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## **PUBLIC PERCEPTIONS OF SALAMANDERS IN GREAT SMOKY MOUNTAINS NATIONAL PARK**

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To the Graduate Council:

I am submitting herewith a thesis written by Savannah Blackman entitled "PUBLIC PERCEPTIONS OF SALAMANDERS IN GREAT SMOKY MOUNTAINS NATIONAL PARK." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Adam S. Willcox, Major Professor

We have read this thesis and recommend its acceptance:

Benjamin Fitzpatrick, Bill Sutton

Accepted for the Council:

Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

**PUBLIC PERCEPTIONS OF SALAMANDERS IN GREAT SMOKY MOUNTAINS  
NATIONAL PARK**

A Thesis Presented for the  
Master of Science  
Degree  
The University of Tennessee, Knoxville

Savannah M. Blackman

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## **ABSTRACT**

Amphibians receive little attention when it comes to public appreciation or support for their conservation. Despite their ecological importance, salamanders are often little known and overlooked by the general public. To better conserve their rapidly declining populations, it is important to understand and consider public knowledge and attitudes toward salamanders and certain behaviors that negatively affect them—like rock stacking in streams and rivers. The Great Smoky Mountains National Park is referred to as the “Salamander Capital of the World!” as it is home to more than 30 different species of salamander. One issue facing salamander populations within the park is the altering of waterways through damming and rock stacking. Our questionnaire sought to understand park visitor knowledge of and attitudes toward salamanders as well as feelings toward rock stacking and potential management actions to mitigate damages to local salamander populations. We surveyed 817 visitors (response rate was 85%) and discovered that visitors had little, if any, previous knowledge of salamanders within the park and generally had neutral feelings toward them. Most visitors also had positive or neutral feelings toward rock stacks before being given a small amount of additional information about the negative side effects of stacking or moving rocks from the water. After the additional information was provided, responses were more negative toward rock stacking. Overall, visitors support the idea of park staff managing areas of streams or trails for salamander conservation. The strongest support was for signs along streams and trails, as well as the addition of ranger talks.

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## Section 1: Introduction

Amphibians are a diverse group of vertebrates, and their decline is one of the most severe examples of the ongoing biodiversity crisis we face (Angelini et al., 2020). In 1989, the First World Congress of Herpetology sparked increased concern and interest in amphibian ecology and decline globally (Green et al., 2020). Due to their biphasic life history and physiology, amphibians are more sensitive to changes in both aquatic and terrestrial environments, making them bio-indicators at the global level (Angelini et al., 2020). A key takeaway from more than three decades of research is that global species decline is more complex than expected and may be attributed to many causes that are dependent on the landscape, climate change, interactions between taxa and populations, emerging diseases, and more (Green et al., 2020).

Salamanders are a cryptic, yet abundant, group of amphibians that play a vital role in many ecosystem processes either through direct (predation) or indirect (energy transfer between aquatic and terrestrial landscapes) ecological food webs (Davic and Welsh 2004). One geographic area of concentrated salamander populations is the southern Appalachian Mountains, specifically Great Smoky Mountains National Park (GRSM, Bailey, 2002). The Park is called the “Salamander Capital of the World!” because 30 species spanning five families of salamander can be found there. In fact, salamanders’ biomass in the park outweighs that of all other vertebrates, including human visitors, on any given day (NPS.gov, 2021). The GRSM is the country’s most visited national park, amassing nearly 12.4 million visitors in 2020 (Lange, 2021) and 14.1 million visitors in 2021, breaking previous park records (NPS.gov, 2022). With so much human traffic, the park needs to understand visitor perceptions of wildlife and proposed management actions to aid in the success of conservation initiatives.

Anthropogenic disturbance is a major threat to the biodiversity of freshwater ecosystems (Brown et al. 1998, Lake et al. 2000) and can alter in-stream habitat and flow regime, disrupt animal behavior, modify water-quality parameters, increase sediment deposition, and ultimately result in direct displacement and mortality of individuals (Unger et al., 2017). Recreational moving of shelter rocks from freshwater streams has been documented as a direct cause of mortality to Eastern Hellbenders (*Cryptobranchus alleganiensis*), a fully aquatic salamander species found within the GRSM (Davic and Welsh 2004), thus any disturbance to the environment could damage eggs or cause them to detach and float downstream, increasing egg damage and predation. The most common reason for moving rocks is to build cairns—stacks of rocks balanced on one another (Figure 1). In some areas, cairns serve as helpful trail markers for hikers, but they are detrimental when created in the middle of a river or stream. Moving rocks and creating dams to make chutes or pools in a stream for tubing are equally as damaging (McDaniel, 2015). In addition to salamanders, aquatic plants, and animals (fishes and macro- and micro- invertebrates) make their homes on, under, and around these rocks (Agouridis, et al., 2015), thus any disturbance may have cascading effects on the entire system.

Despite the importance of studying people’s perceptions of wildlife on conservation efforts, people’s attitudes towards salamanders and rock stacking is an understudied topic. This was an exploratory study that sought to determine visitors’ perceptions and attitudes toward salamanders, rock stacking, and support for potential management actions to improve salamander conservation. It is imperative to understand people’s perceptions towards salamanders to ensure the success of conservation actions regarding these sensitive species.

Failing to consider public perception of a species can impede the success of conservation plans due to social or political backlash, resistance to actions, or lack of general support (Kaltenborn et al., 2006). Furthermore, the park can incorporate public perceptions and attitudes towards specific wildlife to create outreach programs and to promote further public support (Ajzen, 1988; Ajzen and Fishbein, 2005; Fishbein and Ajzen, 2011) for salamanders and the proposed management actions to protect them.

The overall goal of this study was to examine visitor perceptions and knowledge of salamanders and rock stacking within the GRSM, with the goal of providing suggestions for additional outreach strategies that may enhance visitors' educational experiences and promote support for salamander conservation. To our knowledge, no study has examined visitor perceptions of salamanders or rock stacking previously. Our objectives were to survey visitors on their: (1) attitudes towards salamanders, (2) knowledge of and experience with rock stacking within the park, and (3) determine support for proposed management actions.

### **Theoretical framework**

A prevalent theoretical framework used in social sciences to examine the process from thought to action is the cognitive hierarchy approach. This concept emphasizes attitude and value theories (Manfredo & Vaske, 2012) and proposes that human thought is arranged in a hierarchy of cognition (i.e., how respondents perceive, think about, and understand the world) that influences behavior. The cognitive elements (values, value orientations, attitudes and norms, and behavioral intentions) build on one another to predict and influence behavior in an inverted pyramid (Figure 2, Vaske, 2008).

People's attitudes towards wildlife are a well-studied topic in the field of human dimensions of wildlife, as they can be important predictors of behavior (Vaske and Donnelly, 2007; Vaske, 2008) and may indicate potential success or failure of certain management actions for target species. In this study, we focused on the evaluative component of participant attitudes, which refers to whether the individual views the object as positive or negative (Vaske, 2008). According to the cognitive hierarchy model, attitudes are numerous, easy to influence, and quick to change (Vaske, 2008). Once attitudes and perceptions toward a target species or proposed management action are ascertained, wildlife and conservation agencies and organizations can develop better education and outreach materials that will influence those attitudes and thus, change the resulting behavior.

## **Section 2: Methods**

### **Study area**

Great Smoky Mountains National Park is unique in the US National Parks Service as there is neither an entry fee nor visitor number restrictions to outdoor areas, which results in a high volume of visitors annually. The park spans more than half of a million acres, ranking it in the top 20 largest national parks in the United States. It is the only national park in Tennessee. We conducted our study at two different TN sites within the GRSM: Sugarlands Visitor Center and Cades Cove Visitor Center. These locations were chosen due to the heavy visitor traffic received by both during the busy summer season. Sugarlands is inside the park, approximately 2 miles south of Gatlinburg on US-441. This visitor center offers seasonal ranger-led programs, free admission to a 20-minute film about the park, natural history exhibits, and a bookstore. Cades Cove is inside the park, 18 km from the nearest town, and includes a campground and a one-way, 18-km paved road, Cades Cove Loop Road (CCLR). The road allows visitors and park staff to travel through the area, providing scenic views, vehicle pull-offs at four trailheads, and direct access to 25 historical buildings, most of which are < 0.15 km from the road.

### **Sampling design**

From June to August 2021, we attempted to survey 400 adult visitors (18 years of age or older) at both GRSM units, for a total of 800 completed surveys. The sample size was determined based on Vaske's (2008) recommendation that "For most parks, recreation, and human dimensions studies... sample size of approximately 400 is often considered to be suitable for generalizing to a population at a 95% confidence level with a  $\pm 5\%$  margin of error." We utilized intercept sampling to recruit voluntary participants for a tablet-based, self-administered survey at each site. We chose to survey visitors at the visitor center of each site based on the recommendations of the park staff. We collected response data through the program iSurvey (HarvestYourData, 2021). Visitors were approached by the researchers, given a description of the study, and asked if they would like to participate. Every adult park visitor had an equal chance of being approached and recruited for participation in the study when a tablet was available. After visitors completed the survey, they were given a unique sticker designed for the study as compensation for their time. It took visitors 8 to 15 minutes to complete the survey. All research materials and methods were reviewed and approved by the university's institutional review board (UTK IRB-21-06445-XM) and park officials (GRSM-2021-SCI-2153).

### **Survey Design**

Question design was reviewed by three experts and the survey instrument was pretested during cognitive interviews of ten volunteer trial participants to determine appropriate wording and order of questions, the visual design of the survey, and any navigation issues on the tablet (Vaske, 2008; Dillman et al., 2014). All trial participants displayed high comprehension of the questions, with minor wording suggestions. We used expert feedback as well as cognitive interviews to modify the survey instrument accordingly.

This was an exploratory study, so questions were designed to ascertain park visitors' perceptions and knowledge of salamanders and rock stacking within GRSM. The first part of the survey asked about visitors' intended activities in the park and their feelings toward certain resources (i.e., scenic views, large mammalian wildlife, salamanders), threats to them, and efforts to protect them. Following was a suite of attitude questions about salamanders and rock stacking, measured using a five-point Likert-type scale. The suite of rock stacking attitudes contained a photo of a rock stack (Figure 1) and the suite of salamander attitude questions contained an accompanying photo of a black-bellied salamander (*Desmognathus quadramaculatus*), a species commonly found in the park (Figure 3). Participants then answered two identical suites of rock stacking attitude questions—once before reading additional information and again after reading the information. The information provided consisted of a short paragraph describing some of the negative side effects of moving or stacking rocks as follows:

The Great Smoky Mountains National Park (GRSM) is nicknamed the “Salamander Capital of the World!” because it is home to at least 30 different species of salamanders, making it an important biodiversity hotspot.

Rock stacking (cairns), changing the course of streams by building dams or channels, and moving rocks, in general, can have negative effects on salamanders and their habitat.

Additionally, some salamanders breed in the rivers and streams by laying hundreds of eggs that can easily be washed away if the nest area is disturbed.

We then asked visitors if park leaders should manage habitat to protect salamanders and how much they support certain management actions: partially closing areas of streams, creeks, and rivers used by salamanders when breeding; completely closing areas of streams, creeks, and rivers used by salamanders when breeding; stopping people from fishing at certain times of the year; banning the practice of rock stacking; banning the practice of damming or changing the river course by moving rocks; and putting up signs along creeks, rivers, and streams that explain why it is detrimental to stack or move rocks. The final section of the survey focused on socio-demographic characteristics, asking respondents where they were from, how often they visit the park, their education level, and the size of their travel group (Appendix 1).

## **Statistical Analyses**

We assessed non-response error by comparing sociodemographic data from our survey with frequencies available from an NPS report titled “Linking the 2010 Census to National Park Visitors” (Vaske and Lyon, 2014). We used descriptive statistics to calculate measures of frequency for every question and measures of central tendency and variation for questions with interval or scale measurement levels (i.e., attitude questions).

We conducted exploratory factor analysis using principal components analysis to categorize visitor attitudes towards salamanders and rock stacking. We used Cronbach's alpha to assess extracted factor reliability (Vaske, 2008). For these predictor variables, we used the factor scores for items that factored together in later regression analysis. Further exploratory factor analysis was conducted using principal component analysis to categorize visitor attitudes toward

suggested management actions to protect salamander populations and the resulting factor scores were used as the response variables in later regression analysis. We used Cronbach's alpha to assess extracted factor reliability.

Visitor responses to the questions regarding potential management actions were used as the response variable in the regression models. We used multiple linear regression to examine relationships between support for salamander conservation (response variable) and the explanatory variables (attitudes towards salamanders and rock stacking). We assessed normality and homoscedasticity of residuals and checked multicollinearity with variance inflation factor. We evaluated standardized coefficients and 95% confidence intervals to estimate the relative importance of explanatory variables and to determine if a parameter's effect differed significantly from zero. We concluded statistical significance at  $p = 0.05$ . All analyses were conducted in SPSS Statistics 26 (IBM SPSS Statistics for Windows, Version 26.0, Armonk, NY: IBM Corp.).

## **Section 3: Results**

### **Response, demographics, and visitor characteristics**

We collected 817 complete surveys, and non-response equaled 15%. We defined non-response as visitors who refused to take the survey after being spoken to by the researchers. We reached our survey goal of 400 adult visitors at each site, though inadvertently surveyed 17 additional people at Sugarlands Visitor Center ( $n = 417$ ). We found no evidence of non-response bias when compared to available sociodemographic data (i.e., for age, ethnicity, and education) for U.S. National Park visitors (Vaske and Lyon, 2014), suggesting that the data collected in this study may accurately reflect visitors to U.S. national parks in general.

Respondents were 54% female, 87% white, and averaged  $31 \pm 19$  (Mean  $\pm$  SD) years old. Most respondents had earned a bachelor's degree (30%) or more than a bachelor's degree (34%). Less than half of the respondents (42%) indicated that it was their first time visiting Great Smoky Mountains National Park. Nearly 35% of participants indicated they lived in either Tennessee (12%), Ohio (8%), Florida (8%), or Texas (7%), though we recorded participants from 43 states. One respondent indicated that they currently live in Mexico.

### **Attitudes toward salamanders and knowledge of threats**

Overall, respondents had a positive attitude toward salamanders. Most respondents indicated that they were cute (34%) or very cute (28%), valuable (46%) or very valuable (39%), and harmless (35%) or very harmless (41%, Table 1). More than half (53%) of respondents had prior knowledge of salamanders existing in GRSM.

Most respondents indicated that habitat loss (53%), disturbance from people (54%), and pollution (57%) are extreme threats to salamander populations within the park. Disease is currently perceived as a moderate threat (31%). Out of the potential threats listed, most participants indicated disturbance from people (43%) as being the main threat (Table 2).

Of the suite of salamander attitude questions, all factored except the one regarding salamander abundance. Factor analyses determined that park visitors had mostly positive attitudes towards salamanders and those responses explain roughly 56% of the variation in the data with a Cronbach's  $\alpha = 0.56$ , indicating adequate reliability (Vaske, 2008). Four out of the five factors regarding attitudes toward rock stacking explain 75% of the variation in the data with a Cronbach's  $\alpha = 0.56$ , indicating adequate reliability (Table 3, Vaske, 2008).

### **Attitudes toward rock stacking before and after information**

When asked about their attitudes toward rock stacks, nearly half (49%) of the participants indicated that they are pretty or very pretty, neither ugly nor pretty (34%), neither worthless nor valuable (38%), and neither unpleasant nor pleasant (38%, Table 4). Thirty-one percent of respondents indicated that rock stacks are neither harmful nor harmless or are harmful. After answering the first set of questions regarding rock stacking, participants were given a short paragraph describing some of the negative side effects of moving or stacking rocks. Thirty-nine

percent of respondents still answered that rock stacks are pretty or very pretty neither ugly nor pretty (33%), neither worthless nor valuable (30%), and neither unpleasant nor pleasant (30%). However, 37% of respondents then indicated that rock stacks are harmful and another 30% indicated that they are very harmful, which was the biggest shift in perception after receiving the additional information (Figure 4).

### **Attitudes toward educational materials and management actions**

We asked participants how desirable they find the proposed addition of signs, brochures, and ranger talks focusing on salamanders and/or rock stacking within the park, and found that there is strong support for all of the above; 64%, 51%, and 60%, respectively. (Table 5). Additionally, 55% of respondents indicated they would refrain from stacking rocks if the request was written on a nearby sign, and 68% said they would not stack rocks if told by a ranger to stop (Table 6).

The majority of participants (57%) find supporting salamander conservation efforts in the park to be very desirable and 90% support managing streams, creeks, and rivers to protect salamanders during breeding season. The most desired action is for the park to put up signs along creeks, rivers, and streams that explain why it is detrimental to stack or move rocks (61%). Most support park officials banning the practice of damming or changing the river course by moving rocks (47%) and building cairns (39%). Thirty-nine percent of the respondents also support partially closing areas of streams, creeks, and rivers used by salamanders when breeding. There is less support for preventing people from fishing at certain times of the year (34%) and even less support for completely closing areas of streams, creeks, and rivers used by salamanders when breeding (26%). Only 4% of respondents support park managers taking no action to conserve salamander populations (Table 7).

Next, we asked respondents how desirable they find supporting the conservation of salamanders in the national parks and 95% indicated that this was either desirable or very desirable. Finally, we asked visitors how desirable reading about salamander conservation is through educational materials on National Parks' websites, displays in visitor centers, or signs throughout the park and 91% responded that this is desirable or very desirable. Seventy-nine percent of participants responded that it is desirable or very desirable to participate in live or recorded education programs and tours that focus on salamanders and their conservation (Table 8).

Support for salamander conservation was measured using a single statement that asked respondents if park leaders should take action to manage streams, creeks, and rivers to protect salamander populations within the park. Most respondents (90%) indicated that, yes, they want park managers to take some action to further protect salamanders and aquatic habitat. To evaluate the influence of visitor attitudes towards salamanders and visitor attitudes toward rock stacking on their support for salamander conservation actions, we first defined our explanatory variables (attitudes towards salamanders and attitudes toward rock stacking after additional information) by identifying statements within each variable that factored together, were unidimensional, and had high internal consistency. Attitudes towards salamanders included four statements, though one item (abundance) was removed to improve internal consistency as it was

not a good measure of attitudes. The remaining four statements factored together, explaining 56% of the variance with a Cronbach's  $\alpha = 0.59$ , indicating adequate reliability (Vaske, 2008; Table 3). Attitudes toward rock stacking included five statements, though the statement regarding rock stack abundance was removed to improve the internal consistency as it was not a good measure of attitudes towards rock stacking. The remaining four items explained 75% of the variance with a Cronbach's  $\alpha = 0.89$ , indicating adequate reliability (Vaske 2008; Table 3). Attitudes toward six proposed management actions factored together, explained 58% of the variance, and produced a Cronbach's  $\alpha = 0.82$ , indicating adequate reliability (Vaske 2008; Table 9). 'Take no action' was not included in this factor analysis in order to improve internal consistency. Furthermore, very few respondents (4%) want the park to take no action to conserve salamander populations and aquatic habitat.

When we regressed support for salamander conservation actions with the explanatory variables, the resulting model explained 56% of the variance. Attitudes toward salamanders ( $\beta = 0.22$ ,  $p < 0.001$ ) had a positive effect on visitor support for salamander conservation actions. Attitudes toward rock stacking, after additional information describing negative effects of stacking or moving rocks, ( $\beta = -0.36$ ,  $p < .001$ ) had the greatest effect on explaining how likely visitors were to support salamander conservation actions (i.e., more negative attitudes toward rock stacking increases positive attitudes toward management actions) (Table 10).

## Section 4: Discussion

Evaluating public support for conservation initiatives and assessing attitudes towards wildlife species of concern is crucial for achieving conservation objectives. The overall goal of this study was to examine visitor perceptions and knowledge of salamanders and rock stacking within the Great Smoky Mountains National Park in order to provide suggestions for additional outreach strategies that may enhance visitors' educational experiences and to promote support for salamander conservation. We found that visitors had mostly positive attitudes toward salamanders, neutral or negative attitudes toward rock stacking, and positive attitudes toward proposed management actions.

Some local nonprofit organizations, such as the Friends of the Smokies, are actively trying to inform park visitors about the detrimental effects of rock stacking. In a blog post from 2015, the group implores visitors to refrain from stacking rocks in and around streams (McDaniel, 2015). As mentioned previously, moving rocks can disrupt the habitat for aquatic animals like salamanders, but the damage extends throughout the aquatic ecosystem. Aquatic plants like algae provide a vital food source for fish and other aquatic creatures as well as provide oxygen to the stream. Furthermore, algae can help purify the water by absorbing extra nutrients and heavy metals. If rocks with algae on them are removed from the stream or river, an important part of an integrated system disappears. The addition of signs throughout the park, including in visitor centers and around streams and rivers, may reduce the overall abundance of rock stacks in and near the water. Additionally, other studies suggest that implementing more salamander-focused information, especially online and on social media, has the potential to increase visitor engagement and can lead to an increase in desired outcomes, like elevated support for salamander conservation and reduced rock stacking (Knackmuhs, 2011). These additions should increase visitors' positive attitudes towards salamanders and negative attitudes towards rock stacking. In turn, these shifts in attitude should increase support for salamander conservation (Vaske 2008). The results here suggest that even a small amount of information can quickly and positively enhance attitudes toward target species and proposed management actions. In a similar study, researchers asked whether children's judgments of harmful actions toward animals depend on animals' perceived attractiveness (Collado, et al., 2021). For the first part of the study, children were asked to rate different species based on their perceived attractiveness. Afterward, the researchers created short environmental education intervention programs based on the species rated as unattractive to determine whether attitudes could be easily swayed. After the educational intervention, the children rated unattractive animals as more attractive than before the intervention. These two studies suggest that learning about certain species, even in limited capacities, can increase how attractive they are perceived and can influence positive attitudes toward these species. With this information, park managers can create and implement educational programs aimed at communicating the damaging effects of rock stacking while highlighting the importance of salamander conservation within the GRSM and other US National Parks.

More research is needed to support this and other social science studies regarding perceptions of wildlife; empirical biological data are lacking. Unger et al. (2017), found evidence of direct mortality in hellbenders due to rock stacking and stream manipulation, but few studies have assessed instream recreation (e.g., fishing, tubing, swimming) and related habitat alteration in watersheds known to contain protected aquatic species (Unger et al., 2020). Data needs to be

collected and then shared with the public. Most park visitors want to recreate responsibly, but many are unaware of the detrimental effects of their actions. Sharing information and creating more outreach initiatives can spark public support for increased management actions and aid in the success of conservation programs for aquatic species, particularly salamanders. We postulate that social media may be fueling an increase in rock stacking, as people may view the stacks as attractive. This idea was supported by our data as people viewed rock stacks as relatively pretty and pleasant, both before and after information about how they can damage aquatic wildlife like salamanders. Some businesses may also perpetuate these detrimental activities by encouraging patrons to stack rocks in streams on-premises or on specific rock stacking tables/bins while visiting (FoxFire Mountain, 2019). Though it is likely unintentional, people may assume that an activity that is encouraged in one place, may be encouraged—or at least accepted—everywhere. Ultimately, the extent of rock stacking and rock moving across public access streams and rivers in National Parks and National Forests is currently unknown, however this activity warrants further examination. Future and more extensive monitoring of recreational activities may be addressed by deploying interpretive signs at highly trafficked sites and possibly even by stationed personnel or volunteers at these locations so visitors can be informed on conservation efforts, as well as the “dos and don’ts” of freshwater recreation.

For outreach initiatives and conservation efforts to be successful, there must be some emotional or intellectual connection made between visitors and the resource (salamanders and pristine freshwater habitat). A case study by Knapp and Benton (2004) suggests that some interpretive programs fall short of their goals because they do not foster two-way communication between the visitor and interpreter. Therefore, an interpretive experience should include interactive input from the visitors throughout the program and should not be a one-sided lecture (Knapp and Benton, 2004). To further the success of an interpretive program and, ultimately, conservation efforts, there also needs to be community outreach, particularly in those communities surrounding US National Parks and Forests. If these programs are successful, we should see gradual changes in visitor perceptions and attitudes toward salamanders and rock stacking. Recent studies (George et. al, 2016 and Fagan et. al, 2018) have highlighted the shifts in public perception of ‘non-traditional wildlife’, like bats, toward the positive. In the past, bats have been viewed as scary and ugly by the public. The emergence of White-Nose Syndrome (WNS; *Pseudogymnoascus destructans*), an infectious disease of hibernating bats caused by a fungal pathogen, has caused drastic population decline (USGS, 2018). Since the emergence of WNS, there has been an increase in outreach programs and interpretive initiatives highlighting the ecological importance of bats and their ongoing conservation efforts from US National Parks and Forests. Another study found that, “...park visitors had positive attitudes towards bats, were relatively knowledgeable of bat ecology, recognized the importance of bats to ecosystems, and had a high recognition of WNS,” (Shapiro et. al, 2021). It is possible that the increased exposure and attention given to these taxa may contribute to increased positive attitudes toward them (George et. al, 2016). We assert that an increase in salamander-focused programs in parks and surrounding communities may have the same positive effect on salamanders and their conservation. We suggest the park emphasize the detrimental effects of rock stacking and provide visitors with information on how they can help conserve salamander populations. Additionally, we suggest that researchers conduct focus groups with park visitors to discuss how parks can better engage visitors in salamander and freshwater conservation efforts during and after their visit. As salamander populations continue to decline, it will be vital to integrate

biological and social science research to achieve management goals focused on enhancing recreation and conservation.

There were two primary limitations of this study. First, this study only surveyed visitors in one national park. Thus, we caution against generalizing these results to the United States public, as national park visitors may be more inclined to support salamander conservation efforts and may express alternate attitudes toward rock stacking, although more studies are required to determine if this is true. Second, there was the potential for social desirability and acquiescence bias. Although the questions were not highly personal and we did not collect any identifiable information, there is a possibility that people felt the need to answer questions in ways they thought were socially acceptable because they were taking a survey in a national park.

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## Appendices

*Table 1. During June-August 2021, Great Smoky Mountains National Park visitors (n = 817) were asked to describe salamanders based on a suite of attitude questions. Responses were mostly positive, and percentages of participants are displayed in the table.*

<b>Would you describe salamanders as...</b>	<b>Response (%)</b>
Cute	34.0
Very cute	27.7
Valuable	46.0
Very valuable	39.0
Harmless	35.0
Very harmless	41.0

Table 2. During June-August 2021, Great Smoky Mountains National Park visitors (n = 817) were asked to describe potential threats to salamander populations within the park. Responses designated as 'extreme threat' are represented in the table as percentages. When asked to pick one of the threats as the most prevalent, 43% of participants indicated 'disturbance from people'.

<b>Potential threats to salamander populations</b>	<b>Extreme threat response (%)</b>
Habitat loss	53.0
Disturbance from people*	54.0
Pollution	57.0
Disease	31.0

\*Indicated as main threat by 43.0% of total respondents

Table 3. Factors and associated measurement items were assessed in an analysis of Great Smoky Mountains National Park visitor perceptions of salamanders and rock stacking during June to August 2021. We present factor loadings, item means, standard deviations, and Cronbach's  $\alpha$ .

Factors and associated measurement items	Factor loadings	Mean	SD
<i>Attitudes toward salamanders</i>			
<b>Cronbach's <math>\alpha = .59</math></b>			
Ugly/cute <sup>a</sup>	.74	3.86	.94
Worthless/valuable <sup>b</sup>	.79	4.30	.68
Harmful/harmless <sup>c</sup>	.71	4.23	.76
<i>Attitudes toward rock stacking (before)<sup>1</sup></i>			
<b>Cronbach's <math>\alpha = .89</math></b>			
Ugly/pretty <sup>d</sup>	.86	3.43	1.14
Worthless/valuable <sup>b</sup>	.86	2.65	1.10
Harmful/harmless <sup>c</sup>	.81	2.80	1.16
Unpleasant/pleasant <sup>e</sup>	.93	3.13	1.10
<i>Attitudes toward rock stacking (after)<sup>2</sup></i>			
<b>Cronbach's <math>\alpha = .89</math></b>			
Ugly/pretty <sup>d</sup>	.81	3.12	1.15
Worthless/valuable <sup>b</sup>	.89	2.34	1.17
Harmful/harmless <sup>c</sup>	.84	2.23	1.18
Unpleasant/pleasant <sup>e</sup>	.91	2.63	1.16

<sup>a</sup> Ordered responses: 1 = very ugly, 2 = ugly, 3 = neither ugly nor cute, 4 = cute, 5 = very cute

<sup>b</sup> Ordered responses: 1 = very worthless, 2 = worthless, 3 = neither worthless nor valuable, 4 = valuable, 5 = very valuable

<sup>c</sup> Ordered responses: 1 = very harmful, 2 = harmful, 3 = neither harmful nor harmless, 4 = harmless, 5 = very harmless

<sup>d</sup> Ordered responses: 1 = very ugly, 2 = ugly, 3 = neither ugly nor pretty, 4 = pretty, 5 = very pretty

<sup>e</sup> Ordered responses: 1 = very unpleasant, 2 = unpleasant, 3 = neither unpleasant nor pleasant, 4 = pleasant, 5 = very pleasant

<sup>1</sup> Reported attitude toward rock stacking given no additional information.

<sup>2</sup> Reported attitude toward rock stacking given additional information on negative effects of rock stacking.

Table 4. Great Smoky Mountain National Park visitor perceptions of rock stacking before and after additional information describing some negative effects presented as raw numbers and percentages (n = 817).

<b>Description of rock stacking</b>	<b>Before</b>	<b>After</b>	<b>Before (%)</b>	<b>After (%)</b>
Very ugly	73	103	8.9	12.6
Ugly	56	100	6.9	12.2
Neither ugly nor pretty	257	268	33.7	32.8
Pretty	259	245	31.7	30.0
Very pretty	142	75	17.4	9.2
Very worthless	152	202	18.6	24.7
Worthless	170	240	20.8	29.4
Neither worthless nor valuable	307	244	37.6	29.9
Valuable	124	83	15.2	10.2
Very valuable	36	24	4.4	2.9
Very rare	3	9	0.4	1.1
Rare	80	73	9.8	8.9
Neither rare nor common	258	253	31.6	31.0
Common	326	345	39.9	42.2
Very common	119	113	14.6	13.8
Very harmful	98	241	12.0	29.5
Harmful	247	300	30.2	36.7
Neither harmful not harmless	247	130	30.2	15.9
Harmless	117	71	14.3	8.7
Very harmless	84	56	10.3	6.9
Very unpleasant	82	163	10.0	20.0
Unpleasant	105	193	12.9	23.6
Neither unpleasant nor pleasant	306	245	37.5	30.0
Pleasant	220	145	26.9	17.7
Very pleasant	75	43	9.2	5.3

Table 5. During June-August 2021, visitors to Great Smoky Mountains National Park (n = 817) were asked how desirable or undesirable they find the proposed addition of signs, brochures, and ranger talks focusing on salamanders within the park and the detriments of stacking rocks. Their responses are represented as raw percentages in the table below.

	<b>Undesirable</b>	<b>Somewhat undesirable</b>	<b>Neither undesirable nor desirable</b>	<b>Somewhat desirable</b>	<b>Desirable</b>
Signs	0.5	1.0	7.8	26.8	63.3
Brochures	1.5	2.7	13.1	30.8	50.9
Ranger talks	0.5	1.1	11.4	26.3	59.7

Table 6. During June-August 2021, visitors to Great Smoky Mountains National Park (n = 817) were asked to respond to the statement, “I am less likely to build cairns or stack rocks if...”. Their responses are represented as raw percentages in the table below.

	<b>Strongly disagree</b>	<b>Disagree</b>	<b>Neither disagree nor agree</b>	<b>Agree</b>	<b>Strongly agree</b>
The request is written on a sign	0.9	1.3	5.8	37.0	54.1
A ranger tells me not to do it	0.4	0.9	4.4	25.5	67.8
The group I am traveling with is not doing it or tells me not to do it	1.1	1.6	10.4	31.9	53.0
Other visitors are not doing it or tell me not to do it	1.5	3.9	14.6	32.6	45.4

Table 7. During June-August 2021, visitors to Great Smoky Mountains National Park (n = 817) were asked how much they support certain proposed management actions aimed at protecting salamander populations within the park. Their responses are represented as raw percentages in the table below.

<b>Proposed Management Actions</b>	<b>Strongly Oppose</b>	<b>Oppose</b>	<b>Neither Support nor oppose</b>	<b>Support</b>	<b>Strongly Support</b>
Partially close areas of streams, creeks and rivers used by salamanders when breeding	0.5	2.2	8.7	48.2	38.8
Completely close areas of streams, creeks and rivers used by salamanders when breeding	1.7	11.8	25.5	33.5	26.1
Stop people from fishing at certain times of the year	1.1	5.6	13.8	44.3	33.8
Ban the practice of rock stacking	1.8	7.5	19.3	31.5	38.7
Ban the practice of damming or changing the river course by moving rocks	0.7	3.3	10.5	37.0	46.8
Put up signs along creeks, rivers, and streams that explain why it is detrimental to stack or move rocks	0.4	0.9	7.0	29.4	61.2
Take no action	48.3	18.6	10.4	4.3	3.7

Table 8. During June-August 2021, visitors to Great Smoky Mountains National Park (n = 817) were asked to respond to these statements about their attitudes toward proposed management actions and information about salamanders. Their responses are represented below as raw percentages.

	<b>Very undesirable</b>	<b>Undesirable</b>	<b>Neither undesirable nor desirable</b>	<b>Desirable</b>	<b>Very desirable</b>
For me, supporting the conservation of salamanders in the national parks is:	0.1	0.2	4.9	36.8	56.5
For me, reading about salamander conservation in National Parks through educational materials in National Parks' websites, displays in their visitor's center, and signs throughout the park is:	0.1	0.5	8.1	41.4	48.6
For me, participating in live or recorded education programs and tours that focus on salamanders and their conservation is:	0.5	3.7	16.2	38.1	39.8

Table 9. Factors and associated measurement items were assessed in an analysis of the Great Smoky Mountains National Park visitor perceptions of proposed management actions from June to August 2021. We present factor loadings, item means, standard deviations, and Cronbach's  $\alpha$ .

<b>Factors and associated measurement items</b>	<b>Factor loadings</b>	<b><math>\bar{x}</math></b>	<b>SD</b>
<i>Attitudes toward management actions</i>			
Partially close areas of streams, creeks and rivers used by salamanders when breeding <sup>a</sup>	0.75	4.25	0.75
Completely close areas of streams, creeks and rivers used by salamanders when breeding	0.72	3.72	1.04
Stop people from fishing at certain times of the year	0.73	4.05	0.90
Ban the practice of rock stacking (cairns)	0.76	3.99	1.03
Ban the practice of damming or changing the river course by moving rocks	0.80	4.28	0.84
Put up signs along creeks, rivers, and streams that explain why it is detrimental to stack or move rocks	.70	4.52	.70
Take no action <sup>b</sup>		1.78	1.11
<b><i>Cronbach's <math>\alpha = .81</math><sup>c</sup></i></b>			

<sup>a</sup> Ordered responses for each question: 1 = strongly oppose, 2 = oppose, 3 = neither oppose nor support, 4 = support, 5 = strongly support

<sup>b</sup> This option was not included in the factor analysis as it did not factor together with the management actions

<sup>c</sup> Measure of internal consistency and scale reliability.

Table 10. Multiple regression model for support for salamander management actions by visitors to Great Smoky Mountains National Park during June to August 2021 ( $n = 817$ ). We present standardized parameter estimates ( $\beta$ ), standard errors (SE), lower and upper limits of the 95% confidence interval, and statistical significance. Adjusted  $R^2 = .21$ ,  $F = 95.78$ ,  $p < 0.001$ .

<b>Variable</b>	<b><math>\beta</math></b>	<b>SE</b>	<b>Lower CL</b>	<b>Upper CL</b>	<b><math>p(\beta)</math></b>
Attitudes toward salamanders	0.22	0.34	0.15	0.26	<.001
Attitudes toward rock stacking (after additional information)	-0.36	0.34	-0.42	-0.29	<.001



*Figure 1. Rock stack found within the Great Smoky Mountains National Park mid-stream. Photo courtesy of William Britten Photography.*

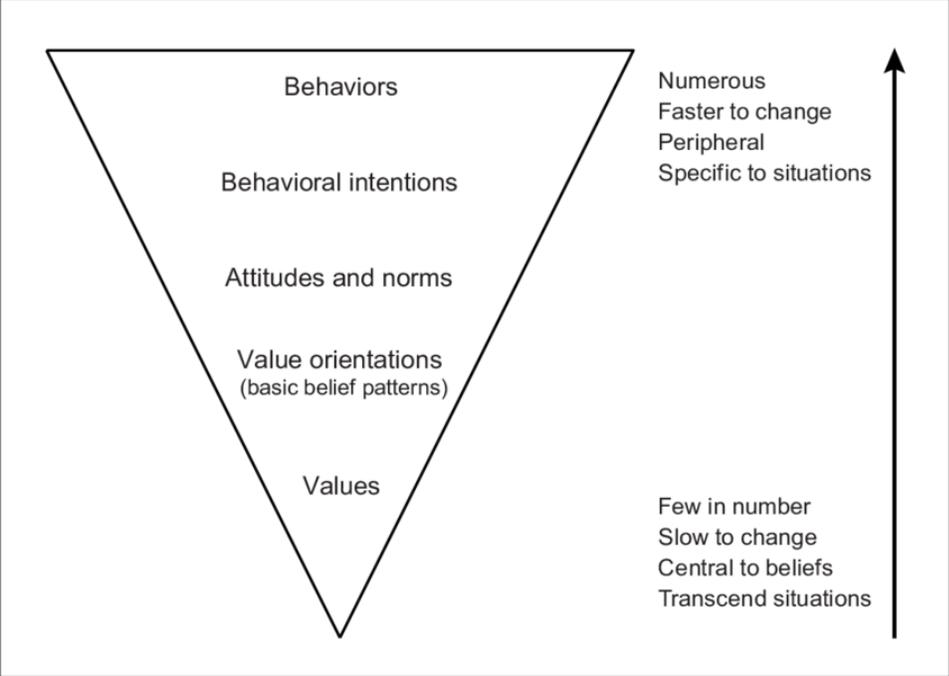


Figure 2. The cognitive hierarchy model of human behavior as presented by Vaske and Donnelly (1999).



Figure 3. Photograph of a black-bellied salamander (*Desmognathus quadramaculatus*), a common species found within the Great Smoky Mountains National Park.

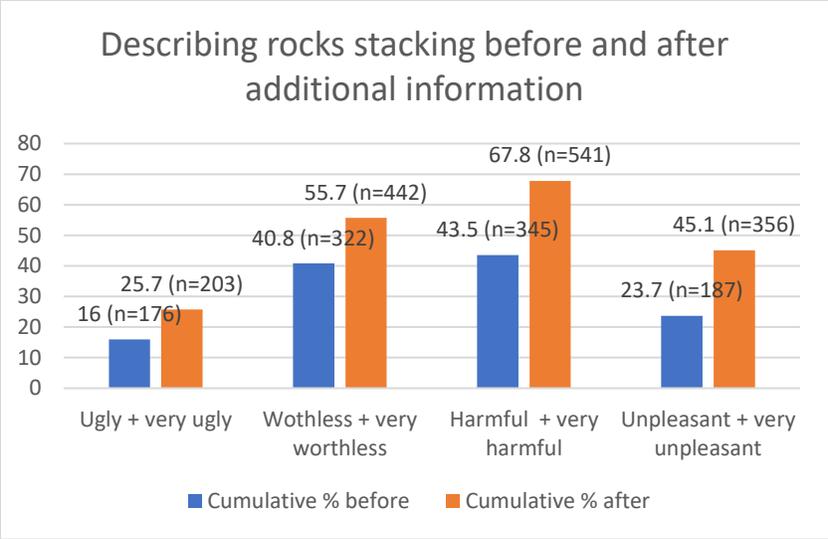


Figure 4. Great Smoky Mountain National Park visitor perceptions were analyzed from June to August 2021. This chart highlights the cumulative percentages of visitor perceptions of rock stacking before and after additional information describing negative impacts was given (n=817).

**SURVEY ITEMS USED TO ASSESS VISITOR PERCEPTIONS OF SALAMANDERS,  
ROCK STACKING, AND PROPOSED MANAGEMENT ACTIONS**

1. Please indicate which of the following activities you have (or plan to) participate in during your visit at Great Smoky Mountains National Park (GRSM) today:

*(Check all that apply)*

- Sightseeing
- Visit a specific natural area
- Visit a specific cultural area
- Attend an interpretive nature tour
- Attend an interpretive historic tour
- Exercise
- Spiritual or restorative experience
- Spending time with family, friends, or guests
- Picnic
- Nature photography
- Wildlife viewing
- Fishing
- Swimming or wading
- Biking
- Other

2. Please indicate how important **you think** it is for the following resources to be protected in GRSM:

	<i>Not important</i>	<i>Slightly important</i>	<i>Moderately important</i>	<i>Important</i>	<i>Very important</i>
Scenic Views					
Historic Buildings					
Streams & Rivers					
Wildlife like black bears, wild turkey, and white-tailed deer					

Wildlife like birds, bats, and salamanders					
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3. Which do you think is the **most important** resource to protect in GRSM? (*Pick one*)

- Scenic views
- Historic buildings
- Wildlife like black bears and white-tailed deer
- Wildlife like birds, bats, and salamanders
- I'm not sure

4. Please indicate the degree to which you oppose or support efforts to protect each of the following types of wildlife.

	<i>Strongly Oppose</i>	<i>Oppose</i>	<i>Neither oppose nor support</i>	<i>Support</i>	<i>Strongly Support</i>
Large-bodied wildlife like black bears, wild turkey, and white-tailed deer					
Small-bodied wildlife like song birds, raccoons, and squirrels					
Amphibians and reptiles like salamanders, frogs, and lizards					



S. Blackman 2019

The southern Appalachian Mountains contain the highest diversity of salamanders in the world. Pictured above is a Black-bellied (*Desmognathus quadramaculatus*) salamander. It is one of 30 different species of salamander found within the Great Smoky Mountains National Park (GRSM). The following four questions ask your opinion about salamanders within the park.

5. Please describe salamanders based on the following characteristic:

- Very ugly
- Ugly
- Neither ugly nor cute
- Cute
- Very cute

6. Please describe salamanders based on the following characteristic:

- Very worthless
- Worthless
- Neither worthless nor valuable
- Valuable

- Very valuable

7. Please describe salamanders based on the following characteristic:

- Very rare
- Rare
- Neither rare nor common
- Common
- Very common

8. Please describe salamanders based on the following characteristic:

- Very harmless
- Harmless
- Neither harmless nor harmful
- Harmful
- Very harmful

9. Prior to receiving this survey, did you know about salamanders in GRSM?

- Yes
- No

10. Have you ever seen a salamander in GRSM?

- Yes
- No

11. How likely do you think it is for you to see salamanders in GRSM?

- Very Unlikely
- Unlikely
- Neither unlikely nor likely
- Likely
- Very Likely

12. How much of a threat **do you think** each of the following are to salamanders in Tennessee?

	<i>Not a threat at all</i>	<i>Low threat</i>	<i>Somewhat of a threat</i>	<i>Moderate threat</i>	<i>Extreme threat</i>	<i>I don't know</i>
Disease						
Habitat Loss						

Disturbance from people						
Pollution						

13. From the list of potential threats above, which do you think is the **one main threat** to salamanders in Tennessee? (*Pick one*)

- Disease
- Habitat loss
- Disturbance from people
- Pollution

14. Please respond to these statements about your attitudes towards the following management actions:

	<i>Very undesirable</i>	<i>Undesirable</i>	<i>Neither undesirable nor desirable</i>	<i>Desirable</i>	<i>Very desirable</i>
For me, supporting the conservation of salamanders in the national parks is:					
For me, reading about salamander conservation in National Parks through educational materials in National Parks' websites, displays in their visitor's center, and signs					

throughout the park is:					
For me, participating in live or recorded education programs and tours that focus on salamanders and their conservation is:					

15. Please indicate how desirable you find these educational materials about **salamanders** in the park:

	<i>Undesirable</i>	<i>Somewhat undesirable</i>	<i>Neither undesirable nor desirable</i>	<i>Somewhat desirable</i>	<i>Desirable</i>
Signs					
Brochures					
Ranger talks					



*William Britten Photography*

Most cairns or rock stacks found within the park are manmade. Above is an example of what one may look like. The next five questions ask your opinion about cairns within the park.

16. Please describe rock stacks (cairns) based on the following characteristic:

- Very ugly
- Ugly
- Neither ugly nor pretty
- Pretty
- Very pretty

17. Please describe rock stacks (cairns) based on the following characteristic:

- Very worthless
- Worthless
- Neither worthless nor valuable
- Valuable
- Very valuable

18. Please describe rock stacks (cairns) based on the following characteristic:

- Very rare
- Rare
- Neither rare nor common
- Common
- Very common

19. Please describe rock stacks (cairns) based on the following characteristic:

- Very harmful
- Harmful
- Neither harmful nor harmless
- Harmless
- Very harmless

20. Please describe rock stacks (cairns) based on the following characteristic:

- Very unpleasant
- Unpleasant
- Neither unpleasant nor pleasant
- Pleasant
- Very pleasant

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*The Great Smoky Mountains National Park (GRSM) is nicknamed the “Salamander Capital of the World!” because it is home to at least 30 different species of salamanders, making it an important biodiversity hotspot.*

*Rock stacking (cairns), changing the course of streams by building dams or channels, and moving rocks in general can have negative effects on salamanders and their habitat.*

*Additionally, some salamanders breed in the rivers and streams by laying hundreds of eggs that can easily be washed away if the nest area is disturbed.*

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*William Britten Photography*

Given the information provided above, please answer the following questions about rock stacking within the park.

21. Please describe rock stacks (cairns) based on the following characteristic:

- Very ugly
- Ugly
- Neither ugly nor pretty
- Pretty
- Very pretty

22. Please describe rock stacks (cairns) based on the following characteristic:

- Very worthless
- Worthless
- Neither worthless nor valuable
- Valuable
- Very valuable

23. Please describe rock stacks (cairns) based on the following characteristic:

- Very rare
- Rare
- Neither rare nor common
- Common
- Very common

24. Please describe rock stacks (cairns) based on the following characteristic:

- Very harmful
- Harmful
- Neither harmful nor harmless
- Harmless
- Very harmless

25. Please describe rock stacks (cairns) based on the following characteristic:

- Very unpleasant
- Unpleasant
- Neither unpleasant nor pleasant
- Pleasant
- Very pleasant

26. Should park leaders manage streams, creeks, and rivers to protect salamanders while they are breeding?

- Yes
- No
- I don't know

27. Following are several hypothetical actions that park managers of Great Smoky Mountains National Park (GRSM) could take to help salamanders when they are breeding. Please indicate the degree to which you would oppose or support each of the following management actions.

	<i>Strongly Oppose</i>	<i>Oppose</i>	<i>Neither Oppose nor Support</i>	<i>Support</i>	<i>Strongly Support</i>
Partially close areas of streams, creeks and rivers used by salamanders when breeding					
Completely close areas of streams, creeks and rivers used by salamanders when breeding					
Stop people from fishing at certain times of the year when salamanders are breeding					
Ban the practice of rock stacking (cairns)					
Ban the practice of damming or changing the river course by moving rocks					

Put up signs along creeks, rivers, and streams that explain why it is detrimental to stack or move rocks					
Take no action to conserve salamanders when breeding					

28. I am **less likely** to build cairns or stack rocks if:

	<i>Strongly disagree</i>	<i>Disagree</i>	<i>Neither disagree nor agree</i>	<i>Agree</i>	<i>Strongly agree</i>
The request is written on a sign					
A ranger tells me not to do it					
The group I am traveling with is not doing it or tells me not to do it					
Other visitors are not doing it or tell me not to do it					

29. Please respond to these statements about your attitudes towards the following management actions:

	<i>Very undesirable</i>	<i>Undesirable</i>	<i>Neither undesirable nor desirable</i>	<i>Desirable</i>	<i>Very desirable</i>
For me, supporting the conservation of salamanders in the national parks is:					

<p>For me, reading about salamander conservation in National Parks through educational materials in National Parks' websites, displays in their visitor's center, and signs throughout the park is:</p>					
<p>For me, participating in live or recorded education programs and tours that focus on salamanders and their conservation is:</p>					

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*The following section asks for some basic information about you and your visit to Great Smoky Mountains National Park (GRSM). This information will be used for research purposes only and will not be associated with you in any way.*

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30. How often do you visit Great Smoky Mountains National Park?

- First visit
- Every few years
- Once a year

- 2-5 times a year
- More than 5 times a year
- Weekly
- Other

31. Which best describes you and your travel group? (*Pick one*)

- Travelling alone
- Adult couple, 18 years and older, no children
- Young family, children under 6 years old
- Mid-life family, children 7-17 years old
- Mature couple, no children at home
- With friends or relatives
- Business associates travelling together
- School, university, or sporting group
- Tour group
- Other

32. What is your current age?

- 18-24 years
- 25-30 years
- 31-40 years
- 41-50 years
- 51-60 years
- 61+ years

33. What is the highest level of education you have attained?

- Less than a high school diploma or equivalent
- A high school diploma or equivalent
- Some college
- Associate degree
- Bachelor's degree
- More than a bachelor's degree

34. Which race/ethnicity best describes you?

- American Indian or Alaskan Native
- Asian / Pacific Islander
- Black or African American
- Hispanic American or Latinx
- White/ Caucasian
- Multiple Ethnicity / Other

35. What is your gender identity?

- Female
- Male
- Non-binary
- Other

36. What state do you currently live in? [ *Please enter the abbreviation for your state. For example, Tennessee = TN* ]

37. If you do not currently live in the United States, where do you live? (*Write in*)

## **Vita**

Savannah Blackman is from Kingsport, Tennessee. After high school, she attended the University of Tennessee, Knoxville, where she earned a B.S. in Wildlife & Fisheries Management, with minors in Forestry and Resource Sustainability. Before graduating with her undergraduate degree, she knew she wanted to further her education in graduate school. She chose to remain at the University of Tennessee, Knoxville and pursue a master's degree in Wildlife and Fisheries with an emphasis on human dimensions of wildlife. Her research interests include human dimensions of wildlife and wildlife conservation.