

Analyzing the Response of Various Species to Native and Known Food Presentation at the
National Bison Range in Western Montana

BIOS 35503-01: Practicum in Environmental Biology-West

Amanda Holly Keyes

Advisor: Dr. David Flagel

2016

Abstract

The global consensus among scientists is that climate is changing. Even the minutest change in the climate can result in a rippling effect of adaptation throughout the globe, as species struggle to survive changing climatic conditions. As a response to the changing climate, it has been shown that species are responding by modifying their ranges. These range modifications could potentially hold negative consequences for foraging species as they struggle to compete with species, whose range they may be encroaching upon. The question under study in this experiment is whether foraging wildlife at the National Bison Range are flexible in their dietary preferences. This study was conducted by placing five feeding trays around the National Bison Range. Dietary preferences were assessed by providing native and novel food sources in the trays, and the species that visited the trays were tracked. The amount of food consumption at each tray and of each food type was also noted. There was found to be no significant preference for any of the three food types: cracked corn, oats, and lumped native food. This may indicate that the foraging wildlife species at the National Bison Range are generalists and are not at risk of struggling to adapt to changing geographical ranges as a result of climate change.

Introduction & Background

Species are adapting to changing climatic conditions by moving their ranges north or to higher elevations (Chen et al., 2011). One of the ways to assess how the distribution of a species could change due to the effects of climate change is through the use of computer modeling, such as bioclimate envelope models (Araújo and Peterson, 2012). In addition to trying to predict where these species will relocate to, it is prudent to also determine how adaptable these species are to changing conditions and resources.

Openness to new resources can be determined by exposing individuals to novel food sources. Knowing how an individual or a species responds to new stimuli can provide us with clues as to which species will readily adapt to the rapidly changing climate, and which will struggle. There are also interesting behavioral traits that can be discerned in food preference studies, and some of those behavioral traits greatly influence whether or not an individual consumes a new food source. These studies have been done on a wide variety of species. For example, presentation of novel food sources to *Cebus apella*, the tufted capuchin, resulted in initial cautious behavior towards the novel stimuli. The capuchins eventually consumed the novel food sources. This indicates that this species could adapt to a new habitat, if required in the future, as a result of their openness to trying new food sources (Visalberghi et al., 2003). Studies of this nature can also be successfully conducted with small mammals, such as voles. A familiar versus novel food study conducted with bank voles (*Clethrionomys glareolus*) found there were differences in what each individual consumed based on whether they were a pregnant female, reproductive male or female, or non-reproductive male or female. This suggested that voles made choices based on the types of food that would address their physiological needs most closely (Eccard and Ylonen, 2006).

Aside from the reproductive status of a particular individual, there are many reasons that could explain why a particular food source is consumed over another. This could be due to whether or not a particular species is a habitat generalist, whether a species seeks out food based on nutritional value or based upon the cost of obtaining or accessing the fruit or nut meat, general food abundance, and plant secondary compound contents (Cramer, 2014, Lobo et al., 2013). Further, studies assessing dietary preferences through camera traps can address questions that studies lacking camera traps cannot definitively determine. For example, a study conducted in

northwestern Connecticut at the Great Mountain Forest on whether seed production affects small mammal populations and whether different small mammal species respond differently to seed production found a confounding result that they could not resolve with their data. They found that *Clethrionomys gapperi*, red-backed voles, did not respond to a red oak seed production event. The researchers were unable to determine whether *C. gapperi* does not cache seeds or whether they just don't eat acorns (Schnurr et al., 2002). Camera traps are an effective means of resolving issues of exactly what a species eats in the wild by capturing wildlife activity that frequently cannot be observed in person. For example, a study in the Afro-tropical forest discovered through camera traps that the forest giant pouched rat, *Cricetomys emini*, contributes to the dispersal of large seeds (Nyiramana et al., 2011). Previously, this fact had been unknown. Camera traps have and will continue to contribute to the discovery of new information in the wild, especially when dealing with diurnal, nocturnal, and otherwise shy species (Trolliet et al., 2014).

Avian species can also make use of novel food sources. A study in the Colombian Andes found that Cauca guan, a large bird that occurs in the Andes of Colombia (*Penelope perspicax*), consumed larger quantities of Chinese ash (*Fraxinus chinensis*) during periods of food scarcity. Chinese ash was planted in the area as part of a reforestation program forty years previously, but is not native to the region (Muñoz et al., 2007). Avians are visually guided through ultraviolet wavelengths and it has been found that changing light conditions affect the seed preference of male zebra finches (*Taeniopygia guttata*) (Church et al., 2001). This study's findings are important when thinking about a species distribution changing because as a species moves more northerly, daily light conditions can change drastically. As has been shown, there are numerous reasons for why an individual makes a particular decision while foraging, and in trying not to

lose sight of the forest for the trees, one may turn to the optimal foraging theory in order to begin to pare down why an individual makes a particular foraging decision.

Optimal foraging theory may play a role in an individual's decision of whether to consume a particular food source. This theory states that, generally, foragers will choose the most profitable food source over a less profitable food source. A study done on whether various avian species preferentially forage on hulled or natural sunflower seeds found that some of the avian species in the study showed a significant preference for hulled rather than natural sunflower seeds. The researcher concluded that this was likely due to the lower handling time required to consume already hulled sunflower seeds (Frens, 2010).

The question being addressed in this study is whether there is a significant difference in the way that seed predator species respond to native, known, and novel food sources when all are presented simultaneously. The null hypothesis is that the various species will consume both the native and novel food sources without any preference shown for either food source. The alternative hypothesis is that the various species will show a preference for either the native or novel food sources. Based on small rodents often being generalists, we predict that the small mammal species will eventually eat all food sources (native and novel) without preference.

Methods

Five study sites were located in the National Bison Range in Dixon, Montana (N 47.316°, W 114.315°). The National Bison Range features intermountain grassland, wetlands, riparian areas, shrublands, and forest. The habitat at the NBR is notable because intermountain grassland is rare, and the wildlife refuge is covered up to 75% in intermountain grassland (U.S. Fish & Wildlife Service, 2013). Set-up at each site consisted of one metal cookie sheet (32.26 cm x 24.64 cm x 1.27 cm) that had been painted white in order to limit heat retention during the day.

The cookie sheet was secured to the ground with two tent spikes that held alternate corners of the tray into the ground. The trays were metal in order to limit damage from visiting species or passing ungulates. Preliminary trials were conducted at each site in order to determine the responsiveness of species in the area to the trays. These preliminary trials consisted of placing twenty grams of in-shell peanuts on the tray for at least twenty-four hours. The preliminary trials allowed the researcher to determine that twenty grams of food during the data collection period should suffice. For our comparison, we used trials with native versus novel/exotic food sources. Native food species were collected from June 18-July 10, 2016 from around the NBR. Native food species collected included maple seeds (*Acer* spp.), service berry (*Amelanchier* spp.), American red raspberry (*Rubus idaeus*), and creeping Oregon grape (*Mahonia repens*). As we were unable to collect enough of any of these species individually for 20 gram trials, these four species were lumped together for this study as native food. For novel/exotic species, we used two commercial agriculture species, *Avena sativa* (oats) and *Zea mays* (corn). These particular known species were offered as they are grown in the croplands of the region, are consumed by rodents, and are of low risk of becoming invasive on the NBR (Singleton, 2010, Valsecchi et al., 1991). Oat fields are more prevalent than corn fields in the area directly surrounding the National Bison Range, and corn is by far less prevalent in the region as a crop compared to oats or other grains. The known species were heat-killed prior to being placed at any of the five sites at the National Bison Range in order to prevent the possibility of germination. During the five day data collection period (July 24-28, 2016), the tray was filled with twenty grams of oats, cracked corn, and native food. One day after presentation of the native and known food sources, the tray was emptied of the remaining food, if any, and refilled with twenty grams each of native and known food type. The remaining food from the previous day was then weighed. Water loss

was accounted for by conducting a desiccation trial in which insects were excluded from accessing the feeding tray in order to ascertain water loss from the three food sources. Water loss values from this desiccation trial were then subtracted from the initial weights of the native food, corn, and oats. This value was then used to determine the amount consumed by subtracting the remaining weight. Using these numbers, preference ratio was then calculated (Page et al., 2001).

$$\text{Preference ratio} = p_c/p_a$$

$$p_c = (\text{mass of species x consumed}) / (\text{total desiccated mass of all species consumed})$$

$$p_a = (\text{mass of species x introduced}) / (\text{total desiccated mass of all species introduced})$$

A resulting value above 1 indicates a preferred food source. A value close to 1 indicates an indifferent food source. A value below 1 indicates a food source that is not preferred.

The five feeding trays were rotationally monitored via three infrared flash camera traps (Bushnell, Overland Park, KS). These cameras use an infrared light flash which causes minimal disturbance to animal behavior. The camera traps allowed the researcher to identify the types of species visiting the tray and the number of visits from each species. Visits were separated by thirty minute intervals as a means of excluding periods where the same individual or group of individuals monopolized the tray. Data was checked for normality using the Shapiro-Wilk test and analyzed by a one-way ANOVA. The ANOVA was conducted in order to see if there was a difference between the means of the preference ratios for the berries, corn, and oats. Statistical tests were run in R Console (R Core Team, 2015). There was no statistical analysis conducted on the information from the camera traps; this information was collected in order to gain perspective on the types of species that were contributing to the preference ratios for this experiment.

Results

Camera Traps

There were a total of 25,525 images captured at the five sites over a five day trial period; species that were captured in the images included rodents, one ungulate, and grasshoppers (Figure 1). There were never any images captured of avian removal from the tray during the five day observation period. Due to the reflective nature of the white paint on the feeding tray, nighttime images were often white in the center, making identification challenging. One of the five sites also became very populated with bison, and the camera post at that site was knocked down multiple times as a result of bison and other ungulate species rubbing on the post. One trial at this site had to be postponed to a later date due to animal interference/obstruction.

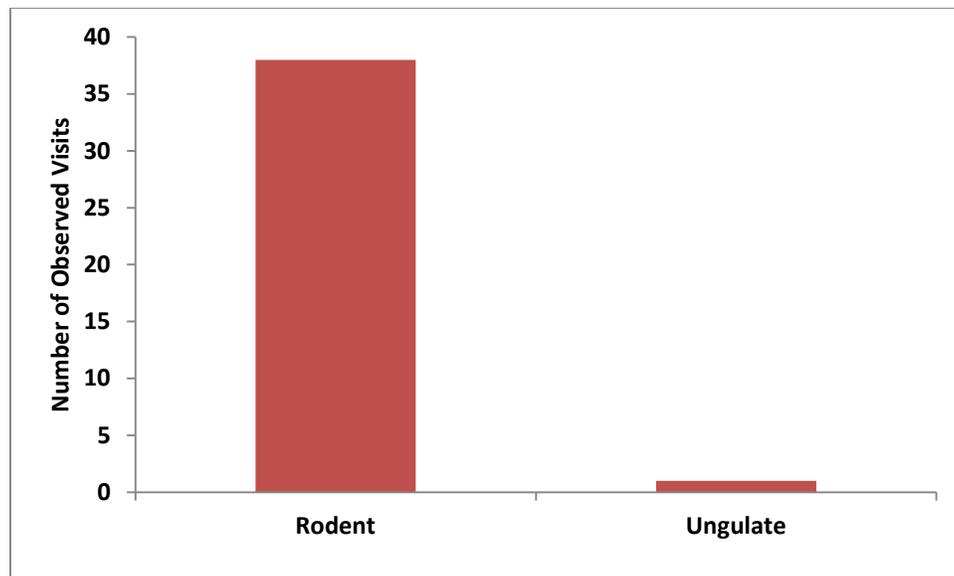


Figure 1: The number of observed visits from rodents and ungulates to any of the five sites at the National Bison Range during the data collection period.

Food Preference

There was no clear preference shown for any of the three available food sources in the feeding tray. The one-way ANOVA revealed more variation of the means within a particular

food type, rather than between food types. The results of the Shapiro-Wilk test were $W = 0.9056$ with a $p\text{-value} = 0.1159$. This indicates that the data is normal. The results of the one-way ANOVA were $F = 1.727$ and $p\text{-value} = 0.211$ with degrees of freedom = 1. These results indicate that the differences between the means of these groups are not significant. The visiting species that consumed from the feeding trays did not display a preference for any of the food types. This finding fails to reject the null hypothesis, which was that the food would be consumed without distinction or differentiation made between food sources.

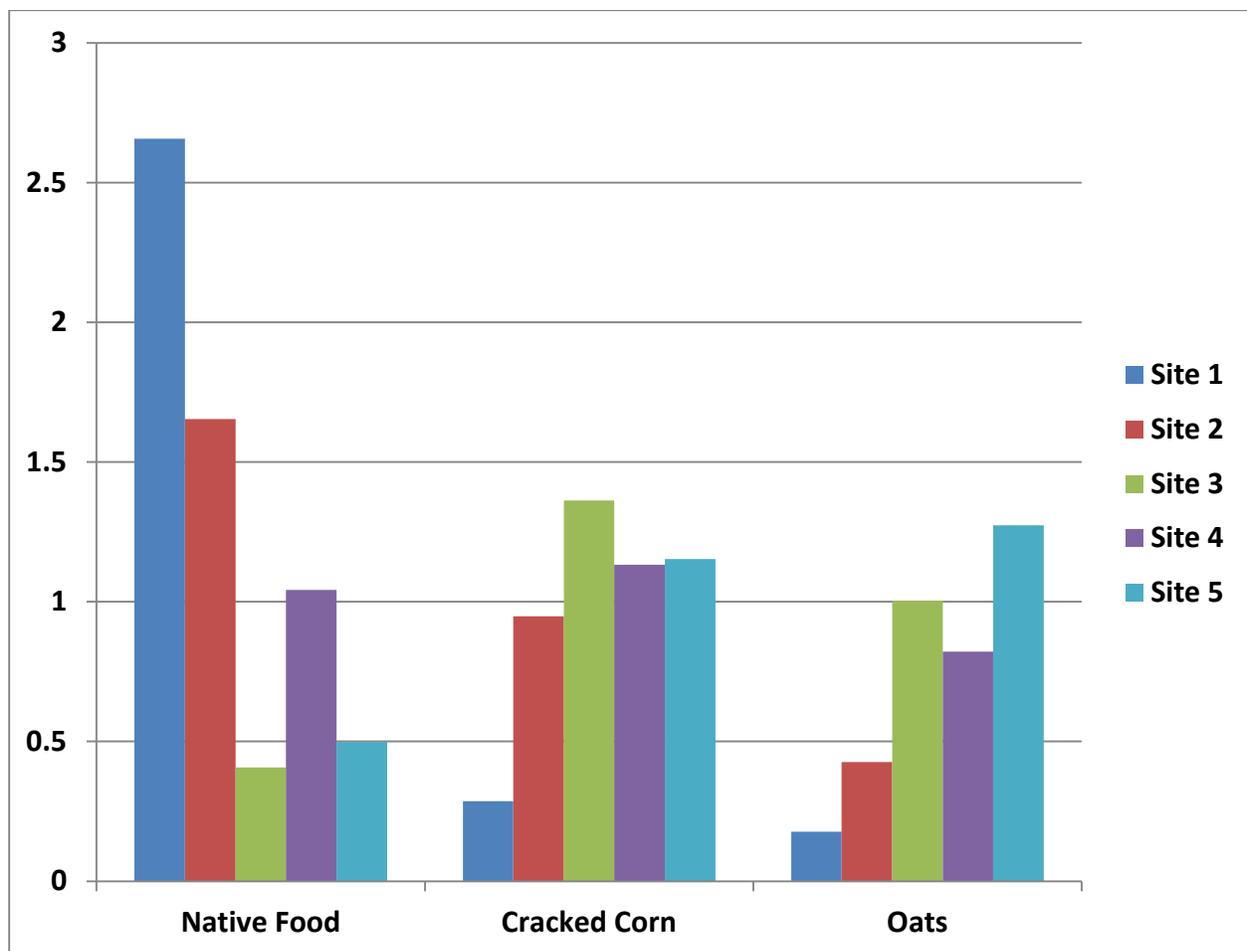


Figure 2: The preference ratios for the native food, cracked corn, and oats from the five sites at the National Bison Range. A value above one indicates preference. A value below one indicates the food is not preferred. A value near one indicates indifference.

Discussion

We did not find any strong preferences among the native versus novel food sources. Corn, oats, and lumped native food all possessed foraging ratios within a standard error of a ratio of one (neutral). These results suggest that rodents foraging at the National Bison Range may be generalists. Generalists are characterized by the ability to utilize a broad variety of resources that are available in their environment. This is in contrast to habitat specialists that require a certain habitat type or resource to be present in order to thrive. The most abundant rodent genus documented in the camera trap images was *Peromyscus*. A study involving *Peromyscus leucopus*, the white-footed mouse, found that even when individuals of this species showed a preference for a food type, they still sampled quantities of food from other, less preferred food types. The researchers posited that individuals do this in order to sample which food types offer the most nutritional reward (Lewis et al., 2001). *Peromyscus* species are typically characterized as generalists with a diet that is primarily constituted of seeds (Drickamer, 1976).

Another potential outcome of the presence of foraging generalists in close proximity to agricultural land is crop destruction. Crop destruction by avian and rodent species contributed to \$168-\$504 million in lost revenue in just ten counties in California in 2009 (Desoky, 2014). However, as both crops are present in the surrounding area, there is some potential NBR inhabitants have been exposed to these species. This study neither showed a preference for nor against the consumption of cracked corn and oats, indicating that these species could consume agricultural resources in the area, if provided the opportunity or confronted with nutritional need and lack of foraging options. Ideas for future research relating to wildlife foraging affecting agriculture around the National Bison Range could potentially be a quantification of the average distance that a rodent will travel to find a reliable food source.

This food preference study successfully investigated the versatility of the species at the National Bison Range in terms of their diet preferences. This area of research is worthy of study because species are beginning to adapt their ranges in the face of dramatic climate change by modifying their ranges farther north and to higher elevations (Chen et al., 2011). Even in the face of dramatic climate change, generalists are not expected to be negatively affected to the extent that a habitat specialist would be, as a result of their flexibility in resource use. Future studies of this nature should aim for a longer data collection period in order to obtain a more comprehensive sampling of potentially interested species in feeding tray studies. There are many questions that are raised by the result that these foraging species at the National Bison Range are generalists. This style of foraging opens up potential avenues for conflict between the prominent agricultural community in the vicinity of the National Bison Range, the interests of the wildlife refuge, and the Fish and Wildlife Service. Versions of this conflict occur all over the world, especially in communities dependent on agriculture that are in habitats of particular concern or that are under protection. This is why research into questions relating to this area of study have been relevant for decades and will continue to be relevant going forward as a result of the confluence of human interests with natural preservation interests.

Acknowledgements

The author wishes to thank the Bernard J. Hank Family Endowment for funding, and Dr. Gary Belovsky, Dr. David Flagel, Sarah Russ, Kate Barrett, Sharlo Bayless, Taylor Clark, Claire Goodfellow, Charmaye OldElk, Anastassia Ryan, Joel Smith, and Maddie Wroblewski for assisting or advising on this project.

Works Cited

- Araújo, M. B., and A. T. Peterson. 2012. Uses and misuses of bioclimatic envelope modeling. *Ecology* 93(7):1527-1539.
- Chen, I-Ching, J. K. Hill, R. Ohlemueller, D. B. Roy, and C. D. Thomas. 2011. Rapid Range Shifts of Species Associated with High Levels of Climate Warming. *Science* 333(6045):1024-1026.
- Church, S. C., A. S. L. Merrison, and T. M. M. Chamberlain. 2001. Avian Ultraviolet Vision and Frequency-Dependent Seed Preferences. *The Journal of Experimental Biology* 204:2491-2498.
- Cramer, M. J. 2014. Seeds of doubt: feeding preferences of white-footed deer mice (*Peromyscus leucopus noveboracensis*) and woodland deer mice (*Peromyscus maniculatus gracilis*) on maple (genus *Acer*) seeds. *Canadian Journal of Zoology* 92(9):771-776.
- Desoky, A. S. S. 2014. Damage caused by birds and rodent in field crops and their control. *J. Glob. Innov. Agric. Soc. Sci.* 2(4):169-170.
- Drickamer, L. C. 1976. Hypotheses linking food habits and habitat selection in *Peromyscus*. *J. Mammal.* 57:763-766.
- Eccard, J. A., and H. Ylonen. 2006. Adaptive food choice of bank voles in a novel environment: choices enhance reproductive status in winter and spring. *Ann. Zool. Fennici* 43(1):2-8.
- Frens, K. M. 2010. Effects of food type and patch location on foraging: a field test of optimal foraging predictions. [Master thesis] Ann Arbor (MI): University of Michigan. 18 p.
- “Habitats.” *National Bison Range*. U.S. Fish & Wildlife Service, March 21, 2013. Web. Accessed August 5, 2016.

- Lewis, C. E., T. W. Clark, and T. L. Derting. 2001. Food selection by the white-footed mouse (*Peromyscus leucopus*) on the basis of energy and protein contents. *Can. J. Zool.* 79:562-568.
- Lobo, N., D. J. Green, and J. S. Millar. 2013. Effects of seed quality and abundance on the foraging behavior of deer mice. *Journal of Mammalogy* 94(6):1449-1459.
- Muñoz, M. C., G. A. Londoño, M. M. Rios, and G. H. Kattan. 2007. Diet of the Cauca Guan: Exploitation of a Novel Food Source in Times of Scarcity. *The Condor* 109(4):841-851.
- Nyiramana, A., I. Mendoza, B. A. Kaplin, and P.-M. Forget. 2011. Evidence for seed dispersal by rodents in tropical montane forest in Africa. *Biotropica* 43(6):654-657.
- Page, K. L., R. K. Swihart, and K. R. Kazacos. 2001. Seed preferences and foraging by granivores at raccoon latrines in the transmission dynamics of the raccoon roundworm. *Canadian Journal of Zoology* 79:616-622.
- R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.
- Schnurr, J. L., R. S. Ostfeld, and C. D. Canham. 2002. Direct and indirect effects of masting on rodent populations and tree seed survival. *Oikos* 96:402-410.
- Singleton, G. 2010. Rodents—gnawing away at crops, stored grain and our health. Technical Innovation Brief. Number 1, January 2010.
- Trolliet, F., M.-C. Huynen, C. Vermeulen, and A. Hambuckers. 2014. Use of camera traps for wildlife studies. A review. *Biotechnology, Agronomy, Society and Environment* 18(3):446-454.

Valsecchi, P., A. Moles, M. Mainardi, and D. Mainardi. 1991. Food aversion learning in mice (*Mus domesticus*): different salience of rice and oats. *Bolletino di zoologia* 58:3, 249-254, DOI: 10.1080/11250009109355761.

Visalberghi, E., C. H. Janson, and I. Agostini. 2003. Response Toward Novel Foods and Novel Objects in Wild *Cebus apella*. *International Journal of Primatology* 24(3):653-675.