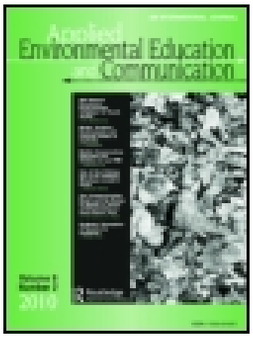

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Identifying strategies to reduce visitor-generated waste in national parks of the United States: the Zero Landfill Initiative

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ABSTRACT

Increasing visitor use in U.S. national parks leads to myriad challenges, one of which is the large amount of waste generated. In this research, visitors to three parks were surveyed to identify potential leverage points for communicating with visitors that may help increase desirable behaviors in visitors as part of the Zero Landfill Initiative (ZLI). The findings suggest that visitors' psychological constructs largely align with ZLI goals. However, moral norms and perceived difficulty significantly predicted behavioral intentions. From these results, a variety of management actions are suggested that may increase desirable behaviors and reduce waste in national parks.

Over 330 million people visited the national parks of the United States (US) in 2017, with record-breaking visitor numbers recorded in many of the 417 units (National Park Service (NPS), 2018). This trend of increasing visitor numbers has continued for several years now, which resulted in 1.5 billion people visiting US national parks over the last five years (NPS, 2018). This creates a variety of challenges including human-wildlife conflicts (Hall, Ham, & Lackey, 2010; Lackey & Ham, 2003; Miller, Freimund, & Blackford, 2018; Olliff & Caslick, 2003), visitor experiences (Anderson, Manning, Valliere, & Hallo, 2010; Miller, Taff, & Newman, 2018; Pilcher, Newman, Manning, 2009; Rapoza, Sudderth, & Lewis, 2015), impacts to natural resources (Gutzwiller, D'Antonio, & Monz, 2017; Marion, Leung, Eagleston, & Burroughs, 2016; Schwartz, Taff, Lawhon, & VanderWoude, 2018), and possible negative consequences to human health and well-being (Abbott, Taff, Newman, Benfield, & Mowen, 2016; Benfield, Nutt, Taff, Miller, Costigan, & Newman, 2018).

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However, despite the remote nature of many parks they also face challenges more typical of urban settings, like traffic (Hallo & Manning, 2010) and increased domestic violence (FitzGerald, 2016).

One issue US national parks are facing that is more typical of an urban setting is the huge amount of waste generated by park visitors. For instance, national parks produce more than 100 million pounds (45,359 tonnes) of waste annually within their boundaries, much of which is produced by the record-breaking numbers of park visitors (Pierno, 2017). While waste management topics such as sustainable infrastructure and design, environmental and social health hazards, disposal practices, and regulations and policies have been studied extensively in urban and rural settings (e.g. Keep America Beautiful, 2009; Morrissey & Browne, 2004; Vaughn, 2009), research in parks and protected areas regarding waste management is scant.

The limited previous research regarding waste management in parks and protected areas has largely focused on littering behavior (e.g. Brown, Ham & Hughes, 2010; Rodriguez-Rodriguez, 2012; Wagstaff & Wilson, 1988). However, while litter is still an issue in some parks, the actual amount of waste and disposal practices (i.e. appropriate disposal of trash and recyclable material) are far more concerning for park and protected area managers (Pierno, 2017). Although managers of parks and protected areas have a variety of tools to use to help address challenges related to visitor use, indirect, "light-handed" management techniques (e.g. communication) are often preferred by managers and visitors alike because they require fewer resources when compared to methods like enforcement, are more in line with self-determinative aspects of park experiences, and are highly effective when designed well (Brown et al., 2010; Buonincontri, Marasco, & Ramkissoon, 2017; Lawhon et al., 2019; Manning, 2003; 2011; Miller, 2017; Miller, Freimund, Nickerson, Metcalf, & Powell, 2019).

The challenge with communications in parks and protected areas is that communication products usually rely on administrative formatting and staff intuition about what they think is effective (Hall, Ham, & Lackey, 2010; Miller, Freimund, & Blackford, 2018). In contrast to this, research shows that communication strategies based in social psychological theory can be successful in influencing waste-related behaviors in parks and protected areas (Brown et al., 2010; Manning, 2003; Oliver, Roggenbuck & Watson 1985; Sibley & Liu, 2003). The purpose of this study is to draw from past research examining communication strategies designed to influence human behavior and inform future management strategies related to reducing human-caused waste in the national parks of the US.

Conceptual framework

One of the most effective and researched theories for understanding and predicting human behavior is the Theory of Planned Behavior (TPB) (Ajzen, 1991; Fishbein & Ajzen, 2011; Miller, 2017). In this theory, behaviors arise from behavioral intentions, which refer to whether someone intends to perform specific behaviors. In turn, three concepts predict behavioral intentions: attitudes, subjective norms, and perceived behavior control. Attitudes are positive or negative evaluations of objects, such as how pleasant (positive attitude) or unpleasant (negative attitude) a certain behavior is. Subjective norms are similar to peer pressure in that they are measures of a person's perception about whether or not others think they should perform a certain behavior. For instance, a person may recycle something because others in the traveling group think that he/she should. Perceived behavioral control (PBC) is a measure of whether or not someone thinks they are able to perform a behavior. An example of PBC is that someone may wish to recycle but cannot find proper facilities to do so. Collectively, these three concepts (attitudes, subjective norms, and PBC) can predict behavioral intention, which in turn predict behavior.

In addition to attitudes, subjective norms, and PBC, many other concepts may also influence behavioral intentions (Armitage & Connor, 2001; Fishbein & Ajzen, 2011; Miller, 2017). For instance, several authors have suggested a difference between PBC and other control concepts, like self-efficacy or difficulty (Armitage & Connor, 2001; Miller, 2017; Terry, 1993; Terry & O'Leary, 1995; White, Terry, & Hogg, 1994). As stated by Armitage and Connor (2001), "Self-efficacy is more concerned with cognitive perceptions of control based on internal control factors, whereas PBC also reflects more general, external factors" (p. 476). When compared to self-efficacy, perceived difficulty is more concerned with external factors and closer to Ajzen's (1991) definition of PBC (Armitage & Connor, 2001; Sparks, Guthrie, & Shepherd, 1997). Additionally, moral norms, defined as an individual's perception about what is ethically appropriate, were found to be independent predictors of behavioral intentions in several studies (Armitage & Connor, 2001; Beck & Ajzen, 1991; Connor, Martin, Silverdale, & Grogan, 1996). Lastly, some studies found that awareness of a particular issue is an important predictor of behavioral intentions, particularly as it pertains to sustainable behaviors (Miller et al., 2019; Stern, Dietz, & Guagnano, 1995; Vezeau et al., 2015). Components such as these can be easily incorporated within a single model that predicts behavioral intentions (Ajzen, 1991; Armitage & Connor, 2001; Fishbein & Ajzen, 2011; Miller, 2017).

Similar to several other studies (e.g. Hrubes, Ajzen, & Daigle, 2001; Lawhon et al., 2013; Miller, Freimund, & Powell, 2018; Vagias, Powell, Moore, & Wright, 2014; Vezeau et al. 2015; Schwartz et al., 2018), statistical

models designed to predict behavioral intentions can reveal points of influence for shaping strategies that can increase behavioral compliance. As a single example, if it was found that subjective norms are a strong predictor of behavioral intentions, messages could be created that target this component of the theory to increase desired behaviors (Ajzen, 1991; Brown et al., 2010; Ham, 2013; Miller, 2017). From this conceptual framework, a single research question was developed:

Research question: How can the management of waste in national parks be informed by understanding the concepts that predict waste-related behavioral intentions?

Methods

Study sites

The Zero Landfill Initiative (ZLI) was initiated in 2016 through a partnership between industry, nonprofit organizations, and the U.S. National Park Service to help mitigate waste impacts in and around parks. The overarching goal of ZLI is to reduce the amount of waste generated in parks while also diverting more recyclable materials, thus decreasing the amount of waste sent to landfill. Three pilot parks were selected for ZLI, including Yosemite, Grand Teton, and Denali National Parks, and were used as field sites for this study. These iconic parks host millions of visitors each year, and offer stunning flora and fauna, iconic viewscapes, and historic park infrastructures. Each park unit faces unique waste management challenges, and different waste processing and diversion processes (e.g. single stream recycling, source separated recycling, etc.). Since ZLI began in 2016 each park has dedicated staff to the project, implemented targeted but minimal communication strategies, and updated infrastructure (i.e. installed new waste and recycling bins) in an attempt to reduce waste and improve waste/recycling diversion rates.

Sampling

Intercept surveys were used at pre-selected high visitation, day-use sites within each park. Specific sites were determined based on consultation with park managers and pretesting among the research team. Data were collected using electronic iPad devices. Sampling was stratified across the selected park units over a three-month period in the summer of 2017. Approximately 20–25 days of sampling were allotted for data collection in each park, and stratified by site (i.e., 2–3 per park), time of day (AM/PM), and weekday or weekend. Three sampling locations were identified in Yosemite, which included the Yosemite Visitor Center, Yosemite Falls Trailhead, and the Swinging Bridge Picnic Area. Yosemite utilizes a

commingled, or single-stream, recycling system, and the park provides recycle bins, and separate waste bins. Two sampling locations were identified at Grand Teton, which included Colter Bay Visitor Center and the Taggart Lake Trailhead. The park utilizes a source-separation recycling program, which requires the visitor to sort materials prior to disposal in the proper unit. The park provides recycling bins for plastic, glass, and aluminum. Three sampling locations were identified at and around Denali, which included the Morino Grill, the Wilderness Access Center, and the Denali Square, which is a location outside of the park that offers lodging to many park visitors. Recyclable materials are source separated in Denali, and include bins for glass, plastic, and aluminum.

Data instrument

The survey instrument was developed through a collaborative, iterative review process among the researchers and park staff. It was developed to incorporate natural resource-based human dimensions questions, including items stemming from established Leave No Trace-focused questions that have been used in numerous peer-reviewed studies (see Lawhon et al., 2013; Taff, Newman, Vagias, & Lawhon, 2014; Vagias & Powell, 2010; Vagias et al., 2014), as well as TPB studies. Based on previous research, measures of moral norms were included, as they have been found to be additive measures when the behavior in question is rooted in underlying morally or ethically grounded beliefs or attitudes (Armitage & Connor, 2001). Additionally, measures of both difficulty and self-efficacy were included, as it is suggested they represent different concepts (Armitage & Connor, 2001; Miller, 2017). Lastly, questions about visitor use history, visitation patterns, waste generation, information sources, and basic demographic information were included. Table 1 includes the wording and measurement of the items used in the study.

Analysis

During data cleaning attention was paid to univariate outliers, non-normality, and missing data. Less than 1% of the data was missing from each variable, and cases with missing data were deleted instead of imputed to be as conservative as possible. This left a final sample size of $n = 2{,}722$. Proportion of responses from each park were nearly equal (Yosemite = 35.9%, Grand Teton = 31.3%, and Denali = 32.8%).

The ultimate goal of the analysis was to produce a structural equation model (SEM) that examines the relationship between psychological constructs and behavioral intentions. As a first step in this process a principal

Table 1. Descriptive statistics and reliability for CFA[1] and SEM variables.

Component	Model code	Variable	Factor loading[1]	Mean *(SD)*
Perceived difficulty[3] α=0.69				–
	PD_1	Reduce the amount of waste materials I bring with me into the park	.67	5.4 *(1.65)*
	PD_4	Reduce the amount of waste materials I create in the park	.85	5.6 *(1.56)*
	PD_5	Avoid the purchase of items in the park that cannot be reused or recycled	.48	5.3 *(1.63)*
Self-efficacy[4] α= 0.81				–
	SE_1	Recycling in this park is inconvenient	.59	2.0 *(1.49)*
	SE_2	Trash disposal in this park is inconvenient	.56	1.8 *(1.34)*
	SE_3	Trash disposal in this park is confusing	.84	1.9 *(1.35)*
	SE_4	Recycling in this park is confusing	.85	2.0 *(1.43)*
Knowledge[4] α=0.79				–
	KN_1	I know what items can be recycled in this park	.71	5.3 *(1.90)*
	KN_2	I know where to take my recyclable items in this park	.92	5.3 *(1.89)*
Attitudes[4] α=0.60				–
	ATT_1	Recycling in national parks is useless	.61	1.2 *(0.80)*
	ATT_3	Recycling in national parks takes too much time	.60	1.5 *(1.12)*
	ATT_4	It is pointless for me to recycle while in national parks	.57	1.2 *(0.89)*
Moral norms[4] α=0.90				–
	MN_4	By recycling in national parks, I am helping to conserve natural resources	.88	6.7 *(0.82)*
	MN_5	By recycling in national parks, I am helping to protect the health of the environment	.96	6.7 *(0.73)*
	MN_6	By reducing the amount of trash I produce in national parks, I am helping to protect the health of the environment	.76	6.7 *(0.78)*
Behavioral intentions[5] α=0.74				–
	INT_1	Reduce the amount of waste materials I bring with me to the park	.76	5.9 *(1.38)*
	INT_2	Take my waste with me when I leave the park	.53	5.8 *(1.70)*
	INT_3	Reduce the amount of waste materials I create while in the park	.89	5.9 *(1.38)*
	INT_4	Only purchase items in the park that can be reused or recycled	.50	5.1 *(1.65)*

[1]All loadings are standardized and statistically significant ($p < 0.01$). Fit statistics: χ^2 =1566.844, $df = 137$, $p < 0.001$; RMSEA = 0.06.
[2]SRMR = 0.0445; CFI = 0.928; TLI = 0.910.
[3]Responses measured on a 7-point Likert-type scale where 1 = very difficult and 7 = very easy.
[4]Responses measured on a 7-point Likert-type scale where 1 = strongly disagree and 7 = strongly agree.
[5]Responses measured on a 7-point Likert-type scale where 1 = very unlikely and 7 = very likely.

components analysis (PCA) with varimax rotation was use to inform the latent structure of the variables. The PCA was used to allow for a more exploratory perspective with the data in the initial stages of analysis. The results from the PCA were then used to inform a series of confirmatory factor analyses (CFA) given that a CFA offers a more rigorous approach to

identifying latent structures in data and is a natural complement to SEM. Because no one fit statistic is universally accepted, the CFA models were examined through a variety of fit statistics including the CFI (comparative fit index), TLI (Tucker–Lewis index), RMSEA (root mean square error of approximation), and SRMR (standardized root mean square residuals). The CFI and TLI should both have values $\geq$.90 (Hu & Bentler, 1998). RMSEA is a "badness of fit" index, and should be $\leq$.10 (Browne & Cudeck, 1993; Kline, 2011). SRMR values should be $\leq$.08. Additionally, all factor loadings should be $\geq$.30, with loading $>$.60 being considered high. Factor loading should also be statistically significant. Lastly, the reliability of latent variables identified through CFA was evaluated using Cronbach's α, with values $\geq$.60 considered sufficient (Gay, 1991).

Once a satisfactory CFA model was identified, a SEM was developed. In this model, behavioral intentions was the single endogenous (outcome) variable, and all other variables were treated as exogenous (predictor) variables. This is in line with previous research that explores the antecedents of behavioral intentions as a way for identifying leverage points for management and communication (Lawhon et al., 2013; Miller, Freimund, & Blackford, 2018; Taff et al., 2013; Vagias et al., 2014; Vezeau et al., 2015). Similar to CFA, SEM procedures allowed for an evaluation of the model through the same fit statistics previously described.

Results

Sample

The sample was nearly even in terms of gender, with 49% identifying as female. Age of respondents varied from 18 to 87 years of age, with a mean of 47 years and a median of 48 years. Group size ranged from 1 to 30 people, with a mean of 4.4 people and a median of 3 people. About 85% of visitors were permanent residents of the US. Out of the approximate 15% of international visitors in the sample, the largest proportions were from Germany (2.2% of all visitors), the United Kingdom (1.9% of all visitors), Canada (1.8% of all visitors), and Australia (1.8% of all visitors). No other country made up more than 1% of all other visitors. About 3% of visitors were traveling with an organized tour group.

Developing a measurement model using CFA

A PCA extracting components with Eigenvalues $\geq$ 1 and varimax rotation was used to inform the structure of the CFA. The results of the final CFA model are found in Table 1, and correlations among latent variables are found in Table 2. The authors recognize that this process is more

Table 2. Correlations among latent variables from the CFA.

	Self-efficacy	Knowledge	Attitudes	Behavioral intentions	Moral norms	Perceived difficulty
Self-efficacy	1.00	–	–	–	–	–
Knowledge	−.45***	1.00	–	–	–	–
Attitudes	.52***	−.23***	1.00	–	–	–
Behavioral intentions	−.09***	.13***	−.18***	1.00	–	–
Moral norms	−.15***	.15***	−.43***	.29***	1.00	–
Perceived difficulty	−.19***	.21***	−.19***	.58***	.22***	1.00

***$p<.001$.

exploratory than confirmatory in spirit. However, CFA is a natural complement to the SEM and further validates the structural components of the data. Overall, the results from the CFA supported the data. Fit statistics met their thresholds (RMSEA = 0.062; SRMR = 0.0445; CFI = 0.928; TLI = 0.910), all factor loadings were statistically significant ($p<.05$), and the reliability for latent constructs was sufficient with α ranging from .60 to .90 (Table 1).

Although correlation among all latent variables was statistically significant, discriminant validity of the variables was achieved as no correlation was ≥.85 (Table 2) (Kenny, 2016).

The SEM constructed using the variables identified in the CFA also had an acceptable fit (RMSEA = 0.062; SRMR = 0.0455; CFI = 0.928; TLI = 0.910) (Figure 1). All loadings in the model are standardized. Overall, the model explained 37% of the variance in behavioral intentions. The only two variables that were statistically significant in predicting behavioral intentions were perceived difficulty and moral norms. Perceived difficulty had a large, positive effect size on behavioral intentions and explained about 30% of the variance. Moral norms had a small, positive effect size on behavioral intentions and explained about 3% of the variance.

Discussion

Overall, the purpose of this study was to identify components that can be used to influence park visitor behaviors to better align with the goals of ZLI. Out of the five components that were tested, only two had a significant impact on behavioral intentions related to waste: moral norms and perceived difficulty.

Perhaps the most salient finding from this research is that the attitudes, norms, and reported behaviors of park visitors included in this sample are largely aligned with proper disposal of waste and recyclable material in national parks. Despite very low visitor awareness of ZLI, the data suggest that many visitors are predisposed to engage in environmentally responsible behaviors that benefit and protect national parks.

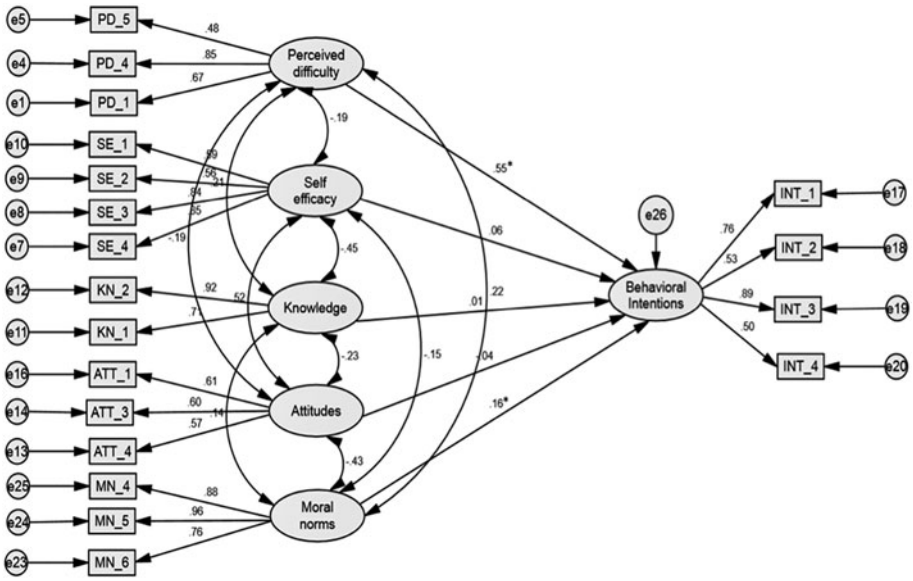

Figure 1. SEM of the relationship between model components and behavioral intentions. Fit statistics: $\chi^2 = 1566.844$, $df = 137$, $p < 0.001$; RMSEA = 0.062; SRMR = 0.0455; CFI = 0.928; TLI = 0.910. * denotes paths that are statistically significant ($p < 0.05$). All loadings are standardized. See Table XX for corresponding variable codes.

Although the model suggested that a few concepts were not related to behavioral intentions, it also revealed that perceived difficulty and moral norms were significant predictors of behavioral intentions. These concepts can act as leverage points for future strategies related to increasing desirable waste-related behaviors (Brown et al., 2010; Miller et al., 2019). For instance, messaging that targets the moral norms concept related to waste behaviors may be effective in better aligning visitor behavior with the goals of ZLI. Such messages could reinforce visitors' latent sense of "the right thing to do" in national parks and surrounding areas. However, the model suggests that perceived difficulty had a much larger effect size when compared to moral norms, and thus is likely a stronger driver of waste-related behavior in park visitors. This indicates that a structural fix may be needed, such as increasing access to waste infrastructure, ensuring visitors know what can be recycled, or selling products with reduced packaging at stores in parks (Manning, 2003). Like moral norms, perceived difficulty may also be used in strategic communications. For instance, the message "One million years or a one-minute walk?" may encourage visitors to walk just a bit further to find infrastructure where they can properly dispose of waste and recycling.

From a theoretical standpoint, this research highlights the need to include additional predictors of behavioral intentions in models that use TPB. As found in previous studies, moral norms were more important

than attitudes, subjective norms, or PBC (see Armitage & Connor, 2001). Additionally, perceived difficulty and self-efficacy were distinct concepts, and simply measuring PBC may not be sufficient (Armitage & Connor, 2001; Miller, 2017). In this current study, only perceived difficulty was a significant predictor of behavioral intentions. However, this may not be the case for many other behaviors.

Limitations and future research

A few limitations of this study should be noted. With regard to methodological considerations and future research, self-reported behaviors do not always align with the actions visitors take in the environment. Therefore, when feasible, future studies should consider pairing visitor surveys and observations. The generalizability of results may also be limited, as this study took place in three large western NPS units with National Park designation and was restricted to 2–3 sampling sites in each unit. The extent to which these results hold across other NPS units, including other national parks, historic sites, and monuments, should be inferred conservatively. It is recommended that this line of research be expanded with additional NPS unit types in different geographic regions. By replicating the study in other NPS unit types (e.g. using smaller, less complex sampling timeframes, but keeping the general methodology for inter-park comparison), the data may be generalizable across the NPS system to ensure long-term efficacy of ZLI.

Although several future research avenues are described above in regards to overcoming study limitations, there are several other recommendations for future research. One recommendation is to explore in a similar way to this study the behaviors of others groups that are integral to successful waste and recycling management in national parks. This could include NPS staff, concession staff, and campground users. These populations were not explicitly represented in the research contained in this report but are fundamental to the overall success of ZLI. Such data could meaningfully inform and contribute to future ZLI efforts. A second possibility for future research would involve message development based on the findings from this study. Targeted messaging for the pilot parks, based on the findings, could be implemented (multi-channel, multi-platform) in the parks for a set period of time. Research would then assess the effectiveness of the messaging to further hone public outreach efforts, preferably using a quasi-experimental observational design. Efficacy testing of research-driven messages as described could ensure long-term success of ZLI with regards to park visitors' role in the effort. Lastly, understanding mediating and moderating variables may also provide useful (Ramkissoon & Mavondo, 2017; Ramkissoon, Mavondo, & Uysal, 2018).

Conclusion

Given the significant amount of waste generated each year in US national parks (Pierno, 2017), it is clear that this growing problem must be addressed by the NPS. While some strategies have been utilized in the past in parks to reduce waste, visitor numbers to parks continues to increase as does the amount of waste generated by park visitors. The ZLI has the support of park managers, and based on reported attitudes about waste and recycling in parks, visitors as well. The results of this study indicate that if parks can provide the appropriate infrastructure coupled with morally-grounded messaging for park visitors, the goal of reducing waste sent to landfill and increasing the recycling diversion rate can likely be achieved over time.

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