Honors Thesis:

A Nonintrusive Evaluation of Mammals in Hobson Forest

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ABSTRACT

Camera trapping is a method of wildlife surveying whose use has greatly increased throughout the world over the past twenty years. Camera trap use has increased because it is considered a less intrusive means of collecting data on wildlife; especially solitary, cryptic, and secretive species. Small mammal populations in Hobson Forest have been surveyed annually for more than twenty years using traditional Sherman live traps, however limited data exist on the species of the larger mammals present. I used eight camera traps and five different scents to identify mammal species present in Hobson Forest and to determine visitation rates for each scent. The study took place over a 12 week period from October 2015 through January 2016 in Hobson Forest. The number of visitation per species per site was recorded for later analysis. My hypothesis was that visitations would increase for the less predatory scent such as beaver, while visitations would decrease for the more predatory scents such as raccoon, marten, bear, and Paws and Claws. There were 17 species seen over the entire study. White-tailed deer (*Odocoileus virginianus*) and gray squirrels (*Sciurus carolinensis*) accounted for almost 70% of the visitations. Wildlife Research Center's Paws and Claws had the most visitations. Wildlife Research Center's Paws and Claws had significantly more visitations than the control, Wildlife Research Center's Ultimate Bear Attractor, Hawbaker's Marten Lure, and Wildlife Research Center's Raccoon Lure #1. These results will be used to develop future management plans for Hobson Forest.

INTRODUCTION:

Wildlife research is used to gain information of wildlife identification (Lyons, et al. 2012), estimating animal abundance (Pierce, et al. 2012) and behavior of the wildlife (Young, 2012). Mist nets, rocket nets and drive nets are used to capture birds for banding (Schemnitz, et al. 2012). Banding provides biologists with information on bird migration patterns and individual survival (Myatt & Krementz, 2007; Bollinger, et al. 1989). Other methods include capturing animals in traps for mark-recapture, trap and collar, or harvesting animals (Schemnitz, et al. 2012).

In field research, there are two general categories of techniques used to study animals. Invasive research involves direct interaction with animals (MacKay, et al. 2008). This method could cause an animal more stress and prove to be difficult when researching endangered, cryptic, or trap shy species (MacKay, et al. 2008). Examples of intrusive research methods include rocket netting and live traps for mark-recapture studies. Nonintrusive methods prevent the need for a researcher to directly handle the desired animal (MacKay, et al. 2008). Examples of nonintrusive methods would include observation in blinds (Weckerly & Foster, 2010), camera traps (Swann, et al. 2011), or scent stations (Ray & Zielinski, 2008). Nonintrusive methods were used in this study. Scent combined with camera trapping was used to gather data on large mammals in Hobson Memorial Forest.

Scents can be useful in luring more cryptic species, such as tigers (Carbone, et al. 2001), which useful in observing animals that are harder to monitor in nature. Certain scents can be used to target specific species, while general categories of scent may attract a wider variety of species. Schmidt and Kowalczyk (2006) used beaver and catnip oil based scents to draw Eurasian Lynx to scent traps. The locations of the scent traps were placed based on Lynx track locations. This is one methodology used to determine location of scent traps. Baldwin, et al. (2006) determined that scent stations need to be located more than 20 meters from each other in order to obtain significant results.

Studying wildlife species that are solitary and secretive has long been a challenge for wildlife biologists. Direct observation attempts may alter their behavior, or cause them to avoid the study area altogether. One early solution to this challenge was the camera traps originally developed in the early 1900s by George Shiras (Kucera & Barrett, 2011). He used a form of camera trapping that involved tying a trip wire to objects animals would move resulting in a photograph. Shiras successfully captured more than 20 species of animals with this method (Kucera & Barrett, 2011). Chapman (1927) used camera traps to identify individual animals photographed and to make observations of animal behavior. Oliver Pearson was the first to use a movie camera to record multiple frames without having to reset the camera station (Kucera & Barrett, 2011). Pearson also recorded the time, temperature and humidity all by placing a clock, thermometer and hygrometer within view of the camera's frame. He also added a ruler for reference to determine the size of mammals that were photographed (Kucera & Barrett, 2011).

Camera traps allow researchers to gather large amounts of data without being present and with only minimal disturbance of the study area. In the past, camera trapping has been used for gathering data on behavioral response, time-specific variation, and simple data collection over a short time (Marnewick, et al. 2008). Camera traps have been used to photograph mountain lions and identify individuals based on coat coloration and pattern (Long, et al. 2003). However, cameras are limited to only capture photographs of animals in a small area and run the possibility of narrowly missing animals if they walk on the wrong side of the camera (Swann, et al. 2011). In order to increase the likelihood of the animals of interest actually being photographed, attractants, such as baits or scents, can be added to the area in front of the camera. McKinney & Haines (2010) used cubes of beef to attract animals to their camera trap dueling as a scent station. These combo traps resulted in the highest camera visitations (McKinney & Haines, 2010).

Cameras added to scent stations help to identify species, while recording data such as time, date, and temperature. The camera will take a picture of the animals that visit the station (Swann, et al. 2011). While cameras can only capture a small section, scents can attract different species to the camera traps and hopefully result in the highest possible visitations.

The overall objective of this study was to provide preliminary data on what mammals were present in Hobson Forest. These data could be used to provide baseline population estimates prior to implementing any future management plans. The secondary objective is to test which mammals would be attracted to or deterred from visiting an area based on the scent used. This information will serve as important baseline reference data in the future to determine which scent to use in order to collect data for a specific species within Hobson Forest.

METHODS

Nonintrusive methods of camera traps with scent were used in this study. These stations were used to determine what species were attracted to five different scents within the study area which took place over a period of 12 weeks from late October 2015 to mid-January 2016.

The location of the project was Bemidji State University's Hobson Forest (Section 22, Township 147, Range 32) approximately 15 kilometers northeast of Bemidji, MN. The study design consisted of eight camera traps placed in predetermined locations in the northeast quarter of Hobson Forest, an area of about 160 acres (Figure 1). Five of the cameras were Bushnell Trophy Cam HD Essential E2, 12MP and were used at 8MP, set for 10 second intervals and took three photos at each time the camera was triggered. The remaining three cameras were Bushnell 10MP Trophy Cam Essential HD, Brown, Low Glow. These cameras were set to the same settings as the previous five. The camera locations were determined by (1) walking the trail and taking GPS coordinates where there were game trails, (2) mapping these locations and determining their distance from one another in ArcGIS, and (3) using a GPS unit to select a location that was over 150 meters from the nearest camera. The cameras were placed in a circular shape with one in the center.

Each station consisted of two main elements: camera traps for recording visitations and scent for attracting animals to the camera side of the station. To deter theft, camera traps were locked in a lock box and bolted to a tree about one meter off the ground. A canister was zip tied to a garden stake about a meter off the ground in view of the camera. The canisters had holes drilled in the top and attached to the top of the stake for optimal aeration. A scent was applied to a cotton ball and placed in the canister for each trial period. The stake was placed approximately 3.5 meters away from the camera. To ensure visibility for the camera, the surrounding vegetation was cleared in a circle approximately five meters across using loppers.

The scents used included Wildlife Research Center's Paws and Claws, Wildlife Research Center's Ultimate Bear Attractor, Hawbaker's Beaver Lure, Hawbaker's Marten Lure, and Wildlife Research Center's Raccoon Lure #1. These lures were advertised as attracting coyotes (*Canis latrans*), wolves (*Canis lupus*), bobcats (*Lynx rufus*), Canadian lynx (*Lynx canadensis*), gray foxes (*Urocyon cinereoargenteus*), red foxes (*Vulpes vulpes*), black bears (*Ursus americanus*), beavers (*Castor canadensis*), fishers (*Martes pennanti*), and raccoons (*Procyon lotor*).

The cameras have an infrared beam that shines out at the scent station. Once the beam is disturbed, the camera takes three photographs. These three photos are referred to as a group of photos in this study. The photographs are stamped with time, date and temperature of when they were taken.

A review of the literature found a widely varied definition of a visitation. Jordan et al. (2011) examined the problems with using a 24-hour period as a visitation. If an animal was pictured within 24 hours, this counted as only one visitation. If the animal visited at 11:59 into the next morning that would count as two visitations, but if an individual of one species visited at midnight and then a different individual visited at noon this would only count as one visitation. Muñoz et al. (2014) discussed if an animal visited a station after a two minute period, this would count as a new visitation. In my study, if a mammal appeared in at least one of the three photos per group, it was a visitation. Each group of photos taken was counted as one visitation. If there was a mammal in all three of the photos, it was still one visitation, just as if it were in only one of the three frames. I am using this definition because it is the simplest explanation of a visitation and will provide me with a large amount of data for later analysis.

During the first two weeks, no scent was used to establish a control period. After the first two-week period, the camera's memory cards were collected and replaced with new memory cards. The old cards' photographs were examined for data analysis. The date, time, temperature, camera number, scent used, number of species observed and how many visits of each species were recorded.

Paws and Claws (Wildlife Research Center, Ramsey, MN), a synthetic predator scent, was used as the first treatment in weeks 3-4 (11/05-11/19). Ultimate Bear Attractor (Wildlife Research Center, Ramsey, MN), an apex predator scent, was the second treatment used for weeks 5-6 (11/19 – 12/03). These first two treatments were predator scents and were expected to have the least visitations. Beaver Lure (Hawbaker, Fort Loudon, PA), a non-predator scent, was used for weeks 7-8 (12/03 – 12/17). This scent was expected to have the highest visitations due to being a non-predator scent. Marten Lure (Hawbaker, Fort Loudon, PA) was used for weeks 9-10 (12/17 – 12/31) and Raccoon Lure #1 (Wildlife Research Center, Ramsey, MN) was used for weeks 11-12 (12/31 – 1/14). These last two treatments used were mesopredator scents. They were expected to have more visitations than the predator scents, but less than the non-predator scent.

All statistical analyses were conducted using SPSS Statistics version 23.0 (IBM 2016). Data were considered statistically significant if $p \leq 0.05$. Frequency tables were used to determine which species had the most visitations, when the most visitations took place, and what species had the highest visitations for which scent. A mixed design factorial analysis of variance (ANOVA) was used to evaluate the effects of scent on different species visitation rates.

RESULTS

Frequencies for each species was taken to see the overall visitations for each species (Table 1). There were 17 species seen over the entire study. White-tailed deer *(Odocoileus virginianus)* and gray squirrels *(Sciurus carolinensis)* accounted for almost 70% of the visitations. Of the ten expected species, six had at least one visitation: raccoon, fisher, gray fox, coyote, gray wolf, and bobcat.

Frequencies for scent were taken for each the two most visited species, white-tailed deer (Figure 2) and gray squirrel (Figure 3), to determine which scent was visited most by each. About 41% of the white-tailed deer visitations were during the predator scent, Paws and Claws (Wildlife Research Center, Ramsey, MN). The least of the visitations from white-tailed deer were for the Raccoon Lure #1 (Wildlife Research Center, Ramsey, MN), a mesopredator scent.

Gray squirrels accounted for over 30% of the overall visitations. For the gray squirrel, about 45% of the visitations were for Beaver Lure (Hawbaker, Fort Loudon, PA), a non- predator scent. Gray squirrel visitations were lowest for the control and the mesopredator scent, Raccoon Lure #1 (Wildlife Research Center, Ramsey, MN).

The number of visitations per trial period was recorded to observe which scent had the most visitations over the study. Figure 4 shows the most visitations were during Paws and Claws (Wildlife Research Center, Ramsey, MN), the predator scent, and Beaver Lure (Hawbaker, Fort Loudon, PA), the non-predator scent, with 219 and 196 visitations respectively.

The overall visitations for each scent was separated to order to provide a more generalized understanding of the visitations (Table 2 and Figure 5). Most of the Rodent visitations were during the Beaver Lure (Hawbaker, Fort Loudon, PA) trial period. The most visitations for Artiodactyl were during the Paws and Claws (Wildlife Research Center, Ramsey, MN) trial period. Lagomorph visitations declined over the duration of the study period. Carnivores dropped for Ultimate Bear Attractor (Wildlife Research Center, Ramsey, MN) and Raccoon Lure #1 (Wildlife Research Center, Ramsey, MN).

The number of visitations was examined using a 4x6 mixed design factorial ANOVA to evaluate the effects of order (Rodentia, Lagomorpha, Carnivora, and Artiodactyl) and scent (control, paws & claws, bear, beaver, marten, and raccoon). There was a significant interaction between Order and Scent, $F(5, 230) = 2.48$, $p < .03$ (Huynh-Feldt correction used for violation of sphericity, $\varepsilon < .70$); partial $\eta 2$ (.14) indicated a weak interaction effect. The interaction was evaluated using post hoc Bonferroni tests for simple main effects. These results are summarized in Table 3. Paws and Claws (Wildlife Research Center, Ramsey, MN) had significantly more visitations than the control, Ultimate Bear Attractor (Wildlife Research Center, Ramsey, MN), Marten Lure (Hawbaker, Fort Loudon, PA), and Raccoon Lure #1 (Wildlife Research Center, Ramsey, MN). The table illustrates that for Paws and Claws (Wildlife Research Center, Ramsey, MN), and Marten Lure (Hawbaker, Fort Loudon, PA), Artiodactyl had significantly more visitations than any other order recorded (Rodentia, Lagomorpha, and Carnivora).

To discover if these findings could be due to seasonality, a Pearson correlation coefficient was conducted to assess the relationship between average temperature and visitation rate. A significant correlation was found between the two variables with $r = .314$, $N = 82$, $p = .004$. A scatterplot summarizes the results (Figure 6). This weak positive correlation shows that as temperatures increased, so did visitation rate.

A Pearson correlation coefficient was run for each species to determine if any individual species did not fit the calculated overall correlation between average temperature and visitation rate. For the gray squirrel, ($r = .000$, $N = 53$, $p > .05$) there was no correlation of visitations with temperature (Figure 7). This meant gray squirrels were visiting the stations in all temperatures without significant variation.

During the study, one of the cameras was stolen. The data gathered from this camera before it was stolen was considered unusable because it could not be compared to the rest of the data. The location of the camera can be seen in Figure 1 in the Appendix.

DISCUSSION

The mammal with the greatest number of visitations was the white-tailed deer. All of the Artiodactyl visitations were white-tailed deer. The visitations spiked during the predator scent, Paws and Claws (Wildlife Research Center, Ramsey, MN). About 41% of the white-tailed deer visitations were during this study period. This finding was unexpected. Paws and Claws (Wildlife Research Center, Ramsey, MN) was advertised as being used to attract predator mammals such as bobcat, lynx, gray wolf, black bear, and coyotes. White-tailed deer are known prey of wolves, coyotes, bobcats, and bears (Hazard, 1982). Predator odors, such as urine, feces, and hair, have been used to deter white-tailed deer (Swihart, et al. 1991; Sullivan et al. 1985; Seamans, et al., 2002). Potentially deer traveled through my stations, even though there was a predator scent, because it was along game trails and not guarding a food source. Seamans, et al. (2002) found if feeding areas were treated with predator hair, deer would avoid those areas, but if the hair was along a trail, the number of visitations would not be affected.

The second greatest number of visitations were from gray squirrels with over 30% of the overall visitations. The majority of the gray squirrel visitations, about 45%, occurred during the Beaver Lure (Hawbaker, Fort Loudon, PA) study period. My hypothesis was that this non-predator scent would result in visitations of beavers and their predators. A beaver's natural predators are the larger predators; coyotes, wolves, bears, and bobcats. A beaver's diet consists of plants (Hazard, 1982). Due to beavers not being a threat to gray squirrels, this could be why gray squirrels visited the beaver scent the most. The control and the Raccoon Lure #1 (Wildlife Research Center, Ramsey, MN) had the two lowest visitations of gray squirrels with only 17 visitations each. Raccoons are known predators of squirrels (Whitaker, 1996). Raccoon scent has been used to repelled squirrels from food (Rosell, 2001). Squirrels may have avoided this scent due to fear of becoming a raccoon's next meal. However, the visitations were the same as the control. Humans have hunted gray squirrels (Hazard, 1982). This could explain the low visitations for the control.

Temperature correlated with the overall visitation rates. As temperature decreased so did visitations. Small mammals seek shelter from temperature extremes (Shuai, et al., 2014). Other mammals use hibernation to shelter themselves from the harsh elements (Hazard, 1982).

LIMITATIONS

Human scent may be a limitation. This limitation was not addressed due to three main factors. First, Hobson Forest is open to the public year round. This forest is used for both recreation and educational purposes. There are field trips weekly in the fall, student and faculty projects, and hiking and skiing throughout the year. According to the Bemidji Ski Club, about 400-500 skiers visit Hobson every year. There is also hunting that takes place in the forest during hunting season. Second, a scent was used to attract specific animals. These attractants tend to be a strong scent that should last for a few weeks. Finally, as long as the cameras are in an appropriate location and the season is one of high wildlife activity, human scent does not affect visitation rates significantly enough for researchers to bother with using scent-masking products (Muñoz, et al. 2014). There is little research on the topic of covering human scent. Researchers have not worried about human scent affecting results too greatly in the past. However, there is some concern about how seasonal changes in wildlife behavior may affect visitation rates.

Due to the scents being placed during different two week periods, the results found in this study could be an argument of seasonality. The changes in temperature for the duration of the study was from about -26°C to 10°C (see Figure 8). These temperatures may have dropped enough to result in some species going into torpor (Schwingel & Norment, 2010). Black bears enter torpor early winter and emerge the end of winter (Harlow, et al., 2004). There would be a different outcome if the study were to take place a different season of the year, such as summer. In future studies, the scents used could be switched to a different week to see if time or scent is the actual attractant. The five scents could also be rotated throughout five sites of the same habitat to see if the scent or time of year is the factor for the appearances of the different mammals.

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Appendix

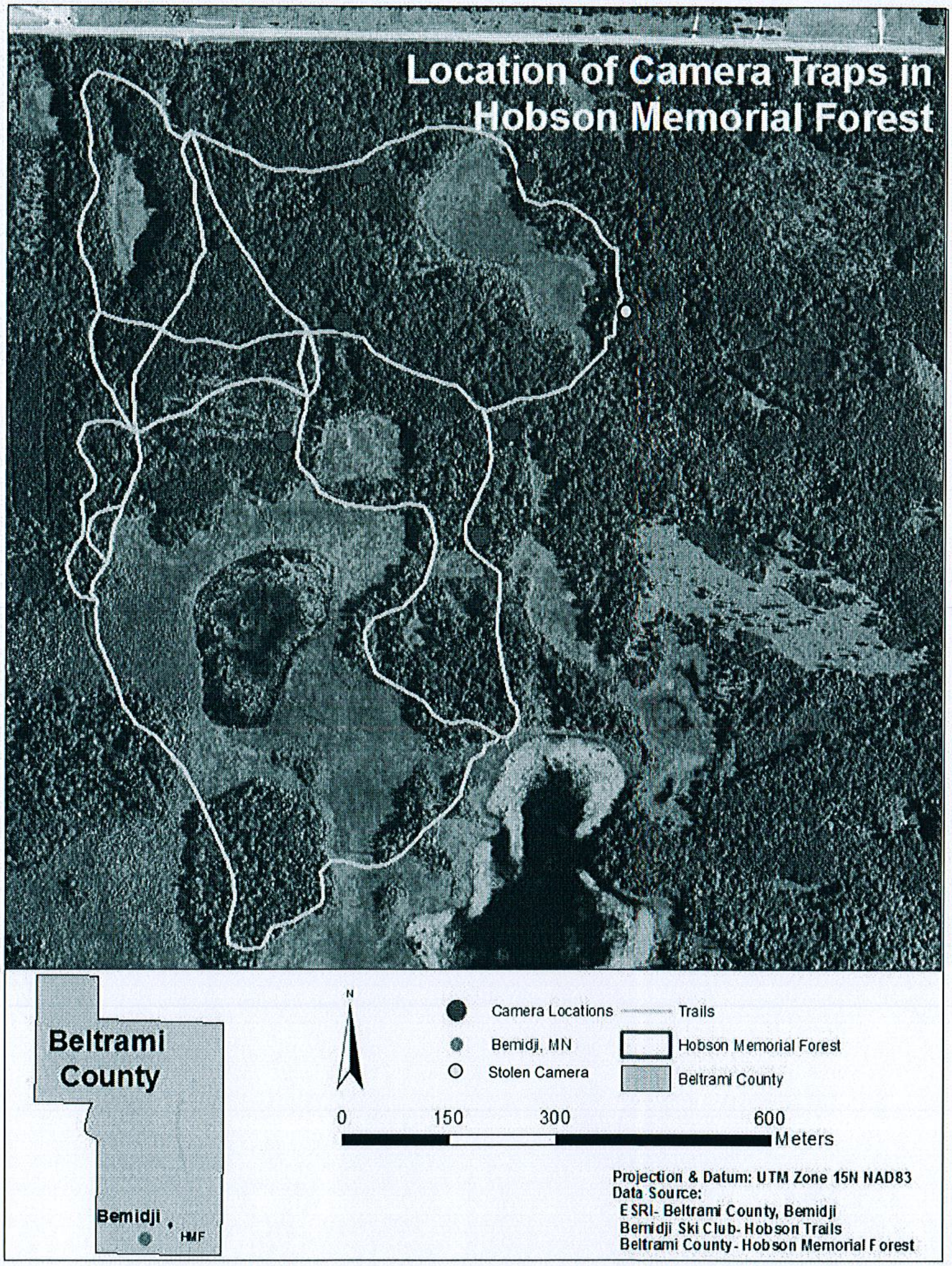

Figure 1. This map shows the location of the camera/scent traps in Hobson Memorial Forest. The cameras were place at least 150m away from each other. The yellow dot is the location of the camera that was stolen between 12/03 – 12/17, or during the beaver lure trial period.

Table 1:
Visitations per Species (Excluding Unknown Species)

Species	Visitations	Percent	Valid Percent
White-tailed Deer *(Odocoileus virginianus)*	322	38.8%	40.1%
Gray Squirrel *(Sciurus carolinensis)*	256	30.8%	31.9%
Snowshoe Hare *(Lepus americanus)*	73	8.8%	9.1%
Red Squirrel *(Sciurus vulgarus)*	44	5.3%	5.5%
Northern Flying Squirrel *(Glaucomys sabrinus)*	42	5.1%	5.2%
Domestic Dog *(Canis lupus familiaris)*	18	2.2%	2.2%
Eastern Cottontail *(Sylvilagus floridanus)*	12	1.4%	1.5%
Raccoon *(Procyon lotor)*	8	1.0%	1.0%
Fisher *(Marten pennanti)*	7	.8%	.9%
Fox Squirrel *(Sciurus niger)*	5	.6%	.6%
Ermine *(Mustela erminea)*	4	.5%	.5%
Bobcat *(Lynx rufus)*	4	.5%	.5%
Gray Wolf *(Canis lupus)*	4	.5%	.5%
Porcupine *(Erethizon dorsatum)*	2	.2%	.2%
Gray Fox *(Urocyon cinereoargenteus)*	1	.1%	.1%
Coyote *(Canis latrans)*	1	.1%	.1%
Total Visitations	803	96.7%	100%
Missing Data			
Unknown	27	3.3%	

Of the 830 total visitations 27 or 3.3% of the visitations could not be identified to species. This data was counted as missing. Most of the visitations were white-tailed deer (322) and gray squirrels (256). This accounts for over 70% of the total visitations.

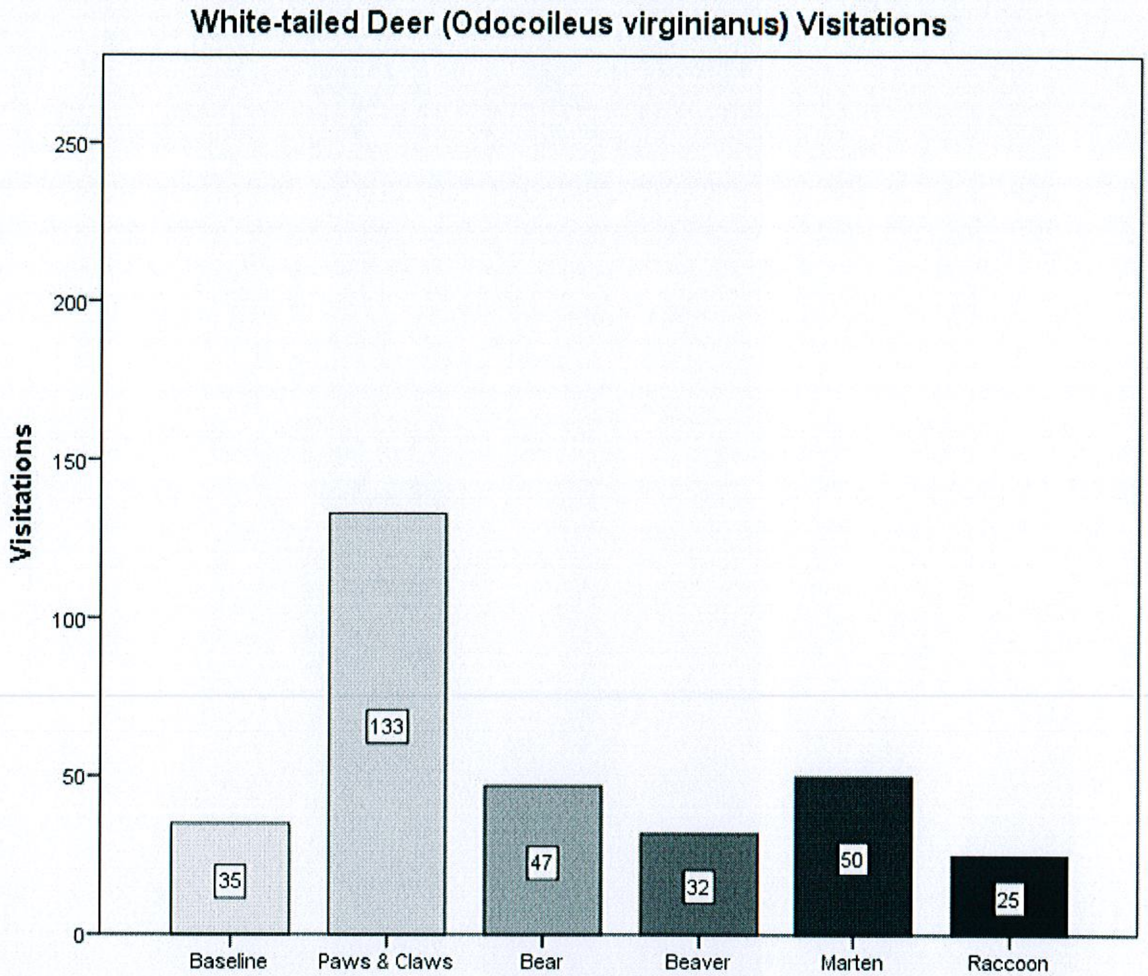

Figure 2. The distribution of white-tailed deer visitations. Most of the visitations (133) were during the Paws & Claws scent. This is about 41% of the white-tailed deer visitations.

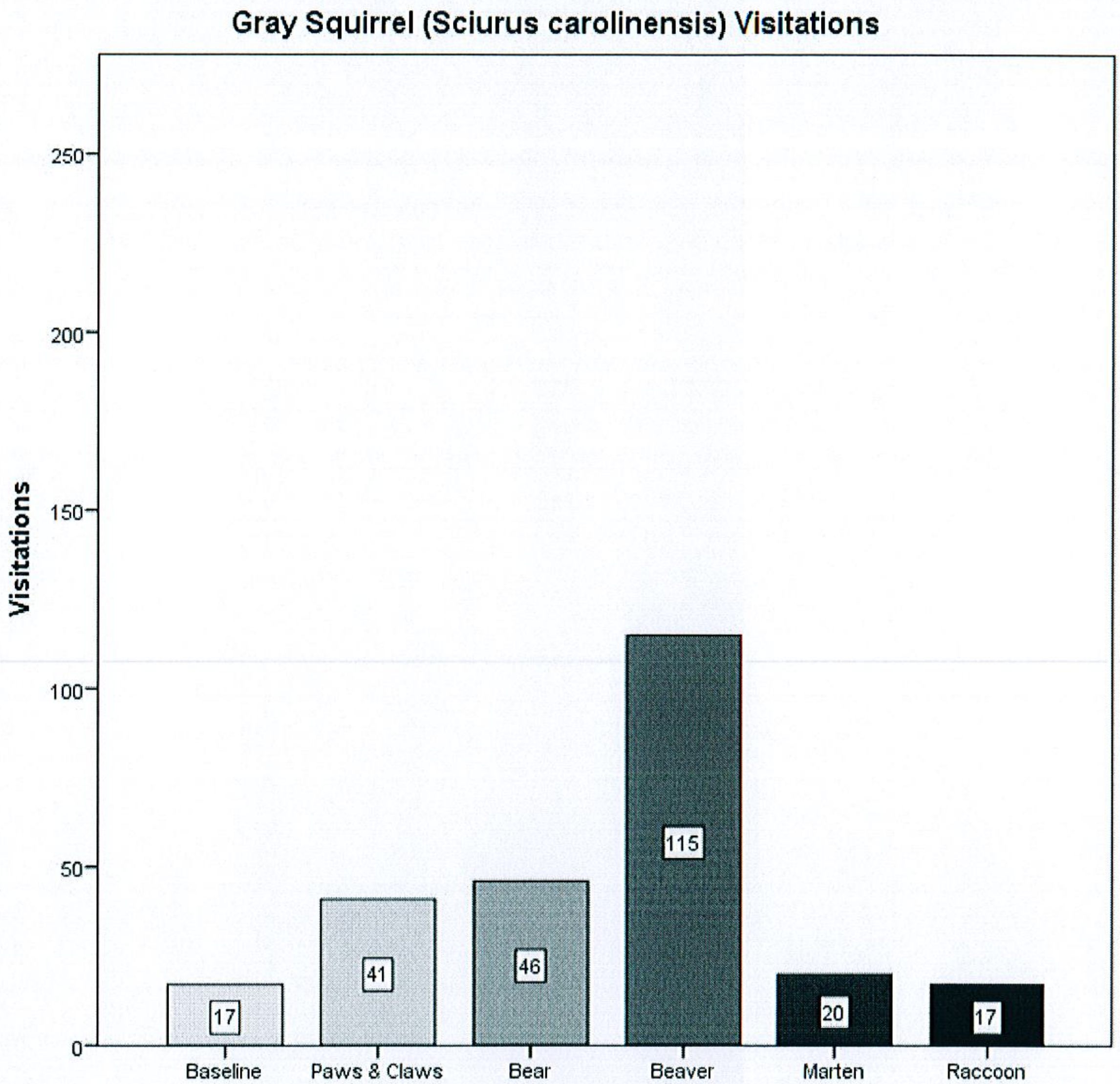

Figure 3. Distribution of gray squirrel visitations. Most of the gray squirrel visitations (115) were during the beaver scent. This is about 45% of the gray squirrel visitations.

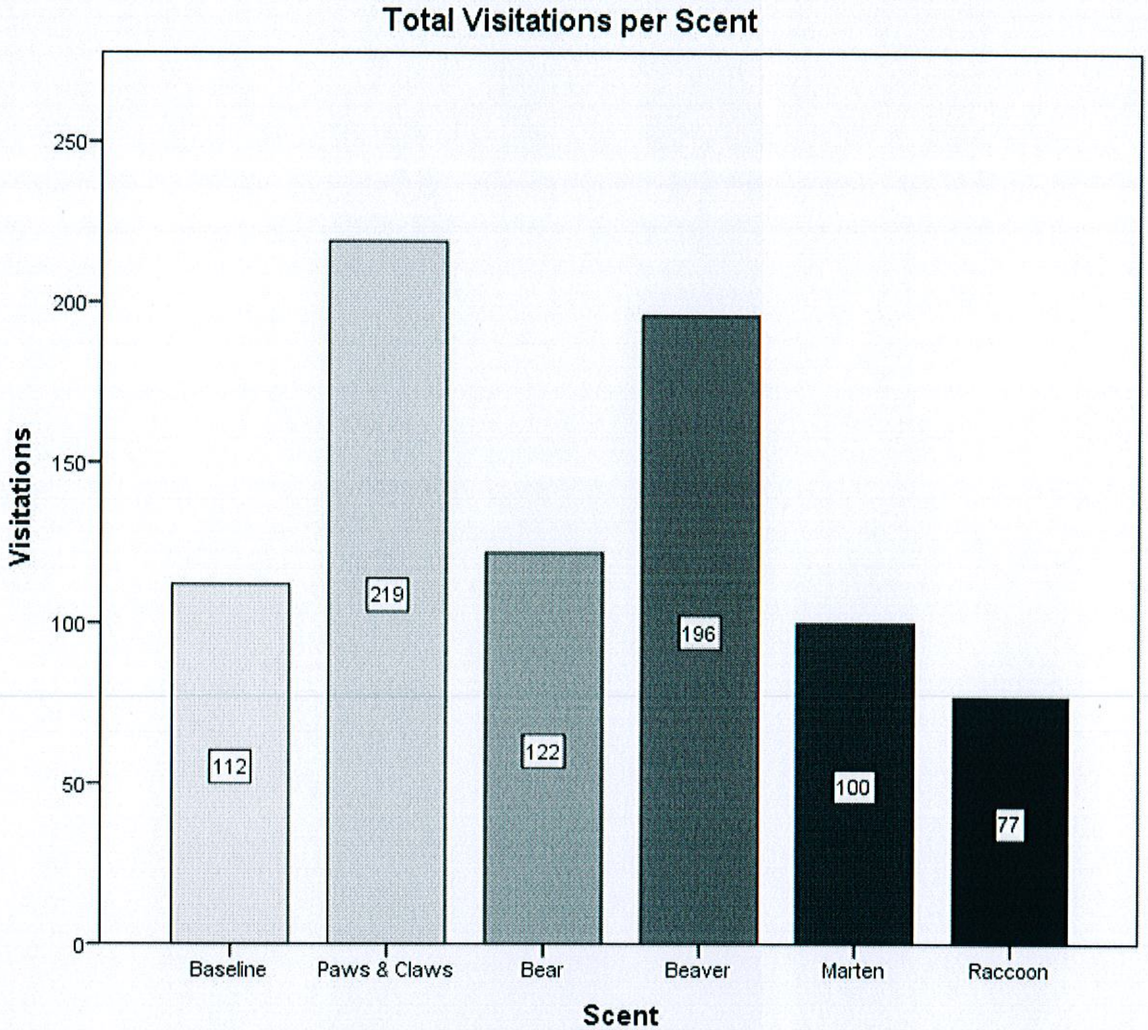

Figure 4. The total visitations per scent is shown here. The most visitations (219) were for Paws and Claws, a predator scent. The least visitations (77) were for the Raccoon scent.

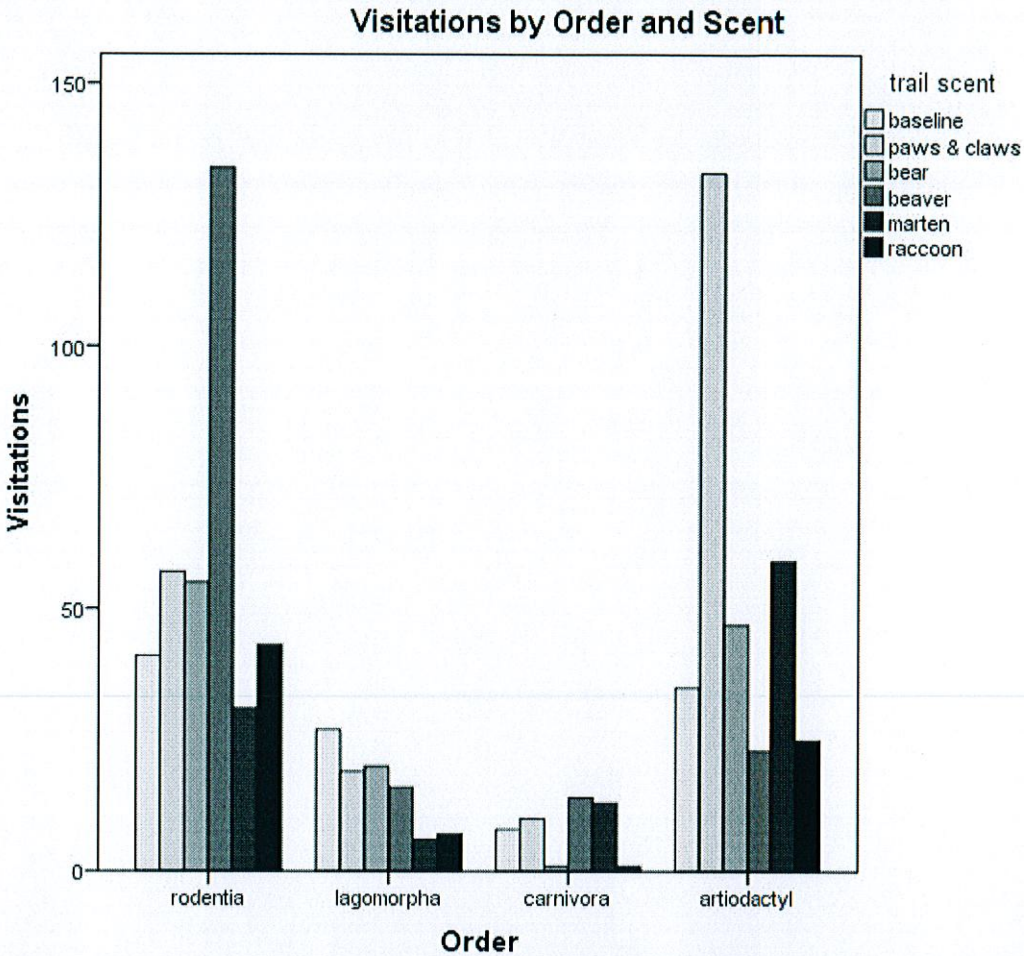

Figure 5. The visitations for each order over the study is shown here. Each order is separated into the 6 study periods (control, paws & claws, bear, beaver, marten, and raccoon). For order Rodentia, the most visitations were during the beaver scent period and the least were for the marten scent, a predator scent. For Lagomorpha, the most visitations were during the control and the overall visitations seemed to drop over the study. The lowest visitation of the lagomorphs was during the marten scent. For Carnivora, the visitations seemed to overall increase over the study. However, carnivore visitations dropped at the bear scent and the raccoon scent. For Artiodactyl visitations spiked during the paws & claws study period and dropped during the beaver study period.

4 x 6 Mixed Methods Factorial ANOVA
Table 2:
Visitations as a Function of Order and Scent Type

	Scent Type					
Order	Control	Paws & Claws	Bear	Beaver	Marten	Raccoon
Rodentia	2.33_a	2.71_a	2.67_a	6.38_a	1.48_a	2.05_a
Lagomorpha	2.38_a	2.38_a	2.50_a	2.00_a	0.75_a	0.88_a
Carnivora	0.57_a	0.71_a	0.07_a	1.00_a	0.93_a	0.07_a
Artiodactyl	5.00_a	19.00_b	6.71_a	4.57_a	7.14_b	3.57_a

Note. Unconfounded means with no subscripts in common are significantly different, $p < 0.05$

Paws and Claws and the Beaver scents had significantly more visitations when compared to the other scents. Artiodactyl had significantly more visitations for the Paws and Claws and Marten scents.

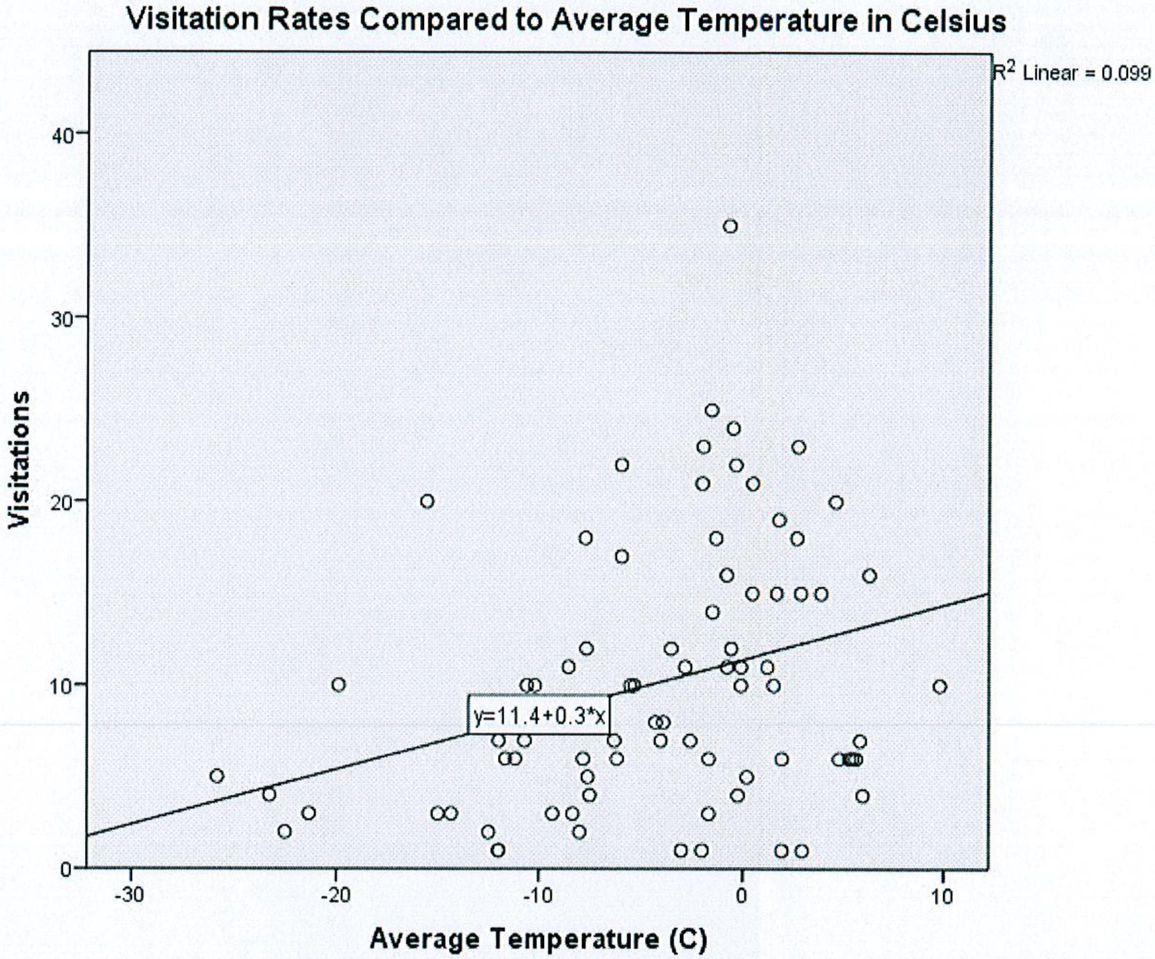

Figure 6. The positive correlation shows an increase of overall visitations as the average temperature increased. Each dot represents a visitation. However, the correlation was not a strong correlation ($r = .314$, $N = 82$, $p = .004$).

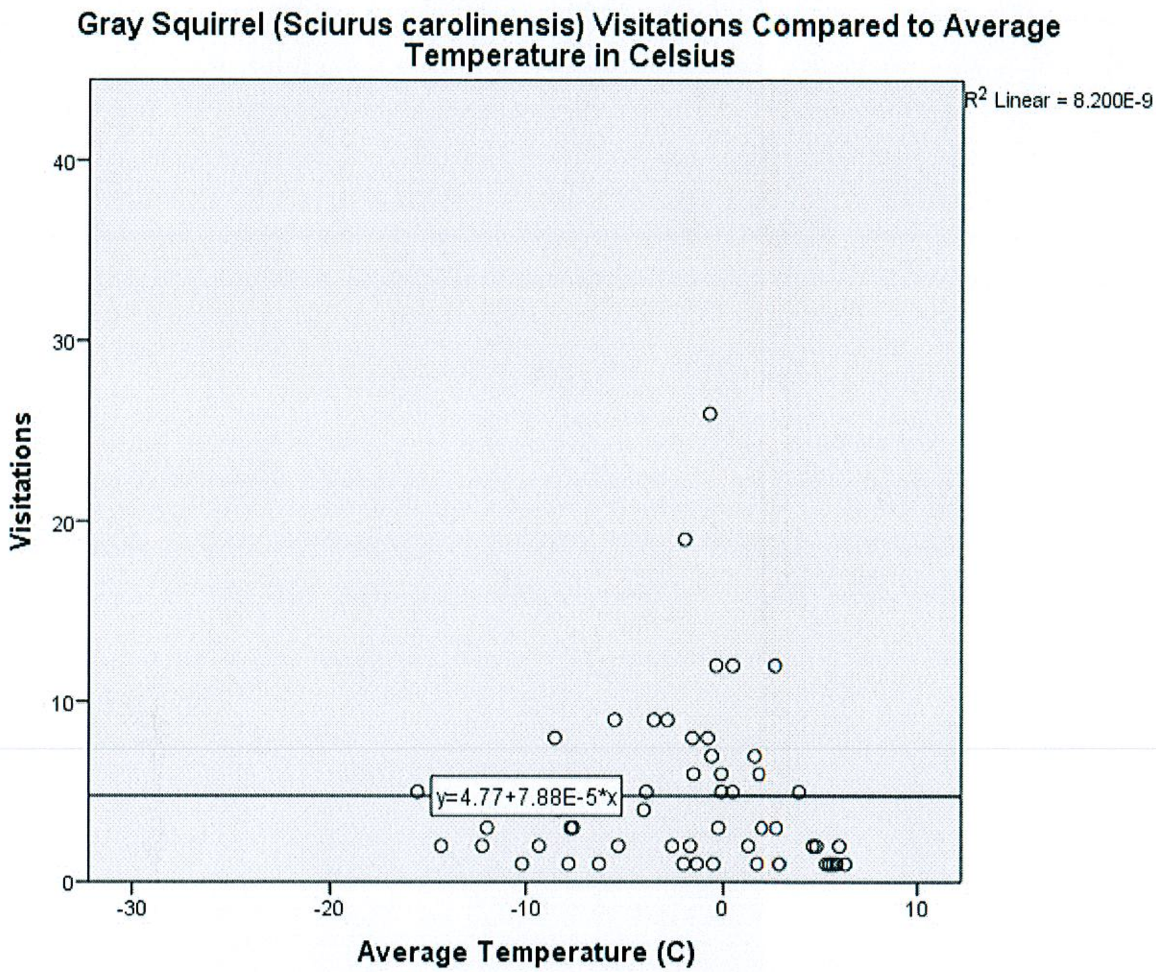

Figure 7. There was not a significant correlation between the two variables ($r = .000$, $N = 53$, $p > .05$). The correlation shows that average temperature does not have an effect on visitations for gray squirrels. Each dot represents a visitation.

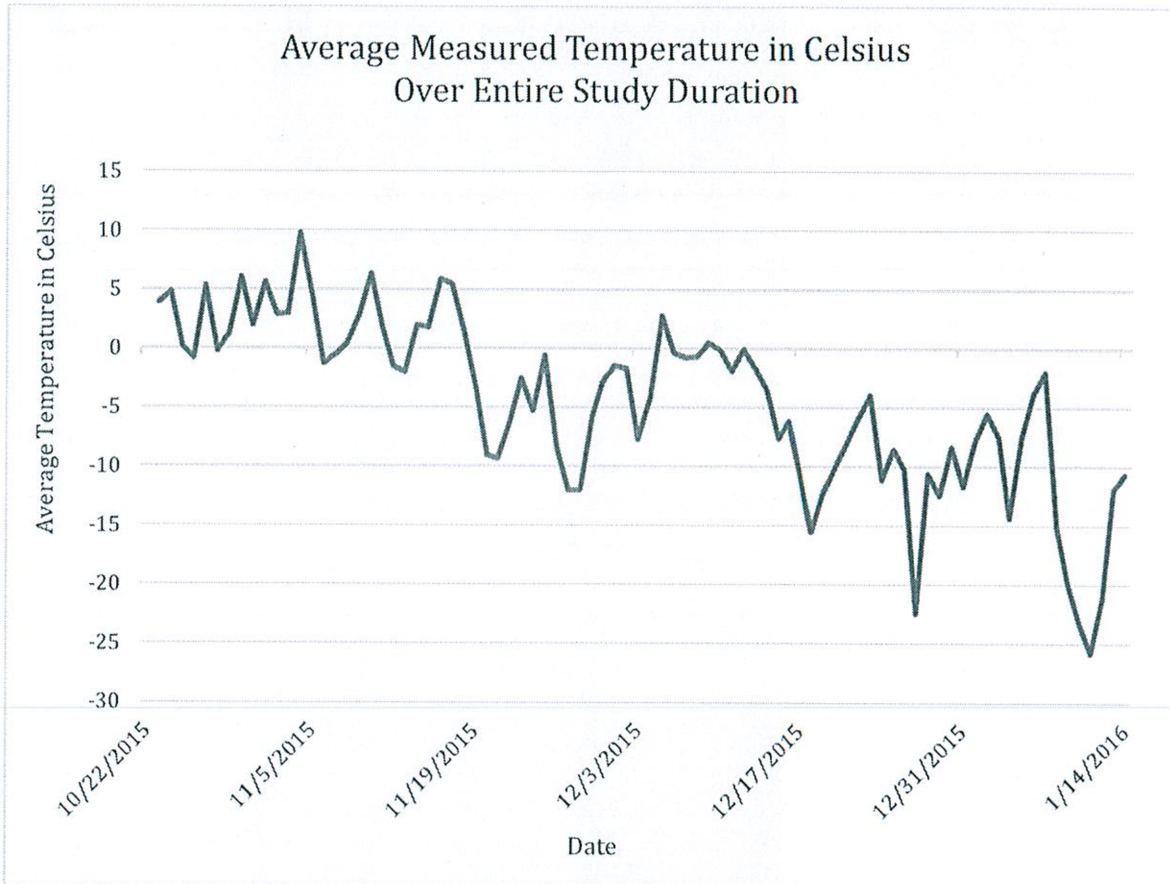

Figure 8. The average temperature measured from the cameras over the duration of the study. These temperatures came from taking the average of the temperatures for each day. Each two week trial period is depicted by the start and end date of each. The control study was during 10/22 – 11/05. Paws and Claws was during 11/05 - 11/19. Bear was during 11/19 – 12/03. Beaver was during 12/03 – 12/17. Marten was during 12/17 – 12/31. Raccoon was during 12/31- 1/14. The highest average daily temperature was during the control at 9.8°C. The lowest average daily temperature was -25.8°C and during the Raccoon scent study period.