Synopsis of a 5 year mountain lion control management action on endangered desert bighorn sheep recovery

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Abstract: Desert bighorn sheep (*Ovis canadensis mexicana*), are a state-listed endangered species in New Mexico (NMDGF 2003). The total population estimate declined to <170 (~140 adults) in 2001, despite the release of 151 adult desert bighorn sheep from Red Rock between 1992 and 1999. Between 1996-2002, the number of extant wild populations declined from 7 to 4 following the extinction of the Alamo Hueco, Animas, and San Andres desert bighorn sheep populations. In October 1999, after determining that the principle proximate cause of mortality on adult desert bighorn sheep was mountain lion (*Puma concolor*) predation, a management action to mitigate this high level of mortality was initiated (Rominger and Dunn 2000). Mountain lions are subsidized predators in the Chihuahuan desert and it is hypothesized that as a result mountain lions are able to exert an unnatural level of predation on native ungulates (Rominger et al. 2004a). New Mexico Department of Game and Fish (NMDGF) using contract hunters and trappers attempted to reduce mountain lion numbers in 4 desert bighorn sheep ranges. Lion control, measured by number of lions removed, did not occur in any range during the first 2 years of the management action. Between years 3 and 5 partial mountain lion control was attained in 3 of 4 ranges (Peloncillo, Sierra Ladron, and San Andres). However, this has allowed for just 1-2 years of data collection following some level of mountain lion control. Preliminary results are reported for individual desert bighorn sheep populations in a case-study format due to variable conditions among populations. A total of 51 adult mountain lions were culled using contractors during the 5 years. However, only 4 mountain lions were culled the first 2 years. Sport hunters harvested an additional 9 mountain lions during this period and there were 2 known roadkills. The number of adult ewes in these 4 populations was estimated to have declined to fewer than 35 prior to attaining some level of mountain lion control, and therefore a population level response is not detectable because of the short timescale. We have assessed mortality of adult radiomarked bighorn sheep attributed to mountain lion predation and lamb:ewe ratios in each of the populations. In ranges with partial treatment, percent mortality of adult desert bighorn sheep declined each year following partial mountain lion control. No mortality, attributed to mountain lion predation, has occurred on radiomarked bighorn sheep (n=58) in the last 14 months in any of the 3 partially treated ranges. However, in the Hatchet Mountains where treatment was not achieved, mortality of radiomarked adults increased from 15% the first 2 years to 22% during the last 3 years. In 2 ranges with pretreatment data (Peloncillo and Sierra Ladron), spring lamb:ewe ratios increased from 36:100 and 28:100 to 67:100 and 52:100 respectively, following partial mountain lion control. In the Hatchet Mountains the lamb:ewe ratio was 40:100 and 42:100 during the same periods. In the San Andres Mountains where 19 mountain lions were culled prior to and following translocation of 51 desert bighorn sheep, the spring lamb:ewe ratios have been 79:100 the 2 years since translocation. The recruitment ratio has been 49:100 both years since the translocation. Although mountain lion numbers were reduced in all ranges, mountain lion sign was

found each year, in all ranges, during annual mountain lion sign surveys (Rominger et al. 2002, Goldstein and Rominger In prep.). Expenditures for the 5-year lion control program were approximately $173,900US (~$34,780US/year). In 2004, the New Mexico State Game Commission increased the length of time for the lion control management until September 30, 2007 to allow for the collection of 5 years of data as was originally designed. A final report, to be completed by March 2008, will include cause specific mortality rates calculated using Program Mark (G. White, Colorado State University).

Background

Desert bighorn sheep have been a state-listed endangered species in New Mexico since 1980 (NMDGF 2003). Recovery efforts for desert bighorn sheep in New Mexico intensified in 1992. Between 1992 and 2003, NMDGF translocated 240 desert bighorn sheep into wild herds and started 3 new populations (Sierra Ladron-1992, Fra Cristobal-1995, San Andres-2003). However, between 1992 and 1997 it was determined that mountain lion predation was the principal limiting factor in all desert bighorn sheep populations where radiomarked individuals were monitored (Rominger and Dunn 2000). Between 1998 and 2001, 3 desert bighorn sheep populations went extinct (San Andres~1998, Alamo Hueco~2000, Animas~2001). By 2001, the statewide population estimate, including lambs, had declined to <170 (~140 adults) (Goldstein and Rominger 2002).

In 1999, the State Game Commission approved a 5-year management action to cull mountain lions in an attempt to mitigate the high level of mortality attributed to mountain lions in desert bighorn sheep habitat (Rominger and Dunn 2000). A synopsis of the first 5-years of this management action in the 4 desert bighorn sheep ranges is contained in this report. Because of the inability to control mountain lions until the 3rd year, results from partial treatment are only available for the 4th and 5th years. In October 2004, the period of mountain lion control was extended for 3 years to enable the collection of 5 years of data as originally designed. A research project on cause specific mortality of desert bighorn sheep lambs resulted in a different mountain lion management strategy in the Fra Cristobal Mountains (Parsons, In prep.). Results from the Fra Cristobal Mountains will be reported in a separate document.

Chronology of Mountain Lion Control

In October 1999, contractors were employed in 3 desert bighorn sheep ranges (Peloncillo, Hatchet, and Sierra Ladron) to conduct range-wide removal of mountain lions within delineated boundaries surrounding desert bighorn sheep habitat. Contract houndsmen were to hunt 80 hrs/month and were to be paid additionally for each mountain lion culled. However in the first 2 years, October 1999-September 2001, no mountain lions were harvested for which NMDGF paid the additional fee. **Note**: 3 mountain lions were taken by contract houndsmen, but because they had clients during the hunt, the contracts stipulated that no bonus would be paid for these mountain lions. A 4th mountain lion was culled from the carcass of a radiomarked desert bighorn sheep by a NMDGF houndsman in the Sierra Ladron population.

After 2 years of essentially no mountain lion control (Table 2), a snareman was contracted to replace the houndsman in the Sierra Ladron. This contractor was paid a flat-fee of $2,300/mountain lion culled. The same snareman conducted pretreatment and post-release mountain lion control in the San Andres Mountains 2 months prior to and for 18 months following the release of 51 desert bighorn sheep in 2002. Because of a 24-hour snare check requirement, stipulated in the Environmental Assessment (USFWS 2002), versus 48-hour snare checks in the Sierra Ladron, the fee for mountain lions taken in the San Andres during the period of range-wide removal was $4,600. Offending mountain lions (lions that killed desert bighorn sheep) are removed at a flat-fee of $2,300. New contract houndsmen were hired in the Hatchet and Peloncillo Mountains in 2000. These contractors were paid $100/day of hunting and $2,300/mountain lion harvested. Poor success in the Hatchet Mountains using houndsmen (Table 2) resulted in no contractor present during 2003-2004. Cost/year averaged $34,800 during the 5-year period and cost/lion averaged $3,400 during the 5 years.

Status of radiomarked desert bighorn sheep

Between 1999 and 2004, 149 radiomarked desert bighorn sheep were present in the 4 mountain ranges (Table 1). Annually, the number of radiomarked bighorn sheep in the 4 mountain ranges was between 30 and 76 (mean=55). The percent of the estimated population of these 4 ranges that was radiomarked each year was 29-42% (mean=37%). However, in some ranges (e.g., Hatchets and Sierra Ladron) the estimated percent radiomarked bighorn declined to <7%.

Between 1999 and 2004, 90 radiomarked bighorn sheep were released from the Red Rock Wildlife Area (RRWA) into these 4 mountain ranges and an additional 20 radiomarked bighorn sheep were translocated from the Kofa National Wildlife Refuge in Arizona to the San Andres National Wildlife Refuge in New Mexico. In 1999, 19 free-ranging desert bighorn sheep were captured and radiomarked in 4 mountain ranges (Peloncillos n=6, Hatchets n=7, Sierra Ladron n=5, San Andres n=1).

Table 1. Numbers of radiomarked bighorn sheep as a percent of the estimated total population in 4 herds, 1999-2004.

Year	No. radiomarked bighorn present on October 1st	Estimate of total number of bighorn	Estimate of total number of female bighorn	Estimate of percent radiomarked bighorn
1999	**61**	**152**	**57**	**40.1**
2000	**43**	**122**	**43**	**35.2**
2001	**30**	**105**	**31**	**28.6**
2002	**64**	**154**	**65**[a]	**41.6**
2003	**76**	**186**	**76**[b]	**40.9**
Means	**54.8**	**143.8**	**54.4**	**37.3**

[a] 31 ewes translocated to San Andres NWR
[b] 20 ewes translocated to Peloncillo Mountains

Number of Mountain Lions Culled

Between 1999 and 2004 a total of 51 adult mountain lions were culled from the 4 mountain ranges using contract hunters/trapper (Table 2). Contractors culled only 4 mountain lions during the first 2 years. Only 9 mountain lions were sport harvested during the 5-year period from the 4 mountain ranges. This low sport harvest occurred despite the liberalization of the annual bag limit to allow the sport harvest of 2 mountain lions in desert bighorn sheep ranges and a year-round season. In addition, 1 road-killed mountain lion was found in each of the Peloncillo and San Andres ranges during this period for a minimum removal of 62 adult mountain lions during the 5-year period (Table 2). **Note**: mountain lions were not culled between 1999 and September 2002 in the San Andres Mountains.

Although some initial success (n=9 mountain lions culled) occurred during the October 2001 through September 2002 year, NMDGF did not feel partial control was attained in any mountain range. It was not until September 2003, following the removal of an additional 29 adult mountain lions from these bighorn ranges did NMDGF feel that partial control was attained in the Sierra Ladron, Peloncillo, and San Andres mountains. This allows for analyses of the effects of this partial lion control in 2003-04.

Because mountain lion harvest (n=8) in the Hatchet Mountains was only about one-half that in the other ranges, NMDGF never felt that partial control was attained in that range. The inability to cull many mountain lions using hounds, despite the confirmed presence of multiple mountain lions, resulted in no further attempt to cull lions after September 2003. NMDGF contracted a snareman in the Hatchet Mountains in spring 2005. Lions killed by NMDGF contractors during this management action have been accessioned in the Museum of Southwestern Biology (MSWB) at the University of New Mexico. When the skulls are cleaned they will be aged by comparing them with a series of known age skulls on deposit at the MSWB. A backlog of unprocessed mountain lions at the MSWB has resulted in too small of a sample size of aged mountain lions to report here.

Table 2. Numbers of adult mountain lions culled from 4 ranges with endangered desert bighorn sheep between October 1999 and September 2004 by NMDGF contractors; additional mountain lions removed by sport harvest/road kill in parentheses.

Year	Peloncillo	Sierra Ladron	Hatchets	San Andres	Total
1999-2000	**0**	**1**	**0**	**0**	**1**
2000-2001	**1**	**1**	**1**	**0**	**3**
2001-2002	**4 (3 [a])**	**4**	**1 (1)**	**0**	**9 (4)**
2002-2003	**4 (2)**	**8 [b] (1)**	**2 (1)**	**15 (1[c])**	**29 (5)**
2003-2004	**6**	**0**	**0 (2)**	**3**	**9 (2)**
Total	**15 (5)**	**14 (1)**	**4 (4)**	**18 (1)**	**51 (11 [a,c])**

[a] this includes 1 mountain lion road-kill on Interstate 10

[b] total includes 1 mountain lion taken on livestock depredation

[c] this includes 1 mountain lion road-kill at San Augustine pass

Numbers of radiomarked desert bighorn sheep killed by mountain lions

We investigated bighorn sheep mortalities in all populations to determine causes of death. Mountain lion predation was determined by kill-site characteristics including: a dragline from kill-site to cache-site, mountain lion tracks at kill-site or cache-site, mountain 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, raked over carcass), broken neck, (generally at cervical vertebrae 1 or more rarely 2), rostrum bones eaten back >10 cm, braincase cracked in females (never males), long bones i.e., humerus and/or femur cracked, mountain lion hair present at kill-site or cache-site, mountain lion scrapes at or near cache-site, hair plucked from carcass, and/or multiple cache-sites.

If mountain lion sign was documented at the kill site, predation was assumed unless evidence of scavenging was detected. The potential for misidentifying a mountain lion kill for a scavenging event existed and 2 mountain lion-scavenged bighorn sheep have been documented in >100 bighorn sheep mortalities in New Mexico since 1995 (NMDGF, Santa Fe, NM, unpublished data). However, an approximate scavenging rate of <2% would make it unlikely bighorn sheep mortalities attributed to mountain lion predation were scavenging events.

Between 1999 and 2004, 149 radiomarked desert bighorn sheep were present in the 4 mountain ranges. During the 5-year period, 33 radiomarked desert bighorn sheep were determined to have been killed by mountain lions (Table 3). During the first 3 years, 17.4% of radiomarked bighorn sheep were killed by mountain lions. In the final 2 years 7.4% of radiomarked bighorn sheep were killed by mountain lions in the 3 herds with partial control. This includes 2003 and 2004 data for the Sierra Ladron and Peloncillo mountains, and 2004 data for the San Andres (Table 3). In the Hatchet Mountains where just 8 mountain lions were removed in 5-years, partial mountain lion control was not attained. Percent of radiomarked bighorn sheep killed by mountain lions in the first 3 years was 15.4% and increased to 22.2% during the last 2 years. In this '*defacto*' control herd the percent radiomarked desert bighorn sheep killed by mountain lions averaged 16.7% during the 5-years. **Note**: Between October 1, 2004 and September 30, 2005 no radiomarked bighorn sheep (n=58) were killed by mountain lions in these 4 ranges for the first time in the last 13 years of monitoring.

Because 4 offending lions were taken from bighorn sheep kills between 1998 and 1999 in the Peloncillo Mountains, the mountain lion kill data are compared using, and excluding, the 2000 data (the year following the removal of 4 offending mountain lions). Using the 2000 Peloncillo data, the percent of radiomarked bighorn sheep killed during the 3 years without substantial levels of mountain lion control averaged 13.9%. Excluding the 2000 Peloncillo data the percent of radiomarked desert bighorn sheep killed by mountain lions is 17.4%.

Following the removal of 19 adult mountain lions from the area of initial occupation by translocated desert bighorn sheep on the San Andres National Wildlife Refuge, there has not been a single mountain lion associated mortality in >21 months. Following the removal of 20 mountain lions in the Peloncillo Mountains there has not been a single mountain lion associated mortality in >13 months. In the Sierra Ladron, where 19 mountain lions have been culled, including 4 since October 2004, no mountain lion associated mortality has been documented in the last 39 months. However, in the Sierra Ladron very few radiocollars have been monitored and recent removal of 4 mountain lions may have been associated with a substantial decline in the number of yearlings seen during the spring 2004 census. Because the total number of adult ewes in these 4 populations was estimated to have declined to fewer than 35 prior to attaining some level of mountain lion control, a population level response is not detectable.

Table 3. Number of radiomarked desert bighorn sheep killed by mountain lions in 4 ranges October 1999-September 2005; denominator is number of radiomarked desert bighorn sheep in the population. No mountain lion control in shaded portion of table, partial mountain lion control in Sierra Ladron and Peloncillos in years 2003-2005 (unshaded portion of table). Partial mountain lion control in San Andres in 2004. Data from October 1-September 30 each year.

	Year	Peloncillo	Sierra Ladron	Hatchets	San Andres	Total
Period of no control	**'99-00**	**0/24[a]**	**1/8**	**3/22**	**1/7**	**5/61 (8.2%)[b]**
	'00-01	**6/16**	**2/9**	**2/12**	**1/6**	**11/43 (25.6%)**
	'01-02	**0/4**	**1/7**	**1/10**	**1/9**	**3/30 (10.0%)**
Period of partial control	**'02-03**	**0/2**	**0/2**	**1/5**	**6/55[c]**	**0/4[d] (0%)**
	'03-04	**3/31**	**0/2**	**1/4**	**3/39**	**6/72[e] (8.3%)**
Period of best control	**'04-05[f]**	**0/26**	**0/1**	**0/2**	**0/31**	**0/58[e] (0%)**

[a] 4 offending mountain lions removed in 1998-1999 from the southern Peloncillos
[b] 13.5% radiomarked bighorn killed excluding the Peloncillo data
[c] only 2 mountain lions culled prior to the translocation of 51 desert bighorn; 16 mountain lions culled after release including 5 at bighorn kills; lions not taken at 4 kills
[d] data from Hatchet Mountains and San Andres Mountains excluded because no partial mountain lion control attained
[e] data from Hatchet Mountains excluded because no partial mountain lion control attained
[f] data from October 2004-September 2005 is from the 1st year of the extension period

Figure 1 shows the percentage of radiomarked desert bighorn sheep killed by mountain lions statewide regardless of lion control status. Essentially no mountain lion control occurred in desert bighorn sheep ranges between 1992 and 2002. Number of radiomarked individuals in October of each ranged from 42-95 (mean = 64) during this period and represented 20-40% of the estimated statewide population.

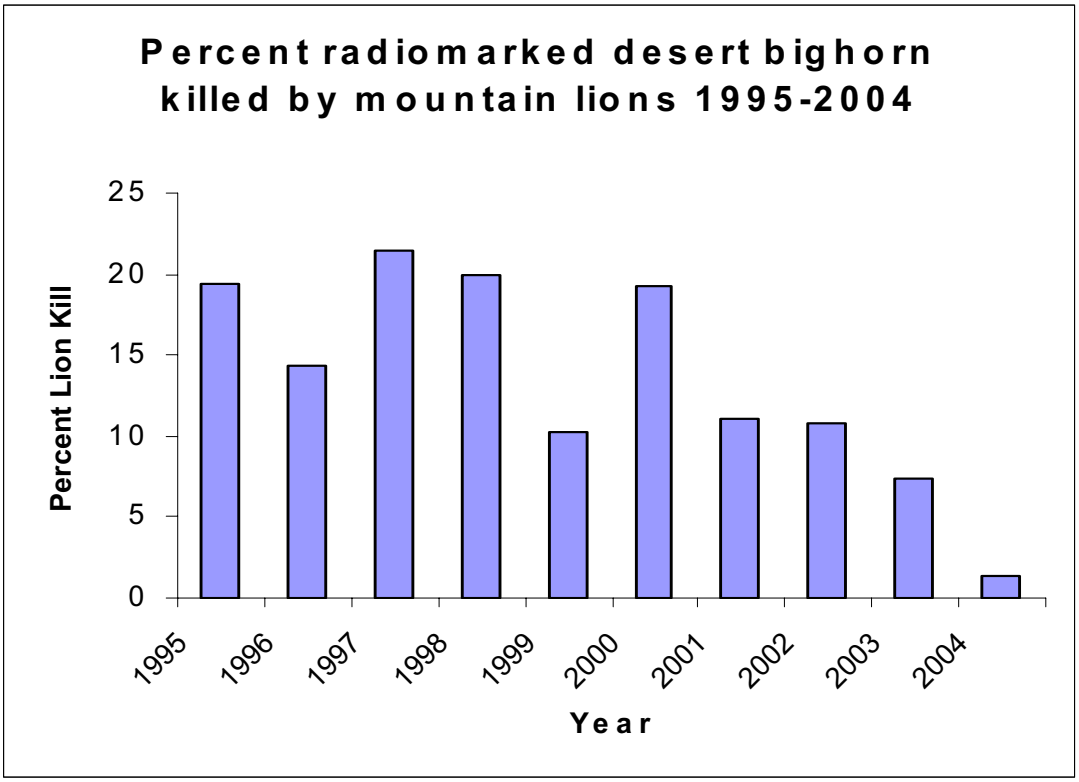

Figure 1. Percent radiomarked desert bighorn sheep killed by mountain lions in 4 ranges in New Mexico, 1995-2005. Between 1995 and 2002 essentially no partial mountain lion control was attained in any range.

Lamb:Ewe Ratios in 4 Desert Bighorn Sheep Ranges

Because mountain lion predation was the primary mortality factor in the Fra Cristobal desert bighorn sheep lamb mortality study (Parsons In prep), it was hypothesized that mountain lion control would increase lamb:ewe ratios. Spring lamb:ewe ratios derived from helicopter surveys, before and after partial mountain lion control, are compared for 3 ranges (Table 4). In addition, fall lamb:ewe ratios were determined for the Peloncillo population. In the Hatchet Mountains, where mountain lion control was never attained, the spring lamb:ewe ratio was 40:100 the first 3 years compared with 42:100 in the final 2 years. In the Peloncillos and Sierra Ladron the spring lamb:ewe increased from 33:100 and 32:100 the first 3 years to 73:100 and 52:100 during the final 2 years. The fall lamb:ewe ratio in the Peloncillo Mountains increased from 18:100 during the first 3 years

to 48:100 the final 2 years. The spring lamb:ewe ratio in the 2 partially treated ranges increased from 33:100 during the first 3 years to 62:100 during the last 2 years.

Table 4. Lamb:ewe ratios in 4 desert bighorn sheep ranges from 2000-004.

Year	Peloncillo		Hatchets		San Andres		Sierra Ladron	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
'99-00	35	19	35	27	--	--	25	18
'00-01	45	22	46	46[a]	--	--	46[d]	46
'01-02	20	14	40	?	--	--	25	?
'02-03	75	50[b]	33	?			73	?
'03-04	71	45	50	?			30[c]	?

[a] Observed spring lamb:ewe ratio was 29:100 but had to have been at a minimum 46:100
[b] minimum known ratio was 25:100 with maximum ratio of 75:100; 50:100=midpoint
[c] 4 mountain lions culled from Sierra Ladron post-lambing--2004
[d] Spring lamb:ewe ratio reported by M. Arana (NMSU graduate student) was 27:100 but had to have been a minimum of 46:100 based on helicopter survey data in fall

Case Histories of Individual Populations

Peloncillo Mountains

The extremely high level of mountain lion predation documented in the Peloncillo population in 2001 nearly extirpated the female component of this population (Table 3). In the spring of 2002, only 5 ewes were confirmed to be alive (NMDGF files). Since October 2001, 20 mountain lions were removed from the Peloncillos. The percent of radiomarked bighorn sheep that were killed by mountain lions averaged 13.6% the first 3 years (30.0% excluding the 1999-2000 data), 9.1% the last 2 years, and 0% for the last year (13 months since the last mountain lion kill). The spring lamb:ewe ratio was 33:100 the first 3 years versus 73:100 the last 2 years. The fall lamb:ewe ratio was 18:100 the first 3 years versus 48:100 the last 2 years. Since late-2001, there have been just 4 radiomarked desert bighorn sheep mortalities. A ram died in late-2004 of unknown, non-predation causes. Between July and August 2004, 3 ewes were killed by a mountain lion(s) in the Pratt Peak area. A female lion was harvested under contract following the 3rd kill and it is probable that this female was responsible for all 3 kills. No radiomarked bighorn sheep have been killed since this female was removed. The Peloncillo Mountains contain an estimated 82 km^2 of desert bighorn sheep habitat.

Six of 14 (43%) mountain lions culled by contract houndsmen were started from beef calf kills (Rominger et al. 2004a). This approximation of the percentage that beef calves may make up in the diet of mountain lions is very similar to the findings of Cunningham et al. (1999) where scat analysis determined that domestic cattle comprised 44% of mountain lion diets in desert bighorn sheep range in Aravaipa, Arizona. These 2 data sets lend evidence to the hypothesis that mountain lions in the Chihuahuan desert are subsidized predators. The effects of a subsidized top carnivore are hypothesized to cascade throughout the ecosystem with deleterious effects on species in addition to desert bighorn sheep (Rominger et al. 2004b).

In Table 5 we compare the deer/hour and javelina/hour observed during desert bighorn sheep helicopter surveys in the Peloncillo Mountains (with partial lion control) and the Little Hatchet Mountains (without partial lion control). Between 1996 and 2002, 8 surveys were flown in the Peloncillo Mountains and 9 surveys were flown in the Little Hatchet Mountains. Surveys were flown in 2003 and 2005 in the Peloncillo Mountains (n=2) and 2003-2005 in the Little Hatchets (n=3). It is assumed that weather patterns were similar between these 2 ranges that are separated by < 50 km (< 30 mi) and therefore the primary difference has been mountain lion control. However, ungulate observation rates can be affected by winds, observer bias, pilot experience, cloud-cover, etc. We did not control for any of these variables.

Table 5. Observation rate (deer/hour and javelina/hour) during desert bighorn sheep helicopter surveys in the Peloncillo Mountains (with partial lion control) and the Little Hatchet Mountains (without partial lion control) before partial control attained 1996-2002 and following partial control, 2003-2005.

	Deer/hour		Javelina/hour	
Years	Peloncillo	Little Hatchet	Peloncillo	Little Hatchet
1996-2002	4.2	9.9	1.9	5.6
2003-2005	9.4	9.1	10.3	2.5

Sierra Ladron

In the Sierra Ladron population, the estimated number of ewes has been <12 since the initiation of mountain lion control. Annual mortality rates due to mountain lion predation between 1992 and 2000 were 11% (Rominger et al. 2004a). Since 2000, 19 mountain lions have been culled from this bighorn sheep range, including 4 since October 2004. In the first 3 years, the percent of radiomarked bighorn sheep killed by mountain lions was 14.3%. No radiomarked bighorn sheep have been killed since April 2002, however very few active radiocollars in the last 2.5 years (n=2) makes for a more tenuous analysis of the effect on adult mortality. However, the spring lamb:ewe ratio was 32:100 the first 3 years and increased to 52:100 the last 2 years. This is despite the culling of 4 mountain lions following the 2004 lambing period that only produced a lamb:ewe ratio of 30:100. The lamb:ewe ratio in 2003, following the removal of 15 mountain lions was 73:100. Despite the use of a snareman since late-2001, mountain lions continue to persist in the Sierra Ladron population. The fact that the Sevilleta National Wildlife Refuge is adjacent to this area and does not allow hunting or trapping, combined with the very large area used by this bighorn population, contributes to this problem. The Sierra Ladron contain an estimated 51 km^2 of desert bighorn sheep habitat based on the Dunn (1994) analysis, however the current range of this herd may be >1,000 km^2 with sightings from I-40 to south of Highway 60 and from the Acoma Pueblo to just west of I-25.

San Andres Mountains

Because the San Andres population was biologically extinct (Rominger and Weisenberger 1999) and reestablished during the 5-year period of mountain lion control

we are only able to report on data collected since the translocation. Only 2 mountain lions were culled prior to the release of 51 bighorn sheep in November 2002. However, 15 additional adult mountain lions were culled inside the release area between December 2002 and December 2003. The percent of radiomarked bighorn sheep killed by mountain lions the first year following release was 10.9%. This declined to 7.7% in the second year (all the first 3 months of the year). No radiomarked bighorn sheep (n=31) have been killed by mountain lions in the last 22 months (since December 2003). Although the exact area currently occupied by bighorn sheep has not been calculated, the total area that was trapped during the mountain lion culling operation was ~195 km^2**.**

Hatchet Mountains

The number of ewes observed during annual helicopter surveys declined from 24 in 1996 to 13 in 2003. Houndsmen contracted to cull mountain lions in the Hatchet Mountains had more difficulty removing mountain lions from this area than in any other range. The very rugged terrain made for difficult hunting and contractors were only able to harvest 4 adult mountain lions in 4 years. This is despite an estimate of >10 mountain lions present each year. Including sport harvest, only 8 mountain lions were harvested during the 5 years and NMDGF never felt that even partial control was attained. This appears to be reflected in the adult and juvenile mortality data. The percent of radiomarked adult bighorn sheep killed by mountain lions was 15.4% the first 3 years but increased to 22.2% the last 2 years. Small sample size of radiomarked bighorn the last 2 years may have affected this increase in mortality. However, the Big Hatchet bighorn population has almost certainly declined to <20 during this period. The spring lamb:ewe ratio was 40:100 the first 3 years and 42:100 the last 2 years. Beginning in the spring of 2005 a snareman will be contracted to remove lions from the Hatchet Mountains to prepare for a proposed autumn 2005 translocation from Red Rock. The Big and Little Hatchet Mountains contain an estimated 110 km^2 of desert bighorn sheep habitat.

Discussion

New Mexico Department of Game and Fish documented the high level of mountain lion predation on state listed endangered desert bighorn sheep (Rominger and Weisenberger 1999, Rominger et al. 2004). All New Mexico desert bighorn sheep populations are considered to be below carrying capacity (Rominger et al. 2004). Therefore, the control effort in desert bighorn sheep ranges was deemed necessary to reduce the risk of extinction of this faunal component in the desert mountain ranges of New Mexico. The hypothesis that mountain lions are a subsidized predator in the Chihuahuan desert is central to this control policy. We hypothesize that mountain lion densities in bighorn sheep habitat following range-wide removal more closely mirror densities that would have occurred prior to European contact during periods of low native ungulate density. Although other management options exist, NMDGF feels that the current policy of range-wide removal, until populations recover to levels where less aggressive control actions such as offending lion removal can be implemented, is the most efficacious method. Following 5-years of population decline between 1996-2001, the population has increased annually since 2001. The population estimate of desert bighorn sheep has

increased from 160-170 in 2001 to 270-280 desert bighorn, including the release of 84 bighorn from Arizona and Red Rock. An additional 50-60 desert bighorn sheep are scheduled for release in autumn 2005 and will result in the largest statewide estimate since the early 1950's. However, a statewide population of 500, with 3 populations or metapopulations >100, is required to down-list this state-endangered species (NMDGF 2003). NMDGF has clearly stated that due to the small number of populations and the imminent risk of extinction, the mountain lion control effort is a management action rather than a research project. However, the declining trends in desert bighorn sheep mortality due to mountain lion predation and the increasing statewide population, suggests that this management effort is accelerating the recovery of this state-listed endangered species.

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