Influence of Predator Presence on Chipmunk (*Tamias*) Activity in Western Montana

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Abstract

The least (*Tamias minimus*), red-tailed (*Tamias rudicaudus*), and yellow-pine (*Tamias amoenus*) chipmunks are the three species that are known to be distribute throughout western Montana. In comparison to chipmunks that are found in the Eastern states, they are understudied species. This experiment tests the amount of chipmunk activity that occurs when the odors of predators are present. The coyote (*Canis latrans*) and the bobcat (*Lynx rufus*) urine were chosen to represent the presences of a predator at each of the nine sites in the National Bison Range, Montana. The hypothesis is that the chipmunk activity of the coyote sites would have less intensity of tracks the bobcat sites. A standard measure for the minimum amount of chipmunk tracks was used to count for smeared areas, due to an increase amount of chipmunk activity.

The treatments for the bobcat and the coyote urine were not significantly different, both of these sites had the greatest amount of chipmunk activity. There was a significant differences when both predator treatments to the control treatments. All control treatments had zero chipmunk activity.

Keywords: *Tamias*, *Tamias minimus*, *Tamias rudicaudus*, *Tamias amoenus*, chipmunks, small mammals, coyote, bobcat, urine, animal behavior, Predator, prey interactions, seeds, foraging behavior

Introduction

Predator-prey interactions are natural behaviors among organisms, a continuous cycle occurring within an ecosystem. Hunting is an example of a continuous cycle that fulfills the predator's needs for survival (Trites, 2002). Predators and preys have shaped each other's behaviors, physiologies, morphologies, and life history strategies. Prey have adapted to become more difficult to capture, and predators have responded by enhancing their hunting strategies to catch and kill prey (Trites, 2002). For example, Steven Lima's research focuses on anti-predator decision-making, when prey alter their behaviors as a result of decreasing their changes of encountering or escaping predators.

Behavioral ecology among predator-prey interactions can be characterized into the following categories;-1) Tradeoffs, 2) consequences for individual prey, 3) benefits of anti-predator decision-making, 4) costs of anti-predator decision-making, and 5) optimal tradeoffs (Lima, 1998). These categories of anti-predator behavior shows how the prey will adjust their responses when a predator is present. The goal is to decrease their chances of mortality, but this comes at the cost of foraging. Some of the typical predator cues include sounds and chemical traces such as odors. In mammals, which particularly rely on scent for communication, these odors may be generated by skin, fur, urine, feces, or various gland secretions (Apfelbach, et al 2005). Felids and canids in particular are known for using urine as a way of marking territories (Apfelbach, et al 2005). Any odor left behind, would be one of the first interactions to occur between predator and prey- even before encountering each other in the presences with one another (Hughes et al, 2010). These early interactions could have substantial impacts on the prey species. For example, predator odors have been shown to alter the reproduction cycle in female rodent populations by decreasing the normal litter size (Hughes et al, 2010). Bank voles (*Clethrionomys glareolu*) are also known to respond to weasels (*Mustela*) and red foxes (*Vulpes vulpes*) scent cues, including avoidance of visited areas, climbing twigs, escaping from burrows, and reduction of mobility (Jędrzejewski et al, 1993).

Chipmunk species found in western Montana includes; least (*Tamias minimus*), red-tailed (*Tamias rudicaudus*), and yellow-pine (*Tamias amoenus*) chipmunks. The Yellow-pine Chipmunk (*Tamias amoenus*) are found in mountain areas of Washington, Oregon, Idaho, northern California, western Montana, and southern British Columbia (Sutton, 1992). *T. amoenus* prefers conifer habitats, cliff dwellings, and not limited to open spaces with some canopy gaps (Cite Mammals Field Guide). The Least Chipmunk (*Tamias minimus*) favors habitats that are similar to desert habitats, and is an excellent climber and can nest in conifer forests. Most *Tamias* species are ground dwellers.The red-tailed chipmunk (Tamias rudicaudus) has one of the smallest distributions only found in Western Montana, therefore it is an under studied species (Patterson, 1987). The habitat for the Tamias rudicaudus includes spruce, pine larch-fir, Yellow Pine coniferous forests, all being a dense forested areas. All three of these Chipmunk species have similar foraging habits; seeds, fruits, berries, grasses, acorns, and invertebrates. The Least Chipmunk is known to eat fungi, invertebrates, and rarely small vertebrates.

A study in central Washington noted the types of predator species of the *Tamias amoenus* includes; the long-tailed weasels (*Mustela frenata*), goshawks (*Accipiter gentilis*), bobcats (*Lynx rufus*), coyotes (*Canis latrans*), American badgers (*Taxidea taxus*), American kestrel (*Falco sparverius*), and a variety of rattlesnakes. Young Yellow-pine Chipmunks (*Tamias amoenus*) were known as easy prey. Weasels and Coyotes had the potential to dig into the dens of *Tamias amoenus* (Broadbooks, 1970).

There are far more publications for eastern chipmunks (*Tamias striatus*) than there are of the western chipmunks. Specifically on the interactions between predatory and prey, some publications have observed the reactions of the Eastern Chipmunks (*Tamias striatus*) to their predators. Eastern Chipmunks (*Tamias striatus*) are known to have three distinctive calls in the presence of predators; chipping, chucking, and trilling. Chipping and chucking calls were known to be repeated within a 30 minute time frame. The trilling calls would only last for a short time period, used while being pursued by a predator. Trills were also used as a warning signal to the relatives of the Yellow-pine Chipmunk (*Tamias amoenus*) (Burke da Silva et al, 2002). Although, the reactions of the Western Chipmunks have not been heavily observed as Eastern

Chipmunks (*Tamias striatus*) there is a possibility that they do have similar behaviors when encountered by predators.

In this experiment, I will compare the amount of chipmunk foraging activity at track plate boxes baited with seeds, treated with the urine odors of two important chipmunk predators, bobcats (*Lynx rufus*) and coyotes (*Canis latrans*). The importance of this study is to scientifically analyze the interactions among organisms and their environment. Based on the literature on the Western Chipmunks, many ecological questions regarding this species remain to be answered. By studying the roles of each species, ecologists can make knowledgeable decisions that minimize the effects made by predators and human interactions. The predator-prey interactions that are observed can explain how both species have evolved together and how their behaviors determines their survival. Predator-prey interactions can also influence the population size. These decisions allows us to make efficient and sustainable efforts to protect the environment and the species within them.

Therefore, the hypothesis for this experiment is that the western chipmunks would respond to the urine odors of the coyote (*Canis latrans*) than the bobcat (*Lynx rufus*). First, the predator's urine scents would decrease the amount of chipmunk activity due to the avoidance of predators. Secondly, the control treatments would have an increase amount of chipmunk activity due to to their being no odors from predators.

Materials and Methods

Study Area- This study was conducted on the National Bison Range near Charlo, Montana. Montane forested areas had an elevation range of 2,500 ft. to 5,500 ft. The following chipmunk species have been identified to inhabit western Montana, least chipmunk (*Tamias* *minimus*), red-tailed chipmunk (*Tamias rudicaudus*), and yellow-pine chipmunk (*Tamias amoenus*). All of these species have a preference for open stands of Ponderosa Pine, Douglas-fir and Subalpine fir. Nine sites were chosen based on the abundance of chipmunks that inhabit these areas. These sites were divided into equal number of controls, coyote urine treatments, and bobcat urine treatments (Figure 2, Figure 3). Each site was equipped with a track plate box which was left out for a brief acclimation period.

Experimental Procedure-Track Plates: Track plates can be made various ways to record the tracks of mammals. Some examples from previous studies include sand, smoked kymograph paper, talc-coated plates, ink-coated tiles, and carpenter's chalk as track media (Matthew, et al. 2005). The base of a track plate or track plate box normally includes an aluminum base while the track media is placed on top or at the side of the aluminum to record the tracks of the mammals. In this experiment we used a mixture of graphite, alcohol, and oil coating over acetate sheet for our track plates (Matthew, et al. 2005). The ratio from the (Connors et al. 2005) of powdered graphite suspended in an ethyl alcohol/ mineral oil solution (15%, 80%, and 5% respectively) worked well for this experiment. 320 ml of pure ethanol, 60 ml of pure graphite powder, and 10 ml of mineral oil sufficed for the 9 sites the following day. The mixture was applied to acetate transparency sheets with a foam brush similar to (Connors et al. 2005, DeSa et al. 2012). The advantage of acetate sheet plates is these are quite water resistant compared to other track media. These track plates were used to measure the spatial scales of the white-footed mouse (*Peromyscus leucopus*) (Connors, et al. 2005). The acetate sheets will be attached to the aluminum plates with four binder clips (Matthew, et al. 2005).

The aluminum sheets dimensions were 18 in. x 24 in. x 0.5 mm. Cardboard was adhered to the bottoms to add extra rigidity and stability of the plate. Acetate sheets had a measurement of 16 in. x 24 in. Corrugated plastic adhered with hot glue and duct tape was used to create the track plate housing, which protects the plate from heat and wind. The corrugated plastic had the dimensions of 16 in. in height, 24 inches long and 18 inches wide. The track plate housing was set out in the field with two wooden stakes at each side to keep the housing from collapsing from nearby winds. After two of our track plate housing had collapsed, we used this method for all sites. Four tent stakes were used to hold down the aluminum sheets, which added extra stability.

A mixture of sunflower seeds and whole was placed at the center of the track plate to attract the chipmunks (Broadbooks, 1970**).** A 3oz Dixie cup was cut in half and was temporary attached to the plate with duct tape. Every morning the acetate sheets and food mixture were set out at every site for a 10 hour period. The acetate sheets and food mixture was collect in the evening times, to avoid mice tracks from obscuring the Chipmunk tracks.

The treatment of bobcat (*Lynx rufus*) and coyote (*Canis latrans*) urine were commercially ordered with small cushioned p-wicks. Nails were attached to wooden stakes to hold up the urine wicks by thread. All sites had wooden stakes with p-wicks, regardless if it was a control treatment. One ounce of urine was sprayed at the sites labeled bobcat or coyote. At the beginning of this experiment, there was a six day acclamation period in which the small mammals familiarized themselves with the track housing.

Statistical Analysis: I used R-Studio (R version 3.4.0) to run our entire statistical analysis. Recording the number of footprints made by each Chipmunk on the acetate sheets. Each of tracks were counted to represent the amount of activity that took place at each site. By using the Shapiro-Wilk Test to find the normality among each of the treatments. I performed a Kruskal-Wallis test to look for statistically significant differences in the number of tracks among the three treatments. I used the Kruskal-Wallis because my data were not normally distributed (Shapiro-

Wilk p-value) and therefore did not meet the assumptions required to perform a parametric One-Way ANOVA.

In most cases the tracks were difficult to analyze due to the high activity of the Chipmunks in one area, which include the tail swipes. To account for this data the tail swipes were not included as tracks. Areas on the acetate sheets that were highly used were calculated based on the area of a circle, graphite mixture that was removed from this area. The standard maximum track measurement we used was 0.5cm by 8cm in length. We mathematically calculated the area of the chipmunk activity and divided by 4 squared centimeters to find the minimum amount of tracks that could have appeared within that area.

Results

We sampled a total of ninety sheets of tracks, two had collapsed during the process, and four sheets were not sampled due to safety precautions of bison and black bears near the sites. The Bobcat sites had a total of 3,992 tracks, Coyote sites had a total of 6,371 tracks, and the Control sites had zero tracks (Table 2, Table 3). Kruskal-Wallis Test determined the significant difference between all treatments (Chi-squared= 18.136, df= 2, p-value=0.0001) (Figure 1). The standard error and standard deviation of each treatment differ from one another (Bobcat: 38.26 ±198.78 n=27, coyote: 43.96 ± 236.71 n=29, control: 0 ± 0 n=28). Conover-Inman Test determined the pairwise comparisons that are significant differences in the Kruskal Wallis test (Bobcat vs. control p-value= 0.0007, bobcat vs. coyote p-value= 0.1067, control vs. coyote p-value= 0.0000). There was a significant difference between the bobcat and control treatments. There wasn’t a significant differences between the bobcat and coyote treatments. There was a significant differences between the control and coyote treatments (Figure 1)

<u>Discussion</u>

Conover-Inman test determined that the comparison between bobcats and coyotes to control treatments did have a significant difference. There wasn't a significant difference between the bobcat and coyote treatments. These results were unexpected because all of the control sites that were collected didn't have any chipmunk tracks. The chipmunks would response to those areas that had urine, where the abundance of chipmunks were higher than other places. There were was one site from the coyote and the bobcat that didn't have any tracks. Although, the coyote areas had more tracks compared to the bobcat- there was no significant difference between them.

Predator odors have the ability to change the behavior patterns such as the inhibitory activities, foraging and feeding patterns, and shifting habitats or locations without the odors present (Apfelbach, et al 2005). However, in some of the recent studies skin and fur have a greater effect on prey species than urine and feces (Apfelbach,et al 2005). All nine sites had chipmunks present within the area, but all control sites didn't have any tracks. All tracks that were collected had either Coyote or Bobcat urine treatments. The Coyote sites had the greatest amount of tracks compared to the Bobcat sites, the Coyote sites had the most malodourous urine comparted to the bobcat. Based on these types of mammal behavior I would normally expect for the chipmunks to reacted strong towards the urine from other mammals and spend the majority of their time in control treated areas.

Some of the things that could have possible contributed to the results are; 1) Patterns of bobcat marking and chipmunk hibernation change the presences of predator, 2) Coyotes being an opportunistic predator, chipmunks don't necessary need to worry about the coyotes lingering nearby, 3) Density of vegetation cover and skillful climbers decrease the chances of the coyote hunting the chipmunks, 4) Greater abundance of resources and population size of chipmunks increased the amount of tracks within those areas, and 5) Isolation from other sites could possibly mean limited resources within an area.

Patterns in bobcat scent marking and communication behaviors usually happen during January because it is usually the peak opportunity of courtship and mating happen. The visitations among each other becomes more nocturnal during the winter and spring time (Allen et al. 2014). Chipmunks actively hoard seeds during the late summer and early fall to prepare for hibernation (Munro et al. 2005). In comparison between the peak moments of the bobcat's scents and the hibernation period of the chipmunks do operate at the same time. This suggest chipmunks may be less likely to be exposed to bobcat territorial markings than other predators, and thus may not react as strongly to an unfamiliar cue. The chipmunks could possibly be storing the baited sunflower seeds for the winter time, meaning they are more concern with collecting seeds than being disturbed by an abnormal bobcat smell.

Coyotes would be consider to be an opportunistic predator of chipmunks (Arjo et al. 2002). Chipmunks are able to climb trees to nest and to quickly flee predators. There is a minimal chance that the coyotes would continue to pursue these small mammals because they can't climb trees. In the case of foxes, which are also skilled at climbing trees could continue to pursue these chipmunks. In addition to, western chipmunks have an average length from of 6-9 inches which means that the coyote could only benefit from a small amount of nourishment than a larger species. A study focused on the dietary overlap between the gray wolves (Canis lupus) and coyotes (C. laterans) done in North Forks of the Flathead area, the reintroduction of wolves within the area has influences the size and types of prey they could hunt (Arjo et al. 2002). Ideally, the coyotes would be hunting small prey than the wolves. For example, during the winter the coyotes would scavenge on the wolf and cougar kills because they would more likely be able to hunt the large predators (Arjo et al. 2002).

Dense vegetation like the berry bushes and dense forest areas could decrease the chances of the coyote being a successful hunter. By manuring quickly through the dense brushes and climbing trees, the chances of coyotes hunting chipmunks are slim. The sites that collected the most tracks were near areas where the dense vegetation was present. Chipmunks in these sites collected the seeds and whole corn from the track plate housing. This is normal behavior for the chipmunks to store their caches for the winter (Sullivan et al. 2004).

Within the National Bison Range, there are areas that are heavily dominated by edible berries. Wildlife such as deer, black bears, birds, and small mammals visit these bushes upon ripening. The ripening of the berries usually occur between July and August. The berry bushes could have had positively influences the abundance of the chipmunks because it offers another source of food besides the grasses and seeds. The berry bushes would be another indicator that there is a source of water, not only hydrating the bushes, but encouraging small mammals to reproduce within the area. Based on the distribution of sites (Figure 2 and 3), some of these sites appeared to be isolated from other to expand the sample size of the Bison Range. Other sites that were selected had resources such as the berry bushes and water. Although, all sites were chosen based on the density of forested area, there was the compromise of the small range of forested areas and the amount of time for myself to visit each site daily. All sites had sighting of chipmunks within the area, but there were sights where no tracks were recorded. These sites had open canopy or open spaces, limited resources, and amount of chipmunk activity was minimal to other sites. All of these could have been major contributors to the control treats having zero chipmunk activity.

Therefore, the hypothesis for this experiment would be rejected because there was a significant difference between the predator treatments and control treatments. The chipmunks were found in areas where the predator treatments were present. The control treatments had no chipmunk activity during the entire course of the experiment.

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Figures

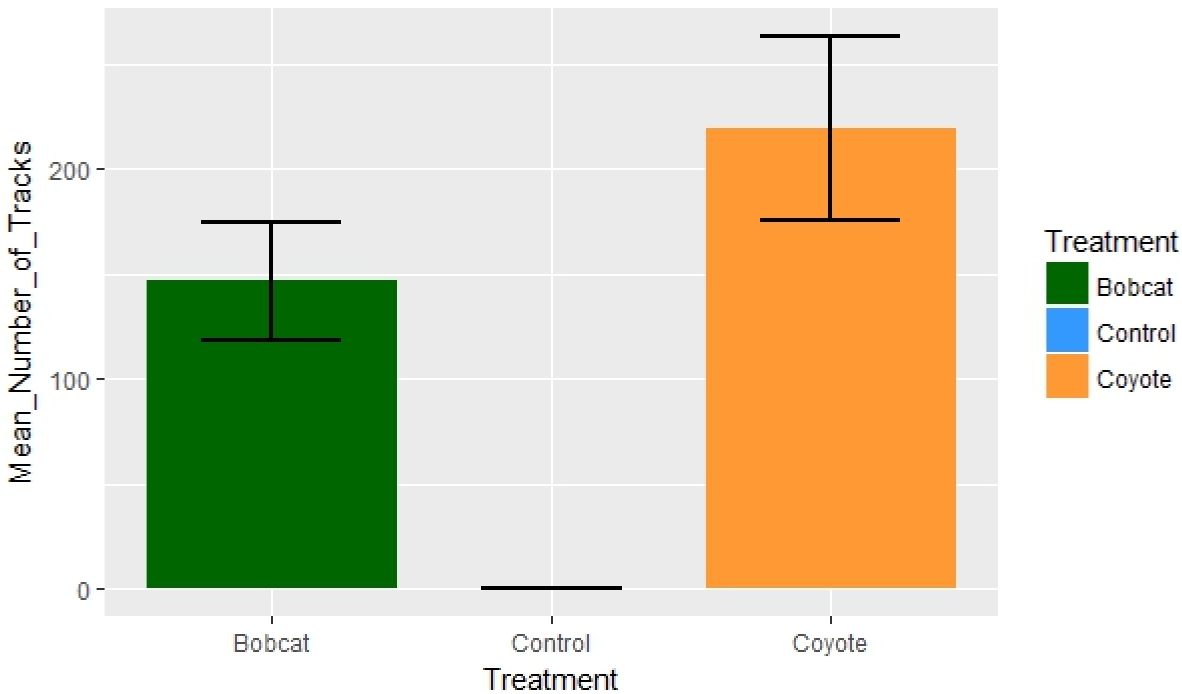

Figure 1. Mean Number of western chipmunk tracks compared to the type of treatments. A Kruskal-Wallis Test determined the significant difference between all treatments (Chi-squared= 18.136, df= 2, p-value= 0.0001). A Conover-Inman test determined the pairwise comparisons that are significant in the Kruskal-Wallis test (Bobcat vs. control p-value= 0.0007, bobcat vs. coyote p-value= 0.1067, control vs. coyote p-value= 0.0000).

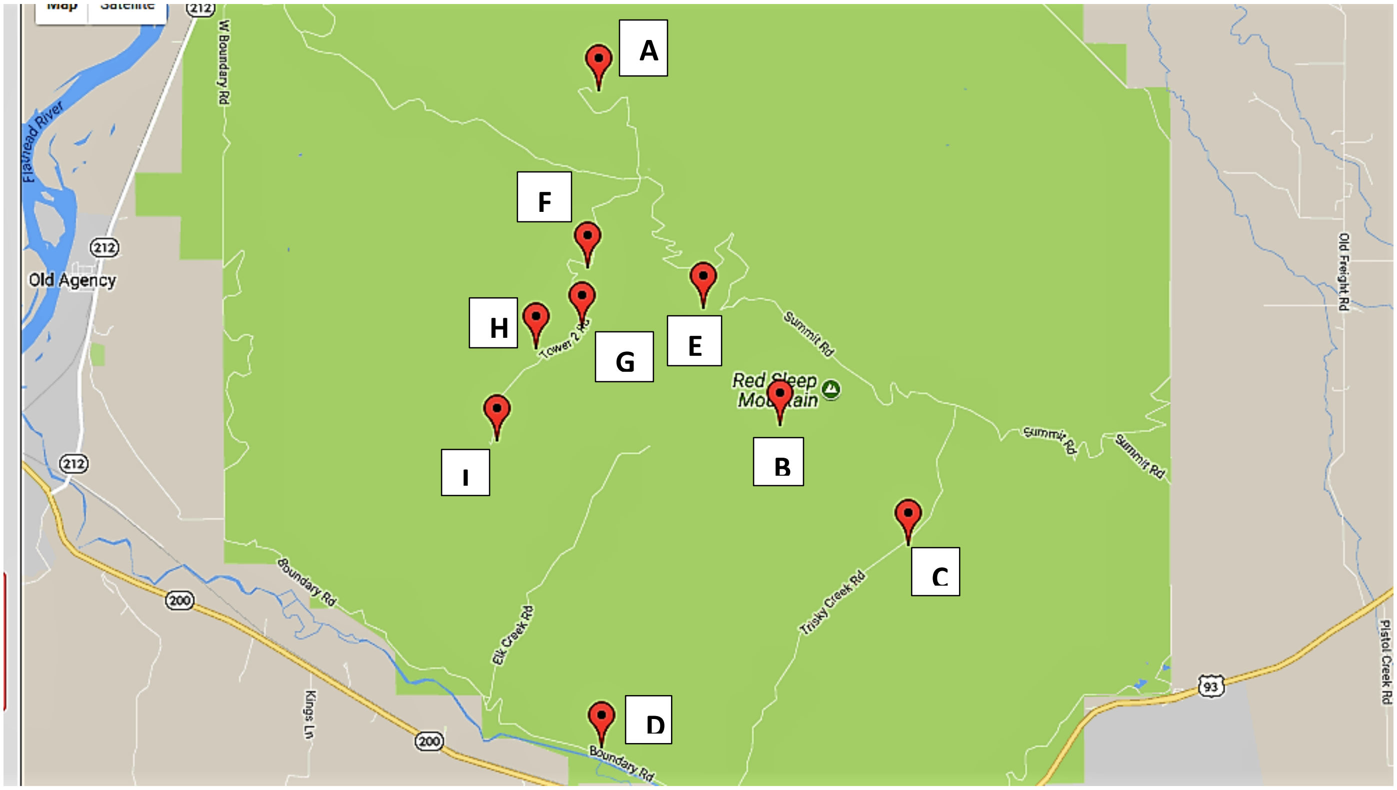

Figure 2. Study Sites on the National Bison Range, showing the main road used to travel to each destination (Key for sites are located in Tables section, below).

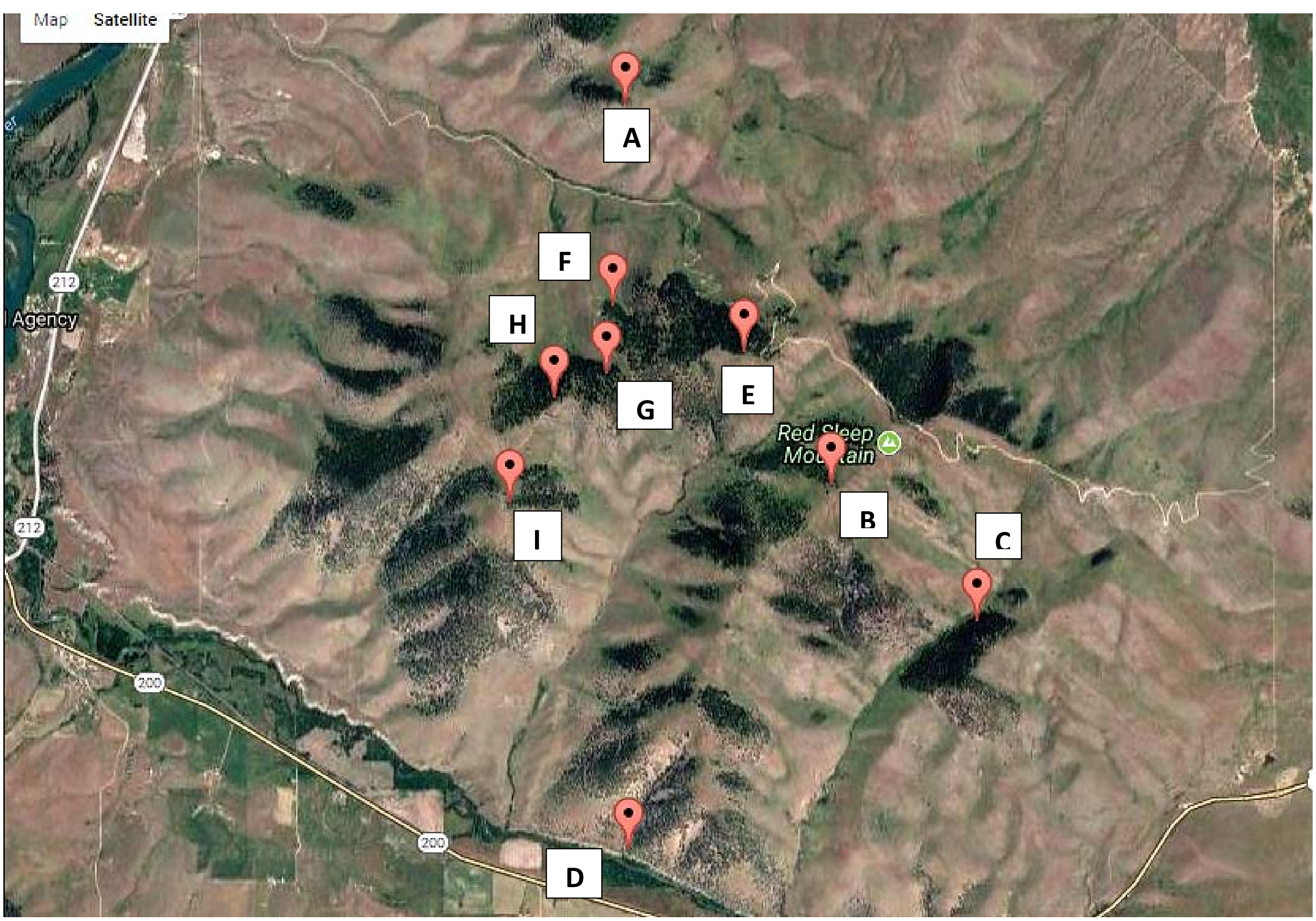

Figure 3. Satellite image of sites located on the National Bison Range, Montana. The density and distribution of trees and other vegetation are the key characteristic to take away from this map (Key for sites are located in Tables section, below).

Tables

Sites	Location
A	Tower 3 Rd
B	High Point
C	Trisky Creek
D	Boundary Rd
E	Hiking Trail (Summit Rd)
F	#1 Tower 2 Rd
G	#2 Tower 2 Rd
H	#3 Tower 2 Rd
I	#4 Tower 2 Rd

Table 1. Name of sites and list of roads used to travel to the destination.

Treatments	Control	Control	Bobcat	Control	Coyote	Coyote	Bobcat	Bobcat	Coyote
Sites	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
17-Jul	0	0	N/A	0	0	0	0	0	0
18-Jan	0	N/A	N/A	0	N/A	0	0	0	0
19-Jul	0	0	237	0	0	398	0	0	0
20-Jul	0	0	382	0	0	452	0	0	0
21-Jul	0	0	315	0	400	449	0	114	0
27-Jul	0	0	0	0	423	553	0	0	0
28-Jul	0	0	562	0	482	612	0	383	0
30-Jul	0	0	311	0	329	398	0	529	0
31-Jul	0	0	301	N/A	476	465	0	482	0
1-Aug	0	0	N/A	0	526	408	0	376	0
Total	**0**	**0**	**2108**	**0**	**2636**	**3735**	**0**	**1884**	**0**

Table 2. Data of all acetate sheets collected through the entire research experiment.

Treatment	Bobcat	Coyote	Control
17-Jul	0	0	0
18-Jul	0	0	0
19-Jul	237	398	0
20-Jul	382	452	0
21-Jul	429	849	0
27-Jul	0	976	0
28-Jul	945	1094	0
30-Jul	840	727	0
31-Jul	783	941	0
1-Aug	376	934	0
Total	**3992**	**6371**	**0**

Table 3. Treatments (Bobcat, coyote, and control) and total number of tracks found on each day.