CHAPTER 1
INTRODUCTION

Shenandoah National Park (SNP) encompasses 70 miles of ridge crest along the Blue Ridge Mountains of Virginia. Rock outcrops and cliffs punctuate the otherwise forested landscape, composing approximately 2% (3920 acres) of the park's 196,000+ acres. Previous Virginia Department of Conservation and Recreation (VADCR) survey work at a few of the park's larger rock outcrops documented the occurrence of 28 rare species, including the federally endangered Shenandoah Salamander (*Plethodon Shenandoah*; Ludwig et al., 1993). Furthermore, previous research identified a rare plant community type, the High Elevation Greenstone Outcrop Barren, believed to be endemic to the park (Hilke, 2002).

The location of the world-famous park tour road, Skyline Drive, along the ridgeline makes many outcrops and cliffs within the park readily accessible to the park's 1.2 million annual visitors. Rock outcrops provide vistas for day hikers and backpackers along the park's 500 miles of trails, including the Appalachian National Scenic Trail, which parallels Skyline Drive for the length of the park. Additionally, in the last several years, some cliff areas in the park have become increasingly popular for rock climbing. Consequently, visitor use of cliff areas within the park has led to natural resource impacts such as vegetation damage and loss, soil exposure, compaction and erosion, informal trail development, and illegal or poorly located campsites (Hilke, 2002).

Despite the clear ecological value and potential threats to the natural resources at SNP cliff areas, managers possess little information on visitor use of cliff sites and presently have no formal planning document to guide visitor management of the park's cliff resources. Presently, only a limited amount of literature exists that examines recreation-related cliff site impacts. What is more, few studies have examined the relative effect of alternative types of recreational use (e.g., rock climbing, hiking, backpacking, etc.) on cliff resources (Parikesit et al., 1995). Rather, it is often inferred, without empirical evidence that cliff impacts are caused primarily by rock climbers (Kelly & Larson, 1997; Camp & Knight, 1998; McMillan & Larson, 2002). Thus, the National Park Service initiated a study of cliff sites designed to help formulate a Cliff Resource Management Plan.

The study presented in this thesis is part of the larger study of cliff sites and recreational use in Shenandoah National Park. This study uses an approach that integrates social science and ecological data to help assess the effects of all recreational use on the vegetation and soils at one of the most heavily visited cliff sites in the park, Little Stony Man Cliffs (LSMC). In particular, this study integrates data from measurements of resource conditions on cliff-associated trails, recreation sites, and campsites with information collected through direct observations of the amount and type of recreational use, and the behaviors of visitors that might contribute to resource impacts at LSMC. The information from this study will assist the park in managing visitor use and developing a plan that protects the park's cliff resources while providing sustainable opportunities for visitor enjoyment.

Study Objectives

The following are the specific objectives of this study;

- To examine and document visitor-caused resource impacts at Little Stony Man Cliffs in Shenandoah National Park, including those that potentially impact rare plant species.
- To document the amount and type of visitor use on the cliff-top of Little Stony Man Cliffs, and the behaviors of visitors that might contribute to cliff-top impacts.
- To integrate resource impact measurements and visitor observation data to identify relationships between visitor use and resource impacts that could assist the park in reducing or eliminating resource impacts at Little Stony Man Cliffs.

The first objective of this study was addressed by adapting standardized campsite and trail monitoring procedures developed by Marion (1991) to measure resource impacts at recreation sites and along trails at Little Stony Man Cliffs. Cliff site resource impacts literature reviewed in Chapter Two of this thesis was instrumental in informing the design of the measurement procedures used in this study. The first objective of this thesis is intended to provide a contribution to the science and management of rock climbing by introducing a new set of procedures to measure visitor-caused resource impacts at cliff sites.

The second objective of this study was addressed by conducting direct unobtrusive visitor observations at Little Stony Man Cliffs during the 2005 visitor use season. This component of the study is designed to contribute to applied and academic knowledge of rock climbing and cliff resource impacts by developing procedures for documenting recreational use of cliff resources and potentially high impact behaviors of visitors at cliff sites.

The third objective of this thesis was addressed by integrating the results of the resource impact measurements with visitor use observations to help identify probable causes of visitor-created resource impacts at Little Stony Man Cliffs. In addition, social science literature on rock climber characteristics, preferences, and management attitudes reviewed in Chapter Two were used to help interpret the results of the research at Little Stony Man Cliffs and identify potential relationships between resource impact measurements and visitor observation data. Thus, the third objective of this thesis is intended to contribute to existing scientific and management knowledge concerning rock climbing by introducing an integrative approach to study visitor-caused cliff site impacts that includes assessing the effects of rock climbing as well as other types of recreational activities that take place at cliff sites.

The remainder of this thesis is organized as follows. Chapter Two provides a review of the peer reviewed published literature concerning studies of visitor-caused cliff resource impacts and social science studies of rock climbing use and users. The resource impact measurement and visitor observation methods used to conduct this thesis research are described in detail in Chapter Three of the thesis. Chapter Four of the thesis consists of a draft journal manuscript describing the study of visitor-caused resource impacts and recreation use at Little Stony Man Cliffs. The draft manuscript will be submitted for review for publication in the *Journal of Park and Recreation Administration* soon after completion of this thesis.

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CHAPTER 2
LITERATURE REVIEW

Introduction

In recent years the sport of rock climbing has grown from obscurity to one of the most popular outdoor sports in the United States with some estimated 500,000 active climbers (Siderelis & Attarian, 2004). While rock climbing was once considered a “fringe” sport, today’s high levels of participation have prompted protected natural area and outdoor recreation management agencies such as the National Park Service to consider rock climbing’s effects on natural resources and visitors’ experiences, and to consequently move towards more regulatory approaches to rock climbing management (Merrill & Graefe, 1997). Therefore, as the popularity of rock climbing has grown, so have management agencies’ information needs, including information about the types and aerial extent of ecological effects caused by rock climbing activities, rock climbers’ use and personal characteristics, and their attitudes and preferences toward various rock climbing and cliff resource management actions (Merrill & Graefe, 1997).

The following sections of this chapter provide a review of peer-reviewed, published studies of rock climbing use, users, and impacts. In particular, the first section reviews studies of ecological impacts of rock climbing, while the second section reviews studies of rock climbers’ personal and use characteristics, perceptions of environmental and social impacts of rock climbing, and attitudes and preferences concerning rock climbing and cliff resource management. It should be noted that despite dramatic growth in rock climbing participation, there have been relatively few studies of rock climbing use, users, and impacts and even fewer studies of rock climbing that have been published in academic journals (McMillan & Larson, 2002). Additionally, variation in results across existing rock climbing studies suggests the development of theory and methodology regarding rock climbing research is far from complete. As a consequence, many conclusions drawn from the studies presented in this review should be treated as providing initial insights, and may reveal more questions than “answers”. Nonetheless, the studies reviewed below provide an initial understanding of resource impacts associated with rock climbing and rock climber perceptions, attitudes, and preferences, therefore supporting the objectives of this thesis.

Cliff Resource Impacts

Cliffs often support distinctly different plant communities than surrounding environments, largely due to the limited moisture availability, high winds, and limited supply of nutrients characteristic of cliff environments. These unique environmental attributes provide habitat for a relatively narrow range of species adapted to extreme environments (Farris, 1998; Krajick, 1999; Nuzzo, 1996). While adapted to harsh cliff environments, cliff plant species' resistance to other forms of disturbance (e.g., trampling) may be limited (Farris, 1998). Until recently, the inaccessibility and potential danger of most cliffs has provided a protective barrier between plant communities and potentially damaging human activities (Camp & Knight, 1998; Kelly & Larson, 1997; Krajick, 1999). However, the growing popularity of rock climbing means that more people are accessing and using cliff sites, which may negatively affect cliff site plant communities (Camp & Knight, 1998; Farris, 1998, Krajick, 1999; McMillan et al., 2003).

The Access Fund (2001) describes six zones that have the potential to be impacted by rock climbing activities: the approach (access trail), staging area (cliff-bottom), climb (cliff-face), summit (cliff-top), descent (descent trail or rappel route), and campsite. Soil compaction and erosion, vegetation damage, tree damage, harassment of wildlife, and visual impacts associated with the presence of chalk and fixed climbing anchors have been cited as impacts of rock climbing activities (Baker, 1999; Monz et al., in press; Siderelis & Attarian, 2004). However, despite an expansive list of documented rock climbing-related impacts, research has largely focused on characterizing and studying vegetation impacts. Furthermore, existing cliff vegetation research has generally focused on studying rock climbing-related impacts in the cliff-top, cliff-bottom, and cliff-face zones.

Several studies have documented negative effects of rock climbing on cliff-top and cliff-bottom vegetation (Camp & Knight, 1998; Kelly & Larson, 1997; McMillan & Larson, 2002; Parikesit et al., 1995). In addition, several studies have documented negative effects of rock climbing on cliff-face vegetation (Camp & Knight, 1998; Kelly & Larson, 1997; McMillan & Larson, 1999; Nuzzo, 1995). However, results of other studies suggest that there is not a statistically significant relationship between rock climbing and cliff vegetation impacts, thus a conclusive relationship between rock climbing activities and cliff site impacts has not been achieved (McMillan & Larson, 2002). Nevertheless, a review of current studies and factors contributing to varied results is warranted in light of the objectives of this thesis and therefore is presented here in chronological order.

Nuzzo (1995) examined the effects of rock climbing on cliff goldenrod (*Solidago sciaphila* Steele) growing on cliff-faces at a rock climbing site in northwest Illinois. Belt transects were established on climbed and unclimbed sections of three cliffs. Initial results at all three study sites suggest that position on the cliff-face is the most significant factor in affecting growth of cliff goldenrod, with 70% of all plants located in the upper three meters of each cliff (Nuzzo, 1995). Furthermore, within the upper three meters, rock climbing use was found to have a statistically significant impact on cliff goldenrod, as the density of cliff goldenrod was 75% lower on climbed cliffs than on unclimbed cliffs. The lower portion (i.e., greater than three meters below the cliff-top) of all cliffs was found to have consistently lower cliff goldenrod density than the upper portion of cliffs, and plant density did not vary between climbed and unclimbed cliffs.

The effects of environmental gradient (position) and trampling on vegetation structure were studied by Parikesit et al. (1995) on cliff-edge trails located on the Niagara Escarpment, Ontario, Canada. Trails included in the study varied in visitor use intensity and were categorized as "active," "abandoned," or "no trail". Furthermore, study sites were ranked according to use levels (low to high) by park wardens for trails categorized as "active". To examine trampling effects on vegetation structure, transects consisting of five quadrats (Q1-Q5) located adjacent to the trail on the cliff-edge side (Q1-Q2), adjacent to the trail on the non cliff-edge side (Q4-Q5), and on the center of the trail (Q3) were used. The number of transects used on each trail varied according to trail length. Plant species richness was significantly lower at more intensively used sites than lower use sites. Lower frequencies of phanerogams (seed producing plants) were found on quadrats positioned on the center of heavily used trails compared to those positioned on both sides of the trail, while cryptogams (mosses, lichens, etc.) were not found to differ according to quadrat position. Abandoned trails, in contrast, were found to exhibit higher frequencies of both phanerogams and cryptogams on the center of trails than on quadrats positioned on either side of the trail. The study also found that soil characteristics affected by trampling (i.e., soil depth, litter cover) had the most significant influence on vegetation structure. Thus, trampling impacts on soils may be the most influential factor in determining cliff-edge vegetation conditions in the study area, regardless of quadrat position or level of use.

As a follow-up to an earlier study of cliff goldenrod, Nuzzo (1996) examined rock climbing effects on vascular vegetation (e.g., ferns, shrubs, etc.) and lichen on climbed and unclimbed cliff-faces at a climbing area in northwest Illinois. Similar to findings concerning the density of cliff goldenrod at the study site (Nuzzo, 1995), 70% of all vegetation was found to grow within three meters of the cliff-top. Lichen density and cover was found to be significantly lower on climbed cliff-faces, although no differences were found in vascular vegetation cover between climbed and unclimbed cliff-faces. While the study did not find a significant relationship between vascular vegetation cover and rock climbing use, vascular vegetation cover was found to vary significantly according to the amount of fracturing in the rock and position on the cliff-face.

Kelly and Larson (1997) examined the effects of rock climbing on tree density and age structure among populations of eastern white cedar (*Thuja occidentalis*) located on the cliff-face and cliff-top on the Niagara Escarpment in Ontario, Canada. In addition, trees were examined for damage caused by rock climbers, such as sawn off branches or rope abrasion. On each of four climbed and three unclimbed cliffs, five transects were extended from the base of the cliff, up the cliff-face, to three meters beyond the top cliff-edge. Damage to trees was classified into three categories reflecting the severity of apparent human-caused impact. Age structure of trees was found to vary among climbed and unclimbed cliff-faces, with the oldest trees found on unclimbed faces. In addition, the mean number of trees in each of five twenty-five year age classes was found to be significantly lower on climbed cliff-edges than unclimbed cliff-edges. Further, tree density was found to be significantly lower on climbed cliff-faces, although no differences were found with regard to tree density on the cliff-top. The presence of rock climbing was also found to coincide with higher rates of moderate to severe tree damage on both the cliff-face and cliff-top.

Eighteen cliff sites in Joshua Tree National Park, differing in level of climbing use (classified as intensive, moderate, and no rock climbing use), were examined by Camp and Knight (1998) for effects of rock climbing on plant communities located at the cliff-base and on the cliff-face. Rock climbing intensity was determined using a combination of onsite assessments (i.e., looking for evidence of rock climbing use such as bolts, slings, chalk) and information from a rock climbing guidebook for the study area. Vegetative cover and species of each plant was recorded in transects established in 10 meter intervals along the base of each cliff site. Sampling of vegetation on the cliff-face was limited to randomly selecting cracks ascending the face vertically, as preliminary analysis found little to no evidence of vegetation on unfractured rock. Results of the study suggest a negative vegetation response to increased climbing intensities on both the cliff-base and cliff-face. The number of plant species per meter, for example, was found to be lower for more intensively used rock climbing sites. Vegetative cover was not found to differ significantly among sites with different intensities of rock climbing use however, although evidence of trampling (i.e., matted or crushed vegetation) was greater at higher use sites. Vegetation cover on the cliff-face was found to be significantly lower on more intensively used rock climbing sites. Thus, the results of this study suggest that there is a relationship between rock climbing use intensity and effects to cliff site vegetation.

A study by Farris (1998) examined the effects of rock climbing on cliff-face vegetative cover on cliff systems at three different rock climbing sites in Minnesota. Building on conclusions of previous research that cited physical characteristics of cliff-faces such as occurrence of fractures as affecting cliff vegetation (Nuzzo, 1996), this study examined three separate cliff systems varying in terms of geological, physical (e.g., slope, number of ledges and overhangs, etc.), and vegetation characteristics (Farris, 1998). Using a modified point-frame analysis (Bonham, 1989), vegetative cover was estimated for plots on climbed and unclimbed sections of cliff a minimum of one meter below the cliff-edge and two meters above the cliff-base to limit the likelihood of observing human-caused impacts created by non-climbers. In addition to vegetation cover, microtopological features (i.e., crack, face, ledge, overhang), slope, and aspect of each plot was documented. Study results found vegetative cover to be significantly different among all three cliff sites, however, vegetative cover was found to be significantly lower on climbed sections than unclimbed sections on only two of the cliffs. In addition, a significant relationship was found between vegetative cover and microtopological features, slope, and aspect. The authors of the study hypothesized that the intervening effects of microtopology, slope, and aspect might help explain the lack of a consistent relationship between rock climbing use and vegetation conditions. Thus, the results of this study suggest that it is critical to take into account physical and topographic features of cliffs in studies of the effects of rock climbing use on cliff-face vegetation, and that these factors may be as important as or more important than rock climbing use alone in explaining the condition of cliff-face vegetation.

Perhaps the most comprehensive study of rock climbing effects on cliff site vegetation involved a survey of the cliff-top, cliff-base, and cliff-face of climbed and unclimbed cliffs on the Niagara Escarpment, Ontario, Canada (McMillan & Larson, 2002). In addition to taking a comprehensive approach by studying the cliff-top, cliff-base, and cliff-face zones, the study also examined the effects of all types of recreational use, including rock climbing, on the cliff-top and cliff-base, rather than assuming those impacts could be attributed solely to rock climbers. Statistically significant reduction in vascular plant density on the cliff-top, cliff-base, and cliff-face of climbed transects was found, while vascular plant cover was only significantly lower on the cliff-top and the cliff-base of climbed sites. Bryophyte cover was found to be statistically significantly lower in climbed transects than unclimbed transects in all three cliff zones (McMillan & Larson, 2002). Lichen cover was found to be similar among climbed and unclimbed cliffs, while species richness was significantly lower on climbed cliffs for all three zones. The study did not draw any definitive conclusions about the relative effect of different types of recreational use on the vegetation impact parameters examined. However, the authors suggested that hikers might be contributing to some cliff-top impacts in the study area, but attributed most of the impacts observed to rock climbing use.

To date, only one published study of cliff site fauna has been conducted (McMillan et al., 2003). The study examined the effects of rock climbing on land snails inhabiting the Niagara Escarpment in Ontario, Canada. Snail density, species richness, and species diversity were surveyed using transects located in all three cliff zones (i.e., cliff-base, cliff-face, and cliff-top) of climbed and unclimbed cliffs. The study found snail density and species richness to be significantly lower in all three zones of climbed cliffs compared to unclimbed cliffs for 14 out of 40 species of snails identified. Furthermore, snail species diversity was found to be lower in climbed cliff sites surveyed than in unclimbed sites. Removal and/or compaction of soils caused by rock climbing use were cited as primary factors affecting snail density, species, richness, and species diversity.

Consistent with the findings of Nuzzo (1996) and Farris (1998), a recent study of rock climbing effects on cliff-face vegetation found that microtoplogical features of cliffs are important determinants of cliff-face vegetation conditions (Kuntz and Larson, in press-a, in press-b). Within their study, Kuntz and Larson (in press-a, in press-b) suggest that previous studies of rock climbing effects on cliff-face vegetation have either ignored or have not properly controlled for microsite characteristics, and as a consequence, the results of these studies concerning the relationship between rock climbing use and vegetation impacts may not be valid. To address these concerns, Kuntz and Larson (in press-a, in press-b) conducted a study to measure vascular plant species conditions at rock climbing sites in the Niagara Escarpment, Ontario, Canada. Using eight vertical transects on each of three cliff sites (for a total of 24 transects), species richness, percent frequency, and community composition was examined for vascular vegetation, bryophytes, and lichens. Results of the study suggest that vascular plant density, species richness, frequency, and community composition are significantly and positively related to complexity of cliff microtopology (e.g., higher frequency of cracks, ledges, overhangs, etc.). Furthermore, analysis of vegetation data showed no difference in species richness or abundance for vascular plants, bryophytes, or lichens between climbed and unclimbed cliffs when microtopograhic factors were controlled.

Rock Climber Use and User Characteristics, Perceptions, and Management Attitudes

To the best of the author's knowledge, this thesis represents the first study to use unobtrusive observation methods to study the relationship between recreation activities, including rock climbing, and cliff resource impacts. However, a number of social science studies have been conducted to characterize rock climber use and personal characteristics, perceptions of social and resource impacts, and attitudes towards management. The findings from these studies provide insights about rock climbing use, users, and management issues that were helpful in designing the study presented in this thesis.

Within the social science literature on rock climbing, some studies have segmented rock climbers into subgroups according to type of climber (i.e., sport, traditional, top-rope, etc.). To better understand how different types of climbers' use characteristics, perceptions, attitudes, and preferences differ, several studies have used rock climber subgroups as the independent variable. Studies that have segmented rock climbers by type have typically focused on two types of climbers - sport climbers and traditional climbers. Sport climbers are commonly characterized as those rock climbers who only climb routes that use pre-placed protection (Schuster et al., 2001). Sport climbing has also been described as being focused on gymnastic ability or pushing one's physical limits on short, often overhanging cliffs rather than focusing on the setting of the climb (Waldrup & McEwen, 1994). Traditional climbers have been described as those climbers that do not rely on pre-placed protection (i.e., bolts, fixed anchors) and are more likely seek wilderness-like social and resource settings (Schuster et al., 2001; Waldrup & McEwen, 1994). Studies of rock climbing have identified a third type of climber, referred to as "hybrid" or "modern" rock climbers (Schuster et al., 2001; Waldrup & McEwen, 1994). Hybrid climbers have been described as those who participate in both traditional and sport climbing (Schuster et al., 2001; Waldrup & McEwen, 1994). Studies involving hybrid rock climbers have found that their attitudes and preferences tend to fall between those of sport and traditional climbers (Schuster et al., 2001; Waldrup & McEwen, 1994).

As previously mentioned, only a limited number of studies exist in published literature. In addition, several studies presented in this review represent initial inquiry and often examine several aspects of rock climbing consequently making organization according to any specific theme complex. Therefore, the following review of social science studies of rock climbing is arranged in chronological order.

Hollenhorst (1988) used recreation specialization theory to examine variation in personal and use characteristics and setting preferences among rock climbers at climbing sites in Minnesota and Ohio. A combination of visitor surveys and direct observation was used to examine climbers' frequency of participation (i.e., number of climbing days per year), level of rock climbing experience (i.e., number of years rock climbing), social and ecological setting preferences, use of technical climbing equipment, social group context (i.e., participation with family/friends versus participation with other climbers), and participation in other "risk recreation" activities. Level of expertise, measured by difficulty of climbing route completed by the respondent prior to survey administration, was used as a proxy for level of rock climbing specialization. Statistical analyses were performed to examine correlations between level of specialization and setting preferences, use of technical equipment, social group context, and participation in other "risk recreation" activities. The study found a significant positive relationship between level of specialization and frequency of participation, years of experience, and preference for rock climbing sites with low use densities. The study also found that more specialized climbers were more likely to participate in rock climbing with other climbers of comparable climbing ability level, than with family and/or friends. Level of specialization, however, was not found to be related to preference for "naturalness" as a characteristic of the climbing setting, age, or use of "technical equipment." Study findings suggest recreation specialization may be a useful concept for classifying rock climbers and that personal and use characteristics as well as setting preferences vary among climbers of differing levels of specialization.

A study by Waldrup and McEwen (1994) examined rock climber attitudes toward wilderness, ecological and social impacts, and regulations, and differences in these attitudes among rock climber subgroups (i.e., sport climbers, traditional climbers, and modern/hybrid climbers). A survey was distributed to 356 rock climbers at three separate sites within Red Rocks Conservation Area (RRCA), Nevada-each site differing in the type of climbing (i.e., sport, traditional, modern/hybrid climbing) and proximity to parking. Findings from the study suggest that rock climbers' personal characteristics and attitudes toward wilderness, impacts, and management of rock climbers are related to the type of rock climbing they participate in. For example, traditional climbers were more likely than sport climbers to rate wilderness-like motivations for selecting a rock climbing site important, including enjoying solitude, quiet, and scenery. Sport climbers, in comparison, consistently rated non-wilderness motivations for selecting a rock climbing site, such as "short distance from car", as more important than traditional climbers. Traditional and sport climbers were also found to differ in terms of attitudes toward the presence of bolts, with 22% of traditional climbers rating them as "moderately offensive", whereas approximately two-thirds of sport climbers rated bolts as not offensive at all. Despite finding some variation in attitudes and preferences among climber subgroups, the study found that all climbers, regardless of type, share similar attitudes toward several issues. The presence of chalk, for example, was rated by over 90% of all climbers surveyed as not offensive. Similarly, approximately 90% of climbers rated crowding at rock climbing sites as offensive. Management of rock climbing was also widely supported (84%) among all climber subgroups if climbing site conditions deteriorate. Results of this study suggest that there is a significant relationship between type of rock climber (i.e., sport, traditional, modern/hybrid) and climbers' personal characteristics and management attitudes.

Ewert and Hollenhorst (1994) examined relationships between rock climbers' personal characteristics and preferences for setting attributes at four popular climbing areas in the United States (New River Gorge, Seneca Rocks, Talquitz/Suicide Rocks, and Falls of the Potomac). Based on recreation specialization theory, Ewert and Hollenhorst (1994) hypothesized a positive relationship would exist between personal characteristics of climbers (i.e., level of experience, skill level, and level of involvement in the sport of rock climbing) and climbers' setting preferences (characterized, for example, by naturalness, social orientation, and level of risk). For example, increasing levels of experience and skill were hypothesized to coincide with stronger preferences for naturalness as a characteristic of the rock climbing setting. Results of analyses using canonical correlation suggest 20 significant relationships within and between individual climber and setting attributes. For example, individual climbers' skill level was found to have a positive significant relationship to level of involvement. Further, as rock climbers' skill level increases results suggest that they seek participation with smaller groups of peers rather than large groups such as those organized by outfitters. In addition, as hypothesized, climbers' skill level was found to have a positive significant relationship with preference for naturalness as a characteristic of the rock climbing setting. However, contrary to the author's hypothesis, study results suggest level of involvement in rock climbing is inversely related to climbers' preference for naturalness as a characteristic of the climbing setting. That is, the results suggest that as climbers become increasingly involved in the sport of rock climbing, the importance they place on climbing in a setting characterized by naturalness decreases. Results of the study led the authors to suggest climbers' selection of climbing sites may be more strongly linked to specific climbing route attributes than to general setting attributes, providing further support for Hollenhorst's (1988) speculations about this issue.

Building on the work of Hollenhorst (1988) and Ewert and Hollenhorst (1994), Merrill and Graefe (1997) examined rock climbing route and physical setting attribute preferences among high and low specialist rock climbers through visitor survey data collected at Seneca Rocks Recreation Area. Level of specialization was measured on a seven-item scale including skill level, prior experience, and commitment (Merrill & Graefe, 1997). Respondents rated the importance of 10 general setting attributes, including "no evidence of man" and "condition of access trails", and 15 rock climbing route attributes, including "difficulty level of the climb" and "scenery viewed from the climb." Results of Pearson correlations suggest that there is a significant relationship between level of specialization and climbers' preferences for physical setting and climbing route attributes. A significant negative relationship was found between level of specialization and the importance of three physical setting attributes - "condition of access trails", "availability of potable water", "short length of approach" - and between level of specialization and one route attribute - "presence of permanent top rope anchors". A significant positive relationship was found between level of specialization and the importance of two rock climbing route attributes - “scenery viewed from climb” and “quality of route” (based on guidebook quality rating). Additionally, results of paired t-tests suggest that the importance of route characteristics is greater than the importance of setting characteristics, for both high and low specialists. This finding, that climbing route characteristics are generally more important to rock climbers than general setting characteristics, is consistent with findings from Hollenhorst (1988) and Ewert and Hollenhorst (1994).

In an effort to identify site-specific needs and issues related to the development of a climbing management plan, Freeman et al. (1997) examined personal characteristics, perceptions, and management preferences of rock climbers at Mount Rushmore National Memorial. Data collected from a total of 295 questionnaires completed by rock climbing visitors were analyzed to examine general, descriptive characteristics of climbers. In addition, data were used to segment respondents by level of rock climbing specialization based on reported level of rock climbing experience and involvement in the sport. Respondents were further segmented into local vs. non-local subgroups. Study results suggest that locals rock climb in the park more frequently than non-locals, and locals are more likely take day trips to the park, while non-locals are more likely to stay overnight in the park. Local and non-local subgroups also differed in terms of their perceptions of rock climbing-related problems. For example, non-locals were more sensitive to crowding than local visitors, while local visitors were more sensitive to the presence of unskilled/unprepared climbers than non-local climbers. In addition, analyses using level of specialization as the independent variable found high and low specialists differed in terms of perceived problems and management preferences. A majority of rock climbers, regardless of place of residence and level of specialization, were found to support management actions including providing more information on minimum impact practices and climbing safety issues. Conversely, a majority of all climbers’ opposed bolting regulations, including restricting installation of new bolts and/or replacement of defective or worn bolts.

Attitudes of rock climbers toward management of climbing and the use of bolts were examined in a study by Schuster et al. (2001). Furthermore, this study sought to examine variation in rock climbing management attitudes between sport climbers and traditional climbers. Questionnaires were distributed at 13 climbing sites located across the United States. Survey respondents were stratified according to type of rock climber (sport, traditional, or hybrid) and were asked to report the extent to which they agreed with 27 statements related to bolts and/or rock climbing management on a five-point Likert-type scale (1=strongly disagree to 5=strongly agree). Results of the study suggest that climbers' attitudes toward rock climbing management in general and the use of bolts in particular, vary depending on type of climber. Traditional climbers, for example, were found to be the least supportive of the use of bolts and were more likely favor management directed toward the use of bolts. In comparison, sport climbers were found to be more supportive of the use of bolts and tended to favor less regulation of the use of bolts. Hybrid climbers' attitudes tended to be between those of sport and traditional climbers. Similar to Waldrup and McEwen (1994), results of the study did suggest that there are some issues on which the different subgroups of climbers share similar attitudes. In particular, although climbers were shown to vary in their attitudes toward management of bolts, the authors conclude there may be common agreement that bolts are necessary in some cases by pointing out that all climber types generally disagree with the statement "bolts should not be used at all" (Schuster et al., 2001). Results also suggest climbers generally believe rock climbing is "micro-managed" and as a result is often treated unfairly in comparison to other outdoor recreation activities. Climbers were also found to believe the management process "is a mystery" (Schuster et al, 2001). The findings from the study suggest that variation in attitudes toward bolts and management among climber subgroups exists. Therefore, efforts to manage rock climbing should take into account the effects of alternative decisions on different subgroups of climbers. However, as results of this study also suggest, climbers have reservations about the management process and actions to more actively include them may be of use (Schuster et al. (2001).

Jones (2004) examined visual preferences among rock climbers and non-climbers in Utah's Rock Canyon Park concerning impacts caused by fixed anchors and climbing chalk on cliffs. Using a series of near-view photos of cliffs containing a mix of fixed anchor/chalk scenarios (i.e. all impacts, anchor removed/chalk present, chalk removed/anchor present, all impacts removed), 143 respondents rated photos on a five-point scale according to visual preference. Results of paired t-tests suggest preferences for photos with impacts were not significantly different than photos without, and rock climbers and non-climbers did not differ in their visual preferences. The results of this study suggest decisions to regulate the use of fixed anchors or climbing chalk on the basis of visual impacts to visitors alone may be unfounded (Jones, 2004).

A recent study of climbers in Adirondack State Park in New York was conducted to examine their perceptions concerning social and resource impacts of rock climbing, as well as their attitudes toward management (Monz et al., in press). The authors of the study note that the majority of rock climbing research prior to this study has focused on evaluating climbers' attitudes towards impacts occurring on the rock face, particularly the presence of fixed anchors. Further, the authors note that cliff-face impacts such as the presence of fixed anchors may not represent the greatest threat to resources posed by rock climbing, and consequently may be over emphasized in literature (Baker, 1999; Waldrup & McEwen, 1994). Therefore, the study of climbers in Adirondack State Park was designed to study climbers' attitudes and perceptions concerning impacts to the cliff-top and cliff-base, in addition to the cliff-face (Monz et al., in press). An on-site visitor survey was distributed to 66 rock climbers during the fall, 2004 climbing season. Respondents were asked to indicate the extent to which they consider a variety of rock-climbing related impacts to be offensive. Respondents were instructed to answer the questions based on their attitudes concerning the impacts in general, rather than with respect to what they saw while climbing in the park on the day they were contacted. Approximately 75% of climbers surveyed reported damaged trees, trampled vegetation, and cliff-top impact as somewhat to extremely offensive. Furthermore, the majority of climbers reported erosion, multiple trails, and bare soil as offensive. Crowding was also reported by a majority of climbers as affecting their climbing experience. Additionally, a majority of climbers did not support more rock climbing management including the regulation of fixed anchors. Fifty-three percent of climbers reported in an open-ended question the presence of litter to be offensive. By focusing on a broader set of rock climbing-related impacts than most previous research, the findings from this study assist in providing a more comprehensive understanding of rock climbers' perceptions of climbing-related impacts and associated management attitudes.

Conclusion

The body of literature reviewed in the preceding sections of this chapter supports the objectives of this thesis. Findings from studies of rock climbing-related resource impacts helped inform the selection of impact parameters and methods to measure resource impacts at Little Stony Man Cliffs. Furthermore, findings from social science studies of rock climbing reviewed in the preceding section of this chapter provided a basic understanding of rock climbers' perceptions of impacts and attitudes toward rock climbing management actions that was helpful in developing management implications based on the results of the research conducted at Little Stony Man Cliffs and presented in this thesis.

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CHAPTER 3
METHODS

Introduction

The study in this thesis employed two separate sets of study methods to examine relationships between resource impacts and amount and types of visitor use at LSMC. A set of procedures adapted from campsite and trail monitoring studies was used to characterize the amount and extent of resource impact at LSMC. Visitor use observation methods were used to document and characterize the type and amount of recreational use and the behaviors of recreationists that may contribute to cliff-top resource impacts at LSMC.

Resource Impact Measurement

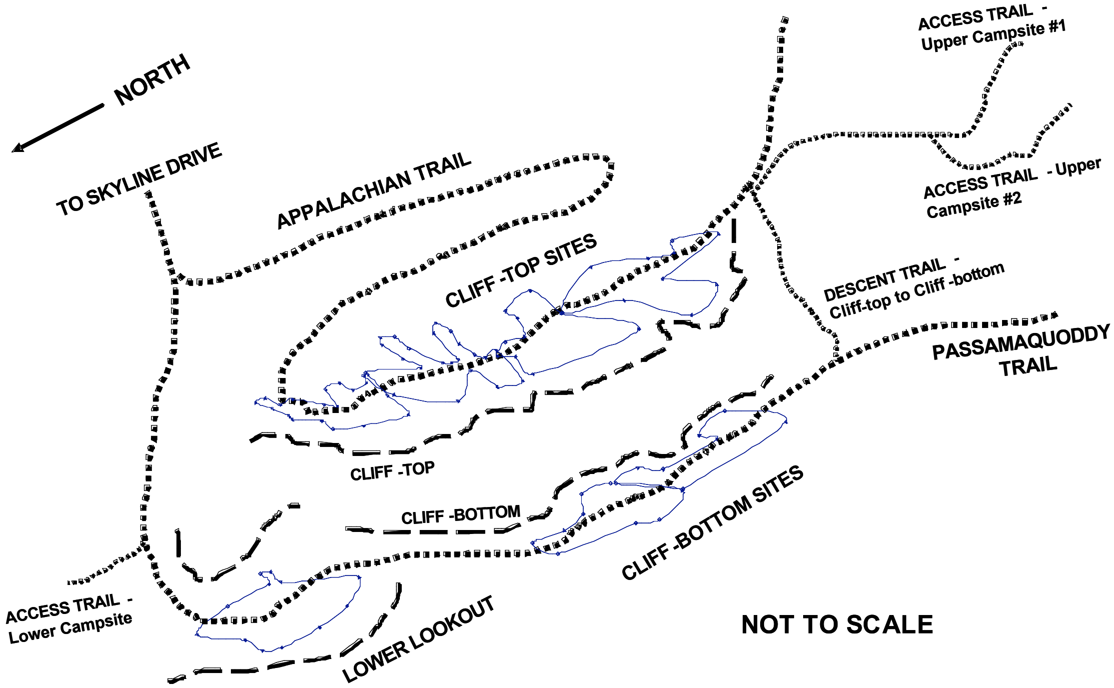
Procedures from campsite and trail impact studies were adapted to measure and characterize the extent of resource impacts associated with all types of recreational uses at LSMC. Recreation site assessments were performed on the cliff-top, cliff-bottom, lower lookout, and the three campsites located within close proximity to LSMC (Figure 3.1). Trail assessments were also conducted on visitor-created/informal trails at LSMC.

Recreation Site Assessment

Recreation sites at LSMC were defined as areas of disturbed vegetation, surface litter, or soils caused by human use. Each cliff site (i.e. cliff-top, cliff-bottom, lower lookout, campsites) was assessed using a set of standardized procedures that included elements of both multi-indicator and condition class assessment systems (described below; Cole, 1989; Leung & Marion, 2000; Marion, 1991). Furthermore, these procedures included both inventory and impact indicators; inventory indicators identified geographic and visitor use characteristics that may influence the type and degree of impact and impact indicators document the present condition of each site.

Identification of site boundaries was determined by pronounced changes in vegetation cover, height/disturbance, or composition. In addition, sites with dense forest overstories have very little vegetation so determination of boundaries was made by examining changes in organic litter (i.e. leaves which are untrampled and intact versus leaves which are pulverized or absent). Each assessment was then conducted within these sites defined by their boundaries.

Figure 3.1. Little Stony Man Cliffs-recreational sites and trails.



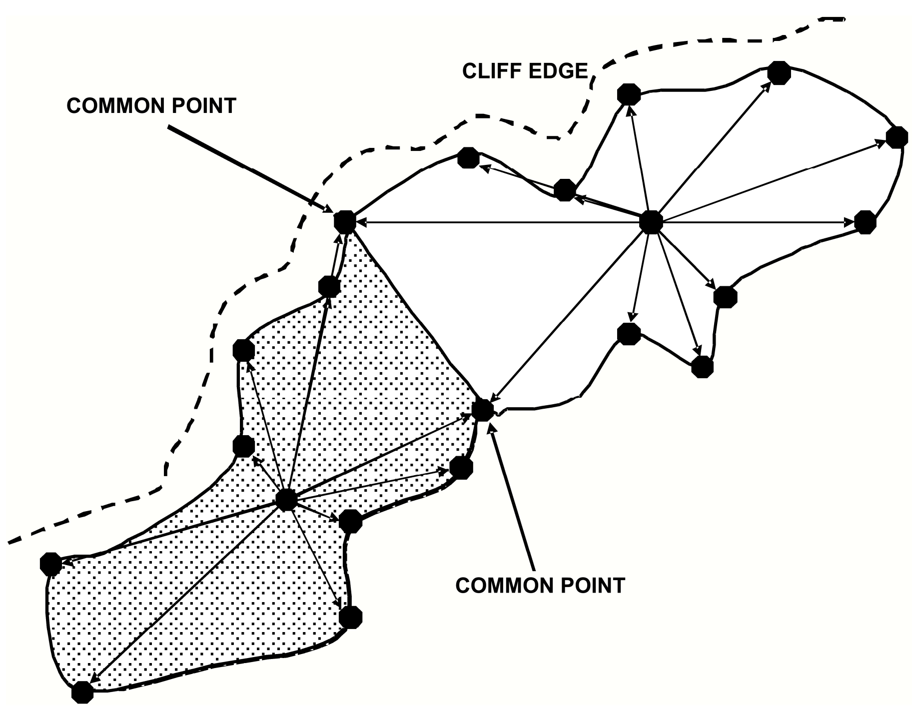
Recreation site assessments were documented on the Cliff Site Visitor Impact Form (Appendix A). Each site was assigned an identification number corresponding to a Global Positioning System (GPS) waypoint and a number from an aluminum tag that was buried with a galvanized nail at a permanently referenced point, unless prevented by bedrock. The waypoint and buried tag allow for future location of the site and reference point for monitoring purposes. In addition, each field staff member present during the time of assessment was recorded along with the date and a brief description of the site (i.e., location within LSMC).

Geographic inventory indicators assessed at each site included site expansion potential, site slope, tree canopy cover, and cliff location (Appendix A). Expansion potential for each site was assessed using a combination of physical site attributes characterized as inhibiting expansion, including rockiness, dense vegetation or steep topography, and recorded as (P = Poor, M = Moderate, or G = Good). Site slope was measured using a clinometer and recorded as (Flat = <5%, Medium = 5-10%, Severe = >10%). Tree canopy cover was estimated as percentage of the site shaded by tree canopy cover and recorded as (1=0-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95%, 6=96-100%). Cliff location (top or bottom) was recorded as (Top = T, Base = B).

Visitor use indicators were assessed using a combination of observations of onsite visitor disturbance as well as approximations made by knowledgeable National Park Service staff. Use type and level were assessed by the above procedures and recorded respectively as Mixed Climbing/Hiking = MCH, Mostly Climbing = MC, Mostly Hiking= MH and Low = L, Moderate = M, Heavy = H. Climbing Type was assessed using information from published rock climbing guidebooks (Horst, 2001; Watson, 1998) in addition to consultation with two experienced rock climbers; climbing type was recorded as (Mixed Sport/Trad = MST, Mostly Sport = MS, Mostly Trad = MT, or NA).

Impact indicators included area of disturbance (ft^2), condition class, vegetative ground cover (on- and off-site), exposed soil, tree damage, root exposure, tree stumps, and number of informal access trails. Area of disturbance was measured using the radial transect method, employing multiple measurements of transect lengths and compass bearings radiating with a permanent reference point to site boundaries (Appendix A; Marion, 1995). Due to the long linear nature of recreational disturbance along cliffs, multiple applications of this method linked by common points were used to provide precise measurements (Figure 3.2).

Figure 3.2. Modified radial transect method used to measure linear recreation sites at Little Stony Man Cliffs.



Additionally, in cases where multiple transects were used, each radial transect was treated as a separate site, therefore general site information, as well as inventory and impact indicators described here were assessed according to their respective radial transect.

Condition class (0-5) assessments were performed and recorded (Appendix A) according to visual evaluation of on-site vegetation damage, amount of organic litter, exposed soil, and erosion. Ground vegetation onsite was assessed by estimating the percentage of live non-woody vegetative ground cover (including herbs, grasses, and mosses and excluding tree seedlings, saplings, and shrubs) within site boundaries using six cover classes (1 = 0-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%). Vegetation offsite was assessed using a paired control site (undisturbed, in close proximity to the study site). The area of exposed soil, defined as ground with very little or no organic litter (i.e., partially decomposed leaf, needle, or twig litter), was also assessed using these onsite coverage class values.

Tree damage, including trunk scars, nails, and broken or missing branches, was assessed for each onsite tree and recorded using three categories (none/slight, moderate, and severe). Root damage for each tree was assessed by examining the amount of exposed roots radiating from the tree and was recorded in the same manner. Representative photos depicting these levels of damage and root exposure were used to standardize assessments. Tree stumps and all informal trails (regardless of length) that connected with each radial transect were tallied and recorded.

Visitor-Caused Trail Assessment

A detailed description of all trail survey procedures is presented in Appendix B and summarized here. Each trail assessment was documented on the Cliff Trail Visitor Impact Form (Appendix B). In addition, the starting and ending point of each trail was documented using GPS waypoints. An identification number was assigned to each trail corresponding to the trail's first GPS waypoint number. A *point sampling method* with fixed intervals based on trail length (Table 3.1), following a randomized start, was employed to assess conditions on all visitor-caused trails at LSMC exceeding 10 feet in length (a decision rule to conserve assessment time on short, minimally impacted trails, Leung & Marion 1999; Marion & Leung, 2001). A trail measuring wheel was used to identify sample point locations.

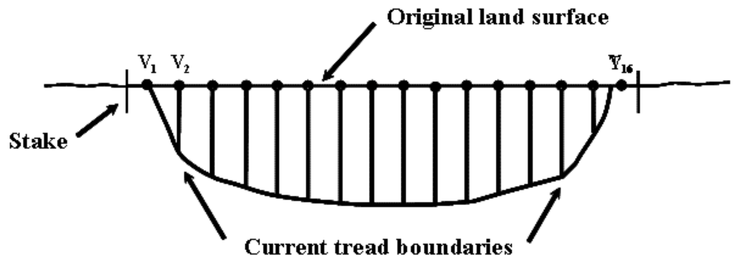
Table 3.1.
Sample Point Intervals for Trails <2400 ft. (.45 mi).

Interval (ft)	Trail Length (ft)
300	>2400
250	1801-2400
175	1201-1800
100	601-1200
75	301-600
50	51-300
1	<51

Inventory indicators use type and use level were determined in the same manner as described in the recreational site procedures; trail position (Ridge, Midslope/Sideslope, Cliff-Bottom, or Valley Bottom) was documented according to its prevailing location. Trail grade was determined by a clinometer reading (% slope) using points five feet on each side of the transect. Trail alignment was documented using a compass to sight azimuths (0-360, not corrected for declination) for the trail and the prevailing slope of the landform, calculating the trail's slope alignment angle as the smallest difference between the trail and landform values ($<90^0$).

At each sample point, a transect was established perpendicular to the trail tread with endpoints defined by visually pronounced changes in non-woody vegetation height (trampled vs. untrampled), cover, composition, or, when vegetation cover is minimal or absent, by disturbance to organic litter. Representative photos promoted consistent judgment. The objective was to select visually obvious boundaries caused by trampling disturbance that contained the majority (>95%) of traffic. Temporary stakes were placed at these boundaries and the distance between was measured as tread width; maximum depth from a taut string tied to the base of these stakes to the trail surface was measured as maximum incision, an indicator of soil erosion (Farrell & Marion, 2002). The cross sectional area (CSA) of soil loss, from the taut string to the tread surface, was also measured using a fixed 0.3 ft interval at each transect in which maximum trail depth exceeded one inch (Figure 3.3). CSA provides an accurate measure of trail soil erosion that can be extrapolated to provide an estimate of total soil loss from each trail. A computer program was developed and used to calculate CSA from data collected at each sample point.

Figure 3.3. Cross sectional area (CSA) method used to measure visitor-caused trails at Little Stony Man Cliffs.

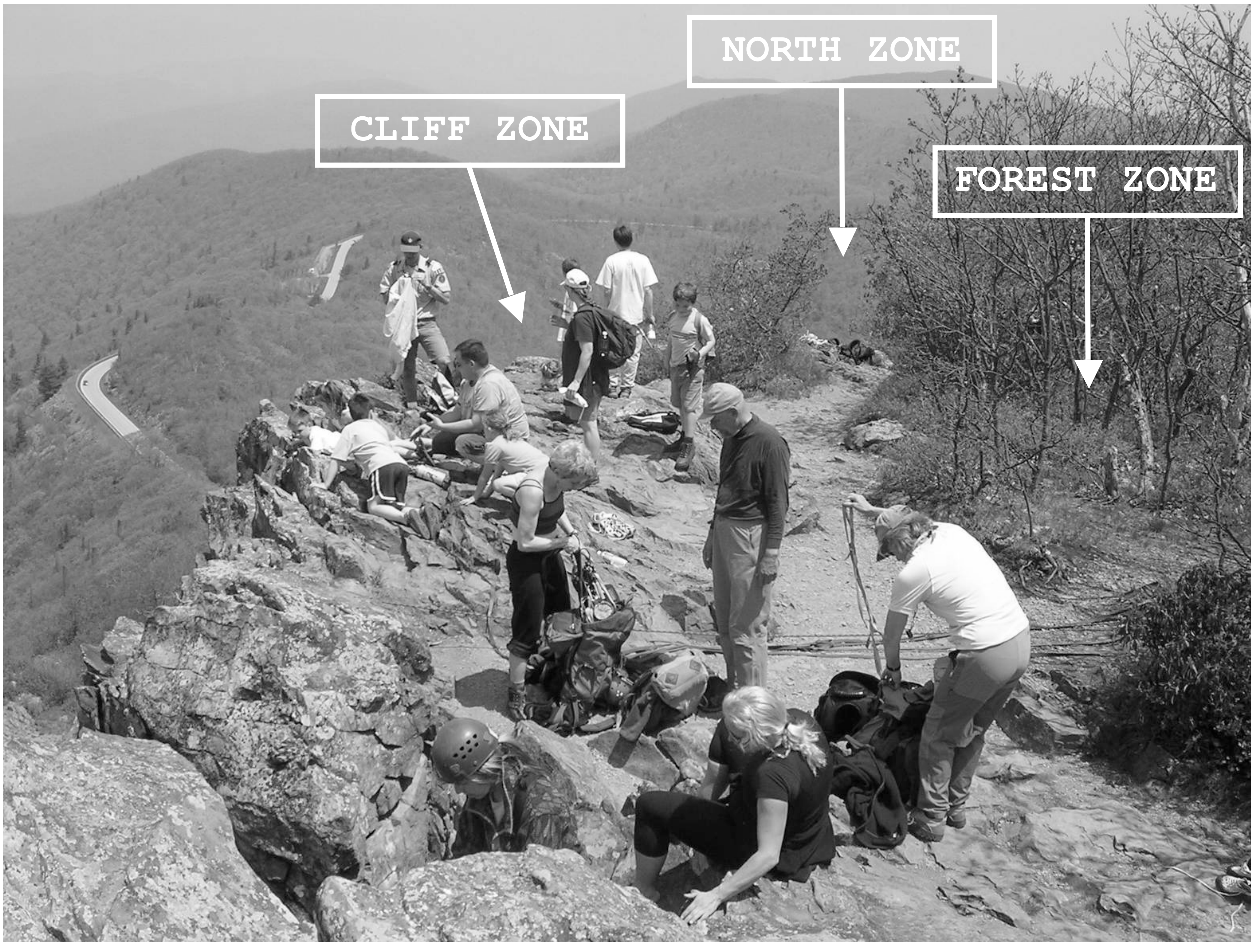


Trail tread condition characteristics, including vegetation cover, organic litter, exposed soil, muddy soil, water, rock, gravel, and roots, were defined as mutually exclusive categories and assessed across each transect. These indicators were evaluated as a proportion of tread width in 10% categories. A count of additional secondary trails that paralleled the survey trail at each sample point provided a measure of the extent of trail braiding.

Visitor Observation Methods

Visitor use observations were conducted on 14 randomly selected days between May 27, 2005 and September 10, 2005. For the purposes of conducting visitor use observations, three LSMC study area observation zones were defined: the North, Cliff, and Forest Zones (Figure 3.4). The North Observation Zone is bordered by dense forest vegetation to the north, cliff edge mixed with vegetation to the northwest, the Appalachian Trail to the southeast and a patch of vegetation to the southwest. The North Observation Zone provides views of Skyline Drive and the surrounding mountains, and is characterized by a mix of bare soil, rock and grass. The Cliff Observation Zone is south of and immediately adjacent to the North Observation Zone. The Cliff Observation Zone is bounded to the west by cliff edge, to the east by the Appalachian Trail, and to the south by a small oak bearing a white Appalachian Trail blaze at which point the trail begins to descend off the cliff-top. The Cliff Observation Zone is the largest of the three visitor use observation zones, receives the majority of visitor traffic on top of LSMC, and is characterized by large rock formations rising towards the cliff edge. The Forest Observation Zone is bordered by the Appalachian Trail to the west and includes a 40 foot wide band of forest extending from the northern boundary of the North Observation Zone to the southern boundary

Figure 3.4. Little Stony Man Cliffs cliff-top observation zones, looking north.



of the Cliff Observation Zone. The area in the center of the photo (Figure 3.4), including the cliff edge and adjacent trail (Appalachian Trail), is the Cliff Observation Zone. A portion of the Forest Observation Zone is depicted in the photo (Figure 3.4) immediately to the right of the Appalachian Trail. The North Observation Zone is not visible from the photograph (Figure 3.4), but is located just beyond and to the left of the portion of the Appalachian Trail visible in the background of the photograph.

During the sampling period, five types of visitor use information were collected through direct observation, including the number of people at one time in each of the three observation zones (PAOT); occurrences of "high-impact" visitor behaviors (Behavior Observations); the number of climbing ropes placed across the Appalachian Trail (Ropes Across Trail); total daily use of the cliff top (Total Daily Use); and visitors' length of stay on the cliff top (Length of

Stay). In addition, data collectors recorded qualitative observations concerning visitor use and behavior at the end of each sampling period.

On each sampling day, visitor use observations were conducted for a total of five hours. Sampling days were stratified by day of the week and time of day. Morning sampling shifts were conducted from 9:00 AM to 2:00 PM and afternoon sampling shifts were conducted from 2:00 PM to 7:00 PM. PAOT, Behavior Observations, and Ropes Across Trail data were collected concurrently by a single data collector, and Total Use and Length of Stay data were collected concurrently by a single data collector. On six sampling days, multiple data collection staff were available and all five types of visitor use information were collected. On the eight sampling days when only a single data collector was available, the observer collected either PAOT, Behavior Observations, and Ropes Across Trail data or the Total Use and Length of Stay data. Thus, visitor use observations were conducted on a total of 14 days. The total number of sampling shifts conducted for each type of data collected are reported in Table 3.2.

Table 3.2.
Number of Sampling Shifts, by Type of Observation Data, Day of Week, and Time of Day

	PAOT/Behavior Observation/Ropes Across Trail	Total Daily Use/Length of Stay
Weekend AM	4	4
Weekend PM	4	4
Weekday AM	3	3
Weekday PM	3	3

Staff conducting the visitor use observations dressed to blend-in with visitors (i.e., casual dress, no uniform), concealed observation sheets, and conducted observations in a subtle manner in an effort to minimize the effects of data collectors' presence on visitors' behavior. On each day visitor use observations were conducted, one or more data collectors were stationed in a fixed location on the cliff top that provided a view of all three observation zones. The following sections describe each of the types of visitor use information collected in this study.

People at One Time (PAOT)

PAOT counts were conducted to record the number of people at one time engaged in different types of recreational activities in each of the three observation zones. During PAOT observations, visitors were counted as either a rock climber, day hiker, or backpacker (Appendix C). At the start of each sampling day that PAOT counts were collected, the data collector conducted an instantaneous count and recorded the number and type of visitors in each observation zone. After completing the count, the data collector recorded Behavior Observations data for five minutes (Behavior Observations procedures are described below). At exactly five minutes after the first PAOT count, the data collector conducted an instantaneous count and recorded the number and type of visitors in each of the three observation zones. The data collector continued making PAOT counts every five minutes throughout the sampling day and collecting Behavior Observations data during the five minute intervals between PAOT counts, using a single form to record both types of data (see Appendix C for a copy of the form used to record PAOT data).

Behavior Observation

Behavior Observations were conducted to quantify the extent to which visitors on the cliff top of LSMC engaged in "high-impact" behaviors, including stepping on vegetation or soil, picking vegetation, or throwing objects over the cliffs. As noted above, the Behavior Observations were conducted in five minute intervals between PAOT counts. On each day that Behavior Observations were conducted, the data collector began the sampling period by conducting a PAOT count (see the previous section for a description of PAOT counts). Immediately following the first PAOT count, the data collector randomly selected one individual from among the visitors in the three observation zones. The data collector observed the behavior of the selected participant for a maximum of five minutes or until he/she was no longer in any of the three observation zones. For the duration of the observation, the data collector recorded whether the individual being observed engaged in any of the "high-impact" behaviors described above, and the location (i.e., observation zone) of each "high-impact" behavior observed. At the conclusion of the observation, the data collector recorded the type of visitor observed (i.e., rock climber, day hiker, backpacker), the total length of time of the observation and an estimate of the percentage of the observation time that the individual was engaged in "high-impact" behaviors (see Appendix C for a copy of the form used to record Behavior Observations data). Immediately following the completion of the observation, the data collector conducted a PAOT count and then randomly selected the next subject for Behavior Observations. This process was repeated throughout the entire sampling period.

Ropes Across Trail

As noted above and depicted in Figure 3.1, the Appalachian Trail runs north to south along the top of LSMC between the Cliff and Forest Observation zones. At times, rock climbers use trees in the Forest Observation Zone to construct climbing anchors. Consequently, there are times when rock climbing ropes and webbing cross the Appalachian Trail and visitors on the cliff top have to step over them to walk along the trail (Hilke, 2002; Smith personal communication, September 23, 2002). For each rope or webbing anchor placed across the Appalachian Trail on days when Ropes Across Trail data were recorded, a data collector recorded the time when the anchor was first placed across the trail and the time it was removed. If an anchor rope or webbing was not removed by the end of the sampling shift, the data collector recorded the time the shift ended rather than the time the anchor rope or webbing was removed. As noted earlier, Ropes Across Trail, PAOT, and Behavior Observations data were collected concurrently by a single data collector and recorded on a single data sheet (see Appendix C for a copy of the form used to record Ropes Across Trail data).

Total Daily Use

Total Daily Use counts were conducted to estimate the total number of people per day who visit the top of LSMC and the types of recreational activities they engage in. On each day that Total Daily Use counts were conducted, the total number and type of visitors entering the study area were tallied and recorded on a data form (see Appendix C for a copy of the form used to record Total Daily Use data). Visitors that left the observation area and returned at a later time were counted each time they entered the observation area unless the data collector recognized the visitor as having been counted earlier in the sampling shift.

Length of Stay

Length of Stay observations were conducted in tandem with Total Daily Use by a single data collector and both types of data were recorded on a single form (see Appendix C for a copy of the form used to record Length of Stay data). At the start of each sampling day that Length of Stay observations were conducted, the data collector selected the first visitor to enter any of the three observation zones. The data collector recorded the type of visitor selected and his/her point and time of entry into the study area. The data collector also recorded the visitor as part of the Total Daily Use count being conducted concurrently with Length of Stay observations, along with all subsequent visitors that entered any of the three study zones while Length of Stay observations were conducted. The data collector observed the selected visitor until he/she left the study area, at which time the data collector recorded the subject's exit point and time, and the total time the visitor was observed in the study area. The data collector then selected the next visitor to enter any of the three observation zones as the subject of the next Length of Stay Observation. The process described above was repeated throughout the entire sampling period.

Informal Observation

Following the conclusion of the observation period, the data collector recorded a brief written summary of visitor use and behavior observations he/she made that were not captured by the measures described above. Informal observations were made on the initial sampling day and on each subsequent sampling day in which previously unrecorded activities and/or behaviors were observed. Data collected as a result of informal observations included possible motivations for visitors engaging in one or more of the high impact behaviors. For example, non-rock climbing visitors were observed stepping on soil or vegetation in the Forest Observation Zone in an effort to seek shade from the sun and others were observed stepping on soil or vegetation in the Cliff Observation Zone to get a closer look at rock climbing activity. Informal observations also included notes describing behavioral responses of non-rock climbing visitors to the presence of rock climbing ropes and webbing placed across the Appalachian Trail on the cliff top. For example, observations of visitors stepping off of the Appalachian Trail into the Forest Observation Zone in order to avoid having to step over the climbing ropes crossing the trail were noted. Data collectors also documented popular climbing routes at LSMC and the location of trees and boulders most often used to construct anchors for each climbing route. Informal observations were recorded on the back of the data sheet (i.e., PAOT/Behavior Observations/Ropes Across Trail form or Total Daily Use/Length of Stay form) the data collector was using that day (see Appendix D for the verbatim transcripts of the informal observations).

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CHAPTER 4
ASSESSING RECREATION IMPACTS TO CLIFFS IN SHENANDOAH NATIONAL PARK: INTEGRATING VISITOR OBSERVATION WITH TRAIL AND RECREATION SITE MEASUREMENTS

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Introduction

Shenandoah National Park (SNP) encompasses 70 miles of ridge crest along the Blue Ridge Mountains of Virginia. Rock outcrops and cliffs punctuate the otherwise forested landscape, composing approximately 2% (3920 acres) of the park's 196,000+ acres. Previous Virginia Department of Conservation and Recreation (VADCR) survey work at a few of the park's larger rock outcrops documented the occurrence of 28 rare species, including the federally endangered Shenandoah Salamander (*Plethodon Shenandoah*; Ludwig et al., 1993). Furthermore, previous research identified a rare plant community type, the High Elevation Greenstone Outcrop Barren, believed to be endemic to the park (Hilke, 2002).

The location of the world-famous ridgeline parkway, Skyline Drive, makes many outcrops and cliffs within the park readily accessible to the park's 1.2 million annual visitors. Rock outcrops provide vistas for day hikers and backpackers along the park's 500 miles of trails, including the Appalachian National Scenic Trail, which parallels Skyline Drive for the length of the park. Additionally, in the last several years, some cliff areas in the park have become increasingly popular for rock climbing. Consequently, visitor use of cliff areas within the park has led to natural resource impacts such as vegetation damage and loss, soil exposure, compaction and erosion, visitor-caused trails, and illegal or poorly located campsites (Hilke, 2002).

Despite the clear ecological value and potential threats to the natural resources at SNP cliff areas, managers possess little information on visitor use of cliff sites and presently have no formal planning document to guide visitor management of the park's cliff resources. Concern over the effects of visitor-caused impacts to cliff areas has prompted the park to initiate a study of cliff sites and to formulate a Cliff Resource Management Plan. As part of this research effort, the study presented in this paper used an approach that integrates social science and ecological data to help assess the effects of recreational use on the vegetation and soils at one of the most heavily visited cliff sites in the park, Little Stony Man Cliffs (LSMC). In particular, this study integrates data from measurements of resource conditions on cliff-associated trails, recreation sites, and campsites with information collected through direct observations of the amount and type of recreational use, and the behaviors of visitors that might contribute to resource impacts at LSMC. The information from this study will assist the park in managing visitor use and developing a plan that protects the park's cliff resources while providing sustainable opportunities for visitor enjoyment.

Related Literature

Cliff Resource Impacts

Cliffs often support distinctly different plant communities than surrounding environments, largely due to the limited moisture availability, high winds, and limited supply of nutrients characteristic of cliff environments. These unique environmental attributes provide habitat for a relatively narrow range of species adapted to extreme environments (Farris, 1998; Nuzzo, 1996). While adapted to harsh cliff environments, cliff plant species' resistance to other forms of disturbance (e.g., trampling) may be limited (Farris, 1998). Until recently, the inaccessibility and potential danger of most cliffs has provided a protective barrier between plant communities and potentially damaging human activities (Camp & Knight, 1998; Kelly & Larson, 1997; Krajick, 1999). However, the growing popularity of rock climbing means that more people are accessing and using cliff sites, which may negatively affect cliff site plant communities (Camp & Knight, 1998; Farris, 1998, McMillan et al., 2003).

Despite the rising popularity of rock climbing, its effects on cliff site environments have received limited attention in the scientific literature (Farris, 1998; McMillan & Larson, 2002). The Access Fund (2001) describes six zones that have the potential to be impacted by rock climbing activities: the approach (access trail), staging area (cliff-bottom), climb (cliff-face), summit (cliff-top), descent (descent trail or rappel route), and campsite. Existing cliff research has generally focused on studying rock climbing-related impacts in the cliff-top, cliff-bottom, and cliff-face zones. Results of these studies have documented negative effects of rock climbing on vascular plant density and/or species richness on cliff-faces (Camp & Knight, 1998; Kelly & Larson, 1997; McMillan & Larson, 1999; Nuzzo, 1995;), on cliff-tops (Kelly & Larson, 1997; McMillan & Larson, 2002) and cliff-bottoms (Camp & Knight, 1998). Additionally, Nuzzo (1996) found lichen cover and frequency to decrease on climbed cliff-faces.

Whereas cliff-face impacts are associated with rock climbers due to technical skill and equipment requirements, the remaining zones are subject to impact by other recreationists such as hikers and backpackers. However, few studies have examined the relative effect of alternative types of recreational use on cliff resources (Parikesit et al., 1995). Rather, it is often inferred, without empirical evidence, that cliff-top and cliff-bottom trampling impacts are caused primarily by rock climbers (Camp & Knight, 1998; Kelly & Larson 1997; McMillan & Larson, 2002). For example, a letter from Virginia's Division of Natural Heritage describing the trampling and loss of globally significant cliff-top plant communities at SNP largely attributed the worst damage to "increased heavy use … by large rock-climbing groups" at LSMC, a conclusion reached through intuition rather than empirical evidence. This letter prompted the park to initiate the study presented in this paper.

While the authors of this paper are aware of only one study examining the trampling effects of non-rock climbing recreational activities on cliff resources (Parikesit et al., 1995), a number of studies have been conducted to investigate soil and vegetation trampling impacts to trails and campsites (Cole, 1995; Leung & Marion, 2000; Marion & Cole, 1996). Procedures used to measure trampling disturbance on trails (Farrell & Marion, 2002; Marion & Leung, 2001) and campsites (Leung & Marion, 2000; Marion, 1995) are reasonably well-developed and appear to be readily adaptable for measuring cliff-top, cliff-bottom, and descent trail impacts. Thus, despite an apparent lack of previous studies evaluating the effects of alternative recreation types on cliff sites, present study methodology and findings from both rock climbing cliff impact studies and trampling literature may provide adequate tools for evaluation and documentation of cliff site impacts. This study is designed to apply these methods and knowledge to assess the extent of resource impacts at LSMC associated with all types of recreational uses, including, but not limited to rock climbing.

Visitor Observation

As noted, previous studies of recreation-related cliff resource impacts lack a social science component. Thus, it is difficult to draw conclusions from these studies about the relative effect of varying amounts and types of recreational use on cliff resources. Furthermore, it is difficult to assess the extent to which cliff resource impacts might be explained by visitor behaviors. In this study, visitor observations were used to document the amount and type of recreational use of LSMC, and the frequency with which visitors engaged in behaviors that directly impact cliff resources (i.e., trampling soil and vegetation). While the authors know of no published applications of visitor observation methods to studies of cliff resource use in general and rock climbing in particular, a number of studies have documented direct observation procedures and methods designed to collect information about visitor use (e.g., amount, time, location of use, etc.) and visitor characteristics (e.g., type of use, group size, activities, etc.; Hendricks et al., 2001; Keirle, 2002; Muhar et al., 2002; Watson, 2000). Furthermore, direct visitor observation methods have been used to study visitors' behavior, including depreciative behavior (Gramann & Vander Stoep, 1986; Hocket, 2000) and visitor etiquette (Hendricks et al., 2001). The study presented in this paper advances previous research on visitor-caused cliff resource impacts by coupling resource impact measurement methods with visitor observations to provide an integrative understanding of recreational use and associated resource impacts at LSMC.

Methods

Study Area

The Little Stony Man Cliffs are one of many greenstone (metamorphosed basalt) cliff formations located within SNP. At an elevation of 3560 feet, these cliffs rise approximately 100 feet, providing visitors with a spectacular view of the Shenandoah Valley to the west and, on clear days, West Virginia. The cliffs are popular among day hikers and backpackers for the views they afford and among rock climbers, including organized groups, for the easily accessed beginner to intermediate climbing routes (Hilke, 2002). Most visitors access LSMC by taking a short hike on the Appalachian Trail from the Little Stony Man Cliffs trailhead on Skyline Drive (Figure 4.1). During the summer and fall of the 2002 visitor use season, trailhead registers were used to monitor the amount of use of LSMC. After adjusting for non-compliance, the trailhead register data suggested that an average of 49 people visit LSMC per day during the summer and fall seasons (Hilke, 2002).

The majority of the LSMC top is characterized by solid rock rising toward the cliff edge at varying heights with a few interspersed patches of vegetation and bare soil. Several day-use recreation sites located along and east of the rocky cliff edge are present on the cliff-top, characterized by a mix of bare soil and trampled vegetation. The Appalachian Trail runs the length of the cliff-top, bisecting the recreation sites which extend west to the cliff edge and east into the forest, and further south to the cliff descent trail and upper campsite access trails (Figure 4.1).

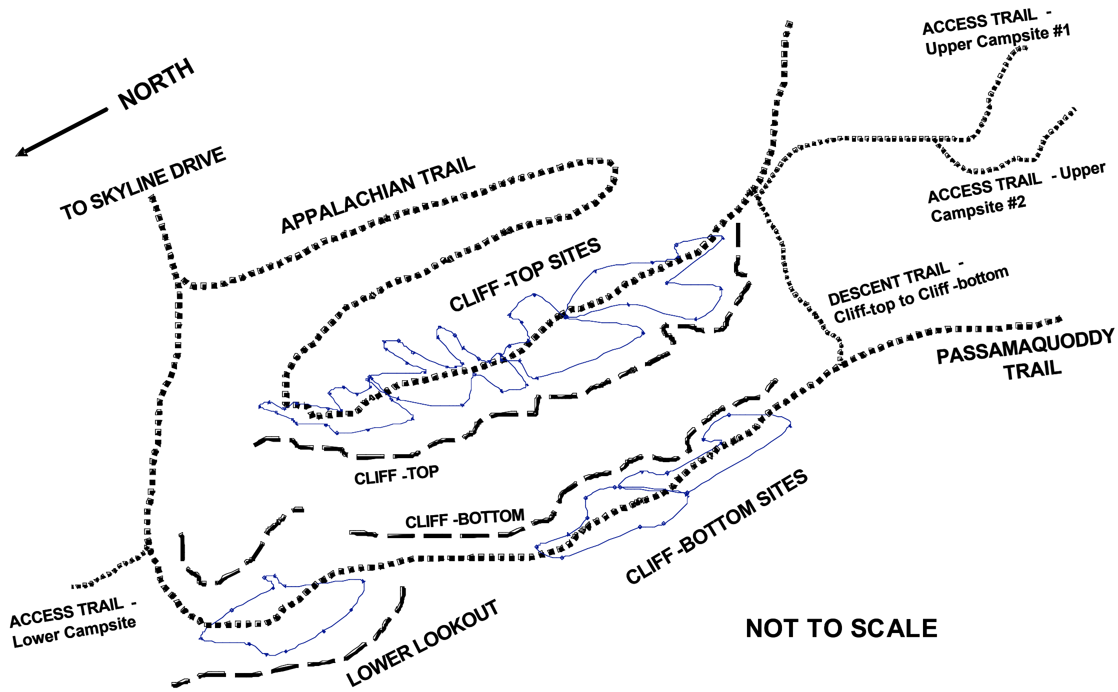
The lower portion of LSMC is comprised of two separate areas, both accessed by the Passamaquoddy Trail - a lower lookout perched on top of a small cliff and the cliff-bottom

(Figure 4.1). The lower lookout shares similar characteristics with the cliff-top - a large recreation site perched on top of a cliff. Few patches of vegetation are found at this site and it lacks a forest canopy. The main cliff-bottom is characterized by two recreation sites containing a mix of bare soil and trampled vegetation along with multiple visitor-caused trails diverging from the Passamaquoddy Trail to the cliff base.

Three visitor-created campsites are located close to LSMC, accessible by visitor-caused trails connected to the Appalachian or Passamaquoddy Trails (Figure 4.1). Two of the campsites are located south of the cliff-top while the remaining campsite is located to the north of the lower lookout. Each campsite contains at least one core area of disturbance characterized by a combination of bare soil, organic litter and trampled vegetation.

In addition to visitor-caused trails associated with recreation sites, one visitor-caused descent trail located south and adjacent to LSMC provides quick access between cliff-top and cliff-bottom. This badly eroded trail follows a steep drainage ravine consisting of loose soil, rock, and other debris. The soil and rock eroded from this trail have accumulated in a large mound found at the base of the trail where it joins the Passamaquoddy Trail.

Figure 4.1. Little Stony Man Cliffs-recreational sites and trails.



Several rare and endangered animal species and plant species and communities are found throughout the LSMC area. The highest occurrence of rare plant species and communities are on the cliff-top and surrounding upper ledges as most species are particularly adapted to the microclimate characteristic of these locations (Hilke, 2002; Nuzzo, 1995). Less frequent concentrations of rare plants are present on the lower lookout and along the cliff-top directly south of LSMC, along the edge of the two upper campsites (Figure 4.1). Furthermore, habitat for the globally rare Shenandoah Salamander is believed to be located within proximity of the descent trail to the south of LSMC (Hilke, 2002; Ludwig et al., 1993).

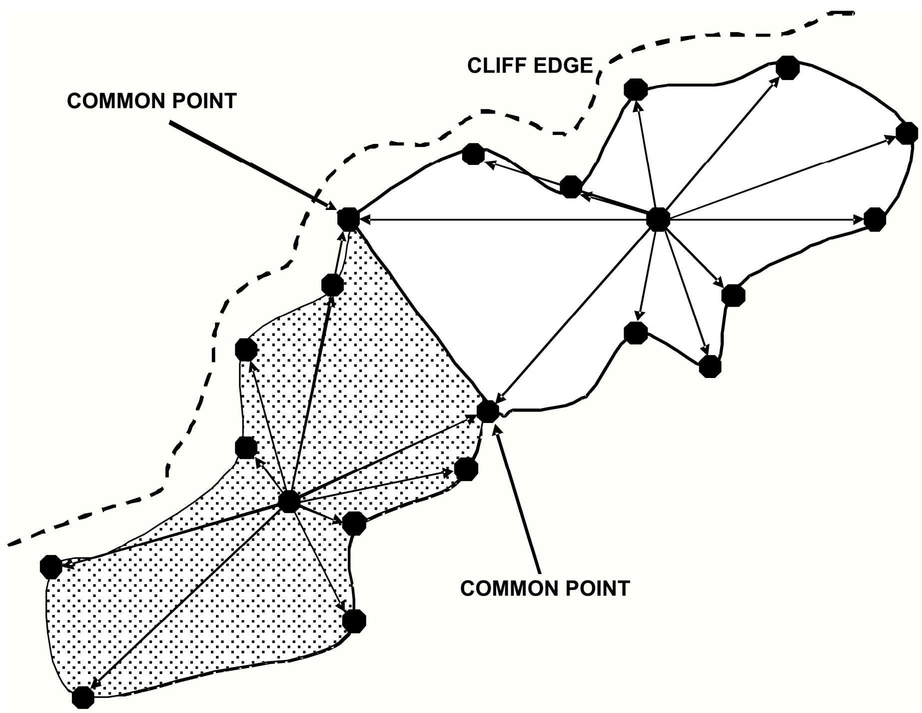
Resource Impact Measurement

In the study presented in this paper, procedures from campsite and trail impact studies were adapted to measure and characterize the extent of resource impacts associated with all types of LSMC recreational uses. Impact indicators assessed at cliff-top and cliff-bottom recreation sites and campsites included area of disturbance, vegetation loss, exposed soil, tree damage, tree stumps, root exposure, number of visitor-caused trails, and expansion potential. Trail condition assessments were also performed on visitor-caused trails at LSMC exceeding 10 feet in length (a decision rule to conserve assessment time on short, minimally impacted trails).

Recreation site and campsite sizes were measured using a variable radial transect method based on measurements of transect lengths and compass bearings radiating from a reference point to site boundaries defined by trampling disturbance (Marion, 1995). Reference points were permanently marked and located using Global Positioning System (GPS) devices. Multiple radial transects that shared common points were used to accurately measure area of disturbance for long linear recreation sites present on both the cliff-top and cliff-bottom (Figure 4.2). Area of disturbance for each radial transect was calculated arithmetically from transect data using Excel spreadsheet formulas.

Ground vegetation on recreation sites and campsites and in environmentally similar but undisturbed control sites, was assessed using six cover classes. Vegetation loss was calculated by subtracting the onsite coverage class midpoint value from its paired control site coverage class midpoint value, resulting in a percentage of vegetation loss. This percentage value was multiplied by the corresponding area of disturbance to obtain an estimate of the area over which vegetation cover has been lost. The area of exposed soil was also assessed by multiplying the onsite coverage class midpoint value for exposed soil by the corresponding area of disturbance.

Figure 4.2. Modified radial transect method used to measure recreation sites at Little Stony Man Cliffs.



Tree damage and root exposure were recorded by category (none/slight, moderate, and severe) for each onsite tree and tree stumps were counted. Visitor-caused trails that connected with each radial transect were counted, regardless of length. Site expansion potential was assessed for each site based on the extent to which expansion appeared to be inhibited by topography, rockiness, or dense woody vegetation. Impact indicator values reported for LSMC reflect summed totals and mean percentages for all sites according to their location at LSMC (cliff-top, cliff-bottom, campsites, and lower lookout).

The condition of visitor-caused trails was assessed using point sampling procedures outlined in Farrell and Marion (2001) and Marion (2006), and included measurement of trail length, width, mean depth, and when depth exceeded one inch, assessments of soil loss using a cross sectional area (CSA) procedure. These measurements were taken at transects spaced at fixed intervals along each trail following a randomized start. The number of transects for each trail was proportional to the trail's length. GPS devices were also used to document each trail's location.

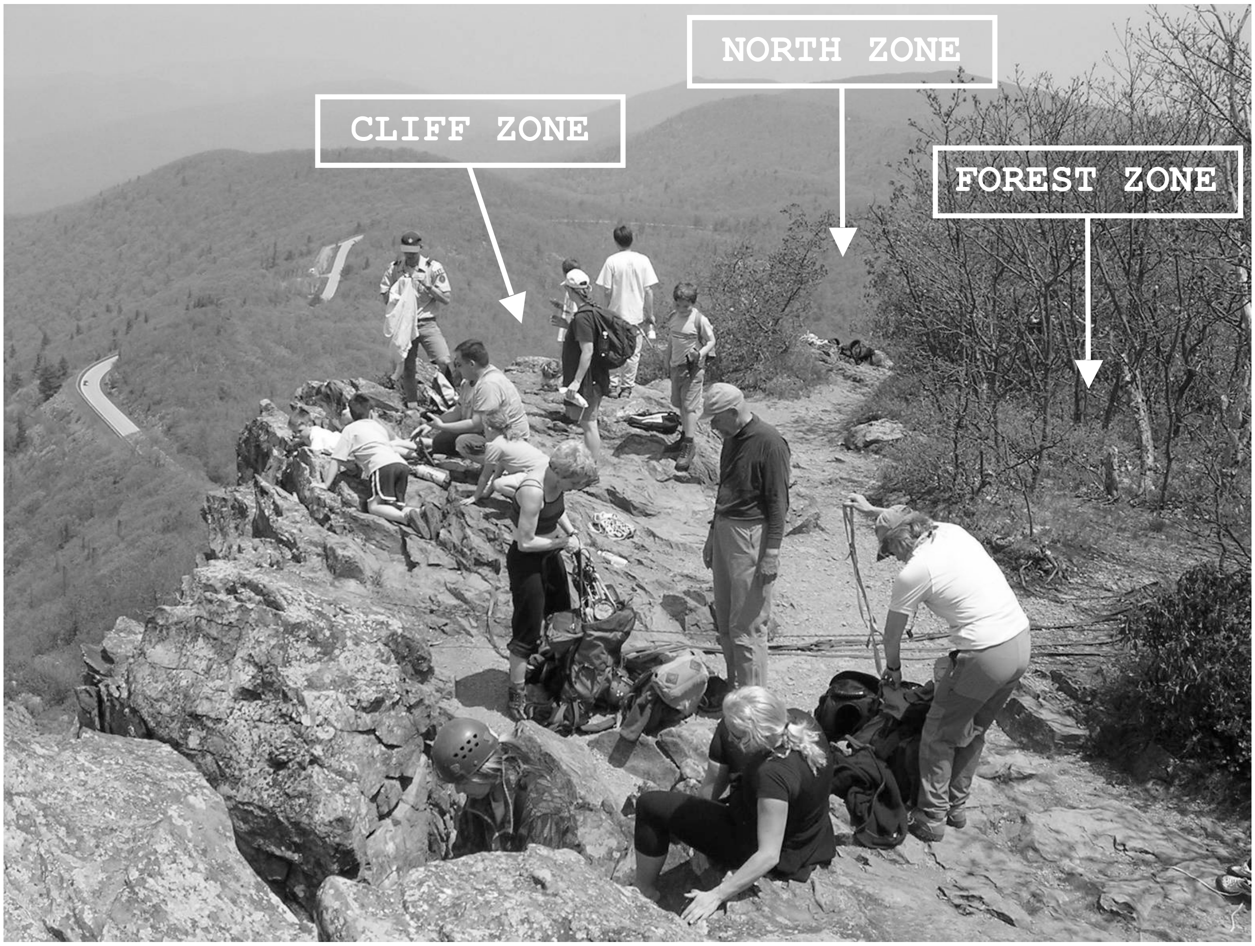
Trail condition measures were calculated for each trail and for all trails combined, including mean CSA, trail width, and trail depth. Trail length was multiplied by mean trail width to produce estimates of the land area intensively disturbed by trail traffic. Excel spreadsheet formulas were used to calculate trail CSA for each transect and to extrapolate these data to estimate mean and total soil loss for each trail.

Visitor Observation

Unobtrusive visitor use observations were conducted on 14 randomly selected days between May 27, 2005 and September 10, 2005 on top of LSMC to document and characterize the type and amount of recreational use the cliffs receive and the behaviors of recreationists that may contribute to cliff-top resource impacts. Observations were restricted to the cliff-top to investigate trampling damage to the rare plant community that occurs here (Hilke, 2002). Sampling days were stratified by day of the week and time of day, with morning sampling shifts conducted from 9:00 AM to 2:00 PM and afternoon sampling shifts conducted from 2:00 PM to 7:00 PM. For the purposes of conducting visitor use observations at LSMC, three observation zones were defined: the North, Cliff, and Forest Observation Zones (Figure 4.3). Data collectors were stationed in a fixed location on the cliff-top that provided a view of all three observation zones. Staff conducting the visitor use observations dressed to blend-in with visitors, concealed observation sheets, and conducted observations in a subtle manner to avoid altering visitor behavior.

During the sampling period, five types of visitor use information were collected through direct observation, including the number of people at one time (PAOT) in each of the three observation zones; occurrences of soil/vegetation trampling (Behavior Observations); total daily use of the cliff top (Total Daily Use); visitors' length of stay on the cliff top (Length of Stay); and informal observations concerning visitor use and behavior.

Figure 4.3. Little Stony Man Cliffs cliff-top observation zones, looking north.



PAOT and Behavior Observations data were collected concurrently by a single data collector. At the start of each sampling day that PAOT counts and Behavior Observations were collected, the data collector conducted an instantaneous PAOT count and recorded the number and type (i.e., rock climber, day hiker, backpacker) of visitors in each observation zone. Immediately following the first PAOT count, the data collector randomly selected one individual from among the visitors in the three observation zones. The data collector observed the behavior of the selected participant for five minutes or until he/she was no longer in any of the three observation zones. For the duration of the observation, the data collector recorded whether the individual being observed trampled soil/vegetation, and the location of each "trampling event" observed. At the conclusion of the Behavior Observation, the data collector recorded the type of visitor observed (i.e., belayer, rock climber, day hiker, backpacker) and the length of time of the observation. At five minutes after the first PAOT count, the data collector conducted a second PAOT count and then randomly selected the next subject for Behavior Observation. The data collector continued making PAOT counts every five minutes throughout the sampling day and Behavior Observations during the five minute intervals between PAOT counts.

Length of Stay observations were conducted in tandem with Total Daily Use by a single data collector. On each day that Length of Stay and Total Daily Use observations were conducted, the total number and type of visitors entering the study area were tallied and recorded. Visitors who left the observation area and returned at a later time were counted each time they entered the observation area unless the data collector recognized the visitor as having been counted earlier in the sampling shift. In addition, at the start of each sampling day that Length of Stay and Total Daily Use observations were conducted, the data collector selected the first visitor to enter any of the three observation zones. The data collector recorded the type of visitor selected and his/her point and time of entry into the study area. The data collector also recorded the visitor as part of the Total Daily Use count being conducted concurrently with Length of Stay observations, along with all subsequent visitors that entered any of the three study zones while Length of Stay observations were conducted. The data collector observed the selected visitor until he/she left the study area, at which time the data collector recorded the subject's exit point and time, and the total time the visitor was observed in the study area. The data collector then selected the next visitor to enter any of the three observation zones as the subject of the next Length of Stay observation. The process described above was repeated throughout the entire sampling period.

Data collectors recorded informal observations concerning visitor use and behavior at the end of each sampling period. Informal observations were made on the initial sampling day and on each subsequent sampling day in which previously unrecorded activities and/or behaviors were observed. Data collected as a result of informal observations included possible motivations for visitors trampling soil or vegetation. For example, non-rock climbing visitors were observed trampling soil or vegetation in the Forest Observation Zone in an effort to seek shade from the sun and others were observed trampling soil or vegetation in the Cliff Observation Zone to get a closer look at rock climbing activity. Informal observations also included notes describing behavioral responses of non-rock climbing visitors to the presence of rock climbing ropes and webbing placed across the Appalachian Trail on the cliff top. For example, observations of visitors stepping off of the Appalachian Trail into the Forest Observation Zone in order to avoid having to step over the climbing ropes crossing the trail were noted. Data collectors also documented popular climbing routes at LSMC and the location of trees and boulders most often used to construct anchors for each climbing route.

Results

Resource Impact Measurement

The area of disturbance for LSMC recreation sites and campsites, characterized by bare soil and vegetation loss, total 12817 ft^2 (Table 4.1). The highest percentage (42%) of total trampling disturbance was found to occur on the cliff-top while the lower lookout accounted for the lowest percentage (15%). Conversely, percentage of exposed bare soil and vegetation loss estimates were lowest on the cliff-top while the lower lookout was the most heavily impacted site, containing roughly 63% bare soil and accounting for an 83% reduction in ground cover compared to the offsite control. The combined area of disturbance for campsites accounted for nearly 25% of trampling disturbance at LSMC, while percentages of both vegetation loss and bare soil were similar to the cliff-top.

All sites where resource impacts were measured contained trees, except the lower lookout site. Within cliff sites where trees are present, most observed tree damage was categorized as none/slight. However, some moderate tree damage was found in all three sites that contained trees, while severe tree damage was observed only at the cliff-bottom. While tree stumps were also observed in all three sites that contained trees, the cliff-top contained the greatest number of stumps and only one stump was observed in each of the other sites. Root exposure was observed within all three sites, but only the cliff-bottom and campsites contained areas with moderate or severe root exposure.

Table 4.1.
Impact Indicator Data for LSMC Recreation Sites.

Impact Indicator	Cliff-top	Cliff-bottom	Campsites	Lowe Lookout	Total
Area of Disturbance (ft^2) [a]	5338	2481	3139	1859	12817
Vegetation Loss (%) [b]	35	46	35	83	
Vegetation Loss (ft^2) [a]	1529	1367	962	1543	5401
Exposed Soil (%) [b]	16	16	21	63	
Exposed Soil (ft^2) [a]	827	943	538	1171	3479
Tree Damage (#)					
Slight	27	9	9	0	45
Moderate	2	6	5	0	13
Severe	0	3	0	0	3
Tree Root Exposure (#)					
Slight	28	14	10	0	52
Moderate	0	1	3	0	4
Severe	0	1	1	0	2
Tree Stumps (#)	4	1	1	0	6
Informal Trails (#)	2	0	4	0	6

[a]Values reported are sums
[b]Values reported are means

Visitor-caused trails were found only on the cliff-top and at the three campsites. The two visitor-caused trails on the cliff-top and one visitor-caused trail at an upper campsite were less than 10 feet in length, thus condition assessments were not performed on them. However, condition assessments were performed for two visitor-caused trails observed at the upper campsites, one for the lower campsite, and the descent trail (Figure 4.1). The condition assessments found that visitor-caused trails used to access campsites at LSMC range from 98-169 feet in length, 34-37 inches in width, and have mean trail depths ranging between 1.4-3.2 inches (Table 4.2). Measurements of the descent trail indicate that the trail is 204 feet in length, has a mean width of 115 inches, and a mean trail depth of 16.8 inches. The total area of disturbance associated with visitor-caused trails is one-quarter (3243 ft^2) the size of the total area of disturbance (12817 ft^2) from recreation sites and campsites. Soil loss on the campsite trails, as indicated by mean CSA, was estimated to be 49 in^2 for the lower campsite trail and 38 in^2 and 144 in^2 for the upper campsite trails, #1 and #2 respectively. Soil loss on the cliff descent trail was much more pronounced than along all other trails, with a mean CSA of 1747 in^2. Additionally, the descent trail made up roughly 82% (2288 ft^3) of the total cumulative soil loss (2803 ft^3) from all visitor-caused trails.

Table 4.2.
Impact Indicator Data for LSMC Visitor-Caused Trails

Impact Indicator	Cliff Descent Trail	Lowe Campsite Trail	Upper Campsite Trail #1	Upper Campsite Trail #2	Totals
Trail Length (ft)	204	169	141	98	612
Trail Width (in)[a]	115	37	34	45	
Area of Disturbance (ft^2)[b]	1955	521	400	368	3243
Trail Depth (in)[a]	16.8	2	1.4	3.2	
Cross Sectional Area (CSA)					
(in^2)[a]	1747	49	38	144	
(ft^3)[b]	2288	440	21	54	2803

[a]Values reported are means
[b]Values reported are sums

Visitor Observation

Results of pairwise comparisons of average daily use by type of visitor suggest that significantly more hikers (t=5.43; p<0.01) and backpackers (t=3.96; p<0.01) visit LSMC during weekdays than rock climbers (Table 4.3). On weekend days, the number of day hikers who visit LSMC is significantly greater than the number of backpackers (t=-8.60, p<0.01) and rock climbers (t=10.87, p<0.01) who do so. Furthermore, while average daily backpacking and rock climbing use did not differ significantly between weekend days and weekdays, day hiking use of LSMC was found to be significantly higher on weekends than during the mid-week (t=-5.41, p<0.01).

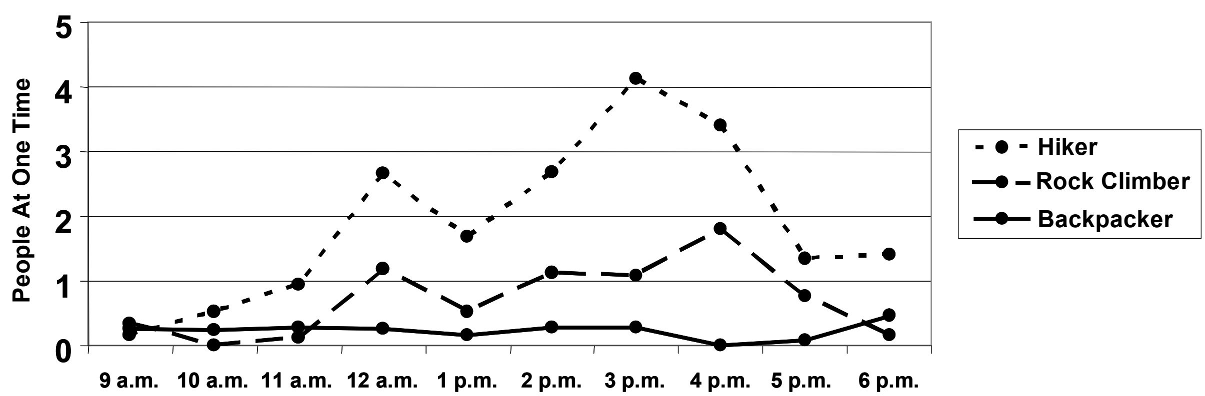
Table 4.3.
Mean Total Daily Use on LSMC Cliff-top, by Day of Week and Type of Visitor

	Weekday	Weekend	Pairwise t - tests of weekday vs. weekend daily use
Rock Climber	0.3[a]	2.7[a]	t=-1.64; p=0.58
Hiker	14.5[b]	48.8[b]	t=-5.41; p<0.01
Backpacker	8.0[b]	7.2[a]	t=0.67; p=0.98

Note: Within each column, means with different superscripts are significantly different at ⊟ 0.05.

Day hiking use of LSMC was found to not only be concentrated more on weekends than weekdays, but also to be unevenly distributed across the hours of the day (Figure 4.4). In particular, day hiking use tends to be bi-modally distributed, with peaks at noon and mid-afternoon. Rock climbing use was observed to follow a similar but less pronounced trend across the hours of the day, whereas backpacking use of LSMC stayed relatively consistent and low throughout the day.

Figure 4.4. Mean number of people at one time (PAOT) on Little Stony Man Cliffs cliff-top, by type of visitor and time of day.



Results of a one-way ANOVA comparing day hikers, rock climbers and backpackers with respect to mean length of stay indicate that the amount of time visitors spend on the cliff-top varies significantly by type of use ((F=10.62; p<.01; Table 4). Specifically, results of post hoc tests (Tukey's HSD) show rock climbers spend significantly more time on the cliff-top than day hikers or backpackers, while day hikers and backpackers were not found to differ significantly with respect to the amount of time they spend on the cliff-top.

Table 4.4.
Mean Length on Stay of LSMC Cliff-Top in Minutes, by Type of Visitor

Rock Climber (n=15)	Hiker (n=71)	Backpacker (n=32)
24.1^{a}	8.8^{b}	5.2^{b}

Note: Means with different superscripts are significantly different at $\alpha=0.05$

The likelihood of visitors to trample soil and vegetation on the LSMC cliff-top was found to differ by type of visitor ($\chi^2=10.68$; $p<0.01$; Table 5). In particular, 39% of day hikers observed during the study stepped on soil or vegetation, compared with 29% of rock climbers and 16% of backpackers.

Table 4.5.
Percent of Observed Visitors Seen Trampling Soil/Vegetation, by Type of Visitor

Rock Climber (n=62)		Hiker (n=224)		Backpacker (n=51)	
Trampling	No Trampling	Trampling	No Trampling	Trampling	No Trampling
29%	71%	39%	61%	16%	84%

$\chi^2=10.68$; $p<0.01$

Within each of the three observation zones, day hikers accounted for the majority of soil and vegetation trampling observed, however, rock climbers accounted for about one-quarter of all observations of soil and vegetation trampling in the Forest Observation Zone (Table 4.6). In all three observation zones, backpackers accounted for the least amount of soil and vegetation trampling observed.

Table 4.6.
Percent of Observations of Soil/Vegetation Trampling, by Observation Zone and Type of Visitor

Cliff Zone (n=28)			Forest Zone (n=64)			North Zone (n=30)		
RC	H	BP	RC	H	BP	RC	H	BP
7%	89%	4%	27%	67%	6%	0%	90%	10%
$\chi^2=7.19$; $p=0.03$			$\chi^2=6.99$; $p=0.03$			$\chi^2=9.38$; $p=0.01$		

Note: RC=Rock Climber; H=Hiker; BP=Backpacker

Discussion and Management Implications

Resource impact measurement data show trampling disturbance present at all four LSMC sites (i.e., cliff-top, cliff-bottom, lower lookout, and campsites), characterized by vegetation loss, exposed soil, and root exposure. Documentation of visitor-caused trails, soil erosion, tree damage, and tree stumps provide further indicators of resource damage at LSMC. Of most concern are areas of disturbance at the cliff-top, the lower lookout, and the upper two campsites due to their potential for further expansion into adjacent known rare plant habitat (Hilke, 2002; Smith, 2002). Findings from the visitor use observation work provide insights into factors that may be driving visitor-caused impacts at LSMC and, coupled with the resource impact measurement data, are suggestive of potential management solutions.

Roughly one-third of all day hikers and rock climbers observed on the cliff-top of LSMC were seen trampling soil or vegetation. Consequently, as the resource data in this study show, large areas of bare soil and solid rock are already characteristic of the cliff-top. Previous recreation ecology research suggests that attempting to address these impacts through use limits would require substantial reductions in use or closure to improve resource conditions under these circumstances (Cole et al., 1987; Cole, 1992; Leung & Marion, 2000). Conversely, educating visitors about rare plants inhabiting LSMC and the consequences of trampling cliff-top vegetation may reduce the amount of travel off existing trails and sites (Cole et al., 1997; Marion & Reid, in press). For example, reduction of instances of trampling may be achieved by communicating minimum impact hiking practices such as Leave No Trace to visitors (www.LNT.org; Cole et al., 1987). Concentrating visitor use on trampling-resistant natural surfaces or on core bare substrates of existing recreation sites through spatial containment strategies may also reduce the extent of trampling impacts (Cole, 1992; Leung & Marion, 1999; Marion & Farrell, 2002).

Results of the visitor observation work in this study suggest day hiking use constitutes the majority of recreational activity at LSMC and is particularly concentrated on weekends and in the afternoon. Furthermore, day hikers were observed trampling soil and vegetation in all three observation zones more frequently than either rock climbers or backpackers. In addition, informal observations found that most day hikers entered LSMC from the north on the Appalachian Trail (Figure 4.1), with many entering the lightly impacted North Observation Zone because it offered the first cliff-top vista. Informal observations also suggest that while rock climbers tend to cluster at the top of climbing routes, day hikers were more likely to disperse along the cliff edge during crowded, peak use periods. Thus, day hikers may have been more likely to trample soil and vegetation in the Cliff Observation Zone as they sought a place to enjoy the cliff-top view away from other visitors. These findings suggest that educational efforts designed to promote low-impact visitor behaviors to minimize soil and vegetation trampling in the North and Cliff Observation Zones might be most productive if they are focused particularly on day hiking visitors.

While representing the lowest percentage of overall visitor use of LSMC, rock climbers' generally spend more time on the cliff-top than day hikers or backpackers. Eighty-nine percent of all trampling by rock climbers observed in this study occurred in the Forest Observation Zone. Informal observation data suggest the high percentage of trampling by rock climbers in the Forest Observation Zone is largely due to time spent constructing climbing anchors using trees. Resource impact measurements provide additional evidence in support of this explanation for the high percentage of trampling by rock climbers occurring in the Forest Observation Zone. In particular, virtually all bark damage on cliff-top trees occurred at the base of trees and was mostly due to abrasion from ropes used for climbing anchors. However, in contrast to findings of Kelly and Larson (1997), no severe tree damage was found on the LSMC cliff-top as a result of rock climbing use. Thus, efforts to reduce rock climbing-related impacts at LSMC should focus on reducing soil and vegetation trampling in the Forest Observation Zone. For example, the installation of fixed anchors on the cliff-edge would eliminate the need for rock climbers to use trees in the Forest Observation Zone to construct anchors and could therefore substantially reduce trampling in the Forest Observation Zone. In addition, installing fixed anchors on LSMC could minimize damage to cliff-top trees and cliff-edge vegetation caused by rope abrasion (Baker, 1999).

Visitor use of LSMC was found to be unevenly distributed, with day hiking, and to a lesser extent, rock climbing use particularly concentrated on weekends and during the afternoons. Enforcement of and perhaps a reduction in parking capacity at the Skyline Drive parking lot might help reduce use density during peak hours. These actions, combined with site management actions that concentrate use to already impacted locations on the cliff-top, may reduce the lateral expansion of trampling along the cliff-top.

In contrast to day hikers and rock climbers, results of this study suggest backpackers are less frequent LSMC visitors, spend the shortest length of time at the cliffs, and are less likely to trample soil and vegetation than day hikers and rock climbers. These findings are consistent with the general nature of backpacking, in which people are typically covering relatively long hiking distances and thus may occasionally stop to enjoy the view from LSMC, but often continue down the trail without spending sustained time at the cliffs. Thus, management actions designed to minimize visitor-caused impacts at LSMC should focus primarily on day hikers and rock climbers as described above.

The incidence of visitor-caused trails at LSMC is low and accounts for relatively little disturbance with the exception of the descent trail south of the cliffs. The descent trail is characterized by a high rate of erosion resulting in substantial soil loss and possible degradation of Shenandoah Salamander habitat (NPS, personal communication). Several factors exist that explain such large scale erosion, most importantly its direct ascent/descent alignment to the topography and steep grade, both of which are influential factors in trail erosion (Cole et al., 1987; Marion & Leung, 2001). Given the substantially degraded state of the descent trail and its unsustainable alignment, one possible management response would be to close the trail. However, it is likely that illegal use of the trail would occur as it provides the most direct access between the cliff-top and cliff-bottom. Thus, the application of site design/hardening measures such as installation of rock steps and tread hardening with stone is likely to be the most effective strategy for making the descent trail more sustainable (Birchard & Proudman, 2000; Marion & Leung, 2000). However, site design/hardening and related efforts to control erosion on the descent trail must also consider habitat protection for the Shenandoah Salamander (NPS, personal communication).

While characterized by less severe erosion than the descent trail, visitor-caused trails on the cliff-top are cause for concern as they may provide impetus for further site expansion and deterioration of areas containing rare plant populations such as the North Observation Zone (Cole, 1993; Cole et al., 1997; Leung & Marion, 2000). To prevent further site expansion associated with the use of visitor-caused trails on the cliff-top, managers might use rocks, natural vegetation, and woody debris to barricade these trails from use by visitors. Educating visitors about the importance of staying on formal trails may also discourage off trail hiking.

Resource impact data show campsites are large contributors to overall site disturbance at LSMC, accounting for nearly 25% of the total area of disturbance in the study area. Past efforts to reduce or eliminate use of the upper campsites through voluntary compliance have been unsuccessful (NPS, direct communication). Thus, effective reduction of impacts associated with campsite use at LSMC might instead require both limiting the number and size of overnight groups and restricting their use to designated, sustainably designed campsites (i.e., sidehill campsites) located away from the rare plant community along the cliff-top (Hilke, 2002; Leung & Marion, 1999; Marion & Farrell, 2002; Smith, 2002).

From a methodological perspective, standard point sampling trail condition assessment methods were readily adapted for documenting the extent and condition of cliff-related visitor-caused trails. The shorter lengths of these trails required the use of variable sampling intervals to match trail length to sampling intensity. Standard campsite condition assessment procedures were also adaptable in measuring cliff-related recreation sites. The linear spatial arrangement of these sites required use of multiple, arbitrarily defined, recreation sites with findings aggregated by cliff location (e.g., cliff-top, cliff-bottom) for presentation. Use of permanently marked recreation site reference points and GPS technology also enables accurate repeat measurements for the purpose of monitoring changes in these conditions over time.

Finally, to the best of the authors' knowledge, this is the first study to have adapted visitor observation methods to document recreational use and behavior to help determine the causes of resource impacts in a cliff environment. In particular, techniques used to observe the amount and type of cliff-top recreational use were combined with methods to study LSMC visitor behaviors. Further, quantitative observation measures were supplemented with informal observations designed to help explain the quantitative observation results. Findings from the quantitative and informal observation data provide a means for interpreting the results of resource impact measurements, resulting in an integrative assessment of cliff resource conditions and recreational use at LSMC.

Conclusion

The research presented in this paper addressed important gaps in previous cliff impact studies by broadening the scope to include assessing the effects of non-climbers. This was accomplished by measuring trampling impacts to cliff-related trails, recreation sites, and campsites, and by incorporating visitor observation to gain greater insights into how different use types and behaviors contribute to cliff resource impacts. The documentation of resource impacts, particularly those which threaten rare and endangered species inhabiting LSMC provides a detailed account of present site conditions in addition to indicators of future conditions if visitor use of the cliff-top proceeds without intervention. Visitor observation offers several insights into contributory factors of cliff-top resource damage by showing differences in use and behavior between visitor types. The findings from this study suggest that a management approach characterized by visitor education, some site hardening, and concentration of visitor use on durable surfaces, along with the installation of fixed anchors at the top of popular climbing routes is likely to have the greatest success at balancing visitor enjoyment with resource protection at LSMC.

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APPENDIX A
CLIFF SITE VISITOR IMPACT MONITORING MATERIALS

Cliff Site Visitor Impact Monitoring Manual

Cliff Site Visitor Impact Monitoring Manual
Shenandoah National Park[1,2]

(*version 6/23/05*)

This manual describes procedures for conducting inventories and resource condition assessments necessary to document changes in the condition of cliff resources from hiking and climbing activities. It was developed for assessing conditions at cliff sites within Shenandoah National Park. Three general approaches are used for assessing cliff site conditions: 1) photographs from permanently referenced photo points, 2) a condition class assessment determined by visual comparison with six described levels of trampling impact, and 3) predominantly measurement-based assessments of several impact indicators. Additional monitoring practices are described in an associated Trail Monitoring Manual for assessing associated trail impacts.

For the purposes of this manual, cliff sites are defined as backcountry areas of disturbed vegetation, surface litter, or soils caused by human use at the base or top of cliffs, excluding associated trails. In areas with multiple sites or use areas there may not always be undisturbed areas separating sites and an arbitrary decision may be necessary to define separate sites.

Monitoring measurements should be taken near the middle or end of the visitor use season but before leaf fall. Site conditions generally recover during the fall/winter/spring periods of lower visitation and reflect rapid impact during early season use. Site conditions are more stable during the mid- to late-use season and reflect the resource impacts of that year's visitation. Subsequent assessments should be completed as close in timing to the original year's measures as possible. Generally monitoring should be replicated at 3-5 year intervals, unless conditions are changing rapidly.

Materials

(Check before leaving for the field)

- Topographic maps (1/24,000) with copier enlargements of areas with dense concentrations of sites (cut out and copy scale bars with enlargements)
- Compass, peephole type (not corrected for declination) and/or KVH Data Scope, digital compass
- Tape measure (100 ft. in tenths) and/or Sonin Combo Pro distance measuring device
- Field forms, maps, and photographs from previous surveys
- Flagged wire pins (25 minimum w/additional set of different color for remeasurement)
- Large steel reference point stake
- Digital camera, w/batteries, charger, extra memory cards or computer/cords to download images
- Aluminum numbered tags, 4 in. galvanized steel nails
- Clipboard, monitoring manual, blank field forms (some on waterproof paper), pencils
- Backpacking trowel
- Magnetic pin locator (site remeasurement only)

1 - Developed by Dr. Jeff Marion, USGS Patuxent Wildlife Research Center, Cooperative Park Studies Unit, Virginia Tech/Department of Forestry (0324), Blacksburg, VA 24061 (540/231-6603) email: jmarion@vt.edu.

2 - Photographs illustrating site boundaries, boundary flag placement, vegetative ground cover classes, soil exposure, tree damage, and root exposure are part of this manual. High quality reproductions of these photographs, some of which are in color, may be found in: Marion, Jeffrey L. 1991. Developing a natural resource inventory and monitoring program for visitor impacts on recreation sites: A procedural manual. USDI, National Park Service, Natural Resources Report NPS/NRVT/NRR-91/06, pages 46-51.

General Cliff Site Information

1) **<u>Site Number</u>**: Each site must have a unique aluminum tag number. Refer to site maps and forms from earlier surveys to identify if the site has been previously surveyed. If it has, follow the site remeasurement procedures below. If the site has not been previously surveyed then assign a new number from an aluminum tag and record it on the form. Criteria for locating the permanent reference point are provided in the Variable Radial Transect section of the manual. If it is impossible to bury an aluminum tag (e.g., due to bedrock), the same numbering system as above should be applied as if aluminum tags were used. If a tag is not buried it should be separated and disposed of to avoid confusion at subsequent sites. If it is a shelter site, bury the tag adjacent to the left front shelter corner post, just under the shelter. Regardless, remarks should be made on the field form indicating whether and/or where a tag was buried.

   <u>Site remeasurement</u> - Examine mapped site locations and field forms to determine if each site was present during the previous survey. Relocate permanent reference points with information from the form and the pin locator and verify site numbers by digging up the number tags. If the site has been previously surveyed but you are unable to locate the nail and tag then record the old number (if positively known) with a note that the nail and tag could not be found. If the reference point can be accurately identified from the previous survey form information and photo then do so, noting this on the new form. Use a new site tag and number, however, and record both old and new numbers on the form. If the reference point cannot be identified then proceed as if the site had never been surveyed before, recording new reference site information and the old and new tag numbers.

   <u>Note</u> – Guidance for odd situations: 1) A satellite use area has become the main site and the previous site is now a satellite site or has recovered. Use the same site number from the earlier survey. Relocate and dig up the nail and tag from the old site. Rebury the nail in the original location, moving the tag along with a new nail to a permanent reference point location on the current site (which was formerly a satellite site). Complete all procedures on the current site. Describe the situation in the comments section. 2) The site was rehabilitated by park staff or has recovered on its own. Complete a new form to allow an evaluation of site recovery for any sites that you can find. Take a photo from previous survey photo points.

2) **<u>Site Type</u>**: Record the most specific applicable code: **L** - current site, also present in last survey; **N** - new site; **S** - current site, satellite in last survey; **RL** - rehabilitated, present in last survey; **RN** - rehabilitated, new site; **SRE** - site is recovered, rehab work evident; **SRN** - site is recovered, no rehab.

3) **<u>Location</u>**: a) Record the cliff code (e.g., C62), and b) Record the cliff name.

4) **<u>UTM Coordinates</u>**: Record the location of the permanent reference point using a GPS device. If necessary do an offset to get an accurate site location.

5) **<u>Date</u>**: Month, day, and year the site was evaluated (e.g. July 1, 2005 = <u>06/01/05</u>).

   <u>Site remeasurement</u> - Due to phenological and site use changes which occur over the use season, it is critical that sites be re-measured as close to the initial assessment month and day as possible, preferably within 1 to 2 weeks if early in the use season, 3 to 4 weeks if later.

6) **<u>Inventoried by</u>**: Identify the field personnel responsible for site.

Locate/Label Site on Topographic Map - Mark the topographic map with a dot precisely indicating the site=s location and label with its site tag number. Be as accurate as possible. At 1/24,000 scale 1/4 inch on map = 500 ft. on ground. Accurate site location descriptions are critical to site relocation. For dense clusters of sites use 150% copier enlargements so that sites can be more accurately mapped.

Describe Location - Describe the site location using local geographic features (trail intersections, large boulders or trees) and paced (or measured) distances. Record the distance of your pace in parentheses, for example: 18 paces (5.5'), each time you record a paced distance. Conversions will be done in the office. Verify your pace periodically. Use sufficient descriptive detail and additional local area maps as so that someone else years later can relocate the site.

Inventory Indicators

7) **Site Expansion Potential**: P = Poor expansion potential - off-site areas are completely unsuitable for any expansion due to steep slopes, rockiness, dense vegetation, and/or poor drainage, M = Moderate expansion potential - off-site areas moderately unsuitable for expansion due to the factors listed above, and G = Good expansion potential - off-site areas are suitable for site expansion, features listed above provide no effective resistance to site expansion.

8) **Site Slope**: Record the site slope category (F = <5% M = 5-10% S = >10%)

9) **Tree Canopy Cover**: Imagine that the sun is directly overhead and estimate the percentage of the site that is shaded by the tree canopy cover. Note: use category 5 for nearly full to full tree canopy cover over the site; use category 6 only if the cover is fairly dense or thick.
(1 = 0-5% 2 = 6-25% 3 = 26-50% 4 = 51-75% 5 = 76-95% 6 = 96-100%)

10) **Use Type**: Mixed Climbing/Hiking = MCH, Mostly Climbing = MC, Mostly Hiking = MH

11) **Use Level**: Low = L, Moderate = M, Heavy = H

12) **Cliff Location**: Top = T, Base = B

13) **Climbing Type**: Mixed Sport/Trad = MST, Mostly Sport = MS, Mostly Trad = MT, or NA

14) **Climbs**: Record the number of different climbs in the immediate vicinity of the impacted area.

Impact Indicators

The first step is to establish the sites' boundaries and measure its size. The following procedures describe the use of the **Variable Radial Transect Method** for determining the sizes of sites. This is accomplished by measuring the lengths of linear transects radiating from a permanently defined reference point to the site boundary. **If the site has previously been assessed with the Variable Radial Transect Method, then skip to the Site Remeasurement procedures below.**

Step 1. Identify Site Boundaries and Flag Transect Endpoints. Walk the site boundary and place flagged wire pins at locations which, when connected with straight lines, will define a polygon whose area approximates the site area. Include the shelter within site boundaries. Use as few pins as necessary, typical sites can be adequately flagged with 10-15 pins. Look both directions along site boundaries as you place the flags and try to balance areas of the site that fall outside the lines with off-site (undisturbed) areas which fall inside the lines. Pins do not have to be placed on site boundaries, as demonstrated in the diagram in Figure 1. Project site boundaries straight across areas where trails enter the site. Identify site boundaries by pronounced changes in vegetation cover, vegetation height/disturbance, vegetation composition, surface organic litter, and topography (refer to photographs following these procedures). Many sites with dense forest overstories will have very little vegetation and it will be necessary to identify boundaries by examining changes in organic litter, i.e. leaves which are untrampled and intact vs. leaves which are pulverized or absent. In defining the site boundaries be careful to include only those areas that appear to have been disturbed from human trampling. Natural factors such as dense shade can create areas lacking vegetative cover. Do not include these areas if they appear "natural" to you. When in doubt, it may also be helpful to speculate on which areas typical visitors might use based on factors such as slope or rockiness. If you cannot discern trampling-related disturbance boundaries for most of the site then skip this procedure, record a 0 for site area (#28) and move on to #14.

Step 2. <u>Establish Site Reference Point.</u> Select a site reference point which is preferably: a) visible from all the site boundary pins, b) close to and easily referenced by distinctive permanent features such as boulders or trees, and c) in a spot permitting the burial of the reference point nail and site tag. Reference this point to at least three relatively permanent and distinctive features. If trees are used select ones that are healthy and unique to the site area, such as an uncommon species or with unique physical characteristics (forked trunk or large size). Try to select reference features in three opposing directions, as this will enable future workers to triangulate the reference point location. Also take the reference point photograph(s) and reference the photopoint(s) as described at the end of this manual.

For each reference feature, take a compass bearing (nearest degree) and measure the distance (nearest 1/10th foot) from the feature (center of trees or the highest point of boulders) to the site reference point. Also measure the approximate diameter of reference trees at 4.5 ft above ground (dbh). <u>Be extremely careful in taking these bearings and measurements as they are critical to relocating the reference point in the future.</u> Record this information on the back of the form.

Examples:
1) Red Maple, 2.9 ft. dbh, 8.9 ft. at 195° (largest tree on site)

2) Boulder, 7.9 ft. at 312°, (distance and bearing to highest point)

3) Sycamore, 1.8 ft. dbh, 8.4 ft. at 78°, (only Sycamore in the area)

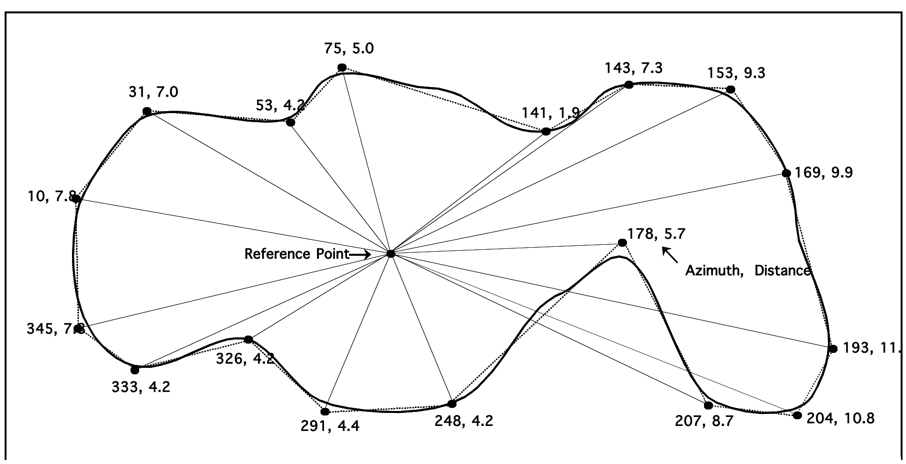
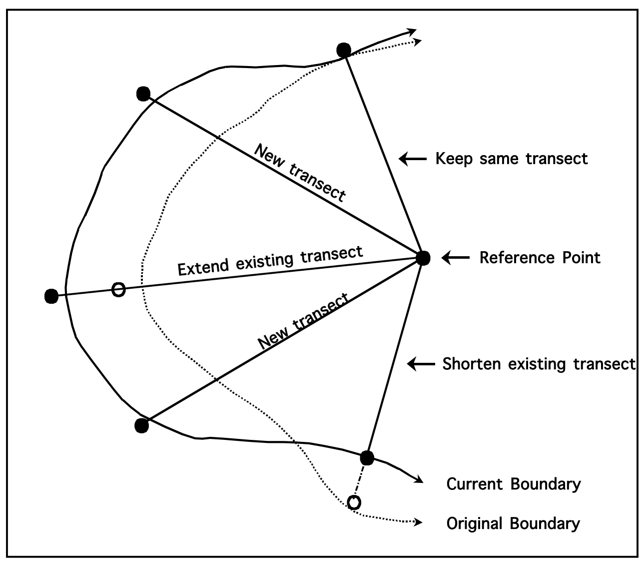


Figure 1. Variable radial transect method.

<u>Options</u>: Some sites may lack the necessary permanent reference features enabling the point to be accurately relocated. If only one or two permanent reference features are available, use these and take additional photographs from several angles. If you are unable to bury a nail and tag (e.g. bedrock) then select a permanent feature (e.g., some obvious bedrock feature) and use it as a reference point. Complete procedures to reference its location, including photographs. <u>Note your actions regarding use of these options in the Comments section</u>.

Step 3. Record Transect Azimuths and Lengths. Standing directly over the reference point, identify and record the compass bearing (azimuth) and distance to each site boundary pin working in a clockwise fashion (in the exact order you would encounter them if you were walking the site boundary). Be careful not to miss any pins hidden behind vegetation or trees. Be extremely careful in identifying the correct compass bearings to these pins as error in these bearings will bias current and future measurements of site size. If a tape measure is used, anchor the end to the large steel reference point stake and route it via the shortest distance around trees or other obstructions. Record the length of each transect (nearest 1/10th foot), starting with the same boundary pin and in the same clockwise order as before. Be absolutely certain that the appropriate pin distances are recorded adjacent to their respective compass bearings. Leave boundary pins in place until you finish all other site measurements.

Step 4. Measure Island and Satellite Areas. Identify any undisturbed "islands" of vegetation (∃ 3x3 feet) inside site boundaries (often due to clumps of trees or shrubs) and disturbed "satellite" use areas (∃ 3x3 feet) outside site boundaries (often due to tent sites or cooking sites). Use site boundary definitions for determining the boundaries of these areas. Use the **Geographic Figure Method** to determine the areas of these islands and satellites (refer to the Figure 3 diagrams at the end of the manual). This method involves superimposing one or more imaginary geometric figures (rectangles, circles, or right triangles) on island or satellite boundaries and measuring appropriate dimensions to calculate their areas. Record the types of figures used and their dimensions on the back of the form; the sizes of these areas should be computed in the office with a calculator. Also, record the compass bearing and distance from the center of each island or satellite site to the site reference point. Remove the reference point stake. Place a 4 inch long galvanized steel nail through the hole in the site number tag and bury at the reference point so that the tag is 3 inches deep.



Site Remeasurement - Relocate the reference point using point references, photos, and a magnetic pin locator. Typically the photo will get you in the right area and the pin locator will allow you to pinpoint the buried nail and tag. If you cannot find it then search for the three reference features, go to each and shoot the back azimuth (small number scale in the peep hole compass viewfinder). Use the tape measure to determine the correct distance and draw an arc on the ground. If the pin locator still does not register then repeat procedure from the other reference features and reestablish the reference point with a new tag and nail (note new site number on form and in database). Insert the large steel stake at the reference point location and reestablish all former site boundary pins using the previous transect data compass bearings and distances. Place wire flags on a single color at each the transect endpoints. Next, reassess these previous boundary locations using the following procedures (illustrated in Figure 2). Place wire flags of a different color at the end of each reassessed transect, both pre-existing and new (including transects whose length has not changed).

a) Keep the same transect length if that length still seems appropriate, i.e. there is no compelling reason to alter the initial boundary determination.

b) Record a new transect length if the prior length is inappropriate, i.e. there is compelling evidence that the present boundary does not coincide with the pin and the pin should be relocated either closer to or further from the reference point along the prescribed compass bearing.

c) Repeat earlier Steps 1 and 3 to establish additional transects where necessary to accommodate changes in the shape of site boundaries. Also repeat Step 4 to account for changes in island and satellite sites. If satellite areas are no longer disturbed, i.e. condition class 0, then note this in the Comments and do not remeasure their size.

d) Take and record new distances and compass bearings for transects that have changed in length and for new transects using the flags denoting <u>current</u> site boundaries. For transects that have not changed in length, copy the old transect data to the new forms (reassessing these would introduce measurement error). Record all transect data on the new form in the exact order you would encounter each transect if you walked the site boundary in a clockwise direction.

Figure 2. Transect site remeasurement procedures.

These procedures are designed to eliminate much of the measurement error associated with different individuals making subjective judgments on those sites or portions of sites where boundaries are not pronounced. These procedures may only be used for sites whose reference points can be relocated.

15) **<u>Condition Class</u>**: Record a site Condition Class using the descriptions below. If a site is underlain entirely by bedrock record "-1" for this item and items 15 - 17 as they are not applicable for bedrock sites. Include an explanation in the field form under Comments.

Class 0:	Site barely distinguishable; no or minimal disturbance of vegetation and /or organic litter. Often an old site that has not seen recent use.
Class 1:	Site barely distinguishable; slight loss of vegetation cover and /or minimal disturbance of organic litter.
Class 2:	Site obvious; vegetation cover lost and/or organic litter pulverized in primary use areas.
Class 3:	Vegetation cover lost and/or organic litter pulverized on much of the site, some bare soil exposed in primary use areas.
Class 4:	Nearly complete or total loss of vegetation cover and organic litter, bare soil widespread.
Class 5:	Soil erosion obvious, as indicated by exposed tree roots and rocks and/or gullying.

16) **<u>Vegetative Ground Cover On-Site</u>**: An estimate of the percentage of <u>live non-woody</u> vegetative ground cover (including herbs, grasses, and mosses and excluding tree seedlings, saplings, and shrubs) within the flagged site boundaries using the coded categories listed below (refer to photographs following these procedures). <u>Include any disturbed "satellite" use areas and exclude undisturbed "islands" of vegetation.</u> For this and the following two indicators, it is often helpful to narrow your decision to two categories and concentrate on the boundary that separates them. For example, if the vegetation cover is either category 2 (6-25%) or category 3 (26-50%), you can simplify your decision by focusing on whether vegetative cover is greater than 25%.

	1 = 0-5%	2 = 6-25%	3 = 26-50%	4 = 51-75%	5 = 76-95%	6 = 96-100%
Midpoints:	2.5	15.5	38	63	85.5	98

<u>Site remeasurement</u> - Also evaluate vegetative ground cover within the site boundaries identified during the last measurement period.

17) **<u>Vegetative Ground Cover Off-Site</u>**: An estimate of the percentage of <u>live non-woody</u> vegetative ground cover (including herbs, grasses, and mosses and excluding tree seedlings, saplings, and shrubs) in an adjacent but largely undisturbed "control" area. Use the categories listed above. The control site should be similar to the site in slope, tree canopy cover (extent of sunlight penetration),

and other environmental conditions. The intent is to locate an area which would closely resemble the site area had the site never been used. In instances where you cannot decide between two categories, select the category with less vegetative cover. The rationale for this is simply that the first visitors would have selected a site with the least amount of vegetation.

Site remeasurement - Start by reexamining the off-site vegetative cover estimate from the last measurement period. Use this value only if it remains an appropriate estimate.

18) **Exposed Soil**: An estimate of the percentage of exposed soil, defined as ground with very little or no organic litter (partially decomposed leaf, needle, or twig litter) or vegetation cover, within the site boundaries and satellite use areas (refer to the photographs following these procedures). Dark organic soil, the decomposed product of organic litter, should be assessed as bare soil when its consistency resembles peat moss. Assessments of exposed soil may be difficult when organic litter forms a patchwork with areas of bare soil. If patches of organic material are relatively thin and few in number, the entire area should be assessed as bare soil. Otherwise, the patches of organic litter should be mentally combined and excluded from assessments. Soil covered by a shelter should be counted as exposed soil. Code as for vegetative cover above.

Site remeasurement - Also evaluate exposed soil within the site boundaries identified during the last measurement period.

Tree Damage: Tally each live tree (>1 in. diameter at 4.5 ft.) within or on site boundaries to one of the tree damage rating classes described below (refer to the photographs following these procedures). **Include** trees within undisturbed "islands" and **exclude** trees in disturbed "satellite" areas. Assessments are restricted to all trees within the flagged site boundaries in order to ensure consistency with future measurements. Multiple tree stems from the same species that are joined at or above ground level should be counted as one tree when assessing damage to any of its stems. Assess a cut stem on a multiple-stemmed tree as tree damage, not as a stump. Do not count tree stumps as tree damage. Take into account tree size. For example, damage for a small tree would be considerably less in size than damage for a large tree. Where obvious, assess trees with scars from natural causes (e.g., lightning strikes) as None/Slight.

None/Slight...... No or slight damage such as broken or cut smaller branches, one nail, or a few superficial trunk scars.
Moderate .... Numerous small trunk scars and/or nails or one moderate-sized scar.
Severe............... Trunk scars numerous with many that are large and have penetrated to the inner wood; any complete girdling of tree (cutting through tree bark all the way around tree).

Site remeasurement - begin by assessing tree damage on all trees within the site boundaries identified in the last measurement period. Place boxes around each tally for trees in areas where boundaries have moved closer to the reference point, i.e., former site areas which are not currently judged to be part of the site. Next, assess tree damage in areas where boundaries have moved further from the reference point, i.e., expanded site areas that are newly impacted since the last measurement period. Circle these tallies. These additional procedures are necessary in order to accurately analyze changes in tree damage over time.

22-24) **Root Exposure**: Tally each live tree (>1 in. diameter at 4.5 ft.) within or on site boundaries to one of the root exposure rating classes described below. **Include** trees within undisturbed "islands" and **exclude** trees in disturbed "satellite" areas. Assessments are restricted to all trees within the flagged site boundaries in order to ensure consistency with future measurements. Where obvious, assess trees with roots exposed by natural causes (e.g., stream/river flooding) as None/Slight.

None/Slight...... No or slight root exposure such as is typical in adjacent offsite areas.
Moderate .... Top half of many major roots exposed more than one foot from base of tree.
Severe.............. Three-quarters or more of major roots exposed more than one foot from base of tree; soil erosion obvious.

Site remeasurement - Begin by assessing root exposure on all trees within the site boundaries identified in the last measurement period. Place boxes around each tally for trees in areas where boundaries have moved closer to the reference point, i.e., former site areas which are not currently judged to be part of the site. Next, assess root exposure in areas where boundaries have moved further from the reference point, i.e., expanded site areas that are newly impacted since the last measurement period. Circle these tallies. These additional procedures are necessary in order to accurately analyze changes in root exposure over time.

25) **Number of Tree Stumps**: A count of the number of tree stumps (> 1 in. diameter at ground and less than 4.5 feet tall) within or on site boundaries. **Include** trees within undisturbed "islands" and **exclude** trees in disturbed "satellite" areas. Do not include windthrown trees with their trunks still attached or cut stems from a multiple-stemmed tree.

Site remeasurement - begin by assessing stumps within the site boundaries identified in the last measurement period. Place boxes around each tally for stumps in areas where boundaries have moved closer to the reference point, i.e., former site areas which are not currently judged to be part of the site. Next, assess stumps in areas where boundaries have moved further from the reference point, i.e., expanded site areas that are newly impacted since the last measurement period. Circle these tallies. These additional procedures are necessary in order to accurately analyze changes in stumps over time.

26) **Access Trails**: A count of all trails leading away from the outer site boundaries. For trails that branch apart or merge together just beyond site boundaries, count the number of separate trails at a distance of 10 ft. from site boundaries. Do not count extremely faint trails that have untrampled tall herbs in their tread.

27) **Human Waste**: Follow all trails connected to the site to conduct a quick search of likely "toilet" areas, typically areas just out of sight of the site. Count and record the number of individual human waste sites, defined as separate locations with human feces present. The intent is to identify the extent to which improperly disposed human feces is a problem.

28) **Total Site Area**: Using a computer program (contact Jeff Marion), compute the site size using the transect data. Using a calculator, compute and sum the area of each island and satellite site (see the *Geometric Figure Method* sheet for procedures and formulas). Record these values in the spaces provided on the back of the form and calculate the Total Site Area. Record this value on the front of the form to facilitate computer data entry.

Comments: An informal list of comments concerning the site: note any assessments that you felt were particularly difficult or subjective, problems with monitoring procedures or their application to this particular site, suggestions for clarifying monitoring procedures, descriptions of particularly significant impacts beyond site boundaries (quantify if possible), excessive litter, human waste, or any other comments you feel may be useful.

Site/Reference Point Photographs: If the site has been previously surveyed, relocate the photo point and use it again. Frame your photo and adjust zoom lens to include the same area depicted in the earlier photo(s). If the site has expanded to areas that are not visible in the viewfinder then turn the camera to capture these areas or move back if necessary (and remeasure photo point distance). If the site has not been previously surveyed, select a vantage point that provides the best view of the site and reference point location. Try to select a location that clearly shows the reference point location in relation to nearby trees or boulders. It is best to have a person stand at the reference point with no one else in the photo. Also take a separate reference point photograph from a closer position that clearly identifies this point in relation to permanent site features. Place the tape measure or some other object against the reference point stake so that it is clearly visible in the camera viewfinder. For both photos leave the camera lens set at a 35-38mm focal length. Take photos with the camera pointed camera down to include as much of the site groundcover as possible. If a camera with a date/time recorder is used (preferred), record the date/time on the field form. ***Photo description procedures***: Use the photo description space to record the photo numbers and to write something unique about the photo that will allow someone to recognize and label the photo for this site. Also record the date and time the photo was taken.

Record the compass bearing and distance from the permanent reference point to the site photopoint (you may be able to use one of the site boundary flags as the photopoint). The intent is to obtain a photograph that includes as much of the site as possible to provide a photographic record of site conditions. The photo will also allow future workers to make a positive identification of the site and assist in relocating the permanent reference point. The location of the reference point photo does not need to be measured or recorded. At the earliest possible time, label the backs of 3x5 prints with the site number, date, film roll number, photograph number, bearing, and distance. Also, label and store the negatives. Store the photographs separately from the survey forms. An opaque plastic box should be used for long-term photo and negative storage.

* **Bury reference point nail and tag about 3 inches deep, compact soil with foot. Collect all site boundary pins, the reference point stake, and all other equipment.**

Equipment Use Procedures

Use of Peep Hole Compasses: Hold the compass level with the viewfinder close to your eye and away from any metal objects. The top of the white floating scale should be centered in the viewfinder. With your chin over the reference point, align the object with the vertical black line in the viewfinder. Hold the compass very steady, allowing the compass scale to come to a rest. Read and record the bearing to the nearest degree. Be careful in reading the bearing from the scale, use large numbers (small numbers are the back azimuth) and note that scale values decrease from left to right. Large-scale interval is 5 degrees, smallest interval is 1 degree. Practice and periodically compare compass readings with your partner to verify their accuracy. (Cost: $42)

Use of KVH Datascope: Read Datascope manual. We will only use the compass bearing function (the distance function is intended only for estimates of long distances). Remove and safely store both lens caps. Hold the datascope approximately level (though it is gimballed for tilt angles up to ∀20$^{o)}$ and away from metal objects. Focus on target by turning rubber eyecup. Turn unit on by pressing any button (it shuts off automatically after 2 minutes of inactivity). If necessary, press the white Amode@ button until you see the ABearing@ mode inside viewfinder. Push both green and black buttons so that the word ABearing@ begins flashing, it is now in continuous scanning and averaging mode. Sighting through the unit, superimpose the vertical line on your target, hold the unit very steady. Read and record the compass bearing to the nearest 2 of a degree. Replace lens caps and store in protective case following use. Accuracy is ∀0.5^{o}, *if used correctly*. The Datascope is waterproof and shockproof but lets not do any product testing - be careful! **Batteries**: Carry spare batteries (3 3-volt #2025 lithium). Unit must be recalibrated each time batteries are replaced or used in a location where the magnetic field is widely different from where it was last calibrated - see manual for procedures. (Cost: $470)

Use of Sonin Combo Pro: Read the Sonin manual. We will only use it in the target or dual unit mode. Turn main Areceiver@ unit on by pressing switch up to the double icons, turn Atarget@ unit on and slide the protector shield up. The units power down automatically after 4 minutes of inactivity. Position units at opposite ends of segment to be measured, pointing the receiver sensors in a perpendicular orientation towards the target sensors. **Note:** The measurement is calculated from the base of the receiver and the back of the target, position units accordingly so that you measure precisely the distance your intended. Press and hold down the button with the line over the triangle symbol. The receiver will continue to take and display measurements as long as you depress the button. Wait until you achieve a consistent measurement, then release the button to freeze the measurement. Measures initially appear in feet/inches. To obtain conversions, press and hold the AC@ button until the measure is converted to the units you want (tenths of a foot). Turn both devices off and store in protective case following use. Unit range is supposed to be 250 ft.; be careful and take multiple measures for distances over 100 ft. Under optimal conditions accuracy is within 4 in. at 60 ft. Device can be affected by temperature, altitude and barometric pressure, and noise (even strong wind). The units are not waterproof. **Batteries**: Carry spare batteries (2 9-volt alkaline). (Cost: $185)

Geometric Figure Method

This method for determining the area of sites, disturbed "satellite" sites, and interior undisturbed "island" sites is relatively rapid and can be quite accurate if applied with good judgment. Begin by carefully studying the site's shape, as if you were looking down from above. Mentally superimpose and arrange one or more simple geometric figures to closely match the site boundaries. Any combination and orientation of these figures is permissible, see the examples below. Measure (nearest 1/10th foot) the dimensions necessary for computing the area of each geometric figure. It is best to complete area computations in the office with a calculator to reduce field time and minimize errors.

Good judgment is required in making the necessary measurements of each geometric figure. As boundaries will never perfectly match the shapes of geometric figures, you will have to mentally balance disturbed and undisturbed areas included and excluded from the geometric figures used. For example, in measuring an oval site with a rectangular figure, you would have to <u>exclude</u> some of the disturbed area along each side in order to balance out some of the undisturbed area <u>included</u> at each of the four corners. It may help, at least initially, to place plastic tape or wire flags at the corners of each geometric figure used. In addition, be sure that the opposite sides of rectangles or squares are the same length.

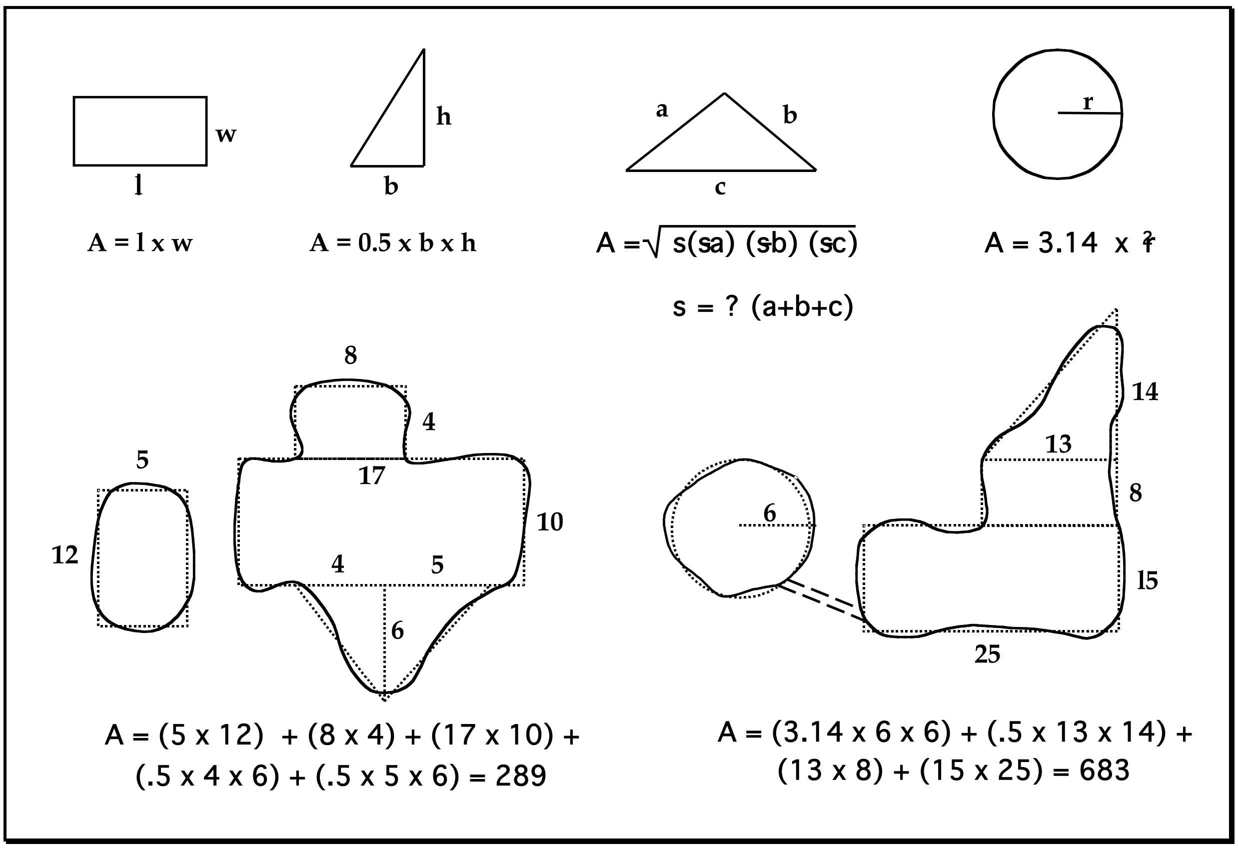


Figure 3. Geometric figure method for assessing site sizes.

Cliff Site Visitor Impact Monitoring Form

Cliff Site Visitor Impact Monitoring Form, Shenandoah NP

ver. 6/23/05

General Site Information

1) Site Tag No. __ __ __ __ 2) Site Type _____ 3) Location Code/Name _________________

4) UTM Coordinates ____________________

5) Date _ _ / _ _ / _ _ 6) Inventoried by: ______________ Locate/Label Site on Map _____

Describe Location: ____

____

____

Inventory Indicators

7) Site Expansion Potential: P M G _____

8) Site Slope: (**F** = <5% **M** = 5-10% **S** = >10%) __

9) Tree Canopy Cover: (**1**=0-5% **2**=6-25% **3**=26-50% **4**=51-75% **5**=76-95% **6**=96-100%) _____

10) Use Type: Mixed Climbing/Hiking = MCH, Mostly Climbing = MC, Mostly Hiking = MH _______

11) Use Level: Low = L, Moderate = M, Heavy = H _____

12) Cliff Location: Top = T, Base = B _____

13) Climbing Type: Mixed Sport/Trad = MST, Mostly Sport = MS, Mostly Trad = MT, or NA _____

14) Climbs: _____

Impact Indicators -- *Apply Variable Radial Transect Method* --

15) Condition Class (0 to 5) _____ ***Previous B.***

16) Vegetative Ground Cover On-Site (Use categories below) _____ _____

	(**1**=0-5%	**2**=6-25%	**3**=26-50%	**4**=51-75%	**5**=76-95%	**6**=96-100%)
Midpoints:	2.5	15.5	38	63	85.5	98

17) Vegetative Ground Cover Off-Site (Use categories above) _____ _____

18) Exposed Soil (Use categories above) _____ _____

19-21) Tree Damage None/Slight ____________________ Moderate _______________________Severe _________

22-24) Root Exposure None/Slight ____________________ Moderate _______________________ Severe _________

25) Tree Stumps (#)________________________ _____

26) Access Trails (#) _____

27) Human Waste (#) _____

28) Total Site Area (Office) _____ft^2

Cliff Site Visitor Impact Monitoring Form, Shenandoah NP

ver. 6/23/05

Comments/Recommendations:____

____

____

____

Site Photo: Photo # ____ Bearing ____ Distance _____ ft Date/time: _____________

Description: ____

Ref. Pt. Photo #: ____ Description ____

Site Reference Point Information

1)

2)

3)

Bury Nail/Tag ___

Satellite Site Dimensions	Bearing	Distance

Island Site Dimensions	Bearing	Distance

Area from computer program ___________

\+ Satellite Area ________

! Island Area ________

= Total Site Area ________ ft^2

Transect Data

	Bearing	Distance (ft)
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		
9)		
10)		
11)		
12)		
13)		
14)		
15)		
16)		
17)		
18)		
19)		
20)		

APPENDIX B
CLIFF TRAIL VISITOR IMPACT MONITORING MATERIALS

Cliff Trail Visitor Impact Monitoring Manual

Cliff Trail Visitor Impact Monitoring Manual
Shenandoah National Park[1]

(*version 6/29/05*)

This manual describes standardized procedures for conducting an assessment of resource conditions on recreation trails used to access cliffs. The principal objective of these procedures is to document the number and lineal extent of visitor-created cliff-access trails and to monitor changes in their condition. All continuous visitor-created trails to cliffs and in the vicinity of cliffs will be surveyed and GPS devices will also be used to record their location for computer mapping. These procedures rely on a sampling approach to characterize trail conditions from measurements taken at transects located every 300 ft (91 m) along selected trail segments. For trails less than 2400 ft (.45 miles) consult Table 1 for reduced sample point interval distances necessary to accurately characterize conditions on shorter trails. Values are calculated to include about 8 sample points for each trail segment (fewer for the shortest distances). Distances are assessed with a measuring wheel.

Trail condition measurements are applied at sample points to document the trail's width, depth, substrate, grade, and other characteristics. These procedures take about 2 minutes to apply at each sample point. Data is summarized through statistical analyses to characterize resource conditions for each trail segment. During future assessments it is not necessary to relocate the same sample points for repeat measures. Survey work should be conducted during the middle or end of the primary use season and during the growing season. This is necessary because determinations of trail boundaries are based on trampling-related disturbance to ground vegetation and leaf litter. Subsequent surveys should be conducted at approximately the same time of year.

Table 1. Sample point intervals for trails <2400 ft (.45 mi).

Interval (ft)	Trail Length (ft)
300	>2400
250	1801-2400
175	1201-1800
100	601-1200
75	301-600
50	51-300
1	<51

Materials

This manual and supply of data forms (some on waterproof paper), pencils, clipboard with compartment for forms, measuring wheel (one that removes distance when backed up), topographic and driving maps, clinometer, 12 ft tape measure (25 ft for wide trails), metal stakes (3), compass, 25 ft of thick non-stretchable line marked off every 0.3 feet on a spool.

Point Sampling Procedures

Trail Segments: Assess all visitor-created trails that are readily discernable, generally based on vegetation and/or organic litter trampling that has occurred during the survey year. In some places there are single trails that access a cliff top or base or a campsite. In others there is a network of trails, often interconnected and accessing the same destinations.

1 - Developed by Dr. Jeff Marion, USGS Patuxent Wildlife Research Center, Cooperative Park Studies Unit, Virginia Tech/Department of Forestry (0324), Blacksburg, VA 24061 (540/231-6603) email: jmarion@vt.edu.

1) **Trail Segment Code:** Record a unique trail segment code based on the cliff code.

2) **Cliff Name:** Record the name for the cliff area.

3) **Surveyors:** Record initials for the names of the trail survey crew.

4) **Date:** Record the date (mm/dd/yr) the trail was surveyed.

5) **Use Type**: Mixed Climbing/Hiking = MCH, Mostly Climbing = MC, Mostly Hiking = MH, MB = Mostly Biologists

6) **Use Level**: Low = L, Moderate = M, Heavy = H

Starting/Ending Point: Use a GPS device to assess and record UTM waypoint data for each trail segment's start and end points, except for trails <25 ft where only a single point is recorded where the trail departs from the initial trail. Turn on the GPS's tracking feature and leave it on for the duration of the survey work.

Measuring Wheel Procedures: Either wheel or pace each trail segment to determine its length, then refer to Table 1 for the sample point interval. For trails <51 ft select a "typical" sample point that is representative of the trail segment. For trails >50 ft select a random number from 1 to the selected interval distance. Record this number on the first row of the form. This will be the first sample point, from which all subsequent sample points will be located at whatever the specified interval is. This procedure ensures that all points along the trail segment have an equal opportunity of being selected.

*** At the first sample point, reset the wheel counter and use it to stop at points separated by your sample interval distance thereafter.**

Push the measuring wheel along the middle of the tread so that it does not bounce or skip in rough terrain. Lift the wheel over logs and larger rocks, adding distance manually where necessary to account for horizontal distances. Your objective is to accurately measure the distance of the primary (most heavily used) trail tread. Monitor the wheel counter and stop at your sample interval to conduct the sampling point measures. If you go over this distance, back the wheel up to the correct distance. If the wheel doesn't allow you to take distance off the counter then stop immediately and conduct your sampling at that point, recording the actual distance from the wheel, not the "missed" distance. Continue to the next "correct" sample point (as though you had not missed the last one).

Rejection of a sample point: Given the survey's objective there will be rare occasions when you may need to reject a sampling point due to the presence of boulders, tree falls, trail intersections, road-crossings, stream-crossings, bridges or other odd "uncharacteristic" situations. The data collected at sample points is intended to be roughly "representative" of the sections of trail on either side of the sample point. Use your judgment but be conservative when deciding if a sample point should be relocated. The point should be relocated by moving forward along the trail an additional 20 ft, this removes the bias of subjectively selecting a point. If the new point is still problematic then add another 20 ft, and so on. Record the distance of the actual point and continue on to the next "correct" point (as though you did not need to move the last one).

For the following data, in the field or office: If an indicator cannot be assessed, e.g., is "Not Applicable" code the data as -9, code missing data as -1.

7) **Distance:** Measuring wheel distance (ft) from the beginning of the trail segment to the sample point.

8) **Trail Position (TP):** Use the descriptions below to determine the trail position of the sampling point. Record the corresponding letter code in the TP column.
   R - Ridge: Ridge-top or high plateau position, **M** - Midslope/Sideslope: Mid-slope positions
   CB - Cliff base, **V** - Valley Bottom: Flatter valley bottom terrain

9) **Trail Grade (TG):** The two field staff should position themselves on the trail 5 ft either side of the transect. A clinometer is used to determine the grade (% slope) by sighting and aligning the horizontal line inside the clinometer with a spot on the opposite person at the same height as the first person's eyes. Note the percent grade (right-side scale in clinometer viewfinder) and record.

10) **Trail Alignment (TA):** Assess the trail's alignment angle to the prevailing land-form in the vicinity of the sample point. Sight a compass along the trail from a point about 5ft before the transect to about 5ft past the transect, record the compass azimuth (0-360, not corrected for declination) on the left side of the column (it doesn't matter which direction along the trail you sight). Next face directly downslope, take and record another compass azimuth - this is the aspect of the local landform. The trail's alignment angle ($<90^0$) can be computed by these two azimuths.

11) **Tread Width (TW):** From the sample point, extend a line transect in both directions perpendicular to the trail tread. Identify the endpoints of this trail tread transect as the most pronounced outer boundary of visually obvious human disturbance created by trail use (not trail maintenance like vegetation clearing). These boundaries are defined as pronounced changes in ground vegetation height (trampled vs. untrampled), cover, composition, or, when vegetation cover is reduced or absent, as pronounced changes in organic litter (intact vs. pulverized) (see photo illustrations in Figure 1, placed at the end of the manual). The objective is to define the trail tread that receives the majority (>95%) of traffic, selecting the most visually obvious outer boundary that can be most consistently identified by you and future trail surveyors. In places where the trail boundary is indistinct at the sample point project the boundary to the sample point from immediately adjacent areas. Measure and record the length of the transect (the tread width) to the nearest inch (don't record feet and inches).

12) **Rock (R):** Record the percentage of rock (bedrock, rock and large gravel) present along the transect. Use 10% categories, 5% where needed.

13) **Cross-Sectional Area (CSA):** The objective of the CSA measure is to estimate soil loss from the tread at the sample point following trail creation. Accurate and precise CSA measures require different procedures based on the type of trail and erosion, some definitions:

    Place two stakes and the transect line to characterize what you judge to be the pre-trail or original land surface. Place the left-hand stake beyond the trail boundary so that the 1st mark on the transect line will fall on what you believe was the "original" ground surface but at the edge of any tread incision, if present (see Figure 2). Thus, the transect incision value you record for the 1^{st} mark (V_1) must be 0. Stretch the transect line (marked in 0.3 ft (3 5/8 in) intervals) tightly between the two stakes - any bowing in the middle will bias your measurements. Insert the other stake just beyond the first transect line mark on the other side of the trail that is on the original ground surface and will be measured as a 0. The transect line should reflect your estimate of the pre-trail land surface, serving as a datum to measure tread incision caused by soil erosion and/or compaction.

Note: If the line cannot be configured properly at the sample point due to rocks or obstructing materials that cannot be moved, then move the line forward along the trail in one-foot increments until you reach a location where the line can be properly configured.

Measurement Procedure: On the CSA data form, label a new row with the measuring wheel distance for the transect (e.g., D=600 ft). Starting on the left side go to the 1st mark on the line (0.33 ft) and measure the first vertical measure from the transect line perpendicular to the ground surface (nearest 1/4 in, e.g., .25, .5, .75). Record this as V_1. Proceed to the second mark and record the vertical for this as V_2. Record the values on the data sheet next to their labeled numbers (e.g., V_1, $V_2 \ldots V_n$). Continue measuring each vertical until you reach the far side of the trail and obtain a measure of 0 for the right-hand stake. ***Note:*** The transect line is not likely to be "level" so be cautious in measuring vertical transects that are *perpendicular* to the horizontal transect line. Contact Jeff Marion for a spreadsheet that calculates CSA for this data.

14) **Comments:** Record any relevant comments.

Collect all equipment and move onto the next sample point.

-Omitted-

Figure 1. Photographs illustrating different types of boundary determinations. Trail tread boundaries are defined as the most pronounced outer boundary of visually obvious human disturbance created by trail use (not trail maintenance like vegetation clearing). These boundaries are defined as pronounced changes in ground vegetation height (trampled vs. untrampled), cover, composition, or, when vegetation cover is reduced or absent, as pronounced changes in organic litter (intact vs. pulverized). The objective is to define the trail tread that receives the majority (>80%) of traffic, selecting the most visually obvious boundary that can be most consistently identified by you and future trail surveyors.

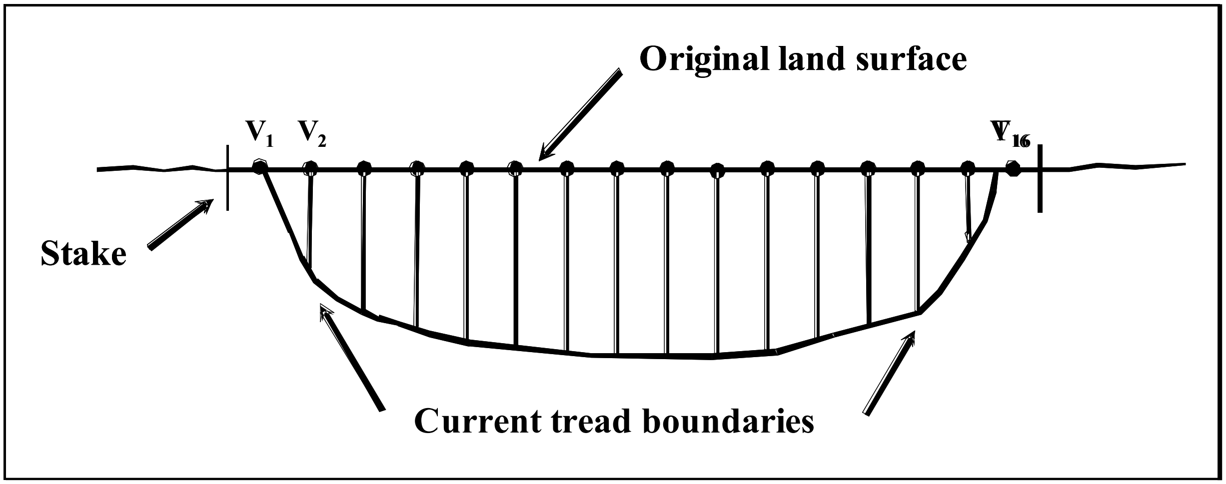


Figure 2. Cross sectional area (CSA) diagram illustrating measurement procedures for visitor-created trails.

Cliff Trail Visitor Impact Monitoring Form