2015 UNDESIGNATED TRAIL MANAGEMENT AND MESSAGING STUDY

FINAL REPORT

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Executive Summary

The use and creation of undesignated trails, also known as "social trails" is a specific area of concern on the City of Boulder Open Space and Mountain Park (OSMP) system. Undesignated trail use can lead to erosion, vegetation damage, unsafe trail conditions, and impacts on local wildlife. Across OSMP lands there are approximately 147 miles of designated trails (DT) and over 150 miles of undesignated trails (UT). Researchers with the Leave No Trace Center for Outdoor Ethics and Penn State University collaborated with OSMP staff and volunteers to collect data at twenty randomly selected designated/undesignated trail junctions across the OSMP trails system. Through a rigorous experimental design, this study examined the effectiveness of indirect and direct management approaches for reducing the use of undesignated trails on OSMP lands. The study specifically focused on the following two hypotheses:

> H_1 All management treatments would reduce use of undesignated trails from control levels.
>
> H_2 A combination of treatments would be more effective than any single treatment in reducing use of undesignated trails from control levels.

The study took place between June 1 and June 30, 2015. During this period researchers deployed four different educational and/or management treatments as well as a control, to twenty randomly selected designated and undesignated trail intersections to determine which treatment was most effective at curbing use of undesignated trails.

Data was collected through both direct unobtrusive visitor observation and visitor surveys. Some data collection days consisted of observations only, while others included paired observation and survey data collection methods.

During survey days trained administrators intercepted visitors on the undesignated and designated trail under review. Two key findings from the survey results include:

- 42% of survey respondents were unaware that UTs existed on the OSMP system;
- Frequent visitors reported being the least likely to stay on designated trails.

During observation days trained observers conducted a census of trail users on both designated and undesignated trails, capturing the specifics of their behavior as it pertained to treatment and control conditions (i.e. interaction with treatment, decision made at trail intersection). Surveys were collected during each paired sampling period, which facilitated a more robust understanding of the efficacy of the educational messages and site management strategies by examining reported behavior and attitudes alongside actual observed behavior.

Observation data suggest the combined physical barrier and educational treatment (Treatment 5) was the most effective at mitigating undesignated trail use. This method was approximately 97% effective at directing visitors to proceed onto the DT rather than traveling on the UT. This treatment was followed in effectiveness by a physical barrier (94%), and a posted sign with an educational message (94%) different from the one used for Treatment 5. Further analysis revealed that only the combined barrier and education message treatment (Treatment 5) produced a statistically significant reduction in undesignated trail use compared to control conditions. Thus, in regards to H1, the authors fail to reject the null hypothesis on the grounds that statistically significant reductions were not produced by all treatments over and above control conditions. Further, the authors reject the null alternative of H2 based on results of post hoc tests indicating a statistically significant relationship was observed between Treatment 5 and reduced undesignated trail use, over and above control conditions.

These findings indicate that the combined educational message ("Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize erosion. This is Not a Designated Trail") with a physical barrier (i.e., Treatment 5) was the most effective method for mitigating use of undesignated trails utilized in this study. However, it was also found that Treatments 3 (educational signage) and 4 (physical barrier) resulted in observed reductions in UT use (though not statistically significant). While these results indicate that among the treatments utilized in the study only Treatment 5 produced a statistically significant reduction in undesignated trail use compared to control conditions, from an applied management perspective the other treatments may merit consideration. On OSMP lands, it may not be physically, aesthetically, or economically practical to treat every undesignated trail intersection in the system with a combination barrier and educational sign (i.e., Treatment 5). Therefore, the other treatment options used in the study should not be eliminated as management options in the face of a statistically significant test result, as statistical significance is but one indicator and it may not always be the most practical approach (Vaske, 2008). This study highlighted the varying level of effectiveness associated with the treatments applied in this study, with statistical comparisons of these conditions.

The results presented here suggest a range of UT management options exist, each with different levels of effectiveness, which provide managers a set of alternative approaches for mitigating the use of UTs on the OSMP system. OSMP staff can utilize the data provided by this research, combined with known practical constraints (i.e. human or financial resources, site characteristics, aesthetics, etc.) to make informed decisions about the most appropriate approach to mitigating the use of undesignated trails on OSMP lands.

See appendix O for a detailed summary of key findings.

Introduction

The City of Boulder Open Space and Mountain Parks (OSMP) manages approximately 45,000 acres of land in and around the City of Boulder, which offers protection of critical habitat for plant and animals and opportunities for passive recreation such as hiking, horseback riding and cycling. As the population across the frontrange of Colorado has steadily increased, annual visitation to OSMP lands is now approximately 5.3 million[1] (Vaske, Shelby & Donnelly, 2009). Research has shown that increasing visitation often leads to increased impacts to soils, vegetation, wildlife and other visitors (Hammitt & Cole, 1998).

In 2008, OSMP began the Restoration Legacy Program to address the restoration needs of the system. An important part of the program was closure and restoration of undesignated trails on OSMP lands. In order to effectively reduce use of undesignated trails, it is essential that OSMP managers have a solid understanding of which types of closure treatments are most effective at ensuring visitor compliance with OSMP trail closures (both voluntary and regulatory closures). Furthermore, an understanding of visitor motivations for using undesignated trails is paramount for implementing specific management actions (or combinations of actions) to reduce use of such trails. Thus, understanding the relationships between closure treatments and visitor behavior supports the development of sustainable trail management strategies for OSMP lands.

Background

The use and creation of undesignated trails, also known as "social trails" is a specific area of concern on the OSMP system. Across OSMP lands there are 147 miles of designated trails and over 150 miles of undesignated trails. Researchers with Leave No Trace Center for Outdoor Ethics and Penn State University collaborated with OSMP staff and volunteers to collect data at twenty randomly selected designated/undesignated trail junctions across the OSMP trails system. Through a multi-method experimental design, which included unobtrusive observation and visitor survey data collection, this study examined the effectiveness of indirect and direct management activities for reducing the use of undesignated trails on OSMP lands.

Study Justification

This was the first known study of its kind on municipal open space lands. As such, this study provides a unique addition to the scientific and professional literature on parks and

[1] Results from the 2004/2005 visitation study were multiplied by the average annual Boulder County population increase to estimate the current number of visits to OSMP.

protected areas, adding information on alternative management practices for reducing visitor impacts in parks and protected areas. Recent trend data (see Outdoor Industry Foundation, 2012) indicate that a continued increase in recreational use of public lands, including open space, is likely to occur over the coming years. Therefore, studies of this kind may be useful for both educational programs such as Leave No Trace and land managers across the country as they work to reduce recreation-related impacts.

Study Objectives

There were three primary study objectives:

1. To explore current use of UTs and DTs on OSMP lands through observation and visitor surveys (see Appendix L);
2. To deploy a series of five educational and/or management treatments/control to twenty randomly selected UTs using a stratified sampling strategy (e.g., attempting distributed stratification by a.m./p.m., weekday/weekend, treatment, location, paired sampling/observation only sampling) over a one-month period, to determine which treatment was most effective at mitigating use of undesignated trails (see Appendices H-K);
3. To pair observed OSMP trail users' response to treatments/control with survey data from those same observed individuals or parties for comparative analysis of observed behavior and reported behavior.

Study Goals

The overarching goal of this study was to apply a range of management treatments in conjunction with associated controls, and use unobtrusive visitor observation and survey methods to assess the effectiveness of the experimental management treatments in achieving closure objectives. More specifically, this study expored the following hypotheses:

> H_1 All management treatments would reduce use of undesignated trails from control levels.
>
> H_2 A combination of treatments would be more effective than any single treatment in reducing use of undesignated trails from control levels.

Literature Review

Recent trend data indicate that a continued increase in recreational use of public lands nationwide, including open space, is likely to occur over the coming years (Cordell, 2012; Outdoor Industry Foundation, 2012). Research has shown that increasing visitation often

leads to increased impacts to soils, vegetation, wildlife and other visitors (Hammitt & Cole, 1987). Of critical concern to this study is the notion that increased visitation likely correlates to an increase in the use of undesignated trails, which leads to myriad impacts (Park, Manning, & Marion, 2008).

Land managers primarily address visitor use issues through one of two approaches: indirectly through visitor education such as Leave No Trace or directly through enforcement or sanctions (Manning, 2003; Marion & Reid, 2007). The most commonly applied principle in wilderness and backcountry management is that indirect actions be applied first, with more direct management actions being applied as a last resort (Marion, 2016). Indirect management strategies have traditionally been the preferred approach to mitigating recreation-related resource impacts (Hammitt, Cole, & Monz, 2015). These strategies tend to be less financially constraining, are perceived by visitors as unobtrusive, and are more in line with the experiential values associated with outdoor recreation (Marion, Leung, Eagleston, & Burroughs, 2016; Park et al., 2008; Reigner & Lawson, 2009). However, a routinely applied indirect management strategy may not always be the most effective approach (Cole, 1995), particularly in areas that receive moderate to high traffic (Marion et al., 2016).

While previous research provides evidence to the efficacy of information/education as a means for addressing recreation-related impacts in a wilderness or backcountry context (Manning, 2003), less is known about the effectiveness of direct or indirect measures designed specifically for mitigating the use of undesignated trails in a frontcountry setting.

Much of the research on the efficacy of visitor education and information has taken place in a wilderness or backcountry setting and has explored issues related to minimum-impact knowledge, behaviors, attitudes and beliefs (Marion & Reid, 2007). These studies have found education and information to be an effective means of increasing minimum-impact knowledge (Cole, Hammond, & McCool, 1997); altering visitor behavior (Bradford & McIntyre, 2007; Johnson & Swearingen, 1992; Reigner & Lawson, 2009); and have provided guidance for message design, delivery, and content (Cole et al., 1997; Winter, 2006; Winter, Cialdini, Bator, & Rhoads, 1998).

While generally found to be efficacious, the extent to which education and information are effective in achieving management objectives varies depending on a number of factors, such as: target resource impacts, recreation settings and contexts, characteristics and circumstances of the message, and visitor experiences and behaviors to which they are applied (Reigner & Lawson, 2009). In the case of undesignated trail use, education and information have been found to be effective tools in minimizing, but not eliminating this behavior. Injunctive prescriptive messages (i.e., positively worded messages informing

visitors of behaviors that align with management objectives) with an appeal to ecological concerns are typically most effective when enforceable laws or regulations do not exist (Bradford & McIntyre, 2007; Johnson & Swearingen, 1992; Winter, Sagarin, Rhoads, Barrett, & Cialdini, 2000). With the exception of Habitat Conservation areas, off-trail travel is generally not an illegal activity on OSMP lands, therefore education and information which utilizes a prescriptive and ecologically-grounded plea might be most effective in this setting.

An aspect of recreational trail behavior that has received little attention is the degree of intentionality regarding the use of undesignated trails. In other words, the impacts of off-trail travel have been well-documented (Guo, Smith, Leung, Seekamp, & Moore, 2015; Wimpey & Marion, 2011), but an understanding of the reasons for which recreationists base their decisions to venture off trail is lacking. Do recreationists travel off designated trails knowingly with intent, or do they end up off trail accidentally due to inadequate signage or some other reason? It behooves managers to invest in efforts to understand the motives behind visitor off-trail behavior to increase the effectiveness of management strategies.

Understanding the reasons underlying problem recreation behaviors can inform managers of the most appropriate and effective approach for directing visitors to practice minimum impact behaviors. Problem recreation behaviors are often classified into 5 basic types (see Table A): illegal, careless, unskilled, uninformed, and unavoidable actions; with each category able to be influenced by messaging/education to varying levels (Manning, 2003). Illegal and unavoidable actions are considered to be little influenced by messaging/education, whereas unskilled and uninformed actions are considered to be highly responsive to messaging/education. By understanding where off-trail behaviors lie on this continuum of problem behaviors, managers can craft strategies to address the underlying causes.

Table A. Application of information/education to wilderness management problems (adapted from Manning, 2003)

Type of Problem	Example	Potential Effectiveness of Information/ Education
Illegal actions	Theft of Indian artifacts; use of wilderness by motorized off-road vehicles	Low
Careless actions	Littering; shouting	Moderate
Unskilled actions	Selecting improper campsites; building improper campfire	High
Uninformed actions	Using dead snags for firewood; camping in sight or sound of another group	Very high
Unavoidable actions	Disposing of human waste; trampling ground cover vegetation at campsites	Low

When problematic recreation behavior does occur, such as off-trail travel in particular, research suggests that resource impacts occur rapidly at the onset, and increase more slowly, if at all, thereafter (see Figure A). In other words, the relationship between use and impact is asymptotic rather than linear (Hammitt & Cole, 1987). The challenge this creates for managers is that moderate to low levels of use can create high levels of impact in a relatively short amount of time. A small minority of visitors who engage in problem behaviors can create high levels of impact that are lasting. In a system that experiences such high visitation as does OSMP, if only a small percentage of visitors engage in problem behaviors, significant and lasting impacts could result.

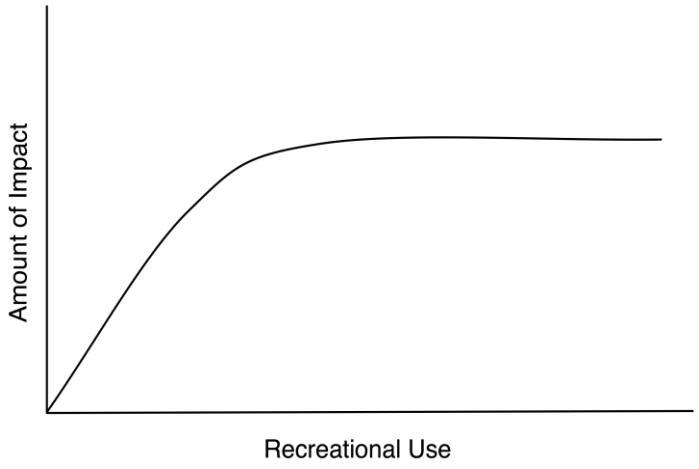

Figure A. Use Impact Curve, adapted from Hammitt & Cole, 1987

A fairly substantial body of recreational trails literature exists, which includes significant contributions from both recreational ecologists and social scientists alike. The recreation ecology literature has focused largely on the ecological impacts of human recreation behaviors, noting the effects of various recreation-related factors such as: hiking (Lynn & Brown, 2003), campsites and campfires (Marion et al., 2016), informal trail use (Wimpey & Marion, 2011), tree cutting for campfire use (Cole, 2016), rock climbing (Monz, 2009), and mountain biking (Marion et al., 2016). The common finding in this line of inquiry is that with human recreation comes inherent resource impacts. The extent of impacts is attributable to numerous factors, some site and context related, some related to the activity and equipment being used, and others specific to human behaviors.

While recreation ecologists have worked to measure and model the causes and extent of impacts, social scientists have worked to fill in the gaps by exploring the cognitive factors underpinning outdoor recreation behaviors. The research in this area has focused largely on the use of persuasive messaging techniques (Cialdini, 2003; Winter et al., 2000) to direct visitors onto designated trails and off of undesignated, or informal, trail networks (Bradford & McIntyre, 2007; Kidd et al., 2015; Park et al., 2008). Results of social science-based recreational trails research suggests that educational and informational messages are generally effective at minimizing off-trail use compared to control conditions. Lacking in these studies has been either the collection of behavioral observation data (Lawhon, Newman, Taff, & Vaske, 2013; Vagias, Powell, Moore, & Wright, 2014), survey data to add depth to observational data (Bradford & McIntyre, 2007), or a method for pairing survey and observation data when both forms are collected (Park et al., 2008).

In sum, the extant literature on indirect visitor management approaches has contributed significantly to our understanding of the efficacy of these efforts. Specifically, visitor education and information campaigns have proven to be successful means for achieving management objectives. However, the predominance of these studies have been conducted in wilderness or backcountry settings, thus less is known of the efficacy in high-use frontcountry settings. Moreover, little research has measured the effectiveness of a range of management approaches --- from indirect to direct --- in changing visitor behavior. Finally, when researchers have been able to collect observational and survey data they have often lacked the ability to pair the data sources - a commonly mentioned suggestion for future research focused on visitor behavior in parks and protected areas.

While limited research of this kind has been done in national parks and wilderness settings, most of which has been hypothetical and attitudinal rather than behavioral and experimental (see Park et al. 2008 and Johnson & Swearingen, 1992), there have been no such studies of this kind on open space lands to date. As such, this multi-method, experimental design study is a unique addition to the scientific and professional literature

on parks and protected areas, and adds to the minimal body of literature on alternative management practices for reducing visitor impacts in parks and protected areas. Studies such as this, in an open space context, may be particularly useful for both informing educational efforts and management actions that can be implemented by managers as they work to reduce recreation-related impacts.

Methods

The design of this study involved collecting data through both direct unobtrusive visitor observation and visitor surveys. Some data collection days consisted of observation only, while others *paired* observation with survey administration. The paired data collection facilitated a more robust understanding of the efficacy of the various educational messages and site management strategies. This section provides a basic overview of the methods utilized in this study. For a more detailed discussion of the applied research design and methods please see Appendix N – Methodological Protocol.

Site and Sample

Sampling design was stratified over a one-month period in June 2015. Twenty-five days of sampling were allotted for data collection, beginning June 1 and concluding on June 30. Stratification was based upon the following considerations: a) 5 treatments; b) 20 sampling locations, or sites; c) a.m. or p.m. data collection; d) weekday (i.e., Monday, Tuesday, Wednesday, and Thursday) or weekend (i.e., Friday, Saturday, and Sunday) data collection; e) paired surveying with visitor behavior observation, or observation of visitor behavior without the survey instrument; f) availability and quantity of OSMP staff/volunteers and research staff; g) the limited sampling period spanning over one-month.

Educational Treatment

The development of the treatments containing behavioral messaging (i.e., Treatments 2, 3, and 5) was informed by an elicitation study with ~30 visitors on OSMP properties in October 2014. Participants rated nine messages, each crafted based upon persuasive communications literature (Cialdini et al., 2006; Hockett & Hall, 2007; Widner & Roggenbuck, 2000; Winter & Winter, 2006). Ultimately respondents evaluated: 1) the persuasiveness of the message, and: 2) the likelihood that the message would influence the visitor to stay on designated OSMP trails. Two statements were rated as being the most influential: 1) "Stay on designated trails: Even when wet and muddy, to protects trailside plants and minimize erosion. This is Not a Designated Trail" (Treatment 2), and 2) "To Protect OSMP Lands: Please Stay on Designated Trails. This is Not a Designated Trail" (Treatment 3).

Researchers deployed the series of five educational and/or management treatments/control to twenty randomly selected designated and undesignated trail intersections using a stratified sampling strategy (AM/PM, weekday/weekend, 5 treatments, 20 locations, paired sampling/observation only sampling) to determine which treatment is most effective at curbing use of undesignated trails. Treatments included:

1. Treatment One – Control – no educational or barrier treatments in place.
2. Treatment Two – Educational treatment #1: "Stay muddy hiker"* – This sign read "Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize eroison. This is Not a Designated Trail."
3. Treatment Three – Educational treatment #2: "Protect hiker"* – This sign read "To Protect OSMP Lands: Please Stay on Designated Trails. This is Not a Designated Trail."
4. Treatment Four – Physical barrier* – Physical barrier made of logs that aesthetically fit with the OSMP environment.
5. Treatment Five – Physical barrier with Educational treatment #1*– Physical barrier made of logs that aesthetically fit with the OSMP environment with the sign that read "*Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize erosion. This is Not a Designated Trail.*" affixed to the center.

*Note: To maintain consistency and accurately determine visitor intentionality, Treatments 2, 3, 4, and 5 were set-back approximately 5 – 10 feet from the point of entry onto an undesignated trail, barring any physical barriers that inhibit this placement at a given site.

Observational Measures

Unobtrusive visitor observation was used to collect behavioral data at the 20 selected research sites. Trained observers conducted a census of trail users on both designated and undesignated trails, capturing the specifics of their behavior as it pertains to study treatments/control (i.e. interaction with treatment, decision made at trail intersection). No personally identifiable markers were captured by observers. Additional observation pairing information such as the color of lead person's bottoms and shoes was noted to ensure that observation ID numbers are appropriately paired with survey ID numbers.

Survey Instrument

The survey instrument was developed through a collaborative, iterative review process between the research team and OSMP staff. The instrument was framed within the context of the of the Theory of Planned Behavior (Ajzen, 1991) and developed to incorporate

established natural resource-based human dimensions questions, including items stemming from the Recreation Experience Preference scales (Driver, Tinsley, & Manfredo, 1991), established Leave No Trace-focused questions that have been used in numerous peer-reviewed studies (Lawhon et al., 2013; Taff et al., 2014; Vagias & Powell, 2010; Vagias, Powell, Moore, & Wright, 2014) questions regarding trail behaviors and perceptions of intervention treatments (Park, Manning, & Marion, 2008), and questions about visitor use preference, history, and basic demographic information.

In the early development of the survey instrument, it was pretested with ~30 Penn State undergraduate students; and was subsequently field tested with visitors on OSMP properties in May 2015. Pretesting allowed respondents to inform researchers of potentially confusing wording and layout issues.

Two trained surveyors worked together during each paired sampling period with one surveyor on the designated trail and the other on the undesignated trail.

Results

Observation Data

This section includes descriptive results related to the observation data.

Table 1: Walkers/hikers comprised the majority of observed visitor activities (76%), followed by runners (18%) and bikers (6%) respectively.

Table 1. Observed activity

Activity		N	Percent
	Hiking/Walking	1692	76.0
	Running	396	17.8
	Biking	123	5.5
	Climbing	2	.1
	Equestrian	3	.1
	Other	10	.4
	Total	2226	100.0
	999	4	
Missing	System	2	
	Total	6	
Total		2232	

Table 2: The majority of visitors were traveling alone (58%), while 31% visited in pairs. Overall mean group size was 1.65.

Table 2. Observed group size

Group Size		N	Percent
	1	1280	57.5
	2	695	31.2
	3	134	6.0
	4	73	3.3
	5	20	.9
	6	9	.4
	7	7	.3
	8	6	.3
	10	1	.0
	12	1	.0
	13	1	.0
	16	1	.0
	Total	2228	100.0
	Mean	**1.65**	
Missing	999	4	
Total		2232	

Table 3: Approximately 25% of visitors were observed traveling with one or more dogs.

Table 3. Number of dogs observed per observation

Number of Dogs	N	Percent
0	1677	75.1
1	430	19.3
2	101	4.5
3	12	.5
4	2	.1
9	1	.0

Table 4: This is a simplified version of Table 3. Approximately 25% of visitors were observed traveling with one or more dogs.

Table 4. Dog present – dichotomous (Yes/No)

Presence of dog(s)	N	Percent
No Dog	1677	75.1
One or more dogs	555	24.9
Total	2232	100.0

Table 5: Dry Creek had the highest percentage of visitors traveling with one or more dogs. Roughly 95% of visitors here were observed with dogs. Cragmoor had the second highest (52%) followed by BVR (42%).

Table 5. Study location by Number of dogs observed

		Number of Dogs						
Location		**0**	**1**	**2**	**3**	**4**	**9**	**Total**
Sanitarium	Count	144	62	18	0	0	0	224
	% within Location	64.3%	27.7%	8.0%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	8.6%	14.4%	17.8%	0.0%	0.0%	0.0%	10.1%
Chautauqua	Count	97	31	5	0	0	0	133
	% within Location	72.9%	23.3%	3.8%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	5.8%	7.2%	5.0%	0.0%	0.0%	0.0%	6.0%
Anemone	Count	64	17	2	0	0	0	83
	% within Location	77.1%	20.5%	2.4%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	3.8%	4.0%	2.0%	0.0%	0.0%	0.0%	3.7%
Hogback	Count	27	1	0	0	0	0	28
	% within Location	96.4%	3.6%	0.0%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	1.6%	0.2%	0.0%	0.0%	0.0%	0.0%	1.3%
Lost Gulch	Count	56	3	2	0	0	0	61
	% within Location	91.8%	4.9%	3.3%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	3.3%	0.7%	2.0%	0.0%	0.0%	0.0%	2.7%
BVR	Count	75	39	12	2	0	1	129
	% within Location	58.1%	30.2%	9.3%	1.6%	0.0%	0.8%	100.0%
	% within Dogs	4.5%	9.1%	11.9%	16.7%	0.0%	100.0%	5.8%
Settler's	Count	155	27	4	1	0	0	187
	% within Location	82.9%	14.4%	2.1%	0.5%	0.0%	0.0%	100.0%

Location		Number of Dogs						Total
		0	1	2	3	4	9	
	% within Dogs	9.2%	6.3%	4.0%	8.3%	0.0%	0.0%	8.4%
Sanitas	Count	299	39	8	2	0	0	348
	% within Location	85.9%	11.2%	2.3%	0.6%	0.0%	0.0%	100.0%
	% within Dogs	17.8%	9.1%	7.9%	16.7%	0.0%	0.0%	15.7%
Red Rocks	Count	67	14	5	1	0	0	87
	% within Location	77.0%	16.1%	5.7%	1.1%	0.0%	0.0%	100.0%
	% within Dogs	4.0%	3.3%	5.0%	8.3%	0.0%	0.0%	3.9%
Cragmoor	Count	19	15	5	0	0	0	39
	% within Location	48.7%	38.5%	12.8%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	1.1%	3.5%	5.0%	0.0%	0.0%	0.0%	1.8%
Amphitheater	Count	112	10	1	0	0	0	123
	% within Location	91.1%	8.1%	0.8%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	6.7%	2.3%	1.0%	0.0%	0.0%	0.0%	5.5%
NCAR	Count	82	20	3	0	0	0	105
	% within Location	78.1%	19.0%	2.9%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	4.9%	4.7%	3.0%	0.0%	0.0%	0.0%	4.7%
Coal Seam	Count	122	16	4	1	0	0	143
	% within Location	85.3%	11.2%	2.8%	0.7%	0.0%	0.0%	100.0%
	% within Dogs	7.3%	3.7%	4.0%	8.3%	0.0%	0.0%	6.4%
Flagstaff	Count	35	5	0	0	0	0	40
	% within Location	87.5%	12.5%	0.0%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	2.1%	1.2%	0.0%	0.0%	0.0%	0.0%	1.8%
Dakota Ridge	Count	194	36	5	1	1	0	237
	% within Location	81.9%	15.2%	2.1%	0.4%	0.4%	0.0%	100.0%
	% within Dogs	11.6%	8.4%	5.0%	8.3%	50.0%	0.0%	10.7%
Gunbarrel	Count	24	0	0	0	0	0	24
	% within Location	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%
Dry Creek	Count	4	51	21	2	0	0	78
	% within Location	5.1%	65.4%	26.9%	2.6%	0.0%	0.0%	100.0%
	% within Dogs	0.2%	11.9%	20.8%	16.7%	0.0%	0.0%	3.5%
Four Pines	Count	17	7	3	0	0	0	27
	% within Location	63.0%	25.9%	11.1%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	1.0%	1.6%	3.0%	0.0%	0.0%	0.0%	1.2%
Red Rocks (S)	Count	20	7	0	0	0	0	27
	% within Location	74.1%	25.9%	0.0%	0.0%	0.0%	0.0%	100.0%
	% within Dogs	1.2%	1.6%	0.0%	0.0%	0.0%	0.0%	1.2%
Shanahan	Count	64	30	3	2	1	0	100
	% within Location	64.0%	30.0%	3.0%	2.0%	1.0%	0.0%	100.0%
	% within Dogs	3.8%	7.0%	3.0%	16.7%	50.0%	0.0%	4.5%
Total	Count	1677	430	101	12	2	1	2223
	% within Location	75.4%	19.3%	4.5%	0.5%	0.1%	0.0%	100.0%
	% within Dogs	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6: This is the same analysis as Table 5 above, with presence of dog collapsed to a Yes or No. Dry Creek had the highest percentage of visitors traveling with one or more dogs. Roughly 95% of visitors here were observed with dogs. Cragmoor had the second highest (52%) followed by BVR (42%).

Table 6. Study location by observed presence of dog(s) – dichotomous (Yes/No)

		Presence of dog(s)		
Location		**No Dog**	**One or more dogs**	**Total**
Sanitarium	Count	144	84	228
	% within Location	63.2%	36.8%	100.0%
	% within Dogs_Dichot	8.6%	15.1%	10.2%
Chautauqua	Count	97	37	134
	% within Location	72.4%	27.6%	100.0%
	% within Dogs_Dichot	5.8%	6.7%	6.0%
Anemone	Count	64	19	83
	% within Location	77.1%	22.9%	100.0%
	% within Dogs_Dichot	3.8%	3.4%	3.7%
Hogback	Count	27	1	28
	% within Location	96.4%	3.6%	100.0%
	% within Dogs_Dichot	1.6%	0.2%	1.3%
Lost Gulch	Count	56	7	63
	% within Location	88.9%	11.1%	100.0%
	% within Dogs_Dichot	3.3%	1.3%	2.8%
BVR	Count	75	54	129
	% within Location	58.1%	41.9%	100.0%
	% within Dogs_Dichot	4.5%	9.7%	5.8%
Settler's	Count	155	33	188
	% within Location	82.4%	17.6%	100.0%
	% within Dogs_Dichot	9.2%	5.9%	8.4%
Sanitas	Count	299	49	348
	% within Location	85.9%	14.1%	100.0%
	% within Dogs_Dichot	17.8%	8.8%	15.6%
Red Rocks	Count	67	20	87
	% within Location	77.0%	23.0%	100.0%
	% within Dogs_Dichot	4.0%	3.6%	3.9%
Cragmoor	Count	19	20	39
	% within Location	48.7%	51.3%	100.0%
	% within Dogs_Dichot	1.1%	3.6%	1.7%
Amphitheater	Count	112	11	123
	% within Location	91.1%	8.9%	100.0%
	% within Dogs_Dichot	6.7%	2.0%	5.5%
NCAR	Count	82	23	105
	% within Location	78.1%	21.9%	100.0%
	% within Dogs_Dichot	4.9%	4.1%	4.7%
Coal Seam	Count	122	21	143
	% within Location	85.3%	14.7%	100.0%
	% within Dogs_Dichot	7.3%	3.8%	6.4%
Flagstaff	Count	35	6	41
	% within Location	85.4%	14.6%	100.0%
	% within Dogs_Dichot	2.1%	1.1%	1.8%

Location		Presence of dog(s)		Total
		No Dog	One or more dogs	
Dakota Ridge	Count	194	43	237
	% within Location	81.9%	18.1%	100.0%
	% within Dogs_Dichot	11.6%	7.7%	10.6%
Gunbarrel	Count	24	0	24
	% within Location	100.0%	0.0%	100.0%
	% within Dogs_Dichot	1.4%	0.0%	1.1%
Dry Creek	Count	4	74	78
	% within Location	5.1%	94.9%	100.0%
	% within Dogs_Dichot	0.2%	13.3%	3.5%
Four Pines	Count	17	10	27
	% within Location	63.0%	37.0%	100.0%
	% within Dogs_Dichot	1.0%	1.8%	1.2%
Red Rocks (S)	Count	20	7	27
	% within Location	74.1%	25.9%	100.0%
	% within Dogs_Dichot	1.2%	1.3%	1.2%
Shanahan	Count	64	36	100
	% within Location	64.0%	36.0%	100.0%
	% within Dogs_Dichot	3.8%	6.5%	4.5%
Total	Count	1677	555	2232
	% within Location	75.1%	24.9%	100.0%
	% within Dogs_Dichot	100.0%	100.0%	100.0%

Table 7a: Direction of travel was operationalized as: DT – visitors approaching on the designated trail from the nearest trailhead (trailhead of interest); Exiting DT – visitors approaching from the opposite direction of the nearest trailhead (assumed to be exiting OSMP property); and UT – visitors observed on an undesignated trail. DT users comprised the majority of the sample (59%), while 31% were exiting on a DT and approximately 10% were traveling on undesignated trails.

Table 7a. Observed direction of travel

Direction of travel		N	Percent
	DT	1309	58.7
	UT	228	10.2
	Exiting DT	692	31.0
	Total	2229	100.0
Missing	999	3	
Total		2232	

Table 7b: On days when a treatment was in place (removing control days from the analysis), 51% of visitors were observed traveling on designated trails, while 39% were exiting the area and approximately 10% were traveling on undesignated trails.

Table 7b. Observed direction of travel – Control days removed

Direction of travel	N	Percent
DT	319	50.9
UT	61	9.7
Exiting DT	247	39.4
Total	627	100.0

Table 7c: Visitors who approached the study site from the opposite direction of the nearest trailhead (operationalized as exiting OSMP property) were assumed to have previously passed by the trail intersection of interest when entering the area. It is likely these visitors had passed the study site upon entry to the area and had already seen/interacted with the treatment, introducing bias to the trail use decision. When excluding these visitors from the analysis, 85% of visitors were observed using designated trails and 15% using undesignated trials.

Table 7c. Observed direction of travel (Exiting DT removed)

Direction of travel	N	Percent
DT	1309	85.2
UT	228	14.8
Total	1537	100.0

Table 8: UT users were significantly more likely to be traveling with a dog (35%) than were DT users (25%).

Table 8. Presence of a dog by trail use (DT or UT)

		Dog or no dog		
Visitor was traveling on DT or UT		**No Dog**	**One or more dogs**	**Total**
DT	Count	983	327	1310
	% within Visitor was traveling on DT or UT	75.0%	25.0%	100.0%
	% within Dog or no dog	87.1%	80.3%	85.3%
UT	Count	146	80	226
	% within Visitor was traveling on DT or UT	64.6%	35.4%	100.0%
	% within Dog or no dog	12.9%	19.7%	14.7%
Total	Count	1129	407	1536
	% within Visitor was traveling on DT or UT	73.5%	26.5%	100.0%
	% within Dog or no dog	100.0%	100.0%	100.0%

Pearson Chi-Square	10.779[a]	1	.001

Table 9: UT visitors in the 'Treatment' category (43%) approached the study site on a designated trail but continued on to the undesignated trail upon arrival at the UT/DT intersection. Those in the 'No Treatment' category (57%) approached the study site from the opposite direction of the treatment.

Table 9. Observed direction of travel on UT

Direction of travel on UT	N	Percent
No Treatment	130	57.0
Treatment	98	43.0
Total	228	100.0

Table 10: A total of 1407 visitors were observed who would have had an opportunity to interact with the treatment in place. This number is obtained when removing the visitors who were observed traveling in the exiting direction on a DT, and those UT users who were coming from the direction opposite the treatment.

Table 10. Trail use decision upon arrival at UT/DT junction

Decision at UT/DT	N	Percent
DT	1309	93
UT	98	7
Total	1407	100.0

Table 11: Treatments were randomized across 20 sites. Sanitas, Dakota Ridge and Sanitarium were the top three most frequently visited sites, with 348, 237 and 228 observations respectively.

Table 11. Location by Treatment

		Treatment					
Location		**Control**	**Ed 1**	**Ed 2**	**Barrier**	**Barrier/Ed**	**Total**
Sanitarium	Count	39	42	50	60	37	228
	% within Treatment	6.2%	8.1%	12.7%	18.0%	10.4%	10.2%
Chautauqua	Count	25	37	31	26	15	134
	% within Treatment	4.0%	7.1%	7.8%	7.8%	4.2%	6.0%
Anemone	Count	20	14	24	16	9	83
	% within Treatment	3.2%	2.7%	6.1%	4.8%	2.5%	3.7%
Hogback	Count	6	5	5	7	5	28
	% within Treatment	1.0%	1.0%	1.3%	2.1%	1.4%	1.3%
Lost Gulch	Count	3	14	18	27	1	63
	% within Treatment	0.5%	2.7%	4.6%	8.1%	0.3%	2.8%
BVR	Count	46	17	14	26	26	129
	% within Treatment	7.3%	3.3%	3.5%	7.8%	7.3%	5.8%
Settler's	Count	67	35	41	20	25	188

Location		Treatment					Total
		Control	Ed 1	Ed 2	Barrier	Barrier/Ed	
	% within Treatment	10.7%	6.7%	10.4%	6.0%	7.0%	8.4%
Sanitas	Count	197	57	46	12	36	348
	% within Treatment	31.4%	11.0%	11.6%	3.6%	10.1%	15.6%
Red Rocks	Count	19	23	23	8	14	87
	% within Treatment	3.0%	4.4%	5.8%	2.4%	3.9%	3.9%
Cragmoor	Count	11	2	7	10	9	39
	% within Treatment	1.8%	0.4%	1.8%	3.0%	2.5%	1.7%
Amphitheater	Count	28	22	16	23	34	123
	% within Treatment	4.5%	4.2%	4.1%	6.9%	9.5%	5.5%
NCAR	Count	22	14	20	12	37	105
	% within Treatment	3.5%	2.7%	5.1%	3.6%	10.4%	4.7%
Coal Seam	Count	36	33	29	37	8	143
	% within Treatment	5.7%	6.3%	7.3%	11.1%	2.2%	6.4%
Flagstaff	Count	12	21	1	7	0	41
	% within Treatment	1.9%	4.0%	0.3%	2.1%	0.0%	1.8%
Dakota Ridge	Count	76	108	36	0	17	237
	% within Treatment	12.1%	20.8%	9.1%	0.0%	4.8%	10.6%
Gunbarrel	Count	4	11	6	3	0	24
	% within Treatment	0.6%	2.1%	1.5%	0.9%	0.0%	1.1%
Dry Creek	Count	3	29	13	20	13	78
	% within Treatment	0.5%	5.6%	3.3%	6.0%	3.6%	3.5%
Four Pines	Count	2	1	5	10	9	27
	% within Treatment	0.3%	0.2%	1.3%	3.0%	2.5%	1.2%
Red Rocks (S)	Count	3	9	0	9	6	27
	% within Treatment	0.5%	1.7%	0.0%	2.7%	1.7%	1.2%
Shanahan	Count	8	26	10	0	56	100
	% within Treatment	1.3%	5.0%	2.5%	0.0%	15.7%	4.5%
Total	Count	627	520	395	333	357	2232
	% within Treatment	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 12: Shift type - observation only or paired (observation and survey) was stratified across treatment type. There was an even split in total observations by shift type, and all treatment types were adequately represented in the observations.

Table 12. Shift Type by Treatment

		Treatment					
Shift Type		**Control**	**Ed 1**	**Ed 2**	**Barrier**	**Barrier/Ed**	**Total**
Observation	Count	453	202	176	124	158	1113
	% within Treatment	72.2%	38.8%	44.6%	37.2%	44.3%	49.9%
Paired	Count	174	318	219	209	199	1119
	% within Treatment	27.8%	61.2%	55.4%	62.8%	55.7%	50.1%
Total	Count	627	520	395	333	357	2232
	% within Treatment	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 13: Observation shifts consisted of four different time periods, which were stratified by treatment and day. The majority of observations were made during the Late AM shift (731). All treatment types were adequately represented across shift periods.

Table 13. Shift Period by Treatment

		Treatment					
Period		**Control**	**Ed 1**	**Ed 2**	**Barrier**	**Barrier/Ed**	**Total**
Early AM	Count	143	85	111	134	109	582
	% within Treatment	22.8%	16.3%	28.1%	40.2%	30.5%	26.1%
Late AM	Count	340	96	71	67	157	731
	% within Treatment	54.2%	18.5%	18.0%	20.1%	44.0%	32.8%
Early PM	Count	53	139	80	97	60	429
	% within Treatment	8.5%	26.7%	20.3%	29.1%	16.8%	19.2%
Late PM	Count	91	200	133	35	31	490
	% within Treatment	14.5%	38.5%	33.7%	10.5%	8.7%	22.0%
Total	Count	627	520	395	333	357	2232
	% within Treatment	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 14a: Treatment interaction was operationalized as "Pass and Read" – the visitor took an obvious look at the treatment but did not stop moving, and a "Stop and Read" – the visitor physically stopped moving to read/observe the treatment. Ed 1 received the highest percentage of "Pass and Reads" (34%), followed by Barrier/Ed 1 (24%) and Ed 2 (20%) respectively. A Barrier received the highest percentage of "Stop and Reads" (27%), followed by Ed 1 (26%) and Barrier/Ed 1 (24%) respectively.

Table 14a. Treatment type by treatment interaction

		Treatment interaction			
Treatment Type		**None**	**Pass and Read**	**Stop and Read**	**Total**
Control	Count	341	3	4	348
	% within Treatment in place	98.0%	0.9%	1.1%	100.0%
	% within Treatment interaction	27.6%	4.2%	4.3%	24.9%
Education 1	Count	283	24	24	331
	% within Treatment in place	85.5%	7.3%	7.3%	100.0%
	% within Treatment interaction	22.9%	33.8%	26.1%	23.7%
Education 2	Count	229	14	17	260
	% within Treatment in place	88.1%	5.4%	6.5%	100.0%
	% within Treatment interaction	18.6%	19.7%	18.5%	18.6%
Barrier	Count	200	13	25	238
	% within Treatment in place	84.0%	5.5%	10.5%	100.0%
	% within Treatment interaction	16.2%	18.3%	27.2%	17.0%
Barrier/Ed	Count	181	17	22	220
	% within Treatment in place	82.3%	7.7%	10.0%	100.0%
	% within Treatment interaction	14.7%	23.9%	23.9%	15.7%
Total	Count	1234	71	92	1397
	% within Treatment in place	88.3%	5.1%	6.6%	100.0%
	% within Treatment interaction	100.0%	100.0%	100.0%	100.0%

*Total N=1407 (10 Missing Cases)

Table 14b: Treatment interaction is collapsed in to a dichotomous variable (interaction or no interaction). Of those who interacted with a treatment, Ed 1 received the greatest percentage of interaction (29%), followed by Barrier/Ed (24%). Of the treatments in place, visitors interacted with Barrier/Ed roughly 18% of the time, followed by Barrier (16%) and Ed 1 (15%).

Table 14b. Treatment type by treatment interaction (collapsed into 2 categories)

		Treatment interaction		
Treatment in place		**No Interaction**	**Interaction**	**Total**
Control	Count	341	7	348
	% within Treatment in place	98.0%	2.0%	100.0%
	% within Treatment interaction	27.6%	4.3%	24.9%
Education 1	Count	283	48	331
	% within Treatment in place	85.5%	14.5%	100.0%
	% within Treatment interaction	22.9%	29.4%	23.7%
Education 2	Count	229	31	260
	% within Treatment in place	88.1%	11.9%	100.0%
	% within Treatment interaction	18.6%	19.0%	18.6%
Barrier	Count	200	38	238
	% within Treatment in place	84.0%	16.0%	100.0%
	% within Treatment interaction	16.2%	23.3%	17.0%
Barrier/Ed	Count	181	39	220
	% within Treatment in place	82.3%	17.7%	100.0%
	% within Treatment interaction	14.7%	23.9%	15.7%
Total	Count	1234	163	1397*
	% within Treatment in place	88.3%	11.7%	100.0%
	% within Treatment interaction	100.0%	100.0%	100.0%

*Total N=1407 (10 Missing Cases)

Table 14c: Here, Ed 1 and Ed 2 have been collapsed as well as Barrier and Barrier/Ed. Of the treatments in place the 'Barrier' category was the most likely to receive a Pass and Read (7%) and Stop and Read (10%).

Table 14c. Treatment type (collapsed) by treatment interaction

		Treatment interaction			
Treatment in place		**None**	**Pass and Read**	**Stop and Read**	**Total**
Control	Count	341	3	4	348
	% within Treatment	98.0%	0.9%	1.1%	100.0%
	% within Treatment interaction	27.6%	4.2%	4.3%	24.9%
Education	Count	512	38	41	591
	% within Treatment	86.6%	6.4%	6.9%	100.0%
	% within Treatment interaction	41.5%	53.5%	44.6%	42.3%
Barrier	Count	381	30	47	458
	% within Treatment	83.2%	6.6%	10.3%	100.0%
	% within Treatment interaction	30.9%	42.3%	51.1%	32.8%
Total	Count	1234	71	92	1397*
	% within Treatment	88.3%	5.1%	6.6%	100.0%
	% within Treatment interaction	100.0%	100.0%	100.0%	100.0%

*Total N=1407 (10 Missing Cases)

Table 14d: In this case, both treatment interaction and treatment in place have been collapsed. The Barrier category received visitor interactions roughly 17% of the time, while the Education category received interaction 13% of the time.

Table 14d. Treatment type (collapsed) by treatment interaction (collapsed)

		Treatment Interaction		
Treatment in place		**No Interaction**	**Interaction**	**Total**
Control	Count	341	7	348
	% within Treatment	98.0%	2.0%	100.0%
	% within Treatment interaction	27.6%	4.3%	24.9%
Education	Count	512	79	591
	% within Treatment	86.6%	13.4%	100.0%
	% within Treatment interaction	41.5%	48.5%	42.3%
Barrier	Count	381	77	458
	% within Treatment	83.2%	16.8%	100.0%
	% within Treatment interaction	30.9%	47.2%	32.8%
Total	Count	1234	163	1397*
	% within Treatment	88.3%	11.7%	100.0%
	% within Treatment interaction	100.0%	100.0%	100.0%

*Total N=1407 (10 Missing Cases)

Table 15a: Among visitors who traveled past the study site, those who made a decision to use the UT were much more likely to interact with the treatment. Nearly 24% of UT users stopped and read the treatment.

Table 15a. Trail use decision by Treatment interaction (Including Control Days)

		Treatment interaction			
Trail use: Decision upon arrival at UT/DT Intersection		**None**	**Pass and Read**	**Stop and Read**	**Total**
DT	Count	1167	63	69	1299
	% within Decision upon arrival	89.8%	4.8%	5.3%	100.0%
	% within Treatment interaction	94.6%	88.7%	75.0%	93.0%
UT	Count	67	8	23	98
	% within Decision upon arrival	68.4%	8.2%	23.5%	100.0%
	% within Treatment interaction	5.4%	11.3%	25.0%	7.0%
Total	Count	1234	71	92	1397
	% within Decision upon arrival	88.3%	5.1%	6.6%	100.0%
	% within Treatment interaction	100.0%	100.0%	100.0%	100.0%

*Total N=1407 (10 Missing Cases)

Table 15b: Here, control days have been removed from the previous analysis. When removing observations when no treatment was in place the percentage of UT users who stopped and read the treatment is closer to 32%.

Table 15b. Trail use decision by Treatment interaction (Excluding Control Days)

		Treatment interaction			
Trail use: Decision upon arrival at UT/DT Intersection		None	Pass and Read	Stop and Read	Total
DT	Count	855	60	66	981
	% within Decision upon arrival	87.2%	6.1%	6.7%	100.0%
	% within Treatment interaction	95.7%	88.2%	75.0%	93.5%
UT	Count	38	8	22	68
	% within Decision upon arrival	55.9%	11.8%	32.4%	100.0%
	% within Treatment interaction	4.3%	11.8%	25.0%	6.5%
Total	Count	893	68	88	1049
	% within Decision upon arrival	85.1%	6.5%	8.4%	100.0%
	% within Treatment interaction	100.0%	100.0%	100.0%	100.0%

*Total N=1049 (9 Missing Cases)

Table 15c: Continuing with the previous analysis here, treatment interaction has been collapsed into a dichotomous variable. In this case, 44% of visitors who made a decision to use the UT had an interaction with the treatment.

Table 15c. Trail use by Treatment interaction (collapsed) (Excluding Control Days)

		Treatment interaction		
Trail use: Decision upon arrival at UT/DT Intersection		**No Interaction**	**Interaction**	**Total**
DT	Count	855	126	981
	% within Decision upon arrival	87.2%	12.8%	100.0%
	% within Treatment interaction	95.7%	80.8%	93.5%
UT	Count	38	30	68
	% within Decision upon arrival	55.9%	44.1%	100.0%
	% within Treatment interaction	4.3%	19.2%	6.5%
Total	Count	893	156	1049
	% within Decision upon arrival	85.1%	14.9%	100.0%
	% within Treatment interaction	100.0%	100.0%	100.0%

Table 16a: When looking at trail use decision by the type of treatment in place it is apparent that the Barrier/Ed treatment is 97% effective at directing visitors to the DT, followed by Barrier (94%), and Ed 2 (94%). This suggests the Barrier/Ed treatment to be the most effective method for mitigating use of UTs.

Table 16a. Treatment type by decision upon arrival at DT/UT Intersection (Take UT or stay on DT)

		Decision		
Treatment in place		**DT**	**UT**	**Total**
Control	Count	319	30	349
	% within Treatment	91.4%	8.6%	100.0%
	% within Decision	24.4%	30.6%	24.8%
Ed 1	Count	306	31	337
	% within Treatment	90.8%	9.2%	100.0%
	% within Decision	23.4%	31.6%	24.0%
Ed 2	Count	245	16	261
	% within Treatment	93.9%	6.1%	100.0%
	% within Decision	18.7%	16.3%	18.6%
Barrier	Count	226	14	240
	% within Treatment	94.2%	5.8%	100.0%
	% within Decision	17.3%	14.3%	17.1%
Barrier/Ed	Count	213	7	220
	% within Treatment	96.8%	3.2%	100.0%
	% within Decision	16.3%	7.1%	15.6%
Total	Count	1309	98	1407
	% within Treatment	93.0%	7.0%	100.0%
	% within Decision	100.0%	100.0%	100.0%

Chi-square = 9.642* (p=.047)

Table 16b: Chi-square analyses were used to examine whether statistically significant differences existed between Treatment and Control conditions. Only Treatment 5 (Barrier/Ed) was found to produce statistically significant differences in UT use, when compared to control conditions.

Table 16b. Treatment effectiveness: Chi-square analysis with post hoc and effect size statistics

	Trail-use decision at treatment[1]					
Treatment in place	**DT**	**UT**	**Total**	X^2	***p*-value**	**Effect size[2]**
Control	319 (91.4)	30 (8.6)	349 (100.0)			
Ed 1	306 (90.8)	31 (9.2)	337 (100.0)	.077	.782	.011
Ed 2	245 (93.9)	16 (6.1)	261 (100.0)	1.302	.254	.046
Barrier	226 (94.2)	14 (5.8)	240 (100.0)	1.570	.210	.052
Barrier/Ed	213 (96.8)	7 (3.2)	220 (100.0)	6.506	.011*	.107
Total	1309 (93.0)	98 (7.0)	1407 (100.0)			

*sig. at .05 level

[1] Cell entries are are observed counts. Values in parenthesis are percentages

[2]phi (ϕ) coefficients presented as an estimate of effect size

Table 16c: Here, control days have been removed from the previous analysis in Table 16a to focus on treatments alone.

Table 16c. Treatment type (excluding control) by decision upon arrival at DT/UT Intersection (Take UT or stay on DT)

		Decision		
Treatment in place		**DT**	**UT**	**Total**
Ed 1	Count	306	31	337
	% within Treatment	90.8%	9.2%	100.0%
	% within Decision	30.9%	45.6%	31.9%
Ed 2	Count	245	16	261
	% within Treatment	93.9%	6.1%	100.0%
	% within Decision	24.7%	23.5%	24.7%
Barrier	Count	226	14	240
	% within Treatment	94.2%	5.8%	100.0%
	% within Decision	22.8%	20.6%	22.7%
Barrier/Ed	Count	213	7	220
	% within Treatment	96.8%	3.2%	100.0%
	% within Decision	21.5%	10.3%	20.8%
Total	Count	990	68	1058
	% within Treatment	93.6%	6.4%	100.0%
	% within Decision	100.0%	100.0%	100.0%

Chi-square = 8.336* (p=.034)

Table 16d: Continuing with the previous line of analysis here, treatments have been collapsed to Ed and Barrier categories. The Barrier category of treatments was found to be 95% effective while the Ed category of treatments was 92% effective.

Table 16d. Treatment type (collapsed) by decision upon arrival at DT/UT Intersection (Take UT or stay on DT)

		Decision upon		
Treatment in place		**DT**	**UT**	**Total**
Control	Count	319	30	349
	% within Treatment	91.4%	8.6%	100.0%
	% within Decision	24.4%	30.6%	24.8%
Ed	Count	551	47	598
	% within Treatment	92.1%	7.9%	100.0%
	% within Decision	42.1%	48.0%	42.5%
Barrier	Count	439	21	460
	% within Treatment	95.4%	4.6%	100.0%
	% within Decision	33.5%	21.4%	32.7%
Total	Count	1309	98	1407
	% within Treatment	93.0%	7.0%	100.0%
	% within Decision	100.0%	100.0%	100.0%

Chi-square = 6.259* (p=.044)

Table 16c: This is the same analysis as Table 16c, but with control days removed.

Table 16c. Treatment type (collapsed excluding Control) by decision upon arrival at DT/UT Intersection (Take UT or stay on DT)

		Decision		
Treatment in place		**DT**	**UT**	**Total**
Education	Count	551	47	598
	% within Treatment	92.1%	7.9%	100.0%
	% within Decision	55.7%	69.1%	56.5%
Barrier	Count	439	21	460
	% within Treatment	95.4%	4.6%	100.0%
	% within Decision	44.3%	30.9%	43.5%
Total	Count	990	68	1058
	% within Treatment	93.6%	6.4%	100.0%
	% within Decision	100.0%	100.0%	100.0%

Chi-square = 4.160* (p=.041)

Table 17: Over 40% of visitors who were observed/surveyed while using a UT reported they "Always" use designated trails. This suggests that these visitors did not know they were in fact traveling on a UT.

Table 17. Behavioral intent vs observed behavior

	Observed Behavior		
Do you travel on designated trails?	**DT**	**UT**	**Total**
Sometimes	14	42	56
Always	41	41	82
Total	55	83	138

Survey Response Rate

Table 18: A total of 220 visitors were invited to complete a survey, yielding a total of 147 completed surveys, for an overall response rate of 68%

Table 18. Overall survey response rate

Survey Response	**N**	**Percent**
Declined	70	32
Complete	147	67
Incomplete	3	.1
Total Requested	220	100
Response Rate		**68**

Table 19: A total of 147 surveys were collected – 86 from UT users and 61 from DT users. UT users were more willing to complete a survey (80% accepted) than were DT users (57% accepted)

Table 19. Survey response by trail use

	Survey Response			
Observed Trail Use	**Declined**	**Complete**	**Incomplete**	**Total (%)**
DT	48	61	2	111 (57%)
UT	22	86	1	109 (80%)
Total	70	147	3	220 (68%)

Table 20a: Surveys were adequately distributed across treatment types.

Table 20a. Survey response by treatment type

	Treatment					
Survey Response	**Control**	**Education 1**	**Education 2**	**Barrier**	**Barrier/Ed**	**Total**
Refused	31	8	5	15	11	70
Complete	42	30	30	15	30	147
Incomplete	2	0	0	0	1	3
Total	75	38	35	30	42	220

Table 20b: Surveys were adequately distributed across treatment types.

Table 20b. Survey response by treatment type – collapsed Tx categories

	Treatment			
Survey Response	**Control**	**Education**	**Barrier**	**Total**
Refused	31	13	26	70
Complete	42	60	45	147
Incomplete	2	0	1	3
Total	75	73	72	220

Survey Response Analysis

Table 21. The large majority of respondents indicated their primary activity to be hiking/walking (74%), followed by Running (16%).

Table 21. What is your primary activity today?

Activity	**Percent (N=137)**
Hiking/Walking	74
Running	16
Walking Dog(s)	4
Biking	2
Climbing/Bouldering	0
Horseback Riding	2
Other	4

Table 22. The majority of respondents were not accompanied by a dog (69%).

Table 22. How many dogs did YOU bring today (please do not include dogs another person in your group brought)?

Number of dogs	Percent (N=144)
0	69
1	26
2	5
3	1

Table 23. Approximately 22% of respondents were visiting this specific section of trail for the first time. 32% had visited between one and twelve times previously, and 24% had made 13-48 prior visits.

Table 23. How many times have you visited this section of trail in the past 12 months?

Previous Visits	Percent (N=144)
Today is my first visit	22
1-12 visits	32
13-48 visits	24
49-144 visits	7
145-240 visits	6
>240 visits	9

Table 24. The majority of respondents (58%) are aware that some OSMP trails are undesignated or not official trails.

Table 24. Are you aware that some trails in City of Boulder OSMP are "undesignated" or not official trails?

Response	Percent (N = 142)
Yes	58
No	42

Table 25. Respondents felt that human recreation behaviors have the potential to cause both ecological and social impact, though the potential for negative ecological impact was believed to be greater than the potential for negative social impact (Mean 4.76 vs 4.12).

Table 25. To what extent do you believe that human recreation behaviors have the potential to cause NEGATIVE IMPACT, a) Ecologically, and b) Socially in City of Boulder OSMP? (Select only one answer per item)

Type of impact as a result of human recreation behaviors	N	Mean	SD	No Impact At All 1	2	3	Moderate Impact 4	5	Extensive Impact 6	7
Ecological	143	4.76	1.711	4	8	12	20	18	20	20
Social	138	4.12	2.093	15	15	7	20	12	12	20

Table 26. Respondents were asked to evaluate the appropriateness of a series of off-trail behaviors in OSMP. *Traveling off a designated trail to get away from crowds* was ranked as the least appropriate reason for off-trail travel (Mean 2.97), while *Traveling off a designated trail because there is an alternative established path* was the least inappropriate reason (Mean 3.85).

Table 26. Please indicate how INAPPROPRIATE or APPROPRIATE you think each of the following activities is for a visitor to do in City of Boulder OSMP. (Select only one answer per item)

				Very Inappropriate			Neutral			Very Appropriate
Activities	**N**	**Mean**	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
a. Traveling off a designated trail to experience the natural environment	144	3.07	1.745	22	24	15	19	10	5	6
b. Traveling around muddy spots on a designated trail	141	3.60	1.665	11	20	17	25	12	11	5
c. Traveling off a designated trail to explore	144	3.20	1.776	20	24	13	17	12	9	4
d. Traveling off a designated trail to take photos	143	3.24	1.707	19	29	29	18	11	8	4
e. Traveling off a designated trail to get away from crowds on the trail	144	2.97	1.683	23	27	13	17	11	6	3
f. Traveling off a designated trail because there is an alternative established path	143	3.85	1.910	14	18	10	20	17	12	11

Table 27. Respondents were asked to indicate how effective they believe certain behaviors are at reducing negative impacts in OSMP. Of the activities provided for reducing negative impacts in OSMP, *Adhering to messages on posted signage* was reported to be the most effective (Mean = 5.77), followed by *Staying on a designated trail* (Mean = 5.55). *Staying off a trail when conditions are wet and muddy* was reported to be the least effective (Mean = 4.81).

Table 27. Please indicate how EFFECTIVE the following activities would be at reducing NEGATIVE IMPACTS in City of Boulder OSMP.

				Never Effective			Sometimes Effective			Effective Every Time
Activities	**N**	**Mean**	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
a. Staying on a designated trail	140	5.55	1.406	1	3	6	12	21	26	32
b. Traveling in the middle of a designated trail, even when wet or muddy	141	4.97	1.507	2	4	11	22	20	24	18
c. Traveling on a designated trail, even when passing other visitors	140	5.23	1.426	1	4	5	18	21	31	19
d. Staying off a designated trail when conditions are wet and muddy	139	4.81	1.719	4	7	11	24	12	22	20
e. Adhering to messages on posted signage	141	5.77	1.397	3	1	3	10	15	32	37

Table 28. Respondents were asked to indicate how difficult various minimum-impact trail-use behaviors are in OSMP. In general, the listed behaviors were considered to be rather easy to perform. Mean scores for all but one item were above 5 on a scale of 1 to 7. *Traveling in the middle of a designated trail, even when wet or muddy* was indicated to be the most difficult behavior, with a mean of 4.96. *Adhering to messages on posted signage* was reported to be the easiest of the behaviors to perform (Mean = 5.89).

Table 28. Please indicate how DIFFICULT you think each of the following activities would be for you to do in City of Boulder OSMP. (Select only one answer per item)

				Very Difficult			Neutral			Very Easy
Activities	**N**	**Mean**	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
a. Staying on a designated trail	142	5.68	1.499	2	2	4	16	10	26	40
b. Traveling in the middle of a designated trail, even when wet or muddy	141	4.96	1.616	1	8	14	15	18	24	21
c. Traveling on a designated trail, even when passing other visitors	138	5.36	1.594	1	5	8	15	12	28	30
d. Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area	138	5.36	1.454	0	3	7	24	14	22	30
e. Traveling on a designated trail, even when an undesignated trail is available in the area	139	5.53	1.309	0	1	7	19	17	27	30
f. Traveling on a designated trail, even when you have observed another visitor traveling on an undesignated trail	139	5.48	1.491	1	4	7	14	17	25	33
g. Adhering to messages on posted signage	138	5.89	1.438	1	2	4	10	9	26	47

Table 29a. Respondents were asked to indicate how often they perform the same set of behaviors listed previously. The large majority indicated they either 'Sometimes', or 'Always' practice the behavior. The most frequently practiced behaviors were *'Always' adhering to messages posted on signage* (65%) and *'Always' staying on designated trails* (60%). While these findings suggest the majority of people 'Always' practice these minimum-impact trail behaviors, there remains a large percentage of visitors who reported to only 'Sometimes' perform the behavior. The likelihood of traveling on a designated trail appears to decline when the visitor has previously traveled a UT in the area, and/or when a UT is available in the area. Moreover, 11% of respondents indicated they 'Never' travel in the middle of a designated trail, even when wet or muddy. This finding supports the previous that this is also perceived as the most difficult of the behaviors to perform.

Table 29a. Current trail use behavior

Activities	N	Percentage		
		Never	Sometimes	Always
a. Staying on a designated trail	138	0	40	60
b. Traveling in the middle of a designated trail, even when wet or muddy	132	11	55	34
c. Traveling on a designated trail, even when passing other visitors	132	3	46	51
d. Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area	131	4	52	44
e. Traveling on a designated trail, even when an undesignated trail is available in the area	133	1	52	47
f. Traveling on a designated trail, even when you have observed another visitor traveling on an undesignated trail	132	4	44	52
g. Adhering to messages on posted signage	130	1	34	65

Table 29b. Intent to perform a behavior in the future is often used as an indicator of the likelihood of one actually following through with said behavior. Here, respondents were asked to indicate how likely they are to perform the same set of previously listed behaviors. Respondents generally indicated a high likelihood of performing each behavior. *Adhering to messages on posted signage* (Mean = 6.02) and *Staying on a designated trail* (Mean = 5.98) have the highest likelihood of being performed in the future. This result follows the previous findings – these are believed to be the easiest behaviors to perform and are currently reported to be performed most frequently. Behaviors with the lowest likelihood of future performance were: *Traveling in the middle of a designated trail, even when wet or muddy* (Mean = 5.50), *Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area* (Mean = 5.60) and *Traveling on a designated trail, even when an undesignated trail is available in the area* (5.68). Again, these results follow the pattern found in the previous analysis, in that these are perceived as the more difficult behaviors and are currently reported to be performed less frequently.

Table 29b. Future trail use behavioral intent

				Percent						
				Extremely Unlikely			Neutral			Extremely Likely
How likely are you to do this in the future?	**N**	**Mean**	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
a. Staying on a designated trail	130	5.98	1.184	0	2	2	10	12	32	42
b. Traveling in the middle of a designated trail, even when wet or muddy	129	5.50	1.387	0	3	6	14	23	22	32
c. Traveling on a designated trail, even when passing other visitors	129	5.81	1.210	0	0	5	12	19	26	39
d. Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area	125	5.60	1.374	0	2	5	18	14	26	34
e. Traveling on a designated trail, even when an undesignated trail is available in the area	130	5.68	1.234	1	0	3	15	21	28	32
f. Traveling on a designated trail, even when you have observed another visitor traveling on an undesignated trail	126	5.77	1.253	1	1	2	13	20	27	37
g. Adhering to messages on posted signage	130	6.02	1.220	2	0	1	11	13	28	46

Table 30. Respondents were asked to report whether they had traveled off a designated trail during their visit. Twenty-eight percent indicated they had, 58% had not, and 13% were unsure.

Table 30. Did you travel off a designated trail during your visit today?

Response	**Percent (N = 130)**
Yes	28
No	58
Don’t Know / Unsure	13

Table 31. Respondents were asked to indicate their reason(s) for traveling off trail during their visit. Of the reasons selected as applicable to their visit, *I didn't mean to travel off the designated trail (it was an accident)* (30%), and *I have done it before and it worked well for my visitor experience* (30%) were the most frequent responses.

Table 31. Indicate whether or not any of the following reasons for traveling off the designated trail(s) applied to your visit today. (Select only one answer per item)

		Percent		
Reasons	**N**	**Does Not Apply Because I Only Traveled On Designated Trails**	**Applies to Me**	**Don't Know**
a. I didn't know that traveling off the designated trail could damage soils and vegetation	129	63	21	16
b. I didn't know that it was recommended to stay on the designated trail	130	64	22	15
c. I didn't mean to travel off the designated trail (it was an accident)	128	57	30	13
d. I think visitors should be able to travel off the designated trail	129	57	27	16
e. I thought that it would improve my visitor experience	130	60	25	15
f. I have done it before and it worked well for my visitor experience	128	60	30	10

g. Other reason (open ended):

- As long as your actions are not detrimental to the wild
- Didn't know this wasn't a trail
- Followed our dog who went off trail
- I try to always travel on designated trails
- Less freedom of travel is more restriction to life itself
- When I didn't know a trail was undesignated
- Mud puddles
- Needed an isolated location for movie
- Only time is when weather or other people and it is rare
- Ordinarily aware and comply with exception of this trail
- This looked like a designated trail
- Wasn't posted thus didn't realize

Table 32. Respondents were provided a list of reasons for traveling only on designated trails and asked to indicate the importance of each. *To not damage soils and vegetation* (Mean = 5.96) was indicated as the most important, with 52% considering this to be 'Extremely Important'. This was followed by *Because Leave No Trace promotes traveling on designated trails* (Mean = 5.41). The least important reason was *Because I do not want anyone to see me travel off designated trails* (Mean = 3.83).

Table 32. Please indicate how IMPORTANT these reasons would be for you to travel only on designated trails in the FUTURE. (Select only one answer per item)

				Percent							
				Not relevant	**Not At All Important**			**Moderately Important**		**Extremely Important**	
Reasons	N	Mean	SD		**1**	**2**	**3**	**4**	**5**	**6**	**7**
a. To improve my outdoor experience on OSMP lands	135	4.99	1.891	6	2	4	2	22	17	24	24
b. Because visitors are encouraged to stay on designated trails	133	5.21	1.600	3	1	1	5	20	23	21	26
c. To not damage the soils and vegetation	134	5.96	1.624	4	1	1	0	9	9	25	52
d. To not break the rules	132	4.53	2.021	7	5	3	11	22	13	23	17
e. Because I do not want anyone to see me travel off designated trails	133	3.83	2.221	9	12	8	11	22	11	11	16
f. Because it is unfair for me to travel off designated trails while many other visitors do not	133	4.45	2.024	7	5	5	10	25	13	19	18
g. Because I have no reason to travel off designated trails	132	4.57	2.035	7	3	5	11	24	9	21	21
h. Because Leave No Trace promotes traveling on designated trails	133	5.41	1.891	5	2	1	3	14	11	27	36
i. Because I feel better about myself by not traveling off designated trails	133	4.68	2.193	9	5	5	3	20	12	24	23

Table 33. The majority of respondents (66%) noticed a sign or barrier meant to keep visitors on designated trails, while 50% noticed a combination sign and barrier.

Table 33. Did you notice the following on this trail today? (Check all that apply)

Items	N	% Yes	% No
Informational signage to keep visitors on designated trails	143	66	34
Fence or barrier to keep visitors on designated trails	143	66	34
Combination of informational signage and fence or barrier to keep visitors on designated trails.	143	50	50

Table 34. Respondents were asked to rank which management action would be most effective in keeping them off an undesignated trail: informational signage, fence or barrier, or a combination of informational signage and a fence or barrier. The combination sign/barrier was reported to be the most effective, followed by fence/barrier, and informational signage respectively.

Table 34. Please RANK the following in order (1st, 2nd, and 3rd), indicating which would be most effective in keeping you off an undesignated trail. (*1st = Most Effective; 3rd = Least Effective*)

Items	N	Mean
Informational signage	110	2.28
Fence or barrier	110	2.05
Combination of informational signage and fence or barrier	112	1.60

Table 35. Mean group size was 1.75, with a mode of 2.

Table 35. How many people, including yourself, were part of your group today?

N	*Mean*	*Median*	*Mode*	*SD*
139	1.75	2	2	.826

Table 36a. All respondents indicated they are residents of the US.

Table 36a. Do you live in the United States?

Response	Percent (N=141)
Yes	100
No	0

Table 36b. Seventy percent of respondents reported they live within the Boulder City limits.

Table 36b. If yes, do you live within Boulder City limits?

Response	Percent (N=119)
Yes	70
No	30

Table 37. Respondents were asked about their beliefs in regard to Leave No Trace practices and the extent to which they would change their behaviors. The majority of respondents (84%) indicated they would change their behavior if they learned their actions in OSMP were damaging the environment. The statement *Practicing "Leave No Trace" does not reduce the environmental harm caused by travel in OSMP* received less support, as only 23% responded in agreement. The standard deviation for this item (2.138) suggests there is a considerable amount of disagreement about this statement among respondents. Most

respondents disagreed that *Practicing "Leave No Trace" takes too much time* (85%). Finally, 84% believe *Practicing "Leave No Trace" effectively protects the environment so that future generations may enjoy it*. The fact that Items b and d are similar concepts but received very different levels of agreement is of note. This might suggest respondents don't believe Leave No Trace to be as effective at the local OSMP level as it is on a broader more general level.

Table 37. Please indicate how strongly you AGREE or DISAGREE with the following statements.

				Percent						
				Strongly Disagree			Neither Agree or Disagree			Strongly Agree
	N	Mean	SD	1	2	3	4	5	6	7
a. If I learned my actions in OSMP damaged the environment, I would change my behavior	138	5.89	1.508	4	1	2	9	11	25	48
b. Practicing "Leave No Trace" does not reduce the environmental harm caused by travel in OSMP	140	3.06	2.138	38	14	8	17	5	6	12
c. Practicing "Leave No Trace" takes too much time	138	2.35	1.745	47	17	11	12	4	3	5
d. Practicing "Leave No Trace" effectively protects the environment so that future generations may enjoy it	137	5.93	1.713	7	0	3	6	5	24	55

Table 38. Respondents were asked about their motivations for visiting OSMP. *Enjoying nature* (Mean = 6.36) was indicated as the greatest motivation for visiting OSMP, followed by *physical fitness* (Mean = 5.76), and *psychological health* (Mean = 5.74). Learning (Mean = 4.08) and *physical rest* (Mean = 4.39) were among the least important motivations for visitation.

Table 38. How IMPORTANT were each of the following reasons for your visit to City of Boulder OSMP today? (Select only one answer per item)

				Percent							
				Not relevant	Not At All Important			Moderately Important			Extremely Important
Reasons	N	Mean	SD		1	2	3	4	5	6	7
a. Physical fitness	139	5.76	1.572	2	2	1	1	12	14	27	42
b. Physical rest	135	4.39	2.425	10	8	7	7	13	10	19	27
c. Psychological health	139	5.74	1.639	3	1	1	1	11	12	27	42
d. Psychological rest	134	5.04	2.176	7	6	3	5	8	16	22	33
e. Escape personal/social pressures	137	5.09	2.121	7	4	3	6	14	11	21	35
f. Enjoying nature	138	6.36	1.017	1	0	0	0	4	12	23	60
g. Learning	135	4.08	2.347	9	13	7	8	16	13	13	22
h. Family/friend togetherness	134	4.81	2.484	11	7	5	3	10	10	18	37
i. Solitude	136	4.75	2.350	11	2	7	6	16	11	12	36

Table 39. Respondents were provided the opportunity to provide additional comments in an open-ended format.

Table 39. Open Ended Comments: Is there anything else you would like us to know? If so, please provide additional feedback below:

4 pines suffers from a great deal of braiding and it is hard to see the designated trail
81 yrs old and cannot climb taller than 1stair thus occasionally will take UTs that enable him to hike area
A lot to say - see survey
Education is the only way to keep people on trail. However, walking off trail to meditate or pull weeds is not the problem. Educate people...
I don't know if I should stay on trail when wet/muddy, and if walking in the middle of trail is best - signage would be good if that's what is right
I feel this trail should remain open. It provides important direct access to Chautauqua and Royal Arch from Bluebell neighborhood
I grew up in British Columbia and live in Switzerland. My answers are impacted by my experiences on trail and backcountry in both. Some areas I stay exclusively on trail; others, off piste is common
I like to lie in meadows to connect with the earth. This requires going off trail and is/has been part of my self-care in my work with the homeless and mentally ill. I don't want to harm the environment, at the same time this has been a way I nourish myself and I believe help others through my work.
I love the trail!
I realize these regulations are important in order to preserve the environment. However, I will always choose personal enjoyment/connection with nature over ANY law or regulation. Sorry.
If ever off a designated trail I am on a trail...not just grass
Let's not turn open space into a "wilderness area". Disagree with closing some social trails when there is no impact or reason to. Use the U. of C. example - they built the sidewalks where the students prefer to walk. No need to over-police!
Love OSMP - you do good work
Love the outdoors!
Maybe provide places for photography
More signage about staying on trails, specifically muddy trails
More trash cans on trails especially for dog poop
My favorite color is green and my spirit animal is a space otter
Need more mountain bike trails
Often is difficult to tell where exactly designated trails exist because of so many social trails
People are loving Chautauqua to death! Too, too crowded. I pick up trash and dog waste often when I walk my dog (not with me today he's injured)
Please finish the Sanitas Valley trail ASAP.
Please take the wooden fence down near the stone cabin/house
Poorly worded questionnaire...Lots of options not listed
Stop making open space restrictive each year
Survey is 3x too long and confusingly worded. I don't know how much valuable info you'll be able to get from it because it's really very hard to understand. Very much appreciate the work y'all do and all of the wonderful trails.
Surveyor note: This individual felt the survey was too complicated and questions not direct enough
Thank you - appreciate these programs
Thank you
Thanks for helping nature!
Thanks for your attention with this issue/ We are loving these trails to death.

The Q11 answers do not make sense and/or are contradictory to one another
The survey seems to miss critical issues like climbing access and established low volume social trails
There are always bits of trash, but I'm pleased so far. Nature is more than outdoors, but habit and happenings
These survey answers did not encompass the full spectrum. Also the future questions were irrelevant if my attitude towards OSMP doesn't change.
Too long of a survey!
Too many dogs - they often outnumber the people!
Trails should be formalized/designated if social trails indicate a logical path; Step off trail to let leashed dogs pass; walk on pasture after mowing, people need to experience this freedom; OSMP needs to be realistic about which vegetation is worth protecting - brome grass is not an endangered species; brome grass does not need protection
When trails have extreme braiding or social trails it is hard to know designated trails
Where trails are muddy - close trails
Would appreciate more signage to ask people not to collect things like mushrooms and asparagus

Survey Response by Use History

The following section includes tables and figures related to analysis that explored survey responses by visitor use history – number of previous visits.

Table 40: Frequent visitors are more likely than those who visit less often to report knowing some OSMP trails are undesignated. Alternatively, those who visit less often are less likely to know some trails are undesignated. This might suggest the more familiar one becomes with the OSMP trails system the more aware they are of the network of undesignated trails. Those who visit less are less aware and might assume UTs to be DTs.

Table 40. Relationship between visitation history and awareness of undesignated trails

		Are you aware some trails are undesignated?		
Number of previous visits		**No**	**Yes**	**Total**
First visit	Count	19	15	34
	% within Previous visit	55.9%	44.1%	100.0%
	% within Are you aware some trails are undesignated?	30.6%	17.9%	23.3%
1-12	Count	24	22	46
	% within Previous visit	52.2%	47.8%	100.0%
	% within Are you aware some trails are undesignated?	38.7%	26.2%	31.5%
13-48	Count	16	20	36
	% within Previous visit	44.4%	55.6%	100.0%
	% within Are you aware some trails are undesignated?	25.8%	23.8%	24.7%
49 or more	Count	3	27	30
	% within Previous visit	10.0%	90.0%	100.0%
	% within Are you aware some trails are undesignated?	4.8%	32.1%	20.5%
Total	Count	62	84	146
	% within Previous visit	42.5%	57.5%	100.0%
	% within Are you aware some trails are undesignated?	100.0%	100.0%	100.0%
Pearson Chi-Square	17.279[a]	3	.001	

Table 41. Significant relationships were found between visitation history and attitudes towards the appropriateness of certain trail use behaviors. Those who had visited 13-48 times previously are least likely to approve of walking around muddy spots. And those who had visited 13-48 times previously are least likely to approve of traveling off trail to get away from crowds.

Interestingly, those who had visited 13-48 times previously showed consistently lower mean scores across the battery of items, meaning their attitudes are more in line with Leave No Trace. Those who had visited 1-12 times consistently had the highest means, meaning less in line with Leave No Trace.

Table 41. Please indicate how INAPPROPRIATE or APPROPRIATE you think each of the following activities is for a visitor to do in City of Boulder OSMP.[1]

		Number of previous visits						
Behavior		**First visit**	**1-12**	**13-48**	**49 or more**	**Total**	***F***	***Sig.***
Travel off a designated trail to experience the natural environment	N	34	46	36	32	148	1.575	.198
	Mean	2.97	3.46	2.64	3.19	3.09		
	Std. Dev.	1.660	1.735	1.570	1.991	1.749		
Traveling around muddy spots while on a designated trail	N	34	44	36	31	145	4.010	.009
	Mean	3.94[b]	3.95[b]	2.83[a]	3.65[a,b]	3.61		
	Std. Dev.	1.650	1.478	1.424	1.872	1.647		
Travel off a designated trail to explore	N	34	46	36	32	148	2.397	.071
	Mean	3.00	3.61	2.67	3.50	3.22		
	Std. Dev.	1.576	1.770	1.656	2.000	1.779		
Travel off a designated trail to take photos	N	34	45	36	31	146	1.604	.191
	Mean	3.03	3.56	2.83	3.48	3.24		
	Std. Dev.	1.403	1.778	1.558	1.981	1.703		
Travel off a designated trail to get away from crowds	N	34	45	36	32	147	2.865	.039
	Mean	2.76	3.31	2.39	3.34	2.97		
	Std. Dev.	1.394	1.794	1.315	1.977	1.677		
Travel off a designated trail because there is an alternative established path	N	34	45	36	31	146	.538	.657
	Mean	3.97	4.04	3.53	3.84	3.86		
	Std. Dev.	1.817	1.758	2.063	2.067	1.908		

[1] Scale: 1=Very Inappropriate – 7=Very Appropriate

[a,b] *Superscripts represent homogeneous subgroups – Tukey's post-hoc*

Table 42. No statistically significant results, but some interesting findings are of note. For example, the most frequent visitors had the lowest mean score (more difficult) for difficulty of staying on designated trails. The same is true of *Adhering to messages posted on signage*.

Table 42. Please indicate how DIFFICULT you think each of the following activities would be for you to do in City of Boulder OSMP. [1]

		Number of previous visits						
Behavior		**First visit**	**1-12**	**13-48**	**49 or more**	**Total**	***F***	***Sig.***
Staying on a designated trail	N	33	45	35	32	145	1.223	.304
	Mean	6.06	5.64	5.60	5.34	5.66		
	Std. Dev.	1.248	1.433	1.718	1.715	1.538		
Travel in the middle of a DT, even when wet and muddy	N	33	44	35	32	144	.906	.440
	Mean	5.09	4.64	5.20	4.91	4.94		
	Std. Dev.	1.721	1.496	1.712	1.614	1.627		
Travel on a DT, even when passing other visitors	N	33	42	35	31	141	2.315	.079
	Mean	5.36	5.17	5.91	4.97	5.35		
	Std. Dev.	1.475	1.607	1.358	1.816	1.591		
Travel on a DT even when you have previously traveled on a UT in the area	N	33	45	34	29	141	.928	.429
	Mean	5.52	5.07	5.53	5.45	5.36		
	Std. Dev.	1.253	1.587	1.581	1.270	1.451		
Travel on a DT, even when a UT is available in the area	N	33	45	34	30	142	1.998	.117
	Mean	5.79	5.20	5.82	5.47	5.54		
	Std. Dev.	1.053	1.440	1.290	1.332	1.313		
Travel on a DT, even when you have observed others traveling on UT	N	33	44	35	30	142	1.534	.209
	Mean	5.45	5.16	5.86	5.63	5.50		
	Std. Dev.	1.543	1.569	1.287	1.520	1.496		
Adhering to messages on posted signage	N	33	43	35	30	141	1.223	.304
	Mean	6.15	5.88	5.97	5.47	5.88		
	Std. Dev.	1.349	1.401	1.403	1.717	1.466		

[1] Scale: 1=Very Difficult – 7=Very Easy

Table 43. No statistically significant relationship was found between visitation history and behavioral intent. However, it is worth noting those who had visited 49 or more previous times were found to be the least likely to *Stay on a designated trail* and *Adhere to messages posted on signage*.

Table 43. Please indicate how LIKELY you are to do the activity in the future by circling the number of your response for each statement.[1]

		Number of previous visits						
Behavior		**First visit**	**1-12**	**13-48**	**49 or more**	**Total**	***F***	***Sig.***
Staying on a designated trail	N	30	42	32	28	132	1.039	.378
	Mean	6.10	5.95	6.09	5.61	5.95		
	Std. Dev.	1.269	1.058	1.118	1.474	1.219		
Travel in the middle of a DT, even when wet and muddy	N	29	42	32	28	131	1.069	.365
	Mean	5.66	5.26	5.75	5.29	5.47		
	Std. Dev.	1.317	1.499	1.368	1.357	1.400		
Travel on a DT, even when passing other visitors	N	29	42	32	28	131	.913	.437
	Mean	5.69	5.76	6.09	5.61	5.79		
	Std. Dev.	1.285	1.376	.856	1.343	1.239		
Travel on a DT even when you have previously traveled on a UT in the area	N	29	41	30	27	127	.527	.665
	Mean	5.66	5.39	5.80	5.56	5.58		
	Std. Dev.	1.233	1.339	1.472	1.577	1.394		
Travel on a DT, even when a UT is available in the area	N	29	43	32	28	132	1.084	.358
	Mean	5.79	5.47	5.94	5.54	5.67		
	Std. Dev.	1.236	1.386	1.076	1.201	1.246		
Travel on a DT, even when you have observed others traveling on UT	N	29	40	32	27	128	.887	.450
	Mean	5.90	5.55	6.00	5.70	5.77		
	Std. Dev.	1.175	1.431	1.191	1.137	1.256		
Adhering to messages on posted signage	N	29	43	32	28	132	1.641	.183
	Mean	6.28	5.95	6.19	5.61	6.01		
	Std. Dev.	1.032	1.253	1.120	1.571	1.263		

[1] Scale: 1=Very Unlikely – 7=Very Likely

Table 44: A statistically significant relationship was found between visitation history and reasons for staying on designated trails. Those who had visited 49 or more previous times indicated the reason *To not damage the soils and vegetation* to be less important of a reason compared to those in the other visitation categories. Moreover, while not statistically significant it is worth noting the '49 or more' previous visits category of survey respondents consistently had the lowest mean scores for the items in this block of questions.

Table 44. Please indicate how IMPORTANT these reasons would be for you to travel only on designated trails in the FUTURE. [1]

		Number of previous visits						
Behavior		**First visit**	**1-12**	**13-48**	**49 or more**	**Total**	***F***	***Sig.***
To improve my outdoor experience on OSMP lands	N	33	44	33	28	138	.542	.654
	Mean	5.03	5.09	5.24	4.64	5.02		
	Std. Dev.	1.667	1.776	2.092	2.077	1.885		
Because visitors are encouraged to stay on designated trails	N	33	43	32	28	136	1.059	.369
	Mean	5.58	5.23	5.13	4.86	5.21		
	Std. Dev.	1.226	1.493	1.773	1.919	1.603		
To not damage the soils and vegetation	N	32	43	32	30	137	3.461	.018
	Mean	6.41	6.23	5.88	5.23	5.97		
	Std. Dev.	1.043	1.324	1.661	2.161	1.613		
To not break the rules	N	32	41	32	29	134	.454	.715
	Mean	4.59	4.66	4.66	4.14	4.53		
	Std. Dev.	1.757	1.944	2.323	2.216	2.047		
I do not want others to see me travel off DT	N	31	43	33	29	136	.897	.445
	Mean	3.81	3.60	4.30	3.45	3.79		
	Std. Dev.	2.136	2.269	2.404	2.131	2.242		
It is unfair for me to travel off DT while others do not	N	33	41	33	29	136	1.389	.249
	Mean	4.15	4.56	4.82	3.83	4.37		
	Std. Dev.	2.063	1.988	2.242	2.089	2.100		
I have no reason to travel off DT	N	33	41	32	29	135	1.913	.131
	Mean	4.79	4.27	5.09	3.97	4.53		
	Std. Dev.	1.816	2.062	2.220	2.146	2.083		
Leave No Trace promotes traveling on DT	N	33	42	32	29	136	1.952	.124
	Mean	5.82	5.50	5.31	4.66	5.35		
	Std. Dev.	1.667	1.811	1.942	2.395	1.968		
I feel better about myself by not traveling off DT	N	33	41	33	29	136	1.317	.271
	Mean	5.18	4.39	4.82	4.17	4.64		
	Std. Dev.	1.960	2.201	2.365	2.391	2.237		

[1] Scale: 1=Not at all important – 7=Extremely important

Table 45: Statistically significant relationships were found between behavioral beliefs and visitation history. A plurality of frequent visitors are less likely to change their behaviors than are those who visit less frequently. Additionally, the most frequent visitors are less likely to agree that practicing Leave No Trace effectively protects the environment than are those who visit less often.

Table 45. Please indicate how strongly you AGREE or DISAGREE with the following statements.[1]

		Number of previous visits						
Statement		**First visit**	**1-12**	**13-48**	**49 or more**	**Total**	***F***	***Sig.***
If I learned my behaviors damaged the environment I would change my behavior	N	33	44	35	29	141	3.869	.011
	Mean	6.27b	5.91a, b	6.09b	5.07a	5.87		
	Std. Dev.	1.039	1.378	1.292	2.154	1.532		
Practicing Leave No Trace does not reduce the environmental harm caused by travel in OSMP	N	33	45	35	30	143	1.473	.225
	Mean	2.73	3.47	2.63	3.33	3.06		
	Std. Dev.	1.989	2.252	1.911	2.279	2.130		
Practicing Leave No Trace takes too much time	N	33	43	35	30	141	.673	.570
	Mean	2.06	2.30	2.46	2.67	2.36		
	Std. Dev.	1.499	1.655	1.837	2.057	1.754		
Practicing Leave No Trace effectively protects the environment for future generations	N	33	44	34	29	140	3.795	.012
	Mean	6.36b	6.25b	5.79a,b	5.10a	5.93		
	Std. Dev.	.994	1.349	1.789	2.366	1.703		

[1] Scale: 1=Strongly Disagree – 7=Strongly Agree

[a, b] Superscripts represent homogeneous subgroups – Tukeys post-hoc

Table 46: Statistically significant relationships were found between visitation motivations and visitation history. Those who visit more frequently rate physical fitness as more important than those who visit less frequently. Family/friend togetherness is more important for the less frequent visitors than for those who visit more often.

Table 46. Relationship between visitation motivations and visitation history[1]

		Number of previous visits						
Reasons		**First visit**	**1-12**	**13-48**	**49 or more**	**Total**	***F***	***Sig.***
Physical fitness**	N	32	44	34	32	142	3.947	.010
	Mean	5.34	5.59	5.74	6.56	5.79		
	Std. Dev.	1.789	1.675	1.601	.669	1.566		
Physical rest	N	31	42	34	31	138	.526	.665
	Mean	4.03	4.36	4.41	4.81	4.40		
	Std. Dev.	2.387	2.377	2.311	2.701	2.427		
Psychological health	N	32	44	34	32	142	1.519	.212
	Mean	5.59	5.64	5.62	6.31	5.77		
	Std. Dev.	1.643	1.780	1.633	1.330	1.630		
Psychological rest	N	30	42	35	30	137	.310	.818
	Mean	4.80	5.29	5.17	5.03	5.09		
	Std. Dev.	2.355	1.979	1.932	2.553	2.172		
Escape personal/social pressures	N	32	44	33	31	140	1.129	.340
	Mean	4.81	5.50	4.73	5.29	5.11		
	Std. Dev.	2.320	1.824	2.198	2.254	2.133		
Enjoying nature	N	31	44	34	32	141	1.985	.119
	Mean	6.29	6.59	6.06	6.47	6.37		
	Std. Dev.	.902	.816	.952	1.319	1.010		
Learning	N	32	44	32	30	138	.668	.573
	Mean	4.00	4.30	3.66	4.40	4.10		
	Std. Dev.	2.328	2.474	2.223	2.283	2.334		
Family/friend togetherness**	N	32	43	32	30	137	5.332	.002
	Mean	5.34	5.53	4.13	3.57	4.73		
	Std. Dev.	2.134	2.323	2.485	2.674	2.513		
Solitude	N	32	42	34	31	139	1.656	.180
	Mean	4.16	4.60	4.79	5.45	4.73		
	Std. Dev.	2.477	2.678	2.143	1.947	2.373		

[1] Scale: 1=Not at all Important – 7=Extremely Important

Paired Survey and Observation: Survey Response by Trail Use (DT or UT)

This section includes tables and figures related to analysis of survey responses by whether the visitor was surveyed while traveling on a designated trail (DT) or undesignated trail (UT).

Table 47. DT users are more likely than UT users to report 'Always' staying on a DT (77% vs 49%). DT users more likely than UT users to report 'Always' staying on DT when UT is available in the area (53% vs 39%).

Table 47. Self-reported frequency of trail behavior by observed trail-use[1]

Item	Never	Sometimes	Always	X^2	*p-value*
How often do you stay on designated trails?				9.624	.002
DT	0	24	77		
UT	0	51	49		
How often do you stay on designated trails when a UT is available in the area?				7.556	.023
DT	8	39	53		
UT	1	60	39		
How often do you adhere to messages on posted signage?				8.180	.017
DT	2	20	78		
UT	0	43	58		

[1.] Cell entries are row percentages, totals may not add to 100 due to rounding

Table 48: Statistically significant results were found for each item in this block of questions. UT users were more likely than DT users to select the *Applies to me* and *Don't Know* response options across all items in this block. Moreover, a large proportion of UT users consistently selected the *Does not apply because I only travel on DTs' option*. This might suggest many respondents were not aware they were traveling on a UT. Among UT users, the most commonly selected reasons for traveling off trails were *I didn't mean to travel off the designated trail - it was an accident* (45%), and *I have done it before and it worked well for my visitor experience* (43%).

Table 48. Self-reported reasons for trail behavior by observed trail-use[1]

Item	Does Not Apply	Applies to me	Don't Know	X^2	*p-value*
I didn't know traveling off DT would damage soils/vegetation				9.473	.009
DT	78	15	7		
UT	52	25	23		
I didn't know it was recommended to stay on DT				18.421	<.001
DT	85	9	6		
UT	49	39	21		
I didn't mean to travel off DT - was an accident				26.887	<.001
DT	83	9	7		
UT	38	45	18		
I think visitors should be able to travel off DT				17.679	<.001
DT	78	11	11		
UT	41	39	20		
I thought it would improve my experience				15.907	<.001
DT	80	13	7		
UT	45	33	21		
I have done it before and it worked well for my visitor experience				17.500	<.001
DT	81	11	8		
UT	45	43	12		

[1.] Cell entries are row percentages, totals may not add to 100 due to rounding

Table 49: A statistically significant difference was found between DT and UT users in the importance they placed on the statement *I have no reason to travel off DTs as a reason for staying on DTs*. This appears to be less important of a reason for UT users than for DT users, which might suggest those who use UTs have reason or intention to use them.

Table 49. Analysis of UT and DT survey responses – Reasons for staying on designated trails

Item	Mean Scores		*t*	*p-value*
	DT	UT		
Reason for staying on designated trails *(Scale: 1=Not at all Important – 7=Extremely Important)*				
I have no reason to travel off designated trails	5.14	4.32	2.344	.021

Survey Response by Place of Residence

This section includes tables and figures related to analysis of survey responses by reported place of residence (Boulder resident vs non-Bouder residents).

Table 50: A significant difference was found between residents and non-residents regarding the difficulty of certain behaviors. Non-residents reported being easier to stay on designated trails than did residents (Mean 6.24 vs 5.44). And compared to residents, non-residents felt *Adhering to messages on postage signage* to be easier (Mean 6.32 vs 5.76). Non-residents are significantly more likely to adhere to messages on postage signage (Mean 6.43 vs 5.91). Residents are significantly less likely to agree that *Practicing Leave No Trace effectively protects the environment for future generations*. (5.81 vs 6.42)

Table 50. Analysis of resident and non-resident survey responses – Statistically significant results

	Mean Scores			
	Non-Resident	**Resident**	***t***	***p-value***
Perceived Difficulty *(Scale: 1=Very Difficult – 7=Very Easy)*				
Staying on a designated trail	6.24	5.44	3.142	.002
Adhering to messages on posted signage	6.32	5.76	2.600	.011
Behavioral Intent *(Scale: 1=Very Unlikely – 7=Very Likely)*				
Adhering to messages on posted signage	6.43	5.91	2.618	.010
Leave No Trace Beliefs *(Scale: 1=Strongly Disagree – 7=Strongly Agree)*				
Practicing LNT effectively protects the environment for future generations	6.42	5.81	2.376	.019

Regression analysis based on Theory of Planned Behavior

This section includes tables and figures related to multiple correlation regression path modeling based on the Theory of Planned Behavior.

Table 51/Figure 1: Multiple regression model that included the independent variables: perceived effectiveness, appropriateness, and difficulty of staying on designated trails, suggested these constructs predict 55% of the variance in one's self-reported intent to stay on designated trails (R^2=.546). In this model all three independent variables contributed significantly to behavioral intent.

Table 51. Multiple Correlation/Regression analysis of the relationships of perceived appropriateness, effectiveness, and difficulty to future behavioral intent.

Independent Variables	Bivariate Correlations	b-values	Partial Correlation
Appropriateness	-.548***	-.161**	-.252**
Difficulty	.666**	.426***	.535***
Effectiveness	.496**	.199**	.248**
Constant		2.854	
Multiple R		.739***	
R^2		.546	
Adjusted R^2		.535	

**significant .01 (2-tailed)
***significant .001 (2-tailed)

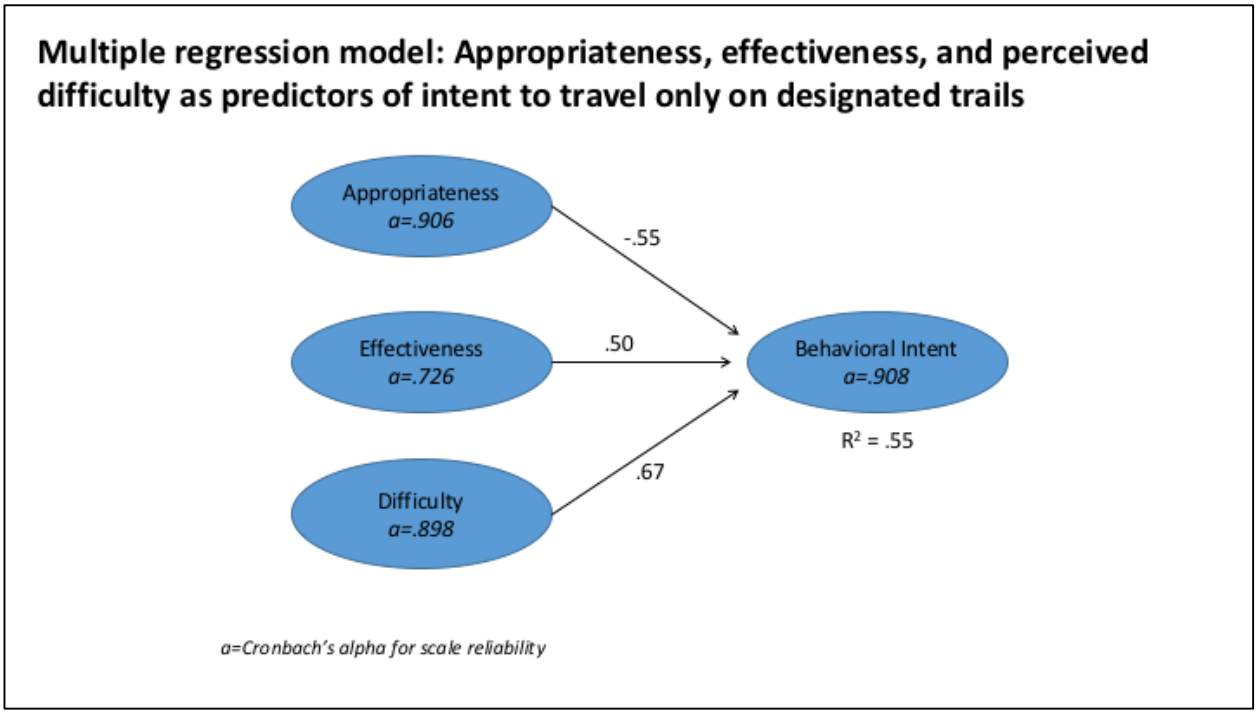

Figure 1. Multiple correlation regression path model - behavioral intent

Table 52/Figure 2: When using the same independent variables in a logistic regression model, this time using actual (observed) behavior (use of a DT or UT) as the dependent variable, the predicitive ability of the model dropped to ~9-12% (Cox & Snell R^2=.086; Nagelkerke R^2=.115). It is also worth noting that in the logistic regression only perceived difficulty held as a significant predictor of behavior (Wald=4.153, p<.05).

Table 52. Linear Regression analysis of the relationships of perceived appropriateness, effectiveness, and difficulty to actual observed trail use (DT vs UT).

Independent Variables	Wald	Exp (B)
Appropriateness	1.558	1.248
Difficulty	4.153*	.656
Effectiveness	.299	1.138
Cox & Snell R^2		.086
Nagelkerke R^2		.115

**significant .05 (2-tailed)

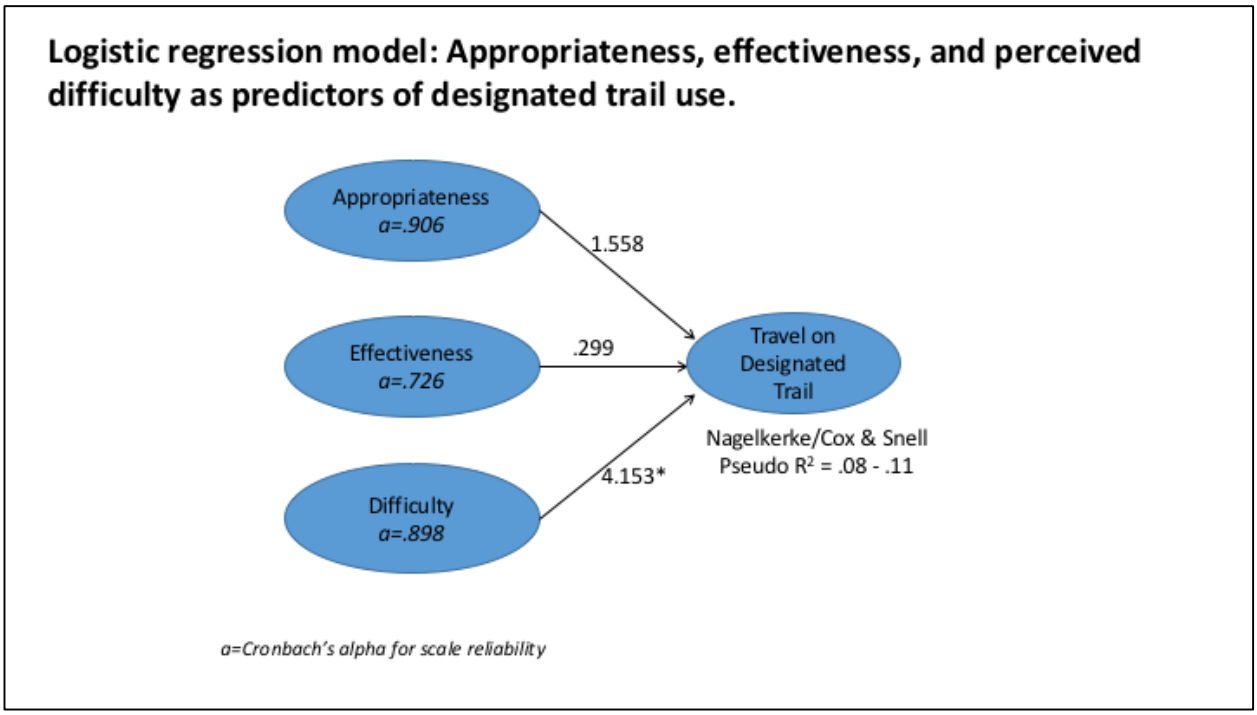

Figure 2. Logistic regression path model - observed trail use behavior

Discussion

The overall goal of this study was to apply a range of management treatments (i.e., two educational signs, a barrier, and a barrier with a educational sign) in conjunction with visitor observations, as well as a self-reported survey, to assess the effectiveness of treaments for reducing undesignated trail use. Specifically, this study explored the following hypotheses:

> H_1: All management treatments would reduce use of undesignated trails from the control level.
>
> H_2: A combination of treatments (i.e., Treatment 5) would be more effective than any single treatment in reducing use of undesignated trails from the control level.

To explore these hypotheses, researchers sampled a total of 25 days over a one-month period and observed a total of n = 2232 visitors interacting across 20 trail junctions that were selected for sampling by OSMP staff. Additionally, an n = 147 respondents completed a paired on-site survey, with a total response rate of 68%.

One of the strengths of this study was the consistent observation methodology, which enabled the researchers to document visitor behaviors at the 20 selected sampling sites, representing a system-wide approach to understanding DT and UT use during the 25-day data collection period. Several of the sites received substantial amounts of visitor use during the sampling period, such as Sanitas, Dakota Ridge, and Sanitarium. The majority of visitors were hiking or walking, without a dog, which also correlated with the findings from the paired survey data.

Discussion of Hypotheses Results

Analysis of observation data suggested that there was a relationship between the management treatments utilized in this study and a decrease in the use of undesignated trails. The level of effectiveness depended on the type of treatment in place. While the results of Treatment 2 ("Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize erosion. This is Not a Designated Trail") suggested that it was slightly less effective than control conditions, all other treatments reduced use of UTs. However, results of chi square post hoc analyses comparing treatment to control conditions reveal that only Treatment 5 (combined barrier and education message) produced a statistically significant reduction in UT use from control conditions (Table 16b). Thus, in regards to H1, the authors fail to reject the null hypothesis on the grounds that statistically significant reductions were not produced by all treatments over and above control conditions. Further, the authors reject the null alternative of H2 based on results of

post hoc tests indicating a statistically significant relationship was observed between Treatment 5 and reduced undesignated trail use, over and above control conditions.

While these results indicate that among the treatments utilized in the study only Treatment 5 produced a statistically significant reduction in UT use compared to control conditions, they should be interpreted with caution from an applied management perspective. That is, a statistically significant relationship may not necessarily translate to one of practical significance (Vaske, 2008). Within the context of OSMP lands, it may not be physically, aesthetically, or economically practical to treat every UT intersection in the system with a combination barrier and educational sign. Therefore, Treatments 3 or 4 should not be eliminated as plausible management options soley based upon the statistically significant test result associated with Treatment 5. In cases where UT use is high or very high Treatment 5 may be warranted. But in other contexts that see relatively low levels of UT use a more minimalist approach (i.e. Treatment 3) may be justified. Ultimately, these results provide OSMP managers with a suite of options and associated effectiveness for consideration, which could mitigate UT use.

In sum, overall observation findings indicate that Treatment 5, the combined educational message ("Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize erosion. This is Not a Designated Trail") with a physical barrier was the most effective method of UT mitigation utilized in this study. Moreover, Treatments 3 and 4 also resulted in observed reductions in UT use (though not statistically significant). The results presented here suggest a range of UT management options exist, each with different levels of effectiveness, which provide managers a set of alternative approaches for use in the mitigation of UT use on the OSMP system depending on resources, management objective, and context.

Discussion of Key Findings and Implications for Management

The majority of visitors were observed traveling on DTs, while only 10%-15% were observed traveling on UTs. Though this is a comparatively small percentage of overall trail use, previous research suggests that a small amount of visitors can create visible and lasting impacts to ecological systems (see Marion, 2016), such as the creation of the numerous UTs (i.e., the ~150 miles of UTs) currently in existence and use on the OSMP system.

A unique component of this study involved the paired self-reported survey with actual visitor observations. Survey results suggested that primary visitor motivations were for nature enjoyment, psychological health, and physical fitness, with the majority of visitors being locals/Boulder residents. Knowledge of visitor motivations provides managers a better sense of the types of experiences people are seeking and expecting during their visit.

Managers might consider leveraging this knowledge in public relations and outreach efforts. For example, undesignated trail closures could be coupled with media outreach discussing management decisions in terms of improving visitor experiences. Since the majority of visitors were local residents, tailored efforts could be focused at the local level.

Results also indicated that visitors to OSMP largely believe that recreation behaviors have the potential to cause both ecological and social impact. The majority of respondents indicated that they would change their behaviors if they learned their actions were damaging the environment. Of the list of potential activities provided for reducing negative impacts in OSMP, A*dhering to messages on posted signage* was reported to be the most effective, followed by S*taying on a designated trail*. Furthermore, *Adhering to messages on posted signage* was reported to be the easiest of the behaviors to perform. Aligning with the message in treatments 2 and 5 ("*Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize erosion. This is Not a Designated Trail*"), the majority of respondents indicated that the most important reason for only using DTs was *To not damage soils and vegetation*. Based on these findings, it is recommended to consider the use of attributional-based messages in the design of future information and education campaigns. While attribution theory was not directly applied or tested in this study, previous research suggests attributional messaging to be a particularly effective approach to visitor messaging.

Attribution theory suggests that people often interpret their behavior in terms of its cause, and these attributions play a central role in human behavior (Kelley & Michela, 1980). Previous studies (see Bradford & McIntyre, 2007; Alessa, Bennett, & Kliskey, 2003) have found that personal attribution is inversely related to depreciative behaviors. That is, the more visitors believed their behavior had the potential to cause resource degradation, the less likely they were to engage in depreciative behavior. Interestingly, Bradford and Mcintyre (2007) found that recreationists typically do not view themselves as the cause of impacts – they tend to attribute impacts to the behaviors of others. Thus, the use of messages informing visitors that their personal recreation behaviors cause, or have the potential to cause, social and ecological resource degradation on OSMP lands is warranted.

The survey data yielded valuable insight regarding visitor attitudes toward trail use and associated behaviors. Results indicated that frequent visitors were more likely than those who visited less often to report knowing that some OSMP trails are undesignated. While not statistically significant, individuals who had visited frequently reported being the least likely to *Stay on a designated trail* and *Adhere to messages posted on signage*. These findings also aligned with the statistically significant differences found between residents and non-residents, as non-residents indicated that it was easier to stay on designated trails. Additionally, residents were significantly less likely to agree that *Practicing Leave No Trace*

effectively protects the environment for future generations than non-residents. Taken together, these findings suggest that education and outreach efforts regarding the impacts related to undesignated trail use, and the importance of staying on designated trails, be strategically designed to reach local user communities and frequent visitors.

More than 40% of survey respondents indicated they were unaware of UTs in the OSMP trail system. This aligned with paired survey and observation data, as nearly 50% of visitors who were observed and surveyed while using a UT reported that they 'always' use DTs, suggesting that these visitors did not know they were in fact traveling on a UT. Furthermore, UT respondents were significantly more likely to report not knowing if they traveled off a DT. Observed behavior paired with survey responses showed that almost half of UT users reported they had not traveled off trail, while approximately 20% of UT users were unsure if they had traveled off the DT. While being unaware may account for a substantial amount of the UT use on OSMP lands, a considerably smaller number of UT users indicated that they had seen management signs than DT users. Thus, this suggests there is a small segment of individuals — as also noted through observation data — that will use UTs despite management interventions. Given the high visitor use of OSMP, it is important to consider wide-scale implementation of those management actions that are most effective in order to improve compliance by the majority of visitors, and in particular those existing UT users.

Survey results suggested that there is a need to better clarify which existing OSMP trails are UTs and DTs. This need also appeared in the open-ended-comments section of the survey. For example, one respondent wrote "Often is difficult to tell where exactly designated trails exist because of so many social trails." Another stated, "When trails have extreme braiding or social trails it is hard to know designated trails." A third respondent suggested, "I don't know if I should stay on trail when wet/muddy, and if walking in the middle of trail is best - signage would be good if that's what is right ." It would be valuable to maintain consistent dissemination of information, signage, and management interventions throughout the trail system that signify which trails are DTs. For example, existing infrastructure on UTs, such as block steps, water bars, or small signs indicating no mountain biking may confuse visitors, as those are typically visual cues that indicate a managed (designated) trail segment. Thus, eliminating existing infrastructure on current UTs, coupled with the implementation of Treatment 5 (i.e., educational message and barrier) from this study could enhance mitigation efforts. Furthermore, the authors also suggest increasing outreach to residents and frequent visitors about the effectiveness of Leave No Trace-related behaviors, and the need for protecting social and ecological wellbeing in OSMP lands.

Ultimately, the data indicate that many OSMP visitors realize that human recreation behaviors have the potential to cause social and ecological impacts. This study provides evidence that the treatments applied in this research, particularly the educational message paired with a physical barrier, can effectively influence behavior and significantly reduce UT useage from baseline control conditions.

Implications for Future Research

With regard to methodological considerations and future research, this study demonstrated the strength in pairing self-reported survey data with actual behavioral observations. As noted, self-reported behaviors do not always align with the actions visitors take in the environment. Thus, when feasible, future studies should consider pairing visitor surveys and observations. While it is important to consider systematic approaches to understanding visitor use, further examination of the most effective treatment in this study, set-up long-term in high UT use locations such as Settler's Park, Dry Creek, or Chautauqua could yield greater understanding of the influence of paired indirect and direct management actions on UT use. For example, if the entire DT trail system and associated UT junctions within the Chautauqua area were treated with the barrier and educational signage over a period of two years for instance, researchers and managers could monitor visitor attitudes and behavior change with the methods used in this study. Furthermore, expanding the study over a multi-year period could afford the opportunity to measure ecological change (e.g., vegetation regrowth) resulting from treatment application.

It is also worth noting that the scope of this study was to collect, analyze, and interpret data at the system-level. That is, the study was designed to provide a snapshot of undesignated trail use and treatment effectiveness across the OSMP system. Hence the systematic random selection of research sites indicated by OSMP staff as representative of the system, and reporting of results in aggregate. Drilling down to site-level analysis was beyond the scope of this project. Thus further analysis of this data at the site-level is suggested and could provide further insight into setting and contextual factors that are at play. A preliminary site-level analysis is provided in Appendix Q as an example of this line of inquiry. As indicated by this analysis, the Sanitarium site for example, did not follow the same UT use patterns as the other sites when Treatment 5 was in place. When examined in greather detail to understand why this might be the case, it is revealed that this specific UT leads to a site of cultural and historic significance (pictured in Figure 3), and is also marked with interpretive signage. Further, one survey respondent made mention of this site in the open-ended comment section, stating "Please take the wooden fence down near the stone cabin/house." Additional site-level analysis such as this could provide further contextual

and situational understanding of motivations for using UTs.

Figure 3. Photograph of stone structure at Sanitarium site

Study Limitations

Observers used their best judgment when determining if a particular trail user had an interaction with a treatment or control. While it was generally easy to detect "no treatment interaction" and "stop and read," it was more challenging to determine if a trail user should have be categorized as "pass and read." Consistant treatment placement (i.e., 5-10 feet from the point of entry onto an undesignated trail) was established to minimize error, and accurately determine visitor intention.

Every effort was made to provide a robust, evenly distributed stratified sample, given the vast number of strata, the limited time span of this study, and the available resources. However, there are limitations that should be noted. For example, this sampling effort took place over 25 days, during a 30-day (one-month) period. Visitation patterns and behaviors may have been subject to weather or other environmental factors beyond our control. Additionally, each of the 20 sites received all five of the treatments, however, a.m./p.m. and weekday/weekend stratification was not evenly distributed, given the one month sampling period. Finally, this study only incorporated 20 randomly selected sites, and other OSMP

undesignated trail sites may produce alternative visitor behaviors and associated perceptions.

Although this study attempted to represent system-wide use, some of the sampling sites selected for this study receive relatively low visitation, which is not ideal for a vistor survey. Thus, this is a trade-off. For instance, while the total *n* could have been increased if the research had taken place at consistently busier OSMP locations, the results would not have represented the entire system, as this study attempted to do. Additionally due to some of the selected sampling sites, the survey sample size is small compared to the large number of visitors observed as part of this study. This can partially be attributed to the purposeful sampling approach whereas only individuals that interacted with a treatment were asked to complete a survey. Finally, it should be noted that some visitors may have felt and acted upon social desirability (i.e., provide responses that they think coincide with the survey administrator's viewpoints) (Vaske, 2008), however, staff were trained extensively to minimize any bias.

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Appendices

Appendix A. Observation Datasheet

General field values: X = Missed obs /=NA ?=Not sure ----- =Delete obs

*Visitor party is any combination of people/dogs that the observer believes is intentionally travelling together

Leave No Trace Project Monitoring Data Sheet: VISITOR PARTY* (Observation of visitor parties near selected treatment)

Date:	**Day of Week:**	**Location/Site ID:**	**Shift Type:** ☐ Observe only ☐ Paired with Survey
Start Time (24-hour):	**End Time (24-hour):**	**Time Period:** ☐ AM ☐ PM ☐ Partial Session	**Treatment:** ☐ Control ☐ One ☐ Two ☐ Three ☐ Four
Skycover: ☐ Sunny ☐ P Cloudy ☐ Overcast	**Temp:** ☐ 50 ☐ 60 ☐ 70 ☐ 80 ☐ 90 ☐ 100	**Precip:** ☐ None ☐ Rain ☐ Snow	**Wind** (m/h): **Closure:** ☐ YES ☐ NO **Observer:**

Time	Observ ID	Visitor Party Data							Treatment Interaction			OSMP Presence	NOTES
		UT or DT	If UT, Direction (Treatment or No Treatment); T or NT	People (#1 to n)	Activity Type (H,R,B, C,E,O)	Dogs (#0 to n)	Observation Pairing Identifier (color of lead person's bottoms and shoes)	If surveyed, survey #	Stop and Read	Pass and Read	None	0=None 1=Ranger 2=Staff	Notes regarding treatment interactions, #children in party, "other" activities, or other notes of interest

Page ____ of ____

General field values: X = Missed obs /=NA ?=Not sure ----- =Delete obs

*Visitor party is any combination of people/dogs that the observer believes is intentionally travelling together

Data Quality Check: Visitor Party		
Date: Field QC	**Initials**	**Comments**
Date: Data Entry	**Initials**	**Comments**
Date: Data Entry QC	**Initials**	**Edits Made**

H	Hiking
R	Running
M	(Mountain) Biking
E	Horseback riding (equestrian)
C	Climbing/Boulderer
O	Other

R	Red
O	Orange
Y	Yellow
G	Green
BL	Blue
V	Violet
W	White
BK	Black
G	Gray
P	Pink
OT	Other

Contacts:

Deonne VanderWoude	303-906-4092
Forrest Schwartz	304-376-0230
Faith Overall	508-742-5283

RETURN HARD COPY DATASHEETS AT END OF SHIFT TO:

1. Faith or Forrest (if on-site)

2. OSMP Staff Person (if on-site)

3. If none of the above are on-site, mail hardcopies using provided postage paid envelope

Page _____ of _____

Appendix B. Designated Trail (DT) Surveyor Datasheet

General field values: X = Missed obs /=NA ?=Not sure ----- =Delete obs

Leave No Trace Project Monitoring Data Sheet: DT Survey Log

Date:	**Day of Week:**	**Location/Site ID:**	**Treatment:** ☐ Control ☐ One ☐ Two ☐ Three ☐ Four
Start Time (24-hour):	**End Time (24-hour):**	**Time Period:** ☐ AM ☐ PM ☐ Partial Session	**Surveyer:**
Skycover: ☐ Sunny ☐ P Cloudy ☐ Overcast	**Temp:** ☐ 50 ☐ 60 ☐ 7☐ 80 ☐ 90 ☐ 100	**Precip:** ☐ None ☐ Rain ☐ Snow	**Wind** (m/h): **Closure:** ☐ YES ☐ NO

Time	Observ ID	Visitor Party Data								NOTES
		Accept/Refuse	Survey #	Activity Type (H,R,C,B, E,O)	Dogs (#0 to n)	Observation Pairing Identifier (color of lead person's bottoms and shoes)	People (#1 to n)	Non-Response Question	Lang Barr Y/N	Notes regarding treatment interactions, #children in party, "other" activities, or other notes of interest

Page ____ of ____

General field values: X = Missed obs /=NA ?=Not sure ----- =Delete obs

Data Quality Check: Visitor Party		
Date: Field QC	**Initials**	**Comments**
Date: Data Entry	**Initials**	**Comments**
Date: Data Entry QC	**Initials**	**Edits Made**

H	Hiking
R	Running
M	(Mountain) Biking
E	Horseback riding (equestrian)
C	Climbing/Boulderer
O	Other

R	Red
O	Orange
Y	Yellow
G	Green
BL	Blue
V	Violet
W	White
BK	Black
G	Gray
P	Pink
OT	Other

Contacts:

Deonne VanderWoude	303-906-4092
Forrest Schwartz	304-376-0230
Faith Overall	508-742-5283

RETURN HARD COPY DATASHEETS AT END OF SHIFT TO:

1. Faith or Forrest (if on-site)

2. OSMP Staff Person (if on-site)

3. If none of the above are on-site, mail hardcopies using provided postage paid envelope

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Appendix C. Undesignated Trail (UT) Surveyor Datasheet

General field values: X = Missed obs /=NA ?=Not sure ----- =Delete obs

Leave No Trace Project Monitoring Data Sheet: UT Survey Log

Date:	**Day of Week:**	**Location/Site ID:**	**Treatment:** ☐ Control ☐ One ☐ Two ☐ Three ☐ Four
Start Time (24-hour):	**End Time (24-hour):**	**Time Period:** ☐ AM ☐ PM ☐ Partial Session	**Surveyer:**
Skycover: ☐ Sunny ☐ P Cloudy ☐ Overcast	**Temp:** ☐ 50 ☐ 60 ☐ 7 ☐ 80 ☐ 90 ☐ 100	**Precip:** ☐ None ☐ Rain ☐ Snow	**Wind** (m/h): **Closure:** ☐ YES ☐ NO

Time	Observ ID	Visitor Party Data									NOTES
		Accept/Refuse	Survey #	Activity Type (H,R,C,B, E,O)	Dogs (#0 to n)	Observation Pairing Identifier (color of lead person's bottoms and shoes)	People (#1 to n)	Treatment Y/N	Non-Response Question	Lang Barr Y/N	Notes regarding treatment interactions, #children in party, "other" activities, or other notes of interest

Page _____ of _____

General field values: X = Missed obs /=NA ?=Not sure ----- =Delete obs

Data Quality Check: Visitor Party		
Date: Field QC	**Initials**	**Comments**
Date: Data Entry	**Initials**	**Comments**
Date: Data Entry QC	**Initials**	**Edits Made**

H	Hiking
R	Running
B	Biking
E	Horseback riding (equestrian)
C	Climbing/Boulderer
O	Other

R	Red
O	Orange
Y	Yellow
G	Green
BL	Blue
V	Violet
W	White
BK	Black
G	Gray
P	Pink
OT	Other

Contacts:

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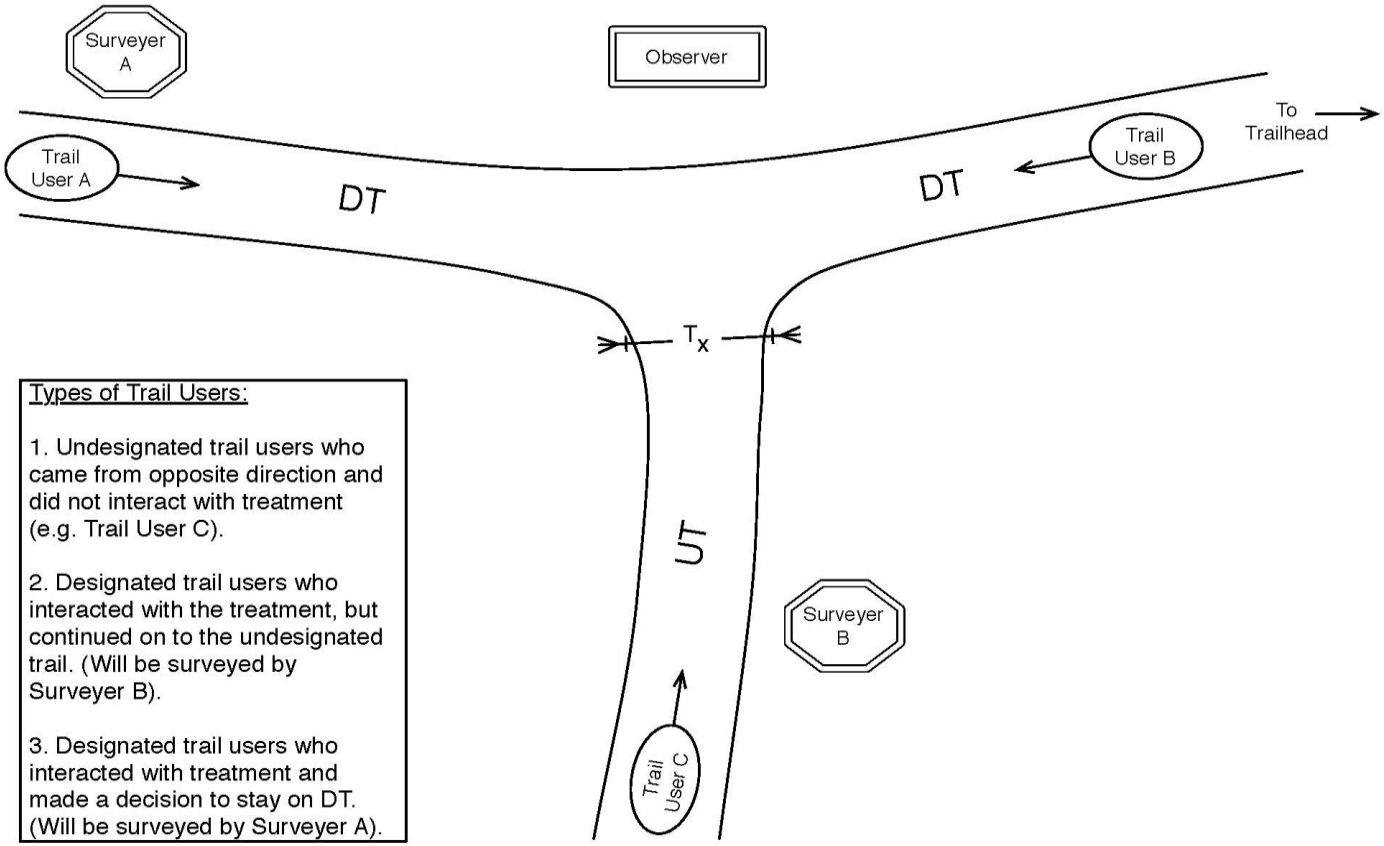
Appendix D. Undesignated Trail Study Codebook

Observation Code	Description	Appropriate Response Categories
Time	Time of visitor interaction	e.g., 11:47 am
Observ. ID	Corresponding assigned visitor # associated with observation	e.g., #17
UT or DT	Visitor observed and/or surveyed coming from an undesignated trail (UT) or designated trail (DT). If visitor goes from DT to UT, they are coded as UT.	"UT" or "DT"
If UT, Direction (Trtm. or NTrtm.)	If visitor observed and/or surveyed on an undesignated trail (UT), did they have an opportunity to experience the treatment (T), or did they not have the opportunity to experience the treatment (NT).	T (if they approached UT from the direction at which they had an opportunity to experience the treatment) NT (if they approached via the UT, with no opportunity to experience the treatment)
# Visitors in Group	Number of visitors in a given group of interest	e.g., 2
# Dogs in Group	Number of dogs in a given group of interest	e.g., 1
Observation Pairing Identifier	Descriptive information about the visitor so that observer and surveyor can match participants	Only applicable on for paired survey periods e.g., shirt or backpack color
Survey ID	Corresponding assigned survey # associated with agreed participation	e.g., #13
Activity Code	Visitor activity	H = Hiker R = Runner B = Biker E = Equestrian C = Climber/Boulderer O = Other (describe in notes)
Treatment Interactions	How did the visitor interact or respond to the treatment?	Stop/Read – If it was apparent that the visitor read the treatment, stopped, and spent > 3 seconds on contemplating
		Pass/Read – If it was apparent that the visitor read the treatment, as they kept moving by
		None – If it was apparent that the visitor did not look at,

		or interact with the treatment
OSMP presence	If OSMP staff or ranger are in area (e.g. you see them in your area or there is a staff or ranger vehicle at the access point)	"0", "1" or "2"
Notes Regarding Treatment Interactions/Notes	Additional notes regarding the visitors' interaction with the treatment, or notes about the visitors' behavior	e.g., "Visitor seemed agitated with signage"
Survey Code	Description	Appropriate Response Categories
Accept/refusen Code	Disposition of visitor inquiry when asked to participate in survey	"Accept", or "Refuse"; can use "A" or "R" if busy
Survey #	Corresponding assigned survey # associated with each visitor; should be in on-going sequential order for each sampling location; check with researcher for each shift's starting number	"1", "2", "3", "4"……
Survey refusal non-response question	"What is your primary activity today?" This question will provide a non-response bias check	"H", "R", "B", "E", "C", "O"; see Activity Code above for definitions
Language barrier	Does the data collector observe a language barrier prohibiting conversation with the visitor?	"Yes", "No"; can use "Y" or "N" if busy

Appendix E. Sampling Site Diagram

City of Boulder Open Space Mountain Parks Trail Study Diagram



Appendix F. Study Site Names and Locations

- UT_Jct-04 Sanitarium; Sanitas-Dakota Ridge Trail
- UT_Jct-07 Chautauqua; Chautauqua –McClintock Trail
- UT_Jct-08 Anemone; Anemone-Red Rocks Trail (Settler's Park TH)
- UT_Jct-09 Hogback Ridge; North Foothills-Hogback Ridge Trail
- UT_Jct-10 Lost Gulch; Flagstaff-Lost Gulch Trail
- UT_Jct-17 BVR; BVR-Cobalt/Sage Trails
- UT_Jct-20 Settler's; Anemone-Red Rock's Spur Trail (Settler's Park TH)
- UT_Jct-27 Sanitas; Sanitas-Sanitas Valley Trail
- UT_Jct-32 Red Rocks; Anemone-Red Rocks Spur Trail (north)
- UT_Jct-35 Cragmoor Connector; Shanahan-Fern Meadow/Cragmoor Connector Trail
- UT_Jct-38 Amphitheater; Chautauqua-Amphitheater Trail
- UT_Jct-39 NCAR; NCAR—NCAR Bear Canyon Trial (neighborhood/water access)
- UT_Jct-41 Coal Seam; Marshall Mesa-Coal Seam Trail
- UT_Jct-42 Flagstaff; Flagstaff-Flagstaff Trail
- UT_Jct-43 Dakota Ridge; Sanitas-Dakota Ridge Trail
- UT_Jct-45 Gunbarrel; Gunbarrel-Gunbarrel Trail
- UT_Jct-46 Dry Creek; Dry Creek-Dry Creek Trail
- UT_Jct-47 Four Pines; NIST (Tippet)-Four Pines Trail
- UT_Jct-48 Red Rocks-south; Anemone-Red Rocks Spur Trail (south)
- UT_Jct-51 Shanahan Connector; Shanahan -Shanahan Connector Trail

Appendix G. Definitions

Access Point: Points where visitors can enter/exit OSMP-managed lands.

Collapse: Process of: 1) classifying the complete suite of ideas represented in verbatim text reported for an open-ended question into a series of categories and/or 2) reducing the full suite of categories into combined categories based upon content analysis of the text.

Designated Trail: A trail that is managed, maintained, and mapped, and promoted to visitors as an official trail for use by OSMP.

Emergent Category: A theme revealed through content analysis and collapsing of semantically similar verbatim text reported for open-ended questions.

Frequency Distribution: The number or percent of respondents giving each possible response to a particular question.

Inter-rater or Inter-observer reliability: The degree to which different raters/observers give consistent ratings/estimates of the same phenomenon using the same rating system. http://www.socialresearchmethods.net/kb/reltypes.php

Naturalistic observation: A research method commonly used by psychologists and other social scientists which involves observing subjects in their natural environment. This type of research is often utilized in situations where conducting lab research is unrealistic, cost prohibitive or would unduly affect the subject's behavior. http://psychology.about.com/od/nindex/g/naturalistic.htm

Pass Rate: Rate at which visitors pass by the survey administrator before staff has the opportunity to contact them.

Population: All OSMP visitors 16 or more years old exiting OSMP lands during the monitoring period.

Proportions: Calculated as the number of survey participants reporting a certain response divided by the total number of valid survey responses.

Range of Acceptability: A set of bounds defining satisfactory conditions for any measured indicator.

Recreation setting: A combination of the physical, biological, managerial and social conditions within a recreation area that gives value to a place (Clark and Stankey 1979).

Refusal Rate: Rate at which visitors asked to participate in the survey refuse to do so.

Reliability: The extent to which an experiment, test or any measuring procedure yields the same result on repeated trials. http://writing.colostate.edu/guides/page.cfm?pageid=1386

Sample: All eligible visitors contacted and agreeable to survey participation at selected study locations during the study period. The sample does not include repeat respondents or any officially sanctioned visitors (OSMP staff, volunteers, contractors, etc.) traveling on the trail for official OSMP business.

Sampling Frame: The list of undesignated trails that meet the undesignated trail selection criteria.

Serial Effect: In survey research, a situation where questions may "lead" participant responses through establishing a certain tone. The serial effect may accrue as several questions establish a pattern of response in the participant, biasing results.

Survey: A research tool that includes at least one question which is either open-ended or close-ended and employs an oral or written method for asking these questions. The goal of a survey is to gain specific information about either a specific group or a representative sample of a particular group. Results are typically used to understand the attitudes, beliefs, knowledge or norms of a particular group.

Undesignated Trail: A trail that is not managed, maintained, mapped, or promoted to visitors as an official trail for use by OSMP.

Validity: The degree to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure.

Visitor: Any person traveling on OSMP lands or trails except those conducting official OSMP business.

Visitor trip: A trip to the study area, regardless of how much time a visitor spent on OSMP during their trip.

Appendix H. Original Sample Schedule - June 2015

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
31	1 Treatment 1 (Control) Paired -A.M. early Sanitarium -A.M. early Chautauqua -A.M. late Anemone -A.M. late Hogback Ridge	2 Treatment 2 (Ed 1) Paired -P.M. early Lost Gulch -P.M. early BVR -P.M. late Settlers Park -P.M. late Sanitas Valley	3 Treatment 3 (Ed 2) Observation -P.M. early Red Rocks -P.M. early Cragmr Con -P.M. late Amphitheatr e -P.M. late NCAR	4 Treatment 4 (Barrier) Paired -P.M. early Coal Seam -P.M. early Flagstaff -P.M. late Dakota Rdg -P.M. late Gunbarrel	5 Treatment 5 (Ed/Bar.) Observation -A.M. early Red Rocks -A.M. early Cragmr Con -A.M. late Amphitheatr e -A.M. late NCAR	6 Treatment 5 (Ed/Bar.) Paired -P.M. early Sanitarium -P.M. early Chautauqua -P.M. late Anemone -P.M. late Hogback Ridge
7 Treatment 1(Control) Observation -A.M. early Lost Gulch -A.M. early BVR -A.M. late Settlers Park -A.M. late Sanitas Valley	8 Treatment 3 (Ed 2) Observation -A.M. early Sanitarium -A.M. early Chautauqua -A.M. late Anemone -A.M. late Hogback Ridge	9 OFF	10 Treatment 1(Control) Paired -P.M. early Dry Creek -P.M. early 4 Pines -P.M. late Red Rks South -P.M. late Shanahan	11 Treatment 2 (Ed 1) Observation -A.M. early Coal Seam -A.M. early Flagstaff -A.M. late Dakota Rdg -A.M. late Gunbarrel	12 Treatment 3 (Ed 2) Paired -P.M. early Lost Gulch -P.M. early BVR -P.M. late Settlers Park -P.M. late Sanitas Valley	13 Treatment 4 (Barrier) Observation -P.M. early Lost Gulch -P.M. early BVR -P.M. late Settlers Park -P.M. late Sanitas Valley

4 Treatment 1(Control) Observation -P.M. early Coal Seam -P.M. early Flagstaff -P.M. late Dakota Rdg -P.M. late Gunbarrel	15 Treatment 4 (Barrier) Observation -A.M. early Dry Creek -A.M. early 4 Pines -A.M. late Red Rks South -A.M. late Shanahan	16 Treatment 2 (Ed 1) Paired -P.M. early Sanitarium -P.M. early Chautauqua -P.M. late Anemone -P.M. late Hogback Ridge	17 OFF	18 Treatment 1(Control) Paired -A.M. early Red Rocks -A.M. early Cragmr Con -A.M. late Amphitheatr e -A.M. late NCAR	19 Treatment 5 (Ed/Bar.) Observation -P.M. early Coal Seam -P.M. early Flagstaff -P.M. late Dakota Rdg -P.M. late Gunbarrel	20 Treatment 3 (Ed 2) Paired -P.M. early Dry Creek -P.M. early 4 Pines -P.M. late Red Rks South -P.M. late Shanahan
21 OFF	22 Treatment 5 (Ed/Bar.) Paired -A.M. early Lost Gulch -A.M. early BVR -A.M. late Settlers Park -A.M. late Sanitas Valley	23 OFF	24 Treatment 3 (Ed 2) Paired -A.M. early Coal Seam -A.M. early Flagstaff -A.M. late Dakota Rdg -A.M. late Gunbarrel	25 OFF	26 Treatment 4 (Barrier) Paired -A.M. early Sanitarium -A.M. early Chautauqua -A.M. late Anemone -A.M. late Hogback Ridge	27 Treatment 2 (Ed 1) Observation -A.M. early Dry Creek -A.M. early 4 Pines -A.M. late Red Rks South -A.M. late Shanahan
28 Treatment 2 (Ed 1) Paired -P.M. early	29 Treatment 4 (Barrier) Paired -A.M. early	30 Treatment 5 (Ed/Bar.) Paired -A.M. early	1 Make-up Sampling Day	2 Make-up Sampling Day	3 Unavailable (Holiday)	4 Unavailable (Holiday)

Red Rocks -P.M. early Cragmr Con -P.M. late Amphitheatre -P.M. late NCAR	Red Rocks -A.M. early Cragmr Con -A.M. late Amphitheatre -A.M. late NCAR	Dry Creek -A.M. early 4 Pines -A.M. late Red Rks South -A.M. late Shanahan				
Code: Paired=Survey & Observation; Observation=Observation Only; A.M. early=6:30-9:30 a.m.; A.M. late=10 a.m.=1 p.m.; P.M. early=1-4 p.m.; P.M. late=4:30-7:30 p.m.						

Appendix I. Revised Sample Schedule (Based on unforeseen events such as weather, illness and treatment issues)

Code: Paired=Survey & Observation; Observation=Observation Only; Weather Cancelation=WC; Red denotes Adjustment Made; Noted Barrier Day which required additional planning for set-up and takedown

A.M. early=6:30-9:30 a.m.; A.M. late=10 a.m.=1 p.m.; P.M. early=1-4 p.m.; P.M. late=4:30-7:30 p.m.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
31	1 Treatment 1 (Control) Paired -A.M. early Sanitarium -A.M. early Chautauqua -A.M. late Anemone -A.M. late Hogback Ridge	2 Treatment 2 (Ed 1) Paired -P.M. early Lost Gulch -P.M. early BVR -P.M. late Settlers Park -P.M. late Sanitas Valley	3 Treatment 3 (Ed 2) Observation -P.M. early Red Rocks -P.M. early Cragmr Con -P.M. late Amphitheatr e -P.M. late NCAR	4 Treatment 4 (Barrier) Paired -P.M. early Coal Seam -P.M. early Flagstaff -P.M. late Dakota Rdg -P.M. late Gunbarrel	5 Treatment 1 (Control) Observation (Was supposed to be Trt 5) -A.M. early Red Rocks -A.M. early Cragmr Con -A.M. late Amphitheatr e (WC) -A.M. late NCAR (WC)	6 Treatment 5 (Ed/Bar.) Paired -P.M. early Sanitarium -P.M. early Chautauqua -P.M. late Anemone -P.M. late Hogback Ridge
7 Treatment 1(Control) Observation -A.M. early Lost Gulch -A.M. early BVR -A.M. late Settlers Park	8 Treatment 3 (Ed 2) Observation -A.M. early Sanitarium -A.M. early Chautauqua (received Treatment 2) -A.M. late	9 OFF	10 Treatment 1(Control) Paired -P.M. early Dry Creek -P.M. early 4 Pines -P.M. late Red Rks	11 Treatment 2 (Ed 1) Observation -A.M. early Coal Seam -A.M. early Flagstaff -A.M. late	12 Treatment 3 (Ed 2) Paired -P.M. early Lost Gulch -P.M. early BVR -P.M. late	13 Treatment 4 (Barrier) Observation -P.M. early Lost Gulch -P.M. early BVR -P.M. late

-A.M. late Sanitas Valley	Anemone -A.M. late Hogback Ridge		South -P.M. late Shanahan	Dakota Rdg -A.M. late Gunbarrel	Settlers Park -P.M. late Sanitas Valley	Settlers Park -P.M. late Sanitas Valley
14 Treatment 1(Control) Observation -P.M. early Coal Seam -P.M. early Flagstaff -P.M. late Dakota Rdg -P.M. late Gunbarrel	15 Treatment 4 (Barrier) Observation -A.M. early Dry Creek -A.M. early 4 Pines -A.M. late Red Rks South -A.M. late Shanahan	16 Treatment 2 (Ed 1) Paired -P.M. early Sanitarium -P.M. early Chautauqua -P.M. late Anemone -P.M. late Hogback Ridge	17 OFF -A.M. early Chautauqua Observation Trt 3 (Making up 6/8) – Faith has volunteered to make-up this day	18 Treatment 1(Control) Paired -A.M. early Red Rocks -A.M. early Cragmr Con -A.M. late Amphitheatre -A.M. late NCAR	19 Treatment 5 (Ed/Bar.) Observation -P.M. early Coal Seam -P.M. early Flagstaff -P.M. late Dakota Rdg -P.M. late Gunbarrel	20 Treatment 3 (Ed 2) Paired -P.M. early Dry Creek -P.M. early 4 Pines -P.M. late Red Rks South -P.M. late Shanahan
21 Treatment 5 (Ed/Bar.) Observation (Making up 6/5) -A.M. early Red Rocks -A.M. early Cragmr Con Missed, treatment error -A.M. late	22 Treatment 5 (Ed/Bar.) Paired -A.M. early Lost Gulch -A.M. early BVR -A.M. late Settlers Park -A.M. late Sanitas	23 OFF	24 Treatment 3 (Ed 2) Paired -A.M. early Coal Seam -A.M. early Flagstaff -A.M. late Dakota Rdg -A.M. late Gunbarrel	25 OFF	26 Treatment 4 (Barrier) Paired -A.M. early Sanitarium -A.M. early Chautauqua -A.M. late Anemone -A.M. late Hogback	27 Treatment 2 (Ed 1) Observation -A.M. early Dry Creek -A.M. early 4 Pines, missed – treatment error -A.M. late Red Rks South

Amphitheatre -A.M. late NCAR	Valley				Ridge -A.M. early Cragmr Con -Missed, treatment error	-A.M. late Shanahan -P.M. early Coal Seam
28 Treatment 2 (Ed 1) Paired -P.M. early Red Rocks -P.M. early Cragmr Con -P.M. late Amphitheatre -P.M. late NCAR	29 Treatment 5 (Ed/Bar.) Paired (swapped w/ 6/30) -A.M. early Dry Creek -A.M. early 4 Pines -A.M. late Red Rks South -A.M. late Shanahan	30 Treatment 4 (Barrier) Paired (swapped w/ 6/29) -A.M. early Red Rocks -A.M. early Cragmr Con -A.M. late Amphitheatre -A.M. late NCAR	1 Make Up	2 Make Up -A.M. early 4 Pines, (Trt 2 (Ed 1) Observation -P.M. early Hogback Ridge -- Trt 2 (Ed 1) Paired	3	4

Appendix J. Educational Signage

Appendix K. Sample Barrier Treatment

Appendix L. Visitor Survey

City of Boulder Open Space and Mountain Parks (OSMP) Visitor Survey

City of Boulder OPEN SPACE & MOUNTAIN PARKS

1. What is your **PRIMARY ACTIVITY today**? (Select only one)

☐ Hiking/Walking ☐ Walking dog(s) ☐ Climbing/Bouldering ☐ Horseback Riding
☐ Running ☐ Biking ☐ Other: _____

2. How many dogs did **YOU** bring today (please **do not** include dogs another person in your group brought)? (Select only one) ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

3. How many times have you visited this section of trail **in the past 12 months**? (Select only one)

☐ Today is my first visit ☐ 1 – 12 Visits ☐ 13 – 48 Visits
☐ 49 – 144 Visits ☐ 145 – 240 Visits ☐ > 240 Visits

4. Are you aware that some trails in City of Boulder OSMP are "**undesignated**" or not official trails?

☐Yes ☐No

5. To what extent do you believe that **human recreation behaviors** have the **potential to cause NEGATIVE IMPACT,** a) **Ecologically**, and b) **Socially** in City of Boulder OSMP? (Select only one answer per item)

Type of impact as a result of human recreation behaviors…	No Impact At All			Moderate Impact			Extensive Impact
a. Ecological	1	2	3	4	5	6	7
b. Social/Experience	1	2	3	4	5	6	7

6. Please indicate how **INAPPROPRIATE** or **APPROPRIATE** you think each of the following activities is for a visitor to do in City of Boulder OSMP. (Select only one answer per item)

Activities	Very Inappropriate			Neutral		Very Appropriate	
a. Traveling off a designated trail to experience the natural environment	1	2	3	4	5	6	7
b. Traveling around muddy spots on a designated trail	1	2	3	4	5	6	7
c. Traveling off a designated trail to explore	1	2	3	4	5	6	7
d. Traveling off a designated trail to take photos	1	2	3	4	5	6	7
e. Traveling off a designated trail to get away from crowds on the trail	1	2	3	4	5	6	7
f. Traveling off a designated trail because there is an alternative established path	1	2	3	4	5	6	7

7. Please indicate how **EFFECTIVE** the following activities would be at reducing **NEGATIVE IMPACTS** in City of Boulder OSMP. (Select only one answer per item)

Activities	Never Effective			Sometimes Effective		Effective Every Time	
a. Staying on a designated trail	1	2	3	4	5	6	7
b. Traveling in the middle of a designated trail, even when wet or muddy	1	2	3	4	5	6	7
c. Traveling on a designated trail, even when passing other visitors	1	2	3	4	5	6	7
d. Staying off a designated trail when conditions are wet and muddy	1	2	3	4	5	6	7
e. Adhering to messages on posted signage	1	2	3	4	5	6	7

8. Please indicate how **DIFFICULT** you think each of the following activities would be for you to do in City of Boulder OSMP. (Select only one answer per item)

Activities	Very Difficult			Neutral			Very Easy
a. Staying on a designated trail	1	2	3	4	5	6	7
b. Traveling in the middle of a designated trail, even when wet or muddy	1	2	3	4	5	6	7
c. Traveling on a designated trail, even when passing other visitors	1	2	3	4	5	6	7
d. Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area	1	2	3	4	5	6	7
e. Traveling on a designated trail, even when an undesignated trail is available in the area	1	2	3	4	5	6	7
f. Traveling on a designated trail, even when you have observed another visitor traveling on an undesignated trail	1	2	3	4	5	6	7
g. Adhering to messages on posted signage	1	2	3	4	5	6	7

9. In Column A, tell us if you **CURRENTLY DO** each activity by circling *Never*, *Sometimes*, *Always*. In Column B, please indicate how *likely* you are to do the activity in the **FUTURE**. (Select only one answer per item, in both Column A, and B)

Activities	Column A			Column B						
	Do you do this now?			How likely are you to do this in the future						
	Never	Sometimes	Always	Extremely Unlikely			Neutral			Extremely Likely
a. Staying on a designated trail	Never	Sometimes	Always	1	2	3	4	5	6	7
b. Traveling in the middle of a designated trail, even when wet or muddy	Never	Sometimes	Always	1	2	3	4	5	6	7
c. Traveling on a designated trail, even when passing other visitors	Never	Sometimes	Always	1	2	3	4	5	6	7
d. Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area	Never	Sometimes	Always	1	2	3	4	5	6	7
e. Traveling on a designated trail, even when an undesignated trail is available in the area	Never	Sometimes	Always	1	2	3	4	5	6	7
f. Traveling on a designated trail, even when you have observed another visitor traveling on an undesignated trail	Never	Sometimes	Always	1	2	3	4	5	6	7
g. Adhering to messages on posted signage	Never	Sometimes	Always	1	2	3	4	5	6	7

10. Did **you travel off a designated trail** during your visit today? ☐ Yes ☐ No ☐ Don't Know/Unsure

11. Indicate whether or not any of the following **reasons for traveling off the designated trail(s)** applied to your visit today. (Select only one answer per item)

Reasons	Does Not Apply Because I Only Traveled On Designated Trails	Applies to Me	Don't Know
a. I didn't know that traveling off the designated trail could damage soils and vegetation	1	2	3
b. I didn't know that it was recommended to stay on the designated trail	1	2	3
c. I didn't mean to travel off the designated trail (it was an accident)	1	2	3

Reasons	Does Not Apply Because I Only Traveled On Designated Trails	Applies to Me	Don't Know
d. I think visitors should be able to travel off the designated trail	1	2	3
e. I thought that it would improve my visitor experience	1	2	3
f. I have done it before and it worked well for my visitor experience	1	2	3
g. Other reason: _____			

12. Please indicate how **IMPORTANT** these reasons would be for you to travel only on designated trails in the **FUTURE**. (Select only one answer per item)

Reasons	Not Relevant	Not At All Important			Moderately Important		Extremely Important	
a. To improve my outdoor experience on OSMP lands	0	1	2	3	4	5	6	7
b. Because visitors are encouraged to stay on designated trails	0	1	2	3	4	5	6	7
c. To not damage the soils and vegetation	0	1	2	3	4	5	6	7
d. To not break the rules	0	1	2	3	4	5	6	7
e. Because I do not want anyone to see me travel off designated trails	0	1	2	3	4	5	6	7
f. Because it is unfair for me to travel off designated trails while many other visitors do not	0	1	2	3	4	5	6	7
g. Because I have no reason to travel off designated trails	0	1	2	3	4	5	6	7
h. Because Leave No Trace promotes traveling on designated trails	0	1	2	3	4	5	6	7
i. Because I feel better about myself by not traveling off designated trails	0	1	2	3	4	5	6	7

13. Did you notice the following on this trail today? (Check all that apply)

☐ Informational signage to keep visitors on designated trails

☐ Fence or barrier to keep visitors on designated trails

☐ Combination of informational signage and fence or barrier to keep visitors on designated trails.

14. Please **RANK the following in order** (1st, 2nd, and 3rd), indicating which would be **most effective in keeping you off an undesignated trail**. (*1st = Most Effective; 3rd = Least Effective*)

___ Informational signage

___ Fence or barrier

___ Combination of informational signage and fence or barrier

15. How many people, including yourself, were part of your group today? _____

16. Do you live in the United States?

☐ Yes ---- If Yes, a.) do you live within Boulder City limits, and b.) what is your zip code?

a.) ☐ Yes, Boulder City limits ☐ No, outside Boulder City limits

b.) Zip code: _____

☐ No (What country do you live in? _____)

17. Please indicate how strongly you **AGREE** or **DISAGREE** with the following statements. (Select only one answer per item)

Statements	Strongly Disagree			Neither Agree or Disagree			Strongly Agree
a. If I learned my actions in OSMP damaged the environment, I would change my behavior	1	2	3	4	5	6	7
b. Practicing "Leave No Trace" does not reduce the environmental harm caused by travel in OSMP	1	2	3	4	5	6	7
c. Practicing "Leave No Trace" takes too much time	1	2	3	4	5	6	7
d. Practicing "Leave No Trace" effectively protects the environment so that future generations may enjoy it	1	2	3	4	5	6	7

18. How **IMPORTANT** were each of the following reasons for your visit to City of Boulder OSMP today? (Select only one answer per item)

Reasons	Not Relevant	Not At All Important			Moderately Important			Extremely Important
a. Physical fitness	0	1	2	3	4	5	6	7
b. Physical rest	0	1	2	3	4	5	6	7
c. Psychological health	0	1	2	3	4	5	6	7
d. Psychological rest	0	1	2	3	4	5	6	7
e. Escape personal/social pressures	0	1	2	3	4	5	6	7
f. Enjoying nature	0	1	2	3	4	5	6	7
g. Learning	0	1	2	3	4	5	6	7
h. Family/friend togetherness	0	1	2	3	4	5	6	7
i. Solitude	0	1	2	3	4	5	6	7

19. Is there anything else you would like us to know? If so, please provide additional feedback below:

_____

_____

_____

Thank you for your participation.

Appendix M. Site Selection Randomization Procedures

Undesignated Trail Management and Messaging Study: Description of Sample Design using Spsurvey in R

Target population: All intersections of undesignated trails mapped in 2011/2012 with designated trails or OSMP boundaries. These intersections comprise the potential sites where visitors may encounter a treatment to close or restore undesignated trails or an untreated control implemented as part of a contractor study of visitor behavior and attitudes related to undesignated trail closures.

Sample Frame: The final sample frame was a point feature class, created through an iterative process of GIS analyses and subsequent staff review and point deletion. OSMP GIS Analyst Jake Cseke produced a shape file **UTintersection_AllAccess** with 1,542 points comprising the initial target population by intersecting undesignated trails with designated trails or external boundaries of OSMP properties. Under the direction of Megan Bowes, staff reviewed this initial set of points and excluded points that on closer examination did not fit into the target population. Points were excluded if they were located at intersections with 1) roads; 2) facility access paths; 3) driveways; 4) cattle trails not used as visitor trails; and 5) climbing accesses. Points were also excluded if they appeared to be artifacts of the GIS spatial analyses that erroneously overrepresented intersections in the initial shape file. The final sample frame file, **UTintersection_final** contained 870 points.

Survey Design: A Generalized Random Tessellation Stratified (GRTS) survey design for a finite point resource was used. The GRTS design includes reverse hierarchical ordering of the selected sites. The GRTS design was run in the library (group of functions) spsurvey using R which is available online at no charge: http://cran.r-project.org/web/packages/spsurvey/index.html

Stratification: There was no implicit stratification in the GRTS design. Post-design stratification is possible in spsurvey on the group Access, which could be considered a subpopulation.

Panels: There was a single panel.

Expected Sample Size: Given a sample of 20 sites, it was expected to draw 12 “high” volume sites and 8 “low” volume sites based on the approximate distribution of these categories in the sample frame. Visitor access volume was approximated using trailhead count data from 2004 and no actual stratification occurred.

Oversample: 40 sites.

Final Sample Design: The initial design had 20 base sites with 16 categorized as "high" volume sites and 4 characterized as "low" volume sites. Sites were listed in UT_jct order and were evaluated in the field in that order. During field evaluations, 13 of the initial base sites were rejected and replaced with the next 13 oversamples that met the study site criteria. Seventeen of these selected sites were located at the intersection of a designated trail and 3 of the sites were at a property boundary.

Description of Sample Design Output:
The sites are provided as a shapefile **UTint_unstratified_sites_031215** that can be read directly by ArcMap. The dbf file associated with the shapefile may be read by Excel.

The dbf file has the following variable definitions:

Variable Name	**Description**
FID	Assigned by ArcGIS
SiteID	Unique site identification (character) based on order to be included in the sample and prefaced by UT_Jct
Xcoord	NAD_1983_HARN_StatePlane X coordinate
Ycoord	NAD_1983_HARN_StatePlane Y coordinate
Mdcaty	Multi-density categories used for unequal probability selection set to Equal for equal probability sampling
weight	Weight (unit?), inverse of inclusion probability, to be used in statistical analyses. Calculated as 1/((1/total sites in sample frame)*#base samples chosen).
stratum	Strata used in the survey design set to None for this unstratified sample
panel	Identifies base sample by panel name "Base" and Oversample by OverSamp
EvalStatus	
EvalReason	
Access	Carried over from sample frame to describe subpopulations of relative access volume

Projection Information

Projected coordinate system:
CS:NAD_1983_HARN_StatePlane_Colorado_North_FIPS_0501_FeetGEOGCS["GCS_Clarke_1866",
Projection: Lambert_Conformal_Conic
False_Easting: 3000000.00031608

False_Northing: Central_Meridian: Standard_Parallel_1: Standard_Parallel_2: Latitude_Of_Origin: Linear Unit: Foot_US

999999.99999600 -105.50000000 39.71666667 40.78333333 39.33333333

Geographic Coordinate System: GCS_North_American_1983_HARN Datum: D_North_American_1983_HARN
Prime Meridian: Greenwich

Angular Unit: Degree

The survey design weights that are given in the design file assume that the survey design is implemented as designed. That is, only the sites that are in the base sample (not in the over sample) are used, and all of the base sites are used. This may not occur due to (1) sites not being a member of the target population, (2) a site is not amenable to UT closure or restoration; (3) site no longer intersects an undesignated trail (it has regrown or become a designated trail) or (4) site not sampled for other reasons. Typically, users prefer to replace sites that cannot be sampled with other sites to achieve the sample size planned. The site replacement process is described above. When sites are replaced, the survey design weights are no longer correct and must be adjusted, however the design implemented equal weights to all sites. EvalStatus is initially set to "NotEval" to indicate that the site has yet to be evaluated for sampling. When a site is evaluated for sampling, then the EvalSelect field indicates a "yes" for all sites selected.

Statistical Analysis

Any statistical analysis of data must incorporate information about the monitoring survey design. In particular, when estimates of characteristics for the entire target population are computed, the statistical analysis must account for any stratification or unequal probability selection in the design. Procedures for doing this are available from the Aquatic Resource Monitoring web page given in the bibliography. A statistical analysis library of functions is available from the web page to do common population estimates in the statistical software environment R.

References:

Diaz-Ramos, S., D. L. Stevens, Jr, and A. R. Olsen. 1996. EMAP Statistical Methods Manual. EPA/620/R-96/002, U.S. Environmental Protection Agency, Office of Research and Development, NHEERL-Western Ecology Division, Corvallis, Oregon.

Stevens, D.L., Jr. and Olsen, A.R. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics, 4:415-428

Stevens, D. L., Jr., and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. Environmetrics **14**:593-610.

Stevens, D. L., Jr., and A. R. Olsen. 2004. Spatially-balanced sampling of natural resources in the presence of frame imperfections. Journal of American Statistical Association:99:262-278.

Web Page: http://www.epa.gov/nheerl/arm

Appendix N. Methodological Protocol

Background

Surveys represent one of the most common types of quantitative, social science research methods. In survey research, the researcher selects a sample of respondents from a population and administers a standardized questionnaire to them. Using surveys, it is possible to collect data from large or small populations, and survey administration provides a systematic and economically feasible method to understand the population's opinions and beliefs on topics of interest. Additionally, standardized questions make measurement more precise when enforcing uniform definitions upon the participants (Babbie, 2005).

On-site surveys are specifically advantageous because they can: 1) yield higher response rates because administrators can explain the rationale and importance of the survey; 2) allow administrators to encourage people to complete all questions; and 3) allow participants to ask for clarification when needed (Vaske, 2008, p. 129).

Unobtrusive visitor observation is a commonly employed research method. Stationary and roving visitor observation work has been utilized on OSMP over the past several years. In most cases the observer will be unobtrusively observing visitors and thus should not be noticed by them. Observational sampling occured during the month of June, which often sees increased visitation on OSMP lands. Therefore, observers were able to blend in and were not overly noticeable to visitors.

Many peer reviewed articles and technical reports (see Peine, 1983; Vande Kamp, 1994) have employed unobtrusive observation methods. The use of such methods was critical to this study. Other methods such as visitor surveys and interviews cannot accurately produce some types of data. However, pairing observed behavior with survery resonses provided robust data on the overall efficacy of each treatment/control utilized in the study. The ability to analyze these relationships was a critical element of the study design.

Study Protocols

Survey

The survey instrument for this study was developed through a collaborative, iterative review process between the PI's and OSMP staff. The instrument was framed within the context of the of the Theory of Planned Behavior (Ajzen, 1991) and developed to incorporate established natural resource-based human dimensions questions, including items stemming from the Recreation Experience Preference scales (see Driver, Tinsley, & Manfredo, 1991; Manfredo, Driver, & Tarrant, 1996), established Leave No Trace-focused

questions that have been used in numerous peer-reviewed studies (see Lawhon et al., 2013; Taff, Newman, Vagias, & Lawhon, 2014; Vagias & Powell, 2011; Vagias, Powell, Moore, & Wright, 2014), questions regarding trail behaviors and perceptions of intervention treatments (see Park, Manning, Marion, Lawson, & Jacobi, 2008), and questions about visitor use preference, history, and basic demographic information. In the early development of the survey instrument it was pretested with ~30 undergraduate students at a large university; subsequently the instrument was field tested with visitors on OSMP properties in May 2015. Pretesting allowed respondents to inform researchers regarding potentially confusing wording and layout issues so that the PI's could revise and improve the instrument for data collection in June 2015. Details regarding the survey instrument questions can be reviewed in in subsequent chapters of this report and the final survey instrument can be found in Appendix L.

The development of the treatments containing behavioral messaging (i.e., Treatments 2, 3, and 5) was informed by an elicitation study with ~30 visitors on OSMP properties in October 2014. Elicitation studies involve a small number of respondents, evaluating a series of potentially influential statements for effectiveness (see Petty & Cacioppo, 1986; Petty & Wegener, 2008). Participants rated nine potential treatment messages, each crafted based upon persuasive communications literature (see Cialdini et al., 2006; Ham & Krumpe, 1996; Hocket & Hall, 2007; Widner & Roggenbuck, 2003; Winter, 2006). Ultimately respondents evaluated: 1) the persuasiveness of the message, and 2) the likeliness that the message would influence their behavior to stay on designated OSMP trails. Two statements were rated as being the most influential: 1) "*Stay on designated trails: Even when wet and muddy, to protects trailside plants and minimize eroison. This is Not a Designated Trail*" (Treatment 2), and 2) "*To Protect OSMP Lands: Please Stay of Designated Trails. This is Not a Designated Trail*" (Treatment 3).

Treatments

Applying the results of the elicitation study, the following conditions (Treatments 2 – 5*) and control (Treatment 1) were developed and employeed for this study (see diagram below, and Appendices J-K):

1. Treatment One – Control – no educational or barrier treatments in place.

2. Treatment Two – Educational treatment #1: "Stay muddy hiker"* – This sign read "Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize eroison. This is Not a Designated Trail."

3. Treatment Three – Educational treatment #2: "Protect hiker"* – This sign read "To Protect OSMP Lands: Please Stay on Designated Trails. This is Not a Designated Trail."

4. Treatment Four – Physical barrier* – Physical barrier made of logs that aesthetically fit with the OSMP environment.

5. Treatment Five – Physical barrier with Educational treatment #1*– Physical barrier made of logs that aesthetically fit with the OSMP environment with the sign that read "*Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize eroison. This is Not a Designated Trail.*" affixed to the center.

**Note: To maintain consistency and accurately determine visitor intentionality, Treatments 2, 3, 4, and 5 were set-back approximately 5 – 10 feet from the point of entry onto an undesignated trail, barring any physical barriers that inhibit this placement at a given site.*

Sampling Design and Site Stratification

Sampling design was stratified over a one-month period in June 2015. Twenty-five days of sampling were allotted for data collection, beginning June 1 and concluding on June 30, with two potential make-up days scheduled for July 1 and 2, which were ultimately needed. Stratification was based upon the following considerations: a) 5 treatments; b) 20 sampling locations, or sites; c) a.m. or p.m. data collection; d) weekday (i.e., Monday, Tuesday, Wednesday, and Thursday) or weekend (i.e., Friday, Saturday, and Sunday) data collection; e) paired surveying with visitor behavior observation, or observation of visitor behavior without the survey instrument; f) availability and quantity of OSMP staff/volunteers and research staff; and g) the limited sampling period spanning over one-month.

Each sampling day was divided into four time slots, either in the morning or afternoon, including: early morning (A.M. Early)/late morning (A.M. Late), and early afternoon (P.M. Early)/late afternoon (P.M. Late). During the sampling effort, the time slots were as follows:

- Early morning: 6:30 a.m.-9:30 a.m.
- Late morning: 10:00 a.m.-1:00 p.m.
- Early afternoon: 1:00 p.m.-4:00 p.m.
- Late afternoon: 4:30 p.m.-7:30 p.m.

Thus, on any given sampling day, there were either two a.m. sampling periods (one early/one late) or two p.m. sampling periods (one early/one late). There was no overlap of sampling periods on any given day during the study.

Sampling locations were selected based on a statistically stratified representation of the various types of trail settings and associated use in OSMP, with the intent to represent DT and UT useage at a systems level. Site selection for this study was suggested and facilitated by OSMP staff.

Sampling Sites

Sanitarium	Chautauqua
Anemone	Hogback Ridge
Dry Creek	4 Pines
Read Rocks South	Shanahan
Red Rocks	Cragmore Con.
Amphitheatre	NCAR
Lost Gultch	BVR
Settler's Park	Sanitas Valley
Coal Seam	Flagstaff
Dakota Ridge	Gunbarrel

Based upon the stratification criteria and the 20 selected sites, accounting for severe weather cancellations, and treatment issues (e.g., one of the treatments was torn down by OSMP visitors), the following represents the final sampling stratification that was used for this study (see final sampling schedule with noted adjustments, Appendix I):

- All 20 sampling sites received all of the conditions (the control, and the four treatments) at least once during the sampling period
- All 20 sampling sites received paired visitor survey with visitor behavior observations ("paired"), as well as observations (not paired with surveys "observed") of visitor behavior

Site Stratification:

Sanitarium:

- Treatment 1, Paired, Weekday, a.m.
- Treatment 2, Paired, Weekday, p.m.
- Treatment 3, Observed, Weekday, a.m.
- Treatment 4, Paired, Weekend, a.m.
- Treatment 5, Paired, Weekend, p.m.

Chautauqua:

- Treatment 1, Paired, Weekday, a.m.
- Treatment 2, Paired, Weekday, p.m.
- Treatment 2, Observed, Weekday, a.m.
- Treatment 3, Observed, Weekday, a.m.
- Treatment 4, Paired, Weekend, a.m.
- Treatment 5, Paired, Weekend, p.m.

Anemone:

- Treatment 1, Paired, Weekday, a.m.
- Treatment 2, Paired, Weekday, p.m.
- Treatment 3, Observed, Weekday, a.m.
- Treatment 4, Paired, Weekend, a.m.
- Treatment 5, Paired, Weekend, p.m.

Hogback Ridge:

- Treatment 1, Paired, Weekday, a.m.
- Treatment 2, Paired, Weekday, p.m.
- Treatment 3, Observed, Weekday, a.m.
- Treatment 4, Paired, Weekend, a.m.
- Treatment 5, Paired, Weekend, p.m.

Lost Gulch:

- Treatment 1, Observed, Weekend, a.m.
- Treatment 2, Paired, Weekday, p.m.
- Treatment 3, Paired, Weekend, p.m.
- Treatment 4, Observed, Weekend, p.m.
- Treatment 5, Paired, Weekday, a.m.

BVR:

- Treatment 1, Observed, Weekend, a.m.
- Treatment 2, Paired, Weekday, p.m.
- Treatment 3, Paired, Weekend, p.m.
- Treatment 4, Observed, Weekend, p.m.
- Treatment 5, Paired, Weekday, a.m.

Settlers Park:

- Treatment 1, Observed, Weekend, a.m.
- Treatment 2, Paired, Weekday, p.m.
- Treatment 3, Paired, Weekend, p.m.
- Treatment 4, Observed, Weekend, p.m.
- Treatment 5, Paired, Weekday, a.m.

Sanitas Valley:

- Treatment 1, Observed, Weekend, a.m.
- Treatment 2, Paired, Weekday, p.m.
- Treatment 3, Paired, Weekend, p.m.
- Treatment 4, Observed, Weekend, p.m.
- Treatment 5, Paired, Weekday, a.m.

Red Rocks:

- Treatment 1, Paired, Weekday, a.m.
- Treatment 1, Observed, Weekend, a.m.
- Treatment 2, Paired, Weekend, p.m.
- Treatment 3, Observed, Weekday, p.m.
- Treatment 4, Paired, Weekday, a.m.
- Treatment 5, Observed, Weekend, a.m.

Cragmoor. Connector:

- Treatment 1, Paired, Weekday, a.m.
- Treatment 1, Observed, Weekend, a.m.
- Treatment 2, Paired, Weekend, p.m.
- Treatment 3, Observed, Weekday, p.m.
- Treatment 4, Paired, Weekday, a.m.
- Treatment 5, Observed, Weekend, a.m.

Amphitheatre:

- Treatment 1, Paired, Weekday, a.m.
- Treatment 2, Paired, Weekend, p.m.
- Treatment 3, Observed, Weekday, p.m.
- Treatment 4, Paired, Weekday, a.m.
- Treatment 5, Observed, Weekend, a.m.

NCAR:

- Treatment 1, Paired, Weekday, a.m.
- Treatment 2, Paired, Weekend, p.m.
- Treatment 3, Observed, Weekday, p.m.
- Treatment 4, Paired, Weekday, a.m.
- Treatment 5, Observed, Weekend, a.m.

Dry Creek:

- Treatment 1, Paired, Weekday, p.m.
- Treatment 2, Observed, Weekend, a.m.
- Treatment 3, Paired, Weekend, p.m.
- Treatment 4, Observed, Weekday, a.m.
- Treatment 5, Paired, Weekday, a.m.

4 Pines:

- Treatment 1, Paired, Weekday, p.m.
- Treatment 2, Observed, Weekday, a.m.
- Treatment 3, Paired, Weekend, p.m.
- Treatment 4, Observed, Weekday, a.m.
- Treatment 5, Paired, Weekday, a.m.

Red Rocks South:

- Treatment 1, Paired, Weekday, p.m.
- Treatment 2, Observed, Weekend, a.m.
- Treatment 3, Paired, Weekend, p.m.
- Treatment 4, Observed, Weekday, a.m.
- Treatment 5, Paired, Weekday, a.m.

Shanahan:

- Treatment 1, Paired, Weekday, p.m.
- Treatment 2, Observed, Weekend, a.m.
- Treatment 3, Paired, Weekend, p.m.
- Treatment 4, Observed, Weekday, a.m.
- Treatment 5, Paired, Weekday, a.m.

Coal Seam:

- Treatment 1, Observed, Weekend, p.m.

- Treatment 2, Observed, Weekday, a.m.
- Treatment 3, Paired, Weekday, p.m.
- Treatment 4, Paired, Weekday, p.m.
- Treatment 5, Observed, Weekend, p.m.

Flagstaff:

- Treatment 1, Observed, Weekend, p.m.
- Treatment 2, Observed, Weekday, a.m.
- Treatment 3, Paired, Weekday, p.m.
- Treatment 4, Paired, Weekday, p.m.
- Treatment 5, Observed, Weekend, p.m.

Dakota Ridge:

- Treatment 1, Observed, Weekend, p.m.
- Treatment 2, Observed, Weekday, a.m.
- Treatment 3, Paired, Weekday, p.m.
- Treatment 4, Paired, Weekday, p.m.
- Treatment 5, Observed, Weekend, p.m.

Gunbarrel:

- Treatment 1, Observed, Weekend, p.m.
- Treatment 2, Observed, Weekday, a.m.
- Treatment 3, Paired, Weekday, p.m.
- Treatment 4, Paired, Weekday, p.m.
- Treatment 5, Observed, Weekend, p.m.

Observation

The following methods were applied to collect visitor behavior data through direct observation at the selected sampling sites:

a. Observers were positioned in a location at the undesignated UT and DT trail intersection under study so as to be as out of sight of visitors as possible. It was very important that the observers presence did not bias/influence the behavior of visitors.
b. Observers recorded observations for every individual or visitor party that passed the sample point/interacted with the treatment, regardless of whether they chose to stay on the DT or to continue onto the UT under

observation (see Appendix E site diagram for specifics; see Appendix D codebook for what observations were made). A visitor party was considered as any recreation group that, in the best judgment of the observer, was intentionally travelling together.

Paired Survey and Observation

Staff administering the survey/conducting observations received training regarding visitor contact procedures, survey administration, observation protocols, and practice providing unbiased responses to visitor inquiries. Specifically, the observers, and surveyors had the following roles during a given session:

Observers:

1. Observers positioned themselves in a location out of sight (as possible) of the trail intersection where treatment was in place, and recorded observations for every visitor party.
2. For visitors who interacted with the treatment, they communicated visitor party identifiers and pairing ID #s to surveyors via a two-way radio:
    a. Procedures included:
        i. Recording observation data as usual.
        ii. Radioing the appropriate surveyor (based on whether a visitor continued on the DT or UT) and provided visitor identifying characteristics, group size and observation ID #s.
    b. Sampling frame included:
        i. Control days (days when NO treatment is utilized): Every 3rd visitor party was surveyed. If the appropriate party (every 3rd) refused the survey, the DT surveyor attempted to survey each subsequent party until a survey was taken by a DT user. Once a survey was administered, they reverted back to every 3rd DT user.
        ii. Treatment days: Every visitor who passed by the designated trail/undesignated trail intersection *and* interacted with the treatment.
        iii. If a designated trail user had no treatment interaction, they were not surveyed*.

Note: Given the research questions focused on the role of the treatments, it was determined that only those visitors that had a meaningful, engaged interaction with the treatment would be considered for the survey.

Surveyors:

Surveyor A (DT surveyor):

The role of the DT surveyor was to intercept DT users who interacted with the treatment and made a decision to stay on the DT. These surveyors sampled only those individuals coming from the direction of the trailhead/access point, because these individuals would have not been previously influenced by the treatment (see site diagram below). The observer communicated the observation ID #s for pairing purposes to surveyor A. Surveyors positioned themselves in a location out of sight of the trail intersection where treatment was in place (to the extent possible). Surveryors did not attempt to survey groups of 6 or more visitors.

1. Sampling strategy:
    a. Control days (days when NO treatment is utilized): Every 3rd visitor party was surveyed. If the appropriate party (every 3rd) refused the survey, the DT surveryer attempted to survey each subsequent party until a survey was taken by a DT user. Once a survey was administered, they reverted back to every 3rd DT user.
    b. Treatment days: Every visitor who passed by the designated trail/undesignated trail intersection *and* interacted with the treatment.
    c. If a designated trail user had no treatment interaction, they were not surveyed*.

Note: Given the research questions focused on the role of the treatments, it was determined that only those visitors that had a meaningful, engaged interaction with the treatment would be considered for the survey.

Surveyor B (UT surveyor):

1. The role of the UT surveyor was to intercept all UT users traveling from opposite direction of treatment (Trail User C on site the site diagram provided in Appendix E).
2. Intercepted all DT users who came from the direction of the treatment, and decided to continue onto the UT. On Treatment and control days the Observer will radioed with observation ID #s for pairing purposes.
3. Intercepted every UT trail user encountered (within reason). For example, if in the process of administering a survey, Surveyor B made an effort to stop others passing by. If a visitor was not willing to stop, they made note on survey datasheet.

The diagram in Appendix E represents how staff observed and surveyed UT and DT visitors.

Survey Administration and Protocol

Staff attempted to contact every adult (16 years of age or older) visitor who met the sampling criteria for either DT or UT use/treatment or control interaction, and ask her/him to participate in the survey. Staff approached visitors saying approximately: "*Hello. My name is [Interviewer's name] I am with Open Space and Mountain Parks (OSMP). We are conducting visitor surveys today to help us get an understanding of visitor experiences and improve our visitor management strategies. Would you be willing to help us by completing a short survey? This survey takes most visitors ~7-10 minutes to complete,"* and offered a clipboard with survey and pen attached. Staff did not attempt to administer the survey to the following ineligible participants:

- Any person, paid or non-paid, conducting official OSMP business (i.e., "on the clock"); this includes OSMP staff, contractors and volunteers
- Any person who had previously completed a survey
- Any trail users who did not meet the specified sampling criteria outlined above

During the sampling session, staff recorded visitors of the target population who did not take the survey. For those visitors who refused to participate in the survey (refused), passed by the survey administrator before he or she could contact them (passed) or informed the administrator that they had already completed the questionnaire (repeat), staff documented the number of each reported primary activity of those visitors on the appropriate session information datasheet. The presence of accompanying dogs were also noted for visitors that were documented as refusals, passes, or repeats. To be considered a refusal, a visitor had to *communicate his or her refusal* to take the survey in response to being directly asked to participate by a staff member. Also, individuals were recorded as "refusals" if they expressed a clear desire to not take the survey, or fail to respond to the surveyor's request to participate. A contacted visitor was recorded as a "repeat" if he/she volunteered that they had already taken the survey. Visitors were recorded as "passed" if the administrator did not explicitly ask them to take the survey, and they did not voluntarily inform the surveyor that they did not want to participate. They are also recorded as "passed" if they did not speak English fluently enough to complete the survey. Non-responding visitors were recorded as individuals (e.g. a party of two hikers and one dog were recorded as one hiker with a dog and one hiker without a dog).

If a visitor passed the survey administrator multiple times during a survey session, they were only contacted to participate once per survey session. Similarly, individuals who were documented as a refusals, pass or repeat were only counted once per survey session, regardless of how many times they may have passed by the survey administrator. If staff recognized a visitor as a survey participant from a previous survey session, the staff did not

contact the visitor again, but they did doument the visitor as a repeat. During observational sessions, similar protocols applied.

Staff were trained to provide unbiased responses to visitor questions about the survey (or the study) so as not to influence a respondent's answers to any survey question. For example, if a visitor asked the survey administrator if survey results will be used to close a particular trail, staff could say generically "results will be used to inform OSMP trail management and improve visitor experience." If a visitor demonstrated strong interest in a facet of OSMP management, staff offered them appropriate contact information for the OSMP study liaison.

A survey was marked as VOID, after the respondent departed, if 1) the respondent was not part of the target population (e.g., too young, repeat respondent, OSMP volunteer "on the clock", not exiting or exiting from a different access point, etc.), or 2) the respondent did not complete at least 75% of the survey.

A sampling session was "cancelled" or finished early if the weather met any of the following conditions: 1) no visitors could be expected; 2) the staff person would be miserable working in those conditions; 3) conditions would put the staff member's health or safety at risk; or 4) conditions prevent the survey from being effectively administered (e.g. blowing rain that would damage survey equipment). If a session started more than one hour later than scheduled, due to staff member delays, that session was treated as cancelled. Similarly, if a session's duration was less than two hours for any reason (e.g. weather deteriorates), that session was treated as cancelled. Weather cancellations and treatment placement issues resulted in several make-up sampling efforts (see Appendix I for final sampling schedule).

Appendix O. Summary of Key Findings

Observed Behaviors

- The majority of visitors observed in this study were hiking/walking (~76%), traveling alone (~58%), without a dog (~75%).
- Of the 20 sites selected for this study, Sanitas (*n* = 348), Dakota Ridge (*n* = 237), Sanitarium (*n* = 228) received the most use, while Gunbarrel (*n* = 24) received the lowest use.
- Approximately 85% of observed visitors were designated trail (DT) users, while 15% were observed traveling on undesignated trails (UT).
- The Education/Barrier combination resulted in the greatest visitor interaction/engagement (i.e., stopped and read, or passed and read).
- Among visitors who traveled past the study site, those who made a decision to use the UT were much more likely to interact with the treatment. Approximately 44% of UT users stopped and interacted the treatment.
- The combined Barrier/Ed treatment was observed to be the most effective at mitigating undesignated trail use. The Barried/Ed method was ~97% effective at directing visitors to the DT, followed by Barrier (94%), and Ed 2 (94%).

Self-reported Survey

- Closely aligning with observed behavior, the majority of respondents were hiking/walking (~74%), without a dog (~69%).
- All respondents were from the U.S., and approximately 70% of respondents indicated that they were residents of Boulder, while 30% stated that they were non-residents.
- Approximately 22% of respondents indicated that this was their first visit, 32% stated that they have previously visited 1 – 12 times, 24% had visited 13 – 48 times previously, and 22% indicated that they have visited 49 or more times.
- Regarding potential motivations for visiting OSMP, *enjoying nature*, *physical fitness* and *psychological health* were rated as most important, while *learning* and *physical rest* were among the least important reasons for visiting.

- Respondents indicated that human recreation behaviors have the potential to cause both ecological and social impact, though the potential for negative ecological impact was believed to be greater than the potential for negative social impact.

- Approximately 42% of respondents indicated that they were unaware of undesignated trails.

- Respondents indicated that Traveling off a designated trail to get away from crowds was the least appropriate reason for off-trail travel, while Traveling off a designated trail because there is an alternative established path was the least inappropriate reason for this behavior.

- Of the list of potential activities provided for reducing negative impacts on OSMP, *Adhering to messages on posted signage* was reported to be the most effective, followed by *Staying on a designated trail*. *Staying off a trail when conditions are wet and muddy* was reported to be the least effective.

- When asked, respondents suggested that *Traveling in the middle of a designated trail, even when wet or muddy* was the most difficult behavior, while *Adhering to messages on posted signage* was reported to be the easiest of the behaviors to perform.

- Regarding self-reported current behaviors, the most frequented of the list provided was 'Always' *Adhering to messages posted on signage* followed by 'Always' *Staying on designated trails*. While these findings suggest the majority of people 'Always' practice these minimum-impact trail behaviors, there remains a large percentage of visitors who reported only 'Sometimes' performing this behavior. The likelihood of traveling on a designated trail appears to decline when a visitor has previously traveled on a UT in the area, and/or when a UT is available in the area.

- Regarding self-reported future behaviors, or intent, respondents generally indicated a high likelihood of performing each appropriate (as prescribed by the Leave No Trace Center and OSMP literature) visitor behavior. *Adhering to messages on posted signage* and *Staying on a designated trail* resulted in the highest reported likelihood of being performed in the future, while behaviors with the lowest likelihood of future performance included: *Traveling in the middle of a designated trail, even when wet or muddy*, *Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area*, and *Traveling on a designated trail, even when an undesignated trail is available in the area*.

- Approximately 28% of respondents indicated they had traveled off trail during their visit, 58% had not, and 13% were unsure.

- Regarding potential reasons for traveling off trail/on UTs, approximately 30% selected I didn't mean to travel off the designated trail (it was an accident) and I have done it before and it worked well for my visitor experience, respectively.

- Regarding important reasons for only using DTs, *To not damage soils and vegetation* was indicated as the most important, with 52% of respondents considering this to be 'Extremely Important'. The least important reason was *Because I do not want anyone to see me travel off designated trails*.

- The majority of respondents, approximately 84%, indicated they would change their behavior if they *Learned their actions in OSMP were damaging the environment*. Approximately 85% disagreed that *Practicing Leave No Trace takes too much time* and approximately 84% believe *Practicing "Leave No Trace" effectively protects the environment so that future generations may enjoy it*. The statement *Practicing "Leave No Trace" does not reduce the environmental harm caused by travel in OSMP* received less support, as 23% agreed with this statement, suggesting that some respondents do not believe Leave No Trace is as effective at mitigating impacts in OSMP.

- The majority of respondents, approximately 66%, noticed a sign or barrier meant to keep visitors on DTs, while 50% noticed a combination sign and barrier.

- The combination sign/barrier was reported to be the most effective management action for keeping visitors on DTs.

<u>*Results by visitation history*</u>

- Statistically significant relationships were found between visitation motivations and visitation history. Those who visit more frequently rate physical fitness as more important than those who visit less frequently. Family/friend togetherness is more important for the less frequent visitors than for those who visit more often.

- Frequent visitors are more likely than those who visit less often, to report knowing some OSMP trails are undesignated. Alternatively, those who visit less often are less likely to know some trails are undesignated. This suggest that the more familiar a visitor becomes with the OSMP trail system the more aware they are of the network of UTs. Those who visit less are less aware and thus might assume UTs to be DTs.

- Respondents who had visited 13-48 times previously showed consistently lower mean scores across the battery of items related to the appropriateness of Leave No

Trace behaviors. Thus, their attitudes are more in line with Leave No Trace, while those that had visited 1-12 times consistently had the highest means, meaning their attitudes are less in line with Leave No Trace promoted behaviors.

- While no statistically significant relationships were found between visitation history and behavioral intent, individuals who had visited 49 or more previous times were the least likely to stay on a designated trail and adhere to messages posted on signage.
- A statistically significant relationship was found between visitation history and reasons for staying on DTs. Those who had visited 49 or more previous times indicated the reason *To not damage the soils and vegetation* to be less important of a reason compared those that selected other, smaller visitation categories. Similarly, the most frequent visitors are less likely to agree that *Practicing Leave No Trace effectively protects the environment* than are those who visit less often.

Results by place of residence: Boulder resident vs. Non-resident

- A statistically significant difference was found between residents and non-residents regarding the difficulty of certain behaviors. Non-residents reported that it was easier to *stay on designated trails* than residents, while non-residents felt *Adhering to messages on postage signage* was easier.
- Non-residents reported that they are significantly more likely to adhere to messages on postage signage than residents.
- Boulder resident respondents are significantly less likely to agree that *Practicing Leave No Trace effectively protects the environment for future generations* than non-residents.

Combined Observation and Survey

- Nearly 50% of visitors who were observed and surveyed while using a UT reported that they 'Always' use DTs, suggesting that these visitors did not know they were in fact traveling on a UT.
- DT users are more likely (~77%) than UT users (49%) to report 'Always' staying on a DT.
- DT users are more likely (~53%) than UT users (39%) to report 'Always' staying on DT when UT is available in the area.

- DT users are more likely (~78%) than UT users (~58%) to report 'Always' adhering to posted messages.

- Compared to DT users (~12%), UT users (~88%) were more likely to report not knowing if they traveled off a DT. Approximately 46% of UT users indicated they had not traveled off a designated trail, while 34% indicated they had traveled off a designated trail. 20% of UT users were unsure if they had traveled off the DT.

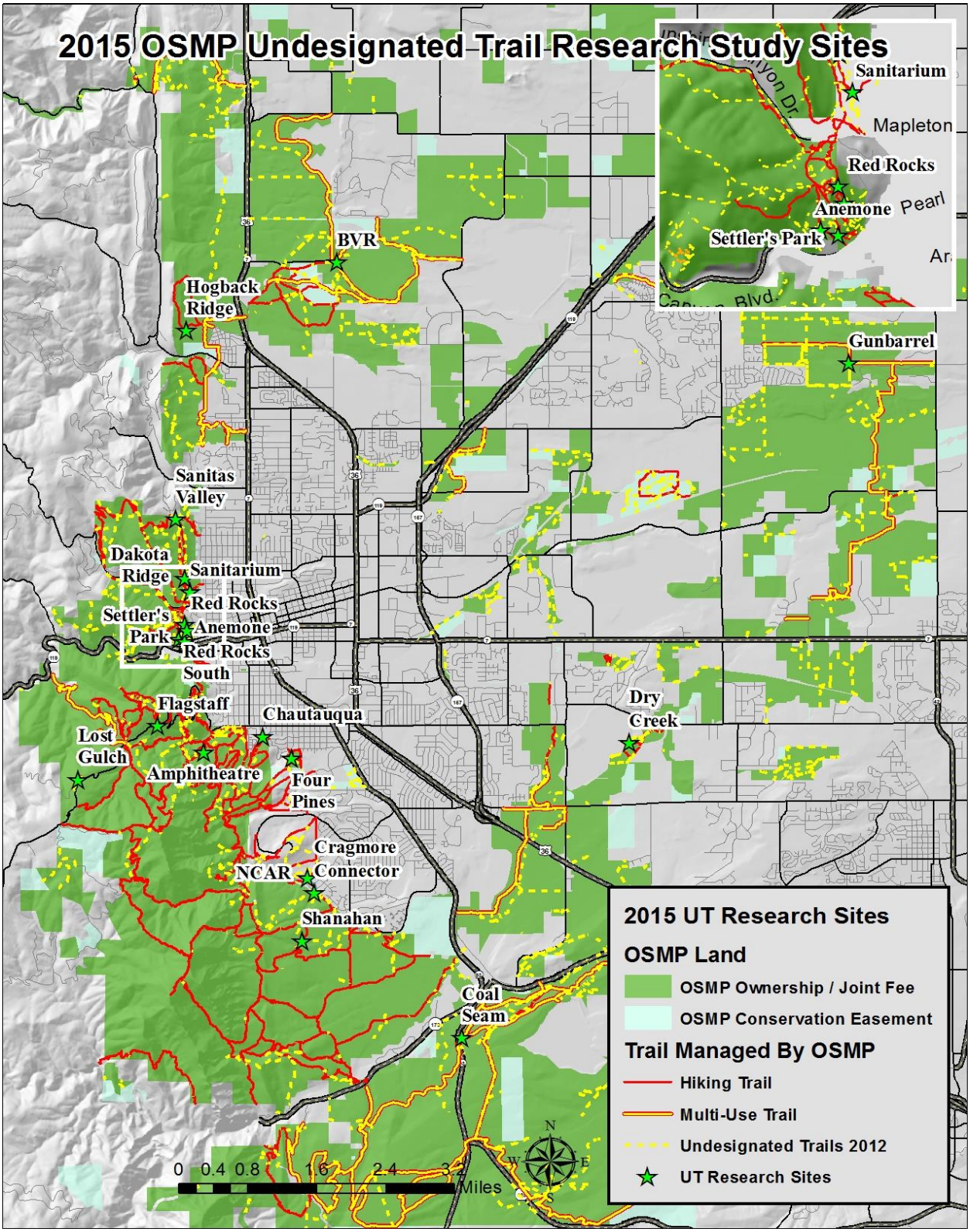
- Statistically significant differences were found between DT and UT users regarding reasons for traveling off trail/on a UT. UT users were more likely than DT users to select the '*applies to me'* and '*don't know'* response options across all items in this block. Moreover, a large proportion of UT users consistently selected the '*Does not apply because I only travel on DTs*' option,' suggesting that many respondents were not aware they were traveling on a UT. Among UT users, the most commonly selected reasons for traveling off trails were *I didn't mean to travel off the designated trail – (it was an accident)* (~45%), and *I have done it before and it worked well for my visitor experience* (~43%).

- A statistically significant difference was found between DT and UT users in the importance they placed on the statement *I have no reason to travel off DTs* as a reason for staying on DTs. This is significantely less important for UT users than for DT users, which could suggest those who use UTs have reason or intention to use them.

- A statistically significant relationship was found between UT and DT users and whether or not they saw posted signage with messages about trails. Approximately 77% of DT users indicated they had seen signs, whereas only 59% of UT users had seen the signs.

- The pairing of survey and observation data provided data analysis opportunities that allowed for deeper exploration into the relationships between attitudes and behavior. For example, a multiple regression model that included the independent variables: perceived effectiveness, appropriateness, and difficulty of staying on designated trails, suggested these constructs predict 55% of the variance in one's self-reported intent to stay on designated trails. In this model all three independent variables contributed significantly to behavioral intent. However, when using the same independent variables in a logistic regression model, this time using actual (observed) behavior (use of a DT or UT) as the dependent variable, the predicitive ability of the model dropped to 12%. Moreover, in the logistic regression only perceived difficulty held as a significant predictor of actual behavior.

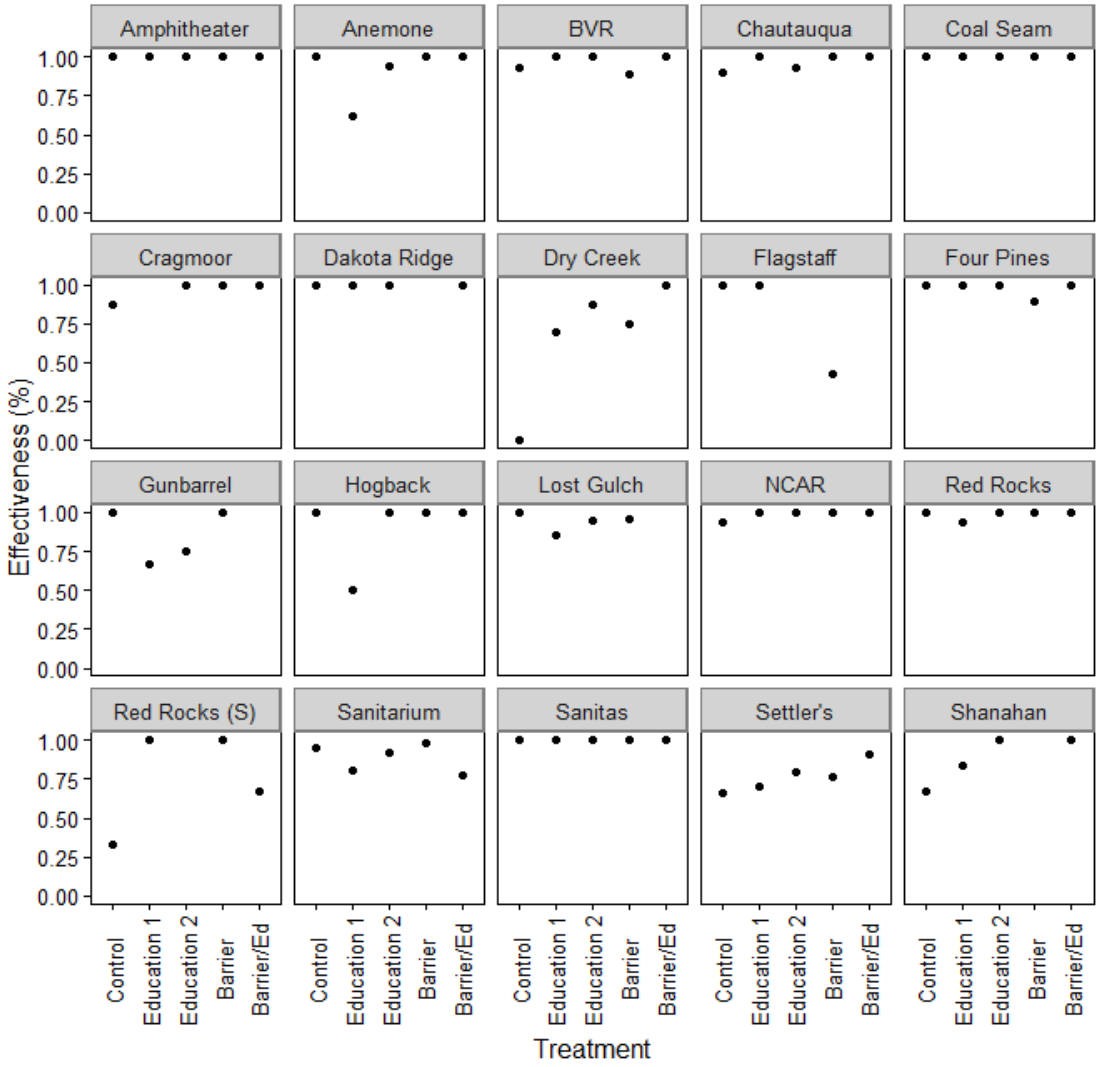
Appendix P. Study Site Map



Appendix Q. Preliminary Site-Level Analysis

Treatment effectiveness, by site

Treatment effectiveness by site is plotted below. Each facet represents a unique site, of which there are 20. Eight of the 20 sites show a pattern consistent with the overall result that Barrier/Ed increases effectiveness over the control. For the 9 additional sites where data was available, the Barrier/Ed treatment had no effect (n = 8), or actually decreased effectiveness (n = 1; Sanitarium). For the remaining 3 sites (Lost Gulch, Flagstaff, Gunbarrel) there were no visitors observed during Barrier/Ed data collection, thus we can make no determination as to the effectiveness of the Barrier/Ed treatment at these sites.



Appendix R. Powerpoint slides from May 26, 2016 research presentation

Effectiveness of Educational and Site Management Actions in Reducing Use of Undesignated Trails on Open Space Lands

Ben Lawhon
Leave No Trace Center for Outdoor Ethics
Boulder, Colorado

Derrick Taff
The Pennsylvania State University
Recreation, Park, and Tourism Management

Forrest Schwartz
The Pennsylvania State University
Recreation, Park, and Tourism Management

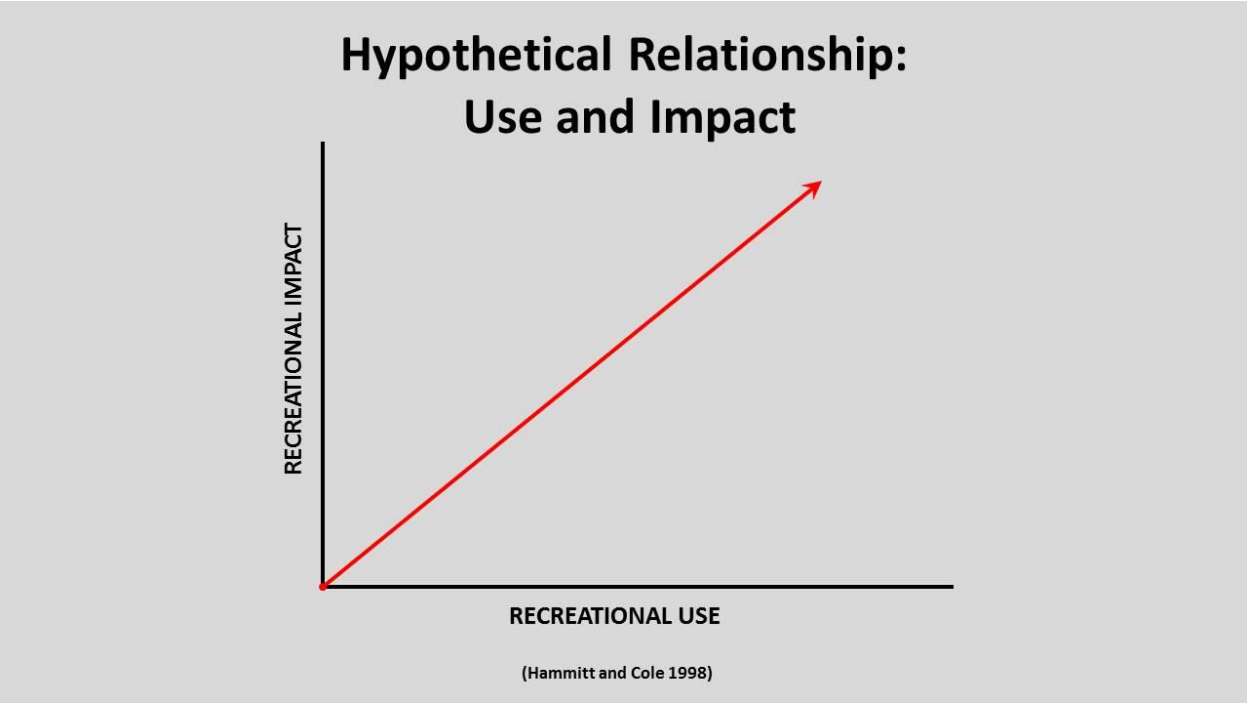
Presentation Overview

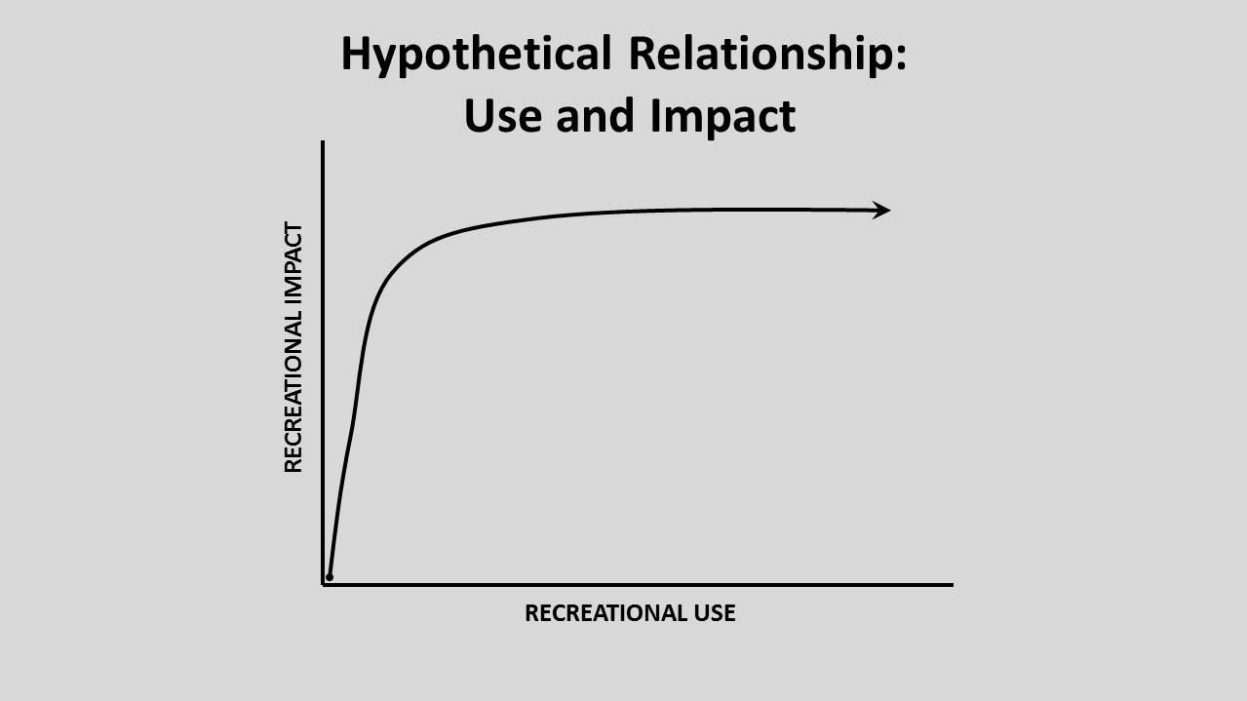
- Research background
- Broad implications of undesignated trail use
- Study methodology, protocols, and data collection
- Study findings
- Discussion and implications

Research Background

- Resource impact resulting from visitor behavior is a significant concern for protected area managers.
- Managers must utilize numerous strategies such as Leave No Trace education to minimize impacts.
- In many protected areas, the proliferation of **undesignated trails** is primary concern for managers.
- Some experimental studies have been conducted on undesignated trail use but this design is a first.

Undesignated Trail Impacts


Hypothetical Relationship:
Use and Impact
RECREATIONAL IMPACT
RECREATIONAL USE
(Hammitt and Cole 1998)


Hypothetical Relationship:
Use and Impact
RECREATIONAL IMPACT
RECREATIONAL USE

What kinds of behavior are we trying to target?

Application of Information/Education to Wilderness Management Problems (Manning, 2003)

Type of Problem	Example	Potential Effectiveness of Information/ Education
Illegal actions	Theft of Indian artifacts; use of wilderness by motorized off-road vehicles	Low
Careless actions	Littering; shouting	Moderate
Unskilled actions	Selecting improper campsites; building improper campfire	High
Uninformed actions	Using dead snags for firewood; camping in sight or sound of another group	Very high
Unavoidable actions	Disposing of human waste; trampling ground cover vegetation at campsites	Low

(adapted from Manning, 2003)

Leave No Trace

- 1960's-1990's: Are we loving our parks to death?
- Leave No Trace created and adopted across the agency spectrum as an indirect approach to managing recreation impacts.
- Population growth, advances in technology, 'get outside' initiatives = more people enjoying outdoor spaces.
- What we need to know:
  - Recreationists attitudes and perceptions of Leave No Trace
  - Effectiveness of Leave No Trace-based education/management approaches
  - Drivers of Leave No Trace behavioral intent

OSMP Use…

- Approximately 45,000 acres of public lands
- Multiple use/Resource protection mandate
- Myriad uses: hiking, running, biking, equestrian, climbing, fishing, dog walking, etc.
- Annual visitation: ~5,300,000

Boulder Open Space

=

Arches

+

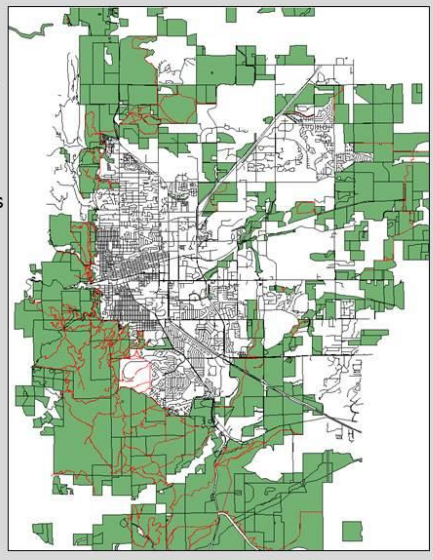
Gettysburg

+

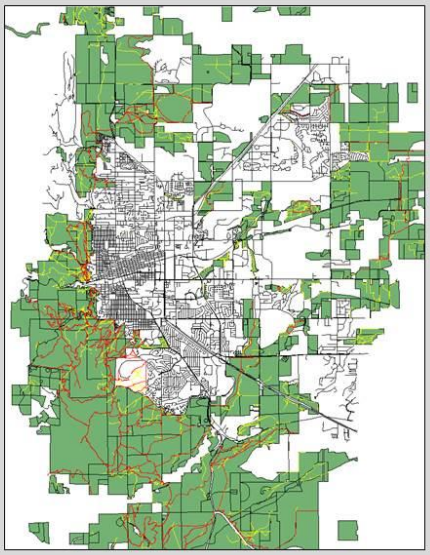
Grand Teton

OSMP Designated (DTs) and Undesignated Trails (UTs)

Approximately 150 miles of <u>designated</u> recreational trails and roads



Over 150 miles of <u>undesignated</u> recreational trails and roads



The Study…

Management Need: Data regarding the effectiveness of various undesignated trail management approaches

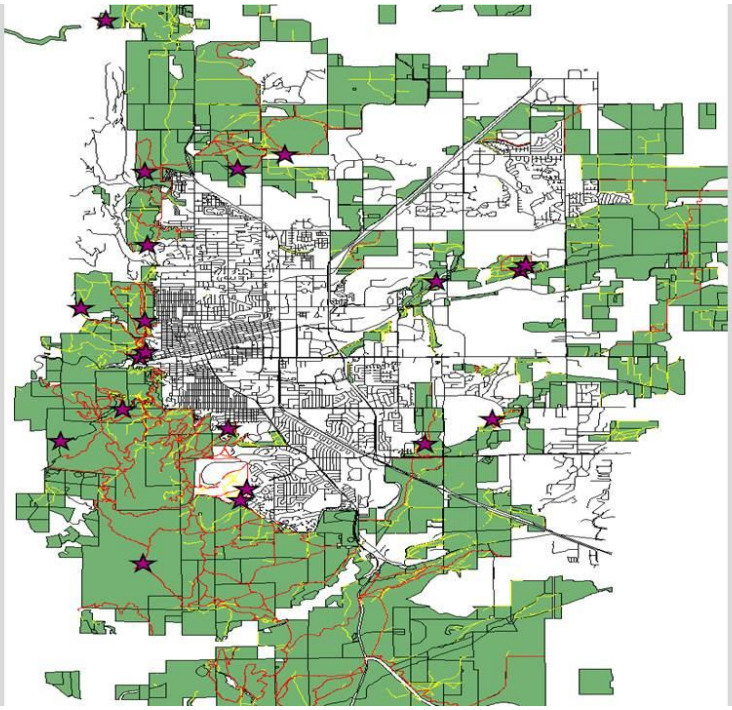
Purpose: Examine effectiveness of alternative management practices in mitigating undesignated trail use

Methods…

Selection of sites:
Site selection for this study was conducted by OSMP managers. Sites selected based on a statistically stratified representation of the various types of trail settings and associated use in OSMP, with the intent to represent DT and UT usage at a system level…

Sanitarium	Amphitheatre
Chautauqua	NCAR
Anemone	Lost Gulch
Hogback Ridge	Boulder Valley Ranch
Dry Creek	Settler's Park
4 Pines	Sanitas Valley
Read Rocks South	Coal Seam
Shanahan	Flagstaff
Red Rocks	Dakota Ridge
Cragmore Connector	Gunbarrel

Sampling Sites…



Paired Survey and Observation

Mountain Parks (OSMP) Visitor Survey

TY today? (Select only one)

lking dog(s) ☐ Climbing/Bouldering ☐ Horseback Riding

ing ☐ Other: _____

y (please **do not** include dogs another person in your group brought)? (Select only

☐ 4 ☐ 5 ☐ 6

s section of trail **in the past 12 months**? (Select only one)

☐ 1 – 12 Visits ☐ 13 – 48 Visits

☐ 145 – 240 Visits ☐ > 240 Visits

of Boulder OSMP are **"undesignated"** or not official trails?

man recreation behaviors have the **potential to cause NEGATIVE IMPACT**

ty of Boulder OSMP? (Select only one answer per item)

Direct (unobtrusive) observation of trail users

Paired

Administer surveys to trail users

Treatments…

Educational messaging based on an on-site elicitation survey at Settler's Park and Chautauqua

n = 30

Rated:

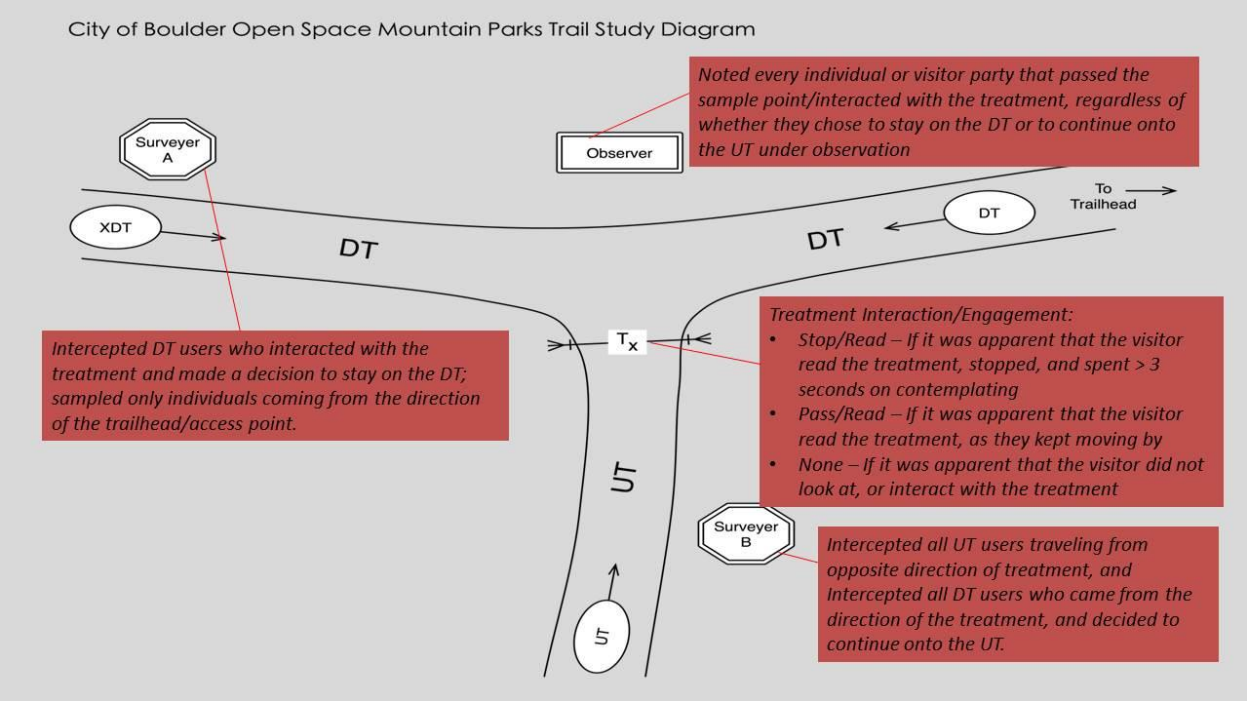
1) the persuasiveness of the message
2) the likeliness that the message would influence their behavior to stay on designated OSMP trails.

Sampling…

June 1 – July 2, 2015 (25 days of sampling)

Stratification:

- 1 control/4 treatments
- 20 sampling locations/sites
- a.m. or p.m. (ranged from 6:30 am – 7:30 pm)
- Weekday (i.e., Monday, Tuesday, Wednesday, and Thursday) or weekend (i.e., Friday, Saturday, and Sunday
- Paired surveying with visitor behavior observation, or observation of visitor behavior without the survey instrument
- Availability and quantity of OSMP staff/volunteers and research staff
- The limited sampling period spanning over ~one-month



Overall Data Collection and Response Rate

- Treatments placed immediately prior to sampling: <24 hour prior
- All 20 sampling sites received all of the conditions (the control, and the four treatments) at least once during the sampling period
- All 20 sampling sites received paired visitor survey with visitor behavior observations ("paired"), as well as observations (not paired with surveys "observed") of visitor behavior
- 15 Paired (survey and observation) sampling days; 10 Observation sampling days

User profile: Sample characteristics – observation and survey

- Total observations *n* = 2232 across 20 sample sites
- *n* = 147 respondents completed a paired on-site survey, with a total response rate of 68%

- **Observation**
  - 76% Hiking/Walking
  - 59% visiting solo
  - 75% visiting without a dog

- **Survey respondents**
  - 74% Hiking/Walking
  - 48% visiting solo; 42% in pairs
  - 69% visiting without a dog
  - 70% Boulder residents

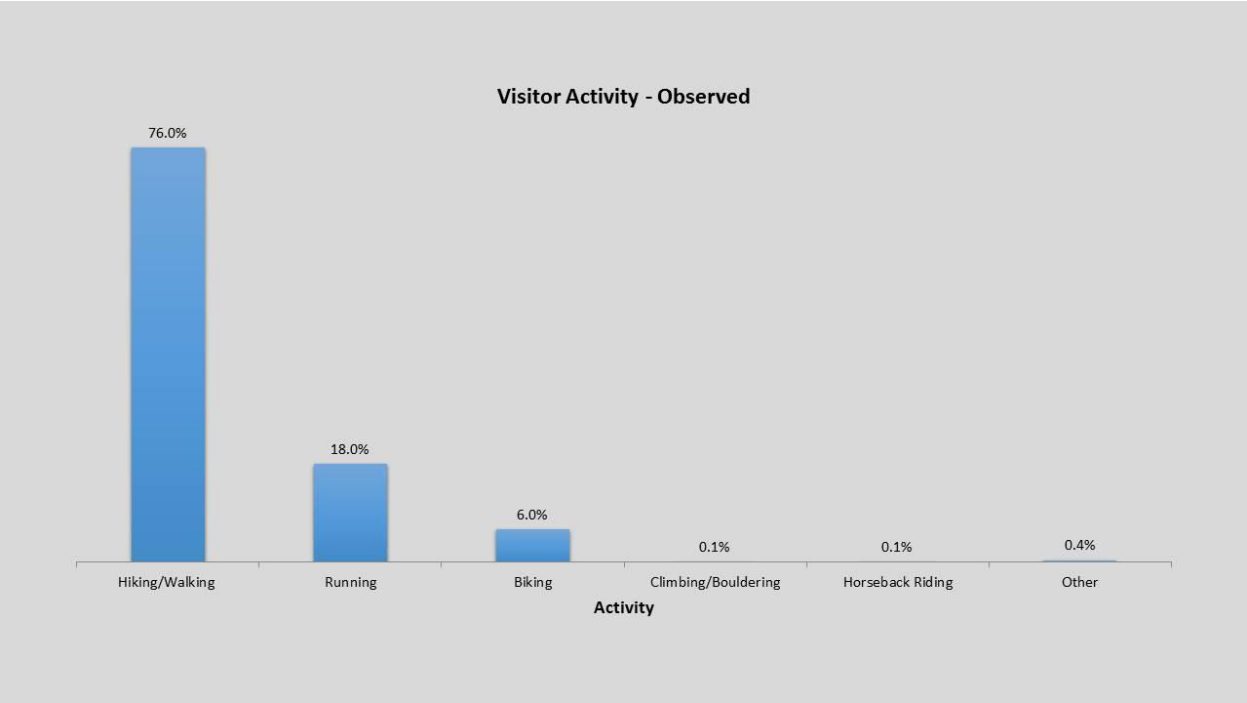
3666 people

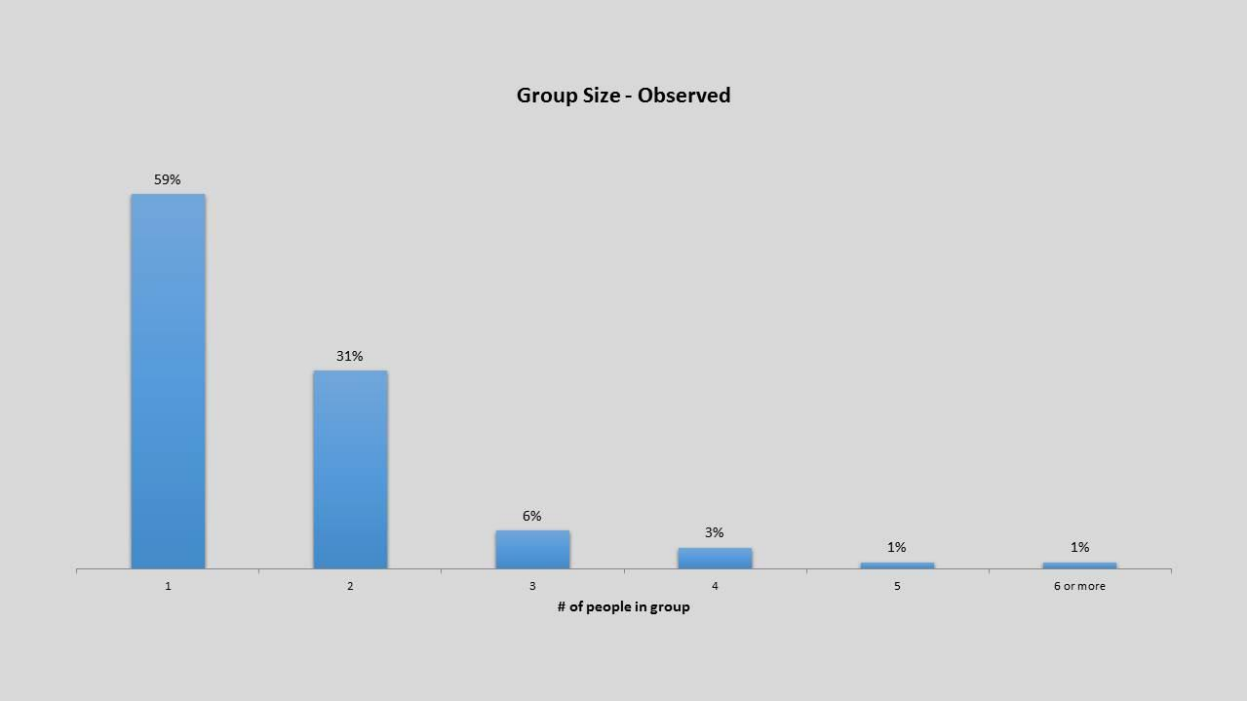
685 dogs

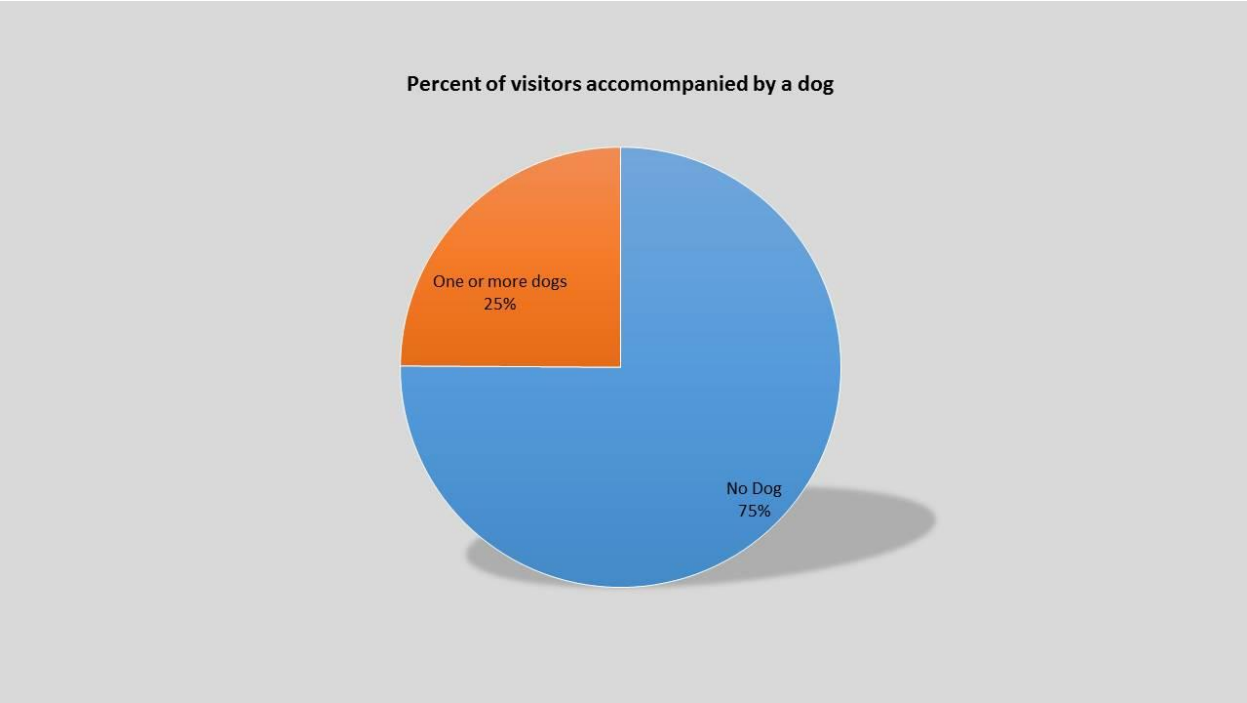
147 Surveys

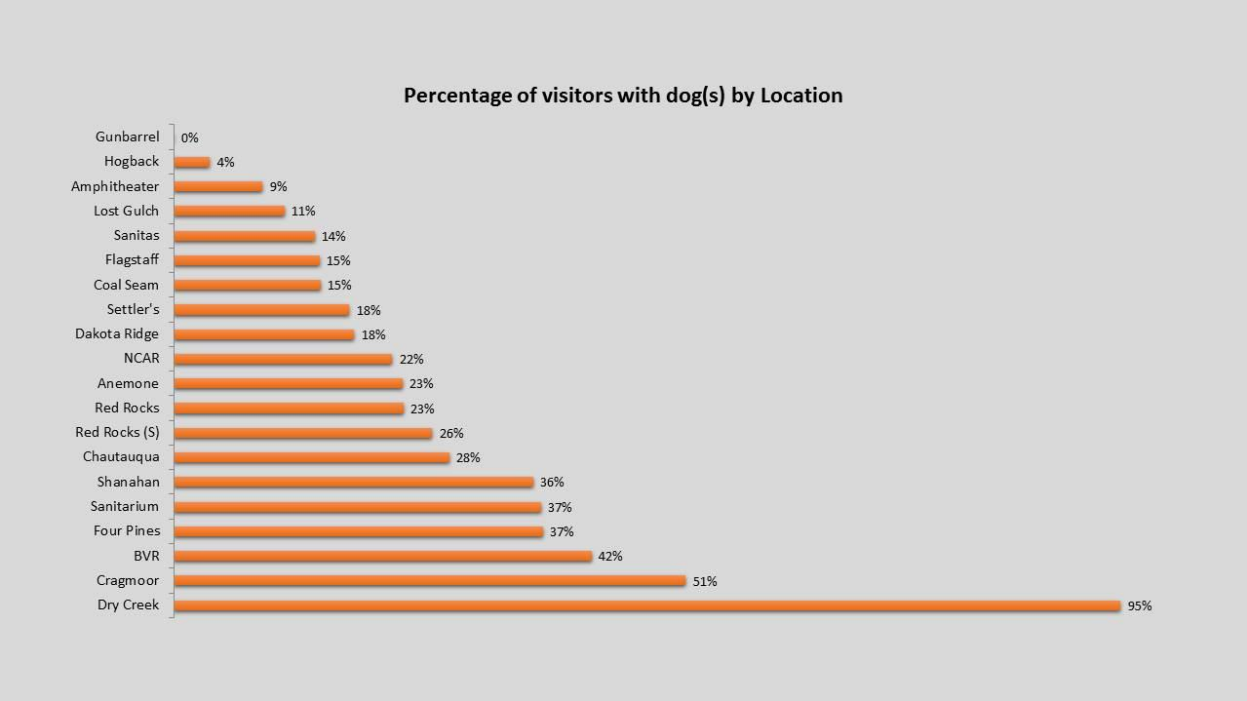
Results

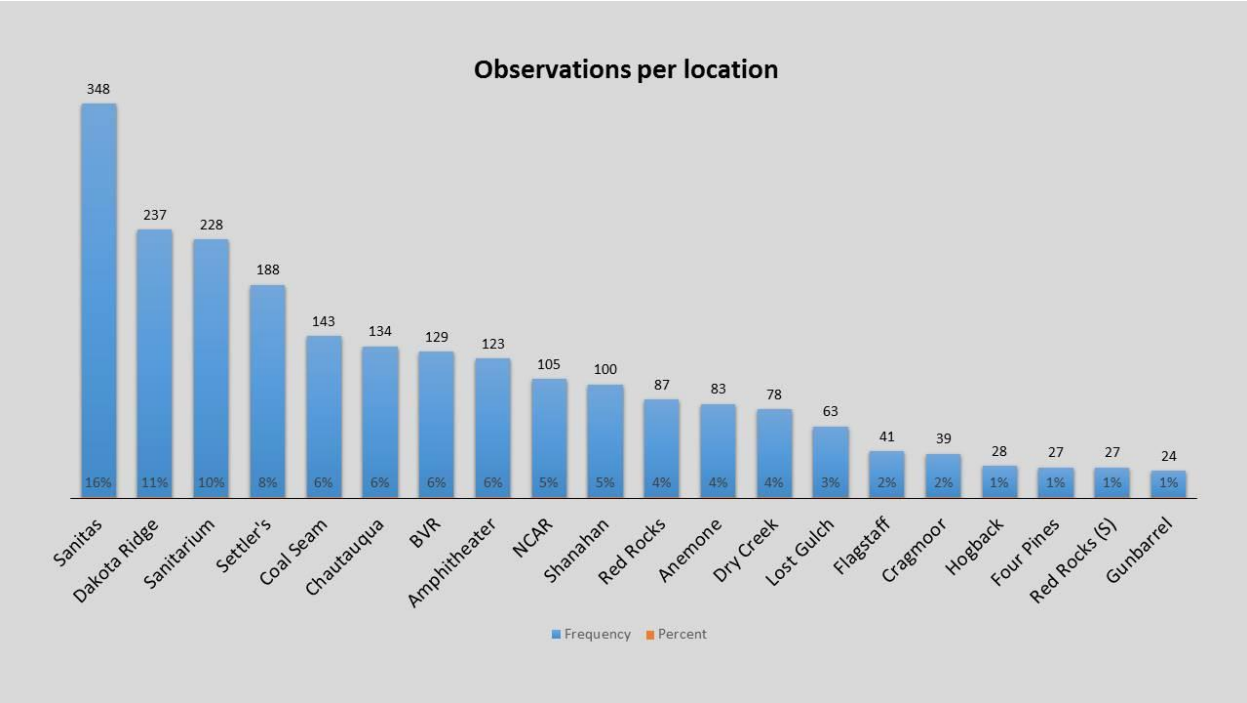
Observation Data

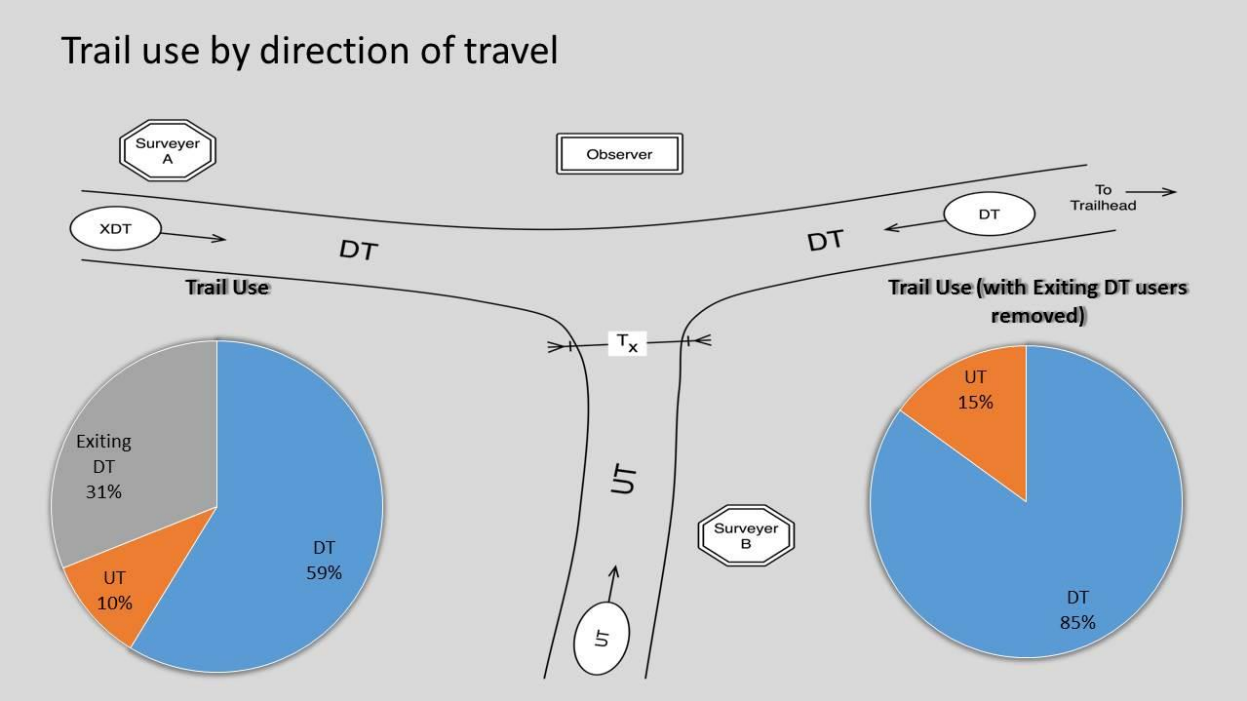

Visitor Activity - Observed
76.0%
18.0%
6.0%
0.1%
0.1%
0.4%
Hiking/Walking
Running
Biking
Climbing/Bouldering
Horseback Riding
Other
Activity

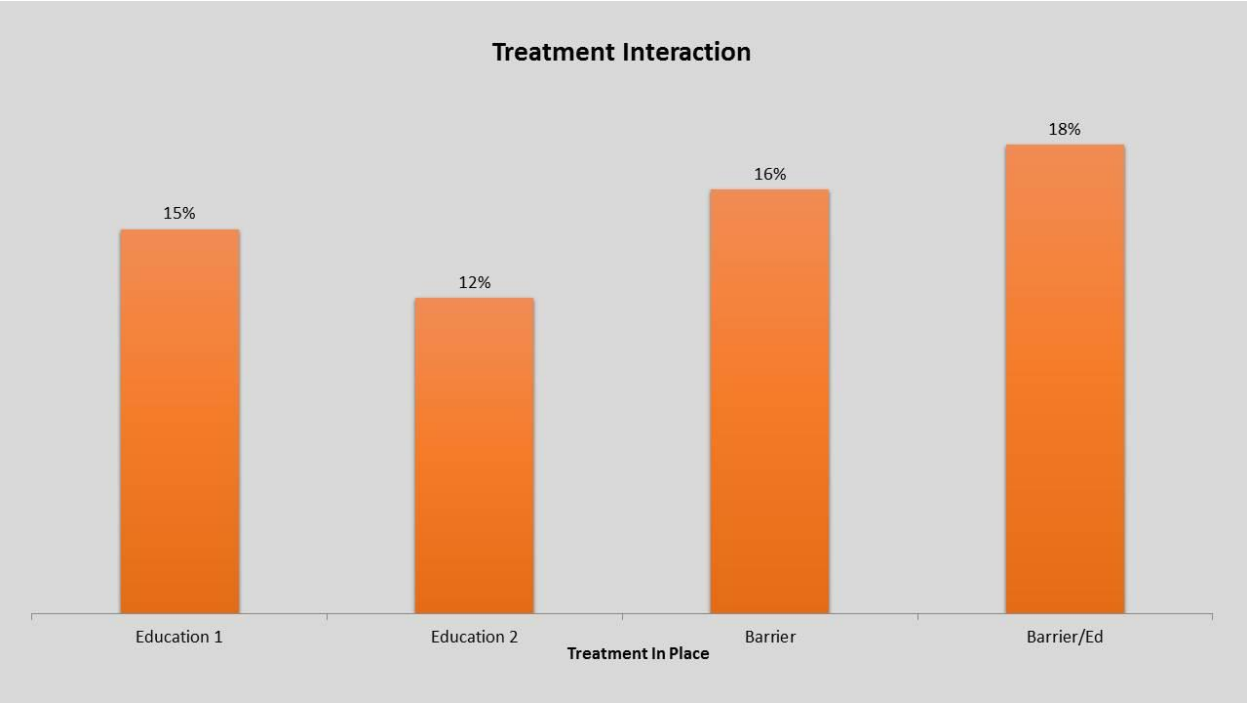

Group Size - Observed
59%
31%
6%
3%
1%
1%
1
2
3
4
5
6 or more
# of people in group

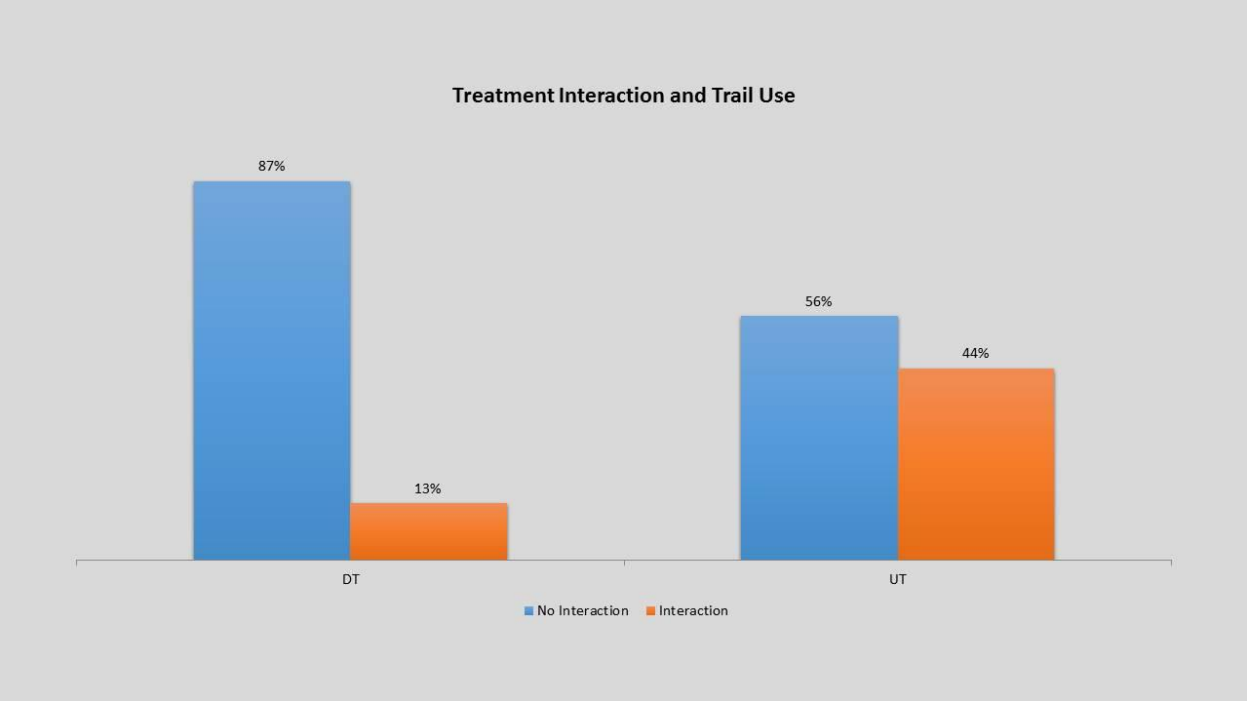

Percent of visitors accomompanied by a dog
One or more dogs
25%
No Dog
75%

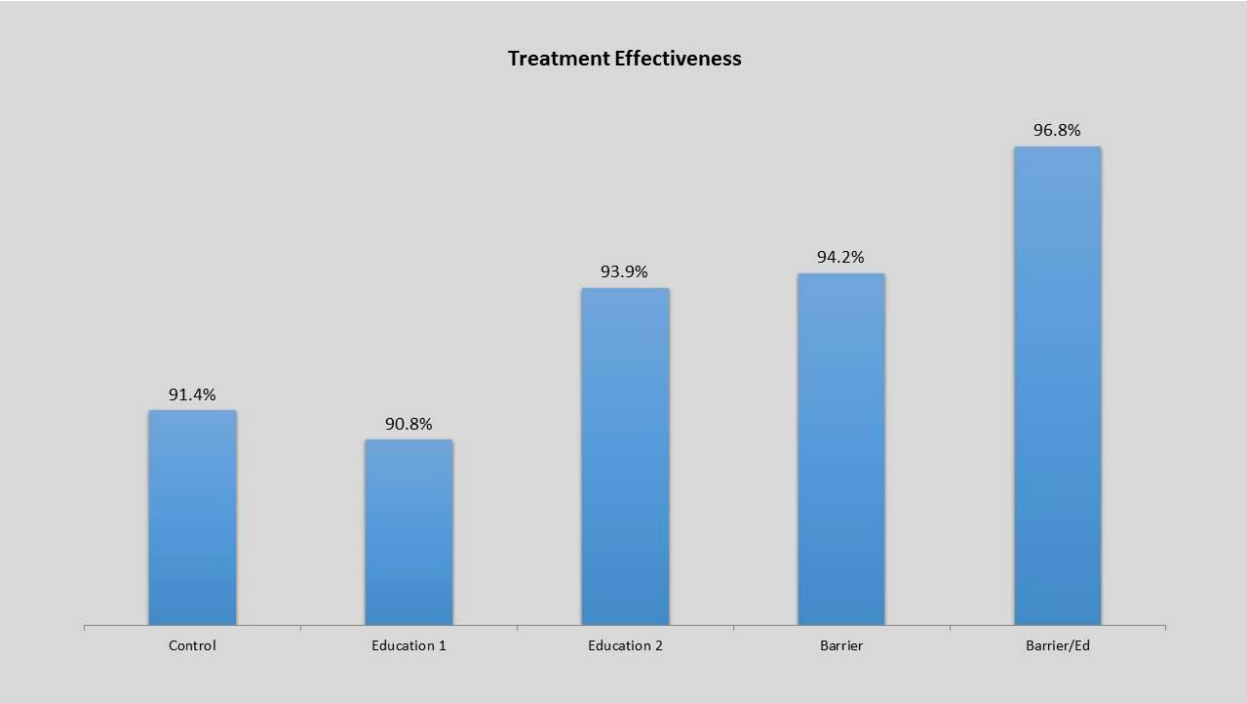

Percentage of visitors with dog(s) by Location
Gunbarrel 0%
Hogback 4%
Amphitheater 9%
Lost Gulch 11%
Sanitas 14%
Flagstaff 15%
Coal Seam 15%
Settler's 18%
Dakota Ridge 18%
NCAR 22%
Anemone 23%
Red Rocks 23%
Red Rocks (S) 26%
Chautauqua 28%
Shanahan 36%
Sanitarium 37%
Four Pines 37%
BVR 42%
Cragmoor 51%
Dry Creek 95%

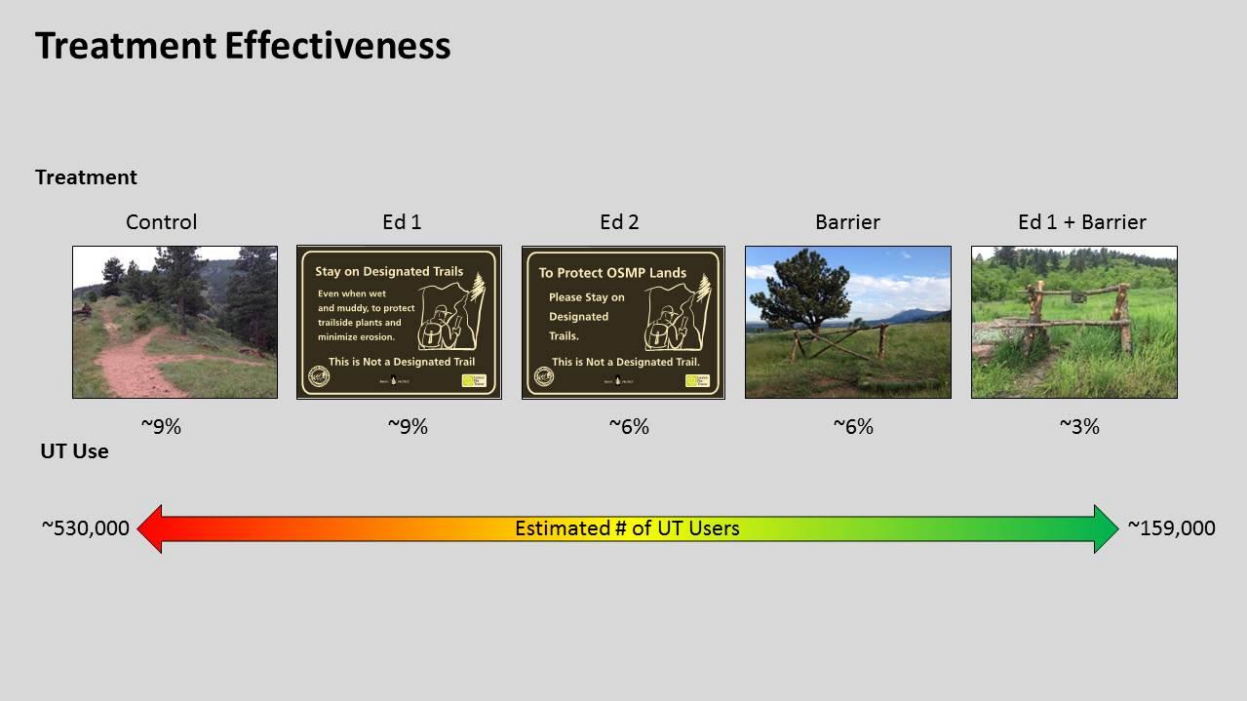

Observations per location
348
237
228
188
143
134
129
123
105
100
87
83
78
63
41
39
28
27
27
24
16%
11%
10%
8%
6%
6%
6%
6%
5%
5%
4%
4%
4%
3%
2%
2%
1%
1%
1%
1%
Sanitas
Dakota Ridge
Sanitarium
Settler's
Coal Seam
Chautauqua
BVR
Amphitheater
NCAR
Shanahan
Red Rocks
Anemone
Dry Creek
Lost Gulch
Flagstaff
Cragmoor
Hogback
Four Pines
Red Rocks (S)
Gunbarrel
Frequency
Percent

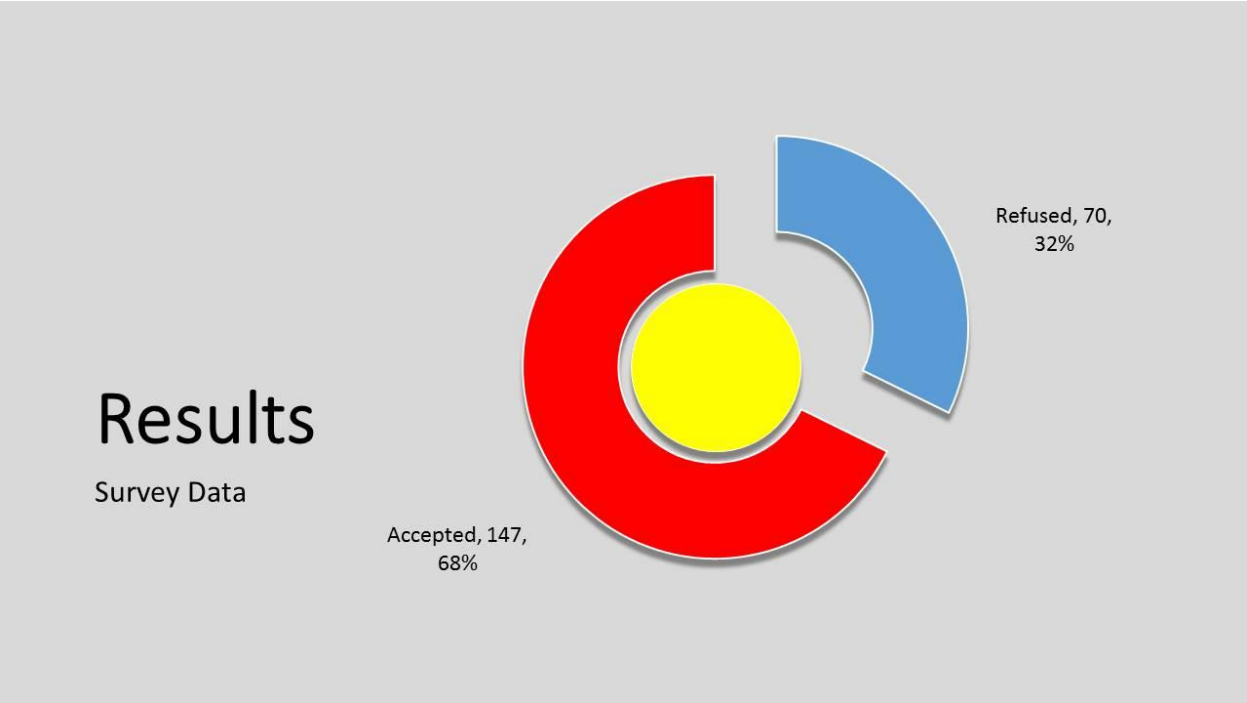

Trail use by direction of travel
Surveyer A
Observer
XDT
DT
DT
DT
To Trailhead
Trail Use
Trail Use (with Exiting DT users removed)
Tx
UT
Surveyer B
UT
Exiting DT 31%
UT 10%
DT 59%
UT 15%
DT 85%

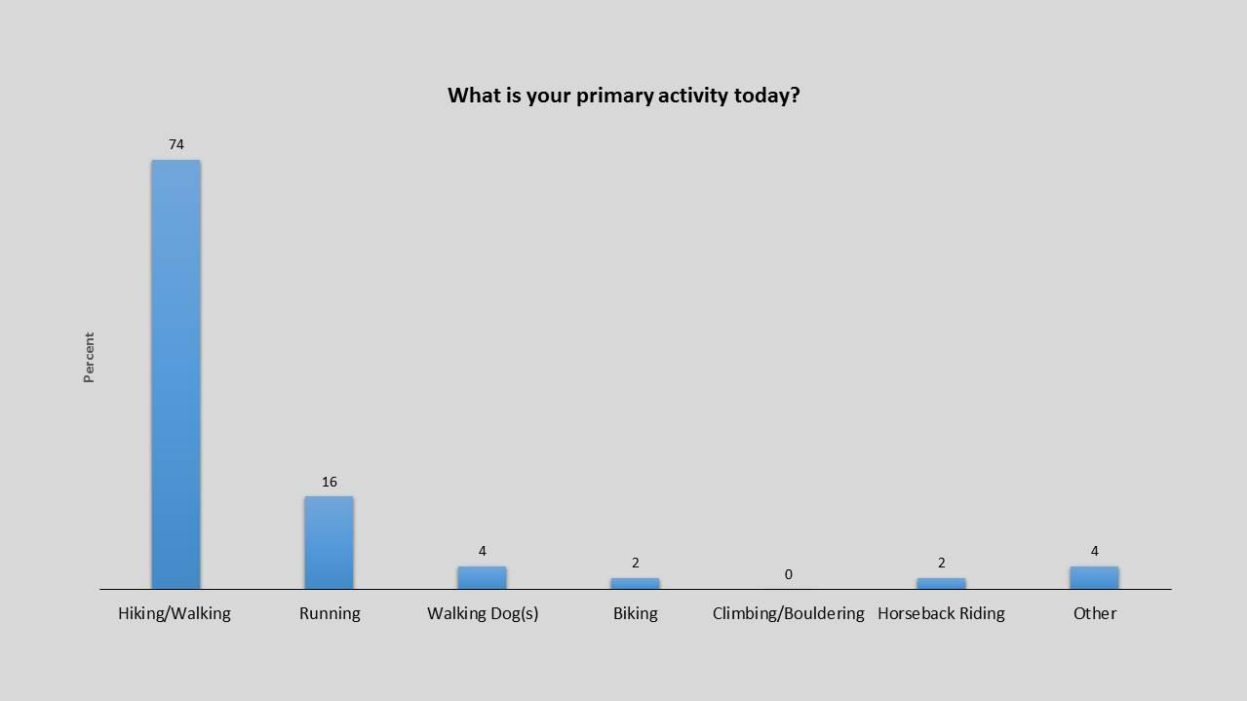

Treatment Interaction
15%
12%
16%
18%
Education 1
Education 2
Barrier
Barrier/Ed
Treatment In Place

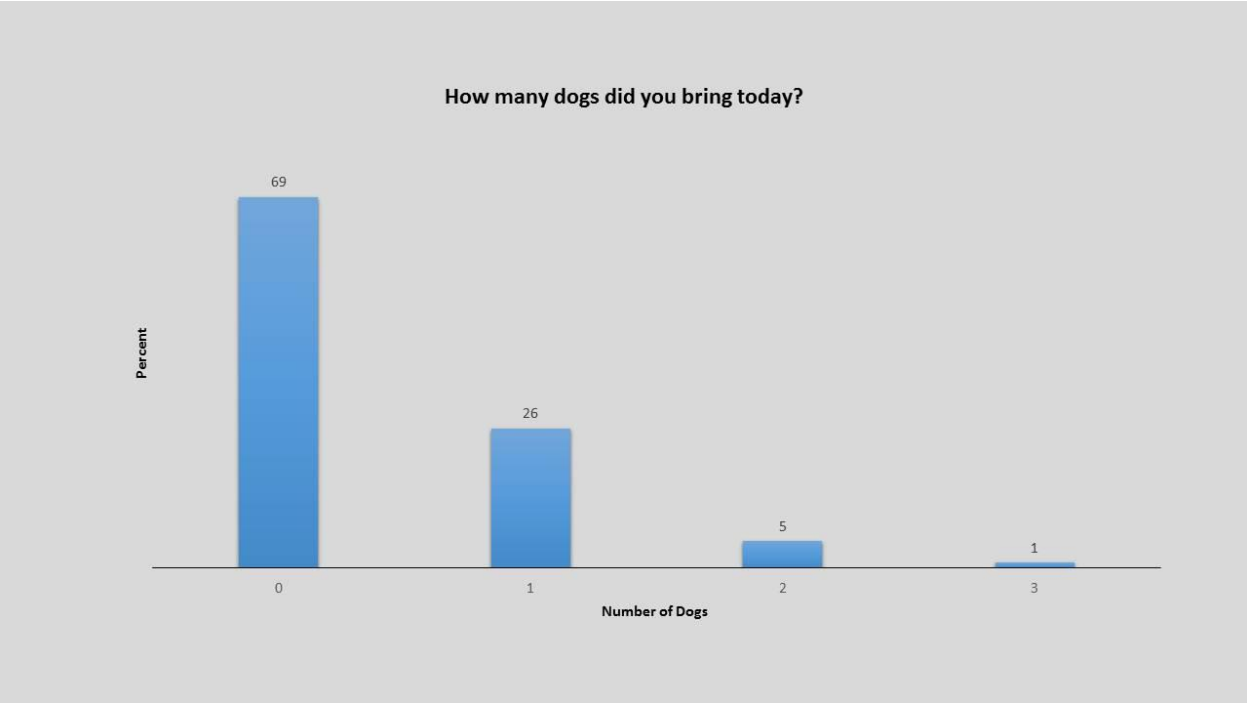

Treatment Interaction and Trail Use
87%
13%
56%
44%
DT
UT
No Interaction
Interaction

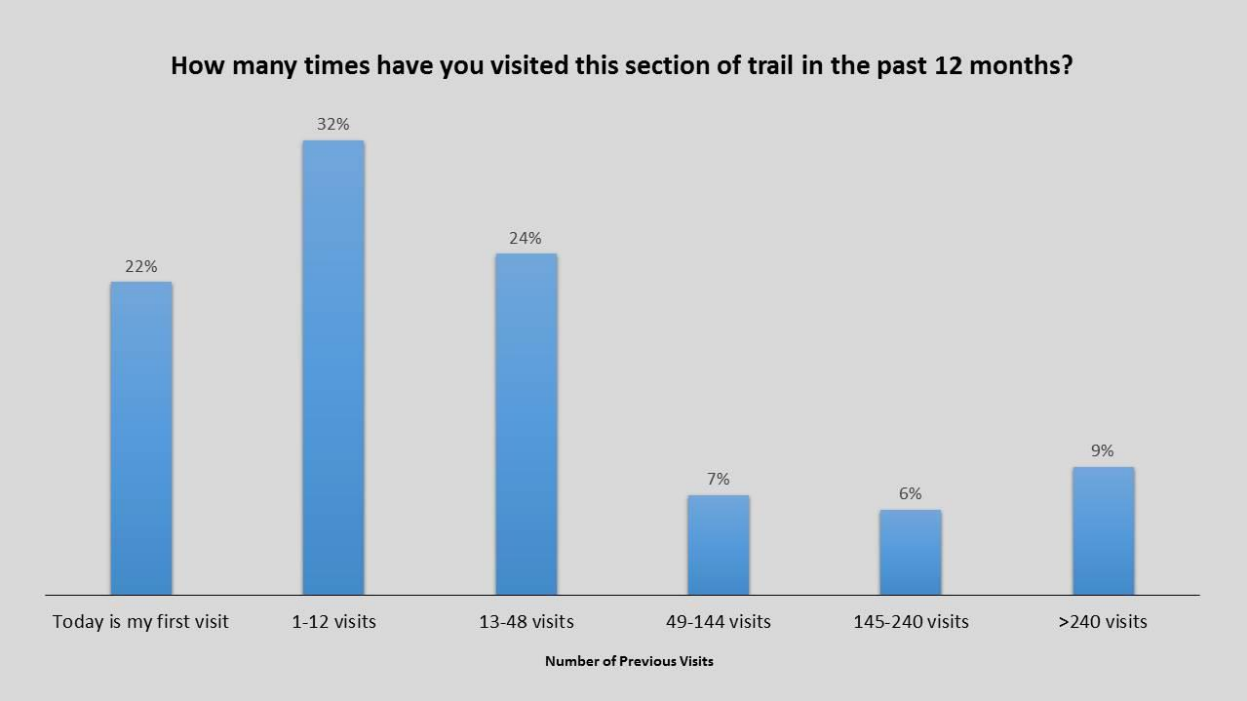

Treatment Effectiveness
91.4%
90.8%
93.9%
94.2%
96.8%
Control
Education 1
Education 2
Barrier
Barrier/Ed

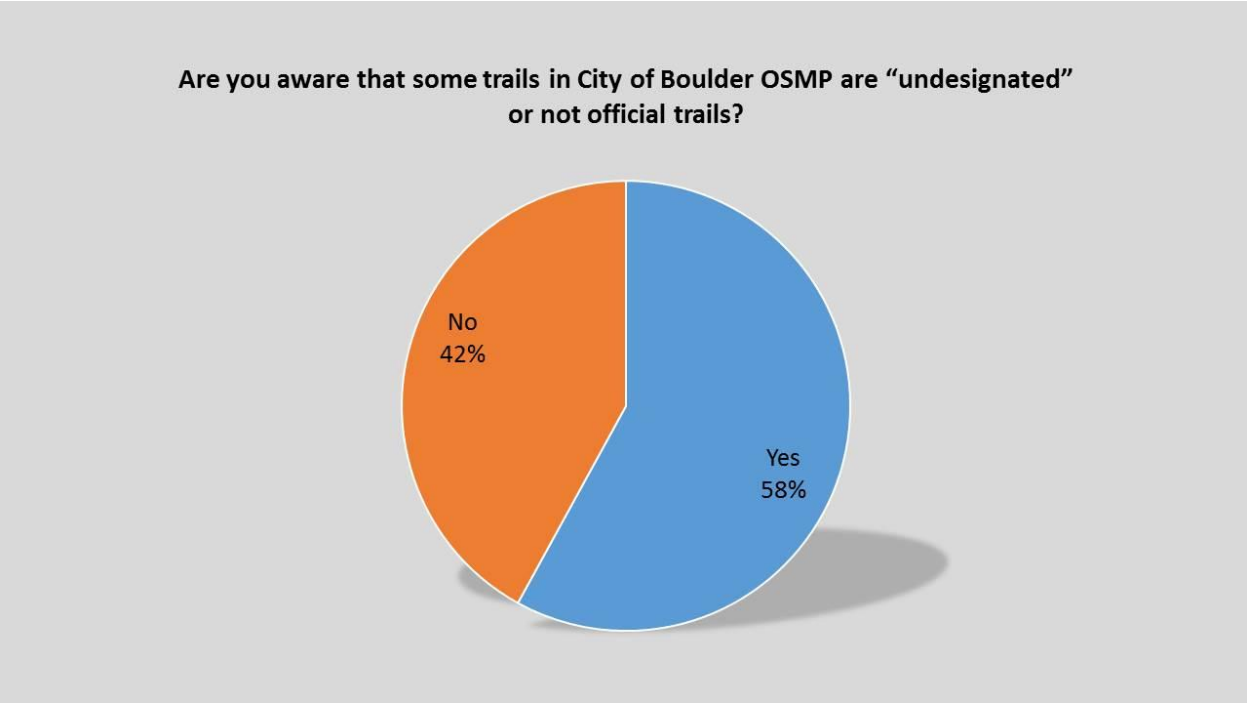

Treatment Effectiveness
Treatment
Control
Ed 1
Ed 2
Barrier
Ed 1 + Barrier
Stay on Designated Trails
Even when wet and muddy, to protect trailside plants and minimize erosion.
This is Not a Designated Trail
To Protect OSMP Lands
Please Stay on Designated Trails.
This is Not a Designated Trail.
~9%
~9%
~6%
~6%
~3%
UT Use
~530,000
Estimated # of UT Users
~159,000

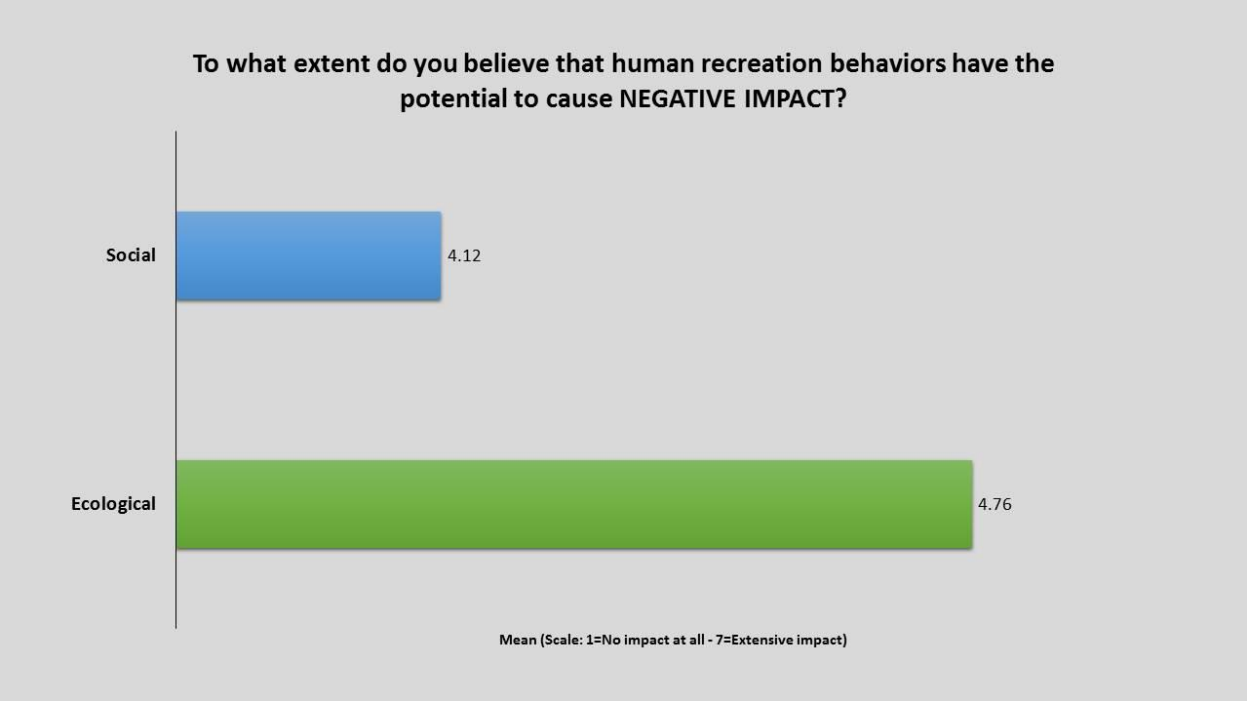

Results
Survey Data
Refused, 70, 32%
Accepted, 147, 68%

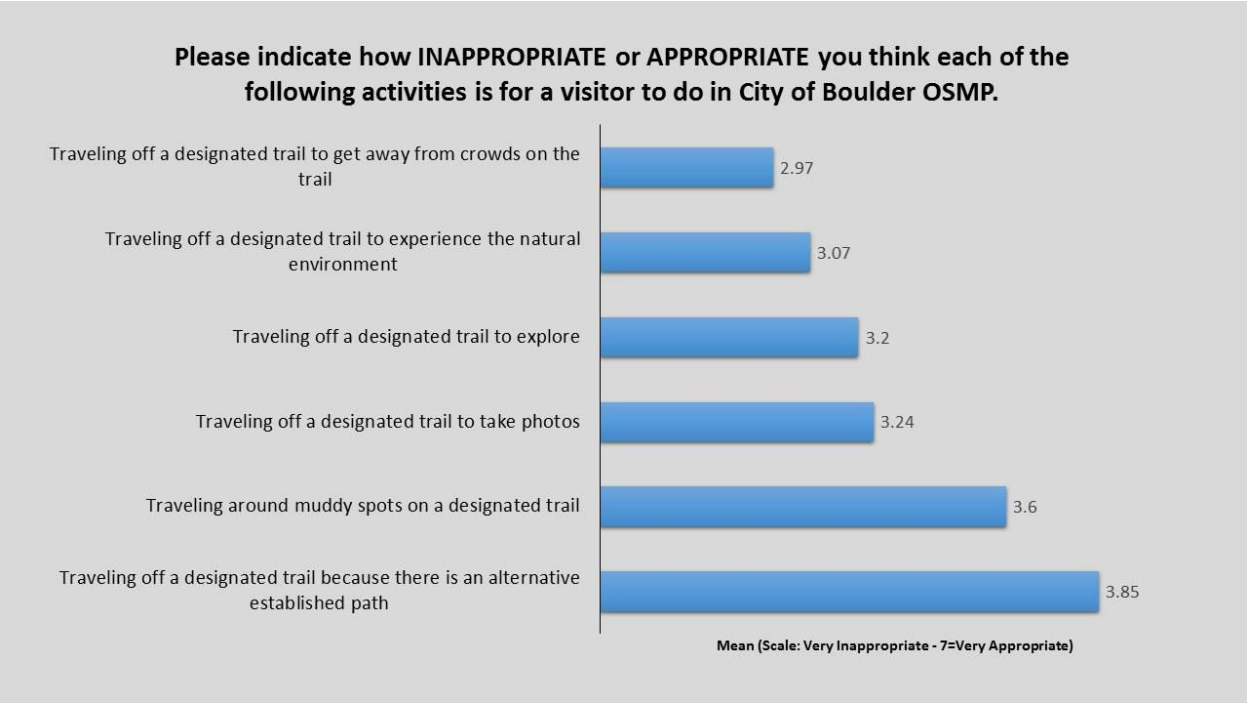

What is your primary activity today?
Percent
74
16
4
2
0
2
4
Hiking/Walking
Running
Walking Dog(s)
Biking
Climbing/Bouldering
Horseback Riding
Other

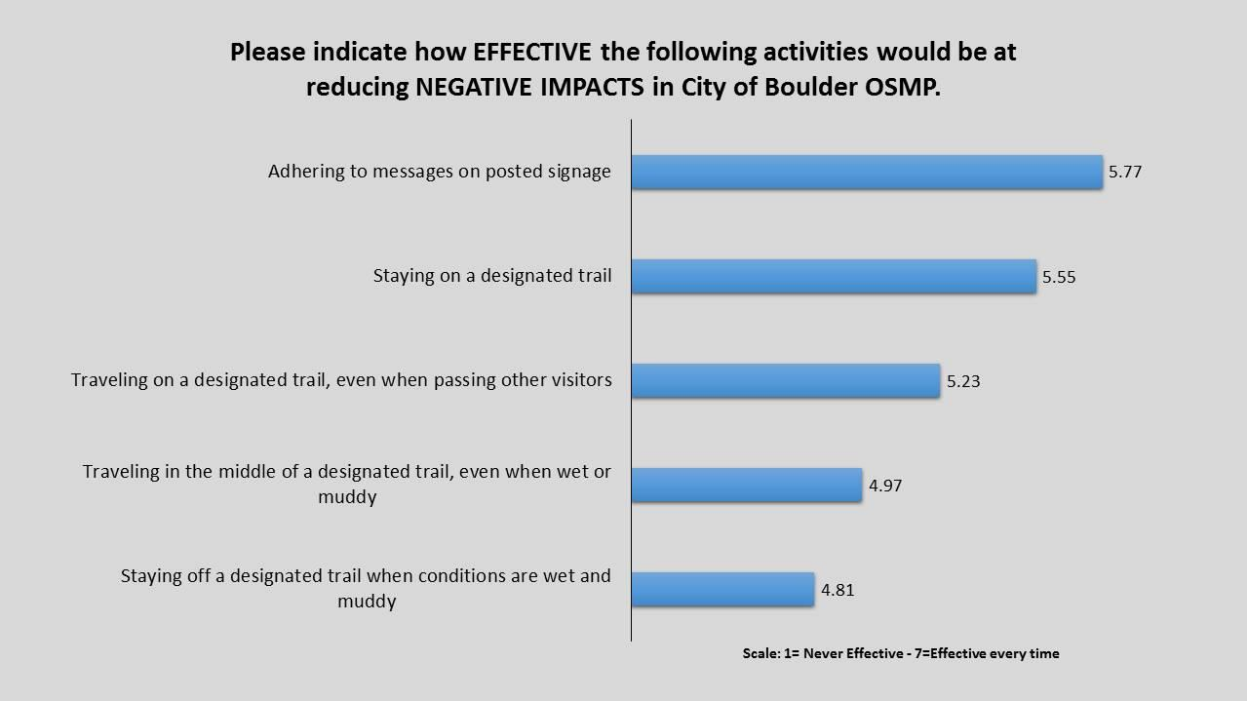

How many dogs did you bring today?
Percent
69
26
5
1
0
1
2
3
Number of Dogs

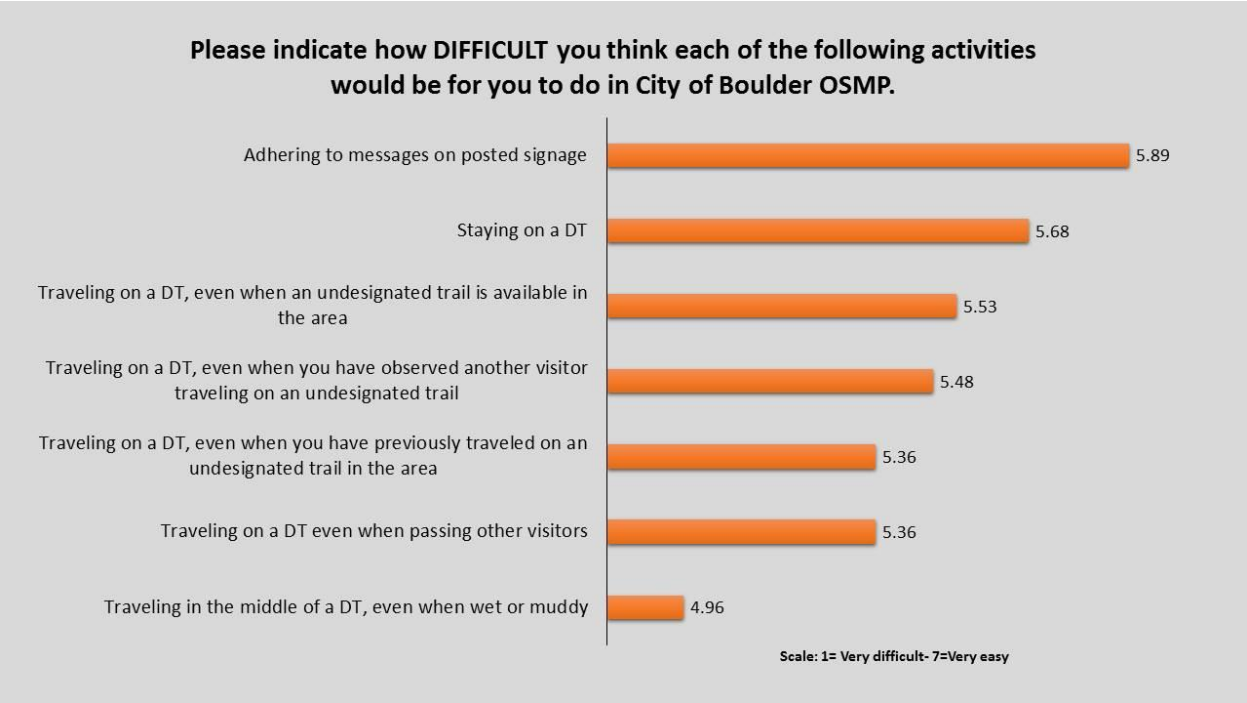

How many times have you visited this section of trail in the past 12 months?
22%
32%
24%
7%
6%
9%
Today is my first visit
1-12 visits
13-48 visits
49-144 visits
145-240 visits
>240 visits
Number of Previous Visits

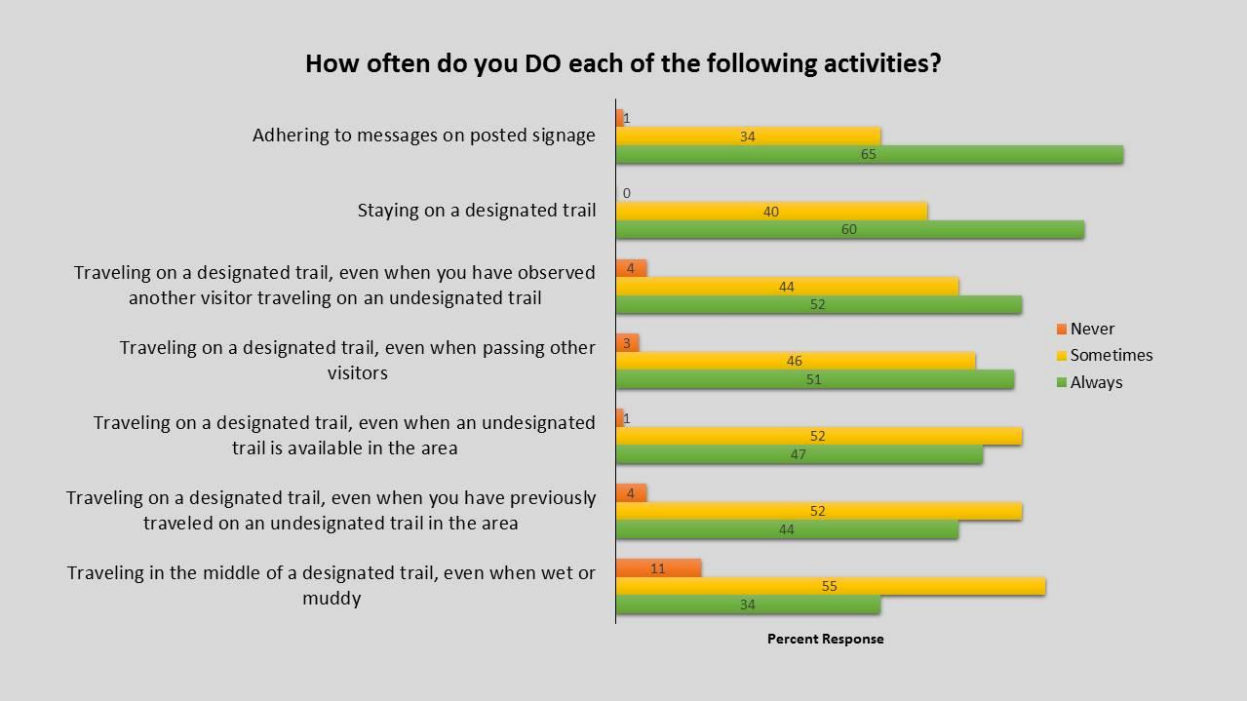

Are you aware that some trails in City of Boulder OSMP are "undesignated" or not official trails?
No
42%
Yes
58%

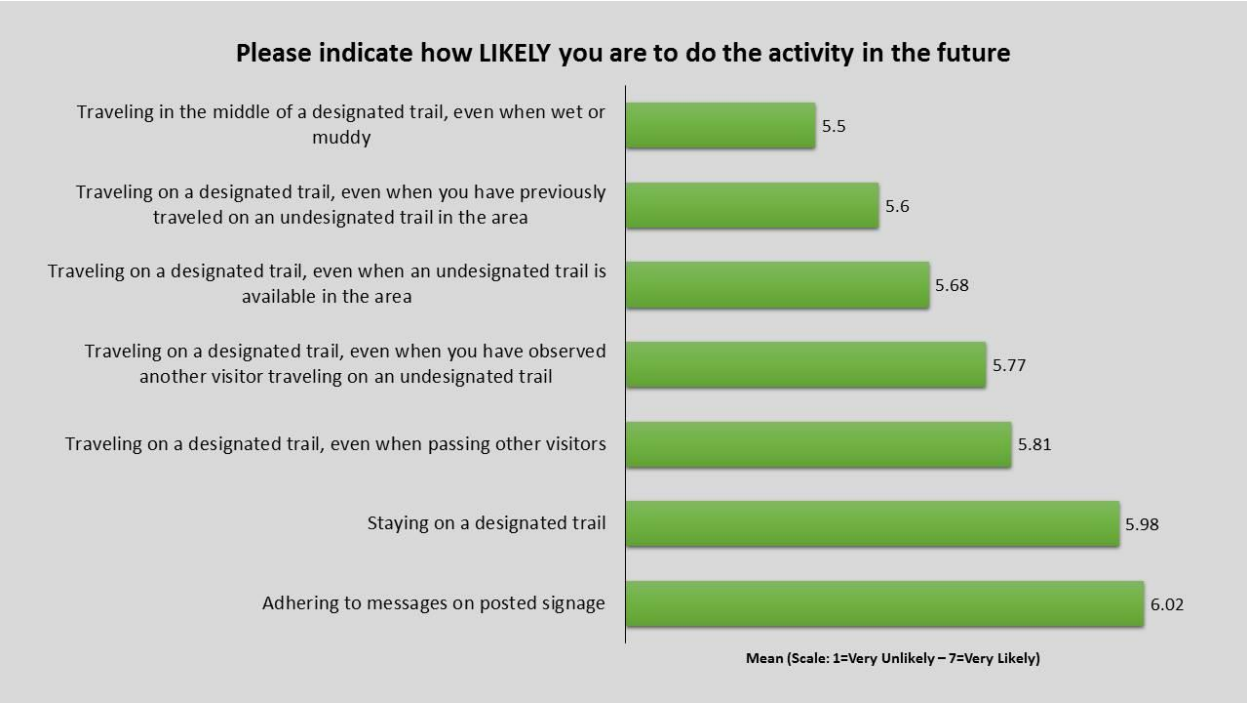

To what extent do you believe that human recreation behaviors have the potential to cause NEGATIVE IMPACT?
Social
4.12
Ecological
4.76
Mean (Scale: 1=No impact at all - 7=Extensive impact)

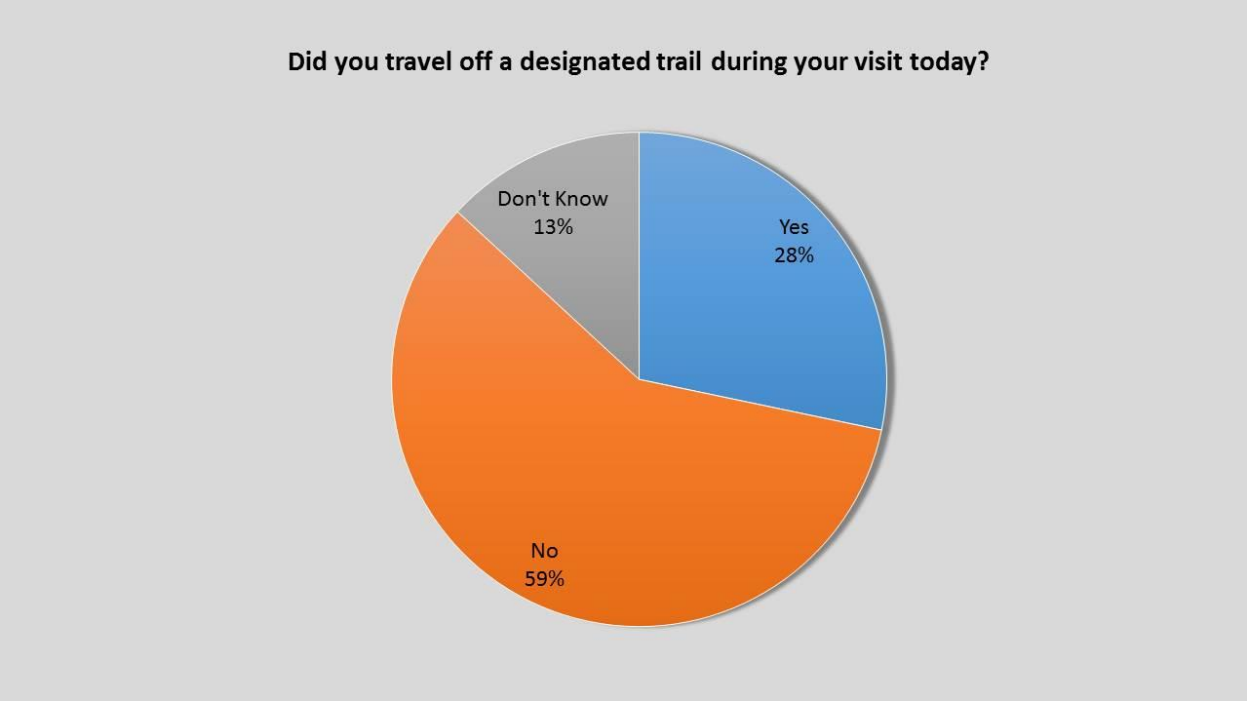

Please indicate how INAPPROPRIATE or APPROPRIATE you think each of the following activities is for a visitor to do in City of Boulder OSMP.
Traveling off a designated trail to get away from crowds on the trail
2.97
Traveling off a designated trail to experience the natural environment
3.07
Traveling off a designated trail to explore
3.2
Traveling off a designated trail to take photos
3.24
Traveling around muddy spots on a designated trail
3.6
Traveling off a designated trail because there is an alternative established path
3.85
Mean (Scale: Very Inappropriate - 7=Very Appropriate)

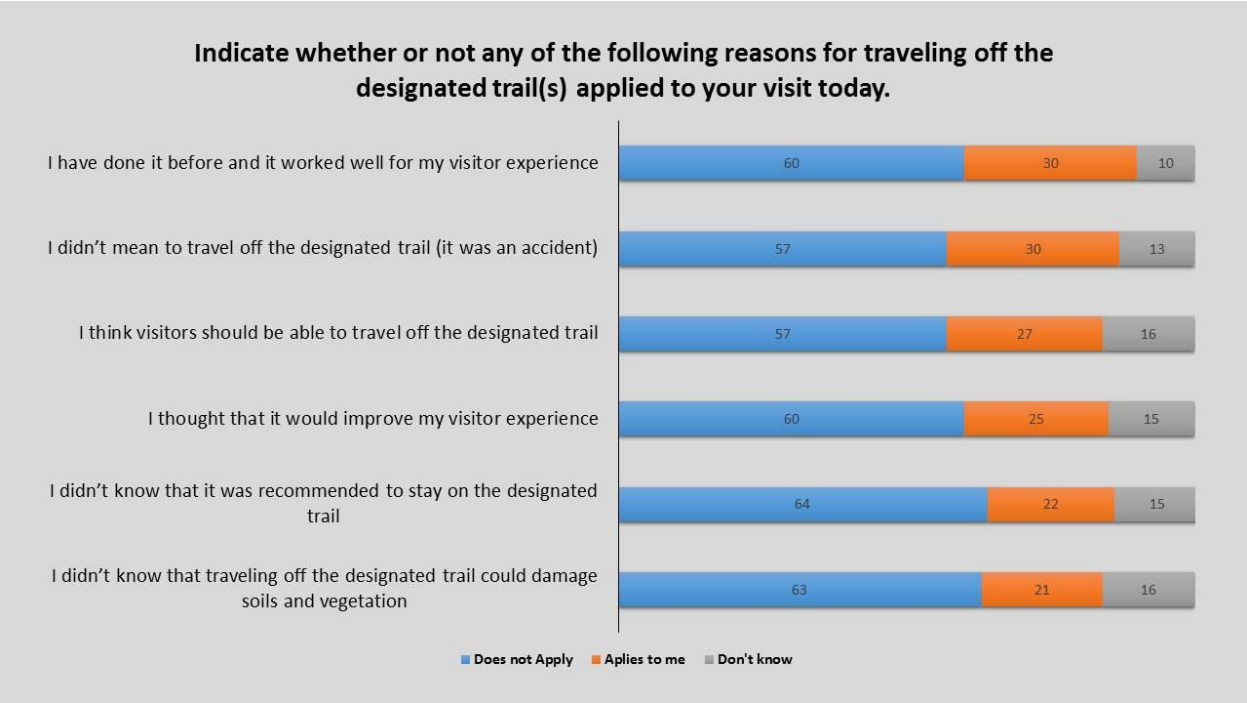

Please indicate how EFFECTIVE the following activities would be at reducing NEGATIVE IMPACTS in City of Boulder OSMP.
Adhering to messages on posted signage
5.77
Staying on a designated trail
5.55
Traveling on a designated trail, even when passing other visitors
5.23
Traveling in the middle of a designated trail, even when wet or muddy
4.97
Staying off a designated trail when conditions are wet and muddy
4.81
Scale: 1= Never Effective - 7=Effective every time

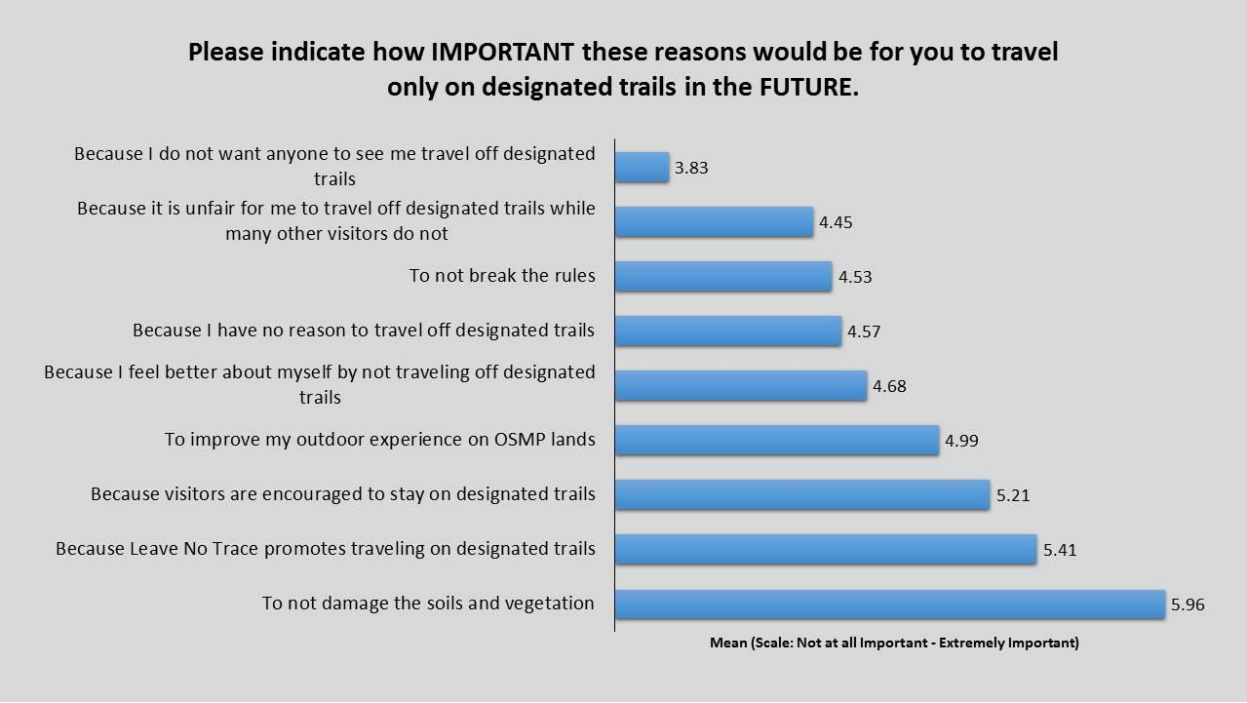

Please indicate how DIFFICULT you think each of the following activities would be for you to do in City of Boulder OSMP.
Adhering to messages on posted signage
5.89
Staying on a DT
5.68
Traveling on a DT, even when an undesignated trail is available in the area
5.53
Traveling on a DT, even when you have observed another visitor traveling on an undesignated trail
5.48
Traveling on a DT, even when you have previously traveled on an undesignated trail in the area
5.36
Traveling on a DT even when passing other visitors
5.36
Traveling in the middle of a DT, even when wet or muddy
4.96
Scale: 1= Very difficult- 7=Very easy

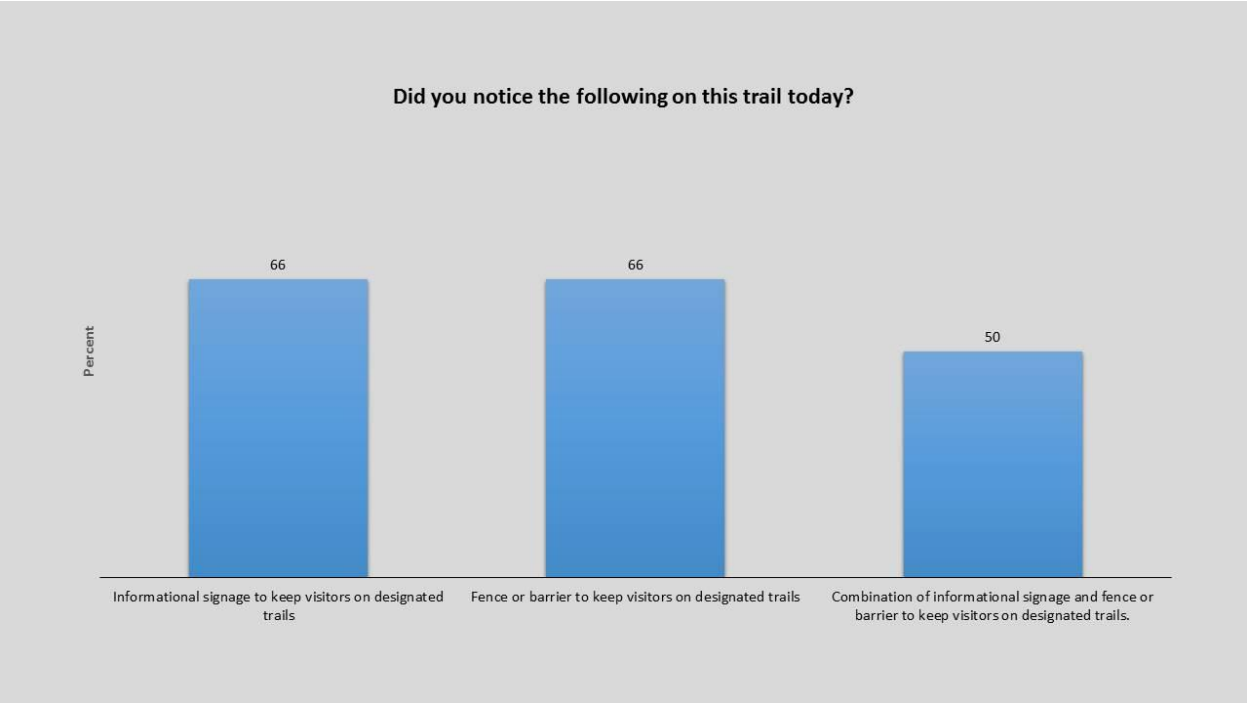

How often do you DO each of the following activities?
Adhering to messages on posted signage
1
34
65
Staying on a designated trail
0
40
60
Traveling on a designated trail, even when you have observed another visitor traveling on an undesignated trail
4
44
52
Traveling on a designated trail, even when passing other visitors
3
46
51
Traveling on a designated trail, even when an undesignated trail is available in the area
1
52
47
Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area
4
52
44
Traveling in the middle of a designated trail, even when wet or muddy
11
55
34
Never
Sometimes
Always
Percent Response


Please indicate how LIKELY you are to do the activity in the future
Traveling in the middle of a designated trail, even when wet or muddy
5.5
Traveling on a designated trail, even when you have previously traveled on an undesignated trail in the area
5.6
Traveling on a designated trail, even when an undesignated trail is available in the area
5.68
Traveling on a designated trail, even when you have observed another visitor traveling on an undesignated trail
5.77
Traveling on a designated trail, even when passing other visitors
5.81
Staying on a designated trail
5.98
Adhering to messages on posted signage
6.02
Mean (Scale: 1=Very Unlikely – 7=Very Likely)

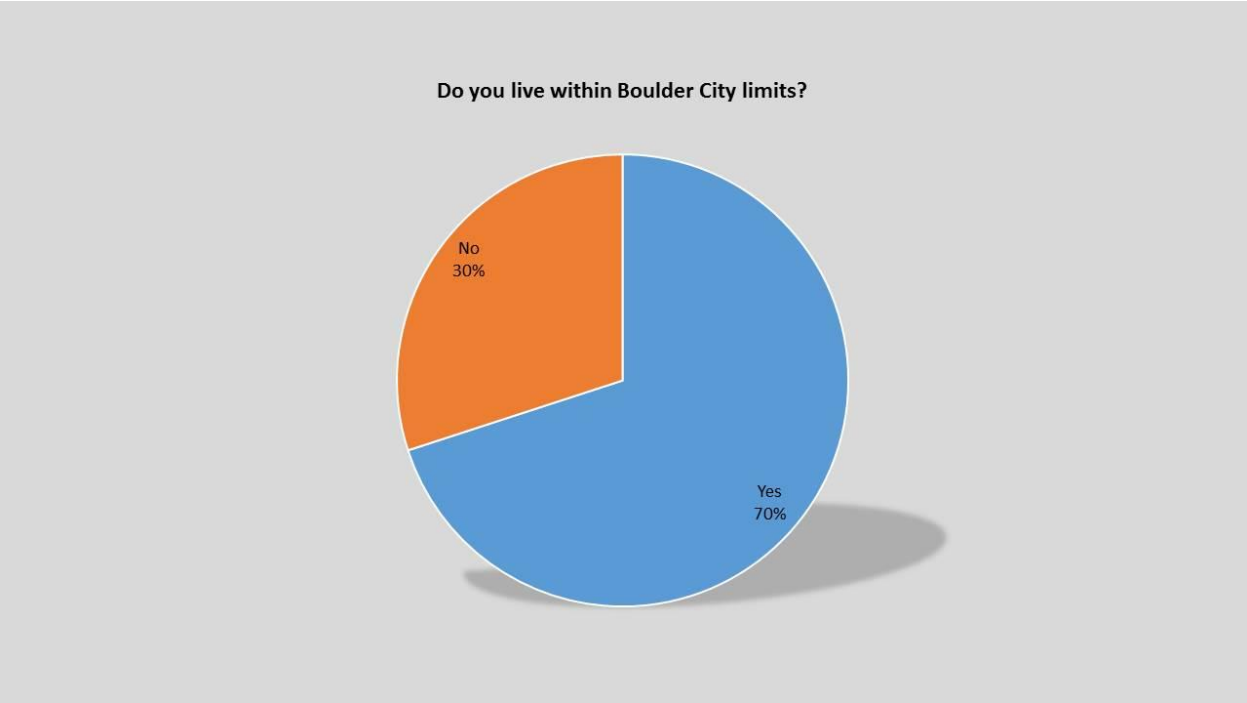

Did you travel off a designated trail during your visit today?
Don't Know
13%
Yes
28%
No
59%

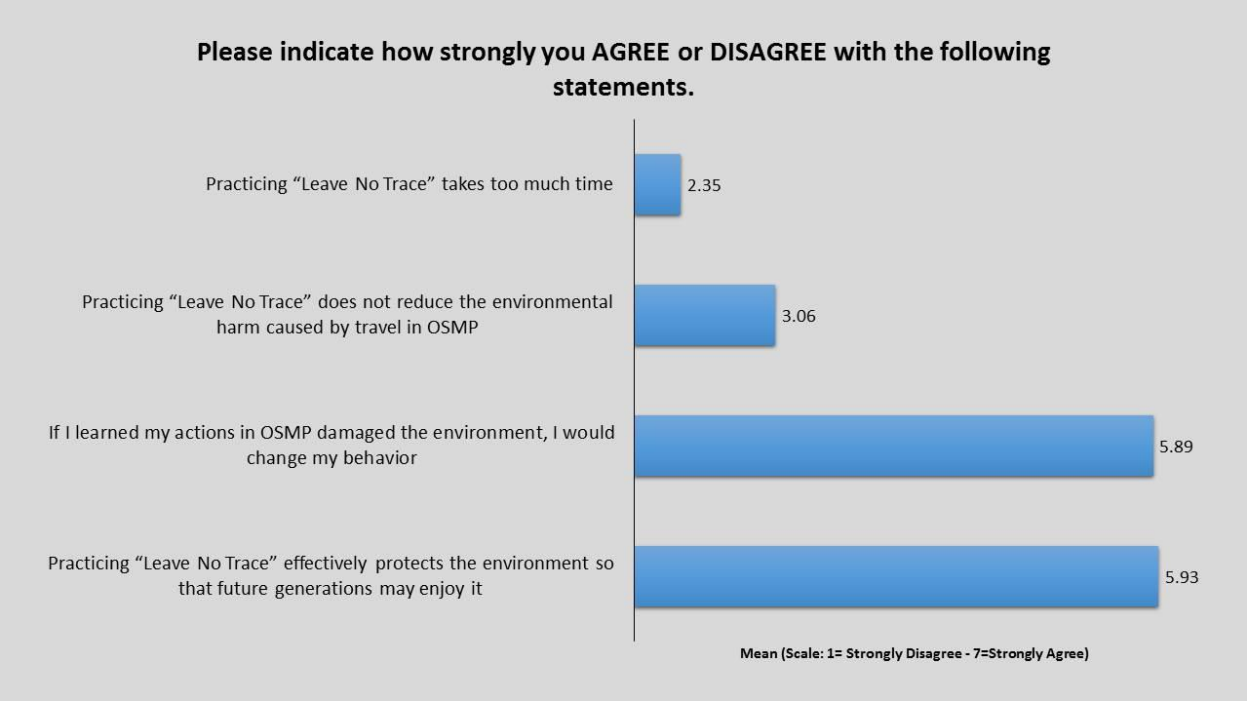

Indicate whether or not any of the following reasons for traveling off the designated trail(s) applied to your visit today.
I have done it before and it worked well for my visitor experience
60
30
10
I didn't mean to travel off the designated trail (it was an accident)
57
30
13
I think visitors should be able to travel off the designated trail
57
27
16
I thought that it would improve my visitor experience
60
25
15
I didn't know that it was recommended to stay on the designated trail
64
22
15
I didn't know that traveling off the designated trail could damage soils and vegetation
63
21
16
Does not Apply
Aplies to me
Don't know

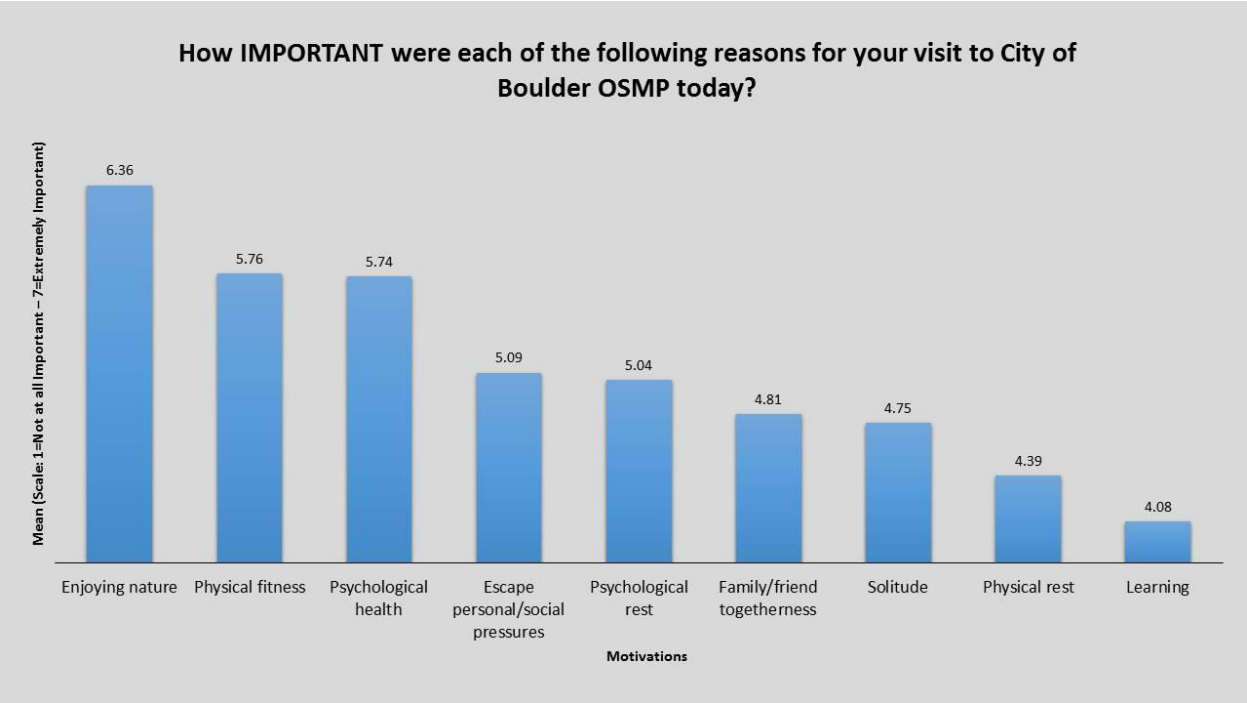

Please indicate how IMPORTANT these reasons would be for you to travel only on designated trails in the FUTURE.
Because I do not want anyone to see me travel off designated trails
3.83
Because it is unfair for me to travel off designated trails while many other visitors do not
4.45
To not break the rules
4.53
Because I have no reason to travel off designated trails
4.57
Because I feel better about myself by not traveling off designated trails
4.68
To improve my outdoor experience on OSMP lands
4.99
Because visitors are encouraged to stay on designated trails
5.21
Because Leave No Trace promotes traveling on designated trails
5.41
To not damage the soils and vegetation
5.96
Mean (Scale: Not at all Important - Extremely Important)

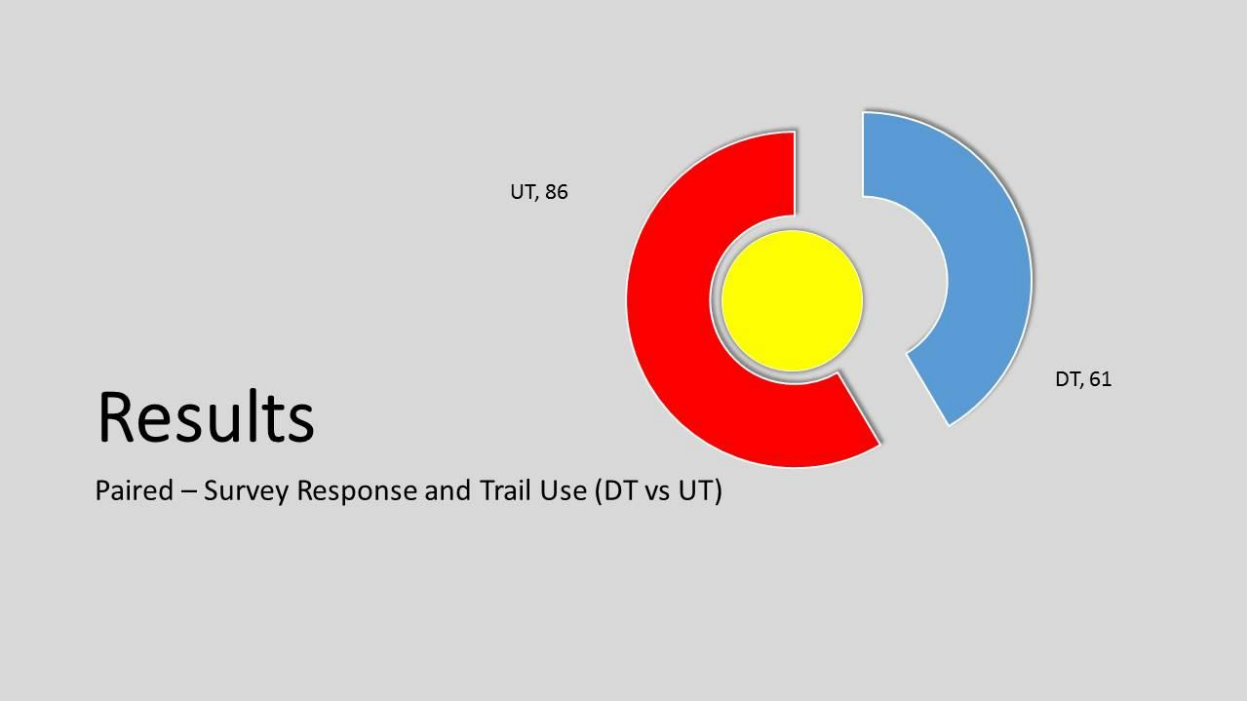

Did you notice the following on this trail today?
Percent
66
66
50
Informational signage to keep visitors on designated trails
Fence or barrier to keep visitors on designated trails
Combination of informational signage and fence or barrier to keep visitors on designated trails.

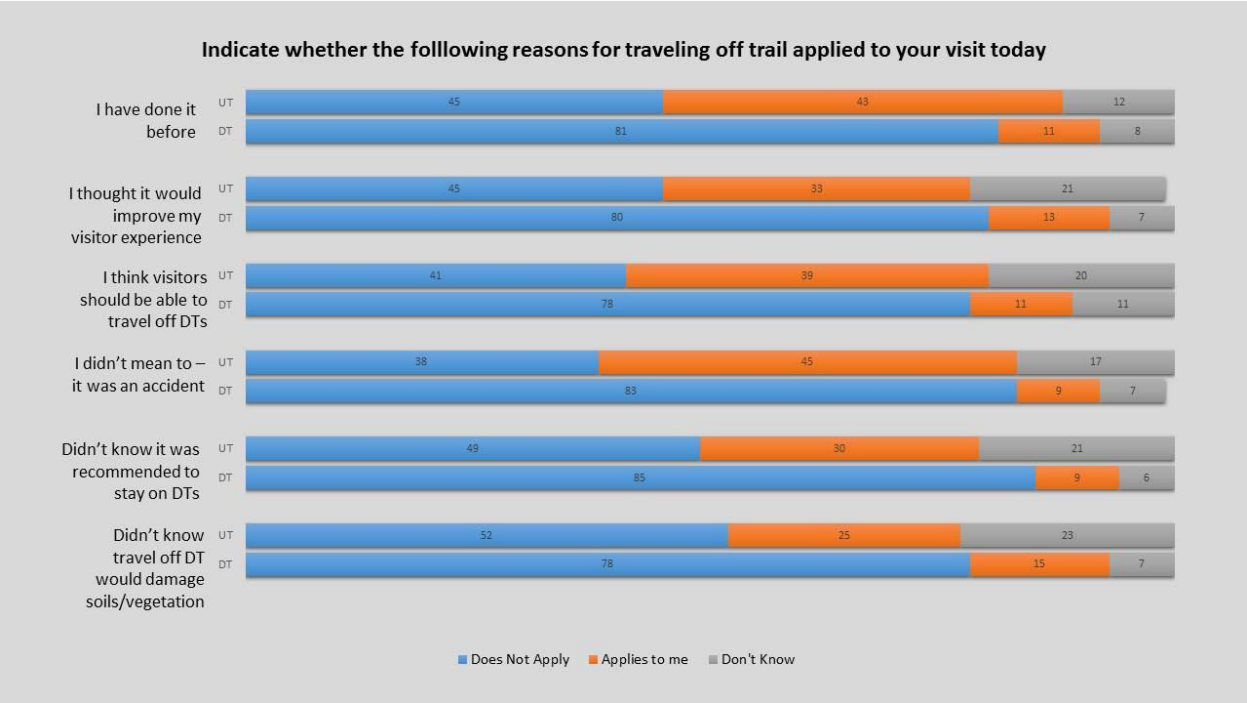
Please RANK the following in order (1st, 2nd, and 3rd), indicating which would be most effective in keeping you off an undesignated trail.
2.28
2.05
1.60
Informational signage
Fence or barrier
Combination of informational signage and fence or barrier

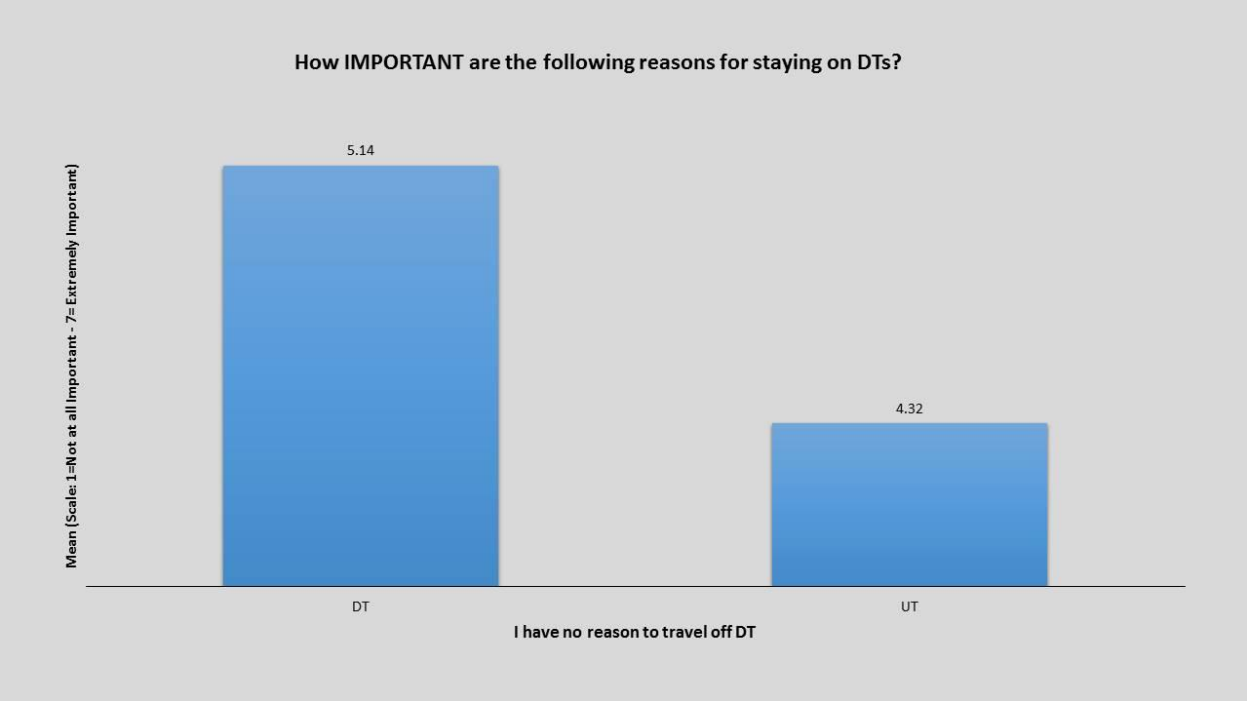

Do you live within Boulder City limits?
No
30%
Yes
70%

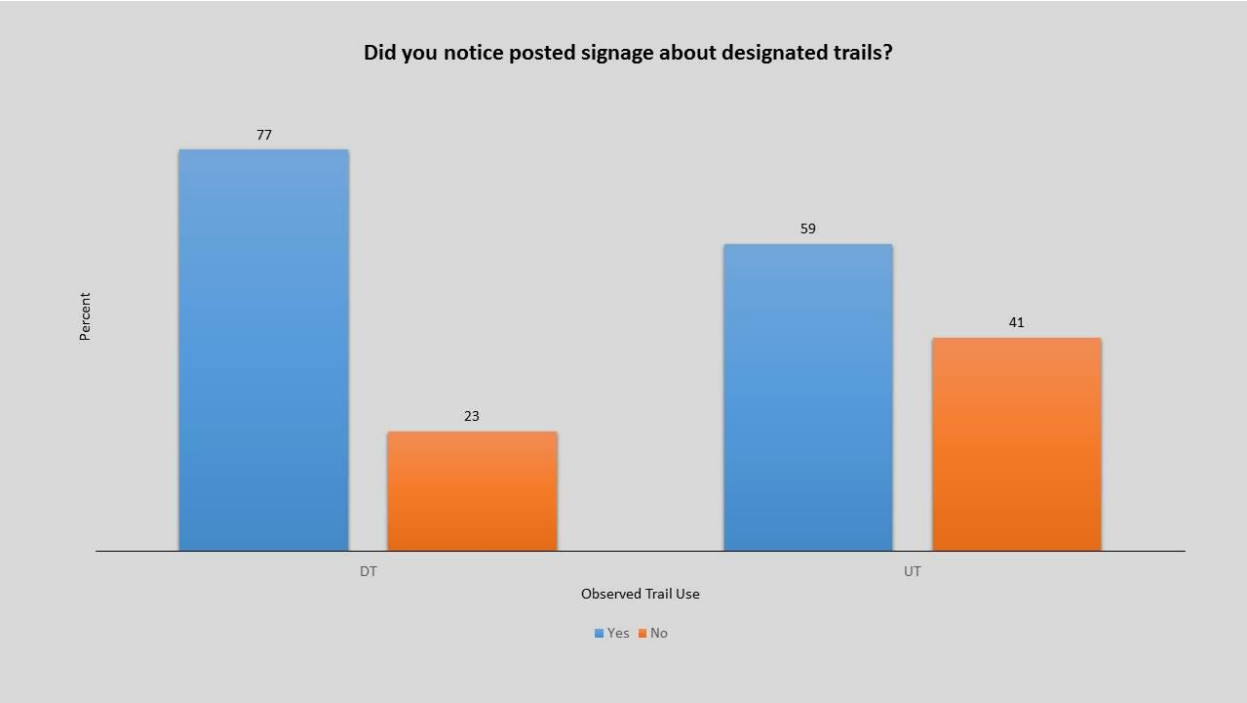

Please indicate how strongly you AGREE or DISAGREE with the following statements.
Practicing "Leave No Trace" takes too much time
2.35
Practicing "Leave No Trace" does not reduce the environmental harm caused by travel in OSMP
3.06
If I learned my actions in OSMP damaged the environment, I would change my behavior
5.89
Practicing "Leave No Trace" effectively protects the environment so that future generations may enjoy it
5.93
Mean (Scale: 1= Strongly Disagree - 7=Strongly Agree)

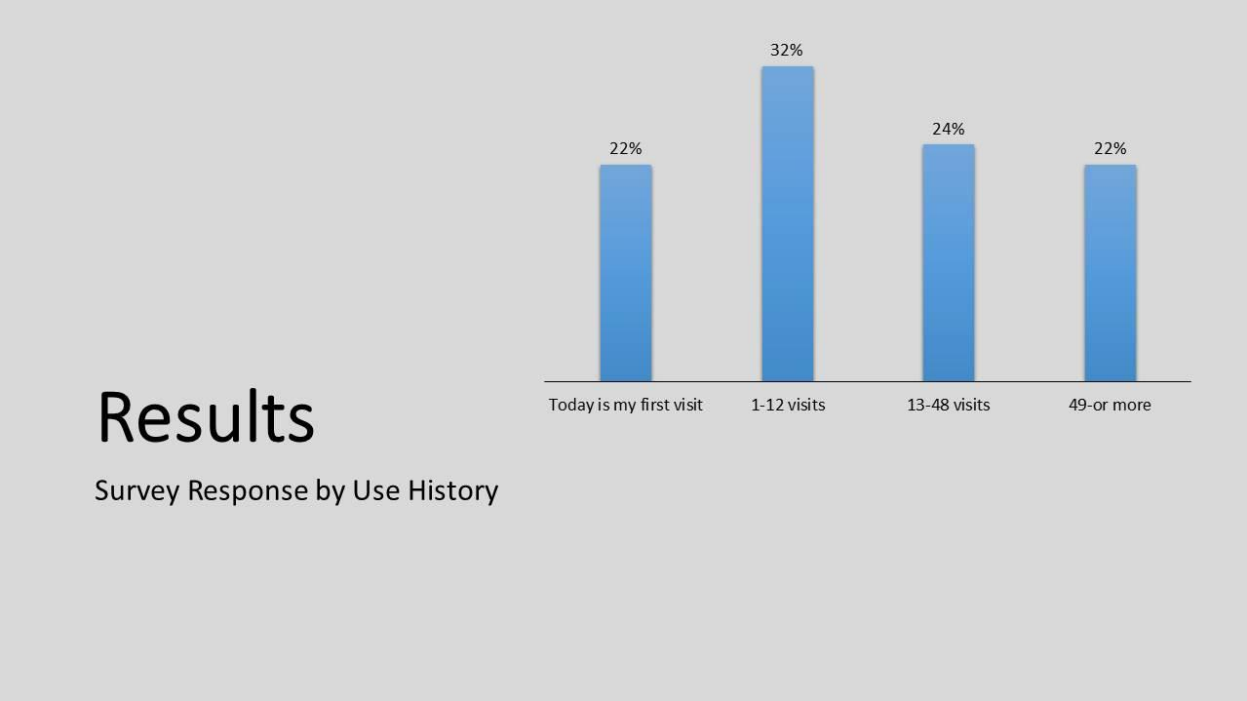

How IMPORTANT were each of the following reasons for your visit to City of Boulder OSMP today?
Mean (Scale: 1=Not at all Important – 7=Extremely Important)
6.36
5.76
5.74
5.09
5.04
4.81
4.75
4.39
4.08
Enjoying nature
Physical fitness
Psychological health
Escape personal/social pressures
Psychological rest
Family/friend togetherness
Solitude
Physical rest
Learning
Motivations


UT, 86
DT, 61
Results
Paired – Survey Response and Trail Use (DT vs UT)

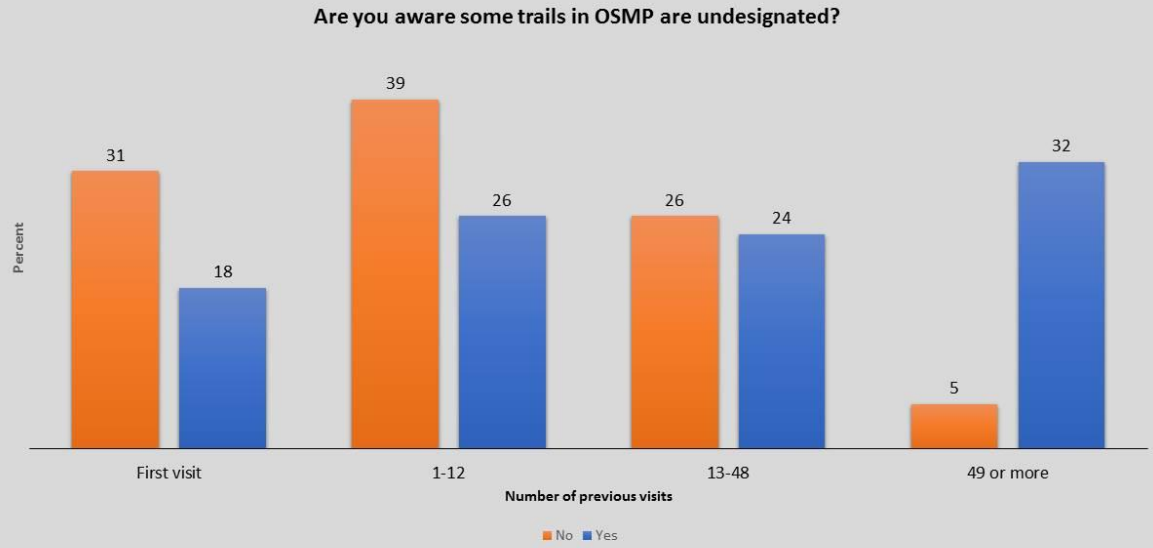

Indicate whether the folllowing reasons for traveling off trail applied to your visit today
I have done it before
UT 45 43 12
DT 81 11 8
I thought it would improve my visitor experience
UT 45 33 21
DT 80 13 7
I think visitors should be able to travel off DTs
UT 41 39 20
DT 78 11 11
I didn't mean to – it was an accident
UT 38 45 17
DT 83 9 7
Didn't know it was recommended to stay on DTs
UT 49 30 21
DT 85 9 6
Didn't know travel off DT would damage soils/vegetation
UT 52 25 23
DT 78 15 7
Does Not Apply
Applies to me
Don't Know

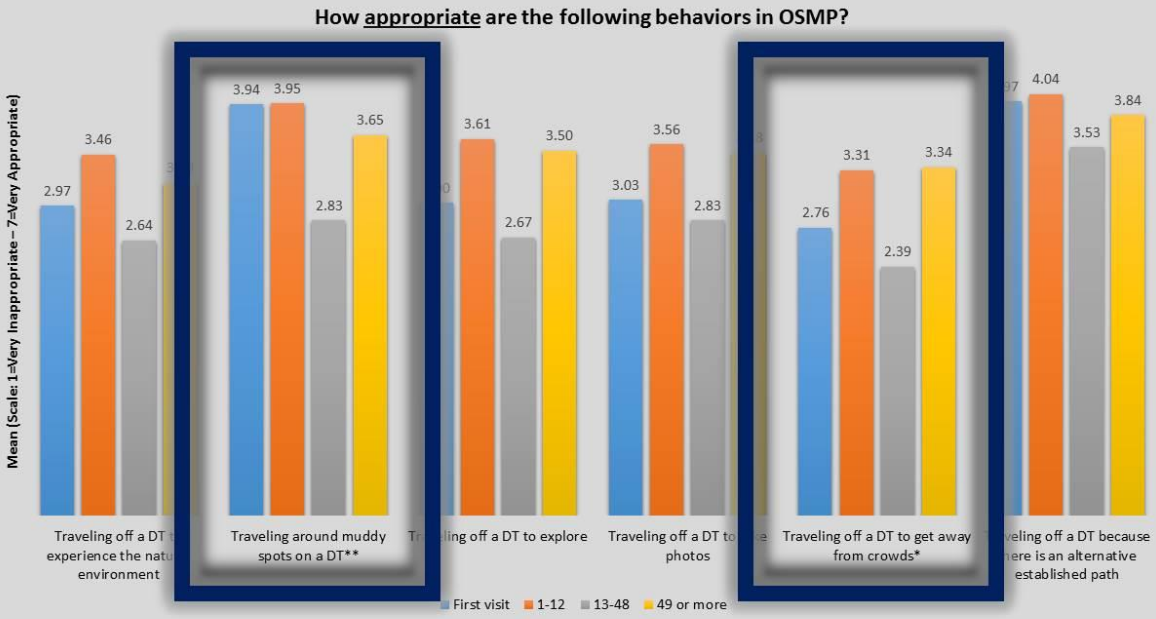

How IMPORTANT are the following reasons for staying on DTs?
Mean (Scale: 1=Not at all Important - 7= Extremely Important)
5.14
4.32
DT
UT
I have no reason to travel off DT


Did you notice posted signage about designated trails?
77
23
59
41
Percent
DT
UT
Observed Trail Use
Yes
No

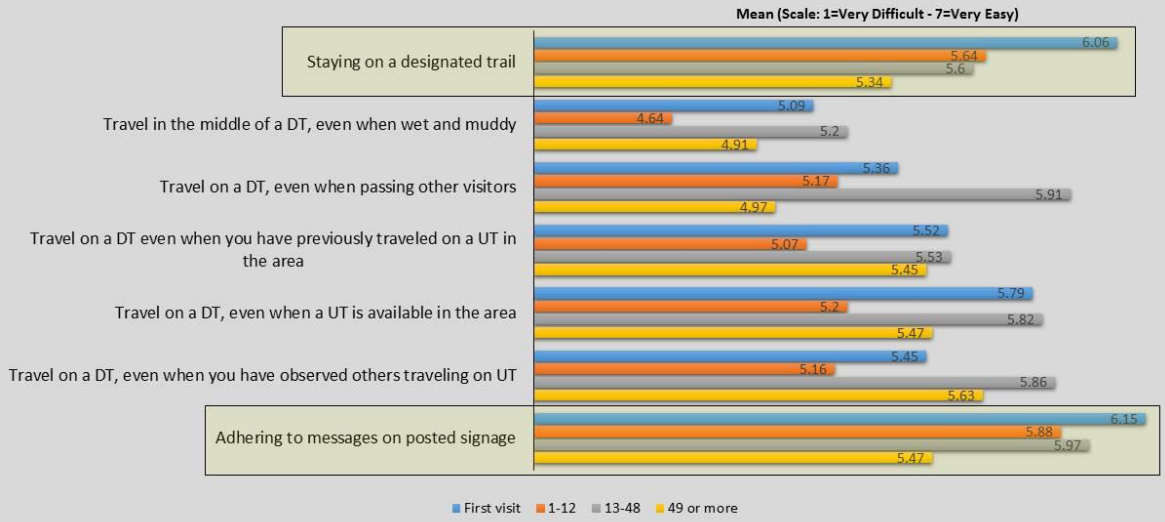

Results
Survey Response by Use History
22%
32%
24%
22%
Today is my first visit
1-12 visits
13-48 visits
49-or more

Awareness of UTs: Significant relationship between visitation frequency and awareness

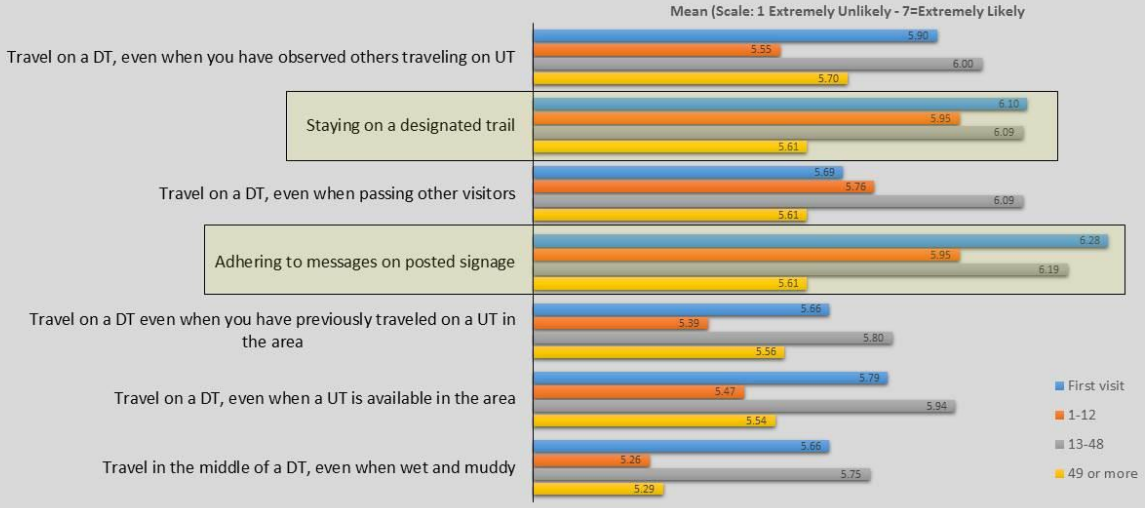




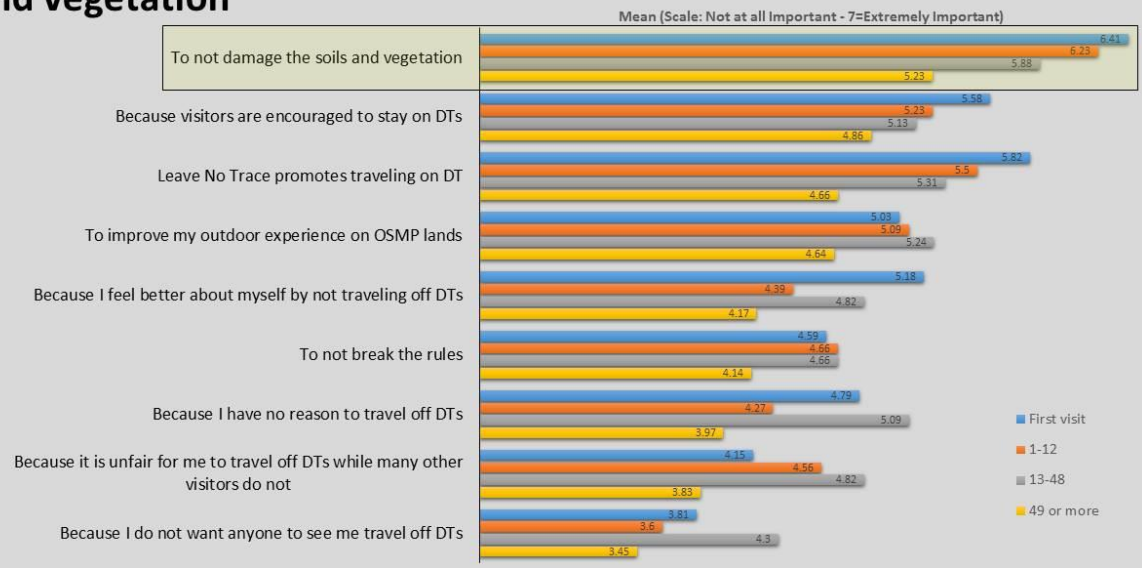
Behavioral difficulty by use history – not statistically significant but some interesting findings



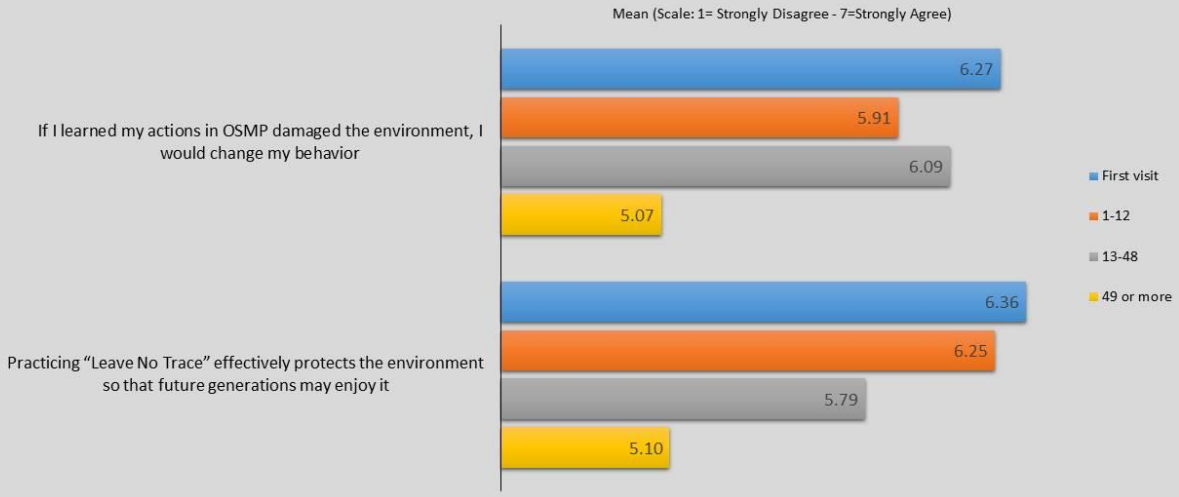
Behavioral intent by use history – not statistically significant but some interesting findings

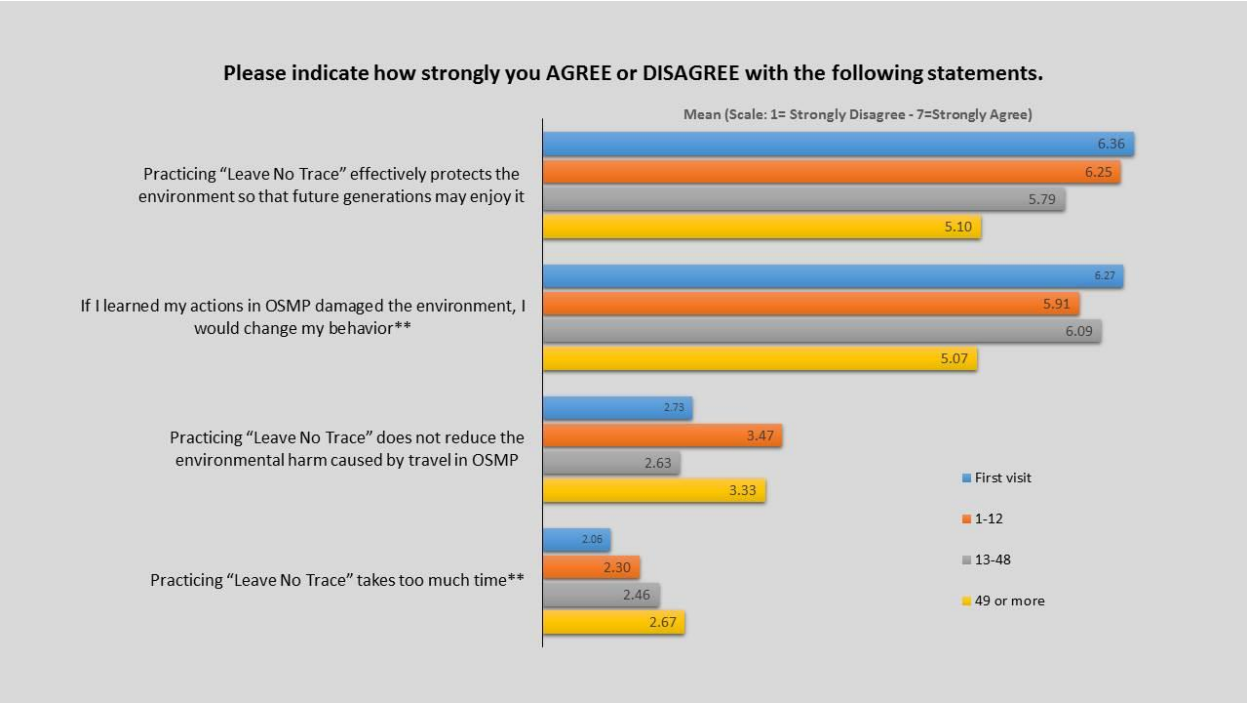


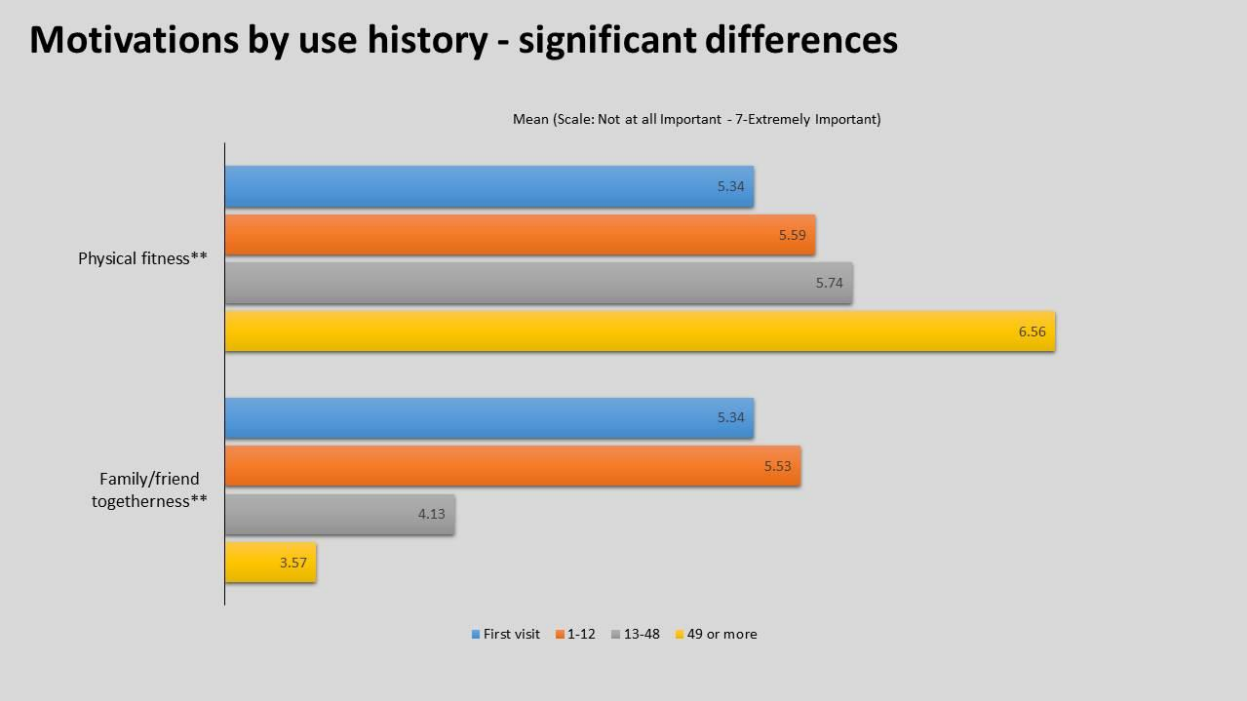
Reasons for staying on DTs by use history – 'To not damage the soils and vegetation'

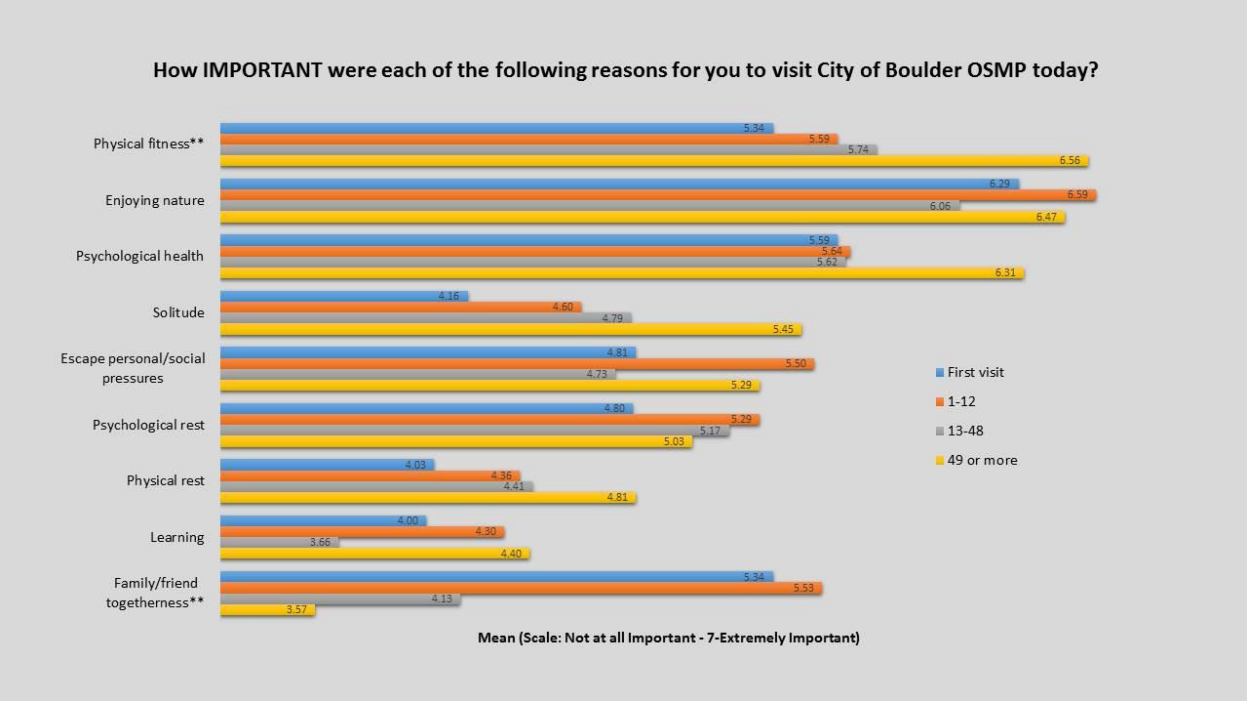


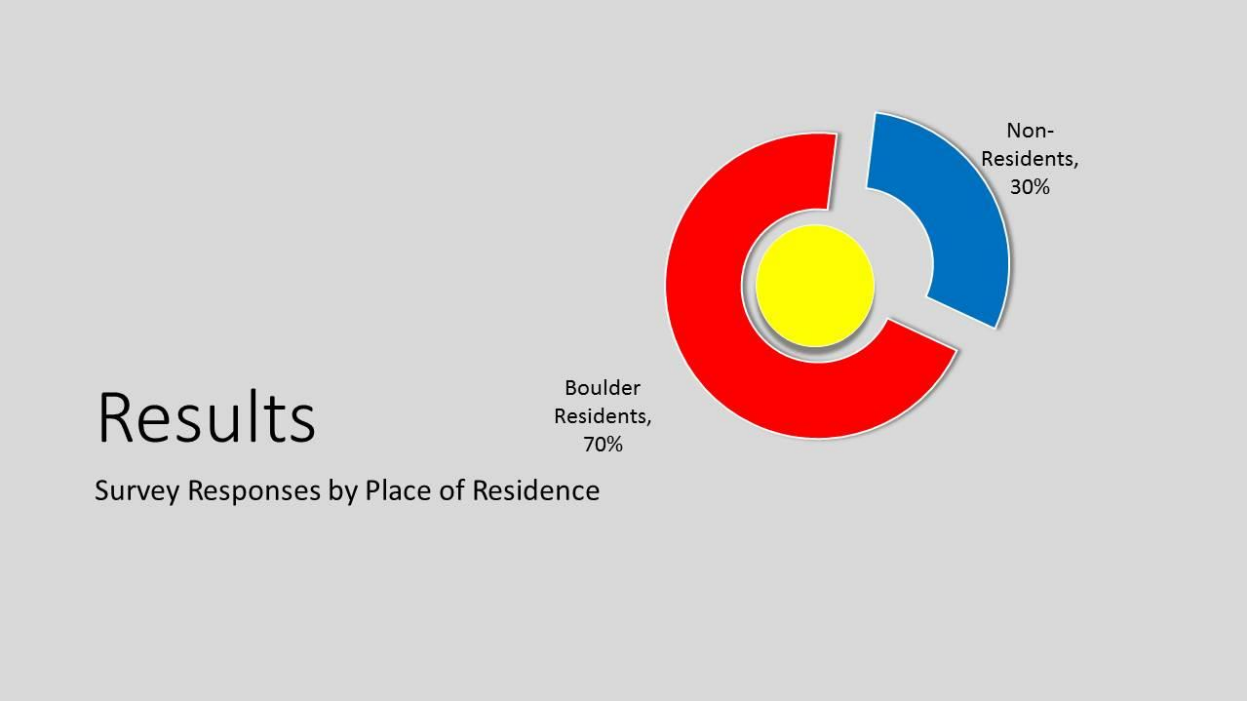
Beliefs by use history significant differences: Behavioral change and Leave No Trace effectiveness

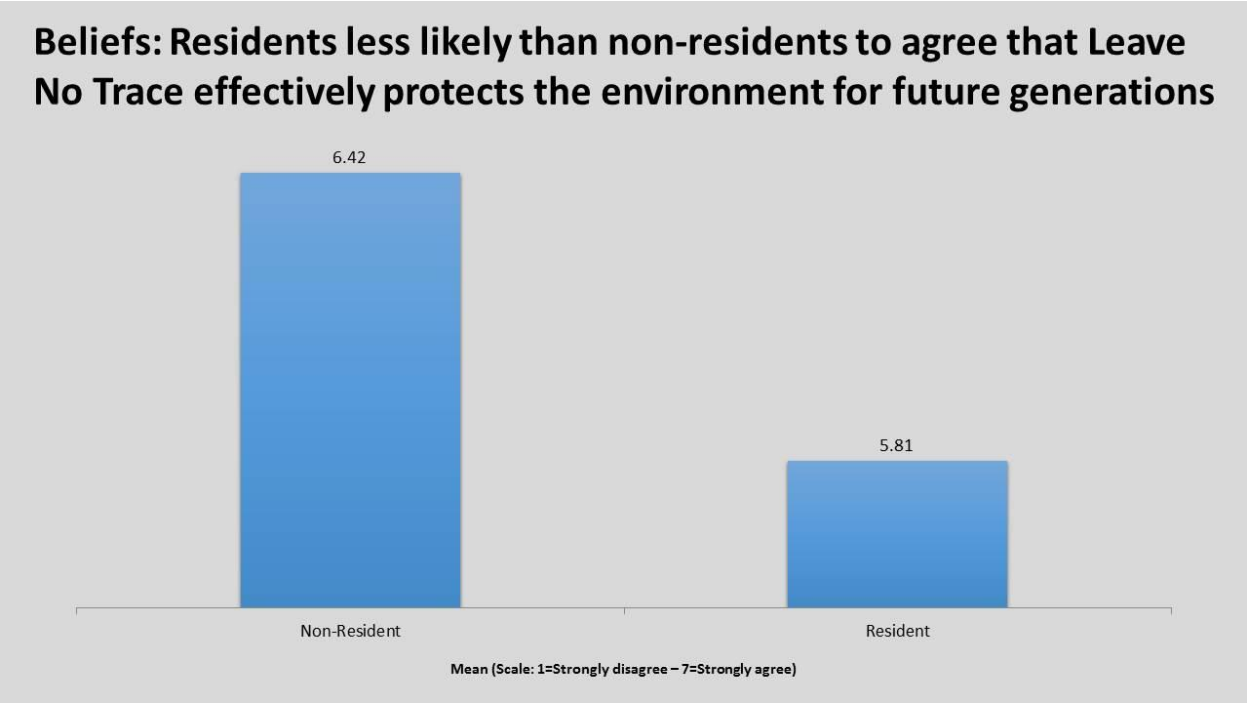


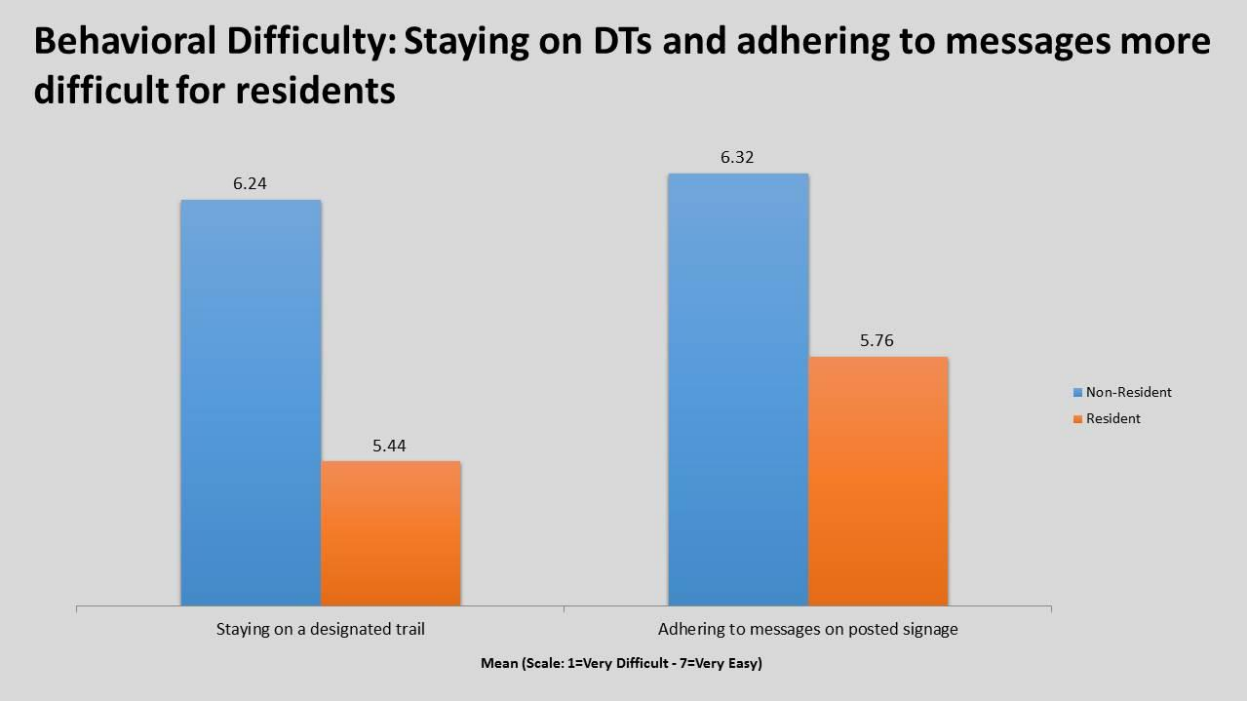

Please indicate how strongly you AGREE or DISAGREE with the following statements.
Mean (Scale: 1= Strongly Disagree - 7=Strongly Agree)
Practicing "Leave No Trace" effectively protects the environment so that future generations may enjoy it
6.36
6.25
5.79
5.10
If I learned my actions in OSMP damaged the environment, I would change my behavior**
6.27
5.91
6.09
5.07
Practicing "Leave No Trace" does not reduce the environmental harm caused by travel in OSMP
2.73
3.47
2.63
3.33
Practicing "Leave No Trace" takes too much time**
2.06
2.30
2.46
2.67
First visit
1-12
13-48
49 or more


Motivations by use history - significant differences
Mean (Scale: Not at all Important - 7-Extremely Important)
Physical fitness**
5.34
5.59
5.74
6.56
Family/friend togetherness**
5.34
5.53
4.13
3.57
First visit
1-12
13-48
49 or more

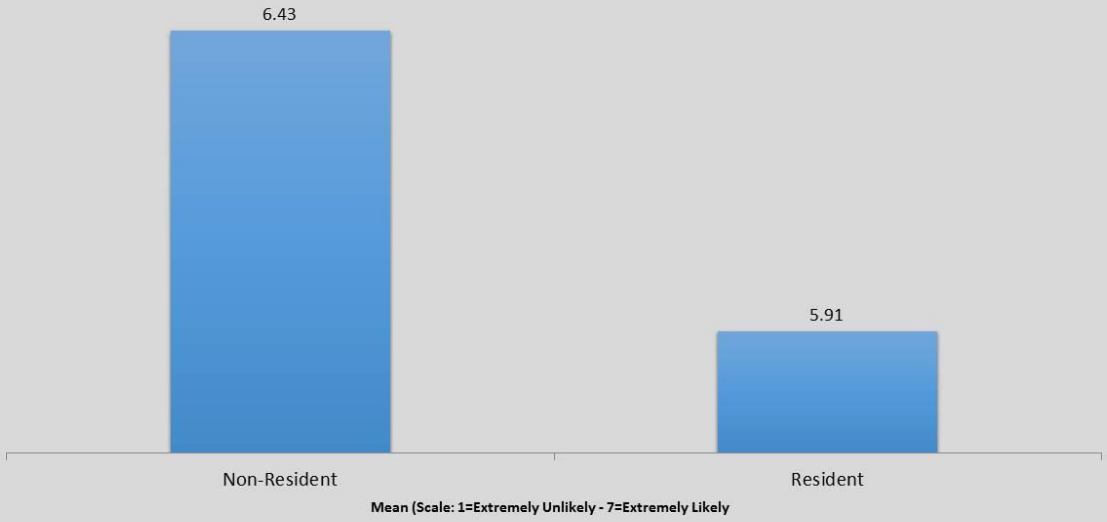

How IMPORTANT were each of the following reasons for you to visit City of Boulder OSMP today?
Physical fitness**
5.34
5.59
5.74
6.56
Enjoying nature
6.29
6.59
6.06
6.47
Psychological health
5.59
5.64
5.62
6.31
Solitude
4.16
4.60
4.79
5.45
Escape personal/social pressures
4.81
5.50
4.73
5.29
Psychological rest
4.80
5.29
5.17
5.03
Physical rest
4.03
4.36
4.41
4.81
Learning
4.00
4.30
3.66
4.40
Family/friend togetherness**
5.34
5.53
4.13
3.57
First visit
1-12
13-48
49 or more
Mean (Scale: Not at all Important - 7-Extremely Important)


Results
Survey Responses by Place of Residence
Non-Residents, 30%
Boulder Residents, 70%


Beliefs: Residents less likely than non-residents to agree that Leave No Trace effectively protects the environment for future generations
6.42
5.81
Non-Resident
Resident
Mean (Scale: 1=Strongly disagree – 7=Strongly agree)

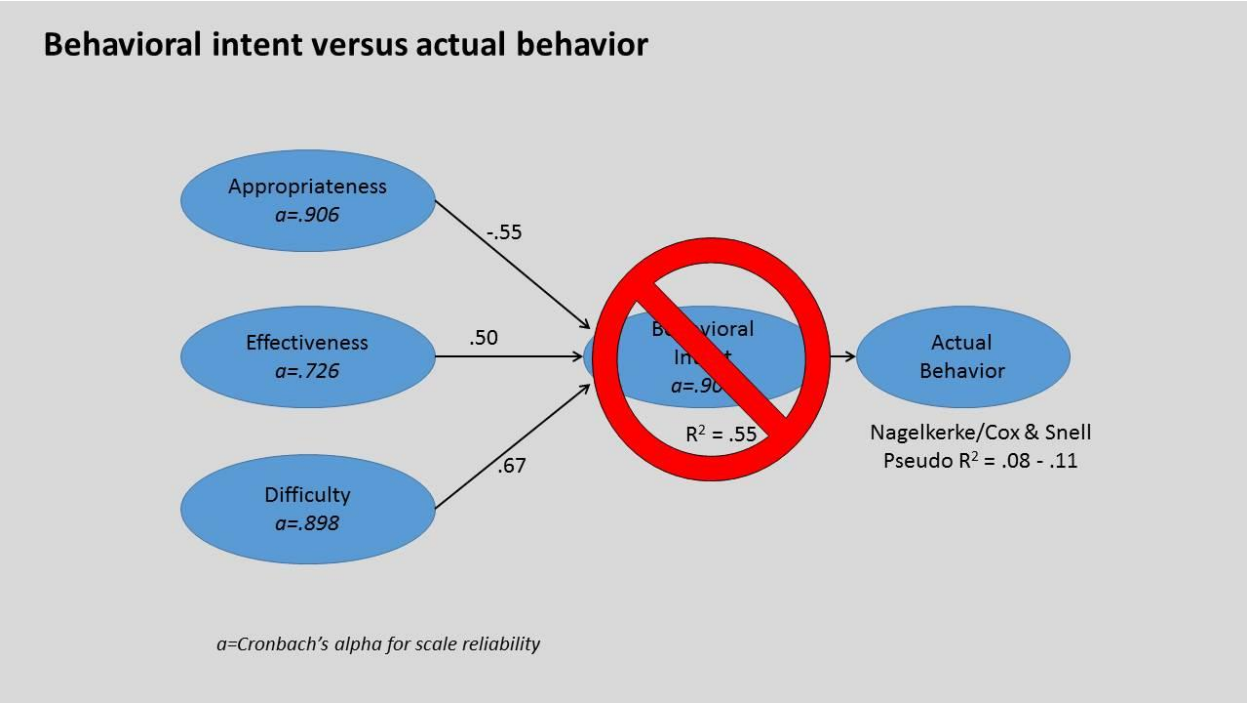

Behavioral Difficulty: Staying on DTs and adhering to messages more difficult for residents
6.24
5.44
6.32
5.76
Non-Resident
Resident
Staying on a designated trail
Adhering to messages on posted signage
Mean (Scale: 1=Very Difficult - 7=Very Easy)

Behavioral Intent: Residents less likely to adhere to posted messages



Attitudes and behavioral intent

a=Cronbach's alpha for scale reliability


Behavioral intent versus actual behavior
Appropriateness
α=.906
Effectiveness
α=.726
Difficulty
α=.898
-.55
.50
.67
Actual
Behavior
R² = .55
Nagelkerke/Cox & Snell
Pseudo R² = .08 - .11
α=Cronbach's alpha for scale reliability

Results Summary

Results Summary…

- 10-15% of observed visitors were UT users
- Barrier/Ed most effective (also perceived to be most effective), and can potentially reduce UT use by 5.4%
- Substantial amount of visitors unsure they were traveling on UTs
- Visitors believe that recreation behaviors have the potential to cause ecological impact (aligns with messaging from treatment)
- Frequent visitors were more likely to report knowing that some OSMP trails are UTs
- Non-residents indicated that it was significantly easier to '*stay on designated trails*'
- Residents were significantly *less likely to agree* that '*practicing Leave No Trace effectively protects the environment for future generations*'

- Visitors believe that recreation behaviors have the potential to cause both *ecological* and *social impact*.
  - The majority of respondents indicated that they would change their behaviors if they learned their actions were damaging the environment.

- Regarding reducing negative impacts in OSMP…
  - '*adhering to messages on posted signage*' was reported to be the most effective, followed by '*staying on a designated trail*.'
  - '*adhering to messages on posted signage*' was reported to be the easiest of the behaviors to perform.

- Majority of respondents indicated that the most important reason for only using DTs was '*to not damage soils and vegetation*.' Although, this reasoning was less important for visitors who had frequented OSMP more often.
  - '*Stay on designated trails: Even when wet and muddy, to protect trailside plants and minimize erosion -- This is Not a Designated Trail*')

- The majority of observed visitors were traveling on DTs, while only 10%-15% were observed traveling on UTs.

- Observations indicate combined educational message ('*Stay on designated trails: Even when wet and muddy, to protects trailside plants and minimize erosion. This is Not a Designated Trail*') with a physical barrier was the most effective method of UT mitigation utilized in this study.
  - Survey results suggested that the combination of a sign in conjunction with a barrier was reported to be the most effective management action for keeping visitors on DTs

- Frequent visitors were more likely to report knowing that some OSMP trails are UTs.

- While not statistically significant, individuals who had visited frequently were found to be the least likely to '*stay on a designated trail and adhere to messages posted on signage*.'

- Non-residents indicated that it was significantly easier to '*stay on designated trails*.'

- Residents were significantly *less likely to agree* that '*practicing Leave No Trace effectively protects the environment for future generations*.'

- More than 40% of survey respondents indicated that they were unaware of UTs in the OSMP trail system.
- UT respondents were significantly more likely to report *not knowing* if they traveled off a DT.
- A significantly smaller number of UT users indicated that they *had seen management signs* than DT users.

Management Implications…

- OSMP work to clarify DT and UT across the system
  - Removing existing UT infrastructure
  - Deploy UT Signage/Treatment (potential to reduce UT use by 5.4%)
- Enhance messaging to visitors about UTs
  - Segment local, non-local, frequent users – to the extent possible
- Visitors believe recreation can lead to resource and social impacts on OSMP
  - Visitors are highly supportive of Leave No Trace for minimizing impacts
  - OSMP should strive to align outreach strategies with these visitor beliefs

Considerations for Future Research…

- Consider examining effectiveness of sign and barrier in a popular trail system (e.g., Sanitas) through wide-scale implementation
  - Use observation methods (vital, given results of behavioral model)
  - Consider concurrent monitoring plan that incorporates recreation ecology components (i.e., measuring ecological change)
- Consider examining effectiveness of similar treatments on double-track UTs
- Consider re-examining attitudes post-educational strategy (particular focus on residents merited)

Next Steps…

- Submit Final Report (Due June 24)
- Dissertation (Dr. Schwartz)
- Anticipated peer-reviewed publications
  - Overall study results and innovative/robust methods
  - Behavioral intent and observation model

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Thank You & Discussion
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