Assessing the Reliability of Computer Simulation Modeling for Monitoring and Managing Indicators of Wilderness Solitude in Great Smoky Mountains National Park

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ABSTRACT

Several studies in the field of outdoor recreation management and planning have used computer simulation modeling to demonstrate its utility as a tool to help managers monitor encounters and similar visitor use-related indicators of quality. However, previous applications of computer simulation modeling to outdoor recreation planning and management have generally done little to assess the reliability, or precision, of model estimates. The purpose of this research is to explore several questions concerning the reliability of computer simulation model estimates for monitoring wilderness solitude-related indicators of quality. In particular, can reliable estimates of solitude-related indicators be generated for low use recreation environments, such as backcountry and wilderness areas? Is there a spatial component to questions about the reliability of computer simulation estimates for low use visitor landscapes? The research presented in this thesis examines the reliability of computer simulation estimates of wilderness solitude indicators that account for the timing and location of hiking and camping encounters in the backcountry of Great Smoky Mountains National Park.

This study was designed to model visitor use and inter-group encounters in the Cosby and Big Creek areas of Great Smoky Mountains National Park, which are located within the park's proposed wilderness area. Two primary types of information about visitor use in the study area were collected to construct the computer simulation model in this study. First, information was gathered about the amount of visitation to the study area; second, information was collected about visitors' travel routes within the study area.

Three alternative methods were used to estimate the number of replications needed to obtain desired levels of precision for the visitor-based and spatially based computer simulation model outputs. The results suggest that computer simulation models of visitor use can generate precise estimates for a small to moderate number of visitor-based and spatially-based outputs. However, there are constraints to generating precise estimates of use-related outputs as the number of outputs estimated simultaneously becomes large. This challenge is particularly

pronounced in cases where at least some of the outputs are derived for low use attractions, trails, or camping locations.

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ATTRIBUTIONS

Several colleagues assisted in the research, preparation, and writing of this thesis, specifically Chapter 4, the book chapter. A brief description of their backgrounds and contributions are included in this section:

Dr. Steven R. Lawson, Ph.D. (University of Vermont, Natural Resources) is the primary advisor and committee chair of this research. Dr. Lawson provided insightful knowledge and answers to the many questions proposed, and also provided numerous proof readings and suggestions for improving this thesis and specifically the book chapter manuscript.

Chapter 4 – Book Chapter

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CHAPTER 1 - INTRODUCTION

The preservation of natural areas for aesthetic, recreational, and environmental values has developed throughout American history (Nash, 2001). One of the most important events in the history of American conservation was the passage of the Wilderness Act of 1964 which introduced a legal mandate for the protection of areas as wilderness. The Wilderness Act mandated that wilderness areas should be managed to provide, among other wilderness qualities, "outstanding opportunities for solitude" to recreational visitors (Hendee & Dawson, 2002). In the last several decades, outdoor recreation and visitation to wilderness areas has increased throughout the country (Cordell, 2004), challenging managers' ability to provide visitors with outstanding opportunities to experience solitude. A primary challenge of managing for solitude in the face of increased use of wilderness areas is that growing use of wilderness can cause perceived crowding and/or visitor conflicts among wilderness users (Manning, 1999). This challenge is exacerbated by the fact that backcountry recreation use tends to be concentrated both spatially and temporally (Hendee & Dawson, 2002). For example, use in most wilderness areas tends to be concentrated relatively close to parking areas and along trails leading to desirable destinations (e.g., waterfalls, overlooks, etc.).

To assist wilderness managers in meeting the mandates of the Wilderness Act of 1964 and related management objectives, several planning and management frameworks have been developed, including the Limits of Acceptable Change (LAC) (Stankey et al., 1985) and the Visitor Experience and Resource Protection Framework (VERP) (National Park Service, 1997). The process involved in these frameworks is similar and involves wilderness managers working with the public to define management objectives, indicators of quality, and standards of quality, and monitoring to track changes in indicator conditions over time. Indicators of quality are measurable, manageable variables that serve as proxies for broader management objectives (Manning, 2001). Standards of quality define minimum acceptable conditions of indicator variables, and must be quantifiable and measurable, time specific, and output oriented (Whittaker & Shelby, 1992). Perhaps the most commonly used indicator to operationalize the broader management objective of wilderness solitude has been the number of encounters visitors have with other groups (Dawson, 2004; Freimund, Peel, Bradybaugh, & Manning, 2003; Stewart & Cole, 2001).

Findings from a recent study of wilderness hikers in Shenandoah National Park suggest that there may be multiple dimensions of encounters that influence the extent to which wilderness visitors experience solitude, and that indicators of wilderness solitude might be expanded to include factors such as the timing and location of encounters (Hall, 2001). For example, several hikers interviewed in the study reported experiencing "episodes" of solitude even though they had encountered many other groups during their trip, suggesting that the "longest period of time without encountering another group" might be a valid indicator of wilderness solitude. Similarly, indicators of wilderness solitude might include the "percent of time during which visitors see no other groups," or for multi-day trips, the "percent of days during which visitors see no other groups." Indicators of wilderness solitude might also include the number of encounters during different phases of the wilderness trip, for example, "entry," "immersion," and "exit" phases (Borrie & Roggenbuck, 2001). Few studies have been conducted that examine the effect of these alternative dimensions of encounters on visitors' experiences of solitude, although some have suggested that the effects of encounters on solitude may vary based on the timing and location of encounters during a trip (Freimund & Cole, 2001).

Inter-group encounters in wilderness areas have traditionally been monitored by three different categories of methods: 1) direct observation; 2) indirect methods; and 3) visitor self-reports (Hollenhorst, Whisman, & Ewert, 1992). Monitoring encounters in wilderness and backcountry recreation areas through direct observation has proven to be difficult, given that visitor use tends to be dispersed over relatively large, remote areas that typically have multiple access points (Lawson, Itami, Gimblett, & Manning, 2006). Although indirect techniques, such as monitoring encounters using mechanical trail traffic counters, overcome some of the staffing challenges associated with direct observation methods, monitoring data are subject to more measurement errors than direct observation (Watson, Cronn, & Christensen, 1998). Furthermore, obtaining visitor-reported encounters after groups have completed their trips may not be reliable due to the lack of precision in visitors' recall process (Watson, Cole, Turner, & Reynolds, 2000). For these reasons, managers have struggled in their efforts to monitor inter-group encounters in wilderness. Moreover, while expanding the concept of inter-group encounters to include spatial and temporal dimensions (as suggested in literature reviewed above) may result in identifying indicators that are better proxies for wilderness solitude than simply overall number of encounters, they present an even greater challenge for monitoring.

Recent research suggests that computer simulation modeling may be a useful tool for monitoring "hard to measure" indicators of quality (Lawson, 2006; Lawson, Manning, Valliere,

& Wang, 2003). Computer simulation models can be developed from information that is relatively easy to obtain (e.g., visitor use counts and trip itineraries collected at trailheads) to generate spatially and temporally specific estimates of visitor use and inter-group encounters throughout a dispersed recreation area, often incorporating these outputs input GIS (Gimblett, Richards, & Itami, 2001; Itami, 2003; Itami et al., 2003). Understanding the spatial and temporal use patterns of recreation visitors is helpful for planners to appropriately manage wilderness areas. Computer simulation allows planners and managers to monitor visitor use patterns and encounter-related indicators of quality across relatively large areas with highly dispersed use. For example, use levels and encounter levels can be determined for specific trail segments, campsites, and destination sites that would require significant staff and time to observe directly. Furthermore, the effectiveness of alternative management practices at meeting standards of quality for solitude-related indicators can be tested using simulation modeling in a way that is less costly than on-the-ground trial and error and without loss of freedom to visitors (Lawson & Manning, 2003a, 2003b). For example, alternative permit quotas can be tested to estimate the potential effects on the number of inter-group encounters within a wilderness area. Similarly, additional facilities, campsites, or trails can be added to the simulation of a system to estimate the potential effects on encounter levels and wait times.

Several studies in the field of outdoor recreation management and planning have used computer simulation modeling to demonstrate its utility as a tool to help managers monitor encounters and similar visitor use-related indicators of quality. However, previous applications of computer simulation modeling to outdoor recreation planning and management have generally done little to assess the reliability and validity of model estimates. The reliability of computer simulation model estimates is a particularly important question because computer simulation models use random numbers and/or empirical distributions to generate input variables (e.g., visitor arrival times, durations at destinations, travel routes) and therefore the estimates from a model vary across replications of the model. Consequently, conclusions should not be drawn from a single replication of a model (Law & Kelton, 2000). While this is true across all simulation models, spatial simulations, such as a simulation model of a wilderness area, contain added variability as multiple outputs are often sought for many different locations throughout the system (e.g., use density and inter-group encounters on numerous trail segments and at several day use and/or overnight destinations). Thus, a significant issue within computer simulation modeling is identifying the number of simulation replications needed to estimate model outputs at a desired level of precision. To determine the reliability of computer simulation estimates, confidence intervals should be estimated for each output of interest (e.g., inter-group encounters) from multiple, independent replications (Centeno & Reyes, 1998). While the reliability of visitor use-related estimates from a computer simulation model has been assessed, this work was conducted in an area with very high levels of visitor use (Itami, Zell, Grigel, & Gimblett, 2005). In wilderness areas, the question of reliability is particularly pronounced because visitor use levels and inter-group encounters tend to be relatively low and even moderately imprecise estimates can lead to very different conclusions about the nature of visitor experiences. Thus, it is unclear whether computer simulation models can generate estimates of inter-group encounters and related outputs at a level of precision that is useful for management purposes.

The purpose of this thesis is to explore several questions concerning the reliability of computer simulation model estimates for monitoring wilderness solitude-related indicators of quality. In particular, can reliable estimates of solitude-related indicators be generated for low use recreation environments, such as backcountry and wilderness areas? Is there a spatial component to questions about the reliability of computer simulation estimates for low use recreation environments? That is, is it possible to generate estimates at a level of precision that is useful for management purposes for some, but not all locations within a low use recreation area (i.e., selected trails/trail segments and camping locations)? Similarly, can more precise estimates be generated for visitor-based outputs (e.g., average number of encounters per group per day) than for spatially-based outputs? The research presented in this thesis explores these questions by applying methods developed within the discrete-event systems simulation field. In particular, these methods are used to examine the reliability of computer simulation estimates of wilderness solitude indicators that account for the timing and location of hiking and camping encounters in the backcountry of Great Smoky Mountains National Park.

The remainder of this thesis is organized in the following format: Chapter Two reviews literature relating to and supporting the research conducted for this thesis; Chapter Three provides a detailed description of the research methods used to conduct the research presented in this thesis; Chapter Four contains a draft journal manuscript examining the reliability of computer simulation model estimates for monitoring wilderness solitude-related indicators of quality; and Chapter Five presents results of a visitor survey administered as part of the research presented in this thesis.

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CHAPTER 2 – LITERATURE REVIEW – PRACTICAL, MANAGERIAL AND ACADEMIC GROUNDS FOR RESEARCH

Introduction

As mentioned in Chapter One of this thesis, computer simulation modeling has been applied in wilderness management and planning to monitor indicators and standards of quality. Specifically, previous research suggests computer simulation modeling offers a potentially efficient and cost-effective means for managers to monitor inter-group encounters in wilderness and backcountry environments under current conditions, varying use levels, and alternative management scenarios. The first section of this chapter provides a review of the literature on the use of encounters as an indicator of wilderness solitude. Then, a review of the literature on computer simulation modeling, particularly for the use of monitoring encounter-related indicators and standards of quality is presented. This includes discussion of the history of computer simulation modeling as applied to outdoor recreation management, beginning with the Wilderness Use Simulation Model (WUSM). The chapter concludes with a review of literature concerning the reliability and validity of computer simulation model outputs and questions about these issues as they relate to the use of computer simulation modeling in relatively low use wilderness and backcountry recreation environments.

LAC and VERP Frameworks

Several frameworks have been developed to help guide and inform the management of visitor experiences and resource conditions within wilderness areas and other types of outdoor recreation settings. The U.S. Forest Service has developed and published the Limits of Acceptable Change (LAC) planning framework (Stankey et al., 1985); similarly the National Park Service has developed a framework referred to as the Visitor Experience and Resource Protection (VERP) planning framework (National Park Service, 1997). These planning frameworks incorporate monitoring of indicators and standards of quality that serve as proxies for more broadly defined management objectives. These indicator-based planning frameworks follow similar steps to help inform effective monitoring and appropriate management of outdoor recreation areas. These steps are briefly reviewed in the following paragraphs.

The first step within indicator-based frameworks is for managers and planners to work with the public to define management objectives for alternative management zones within the area that reflect the purposes and legal mandates of the park or natural area, as well as the desired future conditions of resource and social conditions (Manning, 1999). Management objectives should also incorporate visitor preferences and expectations about wilderness qualities. Within wilderness management, an example of a management objective is providing visitors with outstanding opportunities to experience solitude.

After management objectives have been defined, the next step within indicator-based frameworks is to identify indicators of quality to serve as proxies for management objectives. Indicators of quality are specific, measurable, manageable variables that reflect the essence of the associated management objective(s) (Hendee & Dawson, 2002). Good indicators of quality are specific to a given objective, easily and reliably measured, sensitive to change, and correspond to significant impacts to an area’s resources and/or visitors’ experiences (Whittaker & Shelby, 1992). Following with the example introduced in the previous paragraph, an indicator of quality for wilderness solitude might be the number of encounters visitors have with other groups during their visit.

After indicators have been chosen for each management objective, standards of quality are defined for each indicator variable. Standards of quality define the minimum acceptable condition of the corresponding indicator variable. Good standards of quality are quantifiable, time-bound, specific, reasonably attainable by management, and “output-oriented” instead of focusing on the *process* (i.e., management action) that might be used to achieve a standard (Whittaker & Shelby, 1992). For example a standard of quality for the number of encounters visitors have with other groups might state that visitors will encounter no more than three other groups per hour while hiking in the wilderness area.

Once indicators and standards of quality have been defined, the next step is to implement a monitoring program to periodically assess and document indicator conditions, allowing comparison to standards. For example, monitoring the number of groups visitors encounter during a wilderness trip serves as the basis to assess the extent to which the broader management objective of providing visitors with opportunities for wilderness-solitude are being met. In cases where monitoring suggests one or more indicator variables is out of standard, management actions are taken to “correct” the conditions and move toward meeting management objectives.

Encounters and Opportunities for Solitude

Perhaps the most commonly used indicator to operationalize the concept of wilderness solitude has been the number of encounters visitors have with other groups (Dawson, 2004;

Freimund, Peel, Bradybaugh, & Manning, 2003; Stewart & Cole, 2001). An inverse relationship between the number of encounters an individual has during a wilderness trip and the wilderness visitor's satisfaction level was first measured and reported by Stankey (1972). There has been some debate over the correlation between the number of encounters, crowding, solitude experienced, and visitor satisfaction because results of previous studies of these relationships are variable and, in some cases, contradictory (Hollenhorst & Jones, 2000; Manning, 1999, 2003; Roggenbuck, Williams, Bange, & Dean, 1991; Stewart & Cole, 2001, 2003). However, in some previous studies of wilderness solitude, the number of encounters visitors have with other groups has been found to be inversely related to solitude, and these studies are reviewed in the following paragraphs.

Patterson and Hammitt (1990) studied the relationship between the number of encounters along trails and at campsites and the likelihood of achieving solitude among backpackers at Great Smoky Mountains National Park. Respondents were asked: 1) how important solitude was to visitors; 2) the maximum number of parties and size of parties that visitors would tolerate before reaching unsatisfactory levels; and 3) how the number of parties visitors encountered made them feel towards their solitude experience. Respondents were also asked to report the actual number of encounters they experienced throughout their trip. The majority of backpackers felt that solitude was extremely important, while only 9% felt that solitude was neutral or unimportant to their experience. Of all the respondents, 34% of backpackers indicated that the number of encounters detracted from their solitude experience; however, 93% of those respondents encountered more groups than their specified number of maximum tolerable encounters. Patterson and Hammitt (1990) concluded that the number of encounters may not detract from all visitors' ability to experience solitude, but suggested that "certain types of users" seek and find "certain types of experiences," including experiences of solitude.

Hall and Shelby (1996) studied the relevance of encounters across many different demographic, experience, trip and activity variables. Most of the visitor and trip characteristic variables showed no significant differences among the relevance of encounters. Significant differences were identified for the importance of encounters among varying trailhead use levels. Those visitors that entered the study area through low-use trailheads were more likely to indicate that encounters mattered to their sense of a wilderness experience. Hall and Shelby (1996) speculate that these visitors may be seeking a different experience where outstanding opportunities for solitude are more likely to occur. While some visitors to wilderness areas may rank the impact of encounters on their experience low, many others may rank the impact of encounters very high. Therefore, management should take into consideration the spatial distribution of visitors' views towards encounters, and their effect on visitors' solitude experience (Hall & Shelby, 1996).

In a study of canoeists to the Boundary Waters Canoe Area Wilderness (BWCAW), respondents to a diary type survey were asked to indicate whether they liked or disliked encounters they had and what number of encounters would be acceptable before their experience would be affected (Lewis, Lime, & Anderson, 1996). Eighty-seven percent of the time visitors were asked to respond to the survey in this low-use environment, encounters mattered to the respondent (Lewis et al., 1996). When visitors to BWCAW experienced even one group more than their preferred number of encounters, over 50% disliked the encounters. As the number of groups encountered increased over the preferred number of encounters, the percentage of visitors that disliked the encounters increased. Final conclusions indicated that management could effectively develop indicators and standards using encounter preferences from visitor surveys.

A similar study examined opportunities for solitude in BWCAW (Watson, 1995) by looking at the number of encounters backcountry visitors experienced and the number they would find acceptable. Encounter levels were examined by placing visitors into groups based on which entry point they entered for their trip. Entry points were categorized by use level from overnight permit data. Although preferences for encounter levels differed by entry use level, the proportions of visitors who experienced more encounters than they considered acceptable were not significantly different across entry use level (Watson, 1995). It was determined that management could decrease the number of permits issued to reduce the number of encounters which would increase opportunities for solitude for some visitors.

Research at Grand Canyon National Park (GCNP) examined the relationship between three distinct use level zones, the importance of solitude, and the satisfaction with encounter levels (Stewart & Carpenter, 1989). Using expectancy theory, it was determined that if a visitor found solitude important and was satisfied with the number of encounters they experienced, their need for solitude was fulfilled (Peterson, 1974). Differences between visitors' satisfaction with hiking encounters versus camping encounters were also examined. Across all use level zones, over 20% of those visitors who felt solitude was important to their trip experience were not satisfied with the number of encounters they experienced, although visitors were more satisfied with hiking encounters than camping encounters (Stewart & Carpenter, 1989). In GCNP, visitors in the lower use zones placed more importance on solitude than in higher use zones. Similarly, visitors of lower use zones were also more likely to be satisfied with the number of encounters they experienced. This may suggest that those visitors who find solitude important may hike or camp in areas were they may expect to find more opportunities for solitude (Stewart & Carpenter, 1989).

Spatial and Temporal Dimensions of Encounters

In the 1960's and 1970's outdoor recreation managers and planners determined that recreation areas needed to be managed for multiple uses, activities, and experiences. The Recreation Opportunity Spectrum (ROS) was established to accomplish this planning goal (Driver, Brown, Stankey, & Gregoire, 1987). Using ROS, recreation areas are zoned for specific uses, activities, types of experiences, and different social, physical, and managerial settings. Different recreation opportunities were demanded and preferred by visitors, and many zones could be managed appropriately to provide visitors with a diversity of recreation opportunities and experiences (Driver et al., 1987). While zoning of wilderness is a controversial issue, some people have advocated for adopting a Wilderness Opportunity Spectrum for wilderness areas that is similar conceptually to the ROS approach, but focused on the primitive end of the recreation spectrum. The concept of wilderness zoning is based on the idea that there is a spatial dimension to wilderness conditions and associated visitor experiences, including opportunities for solitude and inter-group encounters. That is, within and across wilderness areas, some locations receive higher levels of use, resulting a greater number of inter-group encounters and potentially diminished opportunities for solitude, while the opposite is true in more remote areas.

As mentioned above, the number of encounters an individual or group has with other visitors within a wilderness area has been the most widely used indicator of wilderness solitude. Most commonly, the average number of encounters per group per unit of time (e.g., per hour, per day, per trip, etc.) has been used as the indicator for wilderness solitude. However, some studies have suggested that the *overall number* of encounters visitors have with other groups may have only a limited effect on visitors' sense of solitude (Patterson & Hammitt, 1990). In a response to a similar critique of the use of encounters as an indicator for solitude, Manning (2003) states that visitors may find the number of encounters less important than the “locations of encounters (e.g., near a trailhead or farther along the trail).” Similarly, Dawson (2004) describes a spatial dimension of encounters when he defines solitude, stating that encounters occur “along trails (e.g., away from access points), at hiking destinations (e.g., lakes, vistas, and landscape features), and at campsites.” He also suggests specific indicators for solitude with similar spatial dimensions, including the average number of encounters per mile on trails *away from access points*. There is empirical support for the idea that spatial dimensions of encounters may be important in fully understanding the relationship between encounters and solitude. For example, the impact encounters have on visitors’ experiences have been shown to vary more by the location and nature of encounters than by the overall number of encounters (Shelby & Heberlein, 1986). Similarly, Aplet and others (2000) suggest using recreation use patterns to examine whether opportunities for solitude are available in an area. Recreation use patterns directly relate to the probability of encountering another individual or group within a given wilderness area.

Findings from a recent study of wilderness hikers in Shenandoah National Park provide empirical evidence that there may also be important temporal factors that help to better understand the relationship between encounters and wilderness solitude (Hall, 2001). For example, several hikers interviewed in the study reported experiencing “episodes” of solitude even though they had encountered many other groups during their trip, suggesting that the “longest period of time without encountering another group” might be a valid indicator of wilderness solitude. Similarly, findings from the study suggest indicators of wilderness solitude might include the “percent of time during which visitors see no other groups,” or for multi-day trips, the “percent of days during which visitors see no other groups.” Results of a study of wilderness visitors in the Okefenokee National Wildlife Refuge suggest indicators of wilderness solitude might also include the number of encounters during different phases of the wilderness trip, such as “entry,” “immersion,” and “exit” phases (Borrie & Roggenbuck, 2001).

A study of wilderness visitors in high-use wilderness destinations in the Cascades Mountains in Oregon and Washington examined temporal and spatial dimensions of inter-group encounters (Cole, Watson, Hall, & Spildie, 1997). Within the study, survey respondents were asked to report the number of encounters they experienced during their trips into the study area, which was then compared to trained observers reports of encounters for many different areas. Results of the study suggest that direct observations with trained observers was a more precise method of monitoring encounters than visitor self-reports (Cole et al., 1997). The number of encounters visitors had was up to three times higher in some lake areas compared to others; encounters were also higher on trails than in campsites. The number of encounters was also three times higher on weekends when compared to weekdays (Cole et al., 1997). These results indicate that encounters among groups in wilderness areas vary both temporally and spatially. In Mount Rainier National Park, a more detailed temporal dimension of encounters was monitored by setting indicators and standards as “encounters per day” and “encounters per hour” (Lah, 2000).

In the study mentioned above in the Boundary Waters Canoe Area Wilderness (BWCAW) (Lewis et al., 1996), findings indicated that there were spatial and temporal patterns to inter-group encounter levels and reported crowding. Respondents to the trip diary often indicated specific lakes or locations where encounters were extremely high or low. Also, encounters were identified to be different between summer versus spring and fall, weekend days versus weekdays, and on holidays versus non-holidays. Management used GIS to visually map visitor use data by lake and region. They spatially analyzed how visitors’ preferences for encounters differed between visitor-reported levels of encounters. The results illustrate that spatially and temporally explicit information about encounter and use levels can aid managers and planners in formulating indicators and standards of quality specific to different management zones (Lewis et al., 1996).

Monitoring Inter-group Encounters

Inter-group encounters in wilderness areas have traditionally been monitored by three different categories of methods: direct observation, indirect methods, and visitor self-reports (Hollenhorst, Whisman, & Ewert, 1992; Watson, Cole, Turner, & Reynolds, 2000). Monitoring encounters in wilderness and backcountry recreation areas through direct observation has proven to be difficult, given that visitor use tends to be dispersed over relatively large, remote areas that typically have multiple access points (Lawson, Itami, Gimblett, & Manning, 2006). Although indirect techniques, such as using mechanical trail traffic counters, to monitor encounters overcome some of the staffing challenges associated with direct observation methods, monitoring data are subject to more measurement errors than direct observation (Watson, Cronn, & Christensen, 1998). Obtaining visitor-reported encounters after groups have completed their trips are subject to recall bias (Watson et al., 2000). For these reasons, managers have struggled in their efforts to monitor inter-group encounters in wilderness. Moreover, while expanding the concept of inter-group encounters to include spatial and temporal dimensions may result in identifying indicators that are better proxies for wilderness solitude than simply overall number of encounters, they potentially present an even greater challenge for monitoring.

Computer Simulation as a Monitoring Tool

Recent research suggests that computer simulation modeling may be a useful tool for monitoring "hard to measure" indicators of quality (Lawson, 2006; Lawson, Manning, Valliere, & Wang, 2003). Computer simulation modeling can be used to understand processes and behaviors of a real system without actually altering the system (Law & Kelton, 2000). Computer simulation models can be developed from easily obtained information (e.g., visitor use counts and trip itineraries collected at trailheads) to generate spatially and temporally precise estimates of visitor use and inter-group encounters throughout a dispersed recreation area. Understanding the spatial and temporal use patterns of wilderness visitors is helpful for informing and guiding management of wilderness areas. Computer simulation allows managers to monitor these use patterns and encounter indicators across relatively large areas with highly dispersed use levels.

First Use of Computer Simulation for Recreation Purposes

Computer simulation modeling has been used in the industrial market for over forty years. Computer simulation modeling offers a unique way to model a system (i.e., a collection of entities, such as people, machines, trails, etc.) without actually modifying or altering the system in any way (Law & Kelton, 2000). Computer simulation models used in recreation settings are dynamic, stochastic, and discrete-event simulations, since most recreation systems share these traits. Dynamic models represent a system as it changes over time, differing from static models that represent a system at one particular point in time. Stochastic simulations are often used to model complex and highly variable systems. Stochastic simulation models take into account the random variation of systems over time through probabilistic components. Discrete-event simulation models imitate systems dynamically where the variables change instantaneously at different points in time when events occur (e.g., a visitor group arrives at a campsite). This is different from continuous systems where variables change continuously over time. A more detailed discussion of computer simulation modeling in general can be found in Law and Kelton

(2000), and a more comprehensive review of computer simulation modeling in recreation settings is presented in Cole (2005).

One of the first computer simulation models used for outdoor recreation applications was the WUSM by Shechter and Lucas (1978). The WUSM was aimed at helping guide management in assessing how varying levels of visitor use in a wilderness area may affect visitors' experiences. The primary inputs into the WUSM consisted of: 1) route networks (i.e., the trail network, trailheads, trail segments, trail intersections, and campsites); 2) user characteristics such as group size, mode of travel, and the hourly, daily, weekly, or seasonal distribution of arrivals of visitors; and 3) visitors' travel routes, including information about the trailhead, trail segments, trail intersections, and camping locations visited during visitors' trips. Outputs that were obtained using the WUSM were dependent on which version of the model that was used. Three main versions were created and the complexity of the inputs and outputs increased as the WUSM evolved from Version I to Version III. The main outputs that were consistent across all three versions were: 1) the amount of use for each trail segment and campsite in the study area; and 2) the number of inter-group encounters per trail segment, campsite, and trip. The development of the WUSM was prompted in large part due to wilderness managers concerns about and interest in obtaining information about inter-group encounter levels. The WUSM produced encounter-related outputs, categorized into four types: 1) camping encounters, resulting from two or more groups using the same camping area on the same night; 2) meeting encounters, resulting when two groups pass each other going in opposite directions on the same trail segment; 3) overtaking encounters, resulting when two groups pass each other going in the same direction on the same trail segment; and 4) visual encounters, resulting when a hiking or camping group is able to see another group hiking on a different trail segment or camping in a different camping location and neither of the three "direct" types of encounters occurs.

The WUSM was first tested in Desolation Wilderness Area in California (Shechter & Lucas, 1978). Thirteen different use level and use pattern scenarios were tested using the WUSM. As use was increased, a proportional increase in the number of encounters was also observed within the outputs of the model. The other scenarios altered use levels differentially by trailhead, resulting in varying levels of trail and campsite encounters as well as varying percentages of groups that met a specific encounter standard. Shechter and Lucas (1978) concluded from this first application of the WUSM that the model had great potential for helping to inform wilderness planning and management. The WUSM was later modified and updated for application to Yosemite National Park (van Wagtendonk, 1978). This application was the first simulation model to be based solely on the information obtained from permit data, as opposed to permit data coupled with survey data. The WUSM model was later applied to model whitewater boating on the Green and Yampa Rivers in Dinosaur National Monument (Lime, Anderson, & McCool, 1978) and on the Colorado River in Grand Canyon National Park (Underhill, Xaba, & Borkan, 1986). Scenarios that were simulated with the WUSM in these studies included varying use levels, types of boats launched, launch schedules, and river flow rates to examine their effects on encounter levels at campsites and delay times at rapids. Different management scenarios and use levels were also simulated using the WUSM on the Appalachian Trail (Potter & Manning, 1984). Camping and trail encounter levels were the primary concern of this simulation model.

Although the WUSM was applied in several areas and management contexts, in the late 1980's use of the model declined. Decline of the model occurred partly due to the high costs of computer hardware and software, and the expense and need for additional computer memory to run the WUSM. Furthermore, the WUSM was not "user-friendly," which served as part of the reason for its decline. Applications of the WUSM demonstrated the potential utility of computer simulation modeling as a tool to help monitor visitor use and inter-group encounter levels in wilderness areas, which proved to be a valuable alternative to the relatively widespread reliance on intuition and best guesses for monitoring managing visitor use and experiences in wilderness areas (Cole, 2005).

Contemporary Computer Simulation Technology

Since the WUSM era of simulation modeling in outdoor recreation management and planning, there have a number of important improvements in computer simulation modeling technology that overcome some of the limitations that led to the decline of the WUSM. Reduced costs and advances in computer hardware and software in the past decade have greatly increased the versatility and capability of computer simulation for all uses, but especially for recreational uses (Cole, 2005). Simulating the behavior of a recreationist has progressed from probability-based decision models to inclusion of rule-based behavior through autonomous agents. Today, two main software packages are used to simulate recreation behavior and are described in this section, although others have been or are being developed. The first software package is a general purpose simulation program called Extend that has been adapted for recreational uses. Extend is an object-oriented, discrete-event dynamic simulation package that requires little to no code writing, and is relatively easy to use to develop models of low to moderate complexity and geographic scope (Manning, Valliere, Wang, Lawson, & Newman, 2002/2003). Extend has been used in studies in several national parks and national forests, including: Acadia National Park (Wang & Manning, 1999);Yosemite National Park (Manning et al., 2002/2003); Arches National Park (Lawson, Manning, Valliere et al., 2003; Lawson, Manning, Valliere, Wang, & Budruk, 2002); Isle Royale National Park (Lawson, Kiely, & Manning, 2003; Lawson & Manning, 2003a, 2003b; Lawson, Manning, & Kiely, 2003); and the Desolation Lake area of the John Muir Wilderness (Lawson et al., 2006). Outputs generated using the Extend software package include: 1) hiking and camping use levels, by location; 2) hiking and camping encounters, by location; 3) the number of people at one time (PAOT) at recreation sites/attractions; and 4) persons-per-viewscape (PPV) along trails and roads. Within the studies outlined above, a primary application of Extend simulation modeling has been to model the potential effects of increasing use levels and/or alternative management scenarios (e.g., permit quotas, changes in infrastructure, regulating the timing and location of visitor use, etc.) on crowding-related indicators of quality like those listed above.

The second computer simulation software package that is currently used for recreational purposes is Recreation Behavior Simulation (RBSim). RBSim was designed and programmed with recreation purposes in mind, and is currently developed specifically for each study area and output requirements. RBSim links directly with geographic information system (GIS) software that allows for visual outputs. These visual outputs provide an effective means for communicating modeling results to managers and the public (Gimblett & Itami, 1997). Like Extend, RBSim also has the capability to incorporate rule-based modeling through autonomous agents. Rule-based modeling within RBSim and Extend are designed to have each simulated group “decide” on a travel route in real-time based on environmental conditions they experience during their trip (e.g., number of people at attractions, distance to parking lot, level of energy expended, etc.; Cole, 2005). Rules used as the basis for agents’ decision-making are based on expert knowledge. While the rule-based approach to modeling within RBSim and Extend has the potential to allow for more valid simulations of novel scenarios (e.g., construction of new roads, parking lots, trails, etc.), the validity of such simulations are dependent on properly defining rules for agents' behavior. Because rule-based simulations are particularly attractive for simulating novel scenarios, however, it is potentially difficult to define rules of behavior for such situations. Research designed to develop rules empirically would strengthen the confidence with which agent-based simulation modeling could be used as a tool to inform outdoor recreation planning and management. RBSim has been used in studies in a number of national parks and recreation areas, including: Grand Canyon National Park (Daniel & Gimblett, 2000); Coconino National Forest (Gimblett, Durnota, & Itami, 1996); Parks Victoria, Australia (Itami et al., 1999); and Banff National Park, Canada (Itami, Zell, Grigel, & Gimblett, 2005). Similar to Extend, outputs generated using RBSim include use levels and encounter levels along trails, in campsites, and at recreation sites. Like Extend, RBSim's visual depictions of model outputs can be generated using maps and visualizations of each simulation can be produced as each simulation is run.

Examples of Computer Simulation Use and Outputs

The most basic use of computer simulation modeling is to understand use patterns at their current level. Understanding how use is distributed throughout an area is helpful for planners and managers to allocate resources and anticipate and understand recreation-related impacts. Simulation modeling can also be used to monitor various indicators of quality that are important to management objectives. Computer simulation models have mainly been used to estimate encounter-related indicators of quality. Using computer simulation for these purposes has been done in many recreation areas. The WUSM was the first of this use, although outputs have increased in complexity since the WUSM. At the Frank Church – River of No Return Wilderness area, RBSim was used to model the current use of the trails and recreation sites around lakes in the study area, including monitoring the number of camping and trail encounters among visitor groups (Gimblett, Cable, Cole, & Itami, 2005). Similar outputs of trail and campsite use and encounter levels have been estimated in Desolation Wilderness Area using the Extend software package (Lawson et al., 2006).

Computer simulation modeling is also used to estimate how implementing different management actions within a recreation area can affect the spatial and temporal distribution of use, as well as the condition of use-related indicators of quality. For example, if management is concerned with campsite encounters, alternative permit systems with varying quotas on permits could be simulated to estimate how different permit levels affect the number and location of camping encounters that occur within the area. Alternatively, the construction of additional campsites could be simulated to estimate the number and most efficient locations of new campsites to reduce camping encounters. In Isle Royale National Park, alternative management actions were tested using Extend to see how the number of visitors that share backcountry campsites in the park would be reduced (Lawson, Kiely et al., 2003). Alternative management scenarios altered permit levels, added campsites, and enforced fixed itineraries to see how the number of groups that shared campsites was affected. Similarly, in Port Campbell National Park in Australia, simulation modeling was used to estimate the effects of adding new parking facilities, toilet facilities, and walkways on the density of visitor use at the primary attraction site in the park (Itami, 2005).

Simulation modeling has also been used to predict how indicators and standards will potentially be affected at future increased levels of visitor use (Itami, 2005; Lawson, Manning, Valliere et al., 2003). Use levels within computer simulation models can easily be increased or decreased to varying degrees. Using computer simulation models to incrementally increase or decrease visitor use away from current use levels can help planners and managers anticipate the effects of future changes in visitation on use and encounter-related indicators of quality (e.g., inter-group encounters, PAOT, etc.).

Reliability and Validity of Computer Simulation Estimates

The studies described in the previous section of this chapter are suggestive of the utility of computer simulation modeling in helping managers monitor encounters and similar visitor use-related indicators of quality. However, previous applications of computer simulation modeling to outdoor recreation planning and management have generally done little to assess the reliability and validity of model estimates. The reliability of computer simulation model estimates is a particularly important question because computer simulation modeling uses random numbers to generate input variables (e.g., visitor arrival times, durations at destinations) and therefore the estimates from a model vary across replications of the model. Consequently, conclusions should not be drawn from a single replication of a model (Law & Kelton, 2000). While this is true across all probability-based computer simulation models, spatial simulations, such as simulation models of wilderness areas, contain added variability as multiple outputs are often sought for many different locations throughout the system (e.g., use density and inter-group encounters, by trail segment, day use and/or overnight destination, management zone, etc.). To determine the accuracy and reliability of computer simulation estimates, confidence intervals should be estimated for each model output of interest (e.g., inter-group encounters) from multiple, independent replications (Centeno & Reyes, 1998). To do this, the computer simulation model is replicated a number of times with independent estimates of the indicator of interest for each replication of the model. The question remains, how many replications must be performed to generate reliable estimates from the simulation model? Itami and others (2005) have examined this question in the context of high use recreation areas (i.e., Banff, Yoho, Kootenay, and Jasper National Parks, Canada). Within the study, the number of replications needed to estimate trail and destination use and encounter levels within specified confidence intervals was estimated. Several conclusions were drawn from the results of the study. First, the higher the sensitivity of the performance indicator to random variation, the higher the number of replications will be needed. For example, use for a specific trail may vary widely from day-to-day, resulting in higher numbers of replications needed to produce reliable estimates. Second, tradeoffs may need to be made between the level of precision of the estimates of performance indicators and the amount of computer time needed, as well as the size of output files. Lastly, the authors suggest that if tradeoffs must be made between reliability and computer resources (i.e., computer run-time, file storage capacity, etc.), the reliability of each performance indicator should be mapped. For example, the reliability of use level estimates for each trail segment within the study area should be mapped to illustrate the precision of model estimates for each trail segment. Managers and researchers can then see how confidence intervals and reliability vary spatially within the study area and make more informed choices about the tradeoffs between reliability and computer resources (Itami et al., 2005).

In wilderness areas, the question of reliability is particularly pronounced because visitor use levels and inter-group encounters tend to be relatively low and even moderately imprecise estimates can lead to very different conclusions about the nature of visitor experiences. Thus, it is unclear whether computer simulation models can generate estimates of inter-group encounters and related outputs at a level of precision that is useful for management purposes. The purpose of the research presented in this thesis is to explore several questions concerning the reliability of computer simulation model estimates for monitoring wilderness solitude-related indicators of quality. In particular, can reliable estimates of solitude-related indicators be generated for low use recreation environments, such as backcountry and wilderness areas? Is there an overall level of use an area must receive below which it is not practical to generate reliable estimates of visitor use and inter-group encounters? Is there a spatial component to questions about the reliability of computer simulation estimates for low use recreation environments? That is, is it possible to generate estimates at a level of precision that is useful for management purposes for some, but not all locations within a low use recreation area (i.e., selected trails/trail segments and camping locations)? This thesis explores these questions by applying methods developed within the discrete-event systems simulation field to examine the reliability of computer simulation estimates of wilderness solitude indicators that account for the timing and location of hiking and camping encounters in the backcountry of Great Smoky Mountains National Park.

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CHAPTER 3: METHODS AND ANALYSIS

Introduction

The study presented in this thesis involved a variety of data collection, modeling, and analysis methodologies. The first section of this chapter describes the study area for the research presented in this thesis. Next, information about the methods used to collect data for the construction of a computer simulation model of visitor use in a portion of the backcountry of Great Smoky Mountains National Park is presented. Final sections describe the modeling of the study data within RBSim simulation software and the output analyses conducted to assess the reliability of the model's outputs.

Study Area

The study area for this thesis research lies within Great Smoky Mountains National Park, located in eastern Tennessee and western North Carolina (Figure 3.1). Great Smoky Mountains National Park is within close proximity to many major metropolitan areas including: Washington, DC; Baltimore, MD; Asheville, Charlotte, and Raleigh, NC; Knoxville and Nashville, TN; Richmond, VA; Atlanta, GA; Louisville, KY; and Cincinnati, OH. The park received over 10 million visitors in 2000, including over 13,000 permits issued to over 34,000 people for overnight trips into the park's backcountry (National Park Service, 2002). A large percentage of the park's overnight backcountry visitors (40% in 2005) camp in shelters along the Appalachian Trail (National Park Service, 2005).

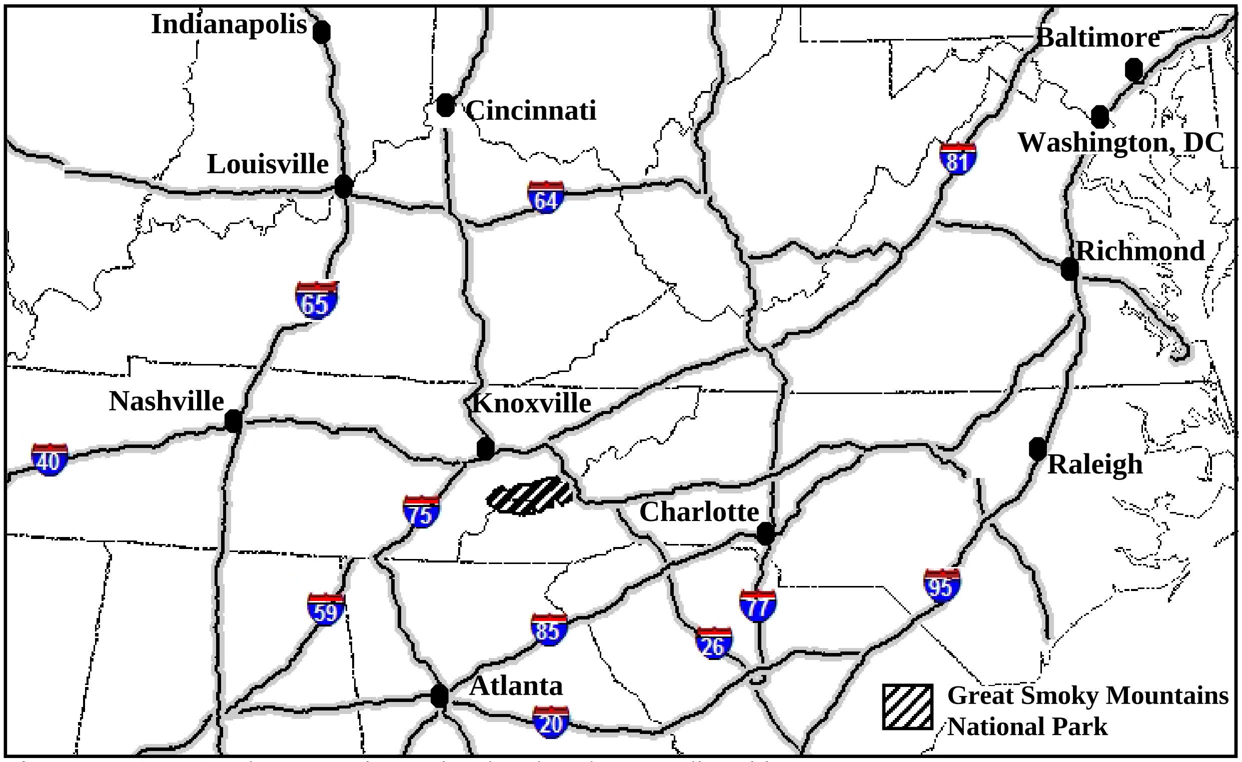

Figure 3.1. Great Smoky Mountains National Park and surrounding cities.

Given the focus of this thesis research on monitoring wilderness solitude-related indicators of quality, an area of the park was chosen for this study that is located in the park's proposed wilderness. Proposed wilderness within Great Smoky Mountains National Park is managed as congressionally designated wilderness, including managing the area to provide visitors with outstanding opportunities for solitude. Further criteria for selecting a study area included focusing on a location that has a relatively limited number of entry locations, a network of backcountry, multiple-use trails and campsites, and a low to moderate level of day and overnight visitor use. The study area was chosen based on these criteria, recommendations from park staff, and several visits to the park. Figure 3.2 presents a map of the park's proposed wilderness areas and the study area for this thesis which includes the Cosby and Big Creek areas of the park.

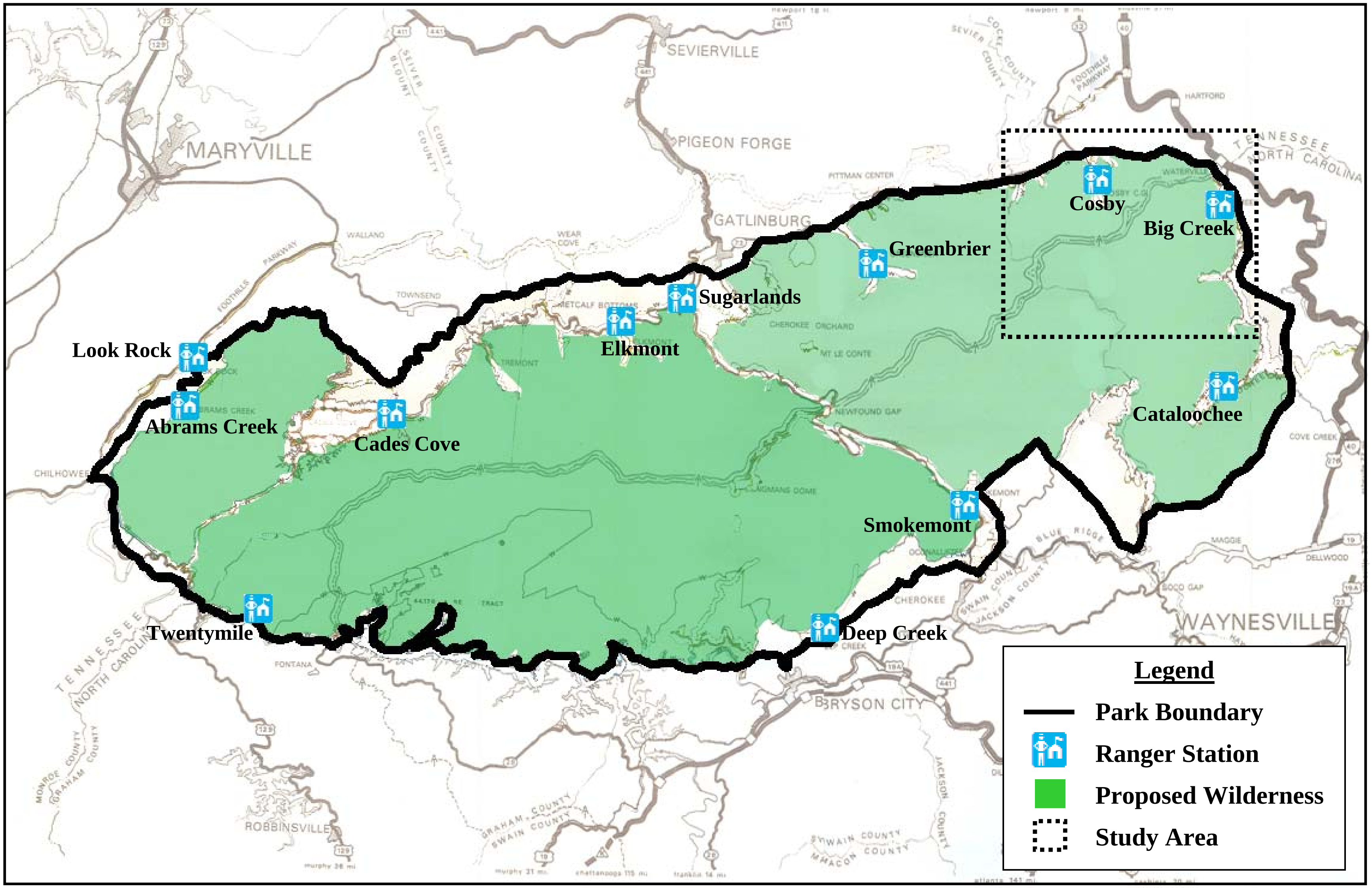

Figure 3.2. The proposed wilderness area of Great Smoky Mountains National Park, with study area marked (National Park Service, 1982).

Figure 3.3 presents a map which provides a detailed view of the trails, campsites, shelters, attractions, and related features in the study area. The Cosby and Big Creek areas are used by day use hikers, day and overnight horseback riders, and backpackers, including Appalachian Trail thru-hikers. Over 85 miles of trails are located in the study area, including 16 miles of the Appalachian Trail. Four of the six campsites and all of the four shelters require visitors to obtain a reservation before visitors can camp overnight. Three of the shelters in the study area are located along the Appalachian Trail and these shelters receive most of the overnight use in the study area (National Park Service, 2005). There are multiple destination sites within the study area that are accessible within a relatively short day's hike, including several waterfalls that are within two miles of a parking lot and trailhead.

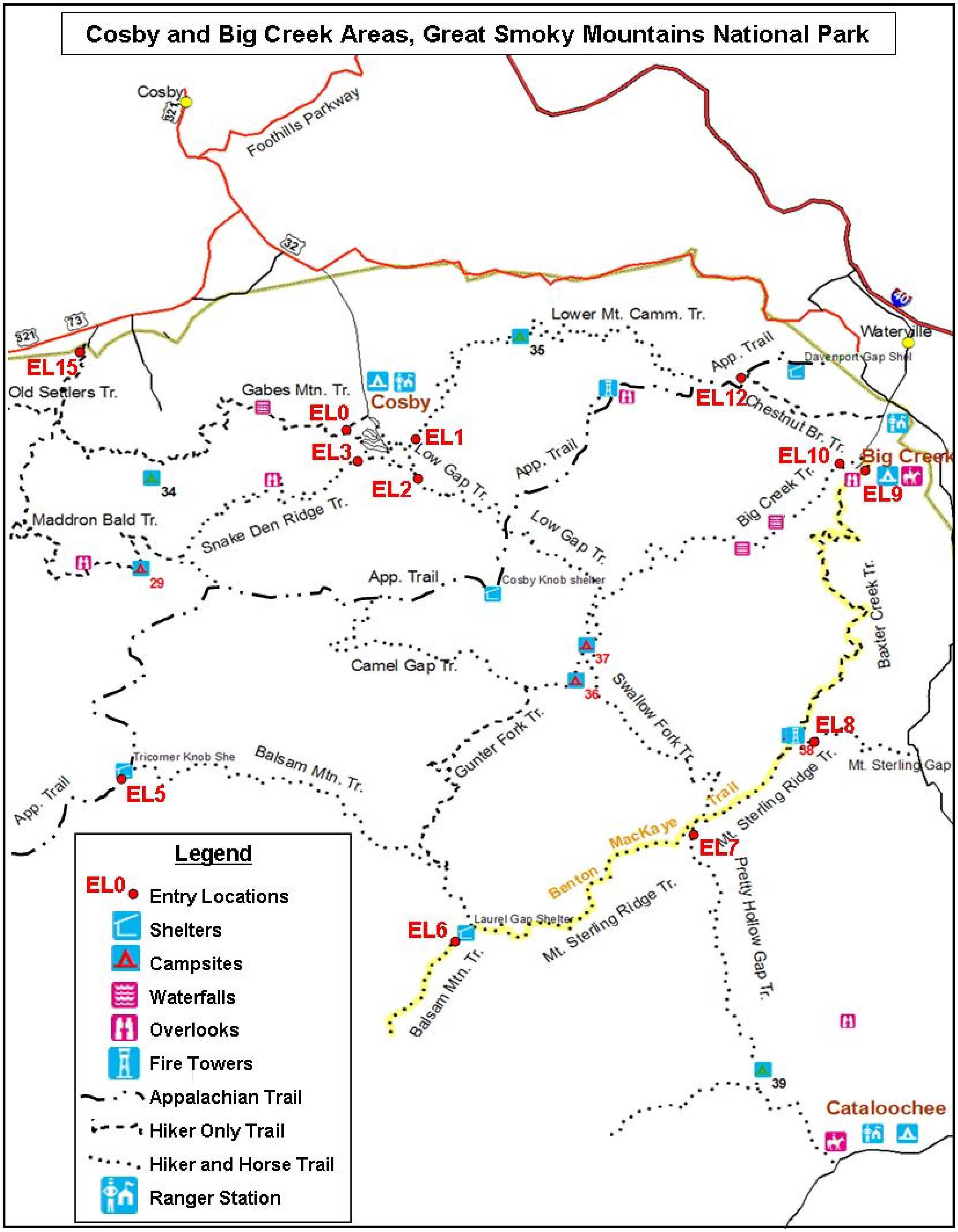

Figure 3.3. Big Creek and Cosby areas of Great Smoky Mountains National Park.

Data Collection

The park's 2002 Backcountry Management Plan outlines areas of research that are important to the success of managing the park's backcountry natural resources and visitor experiences. For example, the park's Backcountry Management Plan details the need for the park to incorporate additional day use monitoring in most of the park, and the use of GIS to categorize the amount, type, and location of visitor use (National Park Service, 2002). The plan also identifies a need for social science research to assess the amount, type, and interaction among backcountry visitor groups. Thus, the research conducted for this study was designed, in part, to address the park's information needs by assessing the temporal and spatial distribution of visitor use and inter-group encounters within the study area through the use of GPS, GIS, and, in particular, the development of a computer simulation model of visitor use in the Cosby and Big Creek areas of the park.

Two primary types of information about visitor use in the study area were required to construct the computer simulation model in this study. First, information was needed about the amount of visitation to the study area. In particular, data were needed on the number of daily arrivals of visitors, by entry location, date, time of day, and type of visitor group (i.e., day use hiker, day use horseback rider, backpacker, and overnight horseback rider). This information was used to parameterize the study model to simulate visitor use levels that correspond to current conditions in May, 2006. These data also provide the basis for "ramping up" the model to simulate increases or decreases in visitation from the status quo use levels. Second, information was needed about visitors' travel routes within the study area, by entry location, time of day, and type of visitor. This information was used to probabilistically assign trip itineraries or travel routes to simulated visitor groups within the computer simulation model.

The data collection procedures used in this study to gather the information needed to construct the computer simulation model of visitor use in the study area include: 1) transcribing backcountry permits; 2) administering a survey of day and overnight visitors; 3) recording visitor use counts using trail traffic counters and direct observation; and 4) conducting direct observations of inter-group encounters on selected trails in the study area. Data were collected for this study from April 23 to May 31, 2006. This period was selected for the study because it represents one of the peak visitor use periods for the study area, and includes the time of the year when most AT thru-hikers pass through the study area. The data collection procedures outlined above are described in the following subsections of this chapter.

Visitor Use Measurement

Day Use Visitors

The amount of day use visitation to the study area was recorded throughout the study period using two separate, complimentary methods. The purpose of this two part approach was to collect a daily count of day use visitation for each entry location into the study area on each day of the study period using indirect observation methods, and to collect information through direct observation on a sample of days to calibrate or "correct" the counts obtained through indirect observation. To obtain a daily count of day use visitation for each entry location into the study area on each day of the study period, mechanical trail-traffic counters were installed at 11 of the 12 entry locations into the study area (Figure 3.3). At each mechanical counter location, a counter was located close to the trailhead, but far enough along the trail to avoid counting casual traffic (i.e., those visitors who did not actually partake in a hike or horseback ride along the trail). The mechanical counters and their sensor scopes were mounted on trees that were approximately 2 to 15 feet away from passing visitors. The counters were camouflaged from visitors' sight using natural materials and camouflaged duct tape. Vegetation and other materials within the counters' sensor ranges were removed to ensure that the counters were not obstructed from detecting passing visitors. Mechanical counters with dual scopes were setup at 8 of the 12 entry locations into the study area (EL1, EL2, EL3, EL5, EL6, EL7, EL8, and EL10 in Figure 3.3), while single scope sensors were setup at the other three entry locations where mechanical counters were installed. The dual scope setup was used to collect separate counts of both foot and horse traffic passing in front of the same counter location (Figures 3.4 & 3.5). On the Gabes Mountain Trail (EL0 in Figure 3.3) and the Baxter Creek Trail (EL9 in Figure 3.3), horse travel is not allowed, so single scope counters were used at these locations to collect counts for foot traffic only. The counts from the mechanical counters were cataloged by location, date, and time of day for each mode of travel (i.e., foot or horseback) using the TRAFx Reporter software package. Frequency distributions of day use visitor group sizes were used to convert these counts of *individuals* to estimates of visitor *group* arrivals.

Figure 3.4. Example of TRAFx mechanical counter installation with dual sensor scopes

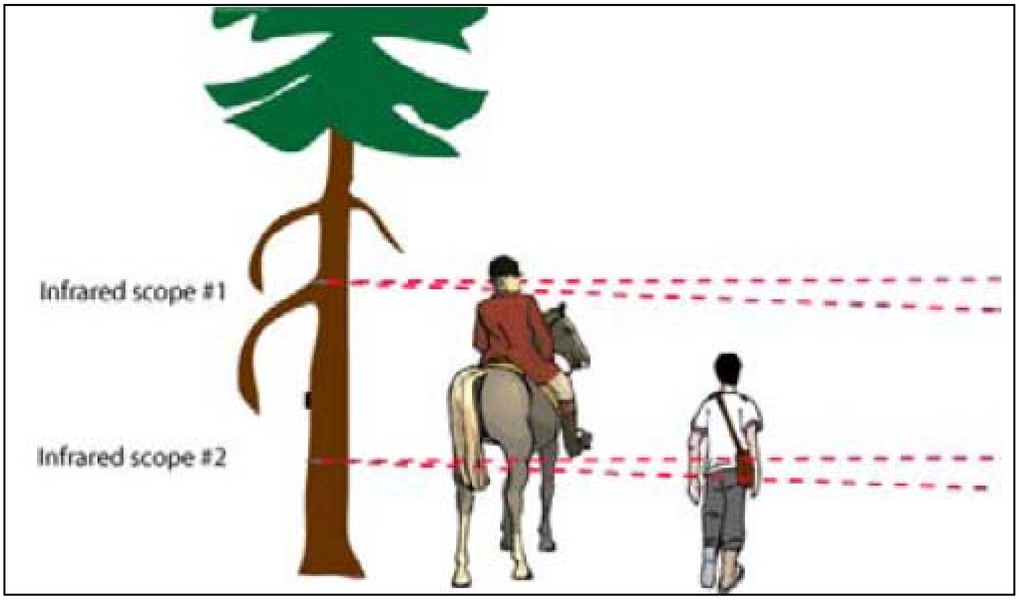

Figure 3.5. Illustration of operation of TRAFx mechanical counter installation with dual sensor scopes (TRAFx, 2006).

The TRAFx trail traffic counters use infrared technology to detect a change in ambient air temperature as visitors pass in front of the sensor scopes. The infrared signal is delayed between triggers to prevent over counting (i.e., counting a single visitor multiple times before they completely pass from the counter's field of detection). The infrared beam widens as the distance between the scope and the trail traffic increases (Figure 3.6). The accuracy of trail traffic counts from the mechanical counters is dependent, in part, on the distance of the scope to the trail traffic, the spacing between individuals, and the delay of the infrared signal. The counters count visitors more accurately if they are in a single file line with some amount of spacing between each visitor. In contrast, visitors walking side-by-side are often counted as only one visitor. If the counter is installed in a location such that visitors pass through the wider portion of the infrared detection cone, a single visitor can be counted multiple times. Thus, despite efforts to install the counters in a manner to minimize counting errors, it was expected prior to the implementation of the study methods that the visitor counts obtained with the mechanical counters would be biased to some degree due to multiple sources of error.

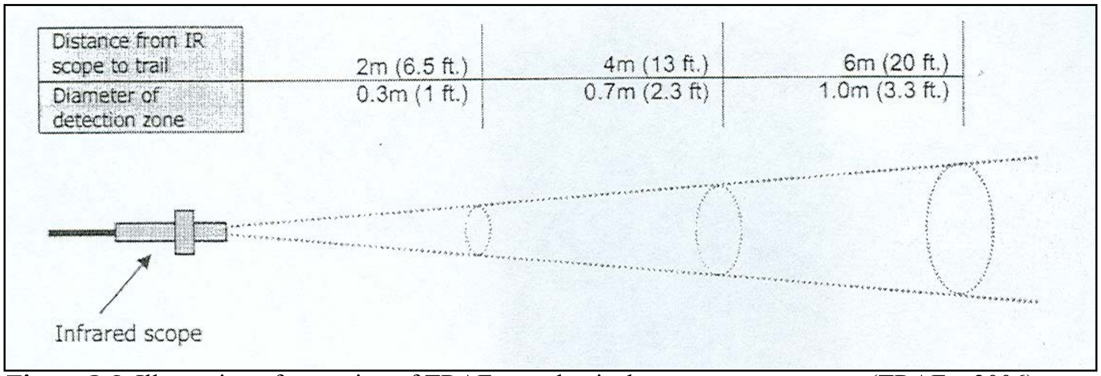

Figure 3.6. Illustration of operation of TRAFx mechanical counter sensor scope (TRAFx, 2006).

As expected, the mechanical counter data reflect biased estimates of visitor use in the study area as a result of several sources of error. For example, while most of the trails within the study area were conducive to single-file travel close to the mechanical counter, on some of the wider trails (e.g., Big Creek Trail), visitors often walk side-by-side. Furthermore, due to mechanical failures, operator errors, and problems with wildlife, mechanical counter data were incomplete for some of the counter locations. In particular, due to errors with downloading of data, most of the counter data were lost at three of the counter locations (EL5, EL9, and EL10 in Figure 3.3). At another counter location (EL12 in Figure 3.3), a black bear was attracted to the scent of the mechanical counter and damaged it beyond repair. Thus, all mechanical counter data were lost for that location. In addition, the Maddron Bald Trail (EL15 in Figure 3.3) was too wide for a mechanical counter to accurately detect visitor use, thus visitor use was not counted with a mechanical counter at this entry location. Table 3.1 reports the total number of days of mechanical counter data that were collected at each entry location into the study area. A combination of statistical methods was used to "backfill" missing counter data and to calibrate counter data for dates and locations without visitor use counts obtained through direct observation. These methods are described in the *Daily Arrivals – Day use* subsection of this chapter.

Table 3.1. Number of Days of Mechanical Counter Data (Out of 31 Days in the Study Period) and Reasons for Missing Days of Data, by Entry Location.

Entry location	Number of days of mechanical counter data	Reason for less than 31 days of mechanical counter data
EL0 – Gabes Mountain Trail	22	Counter installed after May 1
EL1 – Lower Mt. Cammerer Trail	27	Counter installed after May 1
EL2 – Low Gap Trail	31	N/A
EL3 – Snake Den Ridge Trail	24	Counter installed after May 1
EL5 – Appalachian Trail near Tricorner Knob Shelter	3	Operator error
EL6 – Balsam Mountain Trail near Laurel Gap Shelter	5	Operator error
EL7 – Pretty Hollow Gap Trail	28	Counter installed after May 1
EL8 – Mt Sterling Trail	26	Counter installed after May 1
EL9 – Baxter Creek Trail	31	N/A
EL10 – Big Creek Trail	7	Operator error
EL12 – Appalachian Trail near Davenport Gap Shelter	0	Counter destroyed by black bear
EL15 – Maddron Bald Trail	0	No counter installed

As noted above, the a priori assumption about the mechanical counter data was that they would be incomplete and inaccurate. Furthermore, it was known in advance of the study that while the mechanical counter data would be collected for the purposes of measuring the number of *arriving day use* visitors, it would not be possible to differentiate within the raw counter data between counts of overnight and day use visitors, and between counts of arriving and exiting visitors. Thus, the study plan included conducting direct observations of visitor use on a sample of days within the study period. The visitor counts obtained through direct observation were collected in order to "backfill" and calibrate the mechanical counter data, as well as to differentiate day use visitor counts from overnight visitor use counts, and counts of arriving visitors from counts of exiting visitors obtained by the mechanical counters. The direct observations were conducted on at least three randomly selected weekend days and three randomly selected weekdays throughout the study period for every entry location into the study area. Table 3.2 reports the total number of days of direct observation of visitor use for each of the 12 sampling locations.

Table 3.2. Number of Days of Direct Observation of Visitor Use, by Day of Week and Entry Location.

Entry location	Weekdays	Weekend days	Total number of days
EL0 – Gabes Mountain Trail	4	3	7
EL1 – Lower Mt. Cammerer Trail	4	3	7
EL2 – Low Gap Trail	3	3	6
EL3 – Snake Den Ridge Trail	3	3	6
EL5 – Appalachian Trail near Tricorner Knob Shelter	4	4	8
EL6 – Balsam Mountain Trail near Laurel Gap Shelter	3	3	6
EL7 – Pretty Hollow Gap Trail	4	3	7
EL8 – Mt Sterling Trail	3	3	6
EL9 – Baxter Creek Trail	4	3	7
EL10 – Big Creek Trail	5	6	11
EL12 – Appalachian Trail near Davenport Gap Shelter	6	5	11
EL15 – Maddron Bald Trail	6	4	10

On each direct observation sampling day, observations were conducted from 9:00 AM to 5:00 PM. During each observation period, five types of visitor use information were recorded by the observer: 1) the date and time each visitor passed the observation location; 2) visitor type (i.e., day hiker, day horseback rider, backpacker, or overnight horseback rider); 3) gender; 4) group size; and 5) direction of travel (i.e., entering or exiting the study area). Refer to Appendix A for an example of the observation form used to record the direct observation data. A series of linear regression models of the relationship between the direct observation data and corresponding mechanical counter data were estimated and used to adjust the mechanical counter data. The details of the regression analyses are described in the *Daily Arrivals – Day use* subsection of this chapter. Thus, a combination of direct observation and corrected mechanical counter data was used to generate measures of daily *day use* visitation, and this information served as a primary input into the computer simulation model of visitor use in the study area.

Overnight Visitors

Great Smoky Mountains National Park requires all overnight backcountry visitors to fill out a permit before beginning an overnight backcountry trip in the park (see Appendix B for an example of a completed backcountry permit). Many of the campsites and all of the shelters in the park also require a reservation to spend a night at those respective locations. At campsites and shelters requiring a reservation, the National Park Service (NPS) limits the number of visitors per night that can stay at each site. Completed backcountry permits obtained from the park for the dates of the study period were used to collect the following information about overnight visitors' trips to the study area: 1) type of group (i.e., non-AT thru-hiking backpacker, AT thru-hiker, or horseback rider); 2) group size; 3) trip starting location (i.e., trailhead) and date; 4) camping location and date each night of trip; and 5) trip ending location (i.e., trailhead) and date. A total of 412 permits were issued by the NPS for trips taken during the study period and these permits served as a count of the daily amount of overnight visitor use in the study area during the study period. That is, overnight visitor use for each day of the study period was calculated by simply counting the number of permits issued for trips into the study area starting on the corresponding date. Thus, this study treats the 412 backcountry permits as a census of all overnight trips into the study area during the study period and serves as the measure of overnight visitor use in the study area during the study period. This information was coupled with the day use measurements described above to parameterize the computer simulation model to simulate the study area at visitor use levels that correspond to current conditions during May, 2006.

Previous studies have reported relatively high visitor compliance with backcountry permit systems, especially in national parks and areas where permits have been required for a long period of time (Hendee & Dawson, 2002; van Wagtendonk & Benedict, 1980; Watson, 1993). For example, in the Inyo National Forest, visitor compliance with obtaining a permit was reported to be near 95% (DeGraff, 1983). However, visitor compliance rates have been found to be substantially lower in other areas. For example, visitors' compliance rate with the self-issued backcountry permit system in Spanish Peaks Primitive Area was estimated to be only 53% (Lucas & Kovalicky, 1981). Thus, it is likely that our model under-represents total overnight use to a certain degree.

Travel Routes

Day Use Visitors

During the study period, surveys were administered to exiting day use and overnight visitors at 8 of the 12 entry locations into the study area. In particular, surveys were administered at or near the trailheads of the following trails depicted in Figure 3.3: 1) Maddron Bald Trail – EL15; 2) Big Creek Trail – EL10; 3) Baxter Creek Trail – EL9; 4) Appalachian Trail near Davenport Gap – EL12; 5) Gabes Mountain Trail – EL0; 6) Snake Den Ridge Trail – EL3; 7) Low Gap Trail – EL2; and 8) Lower Mt. Cammerer Trail – EL1. The remaining four entry locations into the study area are not trailheads, but rather connect to trails within the park that are outside of the study area. Thus, survey sampling was not conducted at these locations. For each of the eight survey locations, sampling days were randomly assigned to at least four weekdays and four weekend days throughout the study period, although all of the survey locations except the Baxter Creek Trail location received more than the minimum amount of days. Table 3.3 reports the total number of days of survey sampling conducted at each survey location. The day use and overnight visitor survey booklets are presented in Appendices C and D, respectively.

Table 3.3. Overnight and Day Use Visitor Survey Sampling Effort, by Day of Week and Entry Location.

Entry location	Weekdays	Weekend days	Total number of days
EL0 – Gabes Mountain Trail	6	6	12
EL1 – Lower Mt. Cammerer Trail	6	6	12
EL2 – Low Gap Trail	6	6	12
EL3 – Snake Den Ridge Trail	6	6	12
EL9 – Baxter Creek Trail	4	3	7
EL10 – Big Creek Trail	5	6	11
EL12 – Appalachian Trail near Davenport Gap Shelter	6	5	11
EL15 – Maddron Bald Trail	5	5	10

On each survey sampling day, trained survey administrators were located near trailheads within the study area between 10:00 AM and 6:00 PM. Both day use and overnight visitors were asked if they would be willing to participate in the visitor use survey. If they agreed, visitors were administered one of two versions of the visitor survey instrument, depending on whether they had just completed an overnight or day use visit to the study area.

The survey packets administered to day and overnight visitors contained a map of the study area upon which respondents were instructed to record their route of travel during the trip into the study area they just completed. Examples of the route maps day use and overnight visitors were asked to complete as part of the surveys are included as Appendices E and F, respectively. The route maps contained a layout of all trails, campsites, shelters, and destination sites (e.g., waterfalls, fire towers, etc.) within the study area. Using the route map, each respondent traced their route of travel by: 1) marking the starting and ending locations of their trip; 2) recording the starting and ending times of their trip; and 3) placing an 'X' at every location (e.g., at waterfalls, observations points, rest stops, etc.) where they spent more than 5 minutes and recording the total amount of time they spent at each stop. Overnight visitors were also asked to record in the survey booklet: 1) the campsites or shelters at which they camped; 2) the date(s) they camped at each location; and 3) the time they left each camping location in the morning. Survey administrators offered each respondent assistance to locate features on the route survey maps as needed. A database of day use visitor travel routes was constructed from the route maps completed by day use visitor respondents. These routes served as a primary input into the computer simulation model of visitor use in the study area. As described below, the travel routes reported by overnight visitors were not used as inputs into the computer simulation model. Rather, they were used to validate the travel routes reported by overnight visitors on their backcountry permits.

Overnight Visitors

In addition to using the backcountry camping permits issued during the study period as the measure of daily overnight visitor use for the study model, the permits were used to obtain the travel routes and camping locations of overnight visitors. In particular, information recorded by each overnight visitor group on the backcountry permits concerning the starting, camping, and ending locations and dates of their trips was used to construct a database of overnight visitor travel routes. It should be noted that the permit-based overnight visitor routes used in the model may be biased to some degree in cases where visitors changed their itinerary during the course of their trip from what they reported on the permit prior to their trip. For example, in a computer simulation modeling study conducted in Yosemite National Park, it was observed that 62% of overnight visitors made some change to their planned overnight camping itinerary during the course of their trip (van Wagtendonk & Benedict, 1980). The route maps completed in the survey of overnight visitors in this study were used to validate the routes obtained from the backcountry permits. In particular, permit numbers reported on the overnight visitor survey were used to match the travel routes reported on the post-trip visitor survey to the pre-trip routes reported on the backcountry permits. The results of this analysis suggest that 82% of visitors' actual routes matched the travel routes they reported on their pre-trip backcountry permits. It should be noted that the permits of AT thru-hikers did not contain a permit number. Thus, AT thru-hiker routes were not included in this comparison. Park staff estimated approximately 80% of AT thru-hikers' actual routes match the routes on their permits. The overnight travel routes obtained from the backcountry permits were coupled with the day use travel routes obtained from the survey of day use visitors to develop databases used in the computer simulation model to assign travel routes to simulated groups.

Validation Data

Data were collected during the study period to serve as the basis for validating estimates of inter-group encounters from the computer simulation model. In particular, trails in two of the more heavily used portions of the study area were used to conduct encounter observations – the Big Creek and Gabes Mountain Trails (Figure 3.3). Both trail sections where encounter observations were conducted begin at a trailhead adjacent to a parking lot, extend 2.5 miles or less from the parking lot to primary visitor destinations within the study area (i.e., waterfalls), and are popular hiking routes.

On each day encounter observations were conducted, a trained observer randomly selected visitor groups as they initiated their hike/horseback ride into the study area and followed the group from a distance where the group was visible but the observer would not be noticed. While conducting the encounter observations, the researchers recorded the time and location (i.e., UTM coordinates from a GPS unit) of each encounter the observed group had with other groups and three related pieces of information: 1) the type of group encountered; 2) the size of the group encountered; and 3) the type of encounter (i.e., a meeting encounter, in which the groups were moving in opposite directions on the trail, or an overtaking encounter, in which the groups were moving in the same direction on the trail).

The encounter observations were conducted on five weekend days and 11 weekdays on the Big Creek Trail and five weekend days and 15 weekdays on the Gabes Mountain Trail. Trained personnel conducted observations from 10:00 AM to 6:00 PM. A total of 54 groups were observed on the Big Creek Trail and 51 groups were observed on the Gabes Mountain Trail.

RBSim Modeling

Input Analysis

As noted above, procedures used to collect a daily count of day use visitation within the study area resulted in incomplete and biased data. In addition, the day use and overnight use visitation and travel routes data were collected in formats that required electronic formatting to prepare them for implementation within the RBSim modeling environment. Thus, multiple analyses were performed to calibrate, clean, and format the data into a form that could be used in RBSim to construct the computer simulation model of visitor use within the study area. The analyses conducted to convert the "raw" data collected in the field into inputs formatted for use in RBSim are detailed below and organized into topics that correspond to the types of inputs required by the RBSim model. Analyses are described in the following order of input data: 1) daily arrivals of day use and overnight visitors for each day of the study period (referred to hereafter as "daily arrivals"); 2) normalized distributions of day use and overnight visitor arrivals, by day of the week for each week of the study period (referred to hereafter as "normalized weekly arrivals"); 3) hourly arrival distributions for day use and overnight visitors (referred to hereafter as "hourly arrivals"); 4) hourly campsite departure distributions for overnight visitors (referred to hereafter as "campsite departures"); and 5) distributions of travel routes for day use and overnight visitors, by trip starting location, starting time, and mode of travel (i.e., foot or horseback; referred to hereafter as "travel routes"). Due to the programming nature of RBSim, all of the inputs for the simulation model were coded and formatted electronically into Microsoft Access databases.

Daily Arrivals

Day use. As noted above, on a sample of days during the study period, direct observations were conducted to measure daily visitation in the study area. Thus, on this sample of days, the direct observation data were used as the measure of daily day use arrivals. However, since it was not possible to conduct direct observation of visitation on all days of the study period at all locations, mechanical counters were used for the purpose of collecting a count of daily arrivals of day use visitors for each day of the study period. These mechanical counter data were relied on as the basis for measurement of day use visitation on days when direct observations of visitor use were not conducted. However, as described above, data from these counters are incomplete, biased, and do not differentiate counts of arriving day use visitors from counts of overnight and/or exiting visitors. Since the direct observation data represent an accurate count of day use visitation for the days on which direct observations were collected (i.e., not subject to the biases inherent in the mechanical counter data), the respective direct observation data were used to calibrate and "backfill" the counter data. The process of calibrating the mechanical counter data involved several steps designed to produce a day use visitation count for each day of the study period. The first step in correcting the mechanical counter data was to examine each daily count from the mechanical counters to determine if there were any anomalous values within the datasets. Upon looking through the raw mechanical counter data, certain entries could be removed or declared invalid due to counts during hours of the day when there is not expected to be any visitor use (e.g., counts registered at 2:00 AM) or when the counts were much higher than the corresponding direct observation count. For example, counter data from the Big Creek Trail counter location (EL10 in Figure 3.3) had some rare cases of counts that appeared to be invalid. Due to the width of the trail, rocks were positioned to encourage visitors to walk single-file while passing the counter (Figure 3.7). Visitors would occasionally stop to rest or to tie their shoe on these rocks. When this happened, the mechanical counter triggered counts every second or two the entire time someone was in front of the mechanical counter. This and similar types of errors were relatively easily noted by visual examination of the mechanical counter data, and, in the limited number of cases where these types of error occurred, the data were adjusted to reflect a single count.

Figure 3.7. Photo of boulders used to divert visitors into single-file traffic as they pass the TRAFx mechanical counter installation on the Big Creek Trail.

Additional examination of the mechanical counter data was needed to adjust the counter data for erroneous counts from horseback riders. In mechanical counter locations where dual sensor scopes had been set to detect horse and foot traffic, one sensor ("hiker scope") was set at human waist/chest height and a second sensor ("horse scope") was set at roughly seven feet above the trail tread in order to detect people on horseback, but not detect people passing on foot. Thus, when a horseback rider passed by a mechanical counter location with the dual scope setup, both the horse scope and the hiker scope were triggered at the same time (assuming the sensors were operating correctly). Inspection of the mechanical counter data revealed several cases where the hiker scope was triggered multiple times for each passing horseback rider because of the extended length of the body of horses relative to the human body. Since the dual scope setup was used, simultaneous horse scope counts and hiker scope counts could be compared side-by-side. When a horse scope count was observed to occur in tandem with an anomalous spike in the hiker scope counts and direct observation data were available, the observation data were referenced to determine the number and type of visitor(s) that passed by the counter at the time and location in question. In all instances where comparisons among the horse scope, hiker scope, and direct observation counts were possible, only a single horseback visitor was found to have passed by the counter at the time in question. For this reason, all hiker scope counts recorded by the counter at the exact time as horse scope counts were assumed to be erroneous and eliminated from the data, leaving just a single horse count and no hiker count for each of these occasions.

The data screening steps described thus far constitute preliminary steps in cleaning and correcting the daily use counts derived from the mechanical counters. The next step in the process of cleaning and calibrating the counter data was to develop a "correction factor" for the mechanical counter data based on information about daily visitation recorded through direct observation. This was achieved by running a linear regression model comparing the mechanical counter data to counts obtained through direct observation on matching days and at matching locations. A clear pattern of mechanical counter error was observed when the counter values were compared to the direct observation values. In most locations, the hiker scopes systematically over-counted visitor use when compared to the direct observation counts for the same day, times, and locations (Figure 3.8), while in three monitoring locations, the hiker scopes systematically under-counted visitor use (Figure 3.9). In all cases where the dual scope sensor setup was used, the horse scopes systematically under-counted visitor use when compared to the direct observation counts (Figure 3.10). For these reasons, three linear regression models were estimated: 1) a linear regression model for all hiker scope counts that systematically over-counted visitor use; 2) a linear regression model for all hiker scope counts that systematically under-counted visitor use; and 3) a linear regression model for all horse scope counts (Table 3.4). All of the mechanical counter data were adjusted using the respective regression model. Figure 3.11 provides an example of the mechanical counter, direct observation, and adjusted mechanical counter data for one entry location (EL0 in Figure 3.3).

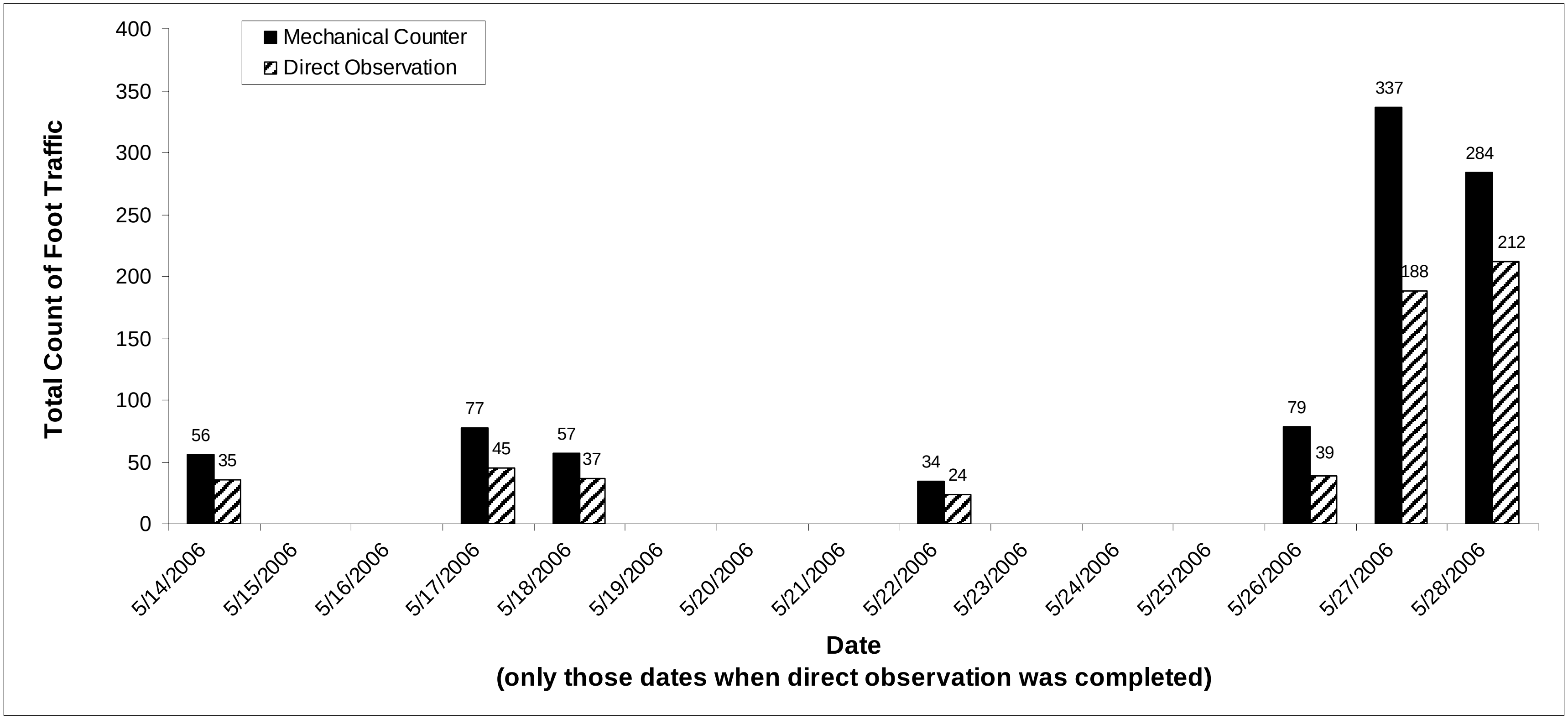

Figure 3.8. Comparison of mechanical counter and direct observation counts for foot traffic at EL0 illustrating systematic over-counting by the mechanical counter.

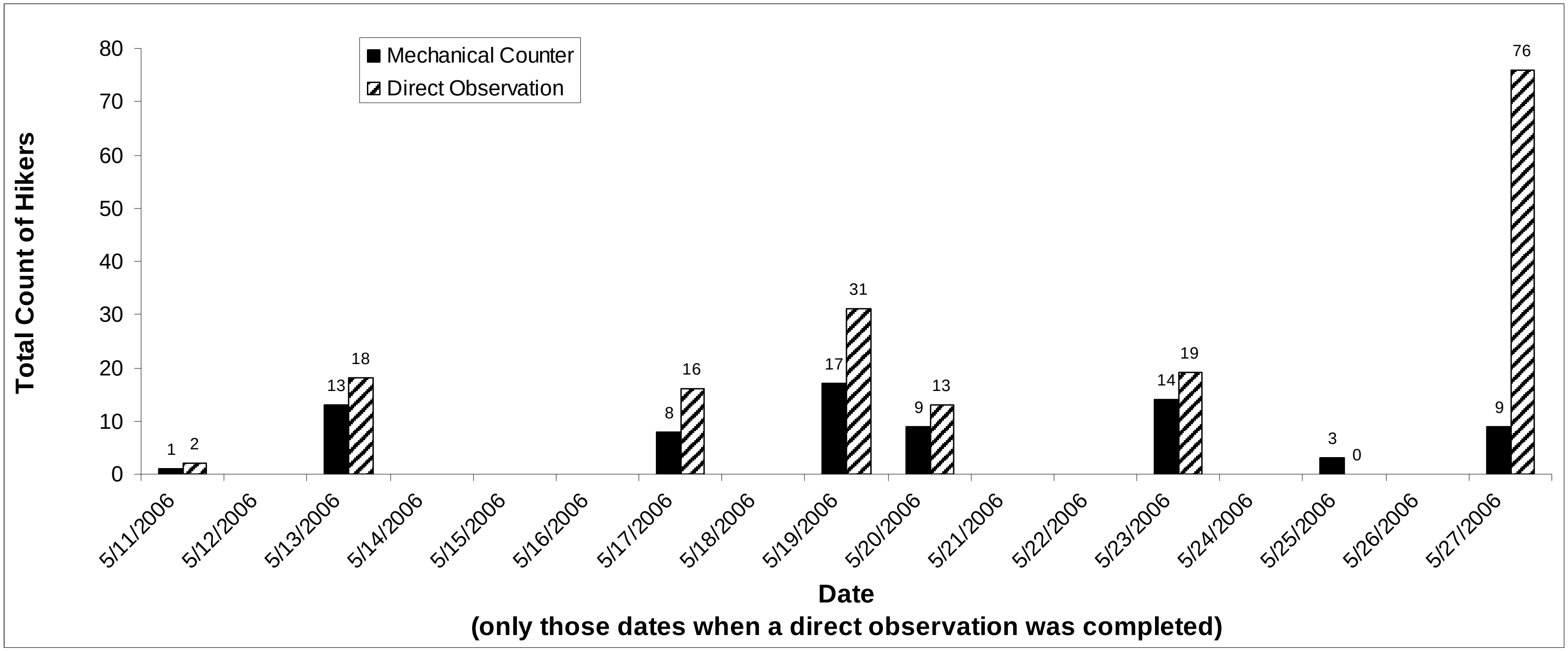

Figure 3.9. Comparison of mechanical counter and direct observation counts for foot traffic at EL1 illustrating systematic under-counting by the mechanical counter.

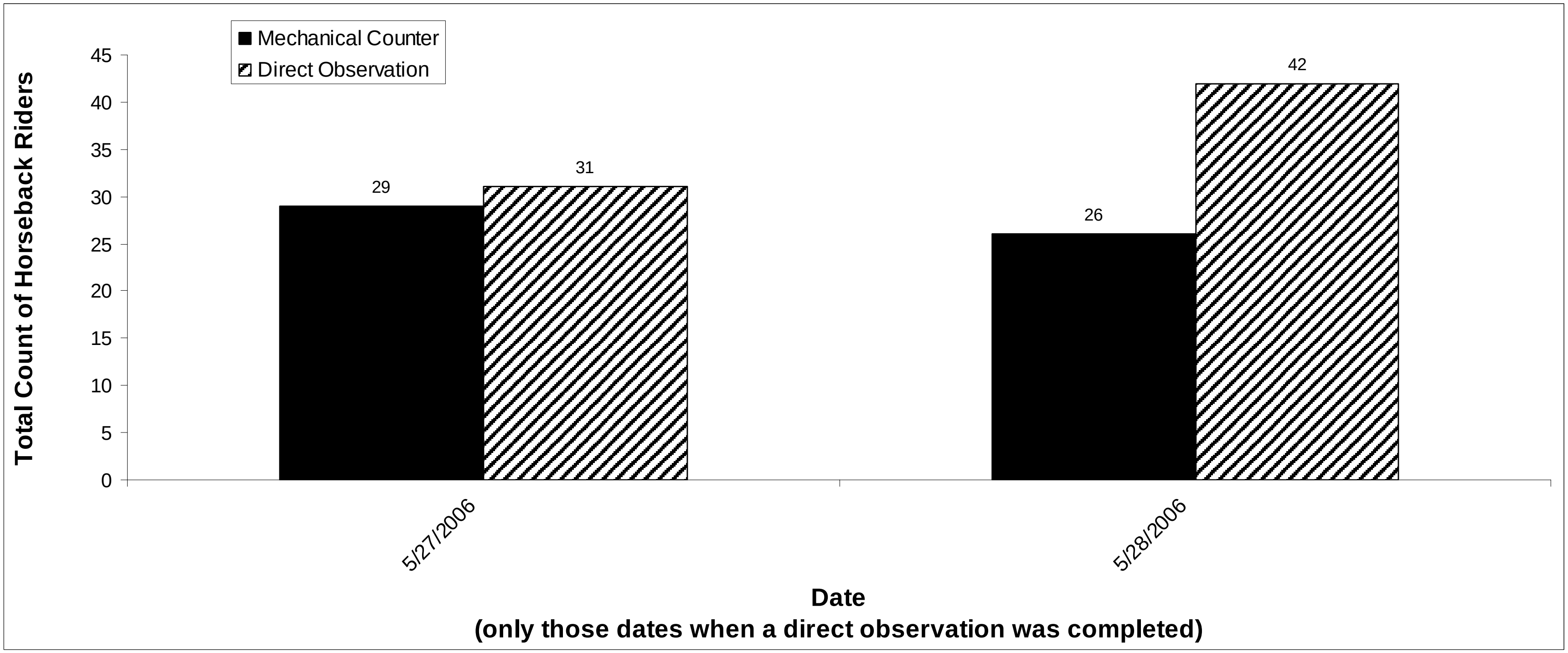

Figure 3.10. Comparison of mechanical counter and direct observation counts for horse traffic at EL10 illustrating the systematic under-counting of horse traffic by the mechanical counter.

Table 3.4. Linear Regression Models of Relationships Between Mechanical Counter and Direct Observation Counts of Visitor Use.

Type of correction	Estimated model	P-value of model parameter	Model R^2
Hiker scopes– Systematic over-counting	0.774 x	< 0.001	0.961
Hiker scopes – Systematic under-counting	1.410 x	< 0.001	0.967
Horse scopes – Systematic under-counting	1.307 x	< 0.001	0.959

Note. In all three regression models, mechanical counter counts were entered as the independent variable, direct observation counts were entered as the dependent variable. All three models were estimated without a constant.

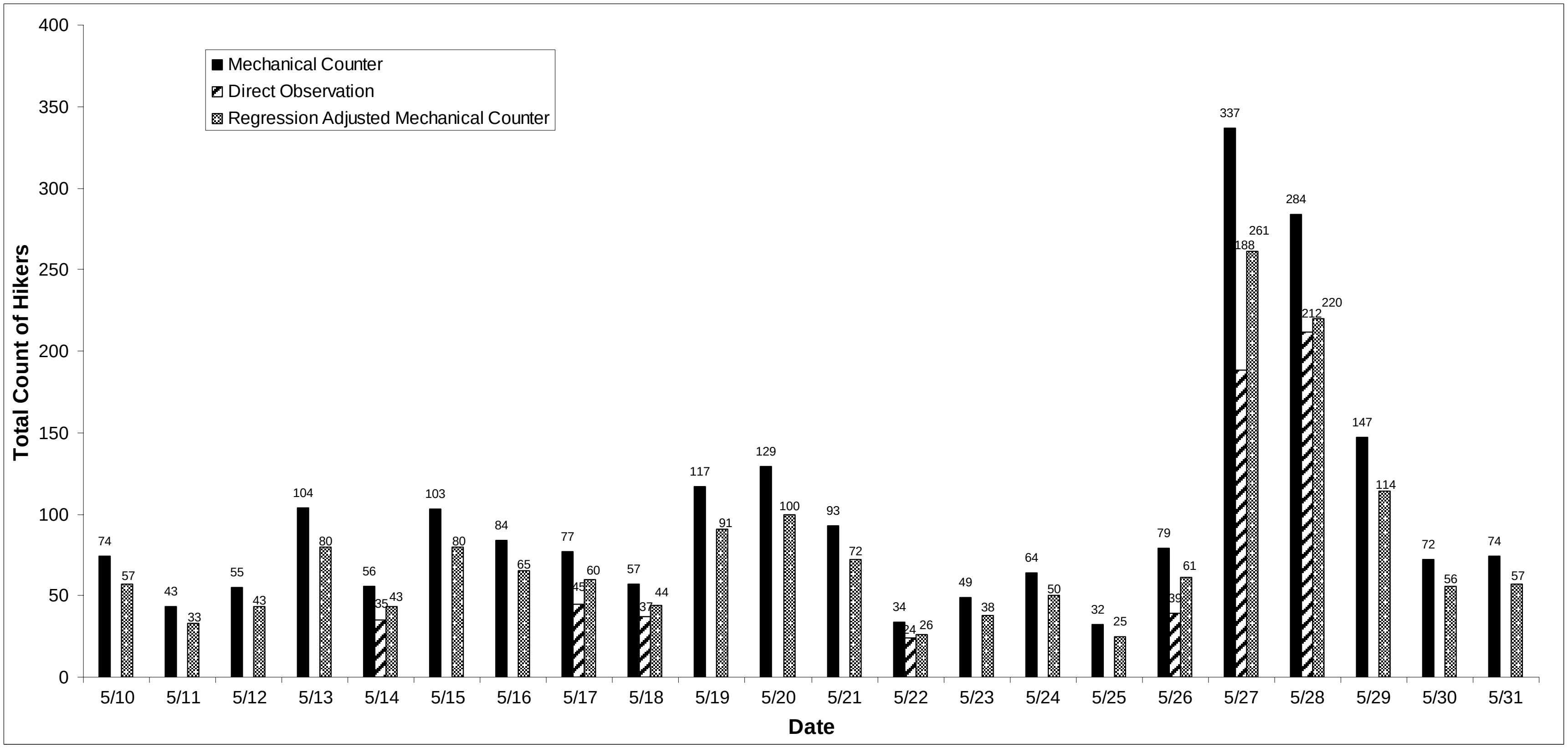

Figure 3.11. Comparison of mechanical counter, direct observation, and regression adjusted mechanical counter counts, Gabes Mountain Trail (EL0).

While the predicted values from the regression models served to reduce the biases in the mechanical counter data associated with systematic over or under-counting of visitor use, the corrected counter data constitute estimates of the *total* number of visitors (i.e., day *and* overnight) arriving *and* exiting the study area from each entry location. Thus, additional steps were needed to convert the adjusted mechanical counter data to estimates of *day use* daily *arrival*s. For each entry location, the direct observation data were used to calculate the average proportion of counts recorded that were of day use hikers and day use horseback riders *arriving* into the study area each hour of the day. For example, the total number of counts during the 9:00 AM hour at EL0 that reflected arriving day use hikers was divided by the total number of counts during the hour to arrive at an estimate of the proportion of counts for that hour and location that constituted day use hiker arrivals. This was repeated for each hour of the day and across all days for which direct observation data were collected. The hourly day use hiker arrival proportions for each day at the location were then averaged. These steps were repeated for day use horseback riders to arrive at mean proportions of day use horseback arrivals, by hour of the day and entry location. The mean hourly proportions of day use visitor arrivals were multiplied by the regression-adjusted mechanical counter values to disaggregate the regression-based estimates of *total* daily use into estimates of *day use* hikers and horseback riders *arriving* into the study area each hour of each day at each entry location. For each date and location where this was done, the hourly day use hiker and horseback arrivals were summed to calculate an estimated daily arrival for day use hikers and horseback riders for the corresponding date.

At some locations and on some dates, neither direct observation nor mechanical counter data were available. In such cases, daily arrivals of day use hikers and horseback riders were based on a combination of direct observation and adjusted mechanical counter data from other dates within the study period. Using data from the days when either direct observation or regression-adjusted mechanical counter values were available, average day use arrivals were calculated for each day of the week (e.g., average "Tuesday day use arrivals") for each entry location separately. For example, if there was a Tuesday within a given location that did not contain a measure of day use visitation based on either direct observation or adjusted mechanical counter data, visitation data for all Tuesdays in the study period for that location were averaged to generate a data point for the Tuesday(s) with missing data. Thus, for all dates within the study period with neither a direct observation nor an adjusted mechanical counter value, the matching “day of the week average” was used to “backfill” the missing data. In cases where there was an entry location where a certain day of the week (e.g., Wednesday for EL7 in Figure 3.3) never had either a direct observation or adjusted mechanical counter value for the study period, an average was obtained from all of the days of a similar type (i.e., a weekday average for weekdays and a weekend average for weekends) and used to “backfill” the data.

Thus, the final daily day use arrival values used as inputs into the computer simulation model constitute a combination of direct observation data, adjusted mechanical counter data, averaged values for specific days of the week based on adjusted mechanical counter and direct observation data, and averaged values for weekend days and weekdays based on mechanical counter and direct observation data. Table 3.5 reports the proportion of days in which the daily day use arrival value was obtained from the direct observation data, the adjusted mechanical counter data, or one of the two averaging techniques for each entry location into the study area. These values were used to create databases of daily arrivals of day use hiking and horseback riding visitors for each entry location and each day of the study period.

Table 3.5. Proportion of Days Alternative Techniques Were Used to Obtain a Measure of Daily Day Use Arrivals, By Entry Location

Entry location	Direct observation	Adjusted mechanical counter data	Day of week average	Weekend/ weekday average
EL0 – Gabes Mountain Trail	22.6	48.4	29.0	0.0
EL1 – Lower Mt. Cammerer Trail	22.6	64.5	12.9	0.0
EL2 – Low Gap Trail	19.4	80.6	0.0	0.0
EL3 – Snake Den Ridge Trail	19.4	61.3	19.4	0.0
EL5 – Appalachian Trail near Tricorner Knob Shelter	25.8	6.5	54.8	12.9
EL6 – Balsam Mountain Trail near Laurel Gap Shelter	19.4	16.1	54.8	9.7
EL7 – Pretty Hollow Gap Trail	22.6	64.5	12.9	0.0
EL8 – Mt Sterling Trail	19.4	61.3	19.4	0.0
EL9 – Baxter Creek Trail	22.6	77.4	0.0	0.0
EL10 – Big Creek Trail	35.5	16.1	35.5	12.9
EL12 – Appalachian Trail near Davenport Gap Shelter	35.5	0.0	51.6	12.9
EL15 – Maddron Bald Trail	32.3	0.0	54.8	12.9

Overnight use. As noted above, the mandatory backcountry permits were assumed to constitute a census of all overnight use in the study area during the study period. Thus, the permits were counted, by date and location, to calculate daily overnight visitor group arrivals. These were coded electronically into an Access database, resulting in databases of total daily arrivals of overnight visitors for each entry location, for each day of the study period.

Normalized Weekly Arrivals – Day and Overnight Use

Modeling visitor use of the study area using the daily arrivals of day and overnight use visitors described above would result in a deterministic model of visitor use. That is, the number of arrivals on any given day of the simulation would always equal the sum of the day use and overnight visitor arrivals generated from the study data for that date. In reality, visitor use of the study area is stochastic and our data represent a single manifestation of that stochastic process. To capture the stochastic nature of visitor use in the study area within the computer simulation model, the daily arrivals data described above were used to generate normalized weekly arrival distributions for day use and overnight visitation. These normalized weekly arrival distributions were used in the simulation model to probabilistically assign the total number of arrivals each week of the simulation to specific days of the week.

For each entry location and visitor type (i.e., day use hiker, day use horseback rider, and backpacker), normalized weekly arrival distributions were generated separately for each of the four weeks of the study period. This was done within each week of the study period by dividing the number of daily arrivals each day of the week (e.g., Monday, Tuesday, etc.) by the total number of arrivals for the entire week. This resulted in a distribution of the proportion of use, by day of week, for each of the four weeks of the study period, for each entry location and each type of visitor use. Kruskal-Wallis tests were performed to merge statistically similar normalized weekly arrival distributions within each entry location and visitor type. Thus, for each entry location, visitor type, and week of the simulation, arrivals by day of the week were simulated in the model based on either: 1) a single, generalized weekly arrival distribution (i.e., in cases where there were no significant differences across any of the four weeks of the study period); 2) four unique weekly arrival distributions for each week of the study period (i.e., in cases where normalized weekly arrival distributions were significantly different each week of the study period); or 3) a combination of one or more generalized weekly distributions for weeks that were not significantly different and week-specific distributions for weeks with statistically different normalized weekly arrival distributions (i.e., in cases where some, but not all four normalized weekly arrival distributions were significantly different). The RBSim modeling environment was programmed to perform the Kruskal-Wallis tests and arrange the data into generalized and/or week-specific normalized weekly arrival distributions for each entry location and type of visitor in an automated manner. These normalized weekly arrival distributions were used to make probabilistic "draws" of the number of simulated arrivals each day of the simulation for each entry location and type of visitor. Thus, the *total* number of day use and overnight visitor arrivals did not vary across replications of the model. However, within each replication of the computer simulation model, the number of arriving visitor groups per day and entry location was modeled stochastically.

Hourly Arrivals

Once the normalized weekly arrival distributions described above were used to "schedule" the total number of arrivals into the simulated study area for each day of the simulation, hourly arrival distributions were needed to assign each simulated group a specific hour within which to start their trip. Hourly arrival distributions were generated separately for day and overnight visitors. Day use hourly arrival distributions were generated from direct observation and mechanical counter data, as well as from the day use visitor survey route maps. Overnight hourly arrival distributions were generated based on the overnight visitor survey route maps. The specific steps to generate hourly arrival distributions for day use and overnight visitors are described in the following subsections of this chapter.

Day use. For the seven entry locations where more than 20 days of regression-adjusted mechanical counter data were available, weekday and weekend day hourly arrival distributions were generated using a combination of the adjusted counter data and the direct observation data. In particular, the number of day use visitor arrivals each hour of the day was summed across all days for which either adjusted mechanical counter or direct observation data were available. The hourly sums of day use arrivals were then divided by the total number of arrivals across all hours of the day and all days for which the data were available to generate a normalized hourly arrival distribution. For the five entry locations where there were 20 days or fewer of mechanical counter data available, entry location-specific hourly arrival distributions were generated from the day use visitor survey route maps upon which respondents were instructed to report the starting time of their trip into the study area. In particular, the start times reported by respondents to the day use survey were used to generate a frequency distribution of trip start times.

Within the simulation model, each simulated day use visitor group is assigned an hour of the day during which their trip starts based on a probabilistic "draw" from the hourly arrival distribution corresponding to the entry location and visitor type of the simulated group. Simulated visitor groups are then assigned a minute within the hour during which their trip is scheduled to start, with each minute of the hour having an equal chance of being assigned.

Overnight use. Trip starting times are not reported on the park's mandatory overnight backcountry permits, thus the overnight visitor survey data were used to generate hourly arrival distributions for simulated overnight trips in the study model. As in the day use visitor survey, respondents to the overnight visitor survey were asked to record their route of travel within the study area, including the time they started their trips. Thus, a total of 87 trip starting times were obtained from the overnight visitor survey. The distribution of starting times reported by respondents to the overnight visitor survey was examined visually by graphing trip starting times by entry location. Two distinct distributions of starting times were observed from this preliminary analysis (Figure 3.12). Earlier starting times were observed to be correlated to "frontcountry" entry locations (i.e., EL0, EL1, EL2, EL3, EL8, EL9, EL10, EL12, and EL15 in Figure 3.3), while later trip starting times were observed for "backcountry" entry locations (i.e., EL5, EL6, and EL7 in Figure 3.3). Those individuals that enter the study area through backcountry locations generally arrive to the study area later in the day and have less mileage to cover to get to their final destination for that day. For this reason, the overnight visitor survey data were used to construct separate hourly arrival distributions for frontcountry and backcountry entry locations. Within the simulation model, simulated overnight visitor groups are assigned a trip starting time based on a probabilistic "draw" from the hourly arrival distribution corresponding to the type of entry location (i.e., frontcountry or backcountry location) where their trip started. Simulated visitor groups are then assigned a minute within the hour during which their trip is scheduled to start, with each minute of the hour having an equal chance of being assigned.

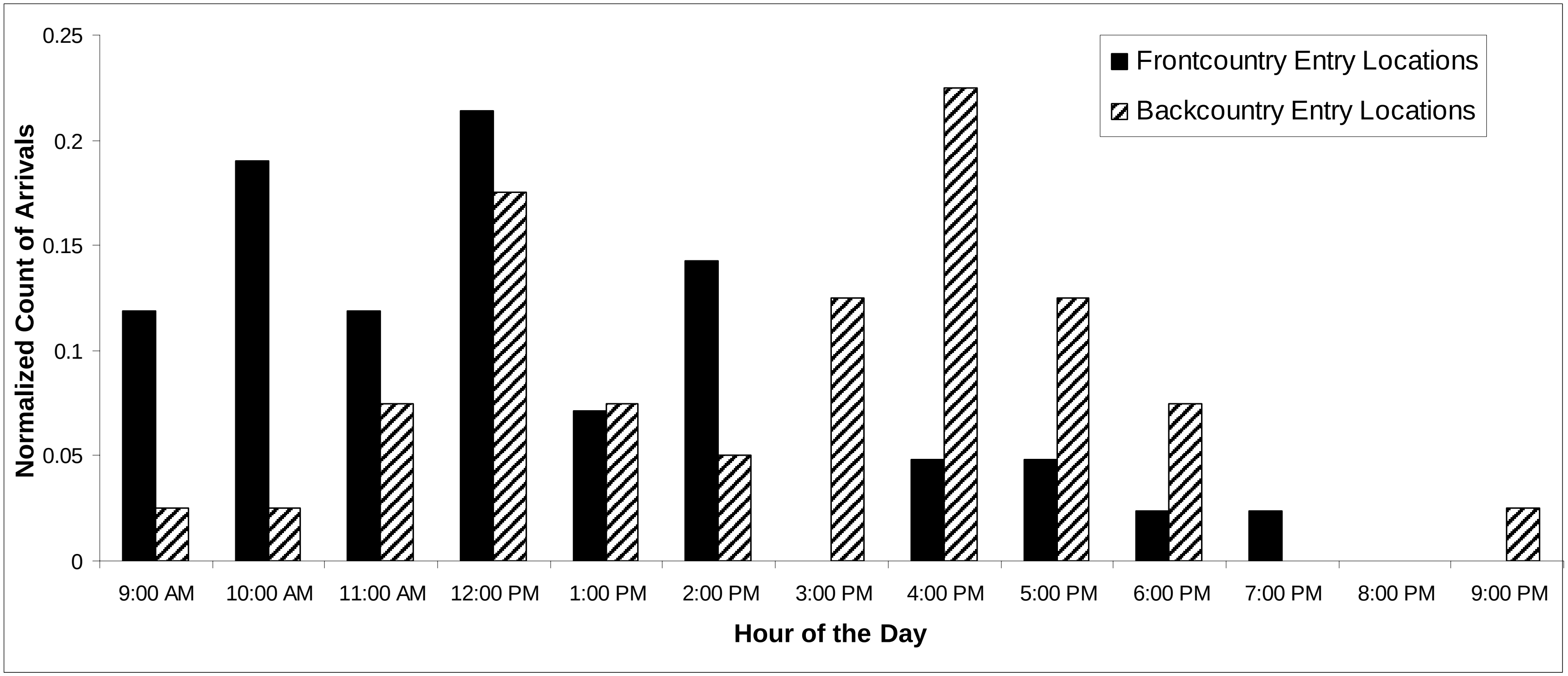

Figure 3.12. Normalized counts of overnight visitors, by starting time.

Campsite Departures

By definition, simulated overnight visitor groups camp at least one night during their simulated trips in the study model. Thus, a distribution of "campsite departure times" was needed to probabilistically assign a time to overnight visitor groups when they would depart their campsite each morning after they had camped during their simulated trip. On the overnight visitor survey, respondents were asked to report the time they departed their campsite each morning of their trip. These reported "campsite departure times" were used to generate an empirical distribution of campsite departure times, and this distribution was used to probabilistically assign a campsite departure time to each simulated overnight group each morning of their simulated trip within the computer simulation model.

Travel Routes

Overnight visitor travel routes obtained from the mandatory backcountry permits and day use travel routes reported by respondents to the day use survey were organized into empirical distributions of travel routes, by time of day, type of visitor (i.e., day hiker, day horseback rider, and backpacker), and trip entry location. These empirical distributions were used to probabilistically assign travel routes to simulated visitor groups within the model based on their entry location, trip start time, and visitor type. The following paragraphs describe the process used to organize the travel routes by time of day.

Day use. Visual inspection of the distribution of day use visitors' travel route lengths (in hours) versus the starting time of those travel routes revealed a clear split between the travel route lengths of 4 and 5 hours (Table 3.6). In particular, a little more than one-quarter (26.8%) of all the travel routes reported in the day use survey were 5 hours or more in length, and all but one of these trips were reported to start before 1:00 PM. In contrast, a little less than three-quarters (73.2%) of all day use survey respondents reported travel routes of 4 hours in length or less, and the start times for these trips were pretty evenly distributed throughout the hours of the day. Thus, two separate day use travel route distributions were generated for each entry location and each day use visitor type (i.e., hikers and horseback riders): 1) a distribution of travel routes of all possible lengths between the hours of 6:00 AM and 12:59 PM (i.e., simulated day use groups are assigned a route from a distribution of all travel routes reported in the day use survey); and 2) a distribution of travel routes that are 4 hours or less in length for the remaining hours of the simulated day.

Table 3.6. Percentage of Day Use Travel Routes by Starting Time.

	Travel route length (in hours)										
Trip start time	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
7:00 AM		0.4									0.4
8:00 AM		0.4	0.4	1.1		1.1	2.5	0.4	0.4	0.4	6.4
9:00 AM	0.4	3.2	2.1	1.1	1.1	3.6	2.9	2.1	0.4		16.8
10:00 PM		3.2	3.2	3.9	2.1	1.8	1.1				15.4
11:00 AM	0.7	3.9	4.6	4.3	2.1	1.8	0.4			0.4	18.2
12:00 PM	1.8	6.4	3.9	2.1	1.4		0.7				16.4
1:00 PM	1.1	6.4	3.9	1.8		0.4					13.6
2:00 PM	0.7	2.5	1.1	0.4							4.6
3:00 PM	1.8	3.2	0.4								5.4
4:00 PM	2.1	0.4	0.4								2.9
5:00 PM											0.0
Total	8.6	30.0	20.0	14.6	6.8	8.6	7.5	2.5	0.7	0.7	100.0

n=280

Overnight use. For overnight trips, the distance traveled on the first day was calculated based on the travel routes respondents reported in the overnight visitor survey (referred to hereafter as “first day miles”). Next, overnight survey respondents’ “first day miles” were plotted against their trip starting times. Visual inspection of the scatter plot of “first day miles” against trip starting times revealed three splits for the times of day trips of various “first day miles” lengths started (Table 3.7). In particular, the data suggest that overnight groups who hike 11 miles or more on the first day of their trip start their trips before 1:00 PM. The data also suggest that all overnight groups who hiked between six and nine miles on the first day of their trip started their trips before 5:00 PM. Furthermore, about half of all overnight groups that hiked 9 miles on the first day of their trip started before 1:00 PM, while the other half started their trips between 1:00 PM and 5:00 PM. Finally, groups who hiked 5 or fewer miles on the first day reported trip starting times that were distributed relatively evenly across the hours of the day. Thus, three separate overnight visitor travel route distributions were generated for each entry location: 1) a “morning distribution” of travel routes with first day hikes of all possible lengths for simulated trips starting between the hours of 6:00 AM and 12:59 PM; 2) a “mid-day distribution” of travel routes with first day hikes of eight or fewer miles for simulated trips starting between the hours of 1:00 PM and 4:59 PM and a random sample of 50% of all of the travel routes with first day hikes of nine miles; and 3) an “evening distribution” of travel routes with first day hikes of five or fewer miles for simulated trips starting after 4:59 PM.

Table 3.7. Percentage of Overnight Use Travel Routes by Starting Time.

	Travel route length (in first day miles)									
Trip start time	<1	2	4	5	6	9	11	12	14	Total
9:00 AM			2.6		2.6			1.3		6.4
10:00 AM				9.0			1.3		1.3	11.5
11:00 AM			1.3		5.1	1.3		1.3		9.0
12:00 PM		1.3	1.3	3.8	5.1	7.7			1.3	20.5
1:00 PM	3.8		2.6	1.3						7.7
2:00 PM			5.1	2.6		2.6				10.3
3:00 PM	5.1					1.3				6.4
4:00 PM	6.4		2.6			3.8				12.8
5:00 PM	6.4		1.3	1.3						9.0
6:00 PM	2.6		1.3							5.1
7:00 PM				1.3						1.3
8:00 PM										0.0
9:00 PM	1.3									1.3
Total	25.6	1.3	17.9	19.2	14.1	16.7	1.3	2.6	2.6	100.0

n=78

Summary of RBSim Input Data Modeling Process

The probabilistic nature of RBSim is a scheduling and routing process that uses the input data described above to produce a simulation model that is stochastic in nature. The scheduling process used by RBSim involves a series of steps that incrementally refines the simulation schedule at higher degrees of specificity. The steps of the scheduling and routing process within the study model are as follows:

1. Define the total number of arrivals per week, by visitor group type and entry location. This step is based on the daily arrivals data and is deterministic, meaning the values are the same each replication of the model.

2. Assign the total number of arrivals per week to specific days of the week, by visitor group type and entry location. This step is based on the normalized weekly arrival distributions and is stochastic, meaning the values vary from one replication of the model to another.

3. Assign an hourly arrival to each scheduled trip within each day of the simulation, by visitor group type and entry location. This step is based on the hourly arrival distributions and is stochastic.

4. Assign a minute within the hour of arrival to each scheduled trip within each day of the simulation, by visitor group type and entry location. This step is based on a random draw, with each minute of the hour having an equal chance of selection, thus it is stochastic.

5. Assign a travel route to each scheduled trip, by visitor group type, entry location, and trip/first day hike length. This step is based on the travel route distributions and is stochastic.

The resultant schedule of simulated trips and associated routes is saved as an Access database and “read” by RBSim to generate a single replication of the model. The process outlined above is repeated for each replication of the model.

Simulations of Visitor Use and Inter-group Encounters

The data inputs described above were integrated into the RBSim modeling environment to conduct probabilistic simulations of visitor use in the study area (Itami, 2003; Itami et al., 2003). The probabilistic simulations were used to estimate a number of visitor-based and spatially-based measures of visitor use and inter-group encounters, assuming current visitor use conditions in May 2006.

Visitor-based outputs generated from model simulations included: 1) the percentage of visitor groups that had at least one period during their hike of 30 minutes or more during which time they did not encounter another group (referred to hereafter as “temporal encounters”); 2) the percentage of visitor groups that, *on average*, encountered fewer than two other groups per hour (referred to hereafter as “hourly encounters”); and 3) the percentage of visitor groups that never encountered more than two groups per hour in the “interior” of the study area (i.e., 0.5 miles or further from any trailhead; referred to hereafter as “interior encounters”). Spatially-based outputs generated from model simulations included estimates of average daily visitor use at three particularly popular destination sites within the study area – Hen Wallow Falls, Midnight Hole, and Mouse Creek Falls (“use_HWF,” “use_MH,” and “use_MF,” respectively). Estimates of average daily visitor use of each trail segment (referred to hereafter as “trail use”) and camping location (referred to hereafter as “camping use”) within the study area were also generated. The outputs were calculated from data generated by the computer simulation model after a warm-up period of 8 days were simulated. The warm up period is designed to “populate” the model with visitor groups representative of the study period (Law & Kelton, 2000). The 8-day period was selected for the warm up period because all trips observed in the backcountry permit data were 8 days or shorter in duration.

Output Analysis

The probability-based computer simulation modeling used to generate the outputs outlined above uses empirical distributions (i.e., normalized weekly arrivals, hourly arrivals, and travel routes distributions) to generate input variables. Therefore, the probabilistic simulations are stochastic, resulting in estimates of the output variables that differ from one replication of the simulation model to another. Thus, it is inappropriate to draw conclusions about the study area from a single replication of the simulation model (Law & Kelton, 2000). Rather, outputs should be averaged over multiple replications of the computer simulation model, and confidence intervals should be reported to document the precision of model estimates. Thus, a challenge within probability-based computer simulation modeling is to identify the number of replications of the model needed to achieve a desired level of precision for model estimates. This challenge is exacerbated in spatial simulations in which multiple outputs are sought (e.g., estimates of visitor use levels and inter-group encounters for multiple destinations, trail segments, and/or campsites within a study area).

RBSim uses three alternative methods to estimate the number of replications needed to obtain specified levels of precision for the model outputs outlined in the preceding section of this chapter (Centeno & Reyes, 1998; Itami, Zell, Grigel, & Gimblett, 2005; Law & Kelton, 2000). It should be noted that the replications analysis methods used in this study are appropriate only for terminating simulations and do not apply in the case of steady-state simulations (Centeno & Reyes, 1998). The first step within each of the three methods used to conduct the replications analysis is to define a desired level of precision for the model outputs. This involves defining a half-width and alpha level for the confidence interval around each model output. In this study, an alpha level of 0.10 (90% confidence) was selected and the confidence interval half-width differed depending on the output. For example, the confidence interval half-width for all of the visitor-based outputs was +/– 5% of visitors, while a half-width of +/– 1 visitor group was specified for the spatially-based outputs. Thus, for "temporal encounters," the three methods described below were used to estimate the number of replications needed to estimate a 90% confidence interval with a half-width of +/ – 5% of visitors.

It should be noted that because the computer simulation model developed in this study was used to generate estimates of multiple outputs simultaneously, the alpha levels for the confidence intervals specified within each of the replications analysis methods used in this study were adjusted using a Bonferroni Correction. In particular, the specified alpha level was adjusted by dividing it by the number of outputs estimated together (Law & Kelton, 2000). For example, the computer simulation model was used to estimate all three of the visitor-based outputs simultaneously. Thus, the Bonferroni Corrected alpha level for the analysis of visitor-based outputs was equal to 0.033 (0.10 divided by 3).Table 3.8 reports the alpha level and confidence interval half-width specified for each of the outputs generated by the computer simulation model in this study.

Table 3.8. Level of Precision and Confidence Interval Half-Widths for Each Set of Outputs Estimated by the Model.

<table>
<tr><th>Model output</th><th>Confidence interval half-width</th><th colspan="5">Alpha level
(Bonferroni Corrected alpha level)</th></tr>
<tr><td>Temporal encounters</td><td>± 5% of groups</td><td rowspan="3">0.1
(0.033)</td><td>-</td><td rowspan="6">0.1
(0.017)</td><td>-</td><td>-</td></tr>
<tr><td>Hourly encounters</td><td>± 5% of groups</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Interior encounters</td><td>± 5% of groups</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Hen Wallow Falls – Average use</td><td>± 1 group</td><td>-</td><td rowspan="3">0.1
(0.033)</td><td>-</td><td>-</td></tr>
<tr><td>Midnight Hole – Average use</td><td>± 1 group</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Mouse Creek Falls – Average use</td><td>± 1 group</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Campsite/Shelter use</td><td>± 1 group</td><td>-</td><td>-</td><td>-</td><td>0.1
(0.01)</td><td>-</td></tr>
<tr><td>Trail use</td><td>± 1 group</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0.1
(0.001)</td></tr>
</table>

The next step within each of the three reliability analysis methods was to run the model for a relatively small number of replications, commonly referred to as the “short run.” All three of the reliability analysis approaches used in this study require that the short run simulation has been replicated a sufficient number of times that the variances of the outputs of interest have stabilized. The steps that follow from the short run simulation vary across the three reliability analysis methods and are described separately in the following paragraphs.

Method of Independent Replications

Within the method of independent replications, the following equation is used to compute the confidence interval half-width around the mean of each output of interest resulting from the short run simulation:

$$\pm t_{n-1,1-\alpha/2}\sqrt{[S^2(n)]/n} \tag{1}$$

Where:

n = number of replications conducted for the short run simulation

$t_{n-1,\, 1-\alpha/2}$ = $(1 - \alpha / 2)$ percentile of the t-student distribution with n-1 degrees of freedom

$S^2(n)$ = sample variance of the output variable from the short run simulation

If the confidence interval half-width is less than or equal to the user-specified value, then no further replications are needed. For example, if the short run simulation results in a confidence interval half-width of less than or equal to 5% of visitors for “temporal encounters,” then the number of replications performed for the short run simulation is sufficient to generate an estimate of this variable with the specified level of precision. Otherwise, the following equation is needed to compute the number of replications needed to achieve the user-specified level of precision:

$$n^* = \text{Round}\left[\, n \times (h / h^*)^2 \,\right] \tag{2}$$

Where:

n^* = estimated number of replications needed to achieve user-specified level of precision

n = number of replications from short run simulation

h = interval half-width computed using short run results and Equation 1

h^* = user specified confidence interval half-width

The model is then run for n^* replications and the computation process using Equations 1 and 2 is repeated until the desired level of precision is obtained.

Iterative Method

Law and Kelton (Law & Kelton, 2000) suggest a modification to the method of independent replications referred to as the iterative method. Within the iterative method, Equation 1 is modified such that if the user-specified level of precision is not achieved within the short run simulation, the number of replications within the equation is increased incrementally by a value of one until the desired confidence interval half-width is achieved, as illustrated in the following equation:

$$n^*(\beta) = \min\{i \geq n : t_{i-1,1-\alpha/2}\sqrt{[S^2(n)]/i} \leq \beta\} \quad (3)$$

Where:

$n^*(\beta)$ = estimated number of replications needed to achieve user-specified level of precision

n = number of replications from the short run simulation

$t_{i-1,1-\alpha/2}$ = $(1-\alpha/2)$ percentile of the t-student distribution with i-1 degrees of freedom

$S^2(n)$ = sample variance of the output variable from the short run simulation

β = the user specified confidence interval half-width

i = number of replications at each iteration of the method

The iterative method is more efficient than the method of independent replications because it does not require additional replications of the computer simulation model after the short run simulation has been conducted. However, the iterative method assumes that the population variance of the output of interest will not change significantly as the number of replications is increased.

Relative Accuracy Method

The relative accuracy method is similar to the iterative method, but is designed to estimate the number of replications needed to achieve a user-specified level of *relative accuracy*, rather than simply a user-specified confidence interval half-width. Within this method, the relative accuracy is calculated as the confidence interval half-width as calculated in Equation 1, divided by the mean of the output variable of interest derived from the short run simulation. Thus, within the relative accuracy method, the equation for computing the number of replications needed to achieve a user-specified level of precision is as follows:

$$n^*(\lambda') = \min\{i \geq n : (t_{i-1,1-\alpha/2}\sqrt{[S^2(n)]/i})/\left|\overline{X}(n)\right| \leq \lambda'\} \quad (4)$$

Where:

$n^*(\lambda')$ = estimated number of replications needed to achieve a user-specified level of relative accuracy

λ' = user specified relative accuracy

n = number of replications from the short run simulation

$t_{i-1,1-\alpha/2}$ = (1-α/2) percentile of the t-student distribution with i - 1 degrees of freedom

$S^2(n)$ = sample variance of the output variable from the short run simulation

$\overline{X}(n)$ = mean of the output variable from the short run simulation

i = number of replications at each iteration of the method

As with the iterative method, the relative accuracy method assumes that the population variance of the output of interest will not change significantly as the number of replications is increased. The relative accuracy method also assumes that the mean of the output variable of interest will not change significantly as the number of replications is increased.

Summary of Output Analysis

The output analyses conducted in this study were organized into three separate steps following the procedures outlined in the preceding subsections. In the first step, estimates of the replications needed to estimate all of the visitor-based outputs within a specified level of precision were generated. Next, estimates of the replications needed to estimate all of the attraction-based outputs within a specified level of precision were generated. Then, estimates of the replications needed to estimate both the visitor-based and attraction-based outputs simultaneously within a specified level of precision were generated. In the same way, estimates of the replications needed to estimate only the camping use outputs for all of the campsites and shelters within a specified level of precision were generated. Similarly, estimates of the replications needed to estimate only the trail use outputs for all of the trail segments within a specified level of precision were generated. Finally, estimates of the replications needed to estimate all of the model outputs simultaneously (i.e., visitor-based, attraction-based, campsite use, and trail use) within a specified level of precision were generated. The results of these output analyses provide insights into the feasibility of using computer simulation modeling to generate estimates of visitor use and solitude-related indicator variables at levels of precision that are useful for management purposes. Furthermore, these analyses provide insights into the extent to which there is a spatial component to questions about the reliability of computer simulation estimates for low use recreation environments.

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CHAPTER 4 – BOOK CHAPTER

Assessing the Reliability of Computer Simulation for Modeling Low Use Visitor Landscapes

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ASSESSING THE RELIABILITY OF COMPUTER SIMULATION FOR MODELING LOW USE VISITOR LANDSCAPES

Introduction

The Wilderness Act of 1964 mandates that Congressionally designated wilderness areas in the United States should be managed to provide, among other qualities, “outstanding opportunities for solitude” to recreational visitors (Hendee & Dawson, 2002). To assist wilderness managers in meeting the mandates of the Wilderness Act of 1964 and related management objectives, several planning and management frameworks have been developed, including the Limits of Acceptable Change (LAC) (Stankey et al., 1985) and the Visitor Experience and Resource Protection Framework (VERP) (National Park Service, 1997). The process involved in these frameworks is similar and involves wilderness managers working with the public to define management objectives, indicators of quality, and standards of quality, and working with staff to develop an associated monitoring program. Indicators of quality are measurable, manageable variables that serve as proxies for broader management objectives (Manning, 2001). Standards of quality define minimum acceptable conditions of indicator variables, and must be quantifiable and measurable, time specific, and output oriented (Whittaker & Shelby, 1992). Perhaps the most commonly used indicator to operationalize the broader management objective of wilderness solitude has been the number of encounters visitors have with other groups (Dawson, 2004; Freimund, Peel, Bradybaugh, & Manning, 2003; Stewart & Cole, 2001). Recent studies have introduced indicators of wilderness solitude that account for the timing and location of encounters (Aplet, Thomson, & Wilbert, 2000; Hall, 2001; Saarinen, 1998).

Several studies in the field of outdoor recreation management and planning have used computer simulation modeling to demonstrate its utility as a tool to help managers monitor encounters and similar visitor use-related indicators of quality (Itami et al., 2003; Lawson, Itami, Gimblett, & Manning, 2006; Lawson & Manning, 2003). However, previous applications of computer simulation modeling to outdoor recreation planning and management have generally done little to assess the reliability, or precision, of model estimates. The reliability of computer simulation model estimates is a particularly important question because computer simulation modeling uses random numbers and/or empirical distributions to generate input variables (e.g., visitor arrival times, durations at destinations, travel routes, etc.) and therefore the estimates from a model vary across replications of the model. Consequently, conclusions should not be drawn from a single replication of a model (Law & Kelton, 2000). Thus, a significant issue within computer simulation modeling is identifying the number of simulation replications needed to estimate model outputs at a managerially relevant level of precision.

The authors are aware of only one study in which the reliability of visitor use-related estimates from a computer simulation model have been assessed, and this work was conducted in an area with very high levels of visitor use (Itami, Zell, Grigel, & Gimblett, 2005). In wilderness and related backcountry areas, the question of reliability is particularly pronounced because visitor use levels and inter-group encounters tend to be relatively low and even moderately imprecise estimates can lead to very different conclusions about the nature of visitor experiences. Furthermore, spatially complex simulations, such as those of recreational use of large, dispersed wilderness areas, contain added variability as it is often the goal to produce multiple outputs from the model simultaneously (e.g., use density and inter-group encounters on numerous trail segments and at several day use and/or overnight destinations). Thus, it is unclear whether computer simulation models can generate estimates of inter-group encounters and related outputs at a level of precision that is useful for management purposes in low use visitor landscapes, such as wilderness areas.

The purpose of the research presented in this chapter is to explore several questions concerning the reliability of computer simulation model estimates for monitoring wilderness solitude-related indicators of quality. In particular, can reliable estimates of solitude-related indicators be generated for low use recreation environments, such as backcountry and wilderness areas? Is there a spatial component to questions about the reliability of computer simulation estimates for low use visitor landscapes? That is, is it possible to generate estimates at a level of precision that is useful for management purposes for some, but not all locations within a low use recreation area (i.e., selected trails/trail segments and camping locations)? Similarly, can more precise estimates be generated for visitor-based outputs (e.g., average number of encounters per group per day) than for spatially-based outputs? The research presented in this chapter examines the reliability of computer simulation estimates of wilderness solitude indicators that account for the timing and location of hiking and camping encounters in the backcountry of Great Smoky Mountains National Park.

Methods

Study Area

This study was designed to model visitor use and inter-group encounters in the Cosby and Big Creek areas of Great Smoky Mountains National Park. The study area is located in proposed wilderness in the northeast corner of the park and is used by day use hikers, day and overnight horseback riders, and backpackers, including Appalachian Trail thru-hikers (Figure 4.1). Over 85 miles of trails are located in the study area, including 16 miles of the Appalachian Trail (Figure 4.2). Four of the 6 campsites and all of the 4 shelters in this area of the park require visitors to obtain a reservation before visitors can camp overnight. Three of the shelters in the study area are located along the Appalachian Trail and these shelters receive most of the overnight use in the study area (National Park Service, 2005). There are multiple destination sites within the study area that are accessible within a relatively short day's hike, including several waterfalls that are within two miles of a parking lot and trailhead.

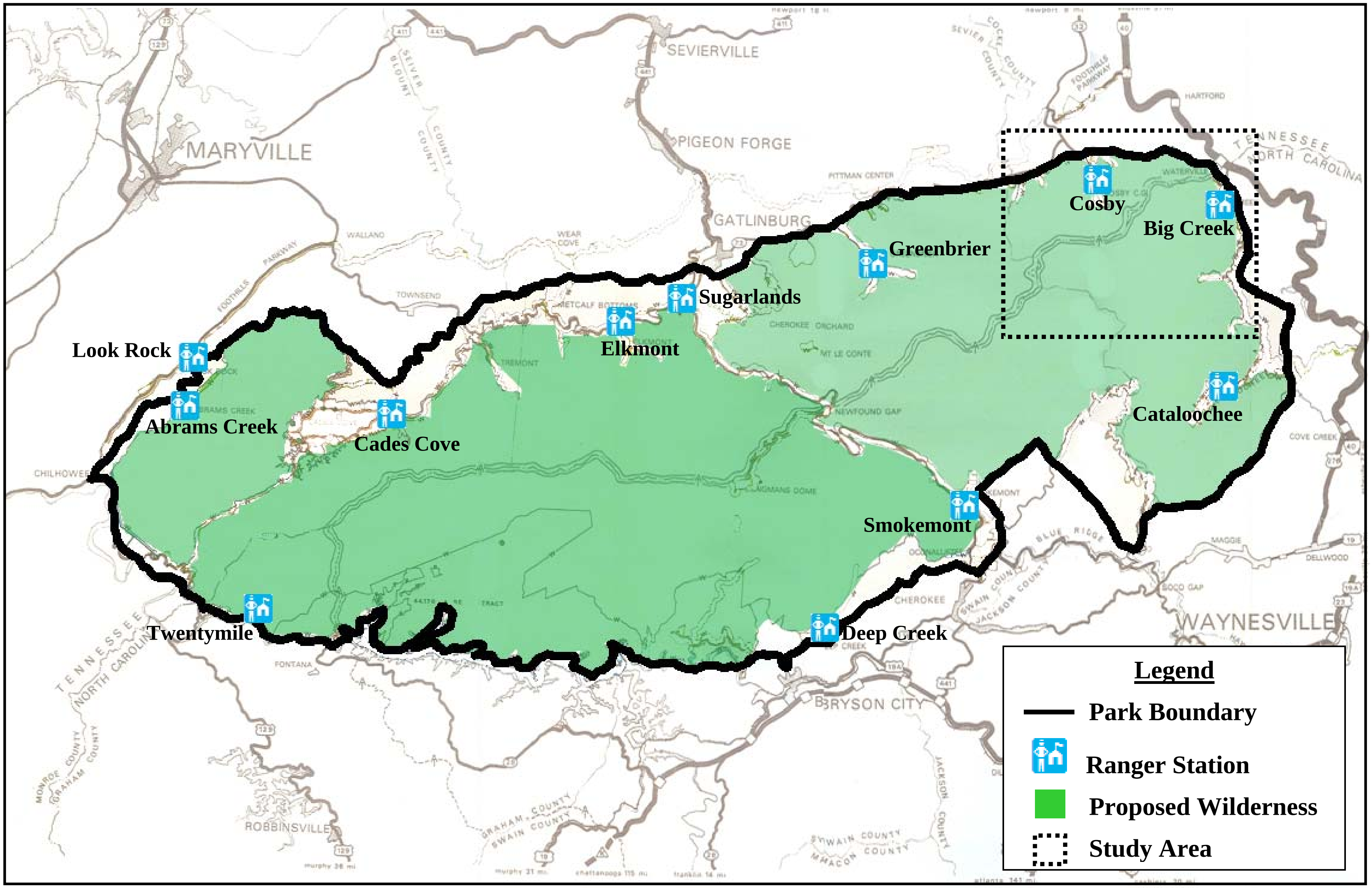

Figure 4.1. The proposed wilderness area of Great Smoky Mountains National Park, with study area marked (NPS, 1982).

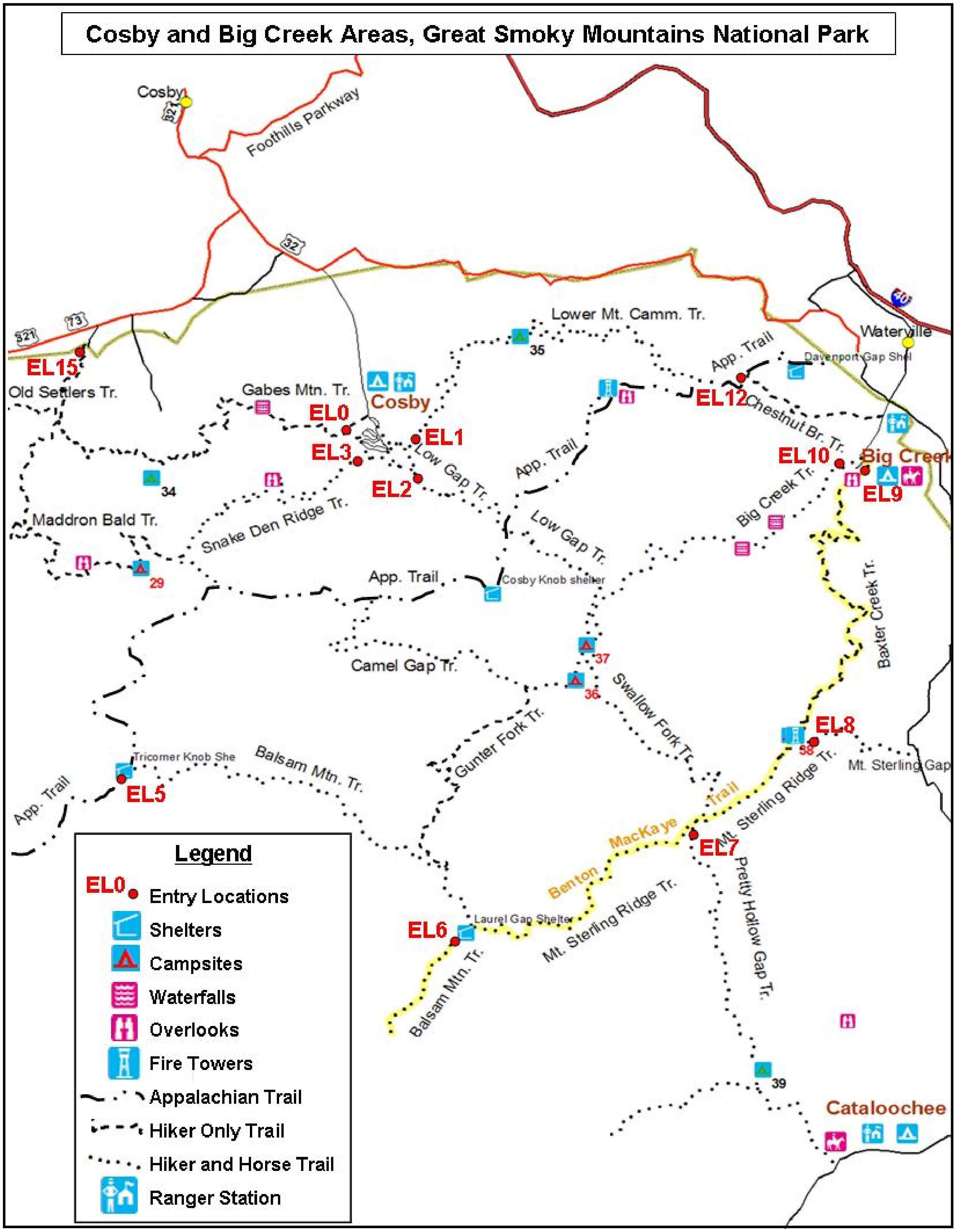

Figure 4.2. Big Creek and Cosby areas of Great Smoky Mountains National Park.

Data Collection

Two primary types of information about visitor use in the study area were collected to construct the computer simulation model in this study. First, information was collected about the amount of visitation to the study area. In particular, a combination of mechanical counters and direct observation was used to obtain counts of daily arrivals of day use visitors, by entry location into the study area, date, time of day, and type of visitor (i.e., hiker or horseback rider). National Park Service (NPS)-issued permits were used to count the number of overnight trips during the study period, by entry location, date, and type of visitor (i.e., backpacker, horseback rider, AT-thru hiker). The day use and overnight visitation data were used to parameterize the study model to simulate visitor use levels that correspond to current conditions in May, 2006. Second, information was collected about visitors' travel routes within the study area, by entry location, time of day, and type of visitor. Day use travel routes were obtained via a survey of day use visitors conducted during May, 2006. Overnight travel routes were obtained from the NPS-issued backcountry camping permits and validated with visitor-reported itineraries collected via an overnight visitor survey. The visitation and travel route data were collected in the study area from April 23 to May 31, 2006. This period was selected for the study because it includes the time of year when most AT thru-hikers pass through the study area.

RBSim Modeling

Input Analysis

The "raw" visitation and travel route data collected in the field and described in the preceding paragraph were formatted into a set of input databases required for the scheduling and routing of simulated visitor groups within RBSim (Itami et al., 2003), the simulation software used to develop the study model. In particular, the visitation data were used to construct databases of daily and normalized weekly arrivals of day use and overnight visitors during the study period. The visitor survey data were used to construct hourly arrival distributions for day use and overnight visitors, and distributions of campsite departure times for overnight visitors. The travel route data from the day use visitor survey and backcountry camping permits were used to construct distributions of travel routes for day use and overnight visitors, by trip starting location, starting time, and model of travel. Due to the programming nature of RBSim, all of the inputs for the simulation model were coded and formatted electronically into Microsoft Access databases. Within each replication of the model, RBSim generates a sequence of random numbers to randomly draw travel routes and departure times from the input distributions. The resultant schedule of simulated trips and associated routes is saved as an Access database and "read" by RBSim to generate a single replication of the model. The process outlined above is repeated for each replication of the model.

Simulations of Visitor Use and Inter-group Encounters

The probabilistic simulation process described above was used to estimate a number of visitor-based and spatially-based measures of visitor use and inter-group encounters, assuming current visitation in May, 2006. Visitor-based outputs generated from model simulations included: 1) the percentage of visitor groups that had at least one period during their hike of 30 minutes or more during which time they did not encounter another group ("temporal encounters"); 2) the percentage of visitor groups that, on average, encountered fewer than 2 other groups per hour ("hourly encounters"); and 3) the percentage of visitor groups that never encountered more than 2 groups per hour in the "interior" of the study area (i.e., 0.5 miles or further from any trailhead; "interior encounters"). Spatially-based outputs generated from model simulations included estimates of average daily visitor use at three particularly popular attraction sites within the study area – Hen Wallow Falls, Midnight Hole, and Mouse Creek Falls ("use_HWF," "use_MH," and "use_MF," respectively). Estimates of average daily hiking use of each trail segment ("trail use") and average nightly camping use of each camping location (i.e., campsites and shelters; "camping use") within the study area were also generated. The outputs were calculated from data generated by the computer simulation model after a warm-up period of 8 days. The warm-up period is designed to "populate" the model with visitor groups representative of the study period (Law & Kelton, 2000), and the 8-day period was selected because all trips observed in the backcountry permit data were 8 days or shorter in duration.

Output Reliability Analysis

Three alternative methods were used to estimate the number of replications needed to obtain desired levels of precision for the model outputs outlined in the preceding section of this chapter (Centeno & Reyes, 1998; Itami et al., 2005; Law & Kelton, 2000). It should be noted that the output reliability analysis methods used in this study are appropriate only for terminating simulations and do not apply in the case of steady-state simulations (Centeno & Reyes, 1998). The first step within each of the three reliability analysis methods was to define a desired level of precision with which to estimate the model outputs. For this study, the three methods described below were used to determine the number of replications needed to estimate, with 90% confidence, the visitor-based outputs within +/- 5% and the spatially-based outputs within +/- 1 visitor group.

Because the computer simulation model developed in this study was used to generate estimates of multiple outputs simultaneously, the alpha levels for the confidence intervals specified within each of the reliability analysis methods used in this study were adjusted using a Bonferroni Correction. In particular, the specified alpha level was adjusted by dividing it by the number of outputs estimated together (Law & Kelton, 2000). For example, the computer simulation model was used to estimate all three of the visitor-based outputs simultaneously. Thus, the Bonferroni Corrected alpha level for the analysis of visitor-based outputs was equal to 0.033 (0.10 divided by 3).

The next step within each of the three reliability analysis methods was to run the model for a relatively small number of replications, commonly referred to as the "short run." All three of the reliability analysis approaches used in this study require that the short run simulation has been replicated a sufficient number of times that the variances of the outputs of interest have stabilized. The steps that follow from the short run simulation vary across the three reliability analysis methods and are described separately in the following paragraphs.

Method of Independent Replications

Within the method of independent replications, the following equation is used to compute the confidence interval half-width around the mean of each output of interest resulting from the short run simulation:

$$\pm t_{n-1,1-\alpha/2}\sqrt{[S^2(n)]/n} \tag{1}$$

Where:

n = number of replications conducted for the short run simulation

$t_{n-1, 1-\alpha/2}$ = (1 - α / 2) percentile of the t-student distribution with n-1 degrees of freedom

$S^2(n)$ = sample variance of the output variable from the short run simulation

If the confidence interval half-width is less than or equal to the user-specified value, then no further replications are needed. For example, if the short run simulation results in a confidence interval half-width of less than or equal to 5% of visitors for each of the visitor-based outputs, then the number of replications performed for the short run simulation is sufficient to generate an estimate of these variables with the specified level of precision. Otherwise, the following equation is needed to compute the number of replications needed to achieve the user-specified level of precision:

$$n^* = \text{Round}\,[\, n \text{ x } (h / h^*)^2 \,] \qquad (2)$$

Where:

n^* = estimated number of replications needed to achieve user-specified level of precision
n = number of replications from short run simulation
h = interval half-width computed using short run results and Equation 1
h^* = user specified confidence interval half-width

The model is then run for n^* replications and the computation process using Equations 1 and 2 is repeated until the desired level of precision is obtained. At each iteration of the method, n^* and $S^2(n^*)$ are substituted into Equation 1.

Iterative Method

Law and Kelton (2000) suggest a modification to the method of independent replications referred to as the iterative method. Within the iterative method, Equation 1 is modified such that if the user-specified level of precision is not achieved within the short run simulation, the number of replications within the equation is increased incrementally by a value of one until the desired confidence interval half-width is achieved, as illustrated in the following equation:

$$n^*(\beta) = \min\{i \geq n : t_{i-1,1-\alpha/2}\sqrt{[S^2(n)]/i} \leq \beta\} \qquad (3)$$

Where:

$n^* (\beta)$ = estimated number of replications needed to achieve user-specified level of precision

β = the user specified confidence interval half-width

n = number of replications from the short run simulation

$t_{i-1, 1-\alpha/2}$ = (1- α / 2) percentile of the t-student distribution with i-1 degrees of freedom

$S^2 (n)$ = sample variance of the output variable from the short run simulation

i = number of replications at each iteration of the method

The iterative method is more efficient than the method of independent replications because it does not require additional replications of the computer simulation model after the short run simulation has been conducted. However, the iterative method assumes that the population variance of the output of interest will not change significantly as the number of replications is increased.

Relative Accuracy Method

The relative accuracy method is similar to the iterative method, but is designed to estimate the number of replications needed to achieve a user-specified level of *relative accuracy*, rather than simply a user-specified confidence interval half-width. Within this method, the relative accuracy is calculated as the confidence interval half-width as calculated in Equation 1, divided by the mean of the output variable of interest derived from the short run simulation. Thus, within the relative accuracy method, the equation for computing the number of replications needed to achieve a user-specified level of precision is as follows:

$$n^*(\lambda') = \min\{i \geq n : (t_{i-1,1-\alpha/2}\sqrt{[S^2(n)]/i})/|\overline{X}(n)| \leq \lambda'\} \tag{4}$$

Where:

$n^* (\lambda')$ = estimated number of replications needed to achieve a user-specified level of relative accuracy

λ' = user specified relative accuracy

n = number of replications from the short run simulation

$t_{i\text{-}1,1\text{-}\alpha/2}$ = (1-α/2) percentile of the t-student distribution with i - 1 degrees of freedom

$S^2(n)$ = sample variance of the output variable from the short run simulation

$\overline{X}(n)$ = mean of the output variable from the short run simulation

i = number of replications at each iteration of the method

As with the iterative method, the relative accuracy method assumes that the population variance of the output of interest will not change significantly as the number of replications is increased. The relative accuracy method also assumes that the mean of the output variable of interest will not change significantly as the number of replications is increased.

Results

Results of an iterative, graphical analysis process to select the number of short run replications needed to achieve variance stability among the visitor-based outputs are reported in Figure 4.3. The visitor-based outputs appear to stabilize between 10 and 20 replications, although the variances increase somewhat as the number of replications increase beyond 20. The same procedure was repeated to select the number of short run replications for the spatially-based outputs. Results for the campsite and trail outputs suggest that population variances for most of the outputs stabilize with relatively few replications (i.e., 15 to 20 replications). While results of the short run replications analysis suggest the population variance for Hen Wallow Falls use stabilizes around 20 or 30 replications, population variances for Midnight Hole and Mouse Creek Falls Use do not appear to stabilize, even with a large number of short run replications. Despite the mixed results with respect to the stability of population variances, 20 replications were used for the short run simulation since many of the outputs of interest report little appreciable change in population variance beyond 20 replications.

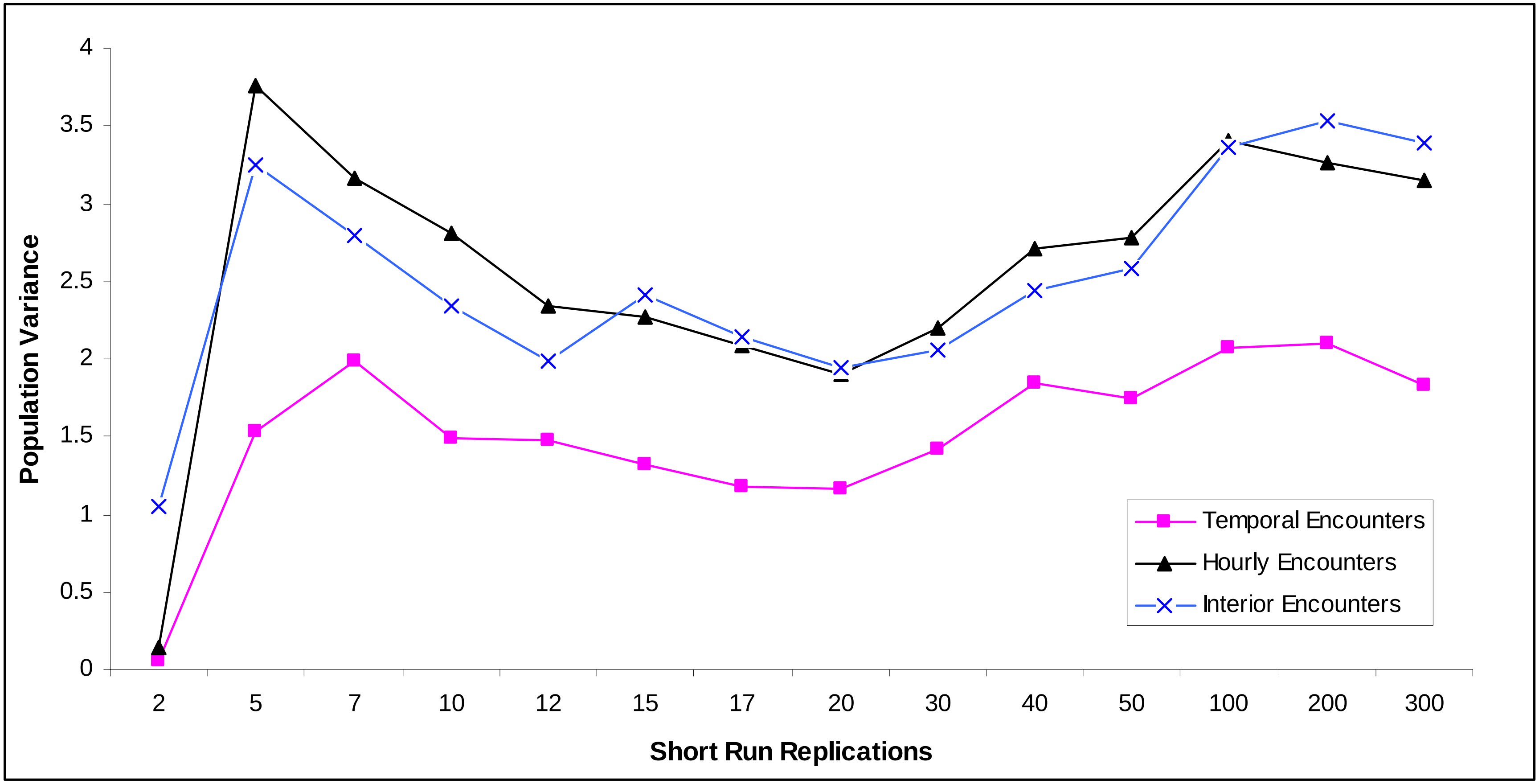

Figure 4.3. Estimates of population variances for visitor-based outputs with alternative numbers of replications for the "short run" simulation.

Table 4.1 reports the estimated number of replications needed to simultaneously estimate with 90% confidence 1) the three visitor-based outputs within +/- 5% of visitor groups; 2) the three attraction-based outputs within +/- 1 visitor group; and 3) the three visitor-based outputs within +/- 5% of visitor groups and the three attraction-based outputs within +/- 1 visitor group, together. Results of all three reliability analysis methods suggest that only 20 replications are needed to estimate the three visitor-based outputs or the three attraction-based outputs alone. To estimate the visitor-based and attraction-based outputs together, the method of independent replications and iterative method suggest that 20 replications are sufficient to do so with the specified level of precision. However, the relative accuracy method suggests 41 replications are needed to estimate the visitor-based and attraction-based outputs simultaneously with the desired level of precision, with visitor use at Midnight Hole being the constraining factor.

Table 4.1. Reliability Analysis Results for Visitor-Based and Attraction-Based Outputs.

Model outputs	C.I. half-width	Alpha level (Bonferroni Corrected)	Estimated replications *Method of Independent Replications*	Estimated replications *Iterative Method*	Estimated replications *Relative Accuracy Method*
Visitor-based outputs	-	-	-	-	-
Temporal encounters	± 5% of groups	0.10 (0.033)	20	20	20
Hourly encounters	± 5% of groups	0.10 (0.033)	20	20	20
Interior encounters	± 5% of groups	0.10 (0.033)	20	20	20
Attraction-based outputs	-	-	-	-	-
Hen Wallow Falls – Use	± 1 group	0.10 (0.033)	20	20	20
Midnight Hole – Use	± 1 group	0.10 (0.033)	20	20	20
Mouse Creek Falls – Use	± 1 group	0.10 (0.033)	20	20	20
Visitor and attraction-based	-	-	-	-	-
Temporal encounters	± 5% of groups	0.10 (0.017)	20	20	20
Hourly encounters	± 5% of groups	0.10 (0.017)	20	20	20
Interior encounters	± 5% of groups	0.10 (0.017)	20	20	20
Hen Wallow Falls – Use	± 1 group	0.10 (0.017)	20	20	20
Midnight Hole – Use	± 1 group	0.10 (0.017)	20	20	41
Mouse Creek Falls – Use	± 1 group	0.10 (0.017)	20	20	20

Table 4.2 reports the results of each of the three reliability analysis methods for estimates of average nightly campsite and shelter use. Since there are 10 campsites and shelters, the Bonferroni Corrected alpha level is 0.01 for each campsite/shelter, with an overall alpha level of 0.1. Results of the method of independent replications and iterative method suggest that a maximum of 58 replications would be needed to estimate, with 90% confidence, average nightly camping use at each camping location, within +/- 1 visitor group. However, results of the relative accuracy method suggest that nearly 300 replications of the model would be needed to estimate average nightly camping use, by location, with the desired level of precision.

Table 4.2. Reliability Analysis Results for Estimates of Average Nightly Camping Use, by Camping Location.

Camping Locations	**C.I. half-width**	**Alpha level** (Bonferroni Corrected)	**Estimated Replications** *Method of Independent Replications*	**Estimated Replications** *Iterative Method*	**Estimated Replications** *Relative Accuracy Method*
Davenport Gap Shelter	± 1 group	0.10 (0.01)	20	20	88
Cosby Knob Shelter	± 1 group	0.10 (0.01)	20	20	48
Tricorner Knob Shelter	± 1 group	0.10 (0.01)	26	25	112
Laurel Gap Shelter	± 1 group	0.10 (0.01)	20	20	55
Campsite 29	± 1 group	0.10 (0.01)	58	52	116
Campsite 34	± 1 group	0.10 (0.01)	50	45	293
Campsite 35	± 1 group	0.10 (0.01)	20	20	26
Campsite 36	± 1 group	0.10 (0.01)	20	20	60
Campsite 37	± 1 group	0.10 (0.01)	20	20	20
Campsite 38	± 1 group	0.10 (0.01)	20	20	35

Since there are over 100 trail segments within the study area, Table 4.3 reports the results of the three reliability analysis methods for estimates of daily trail segment use as the percentage of trail segments that require various ranges of replications. Results of both the method of independent replications and iterative method suggest that only 20 replications are needed to estimate with 90% confidence average daily hiking use, by trail segment, within +/- 1 visitor group. The results of the relative accuracy method, however, suggest that while a little over 50% of the trail segments within the study area require only 20 replications to achieve the desired level of precision, nearly 9% of the trail segments require over 100 replications, and over 2% require more than 1,500 replications. Thus, to estimate, with 90% confidence daily hiking use within +/- 1 visitor group for all trail segments in the study area simultaneously, the results of the relative accuracy method suggest that over 1,500 replications of the model would be required.

Table 4.3. Reliability Analysis Results for Estimates of Average Daily Hiking Use, by Trail Segment.

Estimated number of replications	**Method of Independent Replications**	**Iterative Method**	**Relative Accuracy Method**
	% of trail segments	*% of trail segments*	*% of trail segments*
20 replications	100.0	100.0	53.5
21 – 50 replications	0.0	0.0	28.2
51 – 100 replications	0.0	0.0	6.3
101 – 150 replications	0.0	0.0	6.3
151 – 200 replications	0.0	0.0	1.4
201 – 300 replications	0.0	0.0	2.1
301 – 400 replications	0.0	0.0	0.0
401 – 500 replications	0.0	0.0	0.0
501 – 1000 replications	0.0	0.0	0.0
1001 – 1500 replications	0.0	0.0	0.0
1501 – 2000 replications	0.0	0.0	2.1

n = 111 trail segments
Note. Alpha level = 0.10, Bonferroni Corrected alpha level = 0.001, confidence interval half-width = ± 1 visitor group.

Using the results of the reliability analyses to guide the number of replications performed with the model, the visitor-based, attraction-based, and camping and hiking use outputs were estimated. Table 4.4 reports estimates of the visitor-based and attraction-based outputs, estimated separately with 20 replications each, and together, with 50 replications of the model. The number of replications in the experiments produced confidence interval half-widths well within the reliability standards specified for the study (+/- 5% of visitor groups for the visitor-based indicators and +/- 1 visitor group for the attraction-based indicators). Results of the model suggest that about 60% of visitors to the study area have at least one time period of 30 minutes or more during which they encounter no other visitors. Further, the model estimates that approximately 45% of visitors encounter an average of two or fewer people per hour, and about 50% of visitors encounter two or fewer people per hour on trails in the interior of the study area. The model estimates that average daily use of Hen Wallow Falls and Mouse Creek Falls is about 10 visitor groups per day, while average daily use of Midnight Hole was estimated to be about eight groups per day.

Table 4.4. Visitor-based and Attraction-based Outputs, Estimated Separately and Simultaneously.

Model outputs	**Alpha level** (Bonferroni Corrected)	**Number of replications**	**Output value**	**Standard deviation**	**Confidence interval half-width**
Visitor-based indicators	0.10 (0.033)	20	-	-	-
Temporal encounters			61.36	1.078	0.417
Hourly encounters			45.64	1.378	0.533
Interior encounters			51.19	1.395	0.539
Attraction-based indicators	0.10 (0.033)	20	-	-	-
Hen Wallow Falls – Use			10.53	0.115	0.074
Midnight Hole – Use			8.19	0.312	0.199
Mouse Creek Falls – Use			10.73	0.212	0.136
Visitor and attraction based	0.10 (0.017)	50	-	-	-
Temporal encounters			61.53	1.321	0.500
Hourly encounters			45.76	1.669	0.631
Interior encounters			51.23	1.608	0.609
Hen Wallow Falls – Use			10.51	0.140	0.053
Midnight Hole – Use			8.21	0.314	0.119
Mouse Creek Falls – Use			10.76	0.243	0.092

The estimates of camping use reported in Table 4.5 were generated based on 1) 60 replications of the model, which is approximately the required number of replications estimated from the method of independent replications and iterative method; and 2) 300 replications, which constitutes the number of replications required by the relative accuracy method. While the standard deviations of camping use estimates were generally larger with 300 replications, the confidence interval half-widths were generally smaller compared to the results generated from 60 replications of the model. Although the results of the 300-replications experiment produced outputs with higher reliability than the 60-replications experiment, the confidence interval half-widths in each experiment were all within the standard of reliability for the analysis. Furthermore, the mean output values from each of the two experiments did not differ substantively. The results suggest overnight use in the study area is relatively low, with average camping use ranging from a low of one camping group per night at campsite 35 to a high of about five camping groups per night at the Tricorner Knob Shelter. Camping use estimates were highest along the Appalachian Trail, with the Tricorner Knob Shelter receiving the most camping use along the trail and the Cosby Knob Shelter receiving the lowest amount of camping use along the trail.

Table 4.5. Estimates of Average Nightly Camping Use, by Camping Location.

Estimated number of replications	Alpha level (Bonferroni Corrected)	60 Replications			300 Replications		
		Output value	Standard deviation	C.I. half-width	Output value	Standard deviation	C.I. half-width
Davenport Gap Shelter	0.10 (0.01)	4.500	1.780	0.618	4.240	1.739	0.261
Cosby Knob Shelter		3.067	1.520	0.522	2.960	1.649	0.248
Tricorner Knob Shelter		5.417	1.531	0.525	5.503	1.603	0.241
Laurel Gap Shelter		1.267	0.561	0.193	1.373	0.664	0.100
Campsite 29		3.783	2.666	0.915	3.647	2.657	0.399
Campsite 34		2.200	2.165	0.338	2.170	2.259	0.339
Campsite 35		1.050	0.194	0.067	1.110	0.329	0.049
Campsite 36		1.233	0.476	0.163	1.180	0.443	0.066
Campsite 37		1.867	0.891	0.306	1.660	0.818	0.122
Campsite 38		1.533	0.790	0.271	1.573	0.932	0.140

Table 4.6 reports the percentage of trail segments that fall within various average daily use categories. While the results of the relative accuracy method suggest that over 1,500 replications of the model are necessary to simultaneously estimate, with 90% confidence, average trial use for all of the trail segments in the study area within +/- 1 visitor group, RBSim is unable to process this number of replications with the study model due to file size constraints. Thus, the results reported in Table 4.6 were generated based on 1) 20 replications of the model, which is approximately the required number of replications estimated from the method of independent replications and iterative method; and 2) 1,300 replications, which constitutes the maximum number of replications RBSim is able to process with the study model. It should be noted that this file size constraint is specific to the model developed in this study, and that the total number of replications RBSim can process is a function of the size and complexity of the system being modeled. Further, it is likely that RBSim can be modified in a future release to minimize or eliminate this file size issue. Almost 40% of the trail segments in the study area had an average daily use of less than one visitor group, while 9% of the trail segments had an average daily use of over 20 visitor groups. Confidence interval half-widths for trail use estimates reported in Table 4.6 ranged from 0.005 to 0.575 with 20 replications of the model, and 0.001 to 0.061 with 1,300 replications of the model. Thus, both the 20-replications and 1,300-replications experiments produced confidence interval half-widths for all of the trail use outputs within the reliability standard set for the study.

Table 4.6. Ranges of Estimated Average Daily Hiking Use of Trail Segments.

Average trail use	**20 replications**	**1300 replications**
	% of trails segments	*% of trails segments*
Less than 1 group	37.8	37.8
1 to less than 2 groups	23.4	23.4
2 to less than 5 groups	11.7	11.7
5 to less than 10 groups	16.2	16.2
10 to less than 15 groups	0.9	0.9
15 to less than 20 groups	0.9	0.9
20 or more groups	9.0	9.0

n = 111 trail segments
Note. Alpha level = 0.10, Bonferroni Corrected alpha level = 0.001, confidence interval half-width = ± 1 visitor group.

Discussion

As noted, previous applications of computer simulation modeling to outdoor recreation management and planning have generally done little to assess the reliability of model estimates. This study demonstrates the application of reliability analysis procedures developed in the broader field of discrete-event simulation to modeling recreational use in a low use area. These same procedures are applicable to visitor landscapes, in general, including those that receive greater levels of use (Itami et al., 2005). Thus, this study serves to document reliability analysis procedures that can be adopted as standard practice for computer simulation modeling of visitor landscapes in general. It is interesting to note, however, that the three reliability analysis methods used in this study produced substantively different results. In particular, while the method of independent replications and iterative method generally yielded similar estimates of the number of replications needed to achieve desired levels of precision for the model outputs, the relative accuracy method typically resulted in much larger estimates of replication requirements. For example, results of both the method of independent replications and iterative method suggest that only 20 replications are needed to estimate the visitor-based and attraction-based outputs at the specified level of precision. In contrast, the relative accuracy method results suggest just over 40 replications would be needed. The differences between the results of the relative accuracy method and the other two methods are even more pronounced for the camping use and trail use estimates, with the relative accuracy method estimating the need for more than 5 times as many replications for the camping use outputs than estimated by the other two methods, and estimating the need for over 1,500, rather than 20, replications to estimate the trail use outputs.

While the relative accuracy method produces results that constitute the most stringent requirements for model replications, it is arguably the preferred reliability analysis method because, within its estimation of replication requirements, the variance of the model outputs is considered in relation to the size of the corresponding mean values of the outputs. This is a particularly important issue within low use recreation environments where it is expected that at least some, if not many, of the model outputs' mean values will be relatively small. That being said, the results of this study suggest that the relative accuracy method may overestimate replication requirements. In particular, experiments based on the less stringent replication requirements of the other two reliability analysis methods produced outputs that met the reliability standards specified for the study. These findings suggest that additional research on the relative merits of the three reliability analysis methods used in this study is warranted.

While the results of the reliability analyses conducted in this study varied depending on the method used, the findings regarding the feasibility of generating precise estimates of visitor use-related outputs from simulation models of low use environments are generally encouraging. The study findings are particularly promising for the visitor-based outputs generated with the study model, with only 20 replications of the model needed to achieve precise estimates. The visitor-based outputs include inter-group encounters, which has been the most commonly adopted indicator of wilderness solitude, as well as indicators that account for the temporal and spatial dimensions of encounters. Thus, the results of this study suggest that computer simulation modeling is a reliable tool for helping to implement visitor-based indicators of wilderness solitude within a VERP or LAC monitoring program.

While the findings from the reliability analyses for the visitor-based outputs were encouraging, results from the reliability analyses for the spatially-based outputs were somewhat mixed. Results suggest that precise estimates of visitor use at the three attractions sites for which outputs were obtained can be generated with just 20 replications of the study model. Further, the results suggest that the study model can reliably estimate the visitor-based and attraction-based outputs simultaneously, with fewer than 50 replications. Results of the method of independent replications and iterative method suggest that no more than 60 replications are needed to reliably estimate average nightly camping use at each of the 10 campsites and shelters in the study area, however, the relative accuracy method suggests nearly 300 replications of the model are needed. While this is a substantially larger number of replications than that required for the visitor-based and attraction-based outputs, it involves relatively inconsequential amounts of computer processing time and capacity. In contrast, results of the reliability analyses suggest that as many as 1,700 replications are needed to simultaneously estimate average daily hiking use on all 111 of the trail segments in the study area. This exceeds the maximum number of replications RBSim can process with the study model, due to file size constraints. Thus, the findings suggest that precise estimates cannot be readily obtained for the lowest use trail segments within the study area. However, as noted, 90% confidence interval half-widths for estimates of average daily hiking use on the 111 trail segments based on 1,300 replications were all well below the target half-width of +/- 1 visitor group. Furthermore, confidence interval half-widths produced from the

20-replications experiment were all within the reliability standard specified for the trail use outputs. As noted above, these finding suggest that the relative accuracy may provide an upper-bound estimate, perhaps even an overestimate, of the number of replications needed to generate outputs at specified levels of precisions. If the relative accuracy method systematically produces overestimates of replication requirements, this is not necessarily an inconsequential issue, as the run time required to produce 1,300 replications of the study model totaled more than seven days. In any case, results of this study suggest the feasibility of simultaneously generating a relatively large number of use-related outputs from simulation models of low use visitor landscapes may be limited due to file size and processing time constraints. However, these are limitations that could likely be addressed with advances in computing technology.

Aside from advances in computing technology, there are several alternative approaches to address the challenges associated with generating precise estimates of use-related outputs in low use recreation environments. One option would be to eliminate the lowest use trail segments from simulation model output analyses. In the case of this study, eliminating the three lowest use trail segments from the output analysis would reduce the number of replications needed to obtain precise estimates of average daily hiking use from over 1,700 to less than 250. This approach might be particularly attractive in cases where areas of concentrated use are of particular concern and interest to managers. However, it could be argued that the lowest use portions of backcountry and wilderness areas are the most important to monitor because they afford rare opportunities for solitude that may be threatened by even small increases in visitor use and inter-group encounters. Thus, eliminating low use areas or zones from simulation model output analyses may not be an acceptable approach.

An alternative approach to address issues of reliability in simulations of low use environments would be to produce estimates of visitor use and use-related indicators aggregated by management zone. For example, modeling could be used to generate estimates of average daily use for “primitive zone trails,” “threshold zone trails,” and “corridor zone trails.” Results using this approach would be less spatially precise, but may be equally or more sufficient for the purposes of helping to monitor and manage visitor use and opportunities for solitude in low use environments. This type of approach could be programmed within RBSim and other simulation software packages with relative ease, and the approach could be tailored to the management zoning of a particular study area.

Alternatively, variance reduction techniques could be used to reduce the number of replications that would be needed to obtain precise estimates of all of the outputs of interest. Variance reduction techniques are characterized as methods used to increase the efficiency and speed of simulating a study environment to estimate the outputs of interest as precisely as desired (Law & Kelton, 2000). A few of the more commonly used variance reduction techniques include: 1) using common random numbers to compare two separate, alternative system simulations; 2) antithetic variates, which introduce negative correlation between separate runs of the same system; 3) importance sampling, where the chance of events of interest are increased to occur more often; and 4) conditioning the model to remove one source of variability. While RBSim is programmed to use common random numbers as a default, selection of the appropriate variance reduction techniques are model specific. That is, one or more variance reduction techniques may work well within one simulation modeling application, but perform poorly when applied to other models. Furthermore, the specific efficiency of each separate technique's ability to reduce the variance of the system is unknown for the model of interest. Future research should explore which variance reduction techniques may work best for low use recreation areas, and whether or not variance reduction techniques improve the ability of computer simulation models to produce estimates at managerially useful levels of precision.

Conclusion

This study serves to document procedures to assess the reliability of outputs from computer simulation models of visitor landscapes. It is recommended that these procedures be adopted as standard practice within applications of computer simulation modeling to outdoor recreation planning and management. Further, this study provides insights into the feasibility of generating visitor use-related model outputs at managerially relevant levels of precision. The results suggest that precise estimates can be obtained for a small to moderate number of visitor-based and spatially-based outputs. However, there are constraints to generating precise estimates of use-related outputs as the number of outputs estimated simultaneously becomes large. This challenge is particularly pronounced in cases where at least some of the outputs are derived for low use attractions, trails, or camping locations. Future studies should explore variance reduction techniques to enhance the reliability of computer simulation modeling in cases where a large number of outputs are desired and/or low use environments are modeled.

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CHAPTER 5 – GREAT SMOKY MOUNTAINS NATIONAL PARK DAY USE AND OVERNIGHT VISITOR SURVEY – RESULTS AND MAJOR FINDINGS

Introduction

This chapter presents the results of a visitor survey administered to day use and overnight visitors in the Cosby and Big Creek areas during May, 2006. The chapter also reports the results of direct observations of inter-group encounters on the Big Creek and Gabes Mountain Trails during May, 2006. The following sections of this chapter include: 1) the methods used to administer the visitor survey; 2) the methods used for the direct observations of inter-group encounters; 3) a summary of major findings from the visitor survey and observation research; and 4) tabular and graphical results of the visitor survey and observation research .

Study Methods

Figure 5.1 presents a map which provides a detailed view of the trails, campsites, shelters, attractions and related features in the study area. The Cosby and Big Creek areas are used by day use hikers, day and overnight horseback riders, and backpackers, including Appalachian Trail thru-hikers. Over 85 miles of trails are located in the study area, including 16 miles of the Appalachian Trail. Four of the six campsites and all of the four shelters require visitors to obtain a reservation before visitors can camp overnight. Three of the shelters in the study area are located along the Appalachian Trail and these shelters receive most of the overnight use in the study area (National Park Service, 2005). There are multiple destination sites within the study area that are accessible within a relatively short day's hike, including several waterfalls that are within two miles of a parking lot and trailhead.

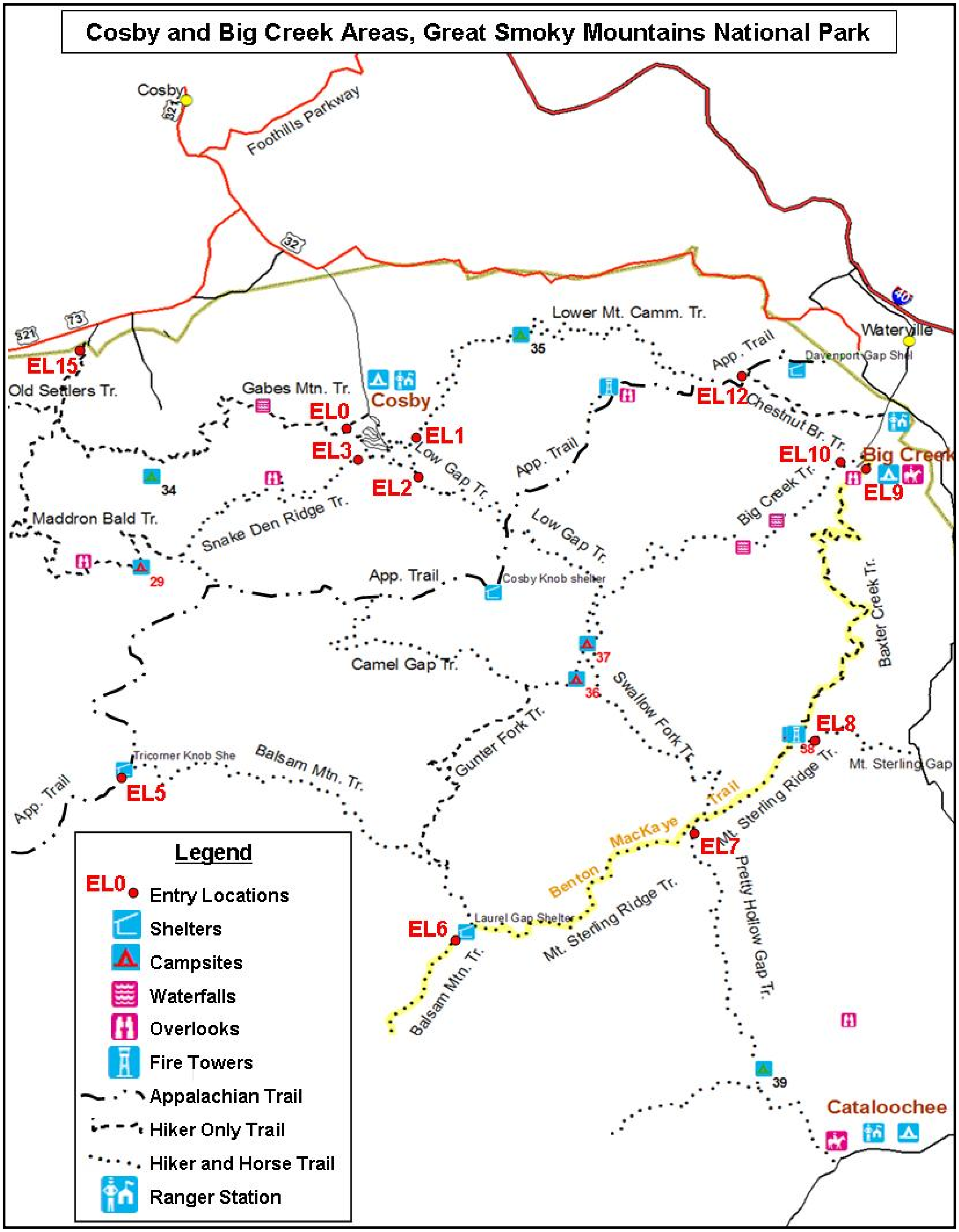


Figure 5.1. Big Creek and Cosby areas of Great Smoky Mountains National Park.

Visitor Survey

A survey of a representative sample of day and overnight visitors to the Cosby and Big Creek areas of Great Smoky Mountains National Park was conducted during May, 2006. The day use and overnight visitor survey booklets are presented in Appendices C and D, respectively. The survey packets administered to day and overnight visitors contained four major sections. The first section of the questionnaire, entitled "Trip Description," includes questions concerning visitors' group size, group type, and a map of the study area upon which respondents were instructed to record their route of travel during the trip into the study area they just completed. Examples of the route maps day use and overnight visitors were asked to complete as part of the surveys are included as Appendices E and F, respectively. The route maps contained a layout of all trails, campsites, shelters, and destination sites (e.g., waterfalls, fire towers, etc.) within the study area. Using the route map, each respondent traced their route of travel by: 1) marking the starting and ending locations of their trip; 2) recording the starting and ending times of their trip; and 3) placing an 'X' at every location (e.g., at waterfalls, observations points, rest stops, etc.) where they spent more than 5 minutes and recording the total amount of time they spent at each stop. Overnight visitors were also asked to record in the survey booklet: 1) the campsites or shelters at which they camped; 2) the date(s) they camped at each location; and 3) the time they left each camping location in the morning. Survey administrators offered each respondent assistance to locate features on the route survey maps as needed. A database of day use visitor travel routes was constructed from the route maps completed by day use visitor respondents.

The second section of the questionnaire is entitled "The Visitor Experience" and includes questions concerning the importance to respondents of characteristics commonly associated with backcountry and wilderness areas as reasons for their visit to the study area, the degree to which visitors experienced solitude, visitors' attitudes and perceptions of inter-group encounters, and the extent to which they adopted various crowding-avoidance behaviors during their visit or previous outdoor recreation trips.

The third section of the questionnaire, entitled "Great Smoky Mountains National Park Management," includes questions regarding the extent to which visitors support or oppose alternative strategies for managing visitor use in Great Smoky Mountains National Park.

The last section of the questionnaire is entitled "Background Information" and contains questions concerning visitors' sex, age, country, state, and zip code of residence, level of education, and race and ethnicity.

During the study period, surveys were administered to exiting day use and overnight visitors at the eight trailheads in the study area. In particular, surveys were administered at or near the trailheads of the following trails depicted in Figure 5.1: 1) Maddron Bald Trail – EL15; 2) Big Creek Trail – EL10; 3) Baxter Creek Trail – EL9; 4) Appalachian Trail near Davenport Gap – EL12; 5) Gabes Mountain Trail – EL0; 6) Snake Den Ridge Trail – EL3; 7) Low Gap Trail – EL2; and 8) Lower Mt. Cammerer Trail – EL1. For each of the eight survey locations, sampling days were randomly assigned to at least four weekdays and four weekend days throughout the study period, although all of the survey locations except the Baxter Creek Trail location received more than the minimum amount of days. Table 5.1 reports the total number of days of survey sampling conducted at each survey location.

On each survey sampling day, trained survey administrators were located near trailheads within the study area between 10:00 AM and 6:00 PM. Both day use and overnight visitors were asked if they would be willing to participate in the visitor use survey. If they agreed, visitors were administered one of two versions of the visitor survey instrument, depending on whether they had just completed an overnight or day use visit to the study area.

Table 5.1. Survey Sampling Effort, by Day of Week and Entry Location.

<table>
<tr><th rowspan="2">Entry location</th><th rowspan="2">Weekdays</th><th rowspan="2">Weekend days</th><th rowspan="2">Total number of days</th><th colspan="2">Number of completed surveys</th></tr>
<tr><th>Day use</th><th>Overnight</th></tr>
<tr><td>EL0 – Gabes Mountain Trail[a]</td><td>6</td><td>6</td><td>12</td><td rowspan="4">121</td><td rowspan="4">28</td></tr>
<tr><td>EL1 – Lower Mt. Cammerer Trail[a]</td><td>6</td><td>6</td><td>12</td></tr>
<tr><td>EL2 – Low Gap Trail[a]</td><td>6</td><td>6</td><td>12</td></tr>
<tr><td>EL3 – Snake Den Ridge Trail[a]</td><td>6</td><td>6</td><td>12</td></tr>
<tr><td>EL9 – Baxter Creek Trail</td><td>4</td><td>3</td><td>7</td><td>6</td><td>5</td></tr>
<tr><td>EL10 – Big Creek Trail</td><td>5</td><td>6</td><td>11</td><td>76</td><td>19</td></tr>
<tr><td>EL12 – Appalachian Trail near Davenport Gap Shelter</td><td>6</td><td>5</td><td>11</td><td>11</td><td>31</td></tr>
<tr><td>EL15 – Maddron Bald Trail</td><td>5</td><td>5</td><td>10</td><td>38</td><td>3</td></tr>
</table>

[a]Sampling occurred at the parking lot common to trailhead EL0, EL1, EL2, and EL3.

Visitor Observation

Direct observations of inter-group encounters were conducted on trails in two of the more heavily used portions of the study area – the Big Creek and Gabes Mountain Trails (Figure 5.1). Both trail sections where encounter observations were conducted begin at a trailhead adjacent to a parking lot, extend 2.5 miles or less from the parking lot to primary visitor destinations within the study area (i.e., waterfalls), and are popular hiking routes.

On each day encounter observations were conducted, a trained observer randomly selected visitor groups as they initiated their hike/horseback ride into the study area and followed the group from a distance where the group was visible but the observer would not be noticed. While conducting the encounter observations, the researchers recorded the time and location (i.e., UTM coordinates from a GPS unit) of each encounter the observed group had with other groups and three related pieces of information: 1) the type of group encountered; 2) the size of the group encountered; and 3) the type of encounter (i.e., a meeting encounter, in which the groups were moving in opposite directions on the trail, or an overtaking encounter, in which the groups were moving in the same direction on the trail). The encounter observation forms for both the Big Creek and Gabes Mountain Trails are included as Appendix G. Trained personnel conducted observations from 10:00 AM to 6:00 PM.

Table 5.2. Encounter Observation Sampling Effort, by Day of Week and Location.

	Number of days sampled			**Number of observations**		
Entry location	*Weekdays*	*Weekend days*	*Total*	*Weekdays*	*Weekend days*	*Total*
Gabes Mountain Trail	15	5	20	40	11	51
Big Creek Trail	11	5	16	42	12	54

Summary of Major Findings

This section summarizes findings from the visitor surveys administered to day use and overnight visitors to the Big Creek and Cosby areas of Great Smoky Mountains National Park, and the encounter observations conducted on the Big Creek and Gabes Mountain Trails during May, 2006. Presentation of findings from the visitor surveys are organized according to the sections of the visitor survey questionnaires. The results of the route map section of the visitor survey questionnaires are summarized in a separate sub-section of this chapter section.

Visitor Survey

Trip Description

- Day use visitors tend to hike in groups larger than overnight groups. The mean group size of day use visitors was 3.06 people, while the mean group size of overnight visitors was 2.23 people.
- AT-Thru hikers average slightly smaller group sizes (1.72) than other backpacking groups in the study area (2.46).
- All of the horse groups that completed a survey consisted of 2 horseback riders.
- The majority of day use visitors (53.3%) were hiking with family, while the majority of overnight visitors (52.3%) were camping with family.

The Visitor Experience

- Both day use and overnight visitors ranked "pristine natural environment" as the most important reason they visit the study area.
- Solitude ranked fourth out of 11 among day use visitors on the list of reasons for visiting the study area, while solitude ranked fifth for overnight visitors.
- Day use and overnight visitors were significantly different in the importance they attached to only two of the characteristics associated with backcountry and wilderness areas. Overnight visitors ranked "requiring self-reliance" and "physically challenging/demanding" higher in importance than day use visitors as reasons visit the study area.
- The three most important reasons both day use and overnight visitors visited the study area were for the pristine natural environment, for fostering a connection with nature, and for fostering a sense of humility towards nature.

- Day use visitors reported encountering an average of 8 hikers and 1 horseback rider on the trail, away from trailheads and attractions with an average trip length of just under 4 hours. Day use visitors also reported encountering an average of 2 people at attractions.
- Overnight visitors reported encountering an average of 5 hikers and less than 1 horseback rider on the trail, away from trailheads and campsites/shelters per each day of their trip with an average trip length of slightly over a day and a half. Overnight visitors also reported an average of 5 encounters at campsites and shelters.
- Day use visitors reported an average of 66.3 minutes as the longest period of time that passed during which they did not see another person. However, over one-third (38.3%) of all day use visitors reported that 30 minutes or less was the longest period of time they had without seeing other people.
- Overnight visitors reported an average of 9 hours and 48 minutes as the longest period of time that passed during which they did not see another person. However, the majority (52.3%) of overnight visitors reported that 4 hours or less was the longest period of time they had without seeing other people.
- On average, both day use and overnight visitors reported that they experienced solitude to a moderate degree during their trip to the study area.
- The majority of day use (53.9%) and overnight visitors (53.5%) disagree with the statement that "the number of other people they saw along the trails interfered with their sense of solitude."
- Less than one-third of overnight visitors (29.6%) agree with the statement that "the number of other people they saw at campsites and shelters interfered with their ability to experience solitude."
- Almost three-quarters of day use visitors (70.7%) and over half of overnight visitors (52.3%) did not actively try to avoid other visitors during their visit to the study area. The most common avoidance technique used by day use visitors (15.0%) was to hiker/horseback ride on specific trails where they expected to see fewer people. Almost one-quarter of overnight visitors (24.4%) reported that they camped at a particular campsite or shelter where they expected to see fewer people.
- When asked whether they had *ever* employed any crowding-avoidance techniques, on average, both day use and overnight visitors reported to have only occasionally or rarely

done so. The most commonly employed avoidance technique for both day use and overnight visitors was to avoid attractions that were crowded.

- A little less than half of both day use (41.1%) and overnight visitors (40.8%) agree that the number of other people they see during any backcountry trip affects their ability to experience solitude.
- The majority of both day use (52.8%) and overnight visitors (53.1%) agree that the amount of time that passes without seeing other people affects their ability to experience solitude.
- Slightly over half of overnight visitors (51.3%) feel that they would need more than 2 hours to pass between seeing other people during their trip to experience solitude.

Great Smoky Mountains National Park Management

- Both day use and overnight visitors tended to either feel neutral or slightly disagree with all of the visitor use management statements they were asked to evaluate in the survey.
- The only visitor use management statement that visitors, on average, slightly agree with is "if solitude is lost, use limits should be imposed."
- Day use and overnight visitors were not significantly different in their evaluations of any of the visitor use management statements.

Background Information

- The majority of day use visitors were male (58.6%), and almost three-quarters of overnight visitors were male (72.3%).
- The mean age of day use visitors (43 years old) was over 10 years older than overnight visitors (30 years old). Over one-third of overnight visitors (36.6%) were in the 18-24 years age category.
- Only 5 other countries outside of the United States were reported as locations of residence on both the day use and overnight visitor surveys.
- Forty percent of day use visitors claim Tennessee as their state of residence, while 26 other states were represented by day use visitors. Tennessee was the most common state of residence among overnight visitors (16.7%), while 27 other states were represented.
- The most common zip codes of residence were located in Tennessee for both day use and overnight visitors, with Knoxville zip codes being the most commonly reported.

- Both day use and overnight visitors reported high levels of formal education, with almost three-quarters of both day use (73.0%) and overnight visitors (74.7%) holding a college degree or higher. Almost one-third of day use visitors have a masters, doctoral, or professional degree (32.3%).
- Less than 1% of day users and 5% of overnight visitors consider themselves to be Hispanic, Latino or Latina.
- The vast majority of both day use (97.3%) and overnight visitors (91.9%) identified their race as white.

Route Maps

- Over one-third of day use visitors (34.6%) started and ended their trip at the Gabes Mountain trailhead, while over one-quarter (26.7%) started and ended their trip at the Big Creek trailhead.
- Less than 5% of day use visitors reported starting and ending their hikes at the Mt. Sterling, Snake Den Ridge, or Baxter Creek trailheads.
- Nearly half of all day use visitors (46.5%) spent three hours or less on their trip.
- Over three-quarters of day use visitors (79.5%) started their trip by 1:00 PM.
- Almost half of all overnight visitors started and ended their trip on the Appalachian Trail (46.4% started at southern end and ended at the northern end, while 2.4% started at the northern end).
- Almost one-quarter of all overnight visitors (22.2%) spent less than 24 hours on their trip, and over three-quarters of overnight visitors (75.3%) spent 2 days or less on their trip.
- Roughly two-thirds of overnight visitors (67.1%) started their trip by 1:00 PM. The majority of overnight visitors (52.7%) ended their trip after 1:00 PM.
- The majority of overnight visitors (56.9%) broke camp by 9:00 AM, with less than one-tenth of overnight visitors breaking camp after 11:00 AM (7.7%).
- The Lower Walnut Bottoms campsite (#37) was the most commonly used campsite in the study area, followed by the Sugar Cove campsite (#34). The AT shelters were the most frequented shelters by overnight visitors, with the Tricorner Knob Shelter being the most frequently used (9.7% of survey respondents).

Encounter Observations

- Encounter observations were conducted following visitors groups both into and out of the park. The average time spent following visitor groups into the park on the Gabes Mountain Trail was over 85 minutes, while only 73 minutes on the Big Creek Trail. The average time spent following visitor groups out of the park on the Gabes Mountain Trail was over 70 minutes, while less than 60 minutes on the Big Creek Trail.
- Average encounters were higher on the Gabes Mountain Trail, both on the trail and at Hen Wallow Falls than on the Big Creek Trail. Visitors on the Gabes Mountain Trail had an average of about 3 total encounters with other groups on the trail away from the trailhead, while on the Big Creek Trail visitors encountered an average of less than two total groups.
- On average, visitors had more encounters with other groups at Mouse Creek Falls (mean = 1.1) than at Midnight Hole (mean = 0.8) on the Big Creek Trail.
- The average maximum time between encounters was over 50 minutes (51.3 minutes) for visitor groups on the Gabes Mountain Trail, and just over 40 minutes (43.1 minutes) for visitor groups on the Big Creek Trail.
- The majority of visitor groups observed had at least one time period greater than 30 minutes during their hike when they did not encounter another visitor group (60.8% for the Gabes Mountain Trail and 59.9% for the Big Creek Trail).

Visitor Survey Results

This section presents the results of the day use and overnight visitor survey administered in the Big Creek and Cosby areas of Great Smoky Mountains National Park during May, 2006. First, the survey sampling results and associated response rate are reported. Then survey results are presented in the order in which the corresponding questions appear in the questionnaires.

Table 5.3. Visitor survey response rate.	
Number of visitor groups contacted	382
Refusals	39
Number of day use surveys completed	256
Number of overnight surveys completed	87
Total number of surveys completed	343
Response rate	89.8%

Trip Description

Table 5.4.1. Including yourself, how many hikers were in your group during your visit to Great Smoky Mountains National Park?

	Day (n=244)		**Overnight** (n=86)	
	Frequency	*Percent*[a]	*Frequency*	*Percent*[a]
1 hiker	30	11.7	18	20.9
2 hikers	118	46.1	47	54.7
3 to 6 hikers	66	27.0	21	24.4
7 or more hikers	23	9.4	0	0.0

[a]($\chi^2 = 14.50$, $p = 0.006$)

Table 5.4.2. Including yourself, how many horseback riders were in your group during your visit to Great Smoky Mountains National Park?

	Day (n=244)		**Overnight** (n=86)	
	Frequency	*Percent*	*Frequency*	*Percent*
1 horseback rider	0	0.0	0	0.0
2 horseback riders	7	2.9	0	0.0

Table 5.4.3. Group size mean comparisons.						
		Mean	*Median*	*t-statistic*	*p-value*	n
Hikers	Day	3.06	2	3.03	0.003	244
	Overnight	2.23	2			86
Day	Hiker	3.06	2	18.37	<0.001	244
	Horseback	0.06	0			244
Overnight	Hiker	2.23	2	N/A	N/A	86
	Horseback	0.00	0			76
Overnight	AT-Thru[a]	1.72	2	3.06	0.003	25
	Not AT-Thru	2.46	2			59

[a]AT-thru hikers were distinguished on the front cover of the survey booklet.

Table 5.5. Which of the following best describes your group during your hike/horseback ride on the park's trails today? (Circle one number.)				
	Day (n=244)		**Overnight** (n=86)	
	Frequency	*Percent*[a]	*Frequency*	*Percent*[a]
Solo	29	11.9	16	18.6
Family	130	53.3	16	18.6
Friends	47	19.3	45	52.3
Family and friends	22	9.0	5	5.8
Organized/School	15	6.1	0	0.0
Other (please specify)				
Research[b]	1	0.4	1	1.2
AT Thru Hiker[b]	0	0.0	3	3.5

[a](χ^2 = 51.37, p = <0.001)
[b]Respondent wrote in these responses as an "other" type of group; they were not included in calculating the Chi-square test.

Table 5.6.1. The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails/go backcountry camping in this part of Great Smoky Mountains National Park. (Circle one number for each item.)

		Day		**Overnight**		*Chi-Square[b], p-value*	*t-statistic, p-value*
		Frequency	*Percent[a]*	*Frequency*	*Percent[a]*		
Remoteness	Not at all important (1)	10	4.0	1	1.3	$\chi^2 = 14.07$, $p = 0.007$	
	2	22	8.9	4	5.0		
	Somewhat important (3)	82	33.1	13	16.3		
	4	80	32.3	38	4.7		
	Extremely important (5)	54	21.8	24	30.0		
	Don't Know / Not Sure	1	0.4	0	0.0		
	Mean	3.59		4.00			t = -3.45, p = 0.001
Solitude	Not at all important (1)	6	2.4	1	1.3	$\chi^2 = 5.70$, $p = 0.222$	
	2	15	6.1	4	5.0		
	Somewhat important (3)	62	25.1	16	20.0		
	4	87	35.2	40	50.0		
	Extremely important (5)	77	31.2	19	23.7		
	Don't Know / Not Sure	3	1.2	0	0.0		
	Mean	3.87		3.90			t = -0.29, p = 0.772

[a]Percentages for "Not at all important" through "Extremely important" are calculated based on the number of respondents who gave a response other than "Don't Know / Not Sure."
[b]Chi-Square tests exclude Don't Know / Not Sure responses.

Table 5.6.1 (continued). The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails/go backcountry camping in this part of Great Smoky Mountains National Park. (Circle one number for each item.)

		Day		Overnight		*Chi-Square[b], p-value*	*t-statistic, p-value*
		Frequency	*Percent[a]*	*Frequency*	*Percent[a]*		
Primitive recreation/few facilities	Not at all important (1)	31	12.8	5	6.4	$\chi^2 = 9.16$, $p = 0.057$	
	2	46	18.9	10	12.8		
	Somewhat important (3)	69	28.4	17	21.8		
	4	57	23.5	27	34.6		
	Extremely important (5)	40	16.5	19	24.4		
	Don't Know / Not Sure	3	1.2	0	0.0		
	Mean	3.12		3.58			t = -2.84, p = 0.005
Pristine natural environment	Not at all important (1)	1	0.40	0	0.0	$\chi^2 = 1.54$, $p = 0.820$	
	2	2	0.80	0	0.0		
	Somewhat important (3)	10	4.0	2	2.6		
	4	53	21.3	19	24.4		
	Extremely important (5)	183	73.5	57	73.1		
	Don't Know / Not Sure	1	0.4	0	0.0		
	Mean	4.67		4.71			t = -0.49, p = 0.625

[a]Chi-Square tests exclude Don't Know / Not Sure responses.
[b]Percentages for "Not at all important" through "Extremely important" are calculated based on the number of respondents who gave a response other than "Don't Know / Not Sure."

Table 5.6.1 (continued). The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails/go backcountry camping <u>in this part of Great Smoky Mountains National Park</u>. (Circle one number for each item.)

		Day		Overnight		*Chi-Square[b], p-value*	*t-statistic, p-value*
		Frequency	*Percent[a]*	*Frequency*	*Percent[a]*		
Physically challenging/ demanding	Not at all important (1)	16	6.4	2	2.5	$\chi^2 = 18.12$, $p = 0.001$	
	2	39	15.6	2	2.5		
	Somewhat important (3)	110	44.0	31	38.75		
	4	60	24.0	31	38.75		
	Extremely important (5)	25	10.0	14	17.5		
	Don't Know / Not Sure	0	0.0	0	0.0		
	Mean	3.16		3.66			t = -4.00, p < 0.001
Unconfined recreation/free from rules and regulations	Not at all important (1)	48	19.4	16	21.1	$\chi^2 = 1.32$, $p = 0.859$	
	2	56	22.7	18	23.7		
	Somewhat important (3)	71	28.7	20	26.3		
	4	45	18.2	11	14.5		
	Extremely important (5)	27	10.9	11	14.5		
	Don't Know / Not Sure	4	1.6	1	1.2		
	Mean	2.79		2.78			t = -0.05, p = 0.957

[a]Chi-Square tests exclude Don't Know / Not Sure responses.
[b]Percentages for "Not at all important" through "Extremely important" are calculated based on the number of respondents who gave a response other than "Don't Know / Not Sure."

Table 5.6.1 (continued). The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails/go backcountry camping <u>in this part of Great Smoky Mountains National Park</u>. (Circle one number for each item.)

		Day		Overnight		*Chi-Square[b], p-value*	*t-statistic, p-value*
		Frequency	*Percent[a]*	*Frequency*	*Percent[a]*		
Requiring self-reliance	Not at all important (1)	17	7.0	0	0.0	$\chi^2 = 24.21$, $p < 0.001$	
	2	25	10.2	3	3.8		
	Somewhat important (3)	101	41.4	19	24.4		
	4	71	29.1	41	52.6		
	Extremely important (5)	30	12.3	15	19.2		
	Don't Know / Not Sure	5	2.0	0	0.0		
	Mean	3.30		3.87			t = -5.30, p < 0.001
Fostering a sense of humility towards nature	Not at all important (1)	7	2.9	0	0.0	$\chi^2 = 3.01$, $p = 0.557$	
	2	12	5.0	5	6.3		
	Somewhat important (3)	44	18.3	14	17.7		
	4	83	34.4	31	39.2		
	Extremely important (5)	95	39.4	29	36.7		
	Don't Know / Not Sure	8	3.1	1	1.2		
	Mean	4.02		4.06			t = -0.30, p = 0.765

[a]Chi-Square tests exclude Don't Know / Not Sure responses.
[b]Percentages for "Not at all important" through "Extremely important" are calculated based on the number of respondents who gave a response other than "Don't Know / Not Sure."

Table 5.6.1 (continued). The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails/go backcountry camping in this part of Great Smoky Mountains National Park. (Circle one number for each item.)

		Day		Overnight		*Chi-Square[b], p-value*	*t-statistic, p-value*
		Frequency	*Percent[a]*	*Frequency*	*Percent[a]*		
Fostering intimacy/ connection with others in your group	Not at all important (1)	28	11.7	8	10.1	$\chi^2 = 2.00$, $p = 0.735$	
	2	26	10.9	11	13.9		
	Somewhat important (3)	48	20.1	20	25.3		
	4	77	32.2	21	26.6		
	Extremely important (5)	60	25.1	19	24.1		
	Don't Know / Not Sure	9	3.5	1	1.2		
	Mean	3.48		3.41			t = 0.45, p = 0.650
Fostering spiritual uplift	Not at all important (1)	17	6.9	9	11.4	$\chi^2 = 5.21$, $p = 0.267$	
	2	23	9.3	9	11.4		
	Somewhat important (3)	53	21.5	15	19.0		
	4	74	30.0	29	11.7		
	Extremely important (5)	80	32.4	17	6.9		
	Don't Know / Not Sure	3	1.2	1	1.2		
	Mean	3.72		3.46			t = 1.65, p = 0.100

[a]Chi-Square tests exclude Don't Know / Not Sure responses.
[b]Percentages for "Not at all important" through "Extremely important" are calculated based on the number of respondents who gave a response other than "Don't Know / Not Sure."

Table 5.6.1 (continued). The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails/go backcountry camping in this part of Great Smoky Mountains National Park. (Circle one number for each item.)

		Day		Overnight		*Chi-Square[b], p-value*	*t-statistic, p-value*
		Frequency	*Percent[a]*	*Frequency*	*Percent[a]*		
Fostering connection with nature	Not at all important (1)	5	2.0	2	2.5	$\chi^2 = 4.85$, $p = 0.303$	
	2	6	2.4	0	0.0		
	Somewhat important (3)	15	6.0	9	11.4		
	4	82	33.0	28	35.4		
	Extremely important (5)	141	56.7	40	50.6		
	Don't Know / Not Sure	2	0.8	1	1.2		
	Mean	4.40		4.32			t = 0.73, p = 0.469

[a]Chi-Square tests exclude Don't Know / Not Sure responses.
[b]Percentages for "Not at all important" through "Extremely important" are calculated based on the number of respondents who gave a response other than "Don't Know / Not Sure."

Table 5.6.2. Rank Order of Importance – The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails/go backcountry camping in this part of Great Smoky Mountains National Park. (Circle one number for each item.)	
Ranked by Importance (Day Users Only.)	*Mean Importance*
Pristine natural environment	4.67
Fostering connection with nature	4.40
Fostering a sense of humility towards nature	4.02
Solitude	3.87
Fostering spiritual uplift	3.72
Remoteness	3.59
Fostering intimacy/connection with others in your group	3.48
Requiring self reliance	3.30
Physically challenging/ demanding	3.16
Primitive recreation/few facilities	3.12
Unconfined recreation/free from rules and regulations	2.79

Table 5.6.3. Rank Order of Importance – The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails/go backcountry camping in this part of Great Smoky Mountains National Park. (Circle one number for each item.)

Ranked by Importance (Overnight Users Only.)	*Mean Importance*
Pristine natural environment	4.71
Fostering connection with nature	4.32
Fostering a sense of humility towards nature	4.06
Remoteness	4.00
Solitude	3.90
Requiring self reliance	3.87
Physically challenging/ demanding	3.66
Primitive recreation/few facilities	3.58
Fostering spiritual uplift	3.46
Fostering intimacy/connection with others in your group	3.41
Unconfined recreation/free from rules and regulations	2.78

Table 5.7. Please indicate the degree to which you experienced solitude while hiking/ horseback riding on the trails in Great Smoky Mountains National park today? (Circle one number.)

		Not at all		Somewhat			Moderately		Extremely		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	*Mean*[b]
Day (n=242)	*Percent*[a]	1.7	2.1	9.5	11.6	9.9	16.5	22.7	19.4	6.6	6.03
Overnight (n=81)		0.0	1.2	8.6	3.7	9.9	22.2	32.1	18.5	3.7	6.32

[a]($\chi^2 = 9.65$, $p = 0.291$)
[b]($t = -1.20$, $p = 0.229$)

Table 5.8.1. Please indicate approximately how many other people you saw at or near the trailhead, at attraction sites (e.g., waterfall, firetower, overlook, etc.), and along the trail away from the trailhead and attractions during your hiker/horseback ride on the parks trails today. (If you did not see any other people in some or all of the locations listed below, please indicate this by reporting "0" in the appropriate spaces.)			
(Day users only.)		*Mean*[a]	n
At or near the trailhead in the first 15 minutes of your trip	# Hikers	3.10	241
	# Horseback Riders	0.46	241
Along the trail, away from trailheads and attractions	# Hikers	8.41	239
	# Horseback Riders	1.03	238
At or near the trailhead in the last 15 minutes of your trip	# Hikers	4.78	239
	# Horseback Riders	0.36	239
At the first attraction where you stopped	# Hikers	3.32	237
	# Horseback Riders	0.09	235
At the second attraction where you stopped	# Hikers	1.59	236
	# Horseback Riders	0.12	236
At the third attraction where you stopped	# Hikers	1.72	233
	# Horseback Riders	0.12	233
Combined Results (Day users only.)		*Mean*[a]	n
Along the trail, in the first/last 15 minutes of your trip	# Hikers	3.94	480
	# Horseback Riders	0.41	480
Along the entire trail, including the first/last 15 minutes of your trip	# Hikers	5.42	719
	# Horseback Riders	0.62	718
At all attractions	# Hikers	2.15	706
	# Horseback Riders	0.12	704

[a]Mean excludes Don't Know / Not Sure responses. Less than 5% of respondents checked Don't Know/ Not Sure.

Table 5.8.2. Please indicate approximately how many other people you saw at or near the trailhead, at attraction sites (e.g., waterfall, firetower, overlook, etc.), and along the trail away from the trailhead and attractions during your hiker/horseback ride on the parks trails today. (If you did not see any other people in some or all of the locations listed below, please indicate this by reporting "0" in the appropriate spaces.)				
		Don't Know/ Not Sure	**Did Not Stop at Attractions**	
(Day users only.)		*Percent*	*Percent*	n
At or near the trailhead in the first 15 minutes of your trip	# Hikers	0.0	-	241
	# Horseback Riders	0.0	-	241
Along the trail, away from trailheads and attractions	# Hikers	1.3	-	239
	# Horseback Riders	0.8	-	238
At or near the trailhead in the last 15 minutes of your trip	# Hikers	4.2	-	239
	# Horseback Riders	3.3	-	239
At the first attraction where you stopped	# Hikers	0.8	3.8	237
	# Horseback Riders	1.3	3.8	235
At the second attraction where you stopped	# Hikers	0.0	35.2	236
	# Horseback Riders	0.0	35.2	236
At the third attraction where you stopped	# Hikers	0.9	44.6	233
	# Horseback Riders	0.9	44.6	233

Table 5.8.3. Please indicate <u>approximately</u> how many other people you saw at or near the trailhead, at campsites and shelters, and along the trail away from the trailhead and campsites and shelters <u>during your backcountry camping trip in Great Smoky Mountains National Park</u>. (If you did not see any other people in some or all of the locations listed below, please indicate this by reporting "0" in the appropriate spaces.)			
Last Day / Last Night (<u>Overnight users only</u>.)		*Mean*[a]	n
At or near the trailhead in the <u>last 30 minutes</u> of your trip	# Hikers	4.19	74
	# Horseback Riders	0.39	61
Along the trail, away from trailheads and campsite/shelter	# Hikers	5.12	78
	# Horseback Riders	0.90	60
At the campsite/shelter	# Hikers	6.01	75
	# Horseback Riders	0.04	57
Previous Day / Previous Night (<u>Overnight users only</u>.)		*Mean*[a]	n
Along the trail, away from trailheads and campsite/ shelters	# Hikers	6.15	71
	# Horseback Riders	0.25	55
At the campsite/shelter *(Circle "N/A" if you only camped 1 night)*	# Hikers	5.52	63
	# Horseback Riders	0.07	46
Previous Day / Previous Night (<u>Overnight users only</u>.)		*Mean*[a]	n
Along the trail, away from trailheads and campsite/ shelters *(Circle "N/A" if you only camped 1 night)*	# Hikers	5.61	54
	# Horseback Riders	0.30	40
At the campsite/shelter *(Circle "N/A" if you only camped 2 nights)*	# Hikers	4.49	41
	# Horseback Riders	0.00	30
Combined Results (<u>Overnight users only</u>.)		*Mean*[a]	n
Along the entire trail	# Hikers	5.23	277
	# Horseback Riders	0.48	216
Along the trail, away from trailheads and campsites/ shelters	# Hikers	5.61	203
	# Horseback Riders	0.51	155
At the campsites and shelters	# Hikers	5.49	179
	# Horseback Riders	0.04	133

[a]Mean excludes Don't Know / Not Sure responses. Less than 5% of respondents checked Don't Know/ Not Sure.

Table 5.8.4. Please indicate <u>approximately</u> how many other people you saw at or near the trailhead, at campsites and shelters, and along the trail away from the trailhead and campsites and shelters <u>during your backcountry camping trip in Great Smoky Mountains National Park</u>. (If you did not see any other people in some or all of the locations listed below, please indicate this by reporting "0" in the appropriate spaces.)

Last Day / Last Night (Overnight users only.)		**Don't Know/ Not Sure** *Percent*	**Not Applicable** *Percent*	**n**
At or near the trailhead in the last 30 minutes of your trip	# Hikers	3.5	-	74
	# Horseback Riders	1.2	-	61
Along the trail, away from trailheads and campsite/shelter	# Hikers	0.0	-	78
	# Horseback Riders	0.0	-	60
At the campsite/shelter	# Hikers	2.3	-	75
	# Horseback Riders	2.3	-	57
Previous Day / Previous Night (Overnight users only.)		**Don't Know/ Not Sure** *Percent*	**Not Applicable** *Percent*	**n**
Along the trail, away from trailheads and campsite/ shelters	# Hikers	3.5	-	71
	# Horseback Riders	1.2	-	55
At the campsite/shelter *(Circle "N/A" if you only camped 1 night)*	# Hikers	4.7	8.1	63
	# Horseback Riders	3.5	8.1	46
Previous Day / Previous Night (Overnight users only.)		**Don't Know/ Not Sure** *Percent*	**Not Applicable** *Percent*	**n**
Along the trail, away from trailheads and campsite/ shelters *(Circle "N/A" if you only camped 1 night)*	# Hikers	2.3	14.0	54
	# Horseback Riders	0.0	14.0	40
At the campsite/shelter *(Circle "N/A" if you only camped 2 nights)*	# Hikers	3.5	22.1	41
	# Horseback Riders	1.2	22.1	30

Table 5.9.1. Approximately, what was the longest period of time that passed during which you did not see other people on your backcountry trip in Great Smoky Mountains National Park?						
	Mean	*Median*	*Minimum*	*Maximum*	*n*	*t-statistic, p-value*[b]
Day Use (*minutes*)[a]	66.5	45.0	5.0	420.0	243	t = -5.04, p = <0.001
Overnight (*hours*)	9.8	5.0	1.0	120.0	86	

[a]Day users were allowed to check a "Don't Know/Not Sure" response. Four respondents chose this option.
[b]The t-statistic was run with both the day use and overnight responses in units of hours.

Table 5.9.2. Approximately, what was the longest period of time that passed during which you did not see other people on your hiker/horseback ride on the park's trails today?		
	Day (n=243)	
(Day users only.)	*Frequency*	*Percent*
Less than 15 Minutes	23	9.5
15 to 30 Minutes	70	28.8
31 to 45 Minutes	26	10.7
46 to 60 Minutes	43	17.7
61 to 90 Minutes	19	7.8
91 to 120 Minutes	25	10.3
More than 120 Minutes	27	11.1

Table 5.9.3. Approximately, what was the longest period of time that passed during which you did not see other people on your backcountry camping trip in Great Smoky Mountains National Park?		
	Overnight (n=86)	
(Overnight users only.)	*Frequency*	*Percent*
Less than 3 Hours	7	8.1
3 or 4 Hours	38	44.2
5 or 6 Hours	13	15.1
7 or 8 Hours	9	10.5
9 to 16 Hours	4	4.7
17 to 24 Hours	12	14.0
More than 24 Hours	3	3.5

Table 5.10. The number of other people I saw along the trails during my backcountry trip in Great Smoky Mountains National Park interfered with my sense of solitude. (Circle one number.)				
	Day (n=246)		**Overnight** (n=80)	
	Frequency	*Percent*[a]	*Frequency*	*Percent*[a]
Strongly Agree (1)	7	2.7	1	1.2
Agree (2)	34	13.3	11	12.8
Neither (3)	67	26.2	22	25.6
Disagree (4)	87	34.0	26	30.2
Strongly Disagree (5)	51	19.9	20	23.3
Mean[b]	3.57		3.66	

[a]($\chi^2 = 1.28$, $p = 0.865$)
[b]($t = -0.66$, $p = 0.508$)

Table 5.11. The number of other people I saw at campsites/shelters during my backcountry camping trip in Great Smoky Mountains National Park interfered with my sense of solitude. (Circle one number.)

(Overnight users only.)	**Overnight** (n=81)	
	Frequency	*Percent*
Strongly Agree (1)	6	7.4
Agree (2)	18	22.2
Neither (3)	22	27.2
Disagree (4)	20	24.7
Strongly Disagree (5)	15	18.5
Mean	3.25	

Table 5.12.1. During your backcountry trip in Great Smoky Mountains National Park, did your group do any of the following to avoid seeing other people? (Check all that apply.)

	Day (n=247)		**Overnight** (n=78)		*Chi-Square, p-value*
	Frequency	*Percent*	*Frequency*	*Percent*	
Schedule your backcountry trip for particular times/days when you expected to see fewer people	26	10.5	10	12.8	$\chi^2 = 0.32$, $p = 0.574$
Hike/horseback ride on particular trails where you expected to see fewer people	37	15.0	17	21.8	$\chi^2 = 1.99$, $p = 0.159$
Choose not to stop at attractions (e.g., overlook, fire tower, waterfall, etc.) because there were too many people there	18	7.3	6	7.7	$\chi^2 = 0.01$, $p = 0.905$
Camp at particular campsites/shelters where you expected to see fewer people	N/A	N/A	19	24.4	N/A[a]
Choose not to camp at a campsite/shelter on your permit because there were too many people there	N/A	N/A	2	2.6	N/A[a]
Other (Please specify[b])	4	1.7	4	5.1	N/A[c]
None of the above apply	181	70.7	45	52.3	$\chi^2 = 6.80$, $p = 0.009$

[a]Day use respondents were not asked these two questions.
[b]Other responses are listed in Table 5.12.2.
[c]There are not enough responses to run a Chi-Square test.

Table 5.12.2. (other). During your backcountry trip in Great Smoky Mountains National Park, did your group do any of the following to avoid seeing other people? (Check all that apply.)				
	Day (n=247)		**Overnight**[a] (n=78)	
	Frequency	*Percent*	*Frequency*	*Percent*
Hiked off trail	3	1.2	0	0.0
Found a secluded spot	1	0.4	0	0.0
Avoided horse campsite	0	0.0	1	1.3
Changed hiking plans to a harder route	0	0.0	1	1.3
Hiked during middle of week	0	0.0	1	1.3

[a]One of the 4 "Other" responses did not specify details.

Table 5.13. In general, the number of other people I see during my backcountry trip in places like Great Smoky Mountains National Park affects my ability to experience solitude. (Circle one number.)				
	Day (n=244)		**Overnight** (n=81)	
	Frequency	*Percent*[a]	*Frequency*	*Percent*[a]
Strongly Agree (1)	24	9.8	2	2.5
Agree (2)	76	31.3	31	38.3
Neither (3)	45	18.4	17	21.0
Disagree (4)	68	27.7	23	28.4
Strongly Disagree (5)	20	8.2	8	9.9
Mean[b]	2.93		3.05	

[a]($\chi^2 = 5.18$, $p = 0.270$)
[b]($t = -0.85$, $p = 0.399$)

Table 5.14.1. Please indicate for each of the following numbers of people seen per hour while hiking/horseback riding on the trails in Great Smoky Mountains National park how likely you would be to experience solitude during such a trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each item.)

		Likelihood of Experiencing Solitude											
		Very Unlikely				Neutral				Very Likely			
(Day users only.)		**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**	**Don't Know/ Not Sure**	**Mean**	**n**
See no other people on the trails	*Percent*	3.1	3.1	3.7	1.9	8.0	1.2	2.5	7.4	43.0	0.8	2.73	162
See 2 other people per hour		0.0	3.1	2.5	2.5	14.3	10.6	13.0	24.2	28.6	1.2	2.09	161
See 4 other people per hour		2.5	2.5	6.3	8.2	18.9	13.2	13.2	20.8	13.2	1.3	1.18	159
See 8 other people per hour		9.4	10.1	15.1	13.8	17.6	6.9	10.1	10.7	4.4	1.9	-0.36	159
See 16 other people per hour		40.9	11.3	10.1	5.0	12.6	8.8	4.4	2.5	2.5	1.9	-1.94	159

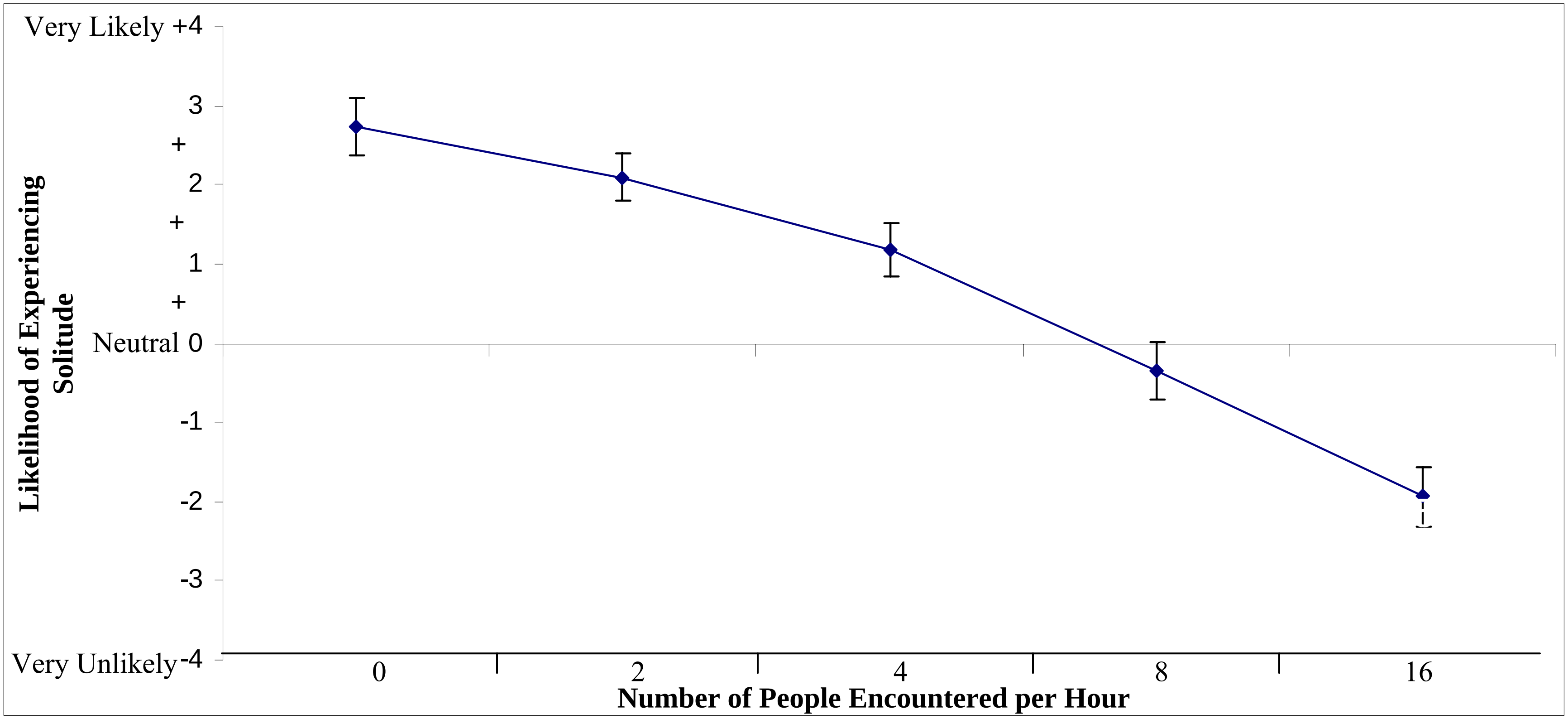


Figure 5.2. Day users' likelihood of experiencing solitude curve for numbers of people encountered per hour. Note. Error bars represent 95% confidence intervals.

Table 5.14.2. Please indicate for each of the following numbers of people seen per day during a backcountry camping trip in Great Smoky Mountains National park how likely you would be to experience solitude during such a trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each item.)

(Overnight users only.)		Likelihood of Experiencing Solitude											
		Very Unlikely -4	-3	-2	-1	Neutral 0	+1	+2	+3	Very Likely +4	Don't Know/ Not Sure	Mean	n
See no other people during the trip	*Percent*	12.0	0.0	0.0	2.0	2.0	2.0	4.0	8.0	66.0	4.0	2.58	50
See 2 other people per day		2.0	4.1	2.0	0.0	4.1	4.1	10.2	34.7	34.7	4.1	2.53	59
See 4 other people per day		0.0	2.0	4.0	2.0	12.0	6.0	24.0	30.0	16.0	4.0	2.00	50
See 8 other people per day		0.0	0.0	10.0	14.0	20.0	22.0	12.0	14.0	4.0	4.0	0.73	50
See 16 other people per day		5.9	19.6	27.5	15.7	9.8	3.9	5.9	3.9	3.9	3.9	-1.25	51

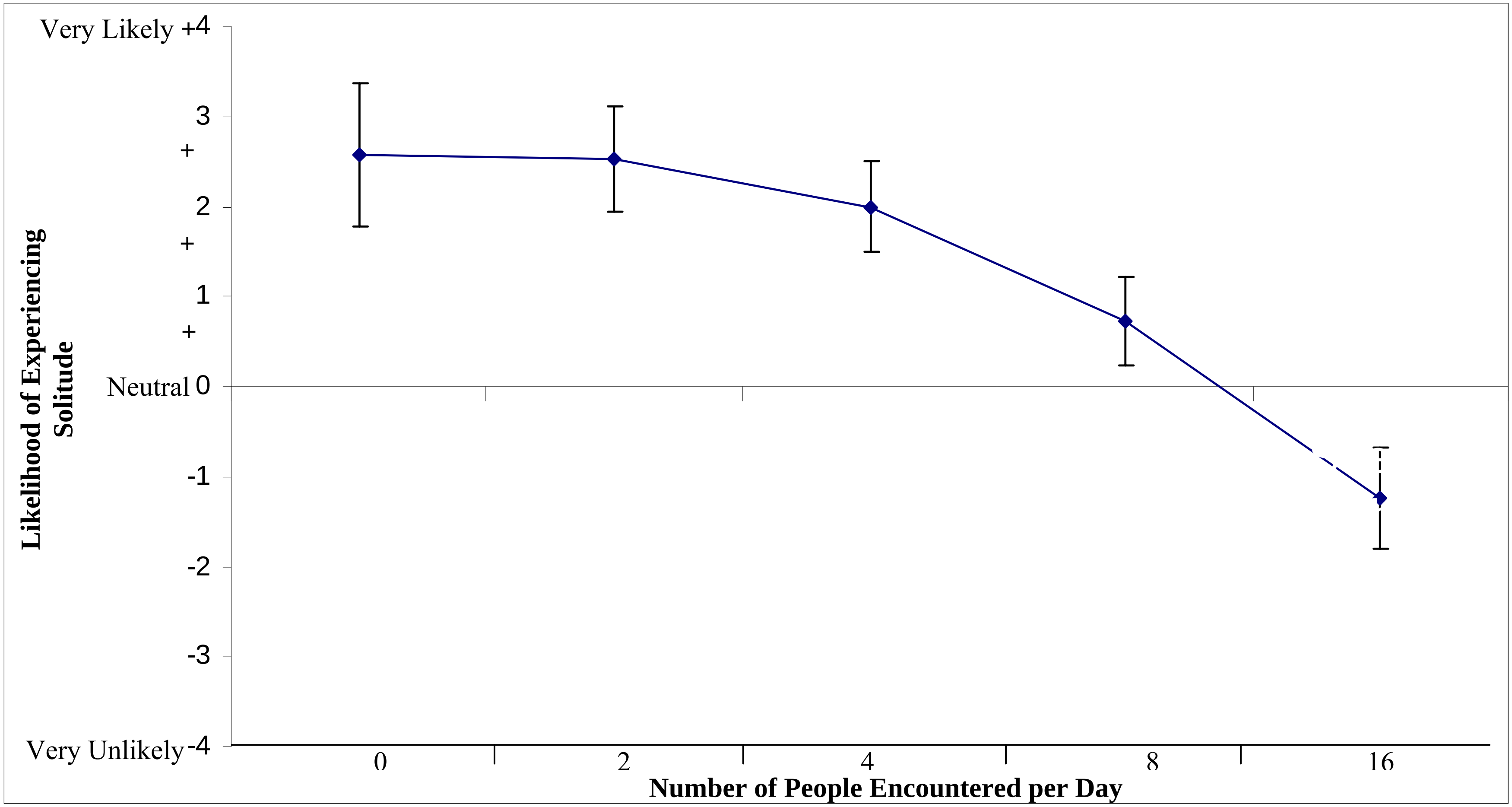


Figure 5.3. Overnight users' likelihood of experiencing solitude curve for the number of people encountered per day. Note. Error bars represent 95% confidence intervals.

Table 5.15. In general, the amount of time that has passed without seeing other people during a backcountry trip in places like Great Smoky Mountains National park affects my ability to experience solitude? (Circle one number.)				
	Day (n=237)		**Overnight** (n=81)	
	Frequency	*Percent*[a]	*Frequency*	*Percent*[a]
Strongly Agree (1)	35	14.8	8	9.9
Agree (2)	90	38.0	35	43.2
Neither (3)	36	15.2	11	13.6
Disagree (4)	61	25.7	20	24.7
Strongly Disagree (5)	15	6.3	7	8.6
Mean[b]	2.71		2.79	

[a]($\chi^2 = 2.09$, $p = 0.720$)
[b]($t = -0.53$, $p = 0.599$)

Table 5.16.1. Please indicate for each of the following lengths of time without seeing other people while hiking/horseback riding on the trails in Great Smoky Mountains National park how likely you would be to experience solitude during that time. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each item.)

(Day users only.)		Likelihood of Experiencing Solitude									Don't Know/ Not Sure	Mean	n
		Very Unlikely -4	-3	-2	-1	Neutral 0	+1	+2	+3	Very Likely +4			
3 hours without seeing other people	*Percent*	7.7	2.8	2.8	0.6	8.8	2.8	2.2	8.3	62.4	1.7	2.40	181
2 hours without seeing other people		5.0	2.2	1.7	1.7	8.9	8.9	13.3	17.2	39.4	1.7	2.17	180
1 hour without seeing other people		0.6	2.8	1.7	7.2	17.2	9.4	17.2	20.0	22.2	1.7	1.75	180
30 minutes without seeing other people		1.7	6.7	11.1	6.7	16.1	13.9	16.1	10.0	16.1	1.7	0.86	180
15 minutes without seeing other people		13.9	7.8	8.3	6.7	19.4	10.6	8.9	10.0	12.8	1.7	0.07	180

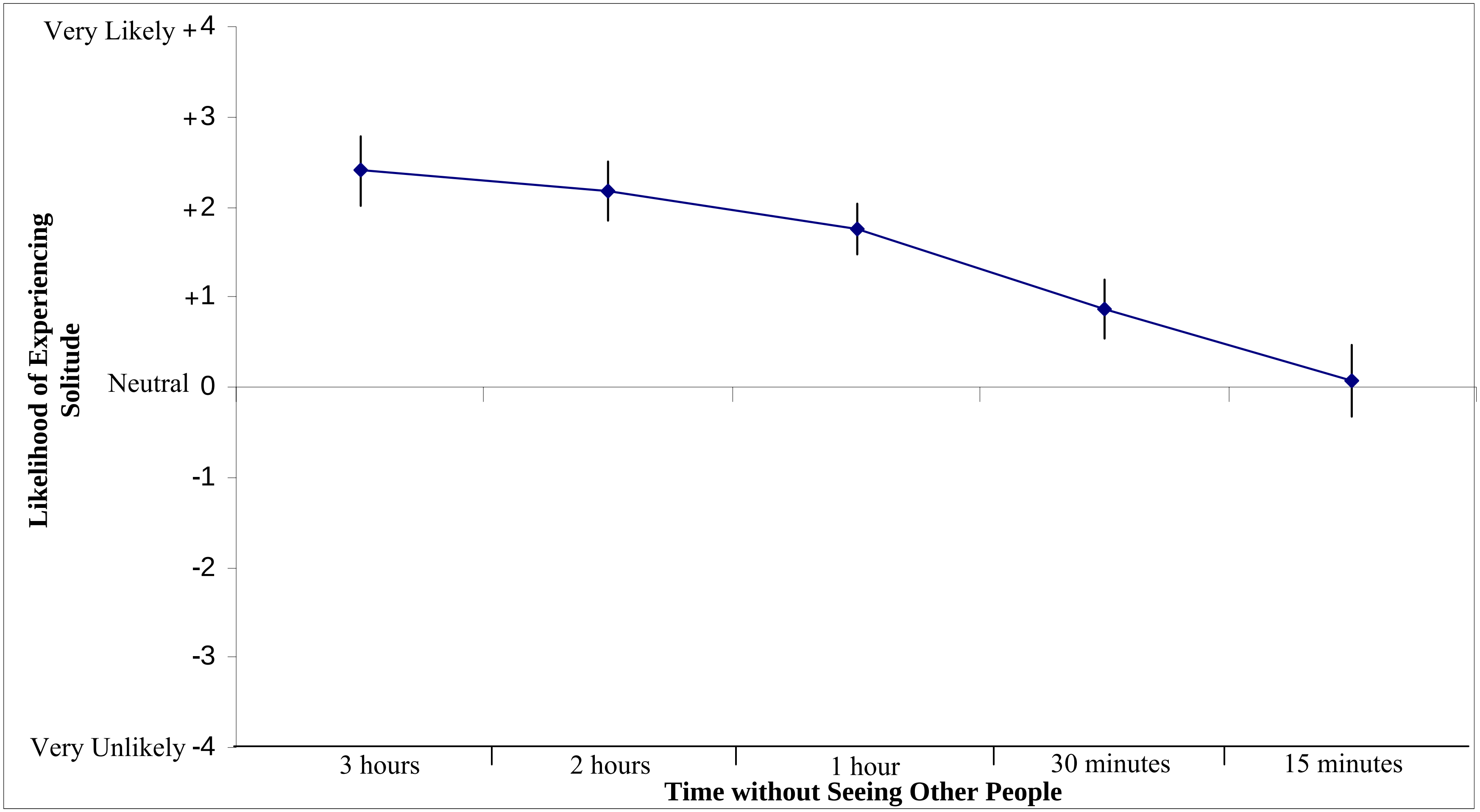


Figure 5.4. Day users' likelihood of experiencing solitude curve for the time without seeing other people.Note. Error bars represent 95% confidence intervals.

Table 5.16.2. Please indicate for each of the following lengths of time without seeing other people during a backcountry camping trip in Great Smoky Mountains National park how likely you would be to experience solitude during that time. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each item.)

(Overnight users only.)		Likelihood of Experiencing Solitude											
		Very Unlikely -4	**-3**	**-2**	**-1**	**Neutral 0**	**+1**	**+2**	**+3**	**Very Likely +4**	**Don't Know/ Not Sure**	**Mean**	**n**
1 day (24 hours) without seeing other people	*Percent*	11.9	6.8	3.4	0.0	1.7	0.0	3.4	6.8	64.4	1.7	2.14	59
5 hours without seeing other people	*Percent*	1.7	5.1	1.7	8.5	6.8	8.5	15.3	23.7	27.1	1.7	1.88	59
2 hours without seeing other people	*Percent*	1.7	0.0	8.5	10.2	23.7	10.2	20.3	15.3	8.5	1.7	0.98	59
1 hour without seeing other people	*Percent*	8.5	3.4	25.4	8.5	8.5	15.3	8.5	10.2	10.2	1.7	0.00	59
30 minutes without seeing other people	*Percent*	23.7	11.9	8.5	10.2	15.3	6.8	8.5	3.4	10.2	1.7	-0.84	59

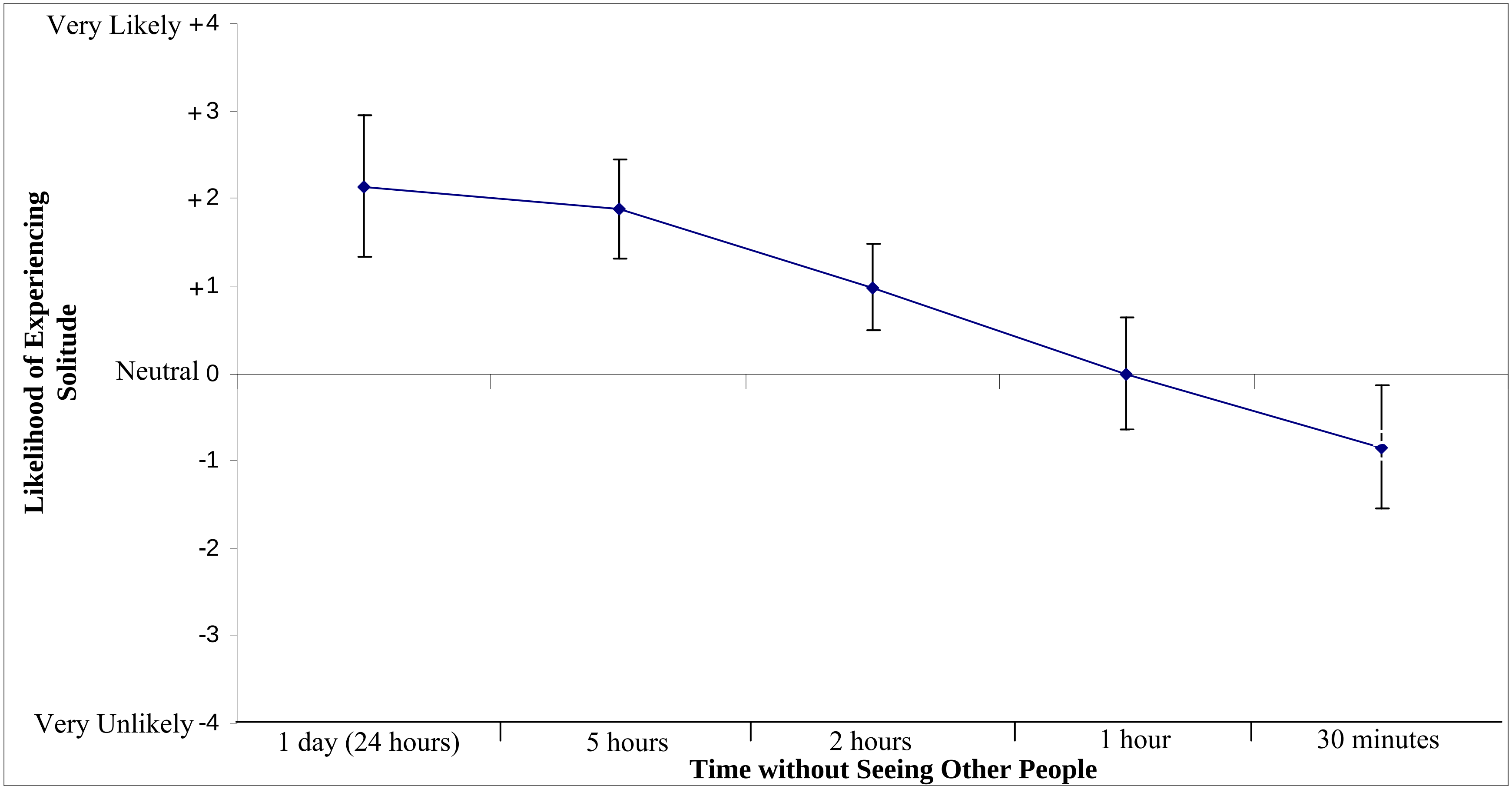


Figure 5.5. Overnight users' likelihood of experiencing solitude curve for the time without seeing other people. Note. Error bars represent the 95% confidence interval.

Table 5.17. Approximately, what is the minimum amount of time that would need to pass without seeing other people during a backcountry camping trip in Great Smoky Mountains National park before you would begin to experience solitude? (Overnight visitors only.)

	Overnight (n=80)	
	Frequency	*Percent*
Less than 31 Minutes	14	17.5
31 – 60 Minutes	5	6.3
61 – 120 Minutes	20	25.0
121 – 240 Minutes	16	20.0
241 – 360 Minutes	13	16.3
More than 360 Minutes	12	15.0
Mean	294 Minutes	

Table 5.18.1. Please indicate for each of the following hypothetical hiking/horseback riding trips in Great Smoky Mountains National park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Hiking/Horseback Riding Trip 1 (Day users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• No other people during the trip	*Percent* (n=246)	3.3	2.4	1.6	1.6	6.9	4.9	4.5	6.9	66.3	1.3	4.35

Hiking/Horseback Riding Trip 2 (Day users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• 6-10 other people in the first 15 minutes • No other people at attractions • No other people along the away from trailheads and attractions • 6-10 other people in the last 15 minutes	*Percent* (n=239)	1.3	2.1	0.8	2.9	10.5	4.6	16.3	26.8	34.7	0.0	2.41

Table 5.18.1 (continued). Please indicate for each of the following hypothetical hiking/horseback riding trips in Great Smoky Mountains National park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Hiking/Horseback Riding Trip 3 (Day users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• 6-10 other people in the first 15 minutes • 6-10 other people at attractions • No other people along the away from trailheads and attractions • 6-10 other people in the last 15 minutes	*Percent* (n=235)	0.9	3.0	8.5	8.9	16.6	14.0	23.4	13.6	9.8	1.3	2.29

Hiking/Horseback Riding Trip 4 (Day users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• 6-10 other people in the first 15 minutes • No other people at attractions • 6-10 other people along the trails away from the trailheads and attractions • 6-10 other people in the last 15 minutes	*Percent* (n=231)	2.2	3.5	6.5	8.7	18.2	18.6	16.0	13.9	10.8	1.7	2.97

Table 5.18.1 (continued). Please indicate for each of the following hypothetical hiking/horseback riding trips in Great Smoky Mountains National park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Hiking/Horseback Riding Trip 5 (Day users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• No other people in the first 15 minutes • 6-10 other people at attractions • No other people along the trails away from the trailheads and attractions • No other people in the last 15 minutes	*Percent* (n=228)	1.3	2.6	3.9	4.8	12.7	12.3	21.5	23.3	16.2	1.3	2.66

Hiking/Horseback Riding Trip 6 (Day users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• No other people in the first 15 minutes • No other people at • 6-10 other people along the trails away from the trailheads and attractions • No other people in the last 15 minutes	*Percent* (n=226)	0.0	3.1	3.1	2.7	12.8	11.1	19.0	27.0	19.5	1.8	2.97

Table 5.18.1 (continued). Please indicate for each of the following hypothetical hiking/horseback riding trips in Great Smoky Mountains National park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Hiking/Horseback Riding Trip 7 (Day users only.)		**Very Unlikely** -4	-3	-2	-1	**Neutral** 0	+1	+2	+3	**Very Likely** +4	**Don't Know/ Not Sure**	**Mean**
• 6-10 other people in the first 15 minutes • 6-10 other people at attractions • 6-10 other people along the trails away from the trailheads and attractions • 6-10 other people in the last 15 minutes	*Percent* (n=224)	24.1	11.6	15.2	9.4	12.1	9.8	6.7	3.1	6.7	1.3	0.21

Table 5.18.2. Please indicate for each of the following hypothetical backcountry camping trips in Great Smoky Mountains National park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Backcountry Camping Trip 1 (Overnight users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• No other people during the trip	*Percent* (n=79)	2.5	0.0	1.3	0.0	2.5	1.3	3.8	7.6	81.0	0.0	3.43

Backcountry Camping Trip 2 (Overnight users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• 6-10 other people in the first 30 minutes • No other people along the trails away from trailheads and campsites/shelters • No other people at campsites/shelters • 6-10 other people in the last 30 minutes	*Percent* (n=79)	0.0	3.8	1.3	0.0	3.8	6.3	10.1	17.7	55.7	1.3	4.14

Table 5.18.2 (continued). Please indicate for each of the following hypothetical backcountry camping trips in Great Smoky Mountains National park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Backcountry Camping Trip 3 (Overnight users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		**Mean**
• 6-10 other people in the first 30 minutes • No other people along the trails away from trailheads and campsites/shelters • 6-10 other people at campsites/ shelters • 6-10 other people in the last 30 minutes	*Percent* (n=78)	2.6	3.8	9.0	5.1	7.7	23.1	19.2	15.4	12.8	1.3	2.41

Backcountry Camping Trip 4 (Overnight users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		**Mean**
• 6-10 other people in the first 30 minutes • 6-10 other people along the trails away from trailheads and campsites/ shelters • No other people at campsites/shelters • 6-10 other people in the last 30 minutes	*Percent* (n=76)	1.3	2.6	2.6	5.3	17.1	11.8	17.1	32.9	7.9	1.3	2.83

Table 5.18.2 (continued). Please indicate for each of the following hypothetical backcountry camping trips in Great Smoky Mountains National park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Backcountry Camping Trip 5 (Overnight users only.)		**How likely would you be to experience solitude on this trip?** Very Unlikely -4	-3	-2	-1	Neutral 0	+1	+2	+3	Very Likely +4	Don't Know/ Not Sure	Mean
• No other people in the first 30 minutes • 6-10 other people along the trails away from trailheads and campsites/shelters • No other people at campsites/shelters • No other people in the last 30 minutes	*Percent* (n=75)	0.0	1.3	1.3	6.7	8.0	10.7	16.0	28.0	26.7	1.3	3.52

Backcountry Camping Trip 6 (Overnight users only.)		**How likely would you be to experience solitude on this trip?** Very Unlikely -4	-3	-2	-1	Neutral 0	+1	+2	+3	Very Likely +4	Don't Know/ Not Sure	Mean
• No other people in the first 30 minutes • No other people along the trails away from trailheads and campsites/shelters • 6-10 other people at campsites/shelters • No other people in the last 30 minutes	*Percent* (n=72)	2.8	6.9	5.6	8.3	13.9	9.7	25.0	11.1	15.3	1.4	2.40

Table 5.18.2 (continued). Please indicate for each of the following hypothetical backcountry camping trips in Great Smoky Mountains National park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Backcountry Camping Trip 7 (Overnight users only.)		**How likely would you be to experience solitude on this trip?**										
		Very Unlikely				**Neutral**				**Very Likely**	**Don't Know/ Not Sure**	**Mean**
		-4	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
• 6-10 other people in the first 30 minutes • 6-10 other people along the trails away from the trailheads and campsites/shelters • 6-10 other people at campsites/shelters • 6-10 other people in the last 30 minutes	*Percent* (n=72)	25.0	18.1	19.4	6.9	8.3	6.9	6.9	4.2	2.8	1.4	-0.18

Table 5.19. Please indicate the extent to which you <u>have ever</u> done each of the following in any wilderness or backcountry recreation area (including Great Smoky Mountains National Park).

		Day		**Overnight**		*Chi-Square, p-value*	*t-statistic, p-value*
		Frequency	*Percent*	*Frequency*	*Percent*		
Visit earlier or later in the season to avoid seeing people	Never (0)	47	20.0	27	34.6	$\chi^2 = 11.44$, $p = 0.022$	
	Rarely (1)	27	11.4	14	17.9		
	Occasionally (2)	78	33.1	18	23.1		
	Usually (3)	70	30.0	16	20.5		
	Always (4)	14	5.9	3	3.8		
	Mean	1.90		1.41			$t = 3.01$, $p = 0.003$
Visit on weekdays to avoid weekend crowds	Never (0)	39	16.6	17	21.8	$\chi^2 = 1.54$, $p = 0.820$	
	Rarely (1)	26	11.1	9	11.5		
	Occasionally (2)	84	35.7	27	34.6		
	Usually (3)	68	29.0	21	26.9		
	Always (4)	18	7.7	4	5.1		
	Mean	2.00		1.82			$t = 1.15$, $p = 0.251$
Go to trails that are less crowded	Never (0)	26	11.0	20	25.6	$\chi^2 = 12.19$, $p = 0.016$	
	Rarely (1)	19	8.1	8	10.3		
	Occasionally (2)	73	30.9	23	29.5		
	Usually (3)	95	40.3	23	29.5		
	Always (4)	23	9.7	4	5.1		
	Mean	2.30		1.78			$t = 3.24$, $p = 0.002$

Table 5.19 (continued). Please indicate the extent to which you have ever done each of the following in any wilderness or backcountry recreation area (including Great Smoky Mountains National Park).

		Day		Overnight		*Chi-Square, p-value*	*t-statistic, p-value*
		Frequency	*Percent*	*Frequency*	*Percent*		
Avoid places that have limits on the amount of use	Never (0)	91	39.6	32	42.1	$\chi^2 = 10.06$, $p = 0.040$	
	Rarely (1)	54	23.5	15	19.7		
	Occasionally (2)	40	17.4	17	22.4		
	Usually (3)	30	13.0	12	15.8		
	Always (4)	15	6.5	0	0.0		
	Mean	1.23		1.12			$t = 0.71$, $p = 0.478$
Go to other areas where you are less likely to see other people	Never (0)	26	11.1	19	24.4	$\chi^2 = 11.32$, $p = 0.023$	
	Rarely (1)	29	12.4	14	17.9		
	Occasionally (2)	78	33.3	20	25.6		
	Usually (3)	85	36.3	21	26.9		
	Always (4)	16	6.8	4	5.1		
	Mean	2.15		1.71			$t = 2.78$, $p = 0.006$
Avoid places that regulate the use of horseback riders	Never (0)	118	50.6	39	50.0	$\chi^2 = 0.22$, $p = 0.994$	
	Rarely (1)	36	15.5	12	15.4		
	Occasionally (2)	32	13.7	12	15.4		
	Usually (3)	36	15.5	12	15.4		
	Always (4)	11	4.7	3	3.8		
	Mean	1.08		1.08			$t = 0.00$, $p = 1.00$

Table 5.19 (continued). Please indicate the extent to which you have ever done each of the following in any wilderness or backcountry recreation area (including Great Smoky Mountains National Park).

		Day		Overnight		*Chi-Square, p-value*	*t-statistic, p-value*
		Frequency	*Percent*	*Frequency*	*Percent*		
Avoid attractions that are crowded	Never (0)	22	9.3	19	24.4	$\chi^2 = 21.12$, $p < 0.001$	
	Rarely (1)	16	6.8	11	14.1		
	Occasionally (2)	62	26.2	22	28.2		
	Usually (3)	93	39.2	16	20.5		
	Always (4)	44	18.6	10	12.8		
	Mean	2.51		1.83			$t = 3.99$, $p < 0.001$

Table 5.20. Please indicate the extent to which you agree or disagree with each of the following statements concerning management of backpacking/horseback riding in Great Smoky Mountains National Park.

		Day		Overnight		*Chi-Square[b], p-value*	*t-statistic, p-value*
		Frequency	*Percent[a]*	*Frequency*	*Percent[a]*		
If solitude is lost, use limits should be imposed	Strong agree (1)	23	9.5	5	6.6	χ^2 =7.12, p = 0.130	
	Agree (2)	65	26.9	30	39.5		
	Neutral (3)	69	28.5	23	30.3		
	Disagree (4)	54	22.3	11	14.5		
	Strongly disagree (5)	25	10.3	4	5.3		
	Don’t Know / Not Sure	6	2.5	3	3.9		
	Mean	2.97		2.71			t = 1.88, p = 0.062
Use limits should never be imposed, even if use is high	Strong agree (1)	21	8.7	2	2.6	χ^2 =8.93, p = 0.063	
	Agree (2)	44	18.2	8	10.4		
	Neutral (3)	48	19.8	13	16.9		
	Disagree (4)	84	34.7	38	49.4		
	Strongly disagree (5)	35	14.5	13	16.9		
	Don’t Know / Not Sure	10	4.1	3	3.9		
	Mean	3.29		3.70			t = -2.97, p = 0.003

[a]Percentages for “Not at all important” through “Extremely important” are calculated based on the number of respondents who gave a response other than “Don’t Know / Not Sure.”
[b]Chi-Square tests exclude Don’t Know / Not Sure responses.

Table 5.20 (continued). Please indicate the extent to which you agree or disagree with each of the following statements concerning management of backpacking/horseback riding in Great Smoky Mountains National Park.

		Day		**Overnight**		*Chi-Square[b], p-value*	*t-statistic, p-value*
		Frequency	*Percent[a]*	*Frequency*	*Percent[a]*		
More trails should be added to reduce the number of people seen	Strong agree (1)	11	4.5	1	1.3	χ^2 =10.40, p = 0.034	
	Agree (2)	64	26.4	11	14.3		
	Neutral (3)	61	25.2	20	26.0		
	Disagree (4)	62	25.6	32	41.6		
	Strongly disagree (5)	34	14.0	10	13.0		
	Don't Know / Not Sure	10	4.1	3	3.9		
	Mean	3.19		3.53			t = -2.54, p = 0.012
More campsites should be added to reduce the number of people seen	Strong agree (1)	-	-	5	6.5	N/A[c]	
	Agree (2)	-	-	24	31.2		
	Neutral (3)	-	-	13	16.9		
	Disagree (4)	-	-	25	32.5		
	Strongly disagree (5)	-	-	8	10.4		
	Don't Know / Not Sure	-	-	2	2.6		
	Mean	-		3.09			N/A[c]

[a]Percentages for "Not at all important" through "Extremely important" are calculated based on the number of respondents who gave a response other than "Don't Know / Not Sure."
[b]Chi-Square tests exclude Don't Know / Not Sure responses.
[c]Question was not included in day use survey.

Table 5.20 (continued). Please indicate the extent to which you agree or disagree with each of the following statements concerning management of backpacking/horseback riding in Great Smoky Mountains National Park.

		Day		Overnight		*Chi-Square*[b], *p-value*	*t-statistic, p-value*
		Frequency	*Percent*[a]	*Frequency*	*Percent*[a]		
More trailheads should be added to disperse use away from busy areas	Strong agree (1)	17	7.0	4	5.2	$\chi^2 = 9.19$, $p = 0.057$	
	Agree (2)	67	27.7	13	16.9		
	Neutral (3)	69	28.5	26	33.8		
	Disagree (4)	50	20.7	26	33.8		
	Strongly disagree (5)	28	11.6	5	6.5		
	Don't Know / Not Sure	11	4.5	3	3.9		
	Mean	3.02		3.20			$t = -1.31$, $p = 0.193$

[a]Percentages for "Not at all important" through "Extremely important" are calculated based on the number of respondents who gave a response other than "Don't Know / Not Sure."
[b]Chi-Square tests exclude Don't Know / Not Sure responses.

Table 5.21. What is your sex?				
	Day (n=249)		**Overnight** (n=83)	
	Frequency	*Percent*[a]	*Frequency*	*Percent*[a]
Male	146	58.6	60	72.3
Female	103	41.4	23	27.7

[a]($\chi^2 = 4.93$, $p = 0.026$)

Table 5.22. What is your age?				
	Day (n=248)		**Overnight** (n=82)	
Age	*Frequency*	*Percent*[a]	*Frequency*	*Percent*[a]
18 – 24 years of age	23	9.3	30	36.6
25 – 34 years of age	39	15.7	29	35.4
35 – 44 years of age	69	27.8	14	17.1
45 – 54 years of age	62	25.0	7	8.5
55 – 59 years of age	26	10.5	1	1.2
60 – 64 years of age	15	6.1	0	0.0
65 years of age or older	14	5.6	1	1.2
Mean[b]	43.3		30.2	

[a]($\chi^2 = 64.99$, $p < 0.001$)
[b]($t = 8.15$, $p < 0.001$)

Table 5.23. What country do you live in?

Country of Residence	**Day** (n=256)		**Overnight** (n=86)	
	Frequency	*Percent*	*Frequency*	*Percent*
USA	254	99.2	82	95.3
Germany	1	0.4	0	0.0
Canada	1	0.4	1	1.2
The Netherlands	0	0.0	1	1.2
United Kingdom	0	0.0	1	1.2
Israel	0	0.0	1	1.2

Table 5.24. If you live in the United States, what is your state of residence?				
	Day (n=245)		**Overnight** (n=78)	
State of Residence	*Frequency*	*Percent*	*Frequency*	*Percent*
Tennessee	98	40.0	13	16.7
North Carolina	25	10.2	6	7.7
Florida	13	5.3	4	5.1
Michigan	12	4.9	3	3.8
Ohio	11	4.5	5	6.4
South Carolina	11	4.5	2	2.6
Kentucky	10	4.1	2	2.6
Illinois	9	3.7	1	1.3
Indiana	8	3.3	4	5.1
Virginia	7	2.9	2	2.6
Alabama	7	2.9	2	2.6
Georgia	6	2.4	7	9.0
Pennsylvania	5	2.0	2	2.6
Wisconsin	4	1.6	1	1.3
Washington	3	1.2	1	1.3
New York	3	1.2	2	2.6
Mississippi	2	0.82	2	2.6
Missouri	2	0.82	3	3.8
New Hampshire	1	0.41	2	2.6
Nebraska	1	0.41	0	0.0
Texas	1	0.41	2	2.6
Maryland	1	0.41	2	2.6
West Virginia	1	0.41	0	0.0
Alaska	1	0.41	1	1.3
Colorado	1	0.41	3	3.8
Delaware	1	0.41	0	0.0
Minnesota	1	0.41	0	0.0
Arizona	0	0.0	1	1.3
California	0	0.0	2	2.6
Rhode Island	0	0.0	1	1.3
Connecticut	0	0.0	1	1.3
Massachusetts	0	0.0	1	1.3

Table 5.25.1. If you live in the United States, what is your zip code of residence?

(Day users only.)	**Day** (n=256)	
	Frequency	*Percent*
Knoxville, TN (37919, 37922)	11	4.3
Cosby, TN (37722)	7	2.7
Newport, TN (37821)	7	2.7
Morristown, TN (37814)	5	2.0
Oak Ridge, TN (37830)	4	1.6
Nashville, TN (37221)	4	1.6
Sevierville, TN (22202)	4	1.6

[a]Table contains most frequently reported zip codes.
To see a complete list of respondents' zip codes of residence, see Appendix H.

Table 5.25.2. If you live in the United States, what is your zip code of residence?

(Overnight users only.)	**Overnight** (n=86)	
	Frequency	*Percent*
Knoxville, TN (37917)	2	0.7
Nashville, TN (37206)	2	0.7
Memphis, TN (38103)	2	0.7

[a]Table contains most frequently reported zip codes.
To see a complete list of respondents' zip codes of residence, see Appendix I.

Table 5.26. What is the highest level of formal schooling you have completed? (Circle one number.)

Level of Education	**Day** (n=251)		**Overnight** (n=83)	
	Frequency	*Percent*[a]	*Frequency*	*Percent*[a]
Some high school, high school graduate, or GED	26	10.4	6	7.2
Some college, business or trade school	42	16.7	15	18.1
College, business or trade school graduate	79	31.5	33	39.8
Some graduate school	23	9.2	7	8.4
Master's, doctoral or professional degree	81	32.3	22	26.5

[a]($\chi^2 = 2.69$, $p = 0.611$)

Table 5.27. Do you consider yourself to be Hispanic, Latino, or Latina?

Race/Ethnicity Group	**Day** (n=251)		**Overnight** (n=83)	
	Frequency	*Percent*	*Frequency*	*Percent*
Yes	1	0.4	4	4.8
No	250	99.6	79	95.2

Table 5.28. Which racial group(s) do you identify with? (Circle all that apply.)

Race/Ethnicity Group	**Day**[a] (n=256)		**Overnight**[a] (n=86)	
	Frequency	*Percent*	*Frequency*	*Percent*
American Indian or Alaska Native	12	4.7	4	4.7
Asian	6	2.3	4	4.7
Black or African American	8	3.1	4	4.7
White	249	97.3	79	91.9
Native Hawaiian	2	0.8	2	2.3
More than one race	15	5.9	8	9.3
Did not respond	5	2.0	5	5.8

[a]A statistical comparison of day use and overnight survey responses to the race and ethnicity question could not be made because there are too few responses for overnight users.

Note. Frequencies in race/ethnicity groups include both those respondents that checked only one group and those that checked more than one group.

Travel Route Maps

This section of Chapter 5 presents the results from the travel route maps administered as part of the visitor survey. The data provided in the following tables provide in-depth information about visitor use patterns within the Big Creek and Cosby areas of Great Smoky Mountains National Park during May, 2006.

Travel Route Information

Table 5.29.1. Please mark the location where you started your hike/horseback ride in the park today.

Entry Location (Day users only.)	**Day** (n=243)	
	Frequency	*Percent*
Gabes Mountain Trail (EL0)	84	34.6
Big Creek Trail (EL10)	65	26.7
Maddron Bald Trail (EL15)	29	11.9
Low Gap Trail (EL2)	21	8.6
Appalachian Trail near Davenport Gap Shelter (EL12)	14	5.8
Baxter Creek Trail (EL9)	11	4.5
Lower Mt. Crammerer Trail (EL1)	11	4.5
Snake Den Ridge Trail (EL3)	5	2.1
Mt. Sterling Trail(EL8)	3	1.2

Table 5.29.2. Please mark the location where you ended your hike/horseback ride in the park today.

End Location (Day users only.)	**Day** (n=243)	
	Frequency	*Percent*
Gabes Mountain Trail (EL0)	81	33.3
Big Creek Trail (EL10)	70	28.8
Maddron Bald Trail (EL15)	33	13.6
Low Gap Trail (EL2)	16	6.6
Lower Mt. Crammerer Trail (EL1)	15	6.2
Appalachian Trail near Davenport Gap Shelter (EL12)	14	5.8
Baxter Creek Trail (EL9)	8	3.3
Snake Den Ridge Trail (EL3)	5	2.1
Mt. Sterling Trail (EL8)	1	0.4

Table 5.30.1. Trip length, by survey location.		
Survey Location (Day users only.)	*Mean (Minutes)*	*Std. Dev.*
Cosby/Gabes Mountain/Maddron Bald (n=150)	228	110
Big Creek/Baxter Creek (n=81)	235	130
Davenport Gap (n=10)	343	159
Overall (n=241)	235	121

Table 5.30.2. Overall trip length statistics.		
	Day (n=241)	
Trip Length (Day users only.)	*Frequency*	*Percent*
Less than 120 Minutes	40	16.6
120 to 180 Minutes	72	29.9
181 to 240 Minutes	43	17.8
241 to 300 Minutes	27	11.2
More than 300 Minutes	59	24.5

Table 5.31. Please record the approximate time of the start of your hike/horseback ride in Great Smoky Mountains National Park today.		
	Day (n=283)	
Start Times (Day users only.)	*Frequency*	*Percent*
6:00 A.M. to 9:00 A.M.	37	13.1
9:01 A.M. to 11:00 A.M.	89	31.4
11:01 A.M. to 1:00 P.M.	99	35.0
1:01 P.M. to 3:00 P.M.	42	14.8
3:01 P.M. or later	16	5.6
Median	11:30 A.M.	

Table 5.32.1. Please record the location of the start of your backcountry camping trip in Great Smoky Mountains National Park.		
	Overnight (n=84)	
Entry Location (Overnight users only.)	*Frequency*	*Percent*
Appalachian Trail near Tricorner Knob Shelter (EL5)	39	46.4
Big Creek Trail (EL10)	14	16.7
Gabes Mountain Trail (EL0)	12	14.3
Snake Den Ridge Trail (EL3)	5	6.0
Baxter Creek Trail (EL9)	4	4.8
Lower Mt. Crammerer Trail (EL1)	2	2.4
Low Gap Trail (EL2)	2	2.4
Balsam Mtn. Trail near Laurel Gap Shelter (EL6)	2	2.4
Appalachian Trail near Davenport Gap Shelter (EL12)	2	2.4
Pretty Hollow Gap Trail (EL7)	1	1.2
Maddron Bald Trail (EL15)	1	1.2

Table 5.32.2. Please record the location of the end of your backcountry camping trip in Great Smoky Mountains National Park.		
	Overnight (n=84)	
End Location (Overnight users only.)	*Frequency*	*Percent*
Appalachian Trail near Davenport Gap Shelter (EL12)	39	46.4
Baxter Creek Trail (EL9)	10	11.9
Gabes Mountain Trail (EL0)	10	11.9
Snake Den Ridge Trail (EL3)	9	10.7
Big Creek Trail (EL10)	9	10.7
Low Gap Trail (EL2)	3	3.6
Maddron Bald Trail (EL15)	2	2.4
Lower Mt. Crammerer Trail (EL1)	1	1.2
Balsam Mtn. Trail near Laurel Gap Shelter (EL6)	1	1.2

Table 5.33.1. Trip length by survey location.			
Survey Location (Overnight users only.)	*Mean (Hours)*	*Std. Dev. (Hours)*	*Mean (Days)*
Cosby/Gabes Mountain/Maddron Bald (n=29)	42.3	21.1	1.8
Big Creek/Baxter Creek (n=24)	49.4	30.8	2.1
Davenport Gap (n=28)	28.6	11.1	1.2
Overall (n=81)	39.7	23.3	1.7

Table 5.33.2. Overall trip length statistics.		
	Overnight (n=82)	
Trip Length (Overnight users only.)	*Frequency*	*Percent*
Less than 1 day	12	14.6
1 day to less than 1 ½ days	29	35.4
1 ½ days to less than 2 days	15	18.3
2 days to less than 2 ½ days	18	22.0
2 ½ days to less than 3 days	2	2.4
3 days or more	6	7.3

Table 5.34.1. Please record the approximate time of the start of your backcountry camping trip in Great Smoky Mountains National Park.		
	Overnight (n=76)	
Start Times (Overnight users only.)	*Frequency*	*Percent*
6:00 A.M. to 9:00 A.M.	12	15.8
9:01 A.M. to 11:00 A.M.	18	23.7
11:01 A.M. to 1:00 P.M.	21	27.6
1:01 P.M. to 3:00 P.M.	13	17.1
3:01 P.M. or later	12	15.8
Median	12:00 P.M.	

Table 5.34.2. Please record the approximate time of the end of your backcountry camping trip in Great Smoky Mountains National Park.		
	Overnight (n=74)	
End Times (Overnight users only.)	*Frequency*	*Percent*
5:00 A.M. to 9:00 A.M.	2	2.7
9:01 A.M. to 11:00 A.M.	12	16.2
11:01 A.M. to 1:00 P.M.	21	28.4
1:01 P.M. to 3:00 P.M.	23	31.1
3:01 P.M. or later	16	21.6
Median	1:45 P.M.	

Table 5.35. Please record the approximate time you departed your campsite and started hiking/horseback riding on the trails the next day.		
	Overnight (n=181)	
Departure Times (Overnight users only.)	*Frequency*[a]	*Percent*
6:00 A.M. to 8:00 A.M.	55	30.4
8:01 A.M. to 9:00 A.M.	48	26.5
9:01 A.M. to 10:00 A.M.	37	20.4
10:01 A.M. to 11:00 A.M.	27	14.9
11:01 A.M. or later	14	7.7
Median	9:00 A.M.	

[a]This question was answered for every campsite the respondent stayed overnight.

Table 5.36.1. Please record the campsite number you camped at each night of your trip.

Campsite (Overnight users only.)	**Overnight** (n=74)	
	Frequency	*Percent*
Lower Walnut Bottoms (37[a])	21	28.4
Sugar Cove (34)	19	25.7
Otter Creek (29)	12	16.2
Mount Sterling (38)	9	12.2
Gilliland Creek (35)	3	4.1
Upper Henderson (19)	1	1.4
Upper Walnut Bottoms (36)	1	1.4
Pretty Hollow (39)	1	1.4
Lower Chasteen Creek (50)	1	1.4
Newton Bald (52)	1	1.4
Jerry Flats (63)	1	1.4
Lower Forney (74)	1	1.4
Pilkey Creek (77)	1	1.4
Lost Cove (90)	1	1.4
Cooper Road (1)	1	1.4

[a]Campsite numbers represent the number assigned by the park.

Table 5.36.2. Please record the shelter name you camped at each night of your trip.		
	Overnight (n=207)	
Shelter (Overnight users only.)	*Frequency*	*Percent*
Tricorner Knob (103[a])	20	9.7
Cosby Knob (102)	18	8.7
Pecks Corner (104)	17	8.2
Icewater Springs (105)	14	6.8
Derrick Knob (109)	10	4.8
Davenport Gap (101)	8	3.9
Mount Collins (106)	8	3.9
Silers Bald (108)	8	3.9
Mollies Ridge (112)	8	3.9
Laurel Gap (116)	5	2.4
Double Spring Gap (107)	4	1.9
Spence Field (110)	4	1.9
Russel Field (111)	4	1.9
Kephart (115)	3	1.4
Birch Spring Gap (113)	2	1.0

[a]Shelter numbers represent the number assigned by the park.

Table 5.36.3. Campsite and shelter frequencies by survey location.				
	Cosby / Gabes Mtn.	**Big Creek / Baxter Creek**	**Davenport Gap**	**Maddron Bald**
Campsite or Shelter (Overnight users only.)	*Frequency (Percent)*	*Frequency (Percent)*	*Frequency (Percent)*	*Frequency (Percent)*
Cooper Road (1[a])	1 (1.7)			
Upper Henderson (19)		1 (1.9)		
Otter Creek (29)	10 (16.9)			2 (0.4)
Sugar Cove (34)	18 (30.5)			1 (0.2)
Gilliland Creek (35)	2 (3.4)	1 (1.9)		
Upper Walnut Bottoms (36)		1 (1.9)		
Lower Walnut Bottoms (37)	3 (5.1)	17 (32.7)	1 (1.1)	
Mount Sterling (38)		9 (17.3)		
Pretty Hollow (39)	1 (1.7)			
Lower Chasteen Creek (50)		1 (1.9)		
Newton Bald (52)		1 (1.9)		
Jerry Flats (63)		1 (1.9)		
Lower Forney (74)		1 (1.9)		
Pilkey Creek (77)		1 (1.9)		
Lost Cove (90)		1 (1.9)		
Davenport Gap (101)	2 (3.4)	2 (3.8)	4 (4.4)	
Cosby Knob (102)	2 (3.4)	2 (3.8)	14 (15.4)	
Tricorner Knob (103)	6 (10.2)	3 (5.8)	10 (11.0)	1 (0.2)
Pecks Corner (104)	3 (5.1)		14 (15.4)	
Icewater Springs (105)	4 (6.8)	2 (3.8)	8 (8.8)	
Mount Collins (106)	1 (1.7)		7 (7.7)	
Double Spring Gap (107)	1 (1.7)		3 (3.3)	
Silers Bald (108)	1 (1.7)	2 (3.8)	5 (5.5)	

[a]Campsite and shelter numbers represent the number assigned by the park.

Table 5.36.3 (continued). Campsite and shelter frequencies by survey location.				
	Cosby / Gabes Mtn.	**Big Creek / Baxter Creek**	**Davenport Gap**	**Maddron Bald**
Campsite or Shelter (Overnight users only.)	*Frequency (Percent)*	*Frequency (Percent)*	*Frequency (Percent)*	*Frequency (Percent)*
Derrick Knob (109[a])	2 (3.4)		8 (8.8)	
Spence Field (110)		1 (1.9)	3 (3.3)	
Russel Field (111)		1 (1.9)	3 (3.3)	
Mollies Ridge (112)	2 (3.4)		6 (6.6)	
Birch Spring Gap (113)			2 (2.2)	
Kephart (115)			3 (3.3)	
Laurel Gap (116)		4 (7.7)		1 (0.2)
Total Counts	59	52	91	5

[a]Campsite and shelter numbers represent the number assigned by the park.

Encounter Observations Results

This section of Chapter 5 presents the results of the encounter observations conducted on the Big Creek and Gabes Mountain Trails in Great Smoky Mountains National Park during May, 2006.

Table 5.37. Number of groups observed, and traveling direction.

Traveling direction	**Gabes Mountain Trail**	**Big Creek Trail**
Followed towards the falls	32	39
Followed towards the trailhead	32	30
Followed both directions	13	15
Total groups observed[a]	51	54

[a]Some of the groups were followed towards the falls and back to the trailhead, therefore the total number of groups followed is not the sum of all directions.

Table 5.38. Length of observation, by direction of travel.

Time followed towards the falls (minutes)	**Gabes Mountain Trail** (n=32)		**Big Creek Trail** (n=39)	
	Frequency	*Percent*	*Frequency*	*Percent*
30	1	3.1	3	7.7
31-45	2	6.2	5	12.8
46-60	3	9.4	8	20.5
61-75	8	25.0	10	25.6
76-100	8	25.0	4	10.3
101-120	6	18.9	3	7.7
>120	4	12.4	6	15.4
Mean	85.5		73.4	
Time followed towards the trailhead (minutes)	**Gabes Mountain Trail** (n=32)		**Big Creek Trail** (n=30)	
	Frequency	*Percent*	*Frequency*	*Percent*
30	0	0.0	3	10.0
31-45	3	9.3	6	20.0
46-60	14	43.8	11	36.7
61-75	3	9.3	4	13.3
76-100	11	34.5	3	10.0
101-120	0	0.0	2	6.7
>120	1	3.1	1	3.3
Mean	70.8		59.6	

Note. Some but not all groups followed towards the waterfalls were also followed back towards the trailhead.

Table 5.39. Average number of groups encountered, by location.		
	Gabes Mountain Trail	**Big Creek Trail**
Location	*Mean*	*Mean*
Within the first half mile of the trail	1.06	0.65
Within the last half mile of the trail	1.06	0.83
Hen Wallow Falls	0.82	-
Midnight Hole	-	0.80
Mouse Creek Falls	-	1.07
On the trail, not within the first half mile of the trail	2.69	1.37
On the trail, not within the last half mile of the trail	3.72	1.68
Total encounters heading towards the falls	4.50	3.29
Total encounters heading towards the trailhead	4.97	4.03

Table 5.40. The average number of groups encountered per hour along each trail.

	Gabes Mountain Trail				Big Creek Trail			
	Mean	*90% CI half-width*	*Max*	*Min*	*Mean*	*90% CI half-width*	*Max*	*Min*
Encounters *per hour* heading towards the falls	3.28	± 0.90	13.91	0.00	2.99	± 0.94	15.00	0.00
Encounters *per hour* heading towards the trailhead	4.54	± 1.17	13.15	0.00	3.77	± 1.15	13.19	0.00

Table 5.41. The maximum amount of time without encountering another group.

Minutes	**Gabes Mountain Trail** (n=51)		**Big Creek Trail** (n=54)	
	Frequency	*Percent*	*Frequency*	*Percent*
<15	1	1.9	3	5.6
15-30	19	37.3	19	35.2
31-45	7	13.7	13	24.1
46-60	11	21.6	7	12.9
61-75	3	5.9	7	12.9
76-100	7	13.7	3	5.6
>100	3	5.9	2	3.7
Mean	51.3		43.1	
90% CI half-width	± 8.96		± 5.47	

APPENDIX A – Direction of Travel Observation Form

Great Smoky Mountains National Park
Direction of Travel Observation Form

Date: ____________________________ **Start Time:** __________________ **End Time:** ________________

Location: _____________________________________ (Refer to Counter and DOT Location Desc. and Map)

Weather: ____ (sunny/cloudy/rainy; approx. temp.)

Observer Name: ____________________________________

Enter 1 Value per Individual						Enter 1 Value per Group	
Time (00:00)	Sex (M or F)	Mode of Travel			Group ID	Group Size	Direction of Travel* (In or Out)
		Day Hiker	Horseback	Backpacker			
Ex1: 12:30	F	✓			1	2	In
Ex2: 12:30	M	✓			1	---	---

* Please see the appropriate Direction of Travel map for your location's travel direction (In vs. Out).

Enter 1 Value per <u>Individual</u>						Enter 1 Value per <u>Group</u>	
Time (00:00)	**Sex (M or F)**	**Mode of Travel**			**Group ID**	**Group Size**	**Direction of Travel* (In or Out)**
		Day Hiker	**Horseback**	**Backpacker**			

* Please see the appropriate Direction of Travel map for your location’s travel direction (In vs. Out).

APPENDIX B – Mandatory Backcountry Camping Permits

3120

GREAT SMOKY MOUNTAINS NATIONAL PARK

BACKCOUNTRY CAMPING PERMIT

(One permit per group-maximum of 8 people)

Name Kimberly		
Address		
City N. WALES	State PA	Zip 19454
Vehicle Make HYUNDAI SONATA	License #	State NC
Reservation # 49308		
No. of people in party 2	No. of horses	

Campsite number or shelter name	Date
# 34	5/27
# 29	5/28
Cosby Knob	5/29
# 37	5/30

BACKCOUNTRY CAMPING REGULATIONS

- Reservations are required to stay at all shelters and some campsites (see trail map).
- Possession of this permit is required while camping in the backcountry.
- One permit per group-maximum of 8 people.
- Larger groups may travel on separate permits but may not share a campsite on any given night.
- Camp only at designated campsites.
- The maximum stay per shelter is one night.
- The maximum stay per campsite is three nights.
- No pets allowed in the backcountry.
- Toilet use must be at least 100 feet from a site/ shelter/water. Human feces must be buried 6" deep.
- Build fires only in existing fire rings.
- Use only dead and down wood.
- Hang food on cable storage system or at least 10' off the ground and 4' away from the tree.

You are responsible for compliance.
Violaters are subject to fines.
(See Trail Map for more information)

Signature ______ Date 5/28/06

4/05

4551

GREAT SMOKY MOUNTAINS NATIONAL PARK

BACKCOUNTRY CAMPING PERMIT

(One permit per group-maximum of 8 people)

Name David		
Address		
City Concord	State NH	Zip 03301
Vehicle Make Thru-hiker	License #	State
Reservation # 11155		
No. of people in party 1	No. of horses	

Campsite number or shelter name	Date
Mollies Ridge	5/20/06
Derrick Knob	5/21
Mt Collins	5/22
Pecks Corner	5/23
Davenport Gap	5/24

BACKCOUNTRY CAMPING REGULATIONS

- Reservations are required to stay at all shelters and some campsites (see trail map).
- Possession of this permit is required while camping in the backcountry.
- One permit per group-maximum of 8 people.
- Larger groups may travel on separate permits but may not share a campsite on any given night.
- Camp only at designated campsites.
- The maximum stay per shelter is one night.
- The maximum stay per campsite is three nights.
- No pets allowed in the backcountry.
- Toilet use must be at least 100 feet from a site/ shelter/water. Human feces must be buried 6" deep.
- Build fires only in existing fire rings.
- Use only dead and down wood.
- Hang food on cable storage system or at least 10' off the ground and 4' away from the tree.

You are responsible for compliance.
Violaters are subject to fines.
(See Trail Map for more information)

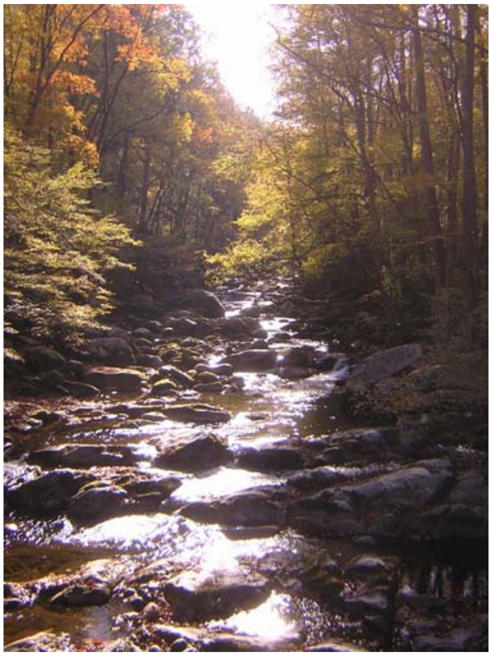
Signature ______ Date 5/18/06

4/05

APPENDIX C – Day Use Visitor Survey Instrument

OMB Approval # 1024-0224
NPS # 06-016
Expiration Date: 7/1/2006

Great Smoky Mountains National Park
Day Use Survey



ID: __________________________ Location: _______________________

Date: ________________________ Time: _______________________ AM / PM

A. Trip Description

1. **Using the map provided and the symbols described in the table below, please trace the route and schedule of your hike/horseback ride on the trails in Great Smoky Mountains National Park today by doing the following:**

    (a) Record the time you started and ended your hike/horseback ride in the park today in the spaces provided at the bottom of the map.

    (b) Mark the locations where you started and ended your hike/horseback ride in the park today on the map.

    (c) Use arrow symbols, as described below, to record your route of travel during your hike/horseback ride in the park today.

    (d) Record the location and duration of stops that you made during your hike/horseback ride in the park today that were a minimum of 5 minutes.

Please use the following symbols to record your travel route and schedule on the map:

Symbol	Meaning
Start	Marks the starting location of your hike/horseback ride
——————→	Indicates your direction and route of travel
X 30 min.	**X** marks each location where you stopped for 5 minutes or longer. Times denote the amount of time spent at each location.
End	Marks the end location of your hike/ride

Please refer to the example route and schedule on the back of the map before starting.

2. Including yourself, how many hikers and horseback riders were in your group during your hike/horseback ride on the park's trails today?

Number of hikers: ____________

Number of horseback riders: ____________

3. Which of the following best describes your group during your hike/horseback ride on the park's trails today? (Circle one number.)

1 Solo

2 Family

3 Friends

4 Family and friends

5 Organized group or club (e.g. Boy Scouts, ATC)

6 School group

7 Other (please specify): ____________________________

4. The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to use the trails <u>in this part of the park today</u>. (Circle <u>one</u> number for each item.)

	Not at all Important		Somewhat Important		Extremely Important	Don't Know/ Not Sure
Remoteness	1	2	3	4	5	DK/NS
Solitude	1	2	3	4	5	DK/NS
Primitive recreation/ few facilities	1	2	3	4	5	DK/NS
Pristine natural environment	1	2	3	4	5	DK/NS
Physically challenging/ demanding	1	2	3	4	5	DK/NS
Unconfined recreation/ free from rules and regulations	1	2	3	4	5	DK/NS
Requiring self-reliance	1	2	3	4	5	DK/NS
Fostering a sense of humility toward nature	1	2	3	4	5	DK/NS
Fostering intimacy/ connection with others in your group	1	2	3	4	5	DK/NS
Fostering spiritual uplift	1	2	3	4	5	DK/NS
Fostering connection with nature	1	2	3	4	5	DK/NS

5. **Please indicate the degree to which you experienced solitude while hiking/ horseback riding on the trails in Great Smoky Mountains National Park today?** (Circle one number.)

Experienced Solitude Today								
1	2	3	4	5	6	7	8	9
Not at all		Somewhat			Moderately		Extremely	

6. **Please indicate approximately how many other people you saw at or near the trailhead, at attraction sites (e.g. waterfall, fire tower, overlook, etc.), and along the trail away from the trailhead and attractions during your hike/horseback ride on the park's trails today. (If you did not see any other people in some or all of the locations listed below, please indicate this by reporting "0" in the appropriate spaces.)**

	# of People Hiking	**Don't Know/ Not Sure**	**# of People Horseback Riding**	**Don't Know/ Not Sure**	**Did Not Stop at Attractions**
At or near the trailhead in the first 15 minutes of your trip	______	DK/NS	______	DK/NS	-
Along the trail, away from the trailhead and attractions	______	DK/NS	______	DK/NS	-
At or near the trailhead in the last 15 minutes of your trip	______	DK/NS	______	DK/NS	-
At the first attraction where you stopped	______	DK/NS	______	DK/NS	Not Applicable
At the second attraction where you stopped	______	DK/NS	______	DK/NS	Not Applicable
At the third attraction where you stopped	______	DK/NS	______	DK/NS	Not Applicable

7. Approximately, what was the longest period of time that passed during which you did not see other people on your hike/horseback ride on the park's trails today?

Amount of time: ________________ (minutes)

– OR –

____ Don't Know / Not Sure

8. The number of other people I saw during my hike/horseback ride on the park's trails today interfered with my <u>sense of solitude</u>. (Circle <u>one</u> number, even if you did not see other groups.)

1 Strongly agree

2 Agree

3 Neither agree nor disagree

4 Disagree

5 Strongly disagree

9. <u>During your hike/horseback ride on the park's trails today</u>, did your group do any of the following to avoid seeing other people? (Check <u>all</u> that apply.)

____ Hike/horseback ride at particular times when you expected to see fewer people

____ Hike/horseback ride on particular trails where you expected to see fewer people

____ Choose not to stop at attractions (e.g. overlook, fire tower, waterfall, etc.) because there were too many people there

____ Other (Please specify): ____

____ None of the above apply

10. In general, the number of other people I see while hiking/horseback riding in places like Great Smoky Mountains National Park affects my ability to experience solitude. (Circle <u>one</u> number.)

1 Strongly agree

2 Agree

3 Neither agree nor disagree

4 Disagree

5 Strongly disagree

(4–5: **SKIP TO QUESTION 12**)

11. Please indicate for each of the following numbers of people seen <u>per hour</u> while hiking/horseback riding on the trails in Great Smoky Mountains National Park how likely you would be to experience solitude during such a trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each item.)

	Likelihood of Experiencing Solitude									
	Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
See no other people on the trails	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
See 2 other people per hour	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
See 4 other people per hour	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
See 8 other people per hour	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
See 16 other people per hour	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

12. In general, the amount of time that passes without seeing other people while hiking/horseback riding in places like Great Smoky Mountains National Park affects my ability to experience solitude? (Circle one number.)

1 Strongly agree

2 Agree

3 Neither agree nor disagree

4 Disagree

5 Strongly disagree

(4, 5: **SKIP TO QUESTION 14**)

13. Please indicate for each of the following lengths of time without seeing other people while hiking/horseback riding on the trails in Great Smoky Mountains National Park how likely you would be to experience solitude during that time. A rating of "-4" means you would be very unlikely to experience solitude within the time period, and a rating of "+4" means you would be very likely to experience solitude within the time period. (Circle one number for each item.)

	Likelihood of Experiencing Solitude									
	Very Unlikely				**Neutral**				**Very Likely**	**Don't Know / Not Sure**
15 minutes without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
30 minutes without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
1 hour without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
2 hours without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
3 hours without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

14. Please indicate for each of the following hypothetical hiking/horseback riding trips in Great Smoky Mountains National Park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Hiking/Horseback Riding Trip 1

You see:

- No other people during the trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Hiking/Horseback Riding Trip 2

You see:

- Several other people (6 – 10) at or near the trailhead in the first 15 minutes of your trip
- No other people at attractions where you stop
- No other people along the trails away from the trailhead and attractions
- Several other people (6 – 10) at or near the trailhead in the last 15 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Hiking/Horseback Riding Trip 3

You see:

- Several other people (6 – 10) at or near the trailhead in the first 15 minutes of your trip
- Several other people (6 – 10) at attractions where you stop
- No other people along the trails away from the trailhead and attractions
- Several other people (6 – 10) at or near the trailhead in the last 15 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Hiking/Horseback Riding Trip 4

You see:

- Several other people (6 – 10) at or near the trailhead in the first 15 minutes of your trip
- No other people at attractions where you stop
- Several other people(6-10) along the trails away from the trailhead and attractions
- Several other people (6 – 10) at or near the trailhead in the last 15 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Hiking/Horseback Riding Trip 5

You see:

- No other people at or near the trailhead in the first 15 minutes of your trip
- Several other people (6 – 10) at attractions where you stop
- No other people along the trails away from the trailhead and attractions
- No other people at or near the trailhead in the last 15 minutes of your trip

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Hiking/Horseback Riding Trip 6

You see:

- No other people at or near the trailhead in the first 15 minutes of your trip
- No other people at attractions where you stop
- Several other people (6 – 10) along the trails away from the trailhead and attractions
- No other people at or near the trailhead in the last 15 minutes of your trip

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Hiking/Horseback Riding Trip 7

You see:

- Several other people (6 – 10) at or near the trailhead in the first 15 minutes of your trip
- Several other people (6 – 10) at attractions where you stop
- Several other people (6 – 10) along the trails away from the trailhead and attractions
- Several other people (6 – 10) at or near the trailhead in the last 15 minutes of your trip

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

15. Please indicate the extent to which you <u>have ever</u> done each of the following in any wilderness or backcountry recreation area (including Great Smoky Mountains National Park):

	Never	**Rarely**	**Occasionally**	**Usually**	**Always**
Visit earlier or later in the season to avoid seeing other people	0	1	2	3	4
Visit on weekdays to avoid weekend crowds	0	1	2	3	4
Go to trails that are less crowded	0	1	2	3	4
Avoid places that have limits on the amount of use	0	1	2	3	4
Go to other areas where you are less likely to see other people	0	1	2	3	4
Avoid places that regulate the use of horseback riders	0	1	2	3	4
Avoid attractions that are crowded	0	1	2	3	4

C. Great Smoky Mountains National Park Management

16. Please indicate the extent to which you agree or disagree with each of the following statements concerning management of hiking/horseback riding in Great Smoky Mountains National Park. (Circle one number for each item.)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know / Not Sure
If solitude is lost, use limits should be imposed	1	2	3	4	5	DK/NS
Use limits should never be imposed, even if use is high	1	2	3	4	5	DK/NS
More trails should be added to reduce the number of people seen	1	2	3	4	5	DK/NS
More trailheads should be added to disperse use away from busy areas	1	2	3	4	5	DK/NS

D. Background Information

The information in this section will help us better understand who uses the trails in Great Smoky Mountains National Park. Your responses to the questionnaire are strictly confidential and results will only be reported as overall averages.

17. What is your sex? (Circle one number.)

1 Male

2 Female

18. What is your age?

Age (in years): ___________

19. If you live in the United States, what is your state and zip code of residence?

State of residence: ___________________________

Zip Code of residence: _______________________

(SKIP TO QUESTION 21)

20. If you do not live in the United States, what country do you live in?

Country of residence: ________________________________

21. What is the highest level of formal schooling you have completed? (Circle one number.)

1 Some high school

2 High school graduate or GED

3 Some college, business or trade school

4 College, business or trade school graduate

5 Some graduate school

6 Master's, doctoral or professional degree

22. Do you consider yourself to be Hispanic, Latino, or Latina? (Circle one number.)

1 Yes

2 No

23. Which racial group(s) do you identify with? (Check all that apply.)

____ American Indian or Alaska Native

____ Asian

____ Black or African American

____ White

____ Native Hawaiian or other Pacific Islander

Thank you for your help with this survey!

Please return the completed questionnaire to the survey administrator.

Please address correspondence regarding the survey to:

Dr. Steven R. Lawson
307 Cheatham Hall (0324)
Department of Forestry
Virginia Polytechnic Institute and State University
Blacksburg, VA 24060

APPENDIX D – Overnight Use Visitor Survey Instrument

OMB Approval # 1024-0224
NPS # 06-016
Expiration Date: 7/1/2006

Great Smoky Mountains National Park
Overnight Use Survey

ID: ______________________ **Location:** ____________________

Date: _____________________ **Time:** ____________________ **AM / PM**

Permit Number: ____________________

A. Trip Description

1. Please record the date, approximate time, and location of the start and end of your backcountry camping trip in Great Smoky Mountains National Park.

	Date	Time (circle AM or PM)	Location
Trip start	_______________	_____________ AM / PM	____________________________
Trip end	_______________	_____________ AM / PM	____________________________

2. Please record the shelter name or campsite number you camped at each night of your trip. Also, please record the approximate time you departed your campsite and started hiking/horseback riding on the trails the next day.

	Campsite #/Shelter Name	Time Departed Campsite
Night 1	_____________________________	________________AM / PM
Night 2	_____________________________	________________AM / PM
Night 3	_____________________________	________________AM / PM
Night 4	_____________________________	________________AM / PM
Night 5	_____________________________	________________AM / PM
Night 6	_____________________________	________________AM / PM

3. Using the map provided, please:

(a) Mark with an "**X**" each location on the map where you stopped for more than 5 minutes, excluding camping locations.

(b) For each location you marked on the map, write the date you stopped and the approximate amount of time you spent at each location.

(c) Use arrow symbols (———→) to mark your direction and route of travel during your backcountry camping trip.

Please refer to the example on the back of the map before starting.

4. **Including yourself, how many hikers and horseback riders were in your group during your backcountry camping trip in Great Smoky Mountains National Park?**

   Number of hikers: ____________

   Number of horseback riders: ____________

5. **Which of the following best describes your group during your backcountry camping trip in Great Smoky Mountains National Park?** (Circle <u>one</u> number.)

   1 Solo
   2 Family
   3 Friends
   4 Family and friends
   5 Organized group or club (e.g. Boy Scouts, ATC)
   6 School group
   7 Other (please specify): ____________________________

B. The Visitor Experience

6. The following is a list of characteristics commonly associated with backcountry and wilderness areas. Please indicate how important each of the items listed below was to you as a reason to go backcountry camping in Great Smoky Mountains National Park <u>on this trip</u>. (Circle <u>one</u> number for each item.)

	Not at all important		Somewhat Important		Extremely Important	Don't Know/ Not Sure
Remoteness	1	2	3	4	5	DK/NS
Solitude	1	2	3	4	5	DK/NS
Primitive recreation/ few facilities	1	2	3	4	5	DK/NS
Pristine natural environment	1	2	3	4	5	DK/NS
Physically challenging/ demanding	1	2	3	4	5	DK/NS
Unconfined recreation/ free from rules and regulations	1	2	3	4	5	DK/NS
Requiring self-reliance	1	2	3	4	5	DK/NS
Fostering a sense of humility toward nature	1	2	3	4	5	DK/NS
Fostering intimacy/ connection with others in your group	1	2	3	4	5	DK/NS
Fostering spiritual uplift	1	2	3	4	5	DK/NS
Fostering connection with nature	1	2	3	4	5	DK/NS

7. **Please indicate <u>approximately</u> how many other people you saw at or near the trailhead, at campsites/shelters, and along the trail away from trailheads and campsites <u>during your backcountry camping trip in Great Smoky Mountains National Park</u>. (If you did not see any other groups in some or all of the locations listed below, please indicate this by reporting "0" in the appropriate spaces.)**

Last Day / Last Night	# of Hikers	Don't Know/ Not Sure	# of Horseback Riders	Don't Know/ Not Sure
At or near the trailhead in the <u>last 30 minutes</u> of your trip	______	DK/NS	______	DK/NS
Along the trail, away from trailheads and campsites/shelters	______	DK/NS	______	DK/NS
At the campsite/shelter	______	DK/NS	______	DK/NS

Previous Day / Previous Night	# of Hikers	Don't Know/ Not Sure	# of Horseback Riders	Don't Know/ Not Sure	Not Applicable
Along the trail, away from trailheads and campsites/shelters	______	DK/NS	______	DK/NS	-
At the campsite/shelter (*Circle "N/A" if you only camped 1 night*)	______	DK/NS	______	DK/NS	N/A

Previous Day / Previous Night	# of Hikers	Don't Know/ Not Sure	# of Horseback Riders	Don't Know/ Not Sure	Not Applicable
Along the trail, away from trailheads and campsites/ shelters (*Circle "N/A" if you only camped 1 night*)	______	DK/NS	______	DK/NS	N/A
At the campsite/shelter (*Circle "N/A" if you camped 2 or fewer nights*)	______	DK/NS	______	DK/NS	N/A

8. Please indicate the degree to which you experienced solitude during this backcountry camping trip in Great Smoky Mountains National Park. (Circle one number.)

Experienced Solitude on This Trip								
1	2	3	4	5	6	7	8	9
Not at all		Somewhat			Moderately		Extremely	

9. Approximately, what was the longest period of time that passed during which you did not see other people on your backcountry camping trip in Great Smoky Mountains National Park? (Fill in the blank and circle hours or days.)

Amount of time: ________________ (hours / days)

10. The number of other people I saw along the trails during my backcountry camping trip in Great Smoky Mountains National Park interfered with my sense of solitude. (Circle one number.)

1 Strongly agree

2 Agree

3 Neither agree nor disagree

4 Disagree

5 Strongly disagree

11. The number of other people I saw <u>at campsites/shelters</u> during my backcountry camping trip in Great Smoky Mountains National Park interfered with my <u>sense of solitude</u>. (Circle <u>one</u> number.)

1 Strongly agree

2 Agree

3 Neither agree nor disagree

4 Disagree

5 Strongly disagree

12. <u>During your backcountry camping trip in Great Smoky Mountains National Park</u>, did your group do any of the following to avoid seeing other people? (Check <u>all</u> that apply.)

____ Schedule your backcountry camping trip for days when you expected to see fewer people.

____ Backpack/horseback ride on trails where you expected to see fewer people.

____ Camp at particular campsites/shelters where you expected to see fewer people.

____ Choose not to stop at attractions (e.g. overlook, fire tower, waterfall, etc.) because there were too many people there.

____ Choose not to camp at a campsite/shelter on your permit because there were too many people there.

____ Other (Please specify): ____

____ None of the above apply

13. In general, the number of other people I see during a backcountry camping trip in places like Great Smoky Mountains National Park affects my ability to experience solitude. (Circle one number.)

1 Strongly agree

2 Agree

3 Neither agree nor disagree

4 Disagree

5 Strongly disagree

} (**SKIP TO QUESTION 15**)

14. Please indicate for each of the following numbers of people seen per day during a backcountry camping trip in Great Smoky Mountains National Park how likely you would be to experience solitude during such a trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each item.)

	Likelihood of Experiencing Solitude									
	Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
See no other people during the trip	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
See 2 other people per day	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
See 4 other people per day	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
See 8 other people per day	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
See 16 other people per day	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

15. In general, the amount of time that passes without seeing other people during a backcountry camping trip in places like Great Smoky Mountains National Park affects my ability to experience solitude? (Circle one number.)

1 Strongly agree

2 Agree

3 Neither agree nor disagree

4 Disagree

5 Strongly disagree

(4–5: **SKIP TO QUESTION 17**)

16. Please indicate for each of the following lengths of time without seeing other people during a backcountry camping trip in Great Smoky Mountains National Park how likely you would be to experience solitude during that time. A rating of "-4" means you would be very unlikely to experience solitude within the time period, and a rating of "+4" means you would be very likely to experience solitude within the time period. (Circle one number for each item.)

	Likelihood of Experiencing Solitude								
	Very Unlikely				**Neutral**			**Very Likely**	**Don't Know/ Not Sure**
30 minutes without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
1 hour without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
2 hours without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
5 hours without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS
1 day (24 hours) without seeing other people	-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

17. Approximately, what is the minimum amount of time that would need to pass without seeing other people during a backcountry camping trip in Great Smoky Mountains National Park before you would begin to experience solitude? (Fill in the blank and circle minutes or hours.)

Amount of time: _______________ (minutes / hours)

18. Please indicate for each of the following hypothetical backcountry camping trips in Great Smoky Mountains National Park how likely you would be to experience solitude during the trip. A rating of "-4" means you would be very unlikely to experience solitude, and a rating of "+4" means you would be very likely to experience solitude. (Circle one number for each scenario.)

Backcountry Camping Trip 1

You see:

- No other people during the trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Backcountry Camping Trip 2

You see:

- Several other people (6 – 10) at or near the trailhead in the first 30 minutes of your trip
- No other people along the trails away from trailheads and campsites/shelters
- No other people at campsites/shelters where you camp
- Several other people (6 – 10) at or near the trailhead in the last 30 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Backcountry Camping Trip 3

You see:

- Several other people (6 – 10) at or near the trailhead in the first 30 minutes of your trip
- No other people along the trails away from trailheads and campsites/shelters
- Several other people (6 – 10) at campsites/shelters where you camp
- Several other people (6 – 10) at or near the trailhead in the last 30 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Backcountry Camping Trip 4

You see:

- Several other people (6 – 10) at or near the trailhead in the first 30 minutes of your trip
- Several other people (6 – 10) along the trails away from trailheads and campsites/shelters
- No other people at campsites/shelters where you camp
- Several other people (6 – 10) at or near the trailhead in the last 30 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Backcountry Camping Trip 5

You see:

- No other people at or near the trailhead in the first 30 minutes of your trip
- Several other people (6 – 10) along the trails away from trailheads and campsites/shelters
- No other people at campsites/shelters where you camp
- No other people at or near the trailhead in the last 30 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Backcountry Camping Trip 6

You see:

- No other people at or near the trailhead in the first 30 minutes of your trip
- No other people along the trails away from trailheads and campsites/shelters
- Several other people (6 – 10) at campsites/shelters where you camp
- No other people at or near the trailhead in the last 30 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

Backcountry Camping Trip 7

You see:

- Several other people (6 – 10) at or near the trailhead in the first 30 minutes of your trip
- Several other people (6 – 10) along the trails away from trailheads and campsites/shelters
- Several other people (6 – 10) at campsites/shelters where you camp
- Several other people (6 – 10) at or near the trailhead in the last 30 minutes of your trip.

How likely would you be to experience solitude on this trip?

Very Unlikely				Neutral				Very Likely	Don't Know/ Not Sure
-4	-3	-2	-1	0	+1	+2	+3	+4	DK/NS

19. Please indicate the extent to which you <u>have ever</u> done each of the following in any wilderness or backcountry recreation area (including Great Smoky Mountains National Park):

	Never	Rarely	Occasionally	Usually	Always
Visit earlier or later in the season to avoid seeing other people	0	1	2	3	4
Visit on weekdays to avoid weekend crowds	0	1	2	3	4
Go to trails that are less crowded	0	1	2	3	4
Avoid places that have limits on the amount of use	0	1	2	3	4
Go to other areas where you are less likely to see other people	0	1	2	3	4
Avoid places that regulate the use of horseback riders	0	1	2	3	4
Avoid attractions that are crowded	0	1	2	3	4

C. Great Smoky Mountains National Park Management

20. Please indicate the extent to which you agree or disagree with each of the following statements concerning management of backpacking/horseback riding in Great Smoky Mountains National Park. (Circle one number for each item.)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know / Not Sure
If solitude is lost, use limits should be imposed	1	2	3	4	5	DK/NS
Use limits should never be imposed, even if use is high	1	2	3	4	5	DK/NS
More trails should be added to reduce the number of people seen	1	2	3	4	5	DK/NS
More campsites should be added to reduce the number of people seen	1	2	3	4	5	DK/NS
More trailheads should be added to disperse use away from busy areas	1	2	3	4	5	DK/NS

D. Background Information

The information in this section will help us better understand who uses the trails and backcountry camps in Great Smoky Mountains National Park. Your responses to the questionnaire are strictly confidential and results will only be reported as overall averages.

21. What is your sex? (Circle one number.)

1 Male

2 Female

22. What is your age?

Age (in years): ___________

23. If you live in the United States, what is your state and zip code of residence?

State of residence: ________________________________

Zip Code of residence: ____________________________

(SKIP TO QUESTION 25)

24. If you do not live in the United States, what country do you live in?

Country of residence: ________________________________

25. What is the highest level of formal schooling you have completed? (Circle one number.)

1 Some high school

2 High school graduate or GED

3 Some college, business or trade school

4 College, business or trade school graduate

5 Some graduate school

6 Master's, doctoral or professional degree

26. Do you consider yourself to be Hispanic, Latino, or Latina? (Circle one number.)

1 Yes

2 No

27. Which racial group(s) do you identify with? (Check all that apply.)

____ American Indian or Alaska Native

____ Asian

____ Black or African American

____ White

____ Native Hawaiian or other Pacific Islander

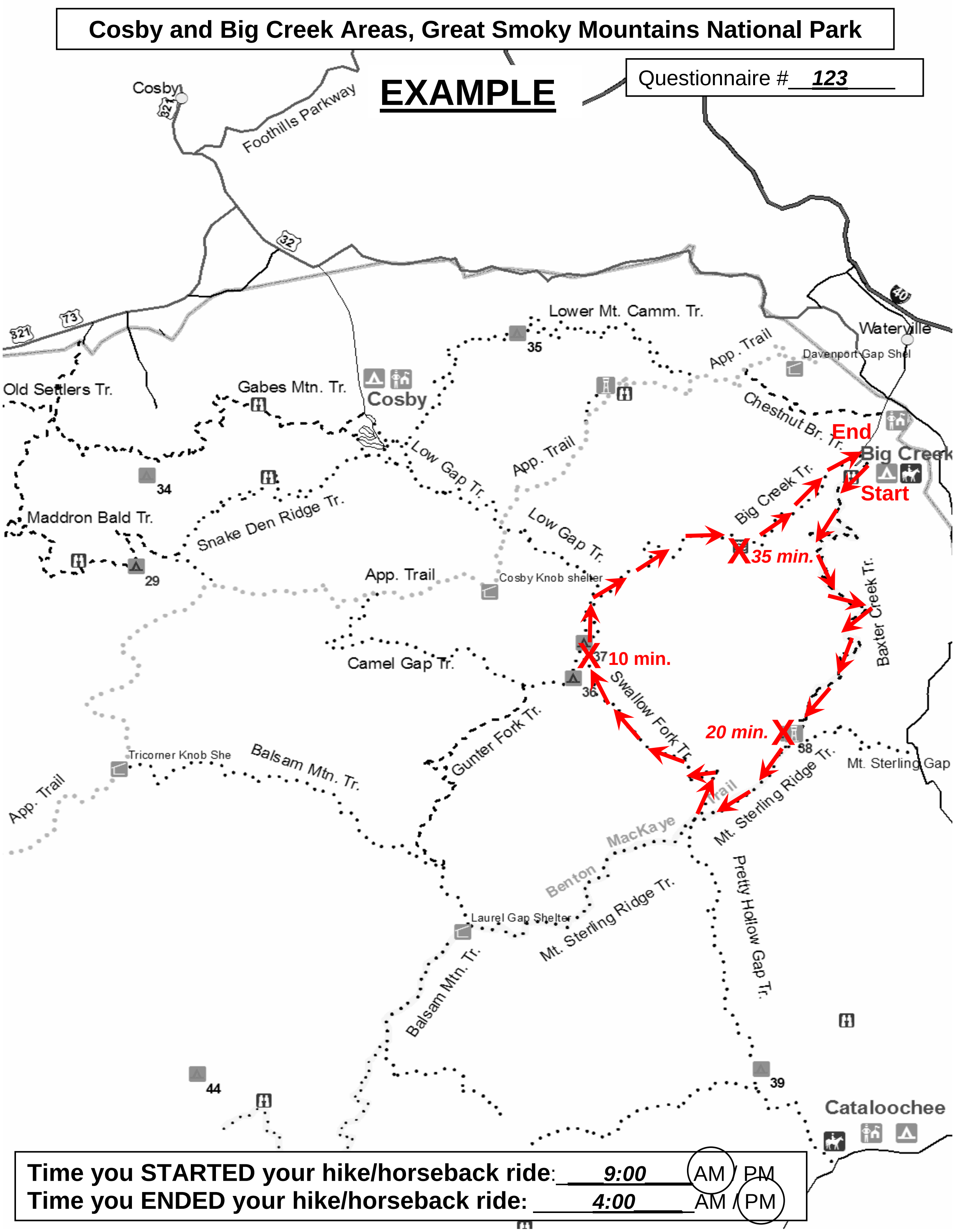
Thank you for your help with this survey!

Please return the completed questionnaire to the survey administrator.

Please address correspondence regarding the survey to:

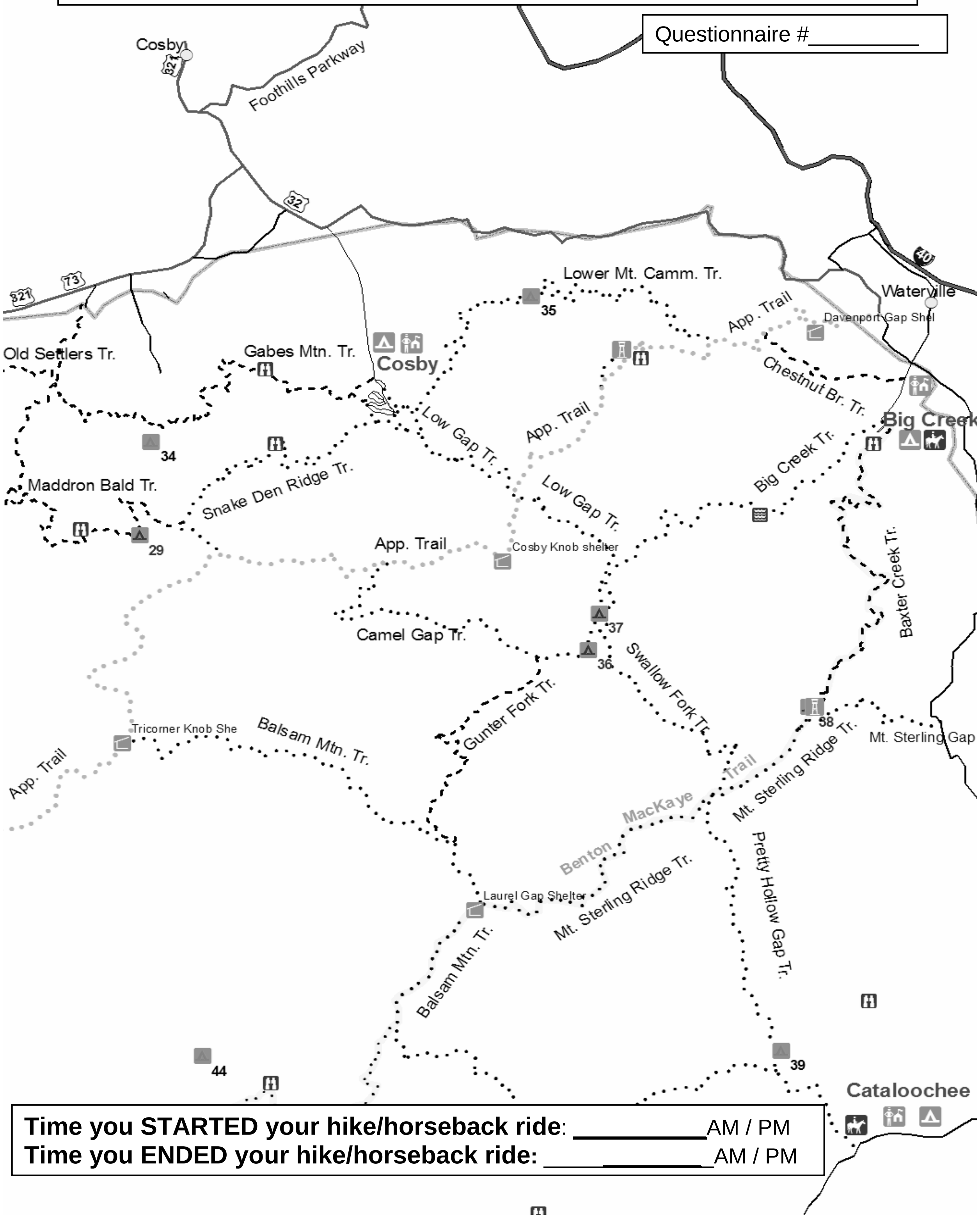
Dr. Steven R. Lawson
307 Cheatham Hall (0324)
Department of Forestry
Virginia Polytechnic Institute and State University
Blacksburg, VA 24060

APPENDIX E – Route Map Administered to Day Use Visitor Survey Respondents


Cosby and Big Creek Areas, Great Smoky Mountains National Park
EXAMPLE
Questionnaire # 123
Cosby
Foothills Parkway
Lower Mt. Camm. Tr.
Waterville
App. Trail
Davenport Gap Shel
Old Settlers Tr.
Gabes Mtn. Tr.
Cosby
Chestnut Br. Tr.
End
Big Creek
Start
Low Gap Tr.
App. Trail
Big Creek Tr.
34
35
Maddron Bald Tr.
Snake Den Ridge Tr.
Low Gap Tr.
35 min.
29
App. Trail
Cosby Knob shelter
Baxter Creek Tr.
Camel Gap Tr.
37
10 min.
36
Swallow Fork Tr.
20 min.
58
Gunter Fork Tr.
Mt. Sterling Gap
Tricorner Knob She
Balsam Mtn. Tr.
Mt. Sterling Ridge Tr.
App. Trail
Trail
MacKaye
Benton
Pretty Hollow Gap Tr.
Laurel Gap Shelter
Mt. Sterling Ridge Tr.
Balsam Mtn. Tr.
44
39
Cataloochee
Time you STARTED your hike/horseback ride: 9:00 AM / PM
Time you ENDED your hike/horseback ride: 4:00 AM / PM

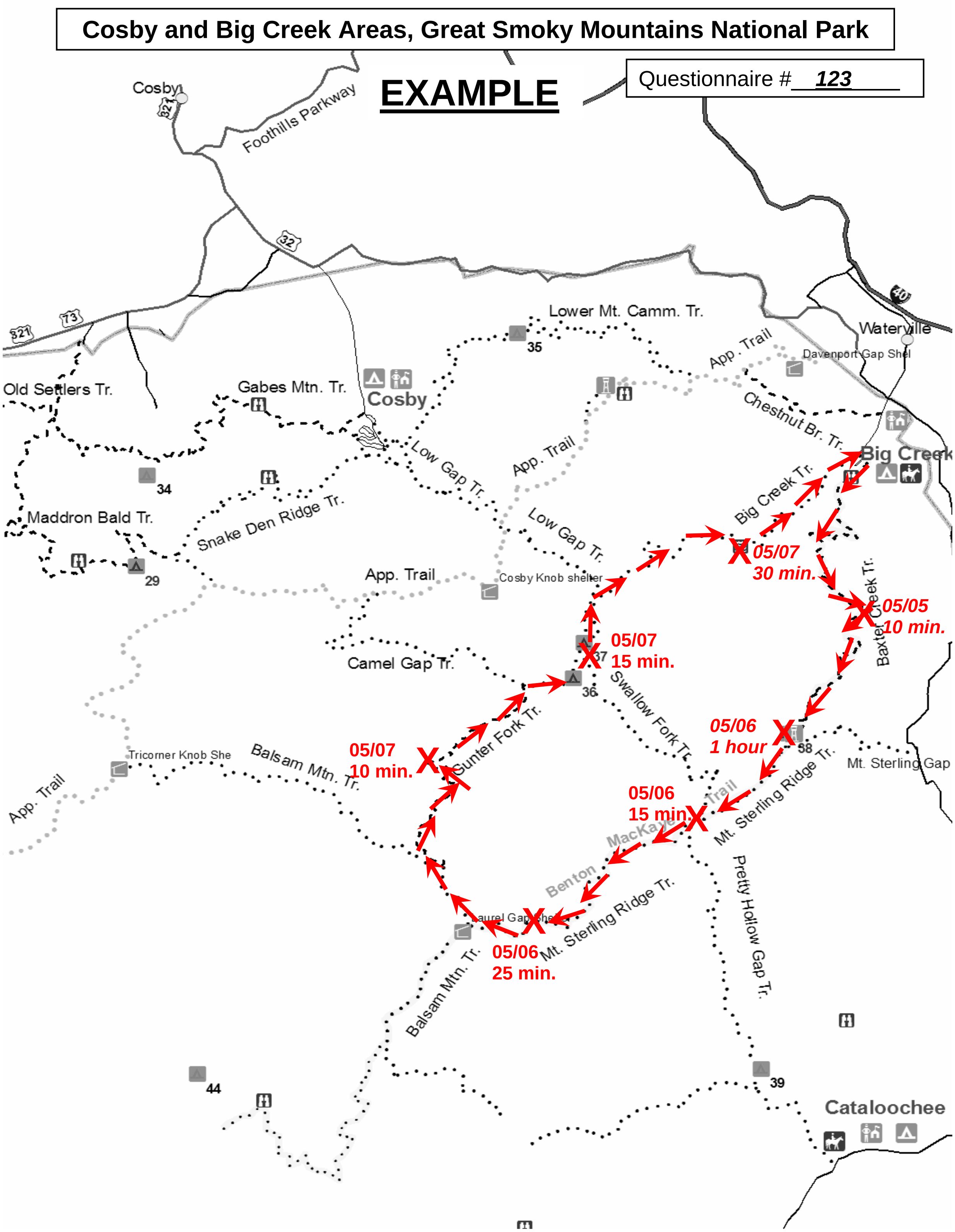
Cosby and Big Creek Areas, Great Smoky Mountains National Park

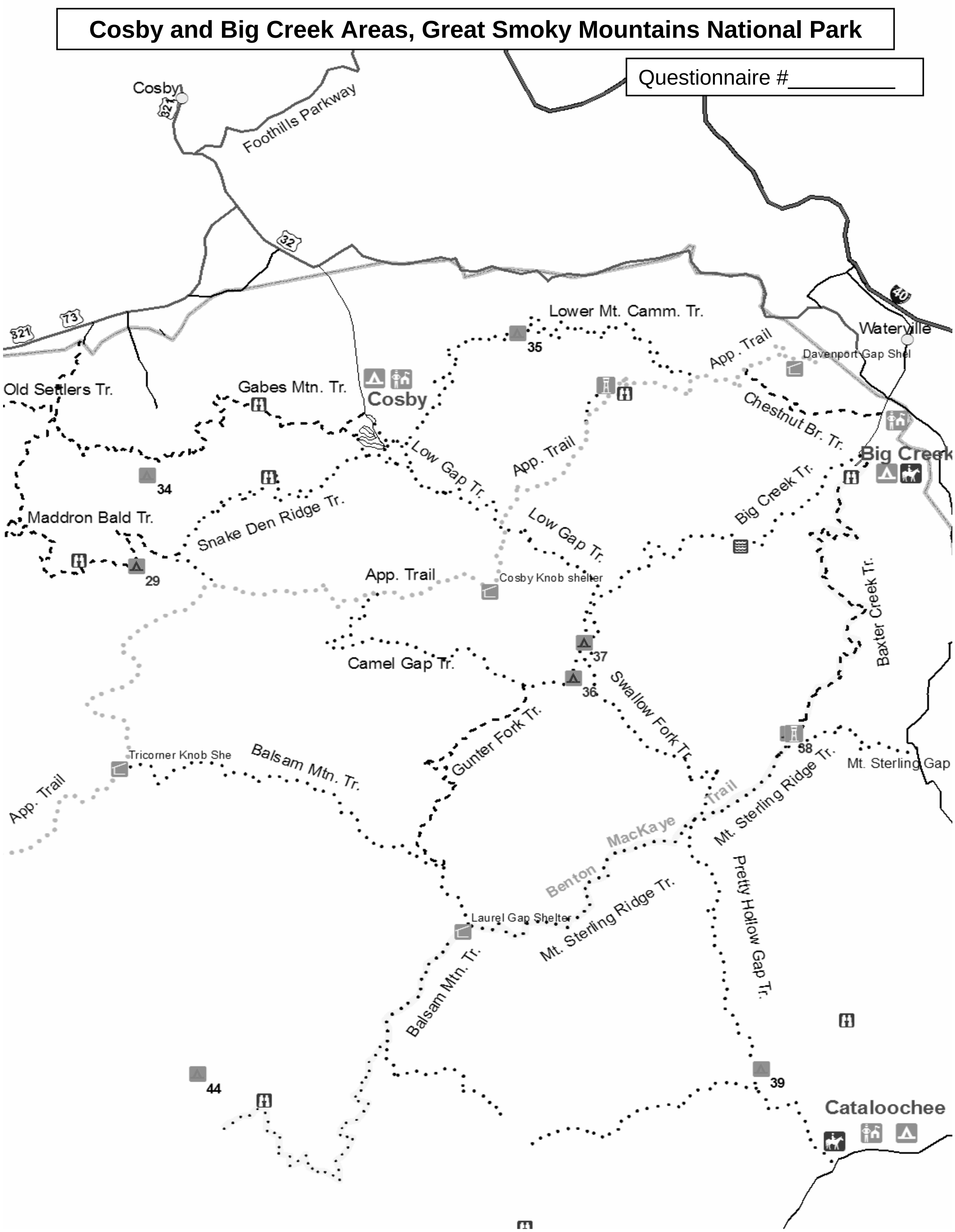
Questionnaire #__________



Time you STARTED your hike/horseback ride: __________AM / PM
Time you ENDED your hike/horseback ride: __________AM / PM

APPENDIX F – Route Map Administered to Overnight Use Visitor Survey Respondents


Cosby and Big Creek Areas, Great Smoky Mountains National Park
EXAMPLE
Questionnaire # 123
Cosby
Foothills Parkway
Waterville
Lower Mt. Camm. Tr.
App. Trail
Davenport Gap Shel
Old Settlers Tr.
Gabes Mtn. Tr.
Cosby
Chestnut Br. Tr.
Big Creek
Low Gap Tr.
Big Creek Tr.
Maddron Bald Tr.
Snake Den Ridge Tr.
Low Gap Tr.
05/07
30 min.
App. Trail
Cosby Knob shelter
05/05
10 min.
Baxter Creek Tr.
05/07
15 min.
Camel Gap Tr.
Swallow Fork Tr.
05/06
1 hour
Tricorner Knob She
Balsam Mtn. Tr.
05/07
10 min.
Gunter Fork Tr.
Mt. Sterling Gap
Mt. Sterling Ridge Tr.
App. Trail
05/06
15 min.
MacKaye
Benton
Trail
Pretty Hollow Gap Tr.
Laurel Gap She
05/06
25 min.
Mt. Sterling Ridge Tr.
Balsam Mtn. Tr.
Cataloochee
34
35
29
37
36
58
44
39


Cosby and Big Creek Areas, Great Smoky Mountains National Park
Questionnaire #__________
Cosby
321
Foothills Parkway
32
321
73
40
Waterville
Lower Mt. Camm. Tr.
35
App. Trail
Davenport Gap Shel
Chestnut Br. Tr.
Big Creek
Old Settlers Tr.
Gabes Mtn. Tr.
Cosby
Low Gap Tr.
App. Trail
34
Maddron Bald Tr.
Snake Den Ridge Tr.
Low Gap Tr.
Big Creek Tr.
29
App. Trail
Cosby Knob shelter
Baxter Creek Tr.
37
Camel Gap Tr.
36
Swallow Fork Tr.
Gunter Fork Tr.
58
Mt. Sterling Gap
Tricorner Knob She
Balsam Mtn. Tr.
App. Trail
Benton MacKaye Trail
Mt. Sterling Ridge Tr.
Pretty Hollow Gap Tr.
Laurel Gap Shelter
Mt. Sterling Ridge Tr.
Balsam Mtn. Tr.
44
39
Cataloochee

APPENDIX G – Encounter Observation Forms

Date: ______________________ **Location:** ___**Big Creek Trail**_________

Weather: __________________________ **Observer Name:** ___________________________

Starting Time	**Starting Location** (i.e. falls, bridge, parking lot, coord.)	**Direction Following** (In or Out)

Midnight Hole Falls			**Mouse Creek Falls**			**First Bridge**	
Time arrive			Time arrive			Time arrive	
Time depart (or start/end observation)			Time depart (or start/end observation)			Time depart (or start/end observation)	

ID	**Number in Group by Type**		
	Day Hiker (____)	Horseback (____)	Backpacker (____)

	Encounter Observations					
	Time (00:00)	**Number in Group by Type**			**Coordinates of Encounter Occurred (UTM)**	**Overtaking (O) or Meeting(M)**
		Day Hiker (#)	Horseback (#)	Backpacker (#)		
Ex.	12:30	2	1	0	17 S 0398542 3955678	O
Enct. 1					17 S ___________ ___________	
Enct. 2					17 S ___________ ___________	
Enct. 3					17 S ___________ ___________	
Enct. 4					17 S ___________ ___________	
Enct. 5					17 S ___________ ___________	
Enct. 6					17 S ___________ ___________	
Enct. 7					17 S ___________ ___________	
Enct. 8					17 S ___________ ___________	

Turn Around Time (if follow both directions)	**Turn Around Location** (i.e. falls, bridge, or coord.)	**Ending Time**	**Ending Location** (i.e. falls, bridge, parking lot, or coord.)

Date: ______________________ **Location:** ___Gabes Mountain Trail_________

Weather: __________________________ **Observer Name:** ___________________________

Starting Time	**Starting Location** (i.e. falls, bridge, parking lot, coord.)	**Direction Following** (In or Out)

Hen Wallow Falls	
Time arrive	
Time depart (or start/end observation)	

ID	**Number in Group by Type**		
	Day Hiker (____)	Horseback (____)	Backpacker (____)

	Encounter Observations					
	Time (00:00)	**Number in Group by Type**			**Coordinates of Encounter Occurred (UTM)**	**Overtaking (O) or Meeting(M)**
		Day Hiker (#)	Horseback (#)	Backpacker (#)		
Ex.	12:30	2	1	0	17 S 0398542 3955678	O
Enct. 1					17 S ____________ ____________	
Enct. 2					17 S ____________ ____________	
Enct. 3					17 S ____________ ____________	
Enct. 4					17 S ____________ ____________	
Enct. 5					17 S ____________ ____________	
Enct. 6					17 S ____________ ____________	
Enct. 7					17 S ____________ ____________	
Enct. 8					17 S ____________ ____________	

Turn Around Time (if follow both directions)	**Turn Around Location** (i.e. falls, bridge, or coord.)	**Ending Time**	**Ending Location** (i.e. falls, bridge, parking lot, or coord.)

APPENDIX H – Complete List of Day Use Visitor Survey Respondents' Zip Codes of Residence

Table H.1. If you live in the United States, what is your zip code of residence?		
Zip code (Day users only.)	**Frequency**	**Percent**
37722	7	2.9
37821	7	2.9
37919	7	2.9
37814	5	2.1
37221	4	1.7
37830	4	1.7
37862	4	1.7
37922	4	1.7
37804	3	1.3
37857	3	1.3
37909	3	1.3
28786	2	0.8
28803	2	0.8
29615	2	0.8
29690	2	0.8
35801	2	0.8
37659	2	0.8
37760	2	0.8
37764	2	0.8
37876	2	0.8
37917	2	0.8
37920	2	0.8
37932	2	0.8
40508	2	0.8
47408	2	0.8
53562	2	0.8
03303	1	0.4
10547	1	0.4
11779	1	0.4
13733	1	0.4
15136	1	0.4
16157	1	0.4
17543	1	0.4
17814	1	0.4
18850	1	0.4
19803	1	0.4
20042	1	0.4
20152	1	0.4
22046	1	0.4
22201	1	0.4
23320	1	0.4

Table H.1 (continued). If you live in the United States, what is your zip code of residence?		
Zip code (Day users only.)	**Frequency**	**Percent**
23693	1	0.4
24060	1	0.4
24354	1	0.4
25312	1	0.4
27104	1	0.4
27540	1	0.4
27603	1	0.4
28358	1	0.4
28607	1	0.4
28655	1	0.4
28692	1	0.4
28701	1	0.4
28707	1	0.4
28713	1	0.4
28716	1	0.4
28721	1	0.4
28748	1	0.4
28759	1	0.4
28778	1	0.4
28787	1	0.4
28791	1	0.4
28801	1	0.4
28804	1	0.4
28805	1	0.4
28806	1	0.4
29020	1	0.4
29605	1	0.4
29611	1	0.4
29650	1	0.4
29708	1	0.4
29909	1	0.4
29928	1	0.4
30032	1	0.4
30313	1	0.4
30324	1	0.4
30344	1	0.4
30707	1	0.4
31804	1	0.4
32136	1	0.4
32301	1	0.4
32327	1	0.4
32765	1	0.4

Table H.1 (continued). If you live in the United States, what is your zip code of residence?		
Zip code (Day users only.)	**Frequency**	**Percent**
32950	1	0.4
32955	1	0.4
33594	1	0.4
33612	1	0.4
33759	1	0.4
34683	1	0.4
34772	1	0.4
35023	1	0.4
35049	1	0.4
35116	1	0.4
35612	1	0.4
36106	1	0.4
36207	1	0.4
36256	1	0.4
37013	1	0.4
37145	1	0.4
37191	1	0.4
37215	1	0.4
37604	1	0.4
37663	1	0.4
37681	1	0.4
37713	1	0.4
37743	1	0.4
37753	1	0.4
37763	1	0.4
37820	1	0.4
37849	1	0.4
37863	1	0.4
37865	1	0.4
37871	1	0.4
37885	1	0.4
37912	1	0.4
37914	1	0.4
37916	1	0.4
37921	1	0.4
37934	1	0.4
37938	1	0.4
37998	1	0.4
38017	1	0.4
38111	1	0.4
38315	1	0.4
38472	1	0.4

Table H.1 (continued). If you live in the United States, what is your zip code of residence?		
Zip code (Day users only.)	**Frequency**	**Percent**
39439	1	0.4
39759	1	0.4
40065	1	0.4
40205	1	0.4
40220	1	0.4
40241	1	0.4
40502	1	0.4
42240	1	0.4
42445	1	0.4
42459	1	0.4
43207	1	0.4
43212	1	0.4
44107	1	0.4
44314	1	0.4
45039	1	0.4
45040	1	0.4
45056	1	0.4
45206	1	0.4
45212	1	0.4
45459	1	0.4
46013	1	0.4
46142	1	0.4
46143	1	0.4
46236	1	0.4
46280	1	0.4
46391	1	0.4
48118	1	0.4
48120	1	0.4
48154	1	0.4
48375	1	0.4
48462	1	0.4
48611	1	0.4
48843	1	0.4
48854	1	0.4
48872	1	0.4
49071	1	0.4
49251	1	0.4
49341	1	0.4
53022	1	0.4
53705	1	0.4
60041	1	0.4
60411	1	0.4

Table H.1 (continued). If you live in the United States, what is your zip code of residence?		
Zip code (Day users only.)	**Frequency**	**Percent**
60450	1	0.4
60605	1	0.4
60618	1	0.4
61820	1	0.4
62034	1	0.4
62613	1	0.4
62704	1	0.4
63069	1	0.4
63376	1	0.4
68106	1	0.4
77520	1	0.4
80016	1	0.4
98118	1	0.4
98119	1	0.4
98362	1	0.4
99504	1	0.4

APPENDIX I – Complete List of Overnight Use Visitor Survey Respondents' Zip Codes of Residence

Table I.1. If you live in the United States, what is your zip code of residence?		
Zip code (Overnight users only.)	**Frequency**	**Percent**
37206	2	2.6%
37917	2	2.6%
38103	2	2.6%
01501	1	1.3%
01609	1	1.3%
02906	1	1.3%
03077	1	1.3%
03777	1	1.3%
06437	1	1.3%
12052	1	1.3%
14850	1	1.3%
19453	1	1.3%
19465	1	1.3%
20603	1	1.3%
20904	1	1.3%
22201	1	1.3%
22938	1	1.3%
27605	1	1.3%
27705	1	1.3%
27858	1	1.3%
28027	1	1.3%
28092	1	1.3%
28806	1	1.3%
29414	1	1.3%
29801	1	1.3%
30062	1	1.3%
30318	1	1.3%
30601	1	1.3%
30606	1	1.3%
31322	1	1.3%
31602	1	1.3%
32601	1	1.3%
32607	1	1.3%
33543	1	1.3%
34243	1	1.3%
35243	1	1.3%
37343	1	1.3%
37738	1	1.3%
37754	1	1.3%
37803	1	1.3%
37814	1	1.3%
37923	1	1.3%

Table I.1 (continued). If you live in the United States, what is your zip code of residence?		
Zip code (Overnight users only.)	**Frequency**	**Percent**
38111	1	1.3%
39154	1	1.3%
39402	1	1.3%
40204	1	1.3%
40517	1	1.3%
43342	1	1.3%
45014	1	1.3%
45211	1	1.3%
45224	1	1.3%
45387	1	1.3%
46123	1	1.3%
46814	1	1.3%
47933	1	1.3%
48185	1	1.3%
48858	1	1.3%
49085	1	1.3%
53715	1	1.3%
57701	1	1.3%
60091	1	1.3%
63011	1	1.3%
63038	1	1.3%
63130	1	1.3%
76247	1	1.3%
78727	1	1.3%
80424	1	1.3%
80920	1	1.3%
86001	1	1.3%
95060	1	1.3%
95926	1	1.3%
99218	1	1.3%
99835	1	1.3%

VITA

Brett Christopher Kiser

Education

Virginia Polytechnic Institute and State University. Master of Science in Natural Resource Recreation. May 2007.

Thesis title: Assessing the Reliability of Computer Simulation Modeling for Monitoring and Managing Indicators of Wilderness Solitude in Great Smoky Mountains National Park

Advisor: Dr. Steven R. Lawson

Virginia Polytechnic Institute and State University. Bachelor of Science in Geology, Minor in Forestry. Graduated Magna Cum Lade. May 2005.

Advisor: Dr. Madeline Schreiber

Research

Master's Research (2005-2007)

Purpose: To examine the temporal and spatial distribution of day and overnight visitor use within the wilderness area of Great Smoky Mountains National Park using computer simulation modeling. To examine the utility, reliability, and validity of using computer simulation modeling to monitor "hard to measure" indicators of quality of the visitor experience, specifically to low use, wilderness and backcountry areas.

Site: Great Smoky Mountains National Park, TN and NC, USA

Methods: Form a survey instrument and conduct a route and visitor experience survey of visitors to the area. Develop a computer simulation model using RBSim at current use levels and using alternative management plans. Performed quantitative data analyses and output analyses to examine the reliability of using computer simulation modeling in low use areas.

Graduate Research (2006-2007)

Purpose: To use visitor use and noise simulation models to monitor the condition of sound related indicators of quality.

Site: Great Smoky Mountains National Park, TN and NC, USA

Methods: Develop a computer simulation model using RBSim at current use levels. Aided in the installation and calibration of acoustical data collection equipment.

Graduate Research (2005-2006)

Purpose: To conduct trail use monitoring involving foot travel (hikers, walkers), bicycle travel, and horse travel using TRAFx and TrailMaster mechanical counters.

Site: Jefferson National Forest (USFS), VA, USA and Gateway Trail, Town of Blacksburg, Department of Park and Recreation, VA, USA.

Methods: Installed and configured TRAFx and TrailMaster trail counters for multiple uses. Conducted multiple data analyses. Developed and produced an introductory short course on TRAFx installation, configuration, and downloading procedures.

Graduate Research (2005-2006)

Purpose: To conduct a visitor survey of visitors to Prince William Forest Park to examine the visitors' experience and their views on access issues to the park.
Site: Prince William Forest Park (NPS), VA, USA.
Methods: Aided in forming the survey instrument. Set up a survey entry database. Performed quantitative data analyses.

Graduate Research (2005)

Purpose: To conduct a climber survey of visitors to Little Stony Man Cliffs in Shenandoah National Park concerning the climbers' experience. Specific concerns were the climbers' views of alternative management plans with concern to the resource impact caused by visitors walking off trail, climber impact to the cliff area, and the use of climbing equipment.
Site: Shenandoah National Park, VA, USA.
Methods: Administered a number of visitor experience surveys to climbers visiting Little Stony Man Cliffs. Set up a survey entry database.

Graduate Research (2005)

Purpose: To conduct a visitor survey of visitors to Cadillac Mountain in Acadia National Park concerning the visitor's experience. Specific concerns were the visitors' view of alternative management plans with concern to the resource impact caused by visitors walking off trail.
Site: Acadia National Park, ME, USA.
Methods: Administered a number of visitor experience surveys to visitors on top of Cadillac Mountain. Manipulated photos in Photoshop for the survey instrument.

Undergraduate Research (2004-2005)

Purpose: To conduct research examining the relative geologic and hydrologic impact of the quartzite rich layer in the New River Valley. To review literature on the topic and aid in a graduate student's research project.
Site: New River Valley, VA, USA.
Methods: Conducted many field excursions to multiple outcrops. Performed survey work on a number of outcrops in the New River. Performed GIS analysis using the obtained data points.

Teaching Experience

Teaching Assistant (Spring 2007)

Class: Outdoor Recreation Field Studies
Responsibilities: Aided in setting up field trips; managed class website; occasional class administration duties.

Teaching Assistant (Spring 2006)

Class: Outdoor Recreation Management
Responsibilities: Graded quizzes and exams; uploaded and managed grades; helped with design of quizzes, exams, and class handouts.

Teaching Assistant (Fall 2005)

Class: Nature and American Values

Responsibilities: Graded papers and quizzes; participated in group discussion; aided in class presentation.

Related Professional Experience

Interpretive Intern and Contact Ranger

Location: Grayson Highlands State Park, VA

Date: 05/2001 – 08/2001

Responsibilities: Answered phones; ran fee booth; made interpretive fliers; contacted newspapers for advertisements; designed and lead interpretive programs and hikes including the Junior Rangers summer program; managed the visitor center; performed various maintenance duties.

Additional Related Studies/Training

Trail and Recreation Site Monitoring

Date: 2006

Location: Shenandoah National Park, VA; and McAfee Knob, VA

Subject Matter: Trained in trail and recreation site (e.g. campsites, overlooks, climbing sites, etc.) monitoring.

Leave No Trace Trainer Course

Date: 2006

Location: McAfee Knob, Jefferson National Forest, and Appalachian Trail, VA

Trainer: Dr. Jeffry Marion, PhD

Subject Matter: Taught the basics of Leave No Trace skills and ethics and how to effectively teach them to others.

Geologic Field Camp

Name: Judson Mead Geologic Field Camp

Date: Summer 2004

University Affiliation: Indiana University (IU), Bloomington, IN

Location: South Dakota, Wyoming, and Montana

Subject Matter: A field course teaching the essentials of geological field work: mapping structural geology, sedimentary, metamorphic, and igneous rocks.

Geologic Field Mapping

Name: Field Mapping in the Island Environment: Data Collection to GIS

Date: Summer 2003

University Affiliation: University of Southern Maine (USM), Gorham, ME

Location: Coastline of central and southern Maine

Subject Matter: Using GPS and GIS to map the geologic structures along the coast of Maine. Used multiple levels of GPS units to map and used ArcMap to analyze the data. Ended with an abstract and poster presentation at the joint Northeastern and Southeastern Geological Society of America Conference in 2004.

Honors, Awards, and Scholarships

Honors and Awards:

College of Natural Resources Outstanding Masters Student: 2006-2007
Geosciences Outstanding Senior: 2005
Geosciences Outstanding Service Recognition: 2005
Academic Excellence Award: 2003, 2004, 2005
Dean's List: 2001, 2002, 2003, 2004
Eagle Scout (BSA): earned in 2001

Scholarships:

John F. Hosner Scholarship: 2006 – 2007
Wallace D. Lowry Scholarship: 2004
Charles J. Gose, Jr. Scholarship: 2003
Judson Mead Field Camp Scholarship: 2003

Academic Honor Societies

Phi Beta Kappa (ΦΒΚ): 2005 – Present
Sigma Gamma Epsilon (ΣΓΕ): 2003 – Present
National Collegiate Scholars (NCS): 2002 – Present

Professional Memberships and Activities

National Recreation and Park Association (NRPA): 2006 – Present
American Park and Recreation Society (APRS)
Student Branch (SB)
National Association of Interpretation (NAI): 2006 – Present
Society of American Foresters (SAF): 2001 – Present
Geological Society of America (GSA): 2003 – Present
American Institute of Professional Geologists (AIPG): 2003 – Present
National Speleological Association (NSA): 2005 – Present

Publications and Technical Reports

Lawson, S. R., Wood, K., Hockett, K., Bullock, S., Kiser, B.C., & Moldovanyi, A. (2007). *Social Science Research on Recreational Use and Users of Shenandoah National Park's Rock Outcrops and Cliffs: Study Completion Report*. Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Lawson, S. R., Hockett, K., Moldovanyi, A., Kiser, B.C., and Bullock, S. (2006). *Monitoring Visitor Use on the Poverty Creek Trail, Jefferson National Forest, Virginia using TRAFx Trail Traffic Counters*. Final Report, Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Lawson, S. R., Hockett, K., Moldovanyi, A., Kiser, B.C., and Bullock, S. (2006). *Monitoring Visitor Use on the Gateway Trail, Blacksburg, Virginia using TRAFx Trail Traffic Counters*. Final Report, Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Lawson, S. R., Moldovanyi, A., Kiser, B. C., & Bullock, S. (2006). *Prince William Forest Park Visitor and Neighborhood Resident Survey: Study Completion Report*. Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Conference Presentations

Lawson, S. R., Kiser, B. C., Hockett, K., Plotkin, K., Itami, R. B., Fristrup, K, Joyce, D., Trevino, K. (2007). *Understanding and Managing Soundscapes in the National Parks: Standards of Quality*. Paper presented at the George Wright Society Biennial Conference on Parks, Protected Areas, and Cultural Sites: Rethinking Protected Areas in a Changing World, St. Paul, Minnesota.

Kiser, B. C., Lawson, S. R., & Itami, R.B. (2006). *Using computer simulation modeling to monitor the multiple dimensions of wilderness solitude in Great Smoky Mountains National Park*. Paper presented at the 3rd International Conference on Monitoring and Management of Visitor Flows in Recreational and Protected Areas, Rapperswil, Zurich, Switzerland.

Moldovanyi, A., Kiser, B. C., & Lawson, S. R. (2006). *Does survey mode affect study results? A comparison of internet-based and onsite surveys of visitors to Prince William Forest Park, USA.* Paper presented at the 3rd International Conference on Monitoring and Management of Visitor Flows in Recreational and Protected Areas, Rapperswil, Zurich, Switzerland.

Kiser, B. C., & Lawson, S. R. (2006). *Examining the utility of computer simulation for monitoring multiple dimensions of wilderness solitude in Great Smoky Mountains National Park* Paper presented at the 28th Annual Southeastern Recreation Research Conference, Wilmington, NC.

Moldovanyi, A., Kiser, B. C., & Lawson, S. R. (2006). *Comparing internet and onsite survey modes for a visitor use study at Prince William Forest Park, Virginia.* Paper presented at the 28th Annual Southeastern Recreation Research Conference, Wilmington, NC.

Doyle, J., Kiser, B. C., Newton, M., Swanson, M. T., and Bampton, M. (2004). *Syntectonic Granites and Transpressional Deformation at Pemaquid Point, Mid-Coast Maine*. Paper presented at the Geological Society of America Northeastern Section (39th Annual) and Southeastern Section (53rd Annual) Joint Meeting, Washington, D.C.