

RMBL Research Proposal

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Title: The influence of human recreational trail use has on rodent and predator activity using motion triggered cameras.

Keywords: trail camera, live rodent trap, human activity, rodents, recreation

Abstract

The recreational trails in Gunnison County, Colorado near the Rocky Mountain Biological Laboratory (RMBL) are a valuable resource for the community. RMBL is a prominent field station surrounded by a largely intact ecosystem whose diverse native plants and animals are key to its scientific research and education programs. Human recreation near these areas generates touristic income for the surrounding cities. However, human recreation can lead to behavioral changes in wild animals. Knowing whether the current regulations being implemented on the trails are sufficient to protect the wildlife is imperative. Utilizing methods from RMBL studies conducted in 2019 and 2020, we studied the effects of human use of recreational trails on small mammals and predators. This three-part study used motion triggered cameras to (1) compare the effectiveness of the non-invasive bucket camera traps with live rodent trapping, (2) measure the impact that human activity on trails has on rodents, and (3) measure the impact that human activity on trails has on predators. We found that bucket traps and live-trapping both capture the same nocturnal species, but bucket traps also capture diurnal species. We determined that human recreation (hiking, biking, dogs) had no significant negative impact on rodents (either nocturnal or diurnal) or on the number of predators. There was a marginally significant increase of predators at Deer Creek Trail with human recreation, but no relationship between predator numbers and rodent numbers. We conclude that recreation in the vicinity of RMBL is not having a detectable negative effect on wildlife species diversity or activity.

Introduction

Humans take advantage of the natural resources provided by the planet, materials such as food, water, wood, fuel, and clothing. Non-material resources such as recreation, spiritual, education, and inspirational are also taken advantage of by humans (Milcu et al. 2013). Recreational trails provide the public access to the wilderness in a safe way and allows for a greater understanding of the environment. Hikers may expect to bird watch, sight-see, collect plants, or interact with animals. Humans clearly take advantage of all the benefits that recreational trails provide, generating \$80 billion in revenue in the U.S (USDA 2019). However, recreational trails can promote or cause trail proliferation, off-roading, vegetation trampling, and habitat alteration

(Muter et al. 2005). Research has shown that trails through meadows have less vegetation, more exposed soil and rock, and greater soil loss (Barros et al. 2013). These human activities can have a negative impact on the environment. Human disturbances can also have a negative impact on wildlife such as pollution and habitat modification (Knight and Cole 1995) and altering animal behaviors.

It is imperative we gain a better understanding of how the presence of humans in nature affects the organisms that inhabit the habitats near trails. The effect humans have on wildlife can be direct and indirect. Nocturnal small mammals that may never see a human can also be affected by the changes humans bring. There can be cascading effects through ecosystems- many carnivores depend on small mammal populations for their own food sources, so their abundance may influence the habitat selection and abundance of their prey. Leslie Macias, a former Rocky Mountain Biological Laboratory (RMBL) student, suggested that human activity may create a safe environment from predators for some mammals (Macias 2019). For example, a study mentions that a bear and her cubs stayed near humans to avoid aggressive male bears (Nevin and Gilbert 2005). These studies show that human presence can indirectly benefit prey species by causing predator displacement. In 2020, we studied how human use of recreational trails effects small rodent species richness and abundance. We found that trails with higher human use resulted in higher rodent abundance (Bermudez et al., 2020). These results were the opposite of what we predicted and led to my question for 2021. Looking more closely at how small mammals and predators are affected by human activity to better manage human use of recreational trails.

To observe the effects of recreational trails on small mammal and predator interactions, we used camera-trapping (images). With camera-trapping, the technology of infrared sensors and digital photography leads to cost-effective and noninvasive means of generating reliable detection of wildlife and their activity (Burton et al 2015). We used trail-cameras to record human and predator usage of trails. For small mammals, we used bucket camera-trapping. Bucket-camera trapping is a new technique, therefore we also tested its effectiveness in measuring small mammal diversity and abundance by comparing the results with the well-studied and established technique of live-trapping. Longworth live-traps were used on established long-term research grids (Dr. Rosemary Smith) to obtain data of small rodent activity. The Longworth live-traps are designed to minimize discomfort without endangering or having a substantial impact on the rodent. Comparing these two methods will further aid in understanding small rodent communities and the best methods to study them.

The aim of this study is to investigate how human use of recreational trails affects predator-prey interactions with differing levels of human activity and habitats. We will measure human activity, predator activity, and small rodent activity at four sites that vary in human usage (hiking and biking, dogs) and habitats (covered and uncovered). Covered habitats are aspen or conifer forest and uncovered habitats are meadows or open areas with no trees. Our null hypothesis is: Human use of recreational trails will not have an influence on predator-prey interactions. We hypothesize that trails with higher human activity will have lower predator activity, creating a safe haven for small rodents from predators along recreational trails, leading to higher rodent

species and activity/abundance. We also expect to see a difference in nocturnal and diurnal rodent responses to human recreation, based on direct and indirect interactions.

Methods

Study Site and Species

The study was conducted near Gothic, Colorado, USA at four trail sites: Deer Creek, 401, RMBL Shortcut, and Judd Falls. Signs of our study were placed at the beginning and end of our study locations at each public trail (“RMBL/UCLA wildlife-trail study. Motion sensitive game cameras ahead. Please do not disturb. Contact RMBL Science Director with questions. (970)349-7231, sd@rmbl.org.” Maxfield, Kettle Ponds, and Bellview meadows were used for the live rodent trapping grids. The sites were selected based upon the amount and type of recreational use (data from 2020) and excluded motorized recreation. Data from the recreational trail cameras was analyzed based upon the type of human activity, biking or hiking. The predators for small mammals that we expected to capture were red fox (*vulpes vulpes*), long-tailed weasel (*Mustela frenata*), marten (*Martes americana*), coyote (*Canis latrans*), and garter snakes (*Thamnophis sirtalis*); we also expect larger carnivores such as bears and lions. The expected diurnal species that would enter the bucket camera traps are golden-mantled ground squirrels (*Callospermophilus lateralis*) and least chipmunks (*Tamias minimus*). The nocturnal species that were expected are deer mice (*Peromyscus maniculatus*), Western jumping mice (*Zapus princeps*), and montane vole (*Microtus montanus*). See Table 2 for a complete species list of the animals that were captured by the cameras per site.

Recreational Camera Traps

The recreational trail cameras were used to capture human and predator activity. We deployed two recreational trail cameras per trail. Each trail camera was paired with two bucket camera traps. One recreational trail camera was in a covered habitat (aspen or conifer forest) and the other was in an uncovered habitat (tall vegetation, no trees). A map for each trail of the cameras locations has been made by Shannon Sprott, GIS/GPS Director at RMBL shown in Figures 1-3. The recreational trail cameras were moved to random locations each week along the trail. The cameras were deployed for five weeks (June 21- July 23, 2020) and retrieved July 26- 30, 2021. The cameras were placed on a stake or tree near the trail, facing at an angle of 45 degrees. Most of the cameras were placed less than a meter from the trail and less than a meter in height. A study found that setting cameras closer to the trail and lower to the ground had a statistically higher species detection rate than cameras set higher above a trail (Meek 2016). Trimble Geo 7x was used the first week to flag the coordinates of the 10 camera locations. Garmin eTrex Vista HCx was used to take waypoints of the camera locations to be found throughout the summer. We used Browning Strike Force HD Pro X (Model BTC-5 HDPX). The camera was set to take still pictures with a ten second capture delay, one shot per trigger, and the resolution was set to low image size (4MP). 32 GB Ultra San Disk (SD) cards was replaced each week along with batteries if the battery percentage was lower than fifty percent.

When cameras were moved to a new a location, we recorded the habitat type, camera number, new SD number, old SD number, meters from trail, camera height in meters, time ON and the Global Positioning System (GPS) coordinates. Once we had switched out the SD cards, we were

able to begin analyzing the pictures that had been captured. The type of activity (pedestrian, biker, predator, dog, other) was counted for each picture captured, this summer we captured 68,273 pictures from the recreational trail cameras.

Live Traps

Longworth live-traps were used to measure small rodents by established trapping grids and the data was compared to the data collected from the bucket camera-trapping. This allowed us to compare the effectiveness of the non-invasive bucket-traps. The trapping grid was established at the three sites and was used from June to August 2021. Live trapping is a part of Dr. Rosemary Smith's annual rodent census, we have incorporated it into our research for this summer.

The trapping grid consists of 49 trap stations arranged in 7x7 configuration; each trap being set 10 meters apart from each other. Traps were baited with a mixture of oats, horse feed, and peanut butter and the bedding was placed in the nesting chamber. The traps were placed facing the inside of a plastic bread bag, the bottom part of the trap was released into the bag. The bait, bedding and rodent fell into the bag. Once the rodent was the only thing in the bag, with some pieces of bait, it was weighed with a Pesola scale in grams. The rodent was then handled to identify species, sex, and to be marked. The rodents are marked with a small paintbrush from a mixture of a teaspoon of Nyanzol fur dye activated with a teaspoon of hydrogen peroxide. Each individual was handled for less than two minutes. Traps were opened at dusk and revisited early in the morning after dawn, for six trap nights per site.

Bucket Camera Traps

The bucket camera traps are similar to a technique that was used by Macias (2019). Two buckets were paired with one recreational camera on each trail. We had four bucket cameras per trail. The bucket camera traps were placed within the live rodent trapping grid. A 26.6 L bucket was modified to hold a camera inside. The bucket lid had two holes poked into it where a metal wire went through to hold the camera facing the inside of the bucket. Two holes, approximately four centimeters round, were cut out of the bottom sides of the bucket to allow access to rodents. A petri dish was glued to the bottom of the inside of the bucket, this held the bait. The bait consisted of oats, peanut butter, and horse feed. Once the camera was set and the bait was placed, we attach the fitted lid. We cover the bucket with a camouflage fabric and placed a tight mosquito net to secure the fabric. The camouflage fabric also helped to reduce overexposure of the pictures, reducing the amount of daylight inside of the bucket.

We used Browning Strike Force HD Pro X (Model BTC-5 HDPX). The camera was set to take still pictures with a ten second capture delay, one shot per trigger, and the resolution was set to ultra-image size (20 MP). Electrical tape was used to cover three of the IR LEDs. We used the electrical tape to minimize the amount of nighttime flash that was used to prevent over exposure from the light reflecting off the white bucket, example shown in Figure 4. 32 GB Ultra San Disk (SD) cards were replaced each week along with batteries. When the bucket camera traps were moved weekly to the new location, we recorded week number, habitat, camera number, new SD number, old SD number, meters from the recreational camera that it is paired with, and time ON.

The pictures captured from the bucket camera traps were scored by species, date, time, and site. The data collected was compared to the live rodent trapping to see if they are consistent with each other, capture the same rodent richness and abundance. If bucket camera traps are consistent with live trapping, it will give us another form taking a rodent census that is non-invasive.

Results

We found that on the established rodent grid, the nocturnal rodent species were captured in both live traps and bucket traps (Table 1). Diurnal species were only captured in the bucket traps. Table 3 is a study comparison of species presence and activity time. The studies shown here are a comparison of UCLA student, Maddy Uetrecht's 2020 study, our 2020 rodent study, and our 2021 predator and rodent study. From the table we can see that Maddy Uetrecht's study found that deer presence was not affected by human recreation, but they did change their activity time to more nocturnal with hikers. Bears increased their presence with more hikers and didn't change their activity time. Human recreation had no effect on foxes. Pedestrians had no effect on coyote presence and coyotes changed their activity time to more nocturnal with bikers. From Table 3 we can see that our 2020 rodent study had weak increase of rodents with human recreation and rodents didn't change their activity time. Lastly, from Table 3, we can see that our 2021 rodent and predator study found no significant effect from human recreation on predators, nocturnal rodents, and diurnal rodents.

To detect difference in trail use and to quantify the usage patterns by activity type (pedestrians, bike, dogs) and time (nocturnal/diurnal (6:00 AM- 8:00 PM set as diurnal) I categorized over 68,000 trail camera pictures. I calculated the average number of pedestrians, bikers, and dogs per trail per week. Figure 5 shows the average number of human activity (hiking, biking, dogs) per week on the y-axis and the site on the x-axis. This graph showed us that the trails that were chosen for this project did vary in human activity and that human activity time was mainly diurnal. As predicted, Judd Falls had the highest number of pedestrians and dogs. The RMBL Shortcut had no bikes and dogs and had the lowest number of pedestrians. 401 had the highest bike usage and a moderate amount of pedestrians and low dogs. Deer Creek had a moderate amount of pedestrians, bikes, and dogs. Figure 6 shows the relationship between predator count and total human recreation. There was no significant decrease of predators with human recreation, 401 trail had a $p = 0.9176$, Deer Creek trail had a $p = 0.0989$, Judd Falls had a $p = 0.2564$, and RMBL Shortcut had a $p = 0.7039$. In Figure 7 we can see that Deer Creek predator count was increasing as pedestrian count increased, these results were marginally significant ($p = 0.0192$). In Figure 8 we can see that Deer Creek trail was the only trail of the four that had marginally significant results. We observed that predator count increased as biker count increased per week, bikers had a slight positive effect on predators ($p = 0.4596$). Figure 9 shows the relationship between predator count and treatment (meadow vs trees). Judd Falls trail and the RMBL Shortcut were the sites with the most predator activity. This graph also shows that at three of the four sites predators were counted more in tree habitats. In Figure 10 we can see the relationship between total diurnal and total nocturnal species and total human recreation. We found that human recreation has no significant direct effect on diurnal ($p = 0.7611$) and nocturnal

rodent ($p = 0.4580$). Lastly, in Figure 11 we can see the relationship between total diurnal and nocturnal rodents compared to trails with the highest use, total predator counts at 401 and Judd Falls trail. Predator count at 401 trail had no significant effect on total nocturnal rodents ($p = 0.3076$) and total diurnal rodents ($p = 0.6660$). Predator count at Judd Falls trail had no significant effect on total nocturnal rodents ($p = 0.7769$) and total diurnal rodents ($p = 0.5977$).

Discussion

Overall, our studies showed that there were no significant negative impacts of human recreation (hiking, biking, dogs) on rodents (either nocturnal or diurnal) or on the number of predators. Opposite of my prediction, however, there was a marginally significant positive impact on predators at Deer Creek Trail with human recreation (Figure 7-8). These results are consistent with the results shown in Table 3. Table 3 shows that in Maddy Uetrecht's 2020 study, she found no negative effect of human recreation on deer, bears, foxes, and coyotes. In our 2020 rodent study we only found a marginally significant, positive, effect on rodents with human recreation (Table 3). These results from 2020 are similar to our results in 2021. We found that human recreation had no effect on nocturnal and diurnal rodent species (Table 3).

The Longworth live traps used in Dr. Rosemary Smith's annual rodent grids are used to only capture nocturnal rodents. As we can see from Table 2, the live traps didn't capture golden-mantled ground squirrels (*Callospermophilus lateralis*) and least chipmunks (*Tamias minimus*). Some of the benefits of the bucket camera traps is that they can capture both nocturnal and diurnal rodents without having to handle the rodent. The bucket cameras are an effective way of determining rodent species diversity in an area. Some of the disadvantages of bucket traps are that they can be flipped over by the public and wind or rain. The bucket camera traps also capture "junk photos," these are pictures that are triggered by insects that get into the buckets, such as grasshoppers, ants, or spiders. This year we learned that the golden-mantled ground squirrels will eat all the bait and leave none behind for the rest of the rodents, once the bait is finished other rodents won't step into the bucket. We also can't tell the difference between individuals using bucket camera traps.

An important part of this study was to determine if the trails we selected varied in human activity. We found that human activity was almost entirely diurnal (6:00 AM- 8:00 PM) (Figure 5). Figure 5 shows that 401 trail had the highest bike use and low pedestrian and low dog. Deer Creek had the second highest bike use and low pedestrian and low dog use. Judd Falls trail had the highest pedestrian and dog use, as predicted. The RMBL Shortcut only had low pedestrian use, this trail is private and only RMBL members are allowed on this trail. Having sites that varied in use allowed us to compare how different human recreation affected rodents and predators. Dogs and pedestrians were highly correlated, so we only used the data on pedestrians. A future study that could be beneficial to look at would be seasonal changes of human activity and how that affects wildlife, as well as the effects of leashed vs. unleashed dogs on diurnal rodents.

Based off our study last year, with a marginally significant increase of rodent abundance with human recreation, I predicted that human recreation would decrease predators near trails and

increase nocturnal rodent abundance. Figure 6 shows the relationship between total predator counts and total human recreation per week. This figure shows that predators were not significantly affected by any type of human recreation (hiking, biking, dog). In fact, Figures 7 and 8 show that at Deer Creek trail predator counts had a marginally significant increase with pedestrians and cyclists. In Figure 9 we can see the predator count by site and by habitat. This graph shows that predators were more common in trees (covered) than in meadows (uncovered) in three out of the four trails. We can also see from this graph that Judd Falls and RMBL Shortcut had the highest predator count.

Figure 10 shows the relationship between total human recreation and total diurnal and total nocturnal rodent activity per week. We can see that there was no significant effect of human recreation on rodents (diurnal and nocturnal). My prediction for this was based on the slight increase of rodent abundance with human recreation from our rodent study last year. This year we found that human recreation had no effect on rodent abundance, making my prediction incorrect. Figure 11 shows the relationship between total predator counts and total diurnal and nocturnal rodent activity per week. We can see from the graph that there was no significant effect of predators on rodent (diurnal and nocturnal) species. From what we have seen from previous graphs, human recreation had no effect on predator activity. Now, we can also see that predator activity had no effect on total rodent activity. I had predicted that human recreation would displace predators and increase rodent abundance. It appears that human recreation, predators, and rodents have no effect on each other's activity.

The camera placement that I chose for this summer was from (Meek 2016), I placed the cameras less than one meter from the trail and less than one meter in height. This was to capture higher species detection. One thing that I learned from this camera placement was that it helps to reduce vegetation pictures, I still captured vegetation swaying in the wind but not as much as I was expecting, and less than in 2020 I also learned that attaching the camera to a thin aspen will trigger the camera to take pictures when the aspen tree sways in the wind. I also found that at Deer Creek covered areas (aspen forest) shadows on the ground of plants swaying also triggers the camera to take pictures. Overall, looking at the pictures with the new camera placement was an improvement from last year for this project because it was able to capture my target predators, long-tailed weasel and red fox. We can improve the way that we count rodent species to reduce the number of times we count an individual within a certain number of minutes. This will give us a more accurate estimate for rodent activity.

In summary, we found that the bucket camera traps are an alternative for detecting nocturnal and diurnal species and determining species diversity in an area. We also found that the trails near RMBL differ in human recreation. Human recreation does not seem to have an effect on the presence or activity of nocturnal and diurnal rodent species. Also, human recreation is not causing predator displacement on the trails near RMBL. Even at our highest pedestrian trail with an average of 3,000 pedestrians per week, this was also the trail with the highest predator count. We also found that predator count had no effect on nocturnal and diurnal rodent species. Although my predictions for this summer were wrong, it makes me feel hopeful that human recreation is not heavily impacting the wildlife near RMBL.

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The small mammal live-trapping was conducted by approval of Idaho State University and RMBL Institutional Care and Use Committees, and under a scientific collecting permit from the Colorado Parks and Wildlife to Dr. Rosemary J. Smith (PI).

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Tables and Figures

Table 1: Species present in live trapping and bucket camera trapping

Species	Activity	Live Traps	Bucket Traps
<i>Peromyscus maniculatus</i> (Deer mouse)	Nocturnal	Present	Present
<i>Microtus montanus</i> (Vole)	Nocturnal	Present	Present
<i>Zapus Princeps</i> (Western jumping mouse)	Nocturnal	Present	Present
<i>Tamias minimus</i> (Least chipmunk)	Diurnal	Absent	Present
<i>Callospermophilus lateralis</i> (Golden-mantled ground squirrel)	Diurnal	Absent	Present

Table 2: Species list of the recreational trail cameras

Species	Deer Creek	401	Judd Falls	RMBL Shortcut
<i>Alces alces</i> (Moose)		✓		
<i>Callospermophilus lateralis</i> (Golden-mantled ground squirrel)	✓		✓	✓
<i>Canis latrans</i> (Coyote)	✓			
<i>Chlorura chlorura</i> (Green-tailed towhee)	✓	✓		✓
<i>Colaptes auratus</i> (Northern flicker)			✓	
<i>Corvus brachyrhynchos</i> (Common crow)	✓		✓	
<i>Dendragapus obscurus</i> (Blue grouse)	✓	✓	✓	✓
<i>Equus caballus</i> (Domesticated horse)		✓	✓	
<i>Euphagus cyanocephalus</i> (Brewer's Blackbird)	✓			
<i>Gymnorhinus cyanocephalus</i> (Pinyon jay)	✓			
<i>Hylocichla guttata</i> (Hermit thrush)	✓	✓		✓
<i>Junco caniceps</i> (Gray-headed junco)	✓			
<i>Lepus Americanus</i> (Snowshoe hare)		✓		
<i>Marmota flaviventris</i> (Yellow-bellied marmot)	✓			
<i>Microtus montanus</i> (Montane vole)	✓	✓		✓

<i>Mustela frenata</i> (Long-tailed weasel)	✓	✓	✓	✓
<i>Odocoileus hemionus</i> (Mule deer)	✓	✓	✓	✓
<i>Passerina amoena</i> (Lazuli bunting)	✓			
<i>Peromyscus maniculatus</i> (Deer mouse)	✓	✓	✓	✓
<i>Puma concolor</i> (Mountain lion)		✓		
<i>Selasphorus platycercus</i> (Broad-tailed hummingbird)	✓			
<i>Tamias minimus</i> (Least chipmunk)	✓	✓	✓	✓
<i>Turdus migratorius</i> (robin)	✓	✓		✓
<i>Urus americanus</i> (American Black Bear)	✓	✓		
<i>Vulpes vulpes</i> (Red fox)	✓	✓		✓

Table 3: Study comparison of effects of recreation on species presence and activity time.

Year	Species	Presence	Activity Time
2020 (Utrecht)	Deer	No effect	More nocturnal with hikers
	Bear	Increase with hiker	-
	Fox	No effect	-
	Coyote	No effect	More nocturnal with bikers
2020 (Bermudez, Novoa, Rodriguez)	Rodents	Weak increase	-
2021 (Novoa & Rodriguez)	Predators	No effect or marginal increase	-
	Nocturnal Rodents	No effect	-
	Diurnal Rodents	No effect overall.	Daily- active only in periods without pedestrians.

Figure 1: Deer Creek Trail, recreational trail camera locations, green dots are covered habitats and blue dots are uncovered habitat.

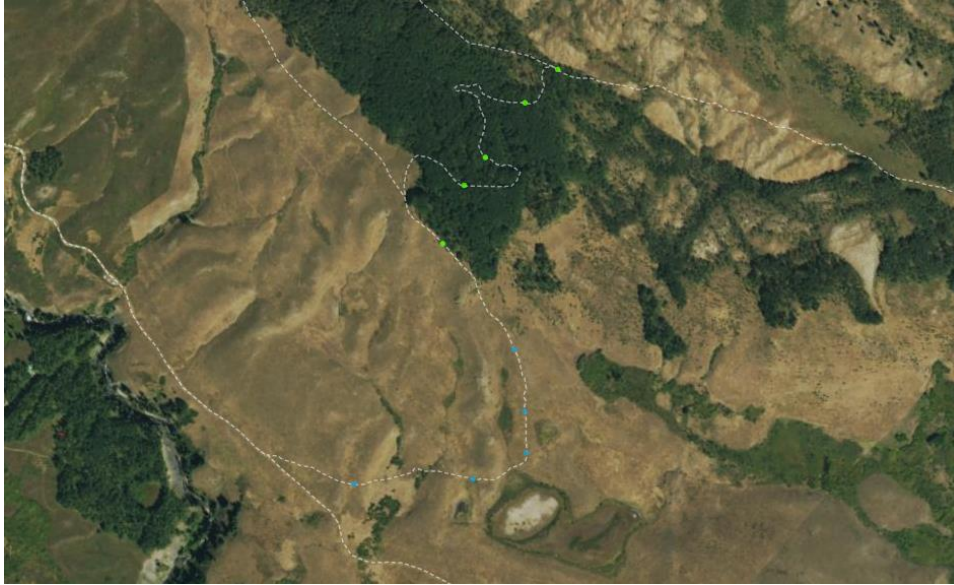


Figure 2: 401 Trail, recreational trail camera locations, green dots are covered habitats and blue dots are uncovered habitats.



Figure 3: Judd Falls (upper trail) and RMBL Shortcut (lower trail), recreational trail camera locations, green dots are covered habitats and blue dots are uncovered habitats.



Figure 4: Bucket camera, example of how to cover the camera flash with electrical tape.



Figure 5: Mean number of pedestrians, bikes, and predators per site (diurnal 6:00 am- 8:00 pm).

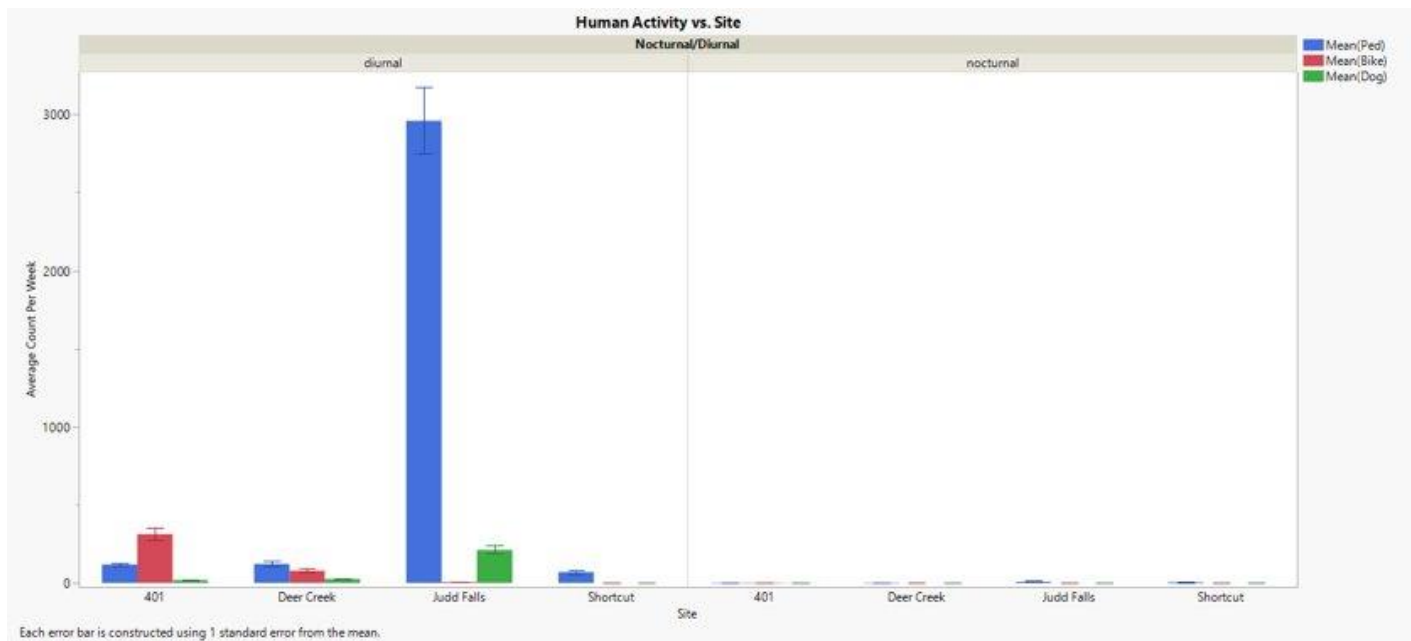


Figure 6: The relationship between total predator vs total human recreation.

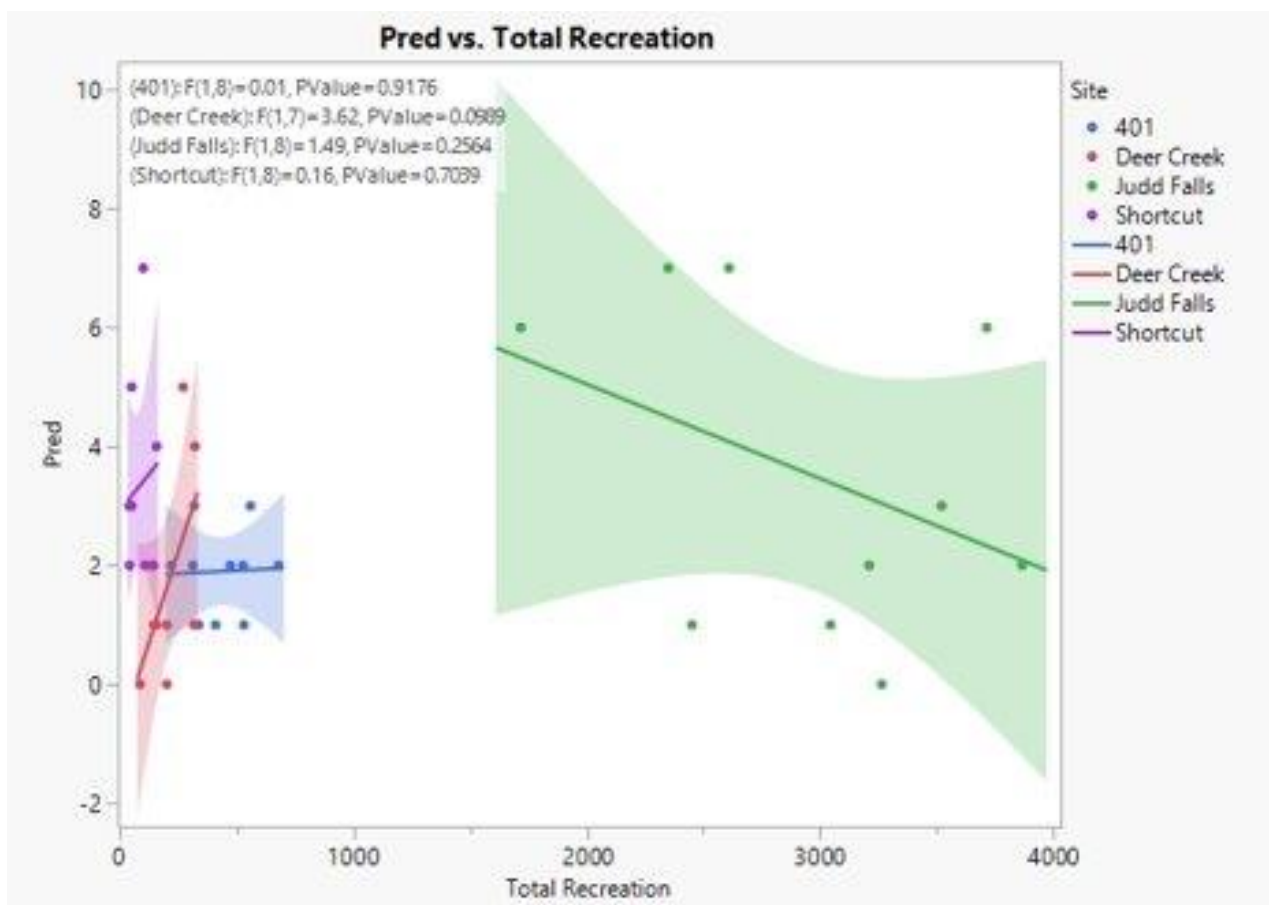


Figure 7: Predator count vs pedestrian count at Deer Creek Trail.

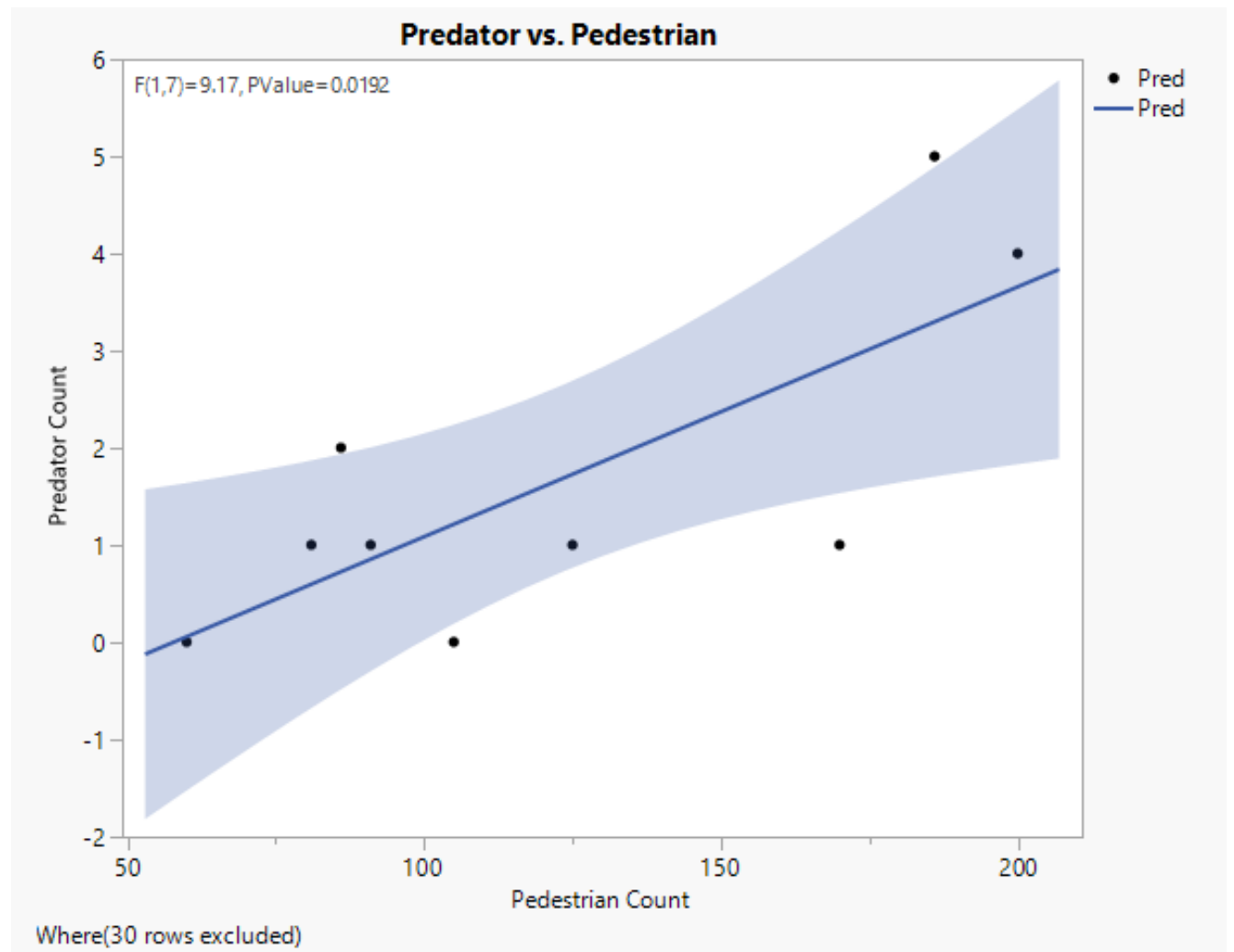


Figure 8: Predator count vs bike count at Deer Creek Trail.

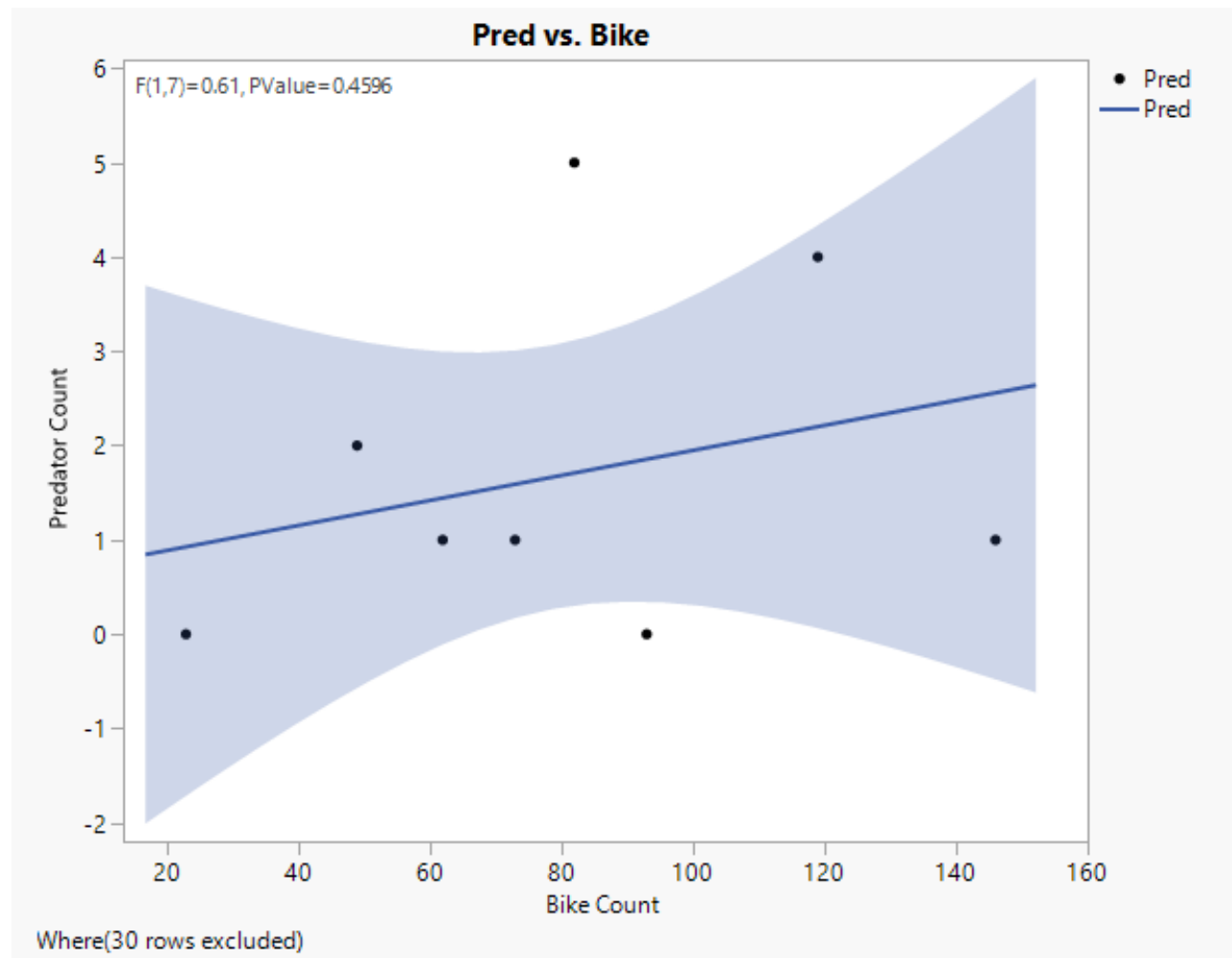


Figure 9: Mean predator count vs habitat type (meadow vs trees).

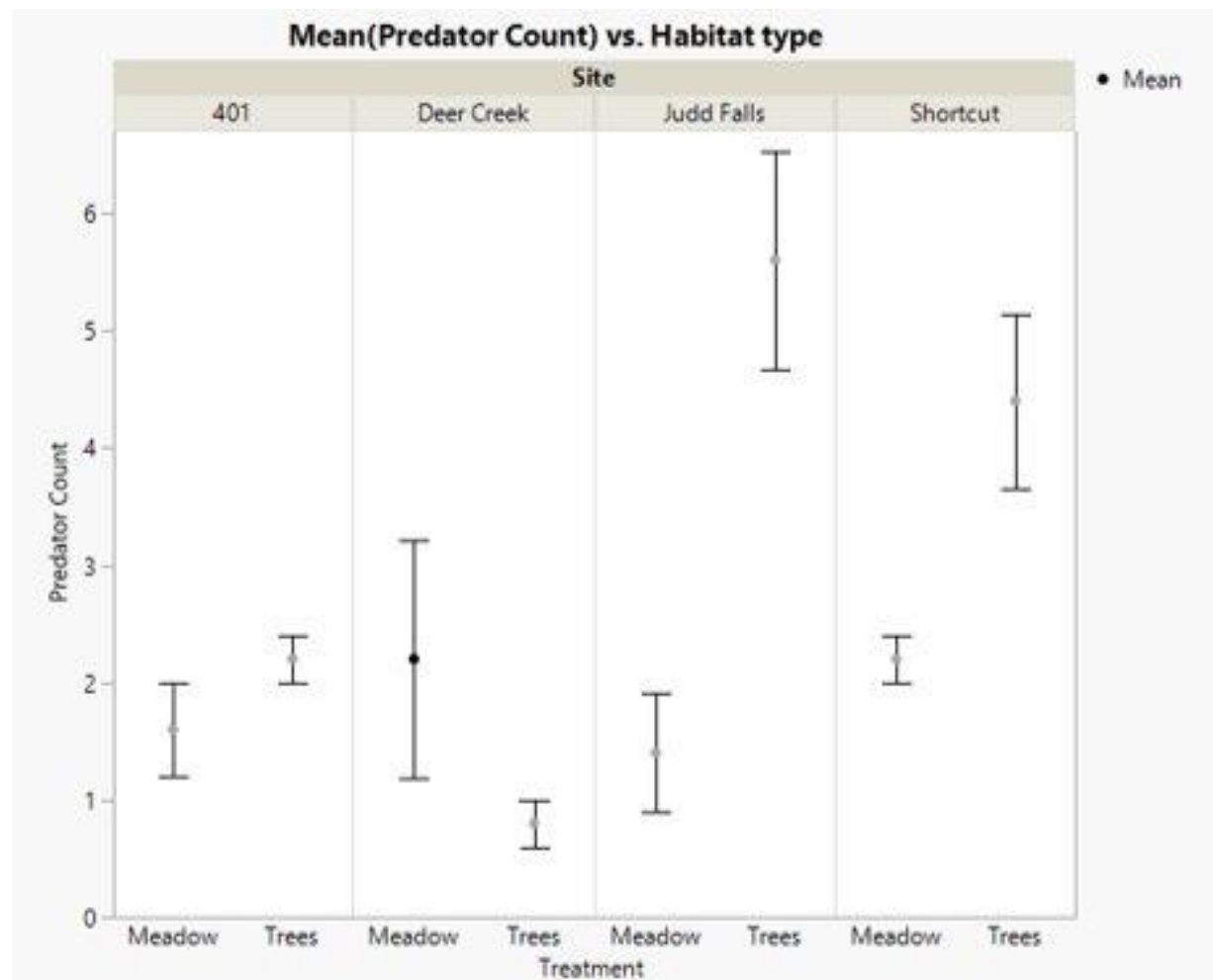


Figure 10: Human recreation relationship with rodent abundance.

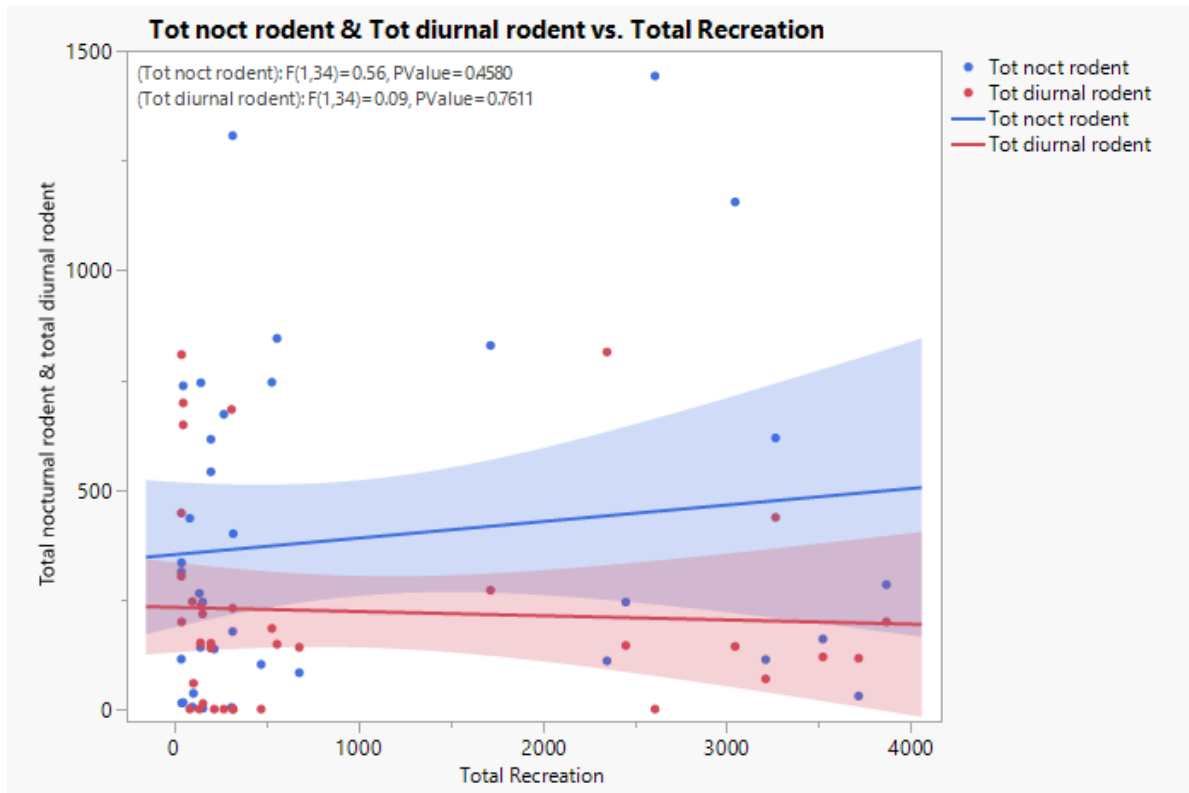


Figure 11: Rodent relationship with predators at 401 and Judd Falls.

