

The Effectiveness of Trail Mitigation and Theory-Grounded Signage
in an Economical Approach to Reducing Social Trail Behaviors

By

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ABSTRACT

Trails perform an essential function in protected lands by routing visitors along planned, sustainable surfaces. However, when visitors deviate from official trails in sufficient numbers, it can lead to the creation of social trails. These visitor-created pathways are not sustainably designed and can severely degrade both the stability and appearance of protected areas. A multitude of recreation motivations among visitors and a lack of resources among land management agencies have made the mitigation and closure of social trails a perennial concern. A sustainable, economical strategy that does not require the continual diversion of staff is needed to address social trails. In this study, two techniques that stand out in the research literature for their efficacy and practicality were tested on a social trail closure in South Mountain Park, a high-use, urban-proximate mountain park in Phoenix, AZ. A research design with additive treatments utilizing the site management technique known as trail mitigation, sometimes referred to as brushing in the literature, followed by theory-grounded signage incorporating injunctive-proscriptive wording, an attribution message, and a reasoning message targeting visitor behavioral beliefs, norms, and control was applied and assessed using unobtrusive observation. Both treatments reduced observed off-trail hiking from 75.4% to 0%, though traces of footsteps and attempts to re-open the trail revealed the existence of unobserved “entrenched” users. With entrenched users attempting to reopen the trail, trail mitigation represented an effective but vulnerable approach while the signage represented a long-lasting “hardened” approach that provides an educational message, management’s stance on the closure, and which might put social pressure on the entrenched user(s).

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CHAPTER 1: INTRODUCTION

Problem Statement

The essential function of trails in parks and preserves is to protect the land by routing visitors along planned, sustainable, hardened surfaces (Marion & Leung, 2004). Unfortunately, not all visitors stay on the official trails, and heavy visitation and a multitude of recreation motivations often lead to trailblazing and the creation of what are sometimes called social trails (Kidd et al., 2015; Marion, Leung, Eagleston, & Burroughs, 2016). Because these social trails form spontaneously from visitor use and are not sustainably designed by managers, they can severely degrade both the appearance and the stability of protected resources (Leung & Marion, 1996; Wimpey & Marion, 2011). The proliferation of social trails and the problems associated with them represent a constant struggle for managers in many protected areas (Leung, Newburger, & Jones, 2011; Marion et al., 2016). Due to this persistent issue of social trails in parks and preserves, site management strategies have been an ongoing topic of research (Hockett, Marion, & Leung, 2017; Marion et al., 2016). Signage has been the traditional strategy for park managers as it allows for the effective delivery of an educational message or park rules intended to encourage the adoption of low impact behaviors or to discourage deprecative behaviors while not requiring the presence of park staff (Marion & Reid, 2007). The effectiveness of the signage depends on the message employed. Narrowing that variety of message options has been the focus of a multitude of research papers in recent years (Bradford & McIntyre, 2007; Cialdini, 2003; Park, Manning, Marion, Lawson, & Jacobi, 2008; Winter, Sagarin, Rhoads, Barrett, & Cialdini 2000).



Fig. 1. Damage to sensitive Cryptobiotic desert soil caused by a social trail

Interpretive contact by park staff or volunteers has been consistently found to be one of the most effective management strategies, but the realities of budget constraints and volunteer inconsistency mean this is not usually a realistic long-term option (Hockett et al., 2017; Kidd et al., 2015). Signage represents a more viable and economical approach for delivering an educational message or park rules. Signage, however, has seen mixed success, even with the use of research-informed messages, because visitors, and especially repeat visitors, do not always read signs (Guo et al., 2017; Kidd et al., 2015). Because of this, recent research has begun to look at adaptive management approaches which integrate signage with site management techniques which represent older, less empirically-founded strategies, as coordinating multiple methods has been found to be more effective than any single method (Hockett et al., 2017; Kidd et al., 2015).

There are a few major gaps in the current literature on addressing social trails, the first of which is the fact that urban protected areas have received far less research attention than large frontcountry zones of protected land like national parks (Alberti et al., 2003; Mora-Bourgeois, 2006). Urban protected areas often face an abundance of frequent, repeat users due to their proximity to homes, and repeat visitors may represent a population that is particularly resilient to certain forms of social trail management strategies due to their habitual behaviors and tendency to ignore signage and management pleas to stay on formal trails (Hockett et al., 2017). For these reasons, there is a gap in the current research and a need for new research looking at the efficacy of social trail mitigation in urban protected areas, particularly large ones facing heavy use from the local population. Another gap in the literature is the lack of empirical evidence on the effectiveness of site management techniques. Most studies have focused on signage or the intervention of employees, so there is a lot of room for exploration on site management techniques such as trail mitigation, sometimes referred to as “brushing” in the research literature, or the practice of applying material to disguise and renaturalize social trails, as well as on more direct approaches such as fencing or rope barriers (Hockett et al., 2017). Additionally, recent studies have acknowledged the limitations of the commonly used research methods to study social trail use such as self-reports on surveys and conspicuous observation, both of which may influence visitor responses and behaviors. (Guo et al., 2017; Hockett et al., 2017; Kidd et al., 2015).

This study examined the efficacy of the site management technique and type of theory-grounded signage that have seen the most success in recent literature.

Additionally, the study was conducted at one of the largest urban-proximate parks in the United States: South Mountain Park in Phoenix, AZ, managed by the City of Phoenix Parks and Recreation Department. Though interventions by park staff and volunteers have been found to be the most effective strategy for managing social trail use, it is not a realistic option for most large parks like South Mountain Park due to budget constraints and volunteer inconsistency (Hockett et al., 2017; Kidd et al., 2015). Park managers need practical, effective, research-informed tools and techniques that can effectively mitigate social trails with minimal staff intervention. Direct experience of the researcher and a review of the literature have both revealed that not only are social trails a major management concern that occupy a great deal of time and resources, but that there is a disconnect between practitioners and the researchers attempting to solve this problem (Marion, 2016.) It is hoped that this study will reveal an effective and realistic strategy to mitigate social trails that can provide a practical tool for managers.

Purpose Statement

The purpose of this experimental study is to test the efficacy of the site management technique known as trail mitigation trail mitigation and theory-grounded signage placed at the junction of the social trail in reducing social trail behaviors for park visitors in a high-use, urban-proximate park: South Mountain Park in Phoenix, AZ.

Limitations and Delimitations

One of the limitations of this study was the sample that was available for observation on the experimental trails, as this was limited to the park visitors who happened to be walking those trails during the prescribed treatment windows. Participants were also limited to non-motorized users as park regulations forbid motorized vehicles on trails.

A delimitation of the study was the amount and variations of management techniques tested. There are limitless options that could be tested, including various types of signage and different combinations and forms of management techniques (trail mitigation, blocking, ropes, logs), but this study purposefully examined the most effective techniques highlighted in past studies, namely trail mitigation and theory-grounded signage planted at the beginning of the social trail (as opposed to trailhead signage). Delimitating the study to two economical mitigation techniques was also in keeping with a more realistic management strategy. Restoration sites for instance have been found to be similar in effectiveness to trail mitigation, but full restoration sites are far more labor and resource-intensive than trail mitigation.

CHAPTER 2: LITERATURE REVIEW

Early History and Focus Theory

One of the earliest research papers on social trail signage was a 1992 experiment by Johnson and Swearingen (1992) in Mount Rainier National Park which confirmed that the effectiveness of sign texts differs greatly depending on the message. They found that the most effective message was one threatening sanctions or fines, which reduced off-trail hiking by 75% and was far more effective than a positive “plea message” which asked park visitors to stay on the trails. Even with this significant early finding, the fact remained that park managers disliked negative or threatening messages and instead preferred to rely on positive ones for public relations reasons. Additionally, Johnson and Swearingen called for future researchers to utilize theory to create more effective messaging strategies. Though there was no theoretical grounding, the Johnson and Swearingen study was the beginning of an idea which would be followed up on over a decade later; i.e. that park visitors are more likely to pay attention to a negative message than a positive one. Research by Winter et al. (2000) reached the same conclusion. Researchers found that signage discouraging negative conduct was far more effective than signage encouraging positive conduct, but also found that the vast majority of park managers believed that the encouraging, positive messages would be more effective.

By the early 2000s, a new “softer” messaging strategy was being employed by the national parks in the United States due to management preference for encouraging, positive messages. This strategy relied on descriptive norms. Descriptive norms are

statements describing what people normally do, in this case with language such as “many people are doing this undesirable thing.” However, hidden within that statement is the powerful normative message “many people are doing this thing.” A 2003 study by Robert Cialdini hypothesized that these messages were not only ineffective, but actually increasing depreciative behaviors. His research revealed that descriptive norms (what people typically do) are not only less effective than injunctive norms (what people typically approve of or disapprove of), they in fact increase depreciative behaviors due to the hidden normative message. In 2006, a follow-up study with Cialdini, Demaine, Sagarin, Barrett, Rhoads, and Winter in Petrified Forest National Park looked at this idea under the lens of what Cialdini called the focus theory of normative conduct. According to this theory, there are two distinct types of social norms: descriptive norms, which refer to what is commonly done and are likely to encourage a behavior, and injunctive norms, which refer to what is approved of or disapproved of and are likely to discourage a behavior. Focus theory dictates that norms will only influence behavior when they are the focal point of attention, and so it is counterproductive to try and discourage a behavior by telling people it is frequent. Park managers wanted to avoid “negative wording” in their messaging, which is why they were using descriptive norm messages in the first place. But Cialdini pointed out that negatively worded injunctive messages (please don’t leave your campfire) need not be any more offensive or threatening than positively worded statements (please stay with your campfire). Focus theory and this idea of telling park visitors what they should not do instead of what they should do represented a first major step in using theory to guide messaging strategies on signage. It was particularly

important due to the fact that managers seemed to unanimously want positive, encouraging, or descriptive signage, even though these types of messages were barely effective at best and had the opposite effect at worst (Cialdini 2003; Winter et al., 2000).

Attribution Theory

While Cialdini was researching the descriptive messages developed by the national parks, Duncan and Martin (2002) published a paper trying to find a new alternative to threatening sanction messages. They were using “awareness of consequence” messages, or messages that tried to inform visitors of the impacts of their deprecative behaviors. This awareness of consequence message was found to be equally effective as sanction messages among some populations in their study, but overall no more effective. Research by Bradford and McIntyre (2007) followed up on this idea with an experimental study at St. Lawrence Islands National Park in Canada. Their study integrated attribution theory. Attribution theory deals with how people make casual explanations about different situations. For Bradford and McIntyre, the idea was to create a sign that would make park visitors understand that it was off-trail hiking and social trail use that was trampling the rare plants and causing erosion damage in the park. They wanted park visitors to realize that their actions were the cause of this situation and that they could control the damage to the park with their choices. This was similar to Duncan and Martin’s “awareness of consequence” messages, but the message was shorter, cleaner, and the consequences were directly attributed to the footsteps of the person reading the sign. Bradford and McIntyre found that an attribution message (your feet

have trampled the vegetation on this island), placed at the beginning of social trails, cut social trail use in half. Their attribution message was a resounding success, but the study suffered from one major fault: the researchers did not or were unable to heed previous research, published the year before they began their study, and they tested this attribution message against a simple, positively stated plea message (please stay on trails) instead of against a stronger injunctive norm message (Cialdini et al., 2006). Even so, this study represented the second major step forward in using theory to ground social trail signage.

Theory of Planned Behavior

In 2009, Hughes, Ham, and Brown (2009) published a study which attempted to integrate the theory of planned behavior into signage. This theory states that in order to influence behavioral intentions, one must first influence attitudes towards a behavior, subjective norms, and perceived behavioral control (Ajzen, 1991). The authors of this study attempted to target the attitudes of park visitors towards certain behaviors in order to change their behavioral intentions. Specifically, they targeted visitor attitudes and beliefs about the effects of feeding birds and letting dogs go off-leash on the park and other visitors. By using signage to educate park visitors of the effects of their behavior, their ability to control that behavior, and how other visitors see those behaviors, Hughes, Ham, and Brown hoped to effectively alter habitual depreciative behaviors. While their signage did not follow recommendations from earlier studies on using injunctive-proscriptive messaging, their integration of belief-targeting education messages did yield

some measurably effective results and set the stage for other researchers to use the theory of planned behavior.

Lawhon et al. (2013) contributed to this line of research by confirming that perceived effectiveness of practices is a meaningful predictor of park visitors following those practices. Essentially, park visitors are more likely to follow recommendations if they understand and believe that those recommendations are effective or are worth doing. This means that an injunctive proscriptive message (telling visitors what they should not do), in line with Cialdini et al. (2006), could be paired with a short reasoning message explaining why park visitors are being told not to perform a depreciative behavior in order to have a greater combined effect. Kidd et al. (2015) conducted a recent study integrating the theory of planned behavior, but they did not utilize injunctive-proscriptive wording. Their signage was similar to the Hughes, Ham, and Brown (2009) study in that it targeted visitor beliefs about the results of their actions, but they did not equally target norms and control. The purpose of the Kidd et al. (2015) study was to test two different ways of targeting visitor beliefs in order to change their behavior: the first treatment focused on ecological impacts of the behaviors, while the second focused on damage to the visitor experience. The ecological impact message was more effective, but neither message was found to be statistically significant in this study (perhaps due to not using an injunctive-proscriptive message). Whatever the case, grounding signage in the theory of planned behavior is one of the most recent trends in the research on social trail signage and represents the third major step forward in the use of theory.

The most recent study in the literature on social trail signage is by Hockett, Marion, and Leung (2017), three of the most well-known researchers on the topic of social trails. They performed an experiment on Bear Island in Chesapeake and Ohio Canal National Historical Park which utilized a combination of the three major theoretical groundings detailed above. Their signage employed injunctive-proscriptive wording (please do not leave paint-blazed trails) in bold text followed by an attribution message (your footsteps could be deadly) in accordance with attribution theory as well as a reasoning message targeting beliefs, norms, and control in line with the theory of planned behavior. This signage represents over thirty years of research and the utilization of focus theory, attribution theory, and the theory of planned behavior, creating a “combined approach” which has the best chance at success. Future research may sharpen this messaging strategy even further, but, for now, this is the most effective message strategy built on previous research and future studies should follow the example of the Hockett et al. (2017) study.

In light of this recent combined approach, where can the research on social trails go from here? There have always been indicators that signage on its own will never be a perfect solution. In 1992 when the research was still focusing on threatening sanction messages, Johnson and Swearingen pointed out that even the most threatening signs were not eliminating rule-breaking behavior, even when placed in an obvious spot where the sign could not be missed. McCool and Cole (2000) found in their study that only 64% of park visitors stopped at trailhead signs, and, of those, only 70% paid any attention to the messages there. That is a little under 50% paying attention to trailhead signs. In 2008,

Park et al. found that in no treatment of their experiment did visitors spend more than eight seconds paying attention to signage (both trailhead and along the trail), and that the majority of visitors either ignored or only glanced at signage without stopping to read it. Kidd et al. (2015) had similar findings, with less than half of surveyed park visitors reporting that they had even seen treatment signage at the trailhead. Hockett et al. (2017) used this research to inform their experiment and incorporated a trailhead sign treatment to test it. They came to the conclusion themselves that trailhead signs are ineffective on their own for signage attempting to mitigate social trail behaviors. Therefore, the conclusion is that signage meant to stop social trail behaviors is of very limited use at trailheads and most likely needs to be placed at the beginning of social trails as suggested by Bradford and McIntyre (2007). Additionally, it should be combined with other management techniques in order to be most effective (Hockett et al., 2017).

Site Management Techniques

Due to the limitations associated with signage, recent research has begun to focus on adaptive management approaches which integrate signage alongside site management techniques (Hockett et al., 2017; Kidd et al., 2015; Park et al., 2008). Park et al. (2008) came to the conclusion that intensive use requires intensive management and recommended a suite of practices to maintain the summit of Cadillac Mountain in Acadia National Park, perhaps one of the most heavily visited points in the national park system. These practices included an aggressive information/education program at the visitor center and trailheads to inform visitors before they got on the trails, unobtrusive fencing

along the margins of heavily used trails to create a symbolic barrier to guide visitors, and enforcement by park staff and volunteers where possible to accomplish what the signage and barriers could not. Hockett et al. (2017) expanded on this adaptive management approach design by integrating and testing the effectiveness of staff interventions, trailhead signage, symbolic barriers, restoration sites, and, most importantly, a form of a technique known as trail mitigation, referred to as “brushing” in the study, which is an attempt to disguise the beginning of a social trail by covering it with local debris. Hockett et al. (2017) hypothesized that integrating multiple methods into one coordinated management technique would likely reduce off-trail travel more than any single method.

According to Gramann and Vander Stoep (1987), the technique of disguising the beginning of a trail reduces what they refer to as a “releaser cue.” This is a phenomenon any experienced hiker could explain; the eye tends to follow the trail and will naturally be drawn to follow any worn tread where it looks like others have traveled. It is not always obvious whether a trail is official or unofficial, especially in large parks or preserves where it is impossible to continuously place trail markers or expect visitors to memorize the layout of official trails before setting out. Trail mitigation provides a way to reduce this “releaser cue” by tricking the eye into not being drawn toward the social trail.

Interestingly, there is very little research on trail mitigation, and it has only recently reentered the literature in the Hockett et al. (2017) study where, notably, it was found to be the most successful treatment via direct observation. Surveys using self-reported behavior in this experiment attributed the most success to staff interventions, though self-reports suffer from a bias that (incognito) observation does not because they rely upon the

honesty of the park visitor in the context of depreciative behaviors. This success with a technique which has been absent from the literature for 30 years means that future research on social trails will certainly need to integrate trail mitigation as a treatment.

Of note, however, are the limitations of trail mitigation that do exist in the literature. For instance, in volume 6 of the *Restoration Manager Notes* for the National Park Service in 1987 (Johnson, Bratton, and Firth), while disguising social trails was found to be effective, the authors warned of several limitations, including the tendency for repeat visitors to dismantle the trail mitigation out of a misguided belief that they were helping to maintain the trail. Additionally, trails that were heavily mitigated with large debris to the point of being blocked were sometimes simply circumvented, creating new social trails to bypass the blockage. Hockett et al. (2017) acknowledged these limitations in their study and utilized a light form of trail mitigation which simply sought to disguise the beginning of a social trail instead of blocking it entirely. Additionally, they integrated a small physical symbolic blockage (a log with a no-hiking symbol) in addition to the trail mitigation in order to avoid park visitors dismantling the trail mitigation out of a misguided sense of trying to help maintain the trail. Any further research on trail mitigation should also acknowledge these limitations and not over-brush to the point of blockage and perhaps not rely on trail mitigation alone without an indicator of one form or another for repeat visitors that the trail mitigation is intentional.

Blocking is the practice of placing an object across the start of a social trail as a true or symbolic barrier to discourage use (Hockett et al., 2017; Marion et al., 2016; Park et al., 2008). This is a management technique which has seen limited success due to the

tendency for stubborn park visitors to simply move physical barriers out of the way in the case of symbolic barriers, or to circumvent them and widen the trail or create new social trails in the case of true barriers (Hockett et al., 2017). Park et al. (2008) saw more success with true blockages than with signage, but they used rope barriers alongside a paved trail in a very high use interpretive area, something that is not practical for most trails and is more realistic around parking lots or other paved areas to direct visitors onto trails. In the Hockett et al. study, both a true blockage and symbolic blockages were tested. The true blockage took the form of a “restoration site,” or an area of transplanted vegetation surrounded by rope barriers at the beginning of a social trail. This blockage was found to be similarly effective to the light trail mitigation, but it was far more resource intensive and forced stubborn visitors to circumvent it. The symbolic blockage took the form of a log with a no-hiking symbol attached to it. The effectiveness of the symbolic blockage is difficult to gauge since it was used with the trailhead signage and light trail mitigation treatments and never separately on its own. However, one could hypothesize that both the true blockage and symbolic blockage in this study served the function of making management intentions known: that access to the trail is not allowed. The symbolic blockage alongside the light trail mitigation is important because it lets repeat visitors know that the trail mitigation is intentional and not simply debris. However, a small sign could serve the same purpose as the symbolic blockage while simultaneously delivering an effective injunctive-proscriptive message that is clearer than a no-hiking symbol and which could also integrate a follow-up reasoning message grounded in focus theory, attribution theory, and the theory of planned behavior. Large

restoration site blockages might appeal to the more ecologically-minded visitors, but they are very resource intensive to install and stubborn users will be forced to circumvent them, widening the trail or creating new social trails, instead of simply walking through them as they can with the light trail mitigation.



Fig. 2. An old circumvented blockage leading to creation of a new social trail

Staff Intervention

It is important to address a social trail mitigation technique which has been found by some researchers to be the most effective of all: staff intervention (Hockett et al., 2017; Kidd et al., 2015). Kidd et al. (2015) found that personal contact by a ranger or volunteer in uniform was the most statistically significant reducer of social trail behaviors and concluded that this was due not only to the impact of an educational message

delivered by a human being, but by the presence of uniformed personnel being a motivator to follow perceived park rules. Hockett et al. (2017) also acknowledged the effectiveness of this approach in the literature and integrated it as a treatment in their experiment. While observational data indicated trail mitigation to be the most effective treatment in the study, self-report surveys from park visitors indicated that staff intervention was the most effective strategy. Hockett et al. (2017) pointed out that even though staff intervention was the chosen technique for Bear Island staff following the study, budget constraints and volunteer inconsistency led to a failure to follow-through on enforcement after the study concluded. Similarly, the staff at Acadia National Park in the Kidd et al. (2015) study faced similar challenges and also ended up failing to follow up on enforcement shortly after the study concluded. Unfortunately this seems to be the reality when it comes to stretching already limited park resources to incorporate new time-intensive management strategies. Most parks and preserves simply do not have the staff or volunteer consistency to directly police off-trail hiking, and for that reason staff intervention may not be a realistic strategy to address social trails (Bradford & McIntyre, 2007). Signage and site management techniques represent much more economic and efficient solutions which may be just as effective as staff intervention in some cases (Hockett et al., 2017; Marion & Reid, 2007).

Recent Literature

In light of all of this, the most up-to-date strategy for mitigating social trails in the research literature is that proposed by Hockett et al. (2017): an integrative management

approach incorporating trailhead signs with injunctive-proscriptive wording and an educational message utilizing attributive wording and informed by the theory of planned behavior alongside trail mitigation and a blockage with a small symbolic sign. However, Hockett et al. (2017) acknowledged that the trailhead signs were almost completely ineffective on their own, and thus one must question if signage could be more effectively placed at the beginning of the social trail which could then replace the blockage (log with symbolic sign). If most users, especially repeat users, are ignoring trailhead signs anyway, it would seem that signage at the social trail junction where repeat visitors will be more likely to read it after encountering a mitigated area would be a more effective strategy. The sign would serve the same purpose as the blockage in making management intentions known and indicating that the trail closure is intentional, and it could prevent stubborn repeat users who might normally displace or circumvent a blockage from continuing by convincing them with a targeted, theory-grounded message on-site. While the trail mitigation would help deter new visitors from following the social trail by keeping their eye from being drawn to it as shown by Gramann and Vander Stoep (1987), the signage could deter repeat visitors who might attempt to clear or ignore the trail mitigation. One thing is clear; there is certainly more room for experimentation on this topic, particularly if it comes in the context of urban parks and preserves. In light of that, this study sought to test what the literature has revealed as the most effective and economical techniques for reducing social trail use: trail mitigation and theory-grounded signage placed at the social trail junction. The study hypothesized the following:

Hypotheses

- 1) The trail mitigation site management technique will reduce social trail usage
- 2) A combined management approach incorporating both the trail mitigation site management technique and theory-grounded signage at the social trail junction will significantly reduce social trail usage

CHAPTER 3: METHODS

Study Site and Trail Selection

South Mountain Park is an urban mountain preserve in Phoenix, Arizona, managed by the City of Phoenix Parks and Recreation Department. Encompassing over 16,000 acres, or 25 square miles, it is the largest municipal park in the United States. While originally designated as a park, South Mountain Park is also officially categorized as a mountain preserve. This means that visitors are limited to trailheads and designated trails, and that any off-trail travel is prohibited. As an urban-proximate park, South Mountain Park receives an extremely high amount of traffic from the surrounding urban population. The Phoenix metropolitan area has a reported population of over 4.7 million, and, in 2017, South Mountain Park recorded over 3.5 million visitors between trail counter and vehicle counter data. In fact, some of its numerous trailheads receive as many as 1000 visitors per day during peak hiking season. South Mountain Park also faces a unique challenge as a mountain preserve surrounded on almost all sides by a dense urban and suburban population with many repeat users who trailblaze from their backyards directly into the preserve.

The social trail used in this experimental study branches off the oldest and one of the most accessible trails in South Mountain Park: Kiwanis trail. Kiwanis is rated moderate in difficulty and is one mile long with a 500 foot elevation gain. It stretches between Kiwanis trailhead, accessible via roadway inside the base of the park, and the Summit road at Telegraph Pass, the public roadway running along the top of South

Mountain. It is a popular trail due to the availability of parking, its accessibility via the roads, its short length, its various trailside attractions including 1000 year old petroglyphs and 80 year old Civilian Conservation Core dams, and the access it grants to the Summit road and the popular Telegraph and National trails. All these features made it an ideal location for a study on social trails, particularly due to the high traffic it sees and the variety of visitors who use it. The social trail itself exists about halfway up Kiwanis trail and forms a shortcut between two sections of the trail. It is a persistent social trail that has existed for years in South Mountain Park and repeatedly resisted management attempts at closure. This spot was also ideal due to nearby terrain and an overlooking lookout that allowed for unobtrusive observation.

Participants

The participants in this experiment were visitors at South Mountain Park in Phoenix, AZ during the spring hiking season in March and April. Spring represents a period between the winter hiking boom and the summer heat when there is a balance of regulars and seasonal guests on the trails. Participants were selected based on the visitors that could be observed on the study trail during the treatment windows. Treatment windows lasted three to four hours and were systematically selected to fall on both mornings and afternoons during both weekends and weekdays in order to capture a more representative spread of trail users. The goal was to observe at least 150 trail users each for the control, the trail mitigation treatment, and the combined trail mitigation and signage treatment.

Research Design

The experimental design of this study was quasi-experimental since traditional random sampling was not possible due to the lack of control over the trail visitor traffic. Observation windows were systematically scheduled to capture a broad spectrum of users by including weekends, weekdays, mornings, and afternoons. Observations were captured during these three to four hour windows until at least 150 observations were recorded for the control and each of the treatments and observations had been recorded on a weekend, a weekday, a morning, and an afternoon. A control was first conducted in order to establish a baseline of social trail usage.

The dependent variable in this study was the number of park visitors observed following the social trail. The independent variables were the trail mitigation site management technique approach and the combined trail mitigation and theoretically-grounded signage approach. Both approaches were intended to reduce social trail behaviors. Treatment one, the trail mitigation technique, disguised and renaturalized the social trail, hiding it from new users who might not otherwise have known it was there and making it look less attractive to follow than the official trail. Treatment two, the combined approach, integrated theoretically-grounded signage incorporating injunctive-proscriptive wording, an attribution message, and a reasoning message targeting behavioral beliefs, norms, and control alongside the trail mitigation site management technique. The signage delivered an educational message intended to sway both new and established social trail users. The control consisted of no treatment.

Potential threats to internal validity in this study were history and diffusion of treatment. With respect to history, because time passed during a study treatment, the conditions of the trail changed over the treatment time due to visitors walking over/disturbing the trail mitigation. These actions were noted in the observer's log, and the observer repaired any damage significant enough to compromise the rest of the treatment. As far as diffusion of treatment, it was possible for experienced local hikers to discover that an experiment was going on if there was a leak from any organizers involved or if the observer was too conspicuous. For this reason, it was important to stress to all parties involved that this study was not to be spoken about to park visitors until after its completion. Additionally, the observer had to remain inconspicuous so that observant park visitors did not figure out what was going on and change their behavior or spread that information.

Potential threats to external validity were interaction of selection and treatment and interaction of setting and treatment. Because the study participants were limited to who was on the trails during the study hours, it may be difficult to generalize the results of this study to wider populations. To counter this, study hours and days were varied and a particularly well-used and representative trail was chosen for the experiment. As far as interaction of setting and treatment, this study occurred in a large desert climate urban-proximate park. For this reason, the results may not be generalizable to park visitors in remote front-country parks and preserves, and the results may not be generalizable to parks and preserves in other climates. However, the reason this study was conducted in a large urban-proximate park is because there is a large gap in the literature for social trail

research in urban parks, and South Mountain Park is one of the largest urban-proximate parks in the world. Therefore, there was a need to conduct the study in a large urban-proximate park such as this, and, additionally, claims will be reined in about the generalizability of the results of this study to remote front-country parks and preserves, as well as those in other, non-desert climates.

Materials and Instrumentation

This experimental study relied upon unobtrusive observation by the researcher. Since a visible onlooker could have influenced social trail behaviors, the researcher remained out of sight on a nearby hillside lookout overlooking the social trail. From there the researcher recorded whether or not passing trail users followed the social trail. The materials required were the McLeod and pick mattock tools to perform the trail mitigation site management technique, the experimental signage, a shovel, pick mattock, and concrete supplies to install the sign post in the social trail tread, and a notebook and pencil to record observations. Notes were recorded detailing whether park visitors followed the social trail under observation and what actions they took in regards to the treatment conditions such as reading the signage or disturbing the trail mitigation. These observations were recorded during each of the treatments. The researcher also utilized hiking gear and basic hiking supplies such as water to blend in as a hiker and stay hydrated throughout the study hours.

Procedure

To establish a control, the researcher first recorded how many park visitors followed the social trail (from the end being tested) without making any changes to the trail. The observations were recorded over four three-hour windows until the minimum of 150 observations were recorded over at least one weekend, one weekday, one afternoon, and one morning.

For the first treatment, the social trail was mitigated by the researcher in accordance with training received from City of Phoenix Park Rangers, numerous trail work manuals, and the research literature. The social trail was re-naturalized and disguised by breaking up the hardened tread, “planting” nearby boulders in the tread, transplanting local plants into the tread, and finally covering the tread with nearby small rock, organic matter, and loose dirt. This method of trail mitigation, or what the research literature sometimes refers to as “brushing,” disguises the social trail and presents minor obstacles while not physically blocking the trail and forcing stubborn users to go around and create new trails. Photo documentation of the trail mitigation was recorded. The trail mitigation was maintained as needed throughout the experiment. The observer recorded how many park visitors followed the social trail with the trail mitigation in place.



Fig. 3. Social trail prior to trail mitigation



Fig. 4. Completed trail mitigation



Fig. 5. Social trail junction prior to trail mitigation, social trail left



Fig. 6. Social trail junction after trail mitigation

The second treatment began by digging a hole in the middle of the mitigated social trail and installing a five foot sign post with concrete a few feet into the trail. A 9 inch by 12 inch aluminum sign was bolted to the sign post with a custom educational sign informing visitors of the impacts of off-trail travel. The language on the signage asked users “please do not leave designated trails” instead of “please stay on designated trails” in accordance with the focus theory of normative conduct and the effectiveness of injunctive-proscriptive wording (Cialdini et al. 2006). Attribution theory was utilized to create a connection between users’ behaviors and depreciative impacts to the preserve by using terms like “your off-trail tracks” and “even one person can prevent recovery” (Bradford and McIntyre, 2007). The theory of planned behavior informed language on the sign meant to change users’ attitudes toward off-trail hiking by revealing the ecological impacts of off-trail hiking, their control over those effects, and societal norms surrounding those effects. The unobtrusive observer recorded how many park visitors followed the social trail with both the trail mitigation and signage in place, maintaining the trail mitigation as needed throughout the treatment.

CITY OF PHOENIX PARKS AND RECREATION DEPARTMENT

PLEASE DO NOT LEAVE DESIGNATED TRAILS

Your off-trail tracks compress the soil
and trample plants, preventing new
growth and causing erosion damage.



Even one person can prevent recovery.
Help us protect our mountain preserves.



City of Phoenix

PHOENIX CITY CODE 24-36

Fig. 7. Educational signage developed for study



Fig. 8. Combined trail mitigation and signage treatment

Measures and Analysis

Data was collected in the form of a tally system in a notebook kept by the researcher during the observation hours. The tally system tracked how many trail users passed by and how many followed the social trail. Notes were kept on whether the users paused at the trail, whether they read the signage once it was installed, and what type of trail user they were.

CHAPTER 4: RESULTS

Control

Control observations were collected over a total of 12 hours during four three-hour observation sessions on a Sunday afternoon, a Tuesday morning, a Thursday afternoon, and a Sunday morning in late March and early April of 2018. Out of a total of 191 observed trail users, 144, or 75.4% of users, were observed taking the social trail. Of those observed trail users, 34, or 17.8%, were observed to be visibly confused, stopping or hesitating at the trail junction. This established a baseline of social trail use, showing the vast majority of trail users were following the social trail.



Fig. 9. View of the social trail from the observation point

Trail Mitigation Treatment

Trail mitigation took approximately one hour to complete on the roughly 30 foot section of trail under study as laid out step by step in the methods section. Data were then collected over 12 hours during three four-hour observation sessions on a Saturday morning, a Thursday afternoon, and a Sunday morning in April of 2018. Observation began immediately following the implementation of the trail mitigation. During the 12 hours of observation, 0 out of 197 trail users were observed following the social trail. Social trail usage was reduced, so H1 was supported. However, damage to the trail mitigation was noted by the researcher when the social trail was revisited before beginning the second and third observation windows. Sparse footprints, visible efforts to kick aside the lighter rock and organic debris, and the removal of the restoration plants from the tread revealed evidence of social trail users not captured during the observation windows. The damage was documented before repairing the trail mitigation and beginning the subsequent observation windows. Due to the boulders that had been buried in the tread and the amount of material deposited on the trail, the trail mitigation weathered the user attempts to remove it relatively well. Additionally, it served its intended purpose of not forming any sort of physical barrier and allowing stubborn users to travel through the trail mitigation without circumventing it to form a new social trail.



Fig. 10. Damage to trail mitigation, seven days since last visit

Trail Mitigation and Signage Treatment

The trail mitigation treatment was successful in reducing all observed social trail usage, down from 75.4% in the control, in support of H1. Yet there was clear evidence of unobserved trail users walking through the mitigated trail and attempting to clear it. With the addition of the signage, the hope was to stop all social trail use by making management intentions clear in regards to the social trail closure with an official indicator as well as swaying the social trail users with the theory-grounded signage message described in the methods section. Following the installation of the signage, data were collected over 12 hours during three four-hour observation sessions on a Thursday morning, a Sunday afternoon, and a Sunday morning in late April and early May of 2018.

Out of 181 observed trail users, 0 were observed following the social trail. Of those 181, 7.1% were observed stopping to read the educational signage. H2 predicted that the addition of the signage would significantly reduce social trail usage, and though the earlier treatment had already reduced all observed social trail usage, H2 was supported by completing the same goal. However, after beginning the treatment, the same pattern of evidence of sparse footsteps and light disturbance to the trail mitigation was found by the researcher upon revisiting the site before each subsequent observation session. Thus, while social trail usage was still significantly reduced down from 75.4% usage, unobserved use continued. No damage to the signage was ever observed during the treatment. Pictures of the light damage to the trail mitigation were documented before restoring it and proceeding with each observation session.



Fig. 11. Damage to trail mitigation with signage installed, 10 days since last visit

Later Observations

The research site was revisited twice by the researcher in the following months after initial data collection was finished, once in early June and once in mid-August. Since the short-term observation data had been so conclusive, the interest in longer-term data collection was to observe the longevity of the trail mitigation and signage without regular maintenance. With long gaps between maintenance on the trail mitigation, a fair amount of the light material was displaced to either side of the trail by the entrenched user(s). The “hardened” elements remained in place, in this case the buried boulders and the signage. Interestingly, during the second visit in mid-August it was noted that some unknown party had written “No” in the sand along with an arrow pointing to the designated trail, implying possible social pressure on the entrenched user.



Fig. 12. Damage to trail mitigation, six weeks since last visit, “No” with arrow pointing to official trail

CHAPTER 5: DISCUSSION

The success of the initial trail mitigation treatment in significantly reducing observed social trail usage from the 75.4% baseline to 0% had two important implications. First, it established that trail mitigation is not only an economical, easy-to-implement technique with minimal drawbacks, but that it is effective on the vast majority of trail users. Second, in stripping away the observed social trail users, it revealed the presence of unobserved “entrenched” users. When the addition of the theory-grounded signage was not successful in swaying the entrenched user(s), the focus of the study began to shift. In a case like this with attempts to remove and sabotage trail mitigation by entrenched users, more resilient, “hardened” site management techniques (that still do not physically block the trail and force circumvention) are required to weather these efforts. While the trail mitigation did not force the entrenched users to circumvent the trail like a physical blockage would have, the repeated attempts to remove the trail mitigation might have eventually completely reopened the trail over time. Thus the educational signage took on a new importance; it represents a resilient measure to indicate the social trail as closed and reduce social trail usage on a permanent basis. The signage will also serve as a lasting educational message to users on the impacts of off-trail hiking and may even serve as a means of putting social pressure on the entrenched user. There was possible evidence of this effect as indicated by the “No” with an arrow pointing to the official tread discovered written in front of the sign on one of the supplemental visits to the research

site months later. Thus the signage excels as a secondary measure when trail mitigation alone is not enough and would be removed over time.

Research Implications

The most recent research on social trails has focused on adaptive site management approaches which integrate the traditional signage strategy alongside site management techniques (Hockett et al., 2017; Kidd et al., 2015; Park et al., 2008). Drawing on that research for the most effective site management techniques and up-to-date signage and applying them to a case-study style trail closure on a problem social trail in a high-use urban-proximate park was the goal of this study. Hockett et al. (2017) found trail mitigation, referred to as a light form of “brushing,” to be the most effective site management technique when utilizing direct observation. Similarly, this study found trail mitigation to be exceptionally effective on trail users, dropping a 75.4% observed social trail use rate to 0%. Alongside its benefits of being both an economical approach and one that does not force stubborn social trail users to circumvent any barriers and form new trails, this cements trail mitigation in the literature as an optimal site management technique.

As far as extending the literature, this study has made a few important strides. First, it has confirmed the effectiveness of trail mitigation. As noted in the literature review, there has been very little research on trail mitigation though it is a common tactic among practitioners who have been combatting social trails for decades. Alongside the recent Hockett et al. (2017) study, this study is another documented record of its

effectiveness, even on its own without any other site management techniques or approaches. Properly disguising and renaturalizing a social trail effectively removes the temptation for visitors not familiar with the trail by reducing the “releaser cue,” as discussed by Gramann and vander Stoep (1987). This study also reinforced that even in the face of entrenched users, trail mitigation will not force users to circumvent the trail and create new social trails, a major potential issue with the blockage and restoration site strategies (Hockett et al., 2017; Park et al., 2008).

Second, this study showed that when the vast majority of trail users are removed from the social trail equation, the presence of entrenched users is revealed. These are users who will not only stubbornly continue to use the trail when it has been disguised and renaturalized, but who will also attempt to clear and reopen the trail. Entrenched behaviors have been touched on in regards to depreciative behaviors when dealing with signage (Guo et al., 2017; Kidd et al., 2015, Marion & Reid, 2007). Ideally the theory-grounded signage in this study would have convinced the entrenched users and put a stop to all social trail behavior, but it seems there is still more work to be done in addressing these entrenched social trail users. Conducting this study at a large urban-proximate park was the ideal location to find users with entrenched behaviors due to the proximity of many local repeat users (Alberti et al., 2003; Mora-Bourgeois, 2006). Research has already shown that trailhead signage is often ignored by repeat users, so placing the signage at the junction of the social trail was the best approach to try and reach the entrenched users (Guo et al., 2017; Kidd et al., 2015). Repeat users have also been shown to ignore management pleas and attempts at persuasion (Hughes et al., 2009). Therefore,

a future direction for research in this area should be to delve further into ways to reach these entrenched, repeat users. One approach could be looking at targeted staff intervention, a technique which has been found to be effective in past research (Kidd et al., 2015). While it is a resource-intensive strategy, the presence of these entrenched users may necessitate targeted educational or enforcement staff intervention when signage and site management techniques have failed. A different direction for future research would be to look into what motivates these entrenched users. Finding out what motivates them might be a more effective way of discovering how to gain compliance and stop depreciative behaviors. For instance, it's possible that these entrenched users are highly attached to the social trail or other site of their depreciative behavior, to the point that they do not see the damage that they are causing or even value their interaction with the site over any perceived impacts. A research study with an emphasis on place attachment could be a good angle to pursue.

The setting of this study was a high-use, urban-proximate park with over 3.5 million visitors recorded in 2017. Surrounded by urban, sub-urban, and rural communities, South Mountain Park in Phoenix, AZ is literally surrounded by users, many of which only need to travel a few minutes to reach the preserve. Not only has this made residential entry social trails a major concern, it means that the preserve faces a huge number of repeat users. It is more than likely that the entrenched user(s) utilizing the social trail in this study are local, repeat users, given the regularity of the disturbance to the trail mitigation noted in the study. It is possible that these entrenched users are acting out of habit and are resisting management pleas out of preference for their habitual

routines or disdain toward management impact on those routines. Other researchers have hypothesized that habitual behaviors are difficult to influence using persuasive communication due to repeat users having strong prior intentions toward non-compliance (Hughes et al., 2009). It may be that educating these users at the site of the depreciative behavior with signage may not be the best strategy given the repetitive nature of their behaviors and the ineffectiveness of signage on repeat users (Guo et al., 2017; Kidd et al., 2015). A future angle for researchers to investigate in regards to high-use urban-proximate protected lands could be education strategies that reach the users in their communities. An education campaign on the impacts of social trails targeting the communities surrounding a protected area like South Mountain Park may be a more effective strategy than signage or site management techniques at reducing social trail behaviors overall across the preserve.

Even with the success of the trail mitigation site management technique in this study, there is still room for more research on this and other site management techniques. As far as trail mitigation, this study looked at a very common type of high-use social trail, a “shortcut” type that was only about 40 feet long. With larger social trails, it may not be feasible to mitigate the entire trail, and future studies could look at the effectiveness of trail mitigation when only the ends (access points) are mitigated on longer social trails. Multiple large-scale social trail closures in an area would make for an enlightening study, but a direct observation-style methodology would be difficult. Hidden cameras or simply looking at the damage to the trails periodically might allow this format to work. Additionally, trail mitigation could be tested on trails with different primary user-groups.

Trails primarily utilized by mountain bikers or equestrian users would create an interesting test for both trail mitigation and educational signage.

As far as signage, this study followed in the tradition of past studies in focusing on one catch-all signage design, specifically one that can be implemented at social trail junctions as suggested by past researchers (Bradford & McIntyre, 2007). It may be that a new direction is needed when it comes to social trail signage. One interesting technique observed among practitioners after this study had commenced was the usage of small, laminated, temporary signage that was designed for a specific trail closure project. It could be that signage designed to educate users on specific trail closures with reasons and graphics specific for that closure may be more effective than catch-all signage. Signs of this type could incorporate satellite photos and give management reasons for the specific trail closure, even showing photographs of actual examples of ecological damage or nearby official trails serving the same purpose. Testing this type of signage against catch-all signage would make for an interesting experiment.

Managerial Implications

In this study, the observed usage of the social trail was reduced from 75.4% to 0%. These results show how effective the trail mitigation site management technique can be on almost all users. These results are significant given the economical nature of trail mitigation in comparison to restoration sites and blockages. Restoration sites and blockages are more expensive, take more work to install, and may force users to circumvent the trail and create new social trails due to the presence of a physical barrier.

Hockett et al. (2017) acknowledged these limitations in their study, which is what led them to utilize trail mitigation, or a light form of “brushing,” as they refer to it, which simply sought to disguise the beginning of a social trail with local materials instead of blocking it entirely. Additionally, when blocking or restoration sites fail, there is a much greater loss of resources and obvious damage left behind for other users to see. Physically blocking a social trail is not recommended outside of very high-usage areas such as trailheads and parking lots where it can “corral” users in the right direction (Park et al., 2008). The idea of restoration site plants permanently reclaiming a social trail is tempting, but a more limited number of restoration plants can simply be planted as part of trail mitigation (not enough to physically block the trail) and accomplish the same goal if the treatment is successful. For all of these reasons, trail mitigation is a highly recommended first response to social trails. Disguising a social trail by “renaturalizing” the area with local materials is quick, cost effective, and highly effective on the majority of trail users. In cases with long social trails, trail mitigation can be applied to only the visible sections of the social trail from connecting trails or at least the junctions themselves. Many trail users are following their feet, and reducing that “releaser cue” is the key (Gramann & Vander Stoep, 1987).



Fig. 13. A successful trail mitigation/signage combination with restoration plants

Ideally, trail mitigation alone would be enough to close a social trail. Future research could delve further into this, but one could assume that the sooner a social trail is mitigated after being formed, the more likely the trail mitigation is to succeed and the less likely entrenched behaviors are to form among users. The effectiveness of the trail mitigation reducing all observed social trail users in this experiment revealed the presence of these unobserved “entrenched” users who not only continued to use the closed trail but even attempted to sabotage the trail mitigation. In these cases, trail mitigation alone is not going to be enough. Eventually the social trail could be reopened, and it may not be worth the effort to continually mitigate the trail if users are continually trying to reopen it. While the “hardened” aspects of the mitigation such as buried

boulders might survive over-time, the type of trail mitigation that can be applied depends on the surrounding environment. Additionally, boulders are not available and would not look natural in every environment. The goal of trail mitigation is to disguise and renaturalize the social trail, matching it to the surrounding environment. In reality there are areas where not even light slough and dead organic material are available or would look natural spread across the trail. In all of these cases, the natural next option is a “hardened” site management technique that can be applied in any environment without presenting a physical barrier, or, in a word, signage. Signage is a hardened option when entrenched users are removing trail mitigation, and it can be installed in areas where there is no material available to do proper trail mitigation. Signage also represents a way of attempting to educate the entrenched users.



Fig. 14. Trail mitigation and signage in a barren area using graded earth

When the signage was introduced in this study, the trail mitigation was already achieving a 0% social trail use among observed trail users. The goals of implementing the signage treatment therefore had become to A) implement an official indicator that the social trail was closed, given that the trail mitigation did not have this, B) install a hardened site management solution that could not be removed by the trail users, and C) see if the entrenched users could be swayed by the theory-grounded language on the signage. Unfortunately, even with the signage in place, periodic visits to the research site revealed that the entrenched social trail behavior was continuing. However, implementing the signage still achieved a number of goals. The signage now represents a long-lasting, hardened, official indicator to trail users that the social trail is non-designated and should not be followed. During the control portion of the study, several comments of confusion were overheard at the trail junction, including: “This is where we weren’t sure,” “Here? Or here?” and “Are we on the right trail?” Almost a fifth (17.8%) of trail users were observed to stop and be visibly confused at the trail junction during the control. Social trails may be started by deliberate trailblazers, but they seem to be reinforced by confused trail users who don’t know which path to follow or are simply following their feet. Disguising the social trail or placing a hardened indicator that the trail is a social trail removes that confusion and brings the usage of the social trail down to only the entrenched users. Secondly, the signage will continue to educate all trail users on the impacts of social trails, even if it did not convince the entrenched users. Finally, the signage adds a powerful social effect to the entrenched user situation. If other hikers observe the entrenched user on the social trail, they will know that this user is violating

park rules and will at least know not to follow this entrenched user and may even step in and put social pressure on the entrenched user not to violate the park rules, some evidence of which was seen in this study. While it is not feasible to station a ranger or a volunteer at the social trail at all hours, a sign serves as a sort of ranger stand-in, making the wishes of the land management agency known and educating users in place of a ranger. In the case that the signage outlasts the entrenched users and all social trail behaviors stop, the trail could be mitigated one final time and the signage could be removed if the land manager deemed it appropriate. Successful trail mitigation/signage treatments allow the option of eventually removing the signage and having an all-natural solution to a social trail.



Fig. 15. A successful trail mitigation/signage treatment

Trail mitigation and signage represent powerful, economical strategies for managers against social trails. But in cases where entrenched users are continually sabotaging trail mitigation and even vandalizing signage, other approaches must be considered. Managers should ask themselves why a social trail exists. Short-cuts exist everywhere: there are switchback cuts, “triangles” at trail junctions for mountain bikers to avoid sharp turns, and residential access trails to name a few. Maybe users are trying to reach an interesting feature like a peak, ridge, or other geological/biological interest point. Sometimes the conditions of the official trail system may not be meeting the needs of all users, for instance if the trail treads are not maintained or suitable for particular users (bedrock being incompatible with equestrian users, for example), or if there are not enough features to meet the demand of users looking for things like connecting loops or long distance trails. There is a lot to consider when looking at whether or not to close a social trail, and sometimes it may be simpler all around to examine the needs of the users and decide to adopt a social trail. This comes with its own list of challenges, especially since most social trails are not sustainable. But ultimately, adopting and making a social trail sustainable may prove to be a far more efficient use of management resources than trying to close the same trail. For instance, in a management plan for South Mountain Park, the City of Phoenix Parks and Recreation Department is currently converting many long-time social trails into sustainable designated trails based on community input. This type of community feedback process allows a land management agency to assess the demand among the community for particular social trails or otherwise a trail system that

meets their desires with features like loops, residential accesses, and trails to interesting features before ultimately deciding which trails to close and which to adopt.

Conclusion

Trail mitigation, or disguising and renaturalizing a social trail with local materials, is an effective and economical way to reduce social trail use with minimal drawbacks. In the case that entrenched users continue to use the mitigated social trail and even attempt to re-open it, a hardened, resilient approach such as theory-grounded educational signage can be utilized at the social trail junction for a more permanent indicator to all trail users that the social trail is non-designated. Even if the educational signage does not influence the entrenched users' behaviors, it will be much more difficult for entrenched users to remove and may continue to reduce usage to only the entrenched users. The signage will also serve to educate users on the effects of off-trail hiking and could even put social pressure on the entrenched users if they are observed on the signed social trail by other visitors. In the case that entrenched usage of the social trail ends and the social trail mitigation is successful, signage can be removed and the social trail can be permanently closed with the all-natural trail mitigation solution alone. While there is no perfect solution to social trails, utilizing trail mitigation to disguise and renaturalize forming social trails early and following up with educational signage as needed is an effective and economical strategy to significantly reduce social trail usage.

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