A photograph of a mountain lion in a forest. The lion is in the lower half of the frame, looking to the left with its mouth slightly open. The background is a dense forest with green grass and trees. A semi-transparent text box is overlaid on the top half of the image.

MOUNTAIN LION ECOLOGY AND PREDATOR-PREY DYNAMICS IN THE DAVIS MOUNTAINS

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INTRODUCTION

Mountain lions are one of the last large predators remaining in the United States, but their distribution is limited to the western states (those west of the 100th meridian) and an isolated population in Florida. Within the distribution of mountain lions in the United States, Texas is unique with more than 95% of the state being privately owned and having varying types of land use and management strategies. Texas is also unique in that mountain lions are classified as nongame animals with no restrictions on their harvest or methods of take. These 2 factors make management for mountain lions very complicated.



A mountain lion in the Davis Mountains.

Land-use and landownership patterns in Texas have changed considerably in the last quarter century. In the Trans-Pecos, livestock have been reduced by almost 50% within the last 30 years. As livestock numbers have declined, interest in wildlife enterprises (e.g., mule deer and other game species) has grown considerably in the Trans-Pecos. This renewed interest in managing ungulates can directly impact mountain lion management.



Researchers from the Borderlands Research Institute working on an anesthetized mountain lion in the Davis Mountains.

There is ever-growing evidence that apex predators, when present in biologically significant numbers, play an important role in preserving biodiversity in an area through top-down regulation of other species. However, given the importance of wildlife enterprises to the economy of the region, it is essential that managers have access to reliable information regarding the effects that mountain lions have on the prey populations in the area, so that they can make informed management decisions.

This report presents the findings of research conducted on the west Texas mountain lion population, primarily in the Davis Mountains, from 2011 through 2015. The goal of this project was to gather information to better understand the ecology of the mountain lion population in Trans-Pecos, Texas, with specific interest in understanding predator-prey interactions. We have accomplished this goal by collecting and analyzing a vast amount of data on the movements, habitat use, survival, and feeding behavior of mountain lions on private lands in the Davis Mountains. This is a population of mountain lions that had never previously been studied, and it is our hope that the results of this study will provide landowners and managers with valuable information that can be used in future sustainable management of mountain lions in Texas.

DEMOGRAPHY, SURVIVAL, AND CAUSES OF MORTALITY

Between April 2011 and October 2014, our research team captured 21 mountain lions (12 female, 9 male) in the mountains of west Texas. Mountain lions were captured using foothold snares or trained hounds. After being fitted with a GPS monitoring collar (or an expandable VHF monitoring collar for kittens) each mountain lion was released at the site of their capture. Mountain lions were monitored with GPS and/or VHF collars for an average of 195 days (range = 20 to 649 days).

For animals in this study, ages at the time of first capture ranged from 4 weeks to 5 years. Captured animals were grouped into 3 age categories based on mountain lion life history. We captured 2 “kittens” (1 female, 1 male). Kittens are cats less than 1 year of age that are still reliant on their mother for some or all of their needs. We captured 9 “subadults at dispersal” (4 female, 5 male). Subadults are cats between the ages of 1-3 years old. The subadult stage is generally the time when a mountain lion leaves its natal range (the place where it was born), and establishes its own home range. The remaining 10 captured mountain lions (7 females, 3 males) were classified as “adults”, which are cats that are 3 years old or greater. Adults are generally independ-



Five of the seven collared adult females were accompanied by young at some point during their monitoring.



The age of mountain lions can be estimated by looking at their teeth, and comparing patterns of wear, staining, and gum recession to that of known-age animals.

ent and have their own established home range.

Collars were equipped with mortality sensors which alerted researchers when the mountain lion was inactive for at least 24 hours. When property access allowed, mortality signals were investigated in person to determine the cause of death. Nine monitored mountain lions were known to have died over the course of the study, 7 due to predator control, 1 during recapture, and 1 due to unknown causes. Based on this mortality data, annual survival for mountain lions was estimated to be 0.536, meaning that about 54% percent of the population survives each year. This rate is similar, though at the low end of previous estimates of mountain lion survival in the Trans-Pecos, and is among the lowest in the United States.

The fact that this mountain lion population continues to exist with such high mortality rates may indicate that the population is being sustained by either high rates of mountain lion immigration from other mountain ranges, high reproductive success, or both. Future research by the Borderlands Research Institute will explore this further to determine what is sustaining the population of mountain lions in the mountains of west Texas.

MOVEMENTS AND DISPERSAL

Mountain lions are a wide-ranging species known to move long distances in search of food, water, adequate habitat, and mates. We examined the movements of mountain lions in west Texas to evaluate their movement rates and to describe the dispersal behavior of subadult animals.



Average daily movement rates ranged between 0.7 and 4.7 miles per day for individual mountain lions.

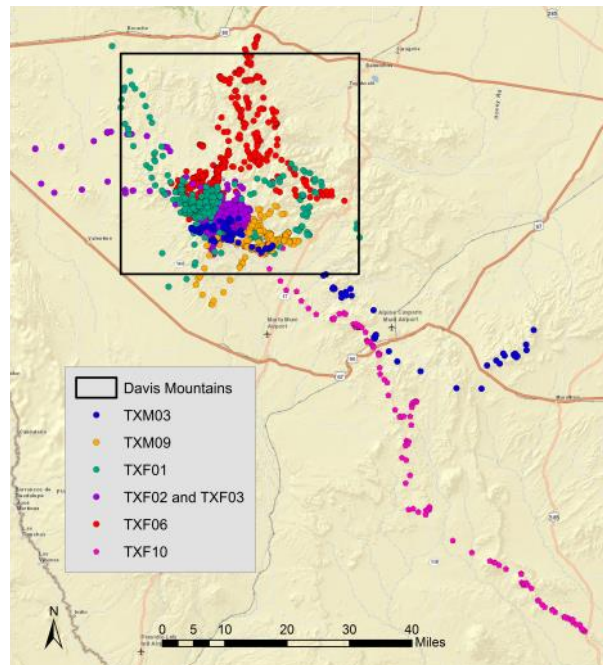
The average daily movement rate for all mountain lions, based on straight line distance between each consecutive GPS point, was 2.3 miles/day. We did not observe any significant difference between the average movement rates of males and females nor did we see significant seasonal differences in movement rates.

When young mountain lions start to become independent, they will often make long-range or “dispersal” movements away from their natal home ranges, in search of a range to establish as their own. We observed long-range or dispersal movements for 7 mountain lions (5 females and 2 males). All except for one, TXF03, were subadults.

TXF03 made a large loop west of her range, along with her kitten, TXF02. They travelled together for 8 days, approximately 25 miles west to within 2 miles of Route 90 before returning back to their normal range. Separately, subadult mountain lions TXF01 and TXF06 made long-range movements to the north, both coming within 2 miles of interstate 10 and then turning around and returning south.

Although mountain lions frequently crossed roads in our study, larger roads with higher traffic volume may have been avoided.

Two mountain lions, TXF10 and TXM03 both successfully left the Davis Mountains. TXF10 dispersed to the south, through the Puertacitas Mountains, before heading farther east toward the Sierra del Carmens. TXF10 was about 90 miles south of her previous range, and nearly across the boundary of Big Bend National Park, when she was killed in a trap. TXM03 travelled southeast, also passing through the Puertacitas Mountains, before turning northeast toward the Glass Mountains, where his collar stopped transmitting.



Map showing dispersal movements made by mountain lions from the Davis Mountains. The dispersal of subadult mountain lions away from their natal range is important to ensuring genetic diversity within mountain lion populations.

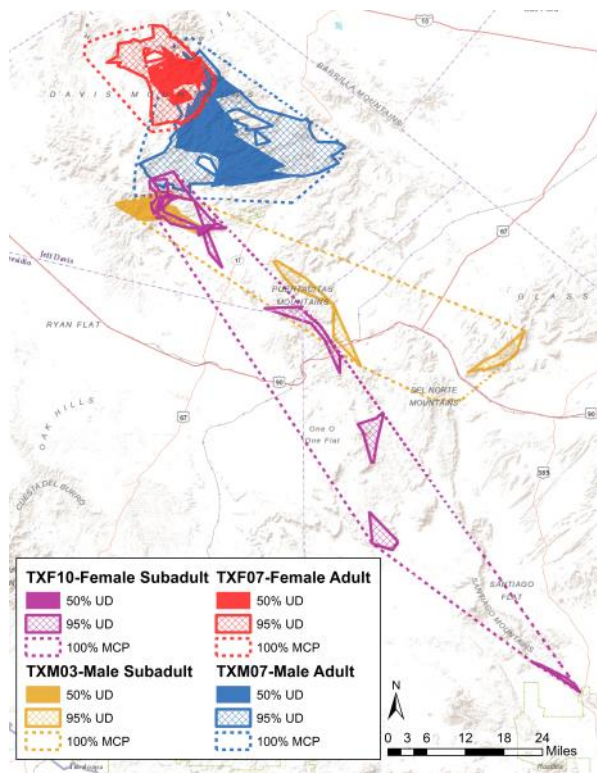
By continuing to observe the long range movements of mountain lions across the west Texas landscape, we will be able to identify important travel corridors for mountain lions and other species of native wildlife.

HOME RANGE ESTIMATES

Individual mountain lions can occupy large areas of land, and on a private lands landscape this means making use of terrain across multiple ranches. Home range estimates are a way of quantifying the area of land that an animal uses. We estimated home range sizes for mountain lions in 2 ways: Minimum convex polygons (MCPs) and Utilization Distributions (UDs).

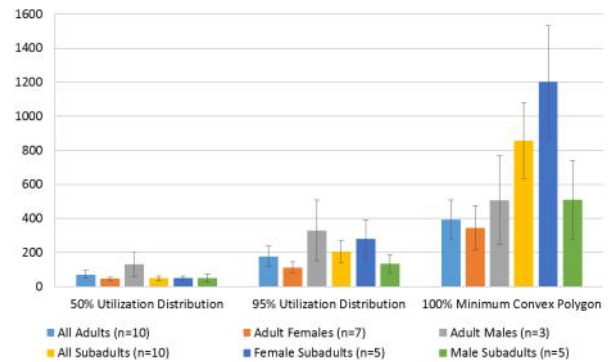
An MCP incorporates all of the location data points that we have collected for a particular animal by drawing a convex polygon around the outermost points. This often overestimates the area that an animal will actually use, but is a good visual representation of the area that an individual could potentially impact.

MCPs averaged 245 mi², but varied considerably between individuals. Average subadult



Map showing home ranges of 4 mountain lions. Subadults on average had larger MCPs due to the inclusion of dispersal movements, but core use areas were similar to those of adults.

MCPs were much larger than adult MCPs, likely because of the inclusion of dispersal or long-range movements that do not necessarily represent increases in actual use. Adult MCPs ranged from 9-400 mi², and averaged 151 mi². In general, the MCPs we observed were larger than have been previously recorded in west Texas.



Home range estimates varied between males and females, and age classes.

The second way we estimated home range was with 50% and 95% UD using a program called T-LoCoH. This method factors in both space and time, to determine which areas the animal spends the most time in and effectively describes a “core” area of use (50% UD) as well as an estimate of overall use of space (95% UD).

Adult female MCP and 95% and 50% UD averages were all smaller than the averages for adult males. TXM07, an adult male, had the largest 50% core area (98 mi²), the largest 95% UD (251 mi²), and the largest MCP (387 mi²) when excluding individuals who made long-range or dispersal movements.

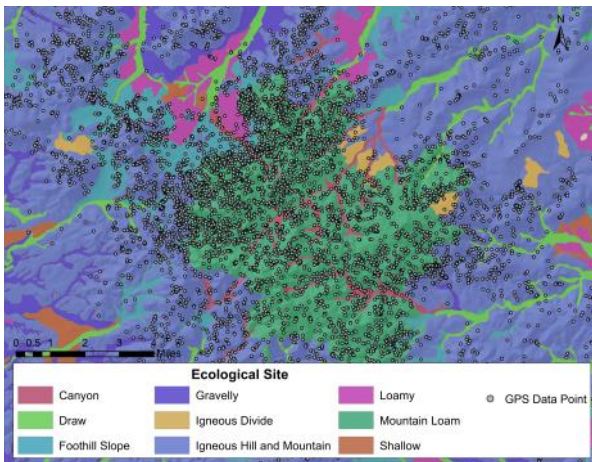
Mountain lions use large areas and travel great distances. Our results show that on average a mountain lion may cross 25 or more private ranches. This accentuates the need for a landscape-level approach to management of mountain lions in Texas.

HABITAT USE

We used GPS collar data to examine habitat use by mountain lions in the Davis Mountains. We looked at 4 criteria of resource selection: elevation, ecological site, fine scale terrain ruggedness, and broad scale terrain ruggedness.

Measures of terrain ruggedness are calculated in a Geographic Information System (GIS) by looking at the changes in elevation and slope within a given area, to determine how rugged or smooth the landscape is. The fine scale terrain ruggedness criteria calculated ruggedness over a small area (around 5 acres), while broad scale terrain ruggedness was calculated over a larger area (around 272 acres).

Ecological sites are classifications determined by the Natural Resources Conservation Service (NRCS) that take into account various conditions including the soil type, topography, region, and moisture conditions in an area. This information is used to classify the type of vegetation that is likely to be found in that area.



Map showing mountain lion movements across different ecological sites in the Davis Mountains, Texas.

For each of the 4 resource selection criteria, we determined which habitats mountain lions selected and which they avoided. We looked at habitat use for the population as a whole, as



In west Texas, mountain lions showed preference for high elevations and rugged habitat on mountains and in canyons.

well as for individual mountain lions within their home range.

Individual mountain lions and the overall population selected for the highest elevations ($\geq 6,234$ feet). Mountain lions also selected for the most rugged habitat on both a fine and broad scale.

Mountain lions preferred the mountain loam and canyon ecological sites. The mountain loam ecological site is found on silty soils on igneous hills and mountains and common plants include ponderosa pine, gray and silver-leaf oak, and alligator juniper. Typical plants found in the canyon ecological site include oaks, ponderosa and pinyon pines, alligator juniper, and Texas madrone. In contrast, the ecological sites avoided by mountain lions tend to be dominated by grass species. This is likely indicative of mountain lions selecting for habitat that provides cover, which is important for safety and stalking prey.

GPS collars allow us to monitor habitat use with precise detail. This data will help us refine our knowledge of where suitable mountain lion habitat is located within the Trans-Pecos.

PREY AVAILABILITY

Understanding the availability of different prey species within habitats occupied by mountain lions is an important step toward understanding the effect that mountain lion populations have on prey populations in the area.



Deer, thought to be a main prey of mountain lions in this region comprised a large portion of photos captured by remote cameras. Deer photos were divided nearly evenly between white-tailed deer and mule deer in the Davis Mountains.

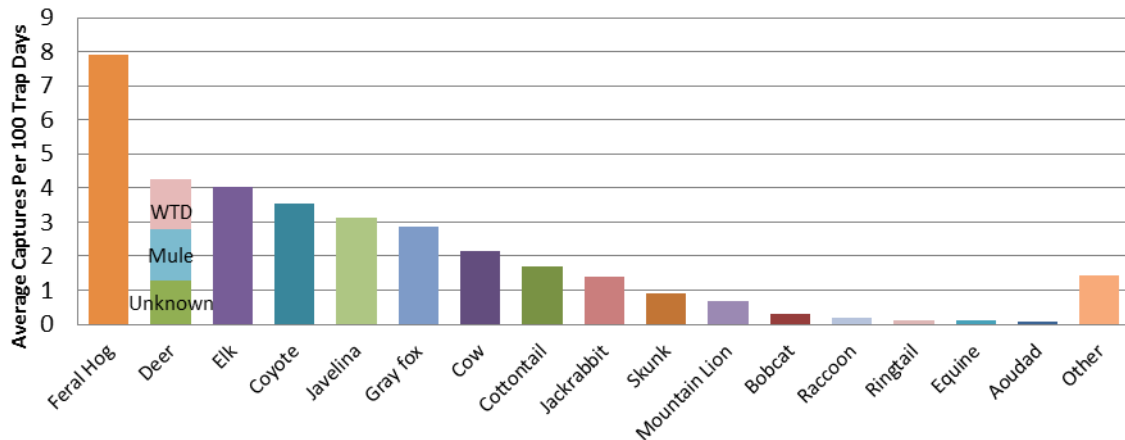
In June 2012, we initiated a camera trapping study to monitor prey availability in the core area of the Davis Mountains study site. Cameras were located in a variety of different habitats, but placed strategically along travel corridors to maximize the probability of capturing a wide variety of species. Over 250,000 photos



Feral hogs, an invasive species in west Texas, have been shown to have destructive effects on native ecosystems through their rooting behavior and competition with native species.

from 7,846 camera trap days have been collected and analyzed resulting in 3,883 individual photo captures. The focus of our analysis was on medium and large-sized mammals, which make up the majority of the mountain lion prey base.

Feral hogs had the highest relative abundance with over 600 camera captures, and were also the most widespread species occurring at 33 of the 38 camera sites. We also photographed 244 javelina, 303 elk, 321 deer, and 148 livestock photos. Coyotes were also widely available, with 275 photo captures. Mountain lions were captured in 54 photos.



Relative species abundance in the Davis Mountains, as observed on camera traps. Twenty-seven species were observed.

DIET COMPOSITION

In addition to information on prey availability, knowledge of the food habits of mountain lions, including where and when they are hunting and what they are consuming, is necessary to understand the potential impact mountain lions may be having on prey populations in west Texas.

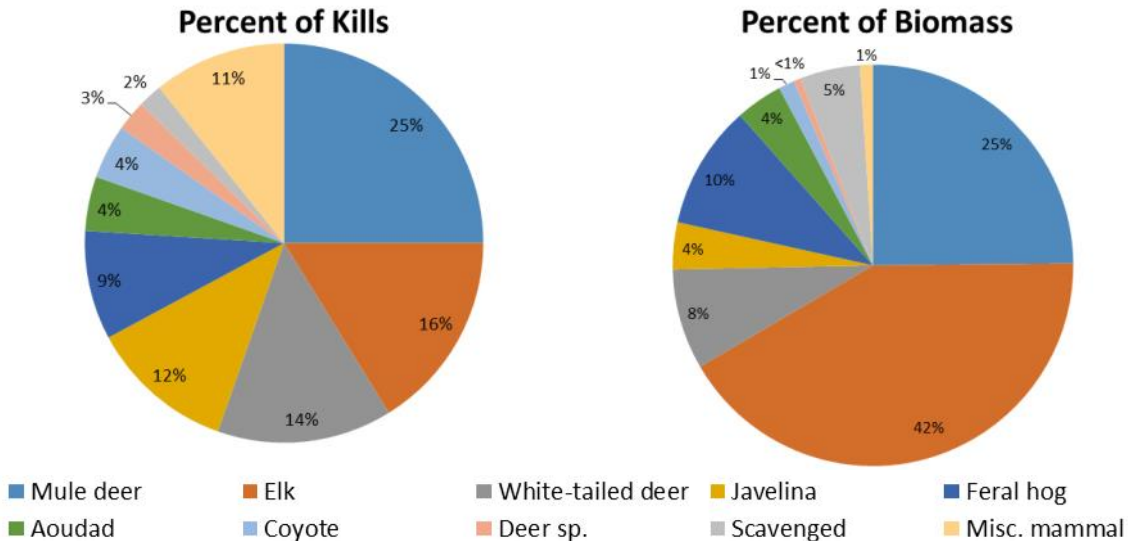
We used GPS collar data to identify potential mountain lion kill sites and investigated these sites to confirm whether or not a kill had taken place. GPS collars were programmed to record 6 locations a day at 0100, 0400, 0600, 1200, 1800, and 2100 hours. We identified potential kill sites as areas with at least 2 locations within a distance of 200 meters on the same night or consecutive nights.

We identified 200 kill sites and 4 scavenged carcasses made by 6 male and 10 female mountain lions. We identified the species, age, and sex of the prey when possible. We also estimated prey weight using average known weights of the prey species from this region, to get an idea of each prey species' biomass contribution to mountain lion diet.



A mountain lion researcher investigates a kill site in the Davis Mountains.

Scavenged carcasses consisted of 3 feral hogs and a bull elk, all killed during feral hog control programs or by hunters. Fourteen species were preyed upon in total, including 6 ungulates, 6 mesocarnivores, 1 lagomorph, and 1 rodent. Mule deer, followed by elk, and white-tailed deer, respectively, were the primary prey species taken by mountain lion. Due to their larger size, however, elk made up the majority of prey biomass eaten, potentially contributing 17% more biomass to the mountain lion diet than mule deer.



The pie graphs above show the diet compositions of mountain lions in the Davis Mountains. Percent of kills (left) is calculated by determining the number of kills of that species as compared to the total number of confirmed kills. Percent of biomass (right) is calculated by determining the estimated weight of all kills of that species compared to the total weight of all kills.

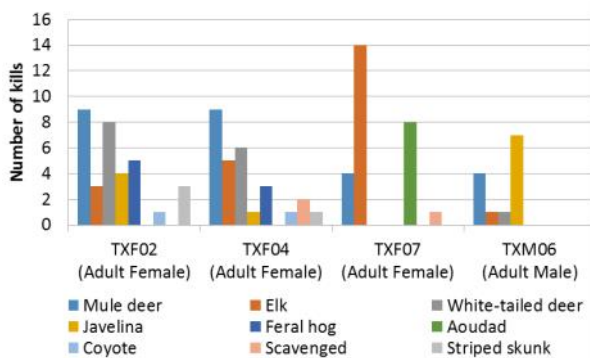
DIET COMPOSITION (CONTINUED)

Ten of the confirmed kill sites were double kills, with 2 animals killed at the same kill site location. Most often double kills were either an adult ungulate with a juvenile or yearling of the same species, or an adult ungulate with a mesopredator (most likely scavenging).

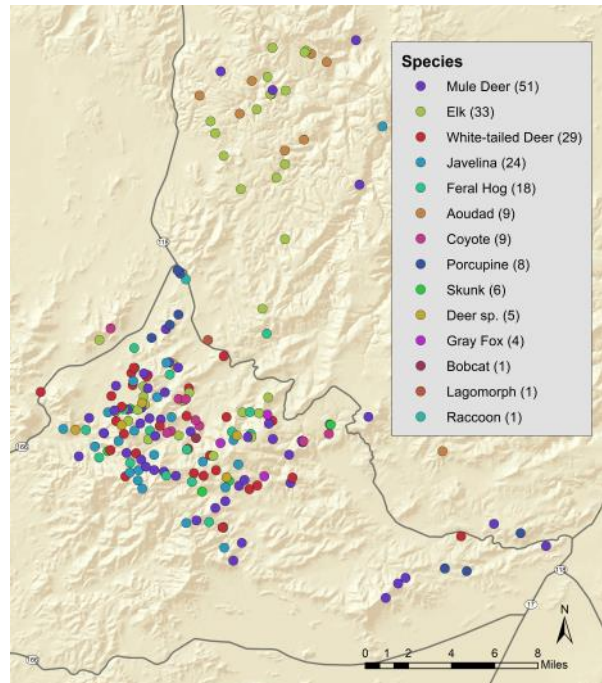
Independent subadult mountain lions (1-3 years) had a diet similar to adults (≥ 3 years), with the main difference being that subadults killed only one elk (a yearling), and six of the eight porcupine. Of those six porcupine killed by subadults, one female cat killed five of them. Subadult mountain lions killed prey < 50 lbs over 3 times as often as prey in any of the 3 heavier weight categories. Interestingly, adult mountain lions also preyed most often on the < 50 lbs weight class, with prey > 150 lbs the next most numerous weight class.

Elk and deer made up 64% of female mountain lion kills but less than 37% of male kills. Javelina were the dominant prey of males at 42%. Preferential prey selection also occurred among individual cats, as well as between sexes. One female, for example, predominantly killed elk and aoudad.

Almost 85% of adult elk killed were female, while roughly half of adult mule and white-tailed deer were does. Although mountain lions killed elk calves, yearlings, and adults in similar



Diets varied between individual animals, even within the same age class and gender.



Fourteen species of prey were killed and consumed by mountain lions in the Davis Mountains.

numbers, over 55% of deer kills (mule and white-tailed combined) were adults, with fawns making up the next most numerous class at just over 20%.

We divided the year into three seasons; Cold-Dry (November-February), Hot-Dry (March-June), and Hot-Wet (July-October). Both mule deer and white-tailed deer were taken by mountain lion in highest numbers during the cold dry season, followed by kills in the hot wet season. Conversely, elk, feral hog, and javelina were most often killed in the hot-wet season followed by hot-dry and then cold-dry seasons.

We calculated handling time, or the amount of time that the mountain lion spent on each kill site, as the time between the first and last point within 200 meters of the kill. The average handling time was 51 hours 34 minutes, and was similar for males and females but varied between individual mountain lions.

PREY SELECTION

By comparing the availability of prey based on our camera trap findings and the use of prey based on kill site findings, we were able to analyze mountain lion prey selection and determine if mountain lions were selecting for or avoiding certain species, or if they were using prey in proportion to their availability on the landscape.

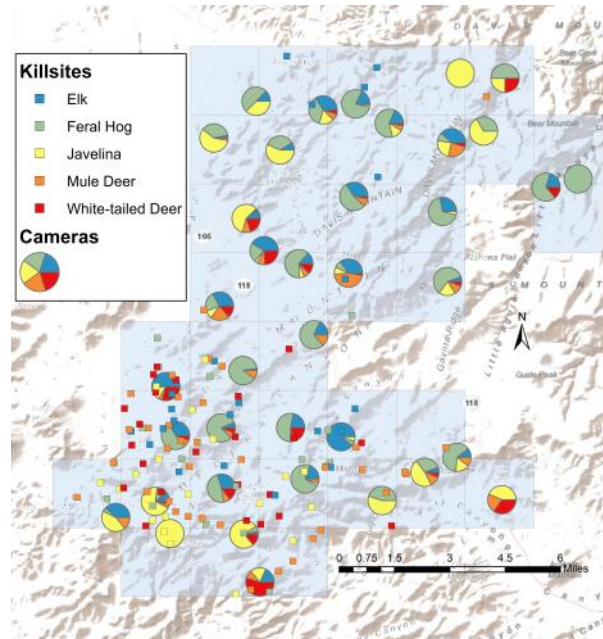
There were several species which were observed on camera, but were not documented as kills including livestock (cows and equines), ringtails, and turkeys. In addition, 1 species which was found at kill sites (porcupine) was not captured on camera.

In determining which species were selected for by mountain lions, we only looked at the kills which fell within the camera trapping area, and only considered the top five prey species, which were observed to make up 79% of total kills within this area (elk, 15%; feral hog, 11%; javelina, 13%; mule deer, 24%; and white-tailed deer, 16%). When the prey composition for all mountain lions was combined, javelina and feral hog were used less than expected (avoided), and mule deer were selected for.

When we analyzed the data by gender, female mountain lions selected for white-tailed deer and mule deer. Male mountain lions did not



Mountain lion TXM07, an adult male, feeds on a javelina kill in the Davis Mountains.



Map showing the distribution of the top 5 prey species at each camera location in the Davis Mountains and the locations of kill sites for each species.

select for any species but they avoided both elk and white-tailed deer.

Analysis for individual mountain lions was performed for the 7 mountain lions that had the most kills within the camera trapping area. All but one showed use of prey different than would be expected based on prey abundance on the landscape. In fact, preference and avoidance of prey was not consistent between individuals. For example one adult female selected for mule deer, while another adult female selected for elk, and an adult male mountain lion selected for javelina. Three other individual mountain lions did not select for any prey species, but did avoid both feral hogs and javelina.

The interactions of mountain lions and their prey are complex and varied, but this research has allowed us to gain insight into these interactions and the influence of mountain lions on the Davis Mountains ecosystem.

CONCLUSIONS

The data we were able to collect from 21 collared mountain lions in the mountains of west Texas has provided tremendous insight into the everyday movements and habits of these elusive animals, and has also highlighted the need for continued research.

We found that mountain lions use far greater areas as their home ranges than had been previously reported in this region. We also observed low survival rates, which has led us to the focus of our next phase of research, which will seek to determine how the west Texas population of mountain lions sustains itself with such high rates of mortality.

In comparison to previous studies which used only VHF monitoring, the use of GPS collars has allowed us to observe mountain lion use of habitat in much finer detail. This information will be important moving forward as we refine maps of suitable habitat, and identify travel corridors for mountain lions.

We observed a wide variety of prey being consumed by mountain lions. Even though livestock were readily available, no livestock kills were found in our study. We also noted differences in the diets of males and females, and different preferences between individual mountain lions. Future predator-prey research will be focused on the ecosystem services that



each mountain lion kill provides by examining the variety of species that use a kill, from scavengers to invertebrates.

In the coming years, we will also focus on analysis of genetic data which we have been collecting over the course of the study. This data will enhance our understanding of the mountain lion population structure and connectivity throughout the region.



Acknowledgements — This research grew out of the interest of landowners in the region, and as we move forward, we hope to continue to address issues in a way that will provide useful information to landowners and those who care about wildlife in west Texas.

We would like to extend our sincere thanks to all of those who have permitted us access to their land in order to conduct this research and those who have provided project funding, without which none of this research would be possible. We are also grateful to the many others who have helped us by working as field volunteers, by providing information on mountain lion sightings in the area, or simply by spreading the word about our research. We would like to especially thank Will and Pam Harte, James King, The Nature Conservancy, The Summerlee Foundation, The Shield-Ayres Foundation, The Potts and Sibley Foundation, and The Mule Deer Foundation for contributing their time, access, and/or resources.

HOW YOU CAN HELP

This work would not be possible without the support of landowner partners and private donors. Within the Davis Mountains, our initial study site (from 2011) expanded from 60,000 acres on 2 ranches to over 500,000 acres on 25 ranches. Aside from the Davis Mountains State Park, all properties were privately owned.

In the coming years, we will continue to collect data on mountain lion movements, habitat use, and predation. Your support for the mountain lion project either as a participating landowner or through a tax-deductible contribution will help us achieve our goal of better understanding the ecology of mountain lions in west Texas and continue to provide valuable information on predator-prey interactions to local landowners.

For more information on the mountain lion program, please visit the Borderlands Research Institute's website at <http://bri.sulross.edu>. You can also watch videos that we have captured of mountain lions in west Texas on our YouTube channel at <https://www.youtube.com/user/brinrm>.



For more information about the Carnivore Research Program, please contact:

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