

**McDonald Hollow Trail Network Visitor Use  
and Trail Impact Study: A First Look**

Matthew Lindsay

Paper submitted to the faculty of Virginia Polytechnic Institute and State University in partial  
fulfillment of the requirements for the degree of

Masters of Forestry

Michael G. Sorice  
J.P. Gannon  
Jeffrey Marion

August 08, 2022  
Blacksburg, Virginia

Keywords: McDonald Hollow Trail Network,  
Trail Use, Visitor Use

# **McDonald Hollow Trail Network Visitor Use and Trail Impact Study: A First Look**

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## **Abstract**

The recent construction of the McDonald Hollow Trail Network located in Blacksburg, Virginia presents an important opportunity to explore early stage soil degradation and visitor use patterns on a public multi-use trail. Through the creation of permanent transects along each trail and the implementation of a visitor use survey, initial usage and impact patterns can begin to be observed. This not only addresses a gap in the outdoor recreation literature in regard to early stage trail impacts, this report will also serve to provide the Town of Blacksburg and other stakeholders a robust tool and dataset to guide future maintenance and trail development on Brush Mountain. The following chapters will provide protocols for the implementation and data collection processes for visitor use and trail impact monitoring as well as an examination of data collected during this initial study period (Fall, 2021 to Summer, 2022). In doing so, the groundwork will be laid for the continual monitoring of visitor use and trail impacts at McDonald Hollow moving forward.

## **Acknowledgements**

First and foremost, I would like to thank my partner Kayla Parrish for pushing me to shift career paths and move into a field that I am passionate about. Without her words of encouragement, long hours of talking through problems, help establishing transects, collecting data, and putting up with me in general, I would not be where I am today.

Second, I would like to thank my academic advisor Dr. Michael Sorice for taking a chance on me as a graduate student, being a constant source of encouragement and insight, and pushing me to craft the paper you are about to read.

Third I would like to thank the additional members of my committee, Dr Jeffery Marion and Dr. JP Gannon. Without their help, guidance, and expertise none of this would have come to fruition. In particular Jeff's help with the selection and establishment of transect at McDonald Hollow was a kickstart at the beginning of my work that helped see me to where I am now, and JP's technical advice when it came to sensor and data processing was a lifesaver.

Lastly but not least, I would like to thank Dean Crane and the Town of Blacksburg for allowing me to bother mountain bikers and hikers over the last 8 months. You have allowed me to conduct research on a trail that has become near and dear to my heart and I hope that as this project moves forward without me important information that will help the town develop more sustainable and accessible trails can be gleaned.

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## ----- 0.0 - Introduction -----

The McDonald Hollow Trail Network is a relatively recent addition to the catalog of outdoor recreation opportunities offered to those who called the New River Valley home. The newness of the McDonald Hollow Trail Network offers an interesting opportunity to explore early stage soil degradation and visitor use patterns, something that has yet to be done on newly constructed trails like those at McDonald Hollow. In addition to addressing a gap in the overarching outdoor recreation literature, study of McDonald Hollow presents the opportunity to collect vital information and observations that can serve to guide future trail sustainable development, management, and visitor use opportunities. Although the scale of this paper will only address current trends at McDonald Hollow, that being between October of 2021 and June of 2022, the project for which the groundwork has been laid will serve to guide continued monitoring into the future.

To that end, the purpose of this project, and by extension this paper, is to begin to paint a picture of those actively using the McDonald Hollow Trail Network as well as the impacts caused by the elements and usage on the trail bed itself. To do so, two monitoring protocols were developed. The first of which was developed in order to gauge the social aspects of trail use among visitors to McDonald Hollow (which will be covered in Ch. 1). This protocol primarily drew from “Studies of Outdoor Recreation: Search and Research for Satisfaction” by Robert E. Manning to serve as the foundation for the development of a robust visitor use survey (Manning, 2010). This survey seeks to gauge usage patterns, activity engagement, satisfaction, motivation, recreational conflict, and substitutability among other indicators. The second of these protocols were developed in conjunction with Dr. Jeffery Marion and drew from his previous fieldwork outlined in his report “Assessing the Condition and Sustainability of the Trail System at Tallgrass Prairie

National Preserve ” published in 2022 by Marion, Johanna Arredondo, and Fletcher Meadema.

Trail impact assessments and data collection will be outlined in detail in chapter 2. This protocol’s prime function is to instruct on the assessing, installation, maintenance, and data collection of transects along each trail at McDonald Hollow. In conjunction, these two protocols comprise robust resources that serve to inform stakeholders as to how the trails are being used and how usage is impacting the health and sustainability of the trails.

In isolation, these two protocols serve as how-to guides; however, the importance of this project in relation to understanding trail impacts and usage cannot be overstated. In particular, there are three distinct value propositions created through this project:

- 1. Long term data on visitor use and impacts at McDonald Hollow through periodic surveys and permanent transects establishment.**
- 2. Information for the Town of Blacksburg and other stakeholders**
- 3. Protocols and data acquisition that begin to address a gap in the current outdoor recreation literature**

As the initial report from a longitudinal study, this paper only seeks to establish a baseline. Such baselines are vital in providing guidance for future monitoring and research as well allowing longitudinal comparisons. In addition to the data collected, this initial project will provide premade surveys as well as permanent transects to future researchers, making future study easier and less time consuming. In the same vein, this project will provide important information on the physical impacts of recreation as well as how visitors are using the trails at McDonald Hollow.

Over time, this data will provide local government, decision makers, and other stakeholder groups information that can guide future development, policy, and maintenance efforts. Lastly, the opportunity to begin addressing a gap in the current outdoor recreation literature is important to the field as a whole. Long term monitoring through permanent transects supports longitudinal

studies of trail sustainability and soil degradation. This project will serve as a resource for future research on sustainable trail construction as well as recreation's impact on trail networks, specifically at McDonald Hollow, but potentially other similar trails and trail networks.

## **Chapter 1: Protocols for Monitoring Visitor Use at McDonald Hollow**

### **----- 1.0 - Introduction -----**

The following chapter outlines the methodology utilized for implementing a visitor use monitoring protocol on a mixed- use trail in Blacksburg, Virginia. Although this project focuses solely on the McDonald Hollow Trail Network, this protocol can be utilized to gauge visitor usage and motivations on any trail. The following subsections will address each step for engaging with visitors, monitoring visitor usage patterns, motivations, and other vital statistics like demographics. These procedures outline in detail the steps necessary for continual monitoring at McDonald Hollow which will allow for accurate and replicable assessments of visitor use into the future.

### **----- 1.1 - Survey Implementation -----**

#### **Overview**

The purpose of the first phase of survey implementation was to begin drawing insights into trail use and develop a sampling frame for a longer survey to be used in phase two. Phase one was implemented through face-to-face conversations with trail users at the trailhead as well as a series of signs located at both trailheads and at each trail junction. A more detailed account of tools used as part of active and passive contact methods will be outlined in subsequent subsections. The second phase survey was developed as a more detailed tool to gauge visitor usage, demographics, satisfaction, motivations, recreational conflict, and potential needs or wants from future development by the Town of Blacksburg along Brush Mountain. This longer form survey was only sent to those who opted in during Phase I. This serves not only to increase

the likelihood that these respondents will fully complete the survey, it also ensures that these respondents are active, or have been active, users of the McDonald Hollow Trails.

Implementation of the phase one survey took place between October 2021 and December 2021 with a total of 120 responses recorded over this period. Phase two took place between March 2022 and April 2022 with emails being sent to participants in mid-March 2022 and final reminders being sent in late-April 2022. At the conclusion of phase two, 64 users had responded to this survey.

Monitoring of trail users took place in two distinct steps:

- 1. Recruitment of Active Trail Users**
- 2. Survey Dissemination**

The survey and recruitment materials were submitted to Virginia Tech's HRPP and determined (IRB #22-123):

This activity does not meet the definition of research, as defined within the Federal Policy for the Protections of Human Subjects. The primary goal is to better understand visitor usage patterns and motivations at the McDonald Hollow Trail Network. The activity involves administering surveys to visitors to McDonald Hollow. This activity does not meet the federal definition of research, since the goal and activity focus on the usage of the McDonald Hollow Trail Network and will not be generalizable.

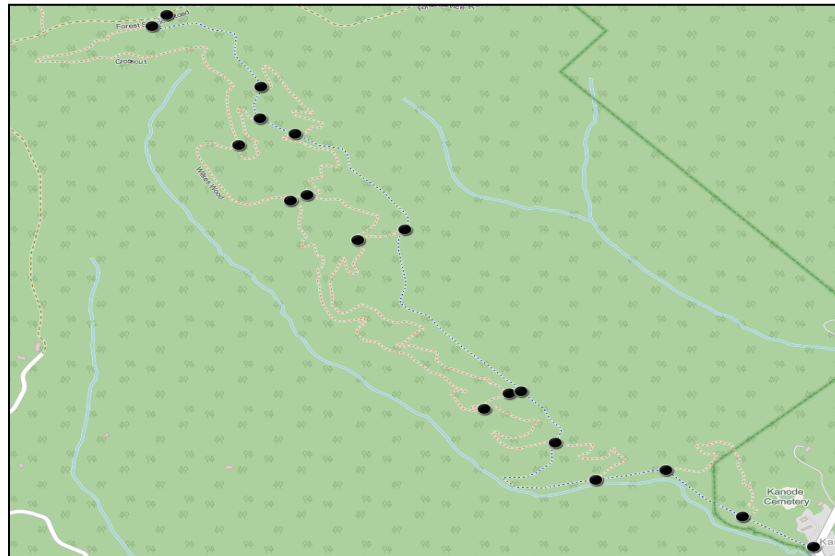
The following subsections will cover in more detail the steps taken to recruit, engage, and examine visitor use patterns at McDonald Hollow.

## Recruitment

Recruitment is a major tenant of any survey implementation and ensures that a survey is able to gather essential data from the group(s) in question. This survey utilizes a two phased approach. As part of phase one, passive and active means of contact were utilized. Active communication took the form of an intercept survey, a targeted form of research used to elicit responses from a particular group, in this case active trail users. This intercept survey was administered at the trailhead and looked to catalog what activity was being engaged, how frequently that user engaged in that particular activity, as well as contact information for the phase two survey. In addition to face-to-face intercepts, signage was placed at McDonald Hollow to elicit responses. This was done in order to allow visitors to McDonald Hollow to learn about and participate in the survey if a researcher was not present to administer the survey in person. This form of passive communication with trail users took the form of colorful signage that briefly explained the project. These signs asked trail users to scan a large QR code that would send those who scanned it to an online version of the intercept survey mentioned above. The image below represents the signage that was placed at each trailhead (top and bottom) and trail junction:



The following is a map of signage coverage at McDonald Hollow. These sites were chosen due to their high traffic and high likelihood that visitors would see one or more signs. Future rounds of surveys will use these sites.



**Figure 1.1:** *Map of all signage locations at McDonald Hollow*

Along with passive means of communication, phase one also utilized face-to-face contact to create more memorable and favorable interactions with potential respondents. It is important to make a good first impression when engaging face-to-face, an important aspect of this is to speak with visitors as if you would talk to a friend, keeping conversation casual and friendly. In order to ensure clear, accurate, and replicable interactions, the first step in face-to-face contact is to use a script. The following is a facsimile of the script that should be used during phase one intercepts, a complete script is available in *appendix i*:

**Interviewer:** *(Standing near the trailhead)*

**Trail User:** *(approaches with Mountain Bike)*

**Interviewer:** Hello! Good Afternoon, my name is [insert name], I am a graduate student at Virginia Tech. I'm out here today talking to trail users about their experience out here at the McDonald Hollow Trails. Do



you have a moment to answer a few questions for me, it should only take about a minute?

< If Trail User Says NO >

**Interviewer:** Thank you. I appreciate your time. Have a great rest of your day.

< If Trail User Says YES >

**Interviewer:** Great! First question, what are you doing on the trail today?

**Trail User:** ANSWER

**Interviewer:** Is that what you typically do on the trails?

**Trail User:** ANSWER

< If Trail User Says NO >

**Interviewer:** Okay, what do you typically do on the trails?

**Trail User:** ANSWER

< If Trail User Says YES >

**Interviewer:** Great Okay. Next question, on scale from 0 to 7, on a typical week how many days do you visit the McDonald Hollow Trails?

**Trail User:** ANSWER

**Interviewer:** Okay, last question. Would you be interested in participating in a future survey that I will be sending out later this year?

< If Trail User Says NO to future survey >

**Interviewer:** That's alright, I appreciate you answering my questions today and I hope you have a great rest of your day!

**Trail User:** You too! (*rides off on Mountain Bike*)

< If Trail User Says YES to future survey >

**Interviewer:** Great! I'll have to collect some contact information so we'll be able to reach you in the Spring. What is your full name?

Prior to heading to the trail, I reviewed the full script to ensure familiarity with the specific questions. The following are materials that I brought when visiting McDonald Hollow:

### ***Before Heading Out***

1. Full Script
2. A Notebook
3. Multiple Pens or Pencils

4. Masks and Hand Sanitizer (due to Covid)
5. Water / Snacks
6. Clothing with Virginia Tech's (or other organizations) logo to show your affiliation
7. A friend (to assist and help with safety concerns)

The following are steps that I took once I reached the trailhead:

1. Wear a mask for extra precaution (due to COVID)
2. Maintain social distance (6 to 10ft)
3. Do not stand at the trailhead (as to not hinder visitors from entering)
4. Seek a high traffic area to intercept potential respondents (i.e. parking lot)
5. Ensure personal safety, if something feels off do not approach
6. Approach visitors in a professional way, make them aware of your presence
7. Introduce yourself and be courteous and friendly throughout the interaction
8. Stress the importance of their help to your project and the brevity of the survey
9. Ask survey questions clearly and in order
10. Thank visitor for their time and participation (even if they refuse to participate)

Overall, the recruitment process, either through passive signage or through face-to-face contact, is undertaken to gather basic usage and contact information on active trail users . As outlined in *Appendix II*, basic usage patterns like activity engagement and frequency are collected, but more importantly this survey gathered contact information for phase two's longer form survey. It is important to collect accurate contact information to ensure ease of contact when phase two begins. Face-to-face contact presents a unique challenge especially when it comes to collecting emails (the prime form of communication for this survey). To counteract potential inaccuracies, double check contact information by repeating names, phone numbers, and email addresses back to the participant. In doing so, all those who wish to participate in future surveys will be allowed to participate.

## **Survey Dissemination**

Once phase one is concluded, the second step is to begin reaching out to the pool of active trail users who responded favorably to participating further. This should be done by collecting contact information, ideally emails, from the initial phase one survey. I used QuestionPro, an online survey software, because Virginia Tech had a license. QuestionPro allows filtering of responses for those who responded favorably, in doing so it will be far easier to compile contact information. Once compiled, premade contact emails should be sent to participants. These premade emails can be found in *Appendix III*. QuestionPro has features that allow for contacting an email list, monitoring how many participants have completed the phase two survey, and following up with those who have not completed the survey. These features make it far easier to contact participants and ensure all those who wish to complete the phase two survey do so. Contact emails should be sent out roughly each week to remind those participants who have not responded to do so. Specific intervals for email contact are listed in *appendix iii* as well. Once all contact emails have been sent and given an additional two weeks to participants to respond the survey will then be closed. Any responses received after two weeks after the last contact email was sent should not be included in any analysis.

### **----- 1.2: Additional Data Sources - Trail Counters -----**

In addition to face-to-face contact and passive forms of communication like QR codes there may be additional resources available to bolster a visitor-use analysis. In the case of McDonald Hollow this additional information comes in the form of trail counters. These trail counters, as of Summer 2022, are located along “The Highway” near the lower entrance of the Pine Forest trail and provide counts of visitors to the trail network, both pedestrian and mountain bikers.

Currently data is provided through the two sensors, one inside of a post along the trail's edge and another located underneath the trail bed roughly in line with the post. The first of these sensors collect counts of total trail usage through an optical style counter, and the second collects counts of mountain bikers through a magnetometer which detects metal as a bike passes. This data is important due its utility in comparing visitor usage over time as well as making inferences regarding visitor impacts on the trail. Detailed instructions on collecting trail sensor data can be read in *appendix iv*.

### ***Interpreting Sensor Data***

After completing the aforementioned steps TRAFx will provide a file containing both pedestrian and mountain bike counts. Taking each counter data file, labeling them to their corresponding user group, and separating them into individual files is necessary for analyzing each user group individually. In addition, it is important to note that counts collected from the pedestrian sensor will also count mountain bikers as they pass. In order to accurately represent user counts, running any collected data through the appropriate R-Script is essential. This will allow for basic observations of visitor usage patterns like time, day, and activity engaged (limited to hiking/running/walking and cycling). The code used for interpreting sensor data is detailed in *appendix v*. It is important to note that counts collected from these counters were divided by two and then the number of mountain bikers were subtracted from the total pedestrian numbers to get a count for hikers. Naturally there are limitations to these counts. Due to a lack of capacity at the beginning of the study period, sensors used were not validated. Moving forward, It is important to conduct an on-site validation of these sensors prior to continued monitoring to ensure more accurate counts of trail users. Not doing so may result in skewed results due to system errors.

Reasons for count errors may be numerous, but the most common are for the laser (infrared) and magnetic sensor used are:

- Two or more hikers walking side by side - ***undercount***
- Two or more mountain bikers riding side by side - ***undercount***
- Visitors walking back and forth in front of the sensor - ***overcount***
- The increased use of carbon fiber (or other non-magnetic) mountain bike components that would not trip the magnetometer - ***undercount***
- Utility vehicles, steel-toed boots, etc. that may trigger the magnetometer - ***overcount***
- Mountain bikers entering the trail from one end and leaving from the other, resulting in half-counts - ***undercount***

Future researchers will need to validate trail sensor counts by manually sitting and counting users as they pass by to ensure greater accuracy.

## **Chapter 2: Protocols for Monitoring Trail Impacts at McDonald Hollow**

### **----- 2.0 - Introduction -----**

The following chapter will outline procedures for the establishment, maintenance, and assessment of permanent trail transects along the newly constructed McDonald Hollow Trail Network located near Blacksburg, Virginia. These procedures are intended to describe in detail the steps necessary for continual monitoring at McDonald Hollow that will allow for accurate and replicable longitudinal assessments. Along with protocols for the establishment of these permanent transects, documentation of trail history, and measuring trail impact indicators like soil and vegetation loss are included to denote factors that are expected to influence trail conditions over time and identify attributes that are more sustainable (e.g. trail grade or trail alignment to landform grade).

For this project, two series of transects were established at McDonald Hollow. Each of which take the level of difficulty of the trail into account (Easiest, More Difficult, and Most Difficult) and then apply their respective transect placement types. The first set of transects were placed using a matrix that described trail grade (3 categories) and landform grade (3 categories). Each cell within that matrix was targeted with at least 5 transects (about 45 transects total) In addition, this method may utilize additional transects to purposefully assess trail conditions on or at unique trail features such as a banked turns, jumps, or landing areas. For the current study, this method resulted in a total of 63 transects being placed along three trails: Ida May, Wilkes Wood, and Blunderbuss. The second set of transects were placed using a systematically random sample approach, which utilized equally spaced transects along the remaining three trails. For this approach, a number was randomly chosen ranging from 0 to 10 and using that number crews

created transects every 0.1 miles (161m/528ft). This resulted in the establishment of 17 transects along Pine Forest, Turkey Trot, and Crosscut trails.

At each transect a series of measurements were taken periodically throughout the year. These included the trails maximum width, the trail's core width, trail substrate composition, depth of tread, and other characteristics. Data was collected on-site through the use of paper forms or digitally through a Google Form. Following the collection of data, analyses were done to characterize trail conditions and soil differences between the initial and final collection periods (Fall 2021 and Summer 2022).

## **----- 2.1 - List of Materials - Check Before Heading Into The Field -----**

### ***Standard Operating & Documentation Equipment***

- [ ] - A day pack with extra clothing, rain gear, snacks, water, hat, sunscreen, wallet, etc.
- [ ] - Maps (Paper and/or Digital)
- [ ] - A Cell Phone with fully charged battery
- [ ] - The Avenza App Downloaded with the transect map available for offline use
- [ ] - This Manual (either printed on waterproof paper or digitally)
- [ ] - Field Measurement Forms ( Backup in case digital form is unavailable)
- [ ] - A Clip Board
- [ ] - (2) Pen or Pencil
- [ ] - A Small Notebook
- [ ] - Handheld or Full-Sized metal detector

### ***Transect Establishment & Monitoring Equipment***

- [ ] - 20ft + Kenson Fiberglass Tape Measure (marked in 10th of a foot increments)
- [ ] - (2) Locking Vice-Grip Pliers
- [ ] - A Folding Stick Ruler or Tape Measure
- [ ] - Compass / Clinometer Combo

- [ ] - Self Leveling Laser
- [ ] - A Small Tripod for the laser (if needed)
- [ ] - (X) 2 Pieces of 2ft rebar (number will vary depending upon number of transects)
- [ ] - (X) Brightly Colored Pin Flag (number will vary depending upon number of transects)
- [ ] - A Hammer or Mallet
- [ ] - A Box of rust-proof hex screws ( $\frac{1}{4} \times 2 \frac{2}{3}$  inches)
- [ ] - A Rechargeable Drill
- [ ] - 1 or 2 Extra Drill Batteries
- [ ] - A Star Drill Bit
- [ ] - A Can of Bright Orange Spray Paint
- [ ] - Handheld Metal Detector (for finding rebar on return trips)
- [ ] - D10 Dice or Random Number Generator
- [ ] - Measuring Wheel

## ----- 2.2 - Known History -----

The following section will outline the known history of the trails located at McDonald Hollow.

This history has been compiled from a meeting with representatives from the Poverty Creek Trails Coalition, The New River Land Trust, as well as the Town of Blacksburg held on location on October 20th, 2021. This meeting primarily addressed methods for trail construction, maintenance, and usage.

- Pine Forest:
  - Primarily constructed by hand and used heavily by hikers and dog walkers
- Ida May:
  - Primarily constructed using machines, but small portions were constructed by hand. Mechanical plate compactors were also used on the tread to achieve between 2700 and 3000 lb/ft<sup>2</sup> of compaction.
- Wilkes Woods:
  - Machine construction with black slopes being hand built
- Turkey Trot:



- Machine construction
- Blunderbuss:
  - Machine constructed and compacted. Rocks located on the trail were within 30 feet of their current location.
- Crosscut:
  - All hand constructed and not compacted
- General Construction & Maintenance:
  - All soils are local and are mostly clay but some portions of trail have high silt contents
  - Large roots are removed from the trailbed
  - Rakes are used to clear large rocks from the trailbed 1 or 2 times a year, these rocks are raked to the down-hill side of the trail
  - Maintenance of all trails at McDonald Hollow is handled by the Poverty Creek Trails Coalition

For any further detail on trail construction or maintenance it is best to contact John Eustis ([nrlt@newriverlandtrust.org](mailto:nrlt@newriverlandtrust.org)) with the New River Land Trust or Michael Nelson ([Michael.Nelson.pe@gmail.com](mailto:Michael.Nelson.pe@gmail.com)) with the Poverty Creek Trails Coalition.

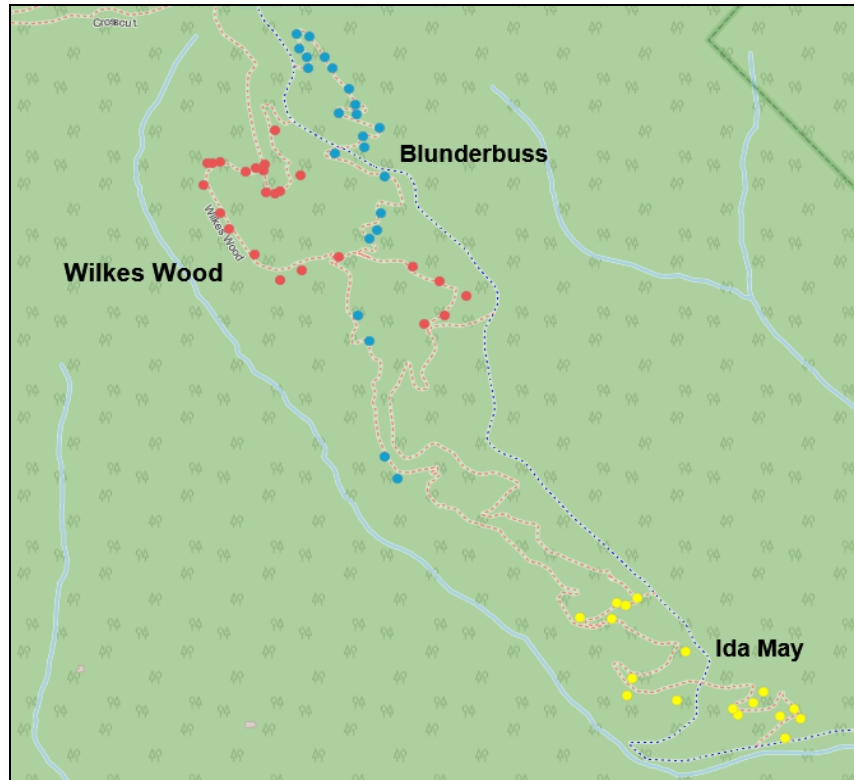
## ----- 2.3 - Point Sampling Procedure -----

### Matrix Transect - Location Selection

Transect locations using the matrix approach were selected purposefully with the target of obtaining 5 transects within each cell of a 3x3 matrix. This matrix utilizes Trail Grade (TG) and Landform Grade (LG) and is reflected in the image to the left of this paragraph. The y-axis reflecting TG and the x-axis reflecting LG. To fill each cell, crew members hiked the

|       |       |        |      |
|-------|-------|--------|------|
| 17+%  |       |        |      |
| 5-16% |       |        |      |
| 0-4%  |       |        |      |
|       | 0-19% | 20-30% | 32+% |

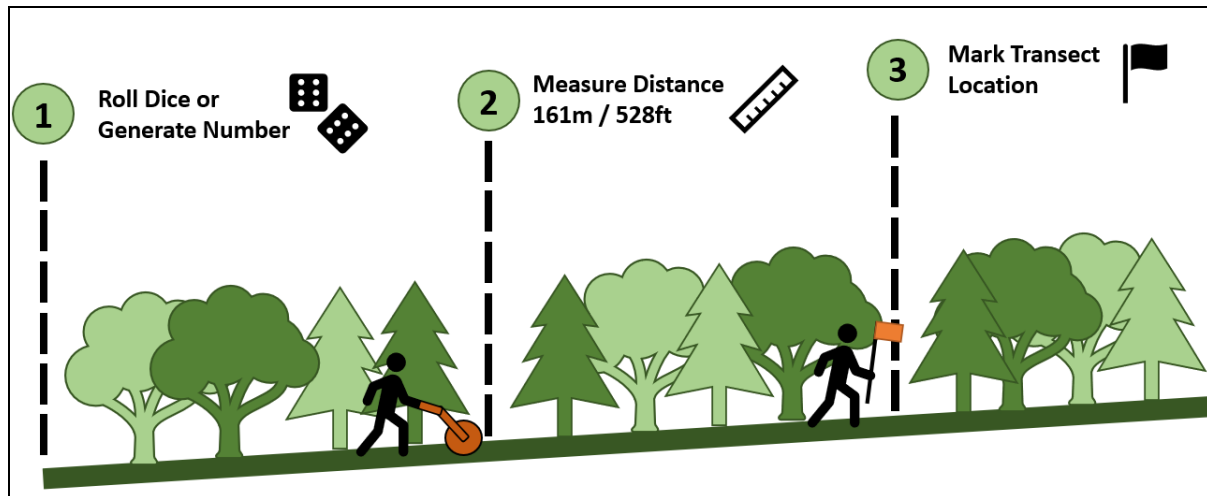
length of Ida May, Wilkes Wood, and Blunderbuss with TG and LG in mind (*Methods for determining TG and LG will be outlined in 2.6*). Once the crew reached a section of trail that looked as if it may fit within a desired cell, the crew should first find a healthy tree on the lower side of the trail, ideally 3 to 6 feet off-trail, to serve as an anchor point. If an adequate tree is found, the crew would then determine the locations TG and LG using a clinometer. If the site was found to fit within the cell, a note would be taken, that transects' number would be documented, and a numbered orange pin flag would be placed off trail to mark that transects location. Following this, the crew would continue hiking the length of the trail until all five cells were filled or they were satisfied with the distribution of transects. As noted above, this method also included a series of transects placed to assess trail conditions at unique features. Using the same method outlined above, crews would document and place a pin flag to denote these locations. In total, this approach resulted in 63 transects being placed along Ida May, Wilkes Wood and Blunderbuss trails.



*Figure 2.1: Map of matrix derived transect locations (Ida May, Wilkes Wood, Blunderbuss)*

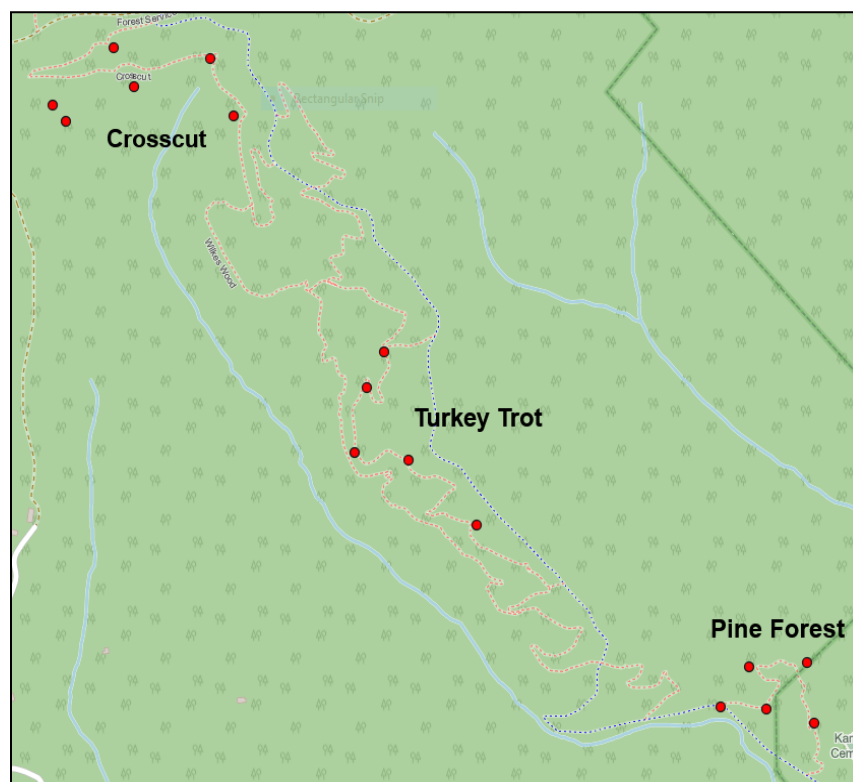
### **Systematically Random Transects - Location Selection**

Transect locations using the systematically random approach were selected using a combination of random chance and purposeful placement. As noted in the introduction, this set of transects were placed by choosing a number between 1 and 10 (using a random number generator or D10 dice), walking that distance onto the trail to place the first transect, and preceding to place transects at equal intervals of 0.1 miles (161m or 528ft) using a measuring wheel. I find it best to visually illustrate this style of location selection to remove any discrepancy.



*Figure 2.2: Method for establishing randomly systematic transects*

The following map illustrates where this method of placement was utilized at McDonald Hollow for a total of 17 transects along Pine Forest, Turkey Trot, and Crosscut trails:



*Figure 2.3: Map of Systematically Random derived transect locations (Pine Forest, Turkey Trot, Crosscut)*

## ----- 2.4 - Transect Establishment -----

As noted in the previous section, proposed transect locations using either method should be marked with a temporary numbered orange pin flag until each transect could be fully established with initial measurements and permanent rebar stakes. This will allow crew members to more easily find transect locations upon return to the site as well as denote the transect they are currently working on. It is also important to ensure that transects are established in an orderly manner. To ensure this, crew members should begin at one end of the trail and make their way towards the other. If crewmembers are unable to establish all transects along the trail, detailed notes on where the crew stopped should be taken. By doing this the likelihood of discrepancies or skipped transects are reduced. To ensure accurate placement and replicability, crewmembers should observe the following steps:

1. crewmembers should begin hiking the trail in question at either the top or bottom and travel in a single direction
2. Once crewmembers locate a orange pin flag they should take note of the flags' number and ensure it logically follows the expected number order
3. If that number is expected, then crewmembers should continue on with the remaining steps. If the number is NOT expected, then crewmembers should retrace their steps to determine where the skipped transect may be.
4. Once the site is confirmed, crewmembers should find a healthy tree off-trail on the downhill side roughly 3 to 6 feet and set that as an anchor point.
5. Once an anchor tree is established, crewmembers should place one piece of 2 feet rebar directly across from the anchor tree on the uphill side of the trail about 3 to 6 feet from the trail edge. All rebar should be hammered into the ground as straight as possible to a depth where only  $\frac{3}{4}$  of an inch is visible above the ground.
6. Once the rebar is secured in the ground, crew members should use a self-leveling laser, placed directly above the rebar, to shine a light across the trail and onto the tree.

7. A measurement from the top of the rebar to where the laser is emitted should be taken to ensure the transect will be as level as possible (for our case this was roughly 3 inches).
8. With the laser shining across the trail, a crewmember should mark where the vertical and horizontal planes meet and measure down the amount determined in step 7.
9. At this location a crew member will screw a star bit wood screw into the surface of the tree facing the rebar stake. It is important to ensure the top of the screw head is exactly level with the top of the rebar stake. Only  $\frac{3}{4}$  of an inch should be left protruding from the tree. Star bit screws reduce the slippage of unscrewing the screws every few years and are less likely to be vandalized by trail users.

Following these nine steps for establishing the transect, crew members should follow these remaining steps to ensure that future crews can easily relocate each transect:

1. Once the transect is established, crew members should take a GPS coordinate in the center of the transect on the trail. This can be done with a handheld GPS unit or a cell phone. This will aid in the creation of a georeferenced map that can be used for return trips.
2. Next, crew members should take up the number orange pin flag.
3. Finally, a crew member, using a can of bright orange spray paint, should mark the anchor tree on 3 sides, 2 facing up and down the trail and 1 facing towards the rebar stake. This gives a visual cue to future crewmembers to the location of a transect and the tree with the transect screw. **Note:** every 1-2 yrs the transect tree must be revisited to unscrew each screw so that about  $\frac{3}{4}$  of an inch is once again exposed, otherwise the tree will grow over the screws and study measurements will no longer be possible.

Once all steps are complete, the crew is then free to continue along the trail and repeat the process at the next orange pin flag they come across.

## ----- 2.5 - Methods for Accurate Recording -----

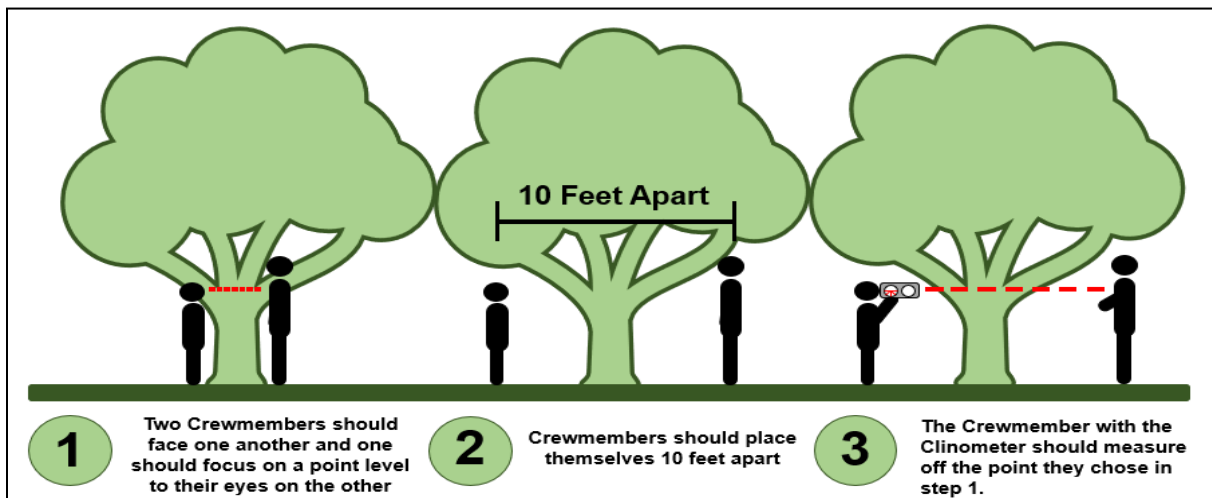
An important aspect of ensuring accurate measurements is to ensure accurate record keeping. To assure this, the following data should be recorded to avoid any discrepancies and ensure subsequent crews will have an easier time finding and monitoring transects.

- **Trail Name:** Record the Trail Segment Name
- **Transect Number:** Record the Transect Number
- **Surveyor(s):** Record the name(s) or initial(s) of those taking measurements
- **Data:** Record the data (mm/dd/yr) measurements are recorded
- **Comments:** Include any relevant observations of the transect in question or happenings surrounding your measurement.

In addition to these transect characteristics, it is also vitally important to ensure that measurements are undertaken methodically and with purpose. Therefore, it is highly recommended that measurements either be taken beginning at the bottom of the trail and proceeding to the top or beginning at the top and proceeding to the bottom. Trails should only be traversed in one direction to reduce the likelihood of skipping or double counting a specific transect. Referring to the transect locations using a georeferenced map (through Avenza) is likely necessary to ensure that all transects are found and recorded. An additional step that can be taken to ensure collected data is retained both physically and digitally is to both record field data on paper and input it digitally into a digital form like Google Forms. This ensures that there is both a physical and digital copy of your work and therefore the likelihood of losing that work is greatly diminished.

----- 2.6 - Inventory Indicators - *Record Only At Transect Establishment* -----

The following are important indicators that will need to be collected when the transect is established. Prior to collecting this data, it may be necessary to determine exactly where to point your clinometer. This can be rather tricky especially if crewmembers are of differing height; however the solution is rather simple. The following visualization explains the steps necessary for ensuring accurate readings.



*Figure 2.4: Method for Assessing Trail and Landform Grades*

**Upslope Trail Grade (TG):** Two crew members should position themselves *on the trail* at the transect and roughly 10 feet in an uphill direction. Using a Clinometer, one crew member should look at the spot they determined using the steps outlined above on a crew member opposite of them. Another crew member should then note and record the nearest degree using the left side of the scale. This should result in a positive number. However, if you find yourself at a local high point (everything within 10ft is at a lower elevation), then record a negative value.

**Landform Grade (LG):** Two crewmembers should position themselves above and below the trail about 20ft apart. If crewmembers find themselves atop any excavated soil or organic material they should move out until they are at original ground level. Crewmembers should align



themselves with the “fall” line, which is the alignment followed by water draining straight downhill. Follow the steps detailed above to determine the landform grade at the site in question.

**Permanent Transect Endpoint 1:** Crews should attach a fiberglass tape measure to the very top of rebar stake and stretch it tightly to tree screw and attach the tape with a pair of vice grips. Once attached, a measurement should be taken to the nearest centimeter to mark one end of the post construction tread. Normally this will be taken from the side of the trail closest to the rebar stake (the uphill side). The image to the left depicts how the tape should be properly affixed to the rebar stake.



**Permanent Transect Endpoint 2:** Crews should attach a fiberglass tape measure to the very top of rebar stake and stretch it tightly to tree screw and attach the tape with a pair of vice grips. Once attached, a measurement should be taken to the nearest centimeter to mark the other end of the post construction tread. Normally this will be taken from the side of the trail closest to the tree (the downhill side). The image to the left depicts how the tape should be affixed to the screw.



**Transect Distance:** With the fiberglass tape measurer still attached, crew members should ascertain the distance from the rebar stake to the tree screw. This is done to document tread distance but also ensure that if the stake is removed crews can re-establish a transect to ensure continual accurate measurements.

**Transect Bearing :** Crew members should take a compass bearing from the rebar stake to the tree anchor when a transect is established. This is also done to ensure that transects can be re-established if disrupted.

## ----- 2.7- Impact Indicators - *Record Every Time* -----

**Trail Tread Boundaries:** tread boundaries are defined as the most pronounced outer boundaries of visually obvious human disturbance created by trail use. These boundaries are typically defined by trampling related changes in ground vegetation cover or composition, or the pulverization/reduction of organic litter covering the ground surface in shady areas that do not support much vegetation cover. Two indicators are assessed, Core Tread Width and Maximum Tread Width. It can be helpful to examine the most recent monitoring data defining these boundaries to determine if there is a compelling reason to change them based on current conditions.

**Core Tread Width (CTW):** This indicator attempts to delineate the core width of the trail corridor *primarily* impacted by visitor usage. As a rule of thumb, this indicator seeks to incorporate roughly 90% of trail usage. In order to determine Core Tread, crew members should attempt to mark where they see the majority of trail impacts. This can be marked using pin flags,

tent stake, or simple rocks to delineate the corridor. Below is a figure that highlights how this indicators should be determined:

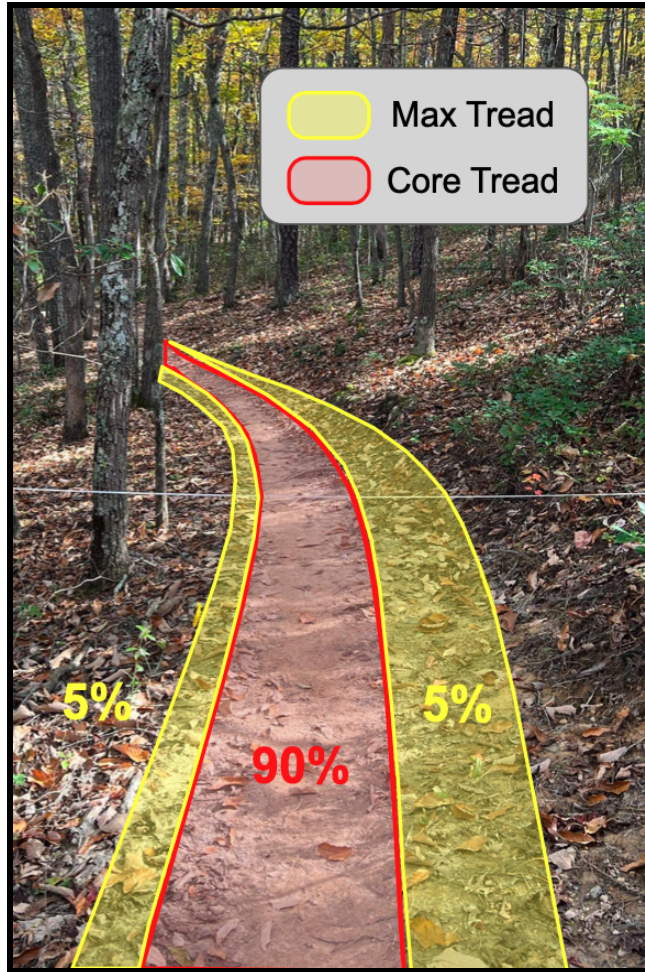
**CTW Endpoint 1:** CTW endpoint 1 should be collected in the same manner as the *Post Construction Tread Surface Endpoint 1*.

**CTW Endpoint 2:** CTW endpoint 2 should be collected in the same manner as the *Post Construction Tread Surface Endpoint 2*.

**Max Tread Width (MTW):** Max Tread Width is an indicator that attempts to delineate the entire width of the corridor that has any possibility of visitor use. As a rule of thumb, this indicator hopes to incorporate the remaining 10% for a total of 100% of trail usage. As with core tread, crew members should attempt to mark the outward bounds of where they believe visitor impacts may be taking place. Again this should be marked using pin flags, tent stakes, or other means of delineating the corridor. Below is a figure that highlights how this indicator should be determined:

**MTW Endpoint 1:** MTW endpoint 1 should be collected in the same manner as the *Post Construction Tread Surface Endpoint 1*.

**MTW Endpoint 2:** MTW endpoint 2 should be collected in the same manner as the *Post Construction Tread Surface Endpoint 2*.



*Figure 2.5: Visual Representation of Core and Max Tread Width*

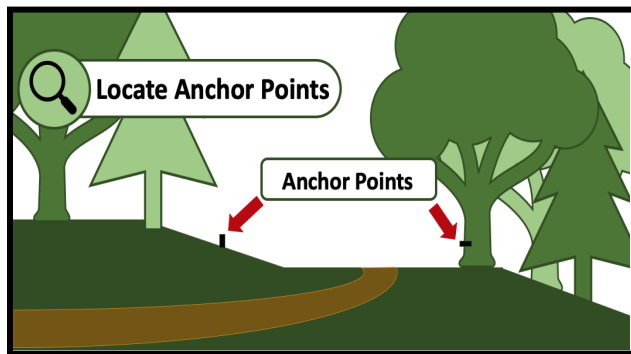
**Cross-Sectional Area (CSA):** The objective of the CSA indicator is to measure soil loss from the bottom of a taught fiberglass tape measure to the current tread surface. CSA should be measured using the following steps:

- Locate both anchor points. Anchor points will be located on both sides of the trail and consist of a piece of rebar protruding roughly  $\frac{3}{4}$  inch from the surface of the ground and a screw, also protruding roughly  $\frac{3}{4}$  inch from the surface of the tree. In the case of a tree-to-tree there will be two screws rather than a rebar anchor and a screw anchor.
- Attach one end of a fiberglass tape measure to the top of the piece of rebar. If one end has a clip, use that to securely attach the tape. If the transect in question is a tree-to-tree (a

transect from one tree to another), then secure the tape measure to the screw on the right hand side of the trail with a pair of vise-grip pliers.

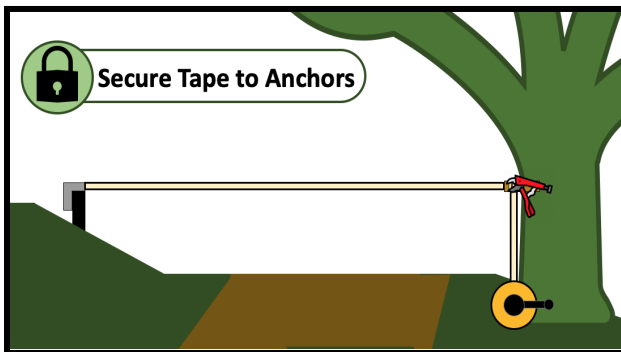
- Stretch fiberglass taught across the trail and attach to the tree anchor screw with a pair of vise-grip pliers.
- Once attached securely, a crew member should begin taking vertical measurements beginning at the stake and move their way across the trail.
- These vertical measurements should be taken using a stick ruler from the top of the fiberglass transect tape to the trail surface at equal intervals of 10cm.
- To ensure accuracy, one crew member should call out the measurement at each interval while another crew member should repeat the number, wait for verification, and then input the data onto a paper form or digital database.
- This process should continue across the trail until reaching MTW Endpoint 2 or a further distance if deemed necessary.
- 

The following is a visualization of this process:



### **Locate Anchor Points**

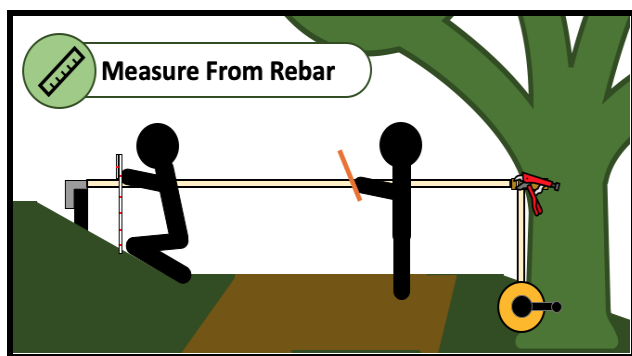
- Anchor points located on trees (screws) are typically located between 1 inch and 2 feet above the forest floor. Rebar stakes are located roughly 90 degrees parallel to the tree and protrude 1 to 2 inches.*



### **Secure Tape to Anchors**

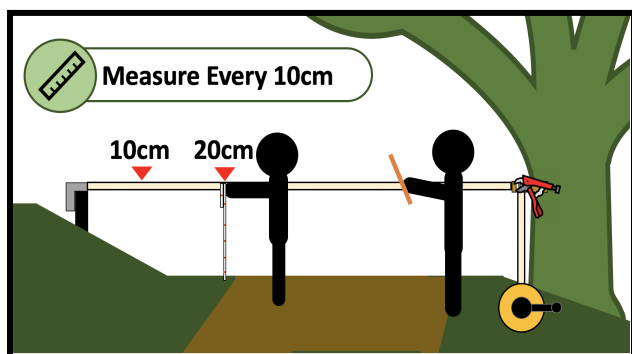
- On the rebar side, simply placing the metal latch over the top of the rebar. On the screw side, secure the tape by folding the tape around the screw and tightly clamping a vice grip to the screw*





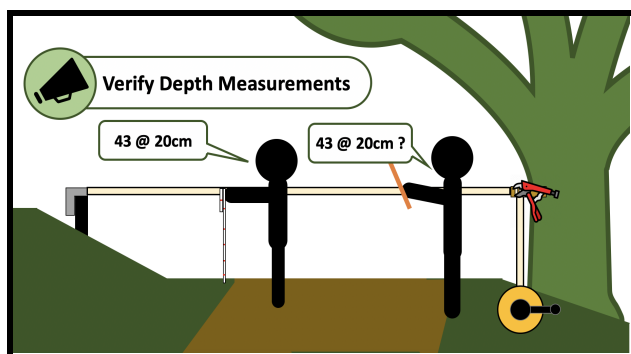
### **Begin Taking Measurements From Rebar**

- a. *Firmly press the stick ruler into the ground to ensure proper measurements. Measure to the closest half and whole centimeter.*



### **Measure Every 10 cm Across the Trailbed**

- a. *Measure each increment of 10 centimeters along the tape. These may be marked, but are also clearly delineated on the tape itself.*



### **Verify Depth Measurements**

- a. *Verify depth measurements at each increment of 10cm. This should be done by having the “Measurer” call the depth and distance out to the “Recorder”.*

**Tread Condition Characteristics:** In order to determine tread conditions characteristics, crewmembers should delineate a corridor around the transect. This corridor should include an area roughly 1 ft around the fiberglass tape measure and continue across the trail tread. This will be done for both Core Tread Width and Max Tread Width. To make estimation simpler it is best to estimate to the nearest 10%, or 5% if necessary. When conducting this assessment ***ensure your estimate equals 100%***. The following is a list of characteristics and their descriptions that will be used for this study:

|                      |                                                                                                                                                                                                                                                                                                   |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>S-Soil:</b>       | All soil types including sand and organic soils, excluding organic litter unless it is highly pulverized and occurs in a thin layer or smaller patches over bare soil.                                                                                                                            |
| <b>L-Litter:</b>     | Surface organic matter including intact or partially pulverized leaves, needles, or twigs that mostly or entirely cover the tread substrate.                                                                                                                                                      |
| <b>V-Vegetation:</b> | Live vegetative cover including herbs, grasses, mosses rooted within the tread boundaries. Ignore vegetation hanging in from the sides.                                                                                                                                                           |
| <b>R-Rock:</b>       | <u>Naturally-occurring</u> rock (bedrock, boulders, rocks, cobble, or natural gravel). If rock or native gravel is embedded in the tread soil, estimate the percentage of each and record separately.                                                                                             |
| <b>M-Mud:</b>        | Seasonal or permanently wet and muddy soils that show embedded foot or hoof prints from previous or current use (omit temporary mud created by a very recent rain). The objective is to include only transect segments that are frequently muddy enough to divert trail users around the problem. |
| <b>G-Gravel:</b>     | <u>Human-placed</u> (imported) gravel on trail or road.                                                                                                                                                                                                                                           |
| <b>RT-Roots:</b>     | Exposed tree or shrub roots.                                                                                                                                                                                                                                                                      |
| <b>W-Water:</b>      | Portions of mud-holes with water, or water from seeps or creeks.                                                                                                                                                                                                                                  |
| <b>WO-Wood:</b>      | <u>Human-placed</u> wood (water bars, bog bridging, decking).                                                                                                                                                                                                                                     |
| <b>O-Other:</b>      | Specify: e.g. paved road or sidewalk.                                                                                                                                                                                                                                                             |

**Transect Photos:** At each transect it is important to document location and trail conditions at the time of transect placement and measurement. For our purposes there should be three photos taken at each transect location each time the site is visited. Those photos should include: a trail conditions photo, a perpendicular photo, and a photo that captures the entire transect. Examine previous transect photos and make an effort to frame your photo to exactly match the original photos.

- **Trail Conditions Photo:** Move your phone, or camera, along the trail until you are able to capture the entirety of the Max Tread Width. This photo will ensure that trail characteristics are captured digitally as well.
- **Perpendicular Transect Photo:** Place your camera above the rebar stake and shoot down the transect tape, make sure to capture the entire length of the trail from rebar stake to tree anchor.
- **Entire Transect Photo:** Move back a good distance from the transect to ensure that the entirety of the transect can be captured in the photo. This will allow for easier identification in the future.

The following are examples of the types of photos that will be required:



*Figure 2.6: Depicts the Entire Length of the Transect*





*Figure 2.7: Depicts a close up of the tread surface, also reflects Max-Tread Width*



*Figure 2.8: Depict a Perpendicular Photo taken down the length of the tape*

## **Chapter 3: Visitor Use Data Analysis**

### **----- 3.0 - Introduction -----**

As an early life trail, the McDonald Hollow Trail Network presents a prime opportunity to gauge the physical impacts caused by repeated visitor use; however, an equally important aspect that must be considered in the same breath are the social impacts McDonald Hollow offers at this stage in its life. In order to gauge these impacts it is important to develop and implement a visitor use monitoring program to capture important indicators that address the who, what, when, where, and why of how the trail is being used. In doing so, land managers, government agencies, and friend groups are provided with information pertaining to trail users, their motivations, and level of satisfaction for example. With this information in hand stakeholders can begin to work towards ensuring a collective desired condition, that being the sustainable enjoyment of the trails. This is important, especially in the case of McDonald Hollow, because it allows for alterations to the trail to be made, increased or decreased catering towards a particular user group, and new opportunities for outdoor recreation to be offered to the public. Beyond the ability to inform future development, information gleaned from visitor use monitoring is integral for painting a picture of those using the trail, those who are not using the trail, and why users may or may not return in the future.

This chapter will address the data collected from the implementation of a visitor use monitoring program between the Fall of 2021 and the Spring of 2022. The objective here is to provide baseline data characterizing visitor use and perspectives. The following subsections will cover a series of vital statistics collected from the phase two survey and trail counters described in the previous chapter. These findings represent a first look at those using the McDonald Hollow Trail Network. However, visitor use will continue to be monitored into the future. Through this

continual analysis, long term trends among active trail users are likely to reveal themselves. Given the construction of additional properties along Brush Mountain, collecting visitor use patterns will become increasingly important as new opportunities come online in the near future. Of particular interest to this visitor use monitoring program are trail usage patterns, demographic characteristics of trail users, activity engagement, usage motivations, satisfaction levels, impressions of the trails, and current wants from active trail users, each of which will be addressed in following subsections.

### **Explanation of Indicators -----**

Initially it is also important to understand the set of indicators this study is interested in analyzing. As noted above, trail usage patterns are simply the ways in which active users are using the trail. In a basic sense, this subsection will look to determine when users are visiting the trail, how many users are visiting the trail on average, and how long users are staying at the trail. This is vital in determining the ebbs and flow of how users are engaging with the site and how that may change into the future.

The next subsection looks to understand who is visiting McDonald Hollow. The first of which, location, seeks to examine where active users reside, the second, age, looks to determine the strata of ages among users, the third, gender, seeks to examine the gender identity of active trail users, and the fourth looks to examine the racial breakdown of trail users. In combination these indicators can begin to paint a picture of those actively using McDonald Hollow.

The next subsection, “activity metrics”, looks to examine the activity engaged in by survey respondents. In particular this subsection looks at the activity engaged among active users and the frequency to which they participated in this activity at McDonald Hollow. This indicator is

vital in understanding what users are doing at McDonald Hollow and allows agencies and trail management to cater experiences to specific user groups if they so choose.

The next subsection, motivations, seeks to determine why users are visiting McDonald Hollow. This too is important in the fact that it allows for researchers, agencies, and land managers to begin to understand the pull factors, both physically, cognitively, and spiritually, of a particular site in terms of outdoor recreation. This subsection particularly focuses on the importance of the activity engaged by the trail users to their decision calculus in visiting McDonald Hollow. This is further broken down by trail user groups to parse out differences.

The next subsection, satisfaction, is examined due to its importance in regard to user enjoyment and their likelihood of return to trail network. Satisfaction can be defined simply as a user's ability to achieve either end goal, which is to engage in a particular activity or set of activities. Of particular interest were users' satisfaction level, but also experiences, interactions, or amenities that negatively or positively impacted satisfaction. These too were broken down by user group (in the case of overall satisfaction), and again among negative and positive impacts on satisfaction. In this way interference can begin to be made in regard to what users hope to see changed, improved, or remedied at McDonald Hollow.

The penultimate subsection, user impressions, seeks to examine substitutability. Substitutability is the ability for one experience to be replaced with another, therefore if a site has high substitutability that site is likely run-of-the-mill or unremarkable, and a site with low substitutability is likely unique or novel. This is an important statistic among active trail users, especially given McDonald Hollows young age, since it has the potential to measure how McDonald Hollow stacks up in comparison to other trails as well as how “hot” or “cold” particular user groups are toward the trail network. In particular, this subsection sought to gauge

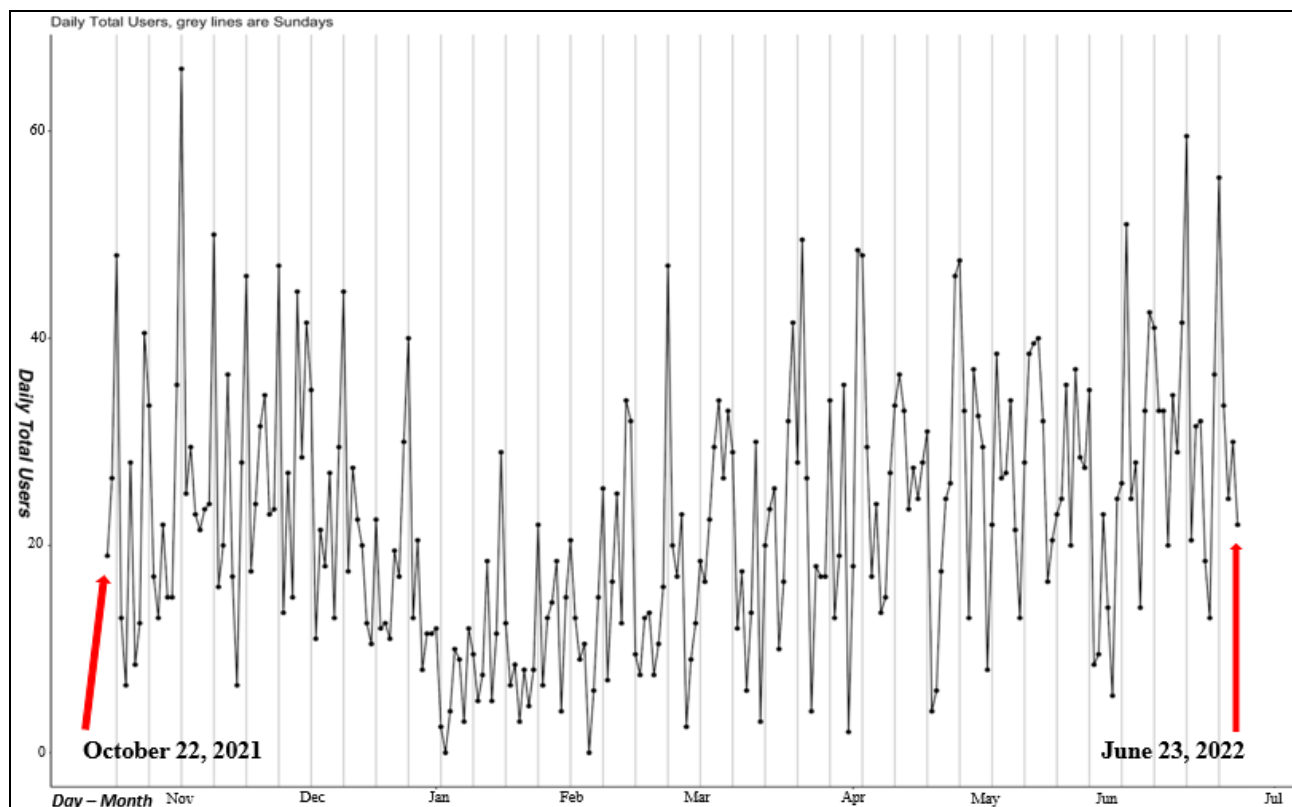
substitutability through overall perceptions of the trails as well as how McDonald Hollow compared to other mountain biking and hiking trails within the New River Valley and Mid-Atlantic region.

The final subsection looks to examine what trail users hope to see from future development at McDonald Hollow. Although simple in nature, this question gives insight into what active users want from the Town of Blacksburg in regard to amenities, maintenance, and experiences at McDonald Hollow and other properties on Brush Mountain, current and future.

### ***All Survey Questions and Responses located in Appendix VI***

#### **----- 3.1 - Trail Usage Patterns -----**

Trail usage patterns were collected through two sensors located near the trailhead at McDonald Hollow. As mentioned in chapter 1, data collected using these sensors may have a level of error due to the sensor not being validated prior to this project's start. Although no large errors were found within the data, it is important that before future research is conducted validation of both sensors is needed. In addition to these sensors, specific questions pertaining to usage were asked of active users in the phase two survey. Both sets of data will be addressed in this subsection. As part of this initial study, data collected between late October 2021 and late June 2022 were utilized to create visualizations of usage patterns of the two most prominent trail user groups, those being pedestrians (hikers and walkers) and mountain bikers. In order to begin to understand how these groups engaged with the trail, it was necessary to investigate overall patterns of usage. Of particular interest is total usage over the course of the study period.



**Figure 3.1. Total Trail Usage Pattern Over Initial Study Period**

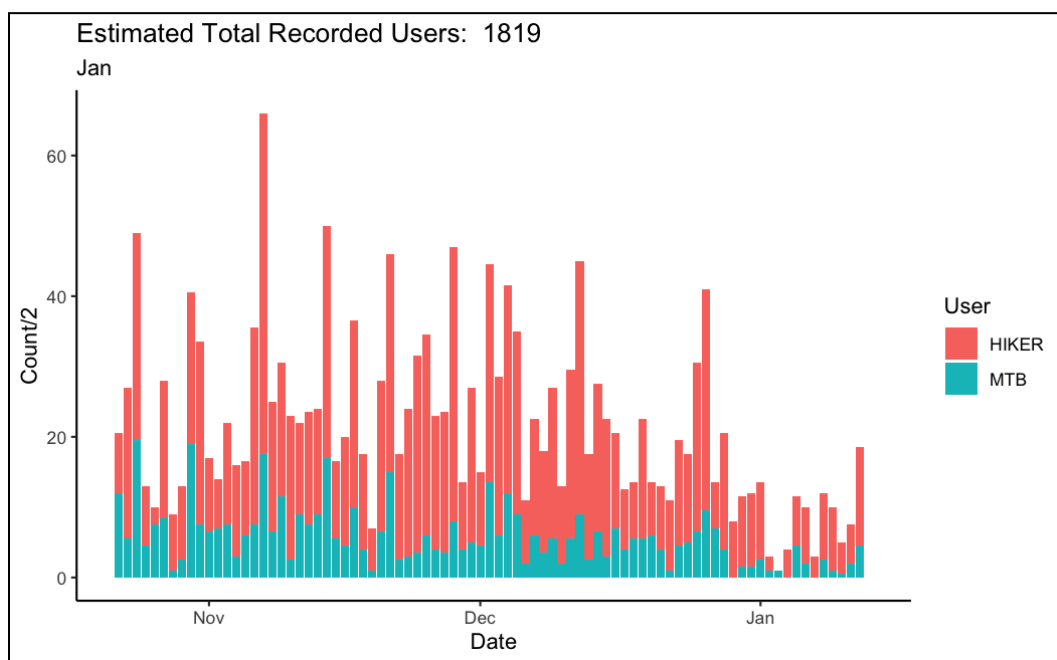
In brief, trail usage totals tend to ebb and flow throughout the period studied. Due to the time period studied, this initial report was not able to capture the entirety of a year; however the trends present in the data allow for insights to be made. In general, it can be surmised that trail usage tends to be higher during the fall, with usage falling off in winter, and usage increasing through the spring and into the summer months. In total, the data collected over this period of time estimates a total of roughly 5,500 users from late October to late June. Following the current trend, it is likely that total usage for the year will reach in excess of 7,000.

Beyond overall perceptions of trail usage, breaking down trail use by activity type is important in determining how the trails are being used. The following bar charts highlight trends in both mountain biking and pedestrian trail usage. Due to a sensor error in mid-January there is a



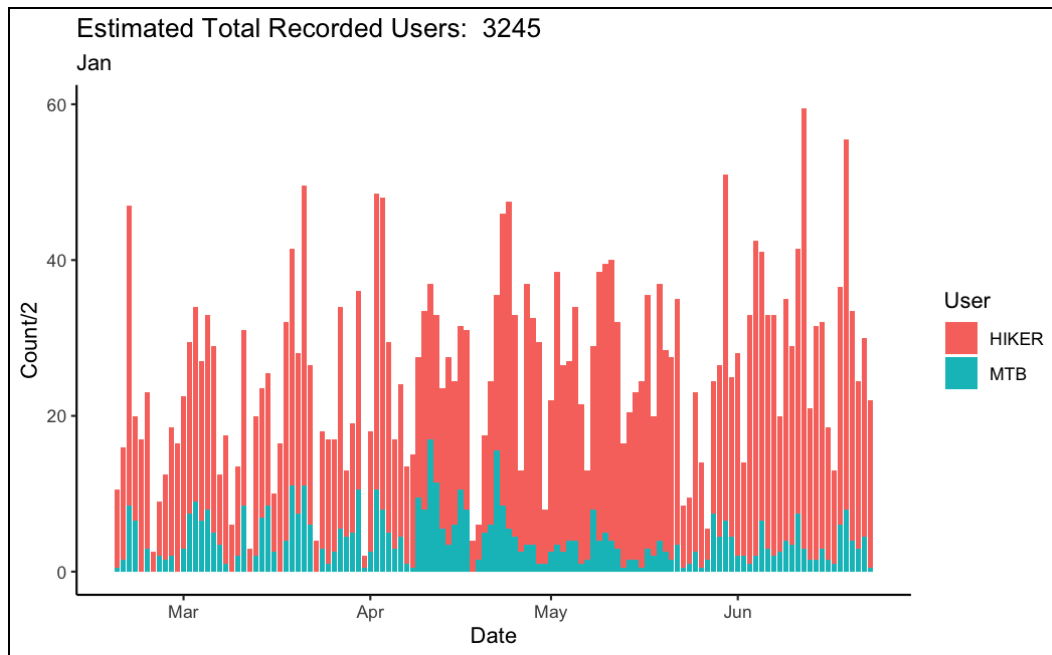
sizable gap in the data; however, due to a series of winter storms and low usage reflected in the overall usage graph, this

lost data is not detrimental in determining usage patterns. In order to remedy this missing data, patterns will be addressed in two distinct chunks. Those two pieces consisting of data collected between October 22, 2021 and January 13, 2022 and February 18, 2022 to June 23, 2022. The first of which will be referred to as “Fall / Early Winter” data and the former will be referred to as “Mid-Winter to Early Summer” data.



***Figure 3.2. Daily Hiker and Mountain Biker Counts Between October 22, 2021 and January 13, 2022***

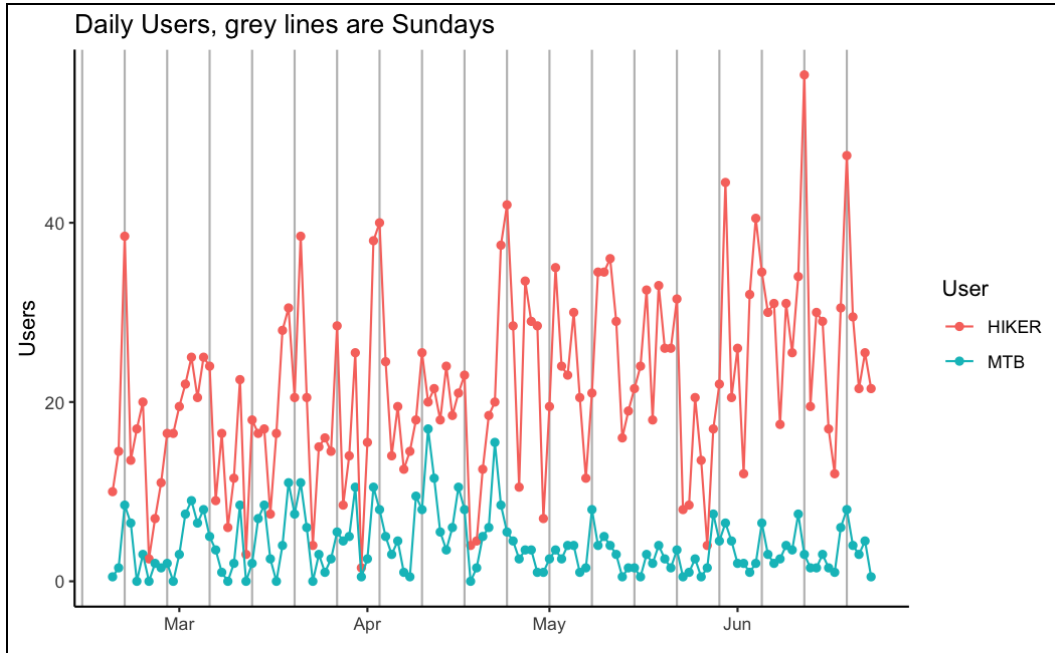
Examining the “Fall/Early Winter” data above, it appears that mountain bikers and hikers share very similar trends of usage; however, hikers appear to outnumber mountain bikers between 2 and 5:1.



***Figure 3.3. Daily Hiker and Mountain Biker Counts Between February 13, 2022 and June 23, 2022***

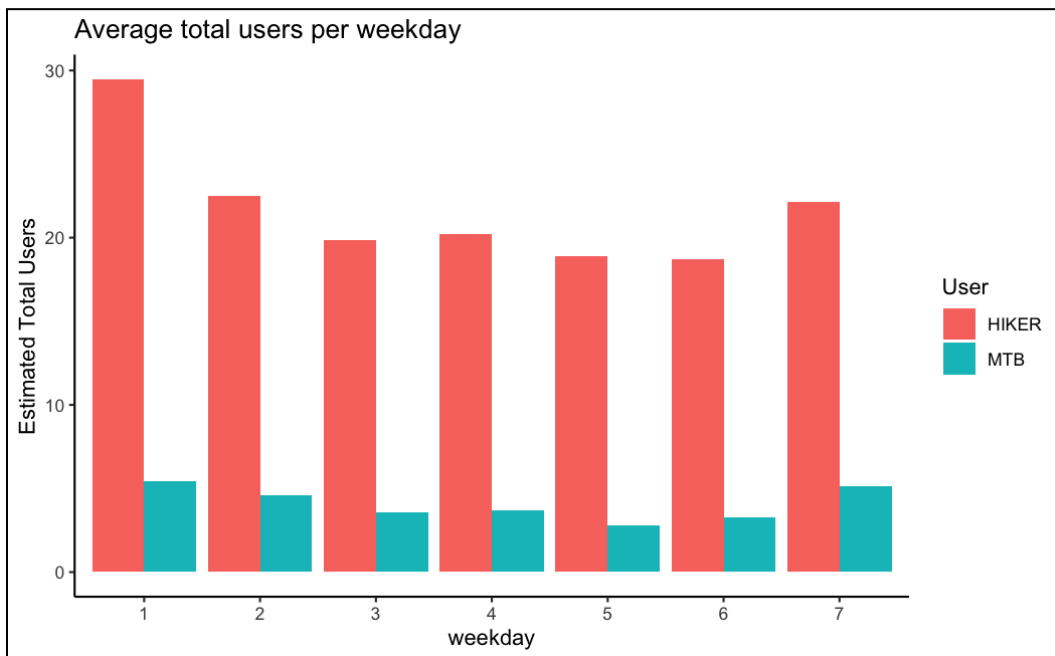
This pattern seems to remain consistent into the early stages of the “Mid-Winter to Early Summer” data; however, as time moves closer to late spring and early summer a sizable gap between mountain bikers and hikers becomes apparent. At this point, hikers outnumber mountain bikers at a rate of roughly 5:1. This indicates that although McDonald Hollow is advertised as a location for Mountain Biking in the NRV, by a large margin hikers (and other pedestrians) are much in a way the largest user group of the trails.





**Figure 3.4. Number of Hikers and Mountain Bikers Over Study Period**

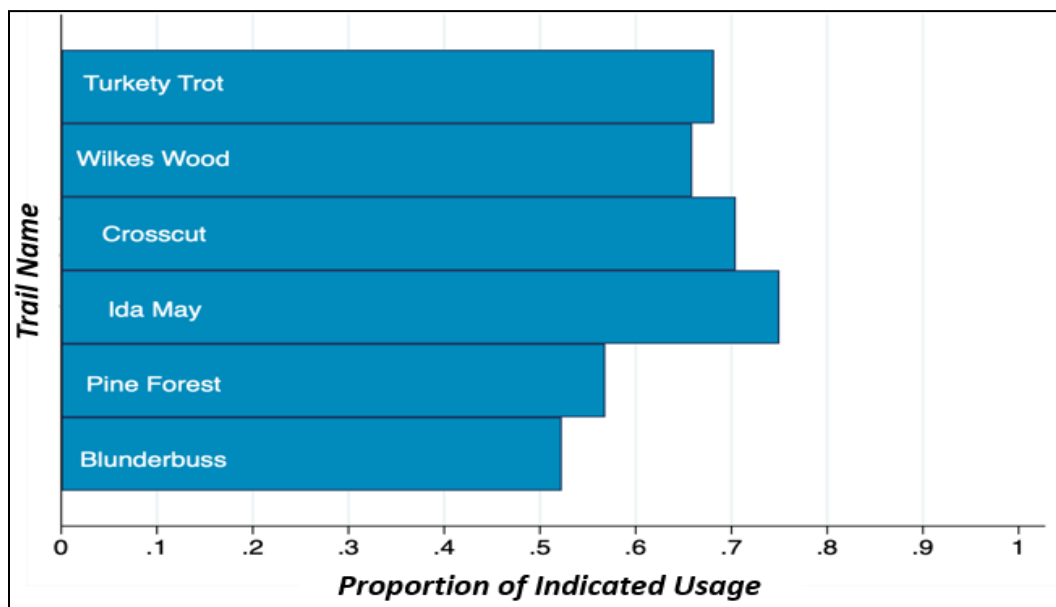
Another important aspect of usage beyond the overall trends, are exactly when users are visiting the trail during the week. This is important not only for basic knowledge of trail usage but also for determining the least impactful time to engage in trail maintenance or research.



**Figure 3.5. Average Daily Count of Hikers and Mountain Bikers. 1 = Monday and 7 = Sunday**

Overall it appears that trail users tend to visit McDonald Hollow at a fairly even rate, with all days of the week reporting between 20 and 30 users on average for hikers and between 3 and 5 mountain bikers on average. Of particular interest is that among both user groups days with highest usage are the same, Monday and Sunday. However, the same cannot be said for the days with the lowest usage, that being Friday and Saturday among hikers and Friday for mountain bikers. This indicates that hikers and mountain bikers tend to follow similar trends but not identical one.

In addition to sensor data, trail users were asked to indicate which trail they typically use while visiting McDonald Hollow. Naturally, these responses were mutually exclusive with those polled being able to select all that applied. In this way, indications of trail popularity as well as general use can begin to be ascertained.

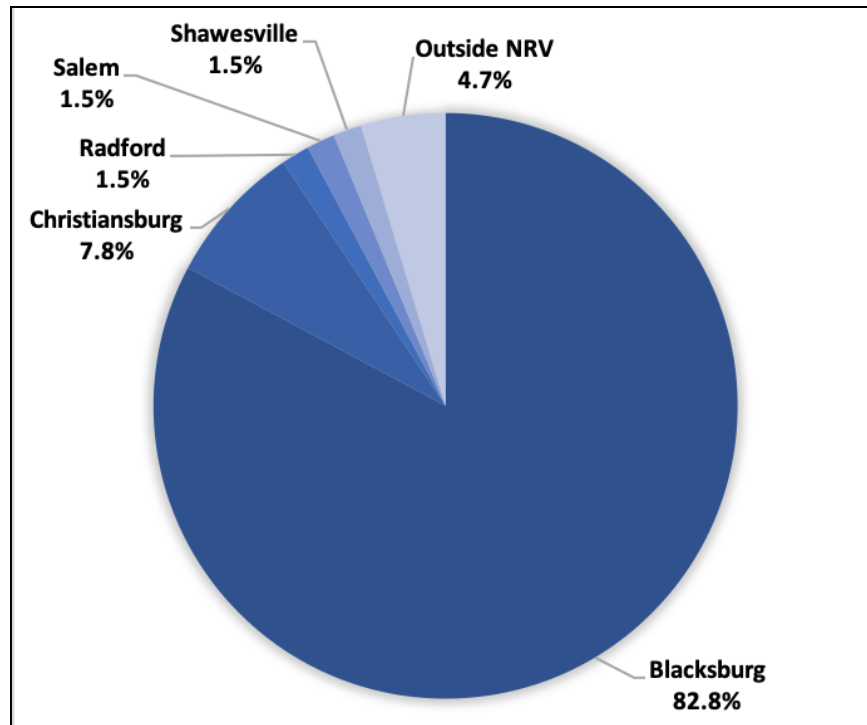


*Figure 3.6. Proportion of Indicated Trail Usage Among Survey Respondents*

Based on responses from those polled it appears that among the trails at McDonald Hollow the clear favorite is Ida May with roughly 75% of visitors indicating they typically use this trail on visits. A close second is Crosscut with roughly 71%, third is Turkey Trot with roughly 68%, Wilkes Wood with 65%, Pine Forest with 56%, and finally Blunderbuss with 52%.

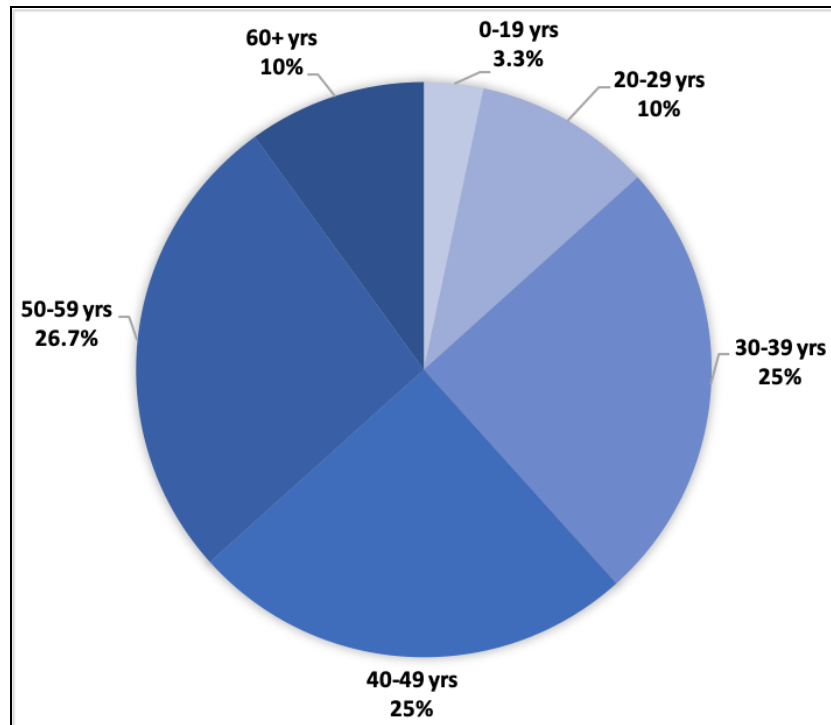
### ----- 3.2 - Demographics -----

Beyond usage patterns and total visitor numbers, it is also important to understand the demographic of those actively using the trails at this early stage. Of particular interest are location, age, gender, and race. Understanding these characteristics are important in understanding who is actively using the trail system, but is also important in determining who is not using the trails. In regard to location of active trail users, the vast majority of users are located within the New River Valley. Of the 64 respondents who indicated where they reside, 61 reported residing in the NRV with 53 (82.8%) coming from ZIP codes corresponding to Blacksburg, Virginia, 5 (3.2%) from Christiansburg, Virginia, and 1 (0.6%) from Radford, Shawesville, and Salem, Virginia respectively. The remaining 3 (1.9%) respondents indicated coming from ZIP codes corresponding to York County, South Carolina (1), Denver, North Carolina (1) and New Haven, Connecticut (1). This indicates a hyper local user population for this trail system with very little reach outside its immediate vicinity.



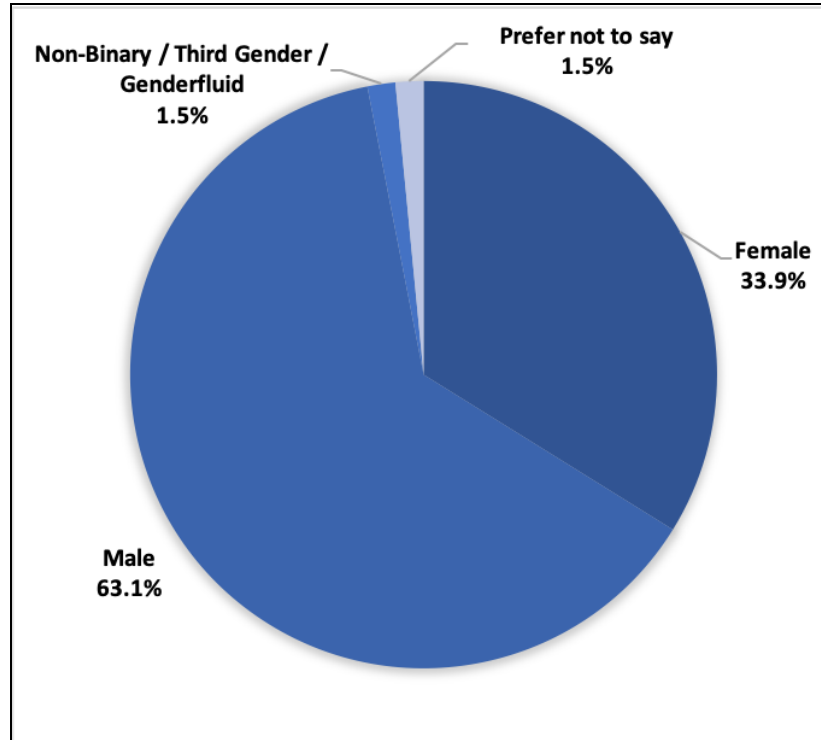
*Figure 3.7. Distribution of Active Trail Users By Location*

Age is also an important metric when looking at those who are actively using the trails at McDonald Hollow. This factor can be beneficial outreach to particular age demographics, marketing, or simply examining who are using the trails. According to those surveyed, the vast majority of trail users are between the ages of 30 and 59 with 67.65% of users falling between these ages. Outside this majority roughly 5.8% of active users fall under 20 (18 and 19 yrs), 7.4% fall between the ages of 20 and 29, and 8.8% of users are 60 years of age and older. This indicates a heavy presence of younger to middle aged adults utilizing the trails, with far less use from younger adults, teenagers, or retired individuals.



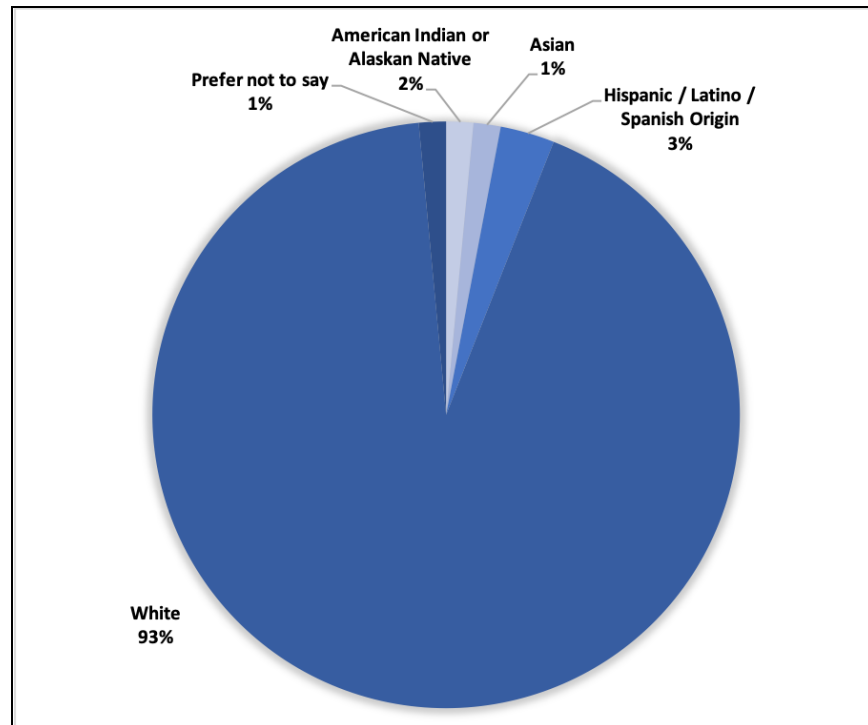
*Figure 3.8. Age Distribution Among Active Trail Users Polled*

Gender identification is also helpful in understanding who is actively using the trail network. Of those polled, roughly 63.1% reported identifying as male, 33.9% identified as female, 1.5% identified as non-binary/ third gendered/ or genderfluid, and 1.5% preferred not to identify. This indicated a sizable portion of those who responded identifying themselves as male, nearly a 2:1 ratio of males to females.



*Figure 3.9. Gender Identification Among Active Trail Users Polled*

A final indicator to touch on is the race of those using the McDonald Hollow Trail Network. This is an important indicator of equitable use among residents of the surrounding community. When asked what race the trail user best identified with, those who responded overwhelmingly identified with “White”. This group comprised 92.5% of all respondents. Of the other potential responses, those who identified as “Hispanic / Latino / Spanish Origin” comprised the second largest percentage at roughly 3%, with “Asian”, “American Indian or Alaskan Native”, and “Prefer not to say” all receiving 1.5% percent of all responses. With this in mind, it is important to note that neither “Black or African American” or “Native Hawaiian or Other Pacific Islander” received any responses. This indicates the vast majority of trail users are likely to identify as “white”, meaning that currently McDonald Hollow is not being utilized to the same extent by people of color.

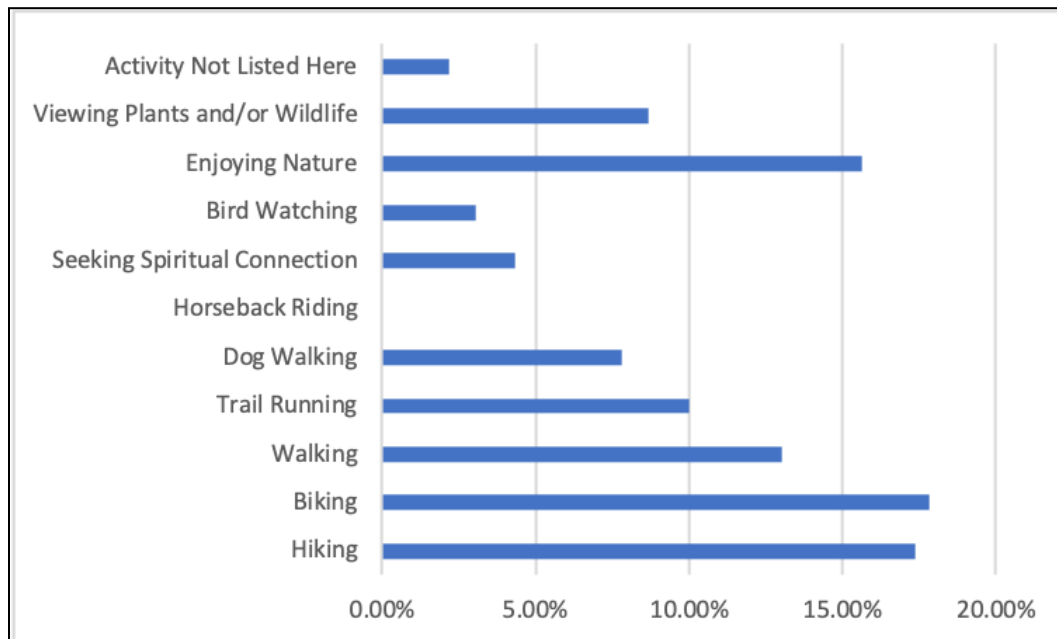


*Figure 3.10. Race Identification Among Active Trail Users Polled*

### ----- 3.3 - Activity Metrics -----

An important data set for understanding how visitors are interacting with the trails are the activities that visitors are engaging in while at McDonald Hollow. According to those polled, the largest user group were mountain bikers with 17.8% of users reporting to engage in “biking” at McDonald Hollow over the past 12 months. The second largest user group were hikers, comprising 17.4% of users polled, with the third largest groups being those “Enjoying Nature” with 15.6%. The remaining groups were as follows: Walking (13%), Trail Running (10%), Viewing Plants and/or Wildlife (8.7%), Dog Walking (7.8%), Seeking Spiritual Connection (4.4%), Bird Watching (3%), and Activity Not Listed (2.2%). It is also important to note that from the responses collected in this initial survey, there were no respondents who selected that they engaged in horseback riding at McDonald Hollow, this was the only activity to receive no responses. Although responses to this question were not mutually exclusive, the survey allowed

respondents to check all that applied, this first round of data highlights that by and large the McDonald Hollow Trail Network is used for Mountain Biking, Hiking, and Enjoying Nature.



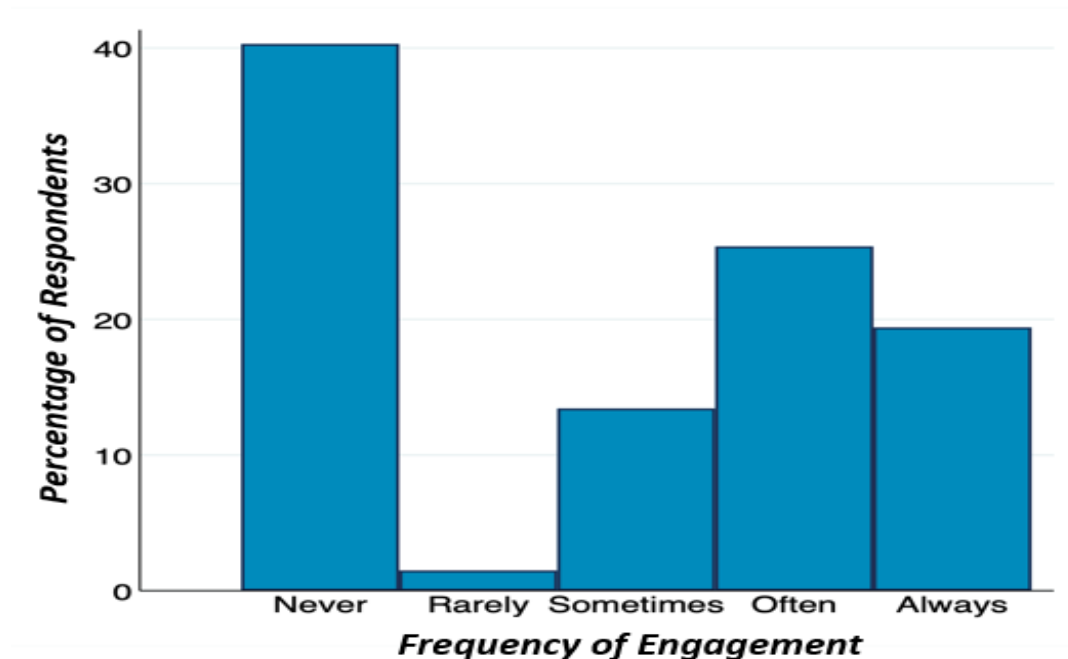
*Figure 3.11. Percentage of Respondents Polled Who Engaged in X Activity in The Previous 12 Months*

As important as what activities are being engaged in at McDonald Hollow is how frequently users are engaging in those activities. To determine this, the question of “how often do you engage in X activity” was asked of respondents. As with the previous indicator, survey respondents' answers were not mutually exclusive with some respondents indicating their frequency to various activities.

To parse out in more detail, the three largest user groups (Mountain Bikers, Hikers, and Nature Enjoyers) will be analyzed in greater detail. The remaining user group’s engagement frequency can be found in **appendix vii**. According to those who indicated they engaged in Mountain Biking (40), the largest portion of respondents, 42.50%, indicated that they visited McDonald Hollow “Most of the time” to engage in Mountain Biking. The second highest were those who indicated they “Always” visited McDonald Hollow to engage in Mountain Biking, 32.50%, with



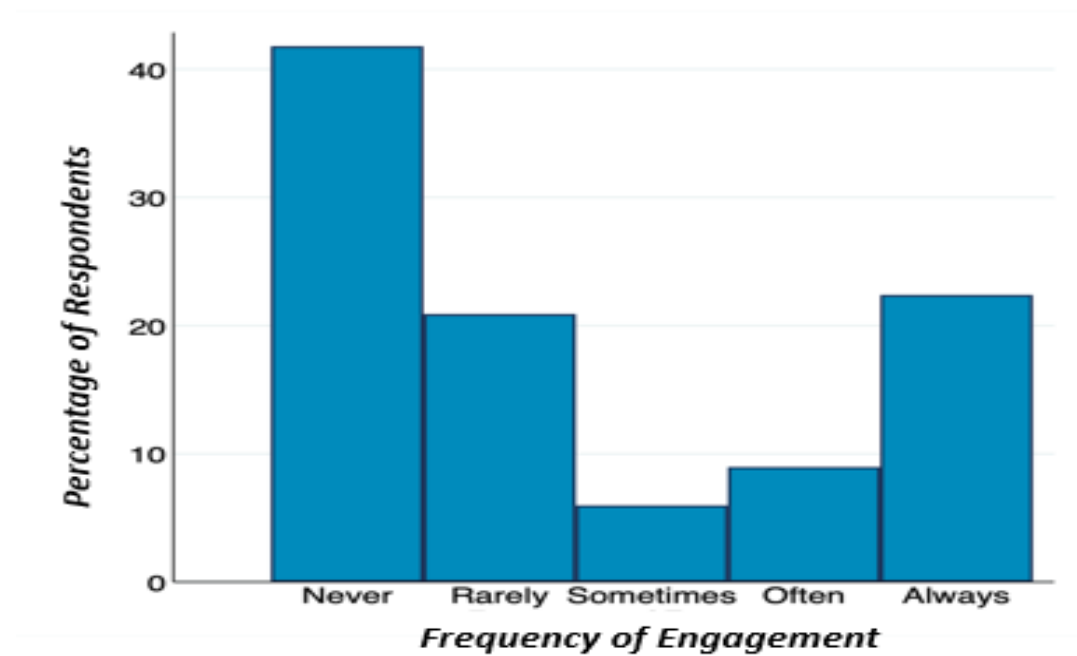
22.50% percent indicating they visited “About half the time” to engage in Mountain Biking. This leaves only 2.5% of respondents indicating they visit “once in a while” to Mountain Bike. This indicates that those who fall within the Mountain Biker category are likely to be highly engaged with 97.50% of respondents in this user group engaging in Mountain Biking “About half the time” or greater.



*Figure 3.12. Percentage of Engagement in Mountain Biking*

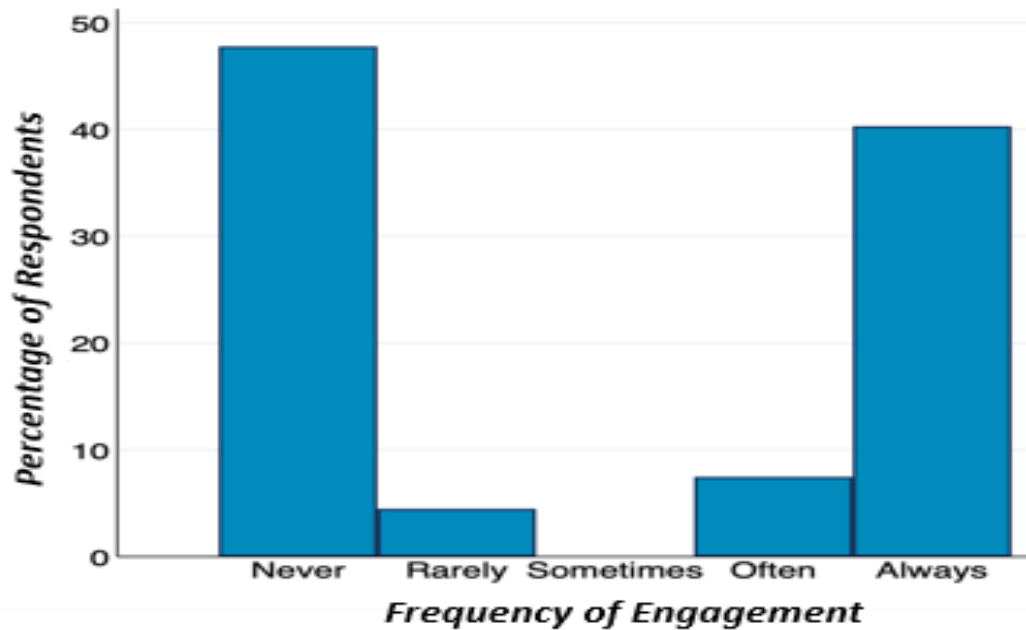
According to those who indicated they engaged in Hiking (39), the largest portion of respondents, 38.5%, indicated that they “Always” visited McDonald Hollow to engage in hiking. The second largest portion of respondents indicated that they visited “once in a while” to engage in hiking, 35.9%, with the third and fourth largest percentages representing “Most of the time” and “About half the time” with 15.4% and 10.3% respectively. This indicates that a sizable portion of this user group is highly engaged with the trail with roughly 64% engaging in Hiking “About half the time” or greater. That being said, it appears that Mountain Bikers have

the edge between these two user groups when it comes to engagement, exceeding hiker's responses by 33.5%.



*Figure 3.13. Percentage of Engagement in Hiking*

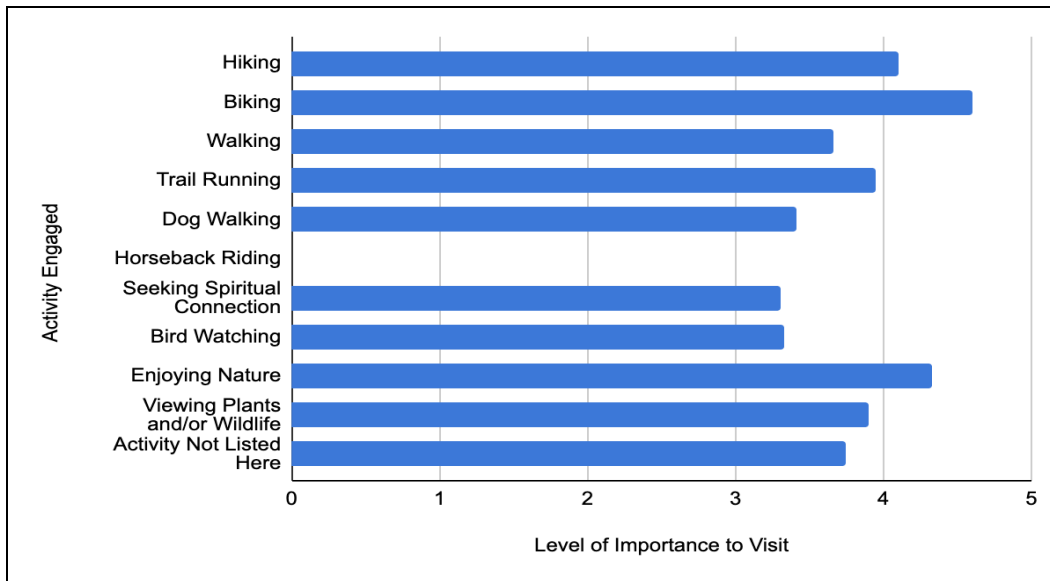
Among all the activities listed, “Enjoying Nature” was unique in the fact that users who responded to engage in this activity were the most highly engaged of all users. According to users within these groups, 77.1% noted that they “Always” engage in “Enjoying Nature” with 14.3% noting they engage in “Enjoying Nature” “Most of the time”. In combination this equates to 91.4% of this group being highly engaged with “Enjoying Nature”. Slightly below Mountain Biking, but the large majority of users indicating they always engage in “Enjoying Nature” is poignant.



*Figure 3.14. Percentage of Engagement in Enjoying Nature*

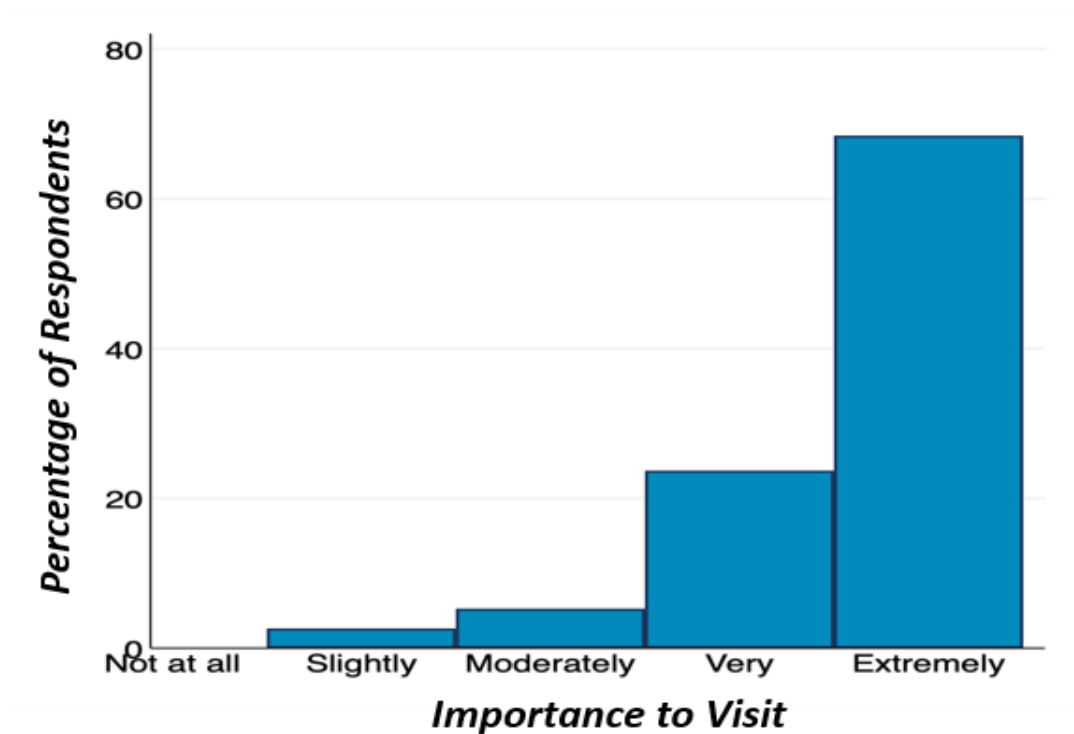
### ----- 3.4 - Motivations -----

Motivations are important to understand when it comes to why a particular trail user is utilizing an outdoor recreational opportunity. This is especially true for the McDonald Hollow trail network at this early stage in its life. Among active trail users polled it was clear that the activity in which they intended to engage in was very impactful in their choice to visit the trail with all activities (except horseback riding) reported average importance ranging from “Moderately Important” to “Extremely Important”. As with the previous section, only the three activities with the largest responses will be covered in detail here - Mountain Biking, Hiking, and Enjoying Nature-. All other activities will be covered in *appendix viii*.



**Figure 3.15. Level of Importance to Visit Per Activity - 1 Representing “Not Important at All” and 5 representing “Extremely Important”**

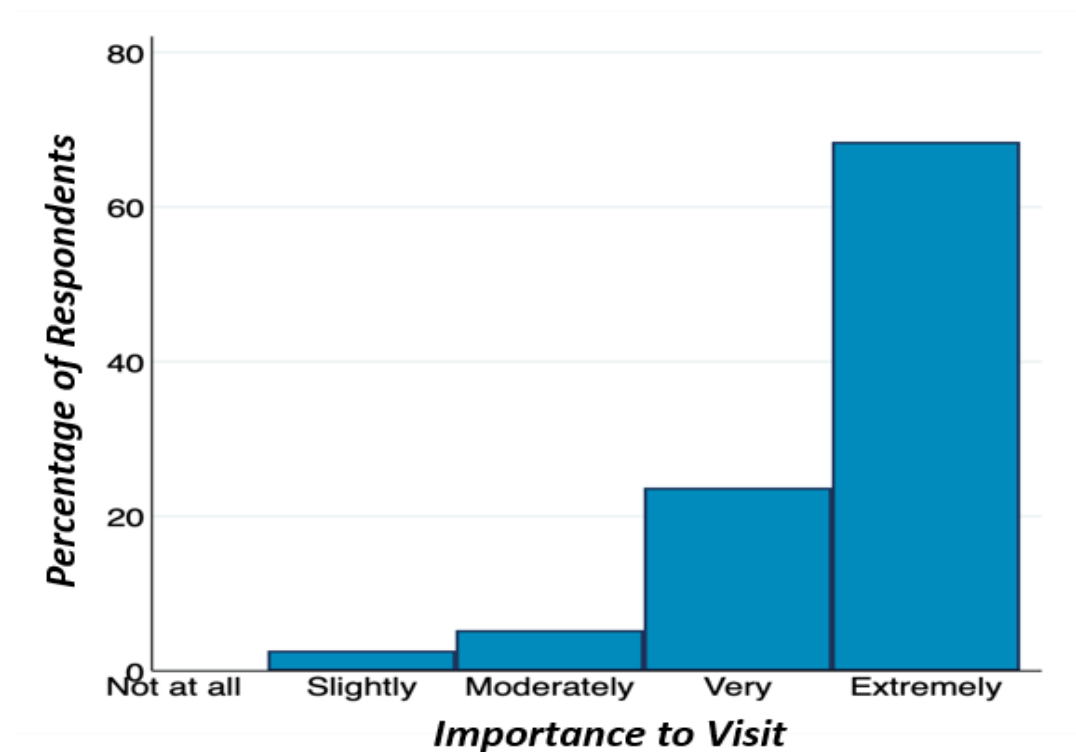
Among trail users who indicated they engaged in Mountain Biking (40), the largest portion of respondents, 65%, indicated that Mountain Biking was “Extremely Important” to their decision to visit McDonald Hollow. The second largest portion of mountain bikers, 25%, indicated that Mountain Biking was “Very Important” to their decision, while the third largest group, “Moderately Important” comprised only 5% of respondents. The remaining 5% was equally composed of mountain bikers who chose either “Slightly Important” or “N/A”. Overall this points to mountain bikers being highly motivated to visit this trail based upon their ability to mountain bike at the site. This is reflected in the 90% of mountain bikers who fell into the top two categories “Extremely Important” and “Very Important”.



*Figure 3.16. Importance of Mountain Biking for Visiting McDonald Hollow*

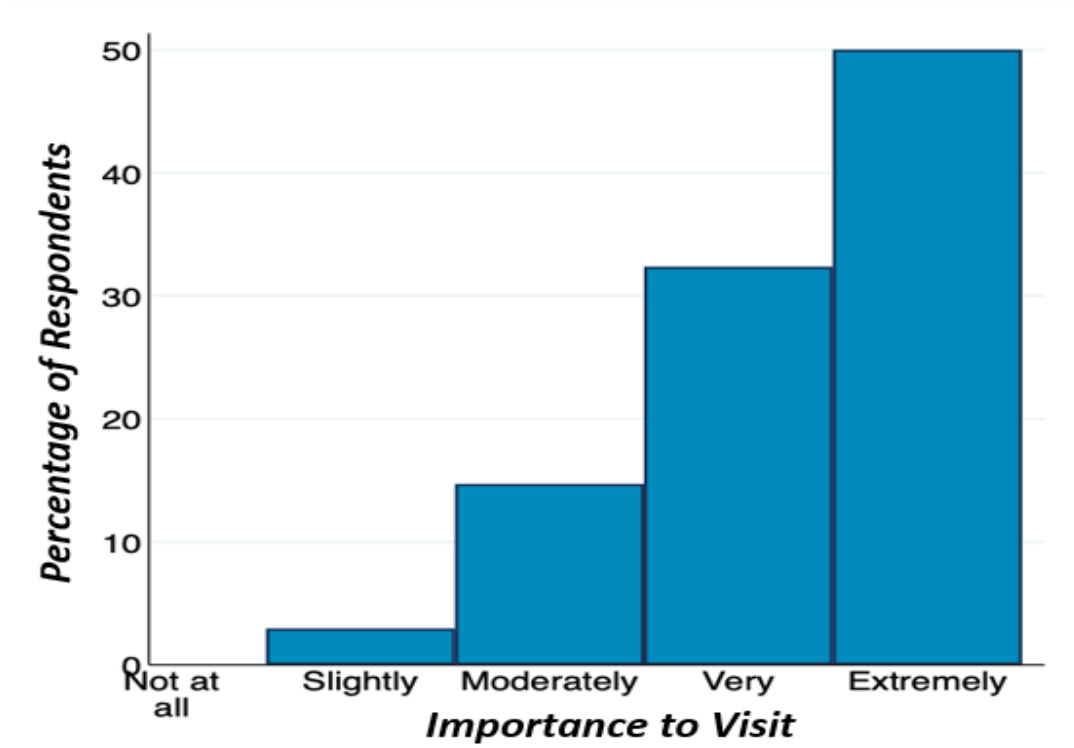
Among trail users who indicated they engaged in Hiking (40), the largest portion of respondents, 42.5%, indicated that Hiking was “Extremely Important” to their decision to visit McDonald Hollow. “Very Important” represents the second largest portion of self-reported hikers with 22.5%, “Moderately Important” represents the third largest group with 20%, and the remaining groups, “Slightly Important”, “Not Important At All”, and “N/A”, comprise 7.5%, 2.5% and 5% respectively. These percentages indicate that self-reported hikers are slightly less likely to take their ability to engage in hiking into their decision calculus when visiting McDonald Hollow. In comparison with Mountain Biking, “Extremely Important” and “Very Important” represent only 65% of respondents, a majority of self-reported hikers, but far less than the 90% reported among mountain bikers. It’s also important to note the small portion of respondents who reported “Slightly Important” and “Not Important At All” (10%). This may indicate that a small portion

of active trail hikers are less concerned with hiking at McDonald Hollow and may opt for other activities or trails in the future.



*Figure 3.17. Importance of Hiking to Visiting McDonald Hollow*

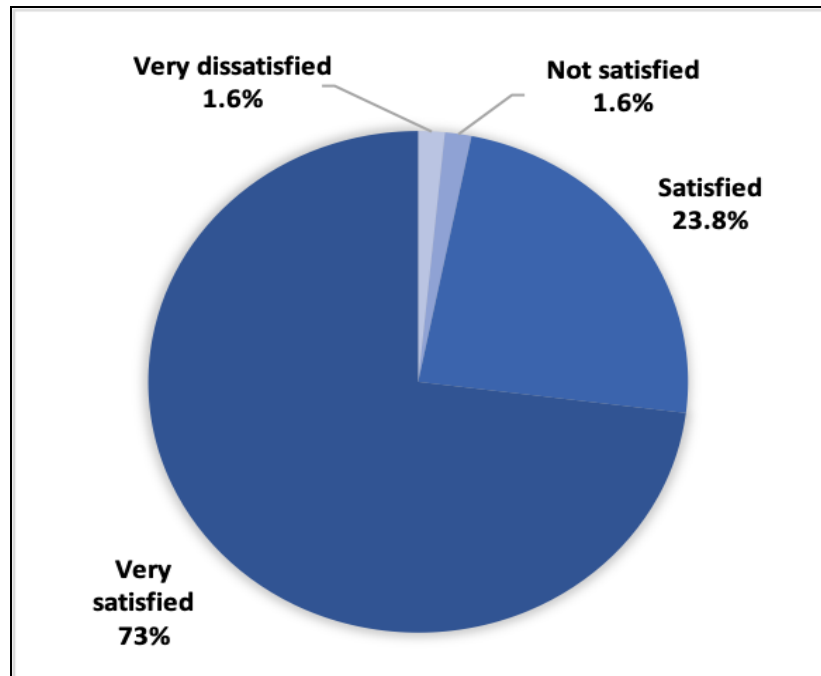
Among trail users who indicated they engaged in Enjoying Nature (36), the largest portion of respondents, 47.22%, indicated that enjoying nature was “Extremely Important” to their decision to visit McDonald Hollow. The second largest cohort were those who indicated “Very Important” at 33.33%, “Moderately Important” comprised 13.9%, while “Slightly Important” and “N/A” both represented 2.8% of respondents respectively. This indicated that those hoping to enjoy nature are almost level with Mountain Bikers in the value they place on their engaged activity to visiting McDonald Hollow (80.55%). Including those who indicated that enjoying nature was “Moderately Important” in their decision to visit McDonald Hollow (bring the total to 94.44%), it’s clear that enjoying nature is a strong pull factor for current active trail users.



*Figure 3.18. Importance of Enjoying Nature to Visiting McDonald Hollow*

### ----- 3.5 - Satisfaction -----

According to this first look at satisfaction among active trail users, it is clear that users are highly satisfied with the trails in their current state. In more detail, 73.02% of respondents indicated that they were “Very Satisfied” and 23.81% indicated that they were “Satisfied” with their most recent trip to McDonald Hollow. This equates to 96.83% (62) of respondents holding a positive feeling towards the trail network. On the other hand, 1.59% of respondents indicated they were “Not Satisfied” or “Very Dissatisfied” respectively. This equates to 3.18% (2) of respondents holding a negative feeling towards the trail network based on their most recent trip. Again, this indicated that the vast majority of active trail users are currently leaving the trail satisfied. This is likely to shift over time to reflect the impressions of future trail users, which will be vital in understanding impressions moving forward.



*Figure 3.19. Overall Satisfaction Among Users Polled*

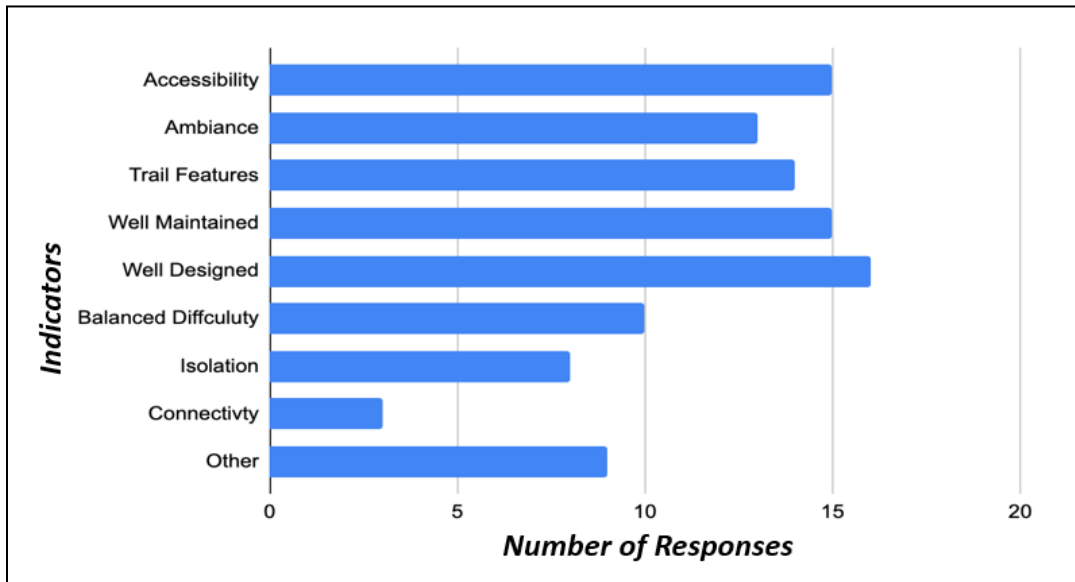
Beyond simply understanding whether or not active users are satisfied with their experience at the trail, it is also important to parse the positive and negative impacts on their experience. The following will detail what most negatively and positively impact respondents experience at McDonald Hollow. In examining this information, inferences can be drawn to inform future development or alterations to the site that may improve user experience.

Among active trail users, there were a series of indicators reported that most positively impact their experience. Although each user responded to what most positively impacted their experience in a long form, their individual responses were grouped into the following categories (all responses can be found in *appendix ix*): Accessibility, Ambiance, Trail Features, Well-Maintained, Well-Designed, Balanced Difficulty, Isolation, Connectivity, and Other. For the purpose of this survey, the aforementioned indicators can be explained as:

- **Accessibility** - ease of use, easy access to the site, and easy access to parking



- **Ambiance** - the beauty of nature, wildlife, plantlife
- **Trail Features** - jumps, banked turns, challenging features
- **Well-Maintained** - trail has obvious upkeep, trails are kept clear of debris
- **Balanced Difficulty** - McDonald Hollow has trails of varying difficulty
- **Isolation** - Users feel alone
- **Connectivity** - Trails are connected within the network and are either directly connected or has ease access other trail networks ( The Huckleberry, Gateway, Poverty Creek Trails)
- **Other** - comments that didn't fall into one of the previous categories



**Figure 3.20. Positive Impact Indicators on Experience**

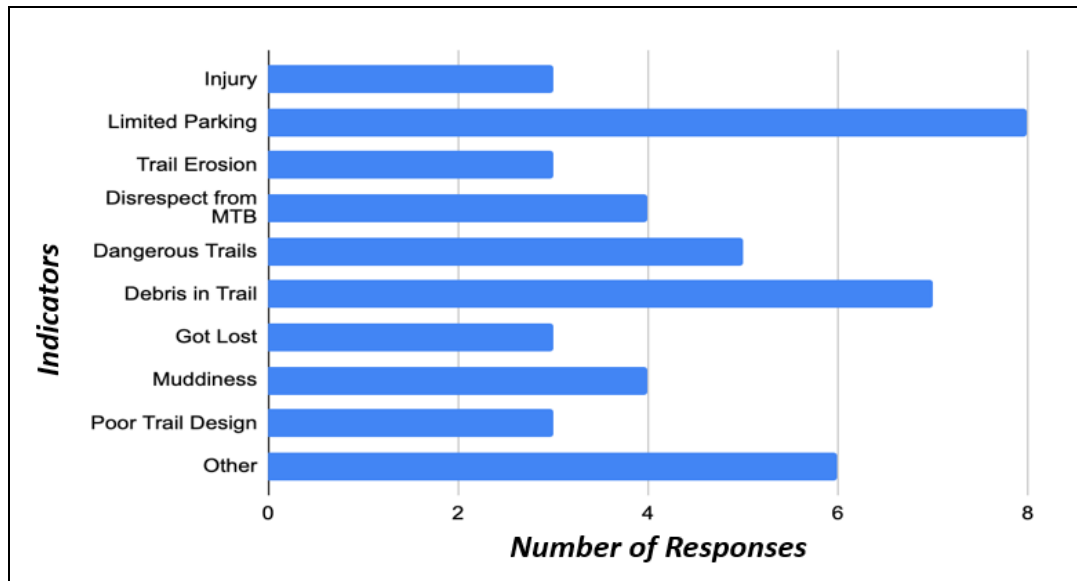
According to users, “Well-Designed” represented the largest impact on a positive experience at McDonald Hollow with 15.5% of responses. Tied for second were both “Accessibility” and “Well-Maintained” with 14.6% of respondents indicating these attributes most positively impacted their experience. This is closely followed by “Trail Features” with 13.6%, “Ambiance” with 12.6%, “Balanced Difficulty” with 9.7%, “Other” with 8.7%, “Isolation” with 7.8%, and “Connectivity” with 2.9%. Overall this indicates that there is no one attribute that most positively impacts current trail users' experiences. Rather it appears that a series of attributes linked directly to the trail itself - “Trail Features”, “Well Maintained”, “Well-Designed”, and “Balanced Difficulty” - are the largest impacts on positive trail experiences with a combined 53.4%. Another cluster of attributes that revolve around the individual’s personal experience,

specifically “Ambiance”, “Isolation”, and “Other”, comprise the second largest group of trail users at 29.1%. Tangentially trail related attributes such as “Accessibility” and “Connectivity” comprise the final subgrouping at 17.5%.

As with positive impacts to experience, users were also asked for what most negatively impacted their experience at McDonald Hollow. In the same manner as with positive experiences, users were allowed to respond in a long form; however, for brevity these responses were grouped into the following categories (all responses can be found in *appendix x*): Injury, Parking, Trail Erosion, Disrespect, Dangerous Trails, Debris in Trail, Got Lost, Muddiness, Poor Trail Design, and Other. For the purpose of this survey, the aforementioned indicators can be explained as:

- ***Injury***- an injury to the respondents person
- ***Parking*** - lack of parking at the trailhead
- ***Trail Erosion*** - excess erosion on the trail that impacted a user’s enjoyment
- ***Disrespect*** - An experience in which the user felt disrespected
- ***Debris in Trail*** - limbs or other organic refuse in the trailbed
- ***Got Lost*** - trail user was lost at some point during their visit
- ***Muddiness*** - the trailbed was excessively muddy on their visit
- ***Poor Trail Design*** - the user found the trail design (slope, banks, features, etc.) to be poorly designed.
- ***Other*** - comments that didn’t fall into one of the previous categories

The following representing these attributes distribution among respondents:

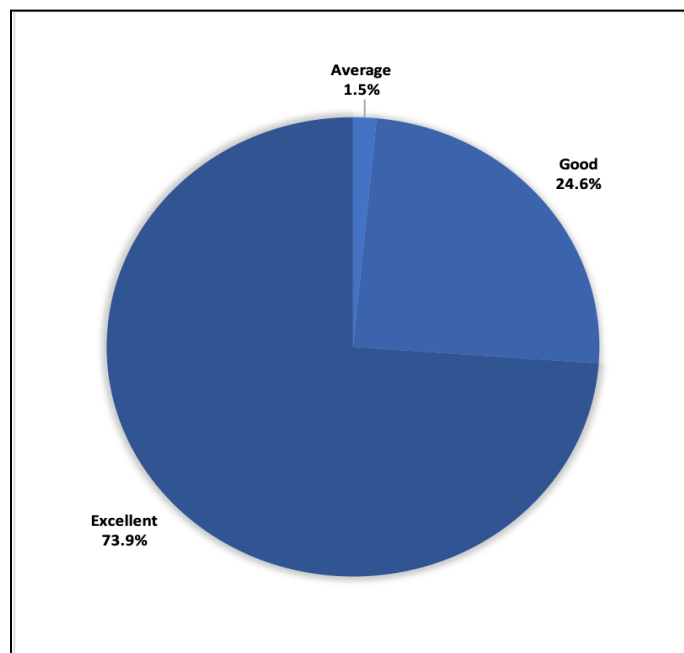


*Figure 3.21. Negative Impact Indicators on Experience*

According to users, “Parking” represented the largest impact on negative experiences at McDonald Hollow with 17.4% of respondents reporting parking as an issue. The second largest indicator was “Debris in Trail” with 15.2%, followed by “Other” with 13%, “Dangerous Trails” with 10.9%, “Disrespect” and “Muddiness” at 8.7%, and “Injury”, “Trail Erosion”, “Got Lost”, and “Poor Trail Design” at 6.5%. As with positive impacts, it appears that no one indicator has an outsized impact on negative experiences at McDonald Hollow. Rather it appears the largest impacts, as with positive impacts, fall into either directly related to the trail, personal, or secondarily related impacts. The first of which can be categorized by “Trail Erosion”, “Dangerous Trails”, “Debris in Trail”, “Muddiness”, and “Poor Trail Design” with a combined 47.8%. The second of which can be categorized by “Injury”, “Disrespect”, “Got Lost”, and “Other” with a combined 34.7%. And finally tangentially trail related can be categorized by “Parking” with 17.4% of responses.

### ----- 3.6 - User Impressions -----

Another important indicator for monitoring how users are interacting with the trails are their current perceptions of the trail network itself. This is important in the fact that it allows for inferences to be made about how the public perceives the trails, but it also allows for comparisons of substitutability. In its basic form, substitutability represents an individual's ability to replace one recreation activity with another. In this way, inferences as to how McDonald Hollow compares to both local (NRV) and regional (Mid-Atlantic) trail systems can be made. In order to gauge these indicators, respondents to the phase two survey were first asked “what is your overall perception of the McDonald Hollow Trail Network” on a scale from poor to excellent.

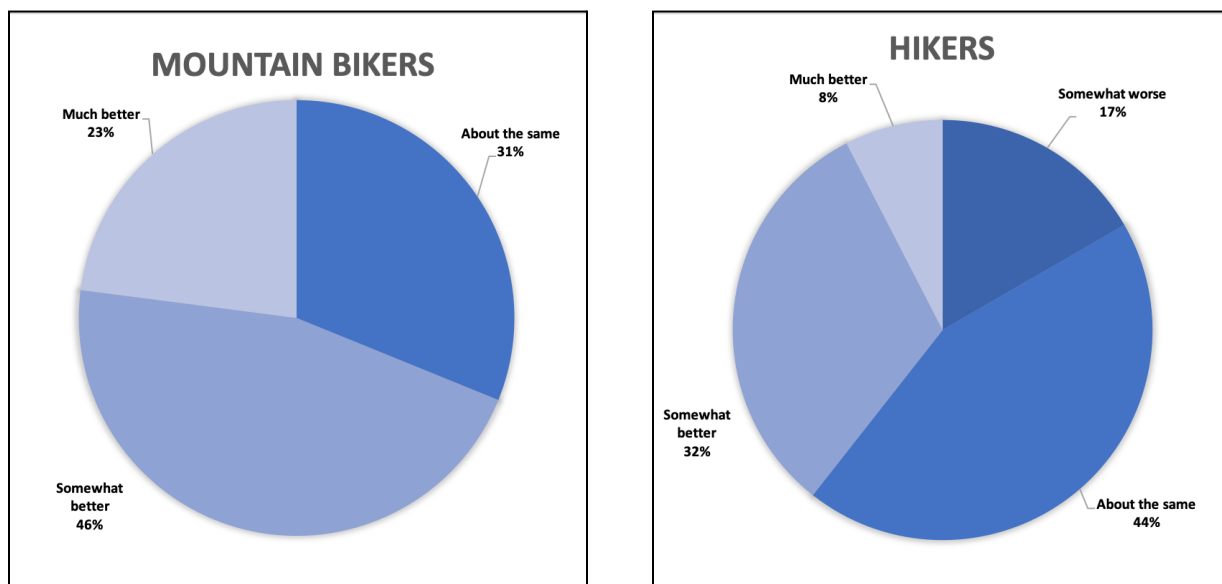


*Figure 3.22. Overall Impression of McDonald Hollow Among Users Polled*

From this graph it is clear that the vast majority of trail users polled have a highly favorable perception of the trails at McDonald Hollow. In more detail, 73.9% of respondents indicated their perception of McDonald Hollow was “Excellent”. 24.6% responded “Good”, and 1.5%

responded “Average”. This indicates that all respondents have perceptions that are neutral at worst and highly positive at best. This is likely to change over time; however, early in the life of the trails at McDonald Hollow it is clear perceptions remain high.

In regard to substitutability, questions utilized in the phase two survey specifically sought to gauge mountain bikers and hikers. In order to do so, both groups were asked to compare McDonald Hollow with other recreation opportunities both locally and regionally.

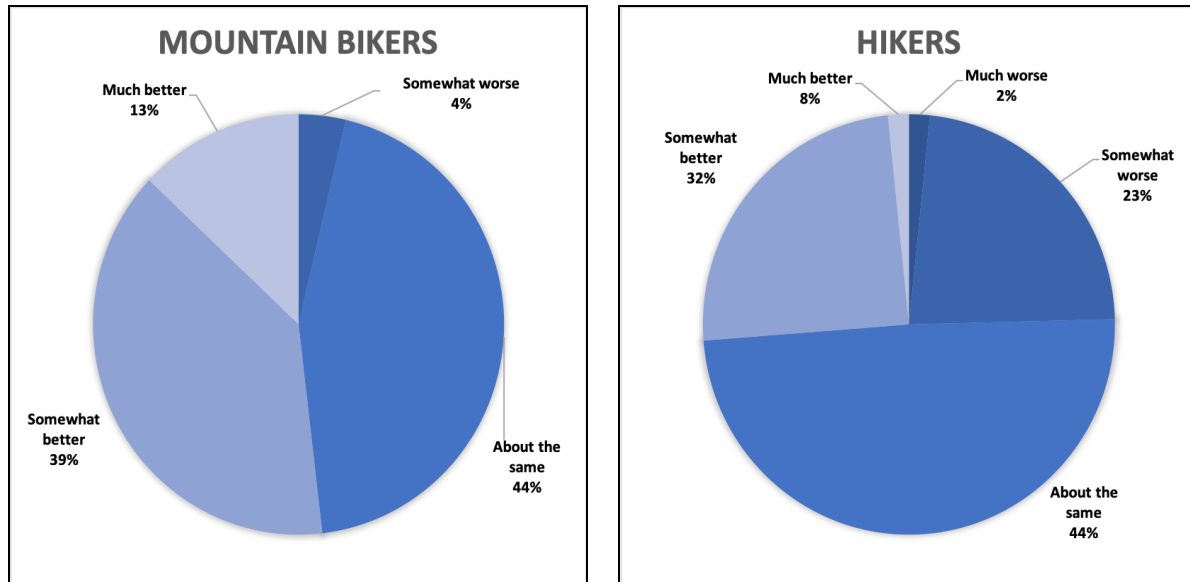


*Figure 3.23. Hikers and Mountain Bikers Perceptions of McDonald Hollow in Comparison to Other Offerings Within the NRV*

In regard to mountain bikers, McDonald Hollow appears to be roughly level, if not better, an experience than other offerings within the NRV. Among mountain bikers, 23% of respondents indicated that McDonald Hollow was “Much Better” than other local offerings, 45.9% indicated “Somewhat Better”, and 31.2% indicated “About the same”. Overall, these responses reveal that mountain bikers have a generally positive opinion of McDonald Hollow in comparison to other local offerings. The combined 68.9% opting to rate McDonald Hollow better than average and the remaining 31.2% rating the trail average indicate that mountain bikers are enjoying the trails

currently offered. Likewise, this likely points to the trail being well-designed, engaging, and worthy of return trips.

In regard to hikers, McDonald Hollow appears to be seen in the same light as mountain bikers; however, responses appear to be more muted among hikers in comparison to other offerings within the NRV. Among hikers polled, the largest portion of respondents rated McDonald Hollow as “About the same”, 43.9%, in comparison to other local offerings, 31.8% “Somewhat Better”, 16.7% “Somewhat Worse”, and 7.6% as “Much Better”. This indicates that roughly 83.3% of respondents hold impressions that rate McDonald Hollow as equal, at worse, and slightly better, at best, which indicates that most hikers are enjoying the trails and see this trail network as “better” or equal to other local offerings. This being said, it is also important to note the portion of respondents who indicated McDonald Hollow was “Somewhat worse”. This indicated that some users do not hold McDonald Hollow in as high esteem as other local trails. This may be due to a series of factors such as McDonald Hollow not initially being intended for hiking or the emphasis on mountain biking by McDonald Hollow (and other surrounding trails); nevertheless, this subgroup of respondents are important to monitor if hikers are a user-group that the trail hopes to attract in the future.



**Figure 3.24. Hikers and Mountain Bikers Perceptions of McDonald Hollow in Comparison to Other Offerings Within the Mid Atlantic**

The graph above addresses respondent’s perception of McDonald Hollow in comparison to mountain biking and hiking offerings within the Mid-Atlantic region of the United States. In regard to mountain bikers, responses are somewhat more muted than comparisons locally; however, opinions of McDonald Hollow in relation to other regional offers are generally positive. The largest group of respondents indicated that McDonald Hollow was “About the same” (44.4%) as other offerings regionally with 38.9% rating the network “Somewhat Better”, 13% “Much Better”, and 3.7% as “Somewhat Worse”. This indicated that the vast majority of respondents consider McDonald Hollow to be level or better in comparison to other mountain biking trails within the Mid-Atlantic (96.3%). As mentioned above, this likely reflects the quality of the trails, high levels of user enjoyment, and ability for users to return to the trail again and again among active users.

In regard to hikers, respondents are far more pessimistic of McDonald Hollow in comparison to other hiking trails regionally. The largest portion of hikers, 49.2%, rate McDonald Hollow as “About the same”, with the second largest, “Somewhat Better”, comprising 24.6%. The

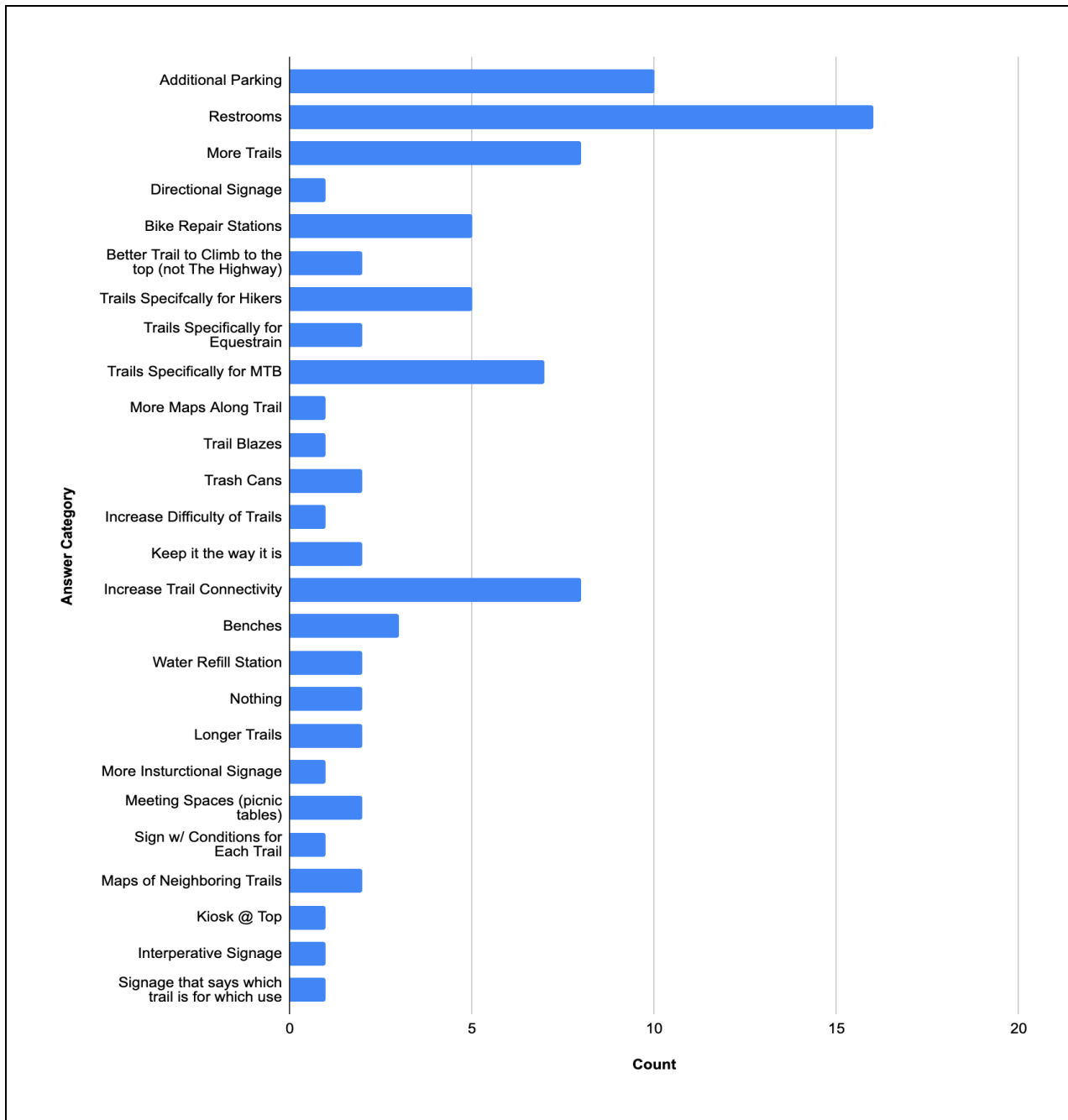
remaining groups were “Somewhat Worse” with 23% and “Much Worse” and “Much Better” with 1.6% respectively. Overall this indicates that the vast majority of hikers hold opinions that paint McDonald Hollow as average or better than average (75.4% combined). However, when compared regionally, it is clear that a sizable portion of respondents do not hold McDonald Hollow in high regard, rating the trail poorly (24.6% combined).

Again, it is important to take into consideration that these perceptions will continue to change over time. Especially given increases in local trail accessibility, perceptions will likely reflect shifts in the current user base as more experienced users flock to new opportunities in the future. Regardless, substitutability serves as an important indicator to gauge specific user-group perceptions of the trail network. Beyond perceptions, indicators of substitutability present the potential to guide stakeholder engagement to bolster insights into trail amenities, features, and experiences at McDonald Hollow.

### ----- 3.7 - Trail Users Wants & Needs -----

A final important indicator collected as part of this initial active user survey were desired amenities from future development. To gauge this, participants were asked “[w]hat amenities would you like to see from future development on Brush Mountain” and respondents were allowed to answer in long form. Naturally, many users noted multiple improvements they would like to see. In order to simplify responses from each user, responses were grouped into one of 26 distinct categories.





**Figure 3.25. Amenities Requested in Future Development By Survey Respondents**

As outlined above, the largest requests from trail users are restrooms (16), additional parking (10), Increased Number of Trails (8), Increased Connectivity to Other Trails (8), specific trails for Mountain Bikers and Hikers (7 & 5 respectively) and Bike Repair Station (5). The remainder fall below three responses, all responses are outlined in *appendix xii*.

### ----- 3.8 - Conclusion -----

McDonald Hollow presents a prime opportunity to gauge visitor usage, motivations, opinions and satisfaction at the early stage of a mix-use trail's life. This first implementation of a visitor use monitoring program at the site illustrated both interesting and expected insights into the way that McDonald Hollow is currently being used. Of particular interest are the manners in which the trails are currently being used, who are using the trails, overall satisfaction, and comparisons to other trails. According to trail usage patterns collected from trail sensors located near the trailhead, it is clear that hikers outnumber mountain bikers by a large margin, upwards of 5 to 1 on an average day (3.1). This is counterintuitive to the preconceived notion that the McDonald Hollow Trail Network is largely a haven for Mountain Bikers due the trail network being designed by and for Mountain Bikers. In the same vein, according to those polled, the 5 largest user groups at McDonald Hollow consist of: Mountain Bikers (18%), Hikers (18%), Nature Enjoyers (16%), Walkers (13%), and Trail Runners (10%). This indicates that while McDonald Hollow's two largest user groups are, as expected, mountain bikers and hikers, there are other user groups, particularly nature enjoyers and walkers, that represent sizable portions of the overall user base. These groups, as well as others, are likely to present differing opinions, needs, and wants from the two largest user groups and therefore should be fully integrated into the decision making process moving forward.

In regard to use over time, the data highlights patterns that are to be expected. This is reflected in usage peaking in the fall, dipping during the winter months, and usage rising throughout the spring and early summer. Although the entirety of the year was not covered during this monitoring period, it can be inferred from the current trend that usage is likely to continue to rise over the course of summer, returning to its peak in early fall. This is important to take into

account, especially in regard to maintenance, since trail construction, repair, and other maintenance will be of lowest impact to trail use in the winter months.

An additional impactful finding from this initial survey of trail users are the demographics of those polled. In particular, among those polled, it was shown that a typical visitor to McDonald Hollow likely to be male, white, middle aged, and from Blacksburg. This indicated that those polled are not representative of the population of Blacksburg at large. Rather, the user base at McDonald Hollow is more male (63% compared to 54% overall), more white (93% compared to 79% overall), and over represented by those between 30 and 59 (74% compared to 21% overall). However, these figures do support other findings (academic and non-academic) that paint mountain biking as largely white and male sport (Schults, 2003; Barber 2016). Nevertheless, the lack of diversity among mountain bikers both locally and nationally indicated efforts may be needed to ensure accessibility to McDonald Hollow (and other trails) to the entirety of those living in and around Blacksburg. In this way, everyone will have greater opportunity to access McDonald Hollow for outdoor recreation activities.

Another important takeaway is the fact that among those polled users have a very positive impression of the trails with all respondents rating the trail above average. This sentiment can be carried over to active user's opinion on the trail in comparison to other trails locally (NRV) and regionally (Mid-Atlantic) with the majority of those polled reporting McDonald Hollow as equal to or better than other offerings. This indicates that current trail users are largely happy with the trail in its current state.

Taken in tandem, the results from this initial survey have uncovered intriguing insights into how McDonald Hollow is currently being used and enjoyed. This data is integral in laying a baseline for future study of users along these same trails. Overall, current trail users are largely satisfied

with their experiences at McDonald Hollow and are likely to return. Current user groups are numerous and are likely to shift over time; however, efforts to include all user groups, not just hikers and mountain bikers, will likely be needed in the future to ensure all users' needs are met. In the same vein efforts may need to be undertaken to ensure equitable trail access to underrepresented groups. Nevertheless, future studies at McDonald Hollow will continue to monitor visitor use revealing new, intriguing, and enlightening insights into how best to create sustainable, equitable, and accessible trails moving forward.

## **Chapter 4: Trail Impacts Data Analysis**

### **----- 4.0 - Introduction -----**

The purpose of this chapter is to report trail impacts from early stage use at McDonald Hollow, in particular this chapter will take an initial look at soil loss both at the trail level and site level. To examine these two important indicators, data collected at three distinct points over the course of this initial study period will be compared. Due to the scope of this report, a detailed analysis of direct and indirect soil loss impacts to specific trails will not be covered, rather generalized soil loss will be addressed. This chapter will outline initial soil loss amounts for all trails within the McDonald Hollow Trail Network. This is not only important for creating a baseline for future research, it also allows for inferences to be made with respect to early stage usage impacts. Overall, the importance of monitoring soil loss along a trail cannot be overstated. Especially given the popularity of McDonald Hollow among hikers, mountain bikers, and other recreation user groups, soil loss from repeated use is an important indicator of trail health that needs to be monitored by stakeholders groups involved in the upkeep of the trail, such as the Poverty Creek Trails Coalition. By collecting this, data analysis and decision-making pertaining to trail erodibility, construction, and maintenance can be made in higher confidence. As a result, organizations and agencies are able to better allocate resources while ensuring more sustainable constructed and maintained trails, higher user enjoyment, and limited impact to users. The following subsection will take a closer look at both trail level soil loss as well as site level soil loss. The first of which will report average soil loss or gain over the course of the trail in question, and the second will address soil loss or gain with the confines of a matrix comparing landform grade and trail grade's impact on soil change. Prior to addressing these two subsections, it is important to understand the shorthand and names that will be used in this

portion of the report. The following will outline important shorthand and trail names used throughout the remainder of this chapter.



*Figure 4.1. Map of the McDonald Hollow Trail Network, Mid-2022*

- **Pine Forest** - An easiest difficulty trail outlined in blue (2)
- **Ida May** - An easiest difficulty trail outlined in red (3)
- **Turkey Trot** - An easiest difficulty trail outlined in orange (4)
- **Wilkes Wood** - A more difficult trail outlined in pink (5)
- **Blunderbuss** - A most difficult trail outlined in yellow (6)
- **Crosscut** - A more difficult trail outlined in green (7)
- **The Highway** - a fireroad that intersects the trail network, connects the McDonald Hollow Trail Network to the Poverty Creek Trail Network (1)
- **Landform Grade (LG)** - a measurement of steepness taken from the transect upwards towards the nearest high point (roughly ten feet apart).

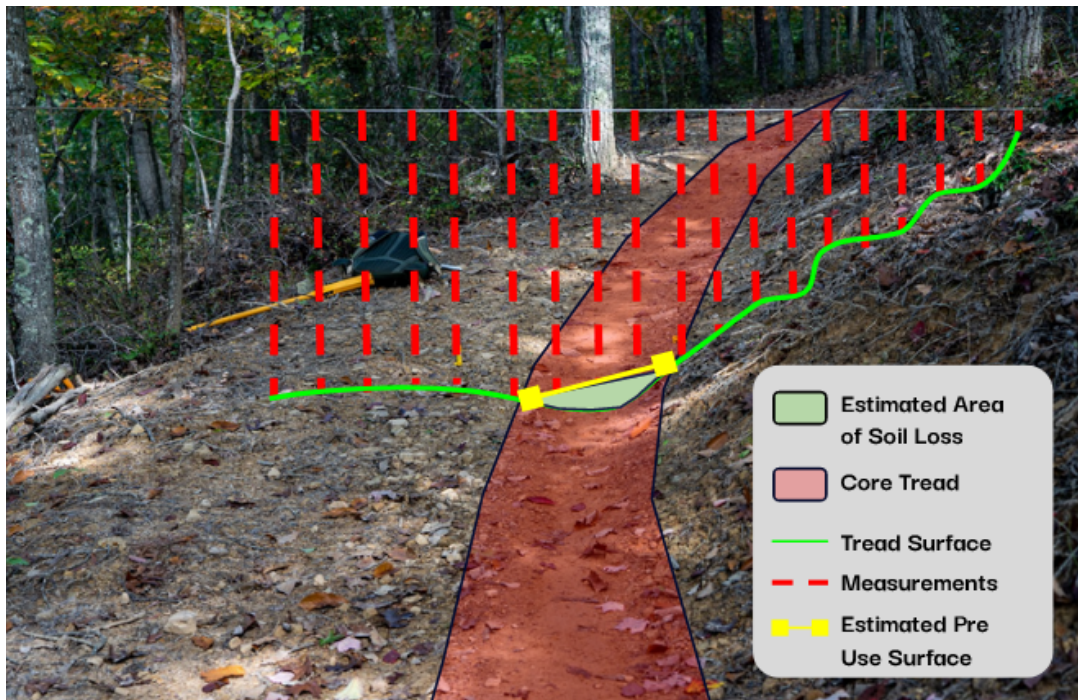
- **Trail Grade (TG)** - a measurement of steepness taken along the trail (crew members located ten feet on either side of the transect)
- **Transect** - an area across the trailbed in which measurements are taken
- **CSA** - Cross Sectional Analysis, measurements of soil loss across a transect
- **Matrix Based Transect** - transects that were placed with a matrix comparing LG and TG (A more detailed explanation can be found in Ch. 1). This type of transect included Ida May, Wilkes Wood, and Blunderbuss.
- **Randomly Systematic Transects** - transects that were placed at equal intervals along the trail (a more detailed explanation can be found in Ch. 1). This type of transect was placed along Pine Forest, Turkey Trot, and Crosscut.

#### ----- 4.1 - Soil Loss: CSA -----

The following subsection will address average soil loss along each trail using CSA, or cross sectional analysis, to determine the impact of use and weather on the trail surface over the course of this initial study period. In its most basic form, CSA is done through the use of two endpoints as anchors, stretching a tape measure across the trail surface, and measuring from the taught tape to the trail surface at equal intervals (10 cm).

Due to the fact that this study was initiated roughly 5 months after McDonald Hollow was open to the public, I was unable to capture pre-use conditions. However, an estimation of the pre-use tread can be made as a best guess of where the surface was prior to the Spring of 2021. For my purposes, I determined that core tread, or the area in which 90% of all visible trail use occurs, was a good measure of where the tread may have been prior to use since the majority of impacts would fall within this corridor and this area would likely be lower than the rest of the trail. In order to perform calculations, endpoint 1 (or the point closest to the stake) of the core tread was used as a zero point with following measurements increasing or decreasing from that point. A slope was calculated from one end of the core tread to the other with any measurements being taken from the slanted line between endpoint 1 and endpoint 2 of the core tread. For example, if the zero point of a transect was at 34 cm and the next point was at 35cm, then the initial point

would equate to 0 and the second to 1. Likewise, if the following point was at 32.5 then this number would become -1.5. In order to ensure soil loss was attributed accurately across collection periods, core tread from the initial collection period was used as a base.



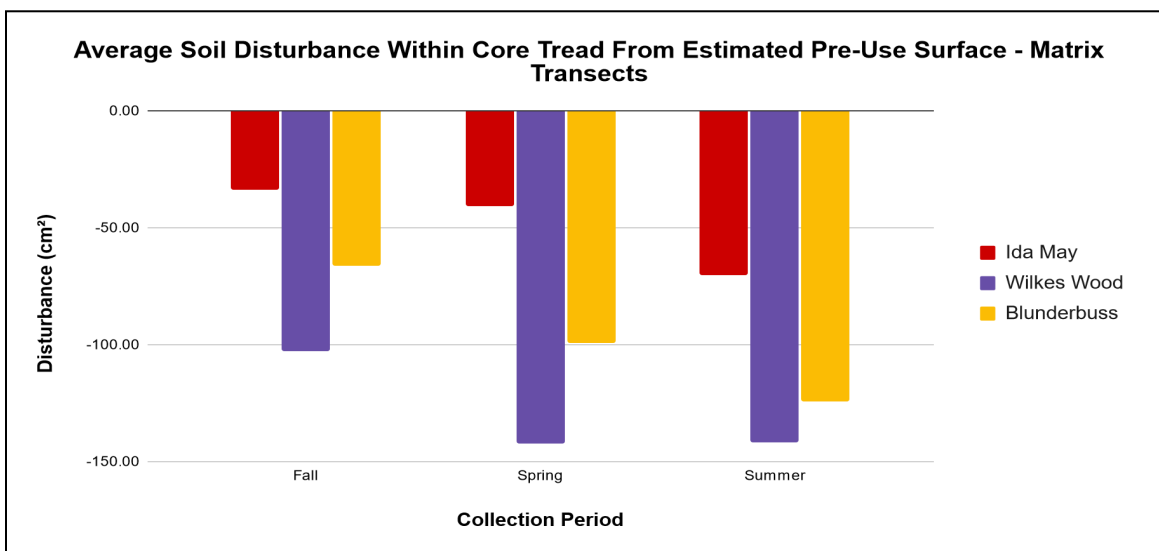
*Figure 4.2. Visual representation of core tread estimation*

In the case of Ida May, Wilkes Wood, and Blunderbuss these measurements were taken in the Fall of 2021 and core tread measurements for Pine Forest, Turkey Trot, and Crosscut were taken in the Winter/Spring of 2022.

An important caveat to note that it is not possible to estimate soil loss for Ida May, Wilkes Wood, or Blunderbuss. Transects along these trails were established in an effort to fill a matrix comparing landform grade and trail grade in order to examine trail sustainability long term. This means that transects were not randomly placed along the trail itself, rather they were placed in order to fill the matrix and observe specific trail features for sustainability. Therefore, any soil disturbance numbers from these transects may be indicative of loss or gain at that point, but not indicative of the entire trail, even when averaged out. That being said, average soil disturbance is

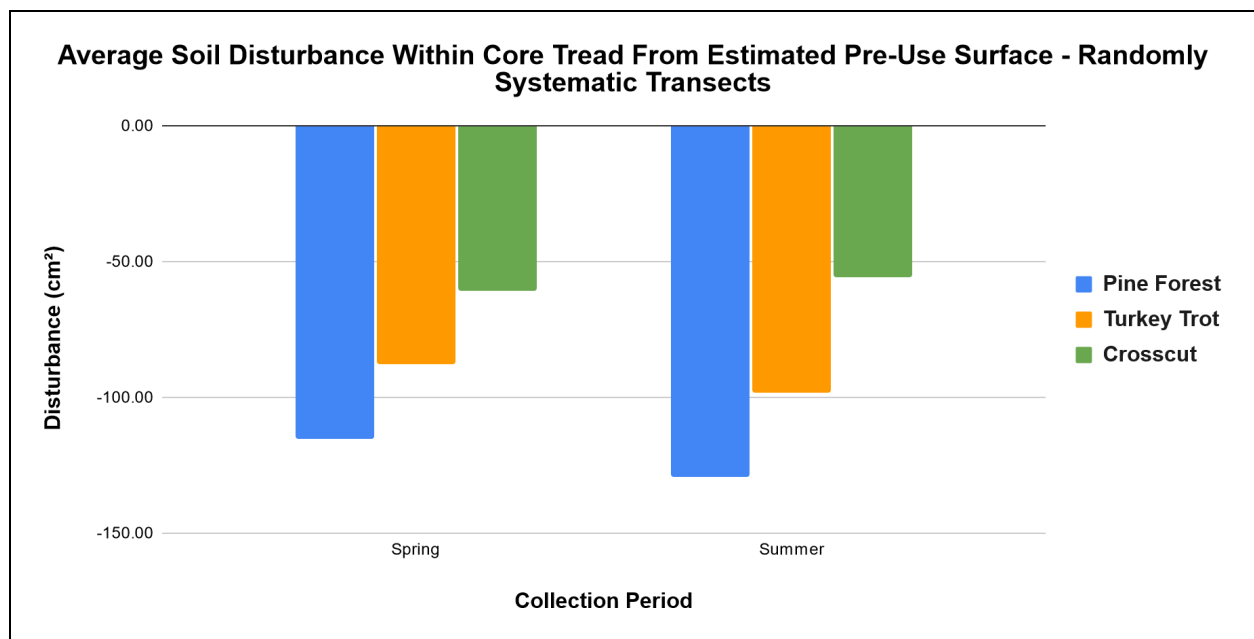


still an important metric to capture regardless of generalizability because it will help highlight current and future trends of disturbance that will aid in maintenance efforts moving forward.



*Figure 4.3. Average Soil Loss Within Core Tread at Each Collection Period - Matrix Transects*

Looking at this data it is clear that within the core tread of each trail there is notable soil loss. Of particular interest are the changes in steeper trails (Blunderbuss and Wilkes Wood particularly) between collection periods. In regard to Blunderbuss, transects located along this trail averaged 58.05 cm<sup>2</sup> or 0.0058 m<sup>2</sup> of soil loss between initial and final collection periods. Due to the placement it wouldn't be appropriate to carry this average out across the entire length of the trail; however, suffice to say there has been noticeable differences between the fall and summer. In the case of Wilkes Wood, soil disturbance differences averaged out to be 38.55 cm<sup>2</sup> or 0.0038 m<sup>2</sup> of soil loss between initial and final collection periods. Again, it would be inappropriate to make generalizability across the entire trail due to the method in which transects were placed



*Figure 4.4. Average Soil Loss Within Core Tread at Each Collection Period - Randomly Systematic Transects*

Beyond Blunderbuss and Wilkes Wood, all trails are reporting soil loss from their estimated pre-use condition. A more detailed breakdown of each trail's soil disturbance can be found in *appendix xii*. As with all data collected as part of this study, it is likely that impacts will continue to change over time but continual monitoring will likely reveal stronger patterns that have yet to be set in stone.

#### ----- 4.2 - Soil Loss: Trail Level Differences -----

As noted above, the trails at McDonald Hollow are a series of multi-use, multi-difficulty, and multigrade trails. As a result, each trail is unique in its design and therefore reports varying levels of soil loss or gain. It is important to note that all calculations performed as part of this subsection are not looking to base soil loss from a pre-construction, pre-use surface. Therefore, all volume calculations within this subsection are compared to the trail as it was in the Fall of 2021.

To calculate soil loss at each transect a method of measurement called CSA or cross sectional analysis was implemented. In order to calculate the difference in soil loss or soil gain, at least two series of measurements must be taken. Unlike a traditional CSA measurement where loss can be directly measured from a perceived pre-use line, the method used here compares volume measurements for the entire area measured. This resulted in large volumes due to the height at which transects were established - due to the variability in elevation and the 3 to 6 foot buffer on both sides of the trail. In order to remedy this, total volume is taken into account, but only volume differences between collection periods were analyzed.

It is also important to consider that measurements were taken for the entirety of the transect as part of this initial study (as outlined in ch 2), this includes areas that are off-trail. These off-trail areas are not pertinent to this analysis, and therefore to capture direct tread impacts only, measurements taken within the maximum tread of each transect were utilized (descriptions of max tread can be found in Ch. 2). Due to the varying nature of maximum tread, either due to the surveyors opinion or the natural meandering of trail ware, maximum tread from the first collection period was used. In the case of Ida May, Wilkes Wood, and Blunderbuss these measures were collected in the Fall 2021 and for Pine Forest, Turkey Trot, and Crosscut in Spring 2022. Once collected, a measure of volume can be calculated for both sets of data using an R-script (outlined in *appendix xiii*). These volumes can then be compared, with any resulting differences representing the amount of soil, or other substrate, lost or gained at the transects in question between collection periods. These averages can then be applied to the length of the trail to get an estimate of soil disturbance between each data collection period.

The following depicts these differences as well as trailbed characteristics across the entirety of the study period. In the case of Ida May, Wilkes Wood, and Blunderbuss these amounts represent

the differences between October, 2021 and June, 2022, while differences from Pine Forest, Turkey Trot, and Crosscut represent data collected between February and June of 2022.

Again, it is important to note that these two groups of trails can not be directly compared due to the methodology used to set up transects. Therefore, only transects established to estimate average disturbance will be examined (randomly systematic) in the following subsection.

### Randomly Systematic Based Transects

| Indicator                                       | Pine Forest | Turkey Trot | Crosscut |
|-------------------------------------------------|-------------|-------------|----------|
| <b>Trail Width</b><br>(Mean, cm)                | 292.38      | 218.00      | 213.33   |
| <b>Max Incision</b><br>(Mean, cm)               | 52.3        | 62.25       | 73.17    |
| <b>Area of Disturbance</b><br>(m <sup>2</sup> ) | 1754.18     | 2059.96     | 2084.10  |
| <b>Soil Loss</b>                                |             |             |          |
| Mean, cm <sup>2</sup>                           | -231.00     | 266.50      | 9.17     |
| Sum, m <sup>3</sup>                             | -18.59      | 25.73       | 1.03     |
| m <sup>3</sup> / mi                             | -37.18      | 42.89       | 1.48     |
| Tons                                            | -6.56       | 9.09        | 0.36     |
| <b>Trail Substrates</b>                         |             |             |          |
| Exposed Top Soil %                              | 13.00       | 22.50       | 15.83    |
| Litter %                                        | 70.00       | 27.50       | 34.17    |
| Vegetation Cover %                              | 0.00        | 5.83        | 0.00     |
| Exposed Rock %                                  | 5.00        | 12.50       | 6.67     |
| Muddiness %                                     | 0.00        | 0.00        | 0.00     |
| Gravel %                                        | 10.00       | 31.67       | 38.33    |
| Roots %                                         | 1.00        | 0.00        | 5.00     |
| Organic Soil %                                  | 0.00        | 0.00        | 0.00     |

*Table 2. Max Tread Volume Differences Between February, 2022 and June, 2022 - Randomly Systematic Transects*

As with matrix based transects, it is also important to note that all randomly systematic transects were established in the winter of 2022 with roughly 5 months between the initial and final collection period. Naturally this is likely to result in smaller disturbance numbers due to less time being monitored; however, long term this is likely to be inconsequential. In regard to Pine Forest, transects along this trail reports a loss on average of  $23 \text{ cm}^2$  or  $0.002 \text{ m}^2$ . This equates to roughly a  $1.85 \text{ m}^3$  soil loss over the entire length of the trail (0.5 miles or 805 meters) between February and June. Turkey Trot reported a sizable gain of  $202.5 \text{ cm}^2$  or  $0.020 \text{ m}^2$  on average equating to a total estimated gain of  $19.55 \text{ m}^3$  across the length of the trail (0.6 or 966 meters) between February and June. And finally, Crosscut reported an average loss of  $108.33 \text{ cm}^2$  or  $0.011 \text{ m}^2$  on average, this equates to a total estimated loss of  $12.20 \text{ m}^3$  across the length of the trail (0.7 miles or 1127 meters).

Naturally these numbers are likely to ebb and flow as time progresses, trail use patterns shift, and seasons change. At this point in the early stages of monitoring there is little that can be drawn from the trends present. However, as time progresses and future measurements are taken soil disturbance trends are likely to reveal themselves.

#### ----- 4.2 - Soil Loss: Matrix Transects -----

In addition to monitoring overall soil disturbance levels, as part of the groundwork for future research, a matrix comparing landform grade (LG) and trail grade (TG) was utilized for the placement of 63 transects. In particular this matrix was utilized in an effort to determine if LG and TG have an impact on soil loss at the site level. This matrix, although slightly different to accommodate for the conditions at McDonald Hollow, was developed in collaboration with Dr. Jeffrey Marion and is based upon a similar matrix used in the final study report “Assessing the

Condition and Sustainability of the Trail System at Tallgrass Prairie National Preserve ”  
published recently by Marion, Johanna Arredondo, and Fletcher Meadema in June of 2022.

## Sustainability -----

Based on the landform grade and trail grade method of defining sustainability outlined in Marion, Arredondo, and Meadema 2022, the following chart depicts how transects located along Ida May, Wilkes Wood, and Blunderbuss compare in terms of sustainability. Data collected as part of our initial field survey in the Fall of 2021 was used to detail site sustainability, full data can be found in *appendix xiv*.

| Trail Grade Categories (%) | Landform Grade Categories (%)                                |            |                |            |                |            |                |            |                |            |                |            |                |            |                |            | ALL |       |
|----------------------------|--------------------------------------------------------------|------------|----------------|------------|----------------|------------|----------------|------------|----------------|------------|----------------|------------|----------------|------------|----------------|------------|-----|-------|
|                            | 0 - 2                                                        |            | 2.1 - 5        |            | 5.1 - 10       |            | 10.1 - 15      |            | 15.1 - 20      |            | 20.1 - 25      |            | 25.1 - 30      |            | 30+            |            |     |       |
|                            | # of Transects                                               | % of Total | # of Transects | % of Total | # of Transects | % of Total | # of Transects | % of Total | # of Transects | % of Total | # of Transects | % of Total | # of Transects | % of Total | # of Transects | % of Total |     |       |
| 0-2                        | 0                                                            | 0.00       | 0              | 0.00       | 2              | 3.17       | 3              | 4.76       | 5              | 7.94       | 0              | 0.00       | 3              | 4.76       | 4              | 6.35       | 17  | 26.98 |
| 2.1-5                      |                                                              |            | 0              | 0.00       | 0              | 0.00       | 0              | 0.00       | 4              | 6.35       | 3              | 4.76       | 0              | 0.00       | 4              | 6.35       | 11  | 17.46 |
| 5.1-10                     |                                                              |            |                |            | 1              | 1.59       | 1              | 1.59       | 2              | 3.17       | 1              | 1.59       | 0              | 0.00       | 3              | 4.76       | 8   | 12.70 |
| 10.1-15                    |                                                              |            |                |            |                |            | 2              | 3.17       | 0              | 0.00       | 1              | 1.59       | 1              | 1.59       | 3              | 4.76       | 7   | 11.11 |
| 15.1-20                    |                                                              |            |                |            |                |            |                |            | 2              | 3.17       | 2              | 3.17       | 1              | 1.59       | 2              | 3.17       | 7   | 11.11 |
| 20.1-25                    |                                                              |            |                |            |                |            |                |            |                |            | 3              | 4.76       | 1              | 1.59       | 4              | 6.35       | 8   | 12.70 |
| 25.1-30                    |                                                              |            |                |            |                |            |                |            |                |            |                |            | 2              | 3.17       | 2              | 3.17       | 4   | 6.35  |
| 30+                        |                                                              |            |                |            |                |            |                |            |                |            |                |            |                |            | 1              | 1.59       | 1   | 1.59  |
| ALL                        | 0                                                            | 0.00       | 0              | 0.00       | 3              | 4.76       | 6              | 9.52       | 13             | 20.63      | 10             | 15.87      | 8              | 12.70      | 23             | 36.51      | 63  | 100   |
| Color Coding               | Sustainable: Low 3 2 1 High<br>Unsustainable: Low 4 5 6 High |            |                |            |                |            |                |            |                |            |                |            |                |            |                |            |     |       |

**Table 3. McDonald Hollow Transects placed into a “Triangle Table” from Marion, Arredondo, and Meadema, 2022.**

|           |                                                                                                                                                                                                                                                                                                        |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 (14.29) | <b>High Sustainability:</b> Side-hill trail alignment with a gentile grade (2 - 5%) in steep (>15% landform grades with steep off-trail slope that compel trail users to remain on the trail while facilitating tread drainage                                                                         |
| 2 (6.39)  | <b>Moderate Sustainability:</b> include segments with gentile trail grades in moderately steep landform grades or moderate trail grades in very steep landform grades                                                                                                                                  |
| 3 (20.63) | <b>Low Sustainability:</b> Side-hill alignments have optimal trail grade (2-10%) located in landform grades that are one category steeper. These alignments ascend the landform more steeply making tread drainage somewhat more challenging and less-steep side-slopes may allow some tread widening. |
| 4 (26.98) | <b>Low Unsustainability:</b> Fall line trails with 5 - 15% trails and landform grades that inhibit drainage and allow tread widening, and steep grades in steep terrain (10-15%).                                                                                                                      |
| 5 (15.87) | <b>Moderately Unsustainable:</b> Trails in flat terrain (0 - 2%) due to poor drainage and susceptibility to tread widening, and fall-line trails in somewhat steeper 5-10% grade terrain where erosion easily occur                                                                                    |
| 6 (15.87) | <b>High Unsustainability:</b> Fall-line trails in very steep terrain (>15%) grades that will develop sustaintial erosion problems when vegetation cover is removed                                                                                                                                     |

**Table 4. Explanation of Trail Sustainability Indicators (Marion, Arredondo, Meadema, 2022)**

Based upon these calculations a sizable portion of transects are situated on sites that are either moderately or highly unsustainable. Of the 63 transects used, roughly 31.75% fell into categories that point to those segments not being sustainable long term (5&6). Findings also indicated that a sizable portion of transects were located at sites that were considered to be either moderately sustainable or highly sustainable (1&2), roughly 20.63%. With the remainder

of transects falling into borderline categories of low sustainability or unsustainability (3&4), roughly 47.62%. This is encouraging and highlights the fact that portions of Ida May, Wilkes Wood, and Blunderbuss are sustainable and are likely to hold up to use over time. However, to fully capture the sustainability of these trails future research is likely needed in which transects are equitably distributed across the length of these trails. Due to the method in which sites were chosen and the unavoidable bunching of transect sites, the inclusion of additional transects are likely needed to fully highlight the sustainability of these trails.

#### **Matrix Transects: Soil Loss -----**

Beyond trail sustainability, it is also important to look at overall soil change among transects within the original matrix outlined above and in chapter 1.

| <b>Trail Grade</b> | <b>Landform Grade</b>                 |                                      |                            |
|--------------------|---------------------------------------|--------------------------------------|----------------------------|
|                    | <b>0-19%</b>                          | <b>20-30%</b>                        | <b>32+%</b>                |
| <b>0-4%</b>        | 4, 10, 13, 18, 34, 36, 38, 39, 48, 53 | 9, 15, 19, 20, 32, 46                | 3, 27, 28, 44, 56, 57, 60  |
| <b>5-16%</b>       | 7, 11, 12, 30, 33, 37, 40             | 2, 5, 16, 47, 50, 51                 | 1, 21, 23, 24, 25, 59      |
| <b>&gt;17%</b>     | 31                                    | 6, 8, 14, 17, 35, 42, 45, 52, 55, 58 | 22, 26, 29, 41, 43, 49, 54 |

*Figure 8. Transect Numbers by Quadrant of LG vs TG Matrix*

| <b>Trail Grade</b> | <b>Landform Grade</b> |               |             |
|--------------------|-----------------------|---------------|-------------|
|                    | <b>0-19%</b>          | <b>20-30%</b> | <b>32+%</b> |
| <b>0-4%</b>        | 358.50                | 17.33         | -183.57     |
| <b>5-16%</b>       | 135.71                | -40.83        | -261.00     |
| <b>&gt;17%</b>     | -355.00               | 113.00        | 28.57       |

*Table 9. Average Soil Difference (cm<sup>2</sup>) per Matrix Quadrant*

Table 9 illustrates the average tread difference between the Fall of 2021 and Summer of 2022. In general it can be said that as trail grade increases so does the rate of disturbance. However, the same can not be said of landform grade as it increases. Due to the apparent weak correlation between these two factors I would argue that another factor has a stronger impact on overall soil loss at McDonald Hollow. That being said, these results do make it clear that soil is being impacted in sizable amounts along the trails at McDonald Hollow, but there doesn't appear to be a pattern from the data collected at this point. Further collection periods and research investigating other impact factors is likely to make patterns more evident and shine light on soil erosion and deposition moving forward.

#### ----- 4.3 - Conclusion -----

This initial look at soil erosion and deposition at McDonald Hollow has returned results that are insightful. It is clear that over the course of this initial monitoring period all trails at McDonald Hollow have shifted and changed, some more than others. Surprisingly, transects located along Ida May, Wilkes Wood, and Blunderbuss paint a picture of trails that are a mix of sustainable and unsustainable sites. This is counter to the preconceived notion that these trails were designed in a sustainable manner; however, this may need to be taken with a grain of salt. It is likely that additional transects located more equitably across the length of the trail may paint these trails in a more flattering light, but regardless at worst it appears that portions of these trails are non-sustainable and are likely to pose management challenges moving forward. Likewise, using matrix based transects as a guide, there does not appear to be a clear correlation between landform grade and trail grade when it comes to erosion and deposition. Although all efforts were taken to insure transects were spaced equidistant from each other, it is likely that due to



bunching results may be skewed. Therefore it is likely that future work at McDonald Hollow needs to place transects in a more equitable manner across Ida May, Wilkes Wood, and Blunderbuss. Future collection periods may bring about clearer insights in regard to trail erosion and deposition, but at this point conclusions are hard to draw.

## **Conclusion**

After this initial round of monitoring at McDonald Hollow the trails have revealed a myriad of findings, some intriguing and some yet to reveal themselves.

In terms of visitor use, McDonald Hollow provides ample opportunity for those within the NRV to mountain bike, hike, enjoy nature, or engage in any number of activities. Among those polled it appears that users are generally happy with the trails, are satisfied with their experiences, and are likely to return. This paints a promising future for McDonald Hollow, and other neighboring trail networks, with an expanding user base of individuals who are better able to enjoy the benefits of outdoor recreation. However, it is also important to note the current user base of McDonald Hollow is not reflective of the community at large according to this initial survey.

Rather those actively using the trail are more likely to be white, male, and middle aged. This reflects current trends in mountain biking, but the fact remains that efforts may need to be taken to ensure more equitable access to outdoor recreation opportunities, like the McDonald Hollow Trail Network, within the NRV moving forward. In the same vein, this report has highlighted the fact that not all users fall into the category of “hiker” or “mountain biker” as previous thought prior to this project being implemented. Although these two user groups are sizable, they are by no means the majority of users. Therefore, it may be necessary to look beyond these two user groups for input on current development and future projects in order to best reflect and understand the opinions of all user groups.

In terms of trail impacts, McDonald Hollow has provided a wealth of information, but little in the way of actionable recommendations. This is to be expected with the shortened nature of this monitoring period and the overall goal of establishing baseline data, but a few inferences can begin to be made. First is the fact that all trails, to varying degrees, have seen overall soil erosion

or deposition. This is to be expected given the fact that the trail is exposed to the elements. However, the level of impact was not in line with what was to be expected, with no discernible pattern being observed between landform grade and trail grade. This is likely due to the shortened monitoring period, but continued monitoring will need to be conducted to bear this assumption out. Second, transects placed using a matrix based approach, when compared for trail sustainability, report that roughly half of transect sights are to some degree unsustainable. It is important to note that transects placed using the matrix were not randomly selected, rather they were placed in order to gauge the implications of landform grade and trail grade in regard to trail sustainability. In addition, transects within this dataset were placed in order to gauge soil disturbance at exceptionally “bad” portions of the trail and features of interest. As a result, it is likely that overall disturbance numbers are skewed by these specific sites. Taken in whole, measures of sustainability collected in this initial study do not necessarily mean that Ida May, Wilkes Wood, and Blunderbuss are unsustainable trails. Rather it points to the fact that sites at which transects were established are unsustainable. However, due to the placement of the transect along these trails, with many being bunched together, is it likely that a more equitable approach may be needed to confirm this initial finding fully address soil loss across the entirety of Ida May, Wilkes Wood, and Blunderbuss.

As an initial look at visitor usage and trail impacts, this report is the first glimpse or baseline for the continuation for monitoring at McDonald Hollow. It is likely that usage patterns, satisfaction level, as well as motivations and wear on the trail will change over time. Only time will tell, but in the meantime those that call the NRV home will continue to have McDonald Hollow as a prime opportunity to engage with nature, others, and themselves in the wilds of Southwest Virginia.

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## Appendices

### ----- Appendix i : Trail Intercept Script -----

**Interviewer:** *(Standing near the trailhead)*

**Trail User:** *(approaches with Mountain Bike)*

**Interviewer:** Hello! Good Afternoon, my name is [insert name], I am a graduate student at Virginia Tech. I'm out here today talking to trail users about their experience out here at the McDonald Hollow Trails. Do you have a moment to answer a few questions for me, it should only take about a minute?

< If Trail User Says NO >

**Interviewer:** Thank you. I appreciate your time. Have a great rest of your day.

< If Trail User Says YES >

**Interviewer:** Great! First question, what are you doing on the trail today?

**Trail User:** ANSWER

**Interviewer:** Is that what you typically do on the trails?

**Trail User:** ANSWER

< If Trail User Says NO >

**Interviewer:** Okay, what do you typically do on the trails?

**Trail User:** ANSWER

< If Trail User Says YES >

**Interviewer:** Great Okay. Next question, on scale from 0 to 7, on a typical week how many days do you visit the McDonald Hollow Trails?

**Trail User:** ANSWER

**Interviewer:** Okay, last question. Would you be interested in participating in a future survey that I will be sending out later this year?

< If Trail User Says NO to future survey >

**Interviewer:** That's alright, I appreciate you answering my questions today and I hope you have a great rest of your day!

**Trail User:** You too! *(rides off on Mountain Bike)*

< If Trail User Says YES to future survey >

**Interviewer:** Great! I'll have to collect some contact information so we'll be able to reach you in the Spring. What is your full name?

**Trail User:** ANSWER

**Interviewer:** And what is your email address?

**Trail User:** ANSWER

**Interviewer:** Thank you very much! We'll be in contact in the Spring, I hope you have a great rest of your day.

----- **Appendix ii : Phase 1 Survey** -----

| #  | Question                                                                                                                                    | Responses                                                                                                                                     |
|----|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | What are you doing on the trails today?                                                                                                     | <input type="checkbox"/> <b>Hiking</b><br><input type="checkbox"/> <b>Biking</b><br><input type="checkbox"/> <b>Other - fill in the blank</b> |
| 2  | Would you say the activity you noted above is the primary activity you engage when visiting the McDonald Hollow Trails?                     | <input type="checkbox"/> <b>Yes</b><br><input type="checkbox"/> <b>No</b>                                                                     |
| 3  | If you answered NO to Question 2 what is your primary activity engaged (if you answered YES answer N/A)                                     | <b>Fill in the Blank</b>                                                                                                                      |
| 4  | On a typical week how many days do you visit the McDonald Hollow Trail?                                                                     | <p align="center"><b>Days Visited</b></p> <p align="center">  0   1   2   3   4   5   6   7  </p> <p align="center">----- -----</p>           |
| 5  | Would you be interested in helping with a more detailed survey that I'll be sending out in the Spring?                                      | <input type="checkbox"/> <b>Yes</b><br><input type="checkbox"/> <b>No</b>                                                                     |
| 6  | What is your name? (First and Last)                                                                                                         | <b>Fill in the Blank</b>                                                                                                                      |
| 7  | How would you like to be contacted?                                                                                                         | <input type="checkbox"/> <b>Email</b><br><input type="checkbox"/> <b>Text Message</b><br><input type="checkbox"/> <b>Phone Call</b>           |
| 8  | Email?                                                                                                                                      | <b>Fill in the Blank</b>                                                                                                                      |
| 9  | Cell Phone Number?                                                                                                                          | <b>Fill in the Blank</b>                                                                                                                      |
| 10 | <b>Parks and Recreation:</b> Would you be interested in volunteering to support the upkeep of this trail?                                   | <input type="checkbox"/> <b>Yes</b><br><input type="checkbox"/> <b>Maybe</b><br><input type="checkbox"/> <b>No</b>                            |
| 11 | <b>Parks and Recreation:</b> Would you be willing to support the development of this and future trails through personal monetary donations? | <input type="checkbox"/> <b>Yes</b><br><input type="checkbox"/> <b>No</b>                                                                     |

----- **Appendix iii : Contact Emails** -----

**Initial Contact Email: March 21, 2022**

Dear [insert name here],

My name is Matthew Lindsay, a graduate student working within the Department of Forest Resources and Environmental Conservation at Virginia Tech, and I'd like to ask for your help with a project I'm working on at Brush Mountain. You may recall meeting me at the trailhead in the Fall or seeing my name on a QR code sign while hiking or mountain biking. Regardless, I want to personally thank you for your willingness to participate in my research on the McDonald Hollow Trail Network here in Blacksburg. Your input, opinions, and experiences are vital in understanding how visitors, like yourself, are using and enjoying the trails, so I greatly appreciate you taking the time to sit down and complete my survey to the best of your ability.

To that end, I have designed an online survey to gauge your experience, motivations, and usage at McDonald Hollow. It should take roughly 10 to 15 minutes to complete. Feel free to take the survey at your own pace and convenience. I ask that you attempt to fill out the survey in its entirety, but if there are any questions that you feel uncomfortable answering feel free to skip that question and move on to the next. Each survey will be anonymized, therefore any responses you provide can not, and will not, be linked to you.

Again, your response to this survey will help myself, the Town of Blacksburg, and trail organizations like the Poverty Creek Trails Coalition better understand how visitors are using the trail, why they are using the trails, and where improvements can be made to the network. This information will not only help inform stakeholders on current usage patterns at McDonald Hollow, it allows for planning and maintenance for future trail development in and around Blacksburg, particularly on Brush Mountain.

If you have any questions about this project, feel free to contact me directly at mattlind@vt.edu. I am more than happy to answer any and all questions. In lieu of contacting me directly, you are welcome to contact my supervisor, Michael Sorice, at msorice@vt.edu as well.

Again, thank you very much for your time and help.

Link to survey: [ **Insert Link Here**]

Always,

Matthew C. Lindsay  
Project Director, McDonald Hollow Trails Project  
Virginia Tech - Masters of Forestry Candidate (2022)  
Virginia Tech - Bachelors of Political Science & Geography (2019)

**First Follow Up Email: March 24, 2022**

Dear [insert name here],

Early last week I sent an email asking for your help with my research on visitor use at McDonald Hollow. If you have already completed the survey thank you very much. If not, feel free to complete the survey at your earliest convenience by following the link below:

**[Insert link here]**

Again, your participation in this survey is completely voluntary but your participation is greatly appreciated. By participating you will help inform and guide development at McDonald Hollow, which at the end of the day will provide you and I more enjoyable, exciting, and memorable experiences.

Always,

Matthew C. Lindsay  
Project Director, McDonald Hollow Trails Project  
Virginia Tech - Masters of Forestry Candidate (2022)  
Virginia Tech - Bachelors of Political Science & Geography (2019)



**Second Reminder Email: March 30, 2022**

Dear [insert name here],

Recently I sent you an email asking you to complete a survey about your usage, motivations, and experiences at the McDonald Hollow Trail Network. If you've already completed this survey, thank you very much, your participation is greatly appreciated. Your answers are helping guide future development at Brush Mountain.

If you have not responded to the survey yet, I'd like to urge you to do so. This survey should only take about 10-15 minutes to complete. Simply follow the link below to begin your survey.

**[Insert link here]**

Although this survey is relatively short, it is very important in noting the who, what, when, where, and why of how visitors, like you, are interacting with the trail. This not only helps guide current maintenance and development efforts, it will also help guide future development at McDonald Hollow and future trails on Brush Mountain. If you have any questions, comments, or concerns feel free to contact me, Matthew Lindsay, directly at (803) 804-0582 or [mattlind@vt.edu](mailto:mattlind@vt.edu).

Again, thank you for your help with this project.

Always,

Matthew C. Lindsay  
Project Director, McDonald Hollow Trails Project  
Virginia Tech - Masters of Forestry Candidate (2022)  
Virginia Tech - Bachelors of Political Science & Geography (2019)

**Third Reminder Email: April 21, 2022**

Dear [Insert Name Here],

A few weeks ago I contacted you asking for your help with the 2022 McDonald Hollow Visitor Use Survey. I am writing to you again today because your response to our survey still remains important in assessing how visitors, like yourself, are using and experiencing the McDonald Hollow Trail Network. I need your help to ensure that the results accurately represent who is using the trails, how the trails are being used, and why visitors are using the trails. By doing this, future development is far more likely to reflect the wishes, needs, and desires of trail users, like you and me.

To complete the survey, please click on the link below. You will then be redirected to an online questionnaire that should take no more than 10 minutes to complete.

**[Insert link here]**

Responses to the survey are kept confidential. Your privacy is of the utmost importance to me and our project team. With this in mind, all responses will be anonymized in order to protect your privacy. If you have any questions, comments, or concerns feel free to contact me, Matthew Lindsay, directly (803) 804-0582 or [mattlind@vt.edu](mailto:mattlind@vt.edu). In lieu of contacting me directly, feel free to reach out to the Project Supervisor, Dr. Michael Sorice, at [msorice@vt.edu](mailto:msorice@vt.edu).

Again, thank you for your help in completing this survey if you have already responded to the survey. If you have not done so already, please consider taking a few moments to share your thoughts. I would greatly appreciate it.

Always,

Matthew C. Lindsay  
Project Director, McDonald Hollow Trails Project  
Virginia Tech - Masters of Forestry Candidate (2022)  
Virginia Tech - Bachelors of Political Science & Geography (2019)

**Fourth and Final Reminder: April 28, 2022**

Dear [Insert Name Here],

I am writing this follow up email to you today after sending a message last week asking you to participate in the 2022 McDonald Hollow Visitor Use Survey. The survey period is drawing to a close and this will be the last reminder I will be sending about our survey. If you have yet to complete the survey, I ask you to complete our 10-15 minute questionnaire. The information you provide is vital in gauging visitor usage patterns, motivations, and experiences at McDonald Hollow.

Please feel free to complete the survey at your earliest convenience by following the link below.

**[Insert link here]**

I also want to let you know that if you are interested in seeing a summary of the results, we hope to have the results posted on Virginia Tech's ETD's website (<https://vtechworks.lib.vt.edu/handle/10919/5534>) in late August. In the meantime I want to personally thank you for participating in this study and hope you get the opportunity to take a walk, hike, or bike ride soon, especially with how beautiful it's been.

Always,

Matthew C. Lindsay  
Project Director, McDonald Hollow Trails Project  
Virginia Tech - Masters of Forestry Candidate (2022)  
Virginia Tech - Bachelors of Political Science & Geography (2019)

----- **Appendix iv : Trail Sensor Collection** -----

### ***Pedestrian Sensor Data Collection***

1. Locate Pedestrian Sensor
2. Located Metal Plate on the back of the post
3. Unscrew metal plate from the post, revealing the sensors storage unit
4. Remove sensor from protective housing
5. Insert shuttle into the sensor, data will download onto the shuttle (light will blink green)
6. Once the light moves to “Downloaded” position you are free to remove the shuttle
7. Return the sensor to its housing and reaffix the metal plate to the post
8. If the sensor is sticking out the front side of the post, ensure it is flush with the post by pressing it backwards

### ***Mountain Biker Sensor Data Collection***

1. The Mountain Bike Sensor should be located directly in front of the pedestrian sensor’s post. To make it easier to find a large rock was placed on top of the sensor.
2. Once the rock is found, remove the rock, and with a trowel dig roughly 3” to 6” into the trailbed
3. Doing this will reveal the sensor's housing surrounded by a sandwich bag (used for additional water protection). It’s wise to bring a bottle of water to rinse the bag off, but it’s not necessary.
4. Remove the sensor housing from the ground
5. Unzip the sandwich bag and remove the sensor from the bag
6. Unlatch the sensors housing and remove the sensor
7. Insert the shuttle into the sensor, data will begin to download onto the shuttle
8. Once the light moves to the “Downloaded” position you are free to remove the shuttle
9. Return the sensor the its housing, and place the housing back inside the sandwich bag ensuring it is securly zipped
10. Place the sensor back into the ground, you may have to dig to ensure the sensor has enough room, and cover it thoroughly.

11. Place the rock back on top of the sensor and return the trailbed to a state as close to the one you found as possible.

### ***Retrieving Sensor Data***

1. Prior to retrieving the data from the shuttle it is important to ensure the computer you will be using has access to the software TRAFx. This software is essential to retrieving the data and without it you will not be able to move forward with the preceding steps.
2. After confirming you have access to TRAFx, connect the shuttle you used to collect your data to your computer. This may have to be done through a series of adapters.
3. Launch the TRAFx application.
4. Once launched and connected, the data will then be transferred and you should be able to view it on your computer. If not, you may have not successfully transferred the data in the field.
5. You can then download the data using the “D” key. This will, ideally, download both the pedestrian and mountain bike data into one file.
6. Once this is done and you feel confident you have gathered all necessary data feel free to wipe your shuttle clean by using the “E” key.
7. Once you have wiped the shuttle feel free to disconnect the shuttle from your computer.

## ----- Appendix v : Trail Sensor R-Code -----

```
---
title: "McDonald Hollow Trail Sensors"
output: html_document
---

```{r}
library(tidyverse)
library(lubridate)
```

```{r}
AllTraffic <- read_csv("McDonald_Hollow_ALL_StudyPeriod") %>%
  mutate(DateTime = paste(Date, Time), Count = as.numeric(Count)) %>%
  mutate(DateTime = ymd_hms(DateTime))

MTB <- read_csv("McDonald_Hollow_MTB_StudyPeriod") %>%
  mutate(DateTime = paste(Date, Time), Count = as.numeric(Count)) %>%
  mutate(DateTime = ymd_hms(DateTime))

#MTB2 <- read_csv("McDonald_Bottom_MTB2_7June21", skip = 14) %>%
# mutate(DateTime = paste(Date, Time), Count = as.numeric(Count)) %>%
# mutate(DateTime = ymd_hms(DateTime))

#MTB <- full_join(MTB1, MTB2, by = "DateTime")

#Test to see if the MTB counters are getting the same number: YES
#plot(MTB$Count.x, MTB$Count.y)
```

```{r}
DailyTraffic <- AllTraffic %>%
  group_by(year = year(DateTime), month = month(DateTime), day = day(DateTime)) %>%
  summarize(Count = sum(Count)) %>%
  mutate(Date = mdy(paste(month, day, year))) %>%
  mutate(DOW = wday(Date))

ggplot(DailyTraffic, aes(x = Date, y = Count/2))+
  geom_vline(xintercept = DailyTraffic$Date[DailyTraffic$DOW == 1], color = "grey")+
  geom_point()+
  geom_line()+
  theme_classic()+
  ylab("Users")+
  xlab(element_blank())+
  ggtitle("Daily Total Users, grey lines are Sundays")

```

```{r}
#Look at MTB and hikers separate

Combined <- full_join(AllTraffic, MTB, by = "DateTime") %>%
  mutate(MTB = Count.y, HIKER = Count.x - Count.y) %>%
  filter(DateTime < mdy("01-14-2022")) %>%
  mutate(HIKER = case_when(
    HIKER < 0 ~ 0,
    HIKER >= 0 ~ HIKER
  ))

DailyByUser <- Combined %>%
  group_by(year = year(DateTime), month = month(DateTime), day = day(DateTime)) %>%
  summarize(MTB = sum(MTB), HIKER = sum(HIKER)) %>%
  mutate(Date = mdy(paste(month, day, year))) %>%

```

```

ungroup()

DailyByUserLong <- DailyByUser %>%
  select(Date, MTB, HIKER) %>%
  pivot_longer(cols = c(MTB, HIKER)) %>%
  mutate(Count = value, User = name)

DailyByUserLong %>%
  ggplot(aes(x = Date, y = Count/2, fill = User)) +
  geom_bar(stat = "identity", position = "stack") +
  theme_classic()+
  ggtitle(paste("Estimated Total Recorded Users: ", sum(DailyByUserLong$Count)/2),
    subtitle = "Jan")
...

```{r, fig.width=4, fig.height=5}
# AllTraffic <- read_csv("McDonald_Bottom_ALL_StudyPeriod") %>%
#   mutate(DateTime = paste(Date, Time), Count = as.numeric(Count)) %>%
#   mutate(DateTime = ymd_hms(DateTime)) %>%
#   mutate(month = month(DateTime)) %>%
#   mutate(day = day(DateTime)) %>%
#   mutate(day = mdy(paste(month, day, "2021")))
#

AllTraffic <- AllTraffic %>% filter(Date >= "10-22-2021" & Date <= mdy("01-14-2022"))

TotalUsers <- sum(AllTraffic$Count)/2

DailyByUserLong %>% filter(Date <= mdy("01-14-2022") & Date >= mdy("10-22-2021")) %>% mutate(month =
month(Date)) %>%
  group_by(User, month = as.factor(month)) %>%
  summarize(count = sum(Count)/2) %>%
  ggplot(aes(x = month, y = count, fill = User))+
  geom_bar(stat = "identity", position = "dodge")+
  theme_classic()+
  ylab("Estimated Total Users")+
  ggtitle(paste("Total estimated users:", TotalUsers))

...

```{r}
DailyByUserLong %>% filter(Date <= mdy("01-14-2022") & Date >= mdy("10-22-2021")) %>% mutate(weekday =
wday(Date)) %>%
  group_by(User, weekday = as.factor(weekday)) %>%
  summarize(count = mean(Count)/2) %>%
  ggplot(aes(x = weekday, y = count, fill = User))+
  geom_bar(stat = "identity", position = "dodge")+
  theme_classic()+
  ylab("Estimated Total Users")+
  ggtitle(paste("Average total users per weekday"))

...

```{r}
ggplot(DailyByUserLong, aes(x = Date, y = Count/2, color = User))+
  geom_vline(xintercept = DailyTraffic$Date[DailyTraffic$DOW == 1], color = "grey")+
  geom_point()+
  geom_line()+
  theme_classic()+
  ylab("Users")+
  xlab(element_blank())+
  ggtitle("Daily Users, grey lines are Sundays")
...

```

## Appendix vi : Phase 2 Survey

4. What is your ZIP Code?

5. What year were you born?

6. What is your Gender Identity?

- ☐ Female
- ☐ Male
- ☐ Non-Binary / Third Gender / Genderfluid
- ☐ Gender not listed here
- ☐ Prefer not to say

7. Please select which of the following best describe your Race? (check all that apply)

- ☐ American Indian or Alaskan Native
- ☐ Asian
- ☐ Black or African American
- ☐ Hispanic / Latino / Spanish Origin
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White
- ☐ Prefer not to say

8. Are you of Spanish, Latino, or Spanish Origin?

- ☐ No - Not of Hispanic, Latino, or Spanish Origin
- ☐ Yes - Mexican, Mexican American, Chicano
- ☐ Yes - Puerto Rican
- ☐ Yes - Cuban
- ☐ Yes - Other Hispanic, Latino, or Spanish Origin

9. In the past 12 months, what activities have you engaged in while visiting McDonald Hollow? (check all that apply)

- ☐ Hiking
- ☐ Biking
- ☐ Walking
- ☐ Trail Running
- ☐ Dog Walking
- ☐ Horseback Riding
- ☐ Seeking Spiritual Connection
- ☐ Bird Watching
- ☐ Enjoying Nature
- ☐ Viewing Plants and/or Wildlife
- ☐ Activity Not Listed Here



10. How often do you engage in the following activities when visiting McDonald Hollow?

|                                | Never                    | Once in a while          | About half the time      | Most of the time         | Always                   |
|--------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Hiking                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Biking                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Walking                        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Trail Running                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Dog Walking                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Horseback Riding               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Seeking Spiritual Connection   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Bird Watching                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Enjoying Nature                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Viewing Plants and/or Wildlife | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|                                | Never                    | Once in a while          | About half the time      | Most of the time         | Always                   |
| Activity Not Listed Here       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

11. On a scale from 1 to 5 how much did the following activities impact your choice to visit McDonald Hollow?

|                                | Not Important At All     | Slightly Important       | Moderately Important     | Very Important           | Extremely Important      | N/A                      |
|--------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Hiking                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Biking                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Walking                        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Trail Running                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Dog Walking                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Horseback Riding               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Seeking Spiritual Connection   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Bird Watching                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Enjoying Nature                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Viewing Plants and/or Wildlife | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|                                | Not Important At All     | Slightly Important       | Moderately Important     | Very Important           | Extremely Important      | N/A                      |
| Activity Not Listed Here       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

12. During the Spring, Summer, and Fall of 2021 how many times did you visit McDonald Hollow on a typical week?

Days Visited 0 7

13. When you visit, how many hours do you typically spend on the trail per visit?

Hrs.  Mins.

14. Please note which trails you typically use when visiting McDonald Hollow:



15. Are you affiliated with an outdoor recreation group?

☐ Yes ☐ No

16. If you answered YES to the previous question, which outdoor recreation group(s) are you associated with?

- ☐ New River Valley Bicycle Association
- ☐ Blacksburg Striders
- ☐ Blue Ridge Gravity
- ☐ Blue Ridge Off Road Cyclists
- ☐ Ultra @ Virginia Tech
- ☐ NRV Chapter of Back Country Horsemen of America
- ☐ Group Not Listed Here

17. How would you rate the conditions of the trail? (Mark "N/F" if trail was not used)

|             | Very Poor             | Poor                  | Adequate              | Good                  | Very Good             | N/F                   |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| The Highway | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Pine Forest | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Ida May     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Wilkes Wood | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Turkey Trot | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Blunderbuss | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Crosscut    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

18. Is there adequate signage located along the trail?

- ☐ Yes
- ☐ No

19. Are the maps for the trails clear and easy to understand?

- ☐ Yes
- ☐ No

20. When typically visiting the trailhead, to what extent have you had issues finding parking?

|                          | Never                 | Rarely                | Sometimes             | Typically             | Every Time            |
|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Extent of Parking Issues | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

21. On your most recent trip to McDonald Hollow, how satisfied were you with your experience?

|                       | Very dissatisfied     | Not satisfied         | Neutral               | Satisfied             | Very satisfied        |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Level of Satisfaction | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

22. Based on the previous question, what most **POSITIVELY** impacted your enjoyment?

23. Based on the previous question, what most **NEGATIVELY** impacted your enjoyment?

24. Based upon previous visits to Brush Mountain, please rate the typical level of crowding you experience.

|                   | Not at all               | Somewhat Crowded         | Crowded                  | Very Crowded             |
|-------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Level of Crowding | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

25. Recreation Conflict is defined as any activity by another trail user that interferes with your ability to have the experience you wanted. Based upon this, to what extent have you experienced a conflict while visiting the trails?

|                     | Never                    | Once in a while          | About half the time      | Most of the time         | Always                   |
|---------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Conflict Experience | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

26. Based upon your previous visits, how would you rate the severity of the conflict you have experienced on a scale from 1 to 4?

|                   | Not Applicable (0)       | No Issue (1)             | Minor Issue (2)          | Moderate Issue (3)       | Major Issue (4)          |
|-------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Level of Severity | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

27. Based upon your past visits, how frequently have you experienced conflict?

|           | Never                    | Once in a while          | About half the time      | Most of the time         | Always                   |
|-----------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Frequency | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

28. Based upon your previous trips to McDonald Hollow, to what extent do you agree or disagree with the following statements?

|                                                       | Strongly disagree        | Disagree                 | Neutral                  | Agree                    | Strongly agree           |
|-------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| There are too many people on the trails               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other visitors are in my way                          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other visitors fail to be aware of others around them | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

29. Based upon previous trips to McDonald Hollow, to what extent do you agree or disagree with the following statements?

|                                                                                                | Strongly disagree        | Disagree                 | Neutral                  | Agree                    | Strongly agree           |
|------------------------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| I would recreate at McDonald Hollow more often if there were fewer Mountain Bikers             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I would recreate at McDonald Hollow more often if there were fewer Hikers/Pedestrians          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I choose to go to McDonald Hollow at times when I think there will be fewer Mountain Bikers    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| I choose to go to McDonald Hollow at times when I think there will be fewer Hikers/Pedestrians | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

30. Do you agree or disagree with the following statement: "Mountain Bikers bother me at McDonald Hollow".

|               | Strongly disagree        | Disagree                 | Neutral                  | Agree                    | Strongly agree           |
|---------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Agreeableness | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

31. Do you agree or disagree with the following statement: "Hikers/Pedestrians bother me at McDonald Hollow".

|               | Strongly disagree        | Disagree                 | Neutral                  | Agree                    | Strongly agree           |
|---------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Agreeableness | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

32. Do you agree or disagree with the following statement: "Mountain Bikers make me feel unsafe at McDonald Hollow".

|               | Strongly disagree        | Disagree                 | Neutral                  | Agree                    | Strongly agree           |
|---------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Agreeableness | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

33. Do you agree or disagree with the following statement: "Hikers/Pedestrians make me feel unsafe at McDonald Hollow".

|               | Strongly disagree        | Disagree                 | Neutral                  | Agree                    | Strongly agree           |
|---------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Agreeableness | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

34. How did you learn about the McDonald Hollow Trails?

- ☐ Social Media (Twitter, Facebook, etc.)
- ☐ Radio
- ☐ Paper Flyers
- ☐ Word of Mouth
- ☐ Newspaper
- ☐ Local Shops
- ☐ Recommended by a Friend
- ☐ Another Method Not Listed Here

35. What is **YOUR** overall perception of the McDonald Hollow Trail Network?

|            | Poor                     | Below average            | Average                  | Good                     | Excellent                |
|------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Perception | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

36. How would you rate this trail in comparison to other **LOCAL (NRV)** Mountain Biking trails?

|        | Much worse               | Somewhat worse           | About the same           | Somewhat better          | Much better              |
|--------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Rating | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

37. How would you rate this trail in comparison to other **REGIONAL (Mid-Atlantic)** Mountain Biking trails?

|        | Much worse               | Somewhat worse           | About the same           | Somewhat better          | Much better              |
|--------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Rating | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

38. How would you rate this trail in comparison to other **LOCAL (NRV)** Hiking trails?

|        | Much worse               | Somewhat worse           | About the same           | Somewhat better          | Much better              |
|--------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Rating | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

39. How would you rate this trail in comparison to other **REGIONAL (Mid-Atlantic)** Hiking trails?

|        | Much worse               | Somewhat worse           | About the same           | Somewhat better          | Much better              |
|--------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Rating | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

40. Do you plan on using the McDonald Hollow Trails again?

☐ Yes ☐ No

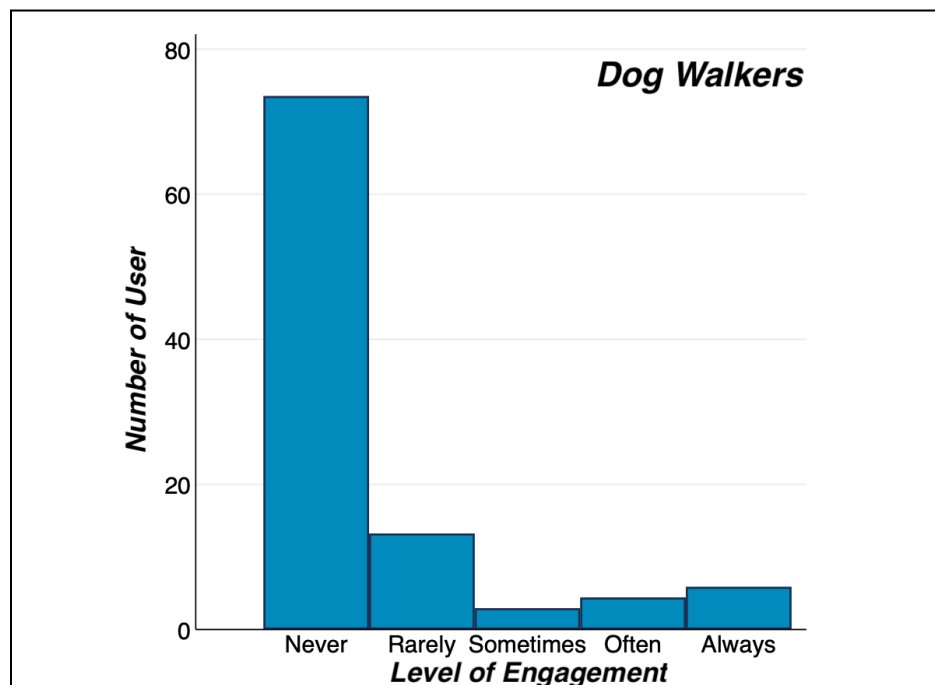
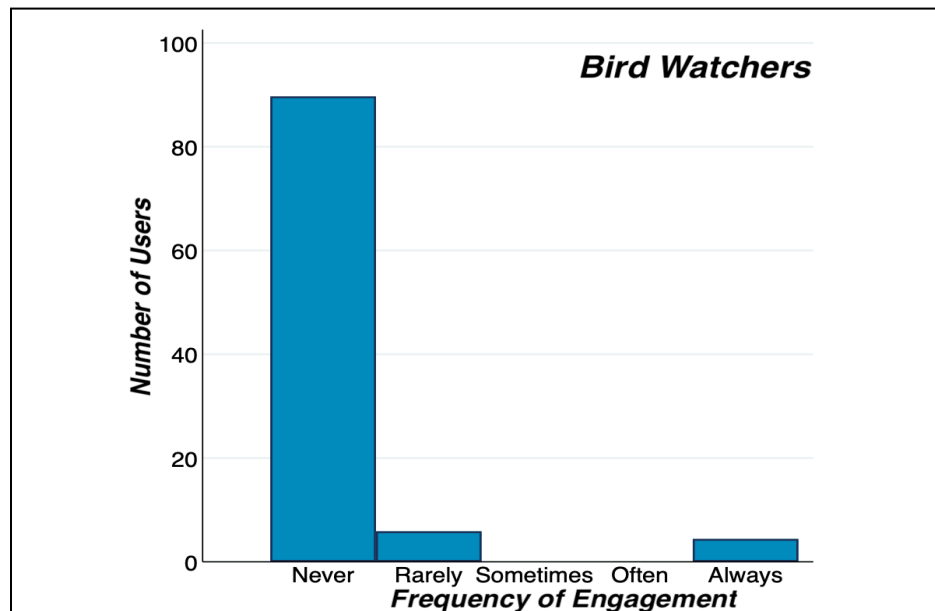
41. Based on the previous question, what is your reasoning for returning, or not returning, to the trails?

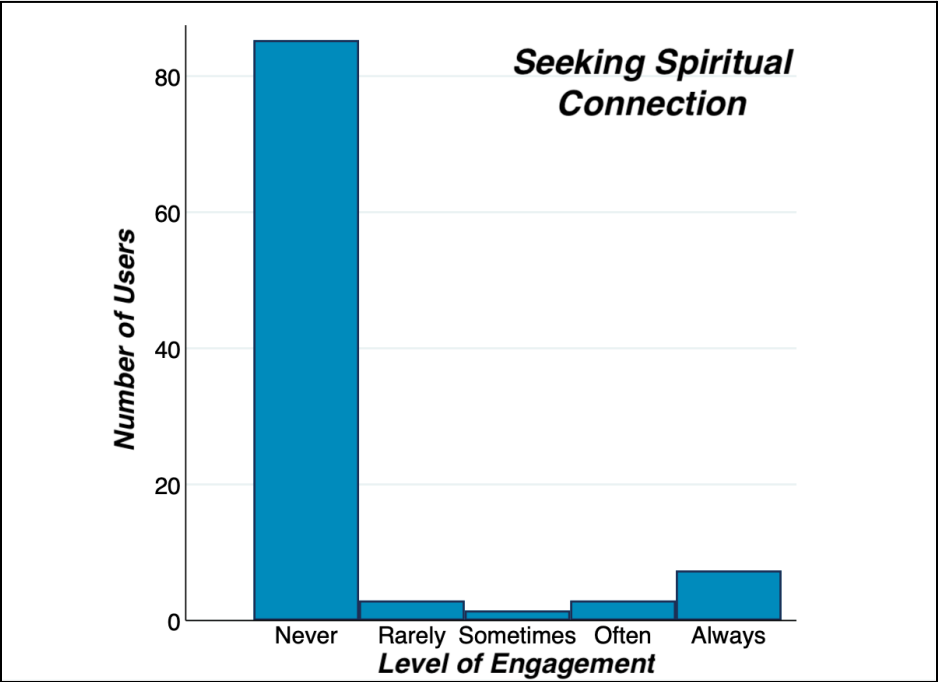
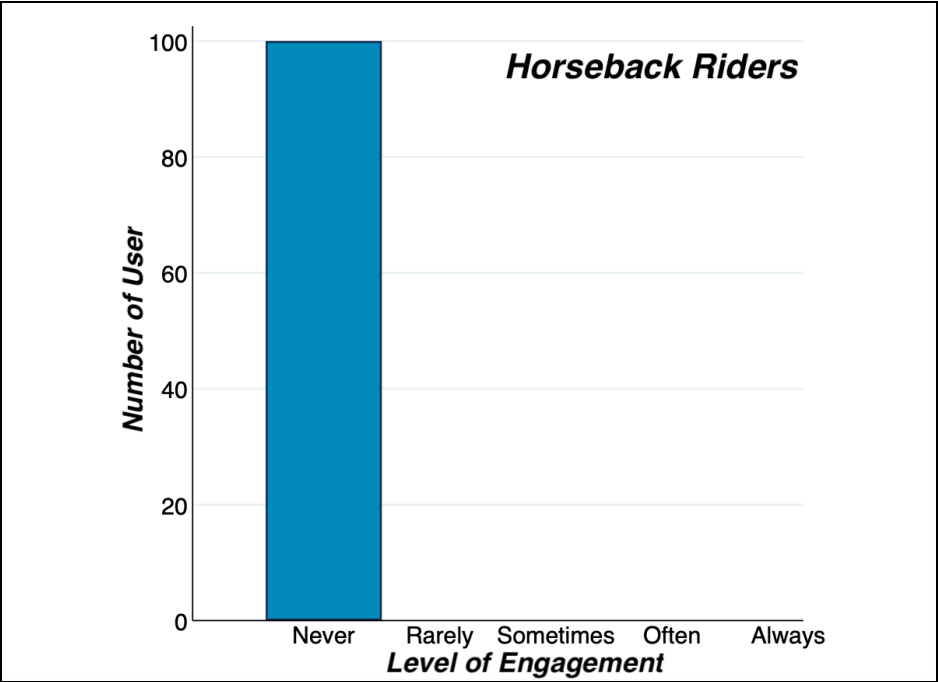
42. What amenities would you like to see from future development on Brush Mountain?

43. Would you be interested in volunteering to support the upkeep of this trail?

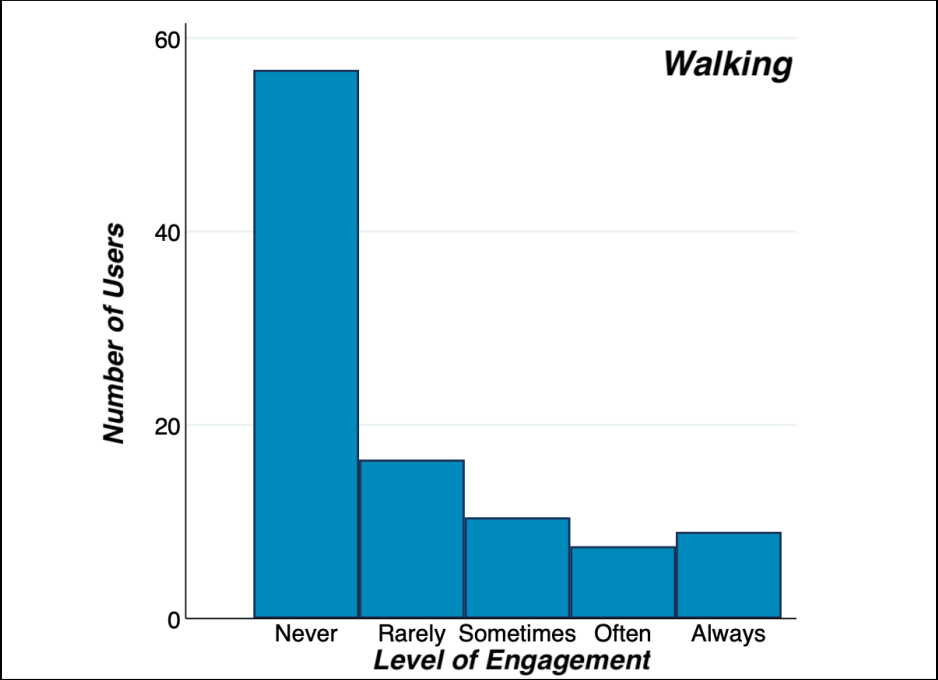
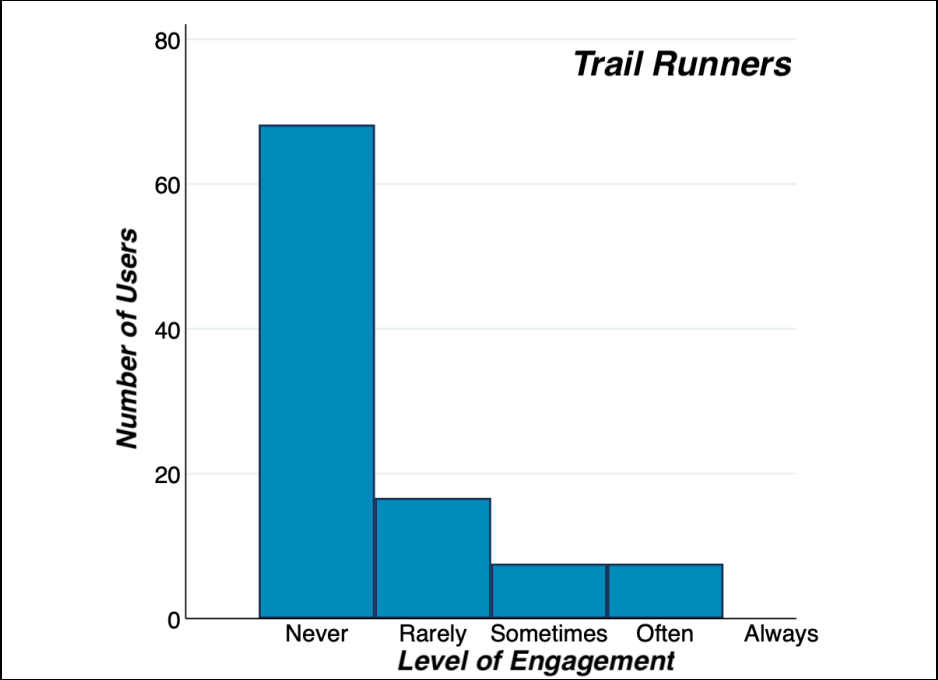
☐ Yes  
☐ No  
☐ I Already Volunteer

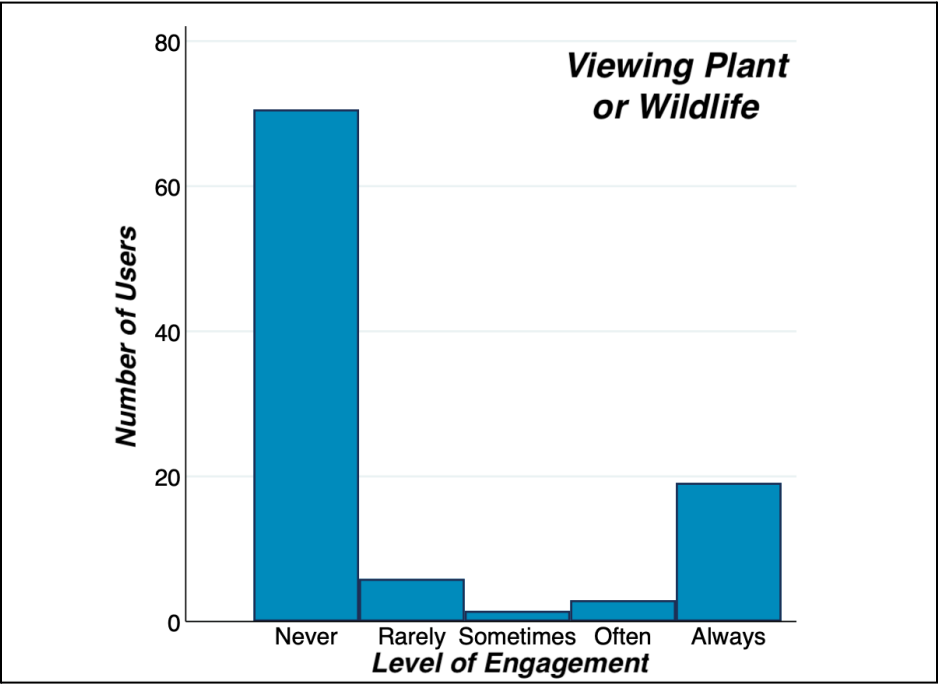
-----Appendix vii : User Engagement Frequencies -----



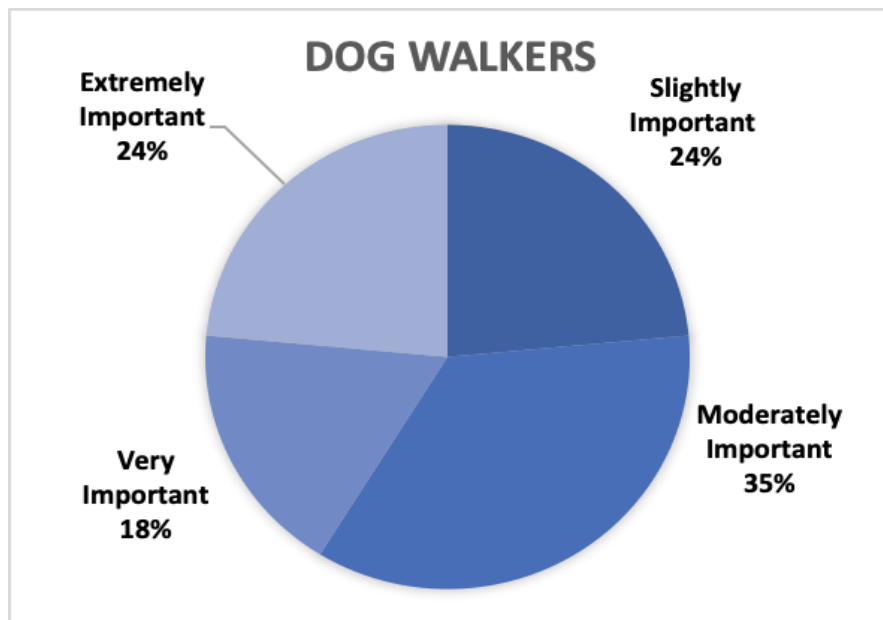
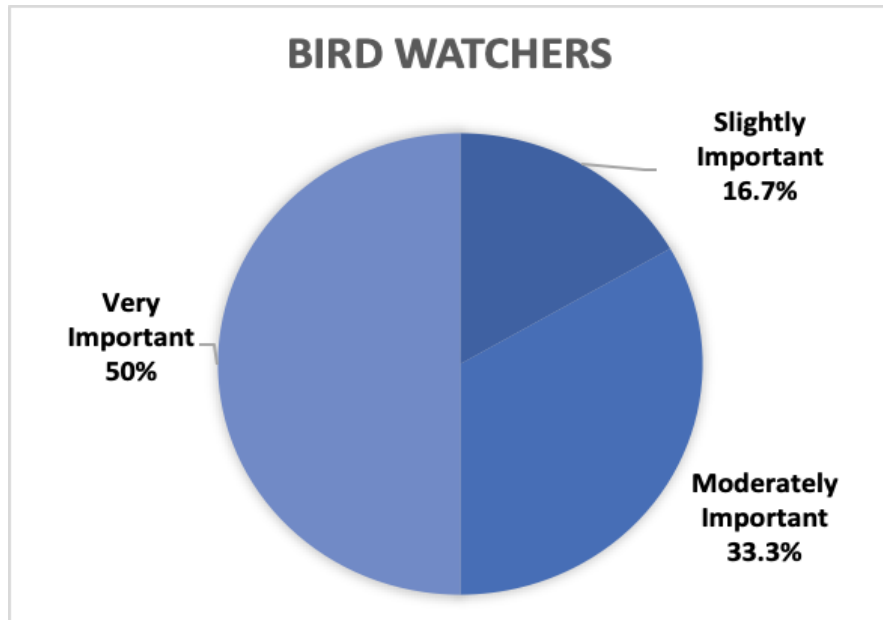




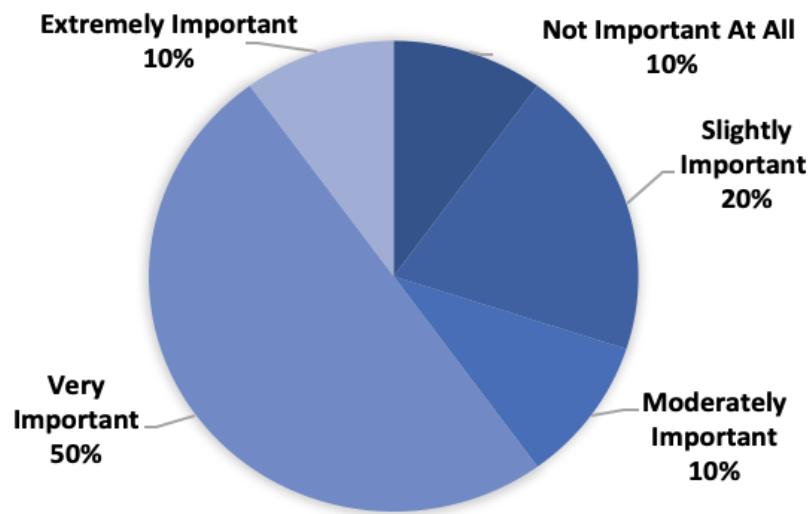




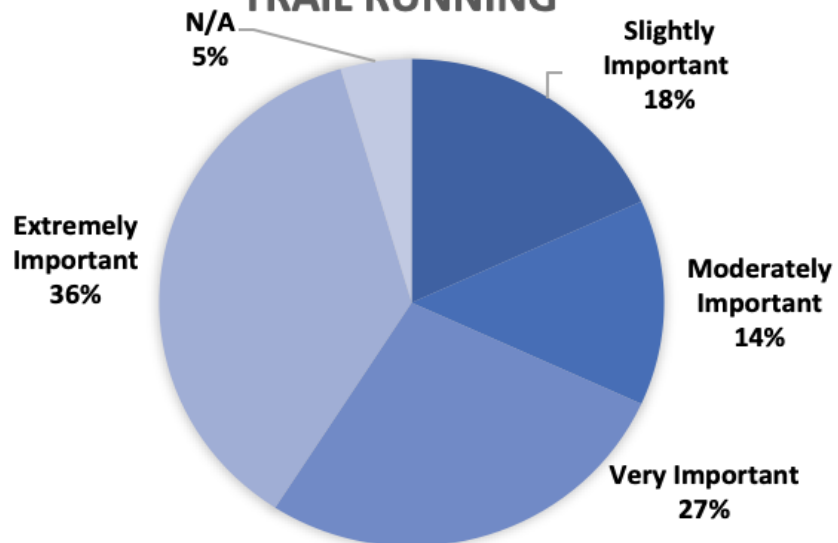
----- Appendix viii : Importance of Activity on Motivation -----

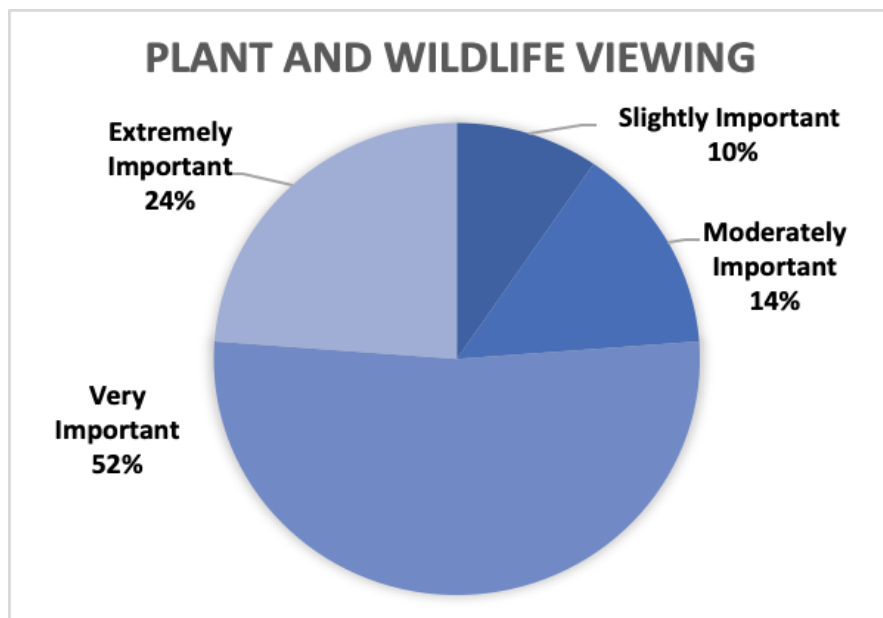
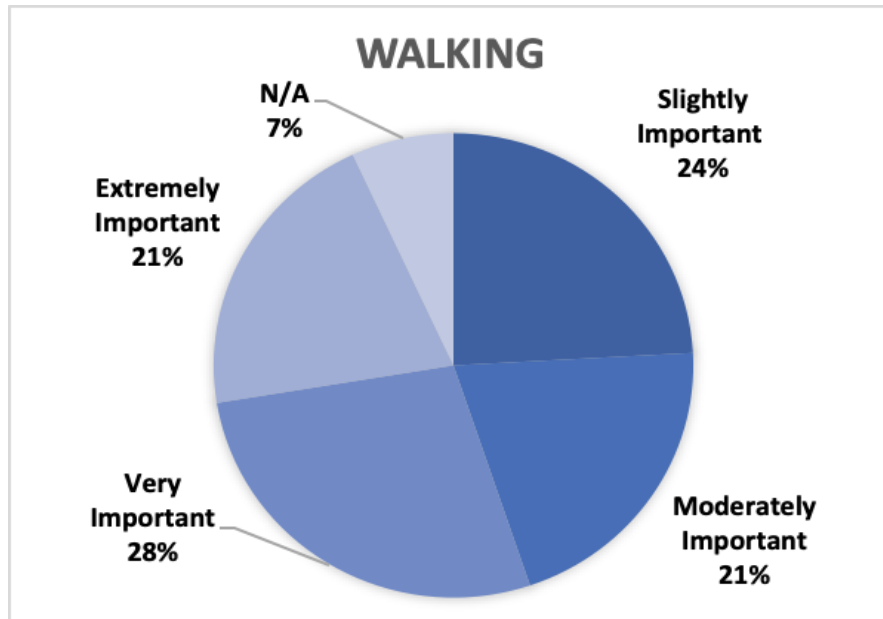


## SEEKING SPRITUAL CONNECTION

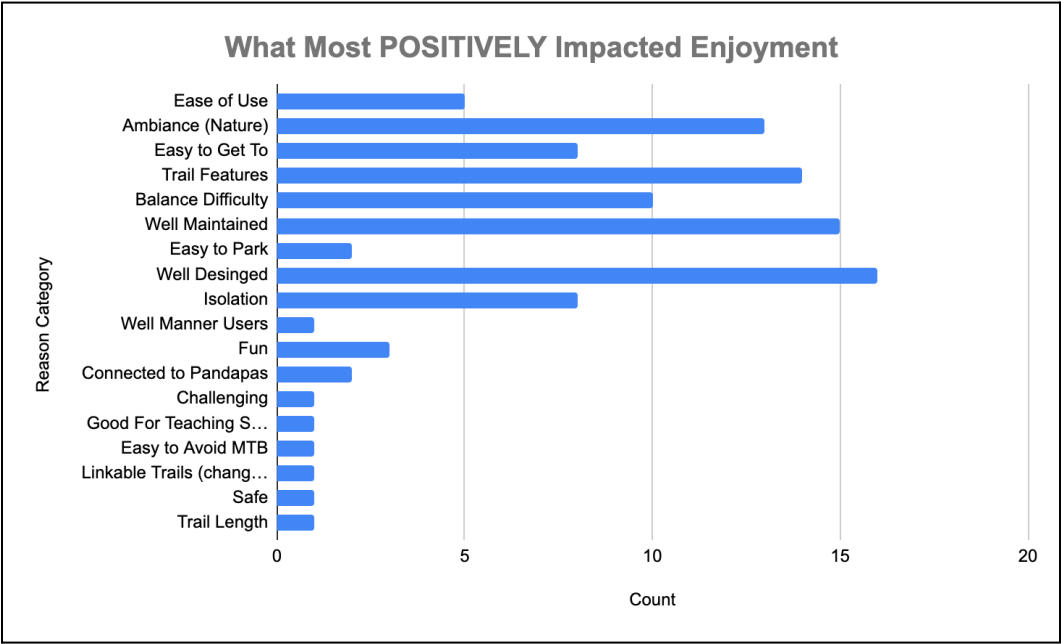


## TRAIL RUNNING

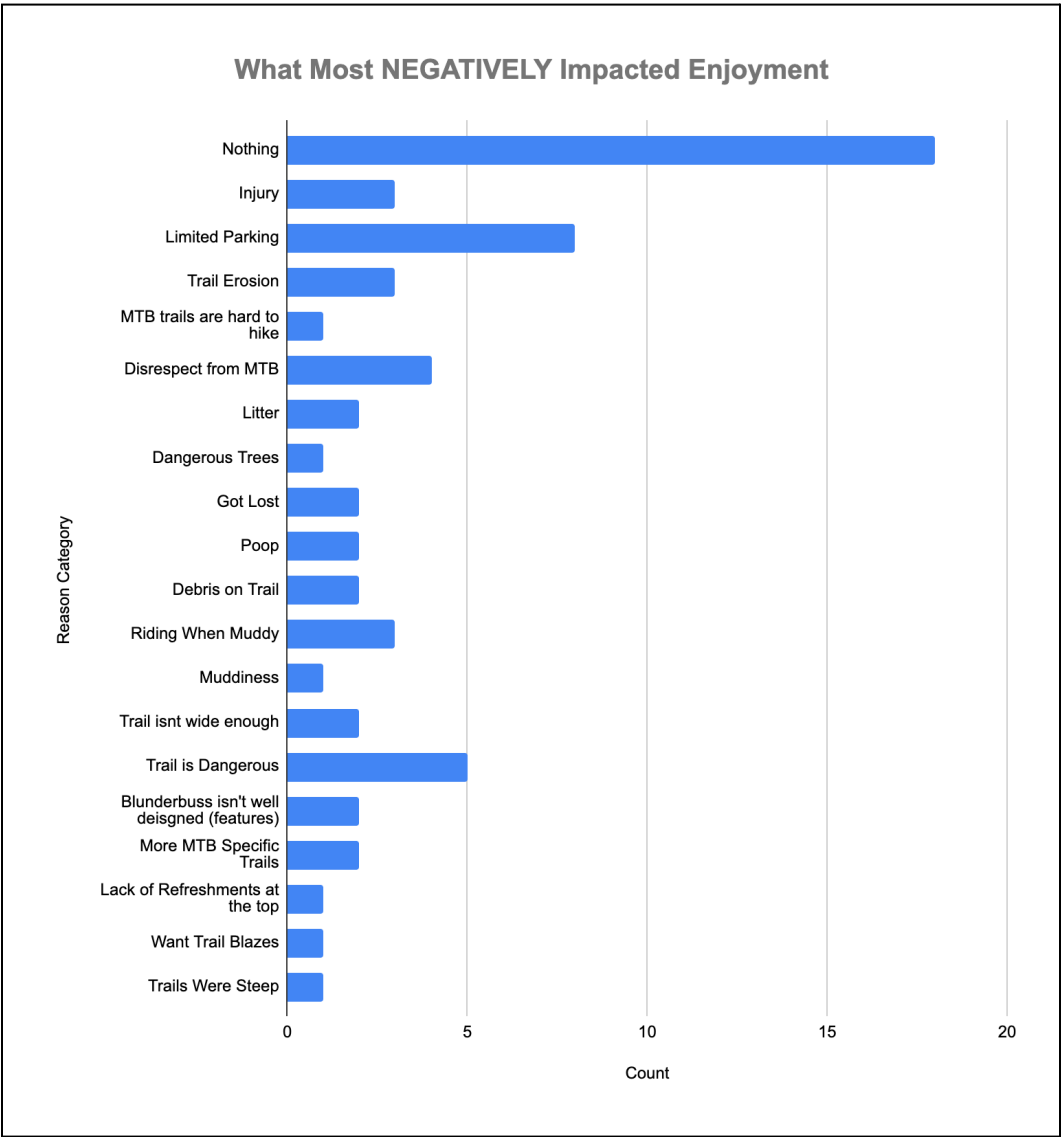




----- **Appendix ix : Positive Impacts on Experience** -----



----- **Appendix x : Negative Impacts on Experience** -----



----- Appendix xi : Trail User Wants and Needs -----

| Responses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A bathroom and more parking.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | larger parking area, paved path along Meadowbrook so I can connect it to BROWN Farm                                                                                                                                                                                                                                                                                                                        |
| safer access to the trailhead from town for pedestrians and bikes--greenway, sidewalks, bike lanes, etc.                                                                                                                                                                                                                                                                                                                                                                                                           | Increased parking                                                                                                                                                                                                                                                                                                                                                                                          |
| a trash can at the parking lot, portable bathrooms                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | I cannot think of any.                                                                                                                                                                                                                                                                                                                                                                                     |
| A lookout & view clearance near the top. Connection trail to the Huckleberry Trail. More annexing of NFS land.                                                                                                                                                                                                                                                                                                                                                                                                     | Seems more parking would be good. Connection to gateway lot via greenway. Restroom. Maybe a picnic table near the parking lot?                                                                                                                                                                                                                                                                             |
| No amenities necessary. More loop possibilities for hikers--maybe the new route to Gateway will make that happen.                                                                                                                                                                                                                                                                                                                                                                                                  | Would always love to see more trails! Additional parking would help with busy times. More signage to teach riders techniques on how to ride sections. More signage teaching trail etiquette such as Downhill riders yield to Uphill riders and pedestrians, standardized language to alert others of your approach, etc. More general knowledge to make the community a better place for all participants. |
| More bathrooms<br>some kind of water station.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | The more trails the better.                                                                                                                                                                                                                                                                                                                                                                                |
| After this survey, I wonder if there is potential to have some trails for hikers only and some for mountain bikers only - it may relieve some of the stress around avoiding the other users. Just a thought, as I personally would feel more comfortable taking my young son to a hike-only trail while he is still young and learning, rather than be worried he may get in the way of a biker (potentially hurting himself and the biker).                                                                       | More Tech and Jank                                                                                                                                                                                                                                                                                                                                                                                         |
| I'd like to see maps that also show both the Pandapas and the McDonald Trails.<br>The first time I hiked McDonald, I did Blunderbuss. I did not feel safe hiking this trail and will never hike it again. I would like to see this trail clearly designated MOUNTAIN BIKERS ONLY at all intersections with other trails. This would be no hardship on hikers -- there are plenty of other hiking options. And I'd be hopeful this would alleviate many of the safety concerns for both mountain bikers and hikers. | more mileage                                                                                                                                                                                                                                                                                                                                                                                               |
| Restroom                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | More dedicated mountain bike trails.                                                                                                                                                                                                                                                                                                                                                                       |
| A bathroom and more parking.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | None I can think of.                                                                                                                                                                                                                                                                                                                                                                                       |
| More trails, sitting areas/benches, and wildlife signs identifying plants and trees.                                                                                                                                                                                                                                                                                                                                                                                                                               | I'd love to see the addition of a bathroom at the McDonald hollow lot and possibly a bike repair station.                                                                                                                                                                                                                                                                                                  |
| Signage regarding the trails on the north side of the mountain                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Trail connectivity to the Prices Fork area to increase access to trails without having to locate parking. Restrooms. Benches. Water refill station.                                                                                                                                                                                                                                                        |
| Upkeep is fine                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Maybe a trash can near the entrance .                                                                                                                                                                                                                                                                                                                                                                      |
| Bahn (old fashioned lift) to take people/dogs to the top where a small concession hut is operated.                                                                                                                                                                                                                                                                                                                                                                                                                 | Maps that show the tie into the Gateway Trail and Pandapas pond. Doesn't make sense the map just shows it ends at the top when the fire road ties in to other places.                                                                                                                                                                                                                                      |



|                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Better trail (non-road) linkage to my area (Village at Tom's Creek). More trails, re-opening of Beauty, etc.                                                                                                                                                                                                             | Hiker/walker ONLY area.                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Bathrooms at the trail heads and more trail connection options into the Pandapas Pond system                                                                                                                                                                                                                             | None- keep it simple and trails well maintained like they are:).                                                                                                                                                                                                                                                                                                                                                                                   |
| Rest rooms at the parking lot. Larger parking lot. Map of larger trail systems at kiosk especially as newer trails come on line or as formerly illegal trails come into system. Trail connection along Meadowbrook to connect to parcel 2, Gateway, and Huckleberry Trail.                                               | More trails. More challenging, difficult trails.                                                                                                                                                                                                                                                                                                                                                                                                   |
| Additional parking. evenings fill the lot routinely. Why such a small paved area!?!                                                                                                                                                                                                                                      | A port-a-potty at the bottom, as there is for Gateway.                                                                                                                                                                                                                                                                                                                                                                                             |
| More parking, extended trail network                                                                                                                                                                                                                                                                                     | More parking & a Bathroom                                                                                                                                                                                                                                                                                                                                                                                                                          |
| More routes to the top of the ridge to help spread out the users. Before McDonald Hollow, Gateway was the only way up, and it was very, very heavily used. More routes to the top, with trail designs focused on different users (bikers, hikers, horses) should help ease the impact and reduce user conflict.          | Trail markings that match the same style (and frequency) as those at Pandapas Pond and nearby (plastic, color-coded markings). At least one trash can should be installed at the bottom of the trail system and it needs to be on the Town's pick-up schedule. As I stated earlier, an effort to have old plastic markings/ribbons on trees should be organized. Also, a trash pick up event(s) is needed, even though trash is relatively scarce. |
| more trails, mountain biker only trails                                                                                                                                                                                                                                                                                  | Restroom access                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Bathrooms, benches, bike racks                                                                                                                                                                                                                                                                                           | Bike tool station at the top of the mountain or at the main entrance much like the station at the skills park/gateway trail.                                                                                                                                                                                                                                                                                                                       |
| More trails                                                                                                                                                                                                                                                                                                              | Maps of trails at more locations on the highway                                                                                                                                                                                                                                                                                                                                                                                                    |
| bike repair station? Conditions guide signage indicating the present condition of certain trails? Some systems use these signs which users can adjust based on real time changes in condition. it may not keep folks OFF certain trails but in practice it can influence which trails they ride more often than nothing. | More trails, so that users can spread out. If there's a way to do it, trails that are designed for hiking and equestrian use, as well as bike use, so that hikers and horses can have a place to get away from bikers. (I try to be as careful as possible while biking, but I understand some folks may want a different experience).                                                                                                             |
| I would like to see the highway signs on the trail indicate direction. Such as this way to the parking lot vs to the top                                                                                                                                                                                                 | A climbing trail that is NOT the highway. Most bikers and hikers use the other trails to climb.                                                                                                                                                                                                                                                                                                                                                    |
| more flow trails                                                                                                                                                                                                                                                                                                         | Better bike repair station.                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Maybe some additional parking and restrooms/port-a-potties.                                                                                                                                                                                                                                                              | Restrooms, meeting spots for group rides.                                                                                                                                                                                                                                                                                                                                                                                                          |

----- **Appendix xii : CSA Core Tread Calculations** -----

**Average Soil Loss From Pre-Use At Each Monitoring Period (cm<sup>2</sup>)**

|        | Ida May | Wilkes Wood | Blunderbuss | Pine Forest | Turkey Trot | Crosscut |
|--------|---------|-------------|-------------|-------------|-------------|----------|
| Fall   | -33.49  | -102.85     | -66.25      |             |             |          |
| Spring | -40.59  | -141.97     | -99.09      | -115.00     | -87.50      | -60.83   |
| Summer | -70.15  | -141.40     | -124.30     | -129.00     | -97.97      | -55.85   |

**Estimated Total Soil Loss in Meters Cubed (m<sup>3</sup>) Since Pre-Use**

|        | Ida May | Wilkes Wood | Blunderbuss | Pine Forest | Turkey Trot | Crosscut |
|--------|---------|-------------|-------------|-------------|-------------|----------|
| Fall   | -25.40  | -51.75      | -63.29      |             |             |          |
| Spring | -23.52  | -58.46      | -63.37      | -32.11      | -45.06      | -27.79   |
| Summer | -29.09  | -54.54      | -112.96     | -33.31      | -43.93      | -28.54   |

**CSA Amounts for Transects (cm<sup>2</sup>)**

| Transect | Fall   | Spring | Summer |
|----------|--------|--------|--------|
| 1        | -20.00 | -30.00 | -30.00 |
| 2        | 15.00  | 0.00   | 5.00   |
| 3        | -83.23 | 52.50  | 340.00 |
| 4        | 60.00  | -35.00 | -15.00 |
| 5        | -45.00 | -55.00 | -35.00 |
| 6        | 197.50 | 115.00 | 197.50 |
| 7        | 60.00  | 10.00  | 20.00  |
| 8        | 277.52 | 322.52 | 287.50 |
| 9        | -50.00 | -40.00 | -65.00 |
| 10       | -10.00 | 25.00  | 30.00  |
| 11       | 115.00 | 80.00  | 95.00  |
| 12       | 140.00 | 65.00  | 60.00  |
| 13       | -30.00 | 27.50  | 10.00  |
| 14       | 62.51  | 87.51  | 122.50 |
| 15       | -35.00 | -15.00 | 15.00  |
| 16       | -15.00 | 15.00  | 35.00  |
| 17       | -70.00 | 65.00  | 120.00 |
| 18       | 46.43  | 157.14 | 187.14 |
| 19       | 30.00  | 90.00  | 74.00  |
| 20       | 155.00 | 155.00 | 170.00 |
| 21       | -13.00 | -30.00 | 15.00  |
| 22       | 142.50 | 215.00 | 257.50 |

|    |         |        |        |
|----|---------|--------|--------|
| 23 | -60.00  | 125.00 | 15.00  |
| 24 | -5.00   | 120.00 | 60.00  |
| 25 | -50.00  | 60.00  | 145.00 |
| 26 | -65.00  | -10.00 | -5.00  |
| 27 | -125.00 | 110.00 | 152.50 |
| 28 | 75.00   | 80.00  | 50.00  |
| 29 | 175.00  | 130.00 | 260.00 |
| 30 | 117.50  | 212.50 | 197.50 |
| 31 | 375.00  | 365.00 | 297.50 |
| 32 | 95.00   | 130.00 | 90.00  |
| 33 | 110.00  | 165.00 | 215.00 |
| 34 | 100.00  | 95.00  | 60.00  |
| 35 | 620.00  | 512.50 | 490.00 |
| 36 | 17.50   | -57.50 | -37.50 |
| 37 | 212.50  | 197.50 | 187.50 |
| 38 | 195.00  | 240.00 | 135.00 |
| 39 | 100.00  | 110.00 | 95.00  |
| 40 | -10.00  | 42.50  | 15.00  |
| 41 | 230.00  | 192.52 | 267.50 |
| 42 | 150.00  | 90.00  | 145.00 |
| 43 | -5.00   | -10.00 | 27.50  |
| 44 | 0.00    | 157.50 | 207.50 |
| 45 | -35.00  | 90.00  | 120.00 |
| 46 | 30.00   | 22.50  | 75.00  |
| 47 | 72.50   | 105.00 | 122.50 |
| 48 | 52.50   | 75.00  | 77.50  |
| 49 | 430.00  | 420.00 | 562.50 |
| 50 | 235.00  | 357.50 | 272.50 |
| 51 | 40.00   | 42.50  | 35.00  |
| 52 | -52.50  | 245.00 | NA     |
| 53 | 115.00  | 152.50 | 115.00 |
| 54 | 130.00  | 95.00  | 125.00 |
| 55 | 55.00   | 20.00  | 100.00 |
| 56 | 45.00   | 70.00  | 75.00  |
| 57 | 5.00    | 70.00  | 55.00  |
| 58 | 17.50   | 125.00 | 92.60  |
| 59 | 60.00   | 90.00  | 40.00  |
| 60 | 52.50   | 15.00  | 50.00  |
| 62 | 70.00   | -80.00 | 300.00 |

|    |        |        |        |
|----|--------|--------|--------|
| 63 | -35.00 | 0.00   | -70.00 |
| 64 | 25.00  | 27.51  | 82.60  |
| 65 |        | 30.00  | 25.00  |
| 66 |        | 65.00  | 75.00  |
| 67 |        | 120.00 | 100.00 |
| 68 |        | 315.00 | 385.00 |
| 69 |        | 45.00  | 60.00  |
| 70 |        | -22.50 | -65.00 |
| 71 |        | 105.00 | 165.20 |
| 72 |        | 90.00  | 112.60 |
| 73 |        | 17.50  | 10.00  |
| 74 |        | 220.00 | 255.00 |
| 75 |        | 115.00 | 110.00 |
| 76 |        | 75.00  | 37.60  |
| 77 |        | 60.00  | 80.00  |
| 78 |        | 20.00  | -2.50  |
| 79 |        | 215.00 | 190.00 |
| 80 |        | -50.00 | -20.00 |
| 81 |        | 45.00  | 50.00  |

----- **Appendix xiii : Area Calculation R-Script** -----

```

```{r}
library(tidyverse)

```{r}
summer_transects_max <- read_csv("Summer 2022 - Max Tread Soil Loss -
Max_Tread_Measurements.csv")

```{r}
measurement_interval = 10

summer_areas_max <- summer_transects_max %>%
  mutate(Depth_times_width = Depth_Measurement * 10) %>%
  group_by(Collection_Period, Transect) %>%
  summarize(summer_areas_max = sum(Depth_times_width))

head(summer_areas_max)

```

----- **Appendix xiv : Transect Trail and Landform Grades** -----

| <b>Transect<br/>Number</b> | <b>Trail slope<br/>(%)</b> | <b>Landform slope<br/>(%)</b> |
|----------------------------|----------------------------|-------------------------------|
| 1                          | 9                          | 45                            |
| 2                          | 16                         | 29                            |
| 3                          | 2                          | 54                            |
| 4                          | 1                          | 17                            |
| 5                          | 5                          | 23                            |
| 6                          | 21                         | 26                            |
| 7                          | 8                          | 15                            |
| 8                          | 25                         | 25                            |
| 9                          | 4                          | 20                            |
| 10                         | 0                          | 15                            |
| 11                         | 5                          | 16                            |
| 12                         | 11                         | 11                            |
| 13                         | 1                          | 19                            |
| 14                         | 23                         | 23                            |
| 15                         | 1                          | 29                            |
| 16                         | 6                          | 24                            |
| 17                         | 18                         | 25                            |
| 18                         | 4                          | 16                            |
| 19                         | 1                          | 28                            |
| 20                         | 3                          | 21                            |
| 21                         | 5                          | 38                            |
| 22                         | 22                         | 40                            |
| 23                         | 12                         | 34                            |
| 24                         | 6                          | 36                            |
| 25                         | 16                         | 40                            |
| 26                         | 29                         | 42                            |
| 27                         | 3                          | 44                            |
| 28                         | 2                          | 42                            |
| 29                         | 21                         | 40                            |
| 30                         | 8                          | 18                            |
| 31                         | 17                         | 19                            |
| 32                         | 4                          | 23                            |
| 33                         | 6                          | 17                            |
| 34                         | 1                          | 14                            |
| 35                         | 18                         | 20                            |
| 36                         | 0                          | 15                            |
| 37                         | 8                          | 9                             |
| 38                         | 1                          | 7                             |
| 39                         | 2                          | 8                             |
| 40                         | 12                         | 12                            |

|    |    |    |
|----|----|----|
| 41 | 28 | 32 |
| 42 | 21 | 25 |
| 43 | 13 | 37 |
| 44 | 7  | 35 |
| 45 | 22 | 30 |
| 46 | 1  | 28 |
| 47 | 14 | 30 |
| 48 | 2  | 18 |
| 49 | 44 | 44 |
| 50 | 13 | 21 |
| 51 | 5  | 20 |
| 52 | 20 | 27 |
| 53 | 1  | 16 |
| 54 | 25 | 32 |
| 55 | 20 | 21 |
| 56 | 3  | 31 |
| 57 | 2  | 40 |
| 58 | 30 | 30 |
| 59 | 13 | 40 |
| 60 | 1  | 44 |
| 62 | 26 | 26 |
| 63 | 20 | 40 |
| 64 | 3  | 36 |