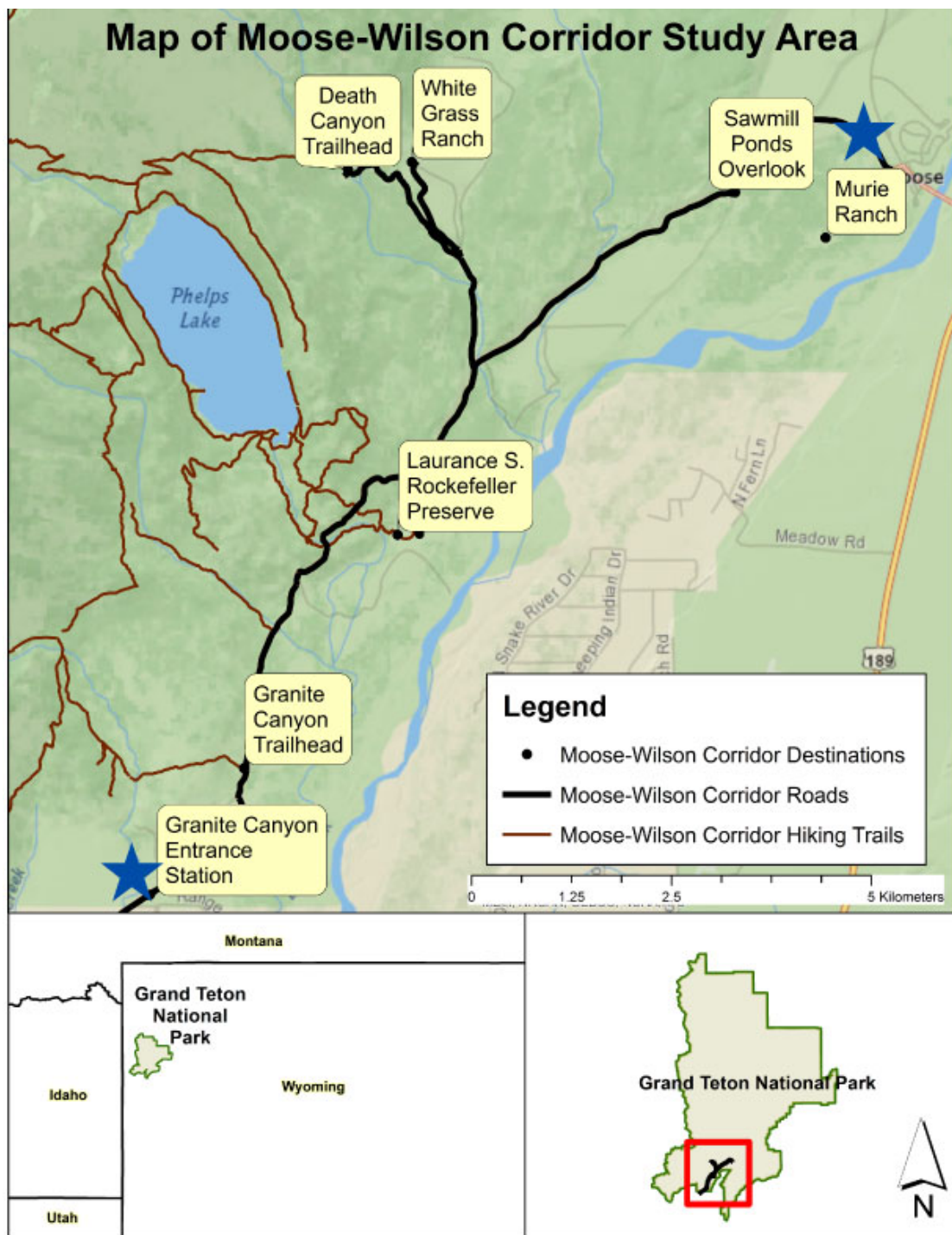
Figure 2.1. Map of the Moose-Wilson Corridor study area. Stars indicate locations where GPS units were given to and collected from visitors during the course of the study. Important destinations, side roadways, and hiking trails are included on this map.
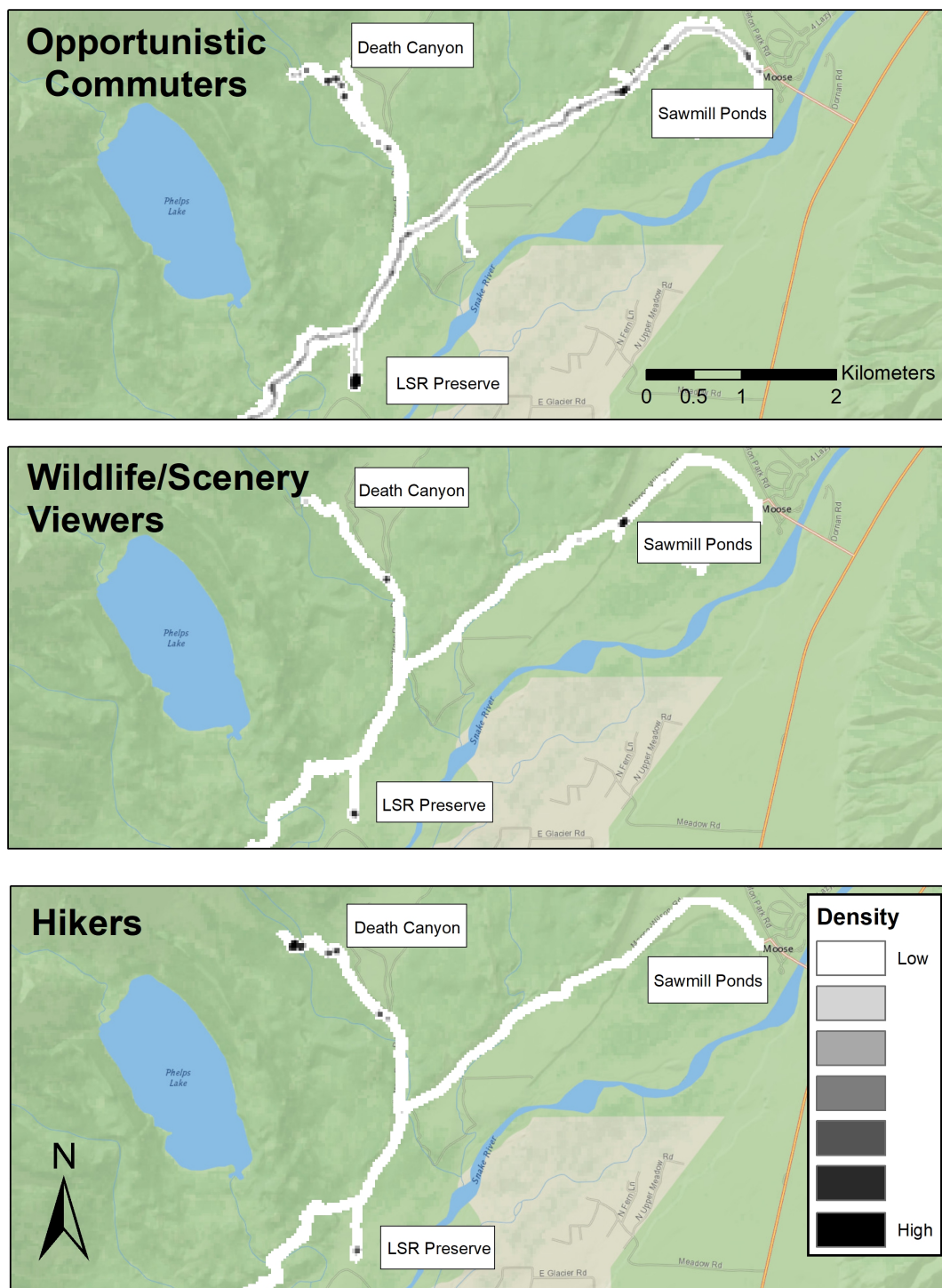
Figure 2.2. Kernel density maps depicting densities of visitor use at different locations in the Moose-Wilson Corridor for the three different visitor cluster types. Areas of high density are shaded in black.

CHAPTER 3

THE EFFECT OF MINIMUM IMPACT EDUCATION ON VISITOR SPATIAL
BEHAVIOR IN PARKS AND PROTECTED AREAS: AN EXPERIMENTAL
INVESTIGATION USING GPS-BASED TRACKING[2]

Abstract

The unmanaged impacts of recreation and tourism can often result in
unacceptable changes in resource conditions and quality of the visitor experience.
Minimum impact visitor education programs aim to reduce the impacts of recreation by
altering visitor behaviors. Specifically, education seeks to reduce impacts resulting from
lack of knowledge both about the consequences of one's actions and impact-minimizing
best practices. In this study, three different on-site minimum impact education strategies
("treatments") and a control condition were applied on the trails and summit area of
Sargent Mountain in Acadia National Park, Maine. Treatment conditions were designed
to encourage visitors to stay on marked trails and minimize off-trail travel. Treatments
included a message delivered via personal contact, and both an ecological-based message
and an amenity-based message posted on signs located alongside the trail. A control
condition of current trail markings and directional signs was also assessed. The efficacy
of the messaging was evaluated through the use of Global Positioning System (GPS)
tracking of visitor spatial behavior on/off trails. Spatial analysis of GPS tracks revealed

statistically significant differences among treatments, with the personal contact treatment yielding significantly less dispersion of visitors on the mountain summit. Results also indicate that the signs deployed in the study were ineffective at limiting off-trail use beyond what can be accomplished with trail markers and directional signs. These findings suggest that personal contact by a uniformed ranger or volunteer may be the most effective means of message delivery for on-site minimum impact education.

Key Words: GPS-based tracking, visitor education, visitor spatial behavior, recreational impact, park management.

1. Introduction

A growing body of research has documented the environmental and experiential impacts of visitor use in protected areas, both within the US and internationally, in the form of soil compaction and erosion, trampling of vegetation, wildlife disturbance, water pollution, aquatic impacts, crowding, and conflicting uses (Monz et al., 2010; Manning, 2011; Leung, 2012; Barros et al., 2015; Hammitt et al., 2015). When unmanaged, these impacts can result in unacceptable changes in both resource conditions (e.g., loss of sensitive or rare plants and animals) and quality of the visitor experience (e.g., crowding and conflict among visitors). Impacts can be especially acute in protected areas with rare or sensitive ecosystems and high use densities (Hammitt et al., 2015). While some degree of resource and experiential change is inevitable as a consequence of recreation use, visitor behavior is a primary driving variable governing the intensity and proliferation of impacts (Monz et al., 2010). Therefore, managers of parks and protected areas often try to

influence visitor behavior in order to accomplish resource and visitor experience protection goals.

1.1 Visitor behavior and management

Influencing visitor behavior can be accomplished by a variety of management practices which are often categorized as direct or indirect. Direct management practices seek to control visitor behavior through actions such as limiting use, regulating visitor behavior, and site management actions. Common applications of direct management practices include regulations, quotas, zoning, limits to length of stay; group size limitations restrictions on activities and use of physical barriers or fencing to restrict visitor access to sensitive areas (Manning, 2011). Indirect management practices, however, attempt to prevent undesired behaviors by influencing the cognitive processes of visitors (Gramann et al., 1992; Manning 2011). Visitor education programs represent a commonly applied form of indirect management. Both managers and visitors prefer these indirect management approaches, as they are more unobtrusive and result in a more "unconfined" recreation experience (Manning and Anderson, 2012). Visitor education programs recognize that most impacts are not from malicious acts but result from insensitivity to the consequences of one's actions or a lack of knowledge regarding appropriate minimum impact behaviors (Bradley, 1979; Roggenbuck, 1992; Manning, 2003; Marion and Reid, 2007). As such, the objective of educational programs is not to "control" visitor behavior but rather, to provide a cognitive basis that encourages appropriate minimum impact visitor behavior in recreation settings (Peterson and Lime, 1979). However, the question remains as to whether or not visitor education programs and other indirect management strategies are able to effectively change visitor behavior.

1.2 Visitor education and messaging

An important consideration in the effective delivery of visitor educational programs is the theoretical basis for message development. Research by Widner and Roggenbuck (2000) suggests that approaches using multiple persuasive and moral techniques are more effective than those developed with no theoretical grounding. Various theoretically grounded messaging interventions and modalities have been studied, including brochures, interpretive signage (with a multitude of different text-based messages), verbal messages, and presence of uniformed personnel (Widner and Roggenbuck, 2003). Findings indicate that messaging that communicates desired behaviors, makes visitors aware of negative consequences of their behavior, and activates visitors' feelings of moral responsibility can minimize behaviors that result in a deterioration of ecological or experiential conditions. Further, use of rewards and sanctions and exposure to uniformed personnel can also decrease such behaviors (Widner and Roggenbuck, 2003).

Additionally, the content and framing of messages themselves can impact visitor behavior. Research indicates that attributional wording (use of "you" or "your") tying visitor behavior to negative consequences and activating visitors' sense of responsibility has been effective in changing visitor behavior (Roggenbuck, 1992; Bradford and McIntyre, 2007). The use of prescriptive injunctive wording (telling visitors what they "should do," e.g., "Please stay on marked trails") is preferable to phrasing that highlights undesired behaviors. This latter type of messaging can serve to activate descriptive norms by illustrating to visitors detrimental behaviors engaged in by other visitors. Research by Cialdini (2003) at Petrified Forest National Park, Arizona revealed this effect. Park

messaging intended to minimize theft of petrified wood from the park ("Your heritage is being vandalized every day by theft losses of petrified wood of 14 tons a year, mostly a small piece at a time") instead served to educate visitors of the past history of thievery.

Minimum impact visitor education programs, such as the popular and widely applied Leave No Trace (LNT) program (Leave No Trace Center for Outdoor Ethics, 2014), have been designed as an ethical appeal to visitors to adopt minimum impact practices. These programs are considered a more appropriate, indirect management response to reduce the potential resource and social impacts of outdoor recreation, and thus are well-received by managers and visitors alike (Roggenbuck, 1992; Manning, 2011). The ability of visitor education programs to influence visitor behavior has been widely studied within the United States and abroad (see Manning and Anderson, 2012 for a comprehensive review of the literature). Despite the popularity of minimum impact educational programming such as LNT, few studies have been conducted which examine the efficacy of these types of messaging and programs on reducing ecological impacts resulting from visitor behavior (Manning and Anderson, 2012).

Research by Widman (2010) evaluating the effects of LNT educational signage on ecological conditions in a heavily visited area (C&O Canal National Historic Park near Washington, DC) indicates that the signage can decrease visitor off-trail behaviors, resulting in reduction of informal trail length, decreased average trail width, a decrease in mean exposed soil, and an increase in mean organic material. While these results indicate that the ecological impacts of off-trail behaviors may be reduced by educational programs, visitor behavior often varies situationally. In particular, ecological impacts in areas of dispersed use can be substantial (Cole and Monz, 2004). This is enhanced in

locations harboring rare or sensitive species, as even small amounts of use can result in considerable ecological impacts (Manning and Anderson, 2012; Hammitt et al., 2015). As such, uncertainty remains regarding the general effectiveness of these management alternatives on minimizing ecological impacts due to recreation.

1.2.1 Messaging and visitor behavior. This study aimed to spatially quantify whether different minimum impact educational treatments have an effect on visitor spatial behavior in an ecologically sensitive area. An experimental design was employed using treatments intended to allow for comparison of both different messaging delivery modalities (personal contact versus signage) and a different theoretical basis for message wording (ecological versus amenity-based). Message wording was developed in the context of both the theory of reasoned action and the theory of planned behavior (Fishbein, 1980; Ajzen, 1991). Widely applied to the study of human behavior and management of natural resources, the theory of reasoned action posits that human behavior is largely driven by intentions to engage in a given behavior. These intentions, in turn, are driven by attitudes (our overall evaluations of people, places and things), norms, values and emotions (Fishbein & Manfredo, 1992; Kollmuss and Agyeman, 2002; Haddock and Maio, 2004; Marion and Reid, 2007; Vagias, 2009; Lawhon et al., 2013).

Also applied to the study of human behavior and natural resource management, the theory of planned behavior builds upon the theory of reasoned action, adding the construct of perceived behavioral control (a product of control beliefs) as an additional factor driving behavioral intentions (Ajzen, 1991; Reigner and Lawson, 2009). Both theories stress that attitude toward a behavior largely determines a person's actions

(Ajzen, 1991; Fishbein and Manfredo, 1992). However, norms also play a significant role

in mediating behavior (Heberlein, 2012). Thus, if education and information can modify

visitor attitudes, and/or address norms that may be underlying visitor behavior, it follows

that visitor behavior may also be modified (Vagias, 2009).

The theory of planned behavior and its predecessor, the theory of reasoned action,

are the basis for many educational programs promoting ecologically based messaging.

Minimum impact education acknowledges that ecological impacts due to recreation result

most often from visitors' lack of awareness of the impacts of their behaviors (Bradley,

1979). As such, these programs prompt visitors to consider the consequences (both

environmental and social) of their actions via delivery of information intended to alter or

activate visitor norms, values, emotions, and sense of responsibility (or control) for their

behavior when recreating.

Research suggests that for messaging intended to minimize ecological impacts to

be effective, visitors must perceive ecological problems (VanRiper et al., 2011;

D'Antonio et al., 2012). Additionally, for management actions designed to minimize

ecological impacts to be considered acceptable, visitors must appreciate the effects of

these actions. Yet visitors often do not perceive ecological impacts resulting from

recreation, and may even realize benefits from recreational impacts, seeing the impacts as

amenities (Monz et al., 2010; Park et al., 2008; Van Riper et al., 2011; D'Antonio et al.,

2012). For example, views from open summits resulting from vegetation trampling, or

trail widening (both often considered ecological impacts due to recreation) may result in

a more positive visitor experience due to the amenity value of these impacts. Research by

Knudson and Curry (1981) suggests that many campers view the conditions of campsites

with highly disturbed ground cover or that are devoid of vegetation as "satisfactory" or "excellent." Similarly, Farrell, Hall, and White (2001) found that wilderness campers perceived campsite impacts to vegetation and soil as having functional benefits. Additionally, vegetation loss at recreation areas used by rock climbers is often perceived as an amenity (Monz, 2009). This research, which suggests that visitors may perceive managerially-defined impacts as amenities, largely informed the development of our "amenity-based" message.

1.3 Studying visitor behavior

While an increasing number of studies aim to examine the efficacy of different management practices in minimizing visitor impacts, much of this research has been hypothetical or attitudinal, based on survey responses and reported behaviors (Roggenbuck and Berrier, 1982; Harmon, 1992; Alpert and Herrington, 1998; Bullock and Lawson, 2008; Park et al., 2008). Use of experimental methods to examine differences in visitor behavior in parks and protected areas is often limited by available funding and the complexities of conducting this kind of research in park settings. However, such studies are critical in understanding and appropriately managing visitor spatial behaviors. Recent experimental and behavioral studies have examined the effect of combinations of indirect and direct management strategies on visitor spatial behavior (Park et al., 2008; Reigner and Lawson, 2009). A study of five different management practices applied at the summit of Cadillac Mountain (an ecologically sensitive area) in Acadia National Park by Park et al. (2008) suggests that although visitors and managers favor indirect management strategies, direct management is more effective at confining

visitor activities to designated trails. However, this study focused on a location with significant infrastructure (road access, visitor facilities) which has been substantially impacted by high visitor use. Subsequently, the direct, intensive management practices evaluated (hardened trails, fencing) were largely acceptable (Bullock and Lawson 2008), that is, visitors were willing to accept onsite behavioral restrictions (i.e., fencing and area closures) and intensive management of the area in order to protect summit resources. Visitors to more remote and less intensely used areas, often are more accepting of indirect management where fewer behavioral restrictions are perceived (Hendee and Dawson, 2002). As such, a better understanding of the effectiveness of more "unconfined" and indirect management strategies, such as use of signage and personal contacts, is necessary to successfully manage these areas.

In contrast to the above findings, an experimental study conducted by Reigner and Lawson (2009) examining the effects of messaging (indirect management) on visitor behavior at Haleakalā National Park in Hawaii revealed that the type of messaging provided in visitor education materials can positively influence visitor behavior (in this case, the decision of whether or not to explore pools) which may result in resource degradation. This study suggests that in some situations, indirect management practices, such as education, may be effective in changing visitor behavior so as to minimize resource degradation. However, in general, managing visitors in less developed situations via setting-appropriate approaches remains to be more thoroughly investigated.

Understanding spatial behaviors is a key component in determining the degree to which visitor disturbance to ecological conditions is occurring. Spatial behavior in parks and protected areas has been monitored and evaluated using a variety of methods

including the use of questionnaires or paper map diaries where visitors record their own travel routes and times, and the use of trained researchers to observe and record visitor spatial behavior (Park et al., 2008; Hallo et al., 2012). Recently, advances in available technology have increased the range of methods available to unobtrusively observe visitor spatial behavior. Use of Global Navigation Satellite System (GNSS)-based approaches, which include Global Positioning System (GPS), GLONASS, and GALILEO systems, to monitor visitor spatial behavior have become well developed for a range of applications. GPS-based technology has been used to observe visitor spatial behavior in both frontcountry (visitors in vehicles travelling on park roads) and backcountry (hikers carrying GPS units) settings within parks and protected areas (Hallo et al., 2005; D'Antonio et al., 2010; Beeco and Hallo, 2014). It has also been used to track pedestrian travel in cities (Shoval and Isaacson, 2006; Shoval, 2008) and at outdoor sporting events (Pettersson and Zillinger, 2011). Comparison of data on visitor spatial behavior collected using different modalities (GPS tracking of visitors versus self-reported routes marked by visitors on a paper map) have revealed much greater accuracy of travel routes and more routes collected using GPS applications than with paper maps (Hallo et al., 2005).

Limitations of GPS and other GNSS technologies include high initial costs, retrieval of units in complex, open systems and trail networks, and loss of signal in areas lacking signal coverage (Hallo et al., 2005, 2012). However, benefits of GPS tracking of visitors include more detailed and accurate records of visitor spatial behavior, the ability to capture visitor spatial behavior that does not follow existing pathways (i.e., off-trail or backcountry use) and higher study participation rates (95% participation with GPS tracking compared to 70% participation in studies where visitors are asked to complete

paper maps) (Hallo et al., 2005, 2012). Research also suggests that use of GPS tracking to monitor visitor spatial behavior may be perceived as less obtrusive and thus less likely to affect or bias visitor behavior (Hallo et al., 2012). Furthermore, use of GPS-based methodologies enable the collection of data on visitor spatial behavior that is more accurate, detailed, and robust than traditional methodologies of self-counting, direct-count, and indirect-count (Hallo et al., 2005; D'Antonio et al., 2010). GNSS-based approaches are particularly useful in determining temporal and spatial patterns of off-trail use; otherwise measurable only through use of direct observational studies. In addition, GNSS tracking of visitors can be used to validate computer models generated to simulate and predict visitor spatial behavior in parks and protected areas (D'Antonio et al., 2010).

The objective of this study was to examine the efficacy of different minimum impact education strategies on visitor spatial behavior using GPS-based tracking of visitor movements. A companion study observed and analyzed visitor spatial behavior using visitor reports as part of a self-administered survey taken as visitors completed their hike (Reigner et al., 2014). Our study focuses on analysis of visitor spatial behavior as observed via the use of GPS-based technologies, and implications thereof for use of minimum impact education as a means for managing visitor behavior in parks and protected areas. Three different on-site minimum impact education strategies ("treatments") and a control condition were applied and examined. Treatments were designed to encourage visitors to stay on marked trails and minimize off-trail travel. The treatment conditions included an ecological-based message delivered via personal contact with a uniformed volunteer, and two sign treatments, consisting of either an amenity-based or ecological-based message posted on signs located alongside the trail that

instructed visitors to engage in the same minimum impact behavior, that is, to stay on trails and close to the summit cairn. A control condition of current trail markings and directional signs was also assessed.

2. Materials and Methods

2.1 Study area

Acadia National Park is located primarily on Mount Desert Island, Maine, USA. Situated mid-way along Maine's Atlantic coast and adjacent to the popular resort community of Bar Harbor, the park is roughly 80 km southeast of Bangor and 425 km north of Boston, MA. Acadia offers its roughly two million annual visitors the opportunity to bike its historic carriage roads, enjoy breathtaking scenery year-round, and hike more than 120 miles (193 km) of historic hiking trails on over 49,000 acres (19,829 ha) (National Park Service, 2012). Many of these trails can be used to access summits of the 26 mountains found in Acadia, the majority of which are only accessible by trail (National Park Service, 2012).

At an elevation of 1,373' (419 m), Sargent Mountain is one of the tallest peaks in Acadia, second only to Cadillac Mountain at 1,530' (466 m) (National Park Service, 2012). Four trails—Southridge, Grandgent, Northwest and East Cliffs—access the open, granite summit of Sargent Mountain. Despite relatively low elevations of mountain summits in Acadia, strong winter winds and summer fog result in alpine-like conditions. Consequently, vegetation in the summit area consists of both alpine and sub-alpine species including lichen, moss and low-growing shrubs, and forbs including three-toothed cinquefoil, mountain cranberry, black crowberry, blueberry, sheep laurel, and stunted red

spruce trees (Wessels, 2001; National Park Service, 2012). Off-trail hiking, which can compact and erode soils as well as injure or kill trampled vegetation, can cause substantial damage to these fragile sub-alpine species (Hammitt et al., 2015). Further, recovery of damaged vegetation on sub-alpine mountain summits is often hindered by acidic, thin soils (Jacobi, 2007). Protecting and preserving fragile and rare ecosystems for future use and enjoyment is a priority of the National Park Service (NPS) (Wellman and Propst, 2004). Thus, Sargent Mountain provides an important venue for understanding the effects of minimum impact education practices on visitor spatial behavior in the context of an ecologically rare and sensitive recreation setting.

2.2 Design of study treatments

Based broadly on the theories of reasoned action and planned behavior (Fishbein, 1980; Ajzen, 1991), and findings from previous applications of messaging in park settings (Widner and Roggenbuck, 2000, 2003), treatments were developed using multiple messaging delivery techniques. A control and three treatment conditions were applied. Treatments consisted of a personal contact and two signs. Experimental conditions were applied independently on consecutive weeks during the busy summer season (July) 2013. The control condition (T0) consisted of existing trail markings and directional signs provided by the NPS to delineate the trail. Trail markings consisted of blue paint blazes on trees and exposed bedrock, and bates cairns (a trail marking consisting of two rocks supporting a horizontal rock slab—see images on signs in Figs. 3.1A and 3.1B) to mark the trail in the sub-alpine environment as visitors approached the summit. Directional signs at the summit and trail intersections indicated the locations of

trails, but no other signage of any kind existed along the trails. These conditions are the "standard conditions" at the study site and have been in effect for many years.

The personal contact treatment (T1) involved delivery of an ecological message to visitors at the summit by a uniformed volunteer. All volunteers were provided with a "script" which consisted of an ecological message identical to that presented on the ecological impact sign. Volunteers were instructed to deliver the message to groups as they reached the summit and lingered within the summit area. Duration of the interaction varied depending on how groups interacted with the volunteer following delivery of the message. When multiple groups were present on the summit simultaneously, the volunteer asked visitors to congregate for delivery of the message. The remaining treatments consisted of two separate sign treatments containing different messaging. Both signs provided visitors with prescriptive messages giving a variety of reasons for engaging in the encouraged behaviors. The signs differed in their approach at eliciting the desired behaviors. Differences in message wording between sign treatments were intended to examine the potential effect of a more standard ecological impact-based message compared to an amenities-based message in eliciting the desired behavior of staying on-trail and close to the summit cairn.

The ecological impact sign (T2) delivered an ecological-based message encouraging visitors to stay on marked trails to minimize ecological impacts to the summit area. This message was thematically similar to the ecological message delivered by the personal contact (T1). Crafted to appeal to visitors' environmental ethic, the ecological impact sign messaging contains conventional content with an environmental center, utilizing Authority of the Resource (personifying the resource by using the place-

name "Acadia" and placing responsibility on the visitor by encouraging them to "protect" the resource) (Wallace and Gaudry, 2002). Intended to activate visitors' desire to protect the environment and help prevent resource degradation, the ecological impact sign (Fig. 3.1A) describes the ecological benefits of engaging in the desired behavior (Wallace, 1990; Widner and Roggenbuck, 2000; Wallace and Gaudry, 2002). The amenities-based sign (T3) was intended to reach visitors who do not perceive trail and summit conditions as impacted. The message's content focuses on hikers' enjoyment and the quality of the experience (emphasizing direct benefits to the visitor). This message (Fig. 3.1B) makes no ecological reference, but rather describes a variety of recreational benefits received by engaging in the desired behavior.

Treatment signs were placed on each of the four trails leading to the summit at the point at which vegetation and topography shifted to a sub-alpine ecosystem characterized by exposed granite bedrock, low-growing vegetation, and fragile mosses and lichens. At this point along trails, trail markings shifted from blue paint blazes on trees to blue paint blazes and bates cairns placed on the rock surface. The location of the designated trail and the sign treatments were mapped using a sub-meter Trimble GeoXT GPS unit.

2.3 Data collection and analysis

Due to the relatively low number of visitors to Sargent Mountain, all visitors hiking any of the four trails leading to the summit (Southridge, Grandgent, Northwest, and East Cliffs) during the study period were intercepted up-trail of the trailheads just after the start of their hike and asked to voluntarily participate in the study. GPS-based tracking methodologies were adapted from protocols used by D'Antonio et al. (2010).

The four trails chosen for the study formed a closed system, minimizing difficulty with

recovery of units. All visitor groups with at least one member over age 18 were solicited

for participation in the study. Of eligible group-members, the member with the next

birthday was asked to perform required study tasks. Participants were asked to carry the

GPS unit with them as they hiked. A companion study (Reigner et al., 2014) used a

survey approach, administered as visitors exited trails at the end of their hike, to evaluate

the potential impact of misalignment between expert and novice visitor knowledge and

ethics regarding visitor ecological impacts, and the efficacy of minimum impact

education strategies. Results obtained from survey data collected by Reigner et al. will be

briefly discussed in order to better understand visitor spatial behaviors observed using

GPS-based tracking methods. For a more complete discussion of survey results, see

Reigner et al., 2014.

GPS tracking of visitors was stratified to include both weekend and weekdays and

occurred only on fair-weather days to ensure consistency. Sampling occurred during peak

use hours of 8am to 4pm. GPS devices (16 total) recorded point locations at 15-second

intervals and were returned to research assistants positioned near the four trailheads as

visitors descended from the summit. Calibration techniques (D'Antonio et al., 2010) were

employed in order to verify GPS unit accuracy. At the start of each sampling day, a

Garmin 60 GPS unit was randomly selected and points were recorded for 5 minutes to

generate a "calibration track." These points were collected in point locations at each

trailhead and at the summit that were previously mapped using a Trimble GeoXT GPS

unit. Upon completion of the study, all calibration tracks collected for each trailhead were

compared to the high-accuracy points mapped using the Trimble unit. ArcGIS software

was used to calculate a Euclidean distance measure in order to determine the average positional error for each Garmin 60 calibration track. The resulting error calculations were averaged in order to determine the overall positional error for the study. Data from GPS visitor tracks were filtered to remove points with velocities greater than 6 km/hr that resulted in gaps in point locations due to loss of signal.

A total of 339 tracks were collected during the study period. Data analysis occurred at two spatial scales; the overall Treatment Area and a smaller Summit Area (Fig. 3.2). The Treatment Area is the area between the locations of treatment signs on the trails to the summit. The Summit Area consists of the terminus of the trail system, marked by a summit cairn, and the adjacent environment within which visitors were able to physically disperse for activities such as resting and exploring. Low-growing sub-alpine vegetation dominated both the Treatment and Summit Areas. As such, loss of signal due to vegetation was minimized in both areas of analysis. The locations of the summit cairn and Summit Area perimeter were mapped in the field using a Trimble GeoXT GPS unit. Analyses of off-trail behaviors were conducted at both the larger scale of the Treatment Area and the smaller scale of the Summit Area. Analyses were separated by area, and more detailed analysis was undertaken for the Summit Area to better describe visitor spatial behavior on the summit, where visitors have more opportunity to disperse.

To characterize the dispersion and orientation of visitor spatial behavior off-trail, spatial statistics were calculated using ArcGIS 10.2, Microsoft Excel, and SPSS 22 software. The projected coordinate system used for GIS-based analysis was NAD 1983 UTM Zone 19N. Visitor spatial behavior under each treatment was examined by

describing the distribution of visitors using directional distribution and Euclidean distance tools in ArcGIS 10.2.

Off-trail visitor tracking points were separated from the overall visitor tracking points by creating an error buffer of 4 m (derived from the measured GPS positional error) around all designated trails. Visitor tracking points located outside of the on-trail buffer were considered "off-trail" visitor spatial behavior. These visitor tracking points representing off-trail use were analyzed using ArcGIS 10.2 software to determine the overall distribution of visitor spatial behavior within the study area and distance travelled from designated trails.

The overall distribution of visitor points located off-trail within the Summit Area was assessed by calculating a directional distribution using the Directional Distribution tool in ArcGIS 10.2. This process determines a distributional center location and a one standard deviational ellipse for all the off-trail visitor tracking points within the Summit Area for each of the three experimental conditions and the control. The resulting ellipse depicts the distribution of 68% of all off-trail points within the Summit Area for each treatment. The total spatial area of each ellipse was then calculated to enable direct comparison of the spatial extent of distribution of visitor use across the study area.

Additionally, Euclidean distances were calculated using ArcGIS 10.2 zonal statistics procedures as another measure of visitor dispersion in the study area. Euclidean distance can be used to determine the dispersion of data by averaging the distances of GPS points from the median center (Hallo et al., 2012). Two types of Euclidean distance analyses were conducted for both the Treatment Area and the Summit Area (resulting in four total Euclidean distance summaries). The first examined overall dispersion of visitor

use, both on and off-trail using the entire GPS-based tracking data set. For this analysis, a

spatial median point for the entire data set of visitor tracking points was generated for

each treatment type and for each sub-area. Then the Euclidean distance from each visitor

tracking point to the median point in the data was determined. The second Euclidean

distance analysis examined the distance visitors traveled away from the designated trail

under each treatment type. As such, this Euclidean distance was calculated from each off-

trail visitor tracking point to the edge of the 4 m on-trail buffer and summarized by

Treatment and Summit Areas (see Fig. 3.3 for flow diagram of analyses used). In order to

determine if the treatments resulted in spatial differences in visitor behavior, ANOVA

was used to compare the Euclidean distances measured among the control and three

treatment conditions. Post-hoc tests were conducted to determine the differences between

treatments for visitor tracking points off-trail within the Treatment Area and Summit

area. To account for positive skew in the distribution of the data, a natural log

transformation was applied to data prior to analysis.

3. Results

3.1 Effect of treatment on visitor dispersion

Participation rates for the study were very high, ranging from 85–93% between

treatments (T0–92.6%, T1–89.9%, T2–84.8%, T3–91.8%). Positional error calculations

for the GPS units used in this study resulted in an overall average positional error of ± 4-

meters. Results of directional distribution analyses indicate that visitor spatial behavior

off-trail varied both within the Treatment and Summit Areas (Table 3.1; Fig. 3.4). Visitor

spatial behavior outside of hardened or maintained surfaces, including designated trails,

have the greatest potential to result in ecological impacts to soil and vegetation. Given

that the treatment signs were designed to encourage visitors to stay on-trail, and that the

personal contact was administered at the summit, our analysis is primarily concerned

with describing off-trail visitor spatial behavior within the summit area under each

treatment type. Within the Summit Area, the personal contact treatment (T1) resulted in

the most compact distribution (least dispersion) around the summit (Fig. 3.4B), whereas

the ecological impacts sign (T2) resulted in the greatest areal distribution around the

summit (Fig. 3.4C).

Results of the ANOVA for distance of off-trail visitor tracking points within the

Treatment Area (F = 15.67, p < 0.001), and distance of off-trail visitor tracking points

within the Summit Area (F = 4.06, p = 0.007) revealed a statistically significant

difference among treatment groups. Results of post-hoc tests (Table 3.1) indicate

significant differences between the following treatments within the Treatment Area for

off-trail behavior: control (T0) and ecological impact sign (T2); personal contact

treatment (T1) and both signs (T2 and T3); and ecological impact (T2) and amenities

 (T3) sign. Within the Summit Area for off-trail behavior: control (T0) and personal

contact (T1) treatment—2,895 m² decrease in area of the standard deviational ellipse; and

 personal contact (T1) treatment and ecological impact sign (T2)—4,055 m² increase in

 area of the standard deviational ellipse.

3.2 Visitor spatial behavior at treatment
signs

A kernel density analysis and ANOVA of time spent within an "area of impact"

around each sign treatment (the area surrounding the sign in which visitors may get the

message—5 m down trail, 5 m laterally around the sign, and 1.5 m up trail) were also

conducted to determine if sign treatments resulted in greater density of points around

those sign locations. Differences in the density of points around sign locations between

treatments could indicate whether visitors were stopping or slowing down to read the

treatment signs. Both analyses resulted in no significant difference in density of

points/length of time spent at the treatment sign locations between the control (T0) and

both the ecological (T2) and amenity (T3) sign treatments.

In order to better understand why no significant difference in behavior was

observed between the control and the treatment signs, survey results from the companion

study conducted by Reigner et al. (2014) were examined. These results help to explain

visitor spatial behavior and give context to anomalies observed in our GPS tracking

study. When asked whether or not they saw a sign other than directional signage during

their hike, only 42% of visitors (54 of 128) surveyed during the ecological impact sign

treatment (T2) reported seeing the sign. Of the 96 visitors surveyed during the amenity

sign treatment (T3), 47 (49%) reported seeing the sign. Within each treatment, of those

who saw the signs, only 54% of visitors exposed to the ecological impact sign (29 of 54)

recalled the impact message, while 36% of visitors exposed to the amenity sign (17 of 47)

recalled the amenity message. Overall, only 23% of visitors exposed to the ecological

impact sign were able to recall the sign messaging, while that percentage drops to 18%

for visitors exposed to the amenity sign (Reigner et al., 2014).

4. Discussion

Protection and preservation of resources for future use and enjoyment is a priority

for managers of parks and protected areas (Wellman and Propst, 2004; Hammitt et al.,

2015). Sensitive or high-use recreation areas often require more intensive management, including confining or restricting use to designated trails (Manning, 2011). Research examining visitor spatial behavior and use patterns under differing conditions (using a variety of visitor management practices) provides vital information to managers concerning the most effective and appropriate means of protecting park resources while also providing the most unconstrained recreation experience for visitors.

In this study, personal contact by uniformed staff significantly altered spatial behavior of visitors, but messaging via posted signs demonstrated little, sometimes incongruous, effects. These findings are largely consistent with previous research suggesting that personal contact is one of the most effective methods for achieving desired visitor behaviors (Fennell, 2001; Manning, 2003). In our study, the personal contact treatment resulted in a 39–47% reduction in potential impact area (based on the area of the standard deviational ellipse) compared to the sign treatments (47% reduction in potential impact area compared to the Ecological Impact sign; 41% compared to the Amenity sign) and control condition (39%). These differences in impact area resulting from personal contact between visitors and park volunteers represent the potential to prevent or even decrease ecological impacts to the fragile summit vegetation and soils caused by recreation. Most impacts to vegetation result from initial use and resultant damage to an area. As such, the observed efficacy of a personal contact represents a viable minimum impact management option that potentially protects ecological resources while also providing a more "unconfined," and from an aesthetic standpoint, higher quality visitor experience. However, whether the decrease in dispersion observed in our

study resulted from the presence of our personal contact or the message delivered by the contact remains unresolved.

While the personal contact treatment effectively decreased areal dispersion of visitors at the summit, the sign treatments did not. The lack of effectiveness of our sign treatments may be due to the nature and placement of the signs. Signs were placed at the transition from deciduous forest to sub-alpine vegetation. This transition occurred on steep sections of trail, and it is possible that visitors, looking down for good footing, did not see the signs. Survey results (Reigner et al., 2014) reveal that less than half of visitors surveyed reported seeing the signs, which, in addition to being placed on steep sections of trail, were also mounted on wooden tripods, which may have been too inconspicuous. Further examination of survey results indicates that of the visitors that did see the signs, 75% were unable to recall either the ecological or amenity-based message. It is possible that the nature of the signs, which featured large, colorful images of the summit cairn and trail markings surrounded by text delivering the intended message resulted in visitors focusing on the images on the signs rather than the text, thus missing the intended message. The inconspicuous nature of the signs, in conjunction with their placement, present a potential limitation of the study.

In a study examining effectiveness of signs in increasing recycling in park campgrounds, Ham (1984) also noted the importance of sign clarity in affecting behavioral change. Only 55 percent of visitors in Ham's study read the recycling signs, and of that group, only 15 percent felt that the information was presented clearly (thus making them more likely to recycle). Our study reinforces the importance of both content and delivery (sign versus personally delivered message and placement of

signage) in interpretive messaging (Widner and Roggenbuck, 2003; Bradford and

McIntyre, 2007; Marion and Reid, 2007), as well as reinforces the use of personal contact

as an effective form of message delivery (Fazio, 1979). Altering placement of signs to

increase likelihood that visitors notice and receive the intended message as well as

ensuring that sign imagery and text conveys the intended message may increase the

efficacy of the sign treatments, resulting in less dispersion of visitors off-trail for these

treatments. More research is necessary to determine optimal sign placement locations and

development of content to ensure retention of the message.

The significant decrease in areal distribution of visitors as a result of the personal

contact treatment has substantial implications for management of recreation sites,

particularly those where confinement strategies are desirable. We selected this site for our

study because it represents an important challenge in recreation management—a high

demand recreation location that is also geographically rare and ecologically fragile (i.e., a

popular mountain summit). The summit area represents a location where visitors are very

likely to disperse due to the open, relatively flat topography. The message delivered at the

summit represented the best possibility to reach visitors at the potential dispersion point.

These results support the use of "Summit Stewards" or "Ridgerunners"—uniformed, park

staff stationed near summit locations—to deliver messaging and provide a management

presence on mountain summits. For example, in Acadia National Park, a staff of four

Ridgerunners have been serving in this capacity since 1997. These volunteers monitor

trail use and engage in informal conversations with visitors about minimum impact

hiking behaviors in general while also providing site-specific examples of the impacts of

off-trail behaviors (e.g., trail braiding or widening). In 2010 alone, 4500 "substantive

contacts" with visitors were made, enabling the minimum impact message to reach a

sizeable audience (Manning and Anderson, 2012). It should be noted as well that visitors

to our study area may be well-informed already, having received a minimum impact

message previously (whether at Acadia or elsewhere within the northeast). This may help

to explain the relative "success" of the control treatment.

4.1 Areas for future research

Comparison of differences in visitor off-trail behavior before and after exposure

to the personal contact treatment may provide observational evidence of whether or not

the ecological impact message delivered at the summit by the uniformed volunteers was

internalized by visitors. Combined analysis of GPS tracking and survey data in which

visitor responses to survey questions regarding on/off-trail behaviors are directly

compared to observe on/off-trail behaviors could yield important information concerning

linkages between observed (actual) visitor behavior and perceived (reported) visitor

behavior. Existing literature indicates that perceived and actual visitor behaviors often

differ substantially (Hallo et al., 2005, 2012; D'Antonio et al., 2010; Pettersson and

Zillinger, 2011). Understanding how visitors perceive their behavior in relation to their

actual behavior could inform the development and implementation of educational

programming designed to not only minimize undesirable visitor behaviors (i.e.,

wandering off-trail), but could also work toward reconciling discrepancies between

visitor perceptions of their behavior and their actual, observed behaviors. Though beyond

the scope of this paper, comparison of survey data and observational data collected in this

study may shed some light on the nature of such discrepancies and suggest possible

avenues for reconciliation. Further, the investigation of cultural differences in perceptions of behavior may provide insight regarding the development of different messages for stateside versus foreign visitors.

Toward this purpose, the visual nature of the dispersion analyses could hold promise for use as messaging in and of themselves. Providing information to visitors about their use patterns (particularly if compared to areas of concern) may provide a concrete reason for visitors to stay on-trail. GPS tracking and analyses provide a relatively simple method for analyzing and disseminating this information in an easily interpretable visual (map) format. However, care must be taken in messaging so as not to inadvertently activate descriptive norms (i.e., highlight off-trail behavior), as this may result in increases of inappropriate or undesired behaviors (Cialdini, 2003, 2007). Additional future research should examine the effectiveness of various messaging approaches, both on site via improved signs, and pre-trip at visitor centers, local businesses, and the park website.

5. Conclusions

Use of GPS-based technologies to experimentally examine the efficacy of minimum impact messaging treatments applied in this study has enabled the observation and analysis of visitor spatial behavior both on and off-trail within a fragile, sub-alpine mountain summit ecosystem in the northeastern US. Results indicate that minimum impact education strategies can potentially influence visitor spatial behavior, however, message modality matters. Personal contact with visitors decreased the areal extent of visitors within the summit area, resulting in a decrease in the potential for ecological

impacts from off-trail travel. However, in this study, both an ecologically-based and an amenities-based message delivered to visitors via signs located on the trails to the summit were not statistically different from control conditions (existing trail blazes and rock cairns marking the trail) in their ability to decrease off-trail behavior.

Understanding the behavioral efficacy of management practices intended to reduce impacts associated with visitation can aid managers in choosing approaches that will encourage visitor behaviors that minimize social and ecological impacts to park resources (Park et al., 2008). Future analyses comparing visitor self-reported behavior from the same dataset collected using visitor surveys to our GPS observations of visitor spatial behavior could be used to examine if cognitive changes are occurring as a result of minimum impact visitor education, and if those cognitive changes lead to behavior modification on the ground.

Most notably, these findings support the continuation of "Summit Stewards" and "Ridgerunner" programs that provide a uniformed presence at recreation sites in general and, as in this study, mountain summits specifically, in order to personally deliver messaging regarding stewardship of the fragile sub-alpine ecosystem.

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7. Highlights

- GPS-based tracking aids visual and statistical analysis of visitor spatial behavior.

- Delivery of messages via personal contact effectively minimizes off-trail
  behavior.

- Messages delivered with signs were ineffective at influencing visitor behavior.

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Table 3.1
A comparison of the influence of minimum impact educational treatments on visitor dispersion within the treatment area and summit area of Sargent Mountain.

Study Area	Experimental Condition				ANOVA Results	
	Control (T0)	Personal Contact (T1)	Ecological Impact Sign (T2)	Amenity Sign (T3)	F	_P_
Treatment Area Off-Trail[1] (m)	6.76[ab]	5.43[a]	8.58[c]	8.04[bc]	15.67	<.001
Summit Area Off-Trail[1] (m)	68.05[b]	56.82[a]	69.10[b]	63.98[ab]	4.06	.007
Ellipse Area (m^2) of Summit Area Off-Trail	7,477	4,582	8,637	7,723		

Note: [1]Mean Euclidean distance of all points outside of the 4 m trail buffer to the edge of the buffer. Means followed by the same letter are not significantly different with the Tukey HSD multiple comparison procedure at p < .05.
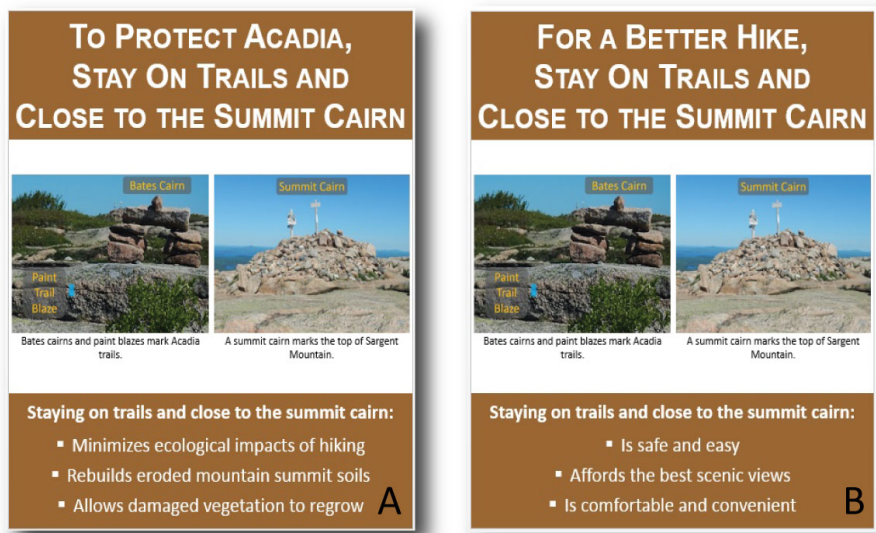
Fig. 3.1. Treatment signs. This figure illustrates: A) the ecological impact sign (T2); B) the amenity sign (T3).
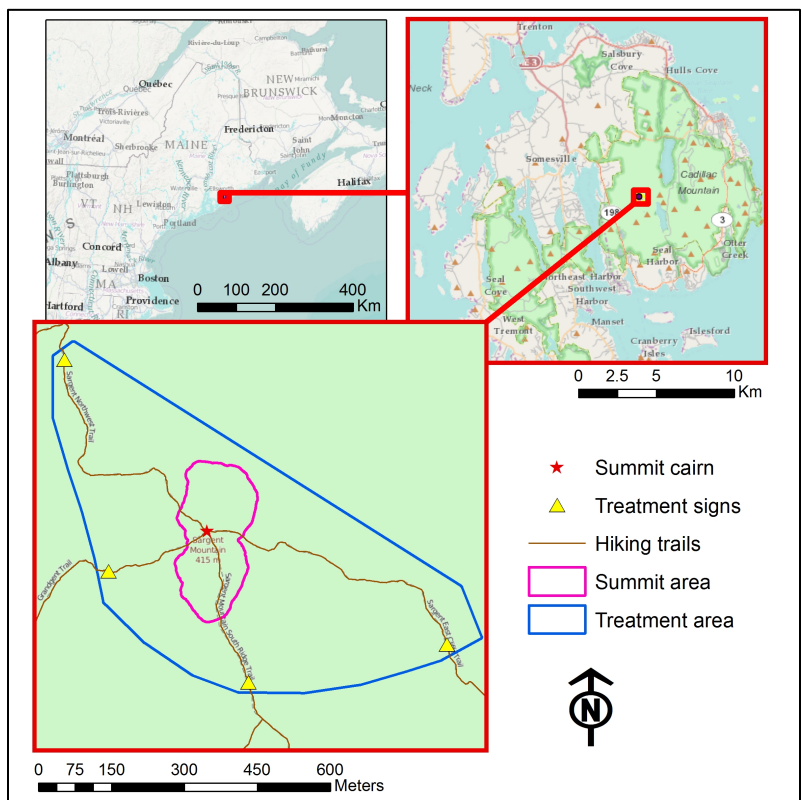
Fig. 3.2. Map of study area. This figure depicts locations of Treatment and Summit sub-areas, treatment signs, and the summit cairn within the Sargent Mountain study area.
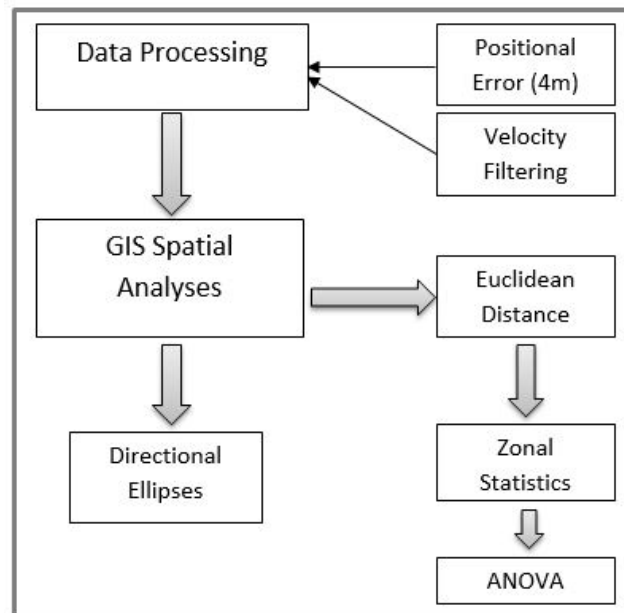
Fig. 3.3. Flow diagram of analyses. This figure illustrates the basic analytic steps taken to describe visitor behavior from GPS-tracking points.
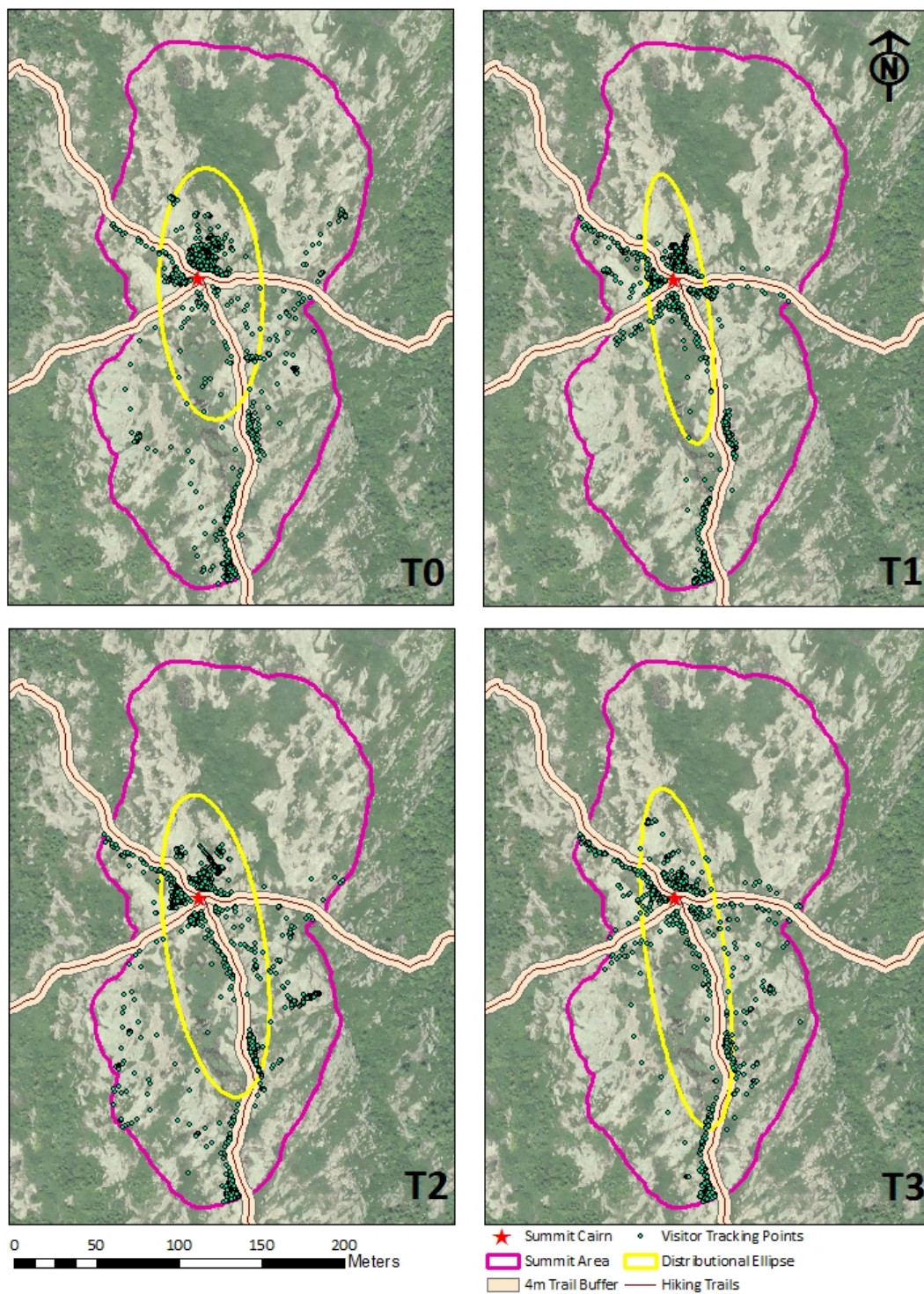
Fig. 3.4. Map of dispersion off-trail within the Summit Area by treatment. In this figure, dispersion of visitors (paths represented by colored dots) is represented by the yellow ellipse. From the top left: T0) control treatment; T1) personal contact treatment; T2) ecological impact sign; T3) amenity sign.

CHAPTER 4

PERSONAL CHARACTERISTICS OF PARK AND PROTECTED AREA VISITORS

AS FACTORS INFLUENCING SPATIAL BEHAVIOR

Abstract

The vast majority of recent research examining visitor spatial behaviors in parks and protected areas has been descriptive in nature, explaining observed visitor use patterns and impacts to park and protected area resources. Very little research to date has examined potential factors influencing visitor spatial behaviors, including visitor motivations, activity type, and visitor characteristics. Existing theory regarding visitor behavior in parks and protected areas falls into two categories: theories explaining visitor behavior patterns and subsequent impacts to park and protected area resources, and psychosocial theories explaining visitor behavior. These existing theories are the basis for most management actions aimed and changing or influencing visitor spatial behavior in parks and protected areas. However, existing theory does not adequately explain or characterize visitor behaviors that result in impacts to park resources—particularly, visitor travel away from designated trails, campsites, and other visitor use areas such as designated viewpoints. This study utilizes combined GPS-based tracking and survey data to examine whether visitor characteristics, including Leave No Trace (LNT) knowledge, level of education, and activity expertise, are influencing observed off-trail visitor spatial behavior in a park or protected area setting. Results indicate that visitors to the study area have high levels of LNT knowledge, education, and activity expertise, and the majority of visitors remain on designated trails. Further, visitor self-reported off-trail behaviors are

congruent with visitor off-trail behaviors observed via the use of GPS-based tracking techniques. Statistical analysis confirms that visitor characteristics are not significantly influencing visitor spatial behavior. However, visitor self-reported reasons for travel off-trail suggest that most off-trail travel is unplanned. This has implications for future management of visitor off-trail travel and associated resource impacts, as existing management efforts (particularly education and messaging campaigns) are theoretically grounded in techniques aimed at changing planned, as opposed to unplanned, visitor behaviors.

Keywords: visitor spatial behavior, off-trail travel, visitor characteristics

1. Introduction

Visitor spatial behavior patterns in parks and protected areas have been studied widely in recent years, both in response to increasing use levels in parks and protected areas globally (Balmford et al., 2015; White et al., 2014) as well as technological advancements (e.g., the use of GPS-based tracking procedures) that enable the collection of high quality spatial data with minimal burden to the visitor (D'Antonio et al., 2010; Hallo et al., 2012). The vast majority of this research has been descriptive in nature, in that it has been used to describe visitor behaviors and subsequent or potential impacts to park resources that might result from the observed spatial behavior patterns. For example, some research has examined dispersed or off-trail spatial behaviors of visitors (D'Antonio & Monz, 2016; Kidd et al., 2015; Walden-Schreiner & Leung, 2013). Other research has examined patterns of visitor use within trail or road networks in protected areas (Beeco & Hallo, 2014; Kidd et al., 2018; Meijles, de Bakker, Groote, & Barske,

2014; Newton, Newman, Taff, D'Antonio, & Monz, 2017; Orellana, Bregt, Lightenberg, & Wachowicz, 2012). However, research investigating the factors that are influencing visitor spatial behavior is less prevalent. As paired participant survey and GPS-based tracking protocols are becoming more common, some research has emerged that examines visitor motivations relative to spatial behavior patterns, but results thus far have been somewhat inconclusive (Beeco & Hallo, 2014; Newton, 2016). However, many other potential factors influencing spatial behavior remain un-examined or under-examined. One such potential factor is visitor personal characteristics.

Spatial patterns of recreation use in parks and protected areas include distribution of visitor use as well as density of visitor use across a landscape. In most parks and protected areas, visitor spatial use is not distributed evenly. Rather, use tends to be highly concentrated (often by design) to a limited number of areas (campgrounds or campsites, picnic or other day-use areas), trails, and access points (Manning, 2011). Generally concentrated use patterns have implications for impacts to resources. While impacts to these areas of concentrated use may be relatively high, a vast majority of park and protected area resources see little to no impact because use to these areas is very low or non-existent due to the lack of visitor amenities or facilities (trails, campground or sites) that promote visitor use of these areas, or regulations preventing visitors from travelling or camping outside of designated areas. Research conducted by D'Antonio and Monz (2016) suggests that presence of other visitors in an area can result in concentration of visitor use, despite previous assumptions to the contrary (that visitors in areas of high visitor use would disperse more than visitors in areas of low visitor use). Despite efforts by park and protected area managers to concentrate visitor use and minimize resource

impacts, dispersed visitor use often occurs, as visitors venture off-trail, create

undesignated campsites, or expand or create day-use sites throughout a recreation area

(Hammitt, Cole, & Monz, 2015). This dispersed use may result in disproportionate

impacts to park and protected area resources, particularly habitat fragmentation, when

visitors travel or camp outside of designated areas (Gutzwiller, D'Antonio, & Monz,

2017; Hammitt et al., 2015). Understanding the factors influencing visitor spatial

behavior, particularly undesired spatial behaviors, such as off-trail travel, is critical for

proactive management of park and protected area resources. If park and protected area

managers know what is influencing visitors to travel off-trail instead of staying on

designated trails, they may be able to accommodate visitors' needs in a manner that

prevents resource impacts before they happen. This study aims to contribute to the field

of recreation ecology by examining the role of visitor characteristics as factors

influencing visitor spatial behavior using combined GPS-based tracking and paired

survey data of visitors to a US national park. To begin, we examine existing literature and

research regarding factors influencing visitor spatial behavior in parks and protected

areas.

*1.1 Factors influencing visitor spatial
behavior: Nodes, linkages and psychosocial
factors*

One of the most widely used recreation management frameworks for describing

patterns and factors influencing visitor spatial behavior is the "node and linkage"

framework described by Manning in 1979 in his examination of impacts of recreation on

soils and vegetation. Manning's framework describes visitor use and subsequent impacts

as being concentrated along travel routes (termed "linkages") and at visitor destinations

("nodes"). These nodes and linkages concentrate visitor use, resulting in direct impacts to

the natural resource base, particularly soil and vegetation. However, these concentrated

areas typically represent a very small percentage of the recreation area as a whole (Cole,

Watson, Hall, & Spildie, 1997). The node and linkage framework suggests that visitor

destinations such as scenic overlooks, campsites, waterfalls, lakes, river edges, and

mountain summits regularly attract visitors (Hammitt et al., 2015). In other words, these

desirable destinations influence visitor behavior, and visitor use is often concentrated at

these destinations and along linkages (often trails) that connect destinations.

Though previous research has speculated that factors beyond desirable

destinations may be influencing visitor spatial behavior (e.g., Wimpey & Marion, 2011),

very little research to date has examined this concept spatially within a park or protected

area. One exception is research conducted by Beeco and Hallo (2014), who used paired

GPS tracking of visitors and a survey instrument to examine the influence of visitor

personal characteristics, user group type, and knowledge of the destination on the spatial

distribution and patterns of visitors to a complex trail system in Clemson, South Carolina.

Beeco and Hallo's results suggest that user group (activity) type was the most influential

variable studied on visitor spatial behavior patterns. However, results also indicate that

knowledge of one's destination (a reflection of a visitor's experience use history or

familiarity with a place measured by frequency of visits), personal characteristics

(including gender and self-reported skill level), and motivations (skill development and

physical fitness), all influenced visitor spatial travel patterns within the park (Beeco &

Hallo, 2014).

While the node and linkage model provides a basis for understanding visitor spatial behavior and resultant impact patterns in parks and protected areas, two commonly applied theories explaining psycho-social drivers of visitor behavior are the Theory of Planned Behavior (TPB) (Ajzen, 1991), and its predecessor, the Theory of Reasoned Action (TRA) (Fishbein, 1980). Both the TPB and TRA theories suggest that visitor behavior is governed by intentions to behave in a certain way. Intentions are determined by beliefs and attitudes held by the visitor, as well as societal, and individually held norms, personal values, and emotions (Fishbein & Manfredo, 1992). The TPB builds upon the TRA by suggesting that an additional factor, perceived behavioral control (the perceived ability of someone to actually engage in a certain behavior, such as recycling) also influences a person's behavioral intentions (Ajzen, 1991). According to these theories, in order to change visitor behavior (specifically to get visitors to adopt more environmentally friendly behaviors), the beliefs, and particularly, the attitudes of the visitor must first change.

Research suggests (though rather ambiguously) that TPB may be effective in changing the behavior of recreationists, but that visitor personal characteristics may influence the effectiveness of TPB in facilitating behavior change. In a study by Hughes, Ham, and Brown (2009) TPB was applied to messaging intended to influence beliefs and behavior of "problem" visitor behaviors in two Australian park sites (feeding wildlife in Yarra Ranges National Park, Victoria, and dogs off-leash in Yellagonga Regional Park in Western Australia). These researchers found that repeat visitors who had established habitual patterns of behavior were less likely to be influenced (change their behavior) as a result of viewing the messages. This suggests that visitor experience level, particularly

their experience with a particular area, may influence their spatial behavior patterns, and that these patterns may be more difficult to change. Additional research examining the influence of habit on the intentions of college students to use cars to travel to campus suggests that habits significantly influence behavioral intentions related to car use (Bamberg & Schmidt, 2003). The relationship between habits and behavioral intentions are not accounted for in the TPB, yet they appear to be potentially important factors influencing behavioral intentions. Despite these potential limitations, TPB has been used to guide development of minimum-impact education as a means of influencing visitor behavior—encouraging visitors, through education, to change their beliefs about how they should behave while recreating, and to actually change their behavior in accordance with their beliefs.

1.2 Minimum-impact education and visitor
spatial behavior

Minimum-impact education campaigns, such as Leave No Trace (LNT), have become popular programs for influencing visitor behavior in parks and protected areas. These programs challenge visitors to "Leave No Trace" by providing education to provide visitors with the skills and knowledge to enable them to engage in behaviors, including packing out trash, travelling on durable surfaces, minimizing fire impacts, and respecting wildlife, among others, designed to minimize their impact to protected area resources such as soil, vegetation, water, and soundscape (Hammitt et al., 2015; Leave No Trace, 2012; Marion & Reid, 2007). While a fair amount of research has examined the effectiveness of LNT/minimum impact education programs, in terms of improved LNT knowledge and observed and reported visitor LNT behaviors or behavioral

intentions (see Marion & Reid, 2007, for a full review), little work to date has actually examined the effectiveness of LNT/minimum impact education on minimizing resource damage in parks and protected areas.

Minimum impact education has also been associated with changes in visitor behaviors such that impacts to natural resources are minimized (Marion & Reid, 2007). Minimum impact education has been associated with decreased tree damage and litter in campgrounds (Oliver, Roggenbuck, & Watson, 1985) as well as decreased visitor building and altering of rock cairn trail markers in Acadia National Park (Jacobi, 2003). Further, educational messaging emphasizing minimum impact practices placed along trails in Mt. Rainier National Park has been associated with decreases in off-trail hiking (Johnson & Swearingen, 1992), and the application of a program of LNT information has decreased visitor campfire use in wilderness areas (Christensen & Cole, 2000). Minimum impact education in the form of a message delivered by a uniformed volunteer resulted in decreases visitor off-trail travel, which results in resource impacts including vegetation trampling, soil erosion, and compaction (Kidd et al., 2015). Research by Kidd et al. (2015) is one of the few studies to tie minimum impact education efforts to changes in visitor spatial behavior in a park setting, though these behavior changes cannot be attributed specifically to the minimum-impact education, as the *presence* of the uniformed volunteer delivering the message may have contributed to the observed behavioral changes.

*1.3 Visitor characteristics and spatial
behavior*

Visitor characteristics have been widely studied relative to how various attributes (including age, experience level, gender, ethnicity, education level, past experiences, etc.) influence preferences for different types of recreation experiences (Bright & Tarrant, 1999; Driver & Knopf, 1977; Pigram & Jenkins, 2006). Differences in visitor characteristics would influence visitors' choices in how visitors recreate (recreation activity), as well as where and when different people choose to recreate. However, factors such as visitor experience level and minimum impact knowledge, also influence the amount of impact that visitors may have on natural resources when they recreate (Hammitt et al., 2015; Manning, 2011), as well as perceptions of crowding (D'Antonio, Monz, Newman, Lawson, & Taff, 2012; Manning, 2011). In related research, individual characteristics including education level, gender, experience level, age, and knowledge have been examined relative to individuals' forest landscape preferences. Results suggest that some demographic variables (age, gender, education level) are not influencing forest landscape preference, but education and experience level do influence individuals' preferences (Kearney & Bradley, 2011).

Visitor characteristics have also been shown to influence visitors' perceptions of resource impacts in parks and protected areas (D'Antonio et al., 2012; Manning et al., 2004). Research conducted by D'Antonio and colleagues (2012) in a popular area within Rocky Mountain National Park examined the influence of visitor prior experience and education on perceptions of impacts including erosion of soil, trampled vegetation, visitor-created (social) trails, off-trail use, and tree damage. Results suggest that visitor

characteristics influence visitors' perceptions of resource impacts (D'Antonio et al.,

2012). Visitor experience use history (EUH), defined by Schreyer, Lime and Williams

(1984) as the "amount and extent of participation" in an activity, has also been shown to

influence visitor perceptions of crowding, though results vary in regard to whether

greater of lesser experience use of an area result in greater perceptions of visitor

crowding. Research conducted in the Shawnee National Forest of southern Illinois

examining experience use history and perceptions of crowding in rock climbers suggests

that climbers with greater EUH experienced greater perceptions of crowding (Fuson,

Goldkuhl, Coulson, & Park, 2016). This contradicts research by Sharp et al. (2015) which

suggests that visitors with lesser EUH for a particular area experience higher levels of

crowding.

However, little to no research has been conducted examining the relationship

between visitor characteristics and off-trail spatial behaviors, with the exception of Beeco

and Hallo (2014) noted above. Additionally, many park and protected area educational

efforts—specifically minimum-impact educational programs such as Leave No Trace,

operate under the assumption that visitors engaging in behaviors that may impact the

natural resource base (i.e., result in trampling of vegetation, soil erosion, increased

sedimentation to nearby bodies of water, etc.) lack knowledge of appropriate minimum-

impact recreation behaviors. This "deficit model" approach to educational efforts (more

information leads to behavior change) has been considered invalid for decades yet

continues to be utilized by education and communication campaigns worldwide

(Kollmuss & Agyeman, 2002). A growing body of research has examined LNT

knowledge and intentions among recreationists (see Lawhon, Taff, Newman, Vagias, &

Newton, 2017; Lawhon, Newman, Taff, & Vaske, 2013; Taff, Newman, Vagias, &

Lawhon, 2014; Vagias, Powell, Moore, & Wright, 2014), but very few have paired this

information with observed visitor behaviors to examine differences in visitor behavior

relative to differences in LNT knowledge. This study seeks to examine the role that

visitor characteristics have on visitor spatial behavior, by examining data on visitor

characteristics derived from survey data paired with GPS based tracking of visitors

(observational data on visitor spatial behaviors). Specifically, we look to answer the

question, 'Are visitor personal characteristics influencing visitor spatial behaviors—

particularly off-trail behavior—in hikers in a protected area setting?

2. Methods

2.1 Study site

Acadia National Park (ACAD) is located largely on Mount Desert Island, Maine,

adjacent to the town of Bar Harbor (Figure 4.1). The island is located about 80km

southeast of the city of Bangor along the mid coast of Maine. In 2016, ACAD, like many

national parks, experienced record levels of visitation, with over 3.3 million visitors

(NPS, 2017). In addition to natural and cultural scenery, including the park's historic

system of carriage roads, visitors have access to over 193 km (120 miles) of historic

hiking trails on over 47,000 acres (19,020 ha) (NPS, 2012). Many of these trails lead to

mountain summits within the park, and are popular visitor destinations. Among the more

strenuous trails in the park are the steep and rocky trails leading to the summit of the

second-highest peak in the park, Sargent Mountain (NPS, 2012, 2016a). Four separate

trails lead to the 1373' (419 m) summit (highlighted area, Figure 4.1), passing through

spruce-fir, pitch pine and deciduous hardwood forests before transitioning to a sub-alpine

environment consisting of large areas of exposed granite interspersed with fragile low-

growing shrubs, including low-bush blueberry, forbs, lichen and moss at the summit

(NPS 2012, 2016b ; Wessels, 2001). Off-trail travel by hikers is particularly damaging in

sub-alpine summit environments of ACAD due to the fragility of the vegetation and thin,

acidic soils, which limit the growth and recovery of damaged vegetation (Jacobi, 2007).

However, visitors to ACAD are permitted to gather up to one dry half-gallon of

blueberries per person, per day for personal consumption (NPS, 2017)—a popular

activity that often requires visitors to travel off of designated trails in the sub-alpine

environment. To encourage visitors to stay on trails in ACAD, all trails are marked by

blue paint blazes and rock cairns (Figure 4.2), and the park emphasizes Leave No Trace

practices among its visitors, particularly travel on durable (granite bedrock) surfaces in

the sub-alpine zone (NPS, 2018a).

2.2 Data collection and analysis

GPS-based tracking methods (D'Antonio et al., 2010) and a paired post-

experience survey (Appendix A) of visitors were used to observe and characterize visitor

spatial behavior, particularly off-trail behavior, on trails to the summit of Sargent

Mountain in ACAD under three different experimental messaging treatments and a

control. Messaging treatments included two different messages delivered via signs placed

on each of the four trails leading to the summit. Messages included an "amenity"-based

message (Amenity) that implored visitors to stay on-trail to improve their experience, and

an "ecological impact"-based message (Ecological Impact) that implored visitors to stay

on-trail to protect park resources. Finally, a uniformed volunteer delivered the

"ecological impact" message (personal contact) to visitors arriving at the summit of

Sargent Mountain during the personal contact treatment. The control treatment consisted

of existing trail markings only. For a detailed discussion of design of study treatments,

including examples of signage deployed, see Kidd et al., 2015 (Chapter 3). Treatments

were delivered separately over four, five-day periods during the month of July, 2013.

Data collection was stratified to include weekend and weekday days and sampling

occurred during hours of peak use, 8am-4pm. Data collection did not occur on inclement

weather days (heavy rain) due to extremely low use levels on those days. Due to

relatively low use on trails to Sargent Mountain, all visitor groups hiking to the summit

on sampling days were asked to participate in the study. A detailed description of GPS

unit administration, calibration, and data cleaning can be found in Kidd et al., 2015.

Data about visitor characteristics (activity expertise, self-reported knowledge of

minimum impact practices and highest level of education) was collected via the survey

instrument under the different treatment and control conditions. Previous research

suggests that the experimental message treatments, particularly the Personal Contact

treatment, had an influence on visitor spatial behavior (see results in Chapter 3; Kidd et

al., 2015). However, it remains unclear whether any other factors, such as visitor

characteristics, may have also been influencing visitor behavior. In order to investigate

whether any visitor characteristics influenced spatial behavior patterns, the following

analyses were conducted, where the variables of self-reported familiarity with minimum-

impact practices (referred to as 'LNT familiarity'), activity expertise (derived from visitor

responses to the survey question "How often do you take hikes like this?"), and level of

education served as independent variables, and visitor self-reported off-trail behavior (from visitor responses to the survey question "Did you hike off-trail"), as well as observed visitor off-trail behavior served as response, or dependent variables. Observed visitor off-trail behavior was derived from visitor GPS-based tracking points and measured as mean Euclidean distance of visitor tracking points that fell outside of a four-meter error buffer surrounding a map layer of designated park trails.

Statistical analyses were conducted using SPSS statistical software (v.25, IBM SPSS Statistics, Armonk, NY, USA), and spatial analyses of GPS-based tracking data were conducted using ArcGIS (v10.3, ESRI, Redlands, CA, USA). Descriptive analyses were conducted to examine frequencies of visitor responses to independent variables (LNT familiarity, activity expertise, and level of education). A descriptive analysis of reported reasons for off-trail travel among visitors was also conducted. The survey instrument provided visitors with ten potential options, including a response for "other" if none of the other given reasons captured why visitors travelled off-trail, and instructed visitors to select all that applied to them on their current visit (see Appendix A). These options were condensed into four interpretable categories to aid analysis and interpretation. Categories are: "Practical/Functional" reasons (e.g., to pass other hikers, to find a spot to go to the bathroom, to take a break, to take a shortcut), "Exploring/ Photographing the Environment," "Lost the Trail," and "Multiple Reasons." The "Multiple Reasons" category encompasses visitors whose responses fell into two or more of the other defined categories.

A series of chi-squared analysis were conducted examining the relationship between the following categorical variables derived from the survey data, split by treatment:

a. Minimum impact practice (LNT) familiarity among visitors and self-reported behavior.

b. Activity expertise and self-reported behavior.

c. Level of education and self-reported behavior.

d. Level of education and self-reported LNT familiarity.

e. Level of education and activity expertise.

f. Activity expertise and LNT familiarity.

Additionally, several two-way Analysis of Variance (ANOVA) tests comparing the independent variables, treatment, and an interaction variable for treatment and the independent variable with the dependent variable of Euclidean distance of visitors' off-trail travel were conducted to examine both whether visitor characteristics were influencing visitor spatial behavior, as well as whether a treatment effect was occurring, and whether the treatment was interacting with the independent variable of interest (Table 4.1).

3. Results

A descriptive analysis of three survey questions pertaining to visitor characteristics (LNT familiarity, activity expertise, and level of education) was conducted to examine potential differences in these visitor characteristics (Tables 4.2–4.4). Responses indicate that the majority of visitors (78%) self-report as being very familiar

with LNT practices (Table 4.2), take hikes like this often (80% take hikes like this once every couple of months or more often, Table 4.3), and are highly educated. The majority of visitors to Sargent Mountain are college educated (85%) and nearly half hold graduate degrees (46%, Table 4.4).

A series of one-way Analysis of Variance (ANOVA) procedures were performed to examine any differences between mean scores between treatments for the Independent Variables of "LNT familiarity," "Education Level," and "Activity Expertise." No significant differences were found between any of these variables and the different treatments (Tables 4.5–4.7).

Additionally, a descriptive analysis was conducted to examine the differences in frequency for visitor reasons for travelling off the designated trail. Visitor responses were categorized as Practical/Functional reasons, Exploring/Photographing the Environment, Lost the Trail, and Multiple Reasons. The most frequent "other" reason given for going off-trail, across all treatments, was to pick blueberries, representing 44% (8/18) of responses in this category. This response was captured in the Exploring/Photographing the Environment category (Table 4.8). Results indicate that visitor responses are distributed fairly evenly across each category.

While previous research has reported a difference in visitor off-trail behaviors as a result of the different messaging treatments (see Kidd et al., 2015—Chapter 3), that research did not examine differences in visitor characteristics and off-trail spatial behaviors. As such, chi squared/Likelihood analyses were conducted to examine the relationships between the responses to visitor self-reported and several categorical variables of interest split by treatment, to examine any potential influence of treatment on

the relationship between variables. Variables of interest include LNT familiarity (Table 4.9) activity expertise (Table 4.10), and education level (Table 4.11).

Results indicate no statistically significant differences between visitor self-reported behavior and the variables of LNT familiarity (Table 4.9) and education level (Table 4.11). However, a statistically significant difference between visitor self-reported hiking behavior and activity expertise for the Personal Contact (T1) treatment and for the relationship as a whole (TOTAL—across treatments) does exist (Table 4.10).

A Chi-squared/Likelihood analysis was also conducted to examine potential differences between visitor education level and LNT familiarity, visitor education level and activity expertise, and LNT familiarity and activity expertise (Tables 4.12–4.14). While no statistically significant relationships were found between visitor education level and LNT familiarity (Table 4.12), a statistically significant relationship was found for visitor education level and activity expertise for T1 and the Impact Sign treatment (T2). However, this relationship was not significant across all treatments, as indicated by the non-significant TOTAL result (Table 4.13). Additionally, statistically significant differences were found between LNT knowledge and activity expertise for the control treatment (T0) and T2. The relationship was also significant across all treatments, as indicted by the significant TOTAL result (Table 4.14).

A series of two-way ANOVA's examining the main effects of independent variables of interest (LNT familiarity, activity expertise, and education level) and treatment on the dependent variable of mean Euclidean distance travelled off-trail as well as the interaction between the independent variables and treatment revealed that there are no statistically significant main effects of any of the independent variables or treatment

on the dependent variable. There are also no statistically significant interaction effects between treatment and the independent variables on the dependent variable (Tables 4.15–4.17).

A two-way ANOVA examining the main effects of visitor self-reported off-trail behavior and treatment on the dependent variable (mean Euclidean distance travelled off-trail) revealed that visitor self-reported behavior has a statistically significant main effect on mean distance travelled off trail (Table 4.18). Visitors who reported that they did not travel off-trail had a mean distance travelled off-trail of 5.8m, while visitors who reported that they did travel off-trail had a mean distance travelled off-trail of 9.7 m. No statistically significant interaction effect of treatment on visitor self-reported behavior was found.

Finally, a two-way ANOVA was conducted examining the main effects of visitor-stated reason for travelling off-trail and treatment on the dependent variable (Table 4.19). This analysis revealed no statistically significant main effects of the independent variable or treatment on the dependent variable. Means range from 8.4 m for the "Practical/functional" category to 10.9 m for the "Lost the trail" category. No statistically significant interaction effect of treatment on visitor stated reason for travelling off-trail was found.

Additionally, a point density analysis was conducted for all points within the treatment area on Sargent Mountain for each treatment to examine areas where visitors may be congregating and/or leaving the trail, and if these locations differed, visually, by treatment (Figure 4.3).

4. Discussion

To date, very little research has examined visitor personal characteristics as drivers of visitor spatial behavior in parks and protected areas. While understanding visitor spatial behavior patterns is important for enabling park managers to identify and address existing impacts to park resources (e.g., soil, vegetation, riparian systems, etc.) as well as the visitor experience (e.g., instances of visitor crowding or conflict), understanding factors that influence visitor spatial behaviors, especially when these behaviors take visitors away from designated trails, viewpoints, or campsites, provides park managers information that may allow them to manage park resources proactively, instead of reactively. When park and protected area managers know what factor or factors are influencing visitors to travel off-trail, they can target messaging, interpretation, and potentially even site design to prevent unnecessary resource impacts.

This study examined the influence of several visitor characteristics (independent variables), derived from a post-experience survey, on the response variables of visitor self-reported behavior (derived from the post-experience survey) and observed mean Euclidean distance of visitor travel off-trail (derived from visitor GPS tracks). While no statistically significant differences in mean scale values for independent variables by treatment were found (Tables 4.5–4.7), a statistically significant relationship was found between activity expertise and visitor self-reported off-trail behavior for the personal contact treatment, as well as for the relationship between both variables when examined across all treatments (Table 4.10). Mean scores for activity expertise were quite high (at or above 2.9, or "once every couple of months" or more—see Table 4.7) for all

treatments, suggesting that high levels of activity expertise influence the accuracy with which visitors self-report off-trail behavior.

The majority (71%) of visitors to Sargent Mountain reported that they did not hike off trail during their visit. ANOVA results examining visitor self-reported behavior and mean Euclidean distance of off-trail travel (Table 4.15) show a significant difference in the distance travelled off-trail of visitors who self-reported that they did NOT travel off trail, compared to those who self-reported that they DID travel off trail. These results suggest that visitors are accurately recognizing and reporting their off-trail behaviors. This result may help to explain the differences in self-reported behavior relative to activity expertise—these visitors, having experienced more hikes like the one they took in Acadia, may be more accurately able to recognize and report when they have travelled off-trail, and away from the blue paint blazes and bates cairns that mark the designated trails to mountain summits in Acadia. A statistically significant relationship was also found between education level and activity expertise for two of the four treatments (Table 4.13) but was not significant across treatments. While mean scores for both education level and activity expertise were not statistically significant when examined by a dependent variable of treatment (see Tables 4.6–4.7), an examination of mean scores by treatment suggests that visitor education level and activity expertise are positively related for these treatments—visitors with higher education levels tend to have higher levels of activity expertise.

Comparison of LNT knowledge and activity expertise (Table 4.14) revealed a statistically significant relationship for two treatments, and for the relationship as a whole. A comparison of mean scores (see Tables 4.5 and 4.7) suggest that visitors with

higher mean LNT knowledge scores tend to also have higher levels of activity expertise. This suggests that for visitors hiking Sargent Mountain in Acadia, visitors that hike more often are more likely to have higher levels of LNT knowledge. Visitors to Acadia who have visited the park previously are likely to have encountered either messaging or personal contact with park interpretive staff or volunteers relative to LNT practices within the park. The park website contains information on two different pages regarding hiking on designated trails or durable surfaces (NPS 2018a, 2018b), such as the exposed bedrock that characterizes much of the area surrounding the summit of Sargent Mountain. In addition, the Friends of Acadia, an independent organization of citizen-stewards of park resources, helps to support the employment of Summit Stewards within the park (Friends of Acadia, 2018). The Summit Stewards (formerly known as Ridgerunners) are typically college students hired by the park to serve as "uniformed volunteers" that educate visitors about LNT practices, particularly travelling on trails or durable surfaces (bedrock) on mountain summits. The Summit Stewards also help maintain trail markings (cairns) and assist with survey administration and other research efforts occurring on mountain summits within the park (Friends of Acadia, 2018; NPS, 2018b). While the survey instrument used in this study did not ask visitors about their experience use history (EUH) within Acadia specifically, repeat visitation and exposure to park messaging and education efforts may help to explain the statistically significant relationship between LNT knowledge and activity expertise.

While the significant relationships between observed visitor spatial behavior and self-reported behavior as well as LNT knowledge and activity expertise are interesting, they do not answer the research question guiding this study—are visitor characteristics

influencing visitor spatial behavior? Results of the two-way ANOVA analyses examining the influence of three visitor characteristics—LNT knowledge, level of education, and activity expertise, on mean Euclidian distance off-trail were not significantly significant. For visitors hiking to Sargent Mountain in ACAD, visitor characteristics do not significantly influence spatial behavior. While no statistically significant differences in the mean Euclidean distance travelled off trail and the visitor reasons for travelling off-trail emerged, the reasons visitors gave for travelling off-trail may shed insight into potential factors influencing visitor off-trail behavior. Reasons for travelling off-trail fell into four categories: Practical/Functional Reasons (including passing other hikers, getting privacy [i.e., going to the bathroom], taking a break, and taking a shortcut), Exploring/ Photographing the Environment (including getting a better view, taking a picture, exploring/playing, viewing plants and animals, and picking blueberries), Lost the Trail, and Multiple Reasons.

Following the node-and-linkage theory of spatial behavior and impacts, the destination (node) of the summit of Sargent Mountain was the greatest factor influencing both visitor on and off-trail behavior across treatments (Figure 4.3). This destination-driven behavior explains a planned visitor behavior—reaching the summit of Sargent Mountain. Off-trail behaviors (with the possible exception of picking blueberries), as self-described by visitors, are largely behaviors that are unplanned and tend to center around meeting visitor personal comfort or social needs, or satisfying visitor curiosity. As such, messaging and educational efforts such as promotion of LNT practices, built upon the Theory of Planned Behavior, may not be effective for changing unplanned visitor behaviors that draw visitors off of the designated trail, and potential result in impacts to

park and protected area resources. Further, many minimum-impact educational campaigns provide information to visitors regarding how to minimize impact when travelling away from designated trails and destinations. For example, one of the seven Leave No Trace principles asks visitors to backcountry areas to "travel and camp on durable surfaces" (Leave No Trace, 2012). As such, it may be the case that some visitors feel that they have high enough levels of LNT knowledge that they can travel off-trail with causing negative impacts to park resources.

4.1 Limitations and future directions

 4.1.1 Study limitations. Several limitations exist relative to this study. First, no psychometric scale to evaluate visitor motivations for their visit was included in the survey instrument administered to visitors at the end of their hiking experience (Appendix A). As such, no data exists in this data set relative to potential visitor motivations for recreating. We were not able to evaluate visitor motivations as potential drivers of visitor spatial behavior, which would have been a beneficial addition to this study, as both early and recent research in the field suggests that visitor motivations may influence spatial behavior patterns in parks and protected areas (Heberlien & Dunwiddie, 1979; Newton, 2016).

 Additionally, the survey instrument measured visitor activity expertise ("How often do you take hikes like this?"), rather than experience use history (EUH). EUH question typically ask visitors multiple questions about their past recreation experience and are used to describe how many times visitors to parks and protected areas have visited the park, or even the trailhead, (a) in the recent past (e.g., the past five years), and

(b) in their lifetime. EUH questions are often tied to visitor place attachment (Watson &

Niccolucci, 1992), and provide information regarding how familiar visitors are with a

specific area. EUH may have been a better metric for understanding the influence of prior

visits to Acadia on visitor spatial behavior, and LNT knowledge. Additionally, local

ecological knowledge is a metric that has been used previously, particularly to understand

and assess visitor perceptions of impacts (D'Antonio et al., 2012). Including that metric

would give additional insight as to potential drivers of visitor spatial behavior.

Finally, the design of the study, including study location, may not have been ideal

for capturing differences in visitor spatial behaviors. In the northeast, including in

ACAD, most trails are densely vegetated, making off-trail travel difficult. Above tree line

in ACAD, the primary hiking surface becomes durable, exposed granite bedrock.

Managers in ACAD have made a substantial effort to educate visitors to travel on

designated trails or durable surfaces (like granite bedrock) within ACAD (NPS 2018a,

2018b). It is possible that less variation exists in off-trail behavior in ACAD than may in

an area where managers have not made an effort to educate visitors on proper LNT

practices, or where the vegetation and geography are more conducive to off-trail travel.

Further, visitors to parks and protected areas tend to be similar to one another in race

(generally white), age (typically middle-aged), income (high) and education level (high)

(Manning, 2011). As such, differences in visitor characteristics may have been minimal

to begin with, thus it is not necessarily surprising that differences in visitor characteristics

were not found to influence visitor spatial behavior patterns. Moreover, this research

examined differences in visitor characteristics of one user group—hikers, to one

destination in a park. An examination of visitor characteristics of multiple user groups

travelling to multiple destinations would likely reveal both different spatial use patterns as well as differences in visitor characteristics. An examination of the relationship between visitor characteristics and spatial behavior patterns across multiple parks and protected areas is warranted to better understand to what degree (if at all) visitor characteristics are influencing visitor spatial behaviors, particularly off-trail travel.

4.1.2 Future research directions. One of the main categories of visitor-stated reasons for travelling off-trail was Exploring/Photographing the Environment, which included visitors looking for and gathering low-bush blueberries that grow in the sub-alpine environment surrounding the summit of Sargent Mountain. An examination of GPS tracking points off-trail in relation to land cover could enable an analysis of both potential landscape features (such as presence of lowbush blueberry) that may be drawing visitors off-trail as well as whether visitors are travelling on durable surfaces when off-trail. Park educational materials encourage visitors to stay on designated trails or durable surfaces, such as granite bedrock (NPS, 2018b). It is possible that visitors who are characterized as travelling "off-trail" for the purposes of this study (i.e., outside of the 4 m buffer surrounding the designated trail) are actually travelling on durable surfaces, and thus following park management's suggested LNT practices.

5. Conclusions

An examination of visitor spatial behavior using GPS-based tracking techniques, paired with a survey instrument providing data about visitor characteristics (LNT knowledge, level of education, and activity expertise) as well as visitor self-reported off-trail behavior revealed that visitor characteristics are not statistically significant factors

influencing visitor off-trail behavior. However, statistically significant relationships between visitor activity expertise and self-reported behavior, as well as self-reported behavior and mean Euclidean distance travelled off-trail suggest that visitors are accurately reporting their off-trail behavior, and this ability may be a function of high levels of activity expertise and LNT knowledge of ACAD visitors hiking to the summit of Sargent Mountain. While the summit destination was clearly influencing planned visitor spatial behaviors, visitor self-reported reasons for travelling off-trail suggest that off-trail behaviors are largely unplanned. Most visitor messaging and education campaigns are based on TPB, which suggests that visitor behaviors are a function of visitor beliefs and attitudes, social norms, and perceived behavioral control (Ajzen, 1991), and may help to explain visitors' intentions to engage in LNT practices while hiking. However, it is often unplanned behaviors, or opportunistic landscape features, such as particularly scenic viewpoints, interesting flora and fauna, and in the case of ACAD, presence of blueberries, that appear to be influencing visitors' off-trail behaviors. These unplanned behaviors are likely resulting in the large majority of off-trail impacts to park and protected areas, including damage to vegetation, soil, and the visitor experience, for visitors that are perceptive of those resource impacts. Managers wishing to proactively manage for prevention of resource impacts may consider evaluating potential landscape features that could draw visitors off-trail, or rethinking visitor messaging and education campaigns to highlight ways to minimize impacts of unplanned behaviors that visitors commonly engage in while recreating, as managers in ACAD have done. In ACAD, where visitor activity expertise and LNT knowledge is high, it is likely that the 29% of visitors who reported that they travelled off-trail are doing so on durable surfaces,

such as the granite bedrock that is widespread as visitors approach the summit of Sargent

Mountain, as this behavior is widely promoted in park literature and by Summit Stewards

within the park (Friends of Acadia, 2018; NPS, 2018b). Future analysis comparing visitor

off-trail use and land cover could confirm this hypothesis, as well as provide insight to

managers regarding potential areas where resource impacts may be occurring.

6. References

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Table 4.1

Variables for Two-Way Analysis of Variance (ANOVA)

Independent Variable	Treatment Variable applied?	Interaction Variable	Dependent Variable
Visitor self-reported behavior	Yes	Treatment*self-reported behavior	Mean Euclidean distance of visitor tracking points off-trail
Visitor reason for travelling off-trail ('OT Reason)	Yes	Treatment*OT Reason	Mean Euclidean distance of visitor tracking points off-trail
LNT familiarity	Yes	Treatment*LNT familiarity	Mean Euclidean distance of visitor tracking points off-trail
Activity expertise	Yes	Treatment *Activity expertise	Mean Euclidean distance of visitor tracking points off-trail
Level of education	Yes	Treatment*Level of education	Mean Euclidean distance of visitor tracking points off-trail

Table 4.2

How Familiar Are You with Leave No Trace (LNT) Practices?

Scale Item	Frequencies
Not at all familiar (0)	2
Limited familiarity (1)	19
Somewhat familiar (2)	73
Very familiar (3)	332
N	*426*
Mean*	**2.73**
SD	**.554**

*Mean scale is out of 3, with "Not at all familiar" = 0 and "Very familiar" = 3.

Table 4.3

How Often Do You Take Hikes Like This?

Scale Item	Frequencies
Less than once a year (1)	29
Once a year (2)	86
Once every couple of months (3)	162
Once a month or more (4)	179
N	*426*
Mean*	**3.09**
SD	**.939**

*Mean scale is out of 4, with "Less than once a year" = 1 and "Once a month or more" = 4.

Table 4.4
What is Your Highest Formal Level of Education?

Scale Item	Frequencies
Less than High School (1)	6
High School Graduate (2)	16
Some College (3)	34
Bachelor's Degree (4)	113
Some Graduate School (5)	49
Graduate Degree (6)	191
N	*417*
*Mean**	**4.76**
SD	**1.33**

*Mean scale is out of 6, with "Less than High School" = 1 and "Graduate Degree" = 6.

Table 4.5
Mean Score for LNT Familiarity by Treatment

Treatment		ANOVA results	
	Mean Scale Score*	F	*p*
Control (T0)	2.816	1.590**	.192
Personal Contact (T1)	2.708		
Impact Sign (T2)	2.705		
Amenity Sign (T3)	2.677		

*Mean Scale is 0–3, with 0 = "Not at all familiar" and 3 = "Very familiar."
**Welch's F statistic reported due to non-homogenous variances.

Table 4.6
Mean Score for Education Level by Treatment

Treatment		ANOVA results	
	Mean Scale Score*	F	*p*
Control (T0)	4.635	1.903	.128
Personal Contact (T1)	4.991		
Impact Sign (T2)	4.613		
Amenity Sign (T3)	4.789		

*Mean Scale is 1–6, with 1 = "Less than high school" and 6 = "Graduate degree."

Table 4.7
Mean Score for Activity Expertise by Treatment

Treatment		ANOVA results	
	Mean Scale Score*	F	p
Control (T0)	3.163	.813	.487
Personal Contact (T1)	3.096		
Impact Sign (T2)	2.975		
Amenity Sign (T3)	3.118		

*Mean Scale is 1–4, with 1 = "Less than once a year" and 4 = "Once a month or more."

Table 4.8
Why Did You Hike Off-Trail?

Category	Frequencies
Practical/Functional (1)	24
Exploring/Photographing the Environment (2)	34
Lost the Trail (3)	30
Multiple Reasons (4)	29
N	*117*

Table 4.9
Relationship Between Visitor Self-Reported Hiking Behavior and LNT Familiarity

Treatment	N	X^2 or Likelihood ratio results		
		df	Test statistic*	p
T0 (Control)	95	2	4.77*	.092
T1 (Personal Contact)	110	2	.368	.832
T2 (Impact Sign)	121	2	2.07	.557
T3 (Amenity Sign)	89	2	.418*	.812
TOTAL	415	2	2.01	.570

*Likelihood ratios are reported where sample sizes are small (n < 100)

Table 4.10

Relationship Between Visitor Self-Reported Hiking Behavior and Activity Expertise

Treatment	N	X² or Likelihood ratio results		
		df	Test statistic*	p
T0 (Control)	95	3	3.35*	.330
T1 (Personal Contact)	111	3	9.55	.023**
T2 (Impact Sign)	120	3	3.90	.272
T3 (Amenity Sign)	89	3	2.30*	.513
TOTAL	415	3	10.90	.012**

*Likelihood ratios are reported where sample sizes are small (n < 100)

** Significant at p < .05

Table 4.11

Relationship Between Visitor Self-Reported Hiking Behavior and Education Level

Treatment	N	X² or Likelihood ratio results		
		df	Test statistic*	p
T0 (Control)	93	5	5.96*	.311
T1 (Personal Contact)	109	4	3.37	.498
T2 (Impact Sign)	118	5	.429	.508
T3 (Amenity Sign)	87	5	6.18*	.289
TOTAL	407	5	7.16	.209

*Likelihood ratios are reported where sample sizes are small (n < 100)

Table 4.12

Relationship Between Education Level and LNT Familiarity

Treatment	N	X² or Likelihood ratio results		
		df	Test statistic*	p
T0 (Control)	92	10	11.47*	.322
T1 (Personal Contact)	108	10	15.06	.130
T2 (Impact Sign)	117	15	15.06	.447
T3 (Amenity Sign)	88	12	5.16*	.953
TOTAL	405	18	14.85	.672

*Likelihood ratios are reported where sample sizes are small (n < 100)

Table 4.13

Relationship Between Education Level and Activity Expertise

Treatment	N	df	Test statistic*	p
		X² or Likelihood ratio results		
T0 (Control)	92	15	11.42*	.722
T1 (Personal Contact)	109	15	37.84	.001**
T2 (Impact Sign)	116	15	31.04	.009**
T3 (Amenity Sign)	88	18	25.34*	.115
TOTAL	405	18	27.86	.064

*Likelihood ratios are reported where sample sizes are small (n < 100)
** Significant at p < .05

Table 4.14

Relationship Between LNT Knowledge and Activity Expertise

Treatment	N	df	Test statistic*	p
		X² or Likelihood ratio results		
T0 (Control)	98	6	24.90*	.000**
T1 (Personal Contact)	113	6	7.86	.249
T2 (Impact Sign)	121	9	28.64	.001**
T3 (Amenity Sign)	93	6	12.42*	.053
TOTAL	425	9	53.83	.000**

*Likelihood ratios are reported where sample sizes are small (n < 100)
** Significant at p < .05

Table 4.15

ANOVA results for Mean Euclidean Distance Travelled Off-Trail by LNT Familiarity and Treatment

Source	SS	df	MS	F	p
LNT Familiarity	225.81	3	75.27	1.356	.257
Treatment	15.77	3	5.26	.095	.963
Treatment*LNT	277.20	6	46.20	.832	.546
Error	12214.75	220	55.52		

Table 4.16

ANOVA results for Mean Euclidean Distance Travelled Off-Trail by Activity Expertise and Treatment

Source	SS	df	MS	F	p
Activity Expertise	65.99	3	22.00	.388	.762
Treatment	50.66	3	16.89	.298	.827
Treatment*Activity	512.13	9	56.90	1.004	.438
Error	12241.48	216	56.67		

Table 4.17

ANOVA results for Mean Euclidean Distance Travelled Off-Trail by Education Level and Treatment

| Source	SS	df	MS	F	p
Education Level	300.01	6	50.00	.857	.528
Treatment	430.44	3	143.48	2.459	.064
Treatment*Education	657.57	14	46.97	.805	.663
Error	11669.99	200	58.35		

Table 4.18

ANOVA results for Mean Euclidean Distance Travelled Off-Trail by Self-Reported Off-Trail Behavior and Treatment

Source	SS	df	MS	F	p
Self-Reported Behavior	681.25	1	681.25	12.195	.001*
Treatment	211.22	3	70.41	1.260	.289
Treatment*Behavior	157.76	3	52.59	.941	.421
Error	12736.90	228	55.86		

*Significant at p < .05

Table 4.19

ANOVA results for Mean Euclidean Distance Travelled Off-Trail by Reason for Travelling Off-Trail and Treatment

Source	SS	df	MS	F	p
Off-Trail Reason	49.72	3	16.57	.187	.905
Treatment	248.76	3	82.92	.935	.431
Treatment*OT Reason	1291.88	9	143.54	1.618	.138
Error	4169.13	47	88.71		
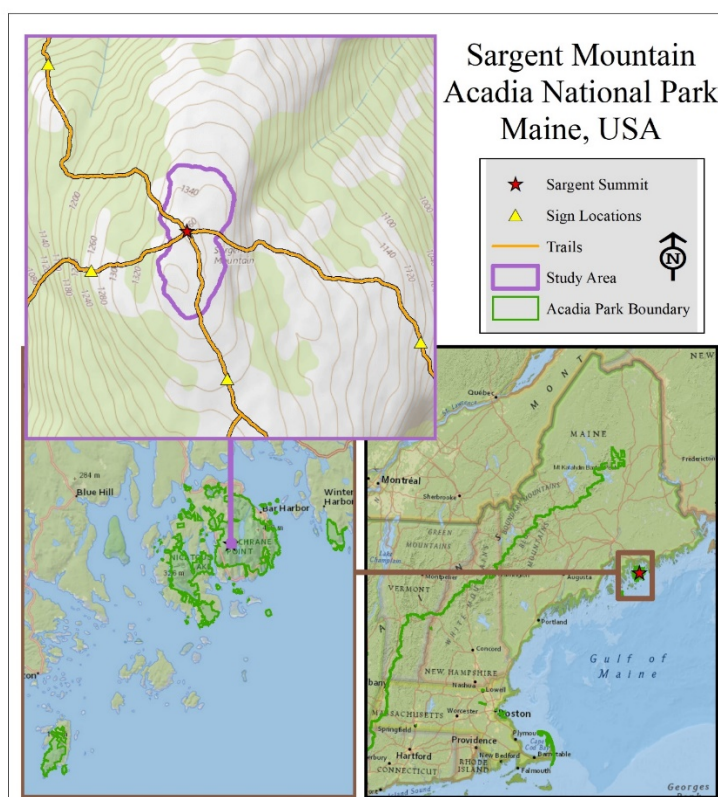
Figure 4.1. Map of Sargent Mountain study area within Acadia National Park, ME, USA.

Figure 4.2. Bates cairns (left) and blue paint blazes (circled in blue, right) mark the trail to the summit of Sargent Mountain above tree line.
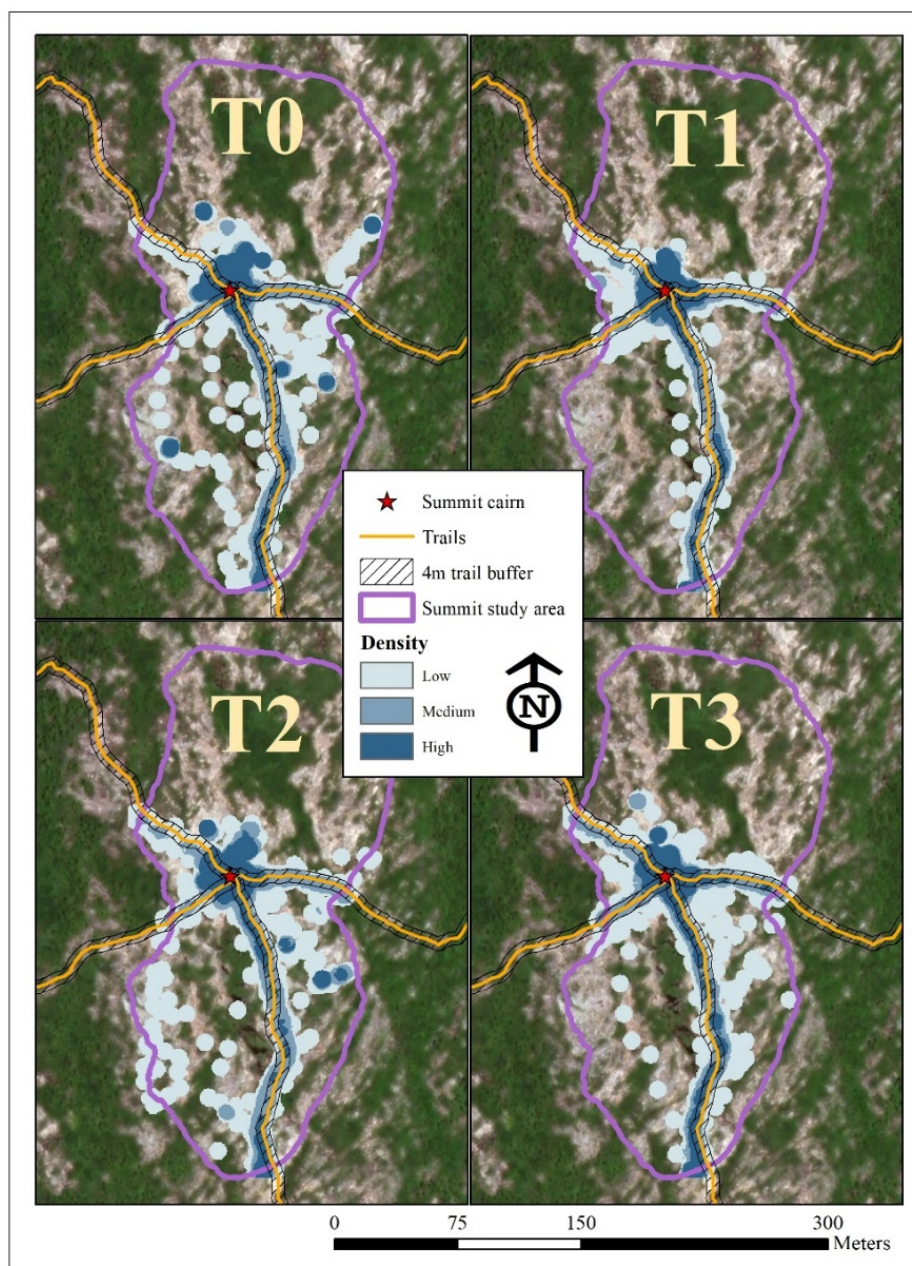
Figure 4.3. Point density of visitors within the summit study area by treatment.

CHAPTER 5

UNDERSTANDING VISITOR BEHAVIOR ASSOCIATED WITH "WILDLIFE JAM"

EVENTS: PROTECTED AREA RESOURCES AS FACTORS INFLUENCING

VISITOR SPATIAL BEHAVIOR[3]

Abstract

As recreation and tourism in parks and protected areas continues to increase, managers face rising concerns of degradation of natural resources and the visitor experience. One experience that visitors often seek is opportunities to view or photograph wildlife. Presence or absence of wildlife often influences visitor spatial behavior in parks and protected areas. Visitor behavior in prime wildlife-viewing areas often involves visitors parking vehicles along park roadways and exiting their cars to view wildlife. A phenomenon known as a "wildlife jam" can result, as visitor wildlife-viewing behaviors stop or slow traffic. To date, no studies have comprehensively investigated the wildlife jam phenomenon. This research quantitatively characterizes the nature of wildlife jams within a park and protected area setting. Global Positioning System (GPS) technology was used to collect high-accuracy data on location and duration of jams. Observations during jams characterize size (how many visitors and cars were involved) and visitor behaviors that occurred. Results suggest that jam characteristics including presence of

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park staff, species involved, and location, can affect the duration, extent, and visitor behaviors that occur during wildlife jam events. Management implications are discussed.

Key words: wildlife jam, visitor behavior, spatial behavior, wildlife, resource management

1. Introduction

Participation in recreation and tourism in parks and protected areas continues to increase both in the United States and worldwide (Balmford et al., 2015; Cordell, 2004; White et al., 2014). Often associated with increasing visitation are concerns regarding both the degradation of the quality of visitor experiences and protected area resources, including vegetation, soil, water, air, wildlife, natural soundscapes and night skies (Hammitt, Cole, & Monz, 2015). Prominent among these concerns are the effects of recreation on wildlife at the individual, population, and community levels (Knight & Gutzwiller, 1995; Taylor & Knight, 2003). The impacts of non-consumptive recreation activities (e.g., wildlife viewing, hiking, backcountry skiing) to wildlife are challenging to characterize, and recent research suggests that the effects of these activities at larger (i.e., landscape level) spatial scales is largely unknown (Gutzwiller, D'Antonio, & Monz, 2017).

The experiences visitors have in parks and protected areas enable them to connect with and experience nature. However, recent reports of undesirable human-wildlife interactions (e.g., Brown, 2016) and general depreciative behavior in parks and protected areas have garnered mainstream media attention. Enabling safe and sustainable visitor-wildlife interactions in parks and protected areas continues to be a time and resource-

intensive challenge for managers of parks and protected areas where large or unique

wildlife species reside. For example, wildlife-related tourism and subsequent

management issues are common in parks and protected areas in southern Africa,

including national parks in Zimbabwe, where visitors are drawn by the opportunity to see

large and/or rare species, including rhinoceros (Mutanga, Vengesayi, Chikuta, Muboko,

& Gandiwa, 2017). Further, research conducted in national parks within Namibia,

Botswana, and South Africa suggests that species diversity within a park, particularly the

likelihood that visitors may be able to see multiple unique or charismatic species,

including, lion, cheetah, hyena, African elephant, rhinoceros, and others, influences

visitor behavior. Researchers found a positive correlation between measures of species

diversity and vehicles present in selected areas within the national parks (Arbieu,

Grünewald, Martín-López, Schluening, & Böhning-Gaese, 2017). The presence of the

very species that these parks are charged with protecting may actually be influencing

visitor spatial behaviors that threaten the species or the resources they depend on.

In the United States, iconic U.S. national parks, such as Great Smoky Mountains,

Yellowstone, Glacier, Rocky Mountain and Grand Teton National Parks, experience

similar challenges in managing visitors seeking wildlife experiences. Further

exacerbating this challenge, many national parks in the U.S. and worldwide are currently

at or above record levels of annual visitation. For example, two national parks in the

Greater Yellowstone Ecosystem (GYE), Grand Teton and Yellowstone, have met or

exceeded previous high visitation levels in the last five years, with approximately 2.6–2.8

million annual visits to Grand Teton and 3.1–3.6 million to Yellowstone (National Park

Service, 2015). Approximately 80% of these visitors come to the parks during June

through September (Monz, D'Antonio, & Heaslip, 2014). Although visitors to these parks ascribe a range of motivations to their park visit, a primary reported motivation are opportunities to view and experience wildlife (Borrie, Davenport, Freimund, & Manning, 2002). In these parks, presence of wildlife may be influencing visitor behavior— particularly visitor spatial behavior patterns, as visitors drive the park roads specifically looking for wildlife to view or photograph. Visitor behavior patterns can be highly variable depending on the presence or absence of wildlife.

The Moose-Wilson Corridor within Grand Teton National Park (GRTE) provides an exceptional recreation opportunity for visitors seeking a "wildlife experience." A range of natural ecological communities, including wetlands, meadows, sagebrush flats, and alpine and subalpine forests provide habitat for many wildlife species, including, but not limited to, mule deer, elk, moose, black bear, grizzly bear, great grey owl, and grey wolf, all in a geographic area roughly seven miles long, five miles wide, and covering 15,000 acres (Monz et al., 2014). Additionally, the "rustic" and scenic nature of the road provides an opportunity for a slow-driving experience conducive to wildlife viewing. As such, this corridor is valued by managers and visitors alike for its ecological diversity, as well as its unique recreation opportunities.

Visitors to the Moose-Wilson Corridor and many other areas within the GYE often seek out opportunities to view the abundant wildlife and drive certain park roads at times when wildlife are likely to be present. Thus, the resource (in this case wildlife) often influences visitor spatial behavior patterns in these prime wildlife-viewing corridors. In order to facilitate safe wildlife viewing in the Moose-Wilson corridor, the park directly manages wildlife-visitor interactions that occur along or adjacent to the

roadway (dubbed "wildlife jams" when these events stop or alter the flow of traffic along the road) utilizing a roving volunteer crew known as the Wildlife Brigade. The Brigade exists to help mitigate concerns surrounding the close proximity of interactions between visitors and wildlife inherent in wildlife jams, including the potential for animal-vehicle collisions (Blackwell et al., 2016), as well as habituation. While wildlife (particularly bear)-to-human habituation (where wildlife adapt and begin to show less wariness to the presence of humans) has long been a management challenge in parks and protected areas, human-to-wildlife habituation may also be of concern (Smith, Herrero, & DeBruyn, 2005). In human-to-wildlife habituation, repeated "uneventful" encounters with wildlife at close proximity may reduce a visitor's sense of caution in the presence of dangerous wildlife such as bears and moose, leading visitors to adopt an air of "careless casualness" when viewing wildlife at close proximity in their natural habitat (Smith et al., 2005). Further, human proximity to wildlife may result in alert or alarm behaviors that cause individuals to be displaced from food sources or preferred habitat, thus increasing energy expended and potentially increasing vulnerability to detection by predators or interfering with parental care (Bateman & Fleming, 2017; Gutzwiller et al., 2017; Gutzwiller, Riffell, & Anderson, 2002). Human-wildlife interactions may also result in impacts to other park resources, such as vegetation and soils, when visitors leave the designated trail in order to get a better view of or photograph wildlife, or when visitors park their cars along roadways in areas that are not specifically designated for visitor parking.

To date, no studies have comprehensively investigated characteristics of wildlife jams, or visitor behavior during wildlife jam events. The Moose-Wilson Corridor, with its prime wildlife habitat, historic wildlife presence, frequent visitor use, and value as an

ecologically diverse, scenic area provides an ideal location to examine the influence of wildlife and wildlife jams on visitor spatial behavior. This study examines the spatial variability and visitor behavior during wildlife jams occurring in a popular wildlife-viewing area, the Moose-Wilson Corridor of GRTE, during the late summer and fall of 2016. Data is evaluated from a both a biophysical and a managerial perspective in order to understand visitor behaviors during wildlife jam events and assess the potential impact of these behaviors on wildlife. The results can be used to inform management such that quality of the visitor experience is maintained and impacts to wildlife, as well as other park resources, from these events are minimized.

2. Methods

2.1 Study site

In many locations along the Moose-Wilson Road and throughout the GYE, wildlife are abundant and in close proximity to park roadways. Visitor behavior when wildlife are present often involves visitors parking along narrow, sometimes two-lane roadways, and exiting their cars to view wildlife. This creates a phenomenon referred to as a "wildlife jam" with informal parking along a roadway, pedestrians on and along roads viewing wildlife, and other motorists attempting to drive through. Further, once a jam begins, it tends to grow in size as other visitors stop to see what is attracting everyone's attention. GYE park managers have identified this issue as a key management problem and as a result they frequently dispatch rangers and uniformed volunteers to these locations in order to direct traffic, manage visitors, and protect wildlife (Monz et al., 2014).

To address these concerns in GRTE, a volunteer-based Wildlife Brigade exists to aid in management of wildlife jams on park roadways. Wildlife Brigade crews help provide visitors with opportunities to view wildlife at a safe distance (100 yards from bears and wolves; 25 yards from all other wildlife), as well as maintaining the flow of traffic (Grand Teton National Park Foundation, n.d.; National Park Service, 2017). Additionally, crews patrol picnic areas to make sure visitors have secured food properly and provide education to visitors about safe ways to experience wildlife in the park (Grand Teton National Park Foundation, n.d.)

To better understand spatial and temporal distribution of wildlife jams and assess the potential disturbance on wildlife and assess visitor behavior during wildlife jam events, both visitor and wildlife behaviors were observed during wildlife jams that occurred during two ten-day periods along the Moose-Wilson Road, within the Moose-Wilson Corridor (Figure 5.1). The road extends 7.7 miles north from GRTE's southernmost Granite Canyon Entrance, at the terminus of Wyoming Route 390, to the town of Moose, where it intersects with Teton Park Road. The road passes through a variety of natural communities, which provide habitat for numerous wildlife species, making it both an exemplary representation of the diversity of natural communities within GRTE, and also a prime wildlife viewing area within the park (Monz et al., 2014). Sawmill Ponds, a designated pull-off on the northern end of the road, is a popular destination for viewing wildlife, particularly moose. A large designated parking area exists to accommodate wildlife viewers, and a short trail (~0.5 mile) extends south from the parking lot (Figure 5.2).

2.2 Data collection and analysis

Wildlife jams that occurred within the Moose-Wilson Corridor during two weeks in August 2016 and two weeks in September 2016 were studied. Jams were identified in two ways. First, a park radio was used to scan for jams called in to dispatch. Second, researchers periodically drove (~once per hour during sampling hours) the Moose-Wilson Road, looking for wildlife jams. Upon arriving at a jam, location and descriptive data (duration, species involved, approximate number of vehicles present and others) were mapped using a 3-5m accuracy Trimble Juno 3B GPS unit fitted with LTI TruPulse360 infrared laser rangefinder (Trimble Inc., Sunnyvale, CA, USA). Additionally, observations on animal and visitor behavior during the events were collected and recorded using unobtrusive direct observation methods for the duration of the jam (Taylor & Knight, 2003; Walden-Schreiner & Leung, 2013) and measures of distance of the wildlife to the road, closest visitor approach distance, and average visitor approach distance were taken (Table 5.1). In addition to the number of vehicles that stopped at a jam and number of visitors who got out of their vehicles to view wildlife, several other visitor behaviors were recorded during jam events. These include whether visitors photographed wildlife, took selfies with the wildlife, approached the wildlife, fed or attempted to feed wildlife, or made noise during jam events.

A descriptive analysis of observational data was conducted, including an examination of the frequency of visitors engaging in various behaviors and measures of central tendency for continuous variables (Jam Duration, Total Number of Vehicles Stopped, Average Visitor Distance [from wildlife], Closest Approach Distance [of visitors to wildlife], and Average # of Cars Present) (Table 5.2). Additionally, a map of

wildlife jams in the corridor and a density analysis of jams by species were generated

using ArcGIS (v10.3, ESRI, Redlands, CA, USA). Finally, a series of one-way Analysis

of Variance (ANOVA) tests were run using SPSS statistical software (v.24, IBM SPSS

Statistics, Armonk, NY, USA) to examine differences in mean values between the

variables of Jam Length, Closest Approach Distance, total number of cars that stopped

during the jam (Total Stop) and total number of people that got out of their vehicles

during the jam (Total Get Out) and the independent variables of a) species causing the

jam b) location of the jam, and c) presence of the Wildlife Brigade at the jam (denoted as

either presence or absence). Where homogeneity of variance was violated, the Welch F-

ratio is reported.

3. Results

3.1 Distribution and characteristics of
wildlife jams

Wildlife jam events were largely concentrated in the northern end of the study

site, i.e., the Moose-Wilson Corridor between Sawmill Ponds and the entrance to the

Laurance S. Rockefeller Preserve (Figures 5.2–5.3). This area provides prime habitat for

both moose and black bear. Additionally, jams involving elk, mule deer, great grey owls,

an unidentified bird species, and a weasel were recorded along the same stretch of road.

Several trends in the data emerged regarding the nature of wildlife jams in the

corridor. Moose jams were confined to the extreme northern portion of the road (Figure

5.3) and were most dense along the section of road adjacent to wetlands, colloquially

known as the "moose ponds." Bear jams were distributed from the junction with the

Laurance S. Rockefeller (LSR) Preserve on the south to Sawmill Ponds on the north. The

highest density of these jams occurred on sections of road just north of the junction with

the LSR Preserve and just south of Sawmill Ponds (Figure 5.3). Jams attributed to other

species were generally of low density and distributed throughout the full extent of the

road (Figure 5.3). Duration of wildlife jams varied from five to 120 minutes. Visitor

behaviors observed during jams, including the number of vehicles that stopped, the

number of visitors that got out of their cars, and the closest approach distance of visitors

to wildlife, also varied widely between jams (Table 5.2).

Analysis of Variance (ANOVA) examining species of animal causing the jam, the

location of the jam on the road, and the presence or absence of Wildlife Brigade

personnel at jams in relation to the variables Jam Length, Closest Approach, Total Stop,

and Total Get Out revealed that Wildlife Brigade presence did not have a significant

effect on any of the variables examined. The species involved in the jam likewise did not

have a significant effect on any of the variables examined. However, location of the jam

in the corridor was significant across all variables (Table 5.3). A two-way ANOVA was

also conducted to examine any potential interaction effects between presence of the

Wildlife Brigade and location of the jam on the road. No significant interaction effects

between these two variables and any of the dependent variables were found.

3.2 Observational data: Visitor behaviors

The vast majority of visitor behaviors observed during jams were photographing

wildlife or viewing wildlife with binoculars. Photography was observed in 40 (67%) of

60 jam events, while visitors viewing wildlife with binoculars were observed during 18

(30%) of jam events. Visitors making noise (yelling or honking the horns of cars) was

observed in nine jams (15%), while visitors taking "selfies" was observed in only two

jams. No instances of visitors feeding or attempting to feed wildlife were observed. In

general, visitors in wildlife jam events are getting much closer to wildlife than

recommended in park literature. On average, visitors are within 50 meters of bears, and

closest approach distances are within 5 meters of the wildlife.

3.3 Observational data: Wildlife behaviors

In 60 wildlife jams observed, only 14 total stress or alarm behaviors by wildlife

were observed in 10 separate jam incidents (17% of all jams). These behaviors were

observed in six different species, representing nearly all species observed during the

sampling periods. These behaviors consisted of wildlife looking up, walking away slowly

or running away. One instance of wildlife running away was a bear that was intentionally

hazed by a Wildlife Brigade member to get it out of the middle of the road for safety

purposes. This finding suggests that wildlife present in the corridor are fairly habituated

to human presence in the corridor.

4. Discussion

Visitors involved in wildlife jams on the Moose-Wilson Road, on average, are

much closer to wildlife than the safe viewing distances recommended by park literature

(National Park Service, 2017; Taylor & Knight, 2003). This is true even when Wildlife

Brigade personnel are present. This does not mean that the Brigade is not actively

working to keep visitors a safe distance from wildlife. Rather, this may be due to the

nature of the road and wildlife habituation to human traffic both within and outside of

vehicles. Several characteristics of the Moose-Wilson Corridor are potentially influencing

the extent, duration and visitor behaviors that occur during wildlife jam events in the corridor. These characteristics include the species involved in the jam, the location of the jam, and the presence of Wildlife Brigade crews.

4.1 Species involved in the jam

While the ANOVA did not reveal significant differences between species causing a jam and closest approach distance of visitors, the number of vehicles that stopped, the number of visitors that got out of their cars to view wildlife, or the variable "Jam Length," mean values for jam length (25.19 minutes on average for jams caused by bears versus 13.70 minutes on average for jams caused by other species) suggest that a functional difference may exist for jams caused by bears compared to other species— particularly, that black bears may be causing longer jams than other species. This suggests that presence of bears, perhaps more so than other species, is influencing the duration that visitors stop to view wildlife in the corridor. Black bears frequent the corridor in late summer and early fall to feed on berries (including huckleberry, hawthorn and chokecherry). Many of these berry patches are road-proximate, and bears will stay in a patch for extended periods of time while feeding, with little regard to passing vehicles and onlookers. These areas are concentrated in the northern section of the corridor as can be evidenced by the location and density of jam events caused by black bears (Figure 5.3).

The dense roadside vegetation and prime bear food source in this area make jam events especially dangerous, as visitors can unknowingly (or knowingly) get much closer to bears than the recommended 100 m when bears are feeding by the road. Additionally,

vehicles that do stop are not able to pull off of the road at all. Because the road is very

narrow, this often completely stops traffic, blocking an important transportation corridor

and creating a hazardous situation for visitors that get out of their vehicles to get a closer

look at the feeding bear(s). While not statistically significant, an additional 11–12

minutes of a jam creating the conditions described above can have potentially significant

impacts on traffic flow and visitor safety. For this very reason, park management

deployed temporary signage instituting a "no stopping zone" (see yellow "sign" icons in

Figure 5.2) in this area in the 2016 season.

4.2 Location of the jam

Sawmill Ponds is a unique location for viewing wildlife. It is the only pull-off on

the northern end of the Moose-Wilson Road with designated parking and interpretation

specifically geared at wildlife viewing. It is situated on the top of a small hill that slopes

steeply down to a pond and adjacent wetlands where moose, particularly, can often be

found grazing. This site offers visitors a prime opportunity to view moose at a safe

distance (average visitor distance for jams observed at Sawmill Ponds was 51.24 m).

Additionally, the large parking area can accommodate many vehicles. During jam events,

visitor parking often exceeds the capacity of the designated lot, and visitors create

undesignated parking spots by pulling off the road, often driving over roadside vegetation

and sometimes impeding the flow of traffic if they are not able to completely pull their

vehicle off of the road. Visitors then get out of their car and walk along the road and

within the parking area to view wildlife in the wetland below or wander down the

adjacent trail (see map in Figure 5.2) in hopes of getting a closer view. The unique nature

of Sawmill Ponds was revealed in the ANOVA analysis. Jams at Sawmill Ponds, the only designated wildlife viewing area in the corridor, are significantly longer, and have more visitors who stop and get out of their cars to view wildlife than elsewhere on the road. However, closest approach distance of visitors at Sawmill Ponds is further away than at other places along the road due to the natural topographical barrier between the parking lot and the wetland below.

Park management's identification and designation of Sawmill Ponds as a prime wildlife-viewing area that naturally keeps visitors a safe distance from wildlife is a statistically significant factor influencing visitor spatial behavior in the corridor when wildlife are present. Sawmill Ponds has become a destination—intended or unintended— for many visitors, who will pull off, especially when other vehicles are present in the parking area, to see what wildlife may be visible. Because visitors are able to safely pull off the road, park, and exit their vehicles, many more do so, and they also stay for longer, but they are also able to do so safely, and at a safe distance from the wildlife they are viewing. However, of 37 wildlife jam events observed, only seven (19%) occurred at Sawmill Ponds. The majority of wildlife jams that occur in the corridor are occurring outside of this designated viewing area, and, as such, are potentially resulting in impacts to park resources. The spatial variability of wildlife presence in the corridor, which fluctuates seasonally with habitat and food-source availability, as well as by time of day, poses a distinct challenge to park and protected area managers looking to minimize impacts to resources, including the wildlife, while also providing visitors with an avenue to safely experience wildlife in their natural habitat.

4.3 Presence of the Wildlife Brigade

The ANOVA suggests that the presence of Wildlife Brigade crews has no statistically significant effect on the duration of wildlife jams, closest approach distance of visitors during jam events, the total number of vehicles that stop, or the total number of visitors that get out of their vehicles during jams. However, this finding does not necessarily suggest that the Wildlife Brigade is ineffective. The Wildlife Brigade is not charged with reducing duration of jams. While the Brigade is responsible for maintaining a safe viewing distance between visitors and wildlife, the variable "Closest Approach" measures the single closest observation of a visitor to wildlife during a jam and is not necessarily representative of the behavior of the majority of visitors during a jam. Average visitor distance may be a better variable for comparison. However, this variable was not observed at all jams. For small jams, a sufficient number of observations was not available to calculate an average visitor distance. As such, "Closest Approach" was used for analysis in this study. While the location of the jam was significant across all dependent variables, no interaction effects between the location of the jam and presence of the Wildlife Brigade were found, suggesting that the presence of the Wildlife Brigade is not influencing visitor spatial behavior.

One of the tasks charged to Wildlife Brigade crews is education and interpretation for visitors (Grand Teton National Park Foundation, n.d.). Presence of uniformed volunteers, like the Wildlife Brigade, has been shown to decrease undesired visitor behaviors in parks and protected areas (Kidd et al., 2015). However, the relative lack of wildlife stress or alarm behaviors observed in the presence of visitors at these jam events suggests that wildlife habituation to humans may be occurring. It is also possible that

visitors are becoming habituated to viewing bears in close proximity within the corridor, or that on average, visitors are less aware that wildlife in national parks are just that—wild life that poses a potential danger to a human in close proximity. Visitor proximity to wildlife, particularly bears, even in the presence of the Wildlife Brigade, suggests that visitors, especially those who have experienced wildlife in close proximity in the corridor (or elsewhere) in the past (Smith et al., 2005), may be adopting an attitude of "careless casualness" around wildlife during these events. It is possible that other visitors, witnessing the close approach of some without negative consequences (e.g., being attacked by wildlife) also adopt attitudes of "careless casualness" when viewing wildlife, particularly bears, in the corridor.

Wildlife jam events provide unique opportunities for park management, via the use of volunteer or paid crews like the Wildlife Brigade, to interpret and possibly change attitudes of "careless casualness" towards wildlife into "respectful caution" thereby also influencing visitor spatial behaviors during jam events. However, the ability and willingness of crews to interpret to visitors may vary with the characteristics and /or severity of the jam, including the species involved, the location of the jam, and the number of visitors present. The effectiveness of interpretive efforts may also vary with the personalities of individual crew members, particularly if these individuals are volunteers. However, research suggests that personal contact with even a uniformed volunteer can minimize undesirable behaviors of visitors (Kidd et al., 2015). As such, training, emphasizing, and utilizing the interpretive and educational capacity of crews may help to influence visitor spatial behavior patterns and minimize undesired visitor behaviors, such as getting out of vehicles and approaching wildlife, during jam events.

The presence of wildlife is influencing visitor spatial behaviors in the Moose-Wilson Corridor. Further, the spatial behaviors of visitors within the corridor are also unplanned and variable. Recent research examining visitor vehicular behavior patterns in the Moose-Wilson Corridor of GRTE suggests several different visitor types exist (Kidd et al., 2018, Chapter 2). These visitor types are based on a statistical classification of observed visitor behaviors, including stopping behavior within the corridor. The most common visitor type observed in the corridor, the "Opportunistic Commuter," represented 90% of visitors observed. These visitors tended to stop at a variety of locations within the corridor, spend the least amount of time stopped, and spend the least amount of time in the corridor compared to the other visitor types (Kidd et al., 2018). In a situation where the location of wildlife may vary day to day, seasonally, and year to year with different vegetation presence or absence and climatic conditions, and when the vast majority of visitors are exhibiting variable and/or unplanned behaviors, stopping opportunistically within the corridor (e.g., when/if they see wildlife), the Wildlife Brigade or a similar roving management or interpretive presence is a potentially powerful tool to help minimize potential impacts to park resources while enabling visitors to have a safe wildlife viewing experience during these jam events.

4.4 Limitations and future research

This research was, by necessity, limited in regard to the scope and scale of the study area, as well as the amount and type of data collected. Future research should examine visitor behaviors and wildlife jam characteristics for the duration of peak wildlife viewing periods at multiple sites throughout any given park and protected area,

and within multiple parks and protected areas in order to examine differences and similarities in visitor behaviors, jam characteristics, and spatial distribution of jams. It is likely that wildlife jam characteristics will vary by species present both within and across parks, as will management presence and actions taken during jam events. As such, it is likely that visitor behaviors will differ from park to park. A spatial examination of wildlife jams in relation to vegetation or habitat types could reveal patterns in wildlife presence relative to vegetation or habitat that may be informative to the management of park and protected area resources and visitor-wildlife interactions. Specifically, this information may enable managers to proactively identify and manage locations where wildlife jams are likely to occur.

The use of visitor surveys in conjunction with spatial data on jam characteristics would also be helpful in order to examine potential relationships between visitor behaviors and visitor characteristics, including knowledge of appropriate wildlife viewing behaviors, and park recommendations for safe viewing distances. Surveys could also provide information about visitor motivations and expectations relative to viewing wildlife, and visitor self-reports of behavior. This information is critical if managers hope to change or inform visitor behavior, for example via minimum-impact messaging.

Finally, mapping of road-proximate impacts to soil and vegetation relative to locations of wildlife jams would provide insight into the extent of ecological impact to park resources, including soils and vegetation, which may be resulting from wildlife jam events. If visitor behaviors are resulting in impacts to park resources, particularly to preferred wildlife habitat or food sources, more aggressive management action may be warranted.

5. Conclusions

Managing and understanding visitor spatial behaviors are critical to successfully managing impacts of wildlife resulting from non-consumptive recreation, such as wildlife viewing and photography. Data collected in this research confirms that presence of wildlife is influencing visitor spatial behaviors, and in some cases causing wildlife jams, in the Moose-Wilson Corridor (including if and where visitors stop along the roadway as well as how long they stop). Additionally, certain characteristics of the wildlife jams (such as species) and location within the corridor (at Sawmill Ponds or elsewhere) are influencing visitor behaviors, including how long visitors stop and how close they get to wildlife, during these jam events. As such, understanding the distribution, frequency, and density of the jam events may provide insight not only into areas of existing human-wildlife conflict, but also may indicate places proximate to roadways where soil and vegetation may be damaged due to vehicles pulling of the road and/or visitors creating social (undesignated) trails in order to get a better view of wildlife. Ultimately, understanding visitor behavior during wildlife jam events, and how wildlife presence may be influencing visitor spatial behaviors in parks and protected areas will provide resource managers with valuable information that may help them better utilize existing management strategies and resources (e.g., the Wildlife Brigade) to minimize impacts to wildlife and other park resources while maximizing the visitor experience during wildlife jam events.

6. Acknowledgements

7. References

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Table 5.1. Assessment variables.

Descriptive Variables	Data Collection Method
Jam Location	Juno GPS
Jam Length	Juno GPS
Species	Visual Observation
Avg Number of Cars	Visual Count
Max Car Estimate	Visual Count
Distance of Wildlife to Road	Laser Range Finder
Closest Approach Distance	Laser Range Finder
Avg Approach Distance	Laser Range Finder
Behavioral Variables	
Stopped Vehicle	Visual Observation/Count
Got out of Vehicle	Visual Observation/Count
Took Picture	Visual Observation/Count
Took Selfie	Visual Observation/Count
Approached Animal	Visual Observation/Count
Fed Animal	Visual Observation/Count
Made Noise	Visual Observation/Count

Table 5.2. Summary of selected descriptive results from wildlife jam observations.

Species	Variable	Sawmill*/Brigade Mean (SD)	Max	Min	Road/Brigade Mean (SD)	Max	Min	Road/No Brigade Mean (SD)	Max	Min
Black Bear	Jam Duration (min)	48.75 (41.59)	120	15	17.73 (18.99)	75	5	26.25 (21.61)	60	5
	Total Stopped[1]	67.75 (58.33)	168	81	22.67 (14.58)	52	6	26.00 (15.79)	47	6
	Total Get Out[2]	193.75 (171.31)	490	81	33.8 (34.72)	121	0	30.00 (21.19)	59	0
	Average Visitor Distance (m)	47.07 (7.21)	53.46	37	43.90 (32.56)	109	26.94	13.13 (3.22)	15.7	8.58
	Closest Approach Distance (m)	20.67 (2.49)	24	18	16.24 (7.98)	25	3	20.50 (27.47)	68	2
	Average # of Cars Present	17.82 (4.10)	22.67	13	9.84 (2.15)	12.5	7	9.5 (1.5)	11	8
Moose	Jam Duration (min)	***	60	---	7.50 (2.50)	10	5	5.00 (0.00)	5	5
	Total Stopped[1]	***	119	---	15.50 (7.50)	23	8	13.50 (5.41)	22	7
	Total Get Out[2]	***	271	---	10.50 (10.50)	21	0	5.75 (8.26)	20	0
	Average Visitor Distance (m)	***	56.1	---	***	10	---	***	20	---
	Closest Approach Distance (m)	***	45	---	***	10	---	20.3 (0.30)	20.6	20
	Average # of Cars Present	***	28.5	---	***	***	***	***	***	***
Other	Jam Duration (min)	***	***	***	***	***	***	8.67 (8.75)	30	5
	Total Stopped[1]	***	***	***	***	***	***	5.29 (4.62)	15	1
	Total Get Out[2]	***	***	***	***	***	***	3.71 (7.09)	21	0
	Average Visitor Distance (m)	***	***	***	***	***	***	***	37	---

Closest Approach Distance (m)	***	***	***	***	***	***	14.94 (9.44)	25.7	0
Average # of Cars Present	***	***	***	***	***	***	***	***	***
N	6			13			17		

*Data presented for presence of Wildlife Brigade only. One Moose jam occurred when no Brigade was present at Sawmill. Jam Duration=5 minutes, Total Get Out =77 and Closest Approach Distance=55m.

ᵗTotal Stopped refers to the total number of vehicles that stopped during the jam event.

ᵗTotal Get Out refers to the total number of people that got out of their vehicles during the jam event.

*** Indicates that no data is available for that variable.

--- Indicates that only one observation exists for that variable.

Table 5.3. Analysis of Variance for jams at Sawmill Ponds vs. other locations on the Moose-Wilson Road.

	ANOVA Results		
Variables	*Mean*	F	p
Jam at Sawmill			
Jam Length (min)	43.57	8.138	.006**
Closest Approach (m)	35.5	10.25	.003**
Total Stop	81.17	6.967*	.044**
Total Get Out	186.71	8.359*	.027**
Jam on road			
Jam Length (min)	17.00		
Closest Approach (m)	15.72		
Total Stop	19.65		
Total Get Out	21.20		

*Welch F-ratio

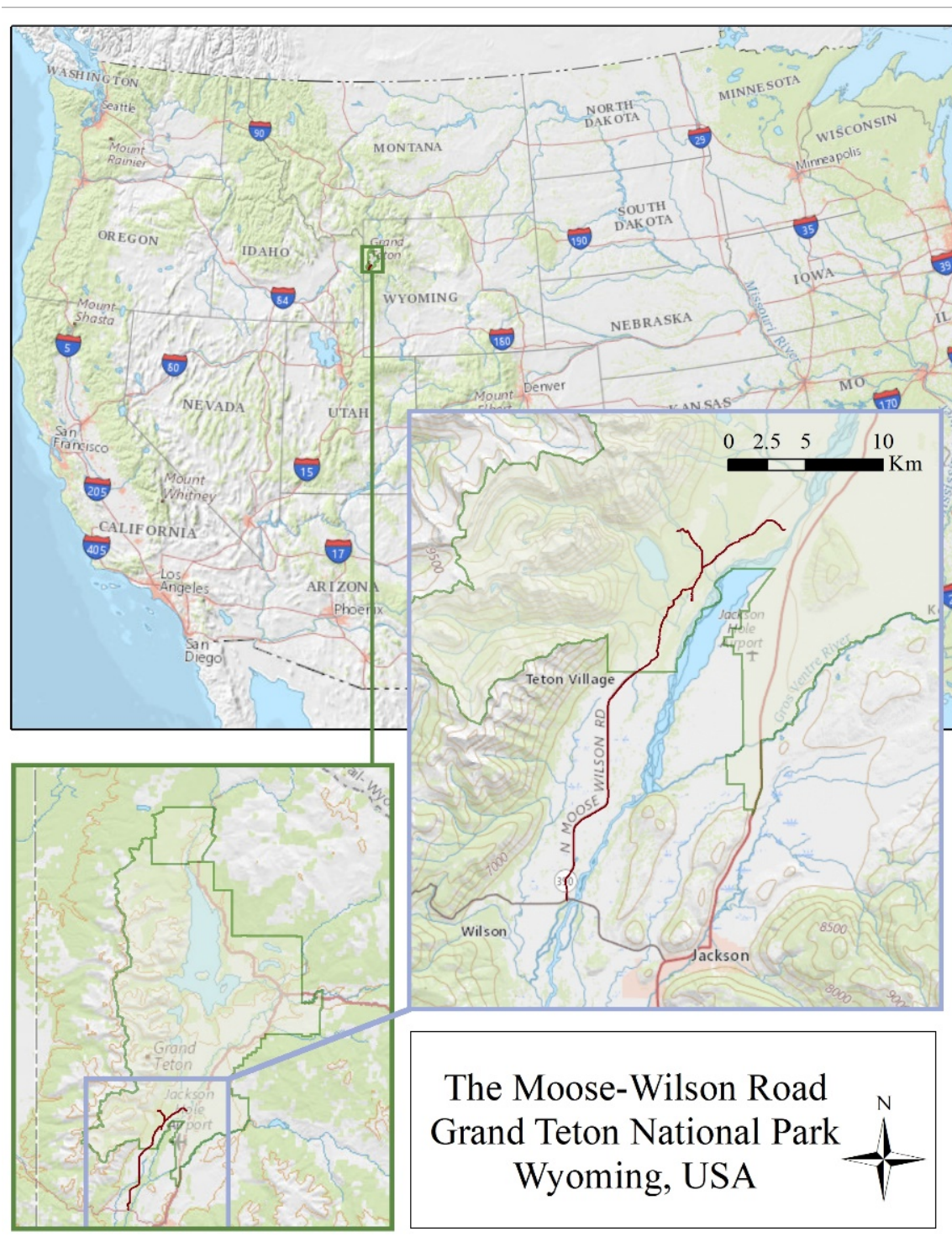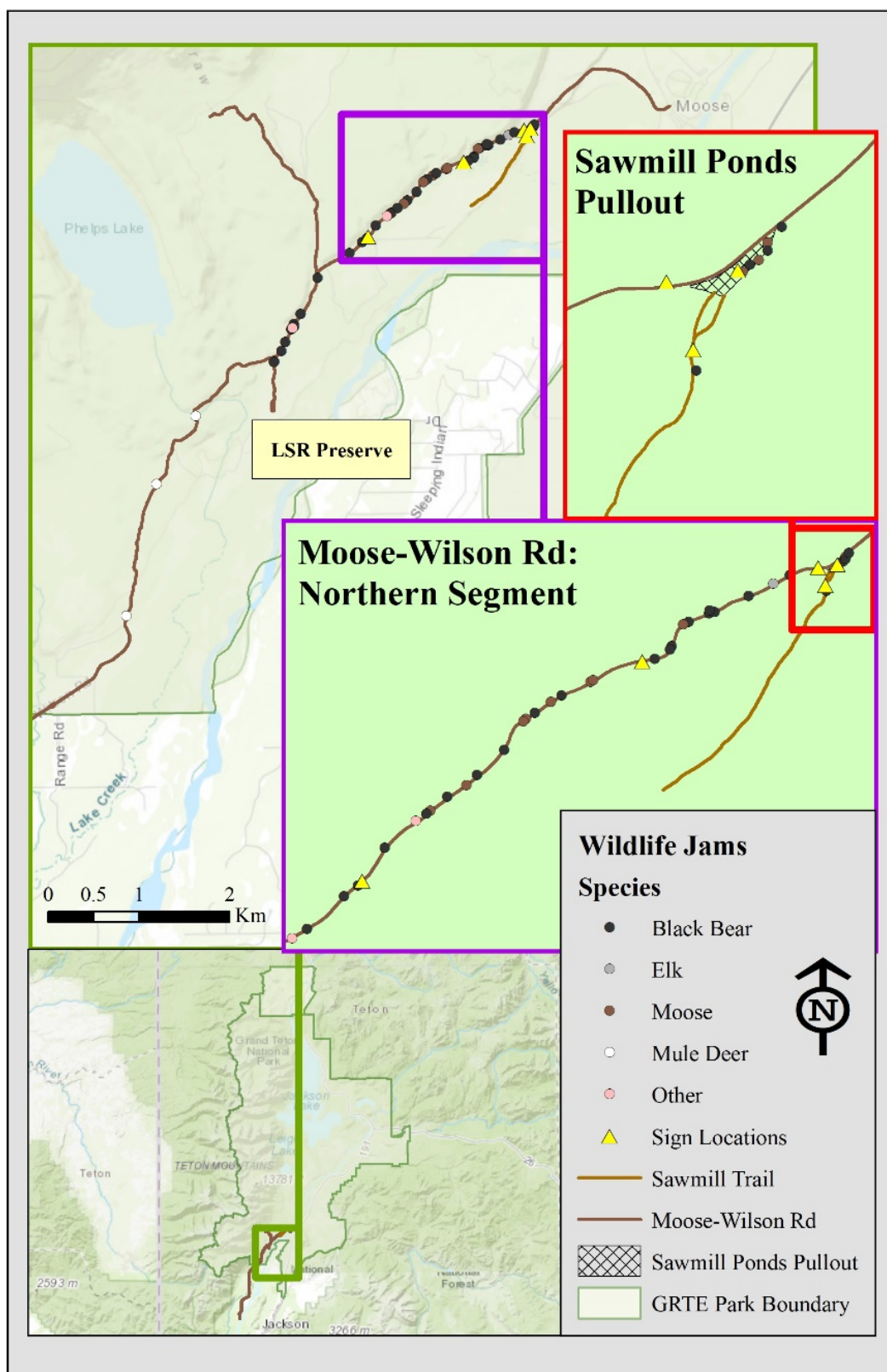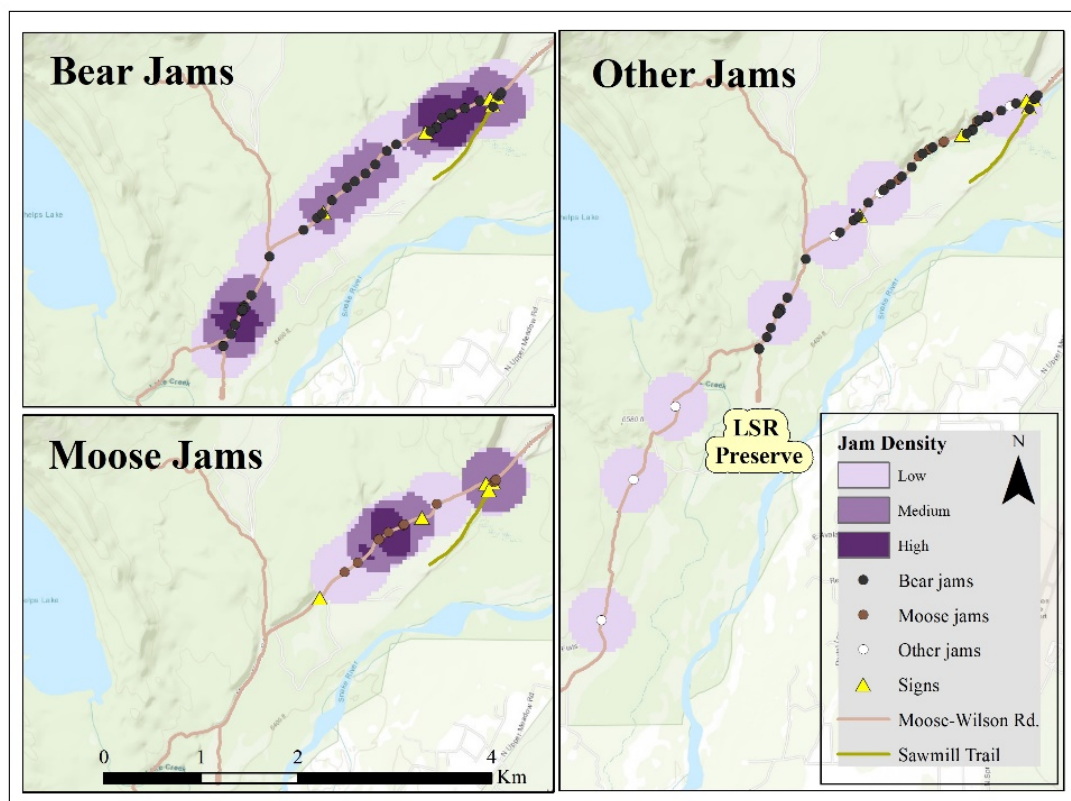** Statistically significant at p < .05

Figure 5.1. The Moose-Wilson Road within Grand Teton National Park.

Figure 5.2. Distribution of wildlife jams in the Moose-Wilson Corridor.

Figure 5.3. Density of wildlife jams by species in the Moose-Wilson Corridor.

CHAPTER 6

CONCLUSIONS

1. Introduction

Existing frameworks for understanding and managing visitor spatial behaviors and associated impacts to natural resources in parks and protected areas assume that visitor behavior is largely destination-driven and confined to known nodes and linkages (visitor destinations and trails connecting these destinations; Manning, 1979) and that visitor behavior is planned, or intentional (Ajzen, 1991). While this may be true, much visitor behavior is unplanned, and these behaviors appear to be influenced by something other than behavioral intentions or destinations. Further, these unplanned visitor behaviors may be disproportionately resulting in impacts to park and protected area resources as they draw visitors away from designated trails, campsites, and viewpoints. The four papers presented in this dissertation are an effort toward understanding what factors, aside from intended visitor destinations, may be influencing visitor spatial behavior in parks and protected areas that result in impacts to park and protected area resources. A better understanding of the factors influencing visitor spatial behaviors may enable park and protected area managers to shift management practices away from reactive efforts to contain impacts that have already occurred, toward predicting and preventing future impacts based on patterns in visitor behavior.

2. The Influence of Resource Features on
Visitor Spatial Behavior

Both Chapter 2 and Chapter 5 examined the influence of park and protected area resources on visitor spatial behavior patterns, using GPS-based technology to observe and document these spatial patterns. In Chapter 2, a statistical classification procedure was applied to visitor spatial data derived from vehicular GPS tracks, an approach rarely taken with spatial data. The application of an exploratory factor analysis of visitor behaviors resulted in the ability to classify visitors into meaningful types based on their behavior patterns. The vast majority of visitors fell into the "Opportunistic Commuter" category. The behavior of these visitors was characterized by multiple, short stops along the study corridor—the area adjacent to the Moose-Wilson Road in Grand Teton National Park. The fewest number of visitors fell into the "Hiker" category, whose behavior was characterized by long stops at known hiking trailheads. This suggests that, in this corridor, most visitor behavior is not destination-driven in the traditional node-and-linkage sense. The corridor is well-known for its rustic, scenic nature, and for wildlife viewing opportunities along and proximate to the roadway (Monz, D'Antonio, & Heaslip, 2014). These resource-related opportunities appear to be the strongest factor influencing visitor spatial behavior patterns, as well as potential impacts to park resources, within the corridor.

Chapter 5 specifically examined the influence of wildlife, and wildlife jam events on visitor spatial behaviors within the same corridor. Several characteristics of the corridor itself appear to be influencing visitor behaviors during wildlife jam events. Wildlife jams caused by bears tend to last longer than jams caused by other species and

are concentrated in the northern end of the corridor. Visitors are stopping their vehicles and often, getting out of their vehicles as a result of the presence of wildlife on or near the roadway. A designated pull-off for wildlife viewing on the northern end of the road often becomes an unplanned stop for visitors when wildlife are present, and wildlife jams are significantly longer in duration and experience greater numbers of visitors who stop their vehicles and get out of their vehicles to view wildlife at this location than elsewhere on the road. However, the majority of wildlife jam events (81%) did not occur at this designated pull-off, highlighting the spatially variable nature of the jam events. Finally, presence of the Wildlife Brigade, a volunteer crew tasked with managing visitor and wildlife safety and maintaining traffic flow during wildlife jam events, do not appear to be influencing visitor spatial behavior during wildlife jam events. Rather, it is presence (or absence) of a park resource—in this case wildlife—that is influencing visitor stopping behavior along the roadway.

**3. The Influence of Minimum-Impact
Education on Visitor Spatial Behavior**

While resource features other than traditional recreation destinations such as lakes, mountain summits, campsites, and scenic viewpoints are important factors influencing visitor spatial behavior patterns, results from Chapter 3 suggest that minimum-impact education efforts may also effectively influence visitor spatial behavior patterns, particularly off-trail travel. However, not all minimum-impact education efforts are created equal. Using three different experimental treatments, Chapter 3 demonstrated that signage bearing two different minimum-impact messages was not effective at reducing visitor off-trail travel as measured by mean Euclidean distance of visitor GPS

tracking points from designated trails. However, a message delivered by a personal

contact with a uniformed volunteer during the visitors' hiking experience resulted in

reducing visitor off-trail travel, though it is unclear whether the message or the presence

of the uniformed volunteer (or a combination) that influenced this change in behavior.

The personal contact treatment also reduced the total areal extent of visitor travel,

decreasing the potential area of impacts to soils, vegetation, and the visitor experience

that may result from visitor off-trail travel. Minimum-impact educational messages

delivered in person during the recreation experience do appear to influence visitor spatial

behavior. However, it is unclear whether the message delivered by personal contact will

result in long-term behavioral change (i.e., as a result of the personal contact visitors will

be more likely to continue minimizing off-trail behaviors in the future).

**4. The Influence of Visitor Characteristics
on Visitor Spatial Behavior**

Chapter 4 investigated the influence of visitor personal characteristics on visitor

spatial behavior patterns—particularly off-trail travel—in a park and protected area

setting. Differences in mean Euclidean difference travelled off-trail were compared in

relation to visitor characteristics of Leave No Trace (LNT) familiarity, education level,

and activity expertise. Visitors were rather homogenous in all three characteristics,

reporting high levels of familiarity with LNT practices, high levels of education (an

average of a Bachelor's Degree or higher), and moderate to high levels of activity

expertise. As such, visitor characteristics were not identified as a statistically significant

factor influencing spatial behavior patterns. Visitor-stated reasons for travelling off-trail

reveal three main categories influencing visitor off-trail travel: practical/functional

reasons (e.g., passing another visitor, taking a break, finding a secluded spot to use the bathroom), opportunities to explore/photograph the environment, and because visitors lost the trail. These categories suggest that visitor off-trail travel is largely unplanned and opportunistic in nature. A comparison of visitor self-reported and observed off-trail behaviors suggests that visitors are able to accurately (and honestly) identify their own off-trail behavior. While park and protected area managers and researchers may identify off-trail travel as a negative behavior (as it results in impacts to park and protected area resources), no social norms appear to be attached to off-trail travel among visitors such that they feel the need to dishonestly represent their spatial behavior patterns on a survey.

5. An Adapted Framework for Understanding Visitor Spatial Behavior

The Theory of Planned Behavior (TPB, Figure 6.1) informs a large portion of human dimensions research (Manfredo, 2008; Miller, 2017), and is a commonly cited theory utilized in studies of environmental attitudes and how those attitudes influence behavior. TPB has also been adapted and applied specifically to messaging intended to change visitor behavior in parks and protected areas (Hughes, Ham, & Brown; 2009; Reigner & Lawson, 2009). While messaging informed by the TPB has been proven effective at reducing depreciative behaviors in parks and protected areas, such as theft (Widner & Roggenbuck, 2003), which carry with them strong injunctive norms (i.e., most people believe that it is wrong to steal), it is unclear whether messaging informed by TPB is as effective on behaviors without strong injunctive norms attached, or which may vary by location, such as off-trail travel and safe distances for wildlife viewing.

TPB, as its name implies, endeavors to explain planned visitor behaviors. However, unplanned visitor behaviors, including stops to view wildlife, wandering off-trail to get a better look at a blooming wildflower or a particularly scenic vista, or taking care of personal needs such as finding a secluded spot to use the bathroom, result in impacts to park and protected area resources. Because these behaviors are more opportunistic in nature, TPB may not be effective at explaining, predicting, or changing these behaviors. Visitor spatial behavior in parks and protected areas is complex and often, multi-faceted. It is influenced by more than just nodes and linkages, visitor beliefs, attitudes, and motivations. The body of research that constitutes this dissertation suggests that visitor spatial behaviors, observed using direct observation techniques and GPS-based tracking of visitors, are influenced by several local factors. Results suggest that visitor activity expertise and knowledge, two visitor characteristics often associated with influencing visitor spatial behavior may not be influencing visitor behavior as much as external, resource-related factors, including terrain, rare wildlife/geographic/vegetation features, and resource conditions, as well as social and personal factors (see Figure 6.2), which often vary from location to location. These factors may interrupt intended behaviors driven by attitudes and beliefs and may help to explain why previous attempts at understanding visitor behavior through the framework of the TPB (Figure 6.1) only explain up to 38% of actual visitor behaviors (Miller 2017; Sutton, 1998).

6. Management Implications

Destinations are not the only factors influencing visitor spatial behavior in parks and protected areas. However, existing frameworks for understanding and managing

impacts to park and protected area resources, namely the node-and-linkage framework (Manning, 1979) attempt to generalize visitor spatial behavior patterns to desired visitor destinations and pathways to those destinations. Unfortunately, visitor spatial behaviors in parks and protected areas are not that straightforward and managing parks and protected areas as such is not conducive to minimizing visitor impacts to park and protected area resources or the visitor experience. This becomes especially prudent as visitor use continues to increase in parks and protected areas worldwide (Balmford et al., 2015), and visitors seek new areas to recreate and/or a more unconfined visitor experience.

Visitor spatial behaviors in parks and protected areas, while initially influenced by choice of destination, are also influenced by natural resource features including vegetation (e.g., blooming wildflowers, presence of edible berries), wildlife presence (or absence), condition of the resource (e.g., muddy, damaged, or obstructed trails), terrain, weather, the relative "scarcity" of the event (i.e., how likely is it that the visitor will have the chance to experience the resource or event ever again), as well as behavior and/or presence of other visitors. Unlike destinations, which are known locations, these natural resource features are often temporary or seasonal in nature, or, as in the case of wildlife, mobile. These characteristics make management of visitor behavior influenced by resource-related factors much more challenging, as they are often opportunistic in nature (i.e., unplanned) and resultant impacts can be widespread, variable, and difficult to predict. The ability to identify what resource-related features may be influencing visitor spatial behavior in any given area is an important first step toward developing a strategy

for effectively managing, and preventing, resource impacts that result from these behaviors.

Personal contact between park staff and visitors shows promise as a means of educating visitors and influencing visitor spatial behavior, including some unplanned behaviors (Kidd et al., 2015). However, this management technique is not practical on a park-wide scale. In ACAD, "Summit Stewards" volunteer to help protect fragile, mountain summit environments within the park, and GRTE employs the "Wildlife Brigade" to manage human-wildlife interactions proximate to roadways. These volunteer crews provide unique interpretive opportunities for park management to teach visitors appropriate behaviors, ask visitors to model these behaviors for others (ask them to become a steward) and create a culture of normative behavior in the park—"this is how we do it here." However, managers should use caution in placing an overreliance on TPB in these management efforts. While TPB can be very effective at changing behaviors for which strong norms, and therefore beliefs exist (such as theft), many visitor spatial behaviors that result in resource impacts in parks and protected areas, such as off-trail travel, are nuanced, and lack injunctive norms that label them as "negative" on a societal (or even a park-wide) level. In addition, the "unplanned" nature of these behaviors make them inappropriate to ground in theory aimed at changing planned behaviors by changing beliefs about those behaviors. Most visitors do not have "beliefs" per se about off-trail travel, especially when they are trying to make sure their personal needs (like using the bathroom) are met.

7. Future Directions

While research presented in Chapters 2, 3, and 5 suggests that resource features other than destinations are influencing visitor spatial behaviors in parks and protected areas, these results are limited to two visitor use areas within two U.S. national parks. Additional research is needed both at larger scales (i.e., within entire parks, or regions) and within a variety of parks and protected areas both within the U.S. and globally (e.g., national park, national forest, state park, etc.) to ascertain whether protected area resource features are influencing visitor behavior on a broad scale.

The scale of this body of research may have also affected the findings from Chapter 4 that visitor characteristics do not influence visitor spatial behaviors. The visitors studied for this analysis were very similar to one another in terms of their education level and activity expertise. An examination of visitors engaging in the same activity (e.g., hiking) at multiple visitor use areas within a park, or within multiple, adjacent recreation areas (e.g., a national park and a national forest, or multiple national parks within the same geographic region) may be more appropriate for examining the potential influence of differences in visitor characteristics on spatial behavior patterns such as off-trail travel.

Further, the survey instrument utilized in ACAD did not assess visitor motivations for recreation. Both early and recent research within the field suggests that visitor motivations may influence spatial behavior patterns of visitors to parks and protected areas (Brunson & Shelby, 1990; Heberlein & Dunwiddie, 1979; Newton, 2016). Future work that examines visitor spatial behavior in conjunction with data collected from visitors via survey instruments should include motivation scales. Information about

differences in spatial behavior due to visitor motivations may be of particular interest to

park and protected area managers concerned with preserving or protecting specific types

of visitor experiences. For example, if visitors motivated by the desire to experience

solitude are exhibiting spatial behavior patterns that are different than visitors not

interested in experiencing solitude (i.e., visitors with different motivations are recreating

in different locations or at different times), managers can use this information to manage

these areas where visitors are going to experience solitude so as to preserve that type of

experience for future visitors. This may take the form of educating visitors about

locations where they may experience solitude, or increasing protections (via LNT

education, use limits or restrictions, or other appropriate management options).

Paired GPS-based tracking and surveying of visitors to parks and protected areas

provides a wealth of spatial data on visitor movements as well as information about

visitor characteristics, motivations, preferences, and visitor thresholds and tolerances to

various resource conditions, including the conditions of trails, visitor recreation sites,

soundscapes and dark skies, as well as social conditions, such as visitor perceptions of

crowding on trails and at visitor use sites. Researchers have by no means exhausted the

potential of these data sets in regard to novel analysis of paired survey and spatial data.

Use of this methodology at a broader scale, including within parks and protected areas

globally, may result in a greater understanding of whether generalizable patterns of

recreation behavior exist at the national and even global level.

While research presented in Chapter 3 suggests that a personal contact delivering

a minimum-impact educational message did appear to influence visitor spatial behavior

patterns (in this case, visitor off-trail travel), additional research is needed to understand

the ability of these volunteers and their educational efforts to change visitor behavior over the long-term. In other words, do these educational efforts that take place during a visitor's recreation experience give visitors the tools and motivation to engage in resource-protecting behaviors such as staying on trails over time and at multiple different locations? Long-term behavior change may prove challenging due to the nature of the resource factors and experience opportunities that appear to be influencing spatial behavior, in that they are often opportunistic and need-driven.

The methodologies employed in this dissertation have helped to shed light into possible resource, social, and personal factors influencing visitor spatial behavior in parks and protected areas. Understanding which of these factors are actually influencing visitor behavior, and to what extent, within different parks and protected areas can help managers tailor solutions to the unique management situations they face. Patterns or similarities that emerge between different parks and protected areas may inform broad-scale policy or management practices designed to address similarities in visitor spatial behaviors and associated impacts. Further, the conceptual framework provided in Figure 6.2 is an effort toward providing a tool to help managers identify what park resources may be influencing visitor spatial behavior patterns. The framework suggests some specific, measurable variables that could be used in the future as inputs in statistical analyses (e.g., confirmatory factor analysis/structural equation modelling) to empirically examine which factors are influencing visitor spatial behavior in parks and protected areas. An analysis of this sort would help researchers and managers to predict, inventory, and map areas susceptible to resource damage given the resource-based factors present in

the area so as to proactively manage visitor spatial behavior before it results in impacts to park and protected area resources.

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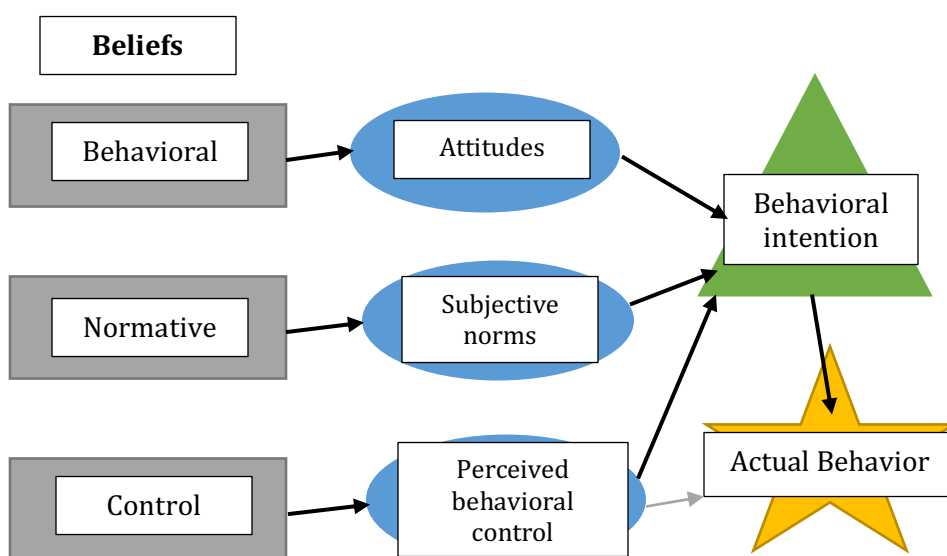Forest National Park. *Journal of Interpretation Research, 5*. 1–18.

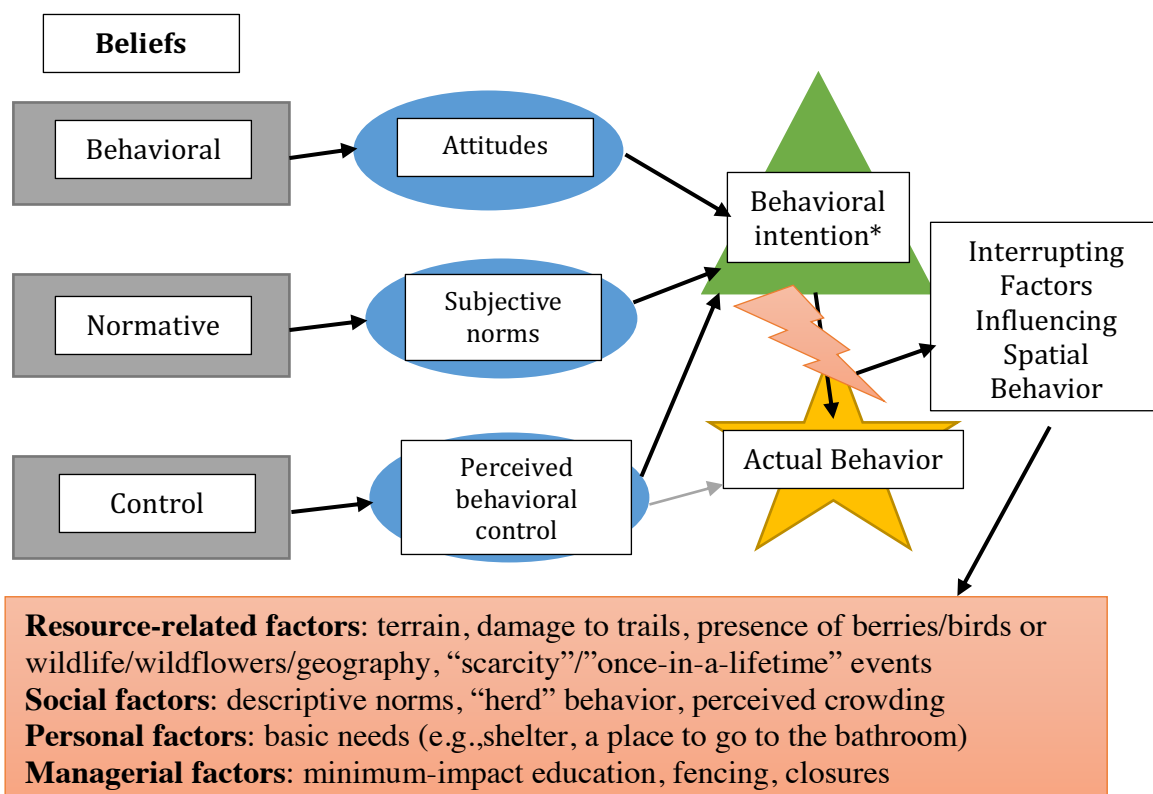Figure 6.1. Theory of Planned Behavior (Ajzen, 1991; Fishbein & Ajzen, 2011).

Figure 6.2. Factors influencing actual visitor spatial behavior. *Represents traditional node (destination) – driven behavior.

APPENDICES

APPENDIX A:

SARGENT MOUNTAIN VISITOR SURVEY

Acadia National Park
Visitor Survey
2013

Sargent Mountain

ID_____   Date _____

Admin._____   Trt._____

Start_____ End_____ GPS_____

1.   **How many people are in the group you are hiking with today?**

_____ people

2.   **Are there any children 14 or under in your group, and if so how many?**

Yes there are _____ children age 14 or under in our hiking group today.

No, there are no children age 14 or under in our hiking group today.

Hiking Sargent Mountain

The following section of this survey asks *questions about hiking* up to and back down from summit of Sargent Mountain. Please respond to the questions to the best of your ability for:

a)   yourself

b) other members of your hiking group
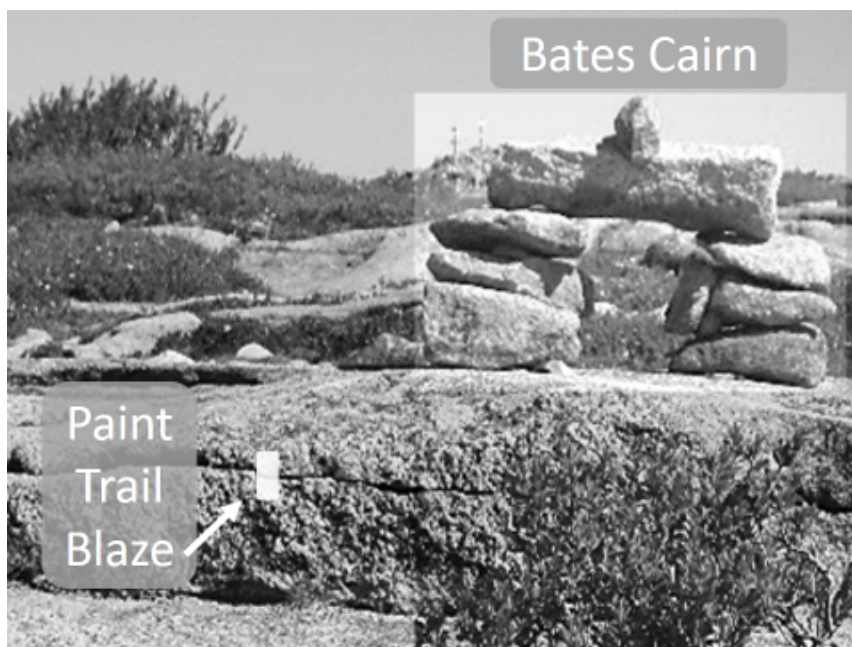
Bates cairns and paint trail blazes mark Acadia trails.

3. **Did you and/or other member(s) of your group hike off the trails marked by Bates cairns and blue paint blazes since having been given a GPS today? If yes, please select all the reasons why you and/or other member(s) may have hiked off the marked trails.** (*select all that apply*)

You	Other members of my hiking group
No	**No**
Yes	**Yes**
To get a better view	*To get a better view*
To take a picture	*To take a picture*
To explore or play	*To explore or play*
To pass other hikers	*To pass other hikers*
To get privacy off trail	*To get privacy off trail*
To take a break or picnic	*To take a break or picnic*
To view plants or animals	*To view plants or animals*
To take a shortcut	*To take a shortcut*
Lost the trail	*Lost the trail*
Other (please specify)	*Other (please specify)*

4. **If you and/or other member(s) of your group hiked off the marked trails, on what type of surface did you hike?** (*select all that apply*)

You	Other members of my hiking group
Rock or Ledge	Rock or Ledge
Gravel or Soil	Gravel or Soil
Vegetation	Vegetation

5. **Did you deliberately remain on trails marked by Bates cairns and blue paint blazes since having been given a GPS to carry today?**

   Yes, I deliberately hiked only on marked trails.

   No, I did not deliberately remain on marked trials while hiking.
   (*skip to Question 7)*

6. **Why did you purposefully remain on marked trails since having been given a GPS to carry today?** (*select all that apply*)

   Because it is easier and/or more comfortable than hiking off trail.

   Because it is safer than hiking off trail.

   Because it affords better views than hiking off trail.

   Because others hikers remained on trails.

   Because it is park policy for hikers to remain on marked trails.

   Because it minimizes impacts on plants and soils from hiking.

   Other
   (please specify):_____

Please continue to the next page.

The Summit of Sargent Mountain

The following section of this survey asks questions about the *time you spent at the summit* of Sargent Mountain. Please respond to the questions to the best of your ability for:

a) yourself

b) other members of your hiking group

A large summit cairn marks the summit area of Sargent Mountain.

Please continue to the next page.

7. **Did you and/or any other member(s) of your hiking group wander away from the large summit cairn while visiting the Summit of Sargent Mountain today? If yes, please select all the reasons why you and/or other member(s) of your group may have wandered away from the summit cairn.** (*select all that apply*)

You	Other members of my hiking group
No	**No**
Yes	**Yes**
To get a better view	*To get a better view*
To take a picture	*To take a picture*
To explore or play	*To explore or play*
To get away from crowds	*To pass other hikers*
To get privacy off trail	*To get privacy off trail*
To take a break or picnic	*To take a break or picnic*
To view plants or animals	*To view plants or animals*
Other (please specify)	*Other (please specify)*

8. **If you and/or other member(s) of your hiking group wandered away from the summit cairn area, on what type of surface did you hike, stand or rest?** (*select all that apply*)

You	Other members of my hiking group
Rock or Ledge	Rock or Ledge
Gravel or Soil	Gravel or Soil
Vegetation	Vegetation

9. Did you purposefully remain close to the summit cairn while at the top of Sargent Mountain today?

       Yes, I purposefully remained close to the summit cairn.

       No, I did not purposefully remain close to the summit cairn.
       (*skip to Question 10)*

10. Why did you purposefully remain close to the summit cairn of Sargent Mountain?
(*select all that apply*)

       Because it is easier and/or more comfortable than wandering away from the cairn.

       Because it is safer than wandering away from the cairn.

       Because it affords better views than places far from the cairn.

       Because other visitors remained close to summit cairns.

       Because it is park policy for hikers to remain close to summit cairns.

       Because it minimizes impacts to plants and soils from wandering away from
       the summit cairn.

       Other
       (please specify):_____

Sargent Mountain Experience

The following section of this survey asks general questions about your ***experience while visiting
Sargent Mountain*** today.

**11. Did you notice any damage caused by hikers to soils or vegetation either on the trails or
at the summit of Sargent Mountain? If you did notice hiker caused damage, please rate
its severity.** (respond for both trails and the summit)

Trails on Sargent Mountain	Summit of Sargent Mountain
Yes	**Yes**
Minor	*Minor*
Moderate	*Moderate*
Severe	*Severe*

No	No

12. Did you notice any signs (other than the directional sign at the summit cairn) while hiking on Sargent Mountain today?

Yes, I noticed a sign other than the summit cairn's directional sign.

No, I did not notice any other signs. (*skip to Question 13)*

13. Please briefly describe what the sign(s) said.

_____

_____

_____

14. Did any National Park Service official talk to you along the trails or at the summit of Sargent Mountain today?

Yes, a National Park Service official spoke with me on the trails or at the summit of Sargent Mountain.

No, a National Park Service official did not speak with me on the trails or at the summit of Sargent Mountain. (*skip to Question 15)*

15. Briefly describe what the NPS official discussed with you.

_____

_____

_____

Please continue to the next page.

Mountain Summit Photographs

The survey attendant has a series of six photographs of a mountain summit like Sargent Mountain to show you for the next section of the survey. Please notify the survey attendant that you are ready to view the photographs.

16. How acceptable do you find the condition of soils and vegetation for mountain summits depicted in each photograph? Please rate each photograph based on the conditions shown. A rating of -4 means the condition of soil and vegetation is very unacceptable, and a rating of +4 means the condition of soil and vegetation is very acceptable. (*circle one number for each photograph*)

	Very Unacceptable								Very Acceptable
Photo 1…..	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 2…..	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 3…..	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 4…..	-4	-3	-2	-1	0	+1	+2	+3	+4
Photo 5…..	-4	-3	-2	-1	0	+1	+2	+3	+4

17. Which photograph is most similar to the condition of soil and vegetation you *typically saw on Sargent Mountain today*?

Photograph # _____

18. Which photograph shows the condition of soil and vegetation you *expected* to see on Sargent Mountain today?

Photograph # _____

19. Which photograph shows the condition of soil and vegetation you would *prefer* to have seen on Sargent Mountain today?

Photograph # _____

20. Which photograph shows the condition of soil and vegetation you think the *National Park Service should maintain on Sargent Mountain*?

Photograph # _____

Mountain Summit Management

Park and forest administrators like the National Park Service have a number of things they can do to *manage mountain summit recreation areas*. For the following two questions, please share your views on mountain summit recreation management.

21. Why do you think park and forest managers would want to manage hiking on mountain summits like Sargent Mountain?

_____

_____

_____

22. How acceptable is each of the following management practices for a mountain summit recreation areas like Sargent Mountain? Please rate each practice. A rating of -4 means the practice is very unacceptable, and a rating of +4 means the practice is very acceptable.

Management Practices	Very Unacceptable								Very Acceptable
Signs that help you enjoy your hike more.	-4	-3	-2	-1	0	+1	+2	+3	+4
Signs that help you have a safer hike.	-4	-3	-2	-1	0	+1	+2	+3	+4
Signs that encourage you to minimize the damage hiking causes to soils and vegetation.	-4	-3	-2	-1	0	+1	+2	+3	+4
Signs that explain park policies and rules.	-4	-3	-2	-1	0	+1	+2	+3	+4
Signs that describe the punishments for violating park policies and rules.	-4	-3	-2	-1	0	+1	+2	+3	+4
Park volunteers who have an informal conversation with you about trails and the impacts of hiking.	-4	-3	-2	-1	0	+1	+2	+3	+4
Uniformed ranger who has an informal conversation with you about trails and the impacts of hiking.	-4	-3	-2	-1	0	+1	+2	+3	+4
Uniformed rangers enforcing park rules and policies along park trails and on mountain summits.	-4	-3	-2	-1	0	+1	+2	+3	+4
Uniformed rangers at mountain summits to enforce park policies and rules.	-4	-3	-2	-1	0	+1	+2	+3	+4

About You

This final section of the survey ask questions about your experience and who you are. This survey is *anonymous* and *confidential*.

23. How often do you take hikes like the one you took on Sargent Mountain today?

Once a month or more frequently

Once every couple of months

Once a year

Once every couple of years or less frequently

24. How familiar are you with Leave No Trace principles and practices?

Not at all familiar

Limited familiarity

Somewhat familiar

Very familiar

25. Do you live in the United States?

Yes (What is your zip code? _____)

No (In what country do you live? _____)

26. What year where you born?

Year born: _____

27. What is your gender?

Female

Male

28. What is the highest level of formal education you have completed?

Less than high school

High school graduate

Some college

Bachelor's degree

Some graduate school

Graduate degree

29. Are you Hispanic or Latino?

Yes

No

30. With what race(s) do you personally identify? (*select all that apply*)

American Indian or Alaska Native

Asian

Black or African American

Native Hawaiian or Pacific Islander

White or Caucasian

Thank you for your help with this important survey!
Your responses are ***anonymous*** and ***confidential***.

Please return your completed questionnaire to the survey administrator.

APPENDIX B:

PERMISSION TO REPRINT LETTERS (JOURNALS)

Abigail Sisneros-Kidd <abigail.kidd@aggiemail.usu.edu>

JPRA, Permission to use published article as part of dissertation
1 message

Jonas Levêque <jonas.leveque@gmail.com>   Mon, Mar 5, 2018 at 11:08 AM
To: abigail.kidd@aggiemail.usu.edu
Cc: Robert Burns <Robert.Burns@mail.wvu.edu>

Dear Abigail Sisneros-Kidd,

After concertation with Sagamore and Dr. Burns, your request has been approved to use your published article as part of your dissertation.

Good luck on your defense!

Best regards,

Jonas

Jonas Levêque, Ph.D.

Postdoctoral Researcher
School of Natural Resources
West Virginia University

Title: The effect of minimum impact education on visitor spatial behavior in parks and protected areas: An experimental investigation using GPS-based tracking

Author: Abigail M. Kidd,Christopher Monz,Ashley D'Antonio,Robert E. Manning,Nathan Reigner,Kelly A. Goonan,Charles Jacobi

Publication: Journal of Environmental Management

Publisher: Elsevier

Date: 1 October 2015

BACK | CLOSE WINDOW

APPENDIX C:

PERMISSION TO USE LETTERS (CO-AUTHORS)

**Department of Forest
Ecosystems & Society**
College of Forestry
Oregon State University
321 Richardson Hall
Corvallis, Oregon 97331

P 541-737-5043
Ashley. D'Antonio@oregonstate.edu

March 1, 2018

Utah State University
School of Graduate Studies
0900 Old Main Hill
Logan, UT 84322-0900

To Whom it May Concern:

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work "*A GPS-based classification of visitors' vehicular behavior in a protected area setting*" as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

Regards,

Ashley D'Antonio, Ph.D.
Assistant Professor of Nature-Based Recreation Management
Oregon State University

VirginiaTech.
College of **Engineering**

Via Department of Civil & Environmental Enginereing (MC0126)
Patton Hall 301-D
750 Drillfield Drive
Blacksburg, Virginia 24061
540-231-2362
email: kheaslip@vt.edu

February 27, 2018

Utah State University

School of Graduate Studies

0900 Old Main Hill

Logan, UT 84322-0900

To Whom it May Concern:

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work "A GPS-based classification of visitors' vehicular behavior in a protected area setting" as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

Regards,

Kevin Heaslip

Invent the Future

PENN STATE

Department of Recreation, Park, and Tourism Management

The College of Health and Human Development
The Pennsylvania State University
801 Donald H. Ford Building
University Park, PA 16802-1307

814 -865-1851
FAX: 814-867-1751
http://www.hhdev.psu.edu/rptm/

B. Derrick Taff
Assistant Professor,
Recreation, Park, and Tourism Management,
College of Health and Human Development,
Penn State University

March 2, 2018

Utah State University
School of Graduate Studies
0900 Old Main Hill
Logan, UT 84322-0900

To Whom it May Concern:

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work "A GPS-based classification of visitors' vehicular behavior in a protected area setting" as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

Regards,

Derrick Taff

PennState

Department of Recreation, Park, and Tourism Management   814-865-1851
                                                         Fax: 814-867-1751
The College of Health and Human Development   hhdev.psu.edu/rptm/
The Pennsylvania State University
801 Donald H. Ford Building
University Park, PA 16802

March 19, 2018

Utah State University
School of Graduate Studies
0900 Old Main Hill
Logan, UT 84322-0900

To Whom It May Concern:

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work *"A GPS-based classification of visitors' vehicular behavior in a protected area setting"* as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

Regards,

Peter Newman

Professor and Department Head

Department of Recreation, Park and Tourism Management

Penn State University

801 Ford Building

University Park, PA 16802

**Department of Forest
Ecosystems & Society**
College of Forestry
Oregon State University
321 Richardson Hall
Corvallis, Oregon 97331

P 541-737-5043
Ashley. D'Antonio@oregonstate.edu

March 1, 2018

Utah State University
School of Graduate Studies
0900 Old Main Hill
Logan, UT 84322-0900

To Whom it May Concern:

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work "*The effect of minimum impact education on visitor spatial behavior in parks and protected areas: An experimental investigation using GPS-based tracking*" as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

Regards,

Ashley D'Antonio, Ph.D.
Assistant Professor of Nature-Based Recreation Management
Oregon State University

The University of Vermont

March 8, 2018

Robert Manning
1829 Starview
Prescott, AZ 86305

To Whom it May Concern:

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work "*The effect of minimum impact education on visitor spatial behavior in parks and protected areas: An experimental investigation using GPS-based tracking*" as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

Regards,

Robert E. Manning
Professor Emeritus

Nathan Reigner, PhD
Recreation & Tourism Science
52 Camp Avenue
North Kingstown, RI 02852

February 27, 2018

Utah State University
School of Graduate Studies
0900 Old Main Hill
Logan, UT 84322-0900

To Whom it May Concern:

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work "*The effect of minimum impact education on visitor spatial behavior in parks and protected areas: An experimental investigation using GPS-based tracking*" as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

I congratulate Abigail on her good work and wish her all the success in the world following graduation.

Regards,

Nathan Reigner, PhD

SOUTHERN
UTAH
UNIVERSITY

351 West University Blvd.
Cedar City, UT 84720
(435) 586-7700
www.suu.edu

351 W. University Blvd.
Cedar City, UT 84720

February 22, 2018

Utah State University
School of Graduate Studies
0900 Old Main Hill
Logan, UT 84322-0900

To Whom It May Concern::

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work "*The effect of minimum impact education on visitor spatial behavior in parks and protected areas: An experimental investigation using GPS-based tracking*" as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

Regards,

Kelly A. Goonan, Ph.D.
Assistant Professor and Program Director, Outdoor Recreation in Parks and Tourism
Department of Kinesiology and Outdoor Recreation
Southern Utah University
(435) 865-8098
kellygoonan@suu.edu

S.J. & JESSIE E. QUINNEY
COLLEGE of
NATURAL RESOURCES
UtahStateUniversity

Charles Jacobi
Acadia National Park
Natural Resource Specialist-Retired

February 28, 2018

Utah State University
School of Graduate Studies
0900 Old Main Hill
Logan, UT 84322-0900

To Whom it May Concern:

I hereby give my permission, as co-author, for Abigail Sisneros-Kidd to use our work *"The effect of minimum impact education on visitor spatial behavior in parks and protected areas: An experimental investigation using GPS-based tracking"* as a chapter in her dissertation. I understand that reference to my co-authorship will be made within the appropriate dissertation chapter.

Regards,

Charles D Jacobi

VITA

Abigail Sisneros-Kidd

Ph.D. Candidate in Environment and Society
Department of Environment and Society
Utah State University
Logan, UT 84322
(262) 412-5735
abigail.kidd@aggiemail.usu.edu
abbykidd19@gmail.com

_____

EDUCATION

2013-2018	**Ph.D**. Environment and Society, *Utah State University*, Logan, UT. Anticipated completion spring 2018.
2006-2008	**MEd**, Teaching and Learning, *DePaul University*, Chicago, IL. November 2008.
2002-2006	**B.A**., Environmental Science (Summa cum Laude), *Carthage College*, Kenosha, WI. May 2006.

Minors: Geography, Spanish

Thesis: Vegetation analysis of native versus non-native species in a disturbed wooded riparian area. (Presented at National Conference for Undergraduate Research, April 2006)

RESEARCH EXPERIENCE

2017-Present *Junior Project Specialist*, UC Irvine/Natural Communities Coalition, Orange County, CA
- Collaborated in site selection, development, and implementation of a field protocol for visitor GPS tracking and survey administration with project stakeholders and PIs
- Developed and administered a survey of visitors characteristics within parks in Orange County
- Coordinated with an array of stakeholders to secure access to housing and field sites
- Managed a team of graduate researchers in the field as well as data analysis of survey and GPS data

2016-2017 *Lead Researcher*, Grand Teton National Park
- Developed a protocol for observing visitor and wildlife behavior during wildlife jam events
- Mapped locations of wildlife jams using a high-accuracy Trimble GPS unit
- Observed, recorded, and analyzed visitor behavior associated with wildlife jams
- Developed and administered a survey to understand visitors who may experience jams

2015-2016 *Research Assistant*, Rocky Mountain National Park
- Mapped informal trails using a high-accuracy Trimble GPS unit
- Installed and calibrated infrared trail counters and motion-activated cameras on Longs Peak
- Implemented and analyzed GPS tracking of hikers on the Keyhole Route of Longs Peak
- Authored a project report to the NPS

2014-2015 *Research Assistant*, Grand Teton National Park
- Managed a GPS tracking study of vehicles and pedestrians along a popular park corridor
- Monitored condition of parking-related impacts along a popular scenic road corridor
- Installed and downloaded data from vehicular turning motion cameras

2013   *Research Assistant*, Acadia National Park
- Implemented GPS tracking and surveying of hikers on popular mountain summit trails
- Analyzed and mapped results of GPS tracking to determine visitor behavior in the summit area
- Authored a peer-reviewed journal article on response of visitor spatial behavior to management treatments

TEACHING AND COACHING EXPERIENCE

Utah State University, Logan, UT
   <u>Undergraduate Course Instructor</u>
Fall 2016-Present   Course: Fundamentals of Recreation Resource Management (ENVS 3300)
Fall 2015-Spring 2016   Course: Outdoor Recreation Management (PRP 2500)
   <u>Teaching Assistant</u>
Fall 2017   Course: Natural Resource Interpretation (ENVS 4600)
Fall 2014   Course: Fundamentals of Recreation Resource Management (ENVS 3300)
Fall 2013   Course: Human Dimensions of Natural Resource Management (ENVS 4000)
   <u>Guest Lecturer</u>
Spring 2018   Course: Environment and Society Seminar (ENVS 7800)
Fall 2016   Course: Disturbance Ecology (WILD 5710)
Fall 2015-2017   Course: Natural Resource Interpretation (ENVS 4600)
Fall 2014-2017   Course: Human Dimensions of Natural Resource Management (ENVS 4000)
2013-2014   Course: Fundamentals of Natural Resource and Environmental Policy (ENVS 3010)

McKinley Middle School (IB Candidate School), Racine, WI
2010-2013   Middle School Science Teacher
2010-2013   Middle School Cross-County and Track Coach
2011-2012   Summer Enrichment Program Instructor, Center for Developing Excellence, Racine, WI

Waukegan High School, Waukegan, IL
2008-2010   Freshman Biology Teacher, Waukegan High School, Waukegan, IL
2009-2010   Girls Freshman and JV Soccer Coach, Waukegan High School, Waukegan, IL
Spring 2008   Student Teacher, Waukegan High School, Waukegan, IL

Other Coaching Experience
Spring 2008   Assistant Girls Varsity Soccer Coach, St. Joseph High School, Kenosha, WI
2004-2008   United FC Youth Soccer Coach, Kenosha Area Soccer League, Kenosha, WI

PUBLICATIONS

<u>Peer Reviewed</u>

Fuentes, A., Heaslip, K., **Kidd, A**., & D'Antonio, A. (Under Review). Evaluating national park entrance station queues: A case study in Grand Teton National Park. Case Studies on Transport Policy

Kidd, A. M., D'Antonio, A., Monz, C., Heaslip, K., Taff, D., Newman, P. (2018). A GPS-based classification of visitors' vehicular behavior in a protected area setting. Journal of Parks and Recreation Administration, 36, 72-92.

Kidd, A. M., Monz, C., D'Antonio, A., Reigner, N., Manning, R., Goonan, K., & Jacobi, C. (2015). The effect of minimum impact education on visitor spatial behavior in parks and protected areas: An experimental investigation using GPS-based tracking. Journal of Environmental Management, 162, 53-62.

<u>Technical/Grant Reports</u>

Graham, R. Monz, C., & **Sisneros-Kidd, A.** (2017). An Assessment of Visitor Created Impacts in Riparian Areas in Rocky Mountain National Park, CO. Project Summary Report. Submitted to Rocky Mountain National Park.

Graham, R., Monz, C., & **Kidd, A**. (2017). An assessment of informal trails and visitor spatial behavior on the Twin Sisters trail in Rocky Mountain National Park, CO. Project Summary Report. Submitted to Rocky Mountain National Park.

Kidd, A. M., & Monz, C. (2017). Understanding and managing wildlife jams in National Parks: An evaluation in Grand Teton National Park. University of Wyoming National Park Service Research Center Annual Report, 40.

Kidd, A., Graham, R., & Monz, C. (2016). Visitor use on Longs Peak: A preliminary assessment in Rocky Mountain National Park, Colorado. Report of Findings. Submitted to Rocky Mountain National Park.

SCHOLARLY PRESENTATIONS

April 2017   Kidd, A., D'Antonio, A., Monz, C., Heaslip, K., Taff, D., & Newman, P. "A GPS-Based Classification of Visitors' Vehicular Behavior in a Protected Area Setting", George Wright Society Biennial Conference on Parks, Protected Areas, and Cultural Sites. April 2-7, 2017, Norfolk, VA.

April 2015   Kidd, A., Monz, C., D'Antonio, A., Reigner, N., Manning, R., Goonan, K., Jacobi, C. "An Experimental Investigation of the Effect of Minimum Impact Education on Visitor Behavior", George Wright Society Biennial Conference on Parks, Protected Areas, and Cultural Sites. March 29-April 3, Oakland, CA.

April 2014   Kidd, A., Monz, C., D'Antonio, A., Goonan, K., Manning, R., Reigner, N., Jacobi, C. "Does Minimum Impact Visitor Education Influence Visitor Behavior? An Experimental Investigation", Northeastern Recreation Research Symposium. April 6-8, Cooperstown, NY.

April 2006   Presenter (poster), National Conference for Undergraduate Research, Asheville, NC

RESEARCH GRANTS

April 2016   University of Wyoming-National Park Service Research Station Small Grant, $5,000
                   Grant title: Understanding and Managing Wildlife Jams in National Parks: An Evaluation in GRTE

SERVICE

	Academic Service
2016-Present	*Peer Reviewer*: Leisure Sciences (1), Extension Fact Sheets (1), Applied Geography (1)
2015-2016	*Department Representative*: College of Natural Resources Graduate Student Council
2013-Present	*Council Member*: College of Natural Resources Graduate Student Council

	Professional Service
2015	IORT Director Search Committee Member, Department of Environment and Society

	Community Service and Activities
2017-Present	*Member*, Stokes Nature Center, Logan, UT
2016-Present	*Member*, American Alpine Club
2016-2017	*Member*, Salt Lake Climbers Alliance (SLCA)
2016	*Volunteer*, SLCA climbers trail improvement project, Little Cottonwood Canyon, UT
2016	*Planning Committee Member*, Namaste Cache Valley Yoga Festival
2014-2015	*Treasurer*, Logan Freeze Women's Hockey Team
2012	Member, Ice Age Trail Alliance
2012	Mobile Skills Crew Volunteer—Ice Age Trail Alliance, WI
2012	American Hiking Society Volunteer Vacation: Gila National Forest, NM

PROFESSIONAL AFFILIATIONS

2018-Present	IASNR Member
2015-Present	George Wright Society Student Member

CERTIFICATIONS AND TRAINING

2018	AIARE Level 2 Avalanche training
2016	AIARE Level 1 Avalanche training
2018	Wilderness First Aid/CPR Certified
2013	Utah State University Teaching Assistant Workshop
2011	IB Level 2 Training
July 2010	*Wisconsin Initial Educator License* (720928)
	Broadfield Science (601), Biology and Life Science (605), Life and Environmental Science (606), age 10-21
July 2008	*Illinois Initial Secondary Certification* (Type 09) Biology
	Secondary endorsement in Environmental Science; Middle grade endorsement in Science, Geography and Spanish
2010	CRISS Level 1 Training
2005	United States Soccer Federation (USSF) Level "D" License
2005	United States Soccer Federation (USSF) "E" Certificate

AWARDS & RECOGNITION

2005	Alpha Chi National College Honor Scholarship Society
2003	Alpha Lambda Delta National Honor Society
2002-2006	*Carthage College Lincoln Scholarship Recipient*
	Four-year, full, competitive, academic merit scholarship awarded to one student per class