An Analysis of Social Trails In Usery Mountain Regional Park

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Abstract

"Two roads diverged in a wood, and I-I took the one less traveled by, and that has made all the difference" (Frost, 1916, as cited in The Academy of American Poets, n.d.). As populations continue to increase and more people realize this desire to wander the trails and float the rivers, recreation facilities struggle to keep up with the demand. Access to wilderness is a right, and there are various reasons why people explore these wild spaces. Vistas and high points are places of high interest, and human nature leads outdoor enthusiasts to explore, get outside and see new places. The downside to this exploration is the potential damage that can occur to the environment. Recently, because of the COVID-19 pandemic, more people are getting outside and sharing the places they visit over their numerous social media outlets. The places being shared are often located in difficult-to-reach places or areas of high interest, often needing a social trail to reach. Increased access to such places and subsequent use of social trails can be an indicator that not only is there a desire to share these places with others but that there is little control over how people access and use these areas as well.

Social trails are informal, unmarked, or non-designated trails that travel from point to point, often appearing as shortcuts along official trails. Social trails can increase erosion and leave scars across the land that last for years. This project aims to locate networks of social trails in Usery Mountain Regional Park and designate them for either an integration process to turn those social trails into new official trails or restore those trails to their pre-disturbed state. The fieldwork conducted in accordance with this project shows that not only is there an abundance of social trails in the park, but that there is ongoing human usage of these trails. Of the trails mapped and observed, a few of them could be integrated into the park network of trails.

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Chapter 1: Introduction

The conservation of wilderness has been a mission of land management agencies around the world for years. It is a mission that walks a fine line between conservation and management for recreation and enjoyment. One of the most iconic phrases regarding this delicate mission was coined by arguably one of the most prominent defenders of the conservation movement, Theodore Roosevelt. On the foundation of what would become the gateway arch at Yellowstone's eastern entrance, he stated that the parks were to be protected "for the benefit and enjoyment of the people" (Roosevelt, 1903, as cited in The American Presidency Project, n.d). This mission has changed with time, and although the overarching message has stayed the same, it has become increasingly difficult to manage park visitors. Addressing social trail usage in any park system is an ongoing and almost never-ending battle. Trails are designed and built in a way that is supposed to provide a scenic and enjoyable experience to the park visitor but do it in a way that is sustainable and durable. However, with damage to the natural environment and increased erosion, among other factors, trails are becoming an increasingly challenging aspect that park management needs to address.

Problem Statement

Park Rangers at South Mountain Regional Park have recently been observing park visitors' use of unsanctioned trails and their adverse effects on the environment (Riske, 2018). These effects being observed at South Mountain may be present at other parks throughout the Phoenix metro area, as they share similar characteristics such as proximity to developments, ecology, and types of usage. Usery Mountain Regional Park has many of the same characteristics

as South Mountain; however, there have yet to be any recent trail studies conducted in the park, which makes it a good candidate for social trail analysis.

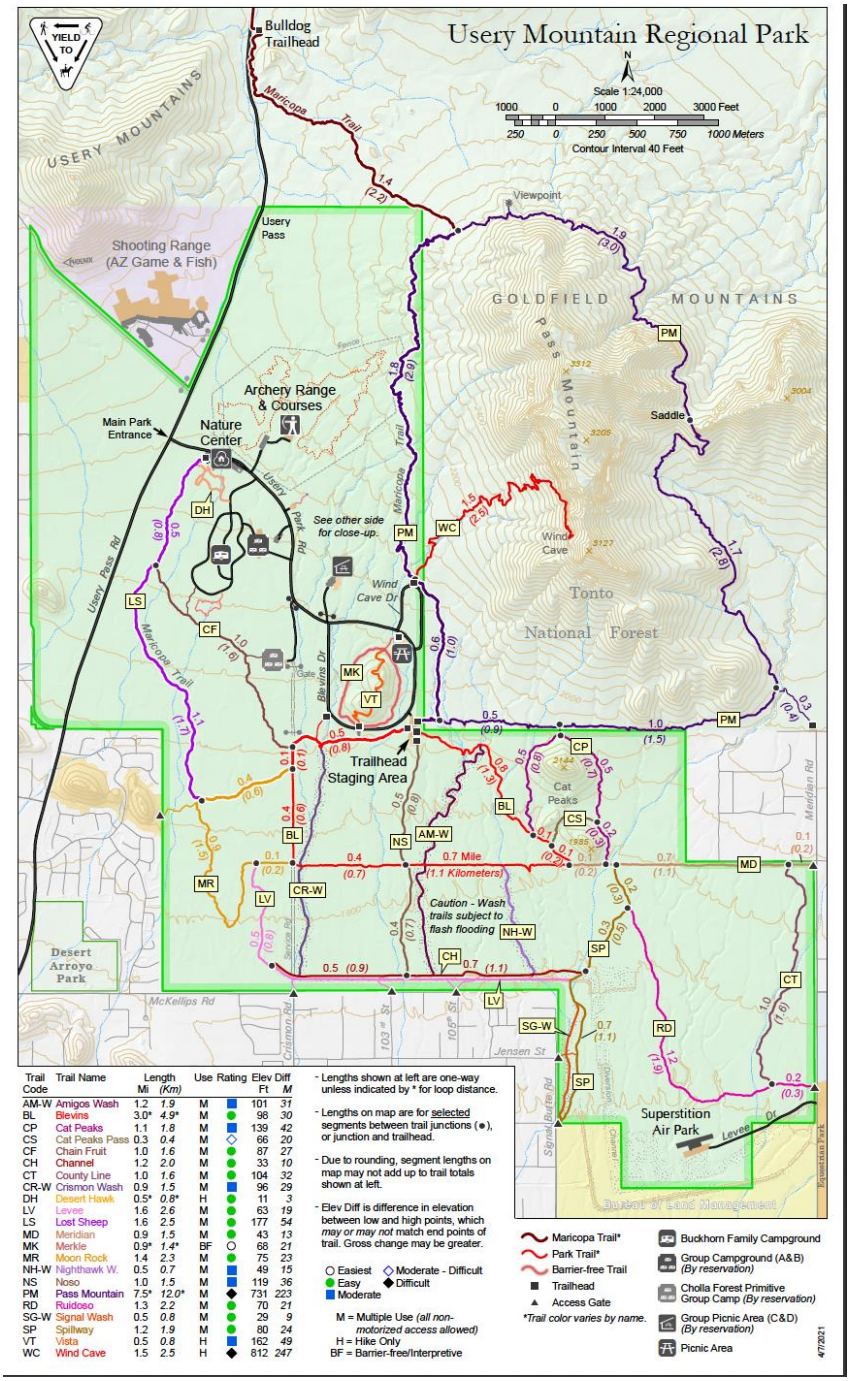
Project Objective

The overall objective of this project is to analyze human movements on official and social trails within the Usery Mountain Regional Park to evaluate whether to convert social trails to new official trails or restore them to their pre-disturbed state.

Project Study Area

Resting in the shadow of Pass Mountain, on the western edge of the Goldfield Mountain Range, Usery Mountain Regional Park protects 3,648 acres of delicate Sonoran Desert landscape. The dry and rugged landscape of the park is home to numerous plant species, including Saguaro, numerous varieties of cholla, low-lying brush, and ocotillo trees (Usery Mountain Regional Park, 2021). A variety of animal species call this landscape home, including large predators such as mountain lions, numerous species of reptiles, and even bats in the caves that dot the sides of Pass Mountain. Located in the foothills, the park preserves some of the delicate flood drainages that come off the high mountains. These vital parts of the desert landscape act as highways for flood waters as they move from high ground down into the lower valley. The park offers a variety of recreational activities to the public, including but not limited to hiking, horseback riding, mountain biking, and camping (Usery Mountain Regional Park, 2021). The official park map, shown in *Figure 1*, shows a detailed map of the park's trails and the surrounding area. Although the park is located along the western edge of the Tonto National Forest and serves as a starting point for many hikers, it is managed by the Maricopa County Parks and Recreation Department.

Social trails, along with other types of trails, have been described using various terms in other papers. These various terms are listed in the appendix.



Trail Code	Trail Name	Length Mi	Length (Km)	Use	Rating	Elev Diff Ft	Elev Diff M
AM-W	Amigos Wash	1.2	1.9	M	■	101	31
BL	Blevins	3.0*	4.9*	M	●	98	30
CP	Cat Peaks	1.1	1.8	M	■	139	42
CS	Cat Peaks Pass	0.3	0.4	M	◇	66	20
CF	Chain Fruit	1.0	1.6	M	●	87	27
CH	Channel	1.2	2.0	M	●	33	10
CT	County Line	1.0	1.6	M	●	104	32
CR-W	Crismon Wash	0.9	1.5	M	■	96	29
DH	Desert Hawk	0.5*	0.8*	H	●	11	3
LV	Levee	1.6	2.6	M	●	63	19
LS	Lost Sheep	1.6	2.5	M	●	177	54
MD	Meridian	0.9	1.5	M	●	43	13
MK	Merkle	0.9*	1.4*	BF	○	68	21
MR	Moon Rock	1.4	2.3	M	●	75	23
NH-W	Nighthawk W.	0.5	0.7	M	■	49	15
NS	Noso	1.0	1.5	M	■	119	36
PM	Pass Mountain	7.5*	12.0*	M	◆	731	223
RD	Ruidoso	1.3	2.2	M	●	70	21
SG-W	Signal Wash	0.5	0.8	M	●	29	9
SP	Spillway	1.2	1.9	M	●	80	24
VT	Vista	0.5	0.8	H	■	162	49
WC	Wind Cave	1.5	2.5	H	◆	812	247

Figure 1: Usery Mountain Regional Park Map (Usery Mountain Regional Park – Maricopa County Parks, n.d.)

Chapter 2: Literature Review

Mission and Visitation

One of the great challenges of outdoor recreation management is the fine line that recreation managers and planners must walk to not only protect the wild spaces that we cherish but also provide access to these wilderness spaces. In 1903 at the cornerstone laying ceremony of what would one day become the eastern entrance into Yellowstone National Park, President Theodore Roosevelt coined the words that would eventually be engraved in the arch itself, “this park, which was created and is now administered for the benefit and enjoyment of the people” (Roosevelt, 1903, as cited in The American Presidency Project, n.d). This defining statement described the necessary intent to protect America’s natural wonders for the people of the country and the world to enjoy and experience. The mission of the National Park Service (NPS), founded 13 years after Roosevelt’s speech, has evolved and changed with the times but has always held the preservation of wilderness and the education of the public at its core. The primary mission of the NPS is to “preserve unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations” (U.S. Department of the Interior, n.d.). Although focused on a more national level, this mission statement holds true to any park and recreation site dedicated to the recreational use and preservation of wilderness.

Sharing similar objectives and goals with the NPS regarding preservation and protection, the Maricopa County Parks and Recreation Department has focused more on recreation quality and opportunities stating that their mission through responsible stewardship “is to provide the quality parks, trails, programs, services and experiences that energize visitors and create life-long

users and advocates" (Maricopa County Parks and Recreation, n.d.). These three statements, although different, have embodied the same goals and objectives that were set forth by conservationists, land managers, and outdoor enthusiasts for years. However, it has become increasingly difficult for park managers to maintain the delicate balance of protecting and conserving wilderness while also providing the access that many people have come to expect from their local parks and trails.

Park visitation increased dramatically in the last few years at the larger National Parks (U.S. Department of the Interior, n.d.). Park visitation peaked in 2016 with approximately 330 million visitors (U.S. Department of the Interior, n.d), coinciding with the National Park Service Centennial celebration (U.S. Department of the Interior, n.d). But as the world changed its focus to managing the fallout of the COVID-19 pandemic, parks at almost every level shut down with the uncertainty of what was to come next.

Year	Recreation Visits	Percent Change
2010	281,303,769	-
2011	278,939,216	-0.83%
2012	282,765,682	1.3%
2013	273,630,895	-3.2%
2014	292,800,082	7%
2015	307,247,252	4.9%
2016	330,971,689	7.7%
2017	330,882,751	-0.02%
2018	318,211,833	-3.8%
2019	327,516,619	2.9%
2020	237,064,332	-27.6%
2021	297,115,406	25.3%

*Table 1: Visitation at National Parks (2010-2021). (*U.S. Department of the Interior, n.d*)*

With the distribution of a vaccine and increased confidence in health and safety practices, people around the country are beginning to return to campgrounds and trails to enjoy the great

outdoors as they once did. This resurgence in "visitation throughout the parks, both local and national, has shown an increased desire for outdoor recreation" (Mateer et al., 2021). This resurgence can be seen in Table 1. Since the end of 2020, the National Park service has seen a 25.3% increase in visitation. One of the reasons behind this surge in park usage, according to *Frontiers in Sustainable Cities* article, is the lack of availability to many parks throughout the early parts of the shutdown. The article states that the "COVID-19 pandemic has also led to widespread closures which may influence the availability of other leisure activities for individuals" (Mateer et al., 2021, para. 13). Overcrowding is an issue that embodies the complex line that park agencies must walk to achieve their individual missions. Vistas and viewpoints are often packed with people trying to get that one Instagramable photo and permits to many parks have become increasingly difficult to obtain. A study conducted on visitor experiences in the Grand Canyon saw a generally weak-to-moderate negative relationship between the number of people/groups encountered and overall quality of the recreation experience (Manning, 2003, p.107). One solution that has seen success in many National Parks has been the implementation of a day-use permit system for more popular trails. This method is designed to manage the number of people on historically crowded trails such as the Half Dome cables in Yosemite National Park. The permit system is offered as a free online lottery-style permit in which approximately 300 permits, with 75 being set aside for backpackers, and the remaining 225 for day hikers (U.S. Department of the Interior, n.d), are awarded to park visitors who have an interest in the trail. Other parks and trails have followed in Yosemite's footsteps, with popular trails such as the Mt. Whitney Trail and, more recently, Zion's famous Angels Landing Trail also having similar permit systems. The success of programs such as these have shown that simple

changes can improve the visitor experience and address park problems. However, as crowds continue to grow, people are moving to other trails in parks and often finding or making their own trails. In search of the solitude that many of us seek when we visit our local and national parks, people often travel off officially marked trails. The use of social trails is of particular concern in the American Southwest, where the impact that social trail creation and use have on delicate desert ecosystems is often irreparable.

What is a Social Trail

Contrary to what many motivational posters may say, "Do not go where the path may lead. Go instead where there is no path and leave a trail" (Emerson, 1903, as cited in Unquote, 2021) is not a transferable message for most park visitors. There are however some who choose to explore a park off the beaten path, which if left unchecked could lead to the creation of unofficial trails, commonly called social trails. Social trails, as defined in a pilot study on social trails in Mt. Rainer National Park conducted by the University of Washington are "informal trails created by erosion due to foot traffic from people and animals. Social trails are not part of the official National Park trail network and are an indication of human disturbance" (Moskal & Halibisky, 2008, p.1). The implementation of a permit system to manage trail usage on more popular trails across the country, although successful, is not the only tactic being used to manage how park visitors use trails. Taylor Riske, a park ranger stationed at South Mountain Regional Park has found that trail mitigation has been one of the most effective practices in preventing the continued use of social trails (Riske, 2018). Trail mitigation is the process in which land managers use features found within the natural environment to disguise or erase the presence of social trails (Riske, 2018). There are, however, limitations to trail mitigation. An example is

outlined in the 1987 edition *Restoration Manager Notes* for the National Park Service; while masking social trails with pieces of the local environment; the authors found visitors repeatedly dismantle the trail mitigation out of a belief that they were aiding in the maintenance of the trail (Johnson et al., 1987). The goal of trail mitigation is to disguise the presence of social trails, thus making it more difficult for park visitors to notice social trails. Despite the existence of limitations to this practice, observations in South Mountain Park show that pairing trail mitigation with educational signage that informs users of the impacts of using social trails, can be a very effective strategy to not only manage the trail but inform visitors (Riske, 2018). Riske noticed that even with proper trail mitigation, they still do not physically block the trail and force users to use official trails. Rather, when trail mitigation is used along with the placement of educational signage that informs users that trails are closed, park visitors were less likely to leave official trails. The practice of trail mitigation often promotes the sustainability of a trail system. The life of a trail is often laid out by how sustainable the trail was designed. The National Park Service describes the qualities of a sustainable trail based on the following five qualities, 1. negligible soil loss, 2. the recognition that pruning or removal of certain plants may be necessary for proper trail maintenance, 3. the trail does not adversely affect the region's wildlife, 4. accommodates the existing use while allowing for the integration of appropriate future use, 5. the trail requires minimal maintenance (National Park Service, Rocky Mountain Region, 1991, p.1).

Addressing social trail usage in any park system is an ongoing and almost never-ending battle. Trails are designed and built in a way that is supposed to provide a scenic and enjoyable experience to the park visitor, but to do it in a way that is sustainable and durable. There are already several methods being utilized to address social trail usage across the state of Arizona.

Oak Creek Canyon, just north of Sedona, has been undergoing a substantial social trail restoration project. The project, which is outlined in a watershed restoration action plan by the United States Forest Service, has already addressed over 200 social trails in Oak Creek Canyon (Shumaker, 2016). The prevention of social trail use in this area is a critical problem that, if eradicated from the canyon, could lower the E. coli levels in the creek, lessen the cliff erosion that is threatening a crucial section of State Route 89A, and crucially restores the canyon's narrow-headed garter snake habitat. A study into social trail use in the Potomac region of Maryland stresses that although educational tactics and site management efforts that were tested in the study were effective at reducing the usage of social trails, further research in the region will need to evaluate off-trail travel on a larger scale (Hockett et al., 2010). Different studies have utilized different recovery and management strategies to solve social trail use. Marion (2019) has identified four strategies that have been shown to be the most effective. 1. Improving the management of formal trails, 2. ignoring or formalizing informal trails, 3. maintaining informal trails, 4. closing and restoring unacceptable trails (Marion, 2019).

Chapter 3: Methodology

Within this study, there were three important aspects of the methodology, 1. test areas and preliminary studies, 2. trail categorization and initial social trail mapping, 3. observation. These three aspects formed the groundwork to create a process of elimination that would allow for trails to be designated for either mitigation or integration into the official park network.

Preliminary Studies

Prior to the start of the project, preliminary visits to the park were conducted to observe some of the trail layouts and visitor habits, from this, potential locations to conduct the remote observation aspect of the project were identified. The study area encompasses all 3,648 acres of the Usery Mountain Regional Park (Maricopa County Parks and Recreation, n.d.). According to the Parks and Recreation Department of Maricopa County, Usery Mountain Regional Park contains approximately 29 miles of official trails (Maricopa County Parks and Recreation, n.d.). To get a better idea of the social trail mileage in the park, three plots were created in different parts of the park and mapped all visible social trails in those areas. The location of the three plots was determined by their proximity to trailheads and the concentration of trails in each section of the park. The first plot, located in the northern corner of the park, is remote compared to the other two, only having one official and one social trail. The second plot in the southeastern corner of the park contains a high density of social trails. This part of the park could have higher social trail use than other areas due to the number of trailheads in the area. The final plot, located in the southwestern corner of the park, was chosen due to the proximity to the surrounding neighborhoods.

I used two online mapping resources to digitally map the social trails. The first was Alltrails, a digital collection of trails around the world that allows people to create digital routes for a variety

of recreational uses. The second was GAIA gps, a detailed gps navigation site that allows users to plot and create their own routes and maps. I began by tracing all visible social trails in each plotted area on Alltrails and then exported those tracks to GAIA gps so that they could be overlaid in the three plots of land. The utilization of both sites was necessary because you could not zoom in close enough when viewing a satellite image on GAIA gps but could get a clearer image when using Alltrails. *Figure 2* details an initial attempt at tracing social trails in three different parts of the park.

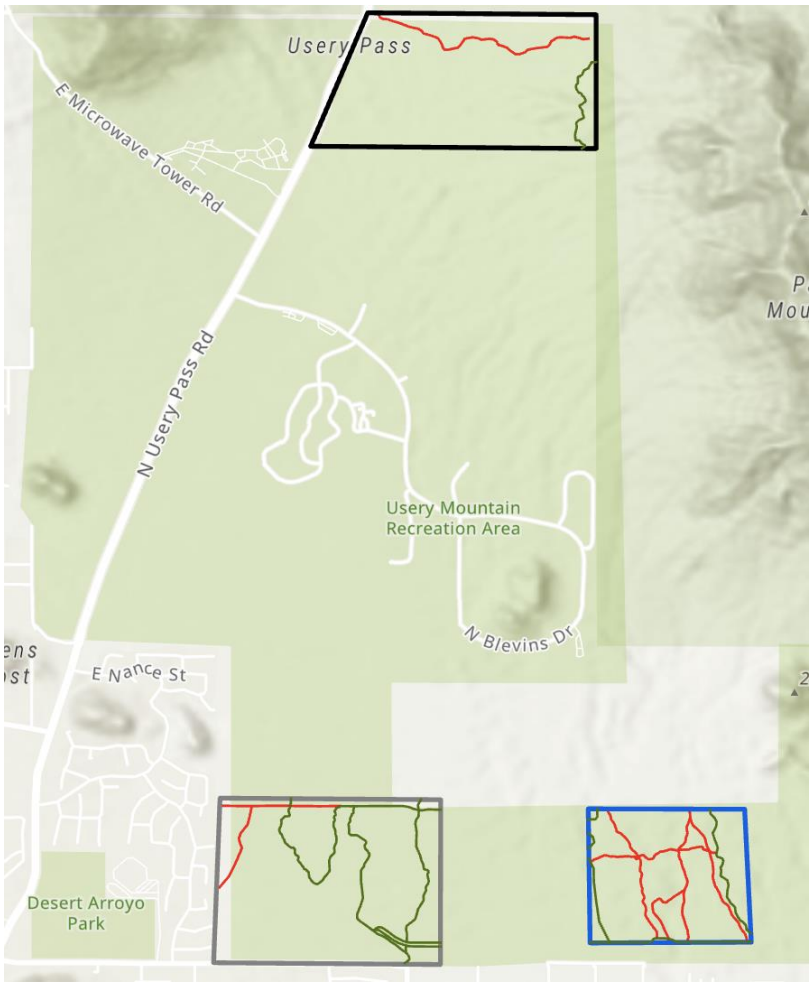


Figure 2: Test Areas. The three test areas in the park (Area 1: Black, Area 2: Blue, Area 3: Grey). Traced social trails are shown in red, and official trails in the test areas are in green.

Data

After reaching out to the Maricopa County Parks and Recreation Department, datasets that contain park infrastructure locations and information was obtained and contain the following data layers: buildings (including ramadas, fire pits, etc.), park trails, park trailheads, parts of the Maricopa Trail that approach the park, Maricopa trailheads, the archery course, pond, and all parking, campsites, and other clearings. Additional data pertaining to parking lots and trailheads that are located on the boundary of the park was collected in 2021 in coordination with a parking lot activity study (Kelly, 2021). This data has been categorized based on the following aspects: parking spots at the trailhead, fee station type, turnover traffic over one hour, and the number of major trails that begin at the trailhead. This study showed that based on the high volume of visitor traffic in the southwest corner of the park, a future proposal could be made to expand the trailhead parking lots. The observed traffic volume over a 2-hour window at the Levee Trailhead parking lot supported the idea that increased demand for the park's recreation-based resources could lead to a need for lot expansion.

Trail Categorization and Initial Social Trail Mapping

The first step in trail mitigation is the identification and categorization of trails within a park system, including official and unofficial trails. Numerous papers and reports have addressed this issue in different ways, categorizing the trails in ways that fit the needs of the paper. While researching the social trail impacts in the Picture Canyon Natural and Cultural Preserve in Flagstaff, Preiss (2020) determined that the best way to categorize the trails was based on use type: single-track and double-track trails. The trails were further broken into subcategories such as single-track animal, single-track social trail, and authorized trail. Other

studies categorized trails based on the physical aspects of a trail, such as trail width. This is the case in a case study conducted by the University of Washington looking at the impacts that social trails are having on meadow environments in Mt. Rainer National Park. The study states that they used depth and width to categorize trails as the information related to environmental impacts rather than trail usage data (Moskal & Halibisky, 2008). Utilizing a similar categorization practice to the Mt. Rainer study, in coordination with Oregon State University, the US Forest Service outlines numerous categorization strategies that can be used when analyzing the social trails in a wilderness area (D'Antonio & Hall, 2016). This paper outlines four categories: average trail width, the condition the trail is in, the presence of human waste, and an optional fourth category based on visitor use and access. These so-called primary categories are each broken down similarly to other studies organizing each categorized trail by specific features. For instance, Category 3, which outlines the presence of human waste on the trail, is broken down further into four categories (0= no human waste, 1=1 instance of human waste, 2=2-3 instances of human waste, and 3=>3 instances of human waste) to describe each trail accurately. The categorization of trails based on the observable human traces on or near trails is a common way for studies to organize trail data. Yoshitaka Oishi (2013) utilized a human traces categorization strategy when looking at the uses of certain trails in Japan's National Parks. Organizing trails based on the remoteness of a given trail and identifying them with a designated group letter allowed for an accurate representation between visitor preferences and the trail settings, which would allow for an appropriate management strategy to be given (Oishi, 2013). Each of the four papers addresses different aspects of trail management, and as such, the categorization systems they each use to identify trails are slightly different. All of them are

designed to best suit the intended goal of each study. However, there are aspects of each system that are applicable to the categorization of trails in the Usery Mountain Regional Park.

After reviewing past work conducted on social trails, the best way to categorize trails for this study is to organize them by the following aspects:

- The type of trail (single track, double track)
- Evidence of a human presence (waste and trash)
- Whether the trail was sanctioned or not
- The presence of a wash or not
- Whether there are signs present indicating the presence of social trails
- How compact the trail surface was due to degradation (Figures 10 and 15 highlight the levels of trail compaction further. With High compaction being equivalent to a packed down or asphalt road, moderate compaction being equivalent to lose gravel, and low compaction being equivalent to loose sand and or natural soil conditions).

This system utilizes physical trail attributes, as well as usage identifiers as the primary method to categorize trails in the park. Some of these physical trail attributes can be seen in *Figure 3,* which highlights the visual and physical differences between an official trail and a social trail. Since this study looked at the usage and presence of social trails in the park, it was essential to be able to identify and categorize the trails in the park, both sanctioned and unsanctioned, based on these factors. Given the results of past studies and the variety of trails in the Usery Mountain Regional Park, this categorization system should provide a wide range of attributes to identify and organize social trails. Furthermore, each trail was given an identification number along with any additional pertinent information, such as the length of the

trail between junctions, surface type, name, and region of the park. This was done by labeling each digitally mapped social trail in ArcGIS, and can be seen in *Figure 7* (in the results section) along with the corresponding data in the appendix.

To accomplish this, features from satellite imagery were traced on Alltrails that indicated the presence of a social trail, thus creating a "trails layer" to rely on when doing the fieldwork portion. The trails traced on Alltrails were then exported to GAIA gps where they were overlayed and separated into six sections of the park. It was more manageable to separate the park into sections as each trip out to the park could focus on a single section.

Figure 3: Site Visits. Examples of an official trail (left) and an unofficial social trail (right) in Usery Mountain Regional Park. Although barely noticeable, faint boot prints can be seen and a noticeable darker coloration to the topsoil makes the social trail stand out in contrast to a clear trail that has been widened and is evidence of heavy usage.

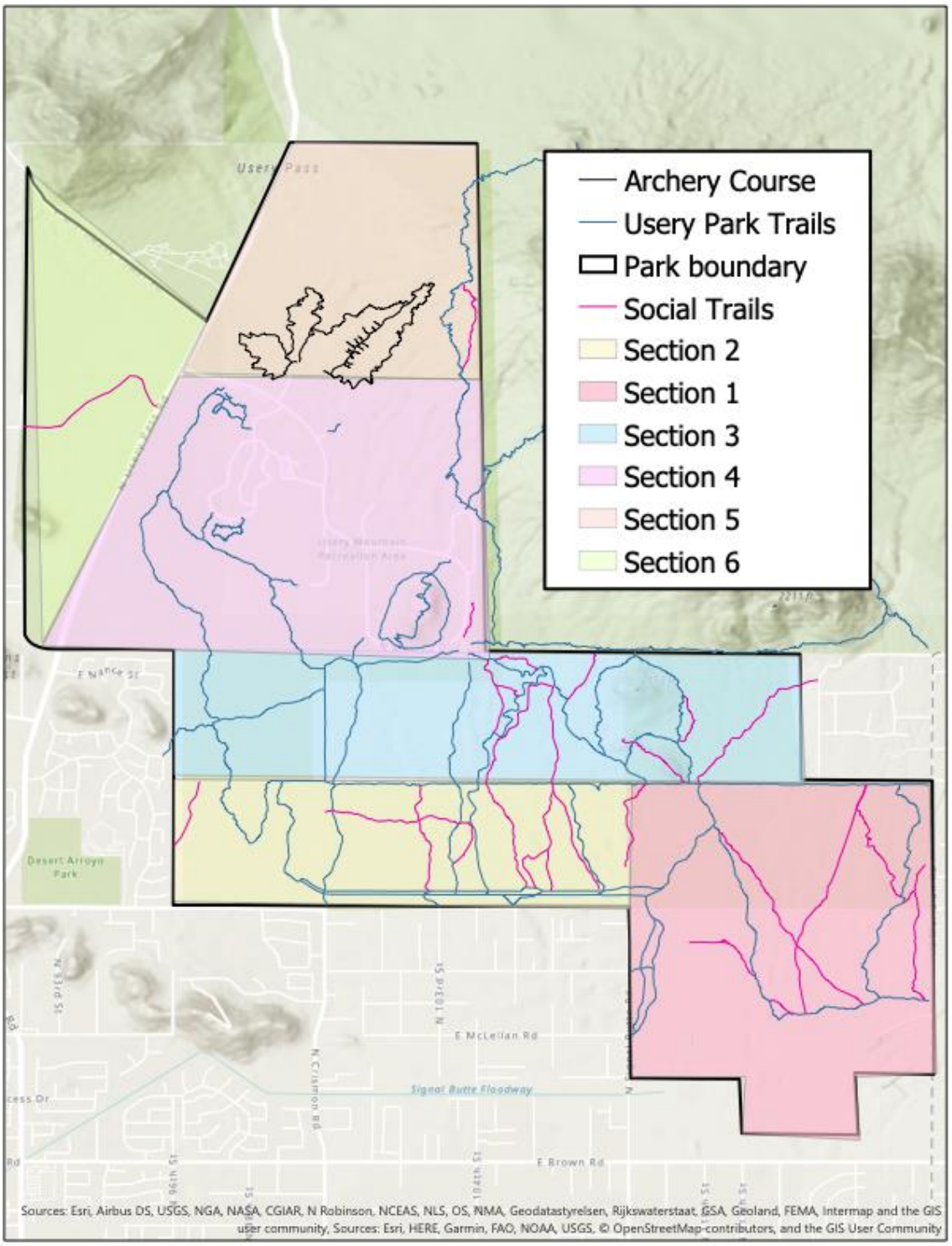


Figure 4: Field Work Sections. The six sections the park was separated into with the initial stages of social trail mapping.

Figure 4 highlights social trails that needed to be revisited in the field to properly categorize them based on the system that has been described**.**

After mapping trails digitally, I was able to tell approximately how long a trail goes as well as where it goes. Because of this, it was determined whether or not the full trail length could be hiked. Shorter trails were able to be hiked, whereas, for the sake of conserving time, longer trails were not. For longer trails, hiking a short portion of the trail gave me the necessary data to categorize the trail. Because trails, especially social trails, will not have been tampered with unless used, it would be safe to assume that the trail features observed along one section of the trail would be present along other portions of the trail. This assumption could also be made about other social trails near each other. Portions of each trail were hiked to make an accurate description of that trail, and when allowed, the full trail was hiked. Additionally, while out in the field trails were photographed to show some of the features described in their respective categories. To maintain consistency when gathering data along the various trails, the following guidelines dictated how much of a trail is hiked to gather the necessary data.

- To not walk the same trails multiple times, the color designation for the trail in GAIA gps was changed to red, indicating that the trail has been categorized.
- Second, one section of the park was focused on per visit during this categorization period. The map in *Figure 4* highlights how the park was separated into six sections to make it more manageable to conduct the fieldwork.
- Finally, the following criteria were used to determine which trails to hike fully. Trails less than or equal to .5 miles in length will be hiked fully. For trails greater than .6 miles, only .25 miles would be walked.

By checking the traced-out tracks from the computer work in the field, each trail was able to be identified and categorized properly.

Observation

With large natural parks such as the Usery Mountain Regional Park, it can often be impractical to conduct thorough and accurate data collection without the interference of park visitors. This is especially important when the study itself is looking at visitor usage within the park, as well as possible illegal use in the park. Most trail-user data is collected using subjective measures, such as surveys and questionnaires because they are inexpensive and easy to conduct, however this method is limited to the respondents' memories and perceptions (Reed, et al., 2007). The data for studies such as this need to be as natural, and behavior based as possible which is why remote observation of park visitors is the most appropriate method to use. Remote observation of park visitors can be conducted using a couple different methods depending on what is needed and best suited for the study area. The Mt. Rainer study was conducted over a seven-month period to collect as much data for a variety of categories as possible (Reed, et al., 2007). Remote observation of park visitors is not a new tactic in the parks of the Phoenix valley. Taylor Riske, a Park Ranger in the South Mountain Park conducted a similar study observing trail use and the correlation between well-signed trail junctions and the likelihood of people traveling off-trail. The observation portion of this study was conducted in several increments, with a twelve-hour observation period that was broken into three four-hour long sessions (Riske, 2018). The researcher in this study returned to the study site twice over the following months to observe the longevity of trail mitigation that had been conducted prior to the study. The observation of park visitors, although a good system to gather data, does have its flaws. A study

conducted in the Potomac river region of Maryland that was looking at ways to deter and prevent the use of social trials along the river noticed that the study was constrained by staffing limitations (Hockett, et al., 2010). This limitation prevented the observation of park visitors along the entirety of a given trail. The strength of remote observation is being able to observe people's behaviors from a distance, thus removing yourself from the action. In large areas such as parks however, unless the study has accommodated for a large observation staff which can increase costs, only a very select part of the trail can be observed. This issue can, however, be avoided by altering the study to focus on visitor behavior near trail junctions with social trails and other major features along a trail.

After reviewing similar academic works on this topic and obtaining the necessary trail use data for this study, remote observation of park visitors was conducted at one trail junction in the park. While conducting the park walk-through as described above, a trail junction was identified where a social trail connected with an official trail, and there was noticeable visitor traffic through that trail connection. While conducting my observations, specific information that pertained to the behaviors of people traveling through the junction was collected. The categories that were used are as follows:

- The type of use (horseback riding, mountain biking, hiking, etc.)
- The number of people in each group
- Whether they stopped at the junction or not, the approximate amount of time spent at the junction.
- Whether they took the social trail
- Their direction of travel, origin, and destination

An example of the data collection table that was utilized can be found in the Appendix. When conducting the observation portion of this study, I was perched up on a high point near the junction over the course of two days, observing one junction for seven hours. This information not only gave me a good idea of how often a trail is used but also allowed me to observe the habits of park visitors. This observation was conducted by utilizing binoculars to remove any interference with park visitors.

After reviewing other papers and their presentation of observation-related data, it was determined the best way to present the data is in a table format. Due to the large number of users observed, the data was compiled to show the percentage of people observed who used a social trail, while also showing what people were doing when using the social trail.

ArcGIS

Since the fieldwork was separated into three sections, satellite imagery, observational and trail mapping, the digital analysis of the collected data was split as well. Initially, the collected trail data was compiled into a single trail layer. This layer displayed the collected data based on the categorization method outlined in previous sections. To make this layer, all mapped trails that were either made in GAIA gps or transferred from Alltrails were transferred to ArcGIS as GPX files. This file type was the easiest to use for this process as there is a geoprocessing tool in ArcGIS that can create a feature class from the file. After inputting the collected data into fields based on the defined categories for both the observation and site visit portions of the fieldwork, a new layer was created, which was able to be manipulated to focus or show certain aspects that were being described.

Analysis

The two objectives of this project were to observe and analyze how trails are used by the public and to identify areas impacted by social trail use. To achieve this, five maps were made using the data that was collected, each with a detailed description of every social trail in the park, categorizing the trails based on the type of trail, evidence of a human presence, or trail degradation. The second layer was based on the remote observation aspect of this study and simply showed the proximity of the observation site and the observed trail junction. This classification system would be used to organize the observed trails based on the data that was collected prior and classifying them as “restoration” or “maintain and formalization of the trail”. Trails would be separated into these two categories based on the number of noted traits each trail has, as well as the varying levels of degradation each trail is showing. The data collected as a part of this classification system will indicate which action needs to be taken based on the level of use and degradation to the trail. With these created layers I was able to combine a known aspect of social trail mitigation, this being that education remains the best way to fight unsanctioned trail use (Riske, 2018), and identify a new approach to identify and manage known social trails within the parks.

Chapter 4: Timeline and Project Details

Following project approval in May, field work began mid-May, and was conducted until mid-August. The focus early was to conduct the trail categorization portion. This decision was made based on the increasing temperatures that would likely skew the collected data for the observation portion. Outdoor recreation demand in the Phoenix area follows the unique weather patterns that have defined this part of the country. After the trail categorization had been completed in June, the next two months were spent analyzing the data, and preparing the necessary tools for gathering the observation related data which would take place in September. September offers much cooler temperatures in the morning hours during the height of the summer season. Because of this, it was an ideal period to observe park users and gather that data as more people hike the trails to explore the natural wonders that surround the metropolitan landscape. The remaining data analysis was conducted during October.

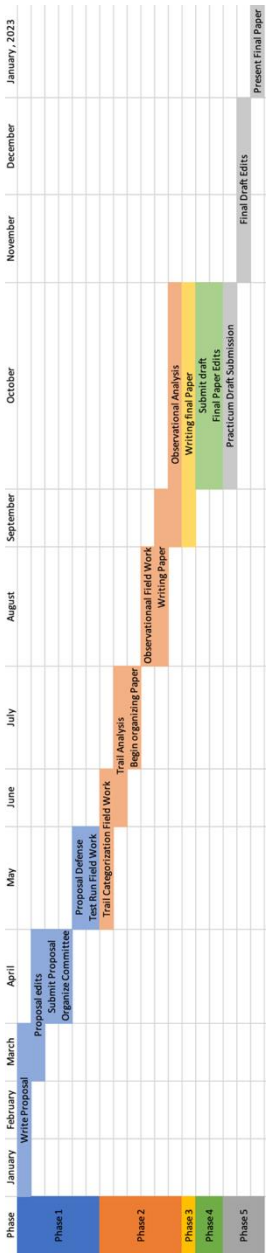


Figure 5: Project Timeline

Chapter 5: Results and Discussion

The objective of this project was to analyze human movements on official and non-official trails within the park, and with that data determine which trails can be classified for restoration through mitigation or become an established part of the existing trail network. Figure 6 below highlights the way the collected data was utilized to get the results.

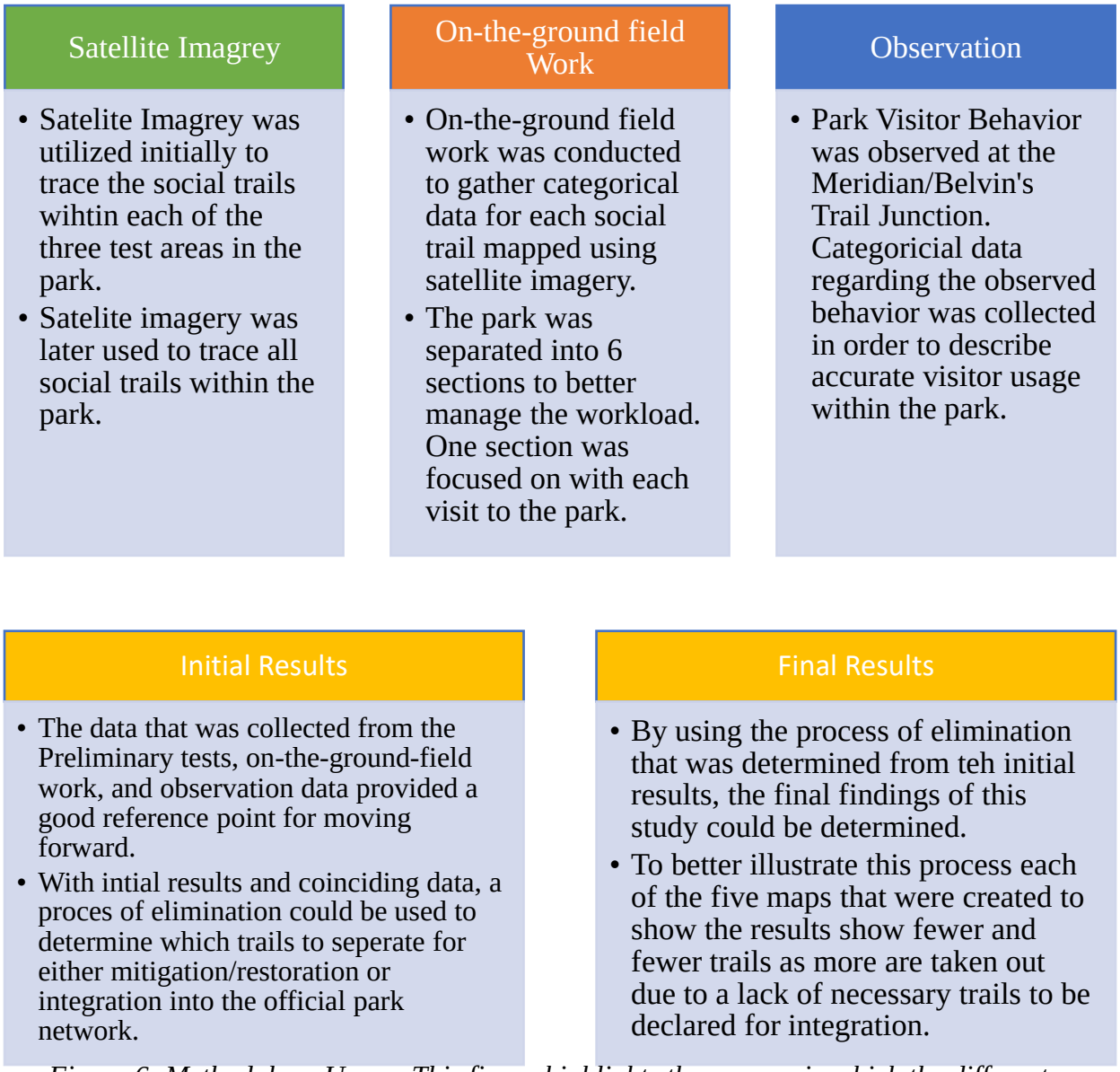


Figure 6: Methodology Usage. This figure highlights the process in which the different methods were utilized.

Preliminary Studies

To determine how many miles of trail had been traced in all three test areas, it was necessary to make sure that every trail began and ended at a junction with another trail. This way, there was no overlap in the mileage covered. Each of the lengths of the trails was then added up to get to the result. The following formulas were used to estimate the total number of miles of social trails in the park, the total number of acres in all three test areas divided by the total number of acres in the park multiplied by 100 to get the percentage of the park the test area contains. This is shown in the formula below:

$$\frac{\text{Test Area Acres}}{\text{Total Park Acres}} = \text{Percent of Park in the test area}$$

The number of social trail miles traced in the test area was then divided by the test area percent and multiplied by one hundred to find an estimated total of social trail miles in the park, represented by the formula below:

$$\frac{\text{Miles of social trails in test area}}{\text{Percent of Park that is in the test area}} \text{ x } 100 = \text{Estimated number of miles in park}$$

Test Area	Test Area Acres	Social Trail miles in test area	Percentage of park	Estimated miles
1 (Black)	186.2	0.67	5.10%	13.13 miles
2 (Blue)	114.8	1.94	3.14%	61.70 miles
3 (Grey)	199.5	0.6	5.46%	10.98 miles
Total Park	3,648	n/a	100%	

Table 2: The table shows the total number of social trail miles in each test area

The results in *Table 2* show that there is a large range in the estimated total mileage found in the park. This range is due to the variations among the three test areas, such as location in the park, trail density, and overall acreage. Categorizing the data into a low, medium, and high system, the data clearly shows that test areas one and three had a low number of estimated miles, and test

area two had the highest estimate of total park social trail miles. Based on this test data, the estimated total social trail mileage within the park boundary is between 10.98 and 61.7 miles. Having two of the three test areas show a low mileage estimate could be related to those test areas either being located in remote areas of the park or having low numbers of trails.

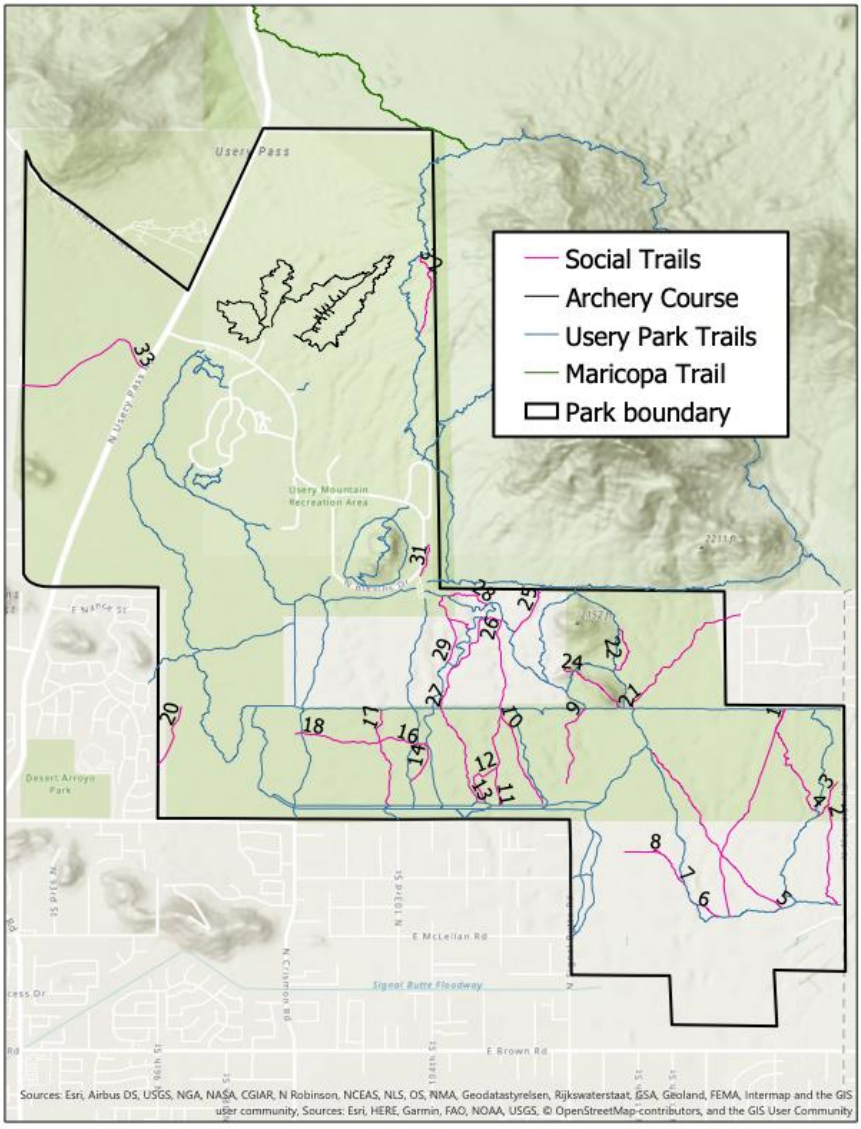


Figure 7: Social Trails. Digitally mapped social trails within the park. Correlating data can be found in the Appendix.

Trail Mapping

By digitally mapping social trails viewable on satellite imagery, a total of 33 social trails combining for 11.18 miles of trail were marked, of which only 6.47 miles or 57.87% of the digitally mapped trails were categorized as unsanctioned social trails with signs of human presence. It was originally estimated there was between 10.98 and 61.7 miles of social trails in the park and although the actual mileage of categorized trails was lower than the estimation, it was accurate when considering the total mileage of actual social trails that were initially mapped. This is backed by the fact that of the total mileage that was mapped, not all of it was categorized as an unsanctioned social trail. Unlike the original estimate, the results for this study had to take into consideration that some of the digitally mapped trails were going to be categorized as social trails with no signs of human presence, thus detracting from the total social trail mileage that was categorized as unsanctioned.

One of the key steps in determining the final designation of the digitally mapped trails was to determine which of the trails to focus on. The trails were initially labeled as either showing signs of usage or not based on noticeable physical attributes such as boot prints and bike tires or animal tracks, bones, and scat. *Figure 7* highlights the distribution of digitally mapped social trails categorized by whether human use was observed on the trails.

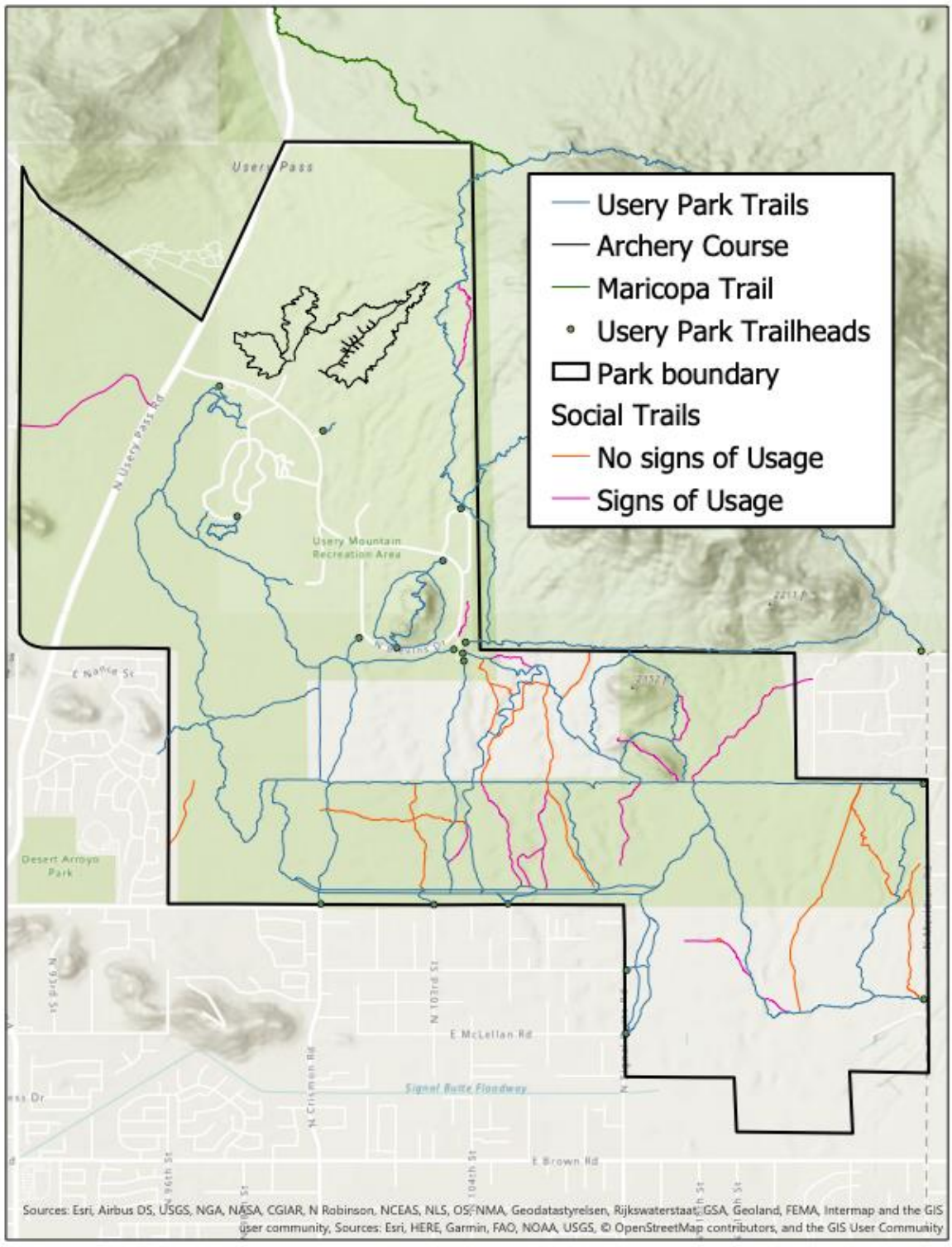


Figure 8: Signs of Usage. The social trails in this map are categorized by whether signs of use were observed on the trails.

A common trend that was seen between both trails that had signs of human usage and those that did not was that they tended to follow the path of least resistance, with only one trail gaining any significant elevation, while others stuck to avoiding other features. One distinct difference between the two categorized trails was that whereas with trails that showed little to no signs of human usage would often lead directly into dense groves of cholla cactus or other vegetation, whereas trails that had signs of human use either stuck to washes or followed the path of least resistance. In many cases, these trails snaked their way through the landscape rather than head in a direct path.

The official park map, highlighted in *Figure 1*, shows a variety of trail options to park users, with certain trails tailored to each type of recreation, mountain biking, horseback riding, or foot travel (hiking, running, etc.). There could be many reasons why people would use a social trail. It was important to identify the types of usage on the mapped social trails categorized as unsanctioned due to the presence of human usage. *Figure 8* displays trails that have been categorized based on the observed signs of usage and have been further separated based on noticeable human presences along those trails. These indicators include boot prints in the dirt, tracks from bike tires, or a combination of the two. One indicator that was not observed on the mapped social trails was equestrian, though it must be noted that equestrian off-trail travel was observed in the park as part of the observation fieldwork.

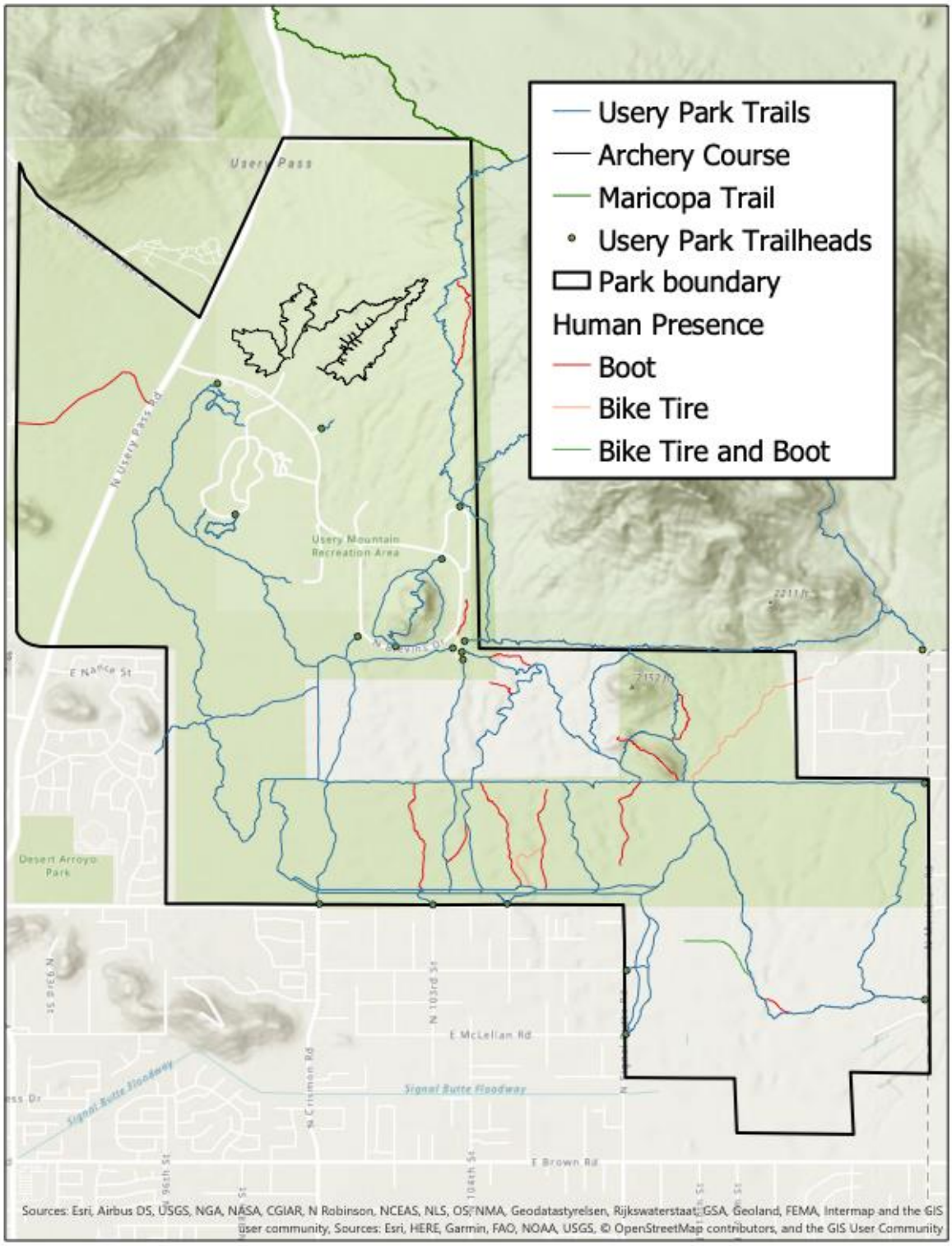


Figure 9: Human presence. The observed human presence on social trails throughout the park.

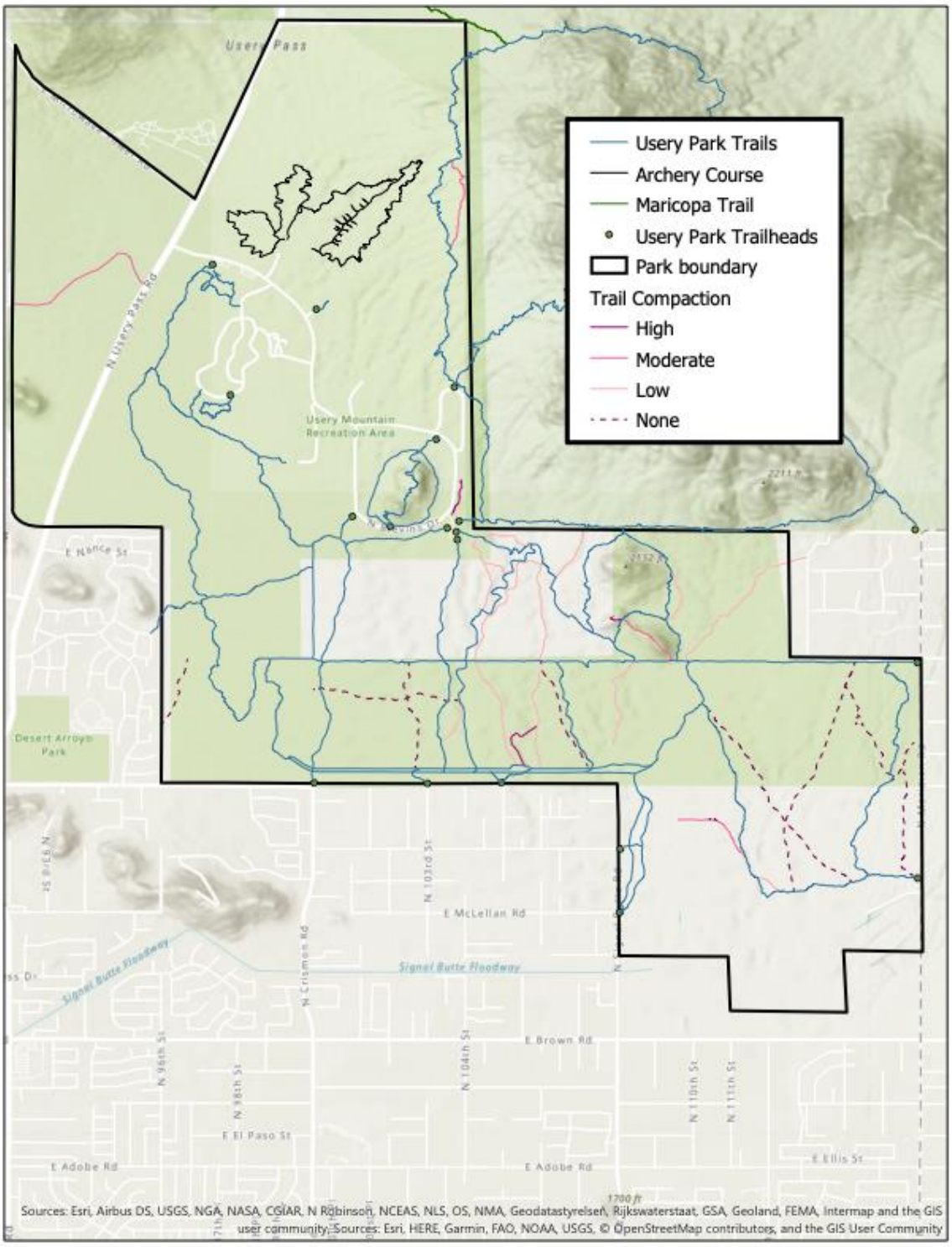


Figure 10: Trail Compaction. Level of trail compactness on observed social trails in the park.

Determining which of the trails shown in *Figure 7*, could become an established part of the current trail network within the park came down to the level of soil degradation along the trail and whether the trail would benefit visitor movements in the park. *Figure 9* shows the various levels of compaction among the social trails that were labeled in *Figure 8.* Of the 33 trails that were included in this study, 17 or 51.51% of them showed signs of human presence and levels of compaction. Three of these trails showed high levels of compaction, four showed moderate signs of compaction, and the remaining 10 trails had low levels of compaction.

Observation

The observation of park visitors occurred over the course of a Saturday and Sunday morning in September 2022. The initial observation period of eight hours on a Saturday morning were cut short due to an unexpected storm which forced the data collection period to be moved to the following morning.

Figure 11: Observation Point. Viewed from a social trail along the Cats Peak Pass Trail, the junction between the Belvin's Trail (north/south) and the Meridian Trail (east/west) as well as unmarked social trail

The observed trail junction was chosen due to a combination of being easily visible from a nearby high point, and because the junction was a meeting point of a social trail and the Belvins/Meridian Trail. This trail traverses the park in an east-west direction with the Belvin's Trail heading west from the junction and the Meridian Trail heading east. This junction is close to the park's border with the nearby Tonto National Forest and the Cat's Peak Loop.

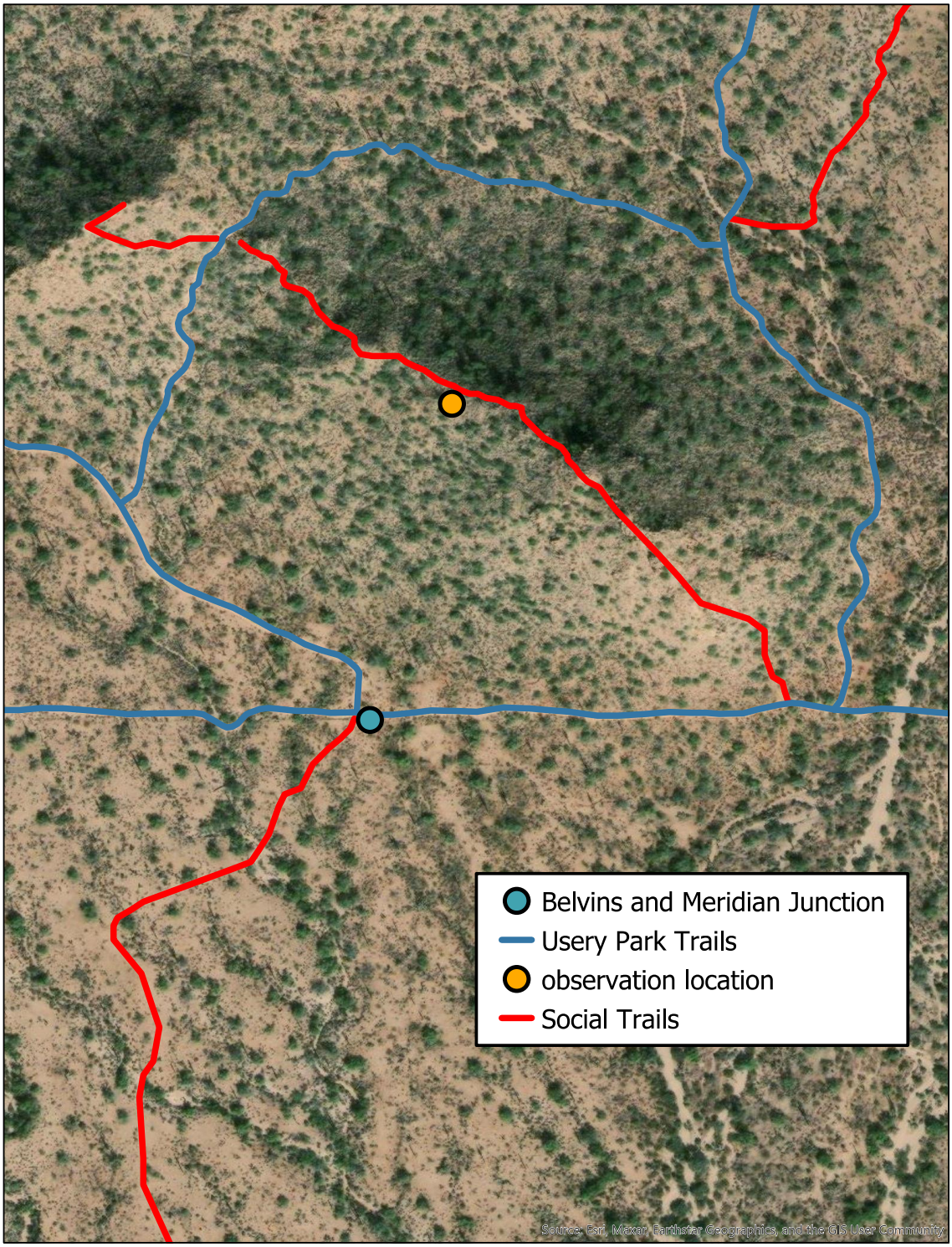


Figure 12: Observation Topographic Map. Junction is shown in blue, with the observation point in orange. The observation point is .12 miles from the trail junction.

Type of usage	Number of groups	Number of individuals	Percentage of individuals observed	Number of Individuals observed off trail	Percentage observed off Trail	Number of individuals stopped at trail junction
Mountain Bikers	32	36	49.31%	0	0%	8
Hikers	15	26	35.61%	0	0%	4
Runners	5	5	6.84%	0	0%	0
Horseback	3	6	8.2%	4	66.66%	4
Total	55	73	n/a	4	5.47%	16

Table 3: Observation data results

One of the surprising findings from this part of the study was that there was no observable evidence that certain people were more likely to travel off-trail than others based on certain factors such as direction of travel, origin or destination. More so, as shown in *Table 3*, specific types of activities were more likely to travel off trail based on the observational data that was collected. It was observed that equestrian users were the only ones to travel off trail, and although it was a small percentage of the total number of people observed, only 5.47%, it was noted that both groups were utilizing washes to maneuver through the landscape. Additionally of the 55 groups that passed through the trail junction, only 11 stopped, and spent some time at the junction. Across the 55 groups who were observed, a total of 73 individuals passed or stopped at the trail junction during the observation period. Out of the 73 trail users observed, 36 or 49.31% of users were mountain bikers, 26 or 35.61% were hikers, 6 or 8.2% were horseback riders and 5 or 6.84% were runners.

Trail Mitigation or Establishment

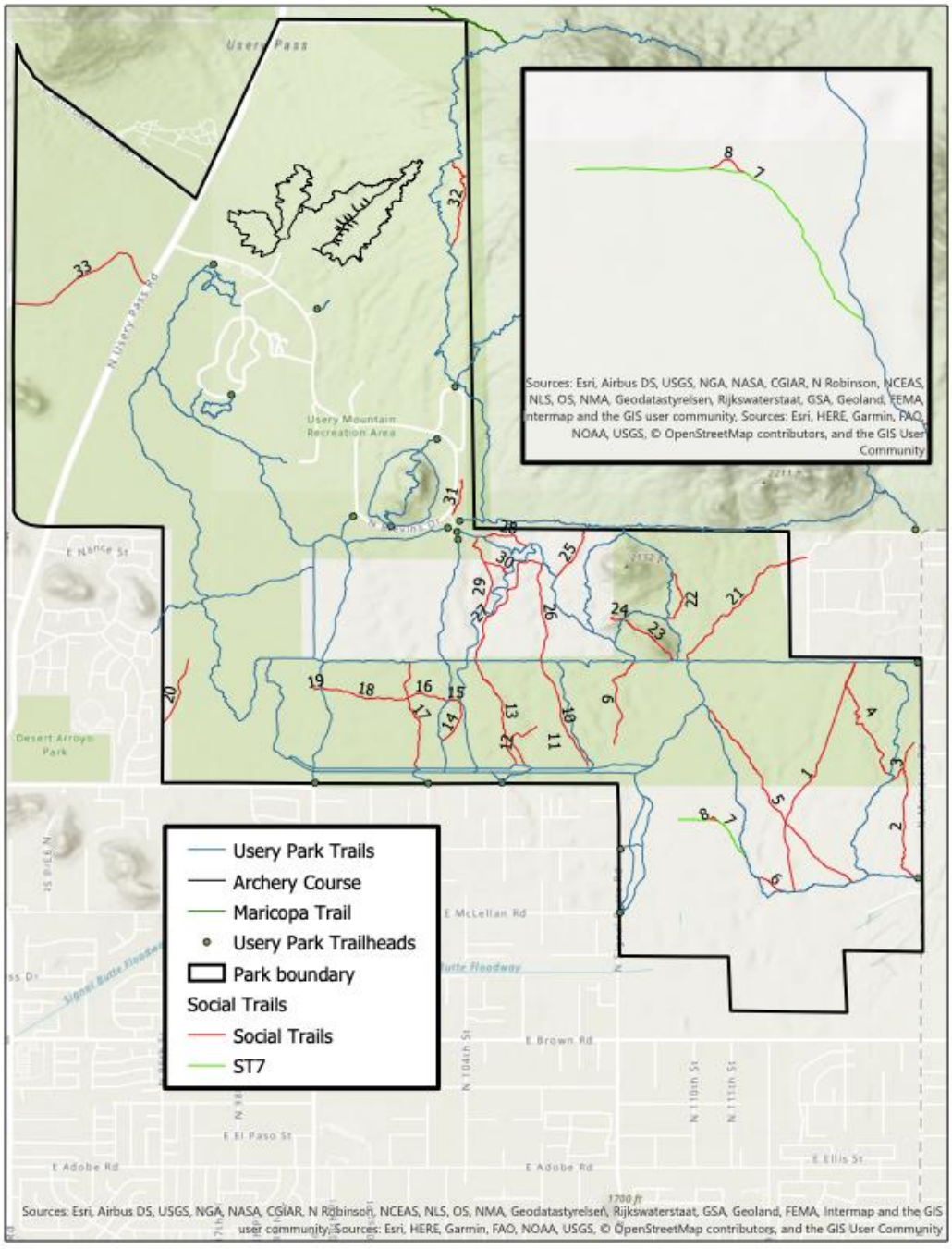


Figure 13: Social Trail 7 Focus. Shown in the highlighted box, Social trail 7 is seen heading west, away from the main trail. ST8 is a minor detour around a grove of cholla.

Figure 14: Trail ST7. Social trail 7 (ST7) (left) splits off the main trail (right). Although not as defined, the social trail is visible enough to be mistaken as an official trail.

Figure 15 highlights the 17 social trails that showed various levels of compaction due to use, seven of which showed moderate to high levels of soil compaction. By prioritizing essential pieces of information such as the level of trail compaction and signs of human presence, certain trails became highlighted as potential candidates for being integrated into the parks official trail network. Of the 33 trails that were included in this study, 17 or 51.51% of them showed signs of human presence and levels of compaction. Three of these trails showed high levels of compaction, four showed moderate signs of compaction, and the remaining 10 trails had low levels of compaction.

One of the trails, Social Trail 7 (ST7), showed signs of heavy mountain bike usage. As depicted in *Figure 7*, ST7 veers in a westerly direction toward a monsoon runoff channel and

heads in the direction of an adjacent neighborhood. Although there are trails that begin along this channel, trail ST7 was not officially labeled on any map and acted as a link for park users to travel between two trail networks that are only connected by a trail farther north in the park. As depicted in *Figure 13,* this section of trail offers a quick shortcut for park users to get to popular trails such as the Levee Trail as well as the five trailheads in the southern part of the park rather than adding mileage to head deeper into the northern part of the park to get the same access.

The case of social trails 32 and 33, both are trails that have already been mitigated by the park. Trail ST32 was once a section of an official trail that has since been rerouted along the lower sections of the nearby Pass Mountain. Despite a rock barrier being placed to disguise the trail, the trail's rock steps are still clearly visible and since the trail has yet to be reclaimed by the surrounding brush, it can still be easy to identify. Trail ST33 on the other hand has had very little mitigation to discourage public use, rather at the western terminus all that can be found is some signage and a fence. Despite coming across some trails that were not visible when conducting digital mapping of the area, many of them had already undergone trail mitigation and were in some cases well disguised amongst the natural brush and rock. An example of trail mitigation practices in the park can be seen in *Figure 16.* In this case logs and large branches have been laid down where the trail once was.

Based on the results from this study, Trails ST7, ST13, ST31 and ST24 would be designated for establishment in the official park trail network. These trails not only showed signs of recent use by visitors, but also were used to meet a need or interest to park users, whether that need, or interest be to get from one place to another or get to a high point. As a result of the signs observed on these trails, they are more suited to become integrated into the official park trail

network. ST31 and ST24 are both trails that provide visitors with access that they don't currently get. ST31 for example is a trail that connects parking lots close to the popular Wind Cave trailhead. As there are no safe pathways to walk along the busy road, visitors are forced to walk-through low-lying brush to get to the trailhead on busy weekends. ST24 on the other hand is a social trail to a high point along the Cats Peak Pass trail. The remaining trails would be designated for mitigation projects in the future due to a need not being met along with inconsistent usage.

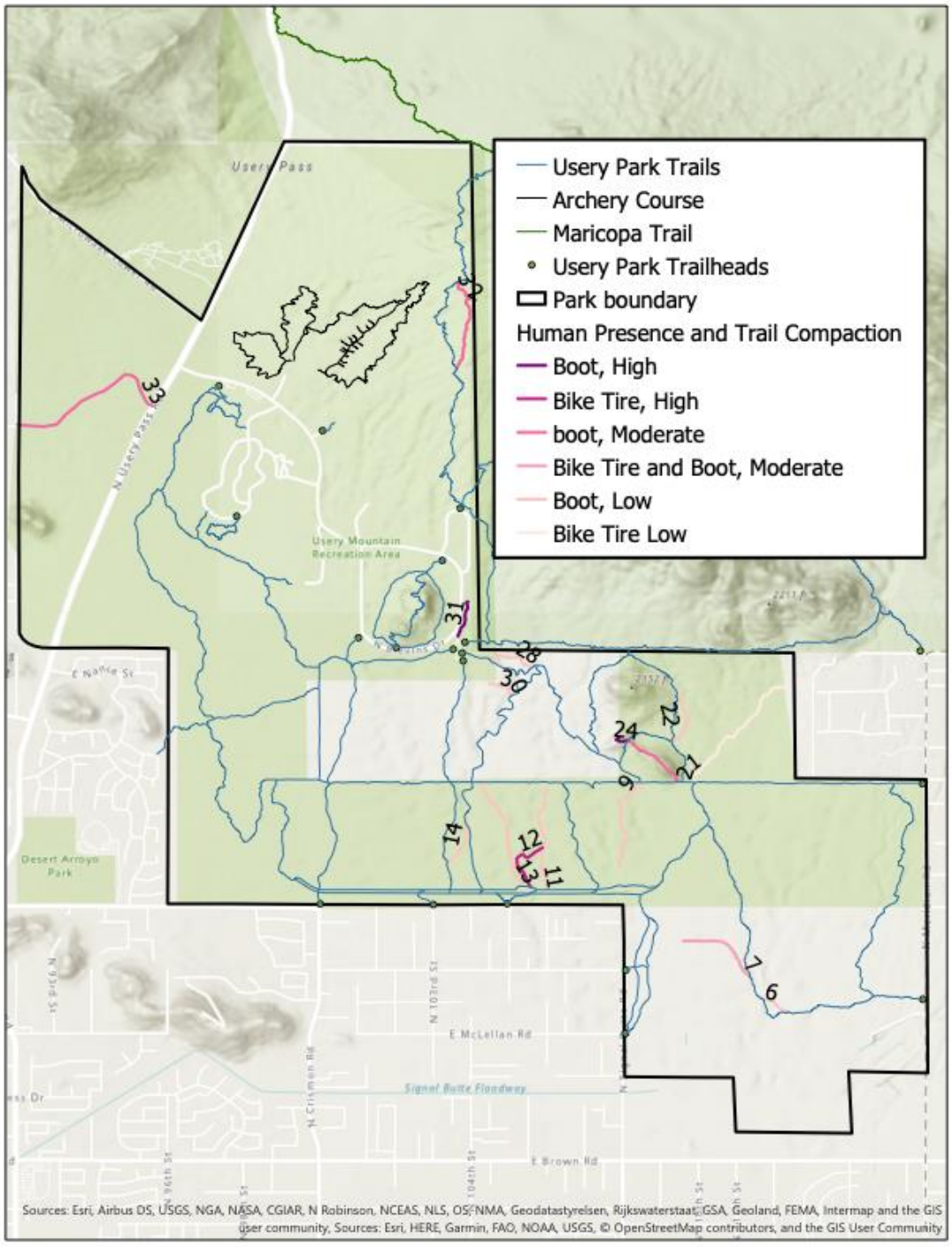


Figure 15: Human Presence and Soil Compaction. The 17 trails shown, which have been categorized by trail type, human presence, and how compact the trail is, have been identified for inclusion in the existing trail network. Social trail ST7 showed signs of degradation which are highlighted in *figure 9*.

Figure 16: Social Trail Mitigation. Example of social trail management in the park. Park staff have attempted to hide what was a social trail with debris and brush.

Chapter 6: Conclusion and Limitations

Figure 17: Closed Trail Signage. Signage indicating a closed trail. This trail although initially wide and clear, becomes a narrow-defined trail that will connect with the Belvin's Trail.

Limitations

When looking at each of the three test areas, two mathematical formulas were used to find the estimated mileage in the park. The acreage within each test area was required, and it must be noted that the acreage in each of those test areas was acquired from GAIA gps. This was done by creating each of the plots, which, when done, showed the acreage of land that was contained in that area. The potential inaccuracy of the mileage estimate as a result of the acreage

of each test area being incorrect must be noted; however, because each test area was a unique plot no pre-existing data was available.

It must be stated that there were some limitations to all three aspects of the methodology. Initial social trail mapping saw its share of limitations early on. The primary reasons that both digital mapping and on-the-ground mapping were utilized is because digital satellite maps can often be blurry, and difficult to identify specific features when zoomed in; and it is possible that satellite maps may not be up to date. There were some trails that were found while conducting my fieldwork, however, these trails showed signs of recent or historic mitigation. Although the Alltrails satellite image was much more detailed and defined, from a bird's eye view, many social trails may have gotten lost among the many washes and other natural features of the park. With this being the case, it was not surprising to find trails that had already undergone mitigation by park staff throughout the park.

The Observation Portion of this project had one of the biggest limitations, not being able to always observe every park visitor. It was unrealistic with the time and resources available to monitor and collect data regarding every park visitor as they traveled through the park's many trail junctions. It was for this reason that only one trail junction was observed, and specific features had to be present at that junction for it to be chosen.

Conclusion

The findings from both trail mapping and observing trail usage within the park showed three surprising results. As shown in the collected data regarding evidence of human presence on the monitored trails, boot prints were the most common human presence seen on trails, and when trail junctions were observed, equestrian activity off trail was seen. Only a few digitally mapped

trails showed evidence of mountain bike activity. One trail that showed traces of severe bike usage was social trail 7 (ST7) located in the southeastern section of the park. As depicted in *Figure 13*, ST7 veers in a westerly direction toward a monsoon runoff channel. Although there are trails that begin along this channel, trail ST7 was not officially labeled on any map and acted as a link for park users to travel between two trail networks that are only connected by a trail farther north in the park. Of all the trail usage types that were observed at the Belvin and Meridian trail junctions, only two groups of equestrian riders were observed traveling off trail, and mainly doing so by using washes as the main route of travel.

Second, of the 33 digitally mapped social trails, 9 or 27.27% of the mapped trails began or ended at either of the two major east-west trails, these trails being the Belvin's/Meridian Trail and the Levee Trail. These two trails represent a major connecting trail for trail users to travel deeper into the park and access other trails. Although there are a few official trails that connect the southern trailheads with the two major east-west trails, the nine trails offer users access to the park's interior without interacting with others. In addition, the evidence of equestrian use along these trails is supported by the equestrian presence in the surrounding neighborhoods along with the observed off trail equestrian usage at the Belvins and Meridian Trail junction.

Lastly, one of the more surprising findings was that although many social trails were able to be digitally mapped using satellite imagery, it was evident that some social trails had already undergone mitigation by park staff. This finding has led me to believe that historically there could have been more trails than the ones digitally mapped. In addition to this, despite signage indicating park visitors should not travel off trail, only 2 of the 33 were digitally mapped trails. Park signage was not present along other mapped social trails.

Through the various steps used in this study, a process of elimination was created to ultimately show which trails could become established official trails. This process of elimination was created by using different parameters based on the collected data. New maps could be made to show more specific information that pertained to certain trails. This new approach will allow parks to not only identify, categorize and focus on specific trails and sections of land but also to document and store updated data pertaining to those trails for future use. The trails highlighted in *Figure 15* are examples of trails that would benefit from this identification and categorization practice. By designating these trails for either mitigation or establishment using the steps and parameters outlined in this study, parks could monitor these trails on a yearly basis and update the maps to show the pertinent information. In the case of trails that are designated for mitigation, the levels of degradation and overall trail conditions would be able to be displayed based on a year-by-year basis to show how the trails have been reclaimed by the landscape over time.

To further prevent and manage social trail use in local parks, park managers will have to rely on a combination of two practices to identify, manage, and prevent social trail use. First is a continuation of mitigation practices to help the landscape reclaim social trails. The second is the utilization of education as a prevention tool. Riske (2018) stated that among mitigation practices, education remained the best tool in preventing social trail use. This study aimed at creating a way for park managers to categorize trails for better management, but the further prevention of continued unsanctioned off-trail travel starts with educating the public on how to travel through an environment. Signage, among other forms of education, is a big part of providing easy

information so that more people are aware of how to enjoy these places ethically and responsibly.

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Appendix

Appendix A

Terminology for different trails used throughout the paper

Trail Type
Social Trail, also referred as • Non-designated • Unmarked • Unsanctioned • Informal • unofficial
Official Trail, also referred as • Formal • Sanctioned

Appendix B

Trail categorization factors

Trail Type	**Wash or No Wash**	**Sanctioned or Unsanctioned**	**Evidence of Human Presence**	**Level of Compactness**	**Presence of Signage**
S - Single Track D - Double Track	W – Wash NW – Not a Wash	SD – Sanctioned UD - Unsanctioned	B – Boot prints T – Trash BT – Bike Tire H – Horse Track	H – Heavy (almost like pavement) M – Moderate (similar to a gravel road) L – Low (sandy mixed with gravel)	Y – Signage was present indicating a social trail N – No signage was present

Appendix C

Trail categorization data results

Trail Number	Trail Type	Presence of a Wash	Trail Designation	Human Presence	Degradation	Signage	Trail Condition	mileage
1	S	Nw	A	N	N	N	0.96	O
2	S	Nw	A	N	N	N	0.47	O
3	S	Nw	A	N	N	N	0.17	O
4	S	Nw	A	T	N	N	0.56	O
5	S	Nw	A	N	N	N	0.87	O
6	S	Nw	Us	B	L	N	0.1	S
7	S	Nw	Us	Bt, b	M	N	0.3	B
8	S	Nw	A	N	N	N	0.034	O
9	S	Nw	Us	B	L	Y	0.38	B
10	S	Nw	A	N	N	N	0.46	S
11	S	Nw	Us	B	L	N	0.41	S
12	D	Nw	Us	Bt	H	N	0.23	B
13	S	Nw	Us	B	L	N	0.45	B
14	S	Nw	US	B	L	N	0.17	S
15	S	Nw	A	N	N	N	0.05	O
16	S	Nw	A	N	N	N	0.15	O
17	S	Nw	A	B	N	N	0.45	S
18	S	Nw	A	N	N	N	0.31	O
19	S	Nw	A	N	N	N	0.024	O
20	S	Nw	A	N	N	N	0.28	O
21	D	Nw	Us	By	L	N	0.63	B
22	S	W	Us	B	L	N	0.23	O
23	S	Nw	Us	B	M	N	0.24	B
24	S	Nw	Us	B	H	N	0.053	B
25	S	Nw	A	N	L	N	0.22	O
26	S	Nw	A	N	L	N	0.4	O
27	S	Nw	A	N	L	N	0.53	O
28	S	Nw	Us	H	L	N	0.17	S
29	S	Nw	A	N	L	N	0.32	S
30	S	Nw	A	N	L	N	0.1	S
31	S	NW	US	B	H	N	0.15	B
32	S	NW	US	B	M	N	0.71	S
33	S	NW	US	B	M	Y	0.6	B

Appendix D

Observation data collection table

Groups	Type of use	Did They Stop	Number of People in Group	Amount of Time Spent at Junction	Direction of Travel	Origin and Destination
Table Key	H – Hiker HB – Horseback MB – Mountain Biker R - Runner	Y – Yes N - No	Total number of people in group		Cardinal Directions	Whether they are coming from another trail to this junction or not
Group 1						
Group 2						
Group 3						
Group 4						

Group 5						