Mountain lion sign survey synopsis 2002 – 2004

Elise J. Goldstein
Eric M. Rominger
April 2006

INTRODUCTION

Through radiocollaring efforts in New Mexico over the last 10 years, we have documented that approximately 85% of known cause desert bighorn sheep mortality has been caused by mountain lions (Rominger and Weisenberger 1999, NMDGF 2003). As a result, the New Mexico Department of Game and Fish (NMDGF) contracted with houndsmen and snaremen in October 1999 to remove mountain lions in three desert bighorn sheep ranges (Peloncillos, Hatchets, Ladrons) to reduce predation on bighorn sheep and to help recover this state endangered species. However, in the first 2 years, October 1999-September 2001, no mountain lions were harvested under this program. Several mountain lions were removed by the hired contractors, but because they were guiding clients NMDGF did not pay for any of these lions. Some initial success occurred during the October 2001-September 2002 year, leading NMDGF to feel that partial control was attained in some of the mountain ranges. This allows for analyses of the effects of this partial lion control in 2003 and 2004 (Rominger and Goldstein 2006).

In conjunction with the radiocollaring and mountain lion removal program, mountain lion sign surveys have been conducted from 1999-2004. These surveys do not attempt to estimate mountain lion population numbers in each mountain range. Rather, they attempt to correlate mountain lion removal with a reduction in mountain lion sign. At a minimum, the surveys can confirm presence of mountain lions, and at best they can be used as an index to monitor large changes in population numbers. The surveys are unlikely to detect small annual changes (Beier and Cunningham 1996).

METHODS

Using methods similar to Beier and Cunningham (1996), biologists from NMDGF, BLM, and the Turner Endangered Species Fund (TESF) have conducted annual lion sign surveys in 4 mountain ranges to create an index of the effectiveness of lion removal. In the Fra Cristobal Mountains, the management plan for mountain lions has been different from the other ranges, and has been modified several times. All surveys have been conducted annually between 1999 and 2004, primarily in September and October. The exceptions are the 2003 Peloncillos and Ladron surveys, which were partially conducted in April 2004. Mountain lion sign was documented along 1 km transects located in randomly selected washes and draws. Modifications were made to transects by eliminating transects that were essentially impassable, and adding transects to replace them. Usually there were few stretches of canyon left to choose from to form a new transect. Transects were not eliminated because of poor substrate because scats and kills can be observed, even if tracks and scrapes might not be possible to detect. Surveys were conducted by trained personnel who walked the transects at speeds $\leq$ 2 km/hr following

at least 5 precipitation-free days. In many instances the same individuals have surveyed the same washes each year.

A lion scrape, a continuous set of similar-sized tracks, a lion scat, or a kill site were mapped and recorded as 1 Standardized Unit of Sign (SUS) (Smith 1987). In the absence of data supporting that multiple signs in one transect or consecutive transects came from multiple mountain lions, we pooled all sign in a 1 km transect, and all sign found in consecutive 1 km transects in the same wash, and considered it as a single SUS (Beier and Cunningham 1996). Heel-pad widths of tracks were measured with calipers to potentially differentiate individual lions (Shaw 1979, Smith 1987). Reported difficulties with this technique, particularly in marginal substrate (Grigione et al. 1997), has led us not to extrapolate individual track measurements to estimate the number of individual mountain lions. Multiple lion tracks within a single transect had to differ by ≥4mm to be considered an independent SUS. If transects were linked, i.e., not independent, and a similar sized set of lions tracks was recorded in >1 linked transect, these tracks were considered 1 independent SUS. Scats were collected using a minimum of a 29mm bore diameter to separate lion scats from mid-size carnivore scat (Cunningham et al. 1999). Track and non-track sign are reported separately and pooled.

An index of independent mountain lion abundance in each range was calculated as the percentage of transects in which lion sign was present. Additional data to index lion abundance include the numbers of lions harvested annually in each range the year before and after the sign surveys. These lions are reported as sport harvested lions or lions specifically removed on contract or because of predation on bighorn sheep. An additional index was the number of lion-killed bighorn sheep documented within each of these ranges. Radiocollared bighorn were monitored from the ground, from monthly or semi-monthly fixed-wing flights, and during both autumn and spring helicopter surveys. All radiocollared bighorn sheep mortalities were investigated and mortality reports completed. Lion predation was determined by kill and kill-site characteristics including: presence of lion at kill, a dragline from kill site to cache site, lion tracks at kill site or cache site, lion scat at cache site, canine puncture wounds in neck or face, canine punctures or claw slices in radiocollar, rumen extracted and uneaten or buried, carcass partially or completely buried i.e., rocks, sticks, grass, etc. raked over carcass, broken neck, generally at cervical vertebrae 1 or more rarely 2, rostrum bones eaten back more than 10cm, braincase cracked in ewes (never rams), long bones i.e., humerus and/or femur cracked, lion hair present at kill site or cache site, lion scrapes at or near cache site, hair plucked from carcass, multiple cache sites. Cause specific annual mortality rates, calculated using MICROMORT (Heisey and Fuller 1985), are reported for the Ladron population (Rominger et al. 2001).

RESULTS

Peloncillos (Tables 1 and 2)

In 2002, 6% of the transects had independent mountain lion sign, and in the year leading up to the survey 7 mountain lions were removed. Of the seven, two were removed by the houndsman off of beef calf depredations, and two were removed by the houndsman

during routine hunting. Two mountain lions were killed by sport hunters, and one was killed in a vehicle collision on I-10. In 2003, 12% of the transects had independent sign. One scrape and one scat were found very close together and were considered a single independent SUS. In addition, one scrape was found at a kill site, and they were considered one single independent SUS. In the year leading up to the 2003 survey 6 mountain lions were removed. Of the six, two were taken off of deer kills, one was taken off of a javelina kill, and one was taken by the houndsman during routine hunting, and 2 were taken by sport harvest. In 2004, 7% of the transects had independent sign. However, one of the dead bighorn had only hair remaining in a pile underneath a juniper tree that was in the flats. In the year leading up to the survey 6 mountain lions were removed. Of the six, 4 mountain lions were removed off of beef calf kills, one was removed off of a bighorn sheep kill, and one was removed by the houndsman during routine hunting. Lion sign surveys have been conducted by J. Barnitz and E. Rominger in all years.

Hatchet Mountains (Tables 1 and 3)

In 2002, 5% of the transects had independent mountain lion sign, and 2 mountain lions were removed from the range. One of the mountain lions was removed by the houndsman during routine hunting, and one was removed by a sport hunter. In 2003, 8% of the transects had independent sign, and in the year leading up to the surveys, 3 mountain lions were removed. One mountain lion was removed off of a bighorn sheep kill, one during routine lion hunting, and one by a sport hunter. In addition, 2 kittens were removed by the houndsman's dogs during pursuit of an adult female. A scat was found at the kill site in one of the transects, and the two signs were considered a single SUS. In 2004, 13% of the transects had independent sign, and in the year leading up to the survey, 2 mountain lions were removed. Both were removed by sport harvest. Surveys have been conducted by a variety of NMDGF personnel, though E. Goldstein was one of the surveyors from 2001-2004.

Ladron Mountains (Tables 1 and 4)

In 2002, 19% of the transects had independent mountain lion sign, and in the year leading up to the survey, 4 mountain lions were removed under contract from the range. A scat was found in the same transect as a scrape, and the two signs were considered one SUS. In 2003, 16% of the transects had independent mountain lion sign, and in the year leading up to the survey, 9 mountain lions were removed from the range. Seven were removed under contract, and one was taken off of a depredation on complaint. In 2004, 16% of the transects had independent mountain lion sign, and no mountain lions were removed from the range. A scat was found in the same transect as a scrape, and the two signs were considered one SUS.

Manzano Mountains (Tables 1 and 5)

In 2002, 18% of the transects had independent mountain lion sign, though only 22 transects were run that year. The tracks and the scrape were in the same transect, and the two signs were considered one SUS.

Fra Cristobal Mountains (Tables 1 and 6)
In 2002, 23% of the transects had independent sign, and in the year leading up to the survey 1 mountain lion was removed from a livestock depredation. There were a total of 13 signs observed, but 4 scrapes and one track were found in the same transect and were considered a single independent SUS. A track was found in the same transect as the kill, and they were considered a single independent SUS. In 2003, 3% of the transects had independent sign, and in the year leading up to the survey 5 mountain lions were removed. One lion was killed by sport harvest after it killed a bighorn ram, and the other 4 were killed by sport harvest for hunting bighorn sheep. In 2004, 21% of the transects had independent sign, and 2 tracks were found in 2 contiguous transects and were considered as a single independent SUS. In the year leading up to the survey 4 mountain lions were removed. One was killed by sport harvest for hunting bighorn sheep, 2 females were removed under the new management plan, and one was killed by the train.

Table 1. Mountain lion sign survey results 2002-2004

Year and Range	# of Transects surveyed	Scrapes	Scat	Kills	Total non-track	Tracks	% Transects w/ independant sign
Peloncillo 2002	34	1	0	0	1	1	6%
Peloncillo 2003 [a,b]	34	2	1	1	4	2	12%
Peloncillo 2004 [c,l]	29	0	0	2	2	0	7%
Hatchets 2002[d]	39	0	1		1	1	5%
Hatchets 2003[e]	40	0	1	2	2	1	8%
Hatchets 2004	39	0	0	0	0	5	13%
Ladron 2002[a]	36	2	1		3	5	19%
Ladron 2003	36	0	0	0	0	7	19%
Ladron 2004[a]	37	1	1		2	5	16%
Manzan 2002 [f,g]	22	1	11	1	0	1	18%
Manzano 2003	Did not do them						
Manzano 2004	Did not do them						
Fras 2002[h,i]	35	4	0	1	5	8	23%
Fras 2003[j]	32	1	0	0	0	0	3%
Fras 2004[k]	29	0	0	0	0	7	21%

a the scat was in the same transect as a scrape.
b Kill was with a scrape
c A lion scrape and scat were found just before the start of one of the transects
d 2 days after running transect 15d there were lion tracks coming down the side of the road to the tailgate of the coops truck where we camped at the big tree. They cut across the creosote back tot he main road.
e The kill was in the same transect as a scat
f scat is 28.5 mm (not included in total)
g tracks and scrape in the same transect
h the 4 scrapes and a track were found in the same transect
i the kill and a track were found in the same transect
j a mule deer kill was found off route
k two tracks were in 2 contiguous transects
l one kill was a small amount of hair found under juniper in the flats

Table 2. Peloncillo Mountains Oct 1998-Sept 2004.

Year	Total adult lion harvest contract (noncontract)	% Transects w/independent sign	Total # lion killed bighorn (#collared; # uncollared)	Autumn bighorn population
Oct98- Sept99	0	31	4 (4;0)	55
Oct99-Sept00	0	24	1 (0;1)	48
Oct00-Sept01	1	21	6 (6;0)	30
Oct01-Sept02	4 (3)	6	0	25
Oct02-Sept03	4 (2)	12	0	55
Oct03-Sept04	6	7	3 (3;0)	65-75

Lion harvest and number of lion killed bighorns is measured throughout each time period. Percent transects with independent sign and autumn bighorn population were usually measured in October of the second year of each time period. This allows for an analysis of the impact of mountain lion removal on amount of sign detected, number of lion killed bighorn, and bighorn population size.

Table 3. Hatchet Mountains 1998-2004

Year	Total adult lion harvest contract (noncontract)	% Transects w/independent sign	Total # lion killed bighorn (#collared; # uncollared)	Autumn bighorn population
Oct98- Sept99	1	17	0 (0;0)	60
Oct99-Sept00	1	37	3 (3;0)	43
Oct00-Sept01	0	11	2 (2;0)	40
Oct01-Sept02	1 (1)	5	2 (1;1)	50
Oct02-Sept03	2 (1)	8	2 (1;1)	35
Oct03-Sept04	0 (2)	13	1 (1;0)	38-47

Lion harvest and number of lion killed bighorns is measured throughout each time period. Percent transects with independent sign and autumn bighorn population were usually measured in October of the second year of each time period. This allows for an analysis of the impact of mountain lion removal on amount of sign detected, number of lion killed bighorn, and bighorn population size.

Table 4. Ladron Mountains, 1998-2004.

Year	Total adult lion harvest contract (noncontract)	% Transects w/independent sign	Total # lion killed bighorn (#collared; # uncollared)	Autumn bighorn population
Oct98- Sept99	0	28	2 (2;0)	30
Oct99-Sept00	1	47	2 (2;0)	21
Oct00-Sept01	1	28	2 (2;0)	26
Oct01-Sept02	4	19	2 (1;1)	27
Oct02-Sept03	8 (1)	19	0	30
Oct03-Sept04	0	16	0	25-30

Lion harvest and number of lion killed bighorns is measured throughout each time period. Percent transects with independent sign and autumn bighorn population were usually measured in October of the second year of each time period. This allows for an analysis of the impact of mountain lion removal on amount of sign detected, number of lion killed bighorn, and bighorn population size.

Table 5. Manzano Mountains, 1998-2004.

Year	Total adult lion harvest contract (noncontract)	% Transects w/independent sign	Total # lion killed bighorn (#collared; # uncollared)	Autumn bighorn population
Oct98- Sept99	0 (2)	26	3 (2;0)	27
Oct99-Sept00	0		1 (1;0)	30
Oct00-Sept01	0 (8)	15	1 (1;0)	30
Oct01-Sept02	0	18	0	21

Lion harvest and number of lion killed bighorns is measured throughout each time period. Percent transects with independent sign and autumn bighorn population were usually measured in October of the second year of each time period. This allows for an analysis of the impact of mountain lion removal on amount of sign detected, number of lion killed bighorn, and bighorn population size.

Table 6. Fra Cristobal Mountains, 1998-2004.

Year	Total adult lion harvest contract (noncontract)	% Transects w/independent sign	Total # lion killed bighorn (#collared; # uncollared)	Autumn bighorn population
Oct98- Sept99	2	2	4 (3;1)	53
Oct99-Sept00	1	9	2 (2;0)	55
Oct00-Sept01	1	26	1 (0;1)	66
Oct01-Sept02	2	23	5 (2;3)	75
Oct02-Sept03	5	3	3 (2;1)	58
Oct03-Sept04	3	21	0	55-65

Lion harvest and number of lion killed bighorns is measured throughout each time period. Percent transects with independent sign and autumn bighorn population were usually measured in October of the second year of each time period. This allows for an analysis of the impact of mountain lion removal on amount of sign detected, number of lion killed bighorn, and bighorn population size.

DISCUSSION

In order to evaluate the impact of mountain lion removal on the survey results, we considered the number of mountain lions removed in a given year, and the amount of sign documented during the survey the following year.

In the Peloncillo Mountains, the average percentage of transects with lion sign decreased from 21% in years before partial mountain lion control was achieved (1998-99 to 2001-02), to 10% during years after partial mountain lion control was achieved (2002-03 to 2003-2004). In the same time periods, the number of documented lion-killed radiocollared bighorn sheep decreased from an average of 2.5 per year (20%), to an average of 1.5 per year (9%). In October 2003, 33 bighorn were transplanted to the Peloncillos to augment the population, increasing our ability to monitor the herd. All 3 bighorn killed in 2004 occurred within a 2 month time frame. A female lion was removed from the area and the killings ceased, illustrating the damage that an individual mountain lion can inflict on a herd.

In the Hatchets, the average percentage of transects with lion sign decreased from 18% in years before partial mountain lion control was achieved (1998-99 to 2001-02), to

11% during years after partial mountain lion control was achieved in other mountain ranges (2002-03 to 2003-2004). However, the number of lions removed in this mountain range is too small to consider this range partially treated in any year. It is interesting to note that there was a 7% decrease in the amount of sign detected in this untreated range, versus and 11% decrease in the amount of sign detected in the partially treated Peloncillos range. The decrease in sign could be the result of different surveyors, different weather patterns that made sign more difficult to detect, or a reflection of the decreased number of lions in the Peloncillos (those animals may have included the Hatchets in their home range). These results make it difficult to know if the reduction in mountain lion sign is a result of a decreased mountain lion population or of survey conditions. The number of radiocollared bighorn in the range increased from 6 in autumn 1998 to 17 in autumn 1999, and decreased to 6 in autumn 2001 and to 2 by autumn 2004. This makes it difficult to comment on the mortality rate from mountain lion kills from 2001 through the present. The bighorn population has remained fairly constant over the 6 year time interval. The Little Hatchet Mountains are scheduled to receive an augmentation of approximately 30 bighorn in November 2005.

In the Ladrones, the percentage of sign dropped from an average of 31% before partial mountain lion control was achieved, to 18% after partial mountain lion control was achieved. With 12 mountain lions removed in the 2002-04 seasons combined, it is possible that the decrease in the percentage of transects with sign is a result of decreased mountain lion numbers. The small number (n=4) of radiocollared bighorn in the herd starting in autumn 2002 reduced our ability to accurately monitor mountain lion caused mortalities or bighorn sheep population numbers. The fact that no mountain lion caused mortalities were detected on bighorn sheep in the 2002-03 and 2003-04 seasons may be attributed to this, providing little information on predator-prey dynamics between mountain lions and bighorn in the Ladrones during these years.

In the Fra Cristobal Mountains, there was a graduate student studying causes of lamb mortality on the range until autumn 2002. Therefore, few lions were removed until this time and we believe that partial control may have been achieved in autumn 2003. Before partial control was achieved, the average percent lion sign observed was 13%, versus 21% in 2003-04. The percent found each year has been highly inconsistent, ranging from 2% - 26%. This inconsistency, coupled with only 1 year of data following partial mountain lion control, makes it difficult to draw conclusions. While no lion killed bighorn sheep were found in the 2003-04 year, three independent scats collected from March-June 2004 each tested positive for bighorn sheep hair. This indicates that lions were having an impact on the herd even though we were not able to detect it from bighorn carcasses.

In the Manzano Mountains, surveys were only run through 2002. Mountain lion removal was never very intense in the range, and none were removed by NMDGF, making it impossible to evaluate the impact of a mountain lion removal program on survey results and on the bighorn population. There are no plans to intensively remove mountain lions from this area, therefore we do not anticipate reinstating the mountain lion sign survey in this mountain range.

The number of functional radiocollars on bighorn sheep declined in the 4 treated herds from ~47 in 1999 to ~27 in 2001, and mountain lions were responsible for 22 of 24 radiocollared bighorn sheep mortalities. Radiocollar numbers remained stable in the 3

desert bighorn herds at approximately 24 radiocollars (17% of the population) during the autumn 2001-2004 period. During these years, the number of radiocollared bighorn killed annually by mountain lions in the 3 treated ranges has ranged from 2-4. While the total number of collars has remained relatively constant, the number of collars per range has varied greatly. In this time frame, 11 of 14 radiocollared bighorn mortalities (78%) were caused by mountain lions.

The ability of these surveys to detect a real change in mountain lion numbers is questionable. There are many sources of variability in running transects from one year to the next. A minimum of 5 precipitation-free days are required before running the surveys, but the actual number of days varied greatly from year to year. The longer the interval since the last precipitation event, the more sign will accumulate without being washed away. However, presence of high winds (also variable from year to year) may cover tracks, depending on substrate type. Different observers with different levels of experience from year to year are another source of variation in amount of sign observed. Additionally, individual mountain lion behavior may influence results. A lion that remains on the mountain a brief amount of time will leave behind less sign than a lion who travels over the mountain but remains in the area for several weeks. Beier and Cunningham (1996) evaluated the statistical power of mountain lion sign surveys to detect a change in mountain lion densities in a mountain range. They concluded that approximately 30 8-km transects (total of 240 km) should be run to detect a 50% decrease in a mountain lion population with 80% power at α=0.2, and about 140 8-km transects (total of 1120 km) should be run to detect a 30% decrease in a mountain lion population with 80% power at α=0.05. The mountains surveyed in New Mexico do not have drainages long enough to support one 8-km transect (the vast majority are long enough for only a 1-km transect), and most drainages at least 1 km long had transects placed in them. We believe that the number of mountain lions in each partially treated mountain range decreased by at least 50% compared to the number in each range during non-treated years. However, given that a maximum of 40 1-km transects were run in each range in New Mexico, it is difficult to know if differences in amount of sign observed each year was caused by the decrease in mountain lion numbers, or by the many sources of variability.

In 1999, the New Mexico State Game Commission approved a 5-year experimental mountain lion removal program to protect desert bighorn sheep. That program was not successfully implemented until 2001. In 2003, the Commission approved a 2-year extension in order to have the program implemented for 5 years. We recommend the continuation of these lion sign surveys in conjunction with the period of intensive lion removal at least until 2006.

LITERATURE CITED

Beier, P., and S. C. Cunningham. 1996. Power of track surveys to detect changes in cougar populations. Wildlife Society Bulletin 24:540-546.

Grigione, M. M., P. Burman, V. C. Bleich, and B. M. Pierce. 1999. Identifying individual mountain lions (Felis concolor) by their tracks: refinement of an innovative technique. Biological Conservation. 88:25-32.

Heisey, D. M., and T. K. Fuller. 1985. Evaluation of survival and cause-specific mortality rates using telemetry data. Journal of Wildlife Management 49:668-674.

NMDGF. 2003. Recovery plan for endangered desert bighorn sheep in New Mexico, 2003-2013. New Mexico Department of Game and Fish, Santa Fe, NM 87504.

Rominger, E. M., and E. J. Goldstein. 2006. Synopsis of a 5 year mountain lion control management action on endangered desert bighorn sheep recovery. New Mexico Department of Game and Fish, Santa Fe, NM 87504.

Rominger, E. M., and M. E. Weisenberger. 2000. Biological extinction and a test of the "conspicuous individual hypothesis" in the San Andres Mountains, New Mexico. Pages 293-307 in Transactions of the 2nd North American Wild Sheep Conference. April 6-9, 1999, Reno, NV. 470pp.

Rominger, E. M., H. Whitlaw, D. Weybright, and W. C. Dunn. 2001. Predation and bighorn sheep transplants in New Mexico: a tale of two herds. Presented at the 8th Annual Conference of The Wildlife Society. Reno, NV.

Shaw, H. G. 1979. Mountain lion field guide: Special Report Number 9, AGFD, third edition.

Smith, T. Field guide for the identification of mountain lion sign. Addendum to: A method of monitoring mountain lion population trends in Carlsbad Caverns and Guadalupe Mountains National Parks. Harvey and Stanley Associates, Inc. Alviso, California 23pp.