Using GIS to Characterize Cougar Movement and Activity in Cougar Management and Conservation

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Abstract

Cougar (*Puma concolors*) management on the Fra Cristobal mountain range, New Mexico has become complicated by the introduction of the endangered Desert Bighorn Sheep (*Ovis canadensis mexicana*) to the range in 1995. Current cougar management is based on the most cost-effective method to diminish sheep predation. This study analyzes the movement data and location of predation events of a collared male cougar on the Fra Cristobal range. Cougar movement statistically varied by season and time of day. Location characteristics (elevation, slope, aspect, topographic roughness, and vegetation type) of cougar points were statistically different from the characteristics of randomly generated points within the study area. When kill sites were compared to the random points, only elevation differed significantly. The results of this study provide data for more detailed cougar habitat models of the Fra Cristobal range and are applicable to long-term cougar management.

Introduction

Cougar populations in New Mexico have been managed on the state level since 1971 when the species was added to the state's protected species list. In response to calls for management reform, current management is based on a harvest quota system in 16 cougar management zones (Beausoleil, 2000). Cougar conservation often conflicts with management of Desert Bighorn Sheep, a state endangered species since 1980.

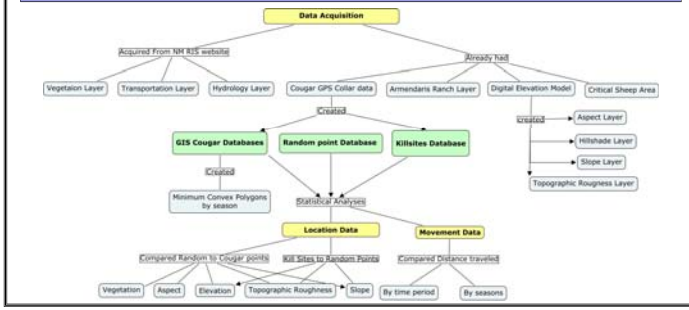
This conflict is seen on the Fra Cristobal mountain range, located on the privately owned Armendaris Ranch. The range is one of three places in New Mexico where the sheep population has not become functionally extinct.

A different cougar in the Fra Cristobal (Photo by Travis Perry)

Cougar predation is a primary limiting factor on sheep populations, accounting for 83 percent of sheep mortality on the Fra Cristobal Range from 1995 to 2005 (NMDGF, 2006). Management of both species is based on the most cost-effective method of reducing sheep predation, relying heavily on euthanasia. In 2003, an experimental management strategy, which removed female cougars and monitored male cougars and their interaction with the bighorn population, was implemented.

On 23 October 2004, the Turner Endangered Species Fund collared a male cougar to research cougar-sheep coexistence. The cougar was tracked for 214 days before it was killed on 25 May 2005 after it killed a collared bighorn sheep. This study analyzed the cougar's movement and characterized point locations and kill sites.

Methodology



Results

Study Site:

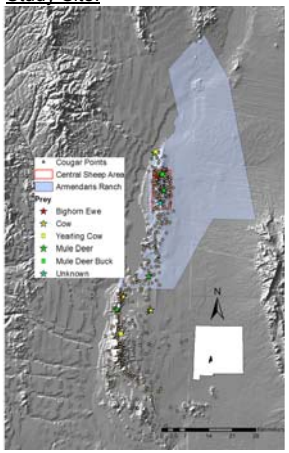


Figure 1. Study Site and kill locations along the Fra Cristobal mountain range, New Mexico. The cougar was tracked for 214 days. The cougar traveled at least 1304 km.

Movement Analysis:

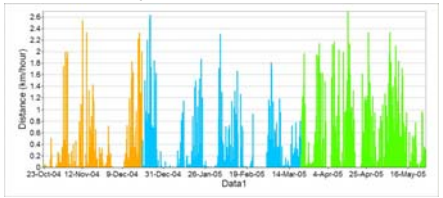


Figure 2. Distance (km/hr) traveled between points. Color coded by season (orange = fall; blue = winter and green = spring). There is significant variation in average distance over the day and among Season (See Table 1).

Table 1. Variation in distance traveled by time of day and season

By Time Period	N	Median Distance * (km/hour)	By Season	N	Mean Distance ** (km/day)
12 pm to 2 am	151	0.0787 [a]	Fall	23	7.587 ± 1.526 [ab]
2 am to 5 am	167	0.393 [b]	Winter	44	6.757 ± 0.994 [a]
5 am to 9 am	149	0.00952 [a]	Spring	44	10.233 ± 0.965 [b]
9 am to 12 pm	144	0.0139 [a]			

*Group medians are significantly different among time periods (Kruskal Wallis one-way ANOVA on Ranks, H = 60.83, p< 0.001). Groups with different superscripts are statistically different (Dunn post hoc, p<0.05).
**There is a significant difference in mean distance among season (one-way ANOVA, F=4.375, p< 0.015). Groups with different superscripts are statistically different (Tukey post hoc, p<0.05).

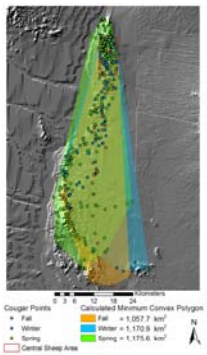


Figure 3. Seasonal home ranges estimated by Minimum Convex Polygons. During the course of the study 41% of the 711 points were within 200m of the Central Sheep Area.

Location Analysis:

Table 2. Topographic Roughness of Random and Cougar Points

Group	Median	25%	75%
Random (N=711)	5.907	1.17	40.72
Cougar (N=711)*	303.28	33.57	1014.5

*Group medians are significantly different (Mann-Whitney Rank Sum Test, t=365507, p< 0.001)

Table 3. Slope of Random and Cougar Points

Group	Median	25%	75%
Random (N=711)	0.942	0.390	2.580
Cougar (N=711)*	7.797	1.469	15.557

*Group medians are significantly different (Mann-Whitney Rank Sum Test, t=389751, p< 0.001)

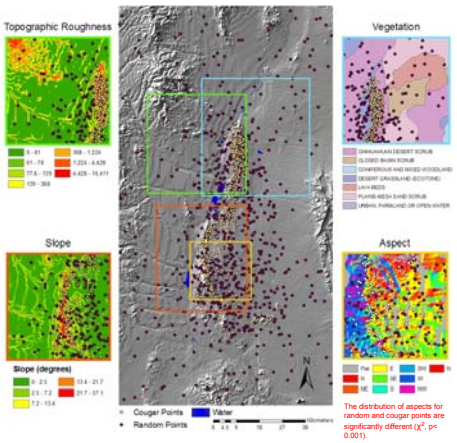


Figure 4. Location characteristics of Cougar points were statistically compared to randomly generated points. The side images are examples of the different layers

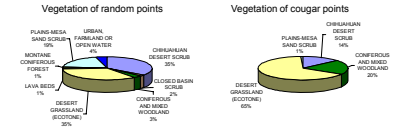


Figure 5. Vegetation composition of random and cougar points. A Chi squared test found compositions to be significantly different between groups (χ^2 = 13,151, p< 0.001).

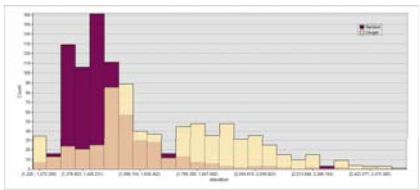


Figure 6. Histogram of elevation (m) for Random and Cougar points.

Table 4. Elevation of Random and Cougar Points

Group	Median	25%	75%
Random (N=711)	1463	1401	1535
Cougar (N=711)*	1580	1487	1731

*Group medians are significantly different (Mann-Whitney Rank Sum Test, t=398356, p< 0.001)

Kill Site Characterization:

Table 5. Elevation, Slope and Topographic roughness of kill sites

Characteristics	Median	Mann-Whitney Test† 25%	75%	T	P
Elevation	1589	1470	1767	5784	0.045
Slope	1.527	1.007	2.426	4859	0.474
Topographic Roughness	233.1	3.102868.86		5603	0.079

† Mann-Whitney test was used to compare the Kill sites (N = 12) to the Random Points (N = 711). Aspect and vegetation were not compare using a Chi square test due to violation of assumptions.

- 64% of kills occurred on western aspects
- Field records of kill sites provide greater detail about vegetation but this occasionally differs from the vegetation layer (Table 6)

Desert Bighorn Rams (Photo by Travis Perry)

Table 6. Comparison of vegetation classification between field observations and generalized vegetation layer for New Mexico used in this study

Date	Prey	Vegetation: field notes	Vegetation: Generalized layer
11/10/2004	Cow	Desert scrub	Desert grassland
11/14/2004	Mule Deer	Desert scrub	Desert grassland
12/2/2004	Mule Deer buck	Desert scrub	Desert grassland
1/5/2005	Mule Deer buck (four)	Montane scrub	Coniferous/mixed woodland
1/14/2005	Mule Deer	Desert scrub	Coniferous/mixed woodland
1/29/2005	Mule Deer	Montane scrub	Desert grassland
2/26/2005	Yearling Cow	Desert scrub	Desert grassland
3/11/2005	Unknown	Desert scrub	Desert grassland
3/24/2005	Cow	Desert scrub	Desert grassland
4/2/2005	Deer	Riparian	Desert grassland
4/21/2005	Yearling Cow	Riparian	Desert grassland
5/23/2005	Desert Bighorn Ewe	Montane scrub	Desert grassland

Discussion

- Significantly larger distances in early morning hours are consistent with cougars as nocturnal animals (Beier *et al.*, 1995)
- Significant season differences (Table 1) in distance traveled may reflect spring dispersal or seasonal changes in home range size seen in other studies (Dickson and Beier, 2002). This study had relatively small seasonal differences (<12%) in polygon area. Only 214 days long, this study may not be long enough to accurately assess seasonality.
- Consistent with other studies, this study shows a non-random selection for certain habitat characteristics such as steeper slopes, rough terrain, and high elevation (Logan and Sweanor, 2001; Dickson and Beier, 2002; Dickson *et al.*, 2005), (Dickson and Beier, 2002). (Logan and Sweanor, 2001).
- As in other studies, the cougar had a strong non-random selection for certain vegetation types (Dickson *et al.*, 2005 ; Galloway and Perry, unpublished). However, the generalized vegetation layer used in this study may not capture local habitat heterogeneity as field records of kill site vegetation often differed. Part of this difference may be a factor of differences in classification. Remotely sensed vegetation data would be beneficial to future studies. Aerial photographs may give a better idea of pinyon-juniper densities on the range.
- Future work on the Fra Cristobal Range should look at pinyon-juniper density and cougar presence and kill site locations. It would also be beneficial to use cluster analysis tools to build a predation model based on clustering (Andersen and Lindzey, 2003) as well as to assess the availability of escape terrain with in the area (McKinney *et al.*, 2006).

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DATA SOURCES:
Vegetation, Hydrology, and Transportation layers were access gathered from the New Mexico GIS Website <http://rgis.unm.edu/>
Digital Elevation Model of study and Armendaris Ranch Layers: Dr. Travis Perry
Cougar GPS Data from the Turner Endangered Species Fund
Projection: UTM Zone 13 Datum: NAD 1983

Acknowledgments

I want to thank Dr. Travis Perry, Sarah Galloway Bowe, and Dr. Suresh Muthukrishnan for their help and guidance on this project. Tom Waddell, the Armendaris Ranch Manager, Mike Phillips of the Turner Endangered Species Fund, and Ron Thompson, the contract biologist who collared the cougar, were also essential to this project. I would also like to thank Dr. Dennis Haney and Dr. Greg Lewis for statistical help and advice, which was significant.