

Spatial Distribution of Mule Deer (*Odocoileus hemionus*): Effects of Plant Palatability and Habitat Structure

Alessandra Pistoia

Mentors: Mary Price, Nick Waser, and Dan Blumstein

Advanced Independent Research
Summer 2011

Abstract:

Scientists at the Rocky Mountain Biological Laboratory (RMBL) have recorded more mule deer (*Odocoileus hemionus*) activity density within the Gothic town site relative to outside the town site. One hypothesis to account for increased deer activity in Gothic is that coyotes, who prey on deer fawns, avoid areas of concentrated human activity, causing deer to aggregate in these “safe sites.” To put this hypothesis under scrutiny, we wanted to test an alternate hypothesis that deals with vegetation as an influence for deer spatial distribution. I hypothesized that if Gothic is rich in preferred plant species and habitats then high deer activity density will correlate. To follow up with previous observations on deer activity density in Gothic, two predetermined routes, inside and outside Gothic, were walked for a four-week period to observe deer spatial distribution. To look at the availability of preferred plants, multiple plant transects were conducted to observe average palatability of a certain area. To look at the availability of habitats, GIS ArcMap was used to define different habitat types and calculate area. We observed that there were more deer outside Gothic than inside. Second, we found that the abundance of palatable plants is similar inside and outside Gothic. Last, we found that the proportion of habitats types was similar inside and outside Gothic, however there were more wet meadow habitat outside Gothic and more meadow habitat inside Gothic. From these results, we conclude that plant palatability does not influence the spatial distribution of mule deer; also, since habitat structure is similar inside and outside of Gothic, this has little, if any, influence on deer spatial distribution. A better understanding of influences of mule deer spatial distribution will lead to improved management of mule deer overabundance in an ecosystem.

Keywords:

mule deer • *Odocoileus hemionus* • spatial distribution • vegetation • palatability • habitat structure • trophic cascade

Introduction:

The concept of species overabundance is best defined in terms of management objectives (Underwood and Porter 1991). Mule deer are considered as overabundant when they limit the abundance or occurrence of other resources or hinder an ecosystem process or human activity (Healy et al. 1997). Since mule deer selectively browse herbaceous plants, they potentially influence ecosystems by altering nutrient cycles, reducing plant cover, plant community composition, and plant species diversity (Tilghman 1989, Arozqueta 2005). Thus, studying the distribution of mule deer population is important for ecosystem management, restoration, and conservation policies (Pace et al. 1999). The number of individuals in a population of mule deer is constantly changing in response to the environment. Individuals may respond to the environment by choosing to stay in a geographic area if there are favorable living conditions, or choosing to leave the area in search for a more favorable environment.

In previous years, researchers found mule deer activity density to be greater inside a fence that surrounds the Rocky Mountain Biological Laboratory (RMBL) in

Gothic, Colorado than outside the fence (Arozqueta 2005, Castro Escobar 2010, Pickens 2010). The fence surrounding RMBL serves to exclude cattle; it also encompasses the area of greatest human activity in the area. The high activity density of deer within the town site could reflect a trophic cascade involving humans, coyotes, mule deer, and plants (Castro Escobar 2010, Pickens 2010). According to this hypothesis, coyotes, who prey on deer fawns, avoid the area of concentrated human activity, causing deer to aggregate in these “safe sites.” It follows that plant browsing is greater in the town site where there is a high density of herbivores. The term trophic cascade describes the relationship between primary producers and higher levels of consumers, and the effect this relationship has on the abundance and productivity of populations at a specific trophic level (Pace et al 1999). In such systems, predators can have indirect and direct effects on prey community structure and population dynamics, prey habitat selection (Hebblewhite et al 2005), and ultimately on the plants consumed by herbivores (Schmitz et al 2000). Ecosystems without top predators are argued to have high herbivore densities with associated negative impacts on plant communities, eventually leading to a reduction in plant biodiversity (Terborgh et al 1999). Indeed, trophic cascades appear to be frequent within terrestrial ecosystems (Pace et al. 1999).

Although the trophic cascade hypothesis may explain high deer densities inside RMBL, I explored two alternative possibilities: palatable plants and favorable habitats. Deer abundance may reflect the spatial distribution of palatable plants, or the distribution of favorable habitats. I hypothesize that if preferred plants and habitats influence deer density, then the area where there is a high abundance of preferred plants and habitats should correlate with a high deer activity density. Palatable plants refer to the species of plants that mule deer consume. The abundance of palatable plants present in an area could play a critical role in whether or not an herbivore will choose to live in the area because there must be enough potential energy available for optimal living conditions. Habitat structure refers to the dominant life form of vegetation in an area (e.g. herbaceous plants, shrubs, or trees). At RMBL there are 3 predominant habitats: willow (large shrubs), meadow (herbaceous plants), and forests (aspen and conifer trees). The habitat structure of an area may influence the risk of predation and affect a prey’s allocation of time and energy to being vigilant as well as its ability to escape attack (Halofsky and Ripple 2008). It follows that a mule deer will choose a habitat structure with high visibility, as well as an area to hide from predators (Halofsky and Ripple 2008).

The goal of this research was to continue and further previous research by addressing the following questions about mule deer inside and outside RMBL: (1) Are mule deer more common inside or outside the RMBL fence? (2) Are mule deer more common in willow, meadow, or forest habitat? (3) Is the abundance of highly palatable plants greater inside or outside the RMBL fence? (4) Is the abundance of highly palatable plants greater in willow, meadow, or forest habitat? (5) What is the relative availability of willow, meadow, and forest habitat inside and outside of the RMBL fence?

Methods:

Study Site

RMBL is an independent field station located in Gothic, CO, USA at ca. 2900m elevation in the East River valley of the West Elk mountains (Inouye et al. 2000). A fence encloses the RMBL town site for the purpose of keeping grazing cattle out. The fence creates a distinction of two different environments: inside RMBL there is human activity and no cattle; outside RMBL there is very little human activity and numerous grazing cattle. The study compares these two environments.

Deer Observation

Are mule deer more common inside or outside the RMBL fence?

I estimated the spatial distribution of deer activity by walking standard routes, the 401 (North Gothic) and Deer Creek (South Gothic), and noted where I observed deer. The data were then expressed as deer observed per minute per unit of area observed.

I walked the two routes to estimate the activity density of deer inside and outside RMBL. These routes included areas outside as well as inside of the RMBL fence (Map 1). I walked the routes during the month of July, at dawn and dusk. In order to avoid confounding estimates with time-of-day or seasonal activity patterns, I blocked observations by week, walking each route equal numbers of times at dawn (05:30-7:00) and dusk (19:00-20:30) each week. I alternated starting at the beginning and the end of a route on successive observations, to avoid consistently sampling particular points later than others. I walked each route twelve times during the sampling period.

Altogether, there were 24 observation points along the routes (Map 1): half of these points were inside the RMBL fence and half were outside the RMBL fence, also half of these points were in meadow/willow habitat and the other half were in forest habitat. Both habitats were sampled in equal numbers inside and outside the fence. I not only observed deer at these observation points, but also at the segments between points. I walked each route at a standard pace and recorded any deer that I saw. I stopped at each of the 24 points and scanned (360° scan) for deer for a minute.

For each route segment and each observation point I estimated the area I could see (viewshed area) by noting landmarks that marked the boundary of the visible area. I used an aerial photograph of the Gothic area to map these limits of visibility, creating a layer in GIS ArcMap (v. 9.3.1; ESRI Inc., Redlands, CA, 1999-2009) from which I could calculate the viewshed area (Map 1). The 24 observation points had a greater radial viewshed than the segments due to the fact that I was standing at the points for a minute, as opposed to walking.

I noted the time I arrived at each observation point while walking routes. From this I could calculate the average time spent walking each route segment and observing at each point. These data, together with viewshed areas, allowed me to express deer activity density as $\# \text{deer} / (\text{minute}) * (\text{hectare})$. The data is expressed in this unit in order to avoid potential bias in the case that I saw more deer in one place than another simply because I sampled larger visible area there or spent more time looking there. To

compare deer activity density inside vs. outside the fence I used an ANOVA test on JMP (v. 9.02; SAS Institute, Inc., Cary, NC, 2010).

Are mule deer more common in willow, meadow, or forest habitat?

Whenever I observed a deer while walking the routes, I recorded the habitat that it was in. I totaled the number of deer sightings in each habitat, regardless if the deer was found inside or outside RMBL. Using a contingency table, I estimated the expected number of deer sightings under the hypothesis that they have no habitat preference. To do this I estimated the relative area of the habitats along the routes using ArcMap (more information under GIS Mapping of Habitat Types).

Plant Transect

Is the abundance of highly palatable plants greater inside or outside the RMBL fence?

In order to measure the relative availability of highly palatable plants for mule deer, a pin was dropped every 1 meter along a single 50 meter transect established at each of my 24 observation points. Any plants that the pin hit were recorded; if the pin hit the same species more than once then the number of hits was totaled. This method estimates the proportion of the ground area covered by tissue of a given species. These transects were conducted once over the summer, over a seven day period, in late July (before the cows came up valley). The direction of the plant transect was chosen in a random manner around the points, however it was guided by interpretations of my deer observations.

We summed the number of hits for each species for each plant transect. Then we multiplied each species' relative abundance (hits of each species divided by hits of all species) by its palatability rating (Table 1). The scale is 1-3 (1=frequently eaten, 2=sometimes eaten, 3=rarely eaten); the ratings of each plant species are based on previous data from Arozqueta and Castro Escobar, as well as observations from scientists at RMBL. After the species relative abundance were multiplied by their respective palatability rating we summed the product over all the species to derive an overall palatability score for each transect. We then used ANOVA to assess whether scores differed for transects located inside vs. outside the RMBL fence.

Is the abundance of highly palatable plants greater in willow, meadow, or forest habitat?

The data from above was used to address this question, however the focus is on the habitat (willow, meadow, or forest) of the all observation points, inside and outside RMBL. We then used ANOVA to assess whether palatability scores differed among habitats.

GIS Mapping of Habitat Types

What is the relative availability of willow, meadow, and forest habitat inside and outside of the RMBL fence?

ArcMap was used to quantify the area of habitats in the visibility viewshed of deer routes in order to estimate my sampling effort in the different habitats inside and

outside the fence. I overlaid a map of the route viewshed onto an aerial photo of RMBL taken in 2006. Then I traced the boundary of each habitat type within the route viewshed and used ArcMap software to calculate the area of each habitat type.

In order to categorize the different habitats (meadow, wet meadow, willow and forest), numerous polygons were created using ArcMap to define the area of these habitats in the route viewshed (Map 2). Once the polygons were created, I used ArcMap to output the cumulative area of each habitat type. For the analysis I decided to distinguish “meadow” and “wet meadow” habitats because the latter are dominated by *Veratrum californicum*, which are much taller than other meadow plants and so give distinct habitat structure. The area of the habitats was found using ArcMap, and the sum of each habitat inside and outside was put onto a graph in order to compare the two.

Results:

Are mule deer more common inside or outside the RMBL fence?

Overall, mule deer were slightly more common outside the RMBL fence than inside (Figure 1). However, it should be noted that this overall difference was not significant ($P = 0.4682$). There was a marginally significant ($P = 0.0712$) difference in distribution of deer in the two routes (Figure 2): along the North Gothic route more deer were observed inside the fence than outside the fence, whereas the opposite was true for the South Gothic route (Table 2). We found does and fawns significantly more common inside the fence than outside relative to bucks contingency habitat in vs. out ($\chi^2 = 4.180493$, D.F. = 2, $P < 0.05$) (Table 3).

Are mule deer more common in willow, meadow, or forest habitat?

Mule deer appeared to prefer forest over meadow or willow habitat (Figure 3), as they were seen in forest more often than expected based on the relative area of forest along routes, and less often in willow or meadow habitat relative to the area of those habitats along the routes (Table 2). We found bucks to be more common in forests relative to does and fawns; we also found does and fawns to be more common in meadows relative to bucks ($\chi^2 = 4.3586$, D.F. = 1, $P < 0.05$) (Table 5).

Is the abundance of highly palatable plants greater inside or outside the RMBL fence?

There was no significant difference in plant palatability inside vs. outside the fence (Figure 4, Table 6). However, the two routes did differ in palatability inside vs. outside the fence (Figure 5); in total, plants along the Deer Creek route were on average more palatable than along the 401 route. (Figure 6, Table 6).

Is the abundance of highly palatable plants greater in willow, meadow, or forest habitat?

Habitats did not differ in palatability of vegetation (Figure 7, Table 6).

What is the relative availability of willow, meadow, and forest habitat inside and outside of the RMBL fence?

The proportion of all meadows, forest, and willow habitats are about equal inside and out the RMBL fence. However, there was relatively more meadow inside the fence than outside the fence and more wet meadow was sampled outside the fence than inside. Forest and willow habitats were similarly represented inside and outside the fence (Figure 8).

Discussion:

The purpose of this study was to observe mule deer spatial distribution and also to observe the effects of plant palatability and habitat structure on deer activity density. We found that deer activity density was not obviously associated with the distribution of preferred plant species or habitats. Thus, my hypothesis was rejected. This study strengthens the trophic cascade hypothesis because it eliminates an alternate hypothesis.

First, The plant palatability findings for both inside vs. outside the fence and the different habitat types was an exciting finding because it suggests that palatable plant availability does not influence where mule deer prefer to live because it is similar everywhere in and around the town site. Palatability differences did vary among the two transects (Figure 6). This possibly explains the deer activity density patterns observed on the separate transects (Figure 2). However, to better assess plant palatability, more transects inside and outside of the fence, and also in different habitats, should sample a broader spatial scale in order to obtain a better idea of what species cover those different areas.

Second, the relative availability of willow, meadow, and forest were proportionate inside and outside the RMBL fence. However, when wet meadow is distinguished from meadow, we find that the relative availability of wet meadow was greater outside the RMBL fence. The implications this may have on deer spatial distribution can only be concluded from natural history observations. Researchers at RMBL have observed that does hide their fawns in willow habitats, possibly because it is viewed as a visually protected area from predators. Wet meadow could also provide the same type of visual cover in mid-late summer due to the large plant species, making it a preferred habitat for mule deer. If this hypothesis is true, then it could be one reason why we saw more deer activity outside the RMBL fence than inside.

Although the result of mule deer activity density inside vs. outside the RMBL fence was not consistent with previous research (Arozqueta 2005, Castro Escobar 2010, Pickens 2010), this could be due to temporal factors. This summer was unique to all living in the town site because there was a large construction project in the center of town. The new laboratory being built brought noise, destruction to surrounding areas, and a drastic increase in human activity. This extra movement could possibly be scaring the already skittish deer farther from the town site. Another possible explanation for the difference in results is the new sampling method used for observing deer. Whereas I walked transects to gather observations, previous researchers were isolated to three

observations points where the observer sat for a period of time and noted any deer (Castro Escobar 2010). When comparing similar points from my transects with the points from Castro Escobar's points, I found that we both had similar deer activity density for North Gothic (outside the fence). However, we had opposite findings for deer activity density for in town and South Gothic (outside the fence) (Table 7).

More does and fawns were observed inside the RMBL fence relative to bucks. Since fawns are the most vulnerable to coyotes, this sex difference could be significant to trophic cascade hypothesis.

To recapitulate, we conclude that the distribution of preferred plant species and habitat structure does not influence the spatial distribution of mule deer in Gothic, CO. The rejection of my hypothesis strengthens the human-coyote-deer-plant trophic cascade hypothesis. Evelyn Strombom, a student at RMBL this summer, produced preliminary results on coyote scat spatial distribution and found that coyotes activity density is greater 500+ meters away from cabins, relative to activity density 0-500 meters from a cabin (Figure 9). This information also strengthens the trophic cascade hypothesis. More research is needed in order to gain a better understanding of influences of mule deer spatial distribution.

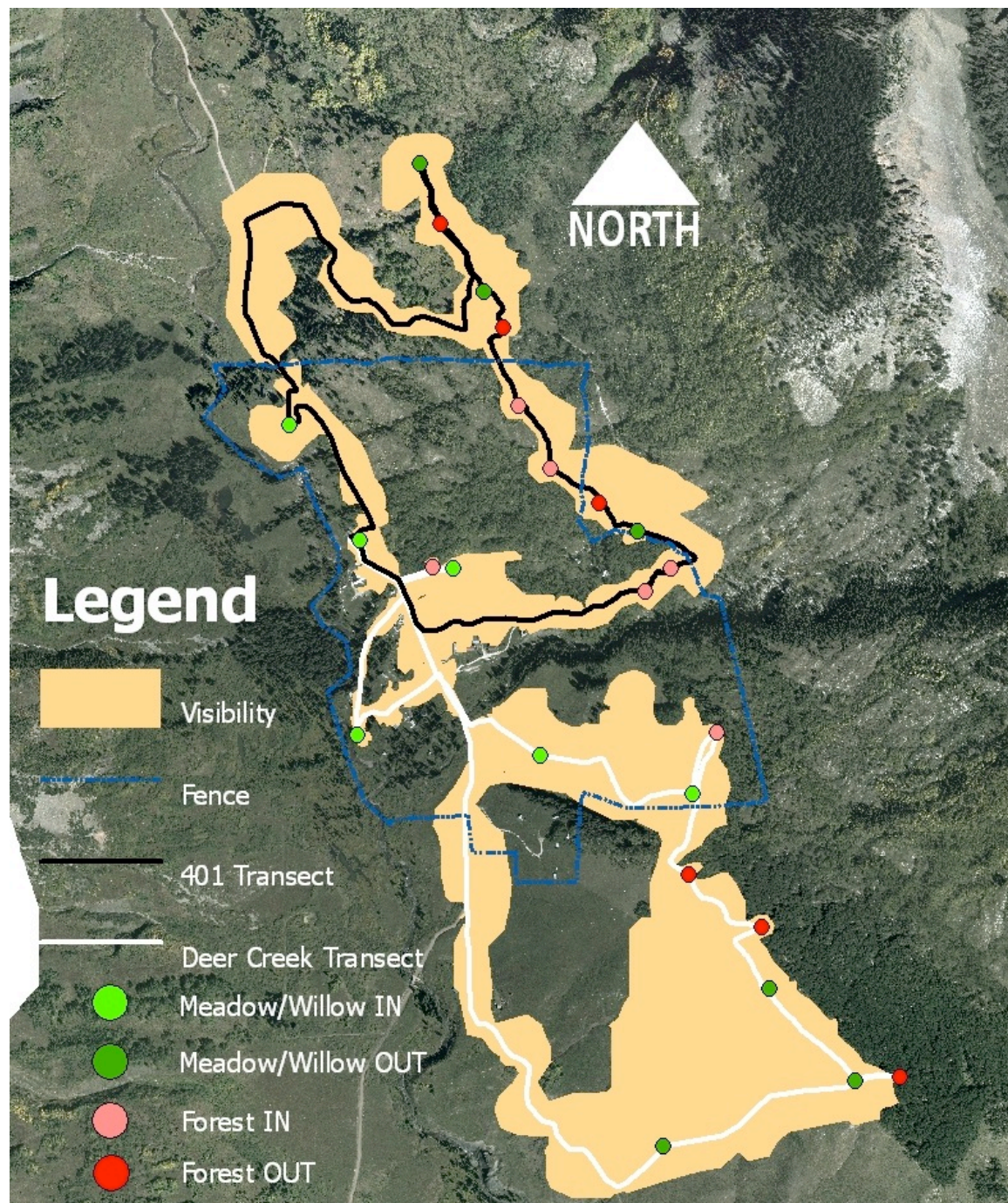
The basic means by which deer influence an ecosystem are known: nutrient cycling, net primary production, and disturbance regime (Hobbs 1996). However, knowledge about how deer and plants respond to management plans remains limited (Healy et al. 1997). Interactions between deer and the environment are complex, involving direct and indirect effects, feedback mechanisms and time-lags (Pastor et al. 1988, Pastor and Naiman 1992, Ostfeld et al 1996). A model of these complex relationships should be a goal for future research on mule deer spatial distribution. This knowledge will lead to improved management of mule deer overabundance in a geographic area.

Literature Cited:

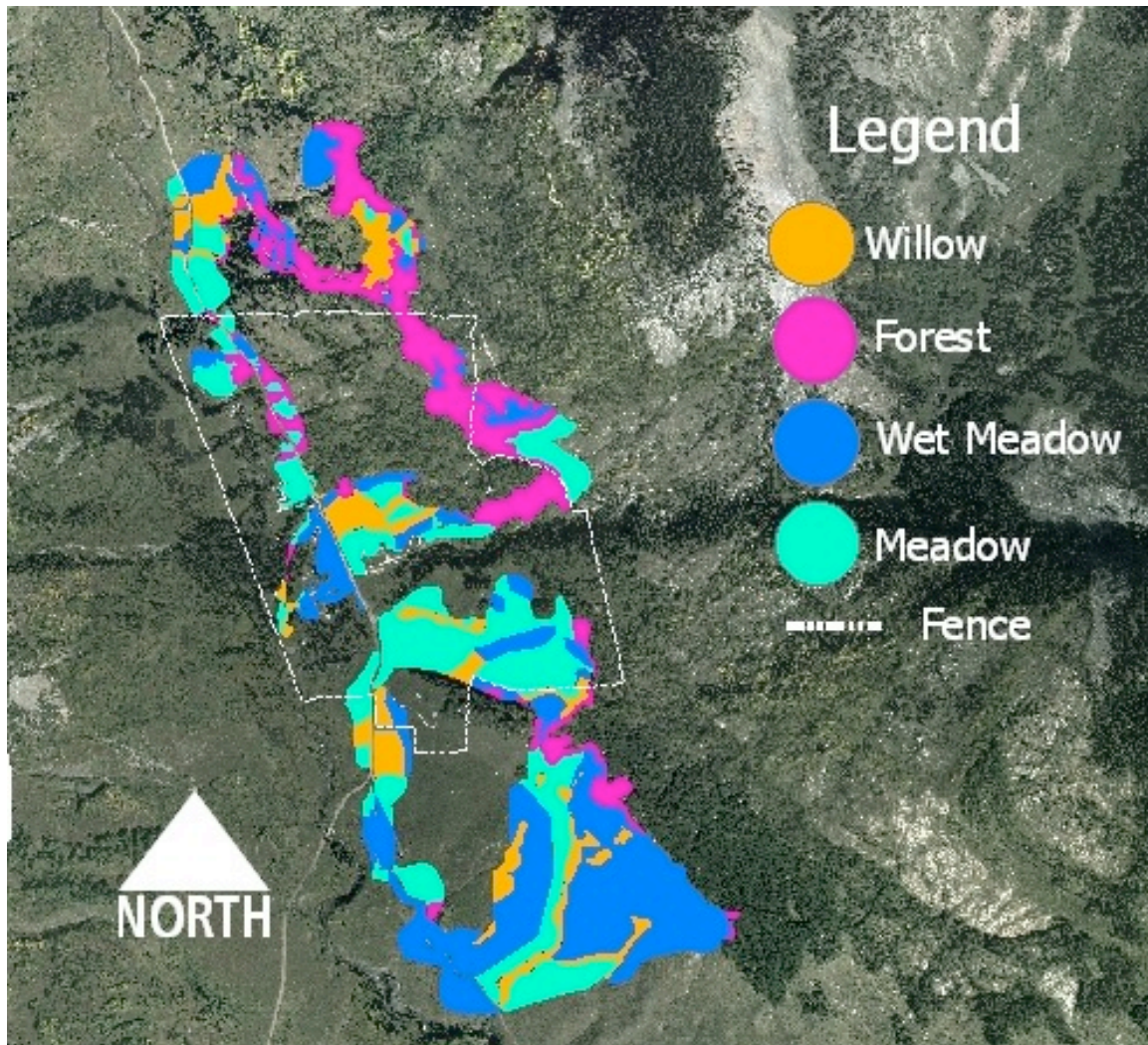
- Arozqueta R (2005) Impacts of Mule Deer Herbivory on Herbaceous Vegetation in the Gothic area, with focus on *Aquilegia coerulea*. RMBL Student Paper.
- Castro-Escobar B (2010) The effect of an introduced predator scent on mule deer (*Odocoileus hemionus*) browsing activities in meadow habitats in Gothic, Colorado. REU Final Paper RMBL.
- Hebblewhite M, CA White, CG Nietvelt, JA McKenzie, TE Hurd, JM Fryxell, SE Bayley, PC Pauet (2005) Human activity mediates a trophic cascade caused by wolves. *Ecology* 86: 2135-2144
- Healy WM, DS deCalesta, SL Stout (1997) A research perspective on white-tailed deer overabundance in the northeastern United States. *Wildlife Society Bulletin* 25(2): 259-263
- Hobbs NT (1996) Modification of ecosystems by ungulates. *Journal of Wildlife Management* 60: 695-713
- Inouye DW, Barr B, Armitage KB, Inouye BD (2000) Climate change is affecting altitudinal migrants and hibernating species. *PNAS* 97: 1630-1633
- Ostfeld RS, CG Jones, JO Wolfe (1996) Of mice and mast. *Ecological connections in eastern deciduous forests*. *Bioscience* 46: 323-330
- Pace ML, JJ Cole, SR Carpenter, JF Kitchell (1999) Trophic cascades revealed in diverse ecosystems. *Trends in Ecology & Evolution* 14: 483-488
- Pastor J, and RJ Naiman (1992) Selective foraging and ecosystem processes in boreal forests. *American Naturalist* 139: 690-705
- Pastor J, RJ Naiman, B Dewey, P McInnes (1998) Moose microbes, and the boreal forest. *Bioscience* 38: 770-777
- Pickens (2010) The landscape of fear and trophic cascades: does human presence at RMBL affect deer behavior? RMBL Student Paper.
- Schmitz OJ, PA Hamback, AP Beckerman (2000) Trophic cascades in terrestrial systems: A review of the effects of carnivore removals on plants. *American Naturalist* 155: 141-153

Tilghman NG (1989) Impacts of white-tailed deer on forest regeneration in northwestern Pennsylvania. *Journal of Wildlife Management* 53: 524-532

Underwood HB, WF Porter (1991) Values and science: white-tailed deer management in eastern national parks. *Transaction of the North American Wildlife and Natural Resources Conference* 56: 67-73



Map 1: Aerial Map of Gothic, CO. The blue line represents routes walked to estimate deer activity density. The light orange represents the areas that could be seen from the routes (viewsheds). The white dashed line represents the RMBL fence. The light green dots represent observation points in meadow or willow habitat inside the fence (6 total). The dark green dots represent observation points in meadow and willow habitat outside the fence (6 total). The pink dots represent observation points in forest habitat inside the fence (6 total). The red dots represent observation points in forest habitat outside the fence (6 total).



Map 2: Aerial map of Gothic, CO showing the mosaic of habitats within the area visible from the routes. Orange is willow habitat. Pink is forest habitat. Blue is wet meadow. Teal is meadow.

Plant Species	%browse Betsy	%browse Renee	Palatability score
Achillea lanulosa	-0.064	0.000	3
Aconitum columbianum	.	.	3
Agoseris auranticaca	0.103	0.000	2
Agoseris glauca	.	0.000	2
Aquilegia coerulea	0.147	0.500	1
Artemisia dranunculus	-0.064	0.000	3
Campanula rotundifolia	.	.	2
Castilleja sulphurea	.	0.333	1
Delphinium barbeyi	-0.038	0.000	3
Delphinium nuttallianum	-0.064	.	3
Dugaldea hoopesii	-0.041	0.000	3
Epilobium angustifolium	-0.064	0.125	1
Erigeron elatior	-0.064	0.000	3
Erigeron formosissimus	.	.	3
Erigeron speciosus	-0.060	0.075	2
Frasera speciosa	-0.064	0.000	2
Fragaria virginiana	-0.064	0.000	3
Galium septentrionale	-0.064	0.028	2
Geranium richardardsonii	.	0.245	1
Geum macrophyllum	-0.005	.	2
Heliomeris (Viguiera) multiflora	-0.064	0.000	3
Helianthella quinquenervis	0.132	0.121	1
Heracleum lanosum	-0.064	0.034	2
Heterotheca villosa	.	.	3
Heuchera parviflora	-0.039	0.625	2
Hydrophyllum capitatum	-0.064	0.000	3
Hydrophyllum fendleri	-0.064	0.000	3
Ipomosis aggregata	-0.064	0.500	1
Lathyrus leucanthus	-0.064	0.019	2
Ligusticum porteri	-0.016	0.052	1
Linum lewisii	-0.064	0.048	2
Lomatium macrocarpum	-0.064	.	2
Lupinus sp.	-0.064	.	3
Mahonia repens	.	0.000	3
Mertensia ciliata	.	0.100	2
Oreochrysum (Pyrrochoma) parryi	0.936	.	2
Osmorhiza occidentalis	-0.064	0.000	3

Pedicularis bracteosa	-0.064	0.500	1
Pneumonanthe parryi	.	0.000	2
Polemonium foliosissimum	.	.	3
Potentilla hippiana	.	.	2
Potentilla pulcherrima	-0.039	0.113	1
Pseudocymopterus montanus	-0.064	0.091	2
Senecio bigelovii	-0.064	0.000	3
Senecio integerrimus	.	0.286	1
Senecio serra	.	0.000	3
Senecio triangularis	.	.	2
Solidago multiradiata	.	0.037	2
Taraxacum officinale	0.036	0.111	1
Thalictrum fendleri	-0.051	0.018	3
Tragopogon pratensis	0.811	.	1
Valeriana edulis	0.054	0.667	1
Valeriana occidentalis	0.023	0.245	1
Veratrum californicum	.	.	3
Vicia americana	-0.064	0.000	3
Viola adunca	.	0.000	3
Viola nutalli	.	0.093	2
small annuals	.	.	2
small perennials	.	.	2
Amelanchier alnifolia	.	.	3
Artemisia tridentata	.	.	3
Lonicera involucrata	.	.	1
Paxistima myrsinites	.	.	3
Picea engelmannii	.	.	3
Populus tremuloides	.	1.000	1
Potentilla fruticosa	.	.	2
Ribes sp.	.	.	2
Rosa woodsii	.	0.143	1
Symphoricarpos rotundifolia	.	.	2
Grasses or sedges	.	.	3
bare ground	.	.	.
unknown herb	.	.	.

Table 1: Species palatability ranking. %browse Betsy is the average deviation of a species from overall browsing rate at a location (Castro Escobar 2010). %browse Renee is the proportion of stalks of a species that were browsed (Arozqueta 2005). Palatability score: 1=frequently eaten, 2=sometimes eaten, 3=rarely eaten.

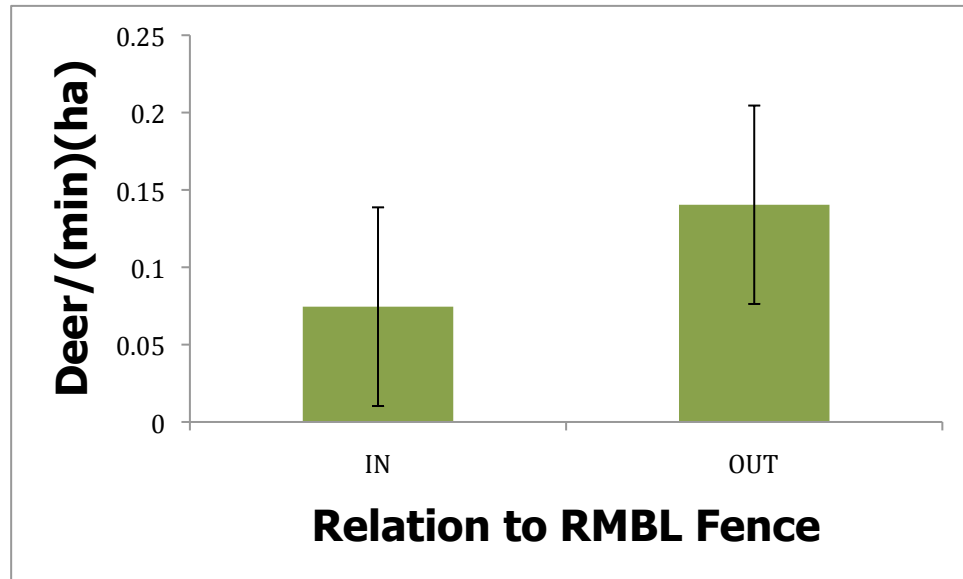


Figure 1: Average deer activity density (deer/(minute*hectare)) for route segments and points inside and outside the RMBL fence. Vertical bars indicate +/-1 standard error of the mean.

	DF	Sum of Squares	F Ratio	P value
Model	3	5.9176	1.4636	0.2233
Route	1	0.8914	0.6614	0.4164
Segment IN or OUT	1	0.7102	0.5269	0.4682
Route*Segment IN or Out	1	4.4010	3.2655	0.0712
Error	651	877.3595	.	.
C. Total	654	883.2771	.	.

Table 2: Summary of factorial ANOVA analysis for deer density (deer/(minute)*(hectare)) inside and outside the RMBL fence.

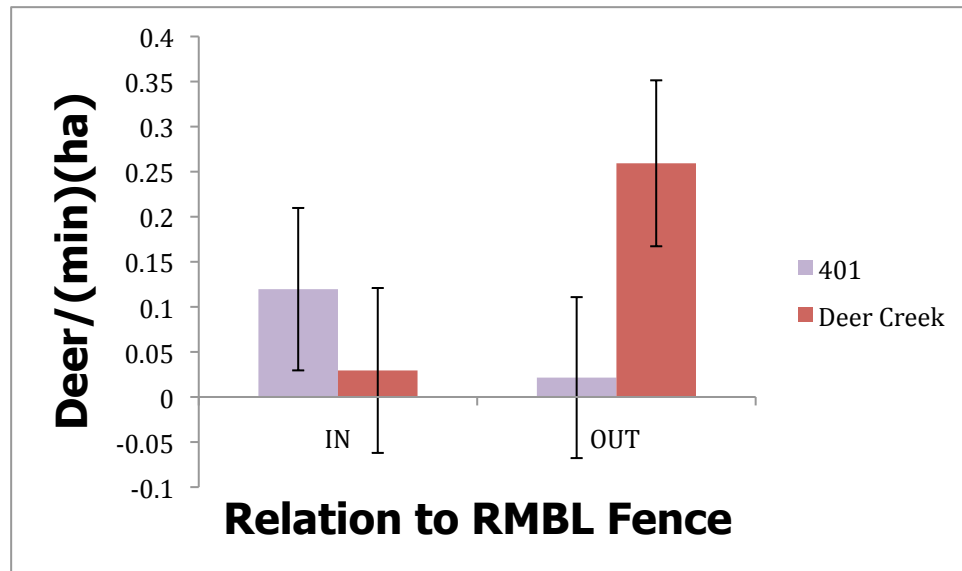


Figure 2: Deer density (deer/(minute*hectare)) on the 401 route (North Gothic) and the Deer Creek route (South Gothic), inside vs. outside the RMBL fence.

	Does & Fawns Observed	Does and Fawns Expected	Bucks Observed	Bucks Expected
IN	53	47.25	11	15.75
OUT	35	39.75	18	13.25

Table 3: Summary of Goodness-of-Fit analysis for number of observed does and fawns observed compared with expected deer inside vs. outside the RMBL fence. The same analysis applies to the number of bucks observed and expected.

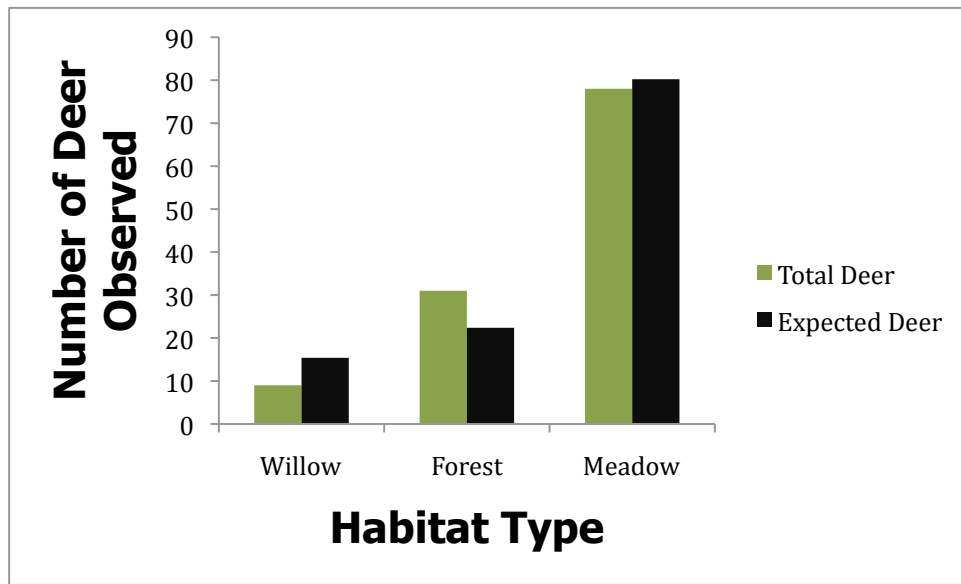


Figure 3: The total number of deer observed in willow, forest and meadow habitat. The total number of deer is compared with the expected number of deer, based on the relative area of habitat. There was significant deviation between observed and expected ($\chi^2 = 6.034$, $DF = 2$, $P < 0.005$).

Habitat	Average Deer of All Deer Observed	Total Deer	Expected Deer	Proportion of Habitat	Total Area
Willow	0.08	9	15.39314928	0.130450418	96877.821
Forest	0.26	31	22.38335717	0.189689468	140871.2
Meadow	0.66	78	80.22349355	0.679860115	504891.956

Table 4: Summary of Goodness-of-Fit analysis for number of deer observed compared with expected deer in willow, forest and meadow habitat.

	Does & Fawns Observed	Does & Fawns Expected	Bucks Observed	Bucks Expected
Willow	6	6	2	2
Forest	19	23.25	12	7.75
Meadow	62	57.75	15	19.25

Table 5: Summary of Goodness-of-Fit analysis for number of does and fawns observed compared with expected does and fawns in forest, meadow, and willow habitat. The same analysis applies to the number of bucks observed and expected.

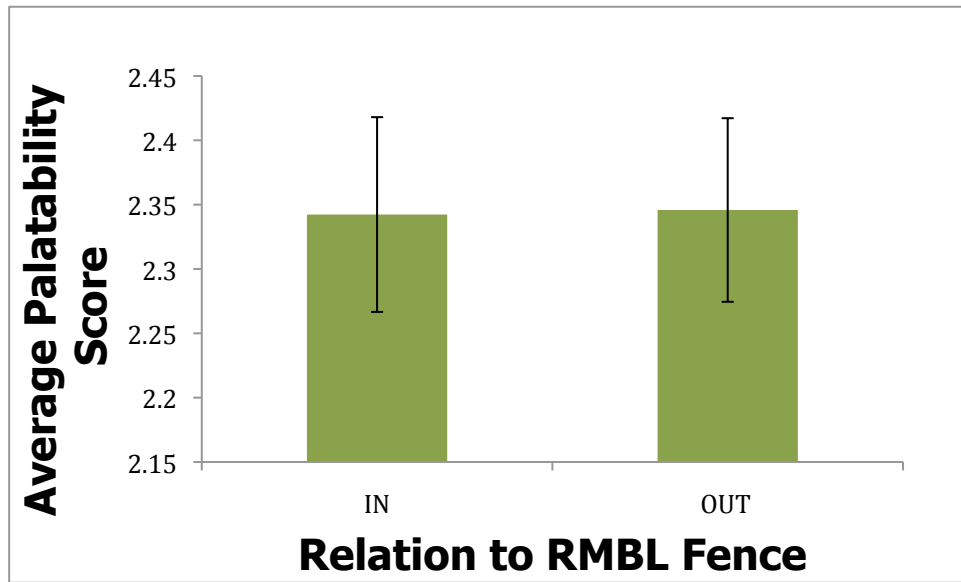


Figure 4: Average palatability score of vegetation at the 12 observation points found inside the RMBL fence vs. the 12 observation points found outside the fence.

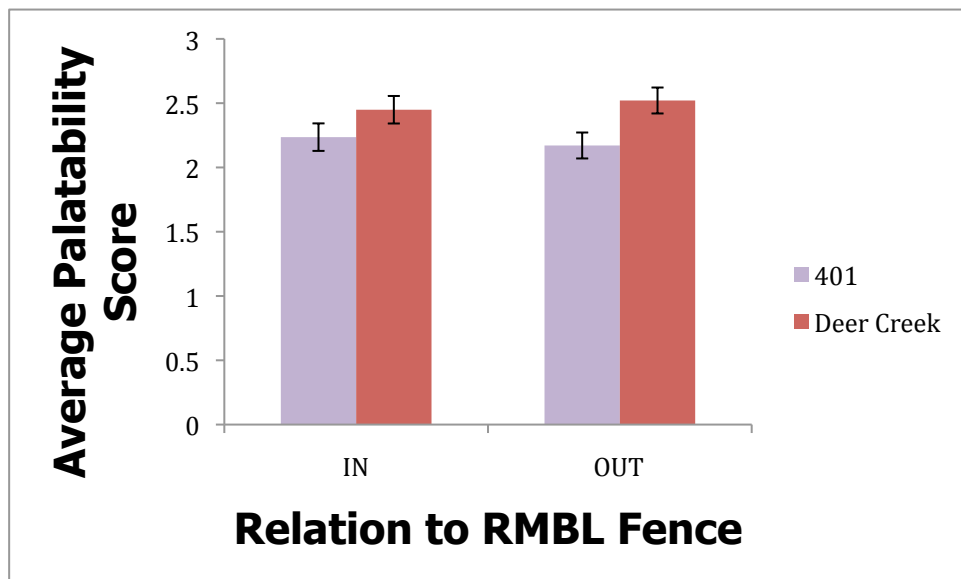


Figure 5: Average palatability score of vegetation inside vs. outside the fence on the 401 and Deer Creek routes.

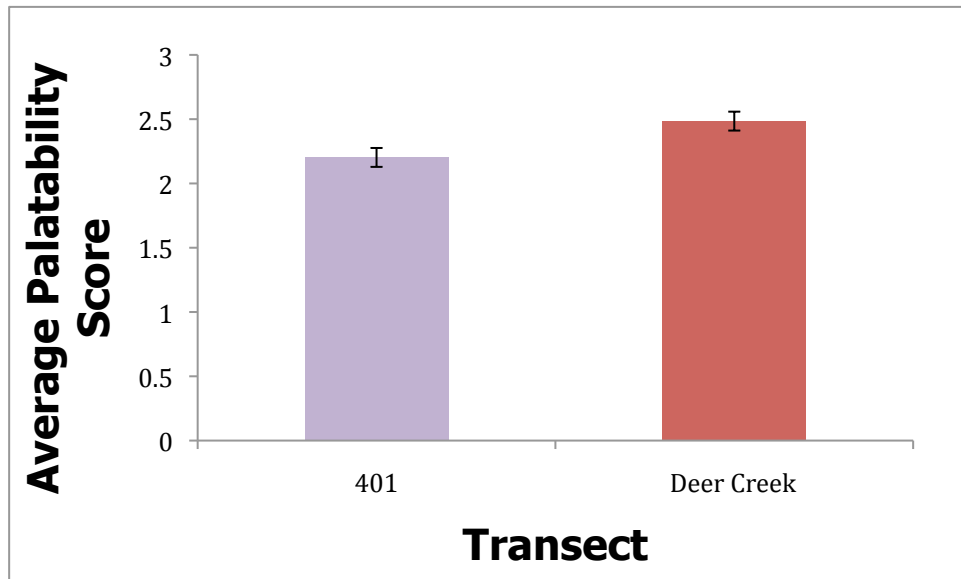


Figure 6: Average palatability score of the 401 route vs. the Deer Creek route. Vegetation along the Deer Creek route was significantly more palatable than the vegetation along the 401 route (Table 4).

	DF	Sum of Squares	F Ratio	P value
Model	7	0.6346	1.4841	0.2418
Route	1	0.4477	7.3286	0.0155
Habitat	1	0.0435	0.7122	0.7062
Route*Habitat	1	0.0090	0.1472	0.7062
INorOUT	1	0.0001	0.0012	0.9734
Route*INorOUT	1	0.0264	0.4322	0.5203
Habitat*INorOUT	1	0.0533	0.8724	0.3642
Route*Habitat*INorOUT	1	0.0221	0.3611	0.5563
Error	16	0.9773	.	.
C. Total	23	1.6119	.	.

Table 6: Summary of ANOVA of the average palatability score inside and outside the fence.

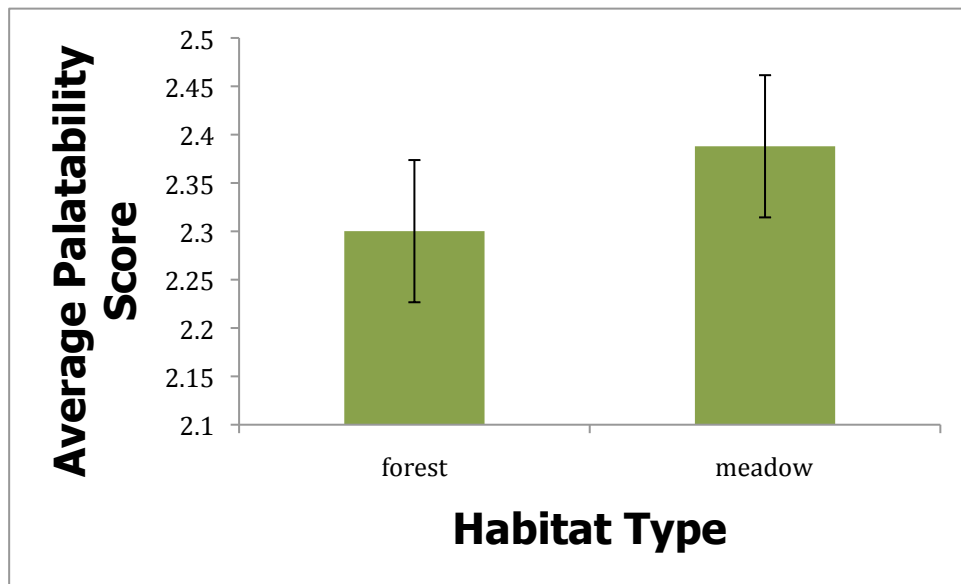


Figure 7: Average palatability score of the 12 observation points in forest habitat vs. the 12 observation points in meadow/willow habitat.

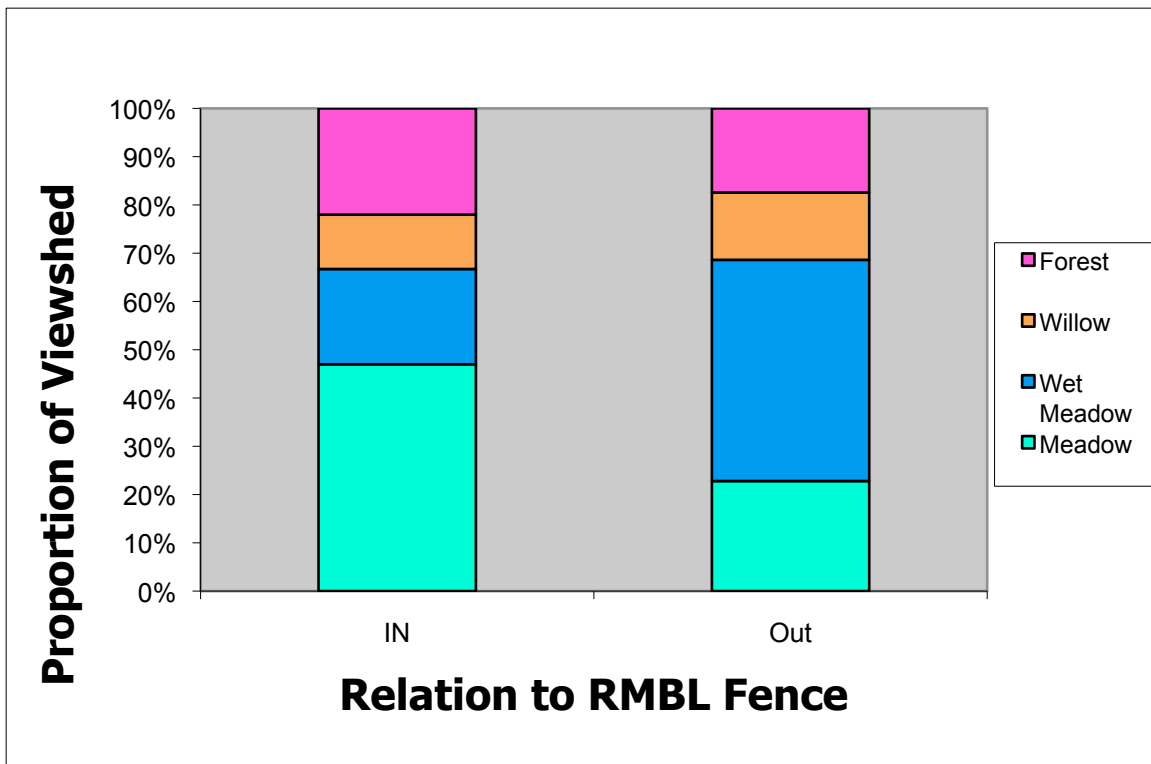


Figure 8: The proportion of area of habitats (forest, willow, wet meadow, and meadow) in the viewsheds of the routes.

Location	Castro Escobar (deer/(scan)(ha))	Pistoia (deer/(min)(ha))
Gothic	0.095	0.062
South Gothic	0.006	1.105
North Gothic	0.000	0.000

Table 7: Comparison of 2010 (Castro Escobar) and 2011 (Pistoia) mule deer activity density data for three observation points that were common to the two studies. Gothic is inside the RMBL fence. South and North Gothic are outside the RMBL fence.

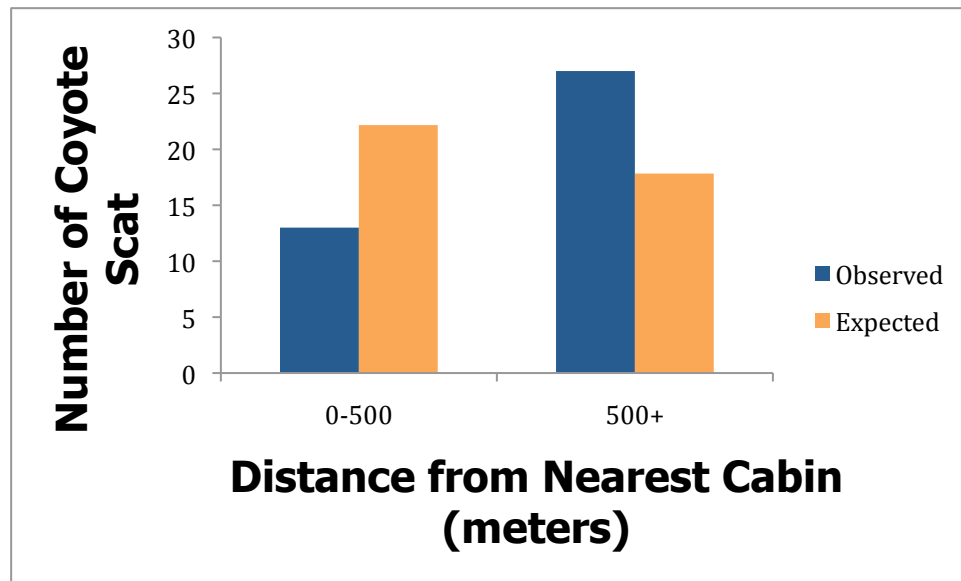


Figure 9: The total number of coyote scat observed 0-500 meters and 500+ meters from a cabin. The total number of coyote scat is compared with the expected number of coyote scat, based on the relative area from the nearest cabin.