

RESEARCH REPORT

**DETECTING OFF-TRAIL HIKING IN PROTECTED
NATURAL AREAS: EVALUATING OPTIONS WITH
SURVEYS AND UNOBTUSIVE OBSERVATION**

Final Report



Virginia Polytechnic Institute and State University
College of Natural Resources
Forestry/Recreation Resources Management

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College of Natural Resources, Forestry/Recreation Resources

DETECTING OFF-TRAIL HIKING IN PROTECTED NATURAL AREAS: EVALUATING OPTIONS WITH SURVEYS AND UNOBTRUSIVE OBSERVATION

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EXECUTIVE SUMMARY

This report presents the results of research conducted on the 96-acre Bear Island along the Billy Goat Trail, Section A (BGT) that evaluated visitor motivations for off-trail hiking and the efficacy of four treatments designed to reduce this activity. This research was prompted by concerns about the impact of an extensive informal (visitor-created) trail network on Bear Island, because it provides habitat for more than 50 species of rare, threatened or endangered plant and animal species.

Methods

The primary study objective was to test the effectiveness of an educational message and different site management actions in reducing off-trail hiking on Bear Island along the BGT. Four different treatments, designed to be additive, were compared against the off-trail hiking rates in the Control or baseline condition. The first treatment (Signs) consisted of educational signs placed at all trailheads that informed visitors of the impacts of informal trail use on Bear Island and asked visitors to stay on paint blazed trails. In addition to the trailhead signs, symbolic “no hiking” prompter signs were placed at every informal trail junction with the BGT (n=155). In the second treatment (Brushing), researchers used nearby twigs, branches, and leaves to naturalize the first 10 to 15 ft of each informal trail; the trailhead educational signs and prompter signs remained in place. The third treatment (Restoration & Fencing) left the signs and brushing in place and added symbolic restoration sites to 14 of the more highly used informal trailheads, which consisted of about 15 ft of Jute matting, a low rope fence, and a restoration sign. The fourth treatment (Personal Contact) was designed to compare the relative effectiveness of the educational trailhead signs versus personal communication in conveying the awareness of consequences and personal responsibility message. The trailhead educational signs were covered and the same educational message was conveyed to hikers via volunteer trail stewards who were stationed at trailheads during this treatment.

Two complementary methods, a visitor survey and direct observation of off-trail hiking behaviors, were used to evaluate the efficacy of each treatment in reducing off-trail travel along the BGT. Surveys were administered to hikers exiting the BGT from May 10, 2007 through June 10, 2007; observations of off-trail behavior occurred simultaneously to survey administration. Each treatment and control was applied to at least two weekday evenings and two weekend days.

The 7-page visitor survey collected information on visitor demographics, trip characteristics, past use of and attachment to the BGT, awareness of the impact of off-trail hiking on rare plants, self-reported off-trail hiking behaviors, and opinions on various management strategies for keeping visitors on formal trails. A total of 1205 surveys were completed with a response rate of 66%.

Visitor behavior was observed at two different locations along the BGT. The specific observation sites were selected because they provided several useful characteristics for unobtrusive observation, including an elevated vantage point, high observer concealment, and a variety of informal trail types within each site’s viewing area. All informal trail junctions within both observation sites (n=5/site) received the prompter signs and were naturalized during the

Sign and Brushing treatments, respectively; the symbolic restoration areas with fences were constructed on one or two of the informal trail junctions. All visitors passing through the observation sites were tallied by direction of travel. Off-trail hiking behaviors were recorded separately for each informal trail. A combined total of 8045 people were observed at the two sampling locations.

Visitor Demographics and Trip Characteristics

- There was a relatively even gender distribution of respondents with 53% being male.
- Visitors to the BGT were highly educated; 46.6% had an advanced degree and an additional 39.2% had obtained a four-year degree.
- More than three quarters (76.7%) of visitors lived within 30 minutes of the BGT.
- Nearly three-quarters were repeat visitors (73.3%). A strong minority (41.2%) had hiked the BGT three or more times in the previous 12 months. The average number of years hiking the BGT was 7.3 years.
- Survey respondents predominantly hiked on a weekend (92.2%) and most hiked the entire length of the trail (69.6%).

Key Findings

- In the Control, 70.3% of survey respondents reported hiking off-trail intentionally for an average of 2.8 different reasons or motivations. The most common motivations for hiking off-trail were to get to a scenic vista or take a photo (50.7%), to avoid or pass others (45.4%), or because of poor or challenging trail conditions (43.0%). Observed off-trail hiking rates in the Control ranged from 18.9% to 37.4% depending on observation location and direction of travel. The observed off-trail hiking rates were lower than the self-reported rates because the observation locations only evaluated the decision to go off-trail at 1 of 5 trails and the survey self-reports reflected the decision to go off at any point (155 informal trail junctions) along the entire 1.7 mile length of the BGT.
- The off-trail hiking rate was very different depending on the specific trail section and direction of travel.
- In the observed sections of trail, off-trail rates declined sharply from 29.6% in the Control to 6.5% with the placement of the educational and prompter signs. The off-trail rate further declined to 2.0% in the Brushing treatments. Overall, 2.0% of the hikers went off-trail in the Restoration & Fencing treatment, but no-one hiked on the two fenced trails. No one was observed hiking off-trail in the Personal Contact treatment, but this result should be interpreted with caution as the sample size was very low due to staffing constraints.
- While the treatments were all very effective at reducing off-trail travel on the limited number of trails observed, the self-reported off-trail rates suggested that many visitors continued to hike off-trail at least once along the trail even after the treatments were in place. The Sign treatment did not reduce the percentage of visitors reporting that they went off trail intentionally (70.6%) from the Control (70.3%). There was a reduction in self-reported off-trail hiking behavior when Brushing was added (60.2%), but little

further change when the Restoration & Fencing Treatment was applied to 14 of the 155 informal trail junctions (58.6%).

- The Personal Contact treatment was the most effective in reducing off-trail travel based on self-reports. Only 43.0% reported hiking off-trail for an average of 1.0 reasons after taught the consequences of off-trail travel by a volunteer trail steward at the beginning of their hike. The most common reasons for going off-trail in the Personal Contact treatment were poor or challenging trail conditions (21.2%), to take a photo or get to a scenic view (19.5%), or to avoid others (19.4%).
- Survey questions revealed that the Personal Contact treatment was more effective than the educational sign in conveying the educational message about off-trail impacts and asking visitors to stay on the blazed official trail. Visitors who had talked to the trail stewards were also more supportive of management actions to reduce off-trail travel than those in the other treatments.
- Hikers with a greater knowledge of off-trail hiking impacts were less likely to hike off-trail than those who had less knowledge.
- Visitors with a greater sense of personal responsibility and commitment to the resource were less likely to report hiking off-trail.

Management Implications

Survey findings suggest that although the treatments significantly reduced off-trail travel many visitors (43.0%) continued to hike off-trail at least once during their hike for a variety of reasons, even when asked not to by a trail steward and informed of the ecological consequences of off-trail travel. Management implications from this study suggest several actions for further reducing off-trail travel along the BGT:

- Improve Communication with Visitors: Many visitors do not know about the special and rare plant and animal communities that live along the BGT. The trail stewards were much more effective in communicating the educational message than the trailhead signs, in part because they were able to contact a greater percentage of visitors. Most visitors simply do not read signs. It is also important to more prominently post the challenging nature of the BGT and suggest alternatives for those who do not feel they are physically able to do the rock scrambles.
- Improve Maintenance and Trail Markings: While we added many new paint blazes to the trail prior to the study, about 30% of hikers in the Control and treatments said they hiked off-trail accidentally because the trail was poorly marked. Although the BGT is designed to be challenging, managers must still ensure that the intended tread is maintained to be a better and preferred route for walking than alternate trail-side terrain. During wet periods managers should identify muddy sections and apply corrective actions so that visitors can remain on the trail.
- Consider Formalizing Some Informal Trails: Some informal trails were created as by-passes around difficult or crowded trail sections. Others were created to get to scenic vistas or favorite places on Bear Island. Managers should consider if those trails are acceptable, including consideration for visitor safety. If they are, they should be formalized, or formal trails should be designed by a trail professional to have sustainable alignments.

- Close and Restore Unacceptable Trails: The closure and recovery of all remaining trails on Bear Island will be a formidable management challenge. Trampling impacts and trail creation occur with limited or low levels of traffic, while unassisted natural recovery requires little to no use over years for vegetation to return. Results suggest that keeping and maintaining the prompter signs is an effective action for reminding visitors not to hike on informal trails. These signs clearly communicate where they should not hike. Brushing the visible portion of all informal trails further reduces off-trail travel by removing the “releaser cue” of a path that others have obviously taken. The study also demonstrated a high degree of efficacy with posting trail stewards at trailheads to intercept hikers as they are beginning their hike. The stewards were much more effective than trailhead signs in conveying the rationale for remaining on the blazed trail and had a positive effect on how visitors portrayed management actions.
- Future Research: Further research along the BGT could be helpful in identifying the locations of and motivations behind visitors who continue to travel off-trail. Future research could also focus on the best ways to communicate the special nature of Bear Island and other urban-proximate natural areas to visitors who view these parks as local public use areas, instead of regionally or nationally significant special places protected for important ecological, cultural, or historical reasons.

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INTRODUCTION

The National Park Service accommodates nearly 300 million visitors per year, visitation that presents managers with substantial challenges. The increasing number of visitors inevitably contributes negative effects to fragile natural and cultural resources and to crowding and conflicts that degrade the quality of visitor experiences. “Providing opportunities for public enjoyment is an important part of the Service’s mission; but recreational activities and other uses may be allowed in parks only to the extent they can take place without causing impairment or derogation of a park’s resources, values, or purposes” (NPS, 2006). This statement, from the National Park Service (NPS) *Management Policies*, provides a strong mandate to guide recreation management decisions in protecting park resources and values at some 388 park units. This policy guidance recognizes the legitimacy of providing opportunities for public enjoyment of parks. However, the *Management Policies* also acknowledge that some resource degradation is an inevitable consequence of visitation and direct managers to “ensure that any adverse impacts are the minimum necessary, unavoidable, cannot be further mitigated, and do not constitute impairment or derogation of park resources and values” (NPS, 2006).

Responding to these concerns, NPS managers at C&O Canal National Historical Park (CHOH) and George Washington Memorial Parkway (GWMP) obtained funding to support this research investigating visitation-related impacts to trails in the Great Falls/Potomac Gorge area. The study area, extending along the Potomac River from Great Falls to the downstream end of Carderock, is one of the most biologically significant natural areas in the eastern United States, supporting more than 400 occurrences of 200 rare species and communities. Located in a densely populated urban landscape, the Potomac Gorge is also recognized for its exceptional recreational and scenic features. More than 4 million people live within the Washington metro region and the Potomac Gorge is a noted tourist attraction in the area.

Despite the clear ecological value and potential recreation-related threats to natural resources, managers possess little information on ways to reduce impacts to park natural resources associated with off-trail hiking. In particular, previous efforts by the NPS and volunteers from the Potomac Appalachian Trail Club (PATC) have not been sufficiently effective to protect the high density of rare flora and fauna found on Bear Island, located just downstream from Great Falls on the Maryland side of the Potomac. The island, due to its high ecological values, is co-owned and managed by The Nature Conservancy (TNC). This island has a 1.7 mile segment of the highly popular Billy Goat Trail, and the island has extensive networks of informal trails that are believed to be degrading the sensitive Bear Island ecosystem. Concerns about extensive off-trail hiking and the potential damage to sensitive plant communities and to rare flora and fauna prompted the sponsorship of this study.

Study Objectives

The overall objectives of the Potomac Gorge trail research program are to determine the extent of off-trail hiking and related impacts on Bear Island and evaluate the efficacy of management actions that deter this behavior. This study determines the rate of off-trail hiking along the Billy Goat Trail, Section A through a visitor survey and direct observation, and assesses the efficacy of various site management and educational message treatments in reducing the use of informal

trails. Specifically, this portion of the study collected and compared information gained during a control (baseline) period and four different treatments. The purpose of the visitor survey is to understand off-trail hiking motivations and behaviors, assess visitor knowledge of the natural resources on Bear Island, solicit opinions on potential management actions to reduce off-trail hiking, and document user characteristics that might aid in developing management strategies. Results of the direct observations are used in conjunction with the survey to understand the efficacy of the treatments. This information will assist park management in continuing to provide high quality recreation experiences while protecting the ecological integrity of the Billy Goat Trail, Section A (hereafter referred to as the BGT) and Bear Island.

This report contains a review of relevant literature describing the potential impacts of informal trails, methods of deterring off-trail hiking behavior, including the efficacy of educational messages and various site management techniques, and a review of the study area and methods employed in this study. Data from the visitor survey describe the visitors who use the trail, visitor knowledge of the area's natural resources, opinions on various management techniques that could be used to deter off-trail travel, and self-reported off-trail hiking. This report also contains the results from direct observation of visitor behavior to document the effectiveness of the tested management techniques in reducing off-trail hiking behavior. The management implications of the survey and observation results are discussed.

Other management reports and journal papers are being prepared to present results from related studies also supported by NPS funding. These include results from:

- A one-year study to evaluate the efficacy of a preferred set of educational and site management actions designed to deter off-trail hiking along the BGT. Efficacy will be determined by examining before and after data describing the lineal extent and conditions of informal (visitor-created) trails on Bear Island, as compared to data from a nearby control area adjacent to the BGT, which received no treatments.
- A survey of all formal and informal trails within the study area on both sides of the Potomac River to provide baseline data on the distribution, lineal extent, and trail resource condition.
- A separate study to document the number, distribution, and condition of cliff-associated recreation sites, informal cliff-associated trails, and cliff-face impacts.

LITERATURE REVIEW

The first part of this review examines impacts to ecosystems caused by formal (official) and informal (visitor-created) trails. Methods used to discourage off-trail hiking are then described, including educational messages and trail site management techniques (e.g. blocking access to informal trails and fencing). An annotated bibliography compiled in support of this study is provided in Appendix L to guide readers to supporting research on the topic of informal trails assessment and management.

Visitation-Related Resource Impacts

Visitors participating in a diverse array of recreation activities, including hiking, wildlife viewing, nature study, climbing, and fishing, contribute to an equally diverse array of effects on protected natural areas resources, including vegetation, soils, water, and wildlife. The term *impact* is commonly used to denote any undesirable visitor-related change in these resources. This study was restricted to assessments of trampling-related impacts to vegetation and soil along formal and informal trails.

Trail Impacts

Trails are generally regarded as an essential facility in protected natural areas, providing access to unroaded areas, offering recreational opportunities, and protecting resources by concentrating visitor traffic on resistant tread surfaces (Marion & Leung, 2001). Unfortunately, many trails are not properly located, constructed or maintained to sustain their intended uses. Many formal trails were originally created by visitors or individuals who lacked trail design expertise, or were directed by objectives (e.g., fire fighting) that resulted in less sustainable designs (Marion & Leung, 2004). Even well-designed and managed trails are susceptible to the many forms of degradation.

Resource impacts associated with trampling on trails include an array of direct and indirect effects (Table 1). Even light traffic can remove protective layers of vegetation cover and organic litter (Cole, 2004; Leung & Marion, 1996). Trampling disturbance can alter the appearance and composition of trailside vegetation by reducing vegetation height and favoring trampling resistant species. The loss of tree and shrub cover can increase sunlight exposure, which promotes further changes in composition by favoring shade-intolerant plant species (Hammitt & Cole, 1998; Leung & Marion, 2000). Visitors and livestock can also introduce and transport non-native plant species along trail corridors, some of which have characteristics allowing them to replace undisturbed native vegetation and migrate away from disturbance-associated trail corridors (Cole, 1987).

The exposure of soil on natural surfaced trails can lead to soil compaction and displacement, muddiness, erosion, and trail widening (Hammitt & Cole, 1998; Leung & Marion, 1996; Tyser & Worley, 1992). The compaction of soils decreases soil pore space and water infiltration, which in turn increases muddiness, water runoff and soil erosion. The erosion of soils along trails exposes

Table 1. Direct and indirect effects of recreational trampling on soils and vegetation.

	Vegetation	Soil
Direct Effects	Reduced height/vigor Loss of ground vegetation, shrubs and trees Introduction of non-native plants	Loss of organic litter Soil exposure and compaction Soil erosion
Indirect Effects	Altered composition – shift to trampling resistant or non-native species Altered microclimate	Reduced soil pore space and moisture, increased soil temperature Increased water runoff Reduced soil fauna

rocks and plant roots, creating a rutted, uneven tread surface. Eroded soils may smother vegetation or find their way into water bodies, increasing water turbidity and sedimentation impacts to aquatic organisms (Fritz, 1993). Visitors seeking to circumvent muddy or badly eroded sections contribute to tread widening and creation of parallel secondary treads, which expand vegetation loss and the aggregate area of trampling disturbance (Marion, 1994; Liddle, & Greig-Smith, 1975). The creation and use of trails can also directly degrade and fragment wildlife habitats, and the presence of trail users may disrupt essential wildlife activities such as feeding, reproduction and the raising of young (Knight & Cole, 1995).

In summary, most trail-related resource impacts are limited to a linear corridor of disturbance, though impacts like altered surface water flow, invasive plants, and wildlife disturbance, can extend considerably further into natural landscapes (Kasworm & Monley, 1990; Tyser & Worley, 1992). However, even localized disturbance within trail corridors can harm rare or endangered species or damage sensitive plant communities, particularly in environments with slow recovery rates.

Informal Trail Impacts

Formal developed trail systems rarely access all the locations that visitors want to go so the establishment of informal visitor-created trails is commonplace in national parks and other protected areas, especially heavily visited areas. Often referred to as *social* trails, their proliferation in number and expansion in length over time are perennial management concerns. Furthermore, because informal trails are not professionally designed, constructed or maintained they can contribute substantially greater impacts to protected area resources than formal trails. Many of these impacts are related to their poor design, including alignments parallel to slopes or along shorelines, multiple trails accessing the same destinations, routes through fragile vegetation, soils, or sensitive wildlife habitats, and disturbance to rare flora, fauna, or archaeological sites. These design attributes also make informal trails far more susceptible to tread impacts, including expansion in width, soil erosion, and muddiness.

Areas previously untrampled by human footprints can become severely degraded when repeated visitation results in the creation of informal trails. A study by Thurston and Reader (2001) found an 81% mean loss of vegetation density in the center zone of new informal trails, and a 71%

decline in the species present. Mean soil exposure also increased by 23% in these areas. Understanding and minimizing the ecological disturbance caused by off-trail hiking is important to maintaining both the environmental and social aspects of the recreation experience. Research demonstrates that the quality of a visitor's experience is likely to decrease if degradation to a trail is present (Lynn & Brown, 2003).

Informal trail proliferation is common in high visitation settings and in some parks is responsible for extensive areas of impact. A study in Mount Rainier National Park on the impacts of informal trail use identified 913 degraded sites and attributed 89% of them to the presence of informal trails (Rocheffort & Gibbons, 1992). Other studies show that certain landscapes and visitor motivations might make some areas more susceptible to informal trail proliferation. In areas such as open moorland in the UK, informal trails and consequent degradation of the landscape are widely visible (Pearce-Higgins & Yalden, 1997). Other areas appear to be more prone to off-trail hiking because most visitors who wander off the official trail are taking a shorter route to a site of interest (Keirle & Stephens, 2004). Conversely, informal trails are less common in areas that have more medium-sized trees, topographical elements, and fallen trees that impede the ease of human access (Lehvavirta, 1999). Regardless of an area's susceptibility to off-trail hiking, this form of depreciative behavior causes hundreds of thousands of dollars in damage each year (Christensen & Clark, 1983). In an effort to reduce the damage caused by informal trail use, educational and site management techniques can be evaluated and tested for their effectiveness in reducing off-trail travel.

Educational Efficacy

Several studies on educational efficacy demonstrate effective methods of reducing depreciative behavior and off-trail hiking through use of signage. Depreciative behavior is impactful behavior by visitors that can range from unintentional actions to intentional acts of vandalism. The motivation or reason behind a depreciative behavior influences the effectiveness of different types of interventions to reduce the undesired behavior (Gramann & Vander Stoep, 1987). For example, if visitors are traveling off-trail because they do not recognize the difference between formal and informal trails or they are not aware of the potential ecological impacts, better trail markings and educational messages will likely be effective in reducing off-trail travel. However, if trails are clearly marked and visitors know that off-trail hiking is prohibited and choose to do it anyway to reach a favorite fishing location, an educational message would likely not be as effective as a sanction (e.g., threat of a fine).

Early studies indicated that compared to ethical, humorous, symbolic, and hybrid signs, the most effective message to reduce depreciative behavior was a sanction sign (Johnson & Swearingen, 1992; Swearingen & Johnson, 1994). Sanction signs threaten an unpleasant outcome in response to a given action, such as "violators who remove ash or pumice will be subject to prosecution" (Johnson & Swearingen, 1992). Despite the effectiveness of sanctions, recent concerns about degrading visitor experience through threatening messages led to the discovery that at least in hypothetical situations interpretive messages were as effective as sanction messages in eliciting the intention to engage in desired recreation behaviors (Duncan & Martin, 2002). Interpretive messages often use images, narratives, or analogies to demonstrate the significance the undesirable behavior can have on the resource. Littlefair (2004) also found support for the use of

interpretive messages, finding that a complete interpretive program reduced shortcutting on a walking tour from 100% of participants to 7%.

The wording of a message plays a significant role in its effectiveness. Selected members of the National Association for Interpretation rated a prescriptive message that encourages positive conduct more effective than a proscriptive message that discourages negative conduct (Winter, Sagarin, Rhoads, Barrett, & Cialdini, 2000). On the other hand, a study on petrified wood theft showed that the most effective sign in deterring theft was a negatively worded injunctive norm (“Please don’t remove the petrified wood from the park”) (Cialdini, Demaine, Sagarin, Barrett, Rhoads, & Winter, 2006).

Since off-trail hiking is a depreciative behavior that affects many outdoor recreation sites, several studies have investigated which messages are most effective. Specific signage research relating to off-trail hiking indicates that an attribution message (“Your feet have trampled the vegetation on this island. Please stay on the main wood chipped trail”) at St. Lawrence Islands National Park, Ontario was more effective than a plea message (Bradford & McIntyre, 2007). Winter (2006) recently found that an injunctive-proscriptive sign (“Please don't go off the established paths and trails, in order to protect the Sequoias and natural vegetation in this park”) was more effective than the descriptive-proscriptive, injunctive-prescriptive, and descriptive-prescriptive messages in reducing off-trail hiking at Kings Canyon National Park (Table 2). The location of signs in relation to off-trail hiking also has significant influence. Bradford and McIntyre (2007) found that 88.3% of visitors left the main trail when no signs were present, and this number reduced to 86.5% when signs were placed at an information booth, and to 64.7% when signs were placed at the point where informal trails intersected the official trail.

Table 2. Sign research terminology definitions and example language.

	Proscriptive Discouraging negative behavior	Prescriptive Encouraging positive behavior
Injunctive Tell visitors what they should do	<i>Please don't go off the established trails, in order to protect the natural vegetation in this park</i>	<i>Please stay on the established trails, in order to protect the natural vegetation in this park</i>
Descriptive Tell visitors what other visitors do	<i>Many past visitors have gone off the established trails, damaging the natural vegetation in this park.</i>	<i>Many past visitors have stayed on the established trails, helping to protect the natural vegetation in this park</i>

Source: Modified from Winter (2006)

Site Management

Site management techniques are another method of deterring off-trail hiking behavior and include physical barriers or alterations. One of the more commonly used methods involves brushing trails with nearby logs and organic litter, but this technique sometimes results in removal and trampling by visitors. This is likely the result of lack of education about rare plants, lack of signage, and a desire to explore (Johnson, Bratton & Firth, 1987).

While brushing alone seems to have limited efficacy, greater success is found using various methods of fencing. Swearingen and Johnson's (1994) study revealed a yellow rope barrier to be the most effective site management technique for reducing off-trail walking. This finding is supported by a recent study at Acadia National Park, which demonstrated that low fencing and signs located near informal trails were most effective (Park, Manning, Marion, Lawson, & Jacobi, 2008) and by a study at Mt. Rainier that showed the presence of a uniformed employee and rope barriers as being most effective (Rochefort & Gibbons, 1992). Such studies that implement multiple techniques demonstrate the utility of fencing in combination with either signage or the presence of a uniformed employee. Several studies found the presence of a uniformed employee to be as effective as educational signage in deterring depreciative behavior (Widner & Roggenbuck, 2000; Ward & Roggenbuck, 2003; Swearingen & Johnson, 1995).

Research on depreciative behaviors over the last 20 years continuously arrives at the conclusion that a combination of methods is more effective than any single method. This is likely due to the fact that people engage in depreciative behaviors for different reasons and different methods are effective for different motivations. In addition to those named above, support for the use of multiple techniques was found in an Australian study on short-cutting, where a complete program of interpretive messages, the presence of a role model, and verbal appeals were most successful in reducing this depreciative behavior (Littlefair 2004; Littlefair & Buckley, 2008). While these studies demonstrate that the greatest reductions in off-trail hiking result from using multiple techniques, it is important to note that no technique eliminated informal trail use completely. In an effort to see the greatest reduction in off-trail hiking, the BGT study implemented several combinations of educational and site management techniques over the course of the study.

STUDY AREA

The Potomac Gorge is located in Maryland and is home to over 100 threatened, rare, or endangered species (The Nature Conservancy, 2005). Located immediately outside Washington, DC, it includes notable areas such as Great Falls and the C&O Canal, and offers a wide range of recreational activities including hiking, cycling, kayaking, rock climbing, photography, fishing, and nature study. The majority of visitors (64%) come to the park to walk, jog, or hike (Meldrum, Littlejohn, Gramann, & Hollenhorst, 2004). The National Park Service and Fairfax County protected natural areas recorded 2,809,968 visitors in 2007 (NPS, 2008), which reflects the popularity of the Potomac Gorge. Located in the Potomac Gorge between the C&O Canal and the Potomac River is Bear Island, a 96-acre tract of land co-owned by the Nature Conservancy and the National Park Service. The island is home to over 50 of Maryland's threatened, rare, and endangered species (The Nature Conservancy, 2005). Bear Island was identified as an ideal study location for visitor management strategies due to its fragile ecosystem and the presence of the popular BGT, Section A that traverses the island. The trail also has a history of failed attempts to deter off-trail hiking and close informal trails.

The BGT, Section A is one of three sections of the BGT. Section A is a 1.7-mile strenuous hike that is popular among visitors for its scenic views of the Potomac River and challenging rock scrambles. The trail is accessible from the C&O Canal towpath at both a North and a South entrance, with a third "emergency exit" access point located about halfway along the trail (Figure 1). There are parking lots within a half-mile of both the North (Great Falls Tavern Visitor Center) and South (Anglers Inn) Trailheads. The Emergency Access is a less-used trail, about midway into the hike, which allows visitors to shorten their hikes by cutting across Bear Island and rejoining the more level and easy walk along the towpath.

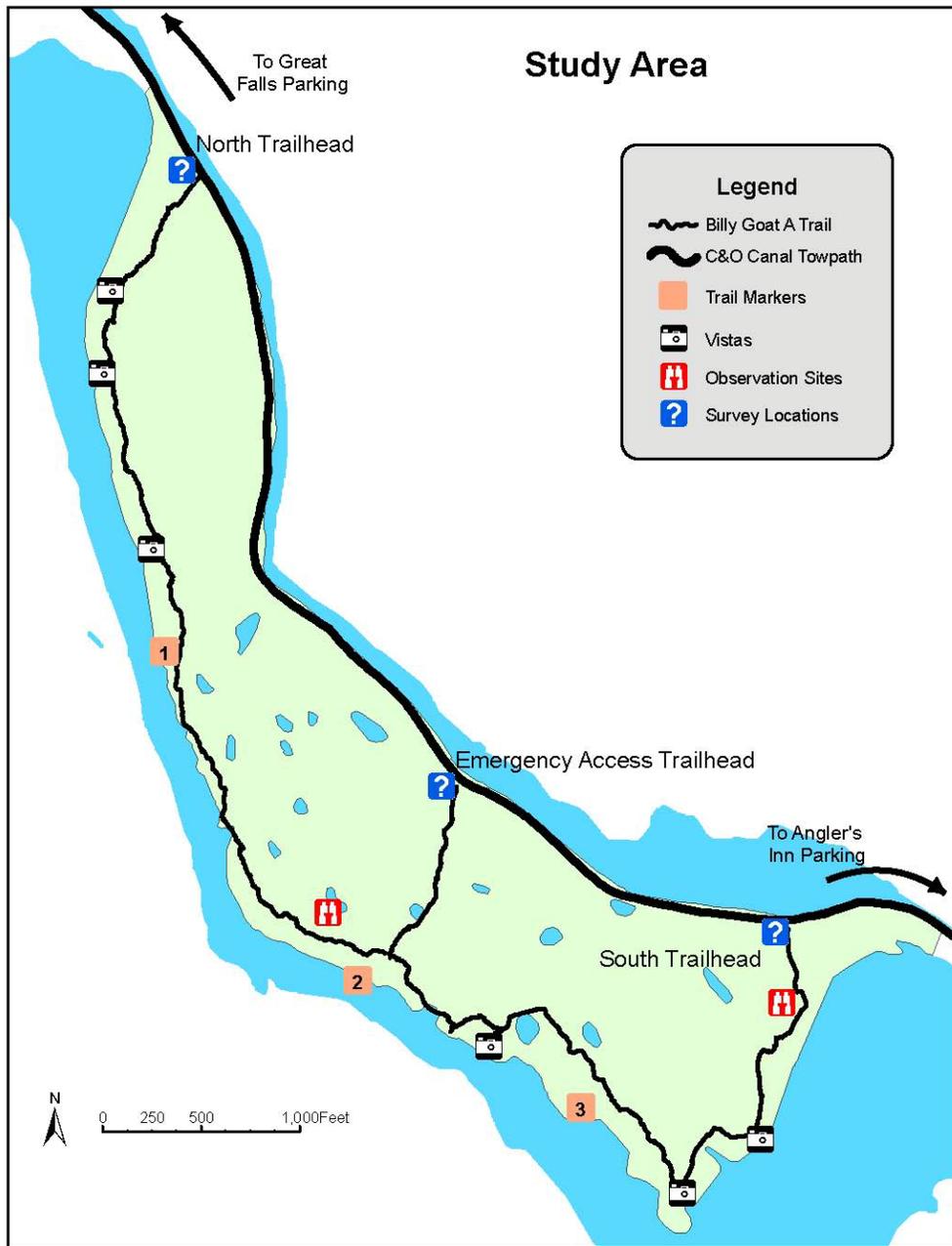


Figure 1. Billy Goat Trail, Section A study area.

METHODS

Study Components

The primary study objective was to test the effectiveness of an educational message and different site management actions in reducing off-trail hiking on Bear Island along the BGT, Section A. Two methods, a visitor survey and direct observation of off-trail hiking behaviors, were used to address this objective. Reported behavior can be misleading if visitors provide incorrect information; direct observation can be misleading if the observed trail sections are not representative of the entire trail. Both methods were employed in this study in an effort to provide a more accurate and complete characterization of relative treatment efficacy. Four different treatments tested the efficacy of an educational message, prompter signs, and site management actions in reducing off-trail hiking, compared to a control condition. The control was the pre-study trail condition, though two management actions were implemented prior to initiation of the study (described below in Pre-Study Preparations).

A visitor survey was used to evaluate the effectiveness of the educational message and different communication modes (i.e., sign versus personal communication) on educating hikers about the damage caused by off-trail hiking behavior, measure perceptions of the treatment signage and site management actions, and gauge the effectiveness of the treatments on reducing off-trail hiking behavior through self-reports.

The observation component directly evaluated the efficacy of the treatments to reduce off-trail hiking behavior by observing hikers at two locations along the BGT, Section A (see Figure 1). The two locations were selected because the topography allowed hidden observers to watch a section of the trail without being detected by hikers. Each location provided a view of five informal trails. It was not possible to link observed behavior with completed surveys, but both components were conducted on the same days, so the same population of hikers was sampled during each treatment.

Detailed descriptions of pre-study preparations, treatments, survey administration, and data analysis of the survey follow. The observational component is discussed separately (see Visitor Observations section).

Pre-Study Preparations

Pre-study preparations were made to improve the marking of the formal trail, increase the number of official vista sites to view the Potomac River, and minimize entry to the BGT, Section A on unofficial trails originating from the towpath. Prior to beginning the study, project staff and trail maintenance volunteers re-painted the existing blue blazes along the BGT, Section A and added blazes in confusing sections to make sure that the official trail was clearly marked in an effort to minimize “accidental” off-trail hiking due to unclear trail markings. In addition, six informal trails leading to informal vista sites were formalized by using white and blue blazes to signify they were officially open to visitors. The purpose of adding official vista sites was to ensure that visitors had ample opportunities to view the Potomac River, a main attraction along the trail, without leaving a formal trail to do so. The six newly formalized vista sites were

selected from 29 previously identified informal recreation sites that were found to originate from the main BGT (Figure 1). The six formalized sites were selected based on the quality of the vista, the availability of a sustainable access trail, and geographic conditions at the vista site that would deter resource impacts and expansion over time. These sites were checked by a botanist for rare plants and NPS officials approved the formal vista site selection. Finally, prior to the start of the study, nine informal trails leading to the interior of Bear Island from the Canal towpath were blocked with symbolic fencing (white plastic posts and white nylon line) and marked with boot print “no-step” signs attached to downed logs (Figure 2). This was done to restrict access to the island to the three formal trails, where study signs would be posted.

Description of Treatments

Four treatments were administered to the BGT, Section A to reduce off-trail hiking behavior. Following a control period, treatments were applied in the order presented below. While it would have been ideal to randomize the treatments, it was not practical because of the extensive site-manipulation involved. The treatments were mostly additive, in the sense that each successive treatment involved more aggressive management techniques added to what was present during previous treatments. The study was intentionally designed to include additive treatments that incorporated increasingly aggressive educational messages and site management techniques because of the history of failed attempts to close informal trails by more subtle measures. The goal was to identify the most effective technique(s) for reducing off-trail travel.

Detailed descriptions of the control and treatment conditions follow; Table 3 provides a quick-reference summary of the treatments. Trail stewards normally patrol the BGT providing visitor outreach contacts, but their patrols were stopped during the course of this study.

Control: The control period consisted of existing signage as well as increased blazing and new formal vista sites, which were added prior to the study (see Pre-Study Preparations above for a detailed description). Signage differed by location, but both major trailheads had a map of the area, a caution about the strenuous nature of the BGT, and trail rules. Survey responses and visitor observations under the control conditions established a baseline with which to compare all subsequent treatments in order to evaluate their effectiveness in reducing off-trail hiking.

Signs: This treatment installed a specially designed educational sign at each of the three BGT, Section A trailheads. The signs were installed about 60 feet from each trailhead in relatively narrow sections of the trail to maximize the chances visitors would notice the study signs and minimize the distractions of other signs and congregating visitors at the trailheads. These signs were developed to communicate the following information: 1) that over 50 species of rare plants on the island were being trampled by off-trail hiking, 2) that off-trail hiking had created miles of unofficial trails that managers want to close, and 3) that visitors can protect these rare plants by staying on formal paint-blazed trails (Figure 3). This sign was submitted to the Harpers Ferry NPS Sign Program office, which created a design and color scheme consistent with NPS standards. The sign’s text was developed using attribution theory (Rees, Ingledew, & Hardy, 2006; Bradford & McIntyre, 2007) to ascribe a sense of personal responsibility and injunctive-proscriptive wording shown in previous studies to be effective in altering visitor behavior. A

map, with formal vista locations and formal trails labeled, was attached to the signpost below the educational sign (Figure 4 & Figure 5).



Figure 2. Symbolic fencing and prompter signs blocked informal trails originating from the C&O Canal towpath.

Please Do Not Leave Paint-Blazed Trails

Protect Our Rare Plants

Your footsteps could be deadly:	What you can do:	
Over 50 rare species call this island home.	Please do not leave paint-blazed trails.	
Your off-trail footsteps have created miles of unofficial tracks that harm these species.	To protect rare plants everyone's cooperation is needed.	
Managers want to close and restore these tracks.	Even a few footsteps can prevent recovery.	

Figure 3. Educational sign (18 x 12 inches) placed at each trailhead.

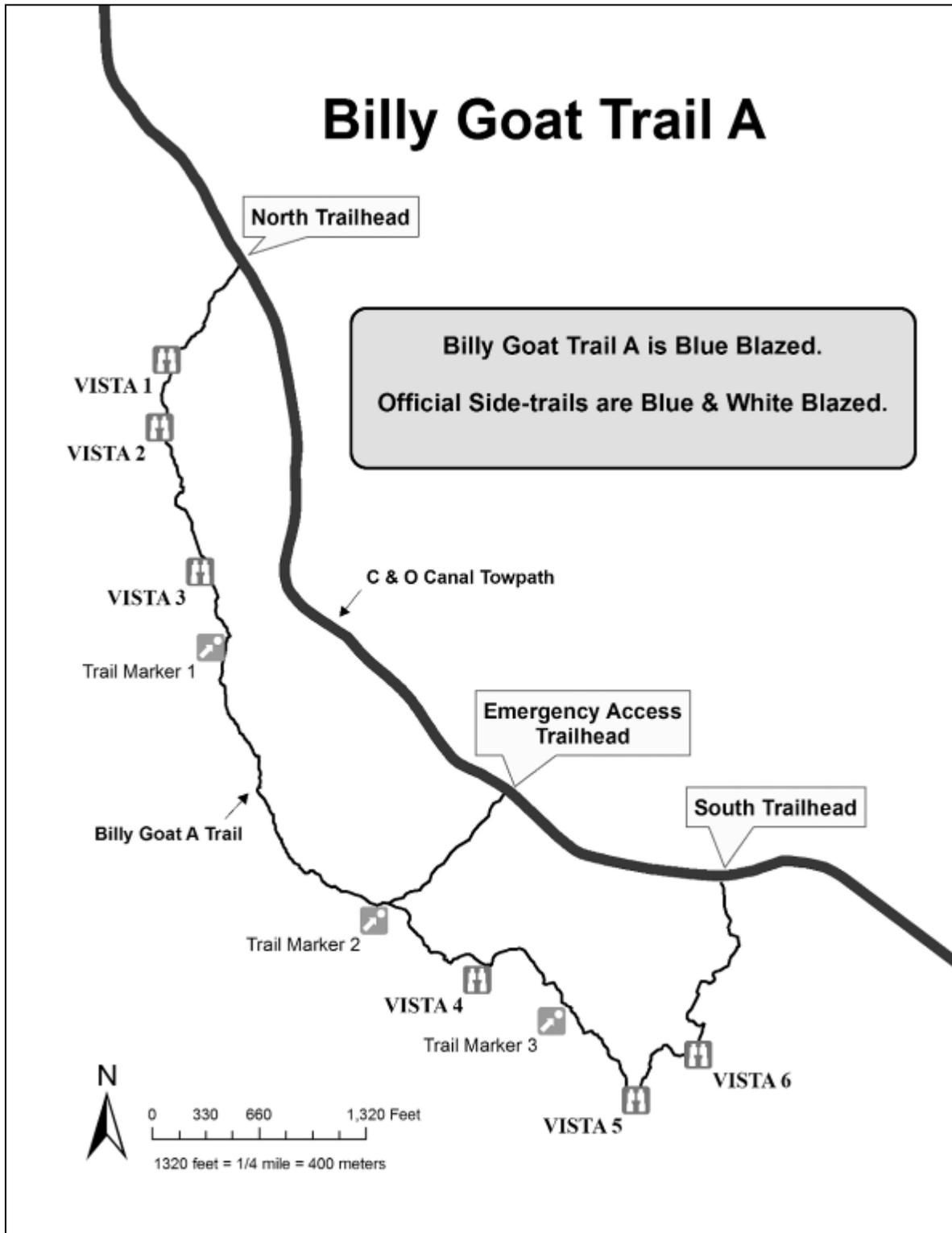


Figure 4. Map (8.5 x 11 inches) attached to the signpost beneath the educational sign with formal vistas marked.



Figure 5. Educational sign and site map with formal trails and vistas labeled that were placed at each trailhead.



Figure 6. Informal trail junction with the BGT, blocked by a log with a prompter sign and brushed behind the log.

In addition to these three educational signs, staff placed a 3”x 3” Vibram boot print prompter sign as a reminder to not hike off-trail at all informal trailheads. These prompter signs were attached to cut logs placed across the beginning portions of 155 identified informal trails that branched off the official BGT on Bear Island (Figure 6). The logs were cut from native materials and were of sufficient size to deter their removal by visitors. They provided a visual barrier that had to be stepped over and the signs clearly communicated the intent to close each of the informal trails. The signs were securely screwed onto the logs to deter vandalism. Sign posts were not used due to: 1) the rocky soils, 2) the ease of pulling them up and throwing them in the woods or carrying them off, and 3) to lessen “sign pollution” – signs screwed to logs are more natural in appearance.

Brushing: The “brushing” treatment added light brushwork to each informal trail junction while maintaining the educational signs at the trailheads and the boot print “no-hiking” prompter signs at 155 informal trail junctions. Project staff and volunteers gathered nearby organic materials to “hide” and naturalize the look of the first 10 to 15 ft of each visitor-created informal trail with twigs, branches, and leaves. The brushing was not intended to physically obstruct traffic, as this would likely cause additional trampling impacts to the rare plants present if hikers decided to forge a new trail adjacent to the one we were attempting to close. Rather, it was designed to mask the presence of a well-trafficked trail that might either attract use because it could lead to an interesting vista or feature, or mislead visitors intending to remain on the formal trail (Figure 6). More thorough naturalization work to hide the entire portion of informal trails visible from the BGT would have been preferred but staffing was unavailable to accomplish this. The level of work done generally consisted of one person spending several minutes of effort.

Restoration and Fencing: This treatment was also additive, keeping the educational signs and brushwork, and adding symbolic restoration sites and fencing. Staff pinned approximately 10 to 15 feet of Jute matting along the informal trails to simulate trail restoration projects at 14 selected “high use” informal trailheads (Figure 8). In addition to the jute, symbolic fencing with white polyester rope (1/4”) and white fiberglass posts (1/2”) was constructed across the junction with the formal trail. Two “no step” prompter signs were placed at the outside edges of the fencing and an additional sign stating that it was a restoration area and asking visitors to protect rare plants was added to the middle of the informal trail (Figure 7). The objective of this work was to suggest to visitors that official restoration work was underway on the informal trail and that they should not hike there – it was not to evaluate the efficacy of the actions implemented in restoring natural conditions at the treated sites.

The level of effort and materials required for the restoration and fencing treatment limited its application to only 14 of the 155 informal trails (9%) that intersected the BGT at the time of the study. However, at least one high use informal trail at each of the two observation sites was treated with the restoration and fencing work and use of the treated trails was directly observed for compliance. Evaluation of this treatment in the survey results is somewhat limited because the treatment was not applied to all informal trails; however, 14 of the more highly used informal trails were treated *and* we conceived that some latent behavioral changes might occur: 1) visitors seeing the restoration work might conclude that it really is important to remain on the formal trail to protect the area’s natural resources, or 2) visitors seeing the restoration work might conclude that only those trails are important to avoid using.



Figure 7. Restoration Area sign (6 x 12 inches) placed at each of 14 restoration sites.



Figure 8. Symbolic restoration and fencing treatments at a large, informal trail junction.

Personal Contact: The last treatment tested the efficacy of personal communication from a trail steward in reducing off-trail hiking. The three main trailhead educational signs and maps (Figure 5) were covered for this treatment; the “no step” prompter signs, brushing, and restoration site fencing, jute, and signage remained in place. Therefore, this treatment was identical to the Restoration & Fencing treatment, except that the educational message was delivered by personal contact with trail stewards instead of a sign. The stewards were trained volunteers with the park and wore their official volunteer attire (i.e., shirts and hats with Trail Steward logos and NPS volunteer embroidered patches). Before beginning this treatment, stewards were trained on how to approach visitors and were given a set of key points to discuss with hikers, which were taken directly from the educational sign. Stewards also carried a laminated copy of the educational sign and the trail map that had the formal vista sites labeled. See Appendix D for the guidance provided to the stewards during training. One or two stewards were stationed about 50 yards down the trail at both primary trailheads during this treatment; because few visitors entered the trail at the Emergency Access, no one was stationed there. As noted above, trail stewards only provided the information on off-trail hiking from the test message during this treatment; as with the other treatments, stewards did not patrol the trail talking to visitors.

Table 3. Summary of management actions applied to reduce informal trail use by treatment.

Management Actions Applied	Treatment				
	Control	Signs	Brushing	Restoration & Fencing	Personal Contact
Educational signs at 3 trailheads	No	Yes	Yes	Yes	No
Symbolic prompter signs at all 155 informal trails	No	Yes	Yes	Yes	Yes
Brushing all 155 informal trailheads	No	No	Yes	Yes	Yes
Symbolic fencing at 14 informal trailheads	No	No	No	Yes	Yes
Restoration at 14 informal trailheads	No	No	No	Yes	Yes
Personal contact with trail stewards	No	No	No	No	Yes

Data Collection (Visitor Survey)

Surveys were administered to hikers exiting the BGT, Section A from May 10, 2007 through June 10, 2007. Each treatment and control was applied to at least two weeknights (from 4:30pm to 7:30pm) and two weekend days (from 10:00am to 6:00pm). Staffing limitations prevented administering surveys to all three trailheads at once. To ensure a representative sample of trail users was obtained for each treatment, survey stations were systematically rotated across the

North Trailhead, South Trailhead, and Emergency Access where the BGT intersects the C&O Canal towpath (Figure 1). Weeknight survey administration was randomly conducted at either the North or South Trailheads on the first night of the treatment and alternated for subsequent weeknight sampling. Weekend survey administration was always conducted at the Emergency Access and at either the North or South Trailheads; the first weekend location was randomly selected and then alternated for the next weekend day (Table 4). Because all trailheads could not be staffed at once, hikers on the towpath were approached and asked if they had just hiked on the BGT, in order to capture at least some of the visitors who had exited at a non-staffed trailhead.

At staffed trailheads, hikers exiting the BGT, Section A were intercepted by volunteers and project staff and asked to fill out an onsite questionnaire that took approximately 10 to 15 minutes to finish. For each exiting group, survey administrators asked the person with the most recent birthday (over age 18) to complete the eight-page questionnaire. See Appendix C for the written survey administration guidance distributed to research staff and volunteers. A total of 1,205 visitors completed the survey for an overall response rate of 66.0%. Refusals were recorded on a log sheet (Appendix B). Sixteen surveys were later removed from the sample because respondents were either park volunteers or participants who indicated they had entered the BGT from an off-trail location, which means they had bypassed at least part of a given treatment. In an effort to make sure that all respondents had been exposed to the educational message delivered by a trail steward during the Personal Contact treatment, potential respondents were asked if they had talked to a trail steward during their hike. Hikers who stated they had not spoken to a trail steward (n=18) were not asked to complete a survey. A breakdown of surveys and response rates across treatments is displayed in Table 5.

Survey Instrument

The 7-page visitor survey collected information on visitor demographics, such as age and gender, and trip characteristics, such as length of hike and primary activity. Visitors were also asked about their past use of the BGT and other hiking trails. Another series of questions was designed to characterize respondent's attachment to the BGT as a place to recreate. A key effort of this study was to communicate through an educational message and physical manipulation of the environment that off-trail hiking is damaging to rare plant communities and that hikers should only travel on formal trails. A series of questions measured awareness of the rare plant communities and impacts of off-trail travel. Respondents were also asked to give their opinions of a range of site management actions that could be taken (some of which were employed in this study) to reduce off-trail hiking on Bear Island. Finally, visitors were asked if they had stayed on the official trail, or had hiked off-trail. If they had hiked off-trail, they were asked for what reason. The survey instrument can be found in Appendix A.

Table 4. Visitor survey sampling schedule.

Treatment	Date	Day of Week	Time	Location
Control (5 days)	5/10/07	Thursday	4:30pm-7:30pm	South Trailhead
	5/11/07	Friday	4:30pm-7:30pm	North Trailhead
	5/12/07	Saturday	10:00am-7:00pm	South Trailhead
		Saturday	10:00am-7:00pm	Emergency Access
	5/13/07	Sunday	10:00am-7:00pm	North Trailhead
		Sunday	10:00am-7:00pm	Emergency Access
	5/14/07	Monday	4:30pm-7:30pm	South Trailhead
Signs (4 days)	5/19/07	Saturday	10:00am-7:00pm	North Trailhead
	5/20/07	Saturday	10:00am-7:00pm	Emergency Access
		Sunday	10:00am-7:00pm	South Trailhead
	5/21/07	Sunday	10:00am-7:00pm	Emergency Access
		Monday	4:30pm-7:30pm	North Trailhead
	5/22/07	Tuesday	4:30pm-7:30pm	South Trailhead
Brushing (4 days)	5/24/07	Thursday	4:30pm-7:30pm	North Trailhead
	5/25/07	Friday	4:30pm-7:30pm	South Trailhead
	5/26/07	Saturday	10:00am-7:00pm	South Trailhead
		Saturday	10:00am-7:00pm	Emergency Access
	5/27/07	Sunday	10:00am-7:00pm	North Trailhead
		Sunday	10:00am-7:00pm	Emergency Access
Restoration & Fencing (4 days)	5/31/07	Thursday	4:30pm-7:30pm	South Trailhead
	6/01/07	Friday	4:30pm-7:30pm	North Trailhead
	6/02/07	Saturday	10:00am-7:00pm	North Trailhead
		Saturday	10:00am-7:00pm	Emergency Access
	6/09/07	Saturday	10:00am-2:00pm	South Trailhead
		Saturday	10:00am-2:00pm	Emergency Access
Personal Contact (4 days)	6/07/07	Thursday	4:30pm-7:30pm	North Trailhead
	6/08/07	Friday	4:30pm-7:30pm	South Trailhead
	6/09/07	Saturday	2:00pm-7:00pm	South Trailhead
		Saturday	2:00pm-7:00pm	Emergency Access
	6/10/07	Sunday	10:00am-7:00pm	North Trailhead
		Sunday	10:00am-7:00pm	Emergency Access

Table 5. Survey response rates.

Treatment	Groups Contacted ¹	Completed Surveys	Refusals	Response Rate
Control	477	304	173	63.7%
Signs	429	278	151	64.8%
Brushing	450	285	165	63.3%
Restoration & Fencing	221	170	51	76.9%
Personal Contact	249	168	81	67.5%
Overall	1826	1205	621	66.0%

¹ Contacts do not include park volunteers or individuals who indicated they had entered the BGT from an informal trail, thus bypassing part of the treatments (n=16) or repeat visitors who previously completed a survey (n=59). The Personal Contact treatment excluded those who indicated they had not spoken to a trail steward (n=18).

Data Analysis

Before conducting statistical analyses to compare visitor survey responses across treatments, it was necessary to establish that respondents in the various treatments were similar. Chi-square analyses confirmed that gender proportions and educational attainment were similar among treatments; however, there were significant differences in age, group size, and the proportion who had previously visited the BGT, Section A (Table 6). Although group size and previous visitor proportions were different, neither characteristic was related significantly to self-reported off-trail hiking behavior, the key dependent variable in this study. However, age was found to be significantly related to off-trail hiking behavior, with youngest respondents being more likely to report hiking off-trail. Respondents in the Control period were significantly older than respondents in the Restoration & Fencing and Personal Contact treatments (Table 7, $p < 0.05$, Tukey's HSD post hoc comparisons). In order to eliminate the effect of age differences among treatments on the comparison of the effectiveness of the treatments, the data were weighted by age category to make each treatment have a similar age distribution (Vaske, 2008; Pike, 2007). The resulting weighted age distribution was based on the age distribution of the entire sample. All results presented in the remainder of the report are from the weighted data, unless otherwise noted.

Survey responses were input into an Excel spreadsheet and then imported into SPSS statistical package for analyses. A Chi-square analysis or analysis of variance was performed on each survey question to determine a significant difference among treatments. The Tukey's HSD test for post hoc comparisons was used to determine statistical differences between pairs of treatments.

Table 6. Comparison of visitor characteristics among treatments.

Visitor Characteristic	Chi-square or Anova
Gender	$\chi^2 = 2.260, p = 0.688$
Educational Attainment	$\chi^2 = 9.462, p = 0.663$
Previous Visitor?	$\chi^2 = 16.577, p = 0.002$
Group Size (categorical)	$\chi^2 = 19.476, p = 0.013$
Age	$\chi^2 = 25.304, p = 0.0013$; $F = 5.385, p < 0.0005$

Table 7. Original respondent age by treatment (un-weighted).

Age Group ²	Treatment ¹					Overall (n=1154)
	Control (n=297)	Signs (n=259)	Brushing (n=275)	Restoration & Fencing (n=162)	Personal Contact (n=161)	
18-24	9.8%	16.6%	16.4%	17.3%	20.5%	15.4%
25-34	37.7	37.5	32.4	44.4	34.8	36.9
35-49	33.7	30.9	37.1	29.0	34.2	33.3
50-80	18.9	15.1	14.2	9.3	10.6	14.4
Mean Age ³ (years)	38.0 ^a	36.2 ^a	36.3 ^a	33.4 ^b	34.3 ^b	36.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 25.304$, $p=0.013$, $df = 12$

³ $F = 5.385$, $p<0.0005$, $df = 4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

VISITOR SURVEY RESULTS

The survey results are organized into ten sections, representing different topic areas. Visitor characteristics (pp. 22-23) are discussed first, followed by a section describing trip characteristics (e.g., duration, route, activity) (pp. 24-28), and a section describing the respondents' history of using the BGT (pp. 28-34). The next sections report visitor beliefs about who manages the BGT, its ecology, and off-trail hiking impacts (pp. 34-40), and visitors' sense of responsibility (pp. 40-42) and level of commitment to protecting the natural resources along the BGT (pp. 42-44). The next sections report visitor evaluations of trail markings (pp. 44-46) and perceptions of park policy regarding off-trail travel (p. 46). The following sections present visitor motivations for hiking off-trail and self-reported off-trail behaviors (pp. 46-52), off-trail hiker characteristics (pp. 52-56), and the efficacy of treatments on appropriate behaviors (pp. 56-58). The final sections report on the effects of the different treatments on visitor experiences (pp. 58-62) and the perceived acceptability of the various management actions employed or potential management actions to reduce off-trail hiking behaviors (pp. 62-69).

Note: Unless stated otherwise, all results presented below are weighted to correct statistically for age differences across treatments in the original sample. Please see the Data Analysis section above for an explanation of the weighting procedure.

Visitor Characteristics

When considering how to approach management issues it is important to understand the type of visitors using an area. Visitor characteristics such as age (Arcury, Johnson & Scollay, 1986), gender (Stern, Dietz & Kalof, 1993; Kellert, 1996), and educational attainment (Hines, Hungerford & Tomera, 1987) have all been shown to influence environmental concern and behaviors. Because visitor demographic characteristics might influence the response to the treatments, it is important to make sure that the type of visitor is similar across all treatments, especially because of the non-random nature of treatment applications due to the additive study design. The tables in this section show the demographic characteristics for each treatment and the overall sample (last column) to demonstrate that the treatments are similar and can be compared.

Respondents to the BGT visitor survey were slightly more likely to be male (53.0%) and the vast majority (85.7%) had attained at least a four-year college degree (Table 8 & Table 9), respectively); gender and educational attainment were similar across treatments. About half (51.9%) of the respondents were younger than 35 years old; after weighting, age proportions were nearly identical across treatments (Table 10).

Visitor Survey Results

Table 8. Gender of respondents by treatment and overall.

Gender ²	Treatment ¹					Overall (n=1146)
	Control (n=297)	Signs (n=259)	Brushing (n=273)	Restoration & Fencing (n=161)	Personal Contact (n=161)	
Male	50.8%	57.1%	50.5%	53.4%	54.4%	53.0%
Female	49.2	42.9	49.5	46.6	45.6	47.0

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 3.138$, $p = 0.535$, $df = 4$

Table 9. Educational attainment by treatment and overall.

Educational Attainment ²	Treatment ¹					Overall (n=1155)
	Control (n=297)	Signs (n=260)	Brushing (n=276)	Restoration & Fencing (n=161)	Personal Contact (n=161)	
High School or less	3.0%	4.2%	2.5%	1.9%	2.5%	3.0%
Associates degree/ some college	8.1	13.1	12.3	13.7	11.2	11.4
Bachelors degree	44.1	37.3	37.3	36.6	39.1	39.2
Advanced degree	44.8	45.4	47.8	47.8	47.2	46.4

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 9833$, $p = 0.631$, $df = 12$

Table 10. Respondent age by treatment and overall.

Age Group ²	Treatment ¹					Overall (n=1154)
	Control (n=298)	Signs (n=260)	Brushing (n=274)	Restoration & Fencing (n=162)	Personal Contact (n=160)	
18-24	15.1%	15.0%	15.0%	14.8%	15.0%	15.0%
25-34	36.9	36.9	36.9	37.0	36.9	36.9
35-49	32.9	33.1	33.2	33.2	33.1	33.1
50-80	15.1	15.0	15.0	15.0	15.0	15.0
Mean Age (years) ³	36.6	36.6	36.1	35.6	35.8	36.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 0.021$, $p = 1.000$, $df = 12$

³ $F = 0.315$, $p = 0.868$, $df = 4$

Trip Description

Visitor behaviors, opinions, and responses to management actions may be influenced by characteristics of their trips, such as distance traveled to the park, length of hike, group size, and motivations for the hike. Because these variables might influence reactions to the treatments (i.e., attempts to close the informal trails), it is important to establish that visitors in the different treatments and control share similar trip characteristics. The tables in this section describe various trip variables by treatment and for the overall sample (last column).

Visitors were asked their home zip code to determine distance traveled to the BGT. Using ESRI ArcMap® the service area of 30 and 60 minutes was determined using the Network Analyst tool. It was calculated that across all treatments 76.7% of the visitors had traveled 30 minutes or less to hike on the BGT (Table 11). An additional 11.7% had traveled 31 to 60 minutes to reach either the Angler's Inn or Great Falls parking areas, so the vast majority of hikers on the BGT are locals. There were also a few (n=12) international visitors from 9 countries in our survey sample. The vast majority (92.2%) of survey respondents hiked the BGT on a weekend (Table 12).

Respondents were asked to describe the type of hike they had completed the day of the survey. Slightly more than half of the hikers (54.3%) spent between 1 and 2 hours on the BGT; very few (6.0%) of the respondents spent a half hour or less on the trail (Table 13). Most respondents (69.6%) hiked the entire length of the BGT, Section A, with about equal proportions hiking from north to south as from the south to the north. Only 18.2% hiked a "half-loop" from one of the main trail entrances to the Emergency Access (Figure 1); similar proportions hiked the northern half-loop (8.6%) as hiked the southern half-loop (9.6%). Few hikers (12.2%) entered and exited at the same trailhead (Table 14). There were no significant differences among treatments for weekend/weekday proportions, length of hike, or routes hiked.

The majority of hikers (64.2%) traveled individually or in pairs; few respondents hiked in groups of 6 or more. Group size was shown to vary significantly by treatment with the Restoration & Fencing and Personal Contact treatments consisting of greater percentages of visitors traveling in groups of 1 or 2 individuals (Table 15).

Respondents were asked to indicate all activities they engaged in during their hike on the BGT, in which we surveyed them. The survey provided a list of 11 potential activities and respondents were given an opportunity to write-in additional activities. Respondents were also asked to indicate what they considered to be their primary activity. Not surprisingly, almost all visitors reported hiking or jogging during their visit (98.3%; Table 16); most (89.7%) also considered hiking or jogging their primary activity (Table 18). Other popular activities were viewing wildlife/birding (37.4%), photography (29.3%), exploring (28.0%), and viewing wildflowers (22.5%). Few (1.0%) reported climbing with ropes but more hikers reported off-trail bouldering (18.0%) during their hike. Fewer hikers reported off-trail bouldering in the Brushing, Restoration & Fencing, and Personal Contact treatments than reported participating in that activity during the Control or Sign treatment (Table 16).

Visitor Survey Results

Table 11. Residence of Billy Goat Trail visitors (unweighted).

Region ¹	N	Percent
Local (Within 30 minutes travel)	862	76.7
Local (Between 31-60 minutes travel)	132	11.7
Neighboring states (DC, DE, MD, VA, WV)	52	4.6
Northeast (CT, MA, ME, NJ, NY, PA, VT)	26	2.3
Midwest (IA, IL, IN, MI, NM, OH, WI)	16	1.4
South (FL, NC, TX)	15	1.3
West (CA, CO, MT, NM, WA)	9	0.8
International visitors (9 countries)	12	1.0

¹ A complete list of the number of respondents by state and country can be found in Appendix E.

Table 12. Day of visit by treatment and overall.

Day of the Week ²	Treatment ¹					Overall (n=1120)
	Control (n=289)	Signs (n=251)	Brushing (n=263)	Restoration & Fencing (n=158)	Personal Contact (n=159)	
Weekday	10.4%	8.8%	8.4%	4.4%	3.8%	7.8%
Weekend	89.6	91.2	91.6	95.6	96.2	92.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 9.230$, $p = 0.056$, $df = 4$

Table 13. Length of hike by treatment and overall.

Minutes on Trail ²	Treatment ¹					Overall (n=1120)
	Control (n=297)	Signs (n=258)	Brushing (n=272)	Restoration & Fencing (n=162)	Personal Contact (n=159)	
1-30 minutes	5.7%	8.1%	4.4%	4.3%	7.5%	6.0%
31-60 minutes	31.6	27.9	23.1	29.0	19.9	27.5
61-120 minutes	50.8	48.4	58.8	58.6	58.4	54.3
120+ minutes	11.8	15.5	10.7	8.0	14.3	12.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 20.225$, $p = 0.063$, $df = 12$

Visitor Survey Results

Table 14. Hiking route by treatment and overall.

Hiking Route ⁴	Treatment ¹					Overall (n=1151)
	Control (n=294)	Signs (n=259)	Brushing (n=275)	Restoration & Fencing (n=161)	Personal Contact (n=162)	
Hiked entire trail (in either direction) ³	64.3%	72.2%	68.7%	73.9%	72.2%	69.6%
South ² to North ²	31.0	32.4	29.5	39.8	40.1	33.4
North to South	33.3	39.8	39.3	34.2	32.1	36.1
Entered/exited at the same location ³	13.3	9.7	12.7	9.9	15.4	12.2
Angler's	5.4	5.0	8.0	3.1	8.0	6.0
Great Falls	7.5	3.9	4.7	5.6	7.4	5.7
Emergency Access ²	0.3	0.8	0.0	1.2	0.0	0.4
Angler's half loop ³	11.9	8.5	9.8	9.9	6.8	9.6
Angler's to EA	10.9	0.8	9.1	9.3	6.8	9.0
EA ² to Angler's	1.0	0.4	0.7	0.6	0.0	0.6
Great Falls half loop ³	10.5	9.7	8.7	6.2	5.6	8.6
Great Falls to EA	9.2	6.9	8.7	5.6	5.6	7.6
EA to Great Falls	1.4	2.7	0.0	0.6	0.0	1.0

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² South Trailhead is near Anglers Inn, North Trailhead is near Great Falls Tavern, and EA stands for Emergency Access Trailhead (Figure 2).

³ Bold/shaded numbers in each column add to 100. Non-bold/un-shaded numbers in each column add to 100.

⁴ $\chi^2 = 13.127$, $p = 0.360$, $df = 12$ (on bold/shaded numbers)

Table 15. Group size by treatment and overall.

Number of people per group ²	Treatment ¹					Overall (n=1131)
	Control (n=292)	Signs (n=253)	Brushing (n=273)	Restoration & Fencing (n=156)	Personal Contact (n=157)	
1-2 people	59.9%	64.0%	58.6%	73.7%	72.6%	64.2%
3-5 people	34.9	28.9	35.2	20.7	23.6	30.1
6+ people	5.1	7.1	6.2	5.6	3.8	5.7

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 19.953$, $p = 0.011$, $df = 8$

Visitor Survey Results

Table 16. Participation in various activities along the Billy Goat Trail, ordered by overall participation rate.

Activity	Treatment ¹					Overall (n=1151)
	Control (n=296)	Signs (n=258)	Brushing (n=274)	Restoration & Fencing (n=162)	Personal Contact (n=161)	
Hiking/Walking	97.3%	98.1%	99.3%	98.1%	99.4%	98.3%
Viewing wildlife/birding	35.3	38.0	39.4	37.7	36.6	37.4
Photography	30.1	32.2	29.2	21.6	31.1	29.3
Exploring	30.2	25.2	29.1	26.5	28.0	28.0
Viewing Wildflowers	23.7	23.2	21.2	17.9	26.1	22.5
Nature Study	18.6	21.3	18.2	17.3	21.1	19.3
Off-trail Bouldering ²	23.7	22.1	13.5	16.0	10.6	18.0
Visiting a favorite place	20.0	18.5	15.3	11.1	20.5	17.4
Running/Jogging	15.6	14.0	13.9	12.3	11.3	13.8
Rock Climbing with ropes	0.7	2.3	0.4	1.2	0.0	1.0
Fishing	0.7	0.0	1.1	1.2	0.0	0.6
Other ³	6.8	8.5	6.6	4.9	9.3	7.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² Indicates significance at the $p \leq 0.05$ level; $\chi^2 = 19.698$, d.f. = 4, $p = 0.001$

³ Open-ended "other" responses are summarized in Table 17 below.

Table 17. Summary of "other" activity responses across all treatments (un-weighted).

Activity	Count (n=84)	Percent ¹
Picnicking	18	21.4%
Social Interaction	16	19.0
Wading/Swimming	12	14.3
Viewing Scenery	8	9.5
Other rock climbing (e.g., free climbing, on-trail bouldering, etc.)	7	8.3
Sunning	5	6.0
Relaxing/Napping	4	4.8
Herpetology (i.e., handling reptiles and amphibians)	3	3.6
Reading	2	2.4
Miscellaneous	10	11.9

¹ Percents do not add to 100 because several individuals listed more than 1 "other" activity. Verbatim responses are given in Appendix F.

Table 18. Primary activity engaged in during hike, by treatment and overall.

Activity	Treatment ¹					Overall (n=1076)
	Control (n=286)	Signs (n=237)	Brushing (n=252)	Restoration & Fencing (n=149)	Personal Contact (n=152)	
Hiking/Walking	87.1%	87.3%	91.3%	91.9%	93.4%	89.7%
Running/Jogging	2.4	0.8	1.6	1.3	1.3	1.6
Exploring	1.4	0.8	0.8	2.0	0.7	1.1
Off-trail Bouldering	1.0	1.3	1.2	1.3	0.0	1.0
Photography	1.0	2.1	0.0	0.7	0.7	0.9
Rock Climbing with Ropes	1.0	0.8	0.0	0.0	0.0	0.5
Visiting a Favorite Place	0.0	0.8	0.0	0.7	0.0	0.3
Viewing Wildlife/Birding	0.3	0.0	0.4	0.7	0.0	0.3
Nature Study	0.3	0.0	0.4	0.0	0.0	0.2
Fishing	0.7	0.0	0.0	0.0	0.0	0.2
Viewing Wildflowers	0.0	0.4	0.0	0.0	0.0	0.1
Other ²	4.5	5.5	4.4	1.3	3.9	4.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² Verbatim open-ended “other” responses are listed in Appendix F.

History of Trail Use and Place Attachment

This survey included questions on past experience and place attachment of visitors, as past research has shown that these two characteristics can have an influence of visitors’ attitudes, management preferences, and behavior (Manning, 1999; Farnum, Hall & Kruger, 2005). Past experience, for example, was found to influence visitors’ site choice (Vaske, Donnelly & Heberlein, 1980) and attitudes toward management actions and site choice (Watson, Roggenbuck and Williams, 1992). Place attachment can be defined as a positive connection or bond between a person and a particular place (William and Vaske, 2003). Past research has identified two major components of place attachment, including place dependence (functional dependence on place) and place identity (emotional bond with place) (Farnum *et al.*, 2005).

The survey also included questions to characterize visitors’ past hiking and trail running experiences in park-like settings in general and on the BGT, specifically. The majority of survey respondents (73.3%) had visited the BGT at least once previously (Table 19). When asked how many times they had hiked or run the BGT in the previous 12 months, the majority (58.8%) were using the trail for the first or second time in the past year. However, a relatively large minority of visitors (6.3%) reported hiking/running the trail 21 or more times within the past 12 months (Table 20). Visitors were also asked to recall the first year they had used the Billy Goat Trail. On average, respondents had been using the BGT for 7.3 years. Over one-quarter of the hikers (27.6%) reported using the BGT for more than 10 years; however, nearly one-third (31.6%) had

hiked the BGT for the first time within the last 12 months (Table 21). There were some significant differences among treatments in past use of the Billy Goat Trail. The Restoration & Fencing treatment, in particular, seemed to be comprised of a greater percentage of first-time or infrequent visitors to the BGT (Table 19, Table 20, & Table 21).

Respondents were also asked about their use of other parks. Most (62.7%) had hiked or run on trails other than the BGT at least 6 times during the previous 12 months; 20.8% had hiked 21 or more times in the previous year on other trails (Table 22). A large majority (71.0%) of BGT hikers had been hiking or running in a park setting for 11 years or more; the mean number of years hiking/running was 19.7 years in a park setting (Table 23). There was generally no difference among treatments in use of other trails, but once-again there was a slight trend for the Restoration & Fencing treatment to have more novice hikers.

Visitors to the BGT were asked 15 questions about their level of attachment to the trail and similar resources to gauge their perceived importance of the location. The question items had been used in prior research to evaluate the level of place attachment (Hammit, Kyle & Oh, 2009). A factor analysis (principal components with a varimax rotation) showed two distinct components of place attachment to the Billy Goat Trail. The factored dimensions can be described as Place Identity, a more emotional attachment to a location, and Place Dependence where the individual depends on a location for its ability to provide opportunities to participate in a desired activity (Table 24). These components are consistent with past research (Farnum *et al.*, 2005).

Respondents were more likely to disagree than agree with the items related to Place Dependence regardless of treatment, meaning they were not very dependent on the BGT as a location to hike or run. One exception was that 51.1% agreed that they got more pleasure out of hiking/running on the BGT than from hiking/running on other trails (Table 25). While not Dependent on the trail, BGT visitors were, on average, found to Identify with the BGT (Table 26). A majority of hikers agreed that they were “very attached to the Billy Goat Trail,” had “many memories of the Billy Goat Trail,” and felt a part of the Billy Goat Trail. Place Identity was relatively similar across treatments, except for the Restoration & Fencing treatment, which tended to report lower Place Identity levels; this is likely due to the higher numbers of first time hikers in this treatment (Table 27).

Table 19. Previous experience using the Billy Goat Trail.

First visit to the Billy Goat Trail? ²	Treatment ¹					Overall (n=1141)
	Control (n=295)	Signs (n=253)	Brushing (n=273)	Restoration & Fencing (n=161)	Personal Contact (n=159)	
Yes	23.4%	26.9%	22.7%	39.8%	26.4%	26.7%
No	76.6	73.1	77.3	60.2	73.6	73.3

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 17.882, p = 0.001, df = 4$

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Table 20. Billy Goat Trail use in the past 12 months, including current trip.

Number of Trips on the Billy Goat Trail Last Year ³	Treatment ¹					Overall (n=1131)
	Control (n=290)	Signs (n=253)	Brushing (n=269)	Restoration & Fencing (n=161)	Personal Contact (n=158)	
1-2 times ²	51.0%	58.5%	58.4%	67.7%	65.2%	58.8%
3-5 times	21.0	17.4	24.5	17.4	22.8	20.8
6-10 times	12.8	7.5	7.8	7.5	7.6	8.9
11-20 times	7.2	5.5	4.8	5.0	1.9	5.2
21-50 times	5.5	8.3	4.1	1.2	1.9	4.7
More than 50 times	2.4	2.8	0.4	1.2	0.6	1.6

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² This category includes first time visitors.

³ $\chi^2 = 44.217$, $p = 0.001$, $df = 16$

Table 21. Years hiking or running the Billy Goat Trail (includes first time visitors).

Number of years hiking or running the BGT ³	Treatment ¹					Overall (n=1129)
	Control (n=289)	Signs (n=252)	Brushing (n=269)	Restoration & Fencing (n=161)	Personal Contact (n=158)	
0 years ²	27.7%	32.1%	28.3%	42.9%	32.3%	31.6%
1-5 years	26.0	22.2	24.9	24.8	25.9	24.7
6-10 years	13.8	16.7	18.2	17.4	13.9	16.0
11-20 years	19.7	18.3	17.5	12.4	19.0	17.7
More than 21 years	12.8	10.7	11.2	2.5	8.9	9.9
Mean number of years ⁴	8.3 ^a	7.7 ^a	7.9 ^a	4.5 ^b	7.0 ^{ab}	7.3

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² This category includes first time visitors.

³ $\chi^2 = 27.665$, $p = 0.035$, $df = 16$

⁴ $F=5.041$, $p<0.0005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

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Table 22. Frequency of using other trails over the previous 12 months.

Number of trips on other trails last year ²	Treatment ¹					Overall (n=1062)
	Control (n=283)	Signs (n=231)	Brushing (n=268)	Restoration & Fencing (n=139)	Personal Contact (n=141)	
1-2 times	18.7%	19.0%	20.1%	20.1%	16.3%	19.0%
3-5 times	18.7	23.8	21.6	26.6	28.4	22.9
6-10 times	20.5	16.0	25.7	15.8	24.8	20.8
11-20 times	19.8	16.5	16.0	11.5	15.6	16.5
21-50 times	15.5	14.3	10.8	14.4	7.1	12.8
More than 50 times	6.7	10.4	5.6	11.5	7.8	8.0

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 31.504$, $p = 0.049$, $df = 20$

Table 23. Number of years hiking or running on any trail in a park setting.

Number of years hiking or running any trail ³	Treatment ¹					Overall (n=1058)
	Control (n=281)	Signs (n=230)	Brushing (n=265)	Restoration & Fencing (n=141)	Personal Contact (n=141)	
0 years ²	3.6%	7.0%	2.3%	9.9%	2.1%	4.6%
1-5 years	10.7	9.1	12.8	9.2	9.9	10.6
6-10 years	12.5	9.6	18.1	14.9	13.5	13.7
11-20 years	24.6	31.3	26.4	23.4	28.4	26.8
More than 21 years	48.8	43.0	40.4	42.6	46.1	44.2
Mean number of years ⁴	20.7	19.6	19.0	18.8	20.1	19.7

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² This category includes first time visitors.

³ $\chi^2 = 31.655$, $p = 0.011$, $df = 16$

⁴ $F = 0.809$, $p = 0.519$, $df = 4$

Table 24. Factor analysis of Place Attachment questions (un-weighted).

Factored Dimension (Item)	Factor Loading ¹
Place Dependence (Cronbach's alpha = .854)	
The Billy Goat Trail is the only place I desire to hike/run.	.819
I consider only the Billy Goat Trail when I go hiking/running.	.772
I rarely ever hike/run at any place other than the Billy Goat Trail.	.751
Hiking/running on the Billy Goat Trail is more important to me than hiking/running on any other trail.	.745
I would not substitute any other area for the hiking/running I do at the Billy Goat Trail.	.623
I get more pleasure out of hiking/running on the Billy Goat Trail than from hiking/running on other trails.	.597
Place Identity (Cronbach's alpha = .923)	
I feel like the Billy Goat Trail is a part of me.	.829
I feel connected to the Billy Goat Trail.	.829
I identify strongly with the Billy Goat Trail.	.814
I feel like I belong at the Billy Goat Trail.	.805
When I am at the Billy Goat Trail I feel I am part of it.	.763
I know the Billy Goat Trail like the back of my hand.	.730
I have many memories of hiking/running at the Billy Goat Trail.	.698
I could draw a rough map of the Billy Goat Trail.	.675
I am very attached to the Billy Goat Trail.	.662

¹ Factor loadings range from 0 to 1 and higher numbers reflect a closer relationship of the individual item to the factor.

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Table 25. Agreement level with Place Dependence questions across all treatments. ¹

	N	Level of Agreement ²			Mean ³
		Agree	Neutral	Disagree	
I get more pleasure out of hiking/running on the Billy Goat Trail than from hiking/running on other trails.	1146	51.1%	36.9%	12.0%	0.5
I would not substitute any other area for the hiking/running I do at the Billy Goat Trail.	1144	27.8	33.5	38.6	0.0
Hiking/running on the Billy Goat Trail is more important to me than hiking/running on any other trail.	1144	20.8	28.8	50.4	-0.4
I rarely ever hike/run at any place other than the Billy Goat Trail.	1146	17.0	17.3	65.7	-0.7
I consider only the Billy Goat Trail when I go hiking/running.	1148	16.9	20.8	62.3	-0.6
The Billy Goat Trail is the only place I desire to hike/run.	1142	10.1	19.6	70.3	-0.9

¹ See Appendix G for complete results by treatment.

² Strongly Agree and Agree responses, and Strongly Disagree and Disagree responses were combined.

³ 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

Table 26. Agreement level with Place Identity questions across all treatments. ¹

	N	Level of Agreement ²			Mean ³
		Agree	Neutral	Disagree	
I am very attached to the Billy Goat Trail.	1124	64.7%	24.7%	10.6%	0.8
I have many memories of hiking/running at the Billy Goat Trail. ⁴	1144	61.2	18.0	20.8	0.6
When I am at the Billy Goat Trail I feel I am part of it.	1131	54.3	30.2	15.6	0.5
I feel connected to the Billy Goat Trail.	1143	47.4	33.8	18.8	0.3
I feel like I belong at the Billy Goat Trail.	1137	46.5	33.4	20.1	0.3
I could draw a rough map of the Billy Goat Trail.	1139	44.4	17.7	37.8	0.1
I identify strongly with the Billy Goat Trail. ⁴	1122	40.4	37.1	22.5	0.2
I feel like the Billy Goat Trail is a part of me. ⁴	1141	35.8	34.9	29.4	0.1
I know the Billy Goat Trail like the back of my hand. ⁴	1135	25.6	22.9	51.5	-0.4

¹ See Appendix H for complete results by treatment.

² Strongly Agree and Agree responses, and Strongly Disagree and Disagree responses were combined.

³ 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

⁴ Bold rows indicate that either the Chi-square or Anova indicated a significant difference ($p < 0.05$) among treatments.

Table 27. Place Dependence and Place Identity averages by treatment and overall.

	Treatment ¹					Anova	Overall Mean (n=1033)
	Control (n=295)	Signs (n=256)	Brushing (n=272)	Restoration & Fencing (n=158)	Personal Contact (n=160)		
Place Dependence ²	-0.3	-0.3	-0.4	-0.4	-0.5	F=0.953 p=0.433	-0.4
Place Identity ²	0.3 ^a	0.2 ^{ab}	0.3 ^{ab}	0.1 ^b	0.2 ^{ab}	F=2.855 p=0.022	0.3

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² Grand mean of all questions within each category; 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ Means with different superscripts are significantly different (Tukey's HSD; p<0.05).

Visitor Beliefs about Management, Ecology, and Off-Trail Impacts

Research on the effectiveness of interpretive messages to reduce depreciative behaviors in natural areas have found that providing visitors with a rationale for changing their behavior is an important component to any message and is sometimes as effective as sanctions in reducing depreciative behaviors (Duncan & Martin, 2002). Visitors have chosen to hike in a natural area because they enjoy and value the outdoors and generally want to help and protect the environment. Knowledge of the issues (Hungerford & Volk, 1990) and awareness of the consequences of visitor actions on cultural or environmental resources (Gramann, Bonifield & Kim, 1995) have been shown to reduce depreciative behaviors or the intention to engage in depreciative behaviors. It is possible that many visitors to the BGT would choose to stay on the paint-blazed trails if they are simply made aware of the special ecology of Bear Island and the consequences of off-trail travel.

Visitors were asked a series of questions to ascertain their knowledge of the management and ecology of Bear Island. Two questions asked visitors to indicate who managed the area and what the primary purpose of the area was. Five questions that focused on off-trail hiking impacts along the BGT were taken directly from the content of the educational sign that was introduced in the Sign treatment and were verbally communicated to visitors in the Personal Contact treatment. Two additional questions about the impacts of off-trail hiking were not addressed directly by the sign or Personal Contact script.

Managing Agency and Purpose of Area

In an open-ended format, visitors were asked to indicate who they thought managed the lands around the Billy Goat Trail. Across all treatments, a majority (59.6%) said they did not know who managed the Billy Goat Trail, and this did not improve with the Sign or Personal Contact communications. Of those who said they knew who managed the trail, 32.4% said they thought the NPS was the sole manager; only 1.6% (19 of 1154 respondents) knew that both the NPS and TNC jointly managed the area (Table 28). Although the majority of hikers were unaware of who managed the area around the Billy Goat Trail, the vast majority (83.8%) believed that the area was managed both for recreation and the protection of natural and cultural resources (Table 29).

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Table 28. Visitors' knowledge of who owns and manages the land around the Billy Goat Trail (open-ended).

Owner(s) ³	Treatment ¹					Overall (n=1154)
	Control (n=298)	Signs (n=259)	Brushing (n=275)	Restoration & Fencing (n=161)	Personal Contact (n=161)	
Don't Know	55.0%	60.6%	60.0%	64.6%	60.9%	59.6%
Correct (NPS² and TNC²)	1.7	1.5	0.7	0.0	5.0	1.6
Partially Correct	39.9	34.7	33.8	31.5	32.1	35.0
NPS	37.9	32.0	32.0	28.0	28.0	32.4
NPS and Other	2.0	2.7	1.1	2.5	1.9	2.0
TNC	0.0	0.0	0.7	0.6	1.9	0.5
Incorrect	3.4	3.1	5.5	4.3	2.5	3.8
State/County Park	1.7	1.2	2.9	2.5	1.2	1.9
Other Federal	0.7	0.4	1.8	0.6	0.0	0.8
Private Organization	0.0	0.4	0.7	1.2	0.6	0.5
Miscellaneous	1.0	1.2	0.0	0.0	0.6	0.6

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² NPS (National Park Service) and TNC (The Nature Conservancy)

³ $\chi^2 = 22.968$, $p=0.028$, $df = 12$ (Chi-square test was conducted on the shaded rows only.)

Table 29. Visitors' beliefs about the primary purpose of Billy Goat Trail management.

Primary Management Purpose ²	Treatment ¹					Overall (n=1117)
	Control (n=290)	Signs (n=248)	Brushing (n=265)	Restoration & Fencing (n=159)	Personal Contact (n=155)	
Both recreation <u>and</u> protection of natural and cultural resources	84.1%	82.7%	82.6%	83.0%	87.7%	83.8%
Protection of natural and cultural resources	3.1	4.0	3.8	3.8	3.2	3.6
Recreation	4.1	2.4	2.6	5.7	2.6	3.4
Don't Know	8.6	10.9	10.9	7.5	6.5	9.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 8.600$, $p=0.737$, $df= 12$

Visitor Beliefs about Off-Trail Hiking Impacts

Survey respondents were asked seven questions about off-trail hiking impacts along the BGT on Bear Island. Five of the questions were taken directly from the content of the educational sign used in the Sign treatment (Figure 3); the same concepts were also communicated to hikers by volunteer trail stewards in the Personal Contact treatment.

The educational Sign treatment reduced the percentage of hikers who felt that it was “acceptable to walk off the paint-blazed trails, if visitors stay on the unofficial trails already created by other visitors” (from 30.4% in the Control to 17.8%, Table 30); however, the most significant reduction occurred in the Personal Contact treatment with only 5.1% finding it acceptable. However, respondents in the Personal Contact treatment were similarly unaware to those in other treatments and the Control that “visitors had created many miles of trails on Bear Island” (Table 31); across all treatments, only 36.9% agreed that off-trail hiking had created many miles of trails. While they were unaware of the extent of unofficial trails, the majority of visitors (63.2%) agreed that even limited use of the unofficial trails could prevent their recovery (Table 32). There was a slight, but statistically insignificant, trend for those receiving the Personal Contact treatment to agree more that limited use prevents recovery ($\chi^2 = 7.197$, $p=0.066$, $df = 3$).

Visitors were asked several questions about the impacts of off-trail hiking on native plants along the BGT. The Sign and Personal Contact script specifically stated that there were many special and rare plants that lived along the trail and that use of unofficial trails was a serious threat to those plants. The Personal Contact treatment was effective in communicating that there were rare plants along the trail; the educational Sign treatment did not effectively communicate that message (Table 33). In the Control condition, only 39.7% knew that there were rare plants along the trail; interaction with the trail steward improved that percentage to 57.0%. Interestingly, more people (59.8%) agreed that “the continued use of unofficial visitor-created trails is a serious threat to rare plants along the Billy Goat Trail” than agreed that there were rare plants along the BGT (44.1%; Table 34).

Two additional questions asked about off-trail hiking impacts to the environment that were not explicitly communicated in the educational sign or trail steward script. When asked if soils and plants along the trail were very hardy and not easily damaged, the majority (61.3%) of hikers in the Personal Contact treatment disagreed, compared to 36.7% in the Control and 41.7% in the Signs treatment (Table 35). While not directly communicated, the educational sign and trail steward script did state that rare plants were damaged by off-trail hiking, so this finding is not surprising. Respondents were also asked if they agreed that “off-trail hiking on Bear Island can spread non-native weedy plants.” The educational sign did not improve the percentage who agreed with this statement, but the Personal Contact did (Table 36).

In order to look at the overall impact of the treatments on conveying information on the environmental impacts of off-trail hiking, a summary score was calculated for the 5 questions taken directly from the sign/steward script content and for all 7 questions. The pro-environmental response was scored a “1” and all other response, including “neutral” and “don’t know” were scored a “0.” For example, “agree” responses to “visitors have created many miles of trails on Bear Island” were scored a “1”, and “disagree,” “neutral,” and “don’t know” responses were scored a “0.” Of the 5 questions taken from the educational sign, those in the Personal Contact treatment answered in a pro-environmental way to 3.4 of them, which was significantly greater than the number who answered pro-environmentally in the Control or other

treatments. Those in the Personal Contact treatment also answered more pro-environmentally than the other treatments or the Control when all 7 questions were considered (Table 37).

One notable finding in this series of belief or knowledge questions about off-trail hiking impacts on native plants was that a relatively high percentage of respondents answered “don’t know” to many of the items. For example, 45.2% in the Control said they didn’t know if there were “many special and rare plants that live near the Billy Goat Trail” (Table 33). Similarly, 47.8% in the Control did not know that “visitors have created many miles of trails on Bear Island” (Table 31). The presence of the educational sign and trail stewards somewhat reduced the “don’t know” responses, but the percentages remained relatively high. This suggests that there is a need to educate visitors about the special and rare plants found on Bear Island and the impact of off-trail hiking on those plants.

Table 30. Agreement level with the statement: "It is acceptable to walk off the paint blazed trails, if visitors stay on the unofficial trails already created by other visitors."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1138)
	Control (n=296)	Signs (n=253)	Brushing (n=271)	Restoration & Fencing (n=160)	Personal Contact (n=158)	
Agree	30.4%	17.8%	16.2%	12.5%	5.1%	18.2%
Neutral	20.6	22.5	13.7	16.9	3.2	16.4
Disagree	49.0	59.7	70.1	70.6	91.8	65.4
Means ⁴	-0.3 ^a	-0.6 ^b	-0.8 ^b	-0.9 ^b	-1.4 ^c	-0.7

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 101.630$, $p < 0.0005$, $df = 8$

⁴ $F = 29.099$, $p < 0.0005$, $df = 4$; means with different superscripts are significantly different (Tukey's HSD; $p \leq 0.05$).

Table 31. Agreement level with the statement: "Visitors have created many miles of trails on Bear Island."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1142)
	Control (n=295)	Signs (n=254)	Brushing (n=272)	Restoration & Fencing (n=162)	Personal Contact (n=159)	
Agree	34.2%	41.7%	32.7%	34.6%	43.4%	36.9%
Neutral	14.9	16.1	19.1	17.3	15.7	16.6
Disagree	3.1	2.4	2.6	3.1	1.3	2.5
Don't Know	47.8	39.8	45.6	45.1	39.6	44.0

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=11.664$, $p=0.473$, $df = 12$

Table 32. Agreement level with the statement: "Even limited use of visitor-created trails can prevent their recovery."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1142)
	Control (n=293)	Signs (n=254)	Brushing (n=272)	Restoration & Fencing (n=162)	Personal Contact (n=161)	
Agree	60.8%	54.7%	67.3%	64.8%	72.7%	63.2%
Neutral	17.7	24.4	14.0	13.6	10.6	16.7
Disagree	7.5	5.1	5.9	9.9	5.0	6.6
Don't Know	14.0	15.7	12.9	11.7	11.8	13.5

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2= 27.770$, $p=0.006$, $df = 12$

Table 33. Agreement level with the statement: "There are many special and rare plants that live near the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1135)
	Control (n=290)	Signs (n=255)	Brushing (n=271)	Restoration & Fencing (n=161)	Personal Contact (n=158)	
Agree	39.7%	41.2%	45.4%	41.6%	57.0%	44.1%
Neutral	13.4	15.7	17.3	17.4	9.5	14.9
Disagree	1.7	2.0	1.5	1.9	1.3	1.7
Don't Know	45.2	41.2	35.8	39.1	32.3	39.4

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2= 19.406$, $p=0.079$, $df = 12$

Table 34. Agreement level with the statement: "The continued use of unofficial visitor-created trails is a serious threat to rare plants along the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1143)
	Control (n=295)	Signs (n=253)	Brushing (n=274)	Restoration & Fencing (n=162)	Personal Contact (n=159)	
Agree	49.2%	59.7%	61.3%	57.4%	79.2%	59.8%
Neutral	18.3	19.0	14.6	16.0	8.2	15.8
Disagree	7.8	5.1	6.2	8.6	3.1	6.3
Don't Know	24.7	16.2	17.9	17.9	9.4	18.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 44.605$, $p < 0.0005$, $df = 12$

Table 35. Agreement level with the statement: "Soils and plants along the Billy Goat Trail are very hardy and not easily damaged."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1140)
	Control (n=294)	Signs (n=254)	Brushing (n=272)	Restoration & Fencing (n=160)	Personal Contact (n=160)	
Agree	13.3%	11.0%	11.4%	10.6%	5.0%	10.8%
Neutral	19.4	19.7	19.1	16.3	13.1	18.1
Disagree	36.7	41.7	44.9	44.4	61.3	44.3
Don't Know	30.6	27.6	24.6	28.8	20.6	26.8

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 29.217$, $p = 0.004$, $df = 12$

Table 36. Agreement level with the statement: "Off-trail hiking on Bear Island can spread non-native weedy plants."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1138)
	Control (n=294)	Signs (n=251)	Brushing (n=273)	Restoration & Fencing (n=161)	Personal Contact (n=159)	
Agree	43.1%	37.8%	47.6%	45.3%	53.5%	44.8
Neutral	16.3	18.7	15.4	16.8	9.4	15.7
Disagree	3.7	2.8	6.2	8.1	3.1	4.7
Don't Know	36.7	40.6	30.8	29.8	34.0	34.8

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 25.571$, $p = 0.012$, $df = 12$

Table 37. Summary of knowledge and beliefs about off-trail hiking issues.

Mean Pro-environmental Beliefs ²	Treatment ¹					Overall (n=1111)
	Control (n=288)	Signs (n=246)	Brushing (n=263)	Restoration & Fencing (n=158)	Personal Contact (n=154)	
Sign Content Only ³	2.3 ^a	2.6 ^{ab}	2.8 ^b	2.7 ^{ab}	3.4 ^c	2.7
All Questions ⁴	3.1 ^a	3.4 ^{ab}	3.7 ^b	3.6 ^{ab}	4.6 ^c	3.6

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² Pro-environmental responses were scored a “1” and anti-environmental, neutral, and don’t know responses were scored a “0”.

³ Sum of 5 questions taken directly from the sign content (Tables 27-31); F=14.212, p<0.0005, df=4; means with different superscripts are significantly different (Tukey’s HSD; p≤0.05).

⁴ Sum of 7 questions taken directly from the sign content and related to the sign content (See Tables 32 and 33); F=13.287, p<0.0005, df=4; means with different superscripts are significantly different (Tukey’s HSD; p≤0.05).

Personal Responsibility

Three questions were asked to ascertain the level of personal responsibility hikers felt toward the natural resources around the Billy Goat Trail. Research has shown that people who internalize responsibility are more likely to engage in helping behavior, either toward others or the environment (Granzin & Olsen, 1991), and a review of pro-environmental behavior literature found that there was a moderately strong relationship between a sense of personal responsibility and pro-environmental behavior (Hines *et al.*, 1987). The educational sign in this study was designed to instill a sense of personal responsibility toward the resource by using personal language. For example, statements like “*your* footsteps could be deadly” and instructions for “What *you* can do” personalized the message; the sign also stated that “everyone’s cooperation is needed.”

The vast majority (80.9%) of hikers indicated they felt “responsible for the care of the Billy Goat Trail,” regardless of treatment (Table 38). Across all treatments, only 2.5% did not feel responsible for caring for the Billy Goat Trail; the highest percentage (3.8%) was in the Restoration & Fencing treatment, which had the highest percentage of first time visitors. In fact, across all treatments, first time visitors were less likely to agree (76.0%) that they felt responsible for the care of the BGT than repeat visitors (82.9%; $\chi^2 = 7.008$, p=0.030, df=2). Hikers across all treatments felt even more strongly (87.7%) that they felt a “responsibility to help protect the special plants and ecosystems along the Billy Goat Trail” (Table 39).

When asked about their level of responsibility for causing damage to the soils and vegetation along the BGT compared with other visitors, about half were neutral (51.3%); most others (39.0%) felt they caused less damage than other hikers (Table 40).

Table 38. Agreement level with the statement: "I feel responsible for the care of the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1140)
	Control (n=295)	Signs (n=257)	Brushing (n=270)	Restoration & Fencing (n=160)	Personal Contact (n=158)	
Agree	81.0%	78.2%	79.3%	81.9%	86.7%	80.9%
Neutral	16.9	18.3	18.9	14.4	12.0	16.7
Disagree	2.0	3.5	1.9	3.8	1.3	2.5
Means ⁴	1.1	1.0	1.1	1.1	1.2	1.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=8.526$, $p=0.384$, $df = 8$

⁴ $F=1.883$, $p=0.111$, $df=4$

Table 39. Agreement level with the statement: "I feel a responsibility to help protect the special plants and ecosystems along the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1147)
	Control (n=296)	Signs (n=257)	Brushing (n=273)	Restoration & Fencing (n=162)	Personal Contact (n=159)	
Agree	88.5%	84.4%	88.3%	88.3%	89.9%	87.7%
Neutral	10.5	13.6	9.5	11.1	8.8	10.8
Disagree	1.0	1.9	2.2	0.6	1.3	1.5
Means ⁴	1.2	1.1	1.2	1.2	1.2	1.2

¹ Refer to Table 1 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=5.997$, $p=0.648$, $df = 8$

⁴ $F=0.429$, $p=0.788$, $df=4$

Table 40. Agreement level with the statement: "Compared to other people I saw on this visit, I am causing less damage to the soils and vegetation along the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1140)
	Control (n=294)	Signs (n=256)	Brushing (n=271)	Restoration & Fencing (n=158)	Personal Contact (n=161)	
Agree	40.8%	40.6%	38.7%	34.8%	37.9 %	39.0%
Neutral	51.0	50.0	50.2	55.7	51.6	51.3
Disagree	8.2	9.4	11.1	9.5	10.6	9.6
Means ⁴	0.4	0.4	0.4	0.3	0.3	0.4

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=3.341$, $p=0.911$, $df = 8$

⁴ $F=0.593$, $p=0.668$, $df=4$

Commitment to the Trail as a Resource

Verbal commitment to engaging in a pro-environmental behavior has been shown to be a relatively strong predictor of environmental concern and behavior (Cottrell & Graefe, 1997). Therefore, those who state that they are willing to stay on the trails to protect the environment or even give up hiking in certain areas of Bear Island are likely to be more inclined to actually stay on the paint-blazed trails.

Respondents were asked three questions to gauge their level of commitment to protecting the natural resources along the Billy Goat Trail. When asked about personal willingness to remain on official trails to protect rare plants, visitors overwhelmingly supported the notion with at least 90% agreeing with the given statement, regardless of treatment. Hikers in the Personal Contact treatment were slightly more likely to say they were willing to stay on the paint blazed trails (Table 41). While almost everyone (91.5%, overall) said they were willing to stay on the paint blazed trails, fewer (85.8%) said they were willing to give up exploring off-trail to protect soils and plants (Table 42); even fewer 80.8% said they were willing to give up hiking or running in some areas of Bear Island to protect rare plants (Table 43). Hikers in the Personal Contact treatment were more willing than those in Control to give up exploring off-trail or hiking in some areas to protect rare plants. These findings suggest that although the vast majority wants to protect rare plants, fewer are willing to give up exploring off-trail or accepting closure of some areas to protect them. Respondents who had talked to a trail steward were generally more committed to protecting the resources along the Billy Goat Trail, even if it meant limiting access or freedoms.

Table 41. Agreement level with the statement: "I am willing to stay on the paint blazed trails to protect rare plants."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1145)
	Control (n=294)	Signs (n=256)	Brushing (n=273)	Restoration & Fencing (n=162)	Personal Contact (n=160)	
Agree	90.5%	91.0%	90.8%	90.1%	96.9%	91.5%
Neutral	5.8	5.9	6.6	8.6	2.5	5.9
Disagree	3.7	3.1	2.6	1.2	0.6	2.5
Means ⁴	1.3 ^a	1.3 ^a	1.4 ^a	1.4 ^{ab}	1.6 ^b	1.4

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=11.411$, $p=0.179$, $df = 8$

⁴ $F=4.400$, $p=0.002$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 42. Agreement level with the statement: "The soils and plants along the Billy Goat Trail should be protected even if visitors are not allowed to explore off trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1143)
	Control (n=296)	Signs (n=255)	Brushing (n=272)	Restoration & Fencing (n=161)	Personal Contact (n=159)	
Agree	82.1%	85.9%	86.8%	83.2%	93.7%	85.8%
Neutral	12.2	11.4	8.8	12.4	3.1	10.0
Disagree	5.7	2.7	4.4	4.3	3.1	4.2
Means ⁴	1.1 ^a	1.2 ^{ab}	1.2 ^{ab}	1.1 ^a	1.4 ^b	1.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=15.894$, $p=0.044$, $df = 8$

⁴ $F=3.756$, $p=0.005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 43. Agreement level with the statement: "I am willing to give up hiking or running in some areas of Bear Island in order to protect rare plants."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1140)
	Control (n=292)	Signs (n=256)	Brushing (n=269)	Restoration & Fencing (n=163)	Personal Contact (n=160)	
Agree	77.7%	80.9%	79.9%	77.9%	90.6%	80.8%
Neutral	16.1	15.2	13.4	16.6	6.9	14.0
Disagree	6.2	3.9	6.7	5.5	2.5	5.2
Means ⁴	1.0 ^a	1.1 ^{ab}	1.1 ^a	1.0 ^a	1.3 ^b	1.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=15.052$, $p=0.058$, $df = 8$

⁴ $F=4.457$, $p=0.001$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Evaluation of Trail Markings and Features

In addition to scenic views visible from the main Billy Goat Trail, six vista sites were blazed to indicate they were considered open to the public (see Figure 4). The majority across all treatments (77.2%) agreed that “there were official paint blazed trails leading to the places I wanted to visit (Table 44). The educational and site management treatments all significantly increased the percentage of hikers who agreed that “the park provides clear indications about which trails should not be used” (Table 45). In the Control, only about half of the hikers (52.0%) felt the park clearly marked which trails should not be used. In the Personal Contact treatment (that included prompter signs, brushing, and the restoration and fencing applications), 89.2% of hikers agreed that the park clearly marked which trails should not be used. Although only about half of the Control group felt that the park clearly marked which trails not to use, the vast majority of hikers in the Control (91.8%) agreed that “the official paint blazed trails were well marked” (Table 46).

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Table 44. Agreement level with the statement: "there were official paint blazed trails leading to the places I wanted to visit."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1136)
	Control (n=292)	Signs (n=252)	Brushing (n=272)	Restoration & Fencing (n=162)	Personal Contact (n=158)	
Agree	77.7%	75.4%	78.7%	69.8%	84.2%	77.2%
Neutral	17.8	16.3	13.2	20.4	10.8	15.8
Disagree	4.5	8.3	8.1	9.9	5.1	7.0
Means ⁴	0.9 ^{ab}	0.9 ^{ab}	0.9 ^{ab}	0.8 ^a	1.1 ^b	0.9

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=15.493$, $p=0.050$, $df = 8$

⁴ $F=3.134$, $p=0.014$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 45. Agreement level with the statement: "the park provides clear indications about which trails should not be used."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1140)
	Control (n=294)	Signs (n=256)	Brushing (n=271)	Restoration & Fencing (n=162)	Personal Contact (n=157)	
Agree	52.0%	75.4%	80.8%	84.0%	89.2%	73.8%
Neutral	18.4	17.6	9.2	9.3	7.6	13.2
Disagree	29.6	7.0	10.0	6.8	3.2	13.0
Means ⁴	0.3 ^a	0.9 ^b	0.9 ^{bc}	1.0 ^{bc}	1.2 ^c	0.8

¹ Refer to Table 1 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=134.229$, $p<0.0005$, $df = 8$

⁴ $F=31.319$, $p<0.0005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 46. Agreement level with the statement: "the official paint blazed trails were well marked."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1140)
	Control (n=292)	Signs (n=256)	Brushing (n=269)	Restoration & Fencing (n=163)	Personal Contact (n=160)	
Agree	91.8%	90.2%	92.6%	90.1%	94.4%	91.8%
Neutral	6.8	6.3	6.3	7.4	3.8	6.2
Disagree	1.4	3.5	1.1	2.5	1.9	2.0
Means ⁴	1.3	1.3	1.3	1.3	1.4	1.3

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2=7.137$, $p=0.522$, $df = 8$

⁴ $F=0.508$, $p=0.730$, $df=4$

Off-trail Hiking

Park Policy Perception

Across all treatments, the majority of visitors believed that the park either required (38.3%) or encouraged (50.6%) visitors to stay on the paint-blazed trails; only 0.5% thought the park allowed visitors to hike anywhere on Bear Island (Table 47). The percentage of visitors who thought the park required visitors to stay on the paint-blazed trails increased as the treatments became more aggressive; only 25.4% in the Control thought that off-trail hiking was prohibited, compared to 51.9% in the Personal Contact treatment. The Personal Contact treatment was extremely effective in reducing the percentage of visitors who said they didn't know what the policy was to 1.3% (from 13.9% in the Control); the Sign, Brushing, and Restoration & Fencing treatments also reduced the percentage who didn't know what the policy was, but to a lesser extent.

Reasons for Hiking Off-trail and Self-Reported Behavior

Respondents were asked to indicate whether they left the official paint-blazed trails on the day of the survey for any of 15 reasons; they were asked to check all that applied. It is important to understand the motivations for leaving the official trail because management strategies would likely differ depending on the reason for hiking off-trail. Although a wide variety of potential motivations for leaving the official trails was provided, the respondent was also given the opportunity to indicate other reasons he or she might have had to leave the official trail. (Note: A few individuals checked most or all of the reasons for hiking off trail; it is likely that some of these individuals misunderstood the question or were not being sincere. If a respondent said that he or she hiked off-trail to fish, but was not an angler, that individual was removed from all analyses in this section (n=35).)

Visitor Survey Results

Several different analyses were conducted to characterize this self-reported off-trail hiking behavior and the efficacy of the study treatments. First, the percentage of respondents indicating they left the official trail was calculated for each of the 15 potential motivations. Then, the list of 15 reasons was reduced to 8 categories of motivations for leaving the trail by combining similar reasons. Additionally, the total number of reasons for leaving the official trails was calculated for each respondent. Lastly, each respondent was categorized as having left the trail intentionally at least once, only leaving the trail accidentally because the trail was poorly marked, or as not having left the official trail at all.

Table 47. Visitors' beliefs about which statement best reflects current park policy.

Current Park Policy ²	Treatment ¹					Overall (n=1122)
	Control (n=287)	Signs (n=254)	Brushing (n=266)	Restoration & Fencing (n=157)	Personal Contact (n=158)	
The park <u>requires</u> visitors to stay on the paint-blazed trails (i.e. off-trail hiking is prohibited).	25.4%	37.0%	42.1%	43.9%	51.9%	38.3%
The park <u>encourages</u> visitors to stay on the paint-blazed trails.	56.4	49.6	50.8	46.5	45.6	50.6
The park allows visitors to hike on <u>any trail</u> on Bear Island, whether it is paint-blazed or unmarked.	3.1	3.1	1.5	1.9	1.3	2.3
The park allows visitors to hike <u>anywhere</u> on Bear Island.	1.4	0.8	0.0	0.0	0.0	0.5
Don't Know	13.6	9.4	5.6	7.6	1.3	8.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 58.424$, $p < 0.0005$, $df = 16$

In the Control, the most commonly reported reason for leaving the official trail was to get to a scenic vista or area of interest, followed by moving past others on the trail, using an existing unmarked trail, and exploration (Table 48). The self-reported off-trail hiking frequency declined significantly as management actions increased for most motivations given for leaving the official trails. Respondents were invited to write-in reasons for leaving the official trail that were not listed; the most commonly reported “other” reasons for going off-trail were for a bathroom break and to cliff jump or swim (Table 49).

In order to more easily consider the primary motivations for leaving the official trail, some of the 15 motivations were combined into categories. Despite providing officially designated vista locations, the most common reason for hiking off-trail was for the view or to take a photo of a view (Table 50). Other common reasons were to avoid other hikers or difficult or poor trail

conditions. Although the treatments significantly reduced off-trail travel for these reasons, about 20% of the hikers continued to report hiking off trail because of the view, other people, and trail conditions even in the most intense treatment that involved Personal Contacts with visitors. Fewer hikers reported going off-trail for nature study or to take a route they always used in the Control, but the treatments seemed less effective in reducing off-trail travel for those reasons, except for the Personal Contact treatment.

Another way of comparing the effectiveness of the treatments in reducing off-trail travel for the different motivation categories is to consider the percentage reduction in off-trail travel across treatments. Table 51 reports the percentage reduction (or occasional increase) in off-trail hiking behaviors during each the treatments versus the Control condition. The treatments had variable rates of success in reducing off-trail hiking for the different motivations, but the general trend was increasing effectiveness as management actions became more aggressive. The largest drops in off-trail hiking rates resulted from the Brushing and Personal Contact treatments. In every motivation category the Personal Contact treatment resulted in the greatest reduction of off-trail hiking rates when compared with the Control (between 51 and 67%; Table 51).

Another interesting finding was that about one-third (33.9%) of respondents in the Control said they left the official trail “accidentally because the trail was poorly marked.” Recall that pre-study preparations involved additional blazing of the formal trail to minimize this issue. Although the treatments were effective in reducing “intentional” off-trail behaviors, the percentage who said they hiked off-trail accidentally was not significantly reduced by the treatments (Table 48). This is somewhat surprising because of the extensive symbolic no-hiking signage at all 155 unofficial trail connections to the main official trail.

In an attempt to more succinctly summarize off-trail hiking behavior, survey participants were divided into three mutually exclusive groups: those leaving the trail intentionally for any reason, those who reported that they only left the official trail accidentally, and those who reported they did not leave the official trails at all (Table 52). While 71.1% of participants in the Control group reported intentionally leaving the official trail for at least one reason, this percentage was reduced to 43.6% in the most comprehensive and intensive treatment (Personal Contact). The percentage of those who reported never leaving the paint-blazed formal trail increased from 25.5% in the Control to a high of 48.1% in the Personal Contact treatment.

Although respondents were not asked the number of times that they left the formal trail, the total number of reasons each respondent listed for intentionally hiking off-trail was summed to provide an indication of the *minimum number of times* the visitor likely left the trail. A surprising 48.6% of the respondents in the Control condition reported going off-trail intentionally for three or more reasons; the average number of reasons for hiking off-trail was 2.8 (Table 53). The Brushing, Restoration & Fencing, and Personal Contact treatments significantly reduced the mean number of reasons hikers strayed off-trail, with the lowest mean (1.0 reasons) for the Personal Contact treatment. Therefore, not only did fewer hikers report leaving the formal trail in the Personal Contact treatment, but they left the trail for fewer reasons, and by proxy, left the trail fewer times.

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Table 48. Percent of participants who confirmed they left the official trail for the reason cited.

Reason for hiking off trail	Treatment ¹					χ^2	p
	Control (n=286)	Signs (n=248)	Brushing (n=264)	Restoration & Fencing (n=157)	Personal Contact (n=158)		
To get to a scenic vista or area of interest	45.1%	41.9%	31.8%	33.8%	15.8%	44.503	<0.0005
To move past others on the trail	39.5	37.1	31.8	26.1	13.9	36.760	<0.0005
Because there was an unmarked trail that already existed	38.8	31.0	24.6	23.1	17.1	30.059	<0.0005
To explore	34.7	31.0	24.2	30.6	11.4	31.750	<0.0005
Accidentally because the trail was poorly marked	33.9	34.3	28.8	24.8	27.8	6.476	0.166
To get around a difficult part of the trail	30.2	27.4	20.5	17.9	15.8	18.319	0.001
To get around poor trail conditions	28.8	25.8	20.8	20.4	11.4	19.939	0.001
To get away from crowds on the trail	28.4	29.8	21.2	17.9	8.9	32.029	<0.0005
To take a picture	20.6	24.1	21.6	17.9	8.2	17.349	0.002
To get to a rock climbing spot	15.7	16.9	14.0	7.6	7.6	13.163	0.011
To get to a picnic spot	12.2	9.3	8.3	6.4	3.8	10.532	0.032
To view wildlife/birds	11.5	14.5	12.1	9.6	3.8	12.299	0.015
To take a route you always use	9.4	8.9	6.1	5.7	3.2	8.144	0.086
To view wildflowers	7.7	8.1	8.7	5.1	3.2	6.269	0.182
To get to a fishing spot	0.7	0.0	0.4	0.0	0.0	3.604	0.462

¹ Refer to Table 3 for an explanation of management actions for each treatment.

Table 49. Summary of "other" reasons given for hiking off-trail (un-weighted).

Other Reasons for Hiking Off-Trail ¹	Count	
	(n=31)	Percent
Bathroom break	10	32.3
To swim/cliff jump	6	19.4
To meditate or read	2	6.5
Miscellaneous	13	41.9

¹ A verbatim list of all responses is provided in Appendix I.

Table 50. Percent of participants who confirmed they left the official trail for each motivation category.

Reason for hiking off trail	Treatment ¹					χ^2	p
	Control (n=286)	Signs (n=248)	Brushing (n=264)	Restoration & Fencing (n=157)	Personal Contact (n=158)		
Photo/scenic view ²	50.7%	51.2%	41.5%	38.5%	19.5%	51.558	<0.0005
Other people ³	45.4	45.1	36.7	32.3	19.4	38.383	<0.0005
Trail condition ⁴	43.0	37.6	32.7	29.0	21.2	25.489	<0.0005
To explore	34.7	31.0	24.2	30.6	11.4	31.750	<0.0005
Activity based ⁵	27.6	24.0	22.5	13.6	11.2	23.636	<0.0005
Nature study ⁶	16.3	17.5	15.6	14.3	5.6	12.998	0.011
An unmarked trail already existed ⁷	38.8	31.0	24.6	23.1	17.1	30.059	<0.0005
To take a route you always use ⁷	9.4	8.9	6.1	5.7	3.2	8.144	0.086

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² Includes "to get to a scenic vista or area of interest" and "to take a picture."

³ Includes "to move past others on the trail" and "to get away from others on the trail."

⁴ Includes "to get around a difficult part of the trail" and "to get around poor trail conditions."

⁵ Includes "to get to a rock climbing spot", "to get to a picnic spot", and "to get to a fishing spot."

⁶ Includes "to view wildlife/birds" and "to view wildflowers."

⁷ These two items are not necessarily mutually exclusive from the other motivations listed. For example, one might have taken "an unmarked trail that already existed" to get to a scenic view or to bypass poor trail conditions.

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Table 51. Percentage reduction or increase in self-reported off-trail hiking behavior for each treatment when compared to the percentage who reported going off-trail for each reason in the control condition.

Reason for hiking off trail ²	Treatment ¹				
	Control (n=286)	Signs (n=248)	Brushing (n=264)	Restoration & Fencing (n=157)	Personal Contact (n=158)
Photo/scenic view	50.7%	+1.0%	-18.2%	-24.1%	-61.5%
Other people	45.4	-0.7	-19.2	-28.9	-57.3
Trail condition	43.0	-12.6	-24.0	-32.6	-50.7
To explore	34.7	-10.7	-30.3	-11.8	-67.1
Activity based	27.6	-13.0	-18.4	-50.7	-59.4
Nature study	16.3	+7.4	-4.3	-12.3	-65.6
Mean Reduction ³		-4.7	-19.1	-26.7	-60.3
To take a route you always use	9.4	-5.3	-35.1	-39.4	-66.0
An unmarked trail already existed	38.8	-20.1	-36.6	-40.5	-55.9

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² See Table 47 for an explanation of the motivation categories.

³ Mean reduction calculations do not include “an unmarked trail already existed” and “to take a route you always use” because those two items are not necessarily mutually exclusive from the other motivations listed. For example, one might have taken “an unmarked trail that already existed” to get to a scenic view or to bypass poor trail conditions.

Table 52. Self-reported off-trail travel summary, by treatment.

Visitors went off trail... ²	Treatment ¹					Overall (n=1113)
	Control (n=294)	Signs (n=257)	Brushing (n=270)	Restoration & Fencing (n=161)	Personal Contact (n=159)	
Not at all	25.5%	25.4%	35.6%	38.9%	48.1%	33.0%
Accidentally	4.2	4.0	4.2	2.5	8.9	4.6
Intentionally	70.3 ^{a 3}	70.6 ^a	60.2 ^b	58.6 ^b	43.0 ^c	62.4

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 41.377$, $p < 0.0005$, $df=8$; The Chi-square test combined “not at all” and “accidentally” categories.

³ Percentages with different superscripts are significantly different ($p \leq 0.05$) when pairwise Chi-square analyses were conducted).

Table 53. Total number of intentional reasons reported by visitors for hiking off-trail.

Total intentional reasons reported for hiking off trail ²	Treatment ¹					Overall (n=1113)
	Control (n=286)	Signs (n=248)	Brushing (n=264)	Restoration & Fencing (n=156)	Personal Contact (n=159)	
0	32.5%	33.1%	41.4%	44.5%	62.3%	40.7%
1 to 2	18.9	21.8	25.5	24.5	20.8	22.1
3 to 5	31.8	29.8	20.9	21.3	12.6	24.6
6 or more	16.8	15.3	12.2	9.7	4.4	12.6
Mean number of reasons ³	2.8 ^a	2.7 ^{ab}	2.2 ^{bc}	1.9 ^c	1.0 ^d	2.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² $\chi^2 = 65.596$, $p < 0.0005$, $df = 12$; total potential reasons = 12 (see motivations listed Table 48 minus “accidentally,” “to take a route you always use,” and “an unmarked trail already existed”)

³ $F = 14.183$, $p < 0.0005$, $df = 4$; means with different superscripts are significantly different (Tukey’s HSD; $p \leq 0.05$).

Off-Trail Hiker Characteristics

In attempting to understand and minimize off-trail hiking behavior it is useful to investigate the characteristics of visitors who are more or less likely to hike off-trail. Based on self-reported intentional off-trail hiking behavior (Table 52), several demographic, experience, responsibility, knowledge, and activity characteristics were considered. These analyses combined visitors from all treatments and the control.

Age (Table 54) and educational attainment (Table 55) were both found to significantly influence self-reported off-trail hiking behavior; the youngest hikers had the highest off-trail rates and the most educated had the lowest. Gender was not found to influence off-trail hiking behavior ($\chi^2 = 1.115$, $p = 0.291$, $df = 1$). Experience hiking on trails everywhere and the number of hiking trips taken last year on any trail were not related to self-reported off-trail hiking rates on the BGT ($\chi^2 = 0.996$, $p = 0.915$, $df = 4$ and $\chi^2 = 5.221$, $p = 0.389$, $df = 4$, respectively). There was a slight, but non-significant tendency for visitors who hiked the BGT frequently (11 or more times a year) to be more likely to hike off-trail (Table 56). There were also differences between the number of years a visitor had hiked the BGT and off-trail behavior, with those who had hiked the trail from 6 to 10 years reporting the higher off-trail rates (Table 57) than those who had hiked both fewer and more years. Place Dependence (Table 25) was not related to off-trail hiking behaviors ($\chi^2 = 0.510$, $p = 0.775$, $df = 2$). Visitors who scored highest on the Place Identity scale (Table 26) were slightly more likely to report hiking off-trail intentionally (Table 58).

While most demographic and experience characteristics showed no or relatively weak relationships to off-trail hiking behaviors, other characteristics related to knowledge of the resource, sense of responsibility, and commitment to the resource showed stronger relationships to off-trail hiking choices. Those with greater knowledge of the special and rare plants and informal trail impacts to Bear Island (Table 30 through Table 37) reported lower off-trail hiking rates than those with less awareness of the consequences of off-trail hiking (Table 59). Similarly,

visitors who reported a stronger sense of responsibility to help protect and care for the BGT and its ecosystems (Table 38 and Table 39) were less likely to report hiking off-trail than those with a lower sense of responsibility (Table 60). Commitment to protecting the resource was measured by asking visitors several questions about their willingness to give up exploring off-trail or using certain areas of Bear Island to protect the special and rare plants (Table 41 through Table 43). Those who indicated the highest commitment levels were least likely to report hiking off-trail (Table 61) than those who were less willing to give up some hiking opportunities to protect the resource.

Several activities were also positively associated with self-reported off-trail hiking behavior (i.e., they had higher off-trail rates than those who did not engage in those activities). Visitors who reported running or jogging, exploring, visiting a special place, and bouldering had higher off-trail hiking rates than those who did not engage in those activities (Table 62). Surprisingly, even though the engaging in the activities of photography, viewing wildlife/birding, viewing wildflowers, and nature study might have a tendency to draw people off-trail, those that reported participating in those activities had similar off-trail hiking rates than those who did not. Anglers and rock climbers mostly reported hiking off-trail, but their participation rates were too low for statistical testing (Table 62).

Table 54. Intentional off-trail hiking self-reports by age category.

Visitors went off trail... ¹	Age (years)			
	18 to 24 (n=170)	25 to 34 (n=425)	35 to 49 (n=379)	50 to 80 (n=172)
Not at all or Accidentally	25.9%	36.0%	39.8%	40.7%
Intentionally	74.1	64.0	60.2	59.3

¹ $\chi^2 = 11.451, p=0.010, df=3$

Table 55. Intentional off-trail hiking self-reports by educational attainment.

Visitors went off trail... ¹	Age (years)			
	High School or Less (n=34)	Associates Degree/ Some College (n=129)	Bachelors Degree (n=450)	Advanced Degree (n=534)
Not at all or Accidentally	26.5%	34.1%	30.7%	42.5%
Intentionally	73.5	65.9	69.3	57.5

¹ $\chi^2 = 16.730, p=0.001, df=3$

Table 56. Intentional off-trail hiking self-reports by number of trips to the Billy Goat Trail in the last 12 months.

Visitors went off trail... ¹	Number of Trips to the Billy Goat Trail in Last 12 Months				
	1 to 2 (n=661)	3 to 5 (n=234)	6 to 10 (n=100)	11 to 20 (n=60)	21 or more (n=70)
Not at all or Accidentally	39.2%	38.6%	30.0%	26.7%	27.1%
Intentionally	60.8	63.2	70.0	73.3	72.9

¹ $\chi^2 = 9.034, p=0.060, df=4$

Table 57. Intentional off-trail hiking self-reports by the number of years hiking the Billy Goat Trail.

Visitors went off trail... ¹	Number of Years Hiking the Billy Goat Trail				
	0 (n=352)	1 to 5 (n=279)	6 to 10 (n=100)	11 to 20 (n=178)	21 or more (n=112)
Not at all or Accidentally	40.1%	32.3%	28.7%	41.7%	37.5%
Intentionally	59.9	67.7	71.3	58.3	62.5

¹ $\chi^2 = 11.204, p=0.024, df=4$

Table 58. Intentional off-trail hiking self-reports by level of Place Identity.

Visitors went off trail... ¹	Place Identity Level		
	Low (n=271)	Medium (n=563)	High (n=227)
Not at all or Accidentally	42.1%	37.1%	31.3%
Intentionally	57.9	62.9	68.7

¹ $\chi^2 = 6.159, p=0.046, df=2$

Table 59. Intentional off-trail hiking self-reports by resource knowledge level.

Visitors went off trail... ¹	Knowledge Level		
	Low (n=368)	Medium (n=523)	High (n=252)
Not at all or Accidentally	29.9%	39.0%	42.5%
Intentionally	70.1	61.0	57.5

¹ $\chi^2 = 12.113, p=0.002, df=2$

Table 60. Intentional off-trail hiking self-reports by level of personal responsibility.

Visitors went off trail... ¹	Sense of Responsibility Level		
	Low (n=261)	Medium (n=646)	High (n=261)
Not at all or Accidentally	31.8%	36.1%	44.1%
Intentionally	68.2	63.9	55.9

¹ $\chi^2 = 8.855, p=0.012, df=2$

Table 61. Intentional off-trail hiking self-reports by level of commitment to the resource.

Visitors went off trail... ¹	Level of Commitment		
	Low (n=256)	Medium (n=630)	High (n=407)
Not at all or Accidentally	23.4%	36.2%	51.1%
Intentionally	76.6	63.8	48.9

¹ $\chi^2 = 43.991, p<0.0005, df=2$

Table 62. Intentional off-trail hiking self-reports by type of activity.

Activity	Participant		Non-participant		Chi-square
	n	% off	n	% off	
Jogging/Running	168	72.6	1014	61.7	$\chi^2 = 7.347, p=0.007$
Exploring	332	72.0	850	59.9	$\chi^2 = 15.058, p<0.0005$
Visiting a special place	210	70.0	972	61.8	$\chi^2 = 4.959, p=0.026$
Bouldering	211	87.2	971	58.1	$\chi^2 = 63.254, p<0.0005$
Fishing	7	85.7	1175	63.1	N/A
Rock climbing with ropes	11	100.0	1171	62.9	N/A

Effectiveness of Treatments on Appropriate Behaviors

In order to further assess the impact of the treatments on visitor behavior, participants were asked to indicate reasons why they chose NOT to hike off the official trail. The most frequently cited reasons were because of the signs with “no hiking” symbols, fear of damaging soils, and fear of damaging plants (Table 63). Nearly 70% or more of the participants in each treatment indicated they had no reason to hike off the official trail. This appears to be in conflict with the 70% to 43% (depending on treatment) who reported hiking off-trail intentionally (Table 52); in fact, in the Control, 66% of the respondents who indicated a reason for intentionally going off-trail responded that they had no reason to hike off-trail. When viewed in the context of the many opportunities to go off-trail during a hike, these results suggest that visitors stay on the formal trail unless they have a compelling reason to leave.

Interestingly, “having no reason” to hike off-trail was the most common reason cited for staying on the official trails during the Control. However, when the treatments were present, staying on the trail so as not “to step on and damage any rare plants by mistake” and because “of the signs with “no hiking symbols” also became commonly cited (61% to 88%, depending on treatment) reasons for staying on the formal trails (Table 63). Few said they chose to stay on the formal trail because they feared being reprimanded by a trail steward during the Control (3.9%). The percentage who feared being confronted by a trail stewards was higher during the Personal Contact treatment (17.4%) even though stewards were only located at the trailheads during the study.

Respondents were given the opportunity to give reasons for not leaving the formal trail that were not listed on the survey. The most common “other” reason for not leaving the formal trail was the fear of getting lost or other safety-related concerns (Table 64).

Table 63. Reasons for not hiking off-trail by treatment.

I chose <u>not</u> to hike off an official paint blazed trail because....	Treatment ¹					χ^2	p
	Control (n=282)	Signs (n=247)	Brushing (n=260)	Restoration & Fencing (n=158)	Personal Contact (n=155)		
General							
I had no reason to hike off-trail	73.7%	69.8%	77.5%	81.4%	75.3%	8.193	0.085
I didn't want to cause any soil erosion or compaction	49.6	65.6	67.0	73.2	87.1	66.940	<0.0005
Sign Related							
of the signs with "no hiking" symbols	N/A	74.8	80.8	82.9	86.4	9.062	0.028
I didn't want to step on and damage any rare plants by mistake	47.0	61.3	67.2	75.8	87.7	83.108	<0.0005
It is not fair for me to walk off the paint-blazed trails when many other visitors don't	35.7	45.5	54.8	58.7	62.7	41.337	<0.0005
Brushing Related							
I could see the park had tried to re-naturalize off-trail areas with brush and leaves	N/A ²	N/A ²	61.2	N/A ²	N/A ²	N/A	N/A
Personal Contact Related							
I was afraid I would be reprimanded or confronted by a trail steward	3.9	8.5	10.8	11.4	17.4	22.960	<0.0005
Other Reasons ³	9.6	5.9	3.9	6.5	7.8		

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² This question was only asked on surveys during the "Brushing" treatment.

³ Open-ended "other" responses are summarized in Table 64 below; verbatim responses are given in Appendix J.

Table 64. Summary of "other" reasons given for not hiking off-trail (un-weighted).

Other Reasons for <u>not</u> Hiking Off-Trail ¹	Count	
	(n=75)	Percent ²
Safety concerns/ fear of getting lost	20	26.7
Don't want to harm the environment	14	18.7
Trails well marked/maintained	13	17.3
Avoid poison ivy and bugs	5	6.7
Stewards asked to stay on trail	4	5.3
I follow rules	3	4.0
Acting as a role model	2	2.7
Miscellaneous	15	20.0

¹ A verbatim list of all responses is provided in Appendix J.

² Note: 1 person listed 2 reasons so percentages don't add to 100.

Effect of Treatments on Visitor Experience

Visitors were asked a series of questions about how various implemented or potential management actions or tools along the BGT impacted their hiking experience. Specifically, visitors were asked if different types of signs, trail closures, and trail stewards had a positive or negative impact on their experience.

Almost all visitors reported seeing paint blazes on rocks and trees along the trail and they overwhelmingly (91.6%) said the blazes were a positive influence on their experience (Table 65). Most visitors (89.4%) reported seeing signs with rules near the trailhead (Table 66). Of those who recalled seeing a sign with rules and regulations, very few visitors (2.5%) said that the rules and regulations signs negatively impacted their experience and most (71.3%) were positively impacted. Similar percentages of visitors reported seeing educational signs near the trailheads across all treatments (79.4% to 87.5%) even though the test educational signs were only present during the Signs, Brushing, and Restoration & Fencing treatments (Table 67). Another surprising finding was that those who recalled seeing the educational signs evaluated them similarly to signs containing rules and regulations (Table 66 and Table 67).

Visitors were asked if the “closure of unofficial trails limited my enjoyment” and most disagreed (61.6% to 74.7%), regardless of treatment (Table 68). Interestingly, similar percentages indicated that closures limited their enjoyment in the Signs, Brushing, and Restoration & Fencing treatments as in the Control condition, when no logs, prompter signs, or symbolic fencing were present. This suggests that the extensive signage and brushing at all 155 informal trail junctions did not significantly impact visitor enjoyment. The Personal Contact treatment had the fewest visitors who said trail closures limited their enjoyment (8.2%). Similarly, visitors in the Personal Contact treatment were significantly less likely to say the boot print “no hiking” signs had a negative effect on their experience than those in the Signs, Brushing, and Restoration & Fencing treatments (Table 69); in fact, the vast majority (83.0%) viewed the “no hiking” signs

positively. Visitors in the Brushing treatment were asked the effect of “using brush and logs to re-naturalize an area” on their experience; of those who noticed, few (3.4%) said the brushing negatively impacted their experience (Table 70).

Visitors were also asked about the effect of trail stewards on their hiking experience. Prior to the study, trail stewards routinely hiked the BGT to answer questions, teach Leave No Trace principles, and reprimand hikers who were breaking the rules, such as bringing their dogs on the trail. During the study period, stewards were asked not to patrol the BGT so that they would not influence the behaviors we were studying; however, stewards were still present on the C&O Canal Towpath. The Control, Signs, Brushing, and Restoration & Fencing treatments all had similar percentages of visitors who reported seeing a trail steward (44.2% to 46.6%; Table 71). In contrast, almost everyone (93.6%) in the Personal Contact treatment reported encountering a trail steward, who were stationed at the north and south trailheads to deliver the educational message on the impacts of informal trails on Bear Island during that treatment. Trail stewards were much more positively received during the Personal Contact treatment (75.5%) than they were during the Control and other treatments (47.3% to 57.9%).

Table 65. Effect of paint blazes on rocks and trees on visitor experience.

Effect on Experience ^{2,3}	Treatment ¹					Overall (n=1137)
	Control (n=294)	Signs (n=254)	Brushing (n=272)	Restoration & Fencing (n=161)	Personal Contact (n=156)	
Positive	90.8%	91.2%	91.4%	90.6%	94.9%	91.6%
Neutral	7.5	6.8	7.5	6.9	5.1	6.9
Negative	1.7	2.0	1.1	2.5	0.0	1.5
Didn't See	0.7	1.6	1.5	1.2	0.0	1.1
Means ⁴	1.4	1.4	1.4	1.4	1.5	1.4

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = very negative, 0 = neutral, +2 = very positive.

³ $\chi^2 = 5.394$, $p=0.715$, $df = 8$; Chi-square test and experience impact percentages do not include “Didn’t See” category.

⁴ $F=1.204$, $p=0.307$, $df=4$

Table 66. Effect of signs with rules near the trailhead on visitor experience.

Effect on Experience ^{2,3}	Treatment ¹					Overall (n=1129)
	Control (n=290)	Signs (n=252)	Brushing (n=271)	Restoration & Fencing (n=161)	Personal Contact (n=155)	
Positive	66.4%	69.6%	72.1%	72.5%	80.4%	71.3%
Neutral	31.3	27.8	24.2	26.1	18.1	26.3
Negative	2.3	2.6	3.7	1.4	1.4	2.5
Didn't See	9.7	9.9	10.0	14.3	11.0	10.6
Means ⁴	0.8	0.8	0.8	0.9	1.0	0.9

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = very negative, 0 = neutral, +2 = very positive.

³ $\chi^2 = 11.933$, $p = 0.154$, $df = 8$; Chi-square test and experience impact percentages do not include "Didn't See" category.

⁴ $F = 1.226$, $p = 0.298$, $df = 4$

Table 67. Effect of educational signs near the trailhead on visitor experience.

Effect on Experience ^{2,3}	Treatment ¹					Overall (n=1138)
	Control (n=293)	Signs (n=256)	Brushing (n=272)	Restoration & Fencing (n=160)	Personal Contact (n=157)	
Positive	69.5%	67.6%	73.1%	73.2%	73.8%	71.0%
Neutral	27.7	31.1	25.2	24.4	23.8	26.9
Negative	2.8	1.4	1.7	2.4	2.3	2.1
Didn't See	15.0	13.3	12.5	20.6	17.2	15.1
Means ⁴	0.8	0.8	0.9	0.9	0.9	0.9

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = very negative, 0 = neutral, +2 = very positive.

³ $\chi^2 = 4.811$, $p = 0.778$, $df = 8$; Chi-square test and experience impact percentages do not include "Didn't See" category.

⁴ $F = 0.588$, $p = 0.671$, $df = 4$

Table 68. Agreement level with the statement: "Closures of unofficial trails limited my enjoyment."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1140)
	Control (n=294)	Signs (n=255)	Brushing (n=270)	Restoration & Fencing (n=163)	Personal Contact (n=158)	
Agree	18.0%	20.0%	16.7%	14.7%	8.2%	16.3%
Neutral	20.4	13.7	14.4	17.8	17.1	16.7
Disagree	61.6	66.3	68.9	67.5	74.7	67.0
Means ⁴	-0.5 ^a	-0.6 ^a	-0.7 ^{ab}	-0.7 ^{ab}	-1.0 ^b	2.3

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 16.848$, $p=0.032$, $df = 8$

⁴ $F=5.081$, $p<0.0005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 69. Effect of boot print 'no hiking' signs on visitor experience.

Effect on Experience ^{2,3}	Treatment ¹					Overall (n=842)
	Control (n=0)	Signs (n=253)	Brushing (n=271)	Restoration & Fencing (n=161)	Personal Contact (n=157)	
Positive	NA	66.9%	73.9%	74.1%	83.0%	73.6%
Neutral	NA	19.4	16.1	19.0	12.4	17.0
Negative	NA	13.6	10.0	7.0	4.6	9.5
Didn't See	NA	4.3	3.7	1.9	2.5	3.3
Means ⁴	NA	0.8 ^a	0.9 ^{ab}	1.0 ^{ab}	1.2 ^b	1.0

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = very negative, 0 = neutral, +2 = very positive.

³ $\chi^2 = 15.965$, $p=0.014$, $df = 6$; Chi-square test and experience impact percentages do not include "Didn't See" category.

⁴ $F=4.004$, $p=0.008$, $df=3$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 70. Effect of using brush and logs to re-naturalize an area on visitor experience.

Effect on Experience ¹	Brushing (n=270)
Positive	73.3%
Neutral	23.3
Negative	3.4
Didn't See	14.1
Mean	1.0

¹ Experience impact percentages do not include "Didn't See" category.

Table 71. Effect of trail stewards hiking the trail on visitor experience.

Effect on Experience ^{2,3}	Treatment ¹					Overall (n=1135)
	Control (n=292)	Signs (n=254)	Brushing (n=271)	Restoration & Fencing (n=161)	Personal Contact (n=157)	
Positive	47.3%	48.7%	57.9%	48.0%	75.5%	56.9%
Neutral	41.9	41.0	33.9	41.3	21.8	35.0
Negative	10.9	10.3	8.3	10.7	2.7	8.1
Didn't See	55.8	53.9	55.4	53.4	6.4	48.1
Means ⁴	0.5 ^a	0.5 ^a	0.7 ^{ab}	0.5 ^a	1.0 ^b	0.7

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = very negative, 0 = neutral, +2 = very positive.

³ $\chi^2 = 32.395$, $p < 0.0005$, $df = 8$; Chi-square test and experience impact percentages do not include "Didn't See" category.

⁴ $F = 6.074$, $p < 0.0005$, $df = 4$; means with different superscripts are significantly different (Tukey's HSD; $p \leq 0.05$).

Perceived Acceptability of Management Actions

In addition to evaluating the positive or negative impact of certain management actions on experience quality, participants were also asked to rate the acceptability of potential management actions. Some of the management actions listed were implemented during the course of the study, and others were potential actions the park might consider in the future.

A strong majority of visitors across all treatments found it acceptable to have educational signs explaining the impact to rare plants from off-trail hiking (79.2%; Table 72), signs directing visitors to remain on official trails (78.6%; Table 73), and "no hiking" signs posted at unofficial

trails (76.4%; Table 74). Very few visitors in all treatments found educational signs or signs directing visitors to remain on the official trails to be unacceptable (6.0% and 4.4%, respectively). Interestingly, visitors were more likely to find “no hiking” signs to be unacceptable in the Control condition; visitors tended to be more supportive after the 155 “no hiking” signs were in place, especially when the trail stewards talked to hikers in the Personal Contact treatment (Table 74).

Visitors also generally found it acceptable (64.7%; Table 75) for managers to “improve trail conditions (eliminate mud, downed trees, etc.)” Survey respondents across all treatments and the Control tended to find restoration of unofficial trails to an undisturbed state to be even more acceptable (80.6%; Table 76). However, visitors in the Control were more likely to find the “blocking of unofficial trails with brush and logs” to be unacceptable (16.2%) than visitors in the treatments, when the blocking with logs and brush had actually been implemented (5.0% to 11.9%; Table 77).

Visitors were generally less supportive of potential management actions that included volunteer trail steward or ranger presence along the Billy Goat Trail. However, visitors tended to find trail stewards asking visitors to stay on the paint-blazed trails to be most acceptable in the Personal Contact treatment (69.7%) than in the other treatments, when the trail stewards were not actually present (47.3% to 57.8%; Table 78). Visitors in the Personal Contact treatment also tended to be more supportive of “increased ranger presence along the trail” (65.4%), especially when compared to Control visitors (45.1%; Table 79).

The majority of visitors in all conditions said that it would be acceptable to have “rules prohibiting visitors from hiking off of the official paint blazed trails” (Table 80); however, the support for such rules was stronger in the treatments, especially the Personal Contact treatment. While most found a rule prohibiting off-trail trail travel to be acceptable, there was much less support for the potential management action of having a “monetary fine for visitors who hike off the official paint blazed trails” (Table 81). However, support for a monetary fine was slightly higher in the Brushing, Restoration & Fencing, and Personal Contact treatments.

Table 82 summarizes the percentage who found each potential management action to be acceptable in each treatment. In general, visitors were most supportive of signage and restoration efforts. They were less supportive of more direct management actions such as increasing trail steward or ranger presence along the trails and imposing a fine for hiking off-trail.

Table 72. Acceptability ratings for the potential management action "educational signs along the trail about the damage that can be caused by walking off trail on rare plants."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1138)
	Control (n=295)	Signs (n=257)	Brushing (n=271)	Restoration & Fencing (n=161)	Personal Contact (n=154)	
Acceptable	80.7%	79.4%	77.5%	76.4%	81.8%	79.2%
Neutral	15.6	15.6	13.7	16.8	12.3	14.9
Unacceptable	3.7	5.1	8.9	6.8	5.8	6.0
Means ⁴	4.2	4.3	4.1	4.1	4.3	4.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1 = Unacceptable to 5 = Acceptable

³ $\chi^2=8.808$, $p=0.359$, $df=8$

⁴ $F=2.220$, $p=0.065$, $df=4$

Table 73. Acceptability ratings for the potential management action "signs directing visitors to remain on the official paint-blazed trails."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1135)
	Control (n=292)	Signs (n=256)	Brushing (n=270)	Restoration & Fencing (n=161)	Personal Contact (n=156)	
Acceptable	77.7%	81.6%	78.1%	75.2%	79.5%	78.6%
Neutral	17.8	15.6	16.7	18.6	16.7	17.0
Unacceptable	4.5	2.7	5.2	6.2	3.8	4.4
Means ⁴	4.1	4.2	4.1	4.0	4.2	4.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1= Unacceptable to 5 = Acceptable

³ $\chi^2=4.571$, $p=0.802$, $df=8$

⁴ $F=1.934$, $p=0.103$, $df=4$

Table 74. Acceptability ratings for the potential management action ""no hiking" signs posted at unofficial, non-blazed trails."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1141)
	Control (n=295)	Signs (n=257)	Brushing (n=271)	Restoration & Fencing (n=161)	Personal Contact (n=157)	
Acceptable	68.5%	77.4%	79.3%	78.3%	82.8%	76.4%
Neutral	17.6	14.4	14.4	12.4	13.4	14.8
Unacceptable	13.9	8.2	6.3	9.3	3.8	8.8
Means ⁴	3.8 ^a	4.1 ^b	4.1 ^b	4.0 ^{ab}	4.2 ^b	4.0

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1= Unacceptable to 5 = Acceptable

³ $\chi^2=21.488$, $p=0.006$, $df=8$

⁴ $F=4.647$, $p=0.001$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 75. Acceptability ratings for the potential management action "improve trail conditions (eliminate mud, downed trees, etc.)."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1136)
	Control (n=295)	Signs (n=255)	Brushing (n=270)	Restoration & Fencing (n=161)	Personal Contact (n=155)	
Acceptable	59.3%	62.4%	67.8%	70.2%	67.7%	64.7%
Neutral	28.8	27.5	24.8	19.9	21.3	25.3
Unacceptable	11.9	10.2	7.4	9.9	11.0	10.0
Means ⁴	0.7	0.8	0.9	0.9	0.9	0.8

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1= Unacceptable to 5 = Acceptable

³ $\chi^2=10.680$, $p=0.220$, $df=8$

⁴ $F=2.155$, $p=0.072$, $df=4$

Table 76. Acceptability ratings for the potential management action "restoration of unofficial, non-blazed trails to an undisturbed state."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1128)
	Control (n=293)	Signs (n=253)	Brushing (n=265)	Restoration & Fencing (n=160)	Personal Contact (n=157)	
Acceptable	75.4%	80.2%	82.6%	82.5%	85.4%	80.6%
Neutral	18.1	15.4	15.8	13.8	12.7	15.6
Unacceptable	6.5	4.3	1.5	3.8	1.9	3.8
Means ⁴	1.1 ^a	1.2 ^{ab}	1.2 ^{ab}	1.2 ^{ab}	1.4 ^b	1.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = Unacceptable to +2 = Acceptable

³ $\chi^2=14.836$, $p=0.062$, $df=8$

⁴ $F=2.834$, $p=0.024$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 77. Acceptability ratings for the potential management action "blocking unofficial trails with brush and logs."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1096)
	Control (n=277)	Signs (n=246)	Brushing (n=261)	Restoration & Fencing (n=159)	Personal Contact (n=153)	
Acceptable	65.7%	79.3%	82.8%	78.0%	81.0%	76.7%
Neutral	18.1	11.0	12.3	10.1	13.1	13.2
Unacceptable	16.2	9.8	5.0	11.9	5.9	10.0
Means ⁴	3.8 ^a	4.1 ^b	4.2 ^b	4.0 ^{ab}	4.2 ^b	4.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1= Unacceptable to 5 = Acceptable

³ $\chi^2=33.956$, $p<0.0005$, $df=8$

⁴ $F=7.041$, $p<0.0005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 78. Acceptability ratings for the potential management action "volunteer trail stewards asking visitors to stay on official paint-blazed trails."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1137)
	Control (n=296)	Signs (n=257)	Brushing (n=268)	Restoration & Fencing (n=161)	Personal Contact (n=155)	
Acceptable	47.3%	52.5%	57.8%	57.8%	69.7%	55.5%
Neutral	30.1	24.5	27.2	21.7	20.6	25.7
Unacceptable	22.6	23.0	14.9	20.5	9.7	18.8
Means ⁴	3.4 ^a	3.4 ^a	3.6 ^a	3.5 ^a	4.0 ^b	3.5

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1= Unacceptable to 5 = Acceptable

³ $\chi^2=29.046$, $p<0.0005$, $df=8$

⁴ $F=7.636$, $p<0.0005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 79. Acceptability ratings for the potential management action "increased ranger presence along trails."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1126)
	Control (n=288)	Signs (n=255)	Brushing (n=266)	Restoration & Fencing (n=161)	Personal Contact (n=156)	
Acceptable	45.1%	47.5%	53.8%	52.8%	65.4%	51.6%
Neutral	30.6	30.2	30.5	27.3	17.3	28.2
Unacceptable	24.3	22.4	15.8	19.9	17.3	20.2
Means ⁴	3.3 ^a	3.4 ^{ab}	3.6 ^{bc}	3.4 ^{abc}	3.8 ^c	3.5

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1= Unacceptable to 5 = Acceptable

³ $\chi^2=23.423$, $p=0.003$, $df=8$

⁴ $F=5.570$, $p<0.0005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 80. Acceptability ratings for the potential management action "rules prohibiting visitors from hiking off of the official paint-blazed trails."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1132)
	Control (n=293)	Signs (n=254)	Brushing (n=268)	Restoration & Fencing (n=159)	Personal Contact (n=158)	
Acceptable	56.7%	66.1%	67.2%	66.7%	72.8%	64.9%
Neutral	24.6	20.9	24.6	23.3	19.0	22.8
Unacceptable	18.8	13.0	8.2	10.1	8.2	12.3
Means ⁴	3.6 ^a	3.8 ^{ab}	3.9 ^b	3.8 ^{ab}	4.0 ^b	3.8

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1= Unacceptable to 5 = Acceptable

³ $\chi^2=23.691$, $p=0.003$, $df=8$

⁴ $F=5.385$, $p<0.0005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table 81. Acceptability ratings for the potential management action "a monetary fine for visitors who walk off the official paint-blazed trails."

Level of Acceptability ^{2,3}	Treatment ¹					Overall (n=1137)
	Control (n=294)	Signs (n=255)	Brushing (n=270)	Restoration & Fencing (n=161)	Personal Contact (n=157)	
Acceptable	22.8%	23.5%	35.9%	34.2%	33.8%	29.2%
Neutral	24.8	24.7	24.4	24.2	27.4	25.0
Unacceptable	52.4	51.8	39.6	41.6	38.9	45.8
Means ⁴	2.5 ^a	2.6 ^{ab}	2.9 ^c	2.9 ^{bc}	2.9 ^{bc}	2.7

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: 1= Unacceptable to 5 = Acceptable

³ $\chi^2=23.317$, $p=0.003$, $df=8$

⁴ $F=5.747$, $p<0.0005$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Visitor Survey Results

Table 82. Frequency of "acceptable" ratings for potential management actions by treatment.

Potential Management Action	Treatment ¹					χ^2	p
	Control (n=277-296)	Signs (n=246-257)	Brushing (n=261-271)	Restoration & Fencing (n=159-161)	Personal Contact (n=153-158)		
Educational signs along the trail about the damage that can be caused by walking off trail on rare plants	80.7%	79.4%	77.5%	76.4%	81.8%	8.080	0.359
Signs directing visitors to remain on the official paint-blazed trails	77.7	81.6	78.1	75.2	79.5	4.571	0.802
Restoration of unofficial, non-blazed trails to an undisturbed state	75.4	80.2	82.6	82.5	85.4	14.836	0.062
"No Hiking" signs posted at unofficial, non-blazed trails	68.5	77.4	79.3	78.3	82.8	21.488	0.006
Blocking unofficial trails with brush and logs	65.7	79.3	82.8	78.0	81.0	33.956	<0.0005
Improve trail conditions (eliminate mud, downed trees, etc.)	59.3	62.4	67.8	70.2	67.7	10.680	0.220
Rules prohibiting visitors from hiking off of the official paint-blazed trails	56.7	66.1	67.2	66.7	72.8	23.691	0.003
Volunteer trail stewards asking visitors to stay on official paint-blazed trails	47.3	52.5	57.8	57.8	69.7	29.046	<0.0005
Increased ranger presence along trails	45.1	47.5	53.8	52.8	65.4	23.423	0.003
A monetary fine for visitors who walk off the official paint-blazed trails	22.8	23.5	35.9	34.2	33.8	23.317	0.003

¹ Refer to Table 3 for an explanation of management actions for each treatment.

VISITOR OBSERVATIONS

In addition to utilizing visitor questionnaires to assess the efficacy of the various management actions on reducing off-trail hiking on Bear Island, we directly observed visitor behavior from two hidden locations during each of the treatments. The rationale for deciding on the observation site locations, data collection methodologies, and results of the observations follow.

Selection of Study Sites

The BGT, Section A is accessible from the C&O Canal towpath at both a North and a South entrance, with a third “emergency exit” access point located about halfway along the trail. Although most visitors hike the entire trail (69.6%, Table 14), some hike only a portion, often using the Emergency Access to cut over to the Canal to shorten their hike on the BGT. In order to capture users hiking different sections of the trail, unobtrusive observation posts were established on the BGT, above and below the Emergency Access trail intersection (Figure 1).

The specific observation sites were selected because they provided several useful characteristics for unobtrusive observation, including an elevated vantage point, high observer concealment, and a variety of informal trail types within each site’s viewing area (Figure 9 & Figure 10). Specifically, from pre-study scouting of each location, hypothesized likely motivations for leaving the formal trail included river access or scenic vista, exploration, bypass around difficult sections, and short-cuts. The observed informal trails were not chosen to be a representative sample of all informal trails along the entire length of the BGT. However, because the chosen locations had a relatively high density of informal trails within a short section, the off-trail rates observed might be higher than for the average trail section.

Treatments

For comprehensive treatment descriptions, refer to the “Description of Treatments” section, page 11; treatment details for each observation site follow. All informal trail junctions within both observation sites received the prompter signs and were naturalized during the Sign and Brushing treatments, respectively. However, the symbolic restoration areas with fences were not constructed at all informal trails within the observation sites. Within Site 1, the Restoration & Fencing treatment was applied to both junctions of informal Trail 2 with the main BGT; this placement also effectively treated Trail 1 (Figure 9). Only Trail 1 in Site 2 received the Restoration Fencing treatment (Figure 10).

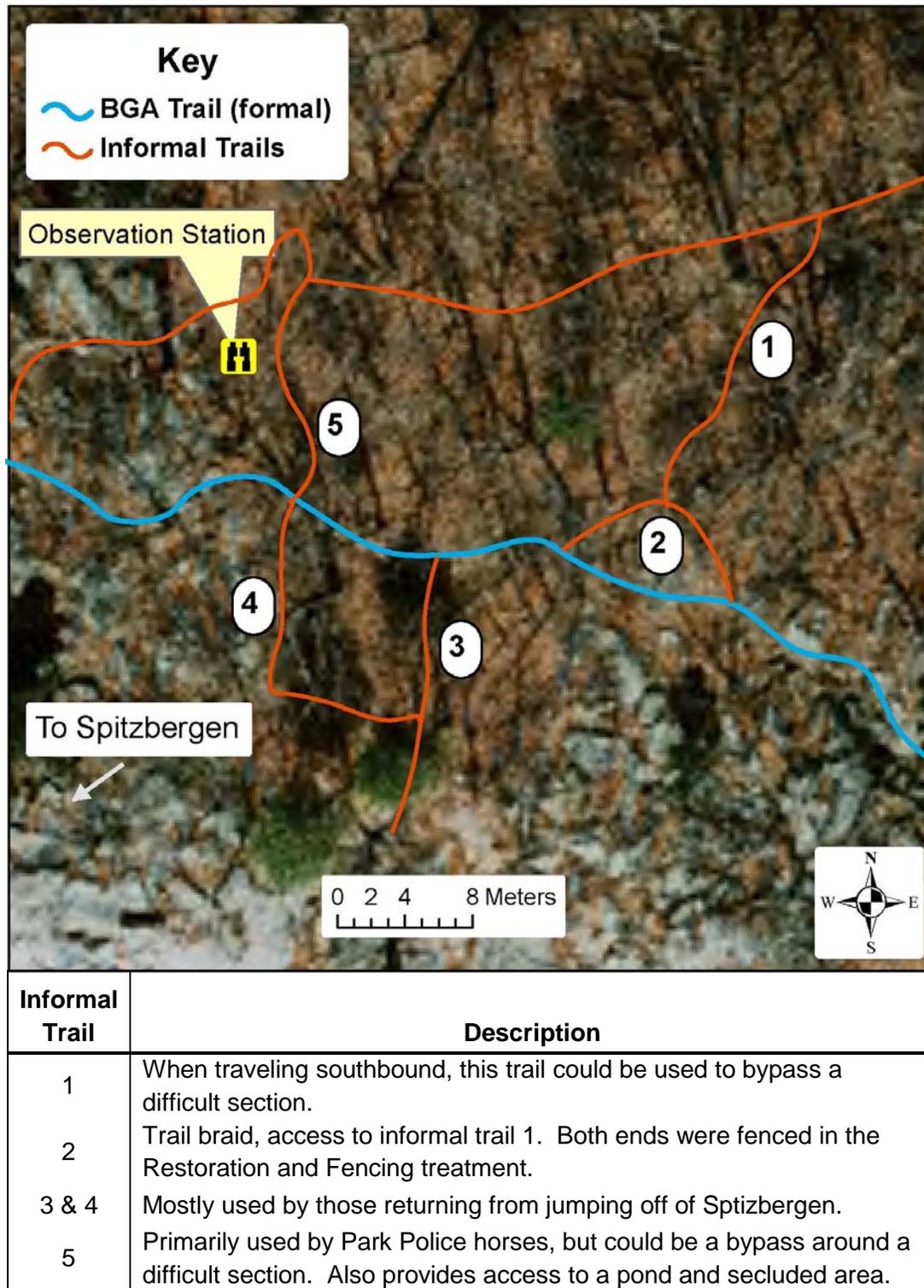


Figure 9. Observation Site 1 schematic map showing position and description of informal trails.

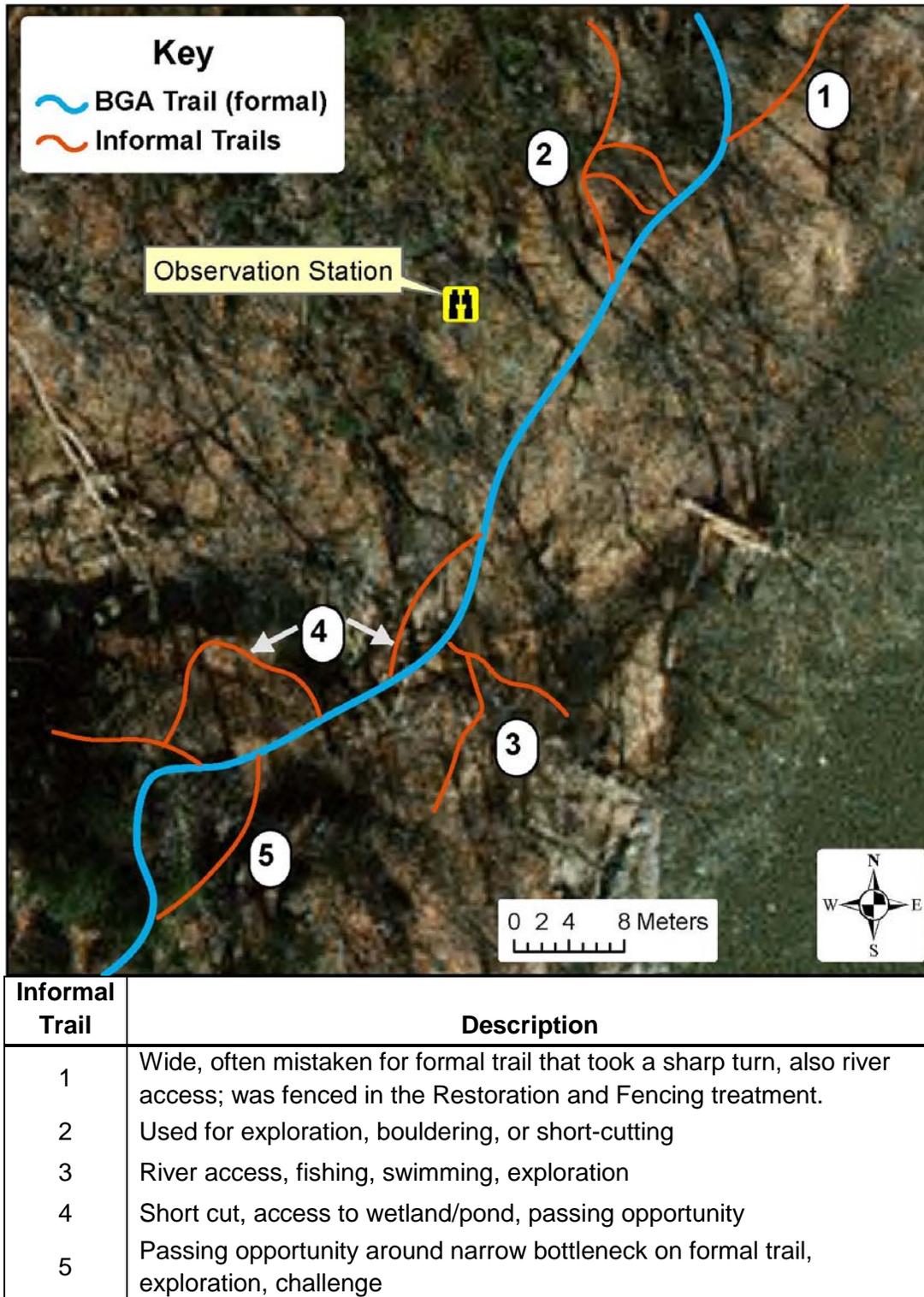


Figure 10. Observation Site 2 schematic map showing position and description of formal trails.

Data Collection

Observational data were collected at both observation sites during the same time periods that surveys were administered. Observations were conducted on at least two weeknights (from approximately 4:30pm to 7:30pm) and on two weekend days (from approximately 10am to 6pm) during the Control and each of the four subsequent treatments, except for the Personal Contact treatment, to ensure a representative sample of trail users was obtained for each treatment (Table 83).

Visitors to the trail during the established observation times between May 10, 2007 and June 10, 2007 were observed by project staff from elevated blinds constructed of natural materials. All visitors passing through the observation sites were tallied by direction of travel (i.e., northbound vs. southbound). If a group consisted of more than one person, each person was counted separately. Children moving on their own were tallied; infants or children being carried were not. Pets were not included in the count. Off-trail hiking behaviors were recorded separately for each informal trail (See Appendix K for the observation log form). Occasionally, a visitor departed the formal trail, but did not use one of the diagrammed informal trails; that off-trail behavior was also recorded in a general off-trail behavior category that encompassed the entire observational zone (Category “6” on the Observational Logs in Appendix K). Visitors were only tallied as off-trail if they were seen departing from the formal, main trail within the study area. Therefore, visitors entering the study area from off-trail were not tallied as off-trail. The decision to count only those leaving the formal trail within the study site was made to ensure that only visitors who made an off-trail decision while subjected to a study treatment were counted as off-trail.

It is important to note that some visitors left the formal trail more than once within an observation site. Off-trail hiking behaviors were counted in two ways because we were interested both in off-trail instances, which are what creates ecological impacts, and off-trail behaviors by individuals, which is the best measure of the effectiveness of the management actions. Therefore, each off-trail choice was tallied separately, so there are counts of the total off-trail hiking instances for each informal trail, and a separate count was made of the number of individuals who chose to hike off-trail within each study site.

Data Analysis

Observation counts were input into an Excel spreadsheet and then imported into SPSS statistical package for analyses. A Chi-square analysis was performed to determine a significant difference among treatments. Off-trail rates by treatment are based on the proportion of hikers who chose to go off-trail (vs. number of off-trail events) because we were most interested in how the treatments influenced whether or not an individual chose to hike off-trail. In contrast, the individual trail data reports the number of off-trail hiking incidents on that trail.

Visitor Observations

Table 83. Visitor observation sampling schedule.

Treatment	Date	Day of Week	Time	Location	# Observed
Control (4 days)	5/11/2007	Friday	4:30pm-16:47pm	1	26
	5/11/2007	Friday	4:25pm-6:30pm	2	36
	5/12/2007	Saturday	9:55am-12:30pm	1	171
	5/12/2007	Saturday	2:00pm-2:50pm	1	61
	5/12/2007	Saturday	2:50pm-5:00pm	1	117
	5/12/2007	Saturday	9:40am-12:45pm	2	253
	5/12/2007	Saturday	1:15pm-4:32pm	2	291
	5/12/2007	Saturday	5:08pm-6:12pm	2	21
	5/13/2007	Sunday	10:00am-1:00pm	1	265
	5/13/2007	Sunday	1:40pm-4:11pm	1	426
	5/13/2007	Sunday	4:15pm-5:30pm	1	56
	5/13/2007	Sunday	10:05am-12:58pm	2	327
	5/13/2007	Sunday	2:00pm-5:00pm	2	432
	5/14/2007	Monday	4:45pm-7:00pm	1	12
	5/14/2007	Monday	4:38pm-7:00pm	2	33
Signs (4 days)	5/19/2007	Saturday	10:16am-1:15pm	1	240
	5/19/2007	Saturday	2:00pm-5:40pm	1	270
	5/19/2007	Saturday	10:17am-2:10pm	2	432
	5/19/2007	Saturday	2:10pm-5:15pm	2	322
	5/20/2007	Sunday	10:30am-2:40pm	1	338
	5/20/2007	Sunday	2:50pm-5:30pm	1	169
	5/20/2007	Sunday	10:49am-5:34pm	2	511
	5/21/2007	Monday	5:00pm-7:10pm	1	22
	5/21/2007	Monday	4:35pm-7:30pm	2	62
	5/22/2007	Tuesday	4:30pm-7:15pm	1	42
	5/22/2007	Tuesday	4:00pm-6:45pm	2	53
Brushing (4 days)	5/24/2007	Thursday	4:30pm-7:00pm	1	32
	5/24/2007	Thursday	4:30pm-7:00pm	2	53
	5/25/2007	Friday	4:30pm-7:00pm	1	43
	5/25/2007	Friday	4:46pm-7:15pm	2	46
	5/26/2007	Saturday	10:15pm-12:30pm	1	237
	5/26/2007	Saturday	12:30pm-5:15pm	1	409
	5/26/2007	Saturday	10:20am-5:00pm	2	604
	5/27/2007	Sunday	10:50am-1:50pm	1	365
	5/27/2007	Sunday	10:45am-1:30pm	2	450
	Restoration & Fencing (4 days)	5/31/2007	Thursday	5:15pm-6:30pm	1
5/31/2007		Thursday	5:00pm-6:30pm	2	26
6/1/2007		Friday	4:45pm-7:15pm	1	22
6/1/2007		Friday	5:12pm-7:00pm	2	22
6/2/2007		Saturday	10:45am-1:49pm	1	128
6/2/2007		Saturday	2:30pm-5:30pm	1	105
6/2/2007		Saturday	11:00am-1:50pm	2	187
6/2/2007		Saturday	2:30pm-5:38pm	2	135
6/9/2007		Saturday	11:00am-1:00pm	1	127
Personal Contact (1 day)	6/7/2007	Thursday	5:00pm-7:00pm	1	31
	6/7/2007	Thursday	5:00pm-6:15pm	2	24

Table 84. Summary observation sampling effort and sample sizes by treatment.

Treatment	# Days	Total Hours	Total Observations
Control	4	34:39	2527
Signs	4	36:42	2461
Brushing	4	27:59	2239
Restoration & Fencing	3	19:05	763
Personal Contact	1	3:15	55
Total	16	121:40	8045

Observation Results

Off-trail rates during the Control differed by observation site and direction of travel. This is not surprising as each observation location presented hikers with different choices about going off-trail, even though the number of informal trails observed was similar. Each informal trail was likely utilized for different reasons (Figure 9 & Figure 10) and also differed in their attractiveness depending on the direction of travel. For example, hikers just beginning their hike may be more attracted to the river than those ending their hike, or a bypass around a difficult area may be more attractive going northbound than southbound. For these reasons, and the fact that equal numbers of visitors were not observed at each location (and by direction of travel) across all treatments, the observation results are presented by site and by direction of travel. Because of staffing constraints, the Personal Contact treatment had a very low sample size of observed visitors, so those results should be interpreted with caution.

All treatments significantly reduced the percentage of visitors hiking off-trail (Table 85); these results represent the proportion of visitors who traveled through each observation site who went off trail, not the total number of off-trail instances. The final column in Table 85 represents the average off-trail rate across sites and direction of travel. The educational and prompter signs dramatically reduced off-trail rates everywhere except for northbound travelers at Site 2. Although the initial off-trail rates in the Control were not among the highest for that site, the off-trail rates northbound travelers at Site 2 remained relatively high during the Sign treatment. The Brushing and Restoration & Fencing treatments had relatively similar off-trail rates at both locations and for both directions of travel, although the northbound hikers at Site 2 continued to have the highest off-trail rates for both treatments. The off-trail rates are presented graphically in Figure 11 by site and direction of travel.

Off-trail hiking instances (i.e., total number of decisions to hike off-trail) differed dramatically by individual trail, even in the Control (Table 87). Informal Trail 2 accounted for 84% of the northbound off-trail traffic and 81% of the southbound off-trail traffic at Site 1. Off-trail travel at Site 2 was more evenly dispersed across several informal trails; informal Trails 1 and 5 accounted for 82% of the southbound off-trail traffic, but Trail 3 accounted for the highest percentage (45%) of northbound off-trail traffic in the Control. Figure 12 & Figure 13

graphically represent the observation results from Table 87. The Restoration & Fencing treatment reduced off-trail hiking to 0.0% (n=763) on the two informal trails that were fenced, compared to an off-trail rate of 0.5% (n=11 of 2239 hikers) on those two trails prior to fencing.

As additional management actions were added to close informal trails the percentage of visitors hiking off-trail in areas between identified informal trails increased (Table 86). In other words, although off-trail rates declined, the percentage of those creating their own paths by hiking cross-country through the woods to achieve their goals increased. While only 4.7% of the off-trail traffic in the Control was cross-country, 31.3% of off-trail travel in the Restoration & Fencing treatment was not on previously created trails. This suggests that when informal trails are blocked or closed, a certain percentage of visitors who are highly motivated to achieve their recreation goals will seek alternative routes, which has the potential of increasing the total area of off-trail impacts. However, it should be noted that the percentage of hikers who hiked cross-country (i.e., did not take an existing informal trail when they left the formal trail), did not increase as the treatments were applied (see last column of Table 86).

Table 85. Off-trail rates of hikers by site and direction of travel.

Treatment ¹	Site 1				Site 2				Average Off-trail Rates (%) ³
	Northbound		Southbound		Northbound		Southbound		
	# observed	% off	# observed	% off	# observed	% off	# observed	% off	
Control	452	37.4	682	18.9	740	20.4	653	26.8	25.9 ^a
Signs	500	5.0	581	3.1	720	15.0	660	2.9	6.5 ^b
Brushing	401	1.7	685	1.6	564	3.7	589	0.8	2.0 ^c
Restoration & Fencing	179	2.8	214	0.0	213	4.7	157	0.6	2.0 ^c
Personal Contact	21	0.0	10	0.0	19	0	5	0.0	0.0 ^{bc}
Chi-square ²	$\chi^2=317.9$, $p<0.0005$, $df=3$		$\chi^2=200.6$, $p<0.0005$, $df=3$		$\chi^2=94.6$, $p<0.0005$, $df=3$		$\chi^2=320.0$, $p<0.0005$, $df=3$		$\chi^2=889.0$, $p<0.0005$, $df=3$

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² Chi-square test did not include the Personal Contact treatment because sample sizes were too small.

³ Rates with different superscripts are significantly different ($p\leq 0.05$) in pairwise Chi-square comparisons.

Table 86. Cross-country off-trail hiking rates compared to off-trail travel on existing informal trails.

Treatment	Total # Off-trail	# Off Cross-Country	% Off Trail From Cross-Country Travel	Cross-Country Off-trail Rate
Control	703	33	4.7%	1.2%
Signs	186	28	15.1%	1.0%
Brushing	49	12	24.5%	0.5%
Restoration & Fencing	16	5	31.3%	0.7%
Personal Contact ¹	0	0	0.0%	0.0%

¹ Small observation sample size for Personal Contact treatment ($n=55$).

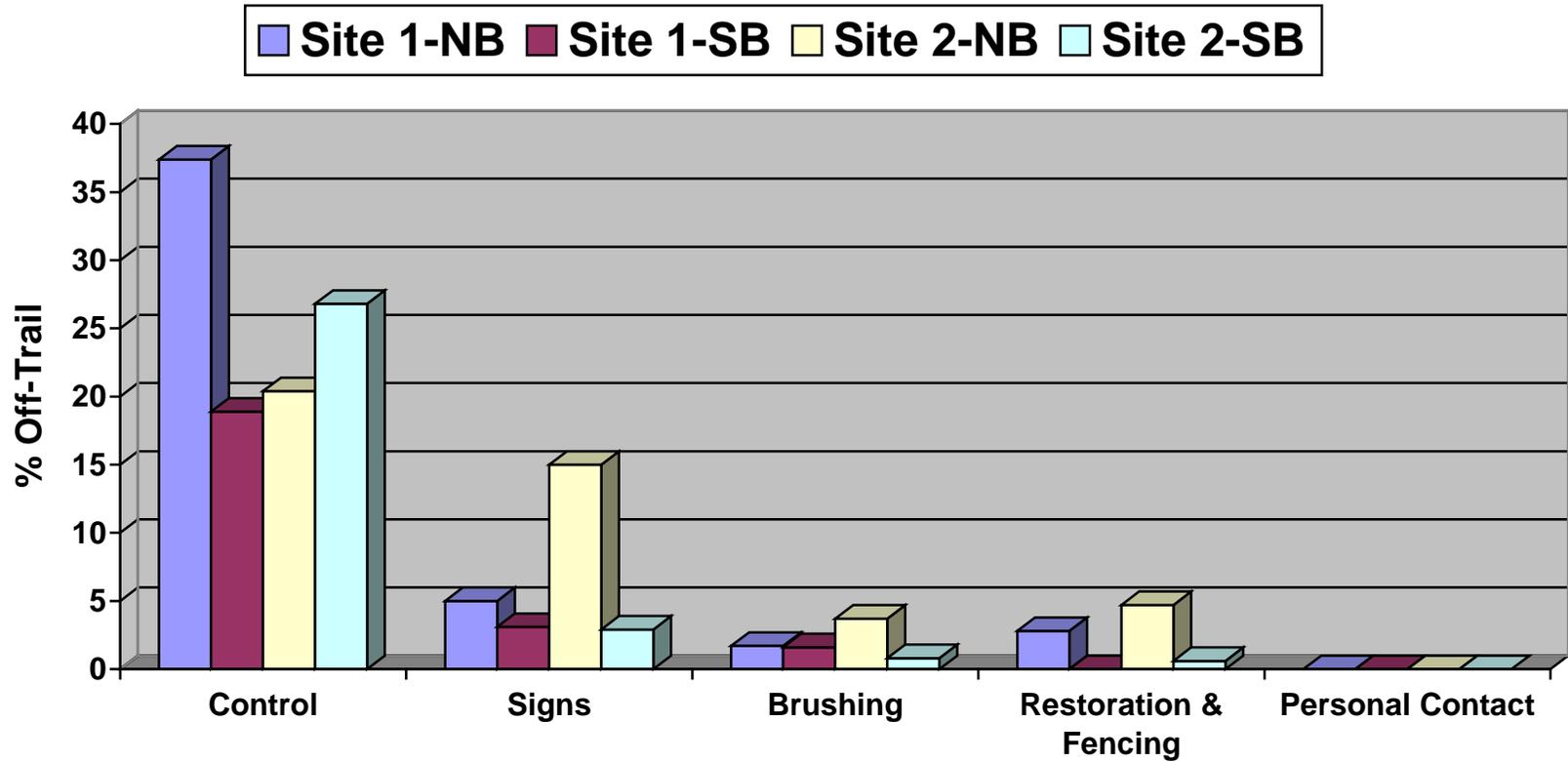


Figure 11. Off-trail rates by site and direction of travel.

Visitor Observations

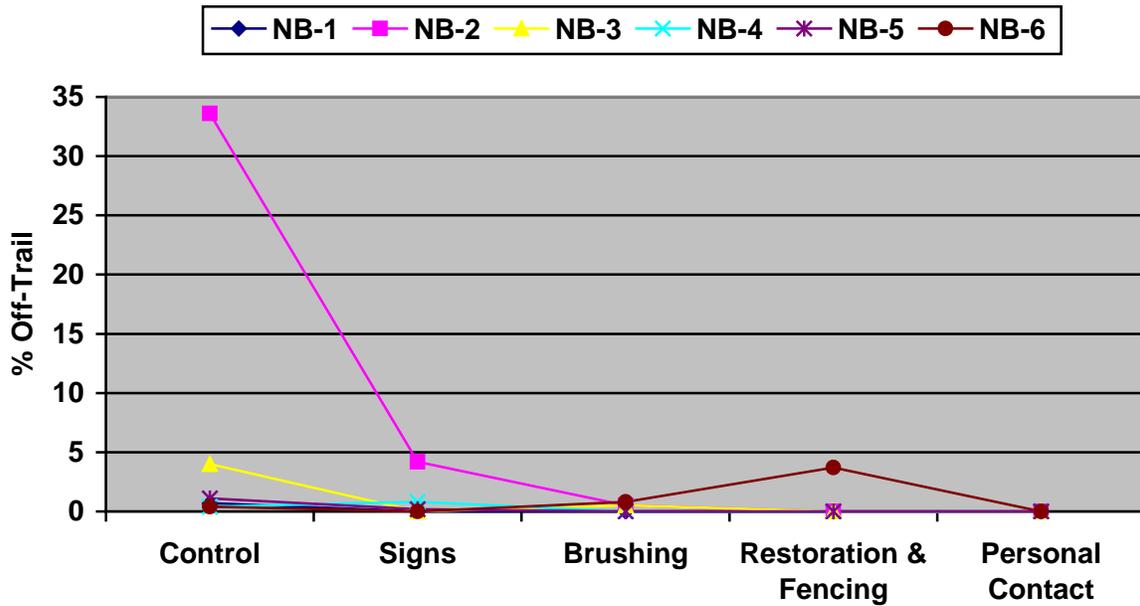
Table 87. Off-trail instances by informal trail and study site, direction of travel, and treatment.

Direction of Travel	Treatment ¹	Off-trail	Trail						Total
			1	2	3	4	5	6	
Site 1 North-bound	Control (452, 16:53)	N	3	152	18	2	5	2	182
		%	0.7	33.6	4.0	0.4	1.1	0.4	40.3
	Signs (500, 18:24)	N	0	21	0	4	1	0	26
		%	0.0	4.2	0.0	0.8	0.2	0.0	5.2
	Brushing (401, 15:00)	N	0	2	2	0	0	3	7
	%	0.0	0.5	0.5	0.0	0.0	0.8	1.7	
	Restoration/Fencing ² (179, 11:49)	N	0	0	0	0	0	5	5
		%	0.0	0.0	0.0	0.0	0.0	3.7	3.7
	Personal Contact (21, 2:00)	N	0	0	0	0	0	0	0
		%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 1 South-bound	Control (682, 16:53)	N	0	123	4	3	1	0	131
		%	0.0	18.0	0.6	0.4	0.1	0.0	19.2
	Signs (581, 18:24)	N	0	9	0	2	1	6	18
		%	0.0	1.6	0.0	0.3	0.2	1.0	3.1
	Brushing (685, 15:00)	N	3	2	0	0	1	5	11
	%	0.4	0.3	0.0	0.0	0.1	0.7	1.6	
	Restoration/Fencing ² (214, 11:49)	N	0	0	0	0	0	0	0
		%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Personal Contact (10, 2:00)	N	0	0	0	0	0	0	0
		%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 North-bound	Control (740, 17:46)	N	22	11	87	8	35	31	194
		%	3.0	1.5	11.8	1.1	4.7	4.2	26.2
	Signs (720, 18:18)	N	9	15	42	4	30	22	122
		%	1.3	2.1	5.8	0.6	4.2	3.1	16.9
	Brushing (564, 12:59)	N	2	3	11	1	6	3	26
	%	0.4	0.5	2.0	0.2	1.1	0.5	4.6	
	Restoration/Fencing ² (213, 9:16)	N	0	0	10	0	0	0	10
		%	0.0	0.0	4.7	0.0	0.0	0.0	4.7
	Personal Contact (19, 1:15)	N	0	0	0	0	0	0	0
		%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 2 South-bound	Control (653, 17:46)	N	84	4	28	3	77	0	196
		%	12.9	0.6	4.3	0.5	11.8	0.0	30.0
	Signs (660, 18:18)	N	6	4	8	0	2	0	20
		%	0.9	0.6	1.2	0.0	0.3	0.0	3.0
	Brushing (589, 12:59)	N	2	0	2	0	0	1	5
	%	0.3	0.0	0.3	0.0	0.0	0.2	0.8	
	Restoration/Fencing ² (157, 9:16)	N	0	0	1	0	0	0	1
		%	0.0	0.0	0.6	0.0	0.0	0.0	0.6
	Personal Contact (5, 1:15)	N	0	0	0	0	0	0	0
		%	0.0	0.0	0.0	0.0	0.0	0.0	0.0

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² Only informal Trail 2 (both ends) in Site 1 (which also impacted Trail 1, see Figure 9) and informal Trail 1 on Site 2 received this treatment.

Site 1 (Northbound Travel)



Site 1 (Southbound Travel)



Figure 12. Off-trail rates for each informal trail at Site 1 presented for each direction of travel.

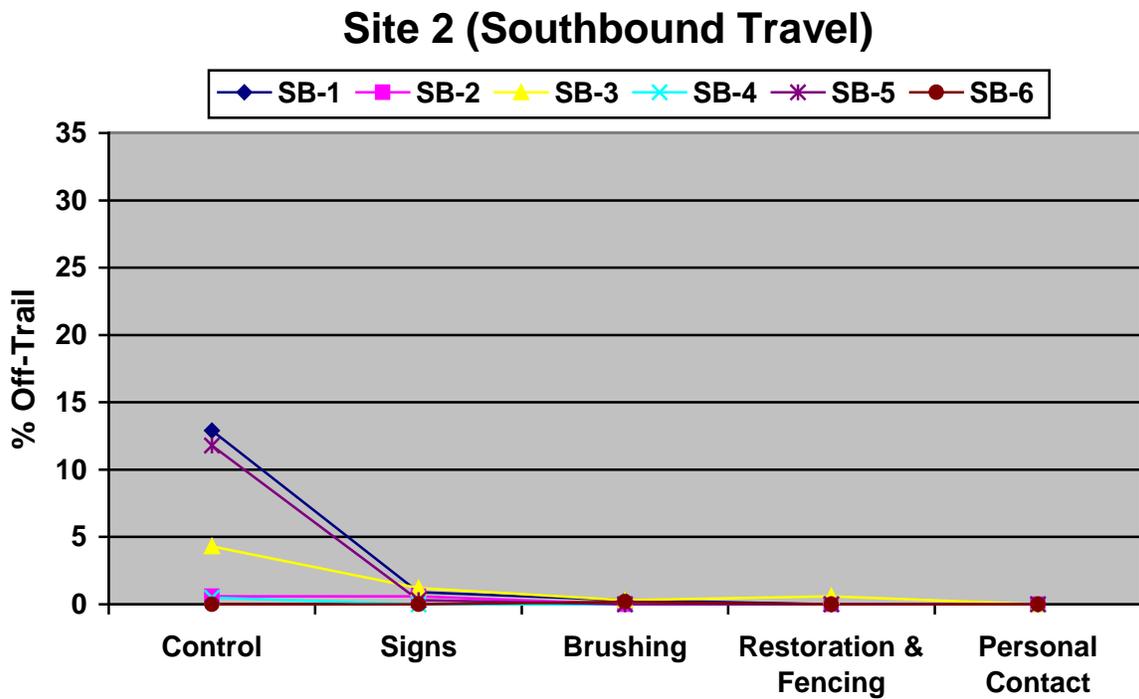
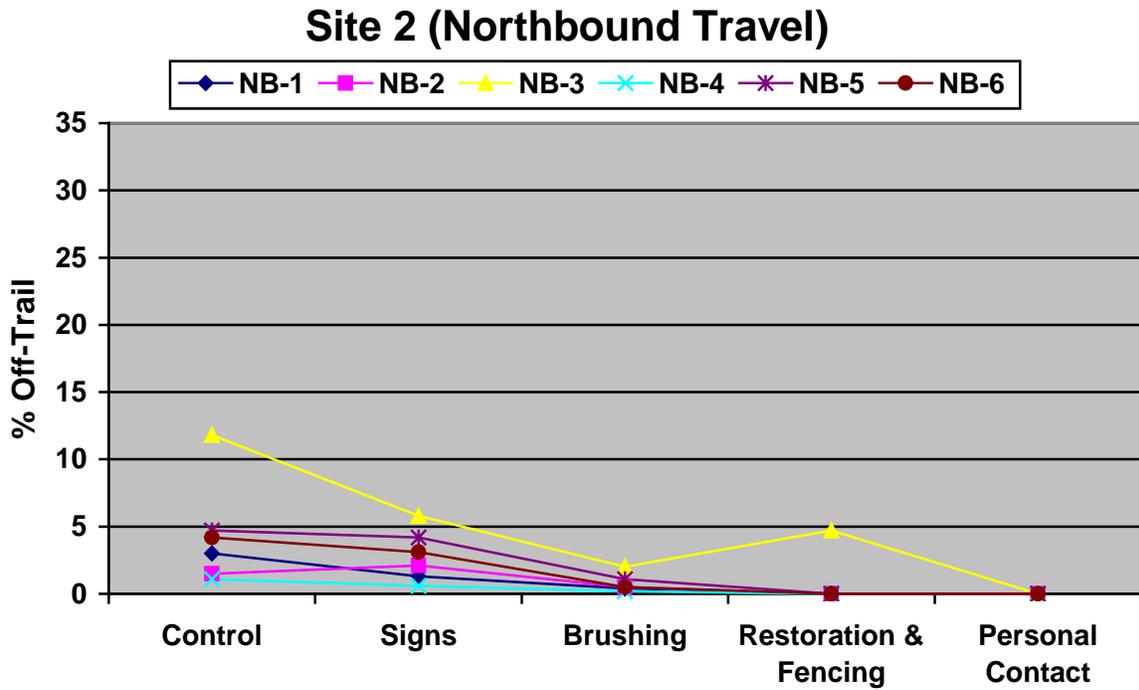


Figure 13. Off-trail rates for each informal trail at Site 2 for each direction of travel.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Discussion

Observations of visitor use of informal trails and visitor self-reports on the survey found that during Control (i.e., baseline) conditions a majority of visitors used informal trails along the BGT, Section A. During the Control, 70.3% of survey respondents reported intentionally going off-trail at least once during their hike (Table 52) and reported an average of 2.8 reasons or motivations for leaving the paint-blazed trail (Table 53). Observed off-trail rates were lower (18.9% to 37.4%, depending on observation site and direction of travel; Table 85) than the self-reported rates because visitors were only observed along two short sections of the trail that included 10 of 155 informal trail junctions, while survey respondents were reporting on their entire hike. In other words, the observed off-trail rates only reflect five decision points along a short section of trail and the survey off-trail rates are based on whether or not the respondent reported hiking off trail at least once along the entire length of the trail and at 155 informal trail junctions. Therefore, it is not surprising that self-reported off-trail rates are much higher than observed off-trail rates. Both methods and results provide valuable insights and complement each other, allowing us to produce a more complete characterization of treatment efficacy. The observations provide verification of self-reported behavior trends and provide information on behavior patterns and the effectiveness of treatments on different types of informal trails; the survey results provide information on the effectiveness of the treatments to convince visitors to always stay on the formal trails and provide clues about the mechanism by which the treatments worked to impact behaviors.

The observed and self-reported off-trail rates along the Potomac Gorge are within the range of those reported in other off-trail studies. For example, the majority (88.3%) of visitors to Camelot Island in the St. Lawrence Islands National Park, Ontario were observed to take an informal trail that was the focus of their study (Bradford & McIntyre, 2007). In a front-country site, 30.9% of visitors were observed hiking off of a paved trail that wound through a giant sequoia grove at four observation locations in Sequoia and Kings Canyon National Parks (Winter, 2006). Park *et al.* (2008) observed that 73.7% of visitors to Cadillac Mountain in Acadia National Park hiked off-trail, and a similar percentage (67.7%) reported hiking off-trail on a survey. These studies illustrate that off-trail hiking is not uncommon in natural areas and occurs at relatively high rates.

Direct visitor observations at both observation locations found that all treatments significantly reduced the use of informal trails (Table 85). There was a significant drop in informal trail use from 25.9% in the Control to 6.5% following the placement of the three trailhead educational signs and the 155 prompter signs at each informal trail junction. The rate dropped even further after Brushing the first few meters of each informal trail (2.0% off-trail), and a similar percentage (2.0%) were observed hiking off-trail in the Restoration & Fencing treatment. Recall that the Restoration & Fencing treatment was only applied to two of the ten informal trails within the two study locations, so we did not expect a large overall decline in off-trail hiking. In fact, no one was observed using those two fenced informal trails; however, the off-trail rate on those trails was already low (0.5%) prior to fencing. The observed off-trail rate was reduced to 0.0% by the Personal Contact treatment, though we believe the sample size was too low to have strong confidence in this finding.

Self-reported off-trail hiking rates showed a different level and pattern of treatment effectiveness in reducing off-trail rates than was observed, but we do not believe the two findings are necessarily in conflict because of the different scales at which they were measured. Unlike the observation results that showed a significant decline in off-trail rates with the educational and prompter signs, a similar percentage of visitors reported hiking off-trail in the Signs (70.6%) treatment as in the Control (70.3%; Table 52). Because the survey self-reports reflected behavior along the entire length of the trail and observations only captured a small percentage of the off-trail opportunities, this suggests that the Signs may have reduced off-trail hiking in some places, but not everywhere. In the Brushing (60.2%) and Restoration & Fencing (58.6%) treatments the self-reported off-trail rate dropped slightly, and was significantly lower than the Control. The self-reported off-trail rate was the lowest in the Personal Contact treatment, but a significant minority (43.0%) continued to report hiking off-trail at least once along the trail. Although 43% of the visitors in the Personal Contact treatment continued to hike off-trail, the number of reasons for hiking off-trail declined from an average of 2.8 in the Control to only 1.0 reasons. Therefore, the Personal Contact treatment (which included the prompter signs and brushing) not only reduced the percentage of people who reported hiking off-trail, but reduced the number of motivations for hiking off-trail. In fact, respondents in the Personal Contact treatment were most likely to say that they decided to remain on the paint-blazed trails so they would not cause soil erosion, damage rare plants, or because of the “no-hiking” symbolic signs (Table 63). These findings suggest that although 43% hiked off-trail at some point during their hike, there were other times when they decided not to go off-trail because of the educational message delivered by the trail stewards and the no-hiking prompter signs.

Although the self-reported off-trail rate along the BGT remained relatively high during even the most effective treatment (Personal Contact off-trail rate = 43%), the findings are consistent with similar off-trail hiking studies. An attribution message placed at each informal trail junction on Camelot Island in the St. Lawrence Island study reduced off-trail travel to 45% from 88% under Control conditions (Bradford & McIntyre, 2007). In a study on off-trail travel in a sequoia grove, off-trail rates at four observation points were reduced from 31% to 5% with an injunctive-proscriptive trailhead sign (Winter, 2006), similar to the one used in our study, but no prompter signs were used at informal trail junctions. In a study of hikers on Acadia National Park’s Cadillac Mountain, Park *et al.* (2008) found that an educational sign at the trailhead and prompter signs at informal trail junctions reduced off-trail hiking to 24% (observations along entire trail length) from 74% under control conditions. Unlike this study, which only observed visitors at two short segments of trail, the Acadia study, which observed visitors along the entire trail length, resulted in self-reported off-trail rates (17%) that were very similar to the observed rates (24%). These studies illustrate that signs can significantly reduce, but not eliminate off-trail travel.

The Personal Contact treatment was clearly the most effective in reducing off-trail behaviors along the BGT (Table 52). It was likely the most effective because all other treatments were in place (prompter signs, brushing, and restoration & fencing) and the stewards were able to communicate the rationale behind the request to keep visitors on the formal, blazed trails to most visitors. While presenting visitors with the same information as the trail stewards, the educational signs at the trailheads were less effective in reducing off-trail travel because a lower percentage of visitors likely stopped to read the signs than were contacted by the stewards, who attempted to intercept each hiking group. Therefore, the educational message content was

effective, but was ineffectively delivered with a trailhead sign. Also, recall that a screening question ensured that nearly all survey respondents in the Personal Contact treatment had been exposed to the educational message because if they did not recall speaking with a trail steward they were not given a survey. Because respondents in the Sign and other treatments were not asked if they had seen an educational sign or not, those samples included visitors who had received the message and those who had not.

For a message to be effective, it must be received, understood, processed and accepted, and then applied (McGuire, 1985). The key components to persuasive communication are described in McGuire’s information processing model (Figure 14). Failure at any stage of the persuasion process could result in non-compliance with the message. Therefore, each stage of the process is critical to achieve success. An educational message will not be effective if people do not receive it (i.e., stop to read the sign completely), understand it, agree with it, and are motivated to comply with it.

While BGT trailhead signs were placed away from other signs and very close to the trail to increase visibility it is not known what percentage of BGT visitors read the trailhead signs. However, survey results suggest that the trailhead signs alone were not successful in either conveying the rationale behind remaining on the blazed trails or persuading visitors to alter their beliefs about off-trail hiking on Bear Island (Tables 30 to 34). Although we did not measure them directly, reading rates were likely relatively low for BGT hikers because such a large percentage were repeat visitors (73%), which reduces their motivation for reading signs. This reasoning is consistent with research in other natural areas indicating that most visitors do not carefully read trailhead educational signs. Cole *et al.* (1997) found that only 28% of backcountry hikers attended to messages posted on a bulletin board long enough to completely read the content. A study in Yosemite National Park found that only 15 to 24% of backcountry hikers spent enough time looking at a trailhead sign to completely read the content (Hall, Hockett & Smith-Jackson, 2001). Park *et al.* (2008) found that only 39% to 46% read an off-trail hiking educational sign posted close to the summit trail on Cadillac Mountain in Acadia National Park.

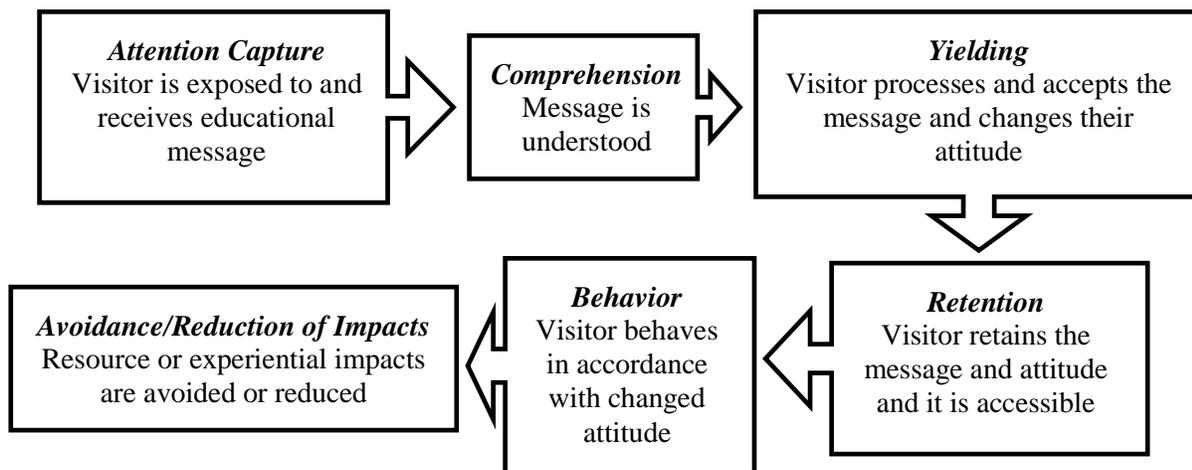


Figure 14. Information-processing model of persuasion and behavioral change. (Adapted from McGuire, 1985)

After attention has been captured, the receiver must be able to comprehend the message. We did not directly measure comprehension, but the sign used simple language and most visitors to the BGT had a very high education level (86% had at least achieved a bachelor's degree), so message comprehension should not have been an issue.

After visitors receive and comprehend a message, they process the message according to prior experience and existing beliefs and decide whether to accept or reject the message arguments. If the message conforms to existing beliefs, it is most likely to be accepted and influence behavior; if the message presents new information or content that is in conflict with existing attitudes, beliefs, or experiences, it is less likely to be accepted and influence behavior (Petty & Cacioppo, 1986; Fazio & Zanna, 1981; Schreyer, Lime, & Williams, 1984). Therefore, persuasive messages are generally less effective on people with prior experiences in the setting (Roggenbuck, 1992) because they have pre-existing attitudes about the area that are relatively strong because they are based on past experiences and prior behaviors. Although most natural area visitors generally have pro-environmental views, this tendency does not necessarily convert to appropriate behaviors. The high percentage of repeat visitors (73%) and high off-trail hiking rate self-reported in the Control (70%) suggests that most visitors likely hiked off-trail on prior visits to the BGT. Therefore, these visitors may be psychologically inclined to reject the educational message about off-trail hiking impacts because they wouldn't want to accept that they had behaved in an environmentally damaging way in the past, and they perceived no impact from their prior actions. Repeat visitors are also more likely to have favorite vistas, quiet spots, or boulders to climb that present a strong motivation for leaving the formal trail that does not exist with first time visitors.

The visitor survey measured acceptance (i.e., persuasive power) of the educational message by asking visitors to agree or disagree with statements taken directly from the educational sign and trail steward script. In the Control condition, 30.4% said it was "acceptable to walk off the paint blazed trails, if visitors stay on the unofficial trails already created by other visitors". The percentage agreeing with that statement declined to 17.8% in the Signs treatment and to 5.1% in the Personal Contact treatment, which suggests that the sign and steward message were effective in communicating the general concept that it is not acceptable to hike off-trail along the BGT. However, in the Sign treatments (including Brushing and Restoration & Fencing) the visitors did not either read, retain, or agree with the more detailed awareness of consequence message. In contrast, the trail steward was effective at communicating the rationale for remaining on the formal blazed trails (see Tables 30 to 34). Therefore, significant opportunities remain to educate visitors about the special ecological nature of Bear Island and the impacts of informal trails on those resources. The relatively high proportion of visitors (up to 44%) who answered that they "didn't know" to many of the knowledge-related statements (Tables 31 to 36) further implies that visitors are not knowledgeable of the area's resources. This could be a critical finding as other research has shown that those who express uncertainty about awareness of consequence statements tend to behave more similarly to those who disagree with the statements (Alessa, Bennett, & Kliskey, 2003). In this study, those who expressed the greatest awareness of the consequences of off-trail hiking were the least likely to hike off-trail (Table 59).

Even if a visitor accepts the reasoning behind remaining on the formal trails, many other variables can intervene to reduce the chances a hiker may behave as desired. One intervening variable is a strong motivation for leaving the informal trail. In some cases, leaving the informal

trail might be required to fulfill the central motivation for the hike, such as seeing a particular vista, fishing, nature study, or exploration. In other cases, visitors might feel they have no choice but to leave the formal trail, such as to take a bathroom break, walk around a muddy spot, or bypass a bottleneck. The visitor survey asked visitors to indicate reasons why they left the formal trail. The most common reasons for leaving the formal trail in the Personal Contact treatment (the most successful treatment) were to get around difficult or poor trail sections (21.2%), to go to a scenic vista/take a photo (19.5%), or to move past or get away from other visitors (19.4%; Table 50). The reasons BGT visitors reported for going off-trail were similar to those reported by Cadillac Mountain visitors; 62% said they left the formal trail to get a better view and to take a photo, 43% wanted to explore, and 8% left to move past others or to get away from crowds (Park *et al.*, 2008). However, BGT visitors did differ by saying that they went off trail to get around difficult or poor trail sections. While poor trail conditions (e.g., muddy sections) should be improved, challenging or difficult sections of the trail present a dilemma because they are part of the unique BGT experience.

The observation data also demonstrated that off-trail travel was not uniform across all informal trails, but was concentrated on certain trails and by direction of travel (Table 87). Therefore, the survey and observation results both suggest that off-trail travel is not random, but concentrated and based on motivations to achieve recreation-related goals. While study limitations prevent further characterization, it is possible that much of the remaining off-trail travel is occurring at relatively few locations (e.g., favorite overlooks, difficult trail sections, bottlenecks where people try to pass slower visitors).

Another common motivation for using informal trails was that “an unmarked trail already existed” (38.8% in the Control to 31.0% in the Signs to 17.1% in the Personal Contact treatment; Table 50). This finding is supported by other research on depreciative behaviors that has found that visitors are more likely to engage in inappropriate behavior if they see others engage in similar behavior (Gramann & Vander Stoep, 1987; Reiter & Samuel, 1980), or in this case see evidence that others have gone off-trail (i.e., the mere presence of an informal trail implies others have gone off-trail at that location). The observed reduction in off-trail hiking from the Sign to the Brushing treatment demonstrated how these “releaser-cue” behaviors can be reduced by removing the cue (i.e., obvious informal trail that others have traveled on). This issue is also related to the importance of making it very clear to visitors where they should travel and where they should not go. Without clear direction to stay on the formal trails and clearly marked formal trails, most visitors probably do not realize they are taking an informal trail that the park prefers they do not use. A well-worn informal tread likely appears to be a formal trail to the average park visitor.

Another key intervening variable between receiving the message, accepting the message, and acting in an appropriate manner is accepting the attribution component of the message. The educational sign used personal language to convey that “your” behavior is important and that “everyone’s cooperation is needed.” However, for this attribution to be internalized and acted upon, visitors must first accept that a problem exists, agree that their actions cause a negative impact, and believe that they have the control or power to act in the appropriate way (Bradford & MacIntyre, 2007). Environmental education models also recognize the importance of conveying a sense of personal responsibility and ownership when trying to improve stewardship behaviors (Hungerford & Volk, 1990). Therefore, knowledge of the ecosystem or impacts is not

necessarily sufficient in altering behavior, visitors must accept that their actions have an impact and feel a sense of personal responsibility to act on those beliefs. Research has supported that variables like personal responsibility, ownership, and commitment are more important in influencing behavior than knowledge alone. For example, Alessa *et al.* (2003) found that personal attribution was inversely correlated with the mean number of depreciative behaviors engaged in by visitors to an intertidal zone; in fact, personal responsibility and perceptions of resiliency were more important in predicting behavior than knowledge of the intertidal zone.

Off-trail hiking and other depreciative behaviors present a challenge to managers because individual actions generally do not have a large impact on resources; it is the combined actions of many visitors that lead to damage. Visitors have been shown to use this reasoning to rationalize inappropriate behaviors. For example, Ward & Roggenbuck (2003) found that many petrified wood thieves had received an anti-theft message but rationalized that stealing small pieces was acceptable and wouldn't hurt anything. The thieves only applied the anti-theft message to larger pieces of wood and not the small chip they took that no one would miss. Theft is a more severe depreciative act than hiking off-trail, but a similar rationalization likely occurs. When informal trails clearly used by previous visitors already exist, no obvious additional impacts occur from one more set of footprints. Recreation ecology research reveals that the majority of trampling impacts occur with initial or low levels of traffic so the impacts of off-trail hikers are most pronounced during trail creation (Leung & Marion 2000). Once vegetation and organic litter are substantially lost, another set of footsteps adds little to no impact.

The BGT visitor survey asked several questions to gauge the efficacy of the educational message in promoting a sense of personal responsibility toward and commitment to the resource. Visitors tended to express a sense of responsibility to care for and protect the resources along the BGT even in the Control condition and the treatments did not significantly improve those views (Tables 38 to 40). The vast majority of visitors also expressed a willingness to stay on the blazed trails to protect rare plants, but they were somewhat less willing when faced with the possibility of not being allowed to explore off-trail or hike in certain areas of Bear Island (Tables 41 to 43). The Personal Contact treatment was the most effective in increasing commitment levels, and visitors who expressed the greatest levels of personal responsibility and commitment to protect the natural resources along the BGT were less likely to report hiking off-trail than respondents with lower levels (Tables 60 and 61).

In addition to the efficacy of the various treatments in reducing off-trail travel, another consideration is the impact of the treatments on visitor experiences. A majority of visitors felt that educational trailhead signs and the boot print no-hiking signs positively impacted their experiences (Tables 67 and 69). Few (8.2% in the Personal Contact treatment) said that closures of unofficial trails limited their enjoyment (Table 68). Visitors were less supportive of the stewards unless the stewards were actually present providing their educational message (Tables 71 and 78); when present in the Personal Contact treatment, 75.5% said the stewards were a positive experience and 69.9% said they approved of having volunteer trail stewards talk to visitors about staying on the official paint-blazed trails. Visitors in the Personal Contact treatment were the most accepting of potential management actions to control off-trail hiking, even the most direct methods such as "rules prohibiting visitors from hiking off of the official paint blazed trails" and "increased ranger presence along trails" (Tables 80 and 79,

respectively). Visitors were generally not supportive of a monetary fine for hiking off-trail (Table 81).

Implications for Bear Island and the Billy Goat Trail, Section A

Study implications are of two types: 1) guidance for managing Bear Island in the discussion that follows below, and 2) general guidance for deterring off-trail hiking and informal trail use in protected natural areas, located in Appendix M. These implications and guidance are based on the research conducted in this study, findings from other scientific studies, and the authors' experience from research and consulting in protected areas.

While this study did document management actions able to substantially reduce off-trail traffic it is clear that many Bear Island visitors continue to hike off-trail. Additional observational work suggested in the Future Research section below could help determine where, why, and how often visitors continue to venture off-trail to guide the selection of additional management actions provided in this section.

We begin this section by calling attention to the need to define the basic resource protection strategy for Bear Island relative to informal trail management. Another component of this research completed a census survey of informal trails, documenting an extensive network of 10.4 miles on Bear Island. In consideration of the potential impacts to rare plants and sensitive cultural resources, the NPS and TNC should develop a general strategy to address informal trail proliferation on Bear Island. While this study was not directed to address cultural resources, such resources do exist in the study area and we presume that management actions that effectively reduce off-trail hiking and trampling will help to protect cultural resources in addition to natural resources. Cultural resource monitoring could be implemented to gage the efficacy of management actions.

To our knowledge, NPS and TNC staff have not seriously considered a prohibition to off-trail hiking so that option will not be considered here. There remain three other general strategies: 1) Containment - formalize some informal trails, close and restore all other informal trails, 2) Partial Containment – leave some informal trails (as needed) but close and restore all other informal trails, and 3) Limited Area Closures to prohibit off-trail hiking in some areas (e.g., an extended “restoration area”), used in combination with one of the above strategies.

The Containment strategy provides the clearest message and setting to visitors. An evaluation of existing trails (formal and informal) with respect to access and safety would be conducted. If needed, formal trails will be expanded to provide access to major attraction features and provide bypasses around the most difficult rocky sections; all other informal trails would be aggressively closed with signage, brushing, and fencing. More specific guidance implementing this strategy is provided in the following sections.

The Partial Containment strategy does not expand the existing formal trail system and instead relies on the tendency of visitors to stay on informal trails when they venture off the formal trail system. A selection of the higher use informal trails would be left in place with the understanding that their continued use is reducing more damaging trampling that would occur if

they were closed and visitors sought multiple alternate routes. All other informal trails would be closed and restored as in the Containment strategy discussed above. This option is pragmatic, given the heavy use on the Island, but is also potentially confusing to visitors because the informal trails left open would not be paint-blazed. There could be “token” efforts to close them, like a log and prompter sign at their intersection with the formal trails, but not brushing or fencing and their continued use would be tacitly but unofficially “condoned” by management.

The Limited Area Closure strategy would be considered if it is determined that off-trail hiking in certain areas along the BGT unacceptably threatens rare plants. In addition to a more general strategy for dealing with informal trails (Containment or Partial Containment), managers could consider limited area closures of off-trail areas to protect rare plants if off-trail hiking cannot be reduced to acceptable levels using other means. Because being able to hike off-trail and explore are likely important and valued experiences along the unique BGT, it is unlikely that off-trail travel can be sufficiently reduced to allow most of the informal trails to recover on Bear Island, even with signage and brushing. While visitors are likely to reject (and not comply with) a complete prohibition on off-trail hiking, they may be willing to accept and comply with limited (and well-signed) area closures, signed as “restoration areas” to protect rare plants. A successful implementation of this option would likely require fencing.

A workshop with NPS, TNC, and various representatives of the public could be convened to discuss these or other general strategies and the specific actions presented below. Regardless of what actions are adopted, an adaptive management decision-making process could assist managers in evaluating management success and altering actions over time to best accomplish management objectives.

Different categories of actions to reduce off-trail travel along the BGT are presented below; efficacy is enhanced when multiple techniques are integrated. Both site management and educational efforts are essential to convey the information necessary for visitors to make informed choices about remaining on the formal trail; one without the other is less likely to be effective. For example, educational signs without clear trail markings (clearly distinguishing formal from informal trails) are not likely to be effective because visitors would be confused about where they should hike. Site management, like brushing, without an explanation, could result in people clearing the brush, either thinking they are helping the park clear trails or because they don’t understand the rationale for closure. A comprehensive approach that combines education (i.e., explaining why one should stay on the trail) with site management (e.g., brushing and restoration) and prompters to remind visitors is likely to be the most effective management regime for reducing off-trail travel.

Improve Communication

Visitors must receive clear information and guidance if managers hope to alter their behaviors sufficiently to increase the protection of the rare and sensitive resources on Bear Island. This research suggests that personal communication more effectively conveys the information and guidance needed than signs because visitors either don’t stop to read the trailhead signs, the information is too substantial or complex for reliance on sign media, or a personal plea from a volunteer is needed to effectively communicate the message to the majority of hikers. Our study

results support development of an enhanced trail steward program, with personal communication of the information presented on trailhead signs.

One option would be to station trail stewards at the trailhead signs during the busiest times, similar to our “Personal Contact” study treatment. While usually cost prohibitive, the existing BGT steward network and visitor characteristics make personal communication a more viable option. The high proportion of repeat visitors (73.3%; Table 19), frequency of use (41.2% visit 3 or more times/yr; Table 20), and number of years visiting the trail (mean=7.3 years; Table 21) suggest that the investment in time and personnel to contact visitors directly would likely yield substantial returns. Another encouraging finding was that despite the traditional role of the trail stewards in enforcing rules along the BGT, as well as educating and aiding visitors, the trail stewards were well-received by visitors when delivering the trailhead educational messages (Tables 71 and 78).

All elements of the trailhead signs are important to communicate effectively to visitors. Survey findings suggest that visitors, if made aware of the island’s rare and sensitive natural communities, would be more willing to avoid off-trail travel. Trailhead signs and the trail stewards should expand communication of the special ecological value and sensitive resources of Bear Island and the off-trail hiking policy. Source credibility is an important component for visitors when evaluating the importance of a message and only 40% of visitors in the Control knew the NPS managed Bear Island; only 1.7% knew TNC and NPS co-managed the area (Table 28). In the Control, 25.4% thought the park “required” and 56.4% felt the park “encouraged” visitors to stay on the paint blazed trails; the rest did not know or thought informal trail use was acceptable (Table 47). Visitors must also be made aware of the impacts associated with off-trail travel. One new way to accomplish this would be to add a “spaghetti map” (Figure 15) of informal trails on Bear Island to the trailhead signs, and a few pertinent facts, like the aggregate lineal extent of informal trails compared to formal trails. The map should be detailed enough to realistically reflect the extent of the informal trail network, but remain vague in terms of actual landmarks so that visitors could not use it to navigate. Finally, additional efforts are needed to make visitors aware that the BGT is a challenging trail with exceptional rockiness and limited “climbing” that requires use of hands. Visitors not able to negotiate such challenges should substitute one of many other nearby trails that are less rocky.

We also suggest improving attention capture by increasing the size of the trailhead signs and adding colorful graphics, such as the “spaghetti map” of the informal trail network. A study by Cole *et al.* (1997) at a wilderness trailhead and observations at 22 signs in Yosemite National park found that large signs (>2000 sq in) and signs with maps increased attention capture (Hall *et al.*, 2001). Graphics have also been shown to successfully illustrate the combined impacts of seemingly insignificant depreciative behaviors. For example, many visitors recalled remembering a series of photos used in a petrified wood theft study illustrating dramatic decreases in petrified wood from past, current, and projected future images to illustrate conditions if just a few people take pieces of petrified wood (Ward & Roggenbuck, 2003).

Study findings support continuation of prompter signs attached to logs placed across all informal trails near their junctions with formal trails. We suggest modifying the symbolic prompter signs (Figure 6) to add the words “Please Stay Off” (see Figure 7, lower portion). We believe that this action will clarify the symbolic sign and increase its size, making it more noticeable to visitors.

These signs could be printed on durable plastic and stapled to blocks of treated lumber, then screwed to sections of logs that provide a symbolic blocking of access to each informal trail. This method proved to very effective. Alternately, thicker plastic signs might be screwed to the logs without the plywood blocking. Careful tracking by patrols during a separate but related one-year study revealed that logs were occasionally pushed aside but rarely carried off any substantial distance. Removal of the signs did occur but was less frequent. Some logs and signs in low-lying areas were lost to flood events so sign placement on durable posts or trees might be considered in these areas.

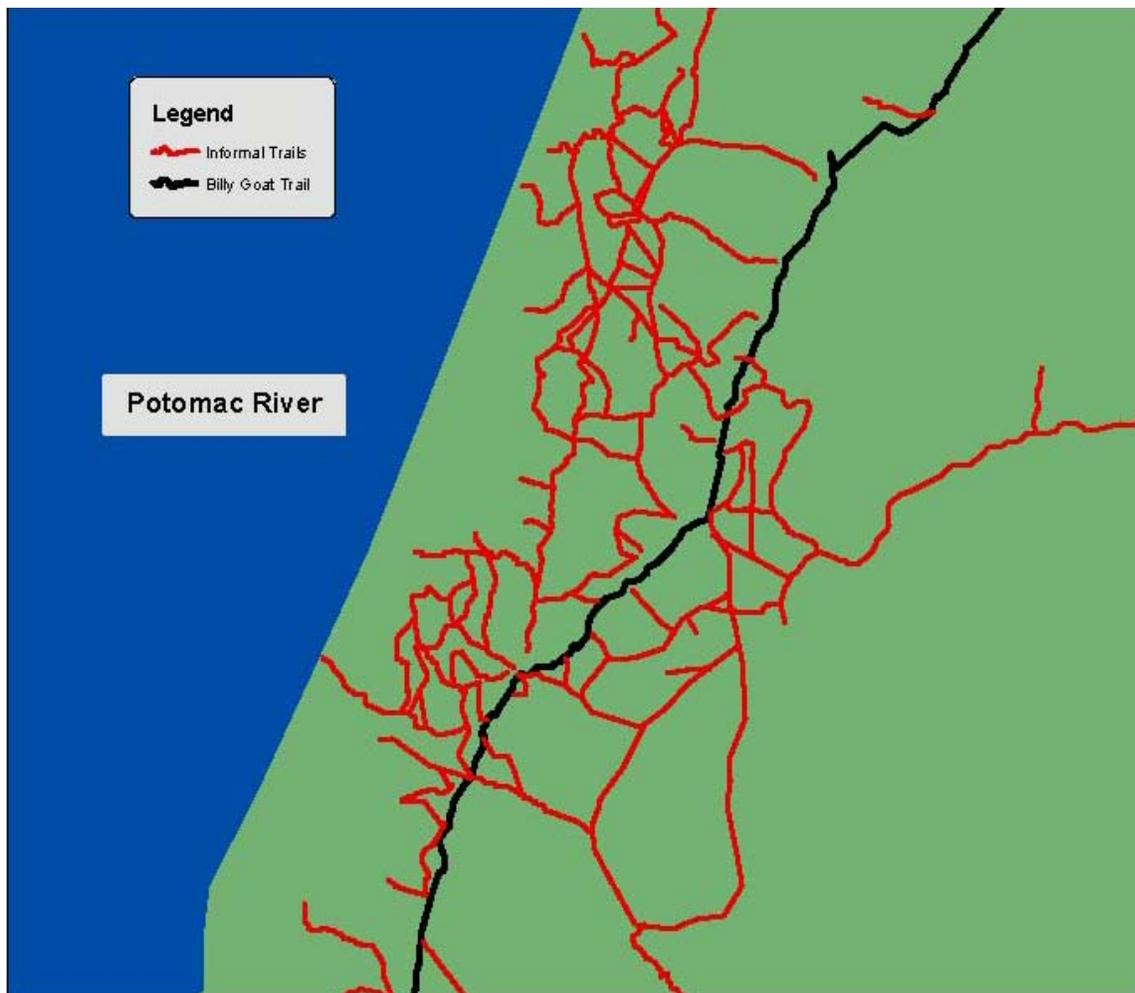


Figure 15. Recommended "spaghetti" map educational sign to visually inform visitors of the extent of the informal trail network on Bear Island.

Improve Maintenance/Marking of the Billy Goat Trail

Some off-trail hiking may yet be attributable to hikers wandering off the BGT due to inattention or confusion in areas with open rock or intersecting informal trails. While we added many new paint blazes to the BGT prior to initiating this study, paint blazes fade with time and require periodic reapplication. Areas with substantial rock require paint blazes on rocks rather than on trees and some confusing areas could benefit from the installation of trail borders, created with rocks or logs to clearly define the intended tread. Even after prompter signs and brushing were in place, 27.5% reported hiking off-trail accidentally.

While the BGT is intended to be a difficult and physically challenging trail, managers must still ensure that its intended tread is maintained to be a better and preferred route for walking than adjacent trail-side terrain. During wet periods managers should identify muddy sections and apply corrective actions so that visitors can remain on the trail. In particularly rocky areas with difficult footing the trail should be aligned with the “easiest” specific route, or alternative off-trail routes need to be made less attractive through the placement of trail borders, rocks, or large brush.

Recognizing that seeing vistas of the Potomac River and Gorge are important attractions for BGT hikers, we identified six high quality vista locations that were relatively safe, could “contain” visitor traffic, and allowed access with short sustainable side-trails or were located on the main tread itself. Visitors are informed of their existence and approximate locations with trailhead signs (Figure 4). Where necessary, bicolor paint-blazes lead visitors to the vistas but some hikers might miss them by failing to see the bicolor blazes. Vista signs need to be readily visible from both directions to avoid this occurrence, which likely contributes to off-trail hiking and continued use of vista-related trails. Each formal vista location should be inspected annually to see if visitor traffic is being contained to the intended use areas. Placement of vista site borders, using rocks or logs to clearly define intended use areas, can help deter dispersed traffic. Brushing and placement of a few “No-hiking” prompter signs just beyond vista borders may also be helpful.

Consider Formalizing Some Informal Trails

Some off-trail traffic is associated with visitor-created by-pass trails that are used for a variety of reasons, including hikers and trail runners seeking to avoid challenging rocky sections of the BGT, by visitors seeking to avoid crowded bottlenecks, and by visitors who hike the BGT during high-water closures. Managers must decide if such trails are acceptable, including consideration for visitor safety. For example, closing bypasses would require hikers who are overly challenged or unable to follow the blazed trail to return along the route they followed, or risk accidents in several areas where the use of hands is required for safe travel. A warning of the challenging nature of the BGT is already provided at one trailhead, but it is located at the bottom of a sign after a series of other messages, and is likely read by few visitors. A more visible warning of the physical challenges along the trail at all trailheads could help provide visitors with this information, and recommend less physically demanding nearby alternative trails (e.g., Billy Goat B and C). If any by-pass trails are considered acceptable a trail professional should evaluate their alignments to select the best preferred single alignment, or design and construct an improved more sustainable alignment. Next, managers must decide if these higher use informal trails

should be formalized and paint-blazed (Containment strategy), or left alone as informal trails which will not be closed (Partial Containment strategy).

Close and Restore Unacceptable Trails

The closure and recovery of all remaining trails on Bear Island will be a formidable management challenge. Trampling impacts and trail creation occur with limited or low levels of traffic, while unassisted natural recovery requires little to no use over years for vegetation to return. This means that virtually all use must be eliminated from the informal trails intended for closure for several years for them to slowly regain their organic litter and vegetation cover and disappear. Since the conclusion of the studies described in this report, trail volunteers have been actively patrolling the BGT to maintain the prompter signs placed at all informal trail intersection with the BGT. A separate but related one-year study was conducted to evaluate the lineal extent and condition of the Bear Island informal trail network under the continued maintenance of the trailhead and prompter signs. Preliminary results show some promising but limited success; presentation of results are forthcoming in a journal paper.

Research results support continuation of the trail closure efforts, with expansion of brushing work to *all visible portions* of the informal trails with the intent of “hiding” them from hikers. The objective of this work is not to physically obstruct visitors but to mimic adjacent natural conditions by moving organic leaf litter and small randomly placed branches onto the informal trails. This is intended to remove the “releaser cue” effect associated with well-used trails that invite visitors down them to discover what interesting sights may be found. Once the initial work is completed, maintenance of prompter signs and brushing must be conducted at least monthly, weekly during times of higher use. This is a substantial amount of work that presumably will become the responsibility of the volunteer trail community; an effective communications and organizational structure must be developed within the NPS and TNC to sustain these efforts and the visitor communication program previously described.

These actions, collectively, will not be completely effective. Some existing informal trails will continue to receive use and new trails will be created. An evaluation of these “closure-resistant” trails should be periodically conducted to evaluate why they are being used and whether some should be formalized or left as “open” informal trails. For example, many visitors are well-aware of the Spitzbergen Cliffs – should it receive a formal paint-blazed access trail? If not, continuation of the prompter signs and brushing should recognize that complete success will likely never be achieved. Additional actions in the form of low symbolic fencing, high fencing, or Limited Area Closures can also be considered in some instances. These may be more appropriate to safeguard certain areas on the island where traffic poses a greater threat to particularly sensitive rare flora or fauna. Additional signs conveying that the areas behind the fence are “restoration” zones to protect rare and sensitive habitats could also be effective in deterring traffic within these areas.

Managers may also wish to consider more extensive restoration actions involving plantings of native species within the treads of informal trails. Such actions can provide a much more convincing appearance of a natural scene. However, restoration work is a high-cost option that should generally be considered only when initial trials reveal that the new plants will not be

quickly trampled and killed. The best available guidance for conducting such work is provided by Therell *et al.* (2006).

Collectively, this broad array of educational and site management actions is necessary to reach visitors who are hiking off-trail for different reasons. The stewards and educational signs can convey information on impacts that can reduce the number of visitors who hike off-trail because they do not know it is harmful. The prompter signs communicate clearly where not to hike and provide reminders of appropriate behavior at decision points. These reminders at the decision points have been shown to be more effective at reducing off-trail hiking than trailhead signs alone (Park *et al.*, 2008; Bradford & MacIntyre, 2007). Brushing the beginning of an informal trail removes the “releaser cue” or evidence that many others have taken that path. Fencing and restoration signs provide additional cues that the park is really concerned about an area and have been shown to be very effective in this and other studies in keeping visitors from using informal trails. However, there is a risk that if a fence is applied to a very popular place, where there is a strong motivation for leaving the trail, visitors might create additional trails to access the area so such an occurrence must be carefully monitored (Johnson *et al.*, 1987).

An important note of caution: Some individuals, including those interested in nature study, photography, fishing, and climbing, “need” to engage in off-trail hiking to fulfill their trip objectives. What will they be told given that their motivations for visiting the trail are in direct conflict with NPS and TNC management objectives? The experiential quality for these individuals is negatively impacted by management guidance asking visitors to remain on formal trails. The history of visitors exploring the island and motivations to explore, including off-trail visits to favorite places, fishing holes, or climbing areas will make it very challenging to achieve high compliance rates. Local visitors may also have strong place attachment, which could make them resistant to management changes.

For visitors or NPS/TNC/volunteer staff who must hike off-trail, there are a number of preferred low impact practices that could be conveyed:

- 1) remain on formal trails as long as possible and minimize off-trail travel,
- 2) when hiking off formal trails use well-established informal trails whenever possible; minimize use of lightly-impacted informal trails to allow their recovery,
- 3) when hiking off formal and informal trails travel on rock, non-vegetated substrates, and grasses; minimize and disperse traffic in all other vegetated areas.

One concern is how such information might be communicated to visitors. If posted on signs or in printed material it could send potentially confusing mixed messages, or that off-trail hiking is really “OK.” To address those concerns it may be preferable to communicate these practices only orally, such as when trail stewards or park/TNC staff see visitors going off-trail or when stewards or park staff are explicitly asked by visitors about off-trail hiking.

If the NPS and TNC are able to effectively implement most of the actions suggested above we can expect conditions to slowly improve on many miles of informal trail and for those most lightly impacted to disappear. A long-term monitoring program could prove valuable to document and evaluate progress. We recommend continuation of the informal trail monitoring protocols that will be included in a separate management report pertaining to the census of formal and informal trails conducted as a separate part of this study. This would provide

quantitative data to track management success and that could also allow managers to set and evaluate standards of quality (see discussions of VERP and LAC in Appendix M). Informal trail management requires an ongoing adaptive management program, where actions are implemented, evaluated periodically, and findings used to support the selection of additional actions as needed to achieve management objectives.

Study Limitations

While much effort was made to ensure the scientific validity of this study, several constraints influence our findings which should be considered before applying results to management decisions. Further research building on this study should seek to overcome these limitations and adopt a research design that permits comparison of results to the current work serving as baseline information. This section briefly describes the study limitations.

Due to staffing limitations, only two observation points could be established along the 2.7 km trail; it would have been ideal to observe visitors during the entire length of their hike, instead of just “snapshots” of behavior. Staffing limitations also prevented us from observing an adequate number of visitors during the Personal Contact treatment; this limited the evaluation of that treatment and comparison between self-reported and observed behaviors. Staffing and material limitations allowed us to only apply the fencing and restoration treatment to a small subset of informal trails, which has limited the interpretation of the results and the comparison among treatments.

Self-reported behavior in any research inherently contains some level of inaccuracy. The environmental complexity of the BGT may have led some visitors to be unsure about the formal trail boundaries, which led them to inaccurately report their behavior. Some respondents may have reported staying on the official trail when they knew they did not because it was socially desirable to say they remained on the formal trail. Nothing in the survey results suggested that either confusion or social desirability was a significant issue in this study.

As discussed earlier, the additive study design was selected based on past research to maximize efficacy while reducing the number of treatments and assessment time and cost. However, a major limitation of this approach is its lessened ability to attribute changes in survey response or observed behavior to a specific treatment or single management action. An additive design only permits detection of the effect of a new action against the aggregate effects of all preceding actions.

A screening question asking visitors if they had encountered a trail steward before being given a survey during the Personal Contact treatment may have altered their subsequent responses by sending them a cue. Also, a comparable screening question was not utilized during other treatments (i.e., did you read the educational sign?). Therefore, other treatments included visitors who did not receive the educational message. Although only a small number (n=18) of potential respondents, who did not recall talking with a trail steward, were eliminated from the Personal Contact treatment, this difference in methodology should be considered when comparing the effectiveness of the treatments.

The exposure of BGT repeat visitors to earlier treatments may have affected the extent to which and where they walked off trail during the subsequent treatments. Completing the visitor survey may also have altered their subsequent off-trail behavior, depending on their perception of potential management options and their attitudes toward park management and/or research personnel. However, only a small percentage of visitors (3.2%) reported having already completed a survey when we solicited their participation, so the impact of repeat visitors or previous study participants on the results is likely quite low.

Future Research

Off-trail hiking impacts remain a significant issue in many natural areas and while educational and site management efforts tested to date reduce off-trail hiking, they often fail to reduce impacts to sufficiently low levels to avoid lasting resource damage or allow natural recovery in moderate to high use areas. Results from this project and other studies (Bradford & McIntire, 2007; Park *et al.*, 2008) suggest that further research is needed to build a better understanding of off-trail hiking behavior motivations, characteristics of visitors who engage in such behavior, and the resource change itself. Such an understanding will be crucial in developing more effective strategies and techniques to minimize off-trail travel in natural areas, particularly in moderate to high use areas and urban-proximate areas that have a high percentage of repeat visitors.

Further research on the BGT should include an evaluation of the off-trail travel that remains after the educational signs, prompter signs, brushing, and trail steward communication are in place. This analysis should document where remaining off-trail travel is occurring and why. For example, 43% reported intentionally hiking off-trail in the Personal Contact treatment, but it could be that the vast majority of the remaining off-trail travel is occurring at just a few locations, such as at Spitzbergen Cliffs and the bypass around the traverse. This would suggest that the strategy is essentially effective and most areas will recover over time. On the other hand, if remaining off-trail travel is not concentrated, but dispersed along the trail, the strategy may be insufficient to permit large-scale recovery. As a component of this evaluation, an in-depth analysis of visitors who continue to hike off-trail would also be helpful. Information such as use patterns and history, activities, demographic characteristics, environmental attitudes and values, attitudes toward the park agency, and an assessment of norms and ethics would help in the development of additional management actions and/or messages that are better tailored to individuals not responding to current management actions. It is possible to create persuasive messages for remaining on the formal trail using different approaches; understanding the perspective of off-trail hikers who are resistant to typical education and site management techniques allows managers to develop strategies that are more likely to resonate with them, similar to advertising campaigns designed to target certain demographics of consumers.

Further research into the challenges that high use, urban-proximate natural areas face in reducing depreciative behaviors with a population of local, repeat visitors would also be useful to managers. Most research on off-trail hiking has focused on more traditional national park areas that have a majority of non-local visitors. While this body of knowledge is undoubtedly valuable, differences in management settings, contexts, and challenges in urban-proximate natural areas (Ewert, 1993; Schroeder, 2007) likely necessitate an adapted research strategy that includes a reconceptualization of the research problem about off-trail hiking, including the study design and variables considered. For example, it is likely that BGT users perceive the park as more of a

local park to visit for exercise with nice scenery than as a place to visit for special natural wonders. The experiences sought by urban-proximate park visitors have been shown to influence their setting preferences, perception of resource conditions, and attitudes toward management and facility development (Andereck & Knopf, 2007). All of these factors present additional challenges to controlling off-trail travel that may require methodologies untested in other areas where visitors might be more receptive to management pleas to stay on formal trails. Further research should be conducted to explore differences in the efficacy of education and site management actions in urban natural areas compared to more traditional national park settings.

Urban-proximate national parks or those used predominantly by locals may also face special challenges in effectively communicating or interpreting the reason the protected area was established and why it is special (Trzyna, 2005). Future research could also focus on the best ways to communicate the special nature of Bear Island and other urban-proximate natural areas to visitors who view these parks as local public use areas instead of special places that are protected for an important reason.

Fertile areas for further research that would apply to all natural areas include relating substrate, terrain, and landscape characteristics to off-trail hiking rates. It would be useful to empirically document what trail characteristics encourage or deter off-trail hiking. Such knowledge, coupled with information about the spatial distribution of sensitive or significant resources, would inform park planners and managers in developing proactive design solutions and management strategies in areas that are most prone to informal trail creation.

As informal trail problems continue to challenge park managers and more natural areas become urban-proximate due to the expansion of urban fringes, research reported in this project and further research as proposed above is crucial in building a knowledge base that informs immediate management needs in the Potomac Gorge, while contributing to the effective management of urban-proximate national park units in the future.

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APPENDIX A: BILLY GOAT TRAIL VISITOR SURVEY

OMB # 1024-0224 (NPS #07-023)

Expiration Date: 12/31/2007

Billy Goat Trail Visitor Survey

2007

Date: _____

Location: Angler's Inn Emergency Exit Great Falls Tavern

Time: _____ AM/PM

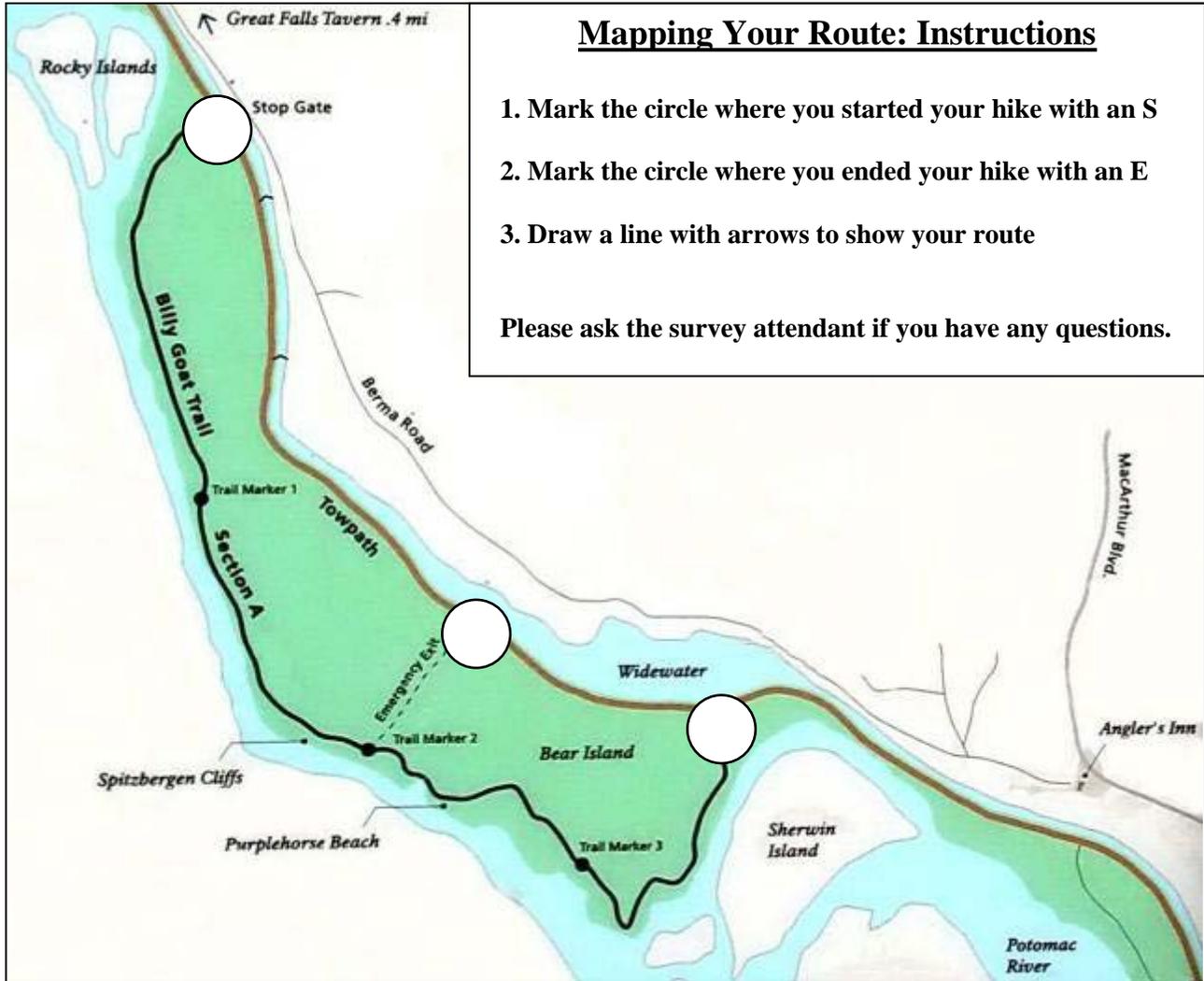
For Researcher's Use Only

Survey ID _____



A. Trip Description

1. Please mark your hiking route on the map below (see the top right corner of the map for instructions):



The map shows the Billy Goat Trail along the Potomac River. Key features include Rocky Islands, Great Falls Tavern (.4 mi), Stop Gate, Berma Road, Towpath, Widewater, Bear Island, Spitzbergen Cliffs, Purplehorse Beach, Sherwin Island, Angler's Inn, and MacArthur Blvd. The trail is marked with Trail Marker 1, Trail Marker 2, and Trail Marker 3. An Emergency Exit is also indicated. Three white circles are drawn on the map to indicate starting and ending points for a hike.

Mapping Your Route: Instructions

1. Mark the circle where you started your hike with an S
2. Mark the circle where you ended your hike with an E
3. Draw a line with arrows to show your route

Please ask the survey attendant if you have any questions.

2. Based on your best estimate how much time did you spend on your hike on the Billy Goat Trail TODAY (the route you indicated in the previous question)?

_____ minutes / hours (circle one)

Please answer all questions based on your visit TODAY to the Billy Goat Trail Section A on Bear Island. If part of your hike included the towpath, please consider only the Billy Goat Trail portion of your hike when answering the questions.

B. Trail Use

3. How many people are in your group TODAY (including yourself)? _____

4. Have you visited the Billy Goat Trail before? (Check one)

- Yes (Continue to Question 5)
- No (Go to Question 7)

**Questions 5 & 6 refer to the
BILLY GOAT TRAIL**

5. To the best of your recollection, in what year did you first use the Billy Goat Trail?

Year: _____

6. Including this trip, about how many times did you run or hike on the Billy Goat Trail in the last 12 months? (Check one)

- 1-2 times
- 3-5 times
- 6-10 times
- 11-20 times
- 21-50 times
- More than 50 times

**Questions 7 & 8 refer to
ANY TRAIL IN A PARK SETTING**

7. To the best of your recollection, in what year did you start hiking or running on trails in a park setting at ANY location?

Year: _____

8. About how many times did you run or hike on ANY trail in a park setting in the last 12 months? (Check one)

- 1-2 times
- 3-5 times
- 6-10 times
- 11-20 times
- 21-50 times
- More than 50 times

C. Activities

9a. On your Billy Goat Trail hike TODAY, which of the following activities did you participate in? (Check all that apply)

- Hiking/Walking Photography Viewing wildlife/birding
- Running/Jogging Exploring Visiting a favorite place
- Nature Study Viewing wildflowers Off-trail Bouldering
- Fishing Rock Climbing with ropes Other (please specify): _____

9b. Of the recreational activities you checked, which one was your primary activity during your visit to the Billy Goat Trail TODAY? _____

D. Visitor Opinions

10. Please indicate to what extent you agree or disagree with each of the following statements about the importance of using the Billy Goat Trail for recreation to you personally. (Circle the appropriate number)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. I rarely ever hike/run at any place other than the Billy Goat Trail.	1	2	3	4	5
b. I get more pleasure out of hiking/running on the Billy Goat Trail than from hiking/running on other trails.	1	2	3	4	5
c. I am very attached to the Billy Goat Trail.	1	2	3	4	5
d. I would not substitute any other area for the hiking/running I do at the Billy Goat Trail.	1	2	3	4	5
e. I have many memories of hiking/running at the Billy Goat Trail.	1	2	3	4	5
f. I feel like the Billy Goat Trail is a part of me.	1	2	3	4	5
g. I feel like I belong at the Billy Goat Trail.	1	2	3	4	5
h. I could draw a rough map of the Billy Goat Trail.	1	2	3	4	5
i. When I am at the Billy Goat Trail I feel I am part of it.	1	2	3	4	5
j. I consider only the Billy Goat Trail when I go hiking/running.	1	2	3	4	5
k. I feel connected to the Billy Goat Trail.	1	2	3	4	5
l. I identify strongly with the Billy Goat Trail.	1	2	3	4	5
m. I know the Billy Goat Trail like the back of my hand.	1	2	3	4	5
n. Hiking/running on the Billy Goat Trail is more important to me than hiking/running on any other trail.	1	2	3	4	5
o. The Billy Goat Trail is the only place I desire to hike/run.	1	2	3	4	5

Park and Trail Management

11. Please indicate your beliefs regarding the ownership and management of the lands around the Billy Goat Trail.

a. Do you know who manages the lands around the Billy Goat Trail?

- Yes (Please list the organization(s) and/or agency(s) here: _____)
- Don't know

b. The Billy Goat Trail is managed primarily for: (Check one)

- Protection of natural & cultural resources
- Recreation
- Both recreation and protection of natural & cultural resources
- Don't know

NOTE: There are many trails on Bear Island. The official trails designated by managers are blazed with blue or white paint. All other trails you may have seen on Bear Island were created by visitors. While they may look like official trails, managers call these trails "unofficial" or "visitor-created trails." In the remainder of the survey, "official" trails refer to designated trails and "unofficial" trails refer to visitor-created trails.

12. Please indicate the extent to which you agree or disagree with the following statements based on your visit to the Billy Goat Trail TODAY by circling a number.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. It is acceptable to walk off of the paint blazed trails, if visitors stay on the unofficial trails already created by other visitors.	1	2	3	4	5
b. Closures of unofficial trails limited my enjoyment.	1	2	3	4	5
c. The park provides clear indications about which trails should not be used.	1	2	3	4	5
d. Compared to other people I saw on this visit, I am causing less damage to the soils and vegetation along the Billy Goat Trail.	1	2	3	4	5
e. I feel a responsibility to help protect the special plants and ecosystems along the Billy Goat Trail.	1	2	3	4	5
f. The soils and plants along the Billy Goat Trail should be protected even if visitors are not allowed to explore off trail.	1	2	3	4	5
g. I am willing to stay on the paint blazed trails to protect rare plants.	1	2	3	4	5
h. I feel responsible for the care of the Billy Goat Trail.	1	2	3	4	5
i. I am willing to give up hiking or running in some areas of Bear Island in order to protect rare plants.	1	2	3	4	5
j. There were official paint blazed trails leading to the places I wanted to visit.	1	2	3	4	5
k. The official paint blazed trails were well-marked.	1	2	3	4	5

13. Please indicate the extent to which you agree or disagree with the following statements based on your visit to the Billy Goat Trail TODAY by circling a number. If you are unsure about an item, circle Don't Know.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Don't Know
a. Even limited use of visitor-created trails can prevent their recovery.	1	2	3	4	5	DK
b. The continued use of unofficial visitor-created trails is a serious threat to rare plants along the Billy Goat Trail.	1	2	3	4	5	DK
c. Soils and plants along the Billy Goat Trail are very hardy and not easily damaged.	1	2	3	4	5	DK
d. Off-trail hiking on Bear Island can spread non-native weedy plants.	1	2	3	4	5	DK
e. There are many special and rare plants that live near the Billy Goat Trail.	1	2	3	4	5	DK
f. Visitors have created many miles of trails on Bear Island.	1	2	3	4	5	DK

14. Managers have many different tools they can use to maintain the trails on Bear Island. Please indicate how each of the following tools affected the quality of your hiking experience TODAY on the Billy Goat Trail by circling a number. If you did not notice an item listed, circle Didn't See.

	Didn't See	Very Negative	Negative	Neutral	Positive	Very Positive
Educational signs near the trailhead	DS	-2	-1	0	1	2
Signs with rules near the trailhead	DS	-2	-1	0	1	2
Boot-print "no hiking" signs	DS	-2	-1	0	1	2
Paint blazes on rocks and trees	DS	-2	-1	0	1	2
Brush and logs used to re-naturalize an area	DS	-2	-1	0	1	2
Trail stewards hiking the trail	DS	-2	-1	0	1	2

15. From the list below, please indicate which statement you think best reflects current park policy. (Check one)

- The park requires visitors to stay on the paint-blazed trails (i.e., off-trail hiking is prohibited).
- The park encourages visitors to stay on the paint-blazed trails.
- The park allows visitors to hike on any trail on Bear Island, whether it is paint-blazed or unmarked.
- The park allows visitors to hike anywhere on Bear Island.
- Don't know

16a. We are interested in learning why people sometimes leave the official paint-blazed trails on Bear Island. Each of the following is a potential reason why you might have walked off the official paint-blazed trails during your visit TODAY. For each item, please indicate whether or not you walked off the trail because of the reason listed.

Did you hike off an official paint-blazed trail	Circle One	
Accidentally because the trail was poorly marked?	Yes	No
Because there was an unmarked trail that already existed?	Yes	No
To get around a difficult part of the trail?	Yes	No
To take a picture?	Yes	No
To move past others on the trail?	Yes	No
To get around poor trail conditions (e.g. mud, downed trees, etc.)?	Yes	No
To get away from crowds on the trail?	Yes	No
To explore?	Yes	No
To take a route you always use?	Yes	No
To get to a picnic spot?	Yes	No
To get to a fishing spot?	Yes	No
To get to a rock climbing spot?	Yes	No
To get to a scenic vista or area of interest?	Yes	No
To view wildlife/birds?	Yes	No
To view wildflowers?	Yes	No

16b. Did you hike off an official paint-blazed trail for any other reason not listed above?

- No
- Yes → Please specify _____

17. You could've walked off the paint-blazed trails at one point today, but chosen not to do so at another point. Therefore, the following list suggests reasons why you chose not to walk off the official paint-blazed trails on your visit TODAY. Please indicate whether or not each item describes why you chose not to walk off of the paint-blazed trails.

I chose <u>not</u> to hike off an official paint blazed trail because....	Circle One	
Of the signs with "no hiking" symbols.	Yes	No
I was afraid I would be reprimanded or confronted by a trail steward.	Yes	No
I had no reason to hike off-trail.	Yes	No
It is not fair for me to walk off the paint-blazed trails when many other visitors don't.	Yes	No
I didn't want to step on and damage any rare plants by mistake.	Yes	No
I didn't want to cause any soil erosion or compaction.	Yes	No
I could see the park had tried to re-naturalize off-trail areas with brush and leaves.	Yes	No
Other (please specify): _____	Yes	No

18. There are many management actions the park could take to help prevent damage to soils and vegetation along the Billy Goat Trail and surrounding area of Bear Island. For each of the following potential management practices, please indicate how acceptable you think each action would be along the Billy Goat Trail.

	Level of Acceptability (Circle one)				
	Unacceptable....			...Acceptable	
a. Educational signs along the trail about the damage that can be caused by walking off trail on rare plants	1	2	3	4	5
b. Signs directing visitors to remain on the official paint-blazed trails	1	2	3	4	5
c. "No Hiking" signs posted at unofficial, non-blazed trails	1	2	3	4	5
d. Blocking unofficial trails with brush and logs	1	2	3	4	5
e. Restoration of unofficial, non-blazed trails to an undisturbed state	1	2	3	4	5
f. Rules prohibiting visitors from hiking off of the official paint-blazed trails	1	2	3	4	5
g. A monetary fine for visitors who walk off the official paint-blazed trails	1	2	3	4	5
h. Increased ranger presence along trails	1	2	3	4	5
i. Volunteer trail stewards asking visitors to stay on official paint-blazed trails	1	2	3	4	5
j. Improve trail conditions (eliminate mud, downed trees, etc.)	1	2	3	4	5

F. Background Information

19. In what year were you born? Year: _____

20. What is your gender? (Check one)

- Male
- Female

21. Do you live in the United States or are you here for an extended stay greater than 90 days? (Check one)

- Yes (What is your Zip code? _____)
- No (What country do you live in? _____)

22. What is the highest level of education you have completed? (Check one)

- Elementary School
- Some college
- Associate's degree or equivalent
- Some high school
- Bachelor's degree or equivalent
- Master's degree or equivalent
- High school diploma
- Some graduate work
- PhD, M.D., or equivalent
- or equivalent

Thank you for your help in completing this survey!

Please return the completed questionnaire to the survey administrator.

PRIVACY ACT and PAPERWORK REDUCTION ACT statement:

16 U.S.C. 1a-7 authorizes collection of this information. This information will be used by park managers to better serve the public. Response to this request is voluntary. No action may be taken against you for refusing to supply the information requested. Permanent data will be anonymous. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

OMB# (1024-0224) NPS# 07-23

Expiration Date: 12/31/2007

Burden estimate statement: Public reporting for this form is estimated to average **15** minutes per response. Direct comments regarding the burden estimate or any other aspect of this form to: Bill Justice, Chief of Interpretation, at 1850 Dual Highway, Suite 100, Hagerstown, MD 21740, Bill_Justice@nps.gov

APPENDIX B: REFUSAL LOG

APPENDIX C: VOLUNTEER SURVEY ADMINISTRATOR GUIDANCE

Billy Goat Trail Visitor Survey 2007

Volunteer Administrator Instructions

Thank you for volunteering to help in this research study. Your time is greatly appreciated. Please review the following information if you will be involved with survey administration.

Greeting Participants

Greet visitor groups with the following script:

“Hello, my name is _____. I am conducting a survey for Virginia Tech and NC State University on your use and opinions of the Billy Goat Trail. Your participation in this survey is voluntary and all answers will be confidential. It will take between 10-15 minutes to complete. Would you be willing to participate?”

If “NO” then, “I understand, enjoy your visit.” Record their information on the Survey Refusal Log (See “Incomplete Surveys” below).

If “YES” then thank them. Ask which of the group had the most recent birthday and ask if this individual would please complete and return the questionnaire.

- **Complete question #1 with the participant.** We found that this question is confusing to participants. Please ask the participant where they began their hike and where they ended. Place an “S” in the circle where they started, an “E” in the circle where they ended, and draw an arrow to show direction (you’re following the instructions for question #1). Then hand over the questionnaire to be completed by the participant.
- Tell visitors they may sit where they want (but should remain near the survey station) to complete their surveys, but all surveys must be completed on site. Please encourage them to sit in the chairs we provide.
- Remind them that there is a **front and back** to the survey.
- Ask participants to pay particular attention to questions containing the bold word **TODAY**. In these instances, we are interested only in their experiences on today’s visit.
- Instruct them to drop their survey into the box on completion.
- **Please make sure that no one leaves the site with a survey.**
- Ask participants to address any questions to the surveyor. Common questions might include:
 - **Why are you doing this survey?** To collect information on trail use and visitor’s opinions on management. This information will be used to more efficiently manage recreational and ecological resources in the area.
 - **Will my answers be anonymous?** All information will be kept anonymous.
 - **Can I find out the results of the study?** Yes. Please leave your preferred contact information on our Results Contact sheet.
 - **Will you be permanently closing the Billy Goat Trail?** No. Trail closures during this study are for research purposes only. Certain sections of trail might be improved in the future through rerouting or restoration.

Incomplete Surveys

- If a participant is willing to fill out a survey but does not have time to complete the questionnaire onsite, collect the incomplete questionnaire before the participant leaves the survey station.
- Thank individuals who are unwilling or unable to participate in the survey for their consideration. Record their information on the survey refusal log.

Completed Surveys:

- You will be provided with a folder of blank surveys, a folder for completed surveys, several clipboards, a box, and several pencils. Participants will place completed surveys into the box.
- When a participant completes a survey, make sure that all fields on the front are completed. Please leave the “Survey ID” field blank. This will be filled in by the research team for data entry.
- At the end of each survey period, please place all finished surveys in your “completed” folder. All supplies should be returned to the graduate student administrator at the end of each day.

NOTES:

APPENDIX D: TRAIL STEWARD GUIDANCE

Trail Steward Treatment Guidance

This study treatment will position Trail Stewards about 50-100 yards in from each of the 3 Billy Goat Trail (BGT) trailheads to personally contact only the inbound hikers. We want the trail steward to hand a laminated double-sided sheet to inbound hikers and talk through what the two sides of the handout says (then retrieve the handout). One side has our message about not walking off-trail (w/rationale), the other side shows a map of the BGT showing the new vista spots. The interaction should take 1-2 minutes and be restricted to those topics. A recommended script is included below to help folks with the wording. Trail Stewards can bring a chair to sit in while waiting. They should be in "uniform" - a shirt and/or hat with the NPS VIP logos. They will not be available to respond to incidents – unless there are extra staff available to fill-in (i.e., our goal is to contact and give the personal message to 100% of BGT hikers).

Draft script for Trail Stewards:

Note that we are asking trail Stewards to disregard their prior training and messages for this work. We need you to be brief and to stick roughly to the script below for this treatment. Basically you are talking them through the text on the trailhead signs, which we will provide on a laminated copy you can hand to (and retrieve from) each group of visitors entering the BGT system.

- 1) Hi, my name is _____ and I'm a Trail Steward for the Billy Goat Trail. If you have just two minutes I'd like to describe some new hiking policies on the island here.
- 2) Great, let me **lend** you this laminated message and map so you can follow along. As you can see, the National Park Service and the Nature Conservancy land managers are asking visitors to stay on paint-blazed trails on the island to protect rare plants. Over 50 rare plants call this island their home. Visitors like yourselves have created several miles of unofficial tracks that can harm these species and managers are trying to close and restore these tracks.
- 3) You can assist them and protect the rare plants by not leaving the paint-blazed trails (point out a paint blaze). Everyone's cooperation is needed – even a few footsteps can prevent recovery.
- 4) If you'll flip that over you can see a site map showing the Billy Goat Trail (orient them to the map and which trailhead they are at). Please note that the Billy Goat Trail is blue blazed and all official side trails, including 6 short trails to six vista sites, are blue and white blazed.
- 5) That's all, thank you for your time and have a great hike.
- 6) If they ask you any questions tell them that you need to catch the next folks coming down the trail but may have some time to answer them. Keep your answers brief and on-topic to the extent possible. Extended discussions about trail length, difficulty, or trail management are not recommended. If they ask about the study you can say that the land managers are interested in their opinions about Billy Goat Trail management options so the university students are conducting a short survey. No decisions have been made concerning changes to management of the trail. If they have a dog with them you can politely remind them that dogs are not permitted on the Billy Goat Trail A but they are permitted on the BGT B and C trails just downriver and the other trails directly across the towpath (the Gold Mine Loop area trails). It would be best if you did not elaborate or become insistent on this topic or discuss other topics that are normally covered by the Trail Stewards (e.g., no swimming).

APPENDIX E: RESIDENCY OF RESPONDENTS

State and country residency of survey respondents.

State	Count	Percent
Maryland	502	44.7
Virginia	356	31.7
District of Columbia	185	16.5
Pennsylvania	10	0.9
North Carolina	7	0.6
New York	6	0.5
Ohio	6	0.5
California	5	0.5
Texas	5	0.5
New Jersey	4	0.4
Florida	3	0.3
Iowa	3	0.3
Massachusetts	3	0.3
Michigan	3	0.3
Delaware	2	0.2
Colorado	1	0.1
Connecticut	1	0.1
Illinois	1	0.1
Indiana	1	0.1
Maine	1	0.1
Minnesota	1	0.1
Montana	1	0.1
New Mexico	1	0.1
Vermont	1	0.1
West Virginia	1	0.1

Country	Count	Percent
United Kingdom	3	0.3
Germany	2	0.2
Canada	1	0.1
France	1	0.1
India	1	0.1
Ireland	1	0.1
Italy	1	0.1
Nicaragua	1	0.1
Spain	1	0.1

APPENDIX F: WRITE-IN OTHER ACTIVITIES

Write-in responses for “other” activities engaged in while hiking the Billy Goat Trail, arranged by category. Numbers in parentheses indicate the number of respondents who listed that identical activity.

Picnicking
<ul style="list-style-type: none">● Ate lunch● Eating● Eating lunch (2)● Lunch (5)● Picnic (9)

Social Interaction
<ul style="list-style-type: none">● Bonding with my spouse● Celebrate father's day● Chatting/bonding● Family fun● Flirting● Fun!● Got engaged● Great conversation● Greeting● Having fun (2)● QT with friends● Sex● Talking (2)● Talking with friend

Wading/Swimming
<ul style="list-style-type: none">● Skinny dipping● Swimming (9)● Wading (3)● Watering feet in river

Other activities engaged in while hiking the Billy Goat Trail, continued.

Viewing Scenery
<ul style="list-style-type: none">● Enjoying scenery● Observing rapids● Seeing views of cliffs● Sightseeing● Viewing● Viewing river● Viewing water● Watching rock climbers

Other Rock Climbing
<ul style="list-style-type: none">● Climbing without rope● Free climbing (2)● On trail bouldering● Rock climbing● Rock scrambling

Sunning
<ul style="list-style-type: none">● Lay in the sun● Sitting in the sun● Sunning

Relaxing/Napping
<ul style="list-style-type: none">● Napping (2)● Relaxing● Resting

Herpetology
<ul style="list-style-type: none">● Herping● Picked up a toad● Snake catching

Reading
<ul style="list-style-type: none">● Reading● Reading a book in the sunshine

Other activities engaged in while hiking the Billy Goat Trail, continued.

Miscellaneous
● 40lb. Pack/boots for exercise
● Biking
● Geology
● Kayaking/canoeing
● Pee in the woods
● Pick up trash
● Play music in the woods
● Sitting on rocks
● Sneaking
● Walk dog

APPENDIX G: PLACE DEPENDENCE

Responses for each place dependent item follow, from each treatment and all treatments combined in the “overall” column.

Table G.1. Agreement level with the statement: "I rarely every hike/run at any place other than the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1146)
	Control (n=294)	Signs (n=256)	Brushing (n=273)	Restoration & Fencing (n=162)	Personal Contact (n=161)	
Agree	19.4%	17.6%	16.8%	13.6%	15.5%	17.0%
Neutral	19.7	15.6	17.2	20.4	12.4	17.3
Disagree	60.9	66.8	65.9	66.0	72.0	65.7
Means ⁴	-0.7	-0.8	0.7	-0.8	-0.8	-0.7

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 8.955$, $p = 0.346$, $df = 8$

⁴ $F = 0.865$, $p = 0.484$, $df = 4$.

Table G.2. Agreement level with the statement: "I get more pleasure out of hiking/running on the Billy Goat Trail than from hiking/running on other trails."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1146)
	Control (n=295)	Signs (n=257)	Brushing (n=273)	Restoration & Fencing (n=162)	Personal Contact (n=159)	
Agree	52.2%	52.9%	54.6%	40.7%	50.9%	51.1%
Neutral	37.6	35.0	34.4	43.2	36.5	36.9
Disagree	10.2	12.1	11.0	16.0	12.6	12.0
Means ⁴	0.5	0.6	0.6	0.3	0.5	0.5

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 10.103$, $p = 0.258$, $df = 8$

⁴ $F = 1.725$, $p = 0.142$, $df = 4$

Table G.3. Agreement level with the statement: "I would not substitute any other area for the hiking/running I do at the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1144)
	Control (n=296)	Signs (n=255)	Brushing (n=272)	Restoration & Fencing (n=163)	Personal Contact (n=158)	
Agree	29.7%	31.0%	29.8%	28.2%	27.8%	29.5%
Neutral	37.8	34.5	28.7	33.7	33.5	33.7
Disagree	32.4	34.5	41.5	38.0	38.6	36.7
Means ⁴	0.1	-0.0	-0.1	-0.1	-0.1	-0.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 7.800$, $p=0.453$, $df = 8$

⁴ $F=1.085$, $p=0.363$

Table G.4. Agreement level with the statement: "I consider only the Billy Goat Trail when I go hiking/running."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1148)
	Control (n=297)	Signs (n=256)	Brushing (n=273)	Restoration & Fencing (n=162)	Personal Contact (n=160)	
Agree	16.5%	19.5%	16.8%	15.4%	15.0%	16.9%
Neutral	19.5	21.1	24.5	20.4	16.9	20.8
Disagree	64.0	59.4	58.6	64.2	68.1	62.3
Means ⁴	-0.6	-0.6	-0.6	-0.7	-0.7	-0.6

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 6.949$, $p=0.542$, $df = 8$

⁴ $F=0.527$, $p=0.716$, $df=4$

Table G.5. Agreement level with the statement: "Hiking/running on the Billy Goat Trail is more important to me than hiking/running on any other trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1144)
	Control (n=296)	Signs (n=256)	Brushing (n=271)	Restoration & Fencing (n=161)	Personal Contact (n=160)	
Agree	19.9%	25.0%	22.1%	18.0%	16.3%	20.8%
Neutral	28.0	25.4	33.6	31.7	24.4	28.8
Disagree	52.0	49.6	44.3	50.3	59.4	50.4
Means ⁴	-0.4	-0.3	-0.3	-0.5	-0.6	-0.4

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 14.258$, $p=0.075$, $df = 8$

⁴ $F=1.947$, $p=0.100$, $df=4$

Table G.6. Agreement level with the statement: "The Billy Goat Trail is the only place I desire to hike/run."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1142)
	Control (n=295)	Signs (n=254)	Brushing (n=270)	Restoration & Fencing (n=162)	Personal Contact (n=161)	
Agree	9.5%	12.6%	9.3%	10.5%	8.1%	10.1%
Neutral	18.3	20.9	22.2	15.4	19.9	19.6
Disagree	72.2	66.5	68.5	74.1	72.0	70.3
Means ⁴	-0.9	-0.8	-0.8	-0.9	-1.0	-0.9

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 6.583$, $p=0.582$, $df = 8$

⁴ $F=0.756$, $p=0.554$, $df=4$.

APPENDIX H: PLACE IDENTITY

Responses for each place identity item follow, from each treatment and all treatments combined in the “overall” column.

Table H.1. Agreement level with the statement: "I am very attached to the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1140)
	Control (n=294)	Signs (n=255)	Brushing (n=270)	Restoration & Fencing (n=163)	Personal Contact (n=158)	
Agree	66.2%	63.6%	67.3%	60.1%	63.7%	64.7%
Neutral	22.9	24.9	23.2	25.9	29.3	24.7
Disagree	10.9	11.5	9.6	13.9	7.0	10.6
Means ⁴	0.8	0.8	0.9	0.6	0.8	0.8

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 7.088$, $p=0.572$, $df = 8$

⁴ $F=1.435$, $p=0.220$, $df=4$

Table H.2. Agreement level with the statement: "I have many memories of hiking/running at the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1144)
	Control (n=296)	Signs (n=254)	Brushing (n=272)	Restoration & Fencing (n=162)	Personal Contact (n=160)	
Agree	62.5%	62.2%	64.7%	53.7%	58.8%	61.2%
Neutral	18.2	15.0	19.1	17.3	21.3	18.0
Disagree	19.3	22.8	16.2	29.0	20.0	20.8
Means ⁴	0.7 ^a	0.5 ^{ab}	0.7 ^a	0.3 ^b	0.5 ^{ab}	0.6

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 13.741$, $p=0.089$, $df = 8$

⁴ $F=3.835$, $p=0.004$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

Table H.3. Agreement level with the statement: "I feel like the Billy Goat Trail is part of me."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1141)
	Control (n=295)	Signs (n=256)	Brushing (n=272)	Restoration & Fencing (n=158)	Personal Contact (n=160)	
Agree	39.0%	35.2%	39.7%	29.7%	30.0%	35.8%
Neutral	35.6	34.8	31.3	38.6	36.3	34.9
Disagree	25.4	30.1	29.0	31.6	33.8	29.4
Means ⁴	0.2	0.1	0.1	-0.1	-0.1	0.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 9.879$, $p=0.274$, $df = 8$

⁴ $F=2.694$, $p=0.030$, $df=4$

Table H.4. Agreement level with the statement: "I feel like I belong at the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1137)
	Control (n=293)	Signs (n=253)	Brushing (n=272)	Restoration & Fencing (n=159)	Personal Contact (n=160)	
Agree	49.1%	45.1%	46.0%	45.9%	45.6%	46.5%
Neutral	32.4	34.0	34.9	31.4	33.8	33.4
Disagree	18.4	20.9	19.1	22.6	20.6	20.1
Means ⁴	0.4	0.3	0.4	0.2	0.3	0.3

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 2.259$, $p=0.972$, $df = 8$

⁴ $F=0.984$, $p=0.415$, $df=4$

Table H.5. Agreement level with the statement: "I could draw a rough map of the Billy Goat Trail"

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1139)
	Control (n=292)	Signs (n=257)	Brushing (n=270)	Restoration & Fencing (n=159)	Personal Contact (n=161)	
Agree	48.6%	45.1%	45.2%	41.5%	37.3%	44.4%
Neutral	13.0	17.9	22.2	19.5	16.8	17.7
Disagree	38.4	37.0	32.6	39.0	46.0	37.8
Means ⁴	0.1	0.1	0.1	0.0	-0.1	0.1

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 15.390$, $p=0.052$, $df = 8$

⁴ $F=1.282$, $p=0.275$, $df=4$

Table H.6. Agreement level with the statement: "When I am at the Billy Goat Trail I feel I am a part of it."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1131)
	Control (n=293)	Signs (n=250)	Brushing (n=271)	Restoration & Fencing (n=160)	Personal Contact (n=157)	
Agree	56.0%	54.0%	57.2%	50.6%	50.3%	54.3%
Neutral	29.0	31.2	26.9	31.9	34.4	30.2
Disagree	15.0	14.8	15.9	17.5	15.3	15.6
Means ⁴	0.5	0.5	0.5	0.4	0.4	0.5

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 4.231$, $p=0.836$, $df = 8$

⁴ $F=1.117$, $p=0.347$, $df=4$

Table H.7. Agreement level with the statement: "I feel connected to the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1143)
	Control (n=295)	Signs (n=256)	Brushing (n=272)	Restoration & Fencing (n=161)	Personal Contact (n=159)	
Agree	49.5%	45.7%	48.5%	46.6%	45.3%	47.4%
Neutral	32.9	35.5	32.7	29.2	39.0	33.8
Disagree	17.6	18.8	18.8	24.2	15.7	18.8
Means ⁴	0.4	0.3	0.4	0.2	0.3	0.3

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 6.889$, $p=0.549$, $df = 8$

⁴ $F=1.236$, $p=0.294$, $df=4$

Table H.8. Agreement level with the statement: "I identify strongly with the Billy Goat Trail."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1122)
	Control (n=289)	Signs (n=253)	Brushing (n=267)	Restoration & Fencing (n=158)	Personal Contact (n=155)	
Agree	43.3%	44.3%	43.4%	32.9%	31.0%	40.4%
Neutral	34.3	33.2	34.1	40.5	50.3	37.1
Disagree	22.5	22.5	22.5	26.6	18.7	22.5
Means ⁴	0.3	0.3	0.3	0.0	0.1	0.2

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 20.025$, $p=0.010$, $df = 8$

⁴ $F=2.066$, $p=0.083$, $df=4$

Table H.9. Agreement level with the statement: "I know the Billy Goat Trail like the back of my hand."

Agreement Level ^{2,3}	Treatment ¹					Overall (n=1135)
	Control (n=293)	Signs (n=255)	Brushing (n=269)	Restoration & Fencing (n=160)	Personal Contact (n=158)	
Agree	31.4%	27.1%	26.0%	20.6%	17.1%	25.6%
Neutral	22.2	24.3	23.8	20.0	23.4	22.9
Disagree	46.4	48.6	50.2	59.4	59.5	51.5
Means ⁴	-0.2 ^a	-0.3 ^{ab}	-0.3 ^{ab}	-0.6 ^b	-0.6 ^b	-0.4

¹ Refer to Table 3 for an explanation of management actions for each treatment.

² 5-point response scale: -2 = strongly disagree, 0 = neutral, +2 = strongly agree.

³ $\chi^2 = 16.848$, $p=0.032$, $df = 8$

⁴ $F=4.412$, $p=0.002$, $df=4$; means with different superscripts are significantly different (Tukey's HSD; $p\leq 0.05$).

**APPENDIX I: WRITE-IN OTHER REASONS FOR HIKING
OFF-TRAIL**

Appendix I: Write-in Other Reasons for Hiking Off-Trail

Appendix I: Write-in “other” reasons for hiking off-trail, arranged by category. Numbers in parentheses indicate the number of respondents who listed an identical reason.

Bathroom break

- To go to the bathroom (4)
- To go to the bathroom in the woods
- To pee (2)
- To relieve myself
- Urinate (2)

To Swim/Cliff Jump

- Cliff jumping!
- Swimming (5)

To Meditate or Read

- Reading and meditation
- To read our book on the rocks

Miscellaneous

- As long as obnoxious dog owners let their dogs run wild, its unfair to cut off the path i use to a shady resting place with a good view of wildlife and river
- Cardio
- Exhausted
- Get engaged!
- I like to walk only on the rocks to avoid damaging the soil on the trail. The rocks are often off the trail
- Just to be
- Nookie
- Not aware I was supposed to be aware
- Painted trail didn't follow rock ridge
- Rocks!
- Simply wanted to
- The signs annoyed me so much i wanted to especially on well worn small areas with no vegetation
- To avoid stewards and rangers seeing my dogs

**APPENDIX J: WRITE-IN OTHER REASONS FOR
REMAINING ON THE FORMAL TRAIL**

Appendix J: Write-in “other” reasons for remaining on the formal trail, arranged by category. Numbers in parentheses indicate the number of respondents who listed an identical reason.

Safety Concerns/Fear of Getting Lost
<ul style="list-style-type: none">● By myself, didn't want to get hurt● Cautious● Dangerous● Did not want to get lost in woods● Didn't want to get lost (8)● Fear● For safety I trust the trail is marked to keep hikers safe● I would break my leg● It's too rocky● Might get lost● Personal injury● Safety (2)

Don't want to harm the environment
<ul style="list-style-type: none">● Areas looked overused● Conservation● Conservation, keep trail in pristine condition● Good steward to environment● I didn't want to contribute to the formation of new unofficial trails● I don't want to hurt the ecosystem● I learned of the rehabilitation program● Its the right thing to do, we have to protect the park in order to keep using it● Leave no trace● Plants● Possible to protect plants and wildlife● Respect for the trail and environment management● Save the snails● Something about a problem with a soil virus and frogs or something

Other activities for remaining on the Billy Goat Trail, continued.

Trail well marked/maintained

- Anything you can see off trail you can also see from trail
- Blazes have been improved
- Don't need to walk off blazed trails. Blazed trails are great
- Followed the markers
- Generally stay on the marked trails
- Good blaze markings
- I focus on trail markers
- Like to follow path
- Marked trails provide the best hiking experience for family (sights and safety)
- No point when the official trail's so good
- The main trail is obvious
- The trail generally goes where i want it to
- The trail is good enough

Avoid Poison Ivy and Bugs

- Fear of bugs/poison ivy
- I didn't want to encounter poison ivy
- Poison ivy avoidance
- Poison ivy/oak
- Prefer to avoid poison ivy seen everywhere

Stewards asked to stay on trail

- Good looking trail stewards told me not to
- Had been educated by a trail steward in the past, so i try to pay more attention
- The steward who asked us not to
- Trail steward told us to stay on trail

I follow rules

- I am a special assistant USA who prosecutes violations on C&O Canal property. I know better than to break these rules, I prosecute the violators
- I try to follow instructions as a rule
- Respect for rules

Other activities for remaining on the Billy Goat Trail, continued.

Acting as a role model

- | |
|--|
| <ul style="list-style-type: none">● Be good role model for son● Teach children proper hiking protocol |
|--|

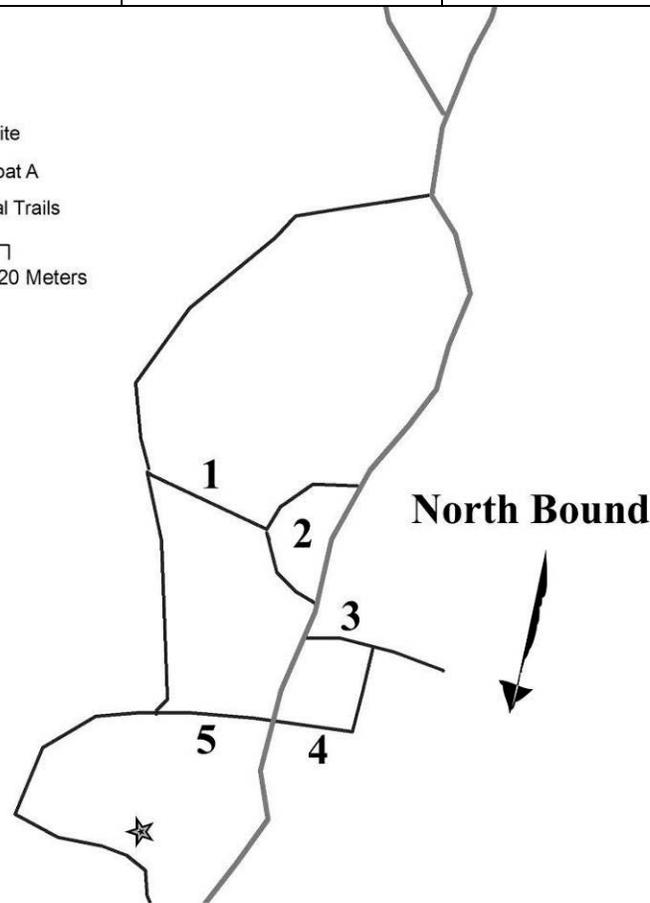
Miscellaneous

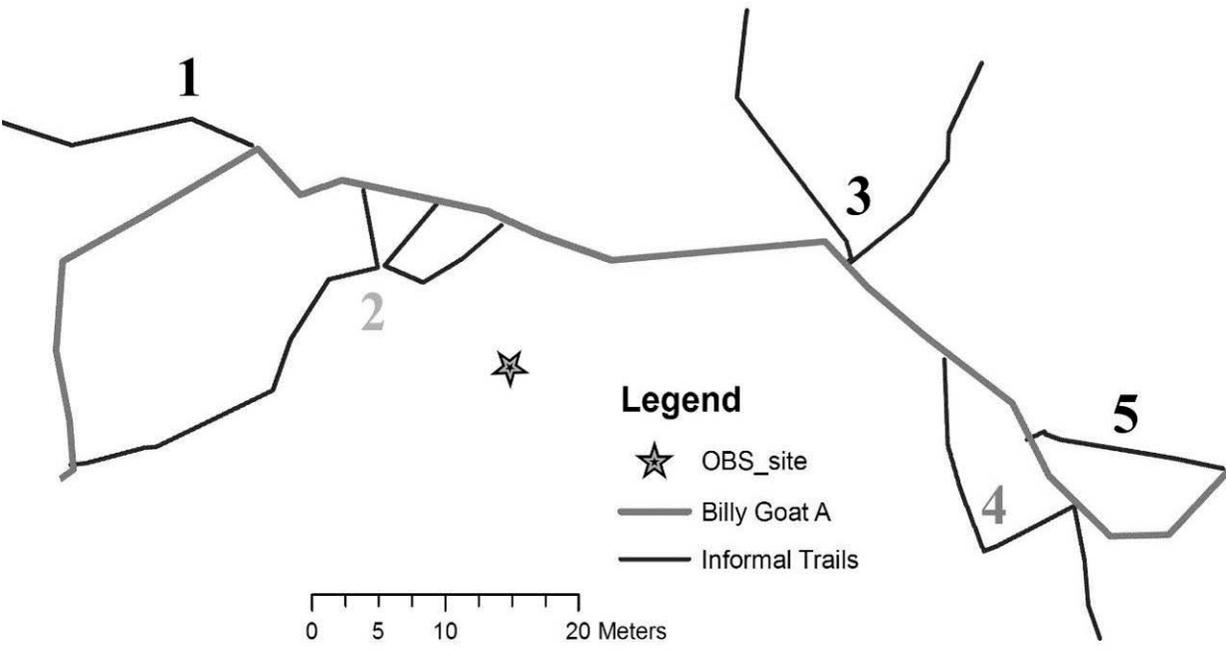
- | |
|--|
| <ul style="list-style-type: none">● Always leave the campsite cleaner than you found it● Be helpful● Because we were playing the "you can only step on rocks" game● But if (<i>name written in was deleted</i>) is there one will be loudly reprimanded a'la kindergarten● Group hiking● Hard to step away from road● I don't want to abuse the priveledge of visiting the area, I've seen other places completely closed to the public● I stepped on rocks not the trail● I went for a run● Lazy● Not enough rocks to balance on to avoid contact with plants and soil● Stayed on rocks off trail● Timing myself● To honor God● Trail changed since last time and I was tricking myself |
|--|

APPENDIX K: OBSERVATION FORMS FOR SITES 1 AND 2

Appendix K: Observation Forms for Sites 1 and 2

Observation forms used by researchers to record hiking and off-trail hiking events along the Billy Goat Trail.

Billy Goat Trail Visitor Observation Form, Site 1					
Date:	Start Time:	End Time:	Observer:		
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 25%;"> <p>Legend</p> <ul style="list-style-type: none"> ★ OBS_site — Billy Goat A — Informal Trails <p>0 5 10 20 Meters</p> </div> <div style="width: 75%; text-align: right;">  <p>North Bound</p> </div> </div>					
North Bound					
1	2	3	4	5	6
South Bound					
1	2	3	4	5	6
North Bound			South Bound		

Billy Goat Trail Visitor Observation Form, Site 2					
Date:	Start Time:	End Time:	Observer:		
 <p>The map shows a trail network with five numbered observation sites (1-5). Site 1 is a large loop on the left. Site 2 is a smaller loop in the center. Site 3 is a loop on the right. Site 4 is a loop at the bottom right. Site 5 is a loop on the far right. A star symbol indicates an observation site. A legend identifies the star as 'OBS_site', the thick line as 'Billy Goat A', and the thin line as 'Informal Trails'. A scale bar shows 0, 5, 10, and 20 meters.</p>					
North Bound 6					
1	2	3	4	5	6
North Bound (Tally each hiker)					
7 South Bound					
1	2	3	4	5	6
South Bound (Tally each hiker)					

APPENDIX L: ANNOTATED BIBLIOGRAPHY

**RESEARCH ON OFF-TRAIL WALKING:
BEHAVIOR, IMPACTS, AND EDUCATION EFFICACY –**

Annotated Bibliography

**(Prepared for a NPS-sponsored Research Study on Trail Impacts and Education Efficacy
at the Potomac Gorge Area, Maryland and Virginia)**



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April 2007

Introduction

This document was created in support of a NPS-funded research study conducted by Virginia Tech and North Carolina State University researchers to evaluate and mitigate natural resource impacts associated with off-trail hiking in two National Park Service units in the Potomac Gorge Area -- Great Falls Park (GRFA) in Virginia and Chesapeake and Ohio Canal National Historical Park (CHOH) in Maryland. Study components include an inventory of unofficial trails and an evaluation of possible educational and site management actions for reducing off-trailing behavior and associated damage.

The bibliography is further organized into four sections: general visitor behavior problems, off-trail walking and impacts, general education efficacy research, and education efficacy research with a specific focus on off-trail walking. Literature was identified through a series of library database searches conducted between September 2006 and March 2007. The searches included the following reference databases and keywords:

- CAB Abstracts -- Hiking- outdoor recreation, hiking-trails, Potomac, DC-hiking trails, Maryland-hiking trails, front country, urban-hiking, Maryland-tourism, Metropolitan-trails, trails- outdoor recreation, environmental impact, and management.
- Web of Science – social trails, informal trails, off-trail
- Agricola -- Visitors- forest rec., visitor behavior, and social trails.
- Psych Info -- Behavior & recreation- recreation area, environmental attitudes- recreation, visitor, trails and hiking.

A. General Visitor Behavior Problems

Dustin, D. L. (1985). To feed or not to feed the bears: The moral choices we make. *Parks and Recreation*, 20(10), 54-57, 72.

Annotation: Dustin provides insights on moral reasoning and considerations that impact the choices made in wilderness. He outlines his understanding of this scale compared to Kohlberg's six stages of moral development. He feels that Kohlberg's theory helps clarify many areas of recreation, and acknowledges that growth occurs from one stage to the next where a person moves on to the next level when a situation can't be morally rectified within their current stage of development. Dustin advocates for using this concept in recreational resource management by packaging educational messages that create some anxiety and help recreationists move up in moral growth. If park messages are well justified, Dustin hopes that the advanced moral thinkers among us will respect them. He also applies the stages to his initial anecdote of Anasazi ruins in the Grand Canyon by recommending a six-part message that incorporates each stage of development.

Keywords: moral development, resource management, messaging, outdoor recreation, signage

Dustin, D. L., & McAvoy, L. H. (1980). Hardining national parks. *Environmental Ethics*, 2(1), 39-44.

Annotation: The authors refer to the tragedy of the commons as presented by Hardin, where the only solution to the issue of common resource management is a change in human values. The current state of Yosemite national park is discussed in the context of a commons, where management of technical aspects of the park such as mass transit networks are the only methods used to combat the increasing tragedy of the commons phenomenon in the park. They argue that Hardin's theory warrants limiting use of the finite resource provided by the park. This conflicts with the National Park Service mandate to preserve the parks and provide for public use, but evidence from the park's draft management plan at the time seemed to reflect a willingness to limit use and choose to favor one part of the mandate over the other.

Keywords: values, park management, use limitation, finite resources, Yosemite National Park

Dustin, D. L., & McAvoy, L. H. (1982). The decline and fall of quality recreation opportunities and environments? *Environmental Ethics*, 4(1), 49-57

Annotation: Human adaptability is a necessary trait for evolution, but it could have negative consequences when adaptation results in acceptance of degraded environments. This is of particular concern for recreation managers, since it implies that even as the quality of recreation experience decreases, demand will continue to increase. This is primarily a result of reactive management, where the management approach is guided by previous user satisfaction. Because there is not an unlimited supply of recreation locations to satisfy the spectrum of demands, it is important to maintain the quality of the resources currently being used. Quality of these experiences should be determined by the preferences of recreationists using a particular recreational setting. The authors suggest using the Recreation Opportunity System (ROS) concept, where recreational settings are placed along a continuum from modern to primitive based on six physical, social, and managerial factors.

Keywords: adaptation, environmental degradation, resource demand, user preferences, Recreation Opportunity System (ROS), park management

Dustin, D. L., & McAvoy, L. H. (1984). The limitations of the traffic light. *Journal of Park and Recreation Administration*, 2(3), 28-32.

Annotation: Dustin is refuting a claim by Lucas that implies regulations only serve to reduce free-choice in leisure. He argues that humans are innately selfish, and regulations for recreationists seek to protect them from selfish counterparts who might over-utilize a resource. He also argues that regulation in areas prone to overuse actually provide additional freedom, which is important in a time of high recreational demand and decreasing supply of resources. Furthermore, recreation regulations operate under a system of checks and balances, where if the public does not like a rule they may voice an opinion to management or another governing body.

Keywords: regulation, leisure, resource demand, free-choice

Gramann, J. H., & Vander Stoep, G. A. (1987). Prosocial behavior theory and natural resource protection: a conceptual synthesis. *Journal of Environmental Management*, 24, 247-257.

Annotation: The article gives the theoretical basis for using indirect management techniques in recreational settings. The authors contend that resource protection is essentially prosocial behavior because it involves understanding why people do or don't help to conserve dwindling resources. They review three major reasons for prosocial behavior: moral obligation, identification (desire to please others), and compliance (not normally linked to this concept, but may promote prosocial behavior in individuals at lower levels of moral development). The authors also define six types of violations that could affect natural resource protection: unintentional, releaser-cue, uninformed, responsibility-denial, status-confirming, and willful. Discussion on how to activate visitors' moral responsibility and communicating with staff about goals is included as a management technique. A hierarchy of indirect management techniques is also introduced to correspond with the various violations.

Keywords: indirect management, resource protection, prosocial behavior, moral development, violations, moral responsibility, management techniques.

Ibitayo, O.O. & Virden, R.J. (1996). Visitor and manager perceptions of depreciative behaviors in urban park settings. *Journal of Park and Recreation Administration* 14(4) 36-51.

Annotation: This study contends that in order to reduce depreciative behaviors, we need to understand the perceived seriousness of the behaviors in urban park settings. When high levels of damaging behavior are perceived by managers or visitors, the perception can often have a negative effect on recreation experience. The study also aimed to identify different subgroups of urban visitors. The author discusses EUH- experience use history, in which past experience is a base for current beliefs, attitudes, and behaviors. Surveys were conducted in two urban parks in Arizona. Results show that visitors perceive significantly lower levels of depreciative behavior than park managers. The author notes that managers may be more sensitive to detecting depreciative behaviors, while certain groups of visitors might be more likely to ignore these behaviors. There was no significant difference in park use history and amount of perceived depreciative behavior, but the author suggests focusing on specific activities in future studies.

Keywords: urban parks, depreciative behavior, experience use history, Arizona, behavior perceptions.

Johnson, D., Rugh, J. C., Vande Kamp, M. E., & Swearingen, T. C. (1994). Minor violations, major damage: A survey of noncompliant visitor behavior and managerial practices. *Park Science*, 14(3), 6-7.

Annotation: Minor rule violations such as off-trail hiking cause large amounts of damage to parks each year. Eighty nine percent of managers surveyed reported damage at frontcountry sites, with repair estimates at around \$66.3 million a year. Eighty seven percent of backcountry sites reported damage, totaling an estimated \$13.7 million. Historic sites were reported as the most damaged areas. Considering all sites surveyed, 72% were categorized as having non-reparable damage with most of these being historic sites. Specific examples of irreparable sites

were totem poles and other historic artifacts, endangered animal nest areas, and slow-growing indigenous plants. Managers also ranked various depreciative behaviors, citing litter as the most damaging followed by disturbing environmental or historic objects in the frontcountry. This trend was reversed in the backcountry survey results. Manager opinions on the best methods for deterring this behavior showed major discrepancies in the most efficient methods. The authors recommend additional scientific data to support preferred methods of visitor management. **Keywords:** depreciative behavior, resource damage, rule violations, litter, visitor management

Lynn, N.A. (2003). Effects of recreational use impacts on hiking experiences in natural areas. *Landscape and Urban Planning*; 64 (1/2), 77-87.

Annotation: This study measured the effect of recreational trail use impacts on the visitor experience. A questionnaire was given to hikers at a trail head in a Canadian park, and asked them to respond to photos of various trail impacts. Results showed a negative relationship between use impacts and visitor experience, indicating that the quality of a visitor's experience is likely to decrease as degradation to a trail is present. The presence of litter, followed by fire rings had the greatest negative effect on visitor perceptions. Plant damage also had an impact on the hiking experience, as did trail-widening. Trail erosion had a moderate impact and muddiness a low impact on quality of experience. The study also revealed no significant relationship between gender, education, and experience when relating to interpretation of impacts. Participants felt they had very minimal contributions to litter, plant damage, and fire rings, and felt they had higher contribution levels to trail widening, muddiness, etc. The author concluded that recreationists are less likely to contribute to degradation that will reduce the quality of their experiences.

Keywords: use impacts, visitor experience, questionnaire, litter, fire rings, resource degradation

Marion, J. L., Leung, Y.-F., & Nepal, S. K. (2006). Monitoring trail conditions: New methodological considerations. *George Wright Forum*, 23(2), 36-49.

Annotation: This paper provides an overview of challenges and methods associated with several monitoring techniques. Challenges to using census-based, sampling-based, and condition class trail monitoring procedures are discussed. Under the broad category of trail monitoring, vegetation sampling methods are mentioned and an overview of recent soil erosion methods are discussed. Recent research shows that interval lengths up to 325 ft. provide an accurate sample of soil erosion. A suggestion for maximum trail incision measures follows that the measurement should be taken after trail construction, and compared with current measures so that only compaction due to recreational use is measured. This method can also be applied to side hill trails by examining local features to determine post-construction incision. Lastly, the article discusses the potential of spatial technology (GPS and GIS) to aid in monitoring informal trails. Mapping can help parks select indicators such as trail density and trail proximity to rare species. Digital orthophotography is also related to the latest GIS mapping techniques and is suggested as a potential option to expedite the monitoring of informal trails.

Keywords: trail assessment, monitoring, GIS, informal trails, soil erosion

Namba, R., & Dustin, D. L. (1992). Towards new definitions of depreciative behavior and vandalism. In Christensen, H. H., Johnson, D. R., and Brookes, M. H. (Tech. Coords.), *Vandalism: Research, Prevention and Social Policy* (pp. 61-69). Portland, OR: USDA Forest Service, Pacific Northwest Research Station.

Annotation: This article addresses appropriate definitions of vandalism and depreciative behavior. The general differences are the degree of intent, awareness of consequences, and feeling of responsibility. Depreciative behavior is not done on purpose. People are not aware of the consequences and are not responsible for such actions, while vandalism reflects the opposite. The authors assert that depreciative behavior should be headed off before it occurs through indirect management, while direct management might be most appropriate for vandalism.

Keywords: vandalism, depreciative behavior, awareness of consequences, indirect management, direct management

Stern, P.C., Dietz, T., & Black, J.S. (1986). Support for environmental protection: The role of moral norms. *Population and Environment*, 8(3&4), 204-222.

Annotation: Discusses the roles of public opinion and resulting action in environmental protection circumstances, mainly under the context of norm-activation theory. The authors argue that people who actively support environmental protection perceive the threat of degradation to resources as morally wrong. They mention two factors guiding morality and resulting behavior: perception of interpersonal consequences (AC) and feeling of responsibility for the outcome (AR). They present a model of individual behavior in steps: overt action, personal norms about an issue, ascription of responsibility for consequences, awareness of consequences, general attitudes values and personality dispositions, and position in social structure. A study was designed for a preliminary test of this altered model, and the methods of the study will be helpful in future model adaptation tests.

Keywords: norm-activation, environmental protection, awareness of consequences, behavior

Swearingen, T. C. (1991). Moral development and environmental ethics: Management implications. In Hope, D. I. (ed.), *Proceedings of the 1990 Southeastern Recreation Research Conference*, 12 pp. 93-108. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station.

Annotation: The purpose of this study was to define a target population of visitors who might engage in depreciative behavior by applying Kohlberg's theory of moral reasoning to an environmental context. The study was based in Mt. Rainier National Park and used two mail questionnaires to determine the level of environmental ethical reasoning of visitors by basing various rankings off the Defined Issues Test (DIT). The first questionnaire received a 72% response (1152 out of 1606), and the second questionnaire received a 49% response (568 out of 1152). Results revealed that patterns of environmental ethical reasoning were similar to the hypothesized stages of social moral development and that there was a significant difference between stages of development. The study also noted that environmental ethical reasoning increased with the age and education level of the subjects. The author concluded that visitors engaging in depreciative behavior exhibit a different level of environmental ethical development

than the group of visitors complying with regulations, and messages should be structured toward this group's level of moral development.

Keywords: depreciative behavior, moral development, mailed questionnaires, environmental ethic, Defined Issues Test (DIT), Mt. Rainier National Park

Van Liere, K.D. & Dunlap, R.E. (1978). Moral norms and environmental behavior: An application of Schwartz's norm-activation model to yard burning. *Journal of Applied Social Psychology*, 8(2), 174-188.

Annotation: The authors describe Schwartz's theory of norm activation, which explains the relationship between moral norms and resulting behavior. Moral norms are generally viewed as cultural ideas of what constitutes "good" and "bad," essentially learned expectations about the treatment of other people. Schwartz identifies two conditions surrounding norm activation: people must be aware of the consequences of their actions in relation to the welfare of others, and that people must accept some responsibility. He also discusses a variety of mechanisms for neutralizing moral norms so that negative consequences no longer fall within the perceived responsibility of an individual. This specific study tested the hypothesis that moral norms will influence yard burning behavior when AR (Acceptance of responsibility) and AC (awareness of consequences) are present. Results show that respondents with higher AC and AR levels regarding the negative effects of yard burning exhibited less yard burning than respondents at lower levels.

Keywords: norm activation, behavior, awareness of consequences, yard burning

B. Off-Trail Walking and Impacts

Bates, G. H. (1950). Track making by man and domestic animals. *Journal of Animal Ecology*; 19, 21-28.

Annotation: This older article discusses formation of various footpaths. In one observation by the author, an unknowing wanderer appears to mindlessly follow his self-created path through a meadow once the path is well-defined. When given the choice between this and a more obvious path made more recently during a snowstorm, the wanderer chose the newer and presumably more worn path. The author attributes observations of the human tendency to weave paths instead of form straight lines to the ground being uneven. They also attest that footpaths often follow long hollows in the ground. Sheep and cattle paths are very similar to human-created paths, although their margins are more sharply defined as demonstrated by an increase of mud during wet weather.

Keywords: footpath formation, social trails, behavior, animal paths

Dumont, B., Roovers, P., & Gulinck, H. (2005). Estimation of off-track visits in a nature reserve: A case study in central Belgium. *Landscape and Urban Planning*, 71(2-4), 311-321.

Annotation: This study attempted to measure off-trail hiking in a nature reserve based on differences in terrain and differences in time. The study site was part of a flood plain and walking was known to be a dominant activity by public visitors. Research at the park consisted

of visitor interviews, comparison between different terrains, and a walking experiment to test the ease of walking in different vegetation types. Results show that accessibility for visitors means areas that accommodate sufficient parking, benches, and trails of good condition. Areas that need to be protected from visitor impacts should not be made more accessible, which is not a problem in this park since the least attractive sites correlate with low accessibility. Results of walkers on different terrains showed that walking off-trail to cross a small bridge or to pass through a field of reeds proved more challenging than staying on an established trail.

Keywords: off-trail hiking, interviews, nature preserve, terrain impact, Belgium

Johnson, B. R., Bratton, S. P., & Marion, J. L. (1987). The Feasibility of Using Brushing to Deter Visitor Use of Unofficial Trails at Craggy Gardens, Blue Ridge Parkway, North Carolina (CPSU Report No. 43). Athens, GA: National Park Service Cooperative Studies Unit, Institute of Ecology, University of Georgia.

Annotation: The study examined the effectiveness of brushing informal trails at Craggy Pinnacles to deter visitor use. Fourteen brushings were measured at installation and then at several later dates to determine remaining quality. Brushing materials included live and dead shrubs and trees as well as leftover trimmings from trail maintenance. After two months, only one brushing was still considered effective. While the majority of other brushings were demolished by users, a few even showed evidence that users trampled surrounding rare plants in an attempt to access the brushed trail. Causes for this were determined through weekend observations to be lack of education about rare plants, lack of signage, desire to explore, and blueberry picking along brushed trails. The authors suggest better signage and interpretation, re-routing trails around fragile areas, redesigning overlooks to include more desirable areas, and improving distinctions between official and unofficial trails.

Keywords: Craggy Pinnacles, brushing, off-trail walking, site management

Keirle, I., & Stephens, M. (2004). Do walkers stay on footpaths? An observational study of Cwm Idwal in the Snowdonia National Park. *Countryside Recreation*, 12(2), 7-9.

Annotation: This study examined the behavior of walkers in an open access area of Snowdonia National Park to determine whether they chose to remain on established paths or wander off-trail when given free choice. Observations were conducted in 15 minute intervals from a central survey point and locations of visitors were marked on a map. The results showed that 90.5% of visitors in groups of 12 or less remained on established paths, while 83.9% of visitors in groups of 13 or more stayed on paths. The study also noted that most visitors wandering off-trail appeared to be taking a short cut to a site of interest. The authors concluded that walkers tend to remain on paths and that more direct routes to sites of interest should be considered.

Keywords: behavior, off-trail hiking, visitor management, Snowdonia National Park

Lehvavirta, S. (1999). Structural elements as barriers against wear in urban woodlands. *Urban Ecosystems*, 45-56.

Annotation: This study focused on urban woodlands and the potential of natural features like rocks and trees as objects that can prevent wear and degradation on recreational areas. Presence

and size of trees, rocks, social trails, fallen trees, shrubs, and garden waste were measured in random plots in a relatively unmanaged urban forest in Finland. Social path wear was also measured. Most sites were similar to those found in rural areas, but nine exhibited evidence of human use such as holes and waste. Of the 30 plots sampled, 71% contained paths. Results showed more barriers and fewer people present in plots that had smaller path areas. Barrier types that were most effective in reducing worn areas were small to medium sized trees, topographical elements, and fallen trees.

Keywords: urban woodland, worn ground, vegetation, degradation, recreational areas, barriers, Finland

Leung, Y.-F., Shaw, N., Johnson, K., & Duhaime, R. (2002). More than a database: Integrating GIS data with the Boston Harbor Islands carrying capacity study. *The George Wright Forum*, 19(1), 69-78.

Annotation: The GIS database at Boston Harbor Islands was initiated to track visitor impacts on park resources. Eleven islands were mapped according to a variety of themes that were to be tracked in the database. Resource indicators showing visitor impacts were selected based on criteria from previous VERP projects. In particular, social trail extent was selected as one indicator. Each social trail was placed into one of four classes based on its level of degradation, width, and vegetation cover. A land use-land cover data set and data from the national wetlands inventory were used to classify land into zones based on sensitivity to visitor impacts. Results showed that most social trails were located outside of sensitive zones.

Keywords: GIS, visitor impacts, social trails, indicators, VERP, degradation, Boston Harbor Islands

Pearce-Higgins, J. W., & Yalden, D. W. (1997). The effect of resurfacing the Pennine Way on recreational use of blanket bog in the Peak District National Park, England. *Biological Conservation*, 82(3), 337-343.

Annotation: The effects of flagstone pavement along the Pennine Way in the U.K. in reducing off-trail walking were evaluated through this study. The path traverses moorland and destruction from social trails was evident. The location of visitors and weather was tracked during the study dates. The number of visitors present correlated strongly with weather and holidays. Results showed 96.2% of visitors who went south of the Pennine Way remained on the road and 90.6 % of those who went north remained on the road. The area that is now paved shows significantly less disturbance: between 0-5% disturbance compared with 5-20% disturbance 10 years ago. The study also notes that there was a two-fold increase in visitor numbers between the current study and the one 10 years prior, leading to speculation that the paved trail encouraged higher use. Dog walking was also examined as part of the study, and 57.5% of all dogs were observed off-leash.

Keywords: off-trail hiking, pavement, dog walking, observation, disturbance, Peak District National Park (England)

Rees, W. G. (2004). Least-cost paths in mountainous terrain. *Computers and Geosciences*, 30, 203-209.

Annotation: This study examined visitor-created paths in terms of why they are located in a particular place. The research looked at “costs” that could be minimized by creation of certain trails between points A and B, and hypothesized that this was related to the steepness of the terrain but also takes into consideration walking time. A digital elevation model (DEM) is used in accordance with Dijkstra’s algorithm. The algorithm was tested on Mount Snowdon, which has several different paths to the summit. Actual footpaths were measured and compared with the least-cost paths generated by the algorithm. Results show that the majority of existing social trails to the summit are similar to the calculated least-cost routes generated mathematically. The author suggests future path creation can use calculations of least-cost paths to create trails that are user-friendly.

Keywords: mountainous terrain, off-trail walking, DEM, Mount Snowdon, social trails

Rochefort, R. M., & Gibbons, S. T. (1992). Mending the meadow: High-altitude meadow restoration in Mount Rainier National Park. *Restoration and Management Notes*, 10, 120-126.

Annotation: In 1986 a program was initiated in Mt. Rainier National Park to address the increasing problem of social trail use and visitor impacts. Nine hundred thirteen significantly degraded areas were recognized, with 89% of these attributed to social trails. Heath-shrub communities at higher elevations were most severely impacted. A variety of surveys and impact measurements were conducted and rankings were given based on soil erosion potential and aesthetic appeal. These rankings were then used to determine site restoration, the details of which are provided in the article. The project also identified a profile for off-trail hikers by using a questionnaire. The general suspect was someone from the local area, under 20 years old, no college education, non-white (usually foreign), and traveling with a group. A sanction sign was very effective as was the presence of a uniformed employee and rope barriers in reducing off-trail hiking.

Keywords: off-trail hiking, soil erosion, vegetation, restoration, questionnaire, visitor profile, Mount Rainier National Park

Thurston, E. & Reader, D J. (2001). Impacts of experimentally applied mountain biking and hiking on vegetation and soil of a deciduous forest. *Environmental management*; 27(3). 397-409.

Annotation: This study compared the impacts of mountain biking and hiking on unmarked areas of forest to gauge the impacts of new trail creation. The research was conducted in Toronto, Canada in a deciduous forest. While the objective of the study was to determine impacts to aid in mountain bike management, the results can also be applied to off-trail hiking impacts. The treatments consisted of either hiking or mountain biking at various pass intensities. The loss in plant density, loss of species richness, and amount of soil exposed were measured to determine impact. Vegetation loss was greatest in zones that were impacted with the greatest intensity, 81% of density was lost in the center zone of linear hiking. Species loss was also greatest in the

central area of the hiking zone, resulting in a 71% decline in species after hiking. Mean soil exposure also increased by 23% in the central zone following hiking impacts. One year after the treatment, these same variables were not significantly different between the control and treatment areas.

Keywords: mountain biking, new trail impacts, off-trail use, vegetation loss, species loss, Canada

C. Education Efficacy General

Christensen, H. H. & Clark, R.N. (1983). Increasing public involvement to reduce depreciative behavior in recreation settings. *Leisure Sciences* 5(4), 359-379.

Annotation: Depreciative visitor behavior costs hundreds of thousands of dollars in damage each year in US parks. This study examined visitor involvement and bystander intervention to prevent littering at Lake Kachess. This was done by presenting an “appeal to help” message either through a cartoon or in person, which resulted in four actions (do nothing, picking up litter, reporting the offender, and dealing with the offender). 128 usable observations were obtained. 83% of campers who received an appeal helped in some way, while 61% of the control helped, leading to the authors’ conclusion that explaining how to deal with the problem increases frequency of helping behavior. In terms of specific behavior, picking up litter was the most common response (73%), followed by direct behavior (26%), and reporting (16%). Smaller camping groups tended to report the problem more often.

Keywords: depreciative behavior, intervention, littering, US parks,

Christensen, H. H., & Dustin, D. L. (1989). Reaching recreationists at different levels of moral development. *Journal of Park and Recreation Administration*, 7(4), 72-80.

Annotation: This study used moral development theory to understand interpretive message roles in reducing depreciative behavior. The article provides examples of signage for each stage of development, and includes several examples derived from female subjects in a study by Gilligan. The authors concluded from Kohlberg's work that interpretive signage should be included to address visitors from each of the six stages of development. They also suggest that classifying signage based on the level of moral development it addresses could help with efficient education.

Keywords: moral development, interpretive messages, depreciative behavior, signage

Cialdini, R. B., Demaine, L. J., Sagarin, B. J., Barrett, D. W., Rhoads, K., & Winter, P. L. (2006). Managing social norms for persuasive impact. *Social Influence*, 1(1), 3-15.

Annotation: With regard to social norms, the authors state that the most effective method to motivate a group of people is to induce a normative focus on the injunctive norm. The study tested the use of signs appealing to either injunctive and/or descriptive norms at Petrified Wood National Forest. All messages were negatively worded in accordance with past studies showing this to be most effective. Four different sign messages were used; including both extremes that either visitors ought not to steal wood (negative injunctive) and that many visitors do steal wood (positive descriptive). Results showed that the most effective sign in deterring theft was the

negatively worded injunctive norm, while the sign deterring theft the least was the negatively worded descriptive norm sign.

Keywords: Petrified Wood National Forest, social norms, signage, theft, observation

Cole, D. N. (1998). Written appeals for attention to low-impact messages on wilderness trailside bulletin boards: Experimental evaluations of effectiveness. *Journal of Park and Recreation Administration*, 16(1), 65-79.

Annotation: The study tested effects of written appeals for visitors to pay more attention to trailside bulletin board messages, theoretically to increase knowledge about low impact practices. A bulletin board was designed with six individual messages on relevant wilderness concepts similar to LNT. Each individual sign could be understood quickly in 5-10 seconds, contained a simple line drawing, and was written to apply to overnight, day use hikers, and equestrians on the trail. Several different banners served as treatments, and each had in bold letters varying appeals to get visitors to read posted information. Attention to messages was measured with a video camera, and 554 visitors were observed. Seventy percent were hikers and 30% on horseback. 61% of visitors stopped to read the messages, and more hikers stopped to read than did horse riders. The average length of attention held was 52 seconds. Results suggested that there is little value in elaborating from a simple appeal message, since this didn't result in additional attention. The number of people stopping to read when a simple appeal was posted was not significantly higher than when no appeal was posted. However, visitor attention increased in time spent reading by 88% when the simple appeal was posted. Solo hikers were also more likely to stop and look at the messages than were groups. The author noted that overnight hikers paid longer attention to the messages when either the "avoid the need to restrict wilderness use" or "be a responsible wilderness user" were posted.

Keywords: interpretive messages, Leave No Trace (LNT), observation, attention to signage

Cole, D. N., Hammond, T. P., & McCool, S. F. (1997). Information quality and communication effectiveness: Low-impact messages on wilderness trailside bulletin boards. *Leisure Sciences*, 19, 59-72.

Annotation: This study examined knowledge retention from trailside signs and the effect of sign design elements- presence of an attractor and number of messages. Six treatments were applied to an area bulletin board, each varying the number of messages presented and/or a map as an attractor. Whether visitors stopped at messages and length of time spent reading were measured by video camera. Message retention was measured through a short quiz. Average scores on the quiz were 33% correct, and hikers scored significantly higher than horse users. 55% of visitors stopped to look at messages, but again the rate was higher for hikers than horse users. There was a significant difference in quiz scores for hikers who passed when messages were posted than for those who passed when no messages were posted. Hikers exposed to more than 2 messages didn't score significantly higher than those exposed to two. There was a positive correlation with time spent reading messages and quiz scores. Both the number of hikers reading messages and time spent reading increased as the number of messages increased. Maps were not shown to distract attention from adjacent messages.

Keywords: signage, attention to signage, message retention, trailside bulletin board use

Daniels, M. L., & Marion, J. L. (2005). Communicating Leave No Trace ethics and practices: Efficacy of two-day trainer courses. *Journal of Park and Recreation Administration*, 23(4), 1-19.

Annotation: This study measured knowledge gain and retention from 2-day LNT trainer courses. Subjects' knowledge, ethics, and behaviors were measured through surveys before the course, immediately after the course, and again four months after the course. Average LNT knowledge increased from 70% correct pre-course to 82% correct post-course, dropping to 78% in the follow-up. The ethical portion showed improvement on 12 of 16 questions between the pre-course survey and post-course survey, and an improvement on 8 of the 16 questions between the pre-course and follow-up surveys. The behavior section showed significant improvement in 7 of 10 areas between the pre-course and follow-up surveys. These scores indicate that course participants retain and use skills at a higher level than when they began the program. The study also revealed that 94% of participants passed their knowledge to others after completion of the course.

Keywords: LNT, survey, training course, knowledge, behavior, ethics

Doucette, J.E. & Cole, D.N. (1993). Wilderness visitor education: Information about alternative techniques. In *General Tech. Report INT-295*. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Annotation: To categorize the use of visitor education programs among parks, 491 questionnaires were mailed to park managers and included questions about educational techniques used and their effectiveness. Two hundred sixty six returned questionnaires indicated that six out of 25 educational techniques were most commonly used; brochures, personnel in offices, personnel in backcountry, maps, signs, and trailhead displays. The survey also indicated that most areas used a variety of techniques. In comparison, the Forest Service focuses educational efforts at agency offices and trailheads, while the Bureau of Land Management focuses efforts at visitor centers. Managers also felt that educational techniques were most useful in reducing harm to fish and wildlife, and least effective for deterring water contamination and vandalism. The publication provides detailed descriptions of media-based and personnel-based educational techniques using information obtained from the park managers surveyed.

Keywords: visitor education, questionnaire, educational techniques, Forest Service, Bureau of Land Management, effectiveness

Duncan, G. S. & Martin, S. R. (2002). Comparing the effectiveness of interpretive and sanction messages for influencing wilderness visitors' intended behavior. *International Journal of Wilderness*, 8(2), 20-25.

Annotation: Interpretive messages were explored as an alternative to sanction messages for decreasing depreciative behavior in wilderness areas, as the authors felt interpretation messages were less likely to detract from the wilderness experience while providing the same effect. Slides demonstrating wilderness settings that featured one of three treatments; control (no message), sanction message, and interpretive message, were shown to 12 groups totaling 237 college students. Results were measured through questionnaires, and showed that through various scenarios both the interpretive and sanction messages were significantly more effective

in eliciting the desired behavior than the control. The interpretive message was at least as effective as the sanction message, and in one instance it was significantly more effective. The authors concluded that participants who are exposed to an “awareness of consequences” message are more likely to obey posted regulations.

Keywords: interpretive messages, depreciative behavior, sanction messages, questionnaire, awareness of consequences

Gramann, J. H., Bonifield, R. L. & Kim, Y. (1995). Effect of personality and situational factors on intentions to obey rules in outdoor recreation areas. *Journal of Leisure Research*, 27 (4), 326-343.

Annotation: This article examines the reasoning behind applications of prosocial behavior to recreational settings and the logic in employing indirect management. It also discusses the use of protection motivation theory in applying direct management to certain situations. The actual study measured social responsibility and rule obedience intentions through “Social Dilemma Questionnaires” of undergraduate students to determine differences in personality. Results show that making visitors aware of consequences makes them more willing to comply, although this cannot be generalized to all groups. Those who scored lower on the social responsibility scale did not show a change in behavioral intent when AC was made known. Sanctions and direct management caused participants of both high and low social responsibility to be more likely to comply, leading to the authors’ conclusion that sanction messages might be a good general method to control behavior.

Keywords: prosocial behavior, indirect management, questionnaires, personality, social responsibility

Gramann, J. H., Christensen, H. H., & Vander Stoep, G. A. (1992). Indirect management to protect cultural and natural resources: research, ethics, and social policy. In Christensen, H. H., Johnson, D. R., and Brookes, M. H. (Tech. Coords.), *Vandalism: Research, Prevention and Social Policy*. Portland, OR: USDA Forest Service, Pacific Northwest Research Station.

Annotation: Direct management is defined as strict enforcement of rules and regulations governing visitor actions, including issuing fines, closing areas, and activity zoning. Indirect management is defined as techniques to encourage voluntary changes in visitor behavior, such as interpretation, site design, and education. The paper discusses bystander intervention and norm activation. It also discusses the Prosocial Behavior Theory, which can be defined as a “helping” behavior not motivated by reward or punishment and is similar to the goals of indirect management techniques. Decreased depreciative behavior is observed when a link is made apparent between visitor actions and resource damage. Visitors must first believe a problem exists, and then personal responsibility for correcting the problem must be promoted. Responsibility can be initiated thru clear instructions, presentation of alternatives, or making visitors feel uniquely qualified to help with a problem. The authors concluded that indirect management is particularly appropriate when ignorance or lack of awareness are primary causes for depreciative behavior. The article also discusses policy and ethical issues of management techniques.

Keywords: direct management, indirect management, visitor behavior, norm activation, prosocial behavior, deprecatative behavior, resource damage

Leung, Y.F. & Attarian, A. (2003). Evaluating the effectiveness of the Leave No Trace Frontcountry Program in the city of Durango, Colorado. Unpublished report from North Carolina State University; Raleigh, NC.

Annotation: Visitor preferences between traditional Leave No Trace (LNT) signs, modern LNT signs, modern LNT signs and brochures, and a control (no sign) were evaluated along the Animas River Trail and knowledge of LNT practices were evaluated through the use of a pre- and post-test. Messages presented in both posters included “share the trail,” “manage your dog,” “stick to the trail,” “trash your trash,” and “respect private property.” Three survey sites surveyed every 5th visitor for 169 total surveys. While more visitors thought the traditional poster was more authoritative, the modern poster was significantly greater in every other instance. For the survey, 232 visitors agreed to participate in the pretest and 78 of those participated in the post test 8 weeks later. The survey showed a general increase in knowledge but there was no significant impact of the LNT signs on knowledge retention. Visitors with higher education, affiliation with a conservation group or previous exposure to LNT scored higher on the survey. Behavior observations of 3,135 visitors were also recorded during the study. Walkers were most likely to stop and read posters (6.1%), while only about 1% of river runners and cyclists stopped to read them.

Keywords: visitor preference, Leave No Trace, surveys, knowledge retention, observations

Marion, J. L. & Reid, S. (2007). Minimizing visitor impacts to protected areas: The efficacy of low impact education programs. *Journal of Sustainable Tourism*, 15(1), 5-27.

Annotation: This study provides a thorough review of current educational practices related to management and outdoor recreation and defines the need for an increase in evaluation of visitor education. The prevalence of various visitor education techniques in U.S. parks is shown and outlines the theories of moral development, reasoned action, decision making, and persuasion. A summary of educational efficacy research shows which methods have been proven most effective. This information is examined in the context of knowledge gained, behavior change, education to redistribute visitor use, and changes in resource conditions. The authors conclude that education can be a useful tool in changing visitor behavior. Messaging should have an ecological rationale, focus on a defined audience, be consistent, be clear, and be concise. Messages should be well-timed based on the intended change in behavior, to provide the message either before a destination is reached or at the moment the behavior change is desired. Multiple methods for message delivery are considered more effective than using only a single method, specifically when the multiple methods consist of a variety of persuasive and moral techniques. This study clearly outlines where further research is needed and provides excellent guidelines for future educational efficacy studies.

Keywords: education efficacy, theoretical basis, research summary, signage

Oliver, S. S., Roggenbuck, J. W., & Watson, A. E. (1985). Education to reduce impacts in forest campgrounds. *Journal of Forestry*, 83(4), 234-236.

Annotation: Methods of deterring depreciative behavior were tested using three treatments on various weekends: distribution of a brochure to visitors when entering the park, presentation of a brochure by uniformed personnel to campsites after visitors' arrival, and the second treatment was also conducted with a request from the ranger to report depreciative activities. Control weekends showed 39% of groups damaging trees; treatment 1 reduced it to 20.2%, treatment 2 to 3.8%, and treatment 3 to 9.6%. Regarding litter, control weekends saw 82% of groups leaving behind at least one piece of litter, treatment 1 dropped to 66.7%, treatment 2 to 41.3% and treatment three to 45.6%. The authors concluded that personal contact as an educational strategy is more effective, and it also appears that simple personal presentation is more effective than a request for help.

Keywords: depreciative behavior, brochures, litter, personal contact, education, tree damage, campsite damage

Roggenbuck, J. W. & Berrier, D. L. (1982). A comparison of the effectiveness of two communication strategies in dispersing wilderness campers. *Journal of Leisure Research*, 14(1), 77-89.

Annotation: The study tested the effect of a brochure (mapping alternative camping areas) and the same brochure with personal contact to disperse campers from a heavily used meadow campsite. The brochure-only method set brochure boxes at the beginning of a trail, while the brochure/personal contact method had the brochure box and an employee to greet visitors as they entered the campground and reinforce the message. Observation of selected camping areas in late night or early morning coupled with conversations determined brochure use and site selection. Percentage of camping in the meadow dropped from 62% (control) to 44% (brochure only) to 33% (brochure and personal contact), although the difference between treatments was not significant. Smaller groups were significantly more likely to find alternative sites in response to the brochure.

Keywords: brochure, personal contact, camping, observation

Vande Kamp, M. E., Johnson, D. R., & Swearingen, T. C. (1994). Preventing visitor-caused damage to national park resources: What do we know? What should be done? *Park Science*, 14(3), 8-10.

Annotation: This is a summary of a literature review and 12 recommendations for deterring visitor non-compliance. Recommendations include: 1. There is a delicate balance between preservation and visitor enjoyment and management techniques should be chosen to maximize both. 2. Multiple deterrent techniques should be used. 3. Techniques should be determined scientifically, not just from personal perspective of a manager. 4. Uniformed park personnel should be stationed near areas of depreciative behavior when possible. 5. Before a technique is implemented, managers should try to determine the cause of depreciative behavior. 6. Messages should be located close to the location and time that the behavior occurs. 7. Educational techniques should focus on actively motivating those who already hold the belief rather than

creating believers out of non-believers. 8. Short-term rewards have a stronger effect over people who dismiss long-term effects of a damaging behavior. 9. Removing evidence of past non-compliance can help reduce future non-compliance. 10. Threats of punishment for non-compliance should be accompanied by rewards for the desired behavior. 11. Messages should not threaten visitors' freedom, since this has been shown to increase non-compliance. Visitors should feel they have choices on how to comply with regulations. 12. Messages to groups should address the leader or all individuals in the group. Suggestions of future research are also mentioned.

Keywords: literature review, non-compliance, management techniques, education, signage

Vander Stoep, G.A. & Gramann, J. H. (1987). The effect of verbal appeals and incentives on depreciative behavior among youthful park visitors. *Journal of Leisure Research*, 19(2), 69-83.

Annotation: Various messages were designed to determine their effect on reducing depreciative behavior of youth hiking groups. The messages were 1. A message designed to increase visitors' awareness of consequences, 2. Previous message plus a resource-protector program message, 3. Previous two messages plus an incentive for completing a Heritage Guardian assignment. Four sites were monitored by hidden video cameras and stickers were given to treatment groups to wear (under a discrete premise) to distinguish them from the control groups who received no messages. The third treatment tended to be least effective. The first and second treatments reduced climbing and hitting (historical park monuments, supposedly) by 88% and the third treatment reduced this by 87%. Groups with no adults exhibited less depreciative behavior than groups with a low number of adults, presumably because youth were older and more responsible.

Keywords: messaging, depreciative behavior, youth, awareness of consequences, video surveillance

Ward, C. W. & Roggenuck, J. W. (2003). Understanding park visitors' response to interventions to reduce petrified wood theft. *Journal of Interpretation Research*, 8(1), 67-82.

Annotation: The study examined the effects of signs, uniformed employee presence, and a signed pledge on reducing petrified wood theft. Thieves and non-thieves were interviewed following site observations and asked a set of generic questions to establish comfort, a set of questions on their impression of various interventions, and a set of questions to assess attitudes and intentions toward petrified wood theft. Thieves were also asked about the reasoning for their personal theft. While all interviewees admitted wood theft was wrong, many thieves felt taking a small piece was acceptable. Thieves also tended to define stealing in ways that made it acceptable. Overall, the three interventions all significantly reduced wood theft in the park, but did not differ from one another.

Keywords: signage, employee presence, signed pledge, petrified wood theft

Widner, C. J. & Roggenbuck, J. W. (2000). Reducing theft of petrified wood at Petrified Forest National Park. *Journal of Interpretation Research*, 5(1), 1-18.

Annotation: Various interventions were tested in Petrified National Forest to determine which had the greatest effect on reducing theft of a non-renewable resource- in this case petrified wood. The presence of a uniformed ranger, an interpretive sign, and a signed pledge were tested at random using on site behavior observations during 10 days. Theft rates were significantly reduced from 2.1% under the control to 1.4% collectively when interventions were used. The interventions did not vary significantly from one another in effectiveness, but the authors noted that management should consider using one of these alternative interventions that incorporate a variety of theories in place of traditional methods.

Keywords: interventions, petrified wood theft, employee presence, signage, signed pledge, observation, management, Petrified National Forest

Winter, P. L., Sagarin, B.J., Rhoads, K., Barrett, D.W., & Cialdini, R.B. (2000). Choosing to encourage or discourage: Perceived effectiveness of prescriptive versus proscriptive messages. *Environmental Management*, 26(6), 589-594.

Annotation: Following previous studies that demonstrated frequent use of proscriptive signs in natural areas to deter depreciative behavior, this study explored perceptions of proscriptive message effectiveness among sign creators and possible differences in this perception in the frontcountry vs. backcountry. The study used a mail questionnaire to survey 219 members of the National Association for Interpretation (NAI), asking them to rate perceived effectiveness of eight pairs of prescriptive and proscriptive messages. Prescriptive messages rated significantly more useful than proscriptive messages, and the messaging was seen as significantly more useful in wildland settings. Results also suggest that reviewers with more experience generating interpretive messages rated prescriptive messages as more effective.

Keywords: proscriptive, prescriptive, depreciative behavior, questionnaire

Wirsching, A., Leung, Y.F. & Attarian, A. (2003). Swatting litter bugs. *Parks & Recreation*; 38(11), 16 & 18-22.

Annotation: This article synthesizes literature on reducing depreciative behavior in recreation settings. Discussion of effective communication explains the four components of source, message, channel, and receiver. Research on visitor preference is examined through past studies on signage. Visitors showed a preference for behavior/environmental signage over regulatory signage, and modern-style designs were often preferred over traditional-style signs. The use of signs as a method of education is also discussed and several studies are cited to demonstrate knowledge retention about outdoor recreation practice. Behavior modification is the goal of messaging and other factors affecting depreciative behavior are discussed.

Keywords: depreciative behavior, signage, messaging, behavior modification, visitor preference

D. Education Efficacy: Off-trail Walking

Aukerman, R. (1985). The effectiveness of signing, pamphlets and restoration in reducing off-trampling. *Tourism Recreation Research*, 10(2), 35-39.

Annotation: The study investigated methods of reducing off-trail hiking through use of signs, pamphlets, and trail restoration during a restoration project at Bear Lake. Observations of 18,003 visitors at four different sites along the main trail showed that prior to any sign construction, an average of 19% of visitors left the established trail. After signs were constructed, 14% of visitors left the established trail. Following complete restoration of trails, rest areas, etc., only 7% of visitors left the established trail. Only 4.8% of visitors took a pamphlet originally, but an estimated 20% of visitors (including groups) were exposed to pamphlets after the box was moved closer to foot traffic. Other observations indicated that the installation of rest areas and fencing were useful in reducing off trail use.

Keywords: off-trail hiking, restoration, brochures, observation, fencing

Johnson, D. R. & Swearingen, T. C. (1992). The effectiveness of selected trailside sign texts in deterring off-trail hiking at Paradise Meadows, Mt. Rainier National Park. In Christensen, H. H., Johnson, D. R., and Brookes, M. H. (Tech. Coords.), *Vandalism: Research, Prevention and Social Policy* (pp. 103-120). Portland, OR: USDA Forest Service, Pacific Northwest Research Station.

Annotation: This project studied the impact of combinations of six different signs and a control (no sign) in deterring off-trail hiking. Observers were trained prior to the study. The control resulted in off-trail hiking 6.9% of the time, while the sanction sign significantly reduced this rate down to 1.7%. There was no significant variation between effectiveness of the hybrid, humorous, ethical-appeal, and symbolic signs. Furthermore, there was no significant difference between the effectiveness of the symbolic sign and the control.

Keywords: signage, off-trail hiking, observation, Mount Rainier National Park

Littlefair, C. J. (2003). The Effectiveness of Interpretation in Reducing the Impacts of Visitors in National Parks. *Unpublished Ph.D. Dissertation*. Gold Coast, QLD: Griffith University.

Annotation: This study examined the effectiveness of interpretation on reducing visitor impacts to the environment on a commercial walking tour. The potential impacts of cutting corners at switchbacks, picking up litter, and noise were evaluated in response to five interpretive programs; control (no interpretation), generic (general interpretation messages about trail and local area), role model (generic program with desired behaviors performed by guide), appeal (generic program with verbal appeals for appropriate behaviors), and complete (generic program with both role modeling and verbal appeals). 449 visitors were observed in the study. Results showed that the Complete program reduced shortcutting the most (Appeal and Role Modeling were also significantly more effective than Generic and Control programs), verbal cues in both the Complete and Appeal program reduced littering significantly more than other methods, and there was no significant difference in the amount of noise generated during any of the programs

tested. Authors concluded that interpretation needs to directly address the impacts it wishes to change, and that role modeling by the guide is necessary to demonstrate desired behaviors.

Keywords: interpretation, visitor impacts, shortcutting, off-trail walking, litter, behavior, role modeling

Park, L., Manning, R., Marion, J., Lawson, S., & Jacobi, C (2008). Managing Visitor Impacts in Parks: A Multi-Method Study of the Effectiveness of Alternative Management Practices. *Journal of Park and Recreation Administration*, 26(1), 97-121.

Annotation: This study used various interventions at Acadia National Park to determine which were the most effective in reducing off trail use. A control and five treatments were exposed to visitors at random over a two week period. The five treatments were Educational Signage (remain on paved trails and rocks), Educational Signage (remain on paved trails), Site Management (low rope barrier and sign to remain on paved trails), Educational Signage (remain on paved trails and inclusion of ground-level “no walking” graphic), and a Personal Message to bus tour passengers. Observations were conducted on 1135 visitors, showing that low rope barriers (reducing off trail usage to 1.2%) and signage near social trails (reducing off-trail usage to 24.3%) were most effective. Researchers also noted that visitors showed little effort to avoid vegetation once off trail and observations demonstrated that the presence of others off trail led to increased off trail use. Demographics of visitors were not a significant factor in who went off trail.

Keywords: off-trail hiking, signage, management, personal contact, barriers, observation, Acadia N.P.

Swearingen, T. C. & Johnson, D. R. (1995). Visitors' response to uniformed employees. *Journal of Park and Recreation Administration*, 13(1), 73-85.

Annotation: The study aimed to examine the effect of uniformed park employees on trails as a method to deter off-trail hiking and to determine various aspects of visitor interpretation of this method. The study was conducted at one meadow site where off-trail hiking was a problem, and also included a mailed questionnaire to examine visitor attitudes about management. All visitors hiking off trail were contacted to participate in the survey (random samples raised the concern of low sample size). When a uniformed employee was present, off-trail hiking decreased significantly by 76%. The survey revealed that 37% of respondents felt interaction with a park employee enhanced their experience, 2.4% felt it detracted from the experience, and 40% felt it made no difference. Negative reactions to the uniformed employee also cited primary reasons as being a verbal sanction from the employee (in response to visitors' depreciative behavior) or fear of enforcement. Positive reactions included the employee providing directions, interpretive role, and resource protection among others. It was determined that a uniformed employee was viewed by visitors as either direct or indirect management depending on the role the employee was fulfilling.

Keywords: off-trail hiking, visitor interpretation, questionnaire, employee presence, management

Swearingen, T.C. & Johnson, D.R. (1994). Keeping visitors on the right track: Sign and barrier research at Mount Rainier. *Park Science*, 14(4), 17-19.

Annotation: 17,416 visitors were surveyed at three sites to determine the effectiveness of six sign texts on reducing off-trail hiking. The threatened sanction sign reduced off trail hiking by 75% compared to the control. Signs revealing mid-range effectiveness included preservation appeal, humorous, and hybrid signs. Novel effect vs. repeated exposure to signs was tested through behavior observation, and resulted in no significant difference in deterring off-trail hiking except when the hybrid sign (prohibitory message with graphic) was shown repeatedly before the study site. In this case, off-trail hiking actually increased. A barrier experiment was also conducted using a split rail fence, yellow rope barrier, and control (no barrier). The yellow rope barrier was the most successful, and both barriers were significantly more successful than the control. 58% of off-trail hikers were adults, 78% occurred when other people went off trail in the vicinity, and the majority of these groups were non-white (foreigners in particular). Uniformed personnel reduced off trail use. Authors suggest that future studies should test the effect of a threatened sanction sign on visitor experience.

Keywords: signage, off-trail hiking, observation, barriers, demographics, Mount Rainier National Park

Unknown authors. Off the beaten track: Messages as a means of reducing social trail use at St. Lawrence Islands National Park. *Journal of Parks and Recreation Administration*, In press.

Annotation: The researchers tested whether sign message type and the location of the sign had any influence on effectiveness in deterring off-trail hiking. Visitors to Camelot Island were observed using hidden video cameras and trail counters to determine whether visitors read the posted signs and visitor behavior as related to social trail use. Message types used were a plea message (Please stay on the wood chipped trails) and an attribution message (Your feet have trampled the vegetation on this island. Please stay on the main wood chipped trail). A week of observations when no signs were present served as the control. Trails on the island were placed into six categories, 20% of all trails were categorized as social trails. Results showed 88.3% of visitors leaving the trail when no sign was present, 77% leaving the trail when the plea sign was present, and 49% leaving the trail with an attribution sign, all of which were significant reductions. Sign location also had a significant impact on social trail use. When signs were placed at an information booth, social trail use dropped to 86.5%. When signs were placed at the social trail, use dropped to 64.7%.

Keywords: off-trail hiking, St. Lawrence Islands National Park, video observation, signage, message type

Winter, P. L. (2005). What Is the Best Wording to Use on Signs? The Impact of Normative Message Types on Off-Trail Hiking (Riverside, CA: USDA Forest Service, Pacific Southwest Research Station.

Annotation: This normative messaging study was conducted at Sequoia Kings Canyon National Park. Four normative message signs designed to look like park signs and one control were used

to deter off-trail hiking on weekends. The actual normative messages used are presented in the paper. Signs were placed at each end of the four trails used. Observations were conducted with a digital camera and outside coders were used to make observations from each recording. 2,897 users were observed, revealing that the most off-trail hiking occurred during the control (no additional sign present) and the least off trail use occurred with the injunctive-proscriptive sign (“Please don’t go off the established paths and trails, in order to protect the Sequoias and natural vegetation in this park”). The most off trail use under a treatment occurred with the descriptive-proscriptive sign (“Many past visitors have gone off the established paths and trails, changing the natural state of the Sequoias and vegetation in this park”). Visitors who remained on formal trails were observed as more likely to be walking or running and to read posted signs. Visitors going off trail were more likely to be taking or posing for photographs or touching natural features. Observations also recorded that evidence of prior off trail use or presence of other visitors off trail seemed to increase off trail use.

Keywords: Sequoia and Kings Canyon National Park, normative messages, signage, off-trail hiking, observations, video

Winter, P.L. (2006). The impact of normative message types on off-trail hiking. *Journal of Interpretive Research*; 11(1), 35-52.

Annotation: Four types of signs were tested in Sequoia National Park to deter off-trail hiking. Signs consisted of the following message types: injunctive-proscriptive, descriptive-proscriptive, injunctive-prescriptive, and descriptive-prescriptive. Sign observations were conducted at four different trails throughout the park, where each trail had differing barriers in existence. Each observation session used a digital camera to record a portion of the trail for 2 hours. Along this portion two of the same sign were posted. Five “coders” were used to watch the DVDs. The greatest amount of off-trail hiking occurred under the control condition with no signs. The injunctive-proscriptive signs allowed the least off-trail hiking, followed by descriptive-prescriptive, then injunctive-prescriptive. Off-trail hikers were observed doing certain activities more often than on-trail hikers, including posing or taking photos and touching natural objects. On the Crescent Meadow trail in particular, it was noted that evidence of previous off-trail hiking through the meadow seemed to encourage this behavior. The author notes that while past research indicated prescriptive messages were more effective, the negative aspect of proscriptive messages may be more memorable. The author also suggests that messages be brief, informational, polite, and worded to ask visitors “not” to do something.

Keywords: off-trail hiking, signage, prescriptive, proscriptive, observations, Sequoia National Park

APPENDIX M: GENERAL GUIDANCE FOR DETERRING OFF-TRAIL HIKING

General Guidance for Deterring Off-trail Hiking

The development, deterioration and proliferation of visitor-created informal trails in protected areas can be a vexing management issue for land managers. Formal trail systems never provide access to all locations required by visitors seeking to engage in a variety of appropriate recreational activities. Traveling off-trail is necessary to engage in activities such as nature study, fishing, or camping. Unfortunately management experience reveals that informal trail systems are frequently poorly designed, including “shortest distance” routing with steep grades and alignments parallel to the slope. Such routes are rarely sustainable under heavy traffic and subsequent resource degradation is often severe. Vegetation impacts include trampling damage leading to changes in species composition, potential introduction and dispersal of non-native plants, and the loss of vegetation cover. Soil impacts include the pulverization and loss of organic litter, and exposure, compaction, and erosion of soil. Soil deposition in streams, disturbance to wildlife, and damage to historic resources are also possible. Creation of multiple routes to common destinations is another frequent problem, resulting in “avoidable” impacts such as unnecessary vegetation/soil loss and fragmentation of flora/fauna habitats.

This guidance is provided to assist land managers and volunteer trail maintainer organizations in evaluating informal trail impacts and in selecting the most appropriate and effective management responses.

Adopt a Decision-Making Process

The management of informal trail networks can benefit from application of a planning and decision-making process or framework that includes public dialogue and input. Decisions regarding impact acceptability and the selection of actions needed to prevent recreation-related resource impacts fall into the domain of carrying capacity decision-making. The NPS defines carrying capacity as “the type and level of visitor use that can be accommodated while sustaining the desired resource and visitor experience conditions in the park” (NPS, 2006). The NPS applies the Visitor Experience and Resource Protection (VERP) decision-making framework (NPS, 1997), while the U.S. Forest Service applies the Limits of Acceptable Change (LAC) framework (Stankey, Cole, Lucas, Peterson, Frissell, and Washburne, 1985) to address carrying capacity issues.

These formal frameworks direct managers to prescribe objectives for biophysical and social conditions they intend to achieve for specific park zones. Numerical standards of quality are established for each indicator and zone to define the critical boundary line between acceptable and unacceptable conditions, establishing a measurable reference point against which future conditions can be compared through periodic monitoring. These frameworks incorporate an adaptive management decision process, whereby managers can apply actions, evaluate their success, and when needed, apply alternative actions as a follow-up until management objectives are achieved. A simplified framework known as Protected Area Visitor Impact Management (PAVIM) employs an expert panel and problem analysis process (Table M.1) that requires less data (Farrell and Marion, 2002). The problem analysis process, which is particularly applicable and useful in informal trail management decision-making, is described below.

Problem Analysis Process

Assemble a group of knowledgeable and experienced individuals with expertise in recreation resources management, visitor management, social science, site and trail management, natural resource management, and interpretation. Visit the site where the impacts or problems are occurring and apply this problem analysis process to guide discussions. Be aware of the need to comply with the Federal Advisory Committee Act (FACA) in any collaborations with the public – see www.gsa.gov/faca for information.

Table M.1. Problem analysis for managing resource and social impacts related to visitation.

I. Identify and Evaluate the Problem

- **Describe area and use(s)** - provide background information about the area, facilities, and visitor use.
- **Describe problem(s)** - briefly describe the facility, resource and social impact problems that are occurring.
- **Problem significance** - consider if and why the impacts are significant or unacceptable to land managers and protected area visitors
- **Previous management actions** - describe the history of the problems and previous actions; discuss the effectiveness of these actions and why they did or didn't work.
- **Causes and influential factors** - discuss the underlying causes for the impacts and the role of non-causal but influential factors that may intensify impacts. Consider use-related factors (type and amount of visitor use, visitor behavior and motives, use density), environmental factors (soil and vegetation type, environmental sensitivity, topography), and managerial factors (siting, design, construction, and maintenance of facilities, visitor management).

II. Identify and Evaluate Strategies and Actions

- **List potential strategies and actions** - create a comprehensive list of appropriate and potentially effective management strategies and actions. Strategies are broad approaches (e.g., modify visitor behavior, manage sites and facilities) and actions are the specific means used to implement a strategy (e.g., educate visitors, relocate campsites).
- **Evaluate strategies and actions** - discuss and evaluate the following attributes for each strategy and action: potential effectiveness, management feasibility (cost, staffing, long-term maintenance), advantages/disadvantages (e.g., costs to visitor freedom), expected visitor compliance, etc.
- **Formulate recommendations** - through group discussion, develop and write recommendations that reflect the group's consensus views. Describe the recommended action or group of actions to implement first and what might be tried next if these are ineffective.

Identify and Evaluate the Problem

The problem analysis begins by developing the group's collective knowledge of the area, amounts and types of recreational uses, and the resource and social problems currently present. Group members most knowledgeable about these topics are asked to share their knowledge with the group. The sharing of differing perspectives, land management agency, trail club, recreation representatives, is encouraged. The significance of the problems and degree to which current conditions are unacceptable are considered when deciding whether management actions are needed. Next, participants with the longest experience in the area are asked to relate the history of the problems or impacts. Previous management actions are described and their effectiveness discussed and evaluated, including why implemented actions were or were not effective.

The core of a good problem analysis is a thorough evaluation of a problem's underlying causes and identification of factors that influence impact severity. For example, substantial off-trail traffic may be the cause for excessive vegetation loss but fragile ground vegetation and poorly marked or maintained formal trails may significantly contribute to the creation of unacceptably extensive or impacted informal trails. The relative influence of three groupings of factors: use-related, environmental, and managerial, should be examined. An improved understanding of these causes and factors are essential to evaluating alternative actions and selecting effective actions.

Identify and Evaluate Strategies and Actions

Step two involves brainstorming by team members to list and then evaluate a diverse array of management strategies and actions. Following list development, study team discussions should focus on careful evaluations of the advantages and disadvantages of each action. A number of important attributes should be considered, including potential effectiveness, management feasibility, costs to visitor freedom and satisfaction, expected visitor compliance, and others as appropriate.

The final step is selecting one or more preferred actions recommended for implementation. Careful consideration of the history of impacts and their management, the desired resource and social conditions for the area, and factors which either cause or influence impacts can help guide more objective and effective decision-making. Management objectives or desired condition statements will suggest the appropriateness of alternative actions relative to the natural, social, and managerial settings of the zone the area is situated within.

Generally, initial actions are feasible, have a low "cost" to visitors, and are judged to have a good chance at effecting the desired change in conditions. For example, indirect actions such as education or site maintenance should be considered before regulatory or site development actions as they are less obtrusive and do not compromise visitor freedom. More restrictive, expensive, and/or obtrusive actions are generally deferred until justified by the failure of one or more preceding actions. However, severe or unacceptable impacts may warrant bypassing such light-handed efforts in favor of actions necessary to achieve more effective or immediate results.

Alternative actions should be identified for potential implementation in the event that initial actions are ineffective.

For each action, identify likely individuals or organizations responsible for implementing the action and describe the necessary resources they will require. An implementation schedule should also be developed and efforts to obtain funding and staff initiated. At this time it is also useful to consider how a planned action should be monitored for evaluating effectiveness. For example, an accurate GPS survey of informal trail networks with condition class assessments provides a baseline for future comparison and should be conducted prior to implementing corrective actions.

Problem Definition: For informal trail management decision-making, an inventory of the informal trail network within an area of management concern is particularly useful. If a GPS device and GIS expertise is available, a simple inventory technique is to conduct a walking GPS survey, provided the terrain and forest canopy permit accurate GPS use. GIS software can be used to map and analyze the data, providing a visual display of the informal trail network relative to designated trails, roads and other resource features. Computation of the lineal extent of the informal trail network is also possible. If GPS devices cannot be used then an inventory can be made by hand-sketching informal trails onto large-scale maps with lengths assessed by pacing or a measuring wheel.

Where possible, managers may also wish to consider various options for assessing the condition of the informal trails. Many options, ranging from simple condition class evaluations, to trail width and depth measurements, or detailed assessments of soil and vegetation loss are possible. Guidance for assessing trail conditions may be found in the scientific literature (Cole, 1983; Leung & Marion, 2000; Marion & Leung, 2001) or contact the author for examples of informal trail monitoring protocols and manuals. An objective assessment of informal trail conditions can produce quantitative data for indicator variables that can be summarized to characterize current trail conditions, or when replicated, to monitor changes in trail conditions over time. Such data can be used in the previously described formal or informal adaptive management decision-making frameworks.

Evaluate Impact Acceptability: The acceptability of informal trail impacts should be evaluated according to park or management zone objectives. Informal trails located in pristine areas where preservation values are paramount are less acceptable than when located in areas that are intensively developed and managed for recreation use. Trails in areas with sensitive cultural and archaeological resources are particularly unacceptable if they threaten such irreplaceable resources.

Environmental factors: Informal trails located in sensitive or fragile plant/soil types, near rare plants and animals, or in critical wildlife habitats are less acceptable than when located in areas that are resistant to trampling damage and lack rare species. Informal trails that directly ascend steep slopes and/or will easily erode are less acceptable than trails with a side-hill design. Informal trails prone to muddiness and widening are less acceptable, as are trails that may contribute soils to water resources.

Use-related factors: Why is a trail in a particular location and what are the visitors trying to access? Which recreation activities are most responsible for creating informal trails? What are the motives responsible for off-trail hiking? Are some impacts avoidable? For example, informal trail impacts related to a poorly marked formal trail or that result from visitors trying to

circumvent muddiness or severe erosion are more easily avoided and should be targeted first. It is not uncommon to find several “duplicative” informal trails in close proximity to each other accessing a common destination. Impacts caused by visitors seeking to shortcut a longer, more resistant route are unacceptable, as are impacts caused by visitors who could alternately access their intended destination by staying on resistant durable surfaces (e.g., rocks or gravel) (www.LNT.org). Informal trails resulting from illegal or inappropriate types of uses are less acceptable than if they are caused by permitted uses.

A careful consideration of these and other relevant factors (e.g., visitor safety) can assist managers in making value-laden decisions regarding the acceptability of informal trail impacts. The acceptability of these impacts, in turn, guides decisions about which trails should be left open, rerouted, or closed, and selection of appropriate and effective management interventions.

Selection of Management Strategies: The problem analysis process can assist managers in considering and evaluating a diverse array of potential management strategies and actions. Note that some degree of degradation to natural resources is an inevitable consequence of recreation use, requiring managers to balance recreation provision and resource protection mandates. Roads and formal trails can never provide complete access to the locations visitors wish to see, hence, some degree of informal trail development is inevitable and should be managed to minimize impacts. The challenge for managers is to evaluate the impacts in light of recreation provision and resource protection objectives, and apply professional judgment to determine which impacts are unacceptable and require management action.

The following section describes four general strategies for managing informal trail impacts: 1) Improve management of formal trails, 2) Ignore or formalize informal trails, 3) Maintain informal trails, and 4) Close and restore unacceptable trails.

Improve Management of Formal Trails

If formal trail problems are contributing to the development of informal trails, then addressing such problems is generally one of the more effective and efficient options available to managers. Make sure that formal trails are well-marked in some distinctive fashion so that visitors can clearly distinguish between formal and informal trails – this is often very confusing to most visitors. In rocky areas, paint blazes may be needed on rocks rather than trees because the terrain demands constant attention to the immediate trail tread. “Overblazing” or clearly defined trail borders (e.g., spaced rocks, logs, or scree walls) may be necessary in some tricky areas. Boardwalks, low symbolic fencing, or higher rustic fencing are more effective but more visually obtrusive and costly. The treads of formal trails should be the most attractive location for walking, maintained to be free of muddiness or deeply eroded ruts with exposed roots and rocks. When braided or multiple parallel treads occur managers should define a single intended tread throughout.

Ignore or Formalize Informal Trails

Some informal trails may have reasonably sustainable design attributes and access locations, such as vistas or campsites (hikers), water resources (fishermen), or cliffs (climbers) that are acceptable to land managers. When visitor access to these locations is appropriate, such trails should generally be left open as informal trails or even designated and managed as formal trails. They serve an important resource protection function by concentrating visitor traffic on a narrow

tread and protecting adjacent vegetation from trampling damage. Recreation ecology studies have consistently found a curvilinear relationship between the amount of traffic and trampling impacts (Leung and Marion, 2000). The majority of trampling impact occurs with relatively low levels of trampling; once a trail is established, further trampling impact is greatly minimized by a “concentration” strategy that focuses all further traffic to its barren tread. An alternate “dispersal” strategy is only effective under conditions of very low use and/or when traffic can be confined to durable substrates (e.g., rock, gravel) or vegetation (grasses/sedges).

Sometimes a portion of such informal trails may require a reroute to improve the sustainability of an alignment, such as a very steep section aligned with the fall-line (parallel to the landform slope). An experienced trails professional should conduct a review and provide recommendations for informal trails left open to use. Generally trail alignments should favor side-hill over fall-line alignments, avoid grades over 15%, and favor rocky substrates and non-vegetated or grassy groundcover. As with formal trails, leaving an informal trail with a poor “impact susceptible” alignment is rarely a preferred long-term solution. Site development actions, such as graveling or installation of water bars and rock steps, could be applied but these are generally less appropriate on informal trails and would be unnecessary on a well-designed alignment. In most instances, relocation to an improved alignment will be a more cost-effective and sustainable long-term solution, even though pristine terrain is affected.

Due to the relatively poor trail design skills of visitors, it may even be necessary to replace several non-sustainable informal trails with a new well-designed informal or formal trail (with appropriate environmental reviews). An objective evaluation of the aggregate or cumulative impacts, including the total area of trampling disturbance and soil loss, will generally support such a decision. However, this option should only be attempted when managers are relatively certain of their ability to effectively close the pre-existing informal trails.

Maintain Informal Trails

Historically, most park managers have not maintained informal trail networks. However, extending maintenance work to those trails with reasonably sustainable designs left open to use can substantially reduce impacts. For example, managers can piece together a single sustainable route in an area with numerous braided trails and trim obstructing vegetation, subtly enhance tread drainage, or install natural-appearing rockwork on steep slopes. These actions will effectively encourage use and reduce impacts on the sustainable route while reducing use and encouraging natural recovery on alternate informal trail segments. Additional actions, discussed in the following section, can be applied to discourage their continued use.

Close and Restore Unacceptable Trails

Informal trails with poor, non-sustainable design attributes, trails that threaten sensitive resources, or unnecessary trails with duplicative routings should generally be closed and rehabilitated. Managers should recognize that successful trail closures and restoration are rare and require substantial and sustained management effort. The principal reason for low success rates is that while trampling impacts occur rapidly with low levels of use, vegetative and soil recovery occurs very slowly and complete recovery is prevented unless nearly all traffic is removed from treads for several consecutive years. A substantial restoration program involving the addition of soil and plantings of native species, with watering as needed to ensure survival, can hasten natural recovery. However, care must be taken to apply such intensive work only

when managers are reasonably certain that effective measures are in place to prevent further trampling of the restoration work.

Selection of Management Actions: An adaptive management program involving education and site management actions is recommended when implementing strategies. Management experience and research have demonstrated that integrating site management and educational actions consistently achieve the highest rates of success. Site management actions are needed to mark and keep visitors on formal trails or to block or hide informal trails; educational actions are needed to inform visitors of the impacts associated with off-trail traffic and what managers would like them to do to protect natural and cultural resources. Visitors frequently misunderstand site management actions that lack signs placed to convey information about impacts of concern and management intent. In the absence of site management actions, visitors may choose to disregard a prompter sign (e.g., symbolic “no-step” sign, Figure 6) placed at an informal trail junction if a well-used informal trail branches off to what looks like an appealing vista.

Educational Actions

An educational component is often critical to communicate a clear rationale for an action – for example, that significant resource impacts can occur in some areas if visitors travel off designated trails. A message with a rationale should be followed by a plea for visitors to remain on formal trails, which need to be clearly designated through site management actions (e.g., blazing, symbolic markers, cairns) to distinguish them from informal trails. Social science research and theory has found that signs with a compelling rationale and clear behavioral plea are more effective than simple “do” and “do not” messages (e.g., “Please Stay on Designated Trails to Preserve Sensitive Vegetation”) (Cialdini, 1996; Cialdini *et al.*, 2006; Johnson & Swearingen, 1992; Marion & Reid, 2007; Vande Kamp, Johnson *et al.*, 1994; Winter, 2006). Such literature should be consulted to improve the efficacy of educational messaging.

Some principal goals that educational efforts seek to communicate include: 1) off-trail travel can cause significant resource impact to vegetation and can lead to the creation of informal trails, 2) managers would like to close and restore these informal trails, but even small amounts of continued traffic prevents their recovery, 3) visitors should stay on the formal, marked trails and avoid any unmarked trail. Unfortunately, providing a rationale for informal trail closure (which is an important message component) creates a rather lengthy message that is challenging to communicate effectively. Research suggests that having park staff or volunteers speak with visitors is more effective than signs in communicating a message, but few natural areas have the personnel to rely solely on personally communicating with most visitors. Educational signs used to deter off-trail travel must be well-designed to capture the attention of hikers and persuasively communicate the message. Figures 3, 4, 6 and 7 depict the signs employed in this study that accomplish these objectives and that have received NPS approval for use. Note the inclusion of the “no-step” icons that communicate the message with just a glance and are understandable by children and non-English speaking visitors. Generally the larger informative signs are placed in conspicuous locations near trailheads and the more numerous “prompter” signs are placed just beyond junctions with informal trails

Site Management Actions

A variety of site management actions are available for closing informal trails. Close lightly used trails by actions that naturalize and hide their tread disturbance, particularly along initial visible

sections where visitors make the decision to venture down them. Effective actions include raking organic debris such as leaves onto the tread, along with randomly placed local rocks, gravel, and woody debris designed to naturalize and hide the tread. These actions also lessen soil erosion and speed natural recovery. On trails that have been effectively closed, transplanting plugs of vegetation at the beginning of wet seasons can hasten natural recovery. Revegetation work conducted before successful closure is achieved can be a frustrating waste of time and materials if visitors continue use of the trail and trample the transplanted vegetation.

For well-used trails, such work (i.e., brushing) generally cannot fully disguise the disturbed substrates and vegetation so additional measures are necessary for effective closures. Construct a visually obvious border along the main trail, such as a row of rocks or a log, to communicate an implied blockage for those seeking to access the closed trail. Alternately, embed large rocks or place large woody materials or fencing to obstruct access at the entrance to closed trails to fully clarify management intent. Even temporary 2 ft tall post and cord symbolic fences can communicate the importance of closures and effectively deter traffic (Figure 8) (Park *et al.*, 2008). Taller plastic fencing (preferably in green or brown) is also easy to transport and install to discourage traffic on trails that prove more difficult to close. However, fencing is generally perceived as visually obtrusive and inappropriate in more primitive settings.

Placing rocks or woody debris that physically obstructs traffic beyond the beginning of closed trails may be ineffective if visitors are able to circumvent these by walking around them. This can result in new trampling and trails parallel to the “closed” trail – a significant problem in areas with sensitive or rare vegetation. In such areas it is better for hikers who ignore closures to remain on the “closed” tread than to create new treads on each side (Johnson *et al.*, 1987). If the trail is in sloping terrain its closure may require the addition of soil to fill ruts and reestablish the original surface contour, and organic litter and vegetation to keep the soil from eroding. Finally, integrating site management work with temporary educational signs may be necessary to obtain a level of compliance that allows vegetative recovery. Also, consider signs to communicate the location of a preferred alternate route when visitors are seeking to reach a particular destination and their only visible access trail is closed.

Conclusions: Informal trail management actions should be implemented as part of an ongoing adaptive management program. Experimentation will be necessary to refine site management procedures that are appropriate in each management zone or location. Some form of periodic monitoring is critical to program success. A 5-year interval could be sufficient for monitoring with quantitative procedures, but annual informal evaluations are needed to effectively guide the application of management actions.

Objective monitoring will be needed if any potentially controversial management actions may be needed (e.g., use restrictions or high fencing). In exceptionally high use areas with sensitive resources there is a good probability that such actions will be necessary. For example, a combination of signs and restoration work may be able to keep 95% of visitors on a designated trail but 5% of 2000 visitors/day is 100 visitors/day, a level of trampling that is sufficient to both create and maintain informal trails. Tall fencing or a regulatory sign that prohibits use of the closed trail and threatens fines may be necessary on trails that are particularly difficult to close. Such situations also indicate a need for further dialogue with trail users to discover their motives and a review of whether the formal trail system should be extended or modified.

Regardless, periodic monitoring provides feedback for gauging the success of management interventions in keeping conditions within acceptable limits. A documented failure of one intervention can be used to justify the use of a more obtrusive or expensive intervention.