Black Mountains Adaptive Predation Management Plan

Revised September 2010

Arizona Game and Fish Department
5000 West Carefree Highway
Phoenix, Arizona 85086

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Introduction

In 2002, the Department became aware that the desert bighorn sheep (*Ovis canadensis nelsoni*) population in Unit 15C South had suffered a significant decline. The Department investigated and found the bighorn sheep population to be below historical levels in the Black Mountains. Mountain lion (*Puma concolor*) predation was identified as one factor potentially limiting the sheep population; others included drought, disease and human disturbance. The Department prepared the Black Mountain Predation Management Plan; approved April 2006 and the Black Mountain Bighorn Sheep Management Plan; approved April 2007.

This Adaptive Predation Management Plan has evolved from the previous plan and is designed to address mountain lion predation only. Predation management plans must be dynamic over time, to incorporate changes that occur from environmental biotic and abiotic factors, in addition to new data and technologies. The plan was initially developed to address mountain lion predation and aid in the recovery of one of the largest and most significant populations of desert bighorn sheep in the state. The revision has been expanded to address mountain lion predation, as well as, collect data on mountain lion biology in a desert mountain environment. The plan follows the spirit and guidance of the Arizona Game and Fish Department Adaptive Management Policy (DOM I1.6), the Predation Management Policy (DOM A2.31), and the Department Predator Management Team Report.

Much has been accomplished since the original predation management plan was adopted. This revision has been written to incorporate new information that was collected. An adaptive management approach will be implemented to better inform management decisions related to this predation management plan, but also to use research approaches to continue expanding the knowledge base of mountain lion biology over a broad area of a desert mountain habitat.

Specifically, the Department's Predation Management Policy states:

> "Actions by the Department should be based on the best available scientific information. Mountain lions and coyotes will be managed to ensure their future ecological, intrinsic, scientific, educational, and recreational values, to minimize conflict with humans, and to minimize adverse impacts on other wildlife populations.
>
> The Department will develop site-specific management plans when either of these two species is considered to be inhibiting the ability of the Department to attain management goals and objectives for other wildlife species."

Furthermore, the Department's Predator Management Team Report states that "predators and their prey cannot be managed separately" and that "as a Department we must strive to develop the biological and social data necessary to manage predators with a program that is biologically sound and publicly acceptable."

The recent development and approval of the Adaptive Management Policy offers new opportunities to use research tools and approaches to expand the knowledge base relative to the predator-prey relationship of mountain lions and bighorn sheep in and around the predation management area (Appendix 1). Following policy guidance, managers will enhance efforts to monitor mountain lion populations in the Black Mountains to better understand the predator-prey relationship in a biologically meaningful geographic context. The ongoing monitoring and data collection will allow the Department to take an adaptive management approach, and to assess whether predation management

approaches in this plan are effectively facilitating the recovery and maintenance of the bighorn sheep herd as a source population for future translocations. Having a better understanding of mountain lion biology and population dynamics is a critical component influencing interactions in the Black Mountains. Managers will monitor lion movements across a broad area, attempt to determine movement corridors, monitor prey selection and use genetic analysis to attempt to estimate a minimum lion population size and relatedness to other lion populations in the state. Ultimately, the Department hopes to better understand the metapopulation dynamics of lions in and around the Black Mountains.

Area Description

The predation management area consists of Game Management Units 15B West (15BW), 15C North (15CN), 15C South (15CS), and 15D within the Department's Kingman Region (Appendix 1). A portion of the area falls within the boundaries of the Lake Mead National Recreation Area (LMNRA), a portion of the land is managed by the Bureau of Land Management - Kingman Office (BLM), small portions are managed by the Arizona State Land Department, and small portions are owned and managed by private landowners. These units cover approximately 1,425 square miles with over 800 square miles being considered critical bighorn sheep habitat as identified in the Black Mountains Bighorn Sheep Management Plan. Topography is generally composed of vertical cliff faces, rugged canyons, mesas, boulder-strewn terrain, rolling hills, and broad alluvial valleys. Elevations range from less than 1,000 feet in the Colorado River valley to approximately 5,460 feet on Mt. Perkins. The predominant vegetation type is Mohave Desert Scrub. Common plants include creosote bush (*Larrea tridentata*), bursage (*Ambrosia dumosa*), catclaw acacia (*Acacia greggii*), paper bag bush (*Salazaria mexicana*), brittlebush (*Encelia* spp.), Mormon tea (*Ephedra* spp.), barrel cactus (*Ferocactus* spp.), hedgehog cactus (*Echinocereus* spp.), teddy bear cholla (*Opuntia bigelovii*), Mohave yucca (*Yucca schidigera*), as well as juniper (*Juniperus monosperma*) and turbinella oak (*Quercus turbinella*) at higher elevations.

Statement of Need

The Black Mountains in northwest Arizona represent the largest contiguous block of bighorn sheep habitat in Arizona and represents 30% of the State's entire desert bighorn sheep population. The Black Mountains population has supported an extensive transplant program in which over 600 sheep have been captured from this range and used to successfully repopulate numerous areas throughout Arizona, Utah, Colorado, and Texas. Sheep near Hoover Dam are often highly visible and provide watchable wildlife opportunities for thousands of tourists from around the world. This area has provided up to 33% of the statewide annual bighorn sheep hunt permits.

In 2002 the Department staff, with the assistance of sheep hunters and guides, investigated several mortalities in units 15CN and 15CS (Appendix 4). Based on rate of decomposition and amount of bleaching, 9 sheep had died within 12 months of detection (Appendix 5). Of the remaining skulls; 3 appeared to have died within the 2 years prior to detection, 3 appeared to be greater than 2 years prior, and one was a horn sheath found without a skull (therefore time since mortality for this sheep could not be determined). Department staff, LMNRA staff, BLM staff, hunters, and outdoor recreationists discover dead sheep regularly in this area, but no baseline data exists on the number or condition of dead sheep found in previous years and data for 2002 is, at best, incomplete. There is likely a reporting bias for ewes and lambs as their skulls are not as desirable and are not collected or reported as often as rams. Although the Department does not have any trend data on pick-up skulls, the reported number of dead sheep found shortly before and during the 2002 hunt season led the Department to believe a mortality event had occurred in the population.

The Department developed an action plan that included disease monitoring, radio telemetry monitoring, and foot and aerial surveys for bighorn sheep (Appendix 6). In 2004, 30 sheep were captured near Hoover Dam as part of a pre-construction US Highway 93 crossing study and an additional 19 were captured in Unit 15CS by the Kingman region to be tested for disease and fitness levels. Blood was drawn from all sheep captured and they were fitted with radio-collars to monitor them for movement and mortality. The sampled bighorn sheep exhibited titers for several diseases including anaplasmosis, EHD, bluetongue, and parainfluenza. Some sheep had low levels of Vitamin E as well, indicative of sheep in poor nutritional condition. In 2005, an additional 21 sheep were captured in Units 15CS and 15D and fitted with radio-collars to monitor the effectiveness of sheep crossings on State Highway 68. These sheep showed similar titers as those captured in 2004. After some mortality on the State Highway 68 project, and in conjunction with a mortality monitoring project initiated by the Kingman region, an additional 35 sheep were captured in Units 15CN and 15CS in 2006. Again, test results were similar to those in the previous two captures. In 2008, the construction phase of the US Highway 93 crossing study began and 30 more sheep were captured, tested and radio-collared. Blood and tissue samples have also been collected from hunter killed sheep since 2002.

For several years, range conditions in the Black Mountains have been affected by low rainfall. Rainfall gauges monitored by the National Weather Service, located within the predation management area, indicate average annual rainfall is approximately 5.2 inches (Appendix 2), with below average rainfall occurring between 1999 and 2002 (67% of normal). Rainfall in 2002 was particularly poor with monitoring sites in the area ranging from only 11.5 to 26.3 percent of normal. Rainfall in Bullhead City on the southwest side of the Black Mountains totaled only 0.67 inches for the entire year. Although conditions improved in 2004 and 2005, the average rainfall in Bullhead City from 2003 through 2009 has been only 70% of normal; indicating drought is an ongoing factor in the region. Severe drought can have a negative impact on plant communities, water distribution, and dependent animal populations. Poor plant production can influence animals by reducing reproduction and recruitment, causing home range shifts or direct mortality, and allowing endemic or introduced diseases to further stress nutrient-weakened animals. Limited water sources force animals to spend more time near available water, increasing the risk of predation, competition with livestock or burros, and disease transmission. In addition, thirty-seven wildfires have burned more than 51,000 acres of bighorn sheep habitat since 1980 (Appendix 7). Burro numbers remain above AML levels, even though habitat conditions and availability have changed, due to drought and fire.

The Department conducts bighorn sheep surveys on a rotational basis, every three years. In 2002, a survey was not conducted in any of these units. In 2003, Unit 15CS was the only unit on the schedule. Because there are no physical barriers between these units, which allows sheep to move across boundaries freely, it was determined the entire mountain range should be surveyed to obtain the best possible data. The Department secured funds to survey Units 15BW, 15CN and 15CS in 2003. Total bighorn sheep observed and sheep seen per hour were down (Appendices 8-10). In Unit 15CS, 4.0 bighorn sheep were seen per hour of survey effort, an 84% decrease from the 1995-2001 average of 25.5 bighorn sheep/hour; where many of the older age class skulls were found in 2002. A complete survey was funded in 2004; sheep numbers were well below average, but similar to the numbers observed in 2003 north of State Highway 68. Unit 15D appeared to be stable (Appendix 11). At that time, the last year the entire Black Mountains were flown on the same survey was in 1997. The sheep population was estimated at 1,815 animals in 1997 and 748 animals in 2004. This represents a 59% reduction in the population.

From 2005-2007, in order to target the area with the largest decline, spring lambing surveys were conducted in Unit 15CS. Although the classification of sheep seen during the spring and fall surveys varied widely, the number of sheep observed during the surveys did not improve. It is not clear whether the spring and fall differences are due to seasonal immigration into the area, differential visibility rates, or a combination of factors. The 2007 survey results for spring and fall in Unit 15CS exhibited low numbers, at 3.5 sheep/hour and 2.9 sheep/hour respectively (Appendix 13).

In 2007-2009 the Department continued to secure additional funds for complete surveys in the Black Mountains. Sheep survey methods have varied in the last 10-20 years; however since 2006 the double-count survey method has been used to estimate the population of sheep in the Black Mountains. The 2007 survey was similar to the 2004 survey in Units 15BW and 15CS, with slight increases in Units 15CN and 15D. All the units showed a significant increase in sheep observed per hour in 2008, except for Unit 15CS which showed only a slight increase. Surveys conducted in 2009 showed similar numbers to that of 2008, with a large increase in Unit 15BW and 15CN. However, the 9.6 sheep observed per hour in Unit 15CS is still well below the 20-year average (1981-2000) of 18.1. Data from the surveys show that sheep observations per hour are increasing, and in 2009 exceeded the 10-year average (2000-2009) of 14.7 sheep per hour for the entire mountain range (Appendix 12). A complete survey is scheduled for 2010. The region plans to seek additional funds for survey for the extent of this project.

Documented mortality of radio-collared sheep since April 2004 indicates that lion predation, as well as disease and drought, may be limiting the population. Thirty of 44 recorded mortalities of radio-collared sheep since April 2004 were attributed to mountain lion predation. Of the 45 total recorded mortalities on radio-collared bighorn sheep, 25 were ewes and 20 were rams. Of the 30 mortalities attributed to lion predation, 18 were ewes and 12 were rams. Cause of death was investigated for several additional bighorn sheep mortalities but could not positively be attributed to mountain lions because of carcass condition. Over 68% of the radio-collared sheep on the 5 study areas (e.g., Hwy 93-Preconstruction, Unit 15CS, Highway 68, Unit 15 Mortality, and Hwy 93-Construction) have been killed by mountain lions in the six-year period. Surveys by Department personnel and expert lion hunters have revealed additional incidences of mountain lion predation. Several old mortalities were discovered in the vicinity of radio-collared sheep mortalities; most recently a young ram and a radio-collared ewe were found to be killed by a lion in July 2009 near Union Pass Spring. Timing of predation events appear to peak during spring and fall; with a decline in the summer months (Appendix 3). Mountain lion predation on sheep within the Black Mountains appears to be higher than it has been in the past. A previous highway crossing research project conducted in the same area (Cunningham and DeVos 1992) found only one mountain lion caused mortality out of 12 total mortalities during the 1989-1991 study period; which is 8%.

Although predation may not have been the primary cause of the initial decline in the bighorn sheep population, the high rate of lion predation has the potential to further depress or inhibit recovery of a herd that is already depressed. Research indicates individual lions may be responsible for a majority of the predation in a given area and adverse effects are most likely to occur (Hoban 1990, Wehausen 1996, Creeden and Graham 1997, Ross et al. 1997, Rubin et al. 2002, Hayes et al. 2000, Sawyer and Lindsey, 2002). Variables influencing predation might include relative availability of alternate prey, escape terrain, vulnerability of individual prey, weather (including seasonal variation), and behavior of individual predators (Leopold and Krausman 1986, Ross et al. 1997, Krausman et al. 1999, Hayes et al. 2000, Ballard et al. 2001, Ernest et al. 2002). Hayes et. al (2000) proposed that sustained high levels of predation may impede recovery of Federally listed bighorn sheep in the Peninsular Ranges in

California, and Wehausen (1996) attributed declines in another Federally listed population (in the Sierra Nevada of California), at least in part, to mountain lion predation. The San Gabriel Mountains population, also in California, declined from over 500 animals to less than 90 during 1989-1995, with the decline hypothesized to be due to lion predation, possibly associated with habitat changes associated with lack of wildfires (Holl et at. 2004, Holl and Bleich 2009). Because a single mountain lion may kill on average one big game animal per work (Anderson and Lindzey 2003), even a small number of lions can inhibit the recover of bighorn sheep in the Black Mountains; having the potential to not only take most recruitment but significant portions of the adult breeding population as well.

Although disease and drought may have caused the initial decrease in the population, high levels of mountain lion predation may be limiting the population's growth. Based on current data it appears that predation on bighorn sheep by lions in the Black Mountains is significant and may represent additive mortality in portions of these units. Removal of offending lions known to be killing multiple sheep important to the recovery of the population is deemed necessary to reduce further declines and will aid in the recovery of the sheep population.

Management Goals, Strategies and Actions

The primary goal of this adaptive predation management plan is to aid in the recovery of the Black Mountains bighorn sheep population through the collection of data on bighorn sheep and mountain lion biology in a desert mountain environment. The target is recovery of the population to a level which is able to support an active transplant program. Additional objectives for this population have been outlined in the Black Mountain Bighorn Sheep Management Plan for a population that is sustainable over the long-term. By addressing predation management on the short-term, our objectives for the bighorn sheep population should be met, including the collection of data on the predators and the predator-prey relationships that exist in this desert mountain environment between mountain lions and bighorn sheep.

Ballard et al. (2001) found several factors common in case studies that dictated when predator reductions were effective and prey populations increased. These factors included:

- Predator control is implemented when prey populations are below habitat carrying capacity
- Predation is identified as a limiting factor
- Control takes place at a focused scale (generally <400 mi^2)

There are several actions that could be taken to reduce the lion population in the predation management area. Sport harvest of lions is already authorized, but its effectiveness has been limited due to the manner in which lions are generally hunted and the rugged terrain of the Black Mountains. Other measures that could be used to remove offending mountain lions are snares, leg-hold and box traps, aerial gunning, shooting, and hunting with the aid of hounds. Snaring has proven to be an effective method to trap lions in the Kofa Mountains Complex in southwestern Arizona. Snaring and radio collaring of lions has facilitated selective removal of repeat offenders, whereas other methods may not.

A multiple bag limit hunt season for mountain lions was initiated in 2004 for those units which encompass the Black Mountains (Units 15BW, 15C, and 15D) and will continue until the triggers have been met. Triggers for the multiple bag limit hunt are isolated to Unit 15CS and are two fold; 1) sheep per hour reaches the long-term average (1981-2000) of 18.1 sheep per hour seen during a survey

and/or 2) number of sheep observed on a fall survey reaches the long-term average (1981-2000) number of sheep seen is >108 total sheep with comparable amount of survey effort.

Since the hunts inception, there have been 9 lions taken by sport harvest (7) or by contract personnel (2) (Appendix 14). Although the majority of the lions were classified as sport harvest, only one lion was taken by a hunter who was not under contract or contract personnel during their own hunt excursions. Five of the lions were harvested in Unit 15D, where the greatest increase in sheep observations has been documented. Two lions were removed in Units 15BW and 15CS. Slight increases in sheep observations are being seen Unit 15BW, but none have been observed in Unit 15CS. Sport harvest will likely continue to have minimal impacts on the sheep population's recovery due to the difficulty for lion hunters to run dogs in the extremely dry, harsh terrain which exists in the Black Mountains.

The Department proposes to capture and collar mountain lions in the Black Mountains. Captured lions will be fitted with GPS satellite tracking collars and monitored remotely starting in summer 2010. Tracking individual lions and their prey selection will allow for the removal of lions that are regularly preying on bighorn sheep, as opposed to a less-discriminate landscape removal of lions. The monitoring effort will provide data on lion condition and real-time use patterns. Predator control is most effective when problem individuals can be identified and removed (Sawyer and Lindzey 2002). There is evidence that some mountain lions in bighorn sheep habitat may kill multiple sheep within a year, some may kill only one sheep in a year, and some may kill no sheep at all (Ernest et al. 2002). This concept is supported by data collected by the Department in the Kofa Mountains and that of Ross et al (1997). Collared lion KM04, in 6 months, made 89% of ungulate kills on bighorn sheep and only 11% on mule deer. In contrast, lion RM01's diet, in 19 months, was 20% bighorn sheep and 80% mule deer (Kofa Mountains Complex Adaptive Predation Management Plan, Yuma Region 2010).

Active efforts to remove offending lions will be guided by two triggers. The first trigger which much be met is outlined in the Black Mountain Bighorn Sheep Management Plan. This trigger is based on bighorn sheep observation rates for fall aerial surveys within the predation management area. When the 20-year average (1981-2000) observation rate of 19.9 sheep per hour is reached for two consecutive years the goal will have been met. The second trigger is specific to Unit 15CS and two fold: 1) sheep per hour reaches the long-term average (1981-2000) of 18.1 sheep per hour seen during a survey and/or 2) number of sheep observed on a fall survey reaches the long-term average (1981-2000) number of sheep seen is >108 total sheep with comparable amount of survey effort. When the first trigger has been achieved, only then will the second trigger be evaluated. Until both triggers are met mountain lion control may or may not be employed based on the totality of the circumstances at the time a radio-collared lion has become an offending lion. Once both triggers have been realized mountain lion control will cease in the Black Mountains; i.e. cease removal of offending lions and closure of the multiple bag limit hunt area. Mountain lions may continue to be captured and fitted with radio-collars to aid in additional monitoring, if the agency deems in necessary.

An offending mountain lion will be defined as a lion which has killed two or more sheep within a 6-month period, as determined by investigation of kill sites. An offending lion may or may not be removed based on the totality of the circumstances surrounding the two or more sheep kill sites. Data that will be evaluated in determining if an offending lion should be removed will include, but may not be limited to the following:

1) sex and age of the sheep killed;
2) the amount of time that elapses between the sheep kills;
3) recruitment in the subunit of the sheep kill;
4) the distance between the locations of sheep kills (based on current survey observations some subunits are increasing and others are not; a sheep kill in an increasing subunit may not have as large an impact on the population as a kill in a subunit that is not increasing); and
5) alternative prey selection.

In order to meet the bighorn sheep objectives while minimizing the necessary impacts to mountain lions, some flexibility is warranted by the Department. Decisions regarding active mountain lion management actions will be based on an adaptive management approach and based on the following factors:

- The current bighorn sheep population trend (an increasing or decreasing population trend of the bighorn sheep in the unit based on the prior 3 years of surveys [annual or triennial surveys as funding allows]).
- The level of lion predation rates on radio-collared bighorn sheep, where available.
- The minimum population estimate of mountain lions based on DNA analysis.

A seasonal wildlife technician will be hired by the Department to capture and monitor movements of mountain lions. Continued annual fall surveys of the mountain range, as long as funding can be secured, should occur. Genetic analysis of collected lion scat has proven to be an effective technique for determining how many individual lions are using a particular habitat in Southwest Arizona (Naidu 2009). Remote cameras will be used in a variety of locations to monitor use patterns, and possibly generate a minimum estimate of the lion population. The collection of this data in the Black Mountains will allow managers to compare lion data to data collected on the bighorn sheep population, and assess the effectiveness of predation management efforts, techniques, and the predation management plan itself. This approach is considered an adaptive management approach, and complies with the Department's Adaptive Management Policy.

Completed and Planned Actions

In 2004, in an effort to assess the situation and prescribe management actions that would aid in the recovery of the depressed bighorn sheep population in Unit 15, the Kingman region developed an action plan matrix. A summary of previous strategies, management actions and the current status of each are listed (Appendix 15). Ongoing actions in the region include:

- Implementation of mountain lion monitoring using GPS radio collars in the Black Mountains to determine movements and prey habits.
- Continuation of complete aerial surveys in the Black Mountains during the fall timeframe.
- Continued collection of sheep observations, lion and lion sign observations, and blood and DNA samples from bighorn sheep harvested by successful Black Mountains hunters.
- Continued collection of lion condition, age, sex and DNA samples from successful mountain lion hunters.
- Direction of sport hunters to the multiple bag limit hunt area.
- Maintenance of water developments in Unit 15 (Appendix 15) and continuation evaluation of possible locations for new water developments.
- Continued review and evaluation of the Black Mountain Bighorn Sheep Management Plan.

- Discussion of possible research opportunities of bighorn sheep movement with completion of the overpasses, and other development impacts to the bighorn sheep population.
- Discussion and possible continuation of radio-collaring and monitoring of bighorn sheep.

The Region and Department are also conducting the following actions with our constituents:

- Numerous presentations to the Arizona Desert Bighorn Sheep Society to provide up-to-date information on current status of the bighorn sheep situation.
- Working with the BLM on grazing management actions within the Black Mountains (Big Ranch A Allotment) that may affect forage availability for bighorn sheep. Domestic livestock may also act as a buffer species maintaining lion populations at a level higher than the habitat would normally support (Rominger, et al, 2005).
- Working with the BLM to implement burro removal efforts to meet burro population levels (AMLs) approved in the *Black Mountain Ecosystem Plan.*
- Working with state and federal land management agencies and Arizona Department of Transportation (ADOT) during project planning and scoping to minimize impacts to bighorn sheep for Highway 95 realignment.

Intensity and Duration of Management Actions

Predator control targeted at offending mountain lions will continue until managers believe the sheep population has reached the desired objectives, until predation by lions is no longer being documented, or until predation no longer limits bighorn sheep population growth. The bighorn sheep population will be considered "recovered" when the population approaches the long-term averages indicated in the Black Mountains Bighorn Sheep Management Plan and outlined below in the 'Measurable Objectives' section of this plan.

The length of the project will increase if capture, or subsequent removal and re-capture, of mountain lions is more difficult than expected and proposed data collection and monitoring indicates predation continues to be a limiting factor for recovery of the population. Because of the extended time frame necessary to achieve recovery of this bighorn sheep population, the Department will re-evaluate these triggers if our sheep population objectives are not being met.

Measurable Objectives

Measurable objectives for recovery of the bighorn sheep population, within the predation management area, are based on the Black Mountain Bighorn Sheep Management Plan. Two objectives will be used as triggers to determine when predation management actions should cease. Funds will be requested for sheep surveys to be conducted annually, in the fall, to monitor population parameters. Surveys should be repeatable, cover the same square miles of habitat and, if possible, use the same amount of survey hours each year. When the 20-year average (1981-2000) of 19.9 sheep per hour are observed, throughout the range for two consecutive years, or the sheep per hour are within a reasonable variation decided by agency personnel, population objectives for the first trigger would be met.

Once the first trigger has been met, a second trigger in Unit 15CS will be used to monitor the multiple bag limit season continuation and determine if further mountain lion removal is warranted. Unit 15CS was selected for this determination as it lies in the center of the predation management area and has experienced the largest decline in sheep population to date. This trigger is two fold; the first objective involves an indication that the sheep population in Unit 15CS has recovered to long-term average levels. Measuring the long-term average (1981-2000) consists of two components derived from the

fall surveys, both of which must be met simultaneously to be considered sufficient. The first component will be achieved when the number of sheep per hour reaches the long-term average of 18.1 sheep per hour seen during a survey. The second component will be achieved when the number of sheep observed on an October survey is >108 total sheep surveyed using a comparable amount of survey effort to the historical averages. However, this effort will depend on continued funding to conduct annual rather than tri-annual surveys.

Adaptive Management

The predation management area represents a population of bighorn sheep within a large, contiguous mountain range; however the population of mountain lions likely extends beyond these boundaries. Metapopulations are defined as a group of sheep subpopulations that are geographically separated, and even though it is limited, there is still genetic exchange between the subpopulations in the larger area. Association of bighorn sheep with mountainous terrain appears to define the separate subpopulations in the Black Mountains, with bighorn sheep, especially females, exhibiting limited movement across flat terrain. Lion movement, in contrast, is not restrained by flat terrain. The amount of mountain lion movement into and out of the management area is currently not well known. The lion metapopulation is much larger, and likely covers a significant portion of the state.

The desired future state for the predation management area is sustainable populations of wildlife. Bighorn sheep populations within this area are isolated and have declined. This population plays a critical role in the restoration of other threatened and extirpated sheep populations within the state and possibly surrounding states. The mountain lion population may be a sink population from other source populations. Long-term management will therefore favor the preservation and restoration of the sheep population.

Primary management decisions revolve around how predation management is implemented. The current proposed level of offending lion removal and the triggers that are in place for implementing predation management are conservative and based on the best available information from the management area and the literature, but there is a recognized need to assess the effect of management actions on the lion population. As biologists track the Black Mountains bighorn sheep population response to lion removal over time, it can begin to be understood what the impacts and effects of the lion population are in the area.

Under the adaptive management approach, biologists will attempt to collar as many lions within the predation management area as possible, and as management decisions are made to remove offending lions, the response of and impacts to other lions can be observed. Biologists will attempt to identify movement corridors; territorial changes post removal, major use areas, and movements in and out of the predation management area, and prey selection. Data collected after a lion is removed and during changes in prey populations may also allow biologists to identify the most preferred habitat areas for lions. Incorporating genetic data from this area and other lion populations will allow biologists to determine the source populations that are assumed to provide dispersers into this population (this assumption can also be tested). Genetic data has also proven useful in identifying individual lions and minimum population sizes.

Data collected across the entire predation management area will provide managers a clearer picture of the lion population and a better evaluation of the effectiveness of predation management decisions related to the bighorn sheep. Other questions to be answered include feasibility of the current approach, whether a vacant lion territory will be immediately filled by another lion, applicability of the

current triggers, and what amount of effort is adequate to reduce predation enough to facilitate recovery of the sheep population. Any changes to the predation management approach that results from the analysis of this data will be captured in future revisions to the adaptive predation management plan in accordance with Department policy.

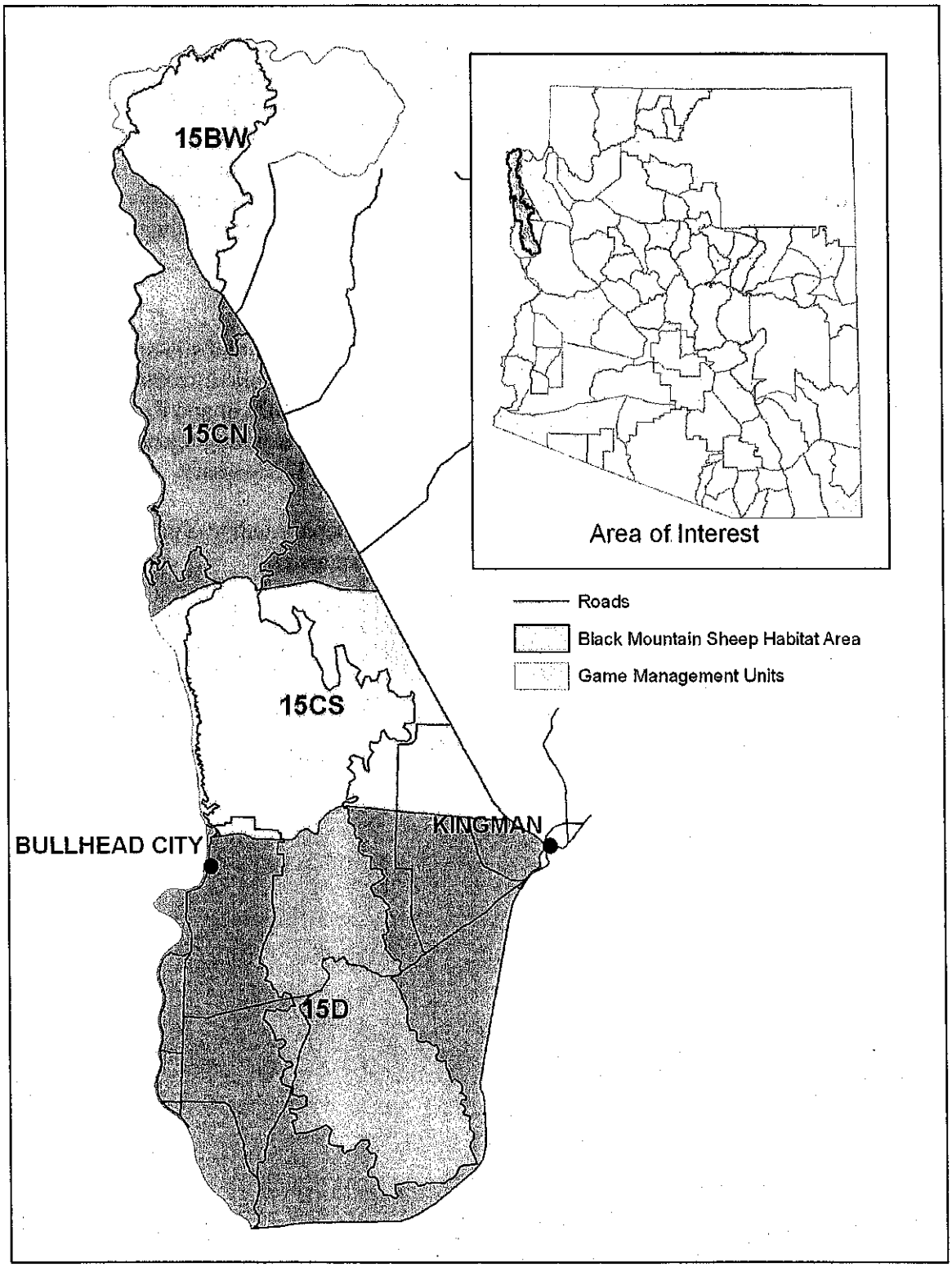
The intent of the data collection component of this plan is to increase knowledge and to evaluate and/or inform management actions across a broad area in an adaptive manner. However, any collared lion in the adaptive management area that becomes an offending lion will be managed under the predation management portion of this plan. Its value as a source of data will be considered when making final determination if it should be removed in accordance with the identified trigger. All data collected will be documented, reported and analyzed in the context of adaptive management. Regional personnel will work collaboratively with respective Wildlife Management Division Branches to implement management actions.

Public Outreach

The Department Predation Management Policy (DOM A2.31) stipulates that all site-specific management plans will contain an outreach component. When needed, public information for this plan will be coordinated and distributed by the Regional Public Information Officer and the Information and Education Division of the Department. Updates will be provided to cooperating agencies when requested. Media releases, FAQ sheets, and the like will be designed, if necessary.

Predation management activities represent an opportunity for the Department to educate the public regarding predation issues and overall management concerns for an area.

Appendix 1: Map of Adaptive Predation Management Area



Appendix 2: National Weather Service Annual Precipitation Values for 1999-2009.

Year	Bullhead City	Temple Bar	Willow Beach
1999	1.79	5.20	4.18
2000	4.27	3.15	2.95
2001	3.99	7.05	6.13
2002	0.67	1.01	1.48
2003	4.88	5.24	6.64
2004	7.40	11.57	11.19
2005	4.11	10.64	8.78
2006	1.57	3.11	3.54
2007	2.53	0.82*	1.11*
2008	5.65	N/A	N/A
2009	2.47	N/A	N/A
Long-term Average	5.84	4.15	5.63

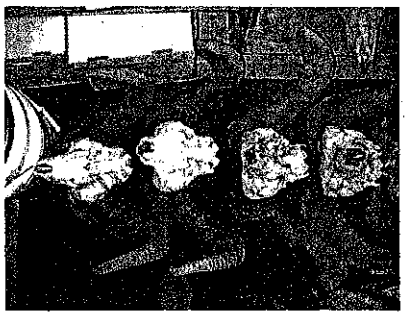
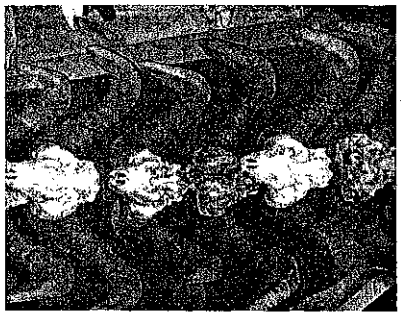
* Only partial readings were completed in 2007

Appendix 3: Bighorn Sheep Mortalities Since 2004.

ID #	Project	Age/Sex	Month-Year	Mortality Location	Unit	Easting	Northing
3258	Hwy 93-Pre	Ram I	May-04	Hills S of Lake Mead	15BW	164591	3992560
3256	Hwy 93-Pre	Ram I	Jun-04	Mine Hills N WR Canyon	15BW	168090	3990590
3270	Hwy 93-Pre	Ewe	Oct-04	Big Nasty	15CN	167942	3971530
3264	Hwy 93-Pre	Ewe	Nov-04	Wilson Ridge	15BW	174462	3980450
3266	Hwy 93-Pre	Ewe	Dec-04	Hills S of Lake Mead	15BW	164610	3992680
3252	Hwy 93-Pre	Ewe	Jul-05	Mine Hills N WR Canyon	15BW	167337	3992830
3268	Hwy 93-Pre	Ewe	Sep-05	1 km W of Hwy 93 at MP 2.5	15CN	164420	3989250
3255	Hwy 93-Pre	Ram II	Sep-05	N WR Canyon in a side canyon	15BW	167447	3989460
3260	Hwy 93-Pre	Ewe	Oct-05	Bighorn Cove	15CN	166259	3971640
3278	Hwy 93-Pre	Ram III	Dec-05	1.6 km W of Hwy 93 at MP 6.2	15CN	168265	3985328
3281	Hwy 93-Pre	Ram III	Jan-06	2 km W of Hwy 93 at MP 12	15CN	171778	3977590
3254	Hwy 93-Pre	Ram II	Mar-06	Mine Hills N WR Canyon	15BW		
3288	Reg 3-15CS	Ewe	Aug-04	Granite Canyon *	15CS	733842	3910350
3298	Reg 3-15CS	Ewe	Jan-05	W of Lost Cabin Spring *	15CS	725957	3925874
3284	Reg 3-15CS	Ram II	Jan-05	E of Portland Mine *	15CS	731055	3918316
3285	Reg 3-15CS	Ram I	Sep-05	Near Granite Canyon	15CS		
3296	Reg 3-15CS	Ewe	Oct-05	N of Portland Mine *	15CS	727640	3921120
3299	Reg 3-15CS	Ewe	Mar-06	Lost Cabin Wash; 2 mi SE of Lost Cabin Spring *	15CS	730075	3923532
196	Hwy 68	Ewe	Mar-06	3 mi W of Burro Spring; N of Hwy 68	15CS	739390	3888740
192	Hwy 68	Ram III	Sep-06	3 mi S of Lost Cabin Spring	15CS	728068	3920923
200	Hwy 68	Ram	Oct-06	Just N of Cottonwood Road	15-CN	721073	3931263
205	Hwy 68	Ewe	Oct-06	Just N of Hwy 68; very east side of range	15-CS	739568	3903415
9700	Hwy 68	Ewe	Feb-07	1.4 mi N of "Cane"	15CS	734748	3907910
3020	Reg 3-Mort	Ewe	Feb-07	6 mi N of Hwy 68; 1.5 mi NE of Gold Chain Mine	15CS	729259	3906546
3024	Reg 3-Mort	Ewe	Feb-07	1 mi W of Rhyolite Spring; 3 mi NE of Box Spring	15CS	733192	3908707
3013	Reg 3-Mort	Ram III	Oct-07	1 mi S of Fire Mtn	15CN	712756	3947488
3011	Reg 3-Mort	Ewe	Oct-08	Malpais Mesa	15CN	709220	3962944
3021	Reg 3-Mort	Ewe	Jul-09	Union Pass Spring	15CS	737663	3902230
3007	Reg 3-Mort	Ewe	N/A (VHF)	1 mi SW of Malpais Mesa	15CN	709087	3960277
5RAM	Hwy 93-Cons	Ram	Mar-09	1.5 mi E of Wildhorse Spring	15BW	718574	3987783

* Locations for Reg 3 - 15CS project were estimated based on the location description

Appendix 4. Photographs of pick up heads collected by sheep guides in 2002.


Appendix 5. Results of sheep pick up head examination from the sheep guide's collection.

Age (Years)	Time Since Mortality (Months)	Unit
4	<12	15CN
7.5	<12	15CN
7.5	<12	15CN
8	<12	15CN
9	<12	15CN
9	<12	15CN
9	<12	15CN
8.5	12-24	15CN
6.5	<12	15CS
8	<12	15CS
8.5	12-24	15CS
9.5	12-24	15CS
5.5	>24	15CS
7.5	>24	15CS
9	>24	15CS
9	Unknown	15CS

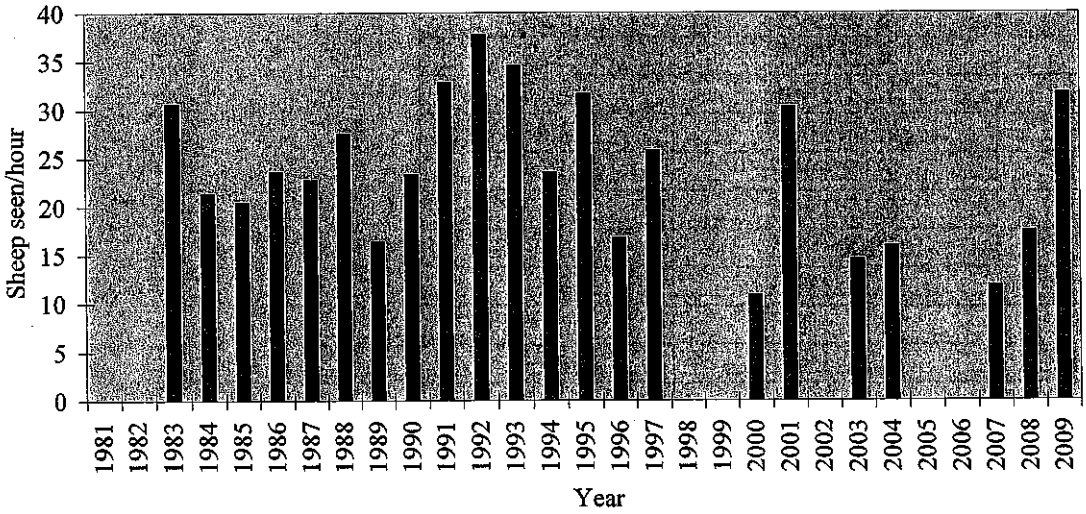
Appendix 6: Kingman Region Bighorn Sheep Population Action Matrix

TASK	OWNER	COMMENTS	COMPLETION DATE/STATUS
Investigate initial reports of pickup heads from guides and hunters	Region staff	15 sheep skull pickups and a horn were examined for cause of death and period of time deceased	Completed May 2003.
Respond to public concerns related to the sheep die off in the Black Mtns	Region staff	Regional supervisor met with interested parties, apply for additional funds for sheep survey time, draft a sheep management plan for Black Mtns	Ongoing.
Draft Black Mtns Predation Management Plan	Region staff	Drafted a predation management plan for the future the Black Mtns, circulated to interested parties and finalize.	Completed April 2004.
Conduct complete aerial surveys of the Black Mtns	Region staff	Conduct complete surveys of the contiguous bighorn sheep habitat in the Black Mtns. In 2006, on Unit 15CS had a fall survey.	Completed annually since 2004. Planned 2010.
Survey hunters for location and condition of sheep carcasses and skulls, collection of blood and lung samples, sheep observations	Research staff, Region staff and Region III hunters	Request for carcasses info included with informational packet to hunters in 2003. Request blood samples 2004-2005 in Units 15CS & D. Included Unit 15BW & CN 2006-09 hunt seasons.	Completed annually since 2003 hunt season. Ongoing.
Summer water catchment surveys	Region staff	Use remote cameras and observers to classify bighorn sheep and specific water sources.	Completed Summer 2004.
Initiate Multiple Bag Limit for the Black Mountains	Region staff	Regional staff and lion experts survey lions and initiate a multiple bag limit for lions in the Black Mountains. To date 8 lions have been harvested.	Initiated for 2004-2005 lion season. Ongoing.
Conduct ground surveys pre- and post-hunt	Region staff	Complete in Unit 15CS primarily	Completed during 2004 hunt season.
Request sheep disease and mortality information from Hoover Dam Bypass Project	Region staff, Research staff	Monitor sheep mortalities due to lion predation on research project along Hwy 93. Twelve of 16 mortalities due to lion predation. Working with ADOT to incorporate overpasses on Hwy 93.	Captured 2004. Completed 2006.
Monitor bighorn sheep mortalities in Unit 15CS	Region staff, Research staff	Radio collared 18 bighorn sheep in Unit 15CS and monitored movement, lion predation; 6 of 10 mortalities from lion predation. Disease testing completed and compiled.	Captured 2004, Completed 2006.
Request sheep disease and mortality information from State Route 68 Crossing Project	Region staff, Research staff	Monitor sheep mortalities due to lion predation on research project along State Route 68. Five of 10 mortalities due to lion predation. Worked with ADOT, evaluate underpasses on State Route 68.	Captured 2005 and 2006. Completed 2008.
Conduct aerial surveys of Unit 15CS for lambing in the spring	Region staff	Secured additional funding and conducted spring surveys to assess the productivity of the sheep population In Unit 15CS.	Completed 2006-2008.
Monitor bighorn sheep mortalities in Unit 15C	Region staff, Research staff	Radio-collared 30 bighorn sheep in Unit 15C to monitored movement, 6 of 7 mortalities from lion predation. Disease testing completed.	Captured 2006. Completed 2009.
Draft Black Mountain Bighorn Sheep Management Plan	Region staff	Drafted a management plan for the future of the bighorn sheep population in the Black Mtns, circulated to interested parties and finalize.	Completed April 2007.
Update Black Mtns Predation Management Plan	Region staff	Summarize all bighorn sheep mortality data and update predation management plan	Completed April 2010.
Conduct lion monitoring project in Black Mtns	Region staff via Wildlife Services	Radio-collar up to 3 mountain lions in the Black Mtns to monitor movement and prey selection.	Ongoing.

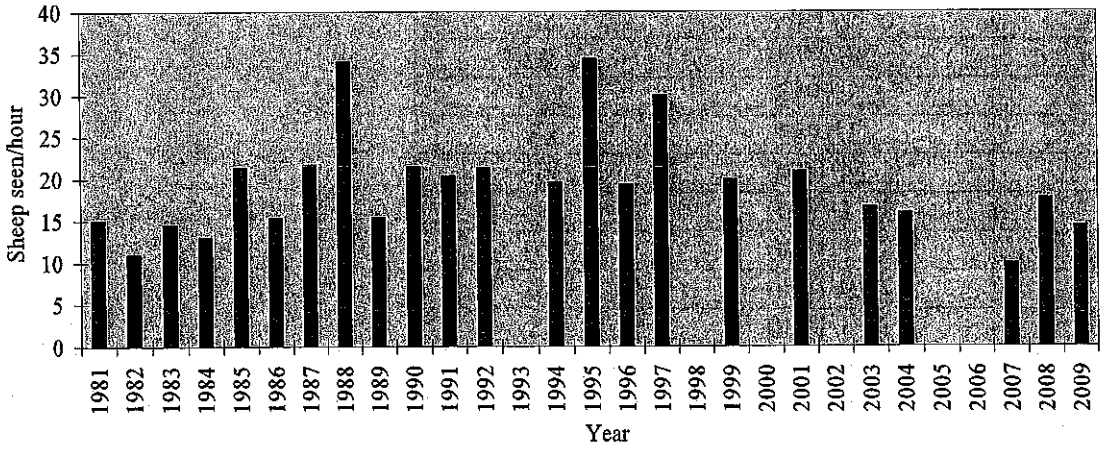
Appendix 7: Black Mountain Wildfires Since 1980.

Fire Name	Date	Acres
Union	6/12/2006	8,380
Secret	6/12/2006	4,108
Nutt	6/12/2006	149
Hopper	8/9/2005	720
Double L	8/1/2005	312
Expo	7/31/2005	240
Twin Mills	7/27/2005	12,426
McCarrin	7/18/1998	154
South	8/12/1996	149
Black Mountain	10/8/1995	597
Nutt	8/31/1995	703
Burn Springs	7/14/1995	67
Perkins Branch	9/29/1994	14,731
Warm	8/15/1994	5,276
Dixie	6/30/1994	268
Jurassic Branch	6/28/1994	1,195
Thorn	6/23/1994	130
Dolan	6/18/1994	1,841
Union	6/7/1994	148
Twin	6/5/1994	51
Santa Claus 2	10/20/1993	765
Springs	10/18/1993	128
Mine	8/8/1993	1,529
Junction	8/8/1993	1,575
Union Pass	6/16/1993	452
Rock	6/12/1993	88
Santa Claus	5/30/1993	2,028
Musgrove	6/5/1988	289
Boundary	5/3/1987	83
Antelope	8/24/1980	355
Burns	8/11/1980	735
Dripping	8/11/1980	101
Cabin	7/29/1980	749
Water	7/23/1980	68
Sacramento	7/23/1980	1,621
Ute	7/23/1980	3,238
Basin	7/23/1980	4,179
Total Acreage of all Fires		69,628
Total Acres of Land Burned (excludes reburns)		60,489

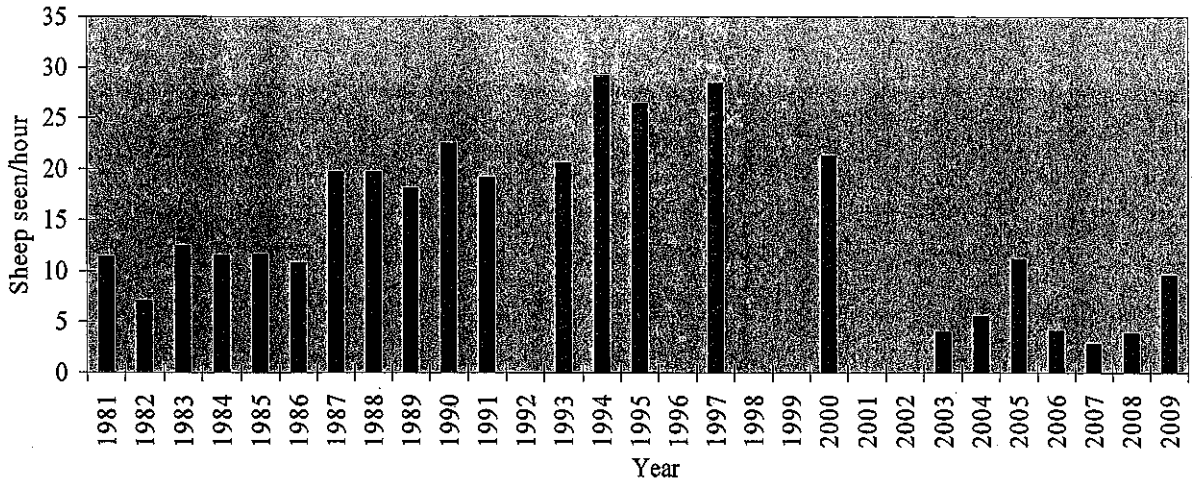
Appendix 8: Unit 15BW bighorn sheep observed per hour of survey effort, 1981-2009.



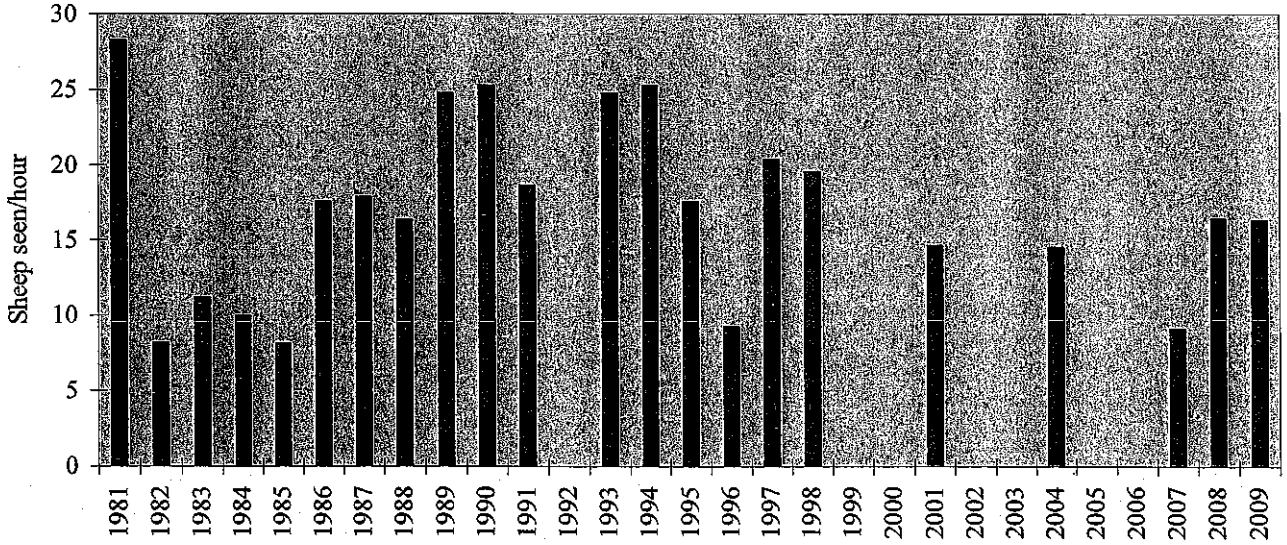
Appendix 9: Unit 15CN bighorn sheep observed per hour of survey effort, 1981-2009.



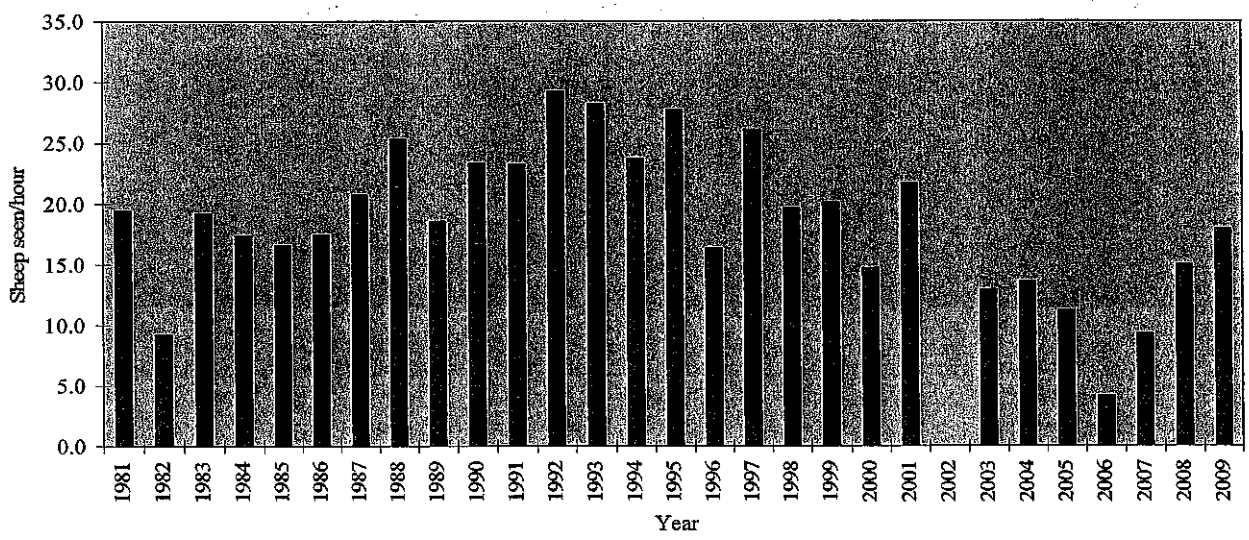
Appendix 10: Unit 15CS bighorn sheep observed per hour of survey effort, 1984-2009.



Appendix 11: Unit 15D bighorn sheep observed per hour of survey effort, 1981-2009.



Appendix 12: Combined bighorn sheep observed per hour of survey effort, 1981-2009.
*Units 15BW, 15CN, 15CS, and 15D.



Appendix 13: Sheep survey results 1981-2009 in Units 15BW, 15CN, 15CS, and 15D.

Unit 15B West								
Year	Rams	Ewes	Lambs	Yrlgs	Uncl.	Total	Hours	Sheep/Hour
1981	NS							
1982	NS							
1983	91	238	72	22		423	13.8	30.7
1984	78	148	42	12		280	13.1	21.4
1985	82	187	44	19		332	16.2	20.5
1986	53	149	51	12	5	270	11.4	23.7
1987	65	127	57	41		290	12.7	22.8
1988	67	184	62	40		353	12.8	27.6
1989	57	115	28	8		208	12.7	16.4
1990	76	93	48	10		227	9.7	23.4
1991	103	180	30	30		343	10.4	32.9
1992	139	184	70	35		428	11.3	37.8
1993	179	172	32	24		408	11.8	34.6
1994	64	147	22	19		252	10.7	23.6
1995	104	183	54	8		349	11	31.7
1996	64	120	15	5		204	12.1	16.8
1997	99	142	59	3		303	11.7	25.8
1998	NS							
1999	NS							
2000	31	64	18	6	0	119	10.9	10.9
2001	75	163	86	19	0	343	11.3	30.3
2002	NS							
2003	26	85	43	7	0	161	11.0	14.6
2004	33	64	41	4	0	142	8.9	16.0
2005	NS							
2006	NS							
2007	31	64	33	3	0	131	11.0	11.9
2008	26	63	41	6	6	142	8.1	17.5
2009	55	133	59	4	0	251	7.9	31.8

Unit 15C North								
Year	Rams	Ewes	Lambs	Yrlgs	Uncl.	Total	Hours	Sheep/Hour
1981	53	73	19			145	9.6	15.1
1982	33	44	29			106	9.4	11
1983	53	74	29	15		171	11.7	14.6
1984	16	18	2	10		46	3.5	13.1
1985	61	100	44	13		218	10.2	21.4
1986	38	95	41	12		186	12.1	15.4
1987	59	110	77	34		280	12.9	21.7
1988	88	189	102	54		433	12.7	34.1
1989	51	120	21	5		197	12.8	15.4
1990	75	99	26	20		220	10.2	21.5
1991	67	128	50	17		262	12.8	20.4
1992	89	119	32	30		270	12.6	21.4
1993	NS							
1994	63	142	15	20		240	12.2	19.7
1995	82	216	73	15	4	390	11.3	34.5
1996	68	128	21	10		227	11.7	19.4
1997	118	168	73	12		371	12.3	30.1
1998	NS							
1999	59	121	31	0	0	211	10.5	20.0
2000	NS							
2001	50	106	41	11	0	208	9.9	21.0
2002	NS							
2003	21	82	39	3	0	145	8.6	16.7
2004	18	58	43	1	0	120	7.5	16.0
2005	NS							
2006	NS							
2007	33	50	37	6	0	126	12.7	9.9
2008	41	85	63	9	0	198	11.2	17.7
2009	42	95	43	1	0	181	12.6	14.4

Unit 15C South								
Year	Rams	Ewes	Lambs	Yrlgs	Uncl.	Total	Hours	Sheep/Hour
1981	21	29	13			63	5.5	11.4
1982	7	13	8			28	3.9	7.1
1983	8	23	17	6		55	4.4	12.5
1984	2	14	4	3		23	2	11.5
1985	28	36	20	3		87	7.5	11.6
1986	22	31	18	7		78	7.2	10.8
1987	39	56	28	11		134	6.8	19.7
1988	39	49	32	14		134	6.8	19.7
1989	40	64	18	14		136	7.5	18.1
1990	42	56	21	14		133	5.9	22.5
1991	26	40	23	11		100	5.2	19.2
1992	NS							
1993	30	56	10	13	2	111	5.4	20.6
1994	51	108	8	17		184	6.3	29.2
1995	52	90	17			159	6	26.5
1996	NS							
1997	34	90	46	1		171	6	28.5
1998	NS							
1999	NS							
2000	39	65	25	2	0	131	6.1	21.4
2001	NS							
2002	NS							
2003	9	11	3	1	0	24	6.0	4.0
2004	7	17	8	2	0	34	6.1	5.6
2005S	8	16	6	0	0	30	5.0	6.0
2005F	13	30	14	0	1	58	5.2	11.2
2006S	2	48	22	0	0	72	5.9	12.2
2006F	21	20	5	0	0	46	11.2	4.1
2007S	0	13	8	0	0	21	6.1	3.5
2007F	6	7	4	0	0	17	5.8	2.9
2008	8	11	7	0	0	26	6.6	3.9
2009	13	12	25	9	0	46	4.8	9.6

Unit 15D								
Year	Rams	Ewes	Lambs	Yrlgs	Uncl.	Total	Hours	Sheep/Hour
1981	**102**	**126**	**44**			**272**	**9.6**	**28.3**
1982	34	40	14			88	10.8	8.2
1983	37	44	22	5		108	9.6	11.2
1984	21	7	7			35	3.5	10
1985	32	27	10	3		72	8.8	8.18
1986	50	65	46	8		169	9.6	17.6
1987	57	92	44	7		200	11.2	17.9
1988	52	81	51	5		189	11.5	16.4
1989	70	134	47	32		283	11.4	24.8
1990	102	114	38	15		279	11	25.3
1991	57	65	46	18		186	9.9	18.7
1992	NS							
1993	74	144	26	4		248	10	24.8
1994	74	157	19	18		268	10.6	25.3
1995	63	114	16	2		195	11.1	17.6
1996	22	30	0	4		56	6	9.3
1997	66	130	28	1		225	11	20.4
1998	43	122	39	12		216	11	19.6
1999	NS							
2000	NS							
2001	39	104	40	10	0	193	13.1	14.7
2002	NS							
2003	NS							
2004	29	87	25	2	1	144	9.9	14.6
2005	NS							
2006	NS							
2007	35	51	19	0	0	105	11.4	9.2
2008	88	110	40	1	1	239	14.5	16.5
2009	89	128	47	0	0	264	16.1	16.4

Combined Units (15BW, 15C & 15D)								
Year	Rams	Ewes	Lambs	Yrlgs	Uncl.	Total	Hours	Sheep/Hour
1981	176	228	76	0	0	480	24.7	19.4
1982	74	97	51	0	0	222	24.1	9.2
1983	189	379	140	48	0	757	39.5	19.2
1984	117	187	55	25	0	384	22.1	17.4
1985	203	350	118	38	0	709	42.7	16.6
1986	163	340	156	39	5	703	40.3	17.4
1987	220	385	206	93	0	904	43.6	20.7
1988	246	503	247	113	0	1109	43.8	25.3
1989	218	433	114	59	0	824	44.4	18.6
1990	295	362	133	59	0	859	36.8	23.3
1991	253	413	149	76	0	891	38.3	23.3
1992	228	303	102	65	0	698	23.9	29.2
1993	283	372	68	41	2	767	27.2	28.2
1994	252	554	64	74	0	944	39.8	23.7
1995	301	603	160	25	4	1093	39.4	27.7
1996	154	278	36	19	0	487	29.8	16.3
1997	317	530	206	17	0	1070	41	26.1
1998	43	122	39	12	0	216	11	19.6
1999	59	121	31	0	0	211	10.5	20.1
2000	70	129	43	8	0	250	17	14.7
2001	164	373	167	40	0	744	34.3	21.7
2002	0	0	0	0	0	0	0	0.0
2003	56	178	85	11	0	330	25.6	12.9
2004	87	226	117	9	1	440	32.4	13.6
2005	13	30	14	0	1	58	5.2	11.2
2006	21	20	5	0	0	46	11.2	4.1
2007	105	172	93	9	0	379	40.9	9.3
2008	163	269	151	16	7	605	40.4	15.0
2009	199	368	174	14	0	742	41.4	17.9

Appendix 14: Harvest During Multiple Bag Limit Season, initiated July, 2004

Unit	Month	Day	Year	Age	Sex	Harvest Location
15D	February	5	2005	8	M	Near Oatman
15BW	March	28	2005	2*	F	Mt Wilson
15D	January	5	2006	2	F	Black Mountains
15CS	October	18	2006	3	F	Union Pass
15CS	February	26	2008	2	M	Princess Peak
15D	January	10	2009	11	F	Antelope Springs
15D	April	10	2009	6	M	Mt Nutt
15BW	January	9	2010	3*	M	Mt Wilson
15D	February	1	2010	8*	F	Mt Nutt

* Estimated age at check out, rather than cementum tooth age

Appendix 15. Unit 15 water development maintenance activities.

Water Name	Date	Action
Lost Cabin Catchment	1/1/2005	Cleaned sediments out
	1/1/2006	Cleaned sediments out
	7/2/2008	Cleaned sediments out of retention dam and drinker, removed brush.
Two Horns Catchment	1/1/2004	Added apron
Tufa Tank	9/19/2003	Water hauled
	10/20/2003	Water hauled, float valve repaired, patched bullet holes
	1/1/2006	Walk-in drinker installed - not functioning yet
Lambing Tank	1/1/2005	Water Hauled, painted
Black Mtns. #2	4/30/1999	Replaced tank cover, ultra flex apron cracks
Black Mtns. #3	7/15/2000	Water hauled
Black Mtns. #4	4/13/1999	General maintenance
Fire Mtn. Pothole		Non-functional - in National Recreation Area
Van Deemen Tank	1/1/2005	Cleaned sediments out, resealed
Slurry Tanks	7/10/2008	Cleaned sediments out of lower tenaja and removed brush from upper tenaja
Pass Tank #3	7/2/2008	Cleaned sediments out of tenaja and removed brush from retention dam
Master Spring	1/4/2004	Redeveloped - sausage and drinker installed
	7/3/2008	Removed brush and cattails from drinker
Mcheffy Spring	1/1/2005	Cleaned sediments out
	1/1/2006	Cleaned sediments out
	7/7/2008	Cleaned sediments out and removed brush from drinker
Lower Lost Cabin Spring	7/3/2008	Cleaned sediments out of trough
Coyote Pass Catchment	5/13/2003	Water hauled
Carl Scrivens (Cone Mt.)	1/1/2004	Built new
Middle Missouri Spring	1/1/2002	Built new
Tipperary Tank	11/8/2009	Redeveloped
Ram Springs	1/1/2006	Cleaned sediments out
	7/9/2009	Cleaned sediments out
Sheep Spring	3/28/2006	Cleaned sediments out of dam, removed weeds and brush from area
Columbine Spring	4/3/2006	Cleaned sediments out of dam, removed weeds and brush from area
	1/1/2005	Removed weeds and brush, repaired fence
Battleship Spring	3/27/2006	Cleaned sediments out of dam, removed weeds and brush from area
	7/7/2008	Trimmed brush and pulled cattails
Trough Spring	7/8/2008	Cleaned sediments out and removed brush from drinker, repaired fence
Golden Door Cistern	9/5/2001	Water hauled
	6/6/2002	Water hauled
	1/1/2006	Redeveloped - sausage and walk-in drinker installed
Cottonwood Spring	1/1/2004	Fence repaired
Metate Spring	6/30/2009	Standard maintenance

Literature Cited

Arizona Game and Fish Department, Yuma Region. 2010. Kofa Mountains Complex Adaptive Predation Management Plan.

Arizona Game and Fish Department. 2004. Arizona Game and Fish Department Predator Management Team Report

Anderson, C. R., and F. G. Lindzey, Jr. 2003. Estimating cougar predation rates from GPS location clusters. Journal of Wildlife Management 67:307-316.

Ballard, W. B., D. Lutz, T. W. Keegan, L. H. Carpenter, and J. C. deVos, Jr. 2001. Deer-predator relationships: a review of recent North American studies with emphasis on mule and black-tailed deer. Wildlife Society Bulletin 29:99-115.

Creeden, P. J., and V. K. Graham. 1997. Reproduction, survival, and lion predation in the Black Ridge/Colorado National Monument desert bighorn herd. Desert Bighorn Council Transactions 41:37-43.

Cunningham, S.C., and J.C. deVos. 1992. Mortality of Mountain Sheep in the Black Canyon Area of Northwest Arizona. Desert Bighorn Council Transactions 36:27-29.

Ernest, H.B., E.S. Rubin, and W.M. Boyce. 2002. Fecal DNA analysis and risk assessment of mountain lion predation of bighorn sheep. Journal of Wildlife Management 66:75-85.

Hayes, C. L., E. S. Rubin, M. C. Jorgensen, R. A. Botta, and W. M. Boyce. 2000. Mountain lion predation of bighorn sheep in the Peninsular Ranges, California. Journal of Wildlife Management 64:954-959.

Hoban, P. A. 1990. A review of desert bighorn sheep in the San Andres Mountains, New Mexico. Desert Bighorn Council Transactions 34:14-22.

Holl, S. A., V. C. Bleich, and S. G. Torres. 2004. Population dynamics of bighorn sheep in the San Gabriel Mountains, California, 1967–2002. Wildlife Society Bulletin 32:412–426.

Holl, S. A., and V. C. Bleich. 2009. Reconstructing the San Gabriel Mountains bighorn sheep population. California Fish and Game 95(2):77-87.

Krausman, P. R., A. V. Sandoval, and R. C. Etchberger. 1999. Natural history of desert bighorn sheep. Pages 139–191 *in* R. Valdez and P. R. Krausman, editors. Mountain sheep of North America. University of Arizona Press, Tucson, Arizona, USA.

Leopold, B. D., and P. R. Krausman. 1986. Diets of 3 predators in Big Bend National Park, Texas. Journal of Wildlife Management 50: 290-295.

Naidu, A. 2009. Genetic analysis of mountain lion (*Puma concolor*) feces from Kofa National Wildlife Refuge, Arizona. MS thesis, University of Arizona.

Logan, K. A., and L. L. Sweanor. 2001. Desert puma. Island Press, Washington, D. C., USA.

McKinney, T., T. W. Smith, and J. C. deVos, Jr. 2006. Evaluation of factors potentially influencing a desert bighorn sheep population. Wildlife Monographs 164:1–34.

Ross, P. I., M. G. Jalkotzy, and M. Festa-Bianchet. 1997. Cougar predation on bighorn sheep in southwestern Alberta during winter. Canadian Journal of Zoology 74:771-775.

Rubin, E. S., W. M. Boyce, and E. P. Caswell-Chen. 2002. Modeling demographic processes in an endangered population of bighorn sheep. Journal of Wildlife Management 66:796-810.

Rominger, E. M., F.S. Winslow, E.J. Goldstein, D. Weybright, and W. C. Dunn. 2005. Cascading effects of subsidized mountain lion populations in the Chihuahuan Desert. Proceedings of the 8th Mountain Lion Workshop 8:156.

Sawyer, H., and F. Lindzey. 2002. A review of predation on bighorn sheep (*Ovis canadensis*). Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, Wyoming, USA.

Wehausen, J. D. 1996. Effects of mountain lion predation on bighorn sheep in the Sierra Nevada and Granite Mountains of California. Wildlife Society Bulletin 24:471-479.