The impact of human presence on yellow-bellied marmot (*Marmota flaviventris*) behavior

Rebecca L. Flynn

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Abstract

Humans impact yellow-bellied marmot (*Marmota flaviventris*) populations, influencing distribution, dispersal, and behavior. Exerting both lethal and nonlethal effects, human presence should elicit similar behavioral responses to predators and other threats. Marmots in low and high disturbance areas may respond differently. Using a mannequin to simulate human presence, scan and focal sampling were conducted at five marmot colonies—two undisturbed on the National Bison Range and three disturbed near Charlo, Montana—for two days each, one with the mannequin present and one without. Human presence was shown to significantly decrease foraging ($p=0.008$), resting ($p=0.023$), and traveling ($p=0.031$) behavior counts. The proportion of foraging behavior decreased significantly ($p=0.042$), while alarm calling significantly increased ($p=0.041$), with a potentially important increase in resting ($p=0.067$), when the mannequin was present. Under both experimental and control treatments, incidence of resting was higher at disturbed sites (C $p=0.007$, E $p=0.003$), while that of perching was higher at undisturbed sites (C $p=0.001$, E $p=0.044$). Alarm calling under experimental conditions was higher at undisturbed sites (E $p=0.048$), but under control conditions was higher at disturbed sites ($p=0.085$). ANOVAs on focal data indicate potentially important treatment effects, with mannequin presence decreasing foraging ($p=0.076$) and perching ($p=0.079$). Lessened foraging has potential survival costs, inhibiting marmots' resource storage for hibernation. Lowered foraging efforts and increased alarm calling indicate marmots perceive humans as a threat. Higher resting at disturbed sites potentially indicates a benefit to colony establishment in human-disturbed areas. More research is necessary to inform management procedures to reduce human impact on marmot populations.

Introduction

Human activities are leaving increasingly little area undisturbed to wildlife. The degree of disturbance varies by region, land use, and human population density. These activities affect the distribution, demographics, and behavior of the specific region's fauna. Historically yellow-bellied marmots (*Marmota flaviventris*) have been exposed to humans. Marmot species have been hunted (Armitage 2003), with varying intensities, for thousands of years; therefore, it would be expected for marmots to treat humans as a threat (Frid & Dill 2002). van Vuren even documented two cases of anthropogenic induced mortality during his study: one road kill and another gun shot wound (2001). Human impact can be measured through recording behavioral responses to determine how simple human presence in their territory affects their behavior.

Many behaviors are devoted to predator avoidance. Of all summer mortality (generally early May through August), 98% of mortality was caused by predation (van Vuren 2001). Predation causes the extinction of many matrilines (Armitage 2004). Important predators are coyotes (*Canis latrans*), badgers (*Taxidea taxus*), martens (*Martes* sp.), black bears (*Ursus americanus*), and golden eagles (*Aquila chrysaetos*) (van Vuren 2001). To prevent extinction and increase survival, anti-predator defenses (behavioral, evolutionary, and ecological) are an important part of marmot evolution (van Vuren 2001). For example, when marmots detect predators, they participate in vigilance behavior (i.e., they perch and look around) and alarm call (Armitage 2004). Foraging has also been shown to decrease and resting behavior to increase in the presence of badgers, a known predator (Armitage 2004). Since foraging is important due to resource needs in hibernation (Armitage 1991), a decrease in foraging may lessen fitness, especially if insufficient body weight is achieved to survive the winter (Salsbury and Armitage 2003).

Marmots have evolved several mechanisms to identify predators, primarily visual and olfactory. According to the multipredator hypothesis (Blumstein 2006), adaptations developed as antipredator protection evolve in conjunction with each other; therefore, prey can respond to extinct predators, provided other predators are still extant. Using visual cues, specifically photographs of various predators, yellow-bellied marmots responded appropriately to different levels of danger, even those that are now virtually extinct—no longer present in areas inhabited by marmots, such as gray wolves (*Canis lupus*)-- consistent with the multipredator hypothesis (Blumstein, Ferando, and Stankowich 2009). One mechanism of predator identification by a species is based on sulfurous metabolites in the urine of carnivorous mammals. Using urine from herbivores, elk (*Cervus canadensis*) and the novel moose (*Alces alces*)—not an inhabitant of the region), as controls and from predators—fox (*Vulpes vulpes*), coyote, mountain lion *(Felis concolor),* and the novel wolf)--, marmot risk assessment was analyzed. Marmots can use olfaction to identify even novel predators. These results suggest that experience with a specific predator is not required to signal risk (Blumstein, Barrow, and Luterra 2008). Since humans have hunted marmots, all populations will likely be wary of human presence, even those that are relatively removed from people, and behave differently when people are present.

Behavioral changes may impact foraging and potentially decrease survival. Many previous studies have been conducted on marmot behavior in response to humans or other predators, using an approach method (Blumstein and Pelletier 2005, Griffin et al. 2007, Rhoades and Blumstein 2007). For example, yellow-bellied marmots have been manipulated into hiding in refugia by simulating a predators approach with a human approach—considered a "standardized alarming stimuli" (Blumstein and Pelletier 2005). That study showed that marmots optimized their hiding, given supplemental food, a manipulated hiding cost (Blumstein and

Pelletier 2005). Most marmots emerged sooner when food was provided—indicating willingness to take extra risk for an extra reward—and some tolerated closer human approaches (Blumstein and Pelletier 2005). Oddly, marmots tolerant of human approach emerged sooner when extra food was present, but intolerant marmots took longer to emerge and emerged from hiding sooner when no extra food was present (Blumstein and Pelletier 2005). This phenomenon was unexplained even by variation in individual behavior patterns (Blumstein and Pelletier 2005). Rhoades and Blumstein also tested optimal foraging in response to human approaches with extra food as a factor (2007). Marmots conduct cost-benefit analyses regarding hiding behavior to balance the costs of waiting too long or not long enough for a predator to leave the area (Rhoades and Blumstein 2007). Bouskila and Blumstein suggested that individuals would be favored by overestimating predation risk and hiding too long than by underestimating it (1992). Hiding too long, though, may make it difficult to reach optimal weight for hibernation, decreasing overwinter survival (Salsbury and Armitage 2003, cited in Rhoades and Blumstein 2007). Rhoades and Blumstein's study tested a predation risk that came and then vacated the area, not a persistent presence.

Griffin et al. studied the effect of tourism on Olympic marmot (*Marmota olympus*) populations in Olympic National Park (2007). These marmots are unable to avoid tourists due to the short foraging season, in summer when tourism is highest. Marmots at highly used sites decreased responses to an approaching human but also looked up more often during foraging activity as compared to marmots in low use areas. The first behavioral difference indicates decreased predator awareness, but the latter suggests increased wariness. Despite behavioral changes, survival, body condition, and reproductive output were similar between the two types of site usage. There is no variation in overall daily activity pattern or change in foraging timing as a

function of tourist activity. They also used the human approach method and recorded how close the person could get before the marmot ran to a burrow and then below ground, as well as how long it remained hiding after the human threat left. Marmots at sites of high traffic allowed humans to approach to a distance less than half that allowed by marmots at low-used sites, suggesting that marmots may become desensitized, learning that cars and humans represent little risk (Griffin et al. 2007). This study of tourism effects addresses the issue of variation in degrees of human impact. However, neither the colonies at high use nor low use have recently experienced humans as predators.

Some *M. flaviventris* populations are still hunted, for food or recreation. In Mission Valley, Montana, there are populations near farms and ranches that are heavily impacted by humans, both lethally and nonlethally. Some marmots get stuck and die in irrigation pipes, and others get run over by farm equipment or vehicles. In this area, marmot colonies are often around rubble and refuse piles, or rock cliffs with rebar, gasoline cans, and other items strewn about. However, there are *M. flaviventris* populations on the National Bison Range near Charlo, Montana that very rarely come into contact with humans and are definitely not hunted. It is quite possible that the differences in response to humans will vary even more drastically across between these two population types than between two levels of tourism traffic, as in Griffin et al. 2007. The disturbed marmot populations will likely treat humans as an extant predator, whereas they may appear to be alien or invasive to undisturbed marmots. Alien predators have an impact twice that of native predators, since prey are naïve to hunting tactics (Salo et al. 2007). Even considering the multipredator hypothesis (Blumstein 2006), and the studies that have shown its applicability to *M. flaviventris* populations (Blumstein, Ferando, and Stankowich 2009; Blumstein, Barrow, and Luterra 2008), the degree and type of behavioral changes between these

two types of marmot colonies will likely differ.

It is important to know how humans affect marmot populations for land usage and management information. This study approaches the effect of humans by simulating a constant presence within the bounds of a colony through use of a human mannequin. I set out to test whether and how marmots alter their behavior when a human is present in their colonial territory. The experiment tests whether behavioral responses to human presence vary between disturbed areas, those that regularly experience human presence or activity, and undisturbed areas. If there is a difference, marmots may respond to humans as if they are a threat, or they may be more naïve and not consider humans a threat. I hypothesize that a simulated human presence will affect marmot behavior and that marmots in disturbed areas will alter their behavior more, treating humans as a threat. Initial alarm to a novel environmental element may occur in undisturbed colonies but it will likely not persist as long as the alarm in disturbed colonies. In this way, marmots will respond to humans as they would an extant predator in disturbed areas but as to an alien predator in undisturbed areas.

Methods

Site Choice

From 22 June through 25 June, 2010, yellow-bellied marmot colonies were scouted in Moiese, MT (47°25’ N, 114°18’ W) and on the National Bison Range (47°22’ N, 114°15’ W). Colonies were located using scat as an indicator of habitation as well as visual confirmation of marmot activity. I selected sites by seeking colonies that experience heavy human disturbance as well as those that rarely experience such disturbance (Griffin et al. 2007). The three disturbed colonies are located on ranch property in Mission Valley, near Moiese, Montana. Moiese Valley

Road runs very close to three colonies. The field abutting the hill is an active hayfield, complete with an irrigation apparatus. There are cows and horses grazed in nearby fields. Man-made objects are strewn across the hill. In addition, local residents have a history of shooting these marmot colonies. Colony designations will be abbreviated MH for Moiese Hill. MH 1 and 2 are closely linked colonies, but separated by hill orientation: MH1 is WNW in orientation while MH2 is WSW (McCabe, unpublished). The colonies interact but are separate, and marmots cross the territory bounds infrequently (McCabe, unpublished). MH3 is located in a rubble pile beside the irrigator pivot. Three undisturbed locations were selected on the National Bison Range (NBR), two located off the West Boundary Rd. in an area designated as the Snake Pit, and one off North Road near Dublin Gulch (NBR1-DG). Only one site is Snake Pit (NBR2-SP) was sampled due to low population densities by late July and early August. Only researchers and park maintenance crews use these two roads. These marmot colonies do not experience hunting or much other human disturbance. The number of cars passing on the road during the hours of observation was recorded at all sites (Griffin et al. 2007).

Sampling

Between 17 July and 4 August, 2010, a partner and I observed each colony for two consecutive days, control on the first day and experimental the second. Observations were taken from areas with good vantage points to watch the colony but with enough distance so as not to disturb the marmots (at least 70 m. away). At NBR1-DG, our presence was partially screened by tall grasses. GPS coordinates were recorded at each observation location. Alternation between observing colonies on MH and NBR will occur to decrease chances of large discrepancies in weather conditions and seasonal activity.

Scan samples occurred every 15 minutes, beginning at the quarter hour after the first

marmot in the colony is sighted awake am until 4 hours later, and then for three hours in the evening between the nineth and twelfth hours after the first is sighted awake, for a total of seven observation hours each day. On experimental days, the mannequin was placed in the site one hour before data collection began. It was centrally placed within the bounds of the colony. It was clad in clothing worn the day previously so that the mannequin will seem more realistic and because marmots can use olfactory indicators of predators (Blumstein, Barrow, and Luterra 2008). I recorded times of observance, temperature, wind speed and approximate cloud cover, how early the marmots begin activity, how many are visible at the time, and what behavior each is participating in, and approximate distance from the mannequin.

Two focal samples of five-minutes duration occurred each hour. An individual in the colony was chosen at random, and its activities and the duration of each were recorded. Total time spent in each activity was calculated. For both scan and focal sampling, behaviors were classified as foraging (including time spent looking around in the grasses while not perched), resting (including time spent sitting on rocks looking around), alarm calling, perching (vigilance), and other (social behaviors and grooming) (similar to Griffin et al. 2007).

Statistics

Statistical analyses were conducted in Mystat. Graphs were created using Microsoft Excel. Counts of colony members at each site participating in given activities were used for Kruskal-Wallis and chi-square analyses. The focal samples were analyzed using ANOVAs on total time spent per day at each colony in each behavior. Due to the time constraints and the resultant low replication, I will consider p-values less than 0.05 as significant and those where $0.05<p<0.1$ as potentially important" (Rhoades and Blumstein 2007).

Results

Scan Results

All data for scan samples was non-normal ($p<0.000$), therefore, non-parametric statistics were employed. The effect of treatment (presence of mannequin) on behavior was tested using a Kruskal-Wallis for each activity. Treatment had a significant effect on foraging ($p=0.008$), resting ($p=0.023$), and traveling ($p=0.031$) but not on alarm calling, perching, or other behaviors (Table 1, Fig. 1). Foraging, resting, and traveling behaviors were less common during experimental treatments than during control ones. A Friedman Test to determine if a block by disturbance type had an effect yielded no significant or potentially important results (Table 2).

In addition, data points for each activity were totaled as counts for each day at each site for chi-square analysis (Table 3). The effect of treatment was statistically significant upon foraging ($p=0.042$) and alarm calling ($p=0.041$) as well as potentially important for resting (0.067) (Fig. 2). Incidence of alarm calling was higher under experimental conditions than control, while foraging was higher under control conditions than experimental ones (Fig. 2). Marmots were counted resting less during control treatments than during experimental treatments (Fig. 2). The effect also varied by colony sampled (Table 3). There were potentially important effects on foraging at MH2 ($p=0.073$), indicating less foraging when the mannequin is present (Fig. 3). There were significant effects at MH3 ($p=o.042$) and potentially important effects on resting at MH2 ($p=0.084$) and NBR2-SP ($p=0.053$) (Fig. 4). Marmots at MH3 rested more on experimental days (Fig. 4); however, at the other two colonies, marmots rested more on control days (Fig. 4). Treatment significantly affected alarm calling at NBR2-SP ($p=0.003$), where marmots alarm called more on the experimental day, and had a potentially important effect at MH3 ($p=0.074$), where they alarm called more on the control day (Fig. 5).

Pairs of chi-squares were then run to determine the effect of type on different behaviors (one chi-square testing type for control, the other testing type for experimental). Disturbance type had an effect on resting (Control p=0.007, Experimental p=0.003) and perching (Control p=0.001, Experimental p=0.044) behaviors under both control and experimental conditions, but only had an effect on alarm calling under experimental conditions (p=0.048), though type was potentially important under control conditions as well (p=0.085) (Table 4, Fig. 2). Resting was witnessed less at undisturbed sites than disturbed, but perching incidence was higher at undisturbed sites (Fig. 2). Under experimental conditions, alarm calling was higher at undisturbed sites, but under control conditions, the behavior was counted more at disturbed sites (Fig. 2).

Focal Results

Focal data was combined as total time spent by focal marmots in each activity during the day because data as proportions at different times of day were non-normal for all activities (p-values <0.000). As total seconds spent at each activity from all focal samples, the data from all activities except alarm calling were normally distributed (Shapiro-Wilk, Rest p=0.383, Forage p=0.114, Travel p=0.650, Perch p=0.858, Other p=0.582, Alarm p=0.002). Alarm calling was quartic transformed to achieve normality (p=0.146). An ANOVA was run for each activity to determine the effect of treatment (mannequin presence or control) (Table 5). The only potentially important result is the effect of treatment on foraging (df=1, F=3.789, p=0.087) (Fig. 6). Two-way ANOVAs of treatment and disturbance type were run to determine their effect on time spent at each activity. For foraging behavior, type has no effect (df=1, F=1.504, p=0.266), treatment has a potentially important effect (df=1, F=4.567, p=0.076), and there is no significant interaction between the two (df=1, F=0.866, p=0.388). Similarly, for perching, type has no effect

(df=1, F=0.848, p=0.393), treatment has a potentially important effect (df=1, F=4.459, p=0.079), and there is no significant interaction (df=1, F=1.672, p=0.244) (Fig. 6). Marmots spent less time foraging and perching when the mannequin was present (Fig. 6). All other behaviors yielded non-significance for both factors and their interaction.

Discussion

The data clearly indicates that the presence of humans, as simulated with a mannequin, influences *M. flaviventris* behavior. Unfortunately, there are discrepancies between the results from the two sampling methods. These discrepancies may be due to the methodology itself. Scan sampling ignores the amount of time spent by individuals at each activity, while focusing solely on the numbers of marmots in a given population involved in each activity at given moments, giving information on proportions of the populace engaged in the various activities. Focal samples correct for lack of information on time spent at each activity, but may ignore what the majority of the population is doing. Greater replication and ability to mark individuals for randomization of focal sampling would likely solve these issues but were not possible within the constructs of this project. Finally, due the very nature of behavioral ecology, some factors cannot be controlled in the field, including environmental variation, presence of other animals that may represent a threat to the test species, human activities, and seasonal variation in behavior (i.e. marmots at some colonies, namely NBR2-SP, may have begun estivating). Despite all of these confounding factors, some behavioral trends were detected in response to the simulated human presence and between disturbance types.

Consistently, foraging behavior was decreased, in amount of time spent and number of marmots involved in the behavior, by the mannequin's presence. Foraging behavior was at times

difficult to see, depending on vantage point and whether the marmots were foraging in areas of dense vegetation; however both scan and focal results indicate a significant or potentially important effect. From the scan data, it's evident that traveling behavior decreased in response to the mannequin as well.

The relationships between resting behavior and treatment and disturbance type are complex. Kruskal-Wallis analysis of scan sampling indicated that resting was lower during experimental treatments, but chi-square analysis indicated the opposite. The chi-square takes into account counts at other behaviors, some of which decrease with the mannequin, such as traveling and perching. In addition, sometimes marmots sat and watched the mannequin but were not perched or alarm calling, so their vigilance behavior was categorized as resting. Were this experiment to be repeated, classifying such behavior as vigilance instead may tease out the convoluted relationship human presence has with resting behavior. There may also be variation between sites and effects of uncontrollable factors. For example, the morning of control conditions at MH3, the irrigator was turned on, causing most of the marmots to flee inside the burrows, while the marmots remained inside their burrows the entire morning of experimental conditions at NBR2-SP. Though the latter may be an expected response to human presence (Blumstein and Pelletier 2005), the former and other such events may be responsible for the effect of disturbance type on resting behavior. At disturbed sites, marmots rest more. It may be that marmots at disturbed sites have more nutrient-rich forage available, due to proximity to irrigated hayfields, allowing them more time to rest. Also, marmots at disturbed sites may be more used to various disturbance types and desensitized to those that pose no lethal threat.

Perching behavior is also significantly affected by disturbance type. Based on scan sampling results, a higher proportion of the population was involved in perching behaviors at

undisturbed sites than at disturbed ones. This, too, may indicate a desensitization of marmots at disturbed sites to threats (Griffin et al. 2007). However, focal sample results indicate that perching behavior decreases in the presence of the mannequin. Part of this may be due to increased hiding or participation in other vigilance behaviors, such as watching the mannequin which was classified as resting. In addition, marmots don't always respond to predators with perching; they have been known to approach or follow badgers in their colonies, frequently alarm calling as they do so (Armitage 2004). When they do perch, they abandon the behavior when the predator gets too close and flee to the burrow (Armitage 2004). Since the mannequin was in close proximity to highly traveled runs or highly frequented burrow holes, there may have been reduced perching behavior.

Treatment also had an impact on alarm calling behavior, according to data from scan sampling. Focal data indicates no effect; however, generally one marmot alarm calls per colony when a threat is perceived, so the methodology may have prevented detection of a trend. Based on results of scan sampling, alarm calling increases in the presence of the mannequin. At some sites, this trend was reversed due to the presence of coyotes, golden eagles, the rancher turning on the field irrigator or riding his motorbike through the colony, members of the Fish and Wildlife Service walking through the colony, and other events outside my control that alarm the marmots. More replication at each site may have helped dilute the influence of these chance occurrences, but was not feasible given the short sampling season. In addition, disturbance type had a significant influence on alarm calling behavior under experimental conditions. Alarm calling was more common at undisturbed sites than at disturbed sites when the mannequin was present. When the mannequin was absent though, alarm calling was more common at disturbed sites. The latter trend may be due to the influence of irrigator use or presence of other predators.

With more replication, time until response to the mannequin ceased could be determined, and then used to compare duration of response across human disturbance types. My data is insufficient to prove my hypotheses. However, it is clear that marmots consider human presence a threat and alter their behavior in response to it. The increase in alarm calling behavior is a clear indicator, as is the decrease in foraging behavior (Armitage 2004). Decreased foraging could have negative impacts upon marmot population survival if human presence persists long enough and marmots fail to gain enough weight for surviving hibernation (Armitage 1991, Salsbury and Armitage 2003). In addition, using marking or tracking to determine variation in hiding duration and incidence (Rhoades and Blumstein 2007) as a response to human presence, especially across disturbance types, could elucidate whether marmots in disturbed versus undisturbed areas respond to humans as extant predators or alien ones (Salo et al. 2007). It would also be interesting to characterize how different age and sex classes of the population respond to humans.

During my observations, I witnessed human activities that must have an impact on marmot behavior. A study of the impact of vehicles on marmot behavior could be used to determine if there exists a difference in how marmots at different disturbance types respond to a perceived common or novel threat. In the fields along Moiese Hill, irrigators make tracks, which I saw marmots walking along on a few occasions. While foraging, marmots may use these as they use runs in their colonies—to forage as optimally as possible (Ozgul et al. 2006) and escape predation by rapidly returning to a burrow (Armitage 2004). If that is the case, human presence could aid in marmot survival in a way. Also, analyzing nutrient content in forage in the hayfields versus that from grasses on the National Bison Range could yield results to answer why marmots remain in colonies that are so highly impacted by humans. Higher-quality forage and already

made runs among that forage may be an incentive. In addition, there may be less risk of predation from other predators where humans are present, if human presence lessens other predator activity.

This study adds to the body of evidence that human presence, in addition to human approach (Blumstein and Pelletier 2005, Griffin et al. 2007, Rhoades and Blumstein 2007), has an impact on *M. flaviventris* behavior. The data suggest that human presence is perceived as a threat, since marmots alarm-called more and foraged less when the mannequin was present than when he was absent. However, the higher incidence of marmot resting at disturbed sites than at undisturbed ones may indicate a benefit to colonizing a disturbed area. More studies examining variation in behavioral responses to humans are necessary to gain insight into the true impact humans have on marmot populations. Once our impact is understood, management procedures can be designed to minimize it.

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Tables

Table 1. Results of Kruskal-Wallis tests on data from scan sampling. The effect of treatment on foraging, resting, and traveling is significant, while it is non-significant for perching, alarm calling, and other behaviors.

Activity	**Df**	**U**	**p-value**
Foraging	1	12,212.5	0.008
Resting	1	12,940.5	0.023
Traveling	1	12,472.5	0.031
Perching	1	11,822	0.172
Alarm Calling	1	10,846.5	0.244
Other	1	11,634	0.226

Table 2. Results of Friedman test on effects of treatment, with a block of type, on counts of each activity.

Activity	**Df**	**Test-statistic**	**p-value**
Foraging	1	2	0.157
Resting	1	2	0.157
Traveling	1	2	0.157
Perching	1	2	0.157
Alarm Calling	1	0	1.000
Other	1	1	0.317

Table 3. Results of Pearson chi-square analyses on activity counts. All have 1 degree of freedom. Numbers are listed as Chi-square value, p-value.

		Forage	**Rest**	**Travel**	**Perch**	**Alarm**	**Other**
Across Colonies	**Value**	4.138,	3.356,	0.903,	1.922,	4.194,	0.730,
	P	0.042	0.067	0.342	0.166	0.041	0.393
MH1	**Value**	0.029,	0.502,	0.688,	1.191,	2.355,	0.217,
	P	0.866	0.479	0.407	0.275	0.125	0.641
NBR1-DG	**Value**	1.210,	1.860,	0.390,	1.323,	2.662,	0.078,
	P	0.271	0.173	0.532	0.250	0.103	0.781
MH2	**Value**	3.210,	2.987,	0.243,	0.212,	0.219,	0.219,
	P	0.073	0.084	0.622	0.645	0.640	0.640
NBR2-SP	**Value**	0.000,	3.758,	1.429,	0.000,	9.000,	0.000,
	P	1.000	0.053	0.232	1.000	0.003	1.000
MH3	**Value**	1.051,	4.138,	1.032,	0.002,	3.198,	1.051,
	P	0.305	0.042	0.310	0.966	0.074	0.305

Table 4. Disturbance type affects behavior, based on results of chi-square pairs (control and experimental). It has an effect upon resting and perching behaviors, with a significant effect on alarm calling under experimental conditions. The effect upon alarm calling under control conditions is potentially important.

Activity	**p-value Control**	**p-value Experimental**
Foraging	0.298	0.397

Resting	0.007	0.003
Traveling	0.071	0.392
Perching	0.001	0.044
Alarm Calling	0.085	0.048
Other	0.370	0.811

Table 5. One-way ANOVA results for each activity classification indicate that the treatment of a mannequin most nearly significantly affects foraging, based on focal sampling.

Activity	**Df**	**F-ratio**	**p-value**
Foraging	1	3.789	0.087
Resting	1	0.003	0.955
Traveling	1	0.886	0.374
Perching	1	3.358	0.104
Alarm Calling	1	0.000	0.995
Other	1	0.006	0.942

Figures

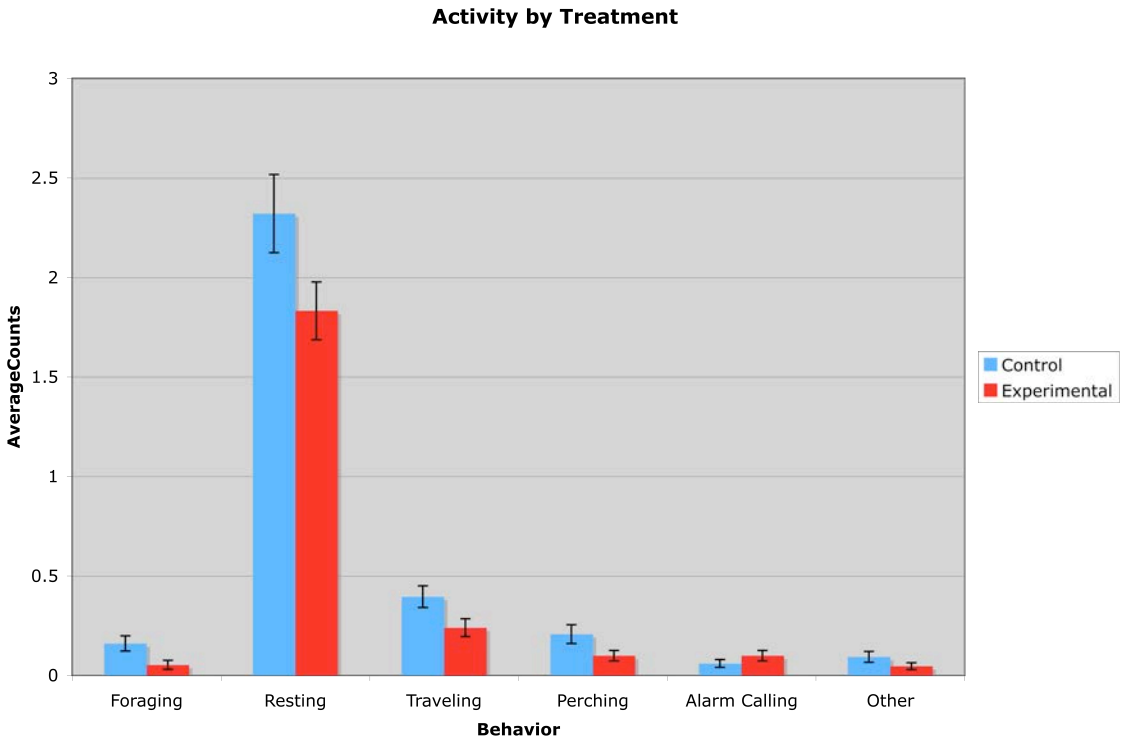

Figure 1. Based on data from scan sampling, treatment had significant effects on foraging (K-W p=0.008), resting (K-W p=0.023), and traveling behaviors (K-W p=0.031). There was less foraging, resting, and traveling during the experimental treatment than during the control. The average number of counts per treatment is indicated on the y-axis, with blue bars indicating the control treatment and red ones indicating experimental. The black lines are standard error bars.

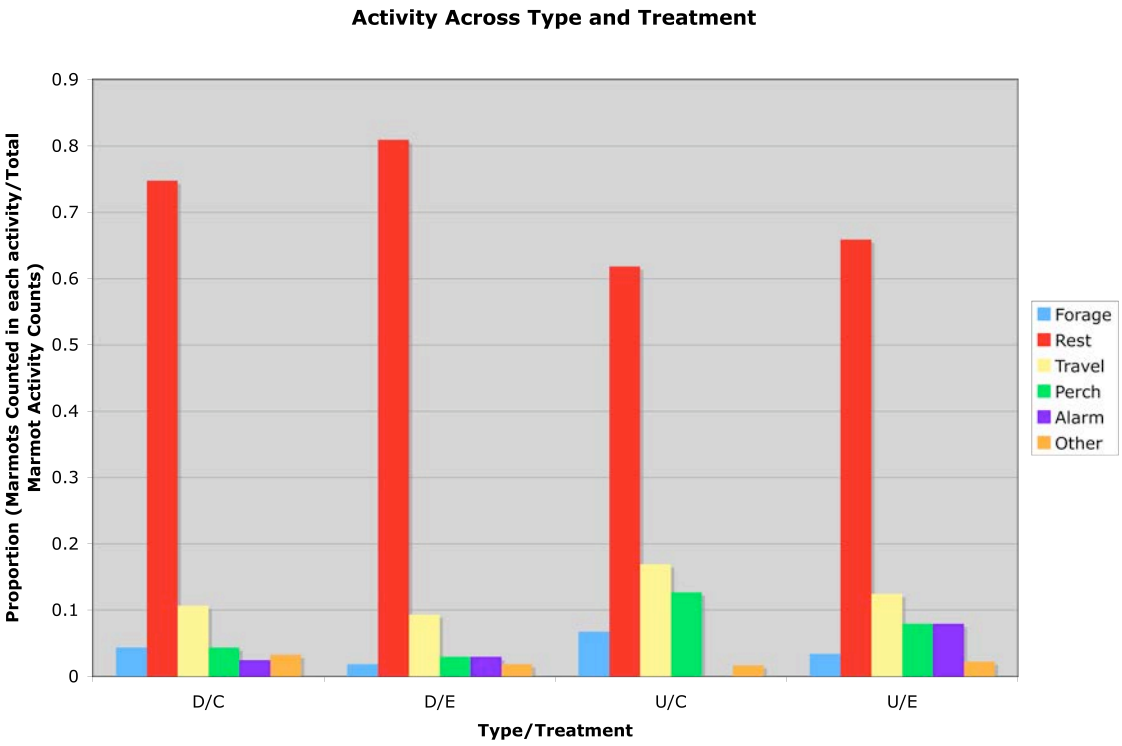

Figure 2. Based on data from scan sampling, as total counts per day at each site, treatment (C-Control or E-Experimental) had a significant effect on foraging and alarm calling behaviors (chi-square p-values of 0.042 and 0.041, respectively) as well as a potentially important effect on resting (p=0.067). Incidence of alarm calling was higher under experimental conditions than control, while foraging was higher under control conditions than experimental. Marmots rested less during control treatments than experimental. Disturbance type (D-disturbed or U-undisturbed) affected resting and perching behaviors regardless of treatment, but only significantly affected alarm calling under experimental conditions with potential importance under control conditions. Resting was witnessed less at undisturbed sites than disturbed. Incidence of perching was higher at undisturbed sites. Under experimental conditions, alarm calling was higher at undisturbed sites. Under control conditions, alarm calling was higher at disturbed sites.

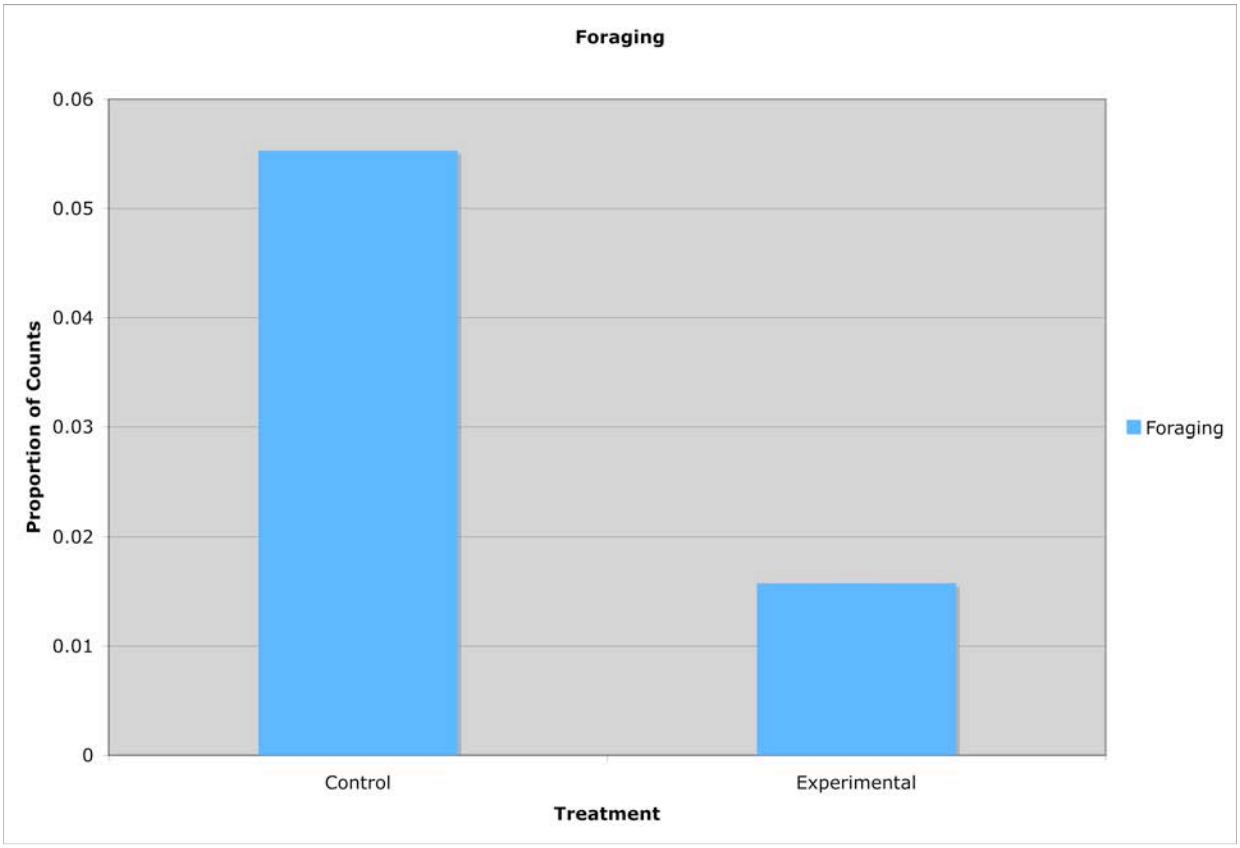

Figure 3. At MH2, treatment had a potentially important effect upon foraging behavior (p=0.073). There was less foraging with the mannequin present (Experimental) than when it was absent (Control).

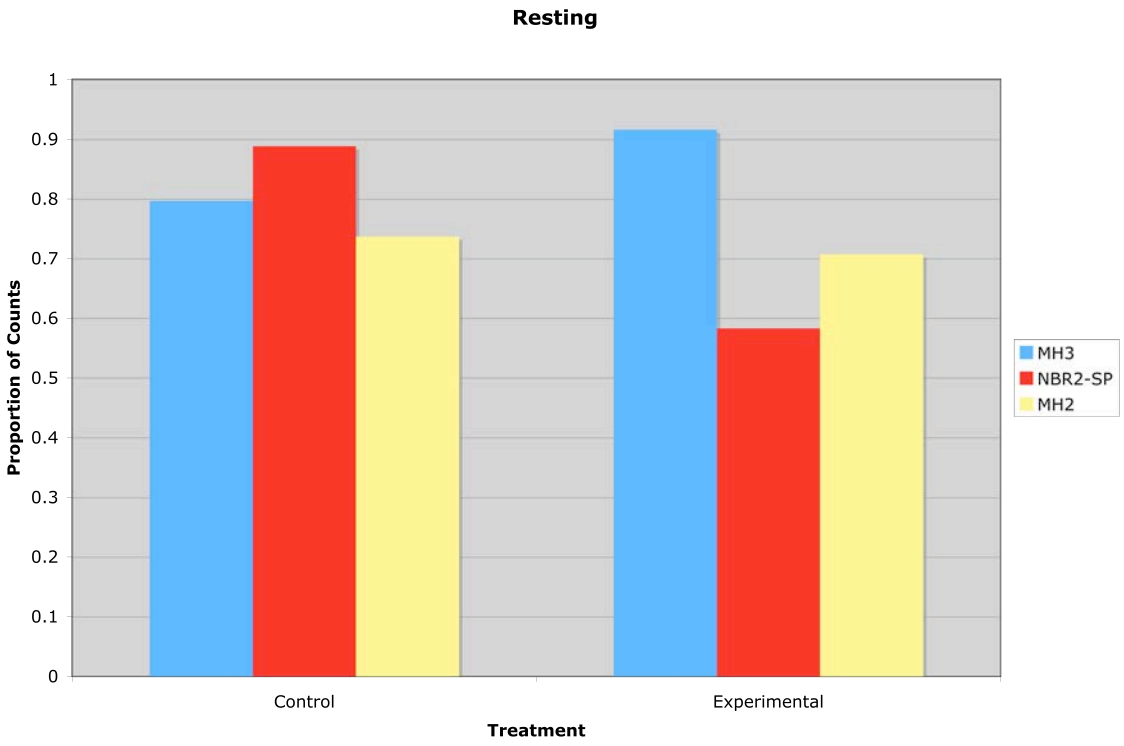

Figure 4. Treatment had a significant effect at MH3 (p=0.042), as shown in blue, on resting behavior. Marmots at MH3 rested more when the mannequin was present than when absent. The irrigator was on during the control day though, causing the marmots to hide. The trend was reversed for marmots at NBR2-SP and MH2, where treatment had potentially significant effects (p=0.053, p=0.084, respectively). At NBR2-SP, no marmots were visible the entire morning of the experimental day, decreasing behavior counts.

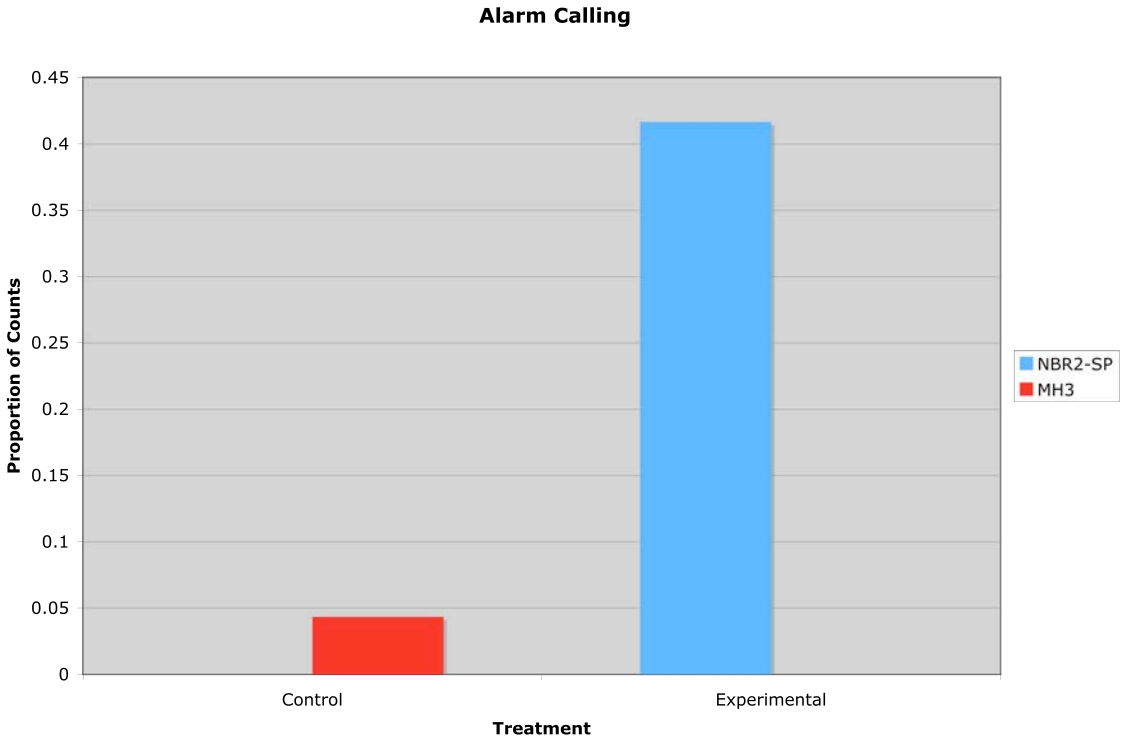

Figure 5. Treatment had a significant effect at NBR2-SP, as shown in blue, on alarm calling behavior (p=0.003). Marmots alarm called more in the presence of the mannequin. Treatment had a potentially important effect at MH3, shown in red (p=0.074), indicating a trend toward more alarm calling when the mannequin was absent. However, at MH3 on the control day, a coyote passed the colony, possibly eliciting the alarm calling.

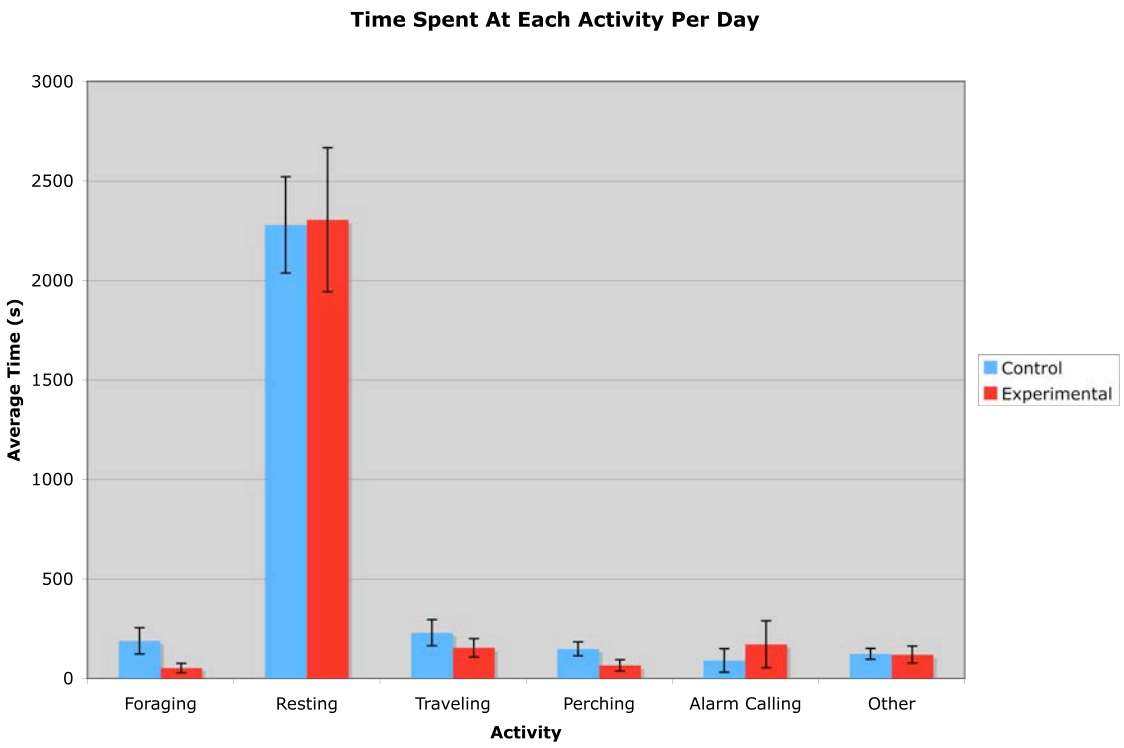

Figure 6. Based on data from focal sampling, treatment has a potentially important effect upon time spent foraging and perching ($p=0.076$ and $p=0.079$, respectively). Control treatment is indicated by blue bars, while experimental treatment is indicated by red. The black lines denote standard error. Both foraging and perching behaviors decrease in the presence of a mannequin.